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(54) **CONDENSED CYCLIC COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING CONDENSED CYCLIC COMPOUND**

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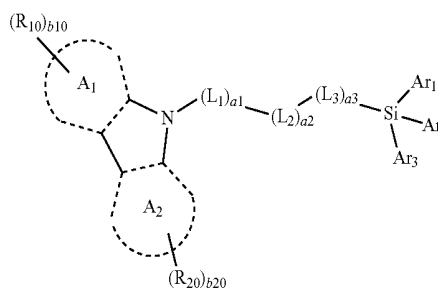
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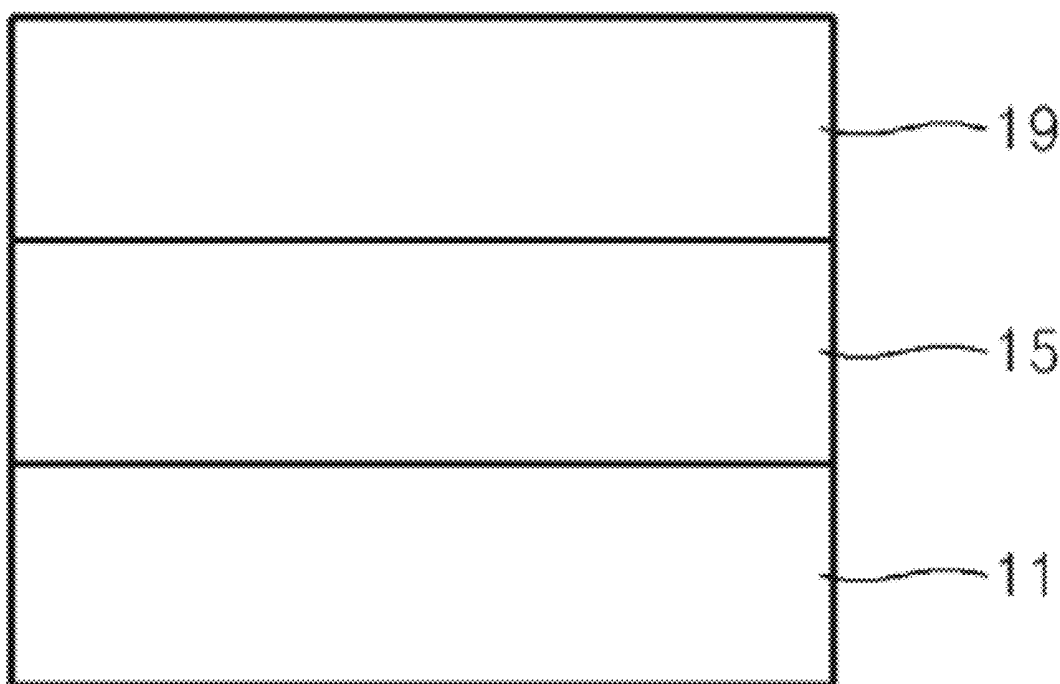
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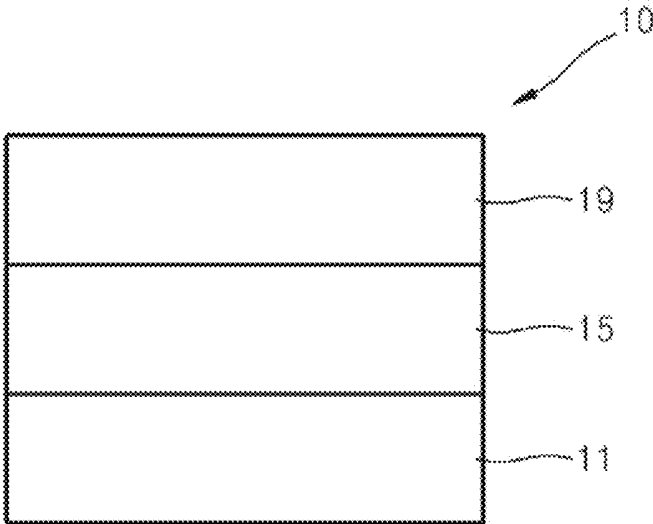
(57) **ABSTRACT**
A condensed cyclic compound represented by Formula 1:



Formula 1

wherein, in Formula 1, groups and variables are the same as described in the specification.





**CONDENSED CYCLIC COMPOUND AND
ORGANIC LIGHT-EMITTING DEVICE
INCLUDING CONDENSED CYCLIC
COMPOUND**

CROSS-REFERENCE TO RELATED
APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2018-0089505, filed on Jul. 31, 2018, in the Korean Intellectual Property Office, and all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

[0002] The present disclosure relates to a condensed cyclic compound and an organic light-emitting device including the condensed cyclic compound.

2. Description of the Related Art

[0003] Organic light-emitting devices (OLEDs) are self-emission devices which have wide viewing angles, high contrast ratios, short response times, and excellent brightness, driving voltage, and response speed characteristics, and which produce full-color images.

[0004] OLEDs include an anode, a cathode, and an organic layer between the anode and the cathode and including an emission layer. A hole transport region may be disposed between the anode and the emission layer, and an electron transport region may be disposed between the emission layer and the cathode. Holes provided from the anode may move toward the emission layer through the hole transport region, and electrons provided from the cathode may move toward the emission layer through the electron transport region. The holes and the electrons recombine in the emission layer to produce excitons. These excitons transit from an excited state to a ground state to thereby generate light.

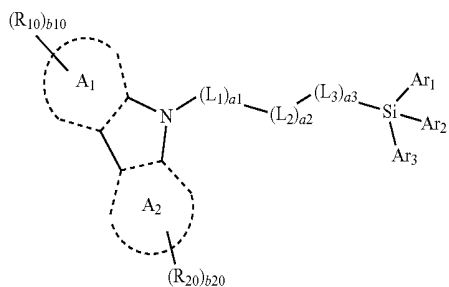
[0005] Various types of organic light emitting devices are known. However, there still remains a need in OLEDs having low driving voltage, high efficiency, high brightness, and long lifespan.

SUMMARY

[0006] Provided are a condensed cyclic compound and an organic light-emitting device including the condensed cyclic compound.

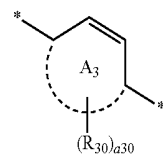
[0007] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0008] According to an aspect of an embodiment, a condensed cyclic compound may be represented by Formula 1:

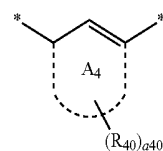


Formula 1

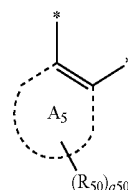
-continued



Formula 2



Formula 3



Formula 4

[0009] wherein in Formulae 1 to 4,

[0010] Ar₁ to Ar₃ may each independently be -(L₄)_{a4}-(R₆₀)_{a60},

[0011] L₁ to L₄ may each independently be a group represented by one selected from Formulae 2 to 4,

[0012] a₁ and a₃ may each independently be an integer from 1 to 3,

[0013] a₂ and a₄ may each independently be an integer from 0 to 3,

[0014] rings A₁ to A₅ may each independently be a C₅-C₆₀ carbocyclic group or a C₂-C₆₀ heterocyclic group,

[0015] R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ may each independently be selected from hydrogen, deuterium, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si(Q₁)(Q₂)(Q₃), -N(Q₄)(Q₅), and -B(Q₆)(Q₇),

[0016] wherein at least one selected from R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ may be a cyano group,

[0017] b₁₀, b₂₀, b₃₀, b₄₀, b₅₀, and b₆₀ may each independently be an integer from 1 to 10, and

[0018] at least one substituent of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀

cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0019] deuterium, —F, —Cl, —Br, —I, — CD_3 , — CD_2H , — CDH_2 , — CF_3 , — CF_2H , — CFH_2 , a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group;

[0020] a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, — CD_3 , — CD_2H , — CDH_2 , — CF_3 , — CF_2H , — CFH_2 , a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{11})(Q_{12})(Q_{13}), —N(Q_{14})(Q_{15}), and —B(Q_{16})(Q_{17});

[0021] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0022] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, — CD_3 , — CD_2H , — CDH_2 , — CF_3 , — CF_2H , — CFH_2 , a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{21})(Q_{22})(Q_{23}), —N(Q_{24})(Q_{25}), and —B(Q_{26})(Q_{27}); and

[0023] —Si(Q_{31})(Q_{32})(Q_{33}), —N(Q_{34})(Q_{35}), and —B(Q_{36})(Q_{37});

[0024] wherein Q_1 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} may each independently be selected from hydrogen,

deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0025] According to an aspect of another embodiment, an organic light-emitting device may include:

[0026] a first electrode;

[0027] a second electrode; and

[0028] an organic layer disposed between the first electrode and the second electrode,

[0029] wherein the organic layer includes an emission layer and at least one condensed cyclic compound represented by Formula 1.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the FIGURE which is a schematic cross-sectional view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0031] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein.

[0032] Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present disclosure. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. Expressions such as “at least one of,” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0033] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein.

[0034] Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. Expressions such as “at least

one of,” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0035] It will be understood that when an element is referred to as being “on” another element, it can be directly in contact with the other element or intervening elements may be present therebetween. In contrast, when an element is referred to as being “directly on” another element, there are no intervening elements present.

[0036] It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers, and/or sections, these elements, components, regions, layers, and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer, or section from another element, component, region, layer, or section. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the present embodiments.

[0037] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0038] The term “or” means “and/or.” It will be further understood that the terms “comprises” and/or “comprising,” or “includes” and/or “including” when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof.

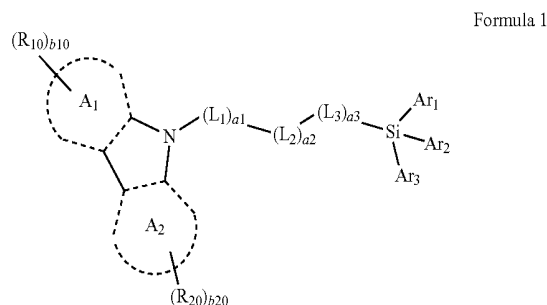
[0039] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this general inventive concept belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0040] Exemplary embodiments are described herein with reference to cross section illustrations that are schematic illustrations of idealized embodiments. As such, variations from the shapes of the illustrations as a result, for example, from manufacturing, are to be expected. Thus, embodiments described herein should not be construed as limited to the particular shapes of regions as illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. For example, a region illustrated or described as flat may, typically, have rough and/or nonlinear features. Moreover, sharp angles that are illustrated may be rounded. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the precise shape of a region and are not intended to limit the scope of the present claims.

[0041] “About” or “approximately” as used herein is inclusive of the stated value and means within an acceptable range of deviation for the particular value as determined by one of ordinary skill in the art, considering the measurement in question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement

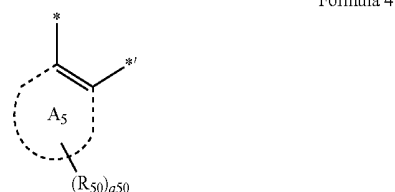
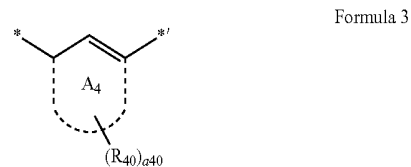
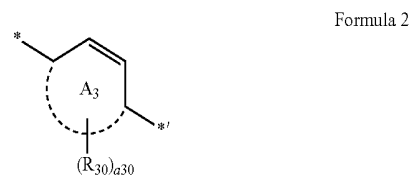
system). For example, “about” can mean within one or more standard deviations, or within $\pm 30\%$, 20% , 10% , 5% of the stated value.

[0042] In an embodiment, a condensed cyclic compound is provided. The condensed cyclic compound may be represented by Formula 1:



[0043] In Formula 1, Ar_1 to Ar_3 may each independently be $-(L_4)_{a4}$, $-(R_{60})_{a60}$. L_4 , a_4 , R_{60} , and a_{60} are described below.

[0044] In Formula 1, L_1 to L_4 may each independently be a group represented by one selected from Formulae 2 to 4,



[0045] In Formula 1, a_1 and a_3 may respectively indicate the number of L_1 and L_3 . a_1 and a_3 may each independently be an integer from 1 to 3. When a_1 is 2 or greater, at least two groups L_1 may be identical to different from each other. When a_3 is 2 or greater, at least two groups L_3 may be identical to different from each other.

[0046] In some embodiments, a_1 and a_3 may each be 1.

[0047] In Formula 1, a_2 and a_4 may each respectively be an integer from 0 to 3. When a_2 is 2 or greater, at least two groups L_2 may be identical to different from each other. When a_4 is 2 or greater, at least two groups L_4 may be identical to different from each other.

[0048] In some embodiments, a_2 may be 0, 1, or 2.

[0049] In some embodiments, a_4 may be 1, 2, or 3.

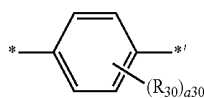
[0050] In Formulae 1 to 4, rings A_1 to A_5 may each independently be a C_5 - C_{60} carbocyclic group or a C_2 - C_{60} heterocyclic group.

[0051] In some embodiments, rings A_1 to A_5 may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, an indene group, a pyrrole group, a thiophene group, a furan group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a quinoxaline group, a quinazoline group, a carbazole group, a benzimidazole group, a benzofuran group, a benzothiophene group, an isobenzothiophene group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a dibenzofuran group, and a dibenzothiophene group.

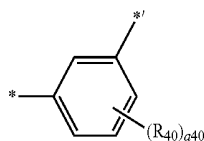
[0052] In some embodiments, rings A_1 and A_2 may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a carbazole group, a triazine group, a dibenzofuran group, and a dibenzothiophene group.

[0053] In some embodiments, rings A_3 to A_5 may each be a benzene group.

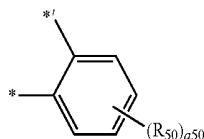
[0054] In some embodiments, L_1 to L_3 may each independently be a group represented by one selected from Formulae 3-1 to 3-9:



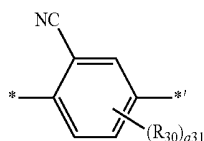
3-1



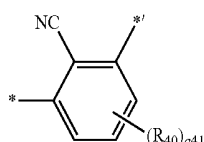
3-2



3-3



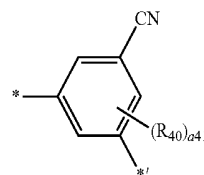
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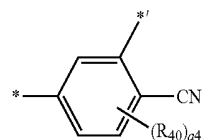
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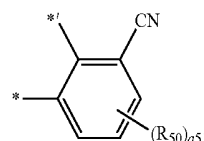
3-6



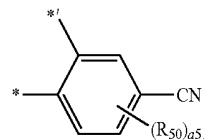
3-7



3-8



3-9



[0055] wherein, in Formulae 3-1 to 3-9,

[0056] R_{30} , R_{40} , R_{50} , a_{30} , a_{40} , and a_{50} may be understood by referring to the descriptions for those provided herein,

[0057] a_{30} , a_{40} , and a_{50} may each independently be an integer from 1 to 4, and

[0058] a_{31} , a_{41} , and a_{51} may each independently be an integer from 1 to 3.

[0059] In Formulae 1 to 4, R_{10} , R_{20} , R_{30} , R_{40} , R_{50} , and R_{60} may each independently be selected from hydrogen, deuterium, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, $-\text{N}(\text{Q}_4)(\text{Q}_5)$, and $-\text{B}(\text{Q}_6)(\text{Q}_7)$, and at least one selected from R_{10} , R_{20} , R_{30} , R_{40} , R_{50} , and R_{60} may be a cyano group.

[0060] In some embodiments, R_{10} , R_{20} , R_{30} , R_{40} , R_{50} , and R_{60} may each independently be selected from hydrogen, deuterium, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof,

a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;

[0061] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, and a triazinyl group;

[0062] a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pyrrolyl group, an imidazolyl group, a pyrazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoxazolyl group, a benzimidazolyl group, a furanyl group, a benzofuranyl group, a thiophenyl group, a benzothiophenyl group, a thiazolyl group, an isothiazolyl group, a benzothiazolyl group, an isoxazolyl group, an oxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, imidazopyridimidinyl group, and an imidazopyridinyl group; and

[0063] a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pyrrolyl group, an imidazolyl group, a pyrazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoxazolyl group, a benzimidazolyl group, a furanyl group, a benzofuranyl group, a thiophenyl group, a benzothiophenyl group, a thiazolyl group, an isothiazolyl group, a benzothiazolyl group, an isoxazolyl group, an oxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, imidazopyridimidinyl group, and an imidazopyridinyl group, each substituted with at least one selected

from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₂-C₂₀ alkenyl group, a C₂-C₂₀ alkynyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a phthalazinyl group, a quinoxalinyl group, a cinnolinyl group, and a quinazolinyl group, and

[0064] at least one selected from R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ may be a cyano group.

[0065] According to another embodiment, R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ may each independently be selected from hydrogen, deuterium, a cyano group, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;

[0066] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group;

[0067] a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

[0068] a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, and at least one selected from R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ may be a cyano group.

[0069] In Formulae 1 to 4, b₁₀, b₂₀, b₃₀, b₄₀, b₅₀, and b₆₀ may respectively indicate the number of R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀. b₁₀, b₂₀, b₃₀, b₄₀, b₅₀, and b₆₀ may each independently be an integer from 1 to 10. When b₁₀ is 2 or greater, at least two groups R₁₀ may be identical to different from each other. When b₂₀ is 2 or greater, at least two groups R₂₀ may be identical to different from each other. When b₃₀ is 2 or greater, at least two groups R₃₀ may be identical to different from each other. When b₄₀ is 2 or greater, at least two groups R₄₀ may be identical to different from each other. When b₅₀ is 2 or greater, at least two groups R₅₀ may be identical to different from each other. When b₆₀ is 2 or greater, at least two groups R₆₀ may be identical to different from each other.

[0070] In some embodiments, in the condensed cyclic compound represented by Formula 1, groups R₁₀ in the number of b₁₀, groups R₂₀ in the number of b₂₀, groups R₃₀ in the number of b₃₀, groups R₄₀ in the number of b₄₀, groups R₅₀ in the number of b₅₀, and groups R₆₀ in the number of b₆₀ may each be a cyano group.

[0071] In some embodiments, b₁₀, b₂₀, b₃₀, b₄₀, b₅₀, and b₆₀ may each be 1, 2, 3, or 4.

[0072] In some embodiments, the number of cyano groups included in the condensed cyclic compound represented by Formula 1 may be 1 to 5. In some embodiments, the number

of cyano groups included in the condensed cyclic compound represented by Formula 1 may be 1 to 3.

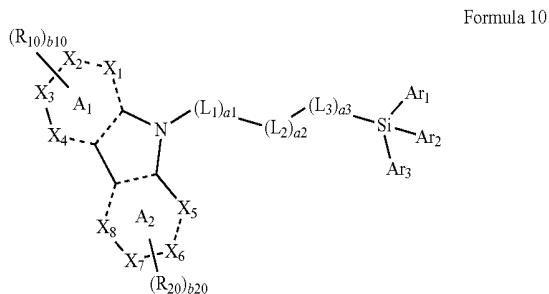
[0073] In some embodiments, (i) at least one selected from R₁₀ and R₂₀ may be a cyano group, and R₃₀, R₄₀, and R₅₀ may each independently be a cyano group,

[0074] (ii) at least one selected from R₃₀, R₄₀, and R₅₀ may be a cyano group, and R₁₀ and R₂₀ may each independently be a cyano group, or

[0075] (iii) R₆₀ may be a cyano group.

[0076] According to another embodiment, at least one selected from R₁₀ and R₂₀ and at least one selected from R₃₀, R₄₀, and R₅₀ may each be a cyano group.

[0077] In some embodiments, the condensed cyclic compound represented by Formula 1 may be represented by Formula 10:



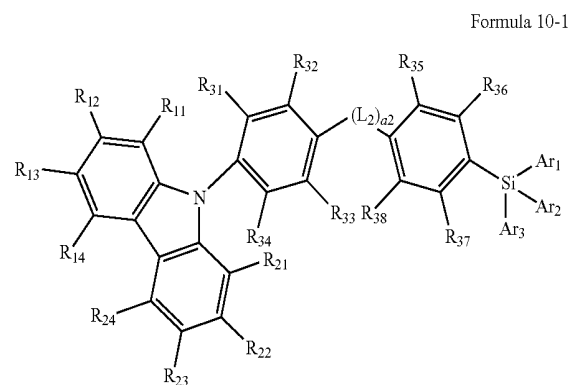
[0078] wherein, in Formula 10,

[0079] A₁, A₂, R₁₀, R₂₀, b₁₀, b₂₀, L₁, L₂, L₃, a₁, a₂, a₃, and Ar₁ to Ar₃ may be understood by referring to the descriptions for those provided herein,

[0080] X₁ to X₄ may each independently be selected from carbon (C) and nitrogen (N), and

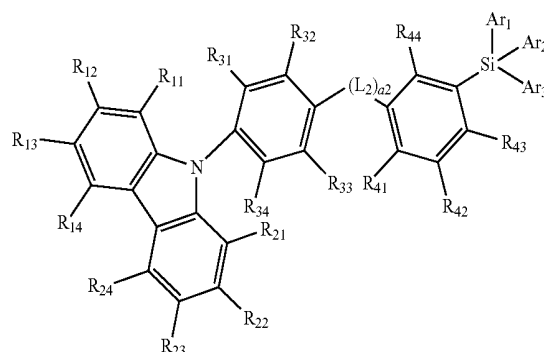
[0081] X₅ to X₈ may each independently be selected from C and N.

[0082] According to another embodiment, the condensed cyclic compound represented by Formula 1 may be represented by one of Formulae 10-1 to 10-9:

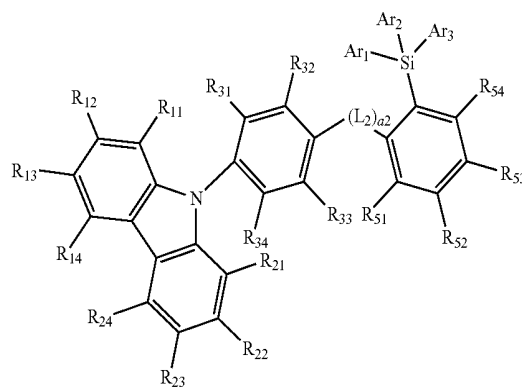


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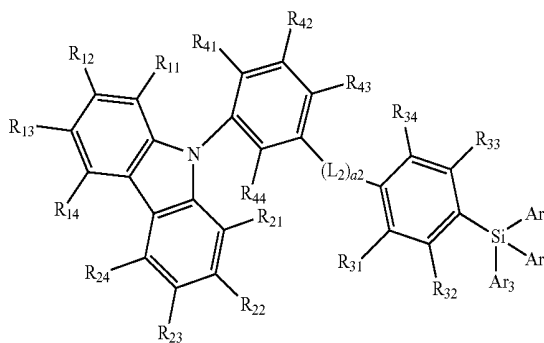
Formula 10-2



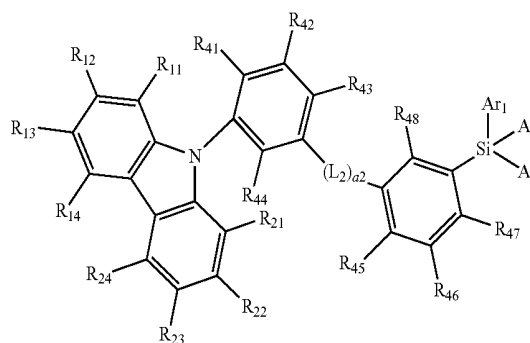
Formula 10-3



Formula 10-4

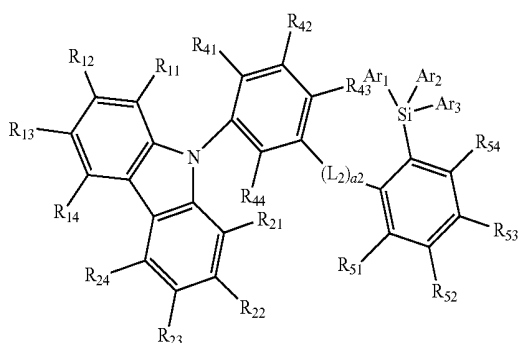


Formula 10-5

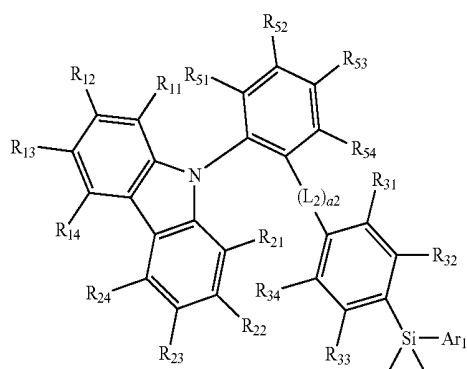


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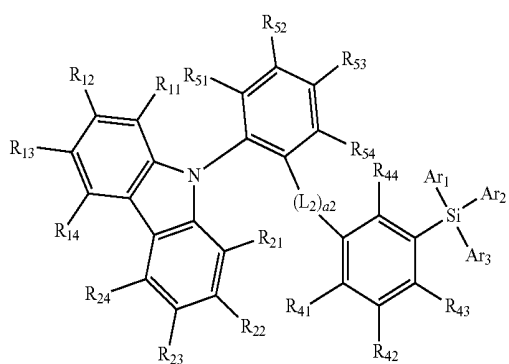
Formula 10-6



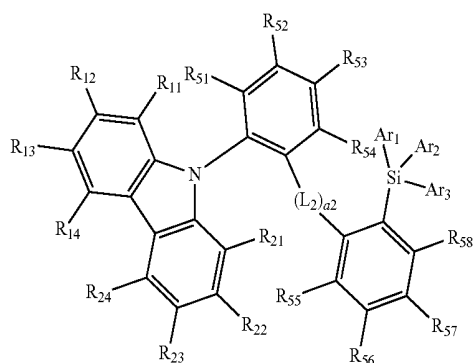
Formula 10-7



Formula 10-8



Formula 10-9



[0083] wherein, in Formulae 10-1 to 10-9,

[0084] L_2 , a_2 , and Ar_1 to Ar_3 may be understood by referring to the descriptions for those provided herein,

[0085] R_{11} to R_{14} may be understood by referring to the descriptions for R_{10} provided herein,

[0086] R_{21} to R_{24} may be understood by referring to the descriptions for R_{20} provided herein,

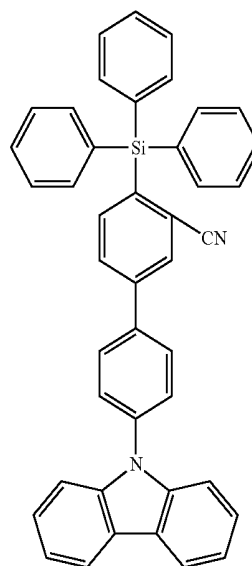
[0087] R_{31} to R_{38} may be understood by referring to the descriptions for R_{30} provided herein,

[0088] R_{41} to R_{48} may be understood by referring to the descriptions for R_{40} provided herein,

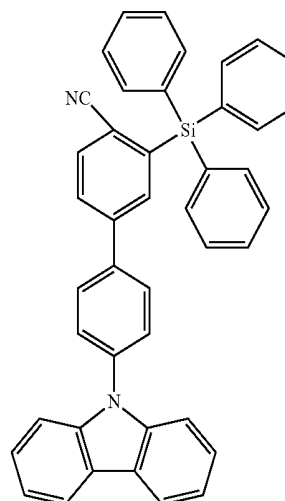
[0089] R_{51} to R_{58} may be understood by referring to the descriptions for R_{50} provided herein, and

[0090] at least one selected from R_{11} to R_{14} , R_{21} to R_{24} , R_{31} to R_{38} , R_{41} to R_{48} , R_{51} to R_{58} , and R_{60} may be a cyano group.

[0091] In an embodiment, the condensed cyclic compound may be selected from Compounds 1 to 671:

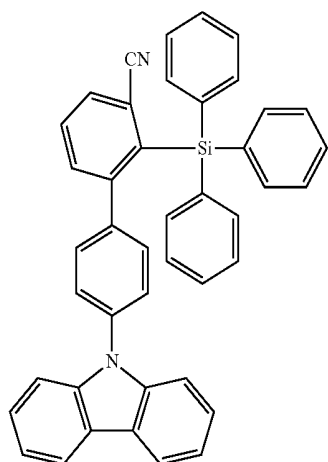


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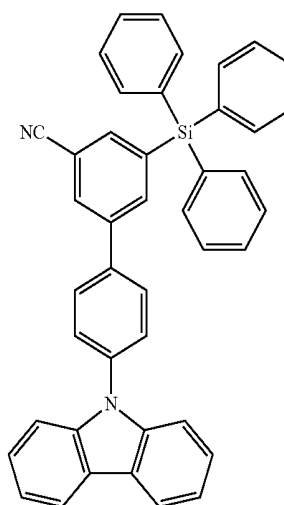
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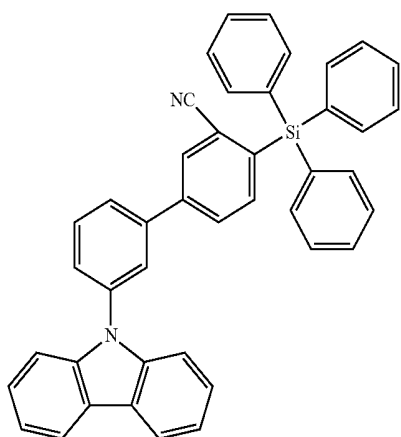
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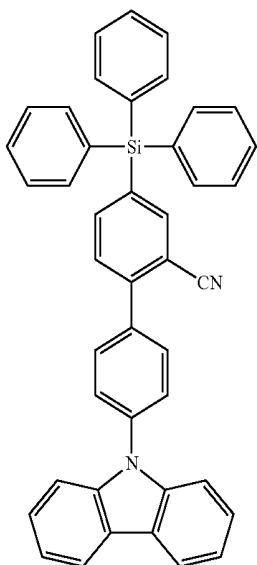
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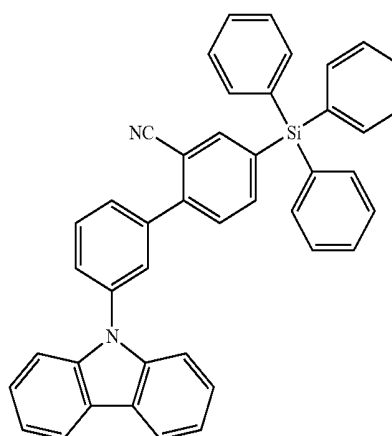


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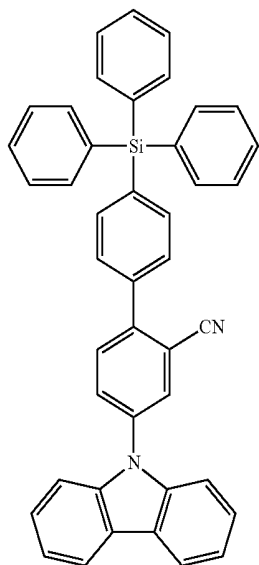
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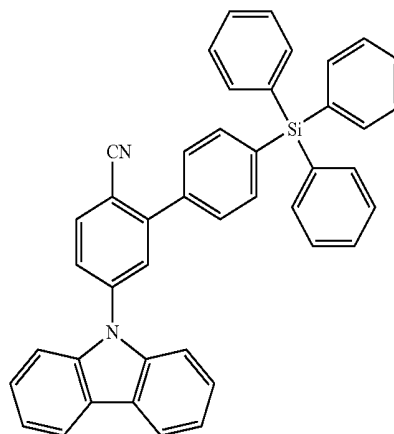


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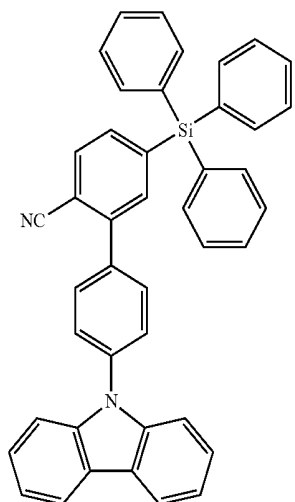
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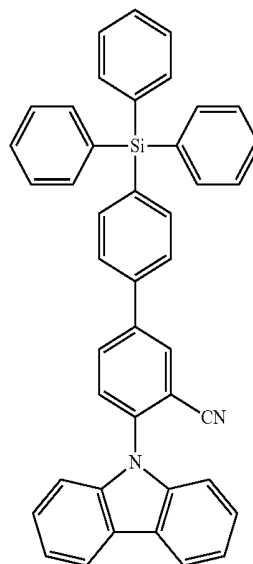


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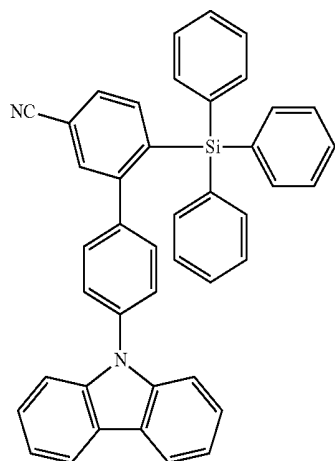
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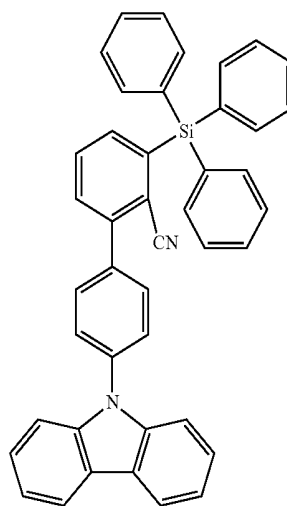
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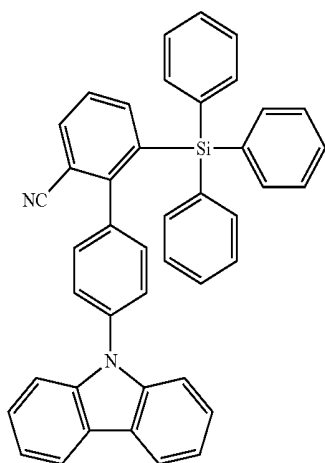
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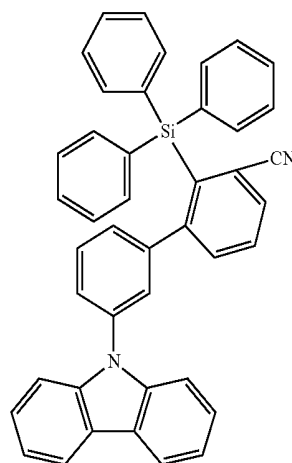


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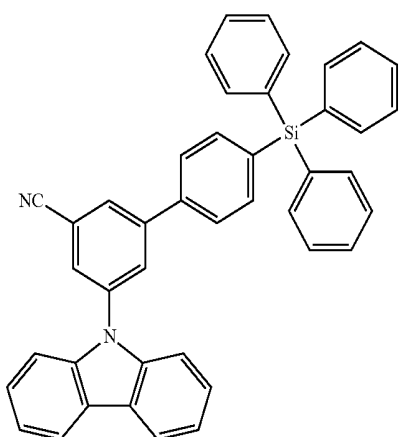


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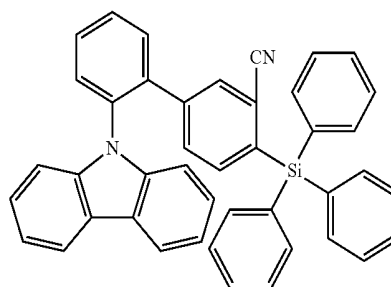
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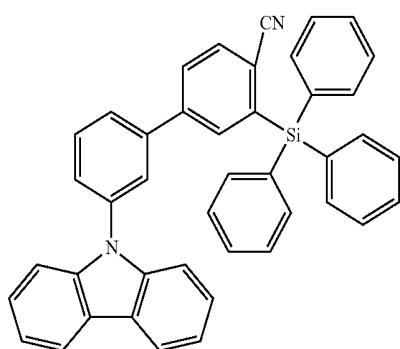
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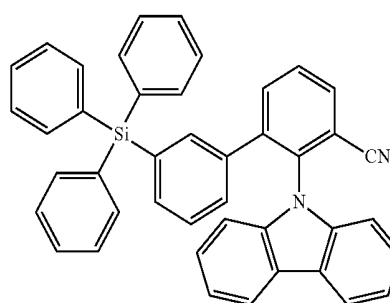
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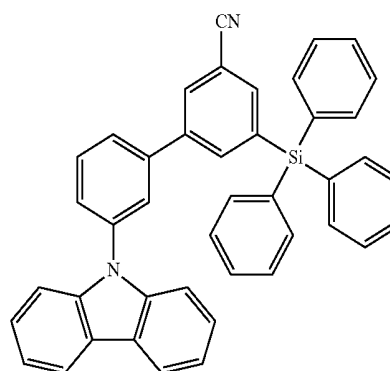
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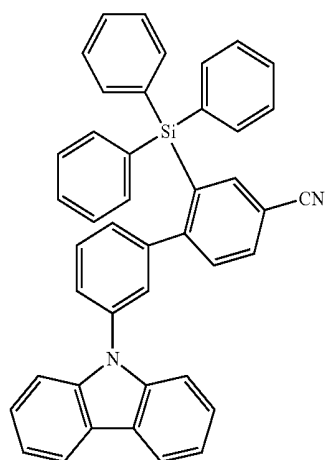


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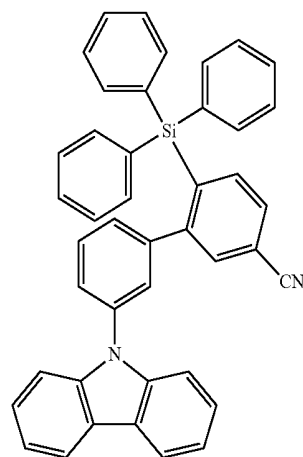
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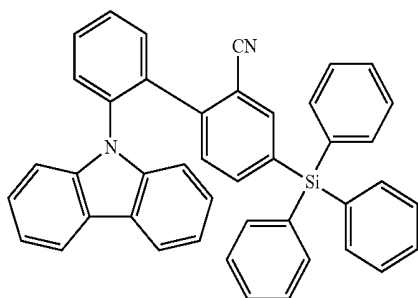


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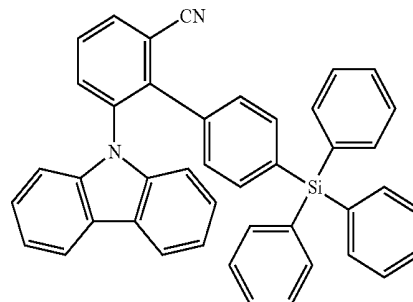
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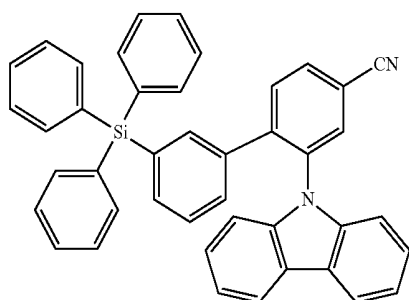
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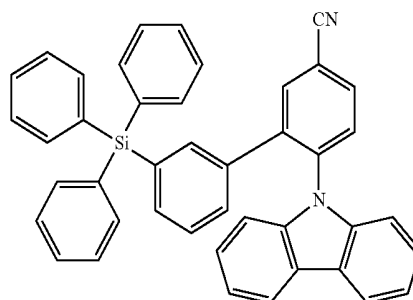
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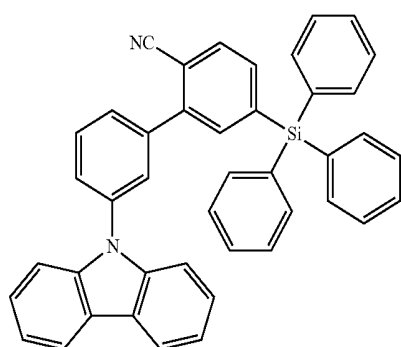
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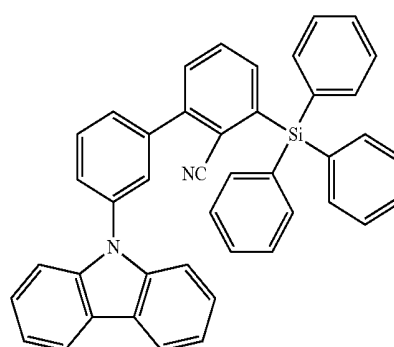
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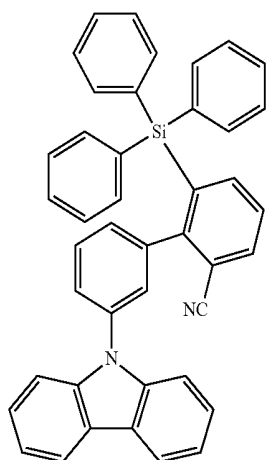


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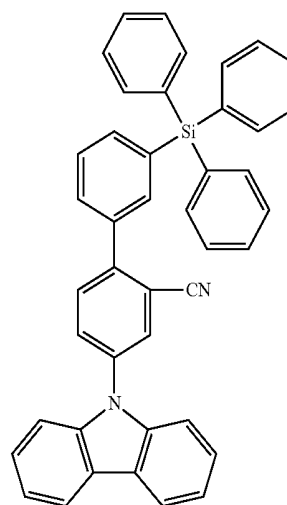
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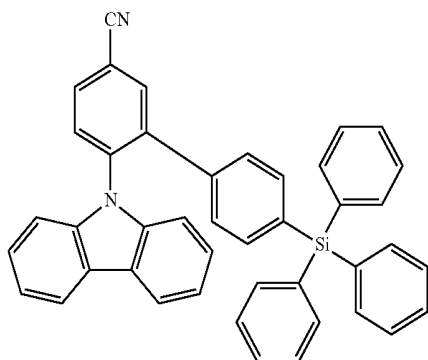
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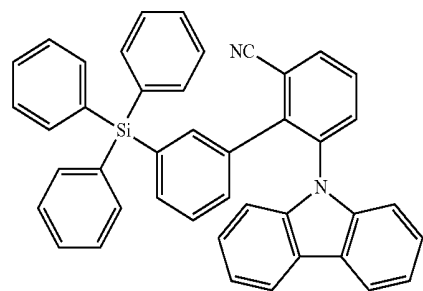
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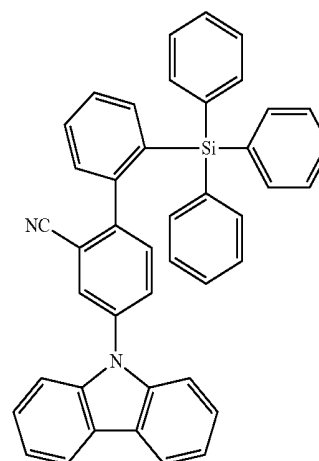


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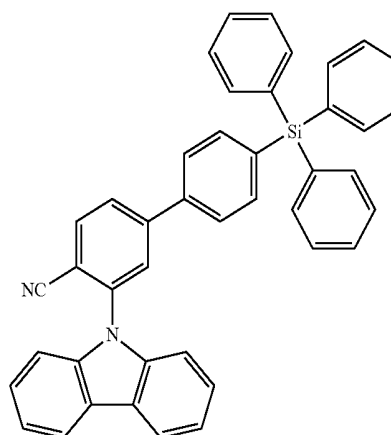
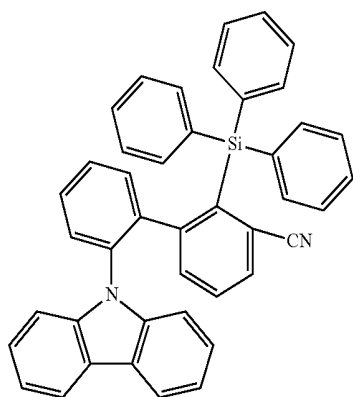
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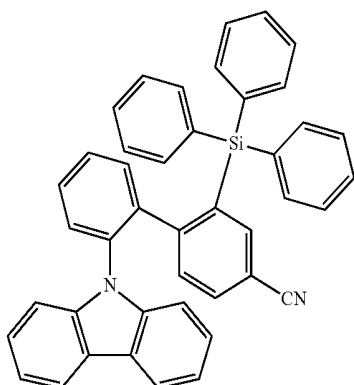
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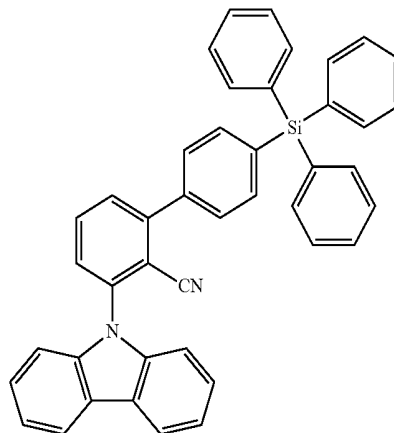


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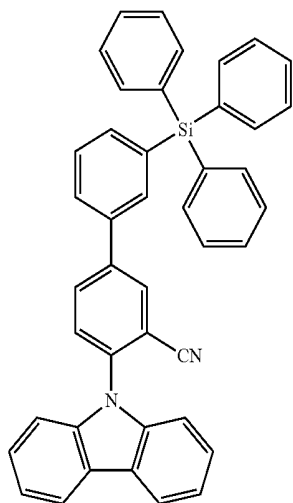
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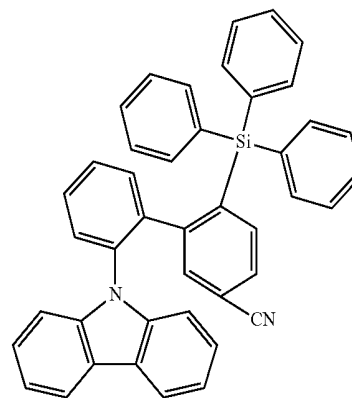


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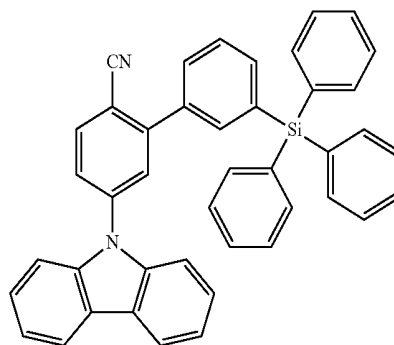
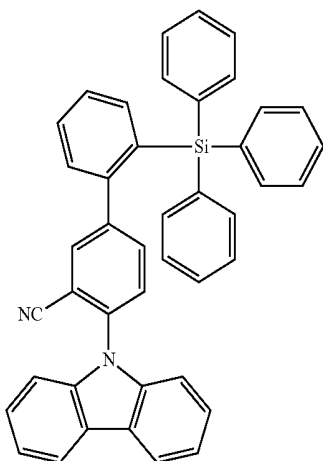


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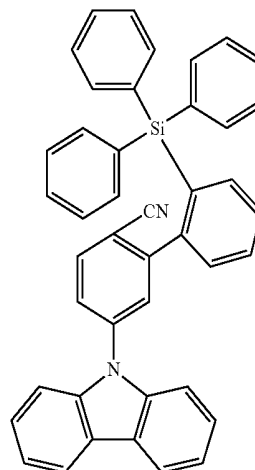


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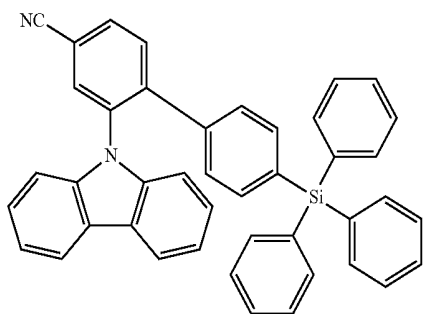
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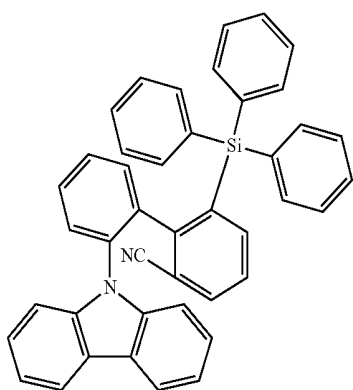
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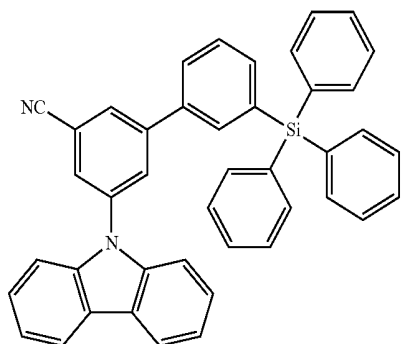
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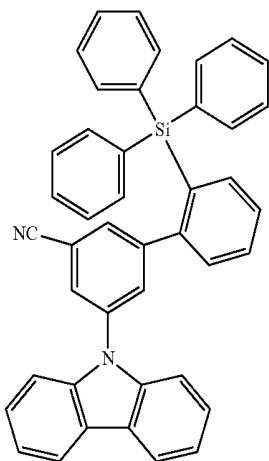
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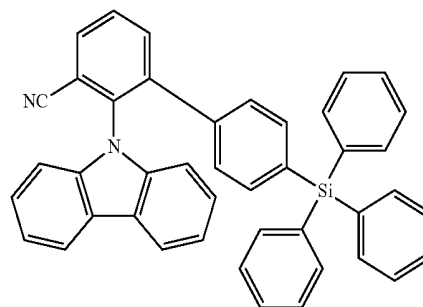


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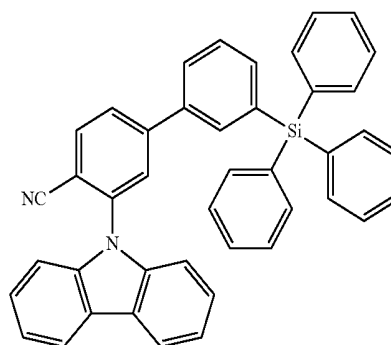


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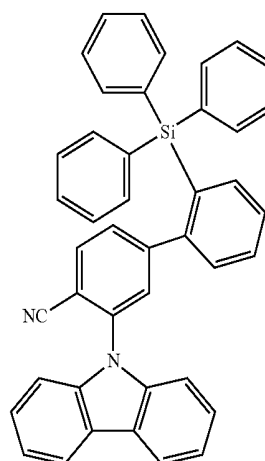
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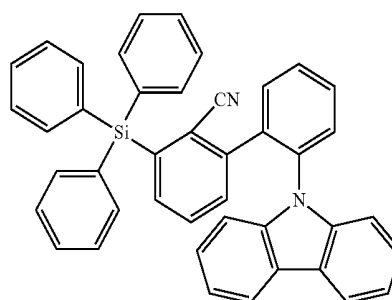
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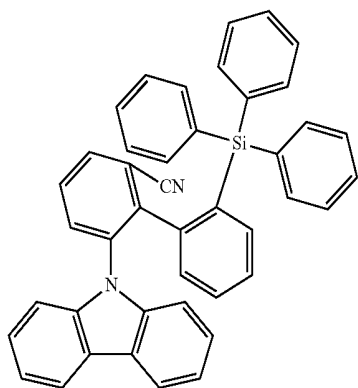


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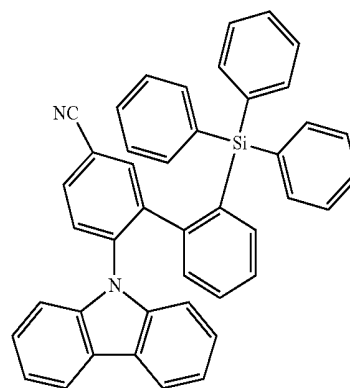
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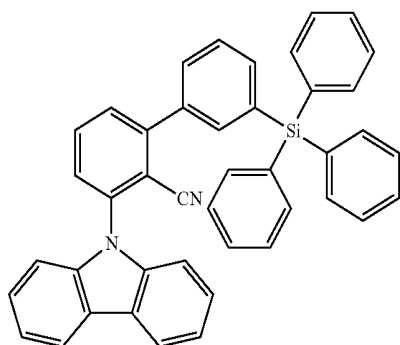


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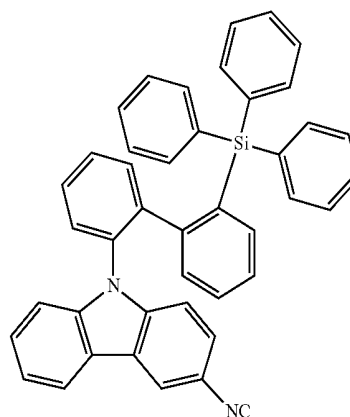
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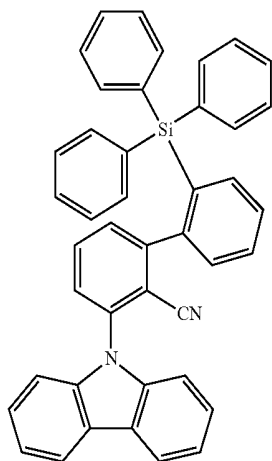
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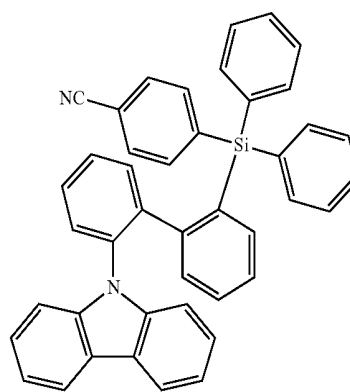
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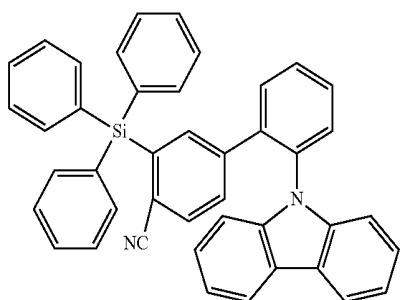
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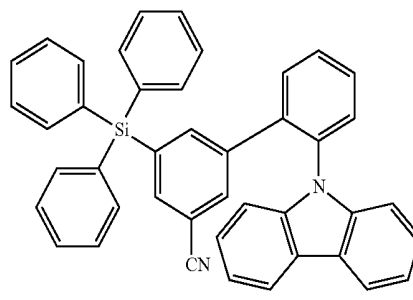
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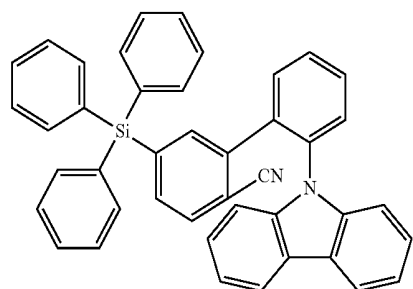
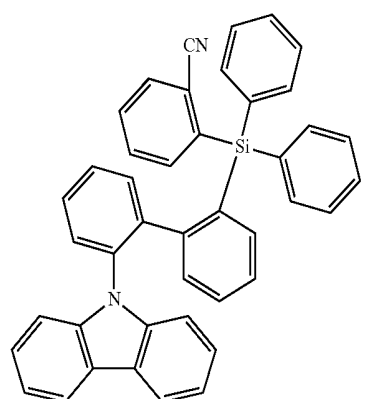
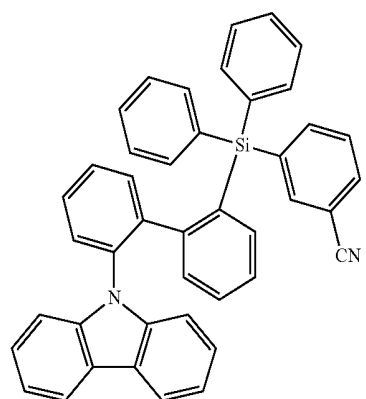
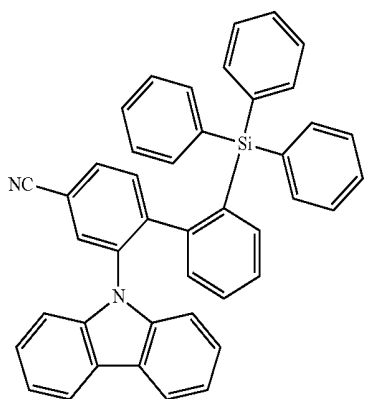


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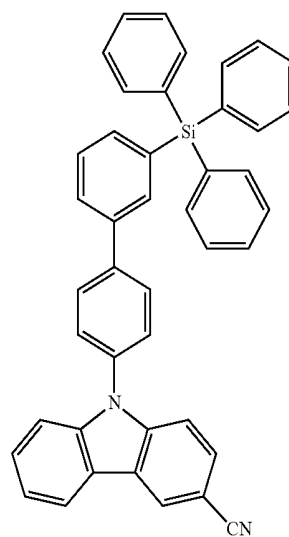
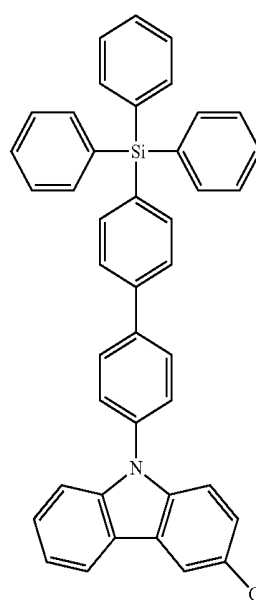
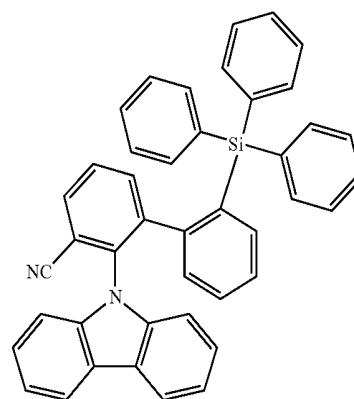


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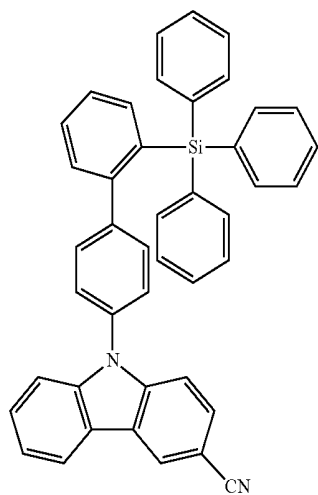
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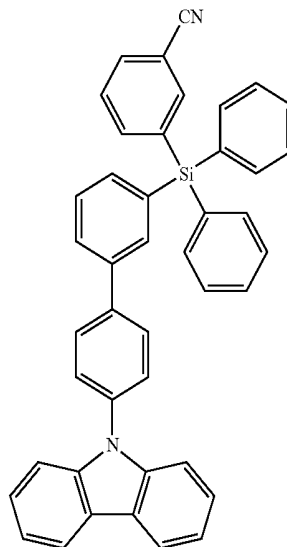


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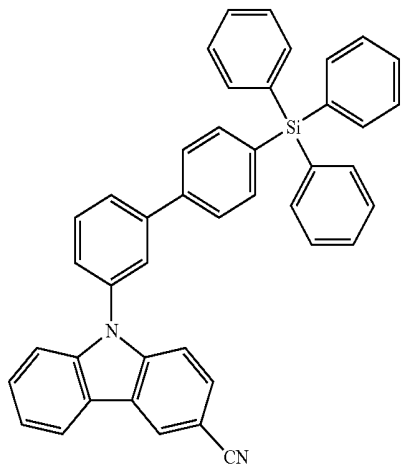


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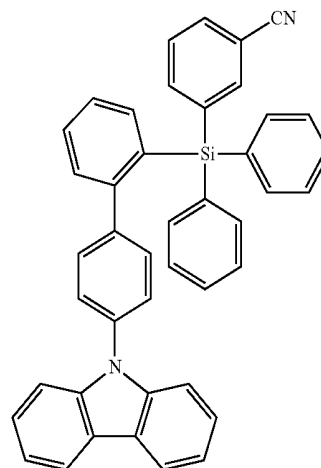
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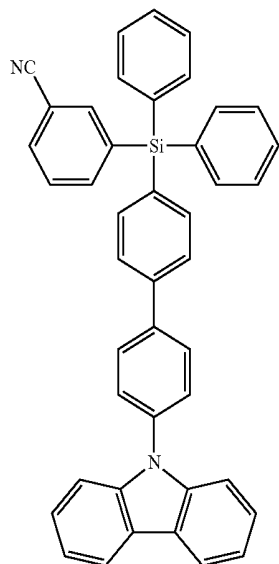
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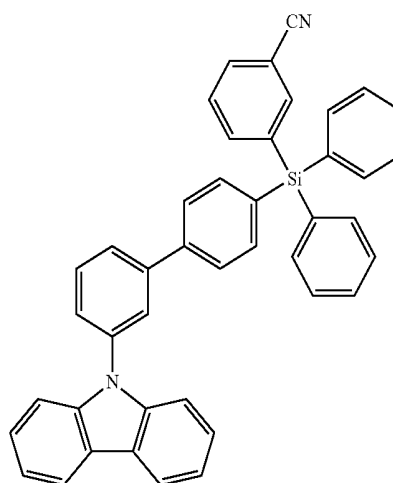
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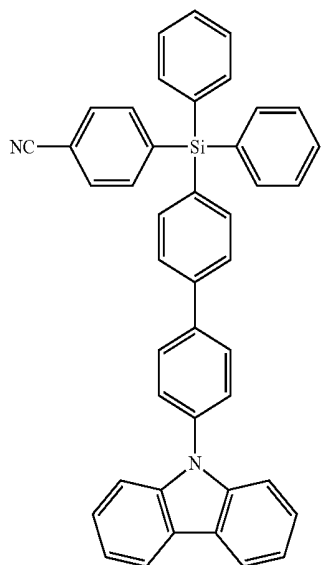


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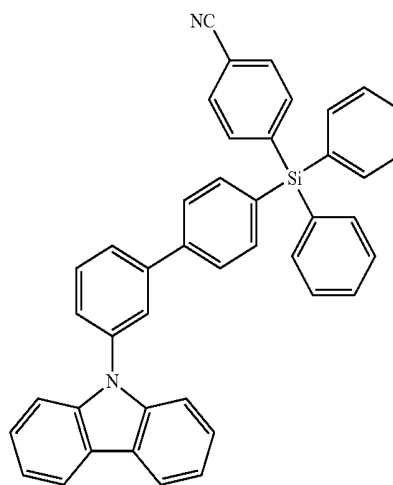
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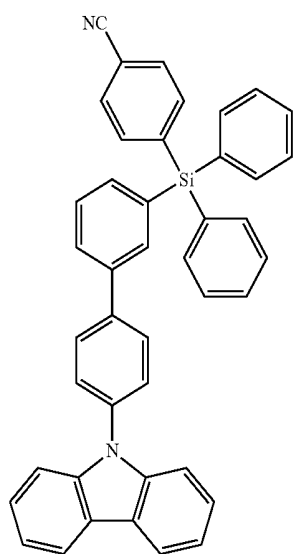


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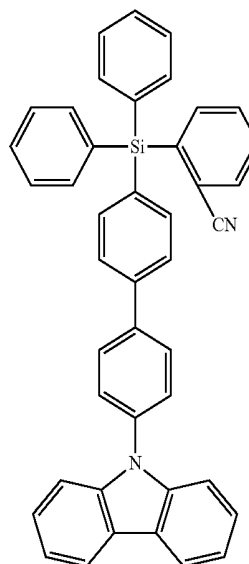
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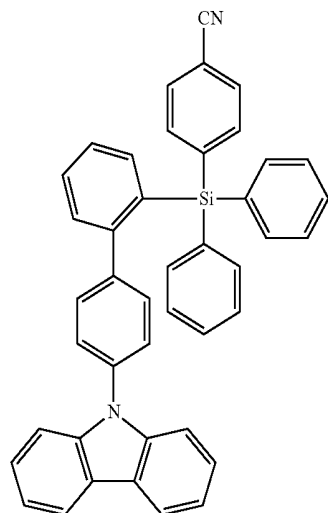
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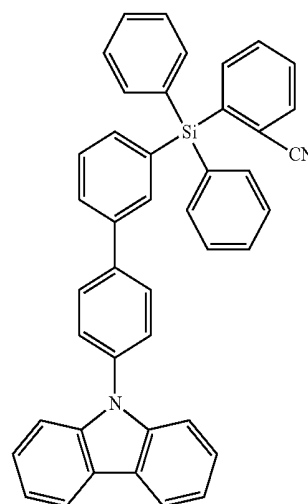
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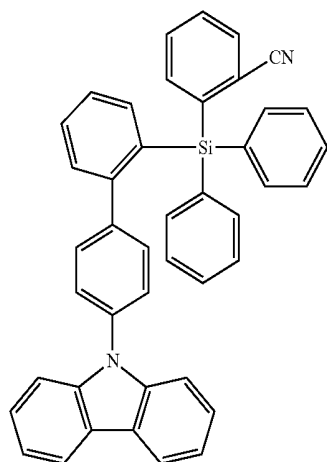


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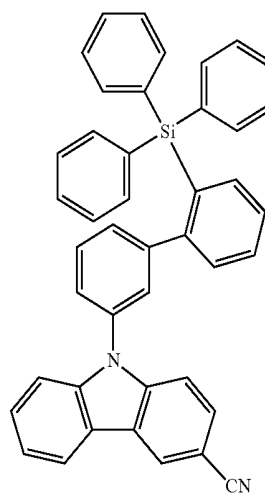
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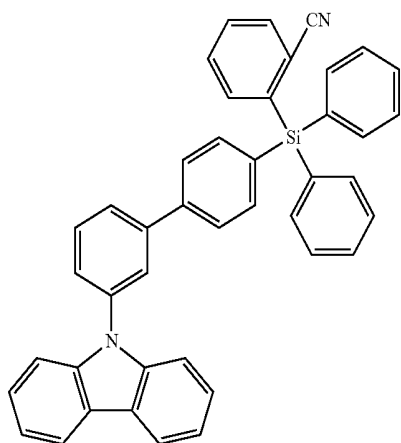


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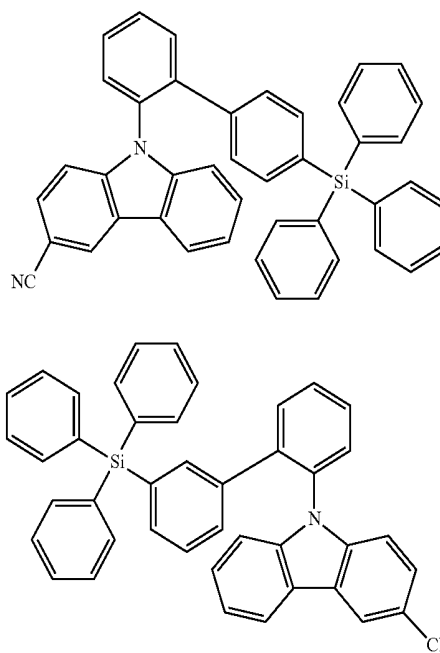
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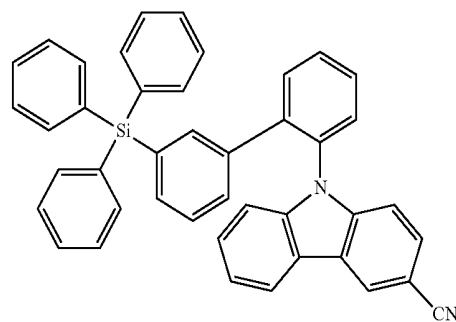
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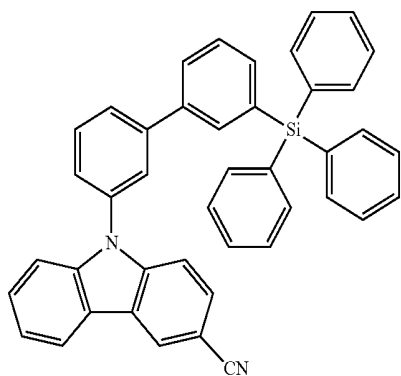
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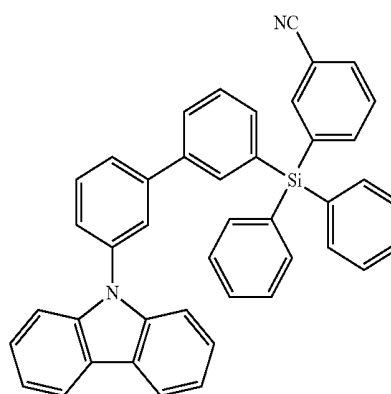
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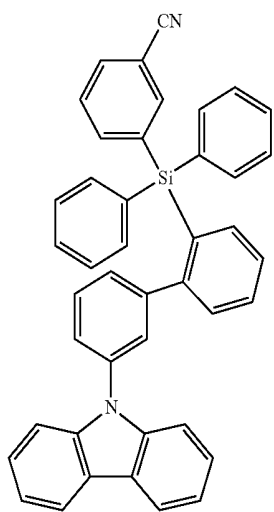


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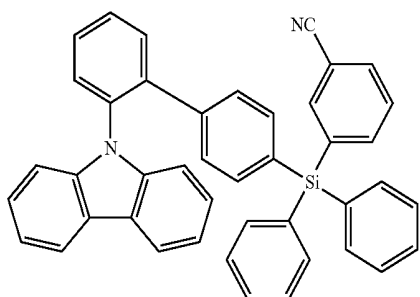


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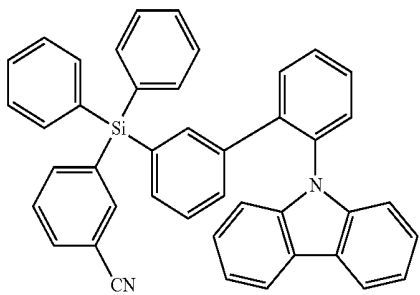
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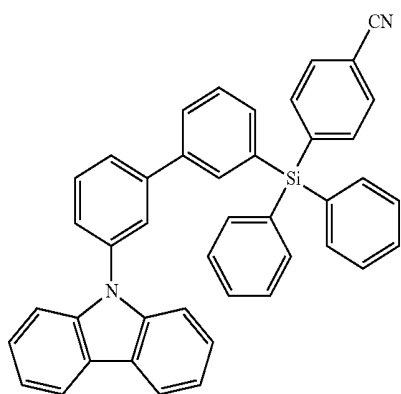
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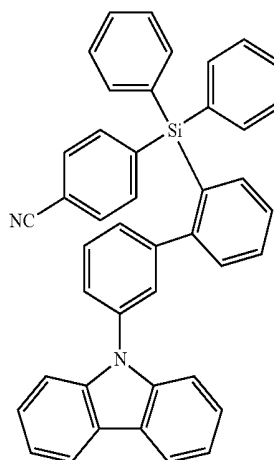


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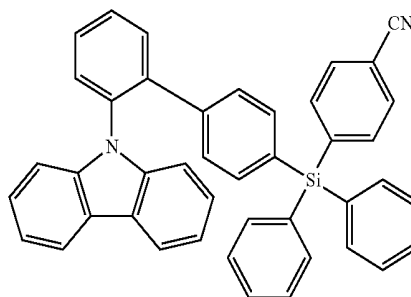


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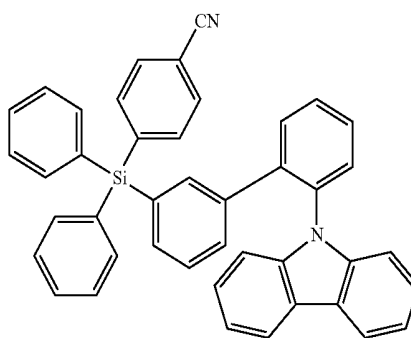
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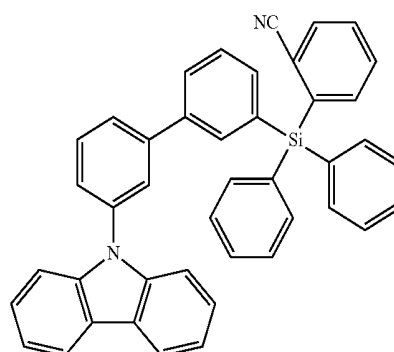
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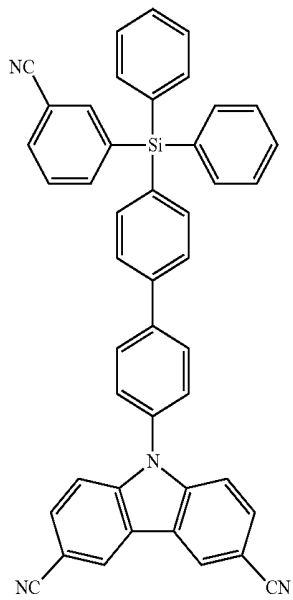
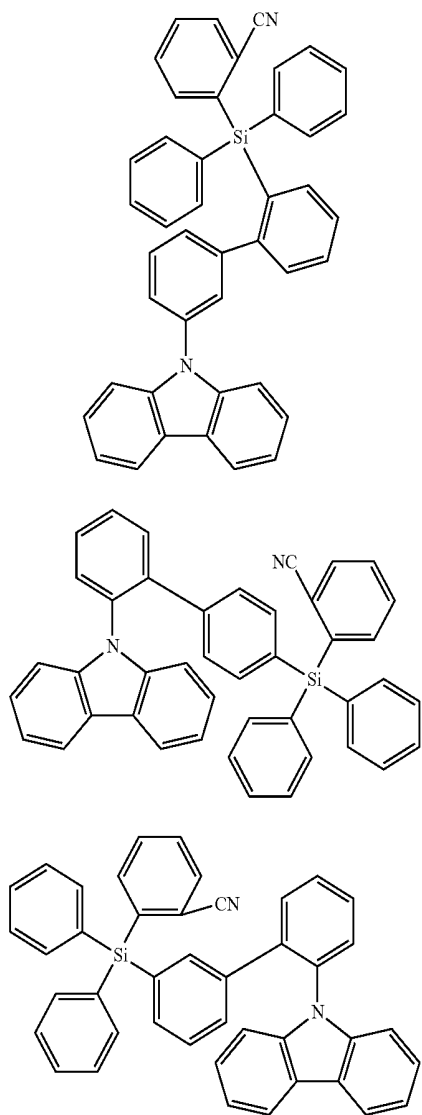


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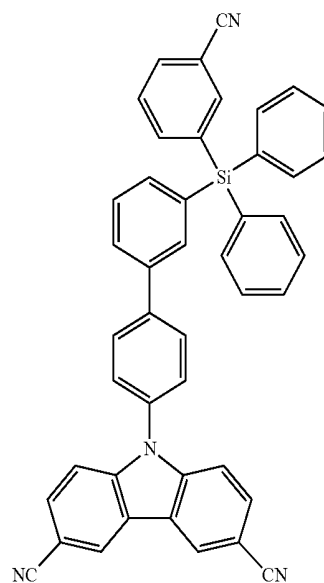


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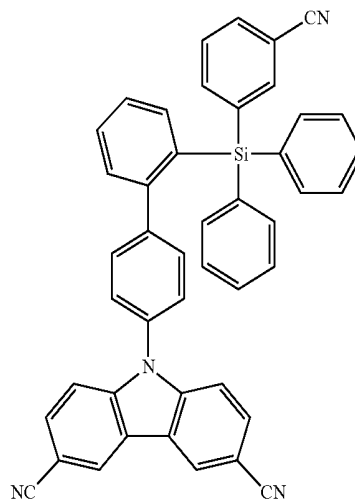
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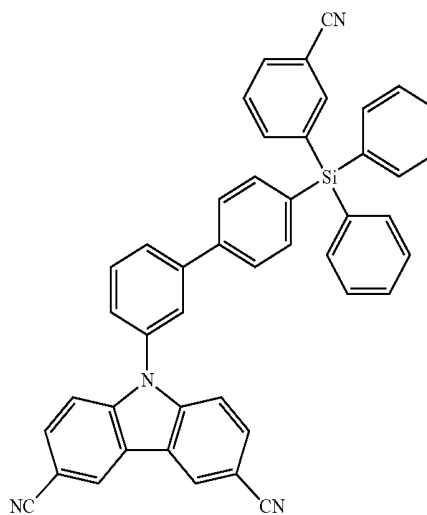
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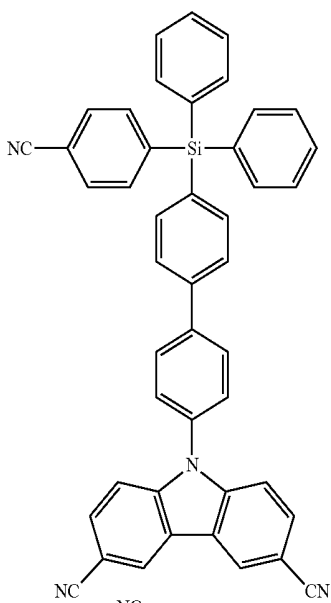


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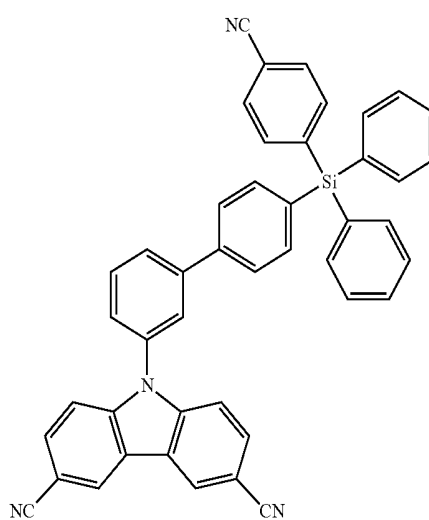


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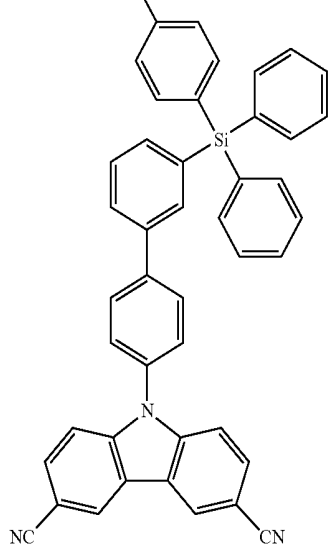


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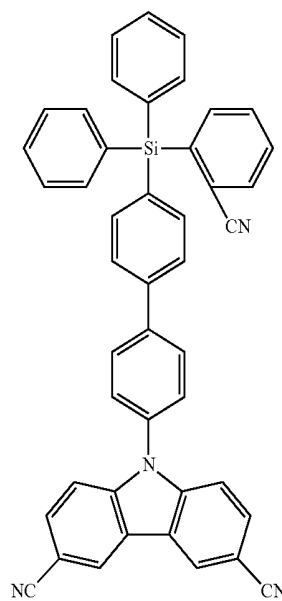
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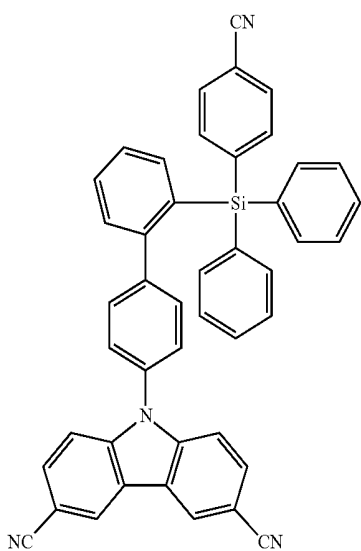
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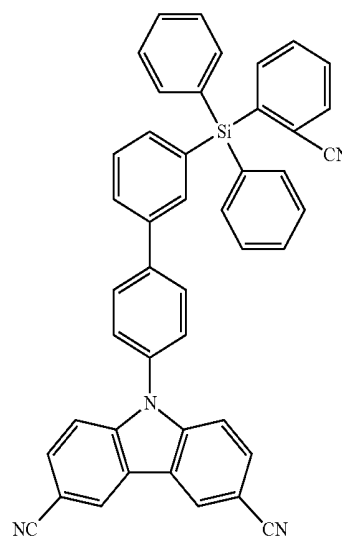
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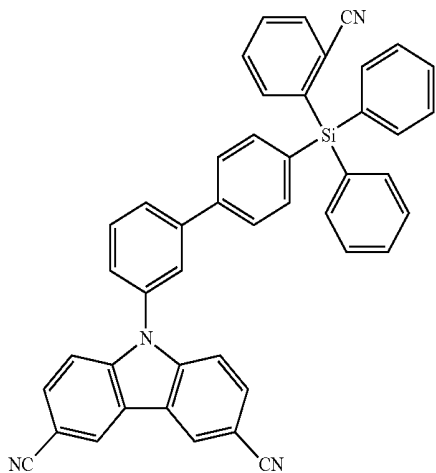
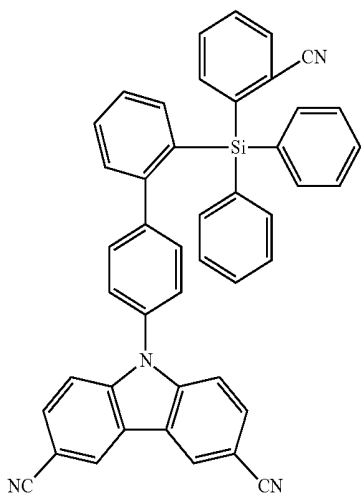


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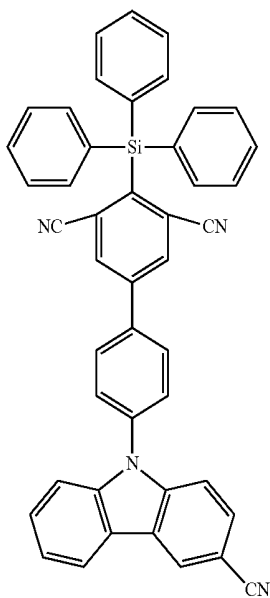
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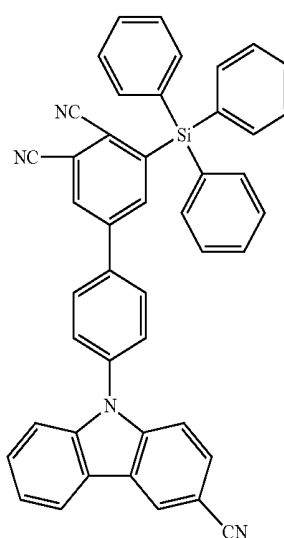


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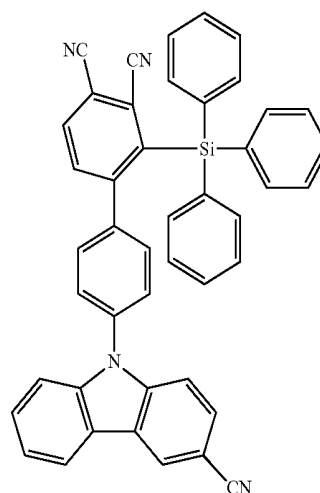


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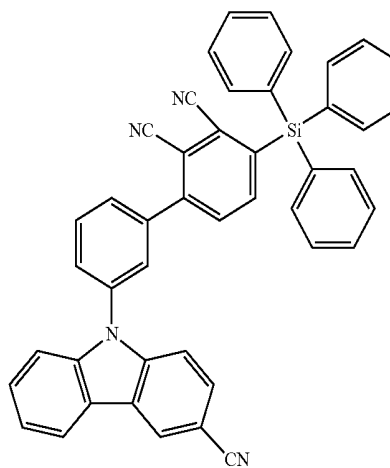


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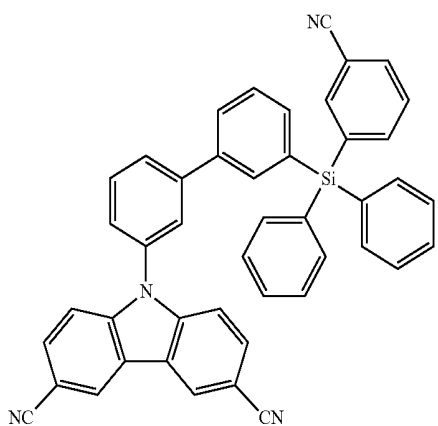
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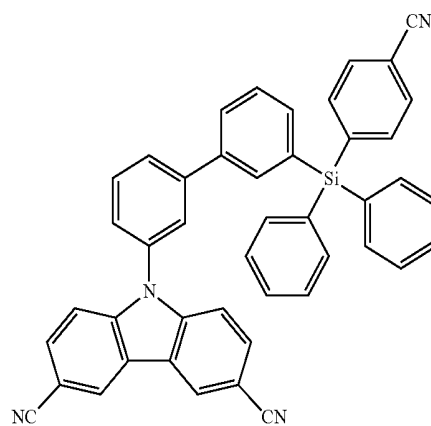


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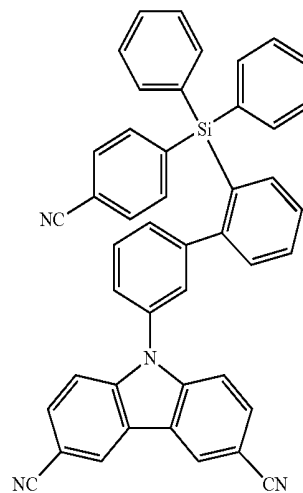
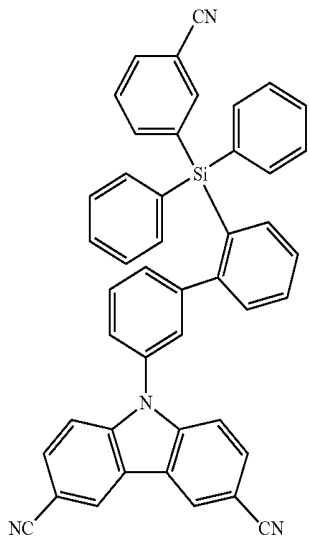
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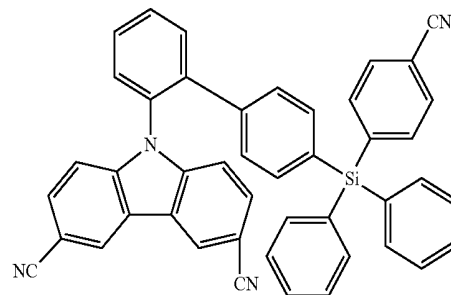
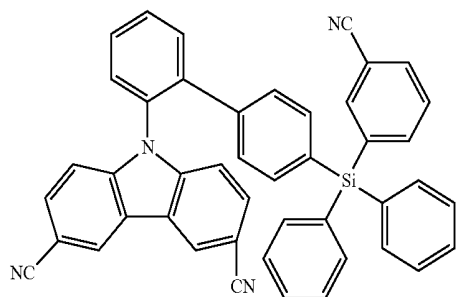
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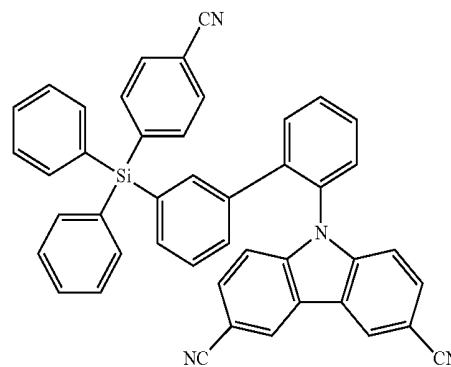
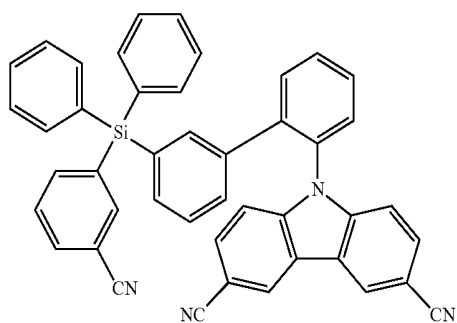
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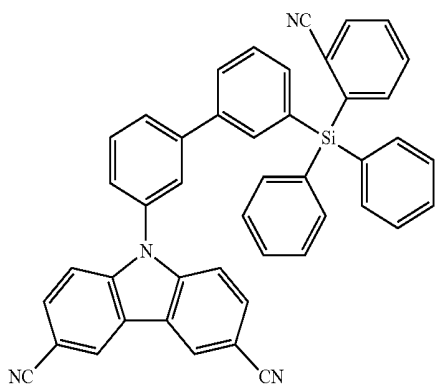


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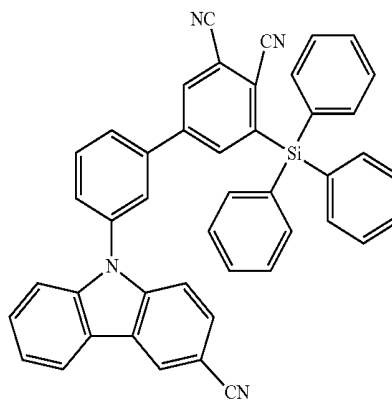


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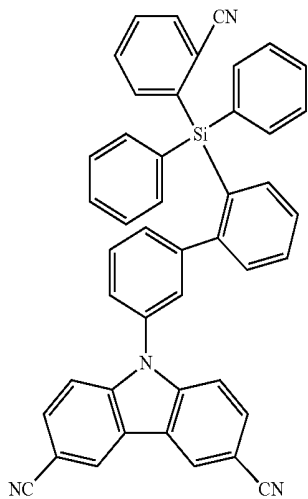
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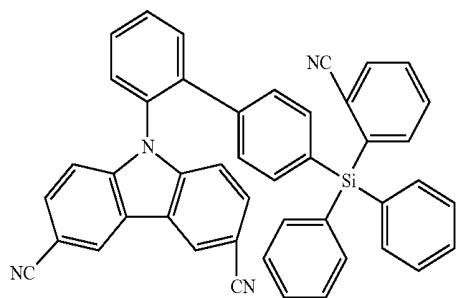
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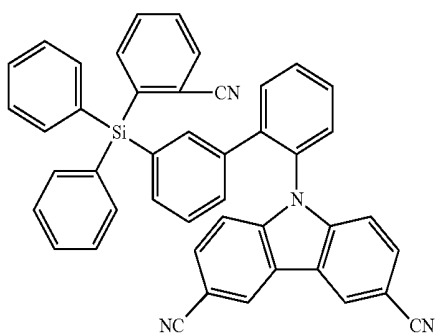
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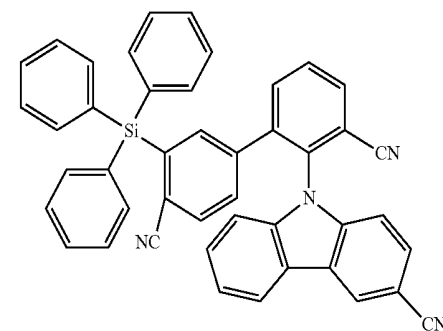


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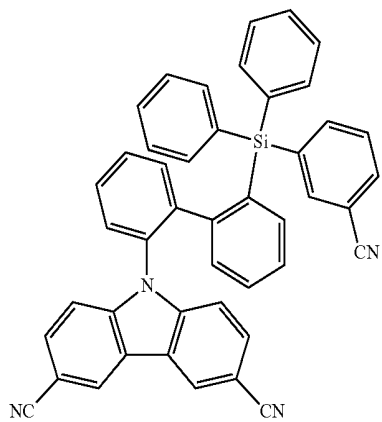
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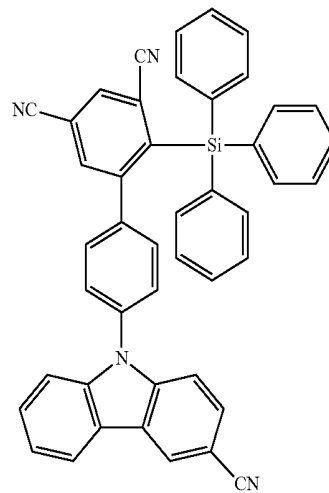


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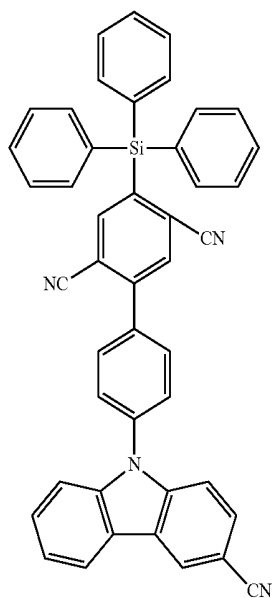
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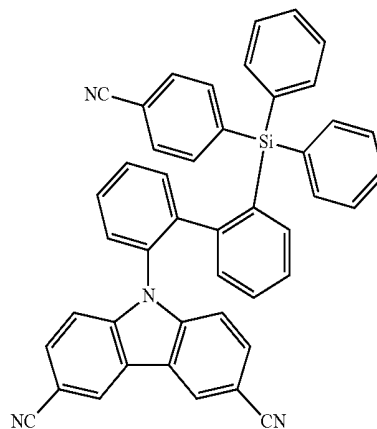


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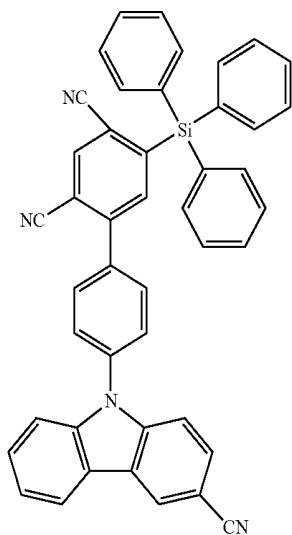
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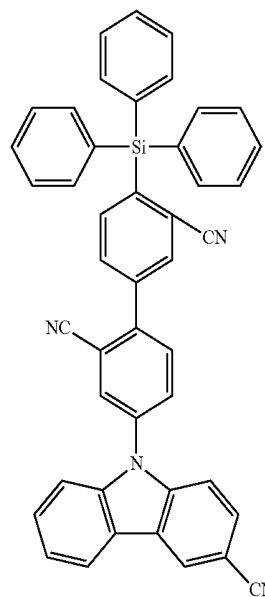
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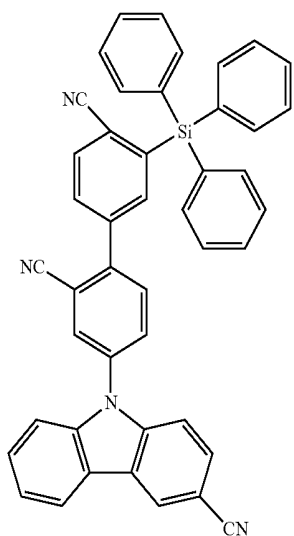


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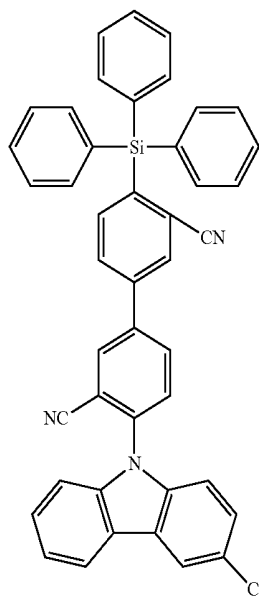
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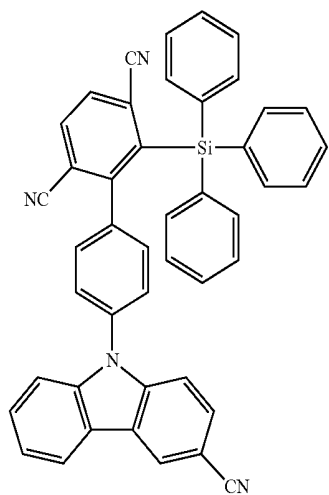
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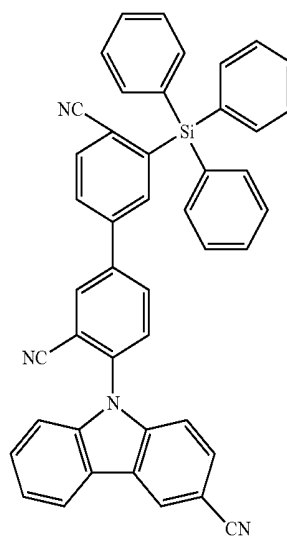


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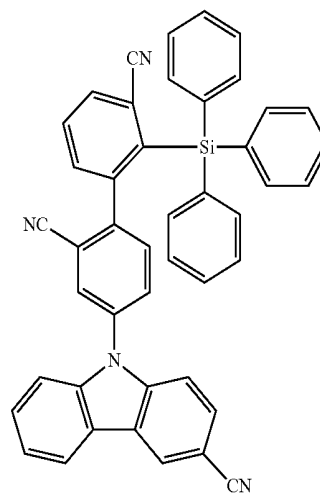
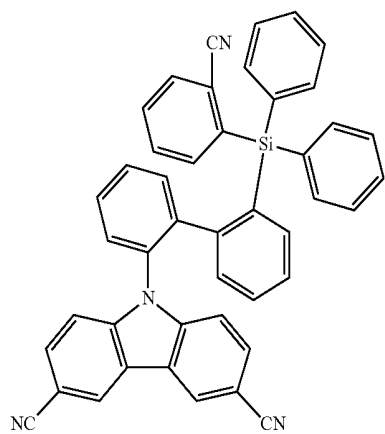


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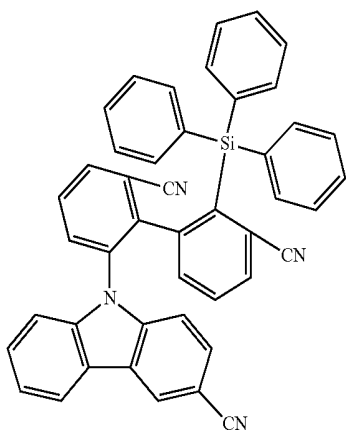


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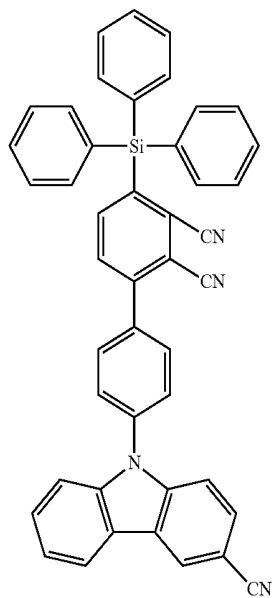
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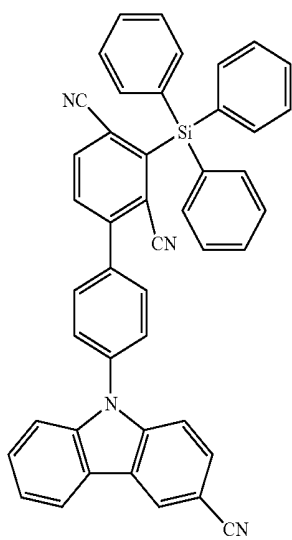
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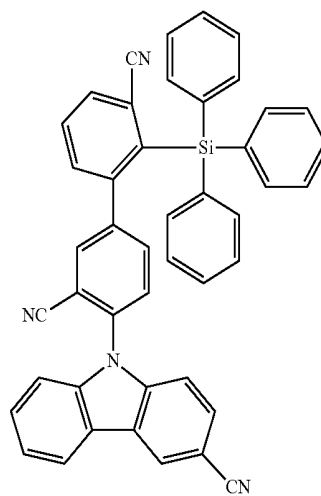


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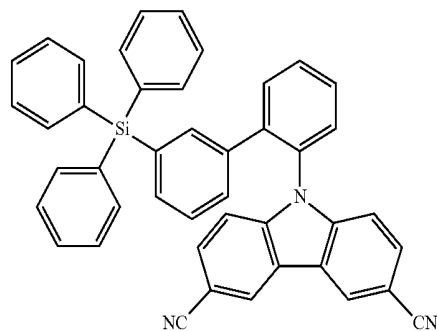


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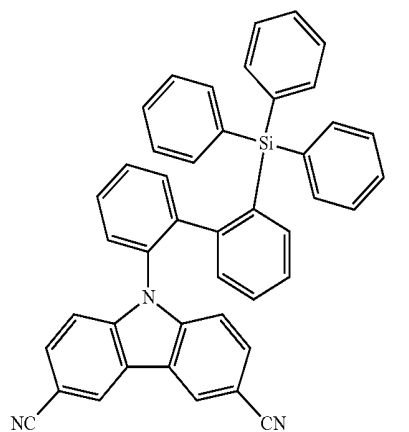
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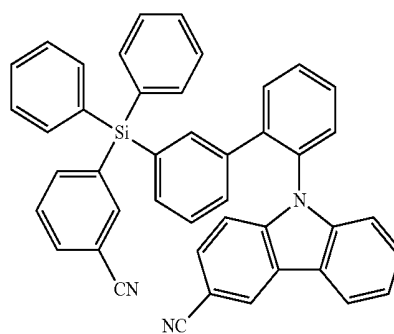
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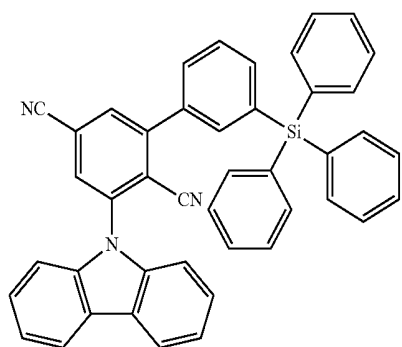
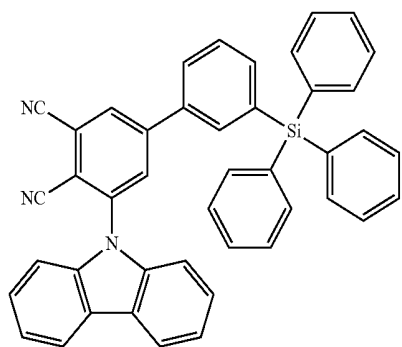
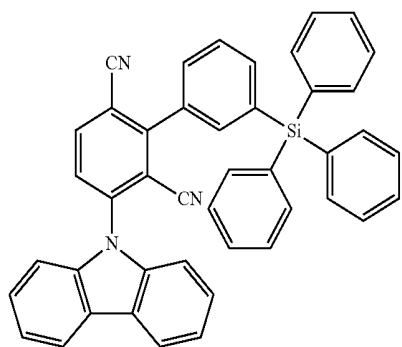
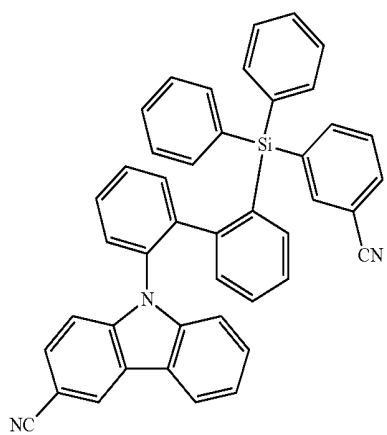


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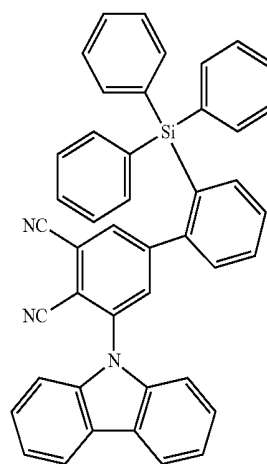
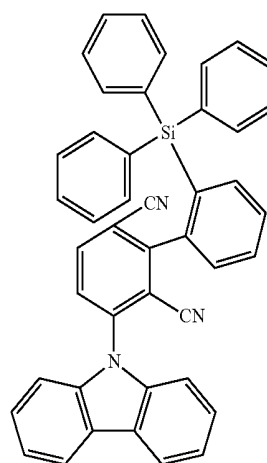
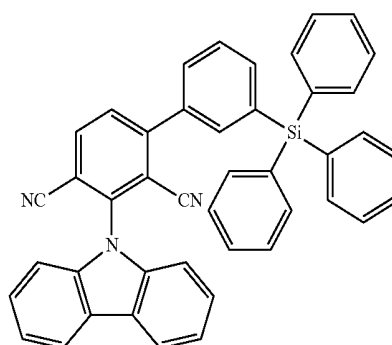


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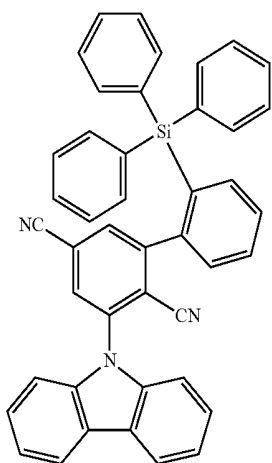
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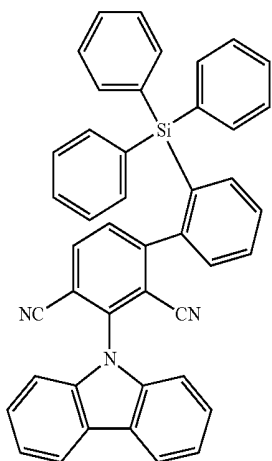
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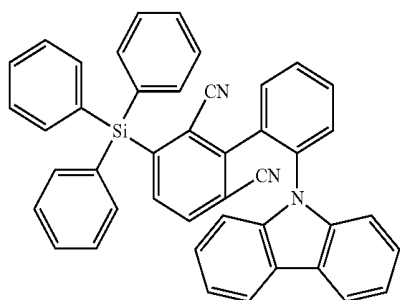
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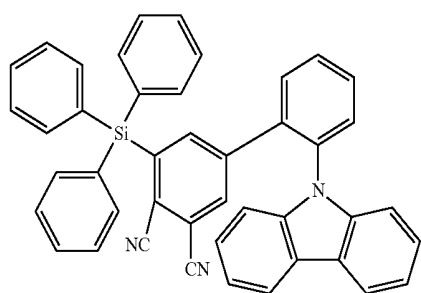
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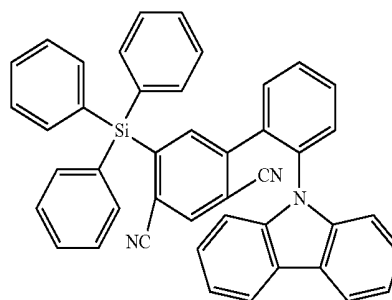


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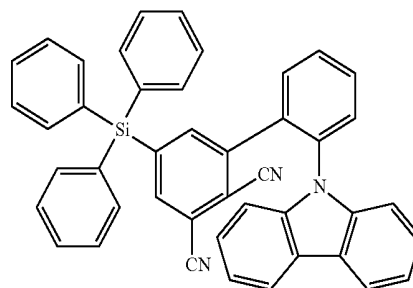


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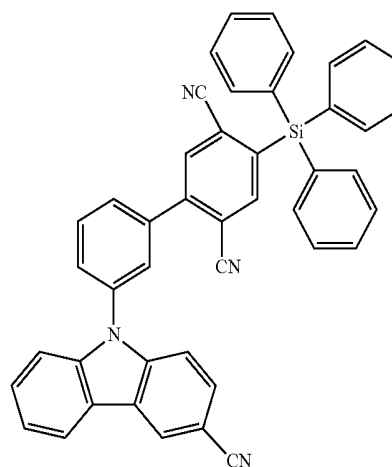
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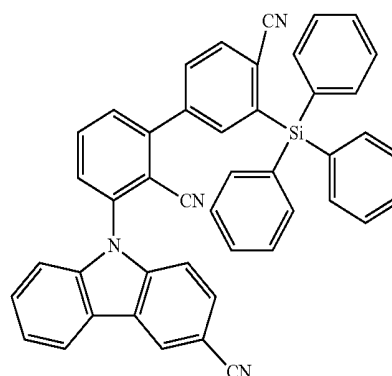
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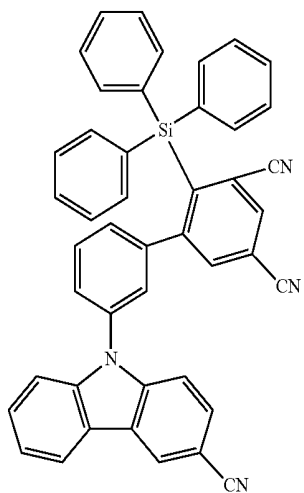


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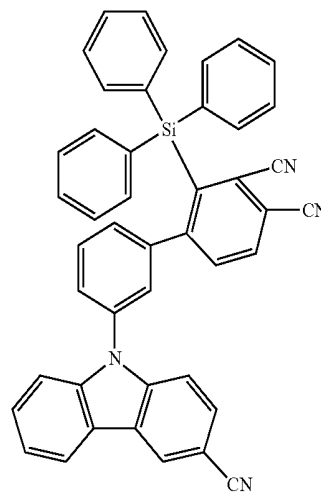
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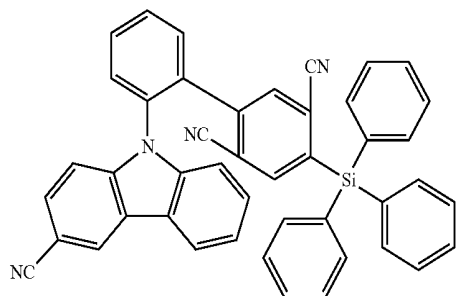


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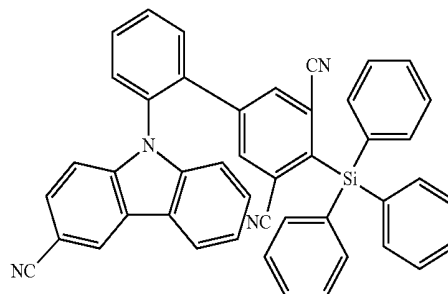
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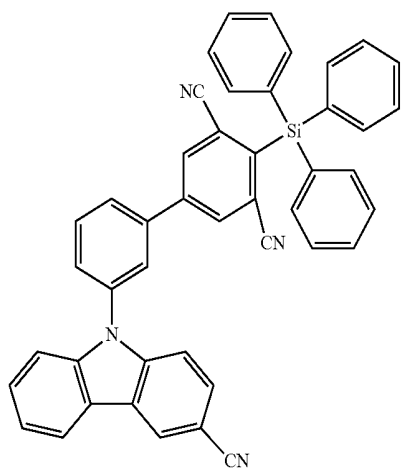
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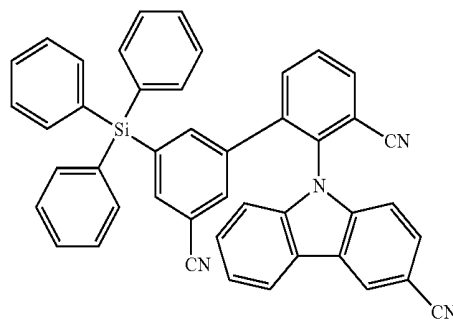
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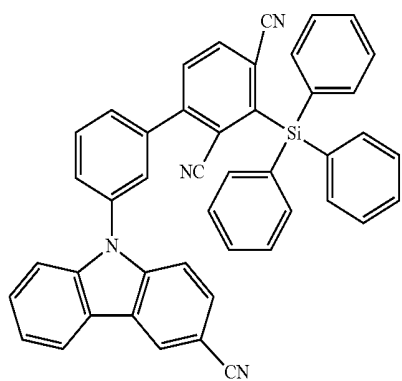
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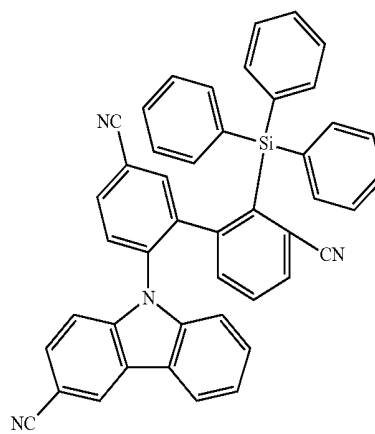
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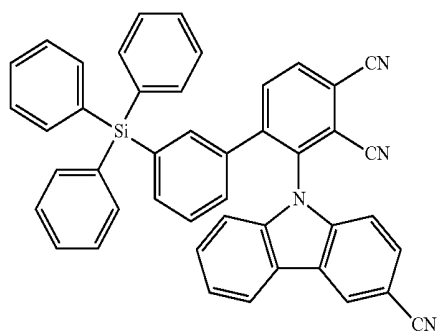


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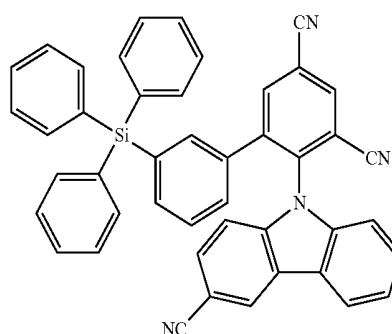
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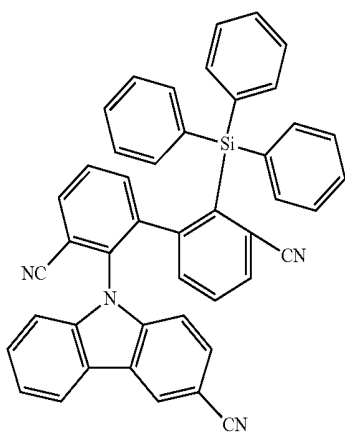


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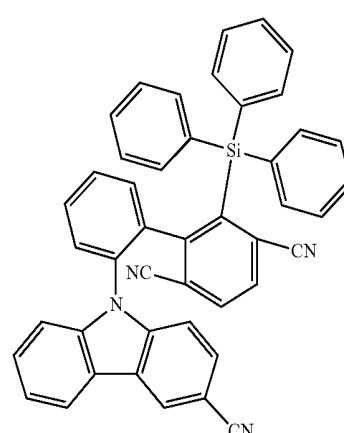
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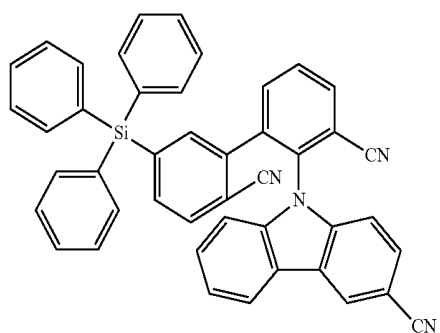
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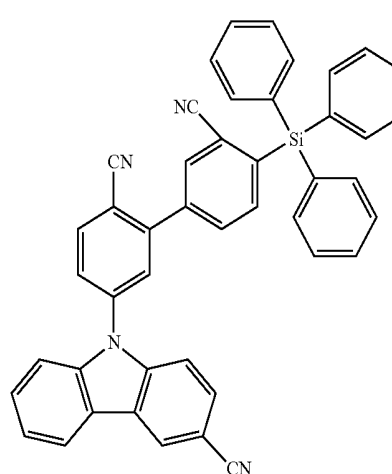
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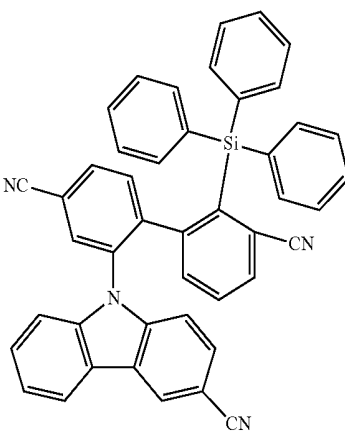
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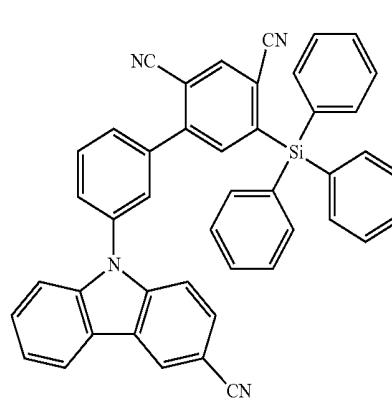
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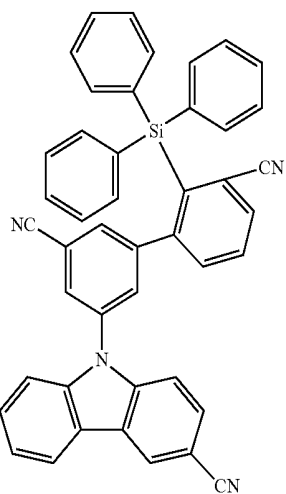


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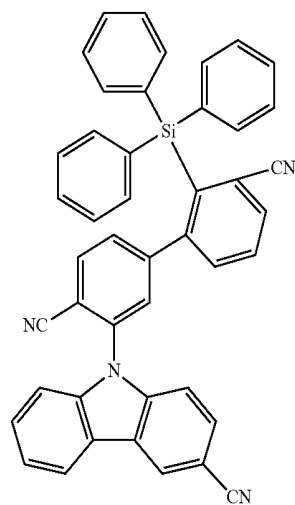
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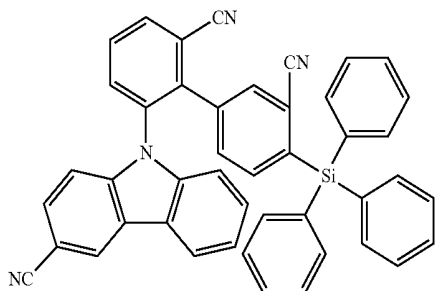


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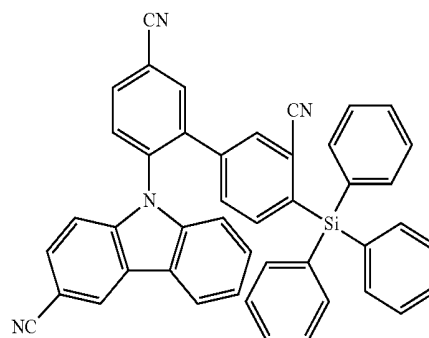
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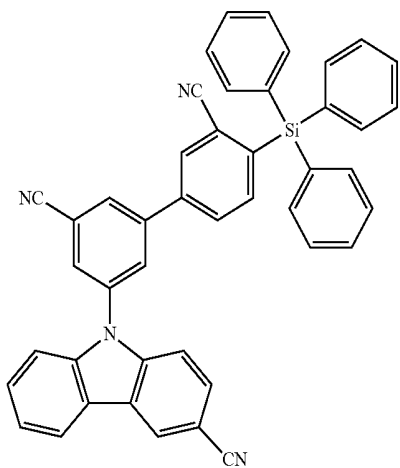
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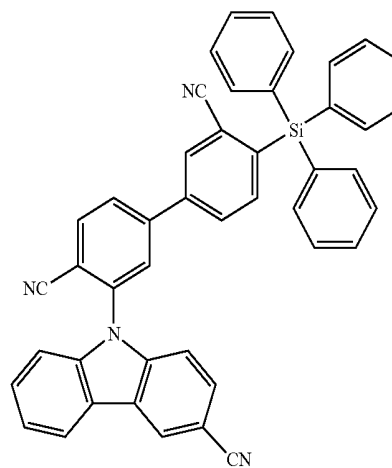
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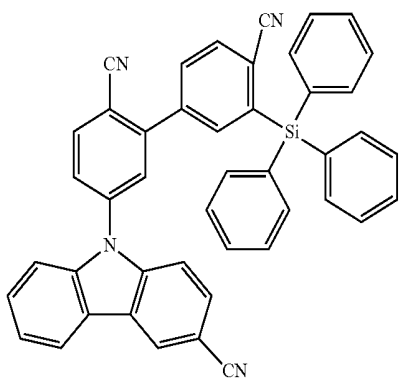
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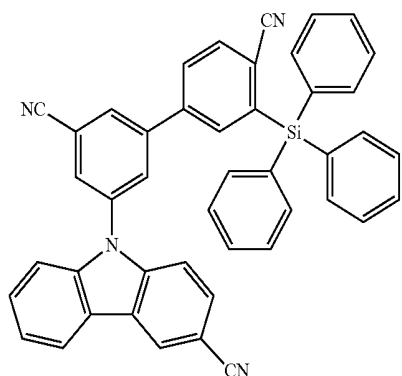


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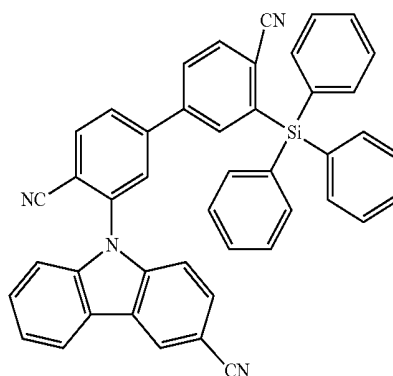


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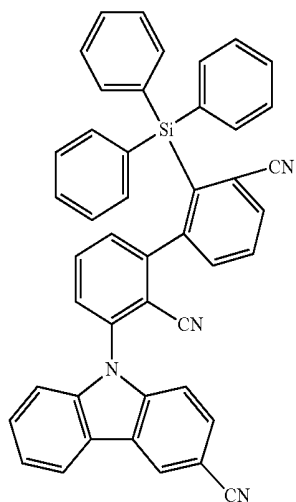
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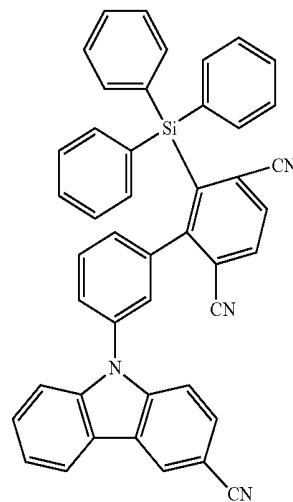
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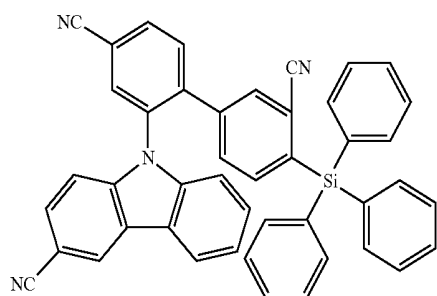
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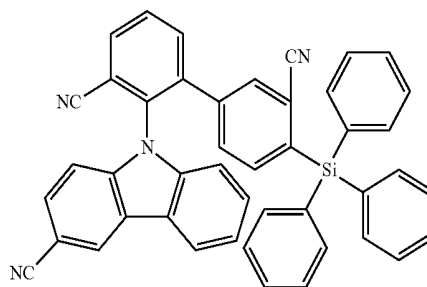
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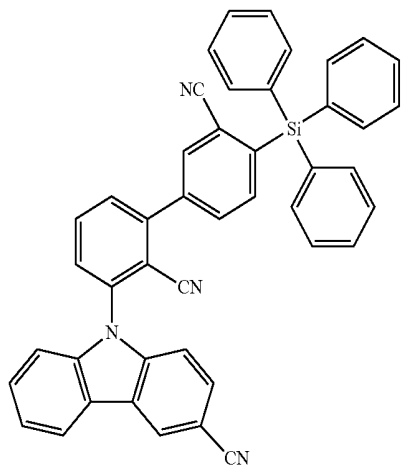
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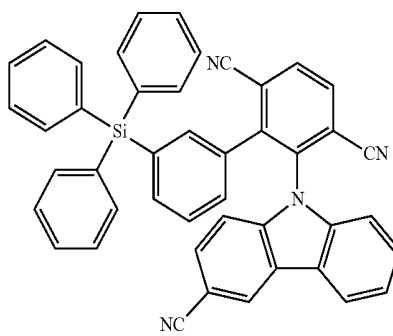
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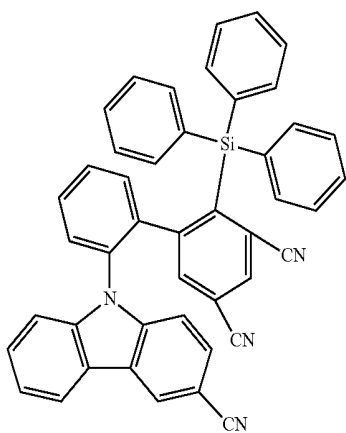
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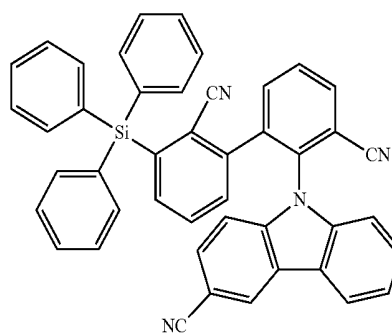


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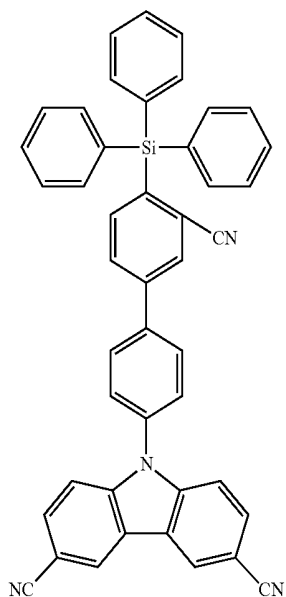
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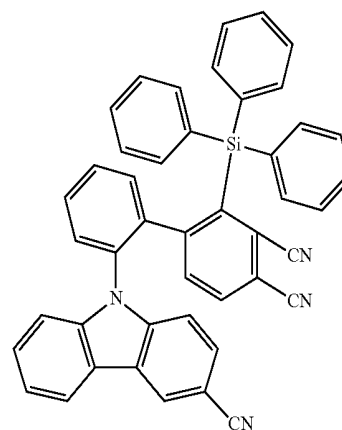


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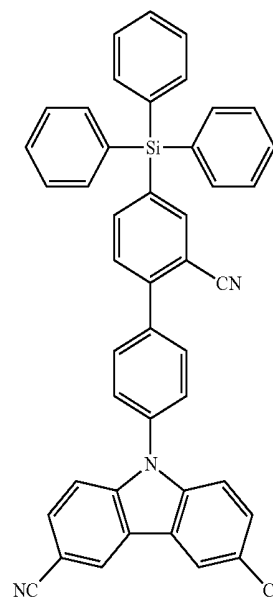
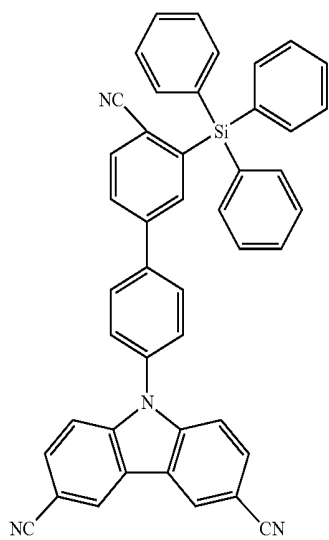


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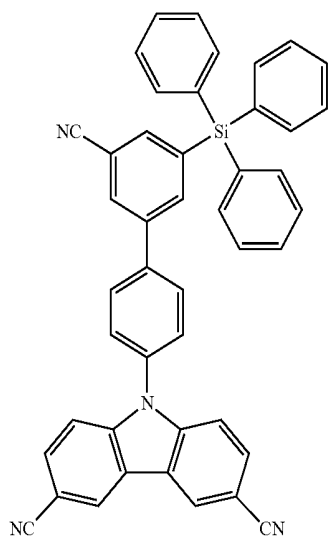


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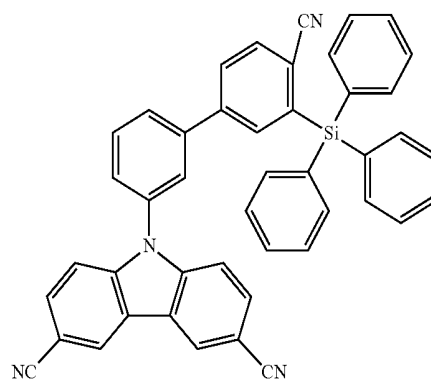
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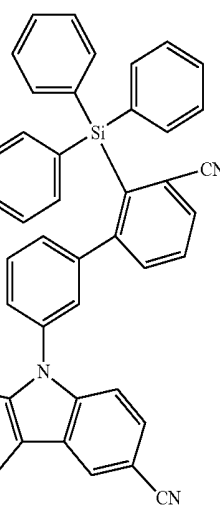
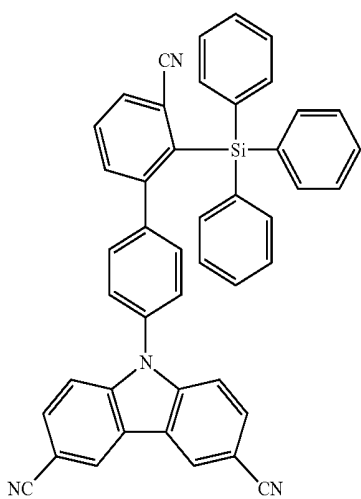
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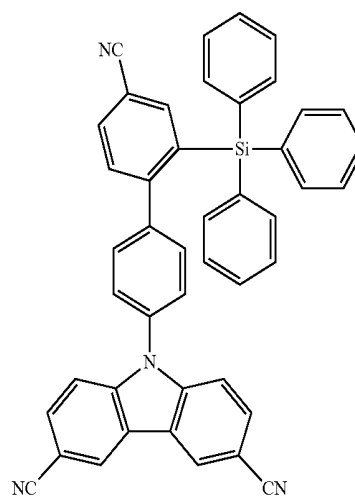
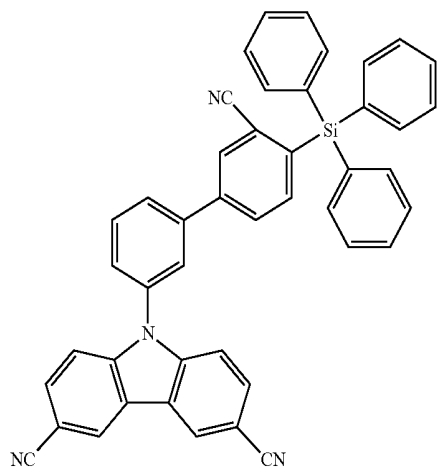
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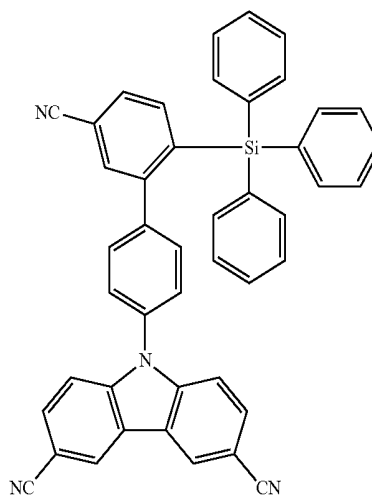
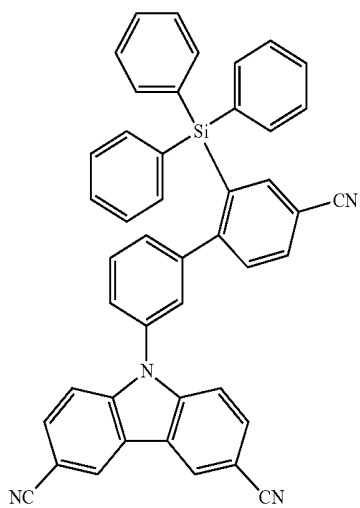
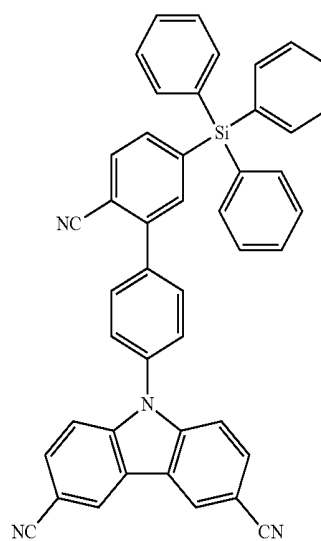
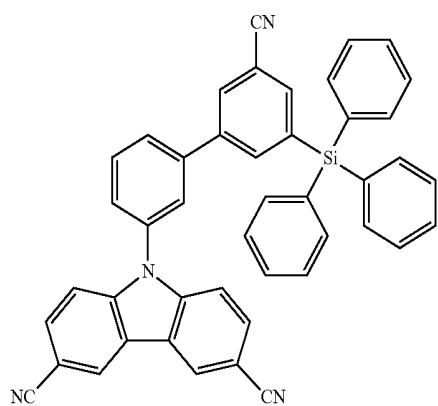
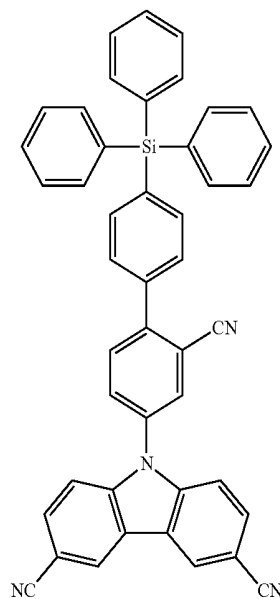
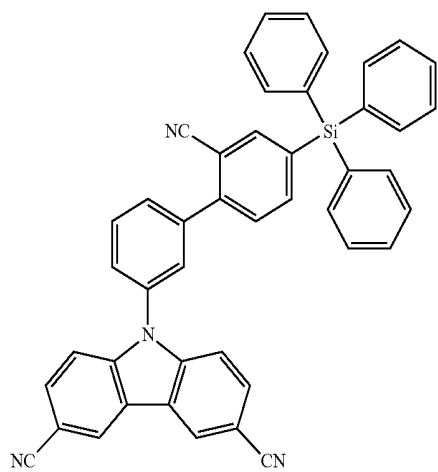
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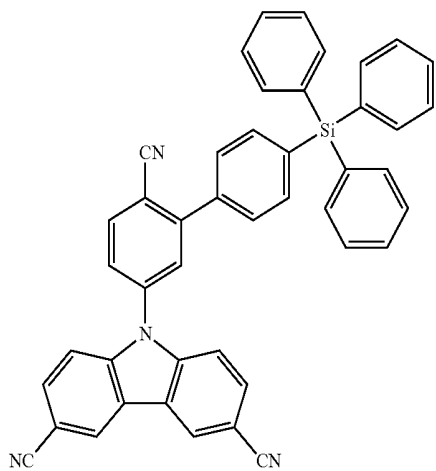
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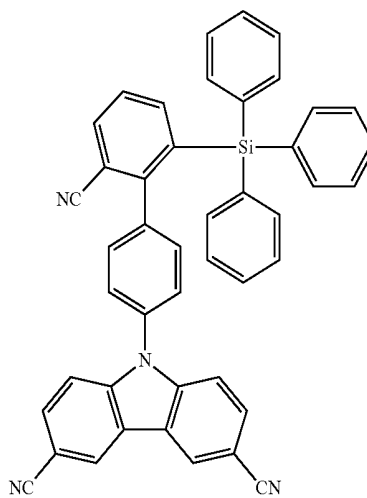


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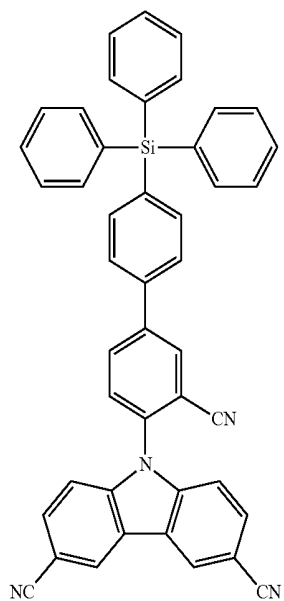
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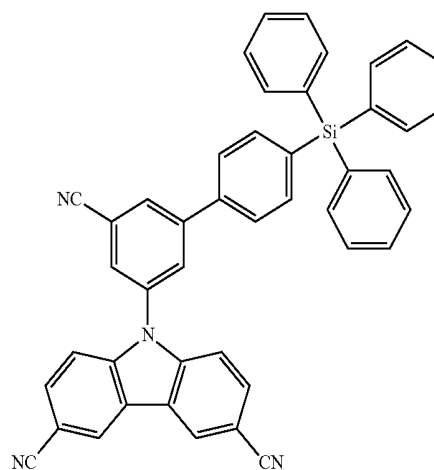


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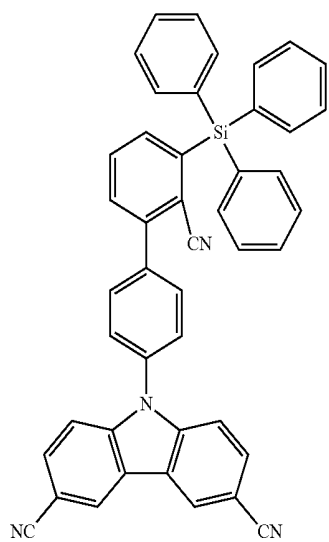
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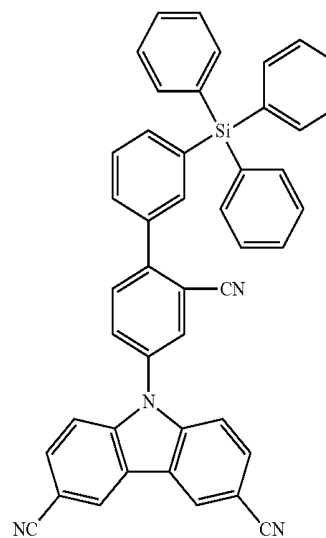
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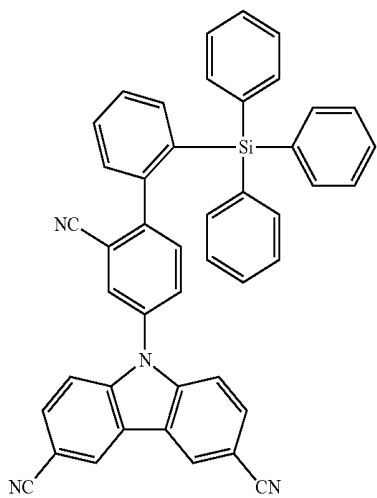
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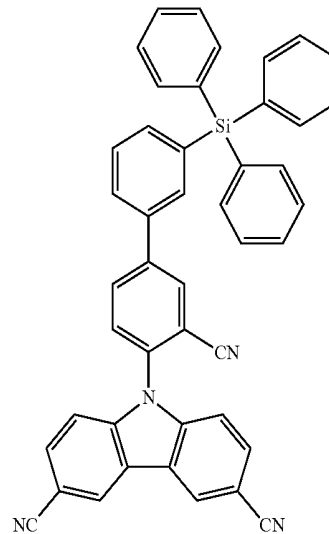
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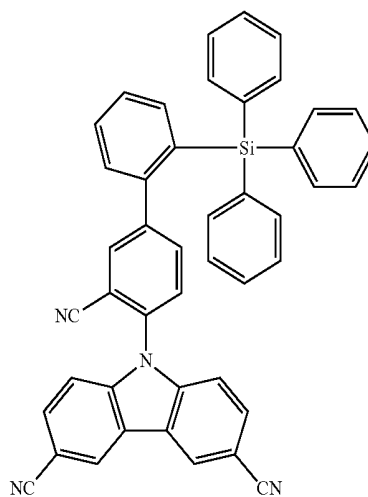
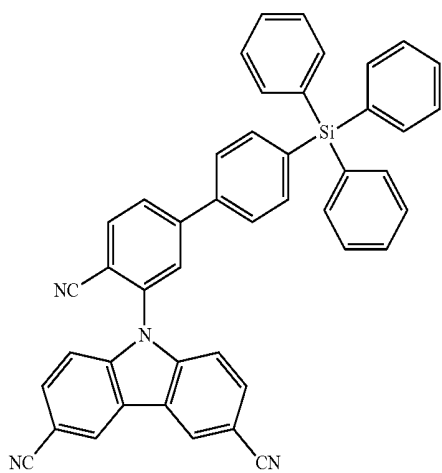


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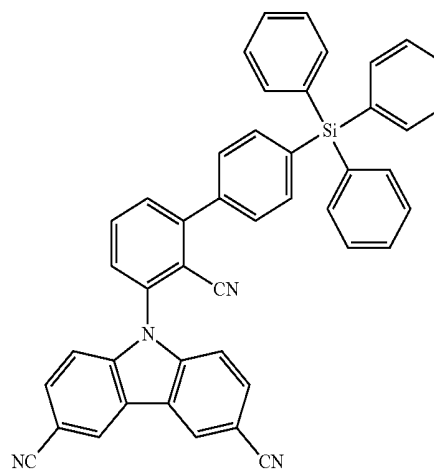
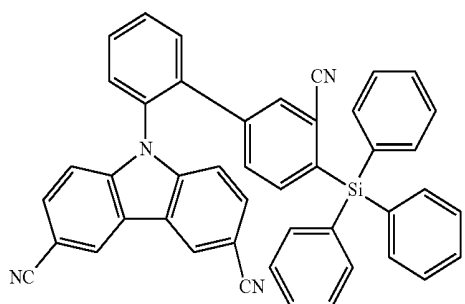
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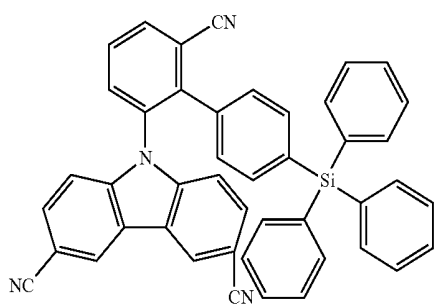
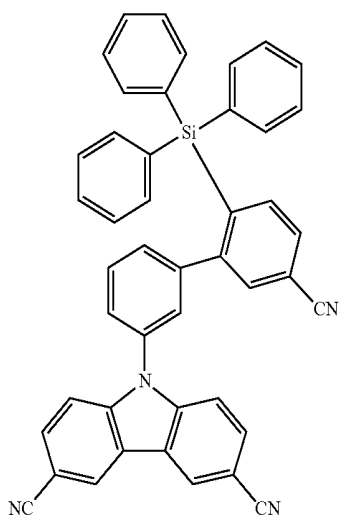
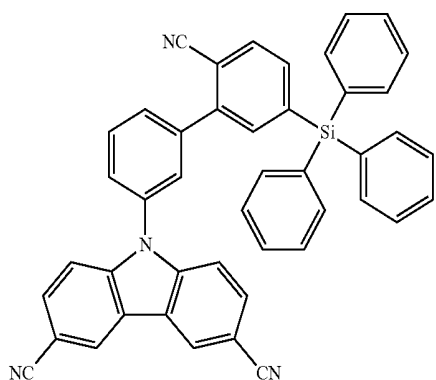
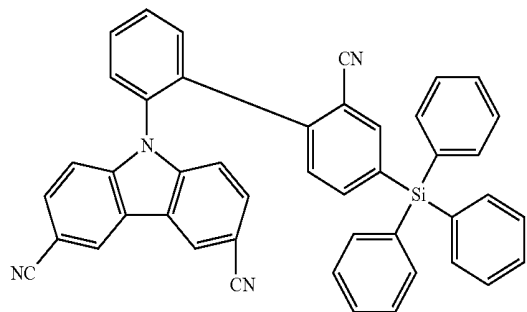


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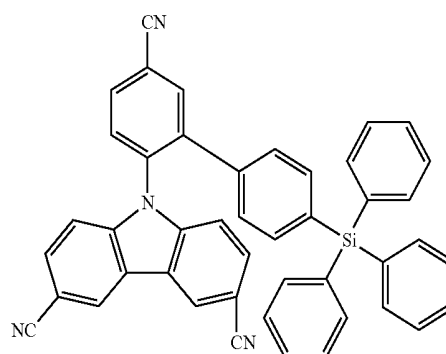
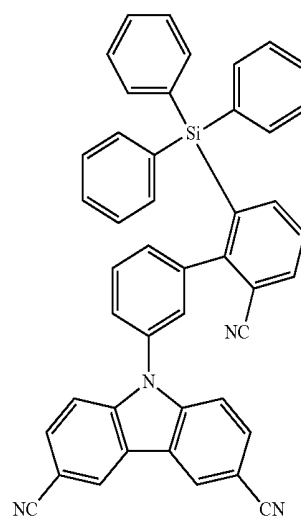
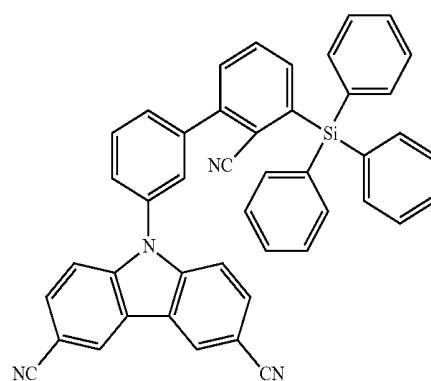
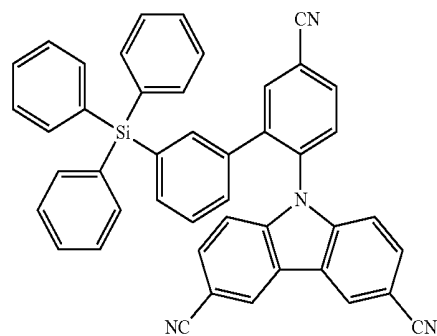
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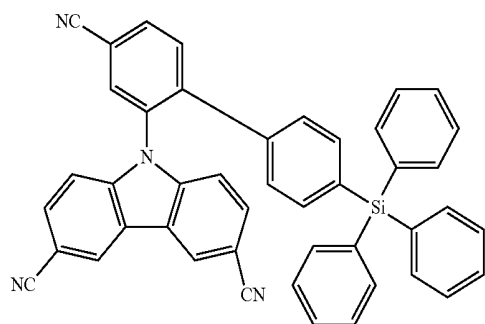
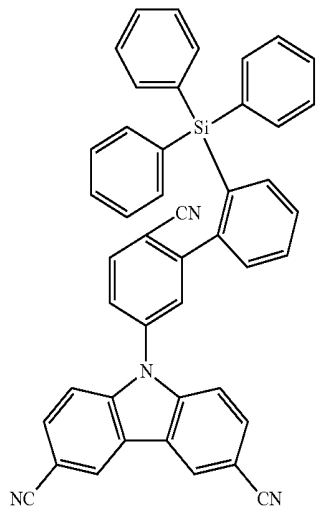
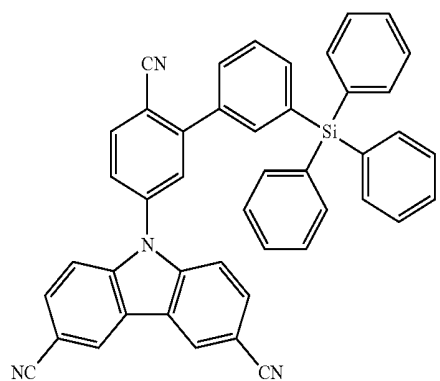
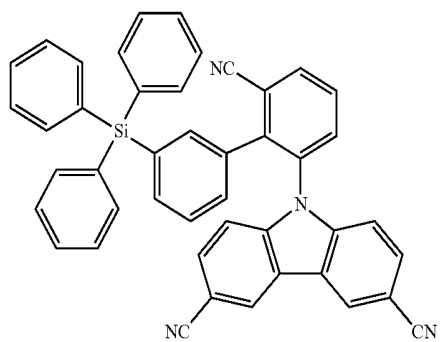
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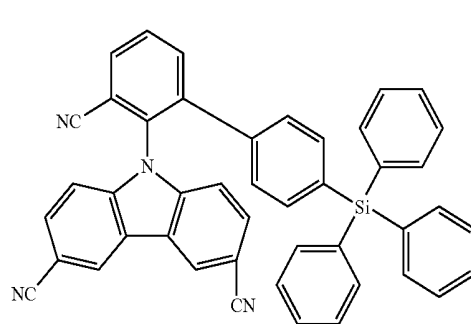
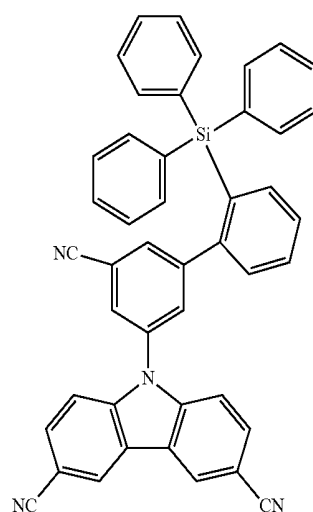
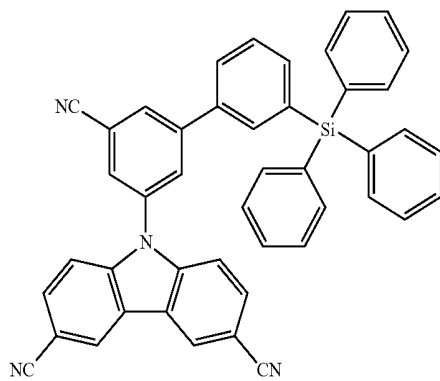
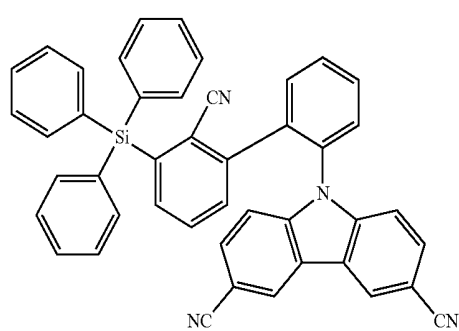
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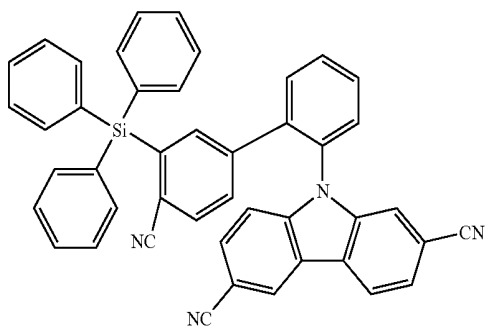


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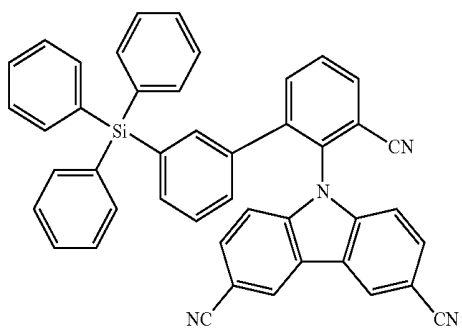


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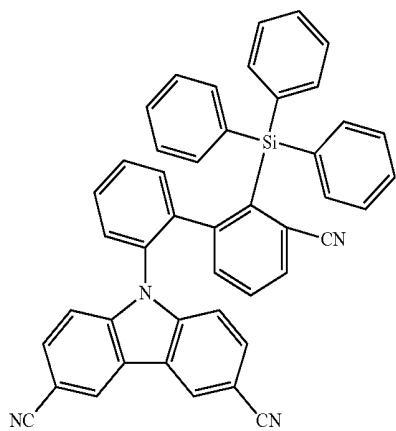
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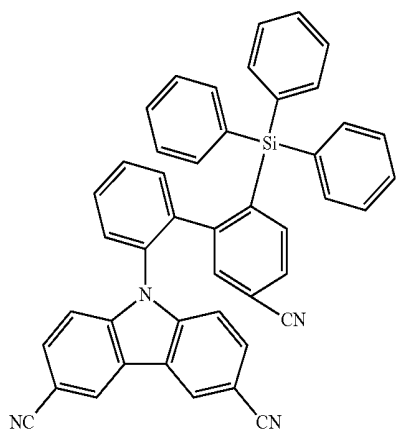
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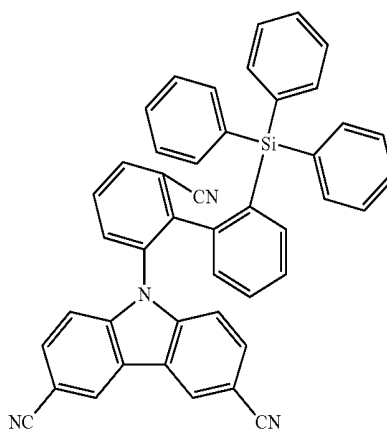


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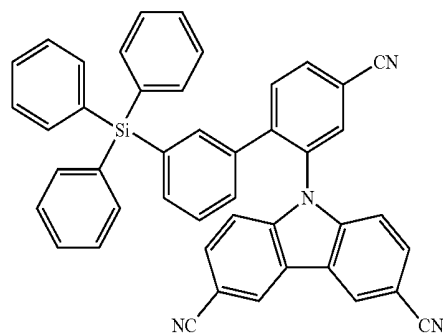


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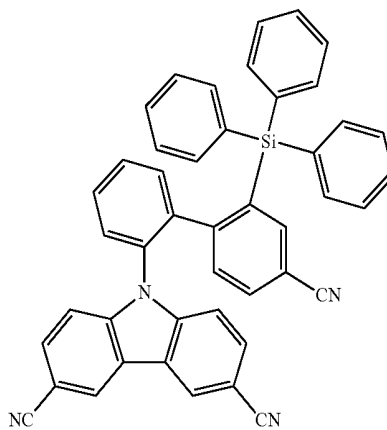
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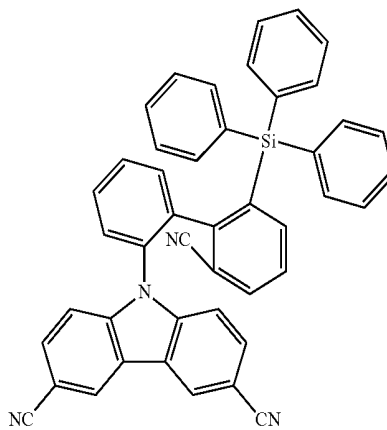
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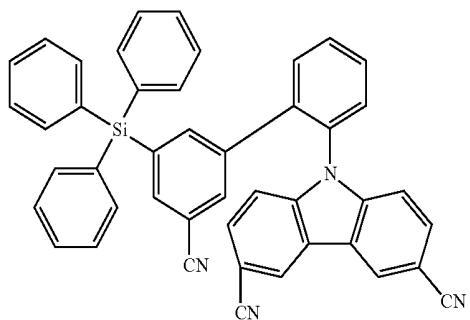
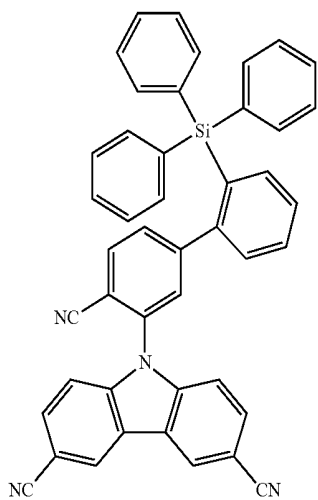
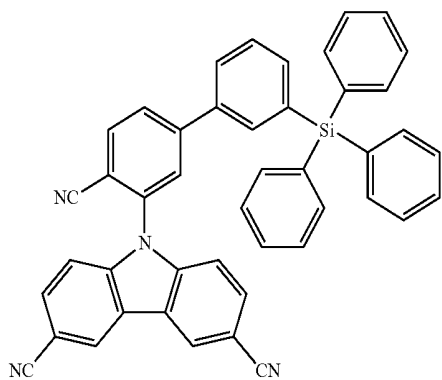
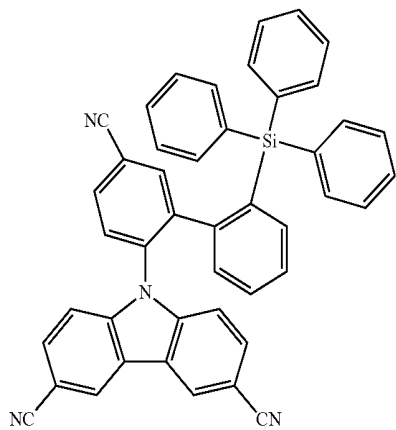
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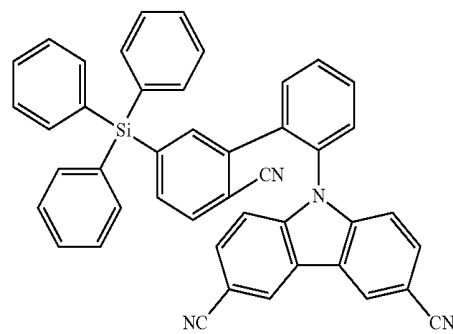
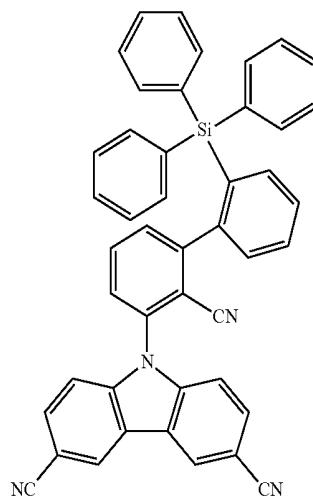
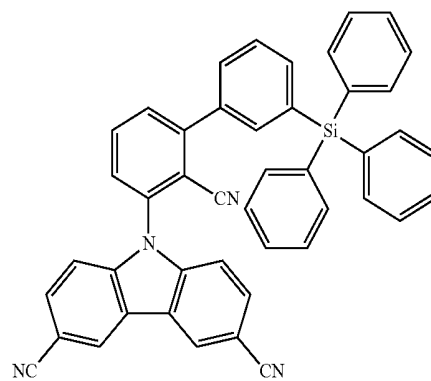
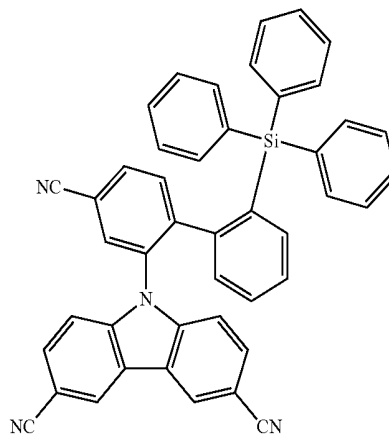
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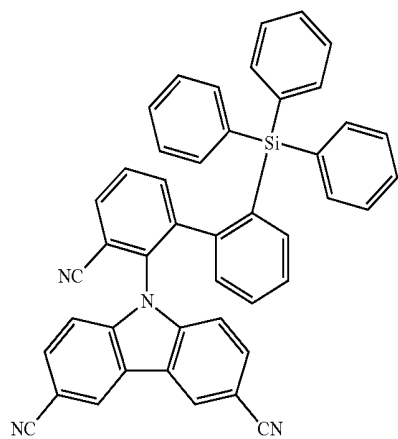
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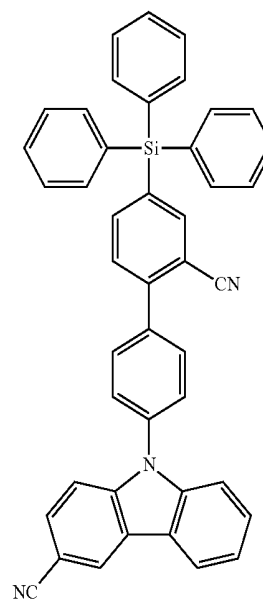
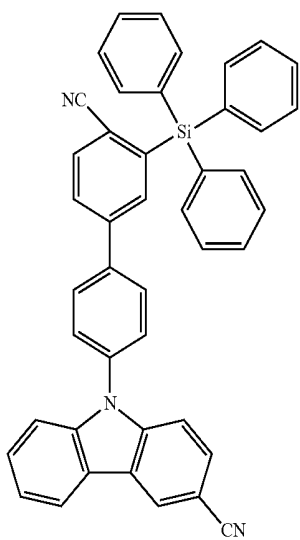
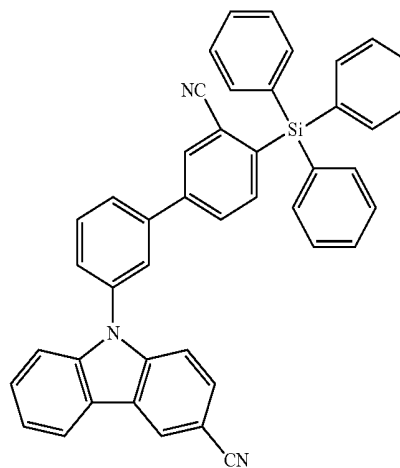
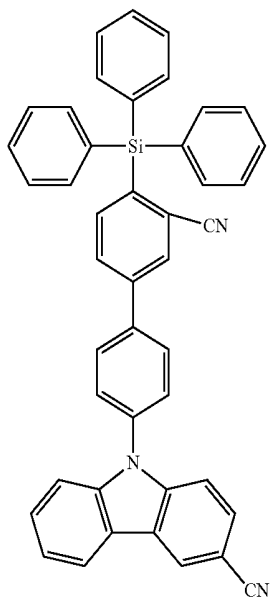
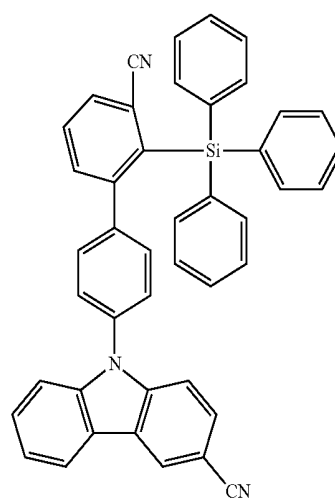
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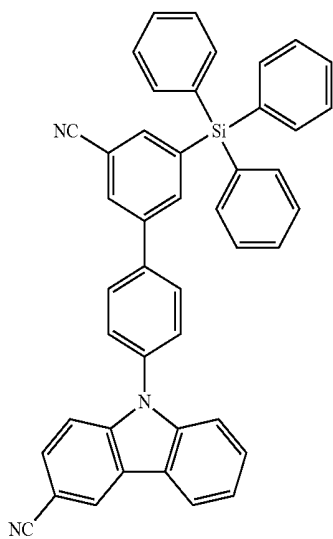
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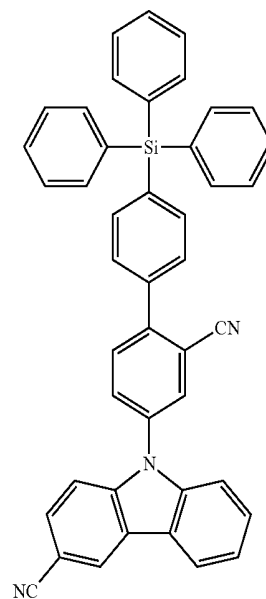
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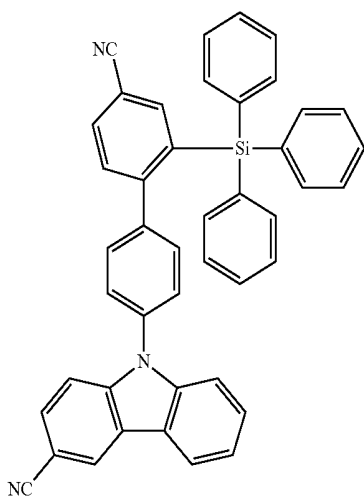
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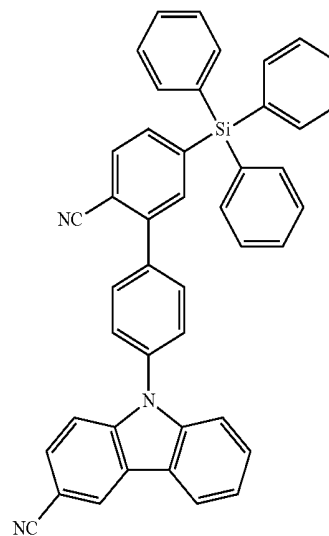
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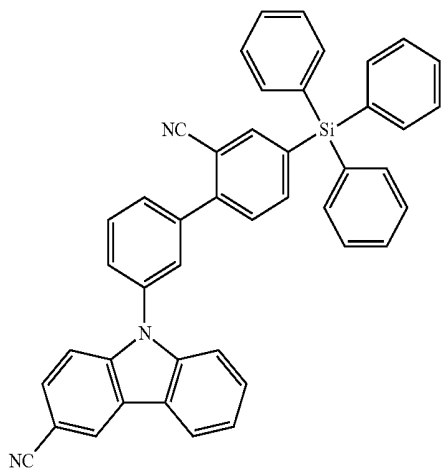
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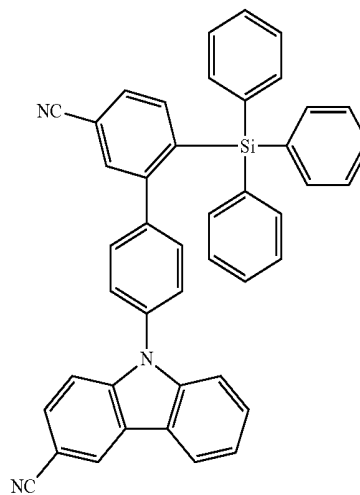
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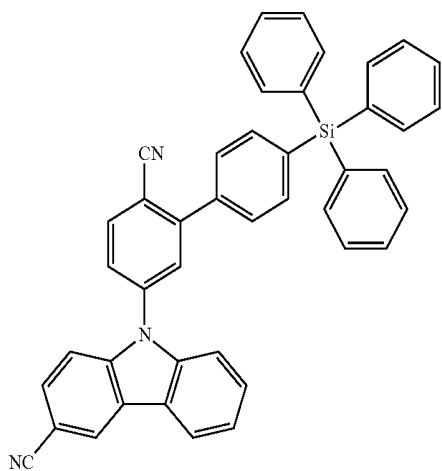
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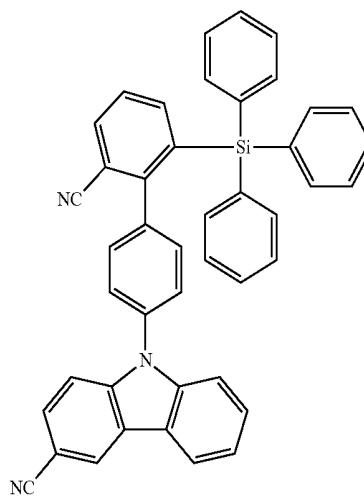


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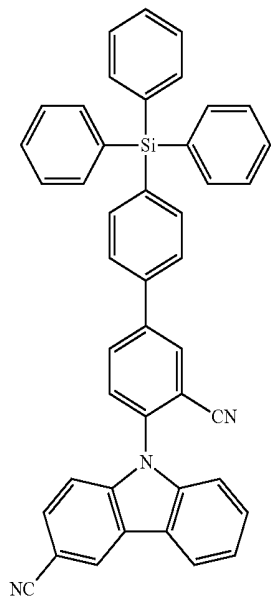
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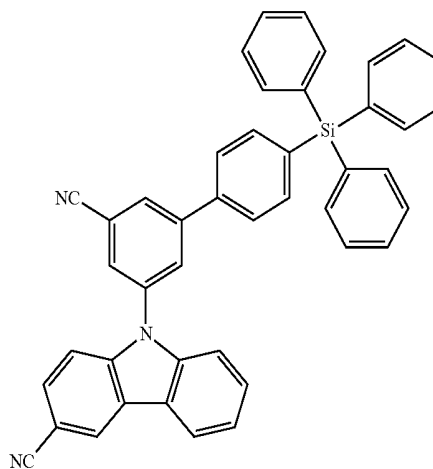


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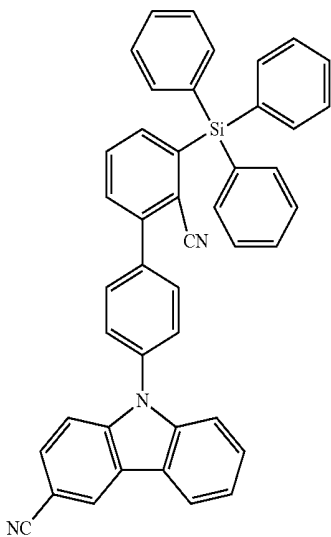
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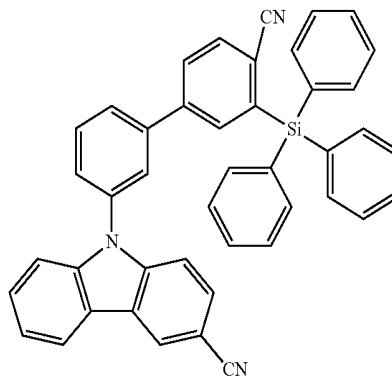
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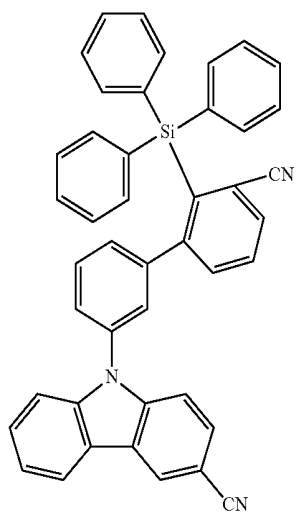
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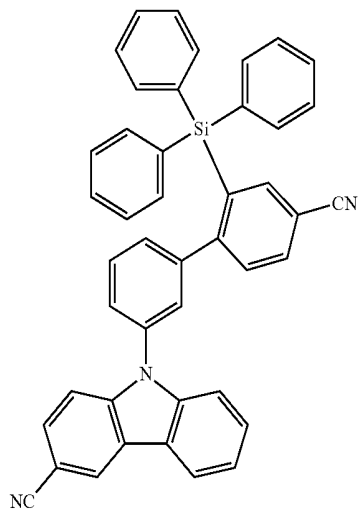


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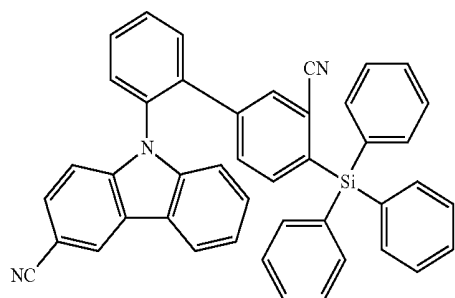


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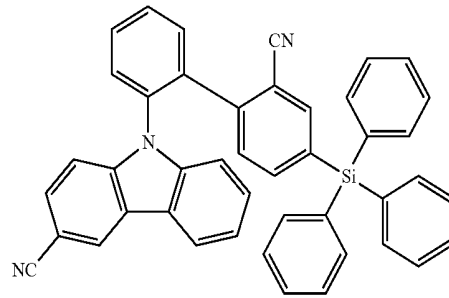
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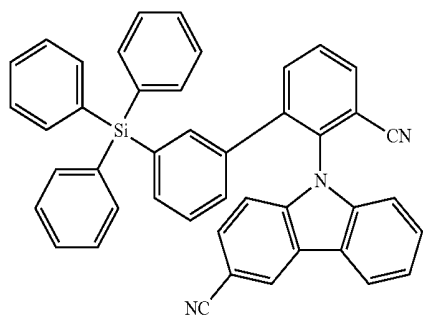
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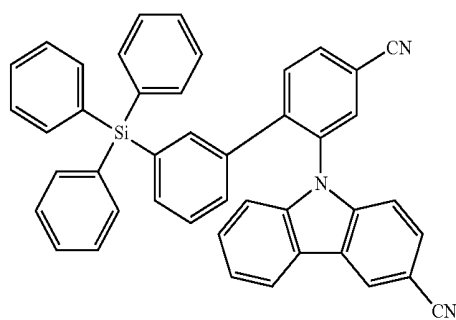
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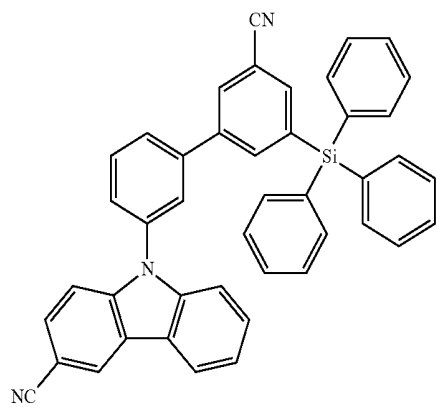
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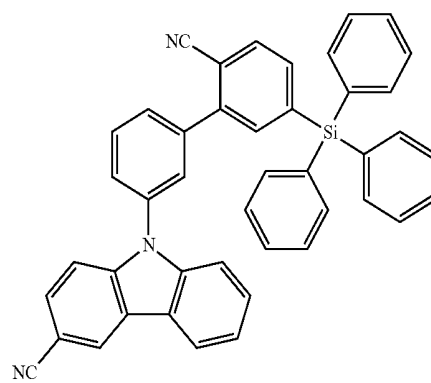
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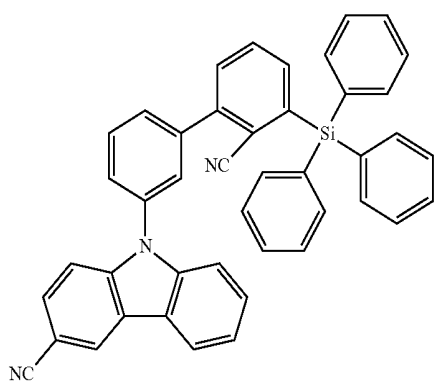
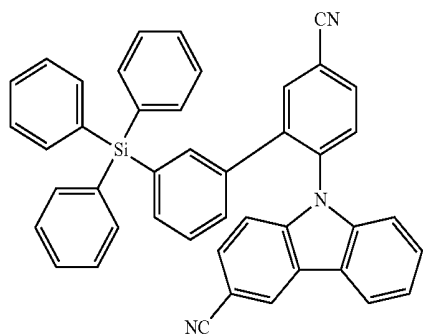
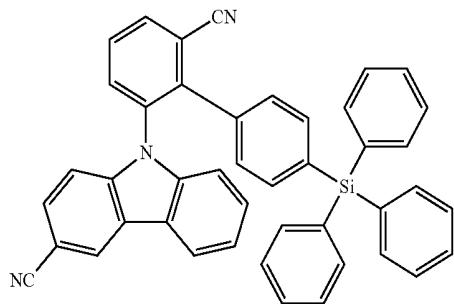
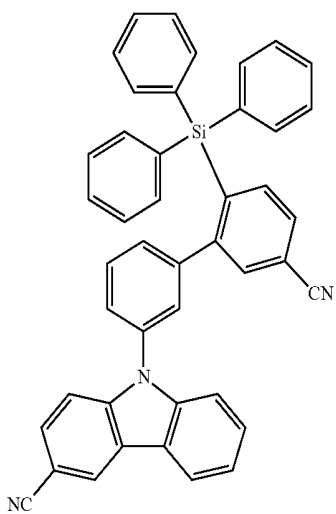


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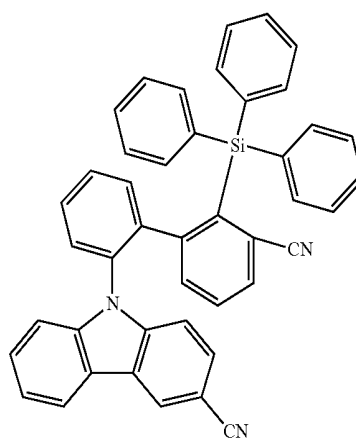
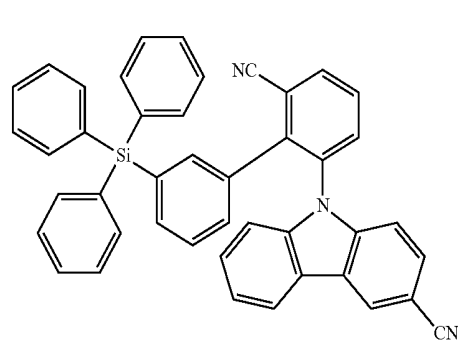
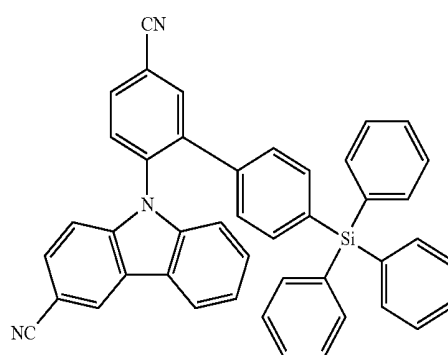
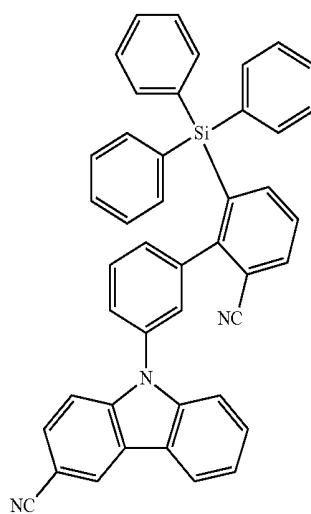


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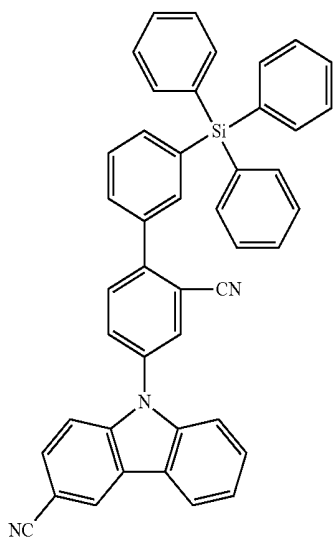
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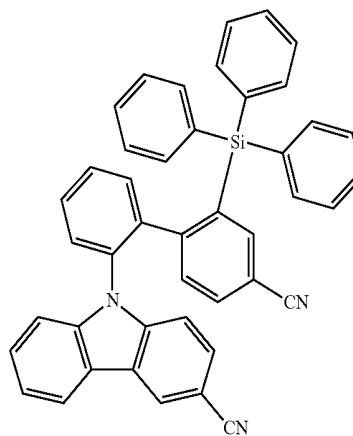


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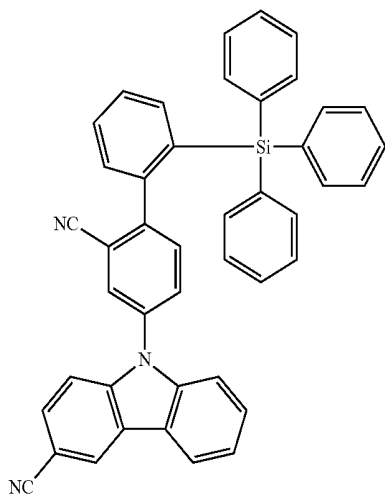
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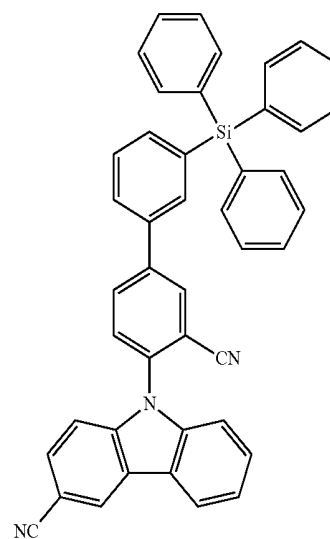


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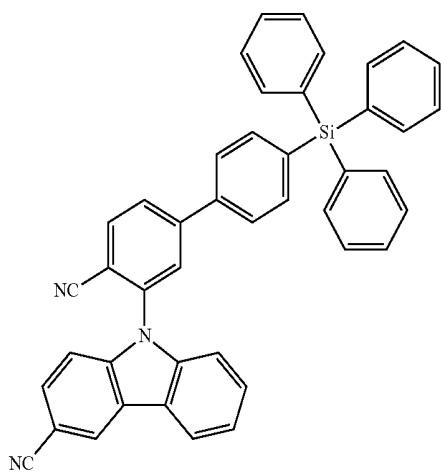
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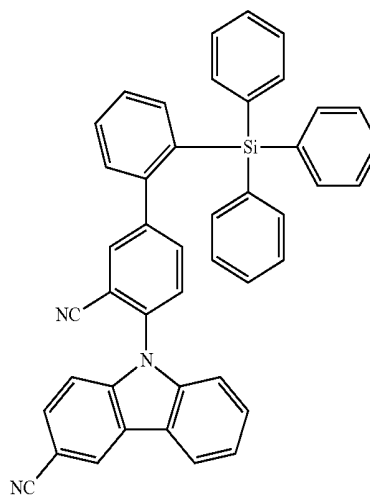
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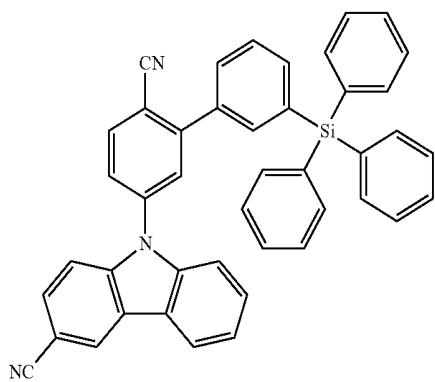
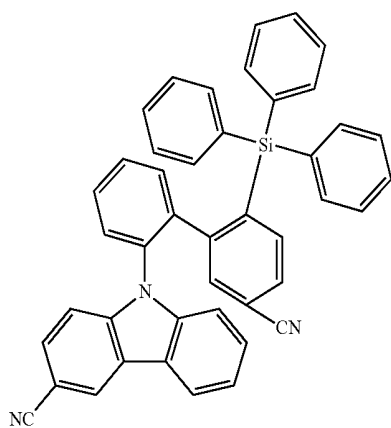
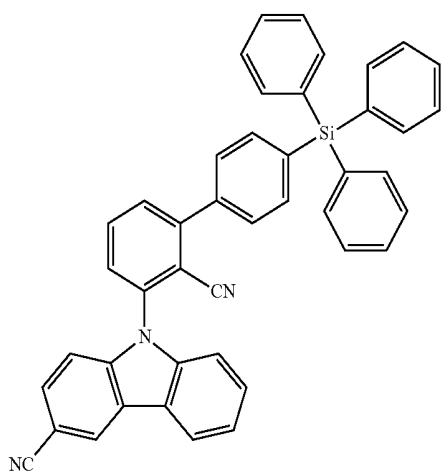
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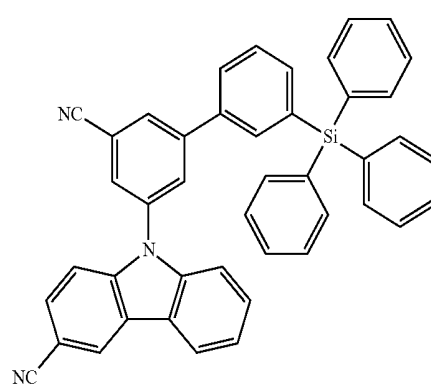
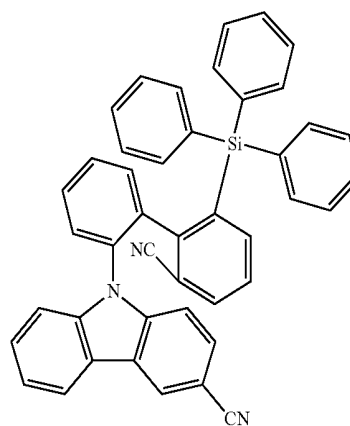
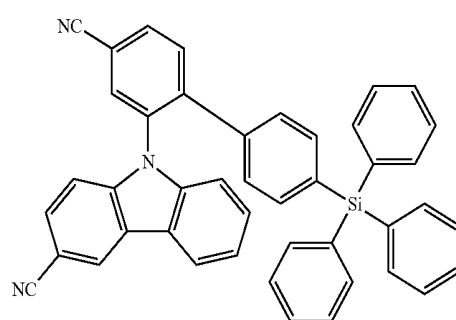
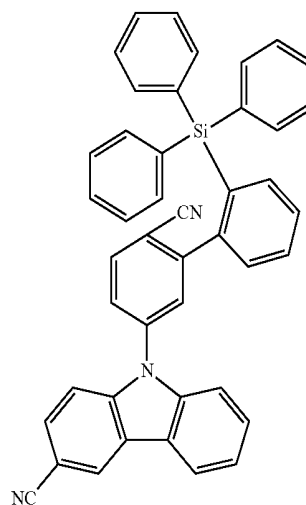
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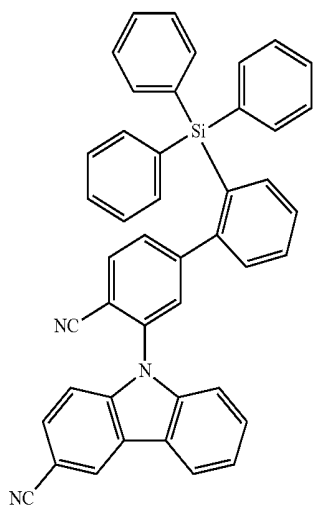
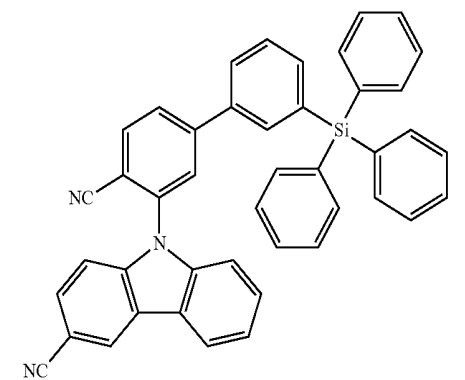
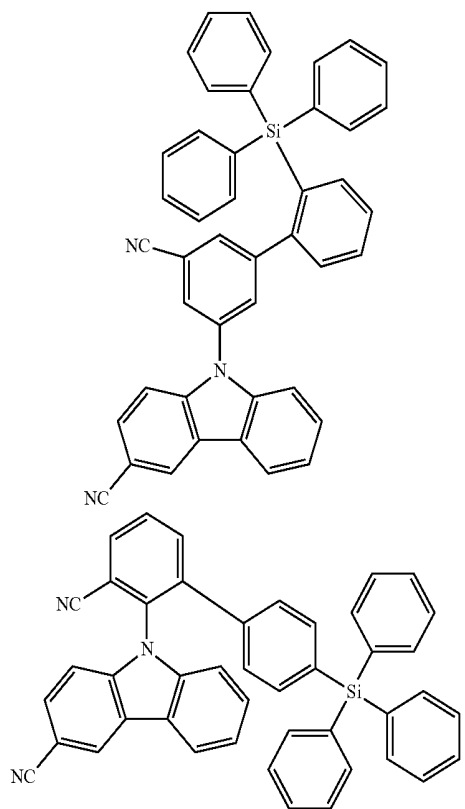
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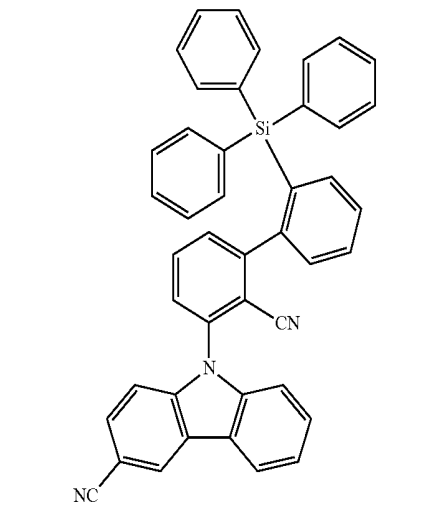
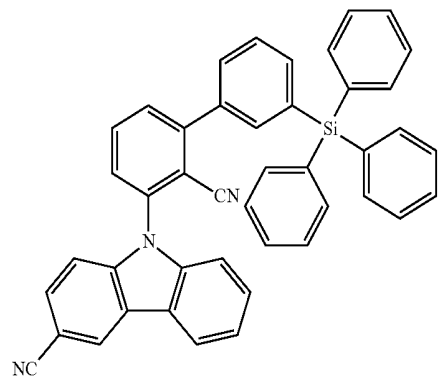
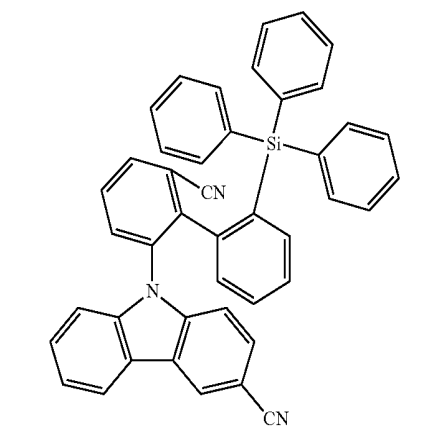
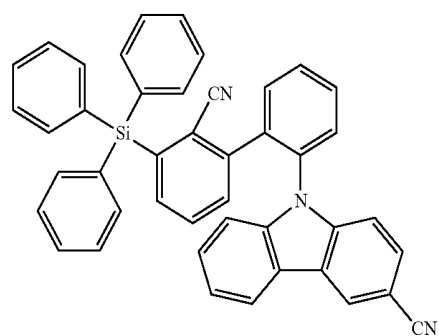
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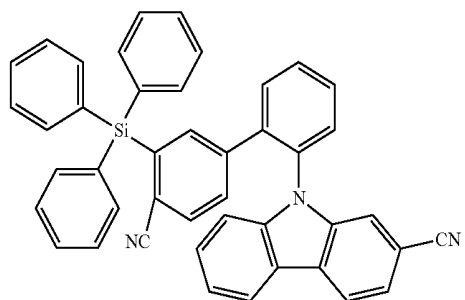
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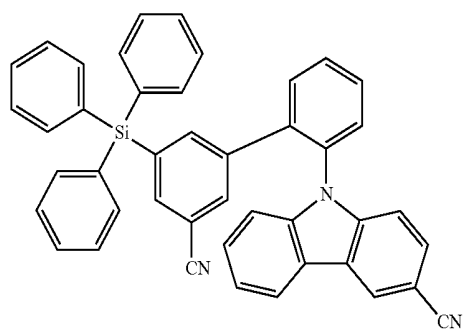


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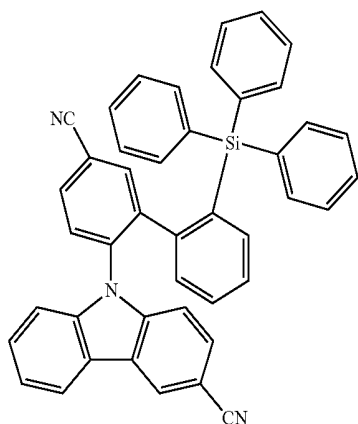
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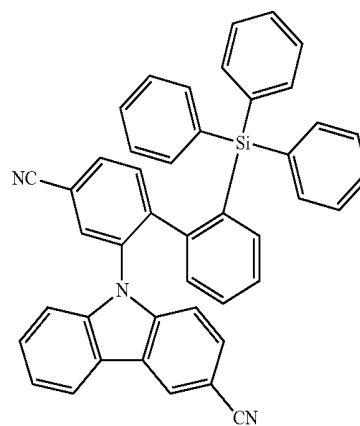


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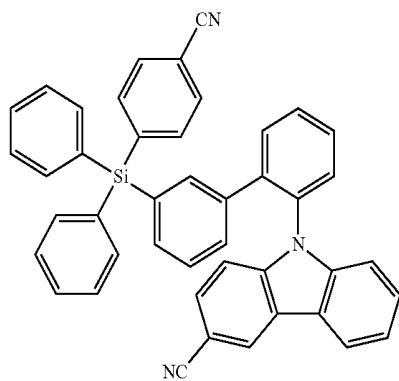
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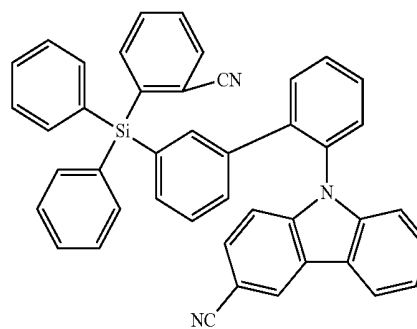
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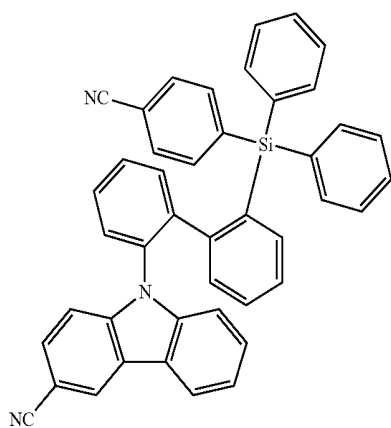
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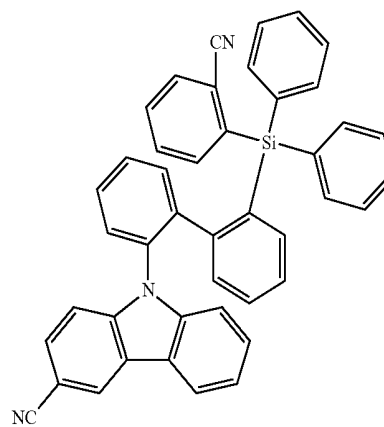
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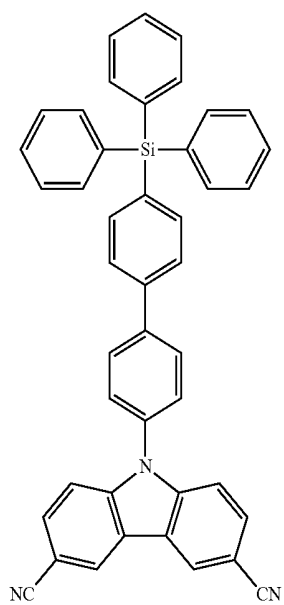
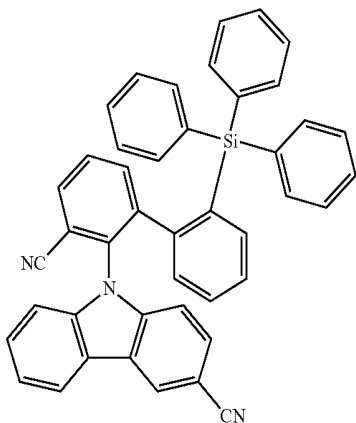
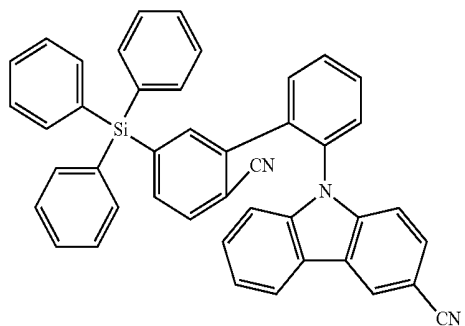
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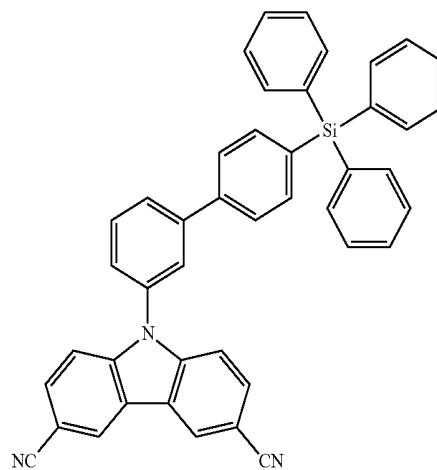
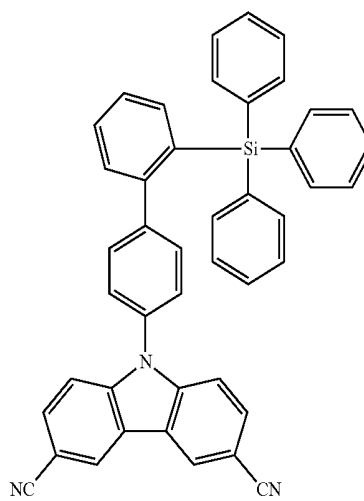
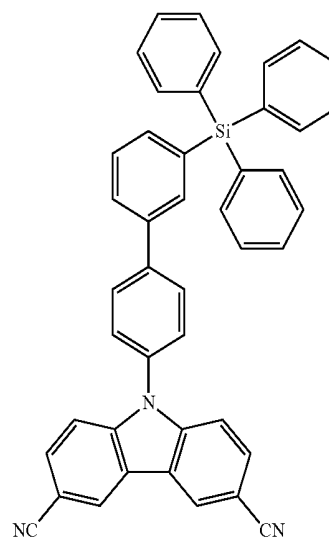
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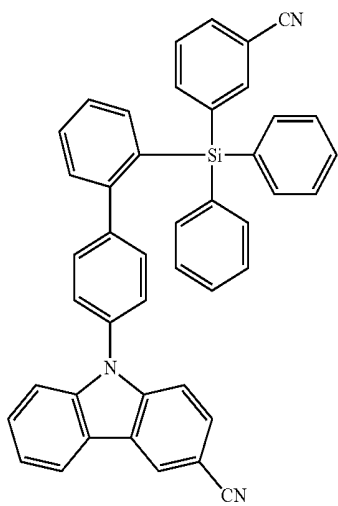
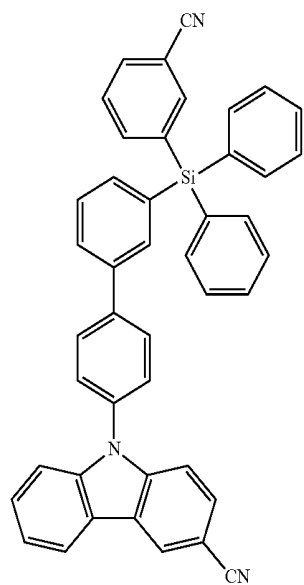
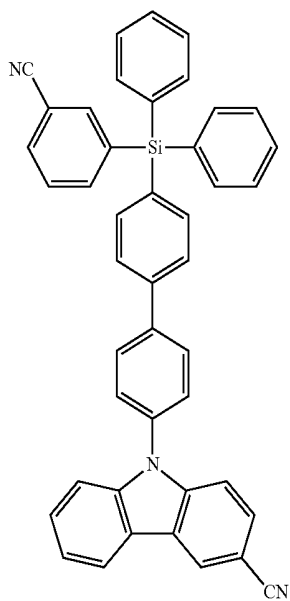
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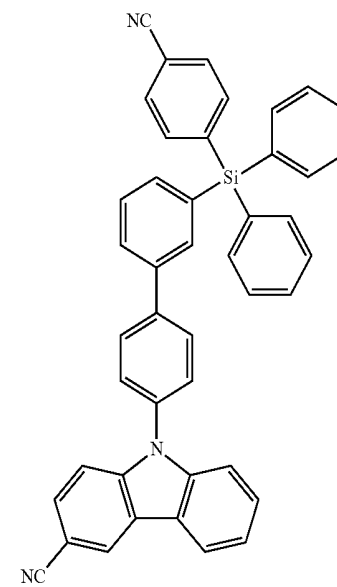
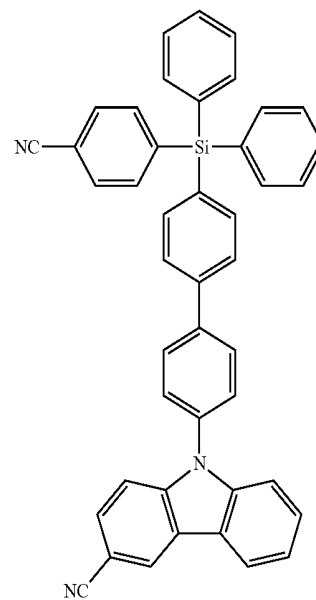
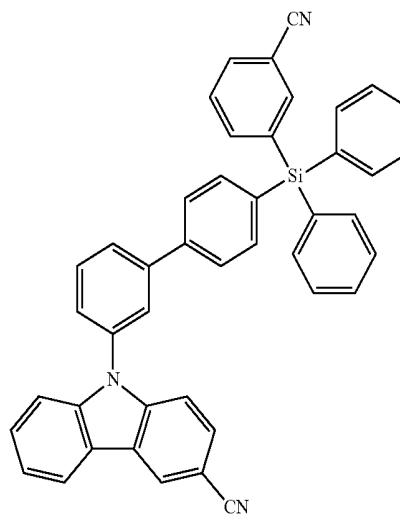
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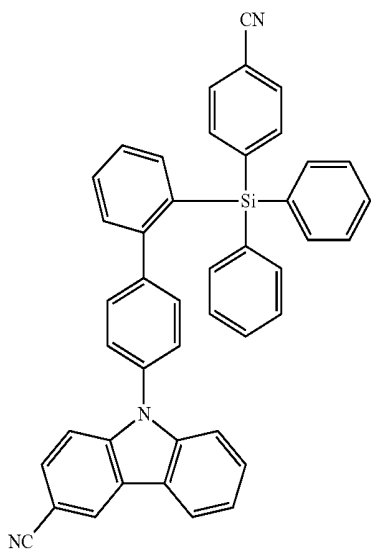
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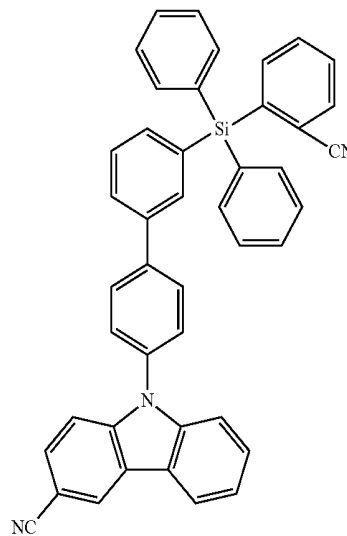
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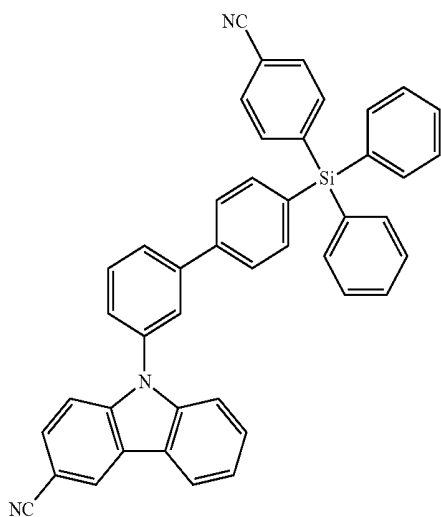
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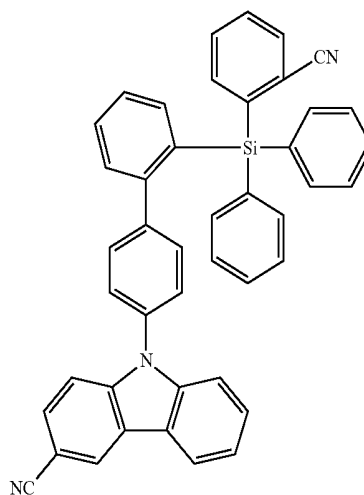
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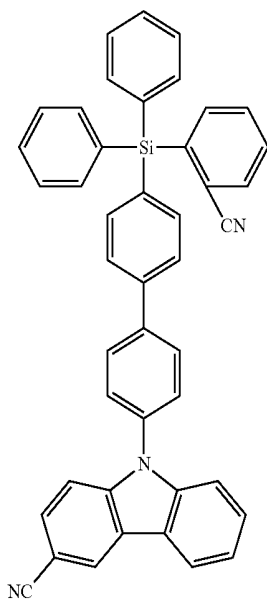
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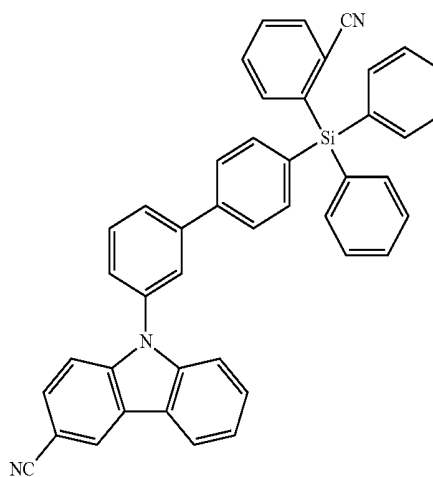
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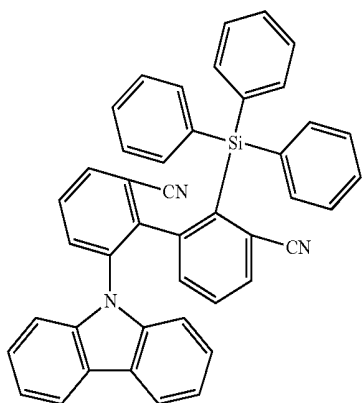
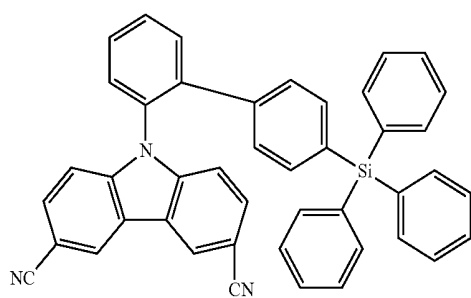
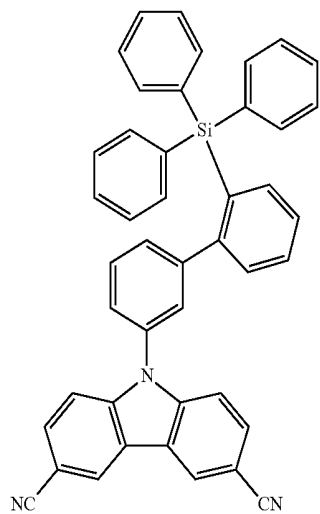
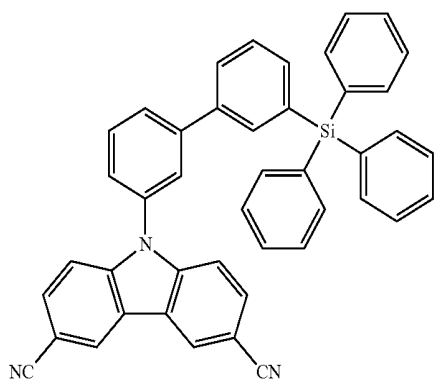
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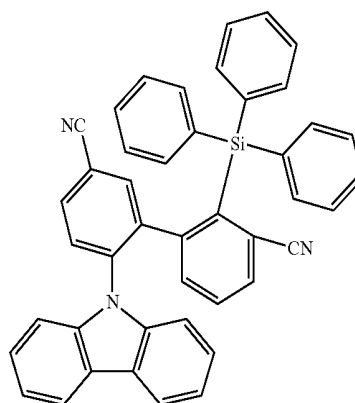
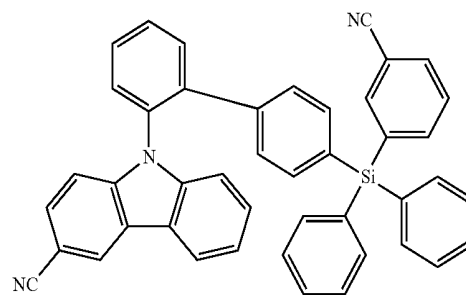
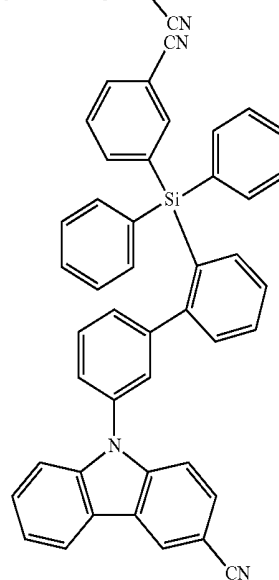
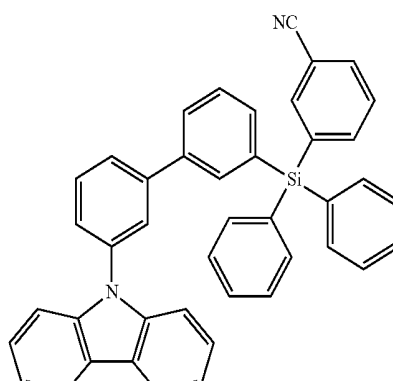
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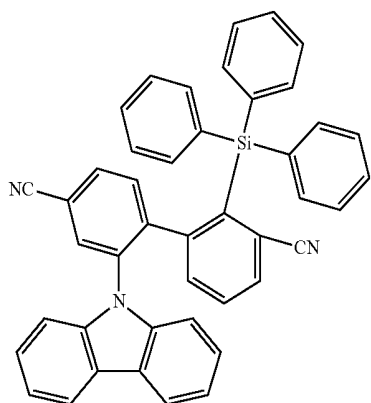
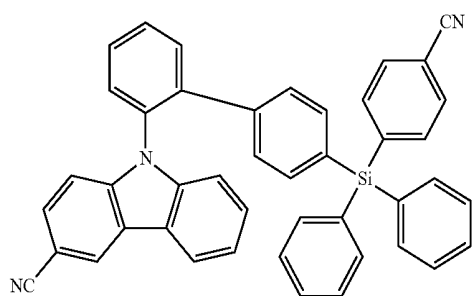
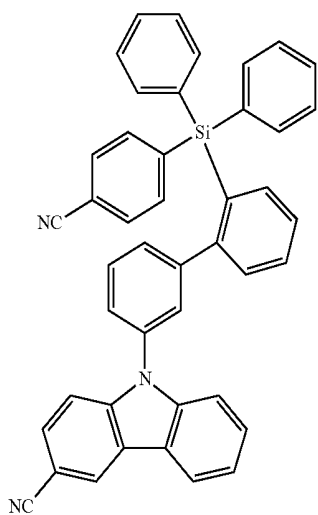
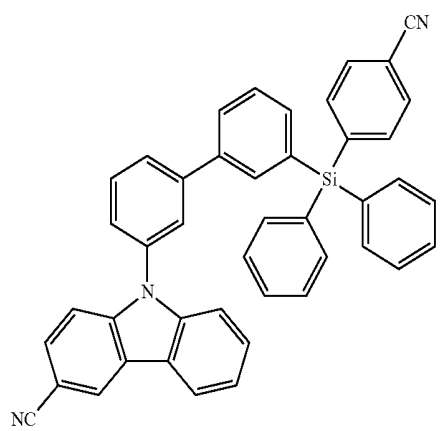
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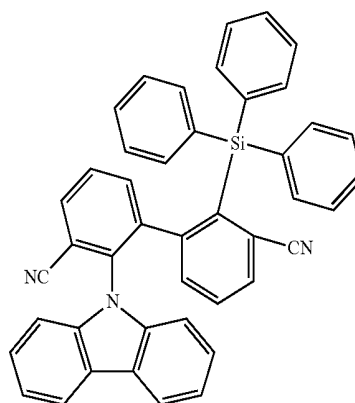
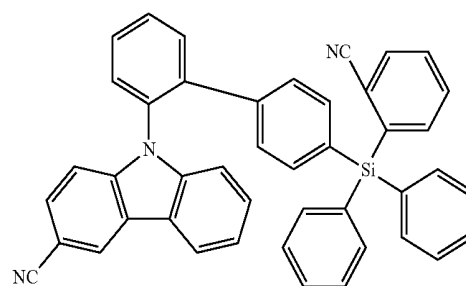
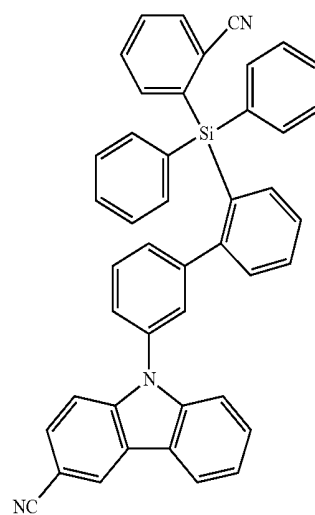
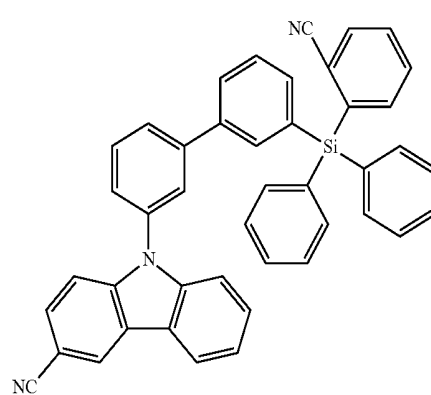
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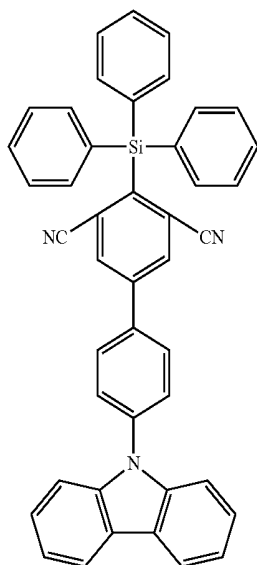
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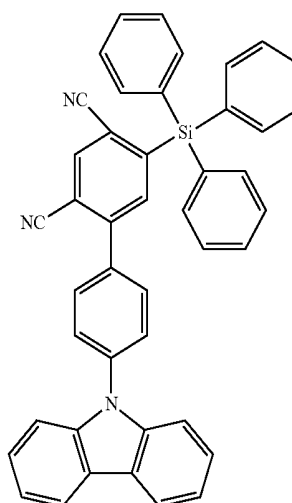
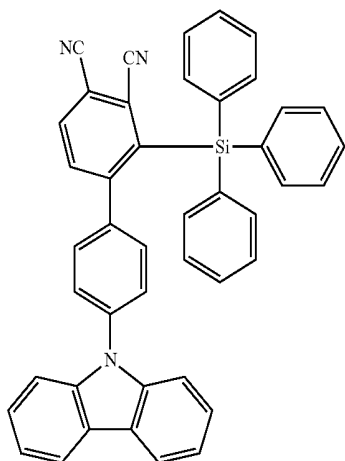
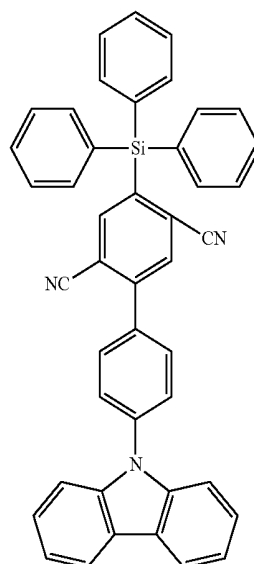
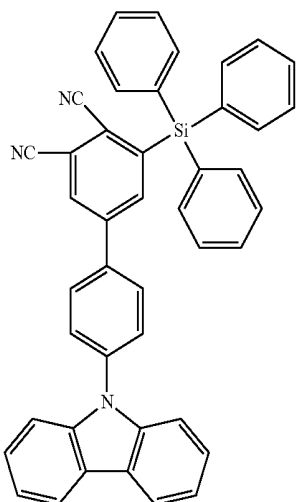
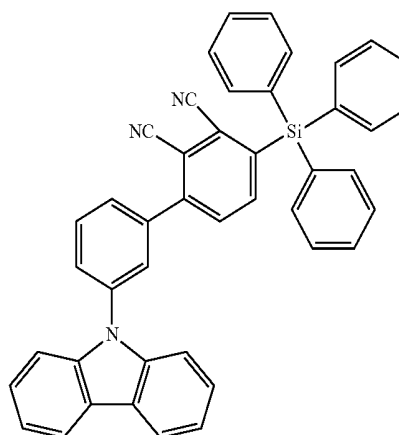
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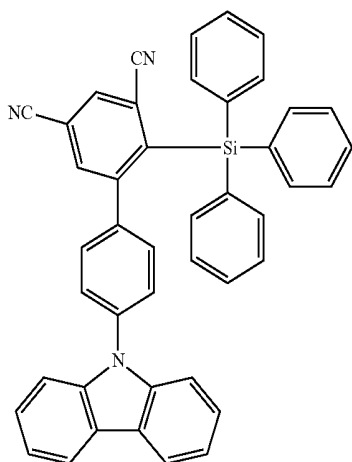
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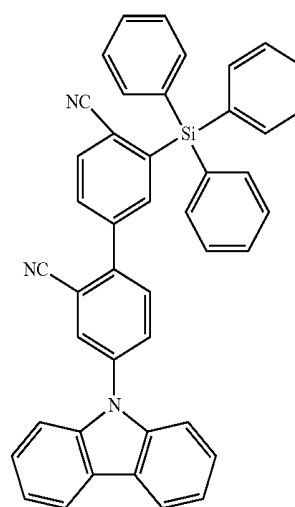


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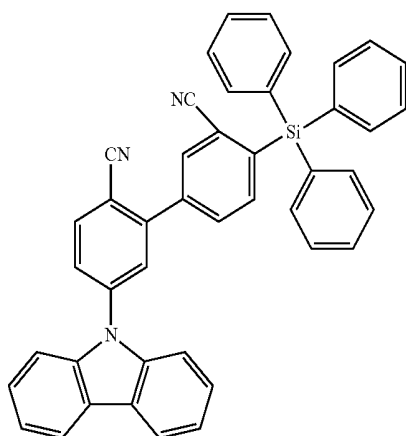
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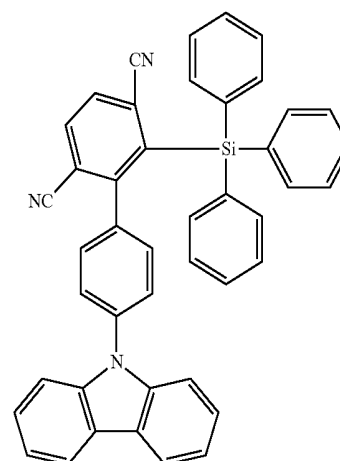


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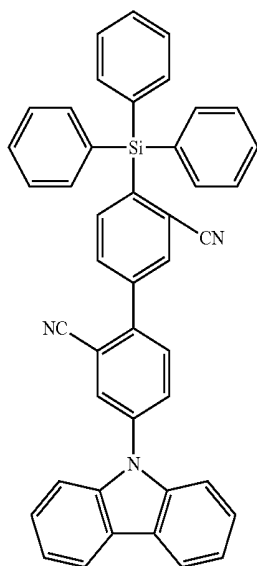
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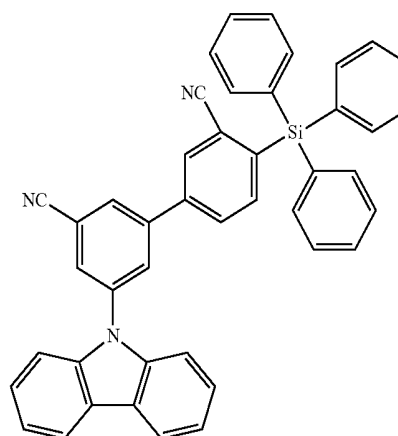
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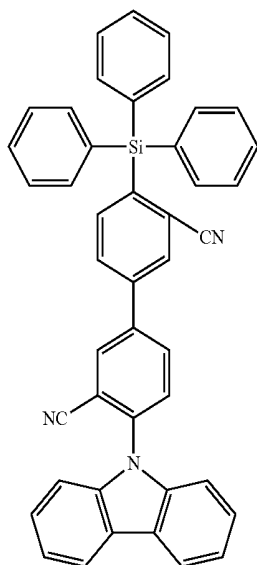
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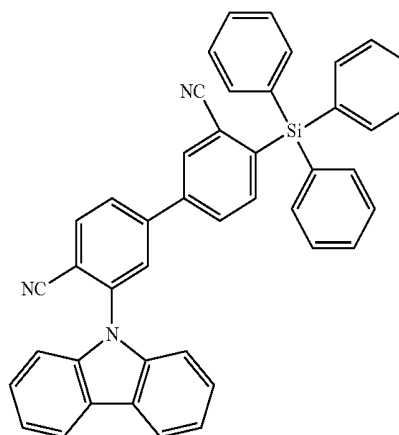


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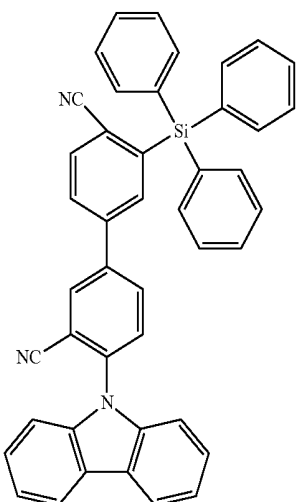


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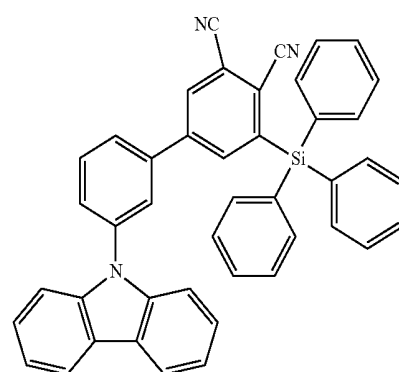
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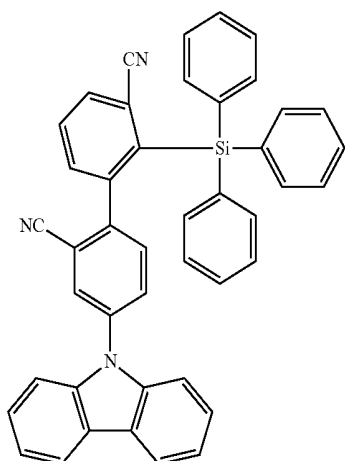
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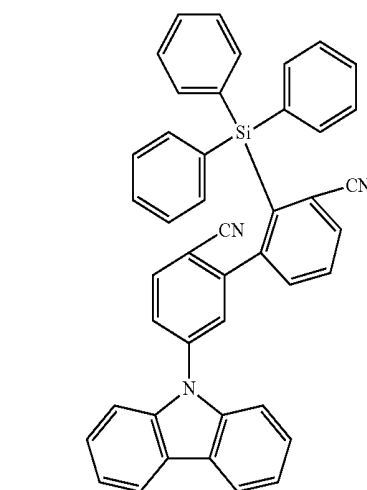
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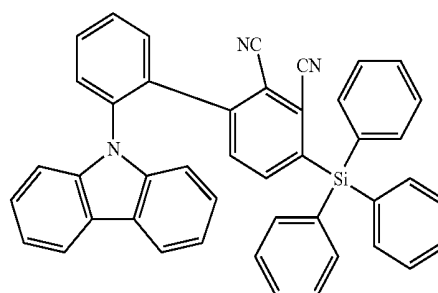
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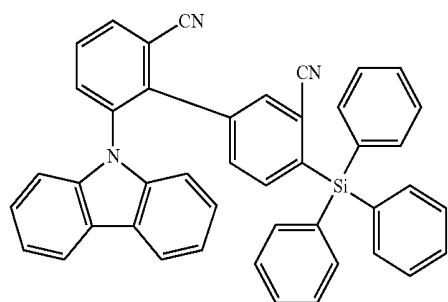
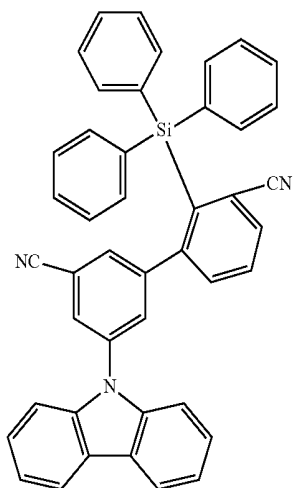
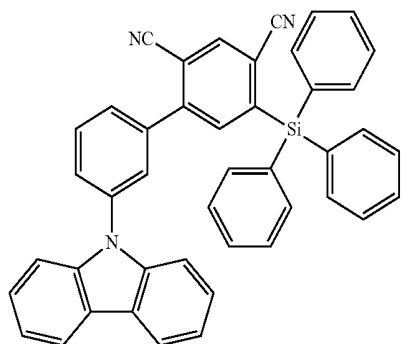
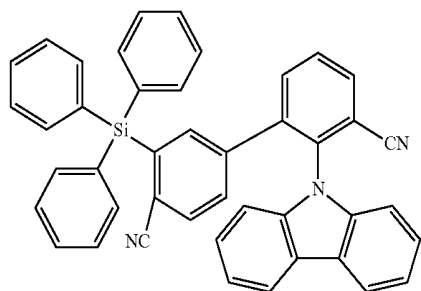


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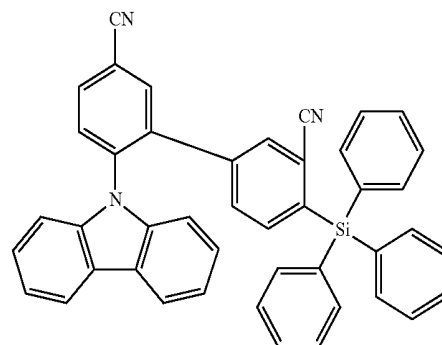
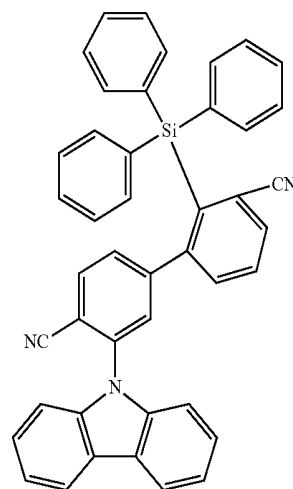
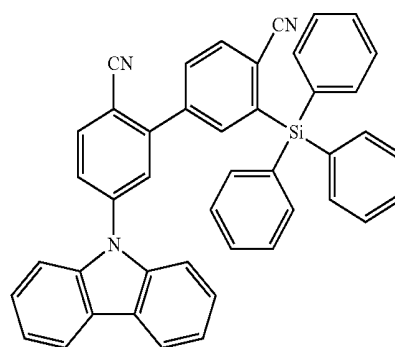
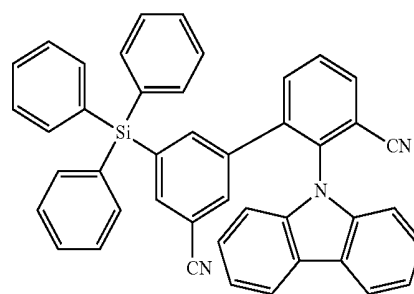


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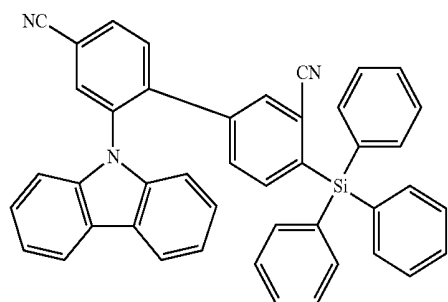
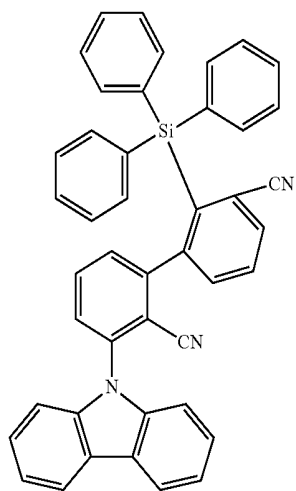
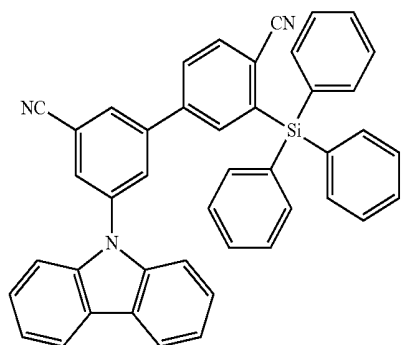
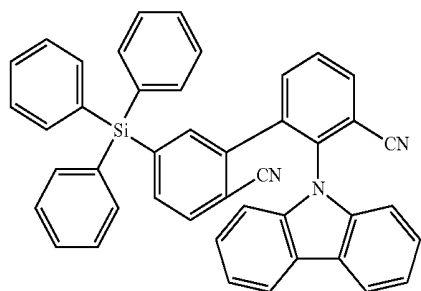
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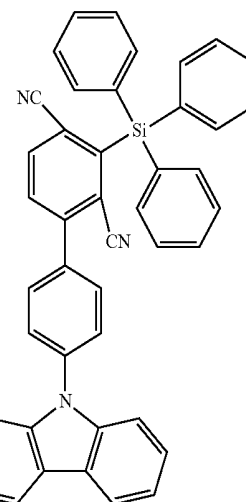
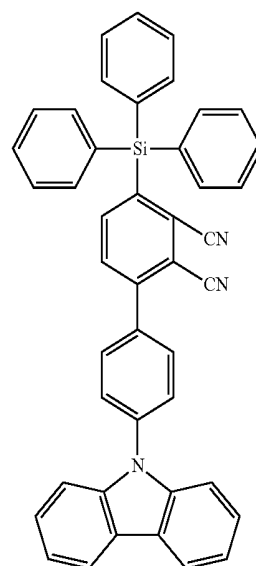
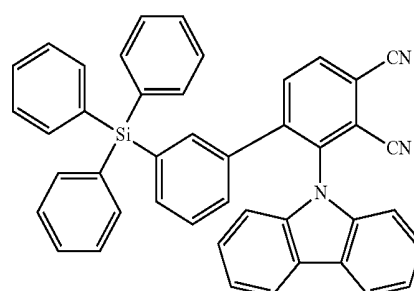
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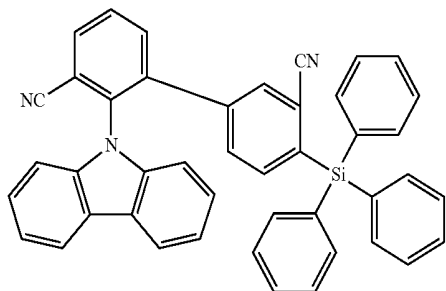
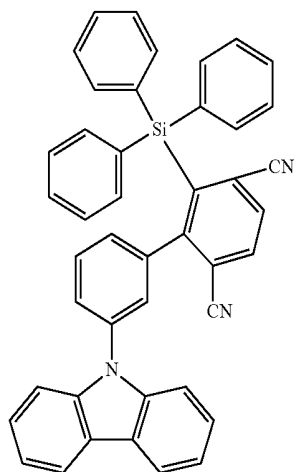
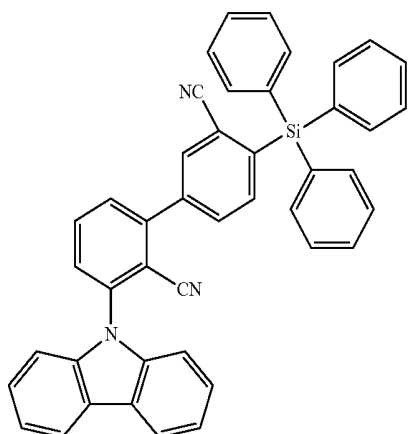
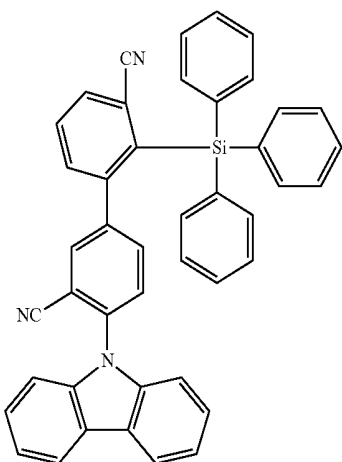
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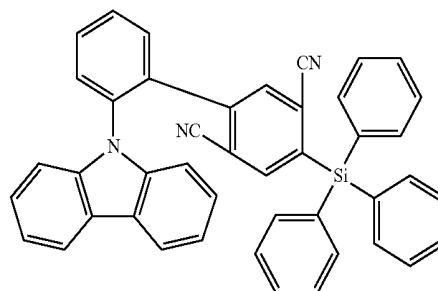
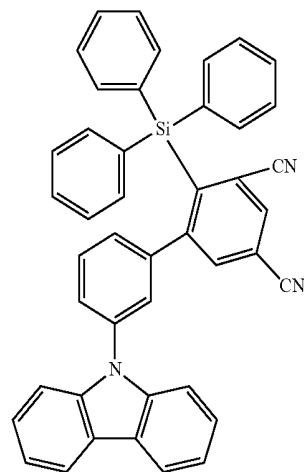
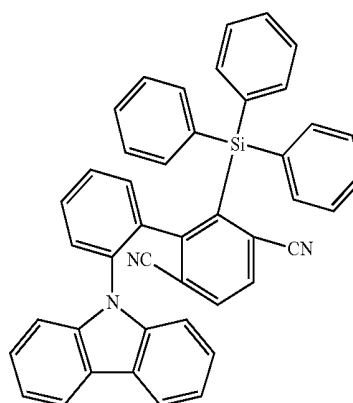
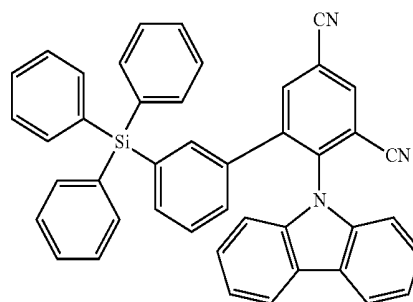
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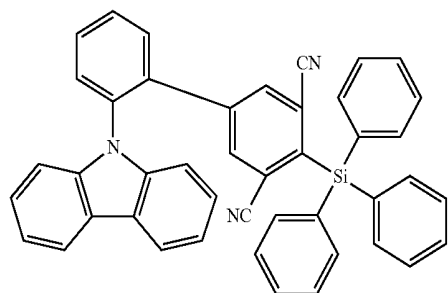
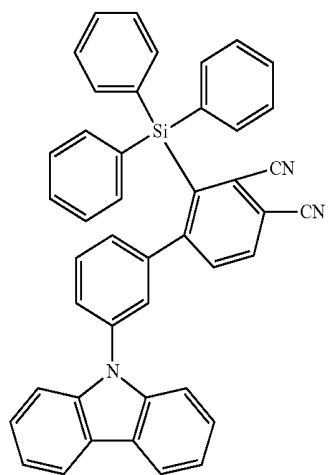
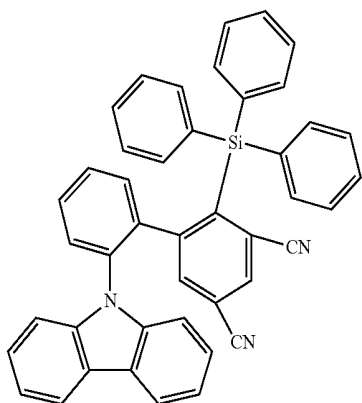
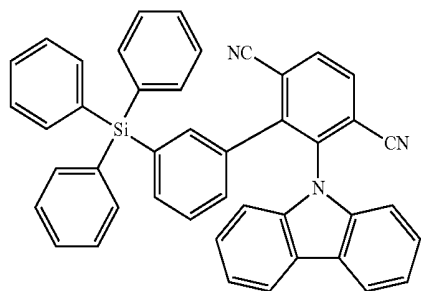
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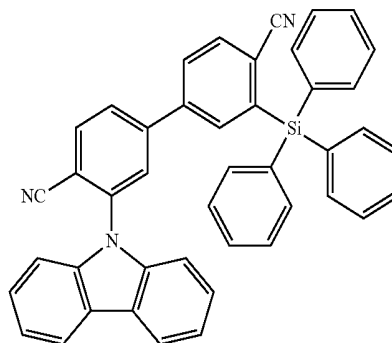
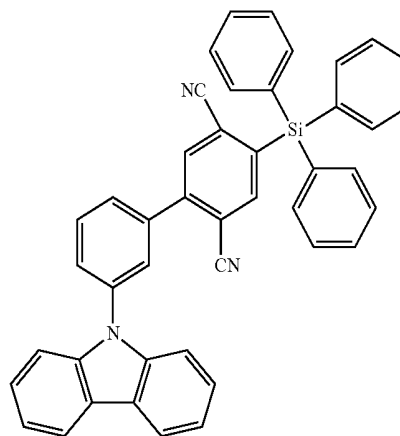
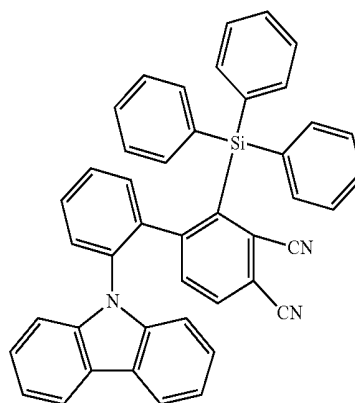
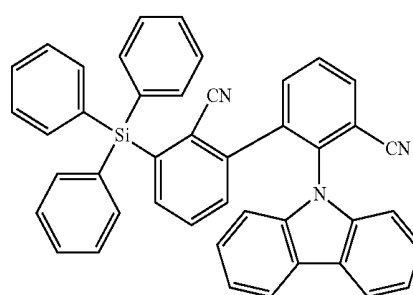
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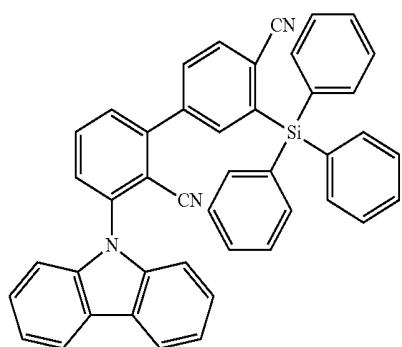
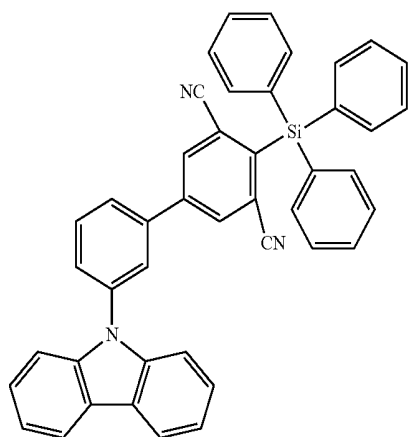
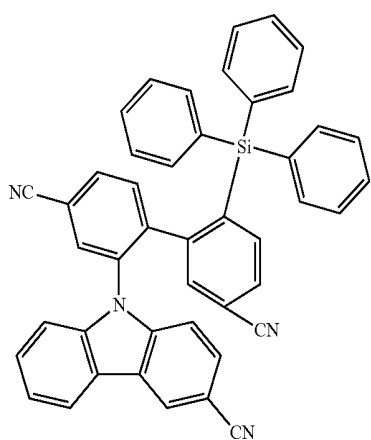
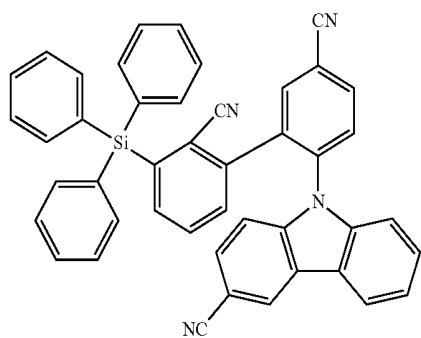
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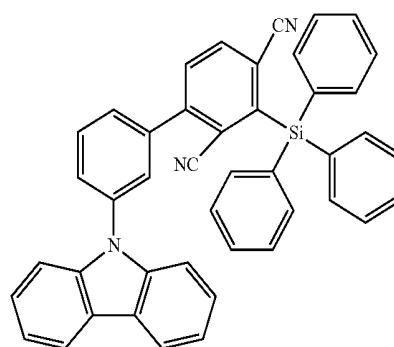
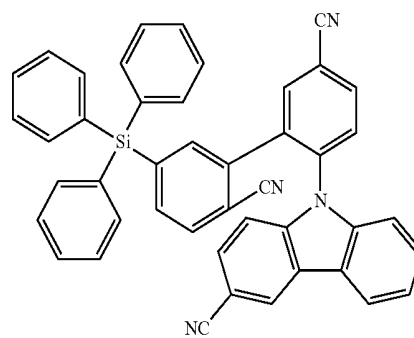
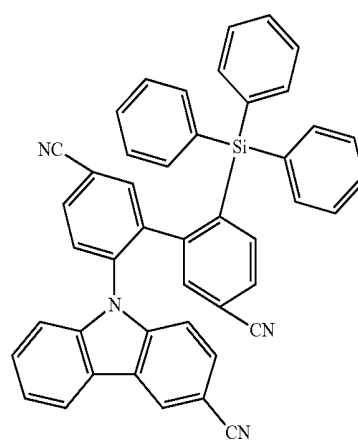
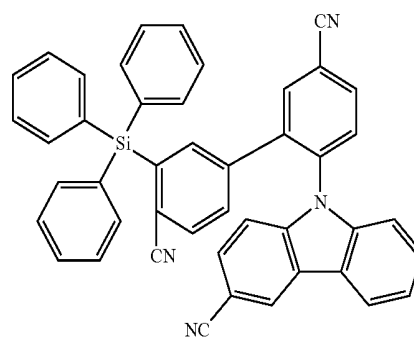
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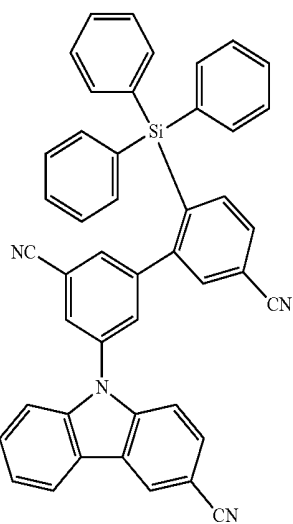
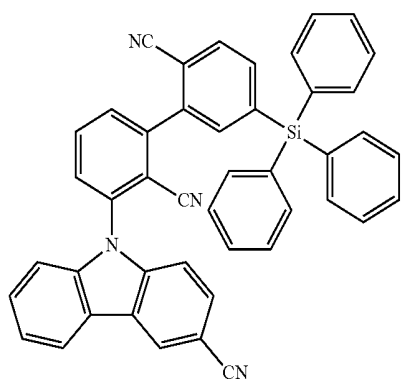
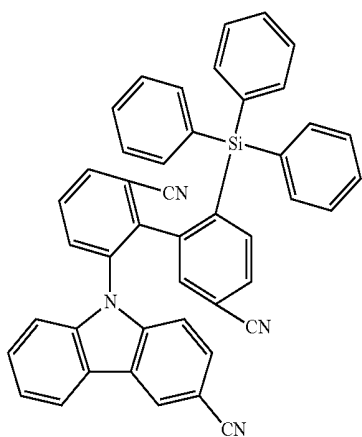
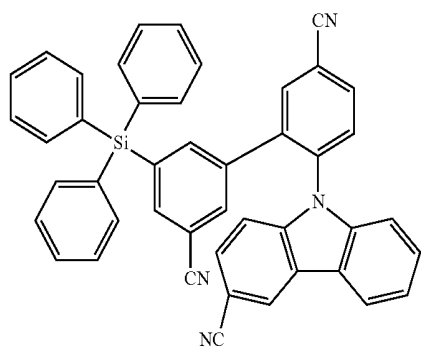
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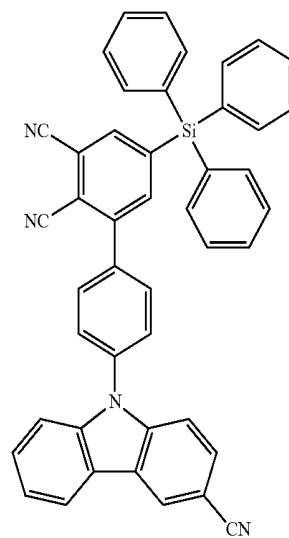
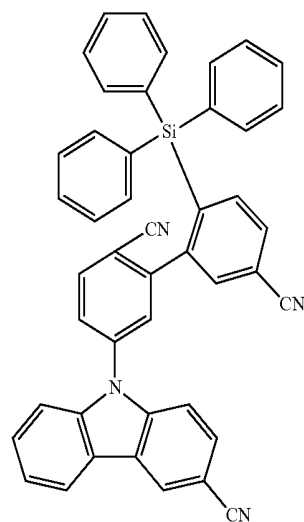
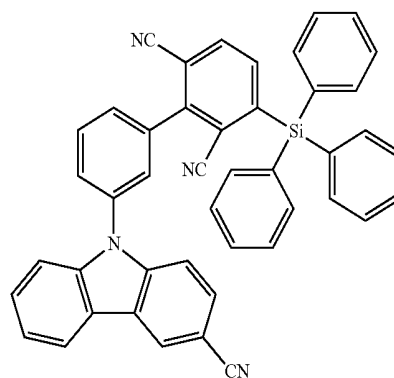
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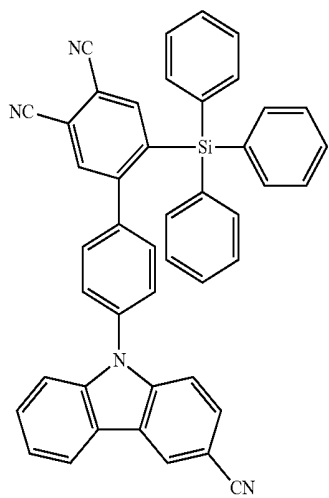
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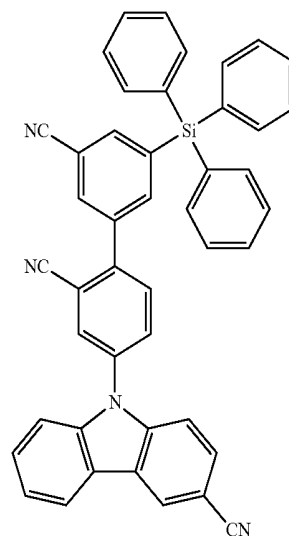


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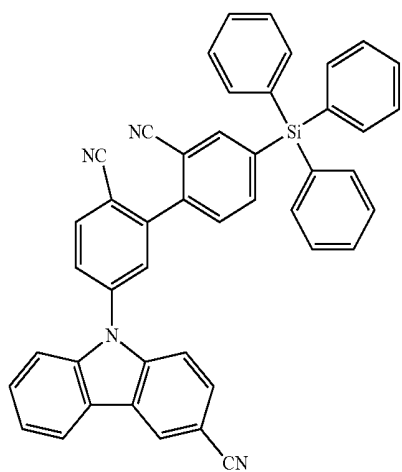


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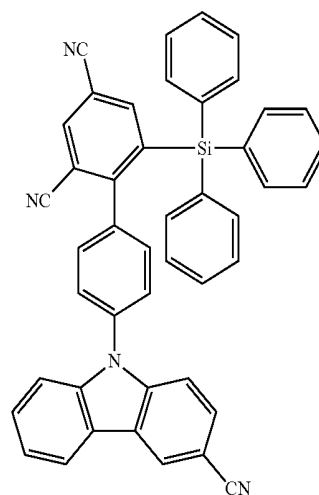
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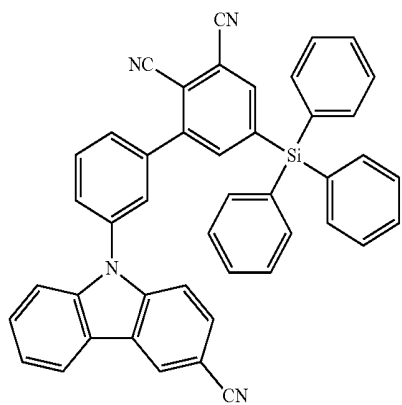
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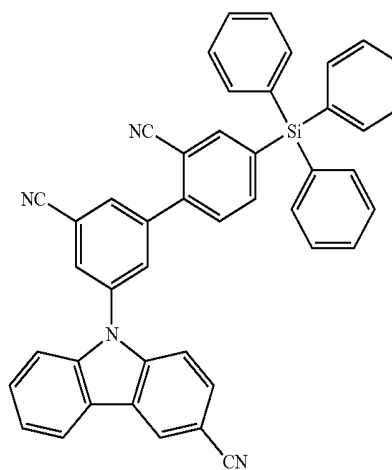
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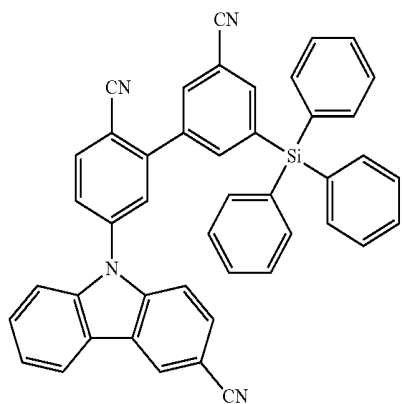


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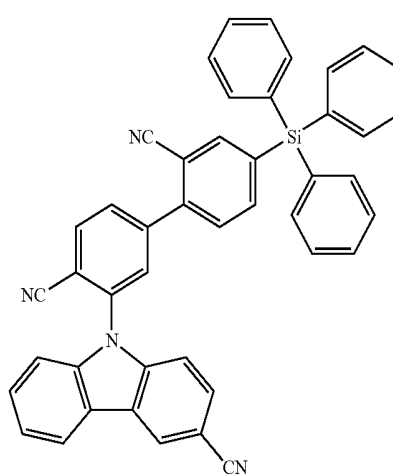


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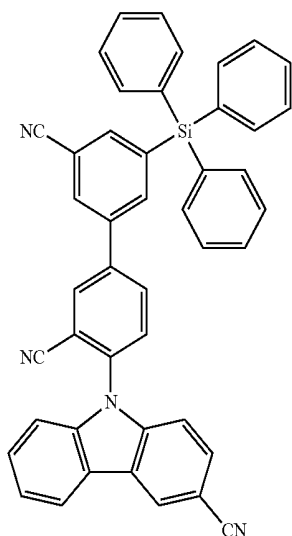
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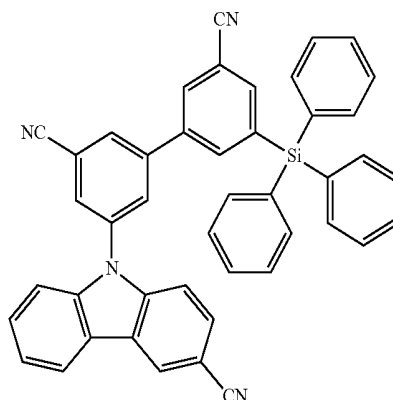
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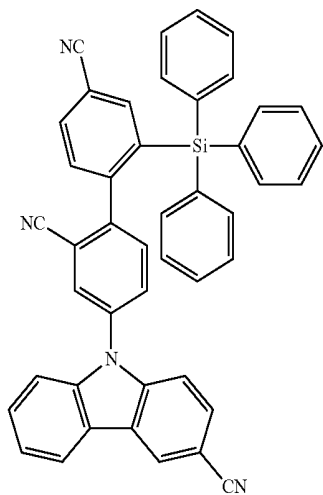
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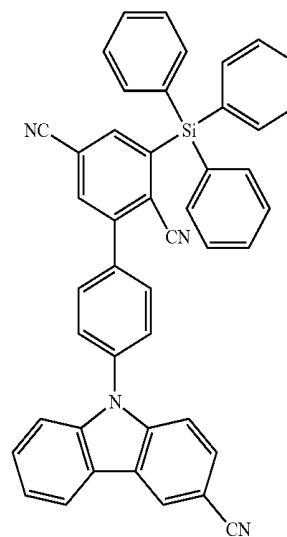
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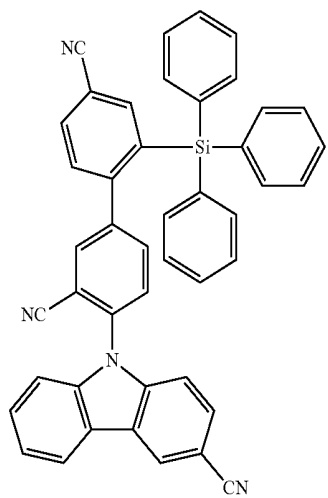
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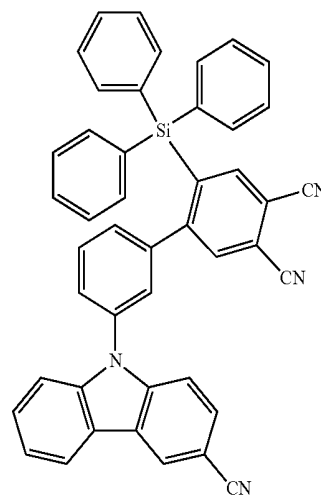


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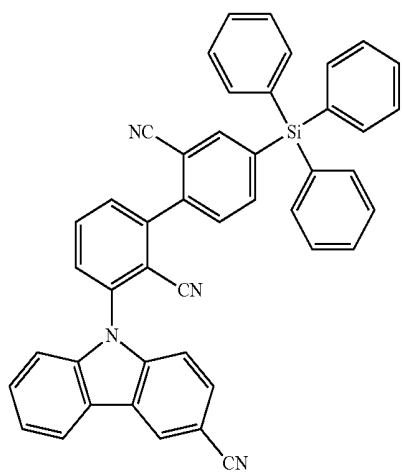


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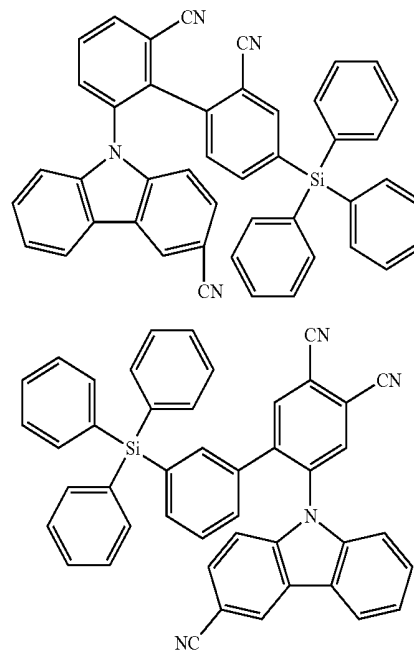
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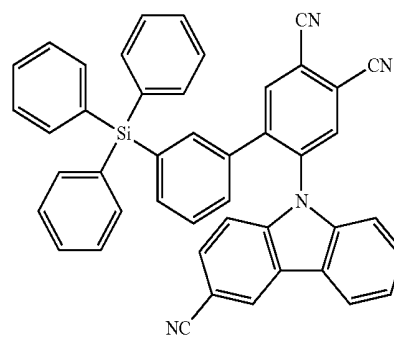
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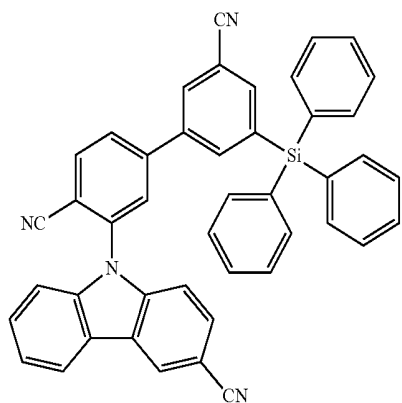
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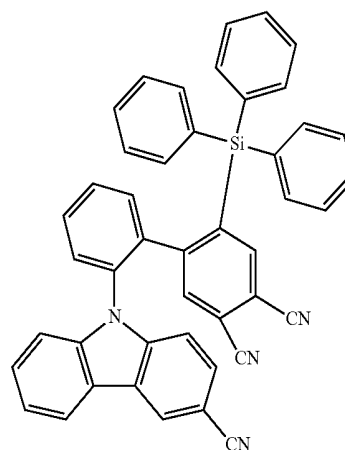
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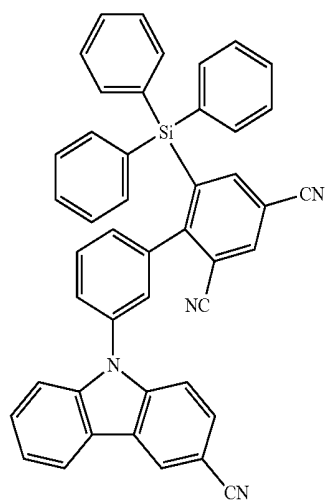


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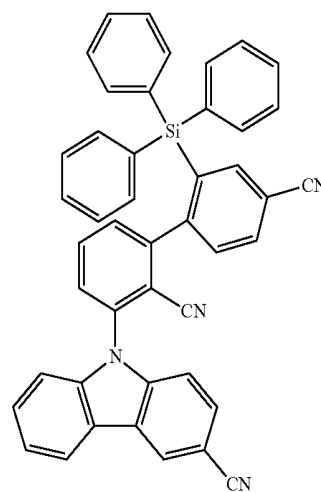
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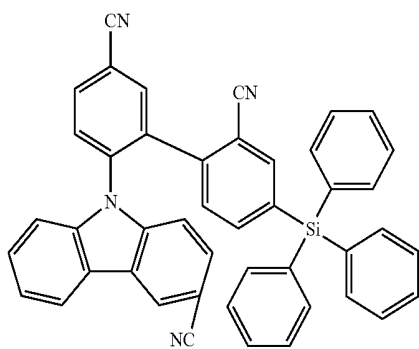


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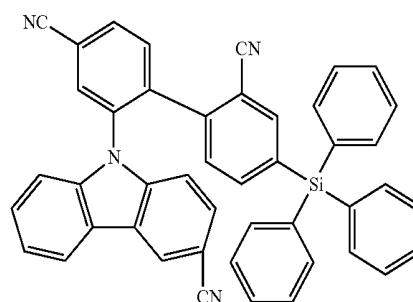
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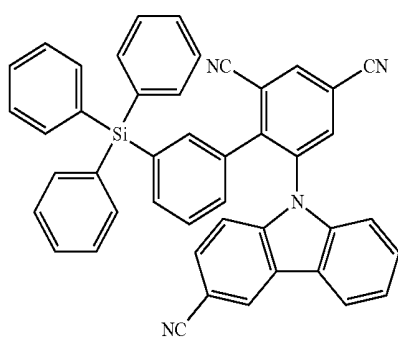
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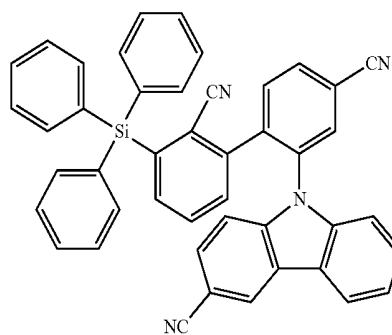
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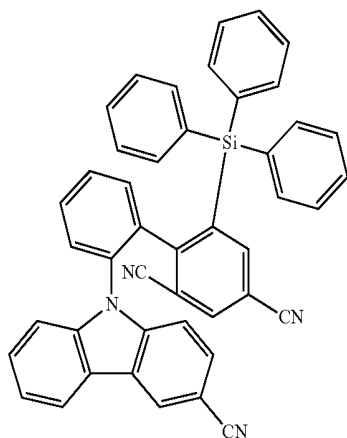
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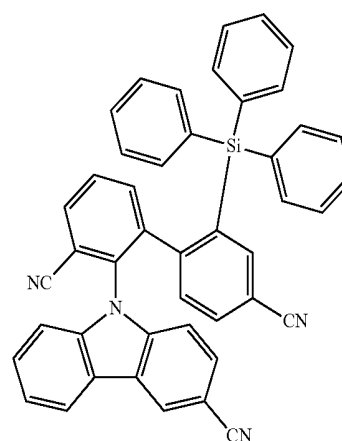
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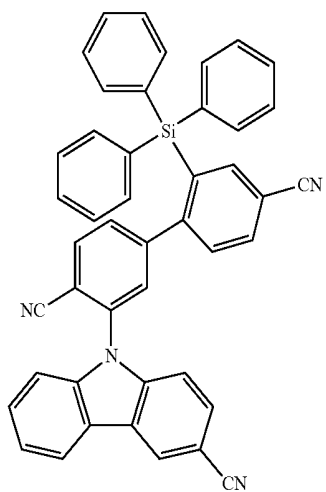


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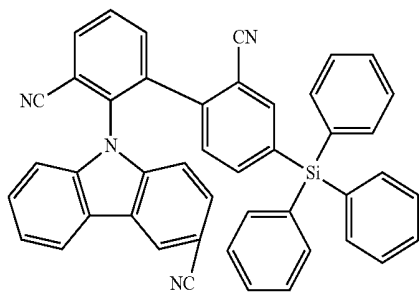


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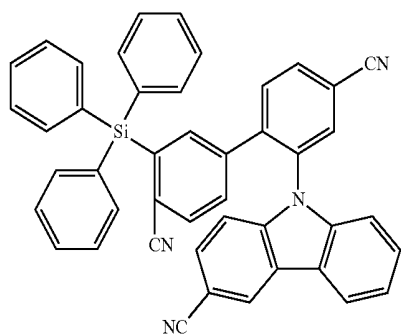
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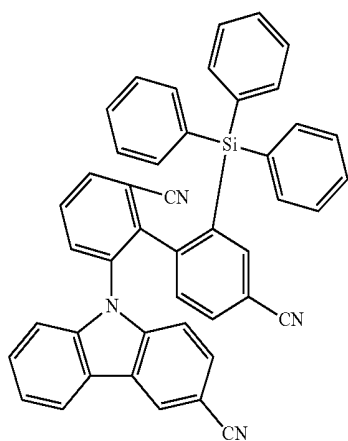
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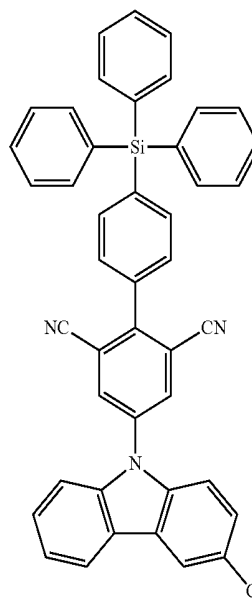


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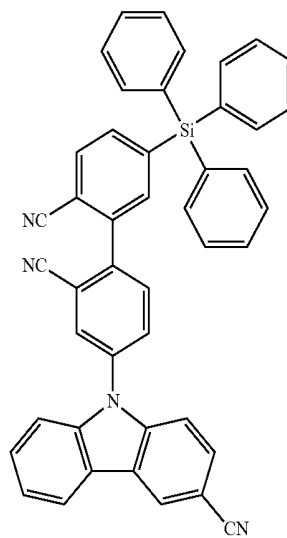


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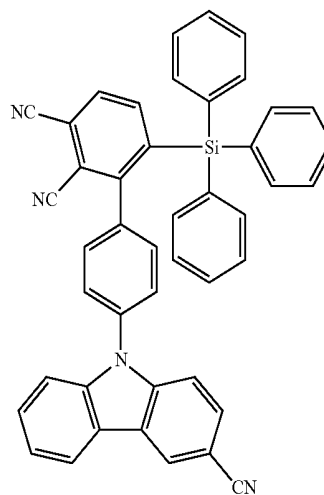
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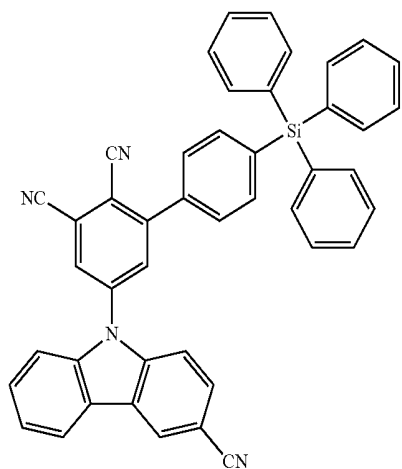


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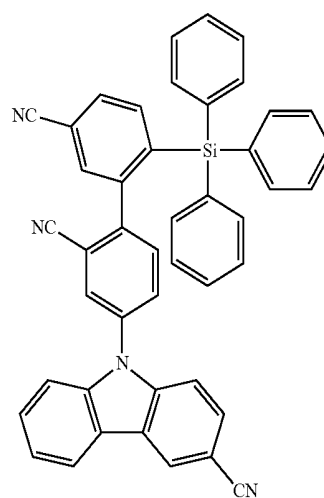
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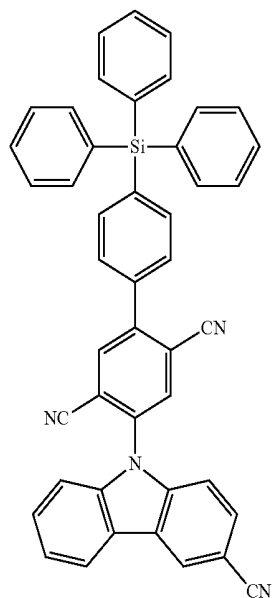
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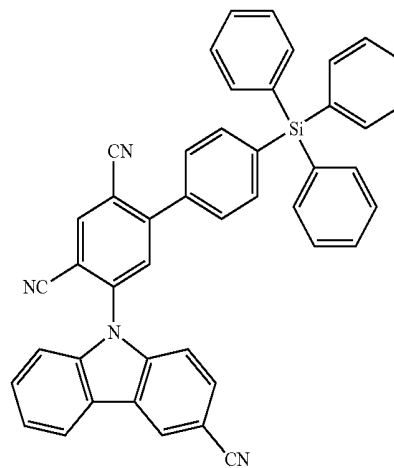


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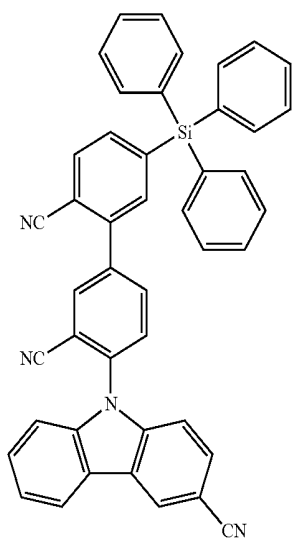
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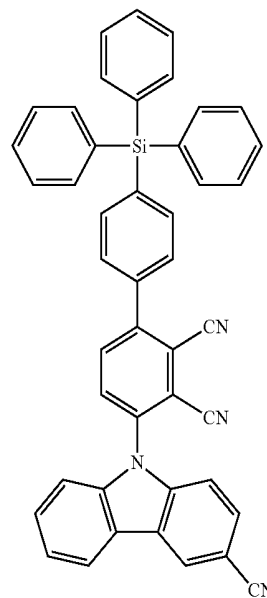
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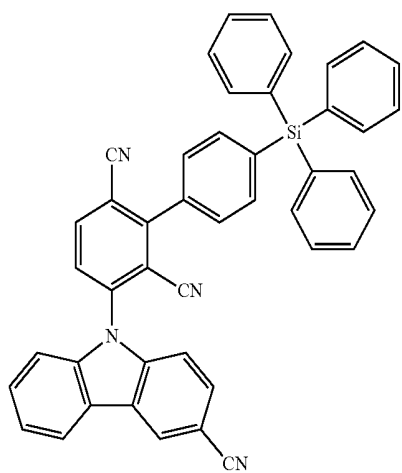
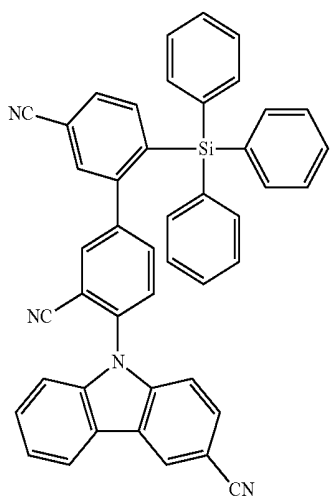
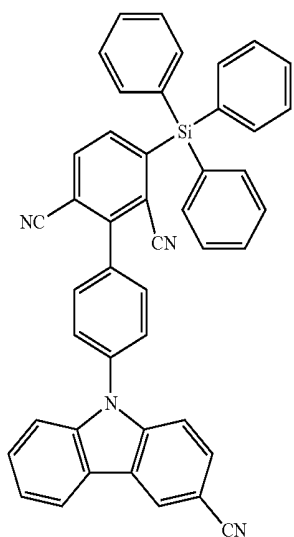
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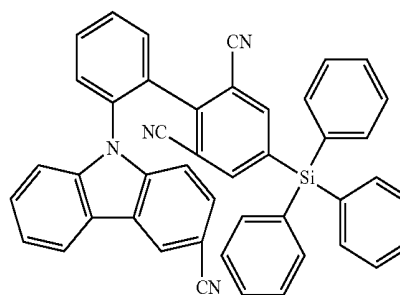
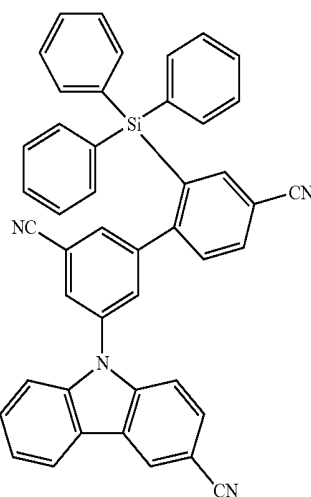
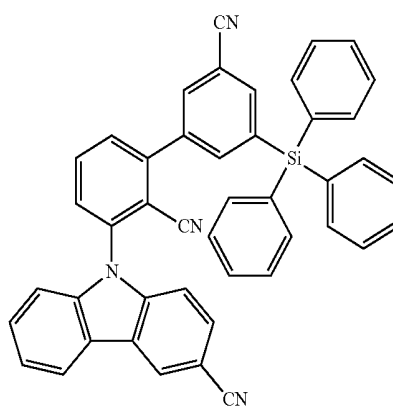
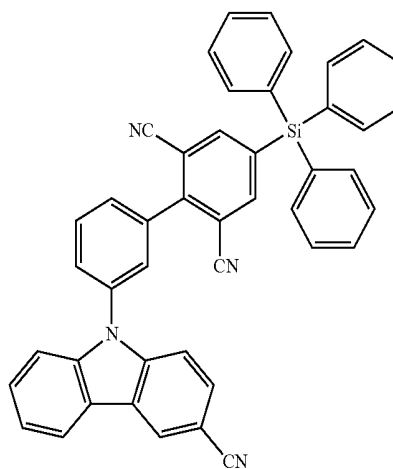
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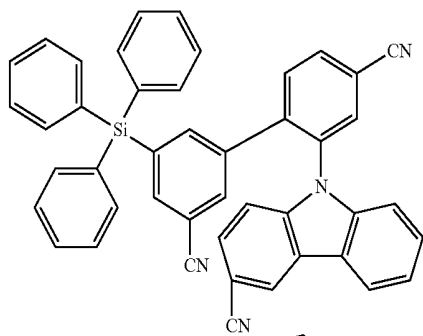
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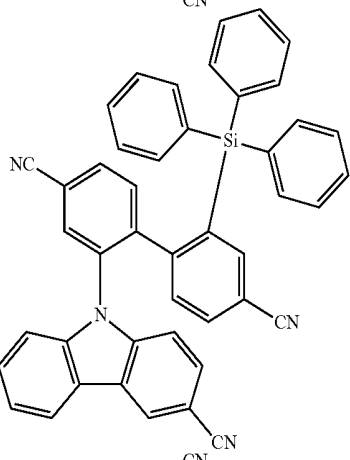
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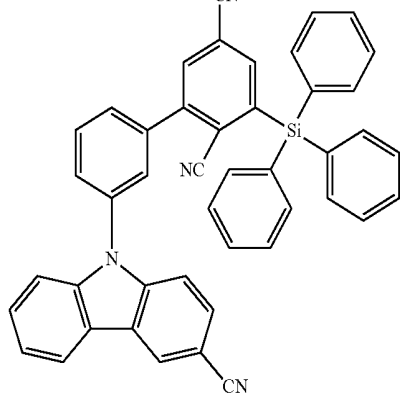
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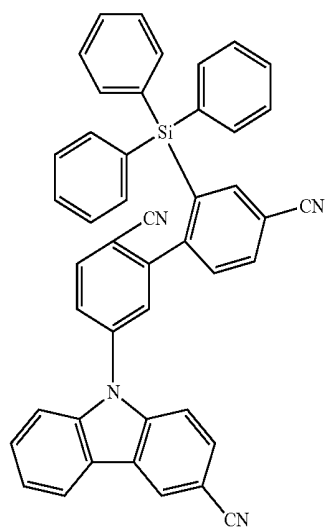
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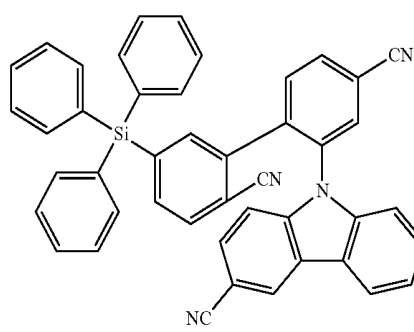


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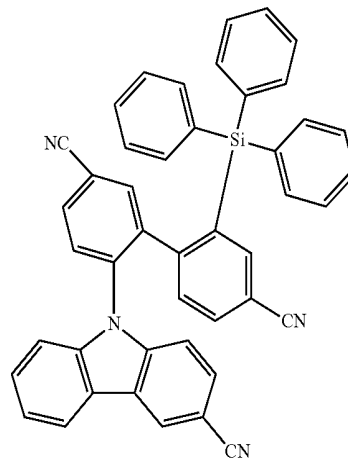


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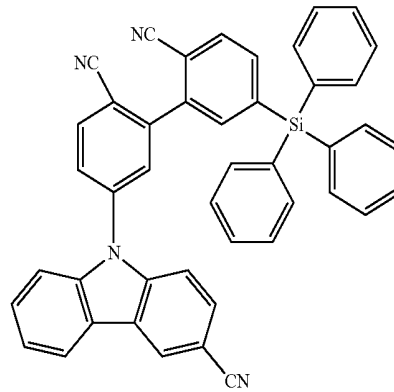
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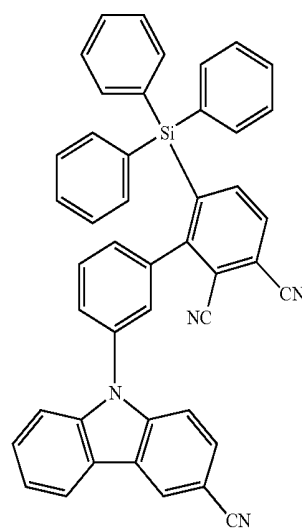
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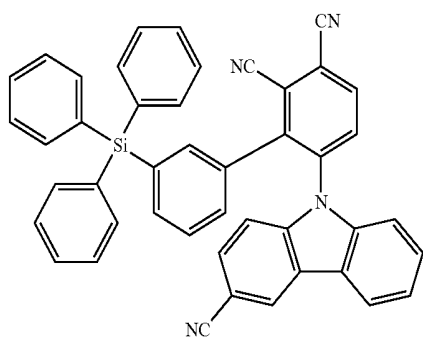


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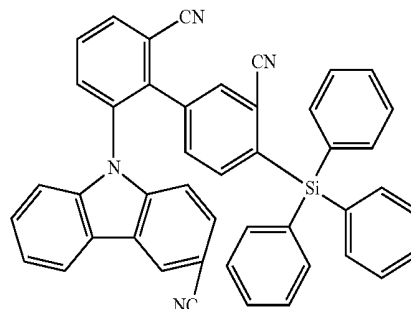
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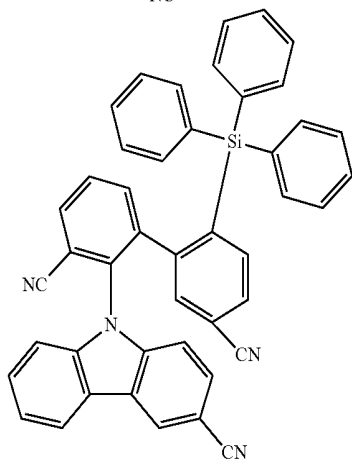
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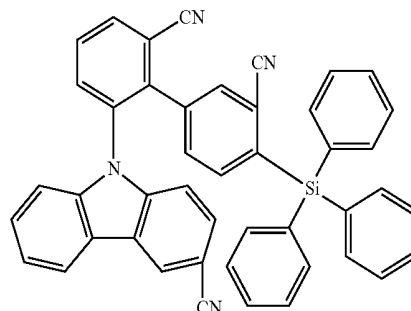


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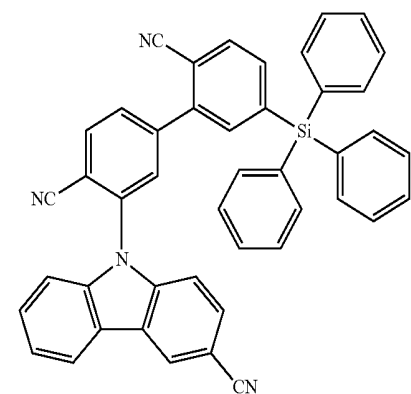
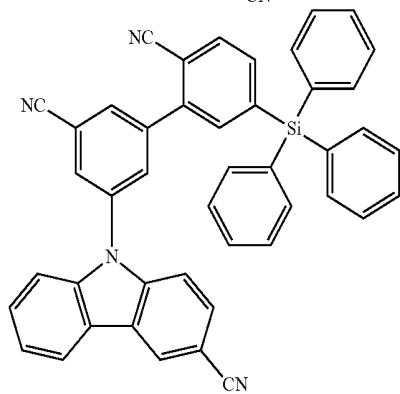


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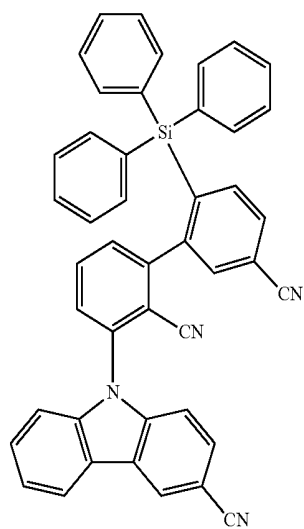


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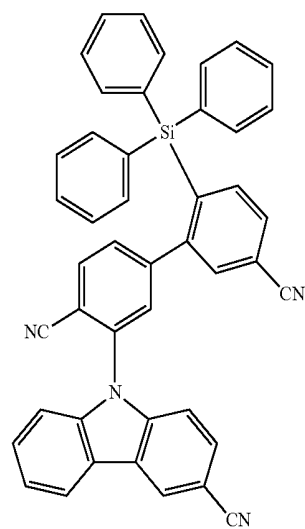
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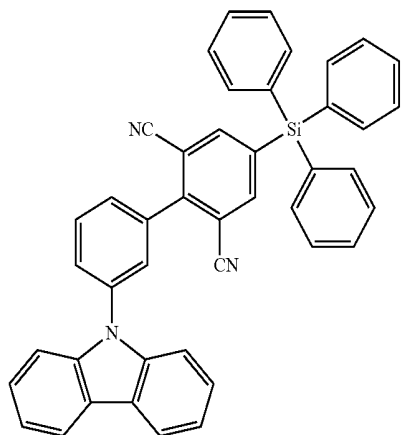
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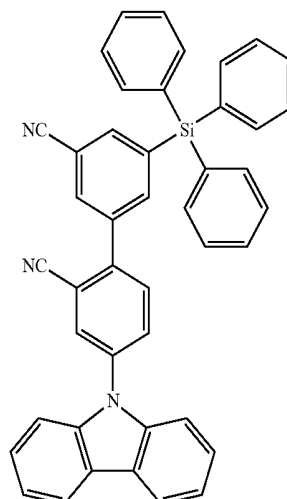
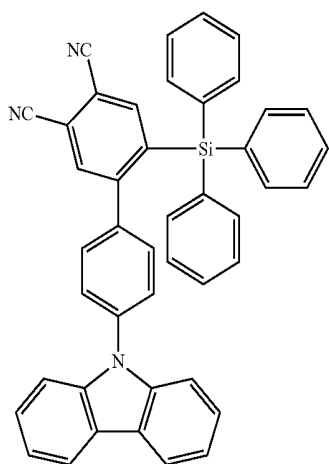
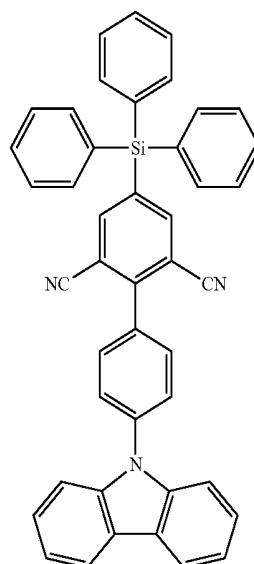
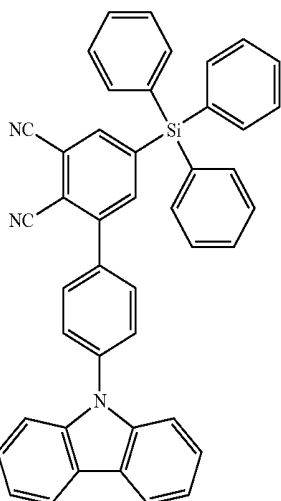
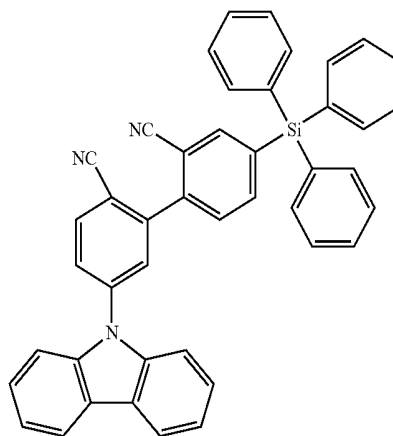
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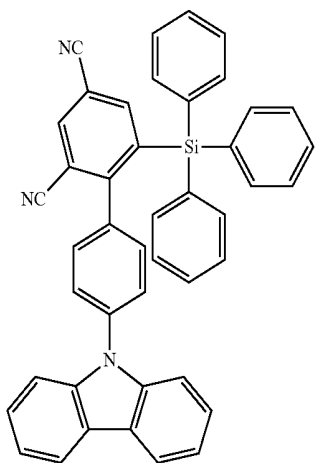
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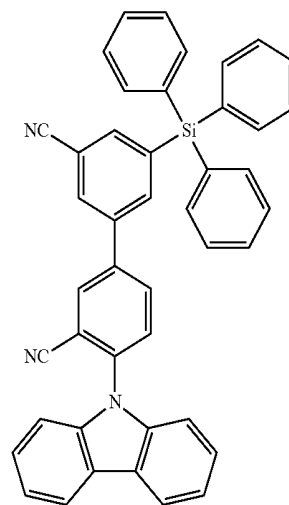


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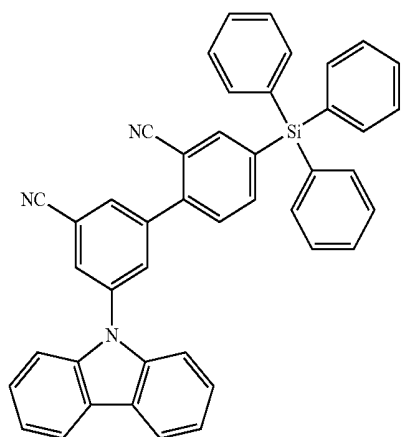


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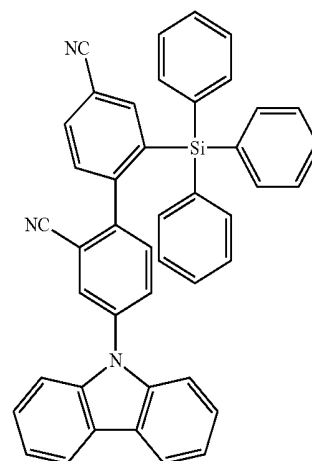
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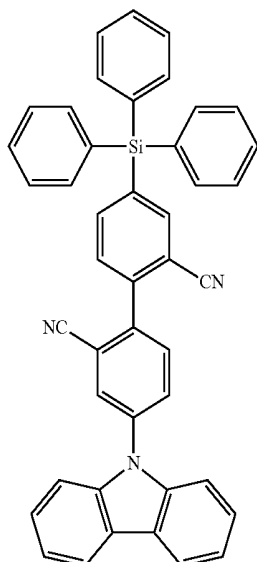
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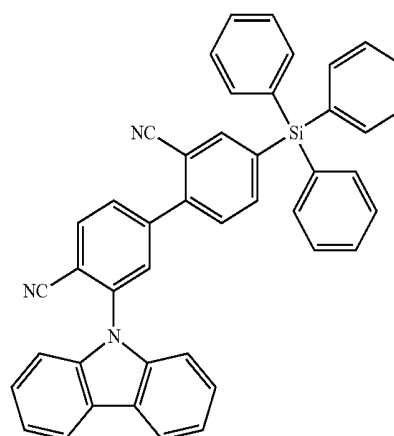
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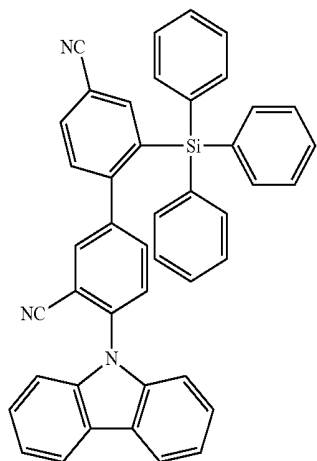
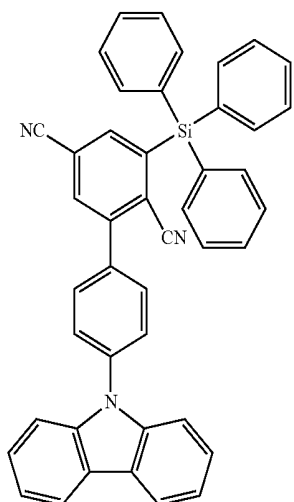
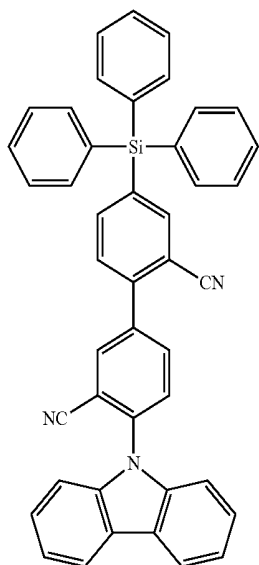


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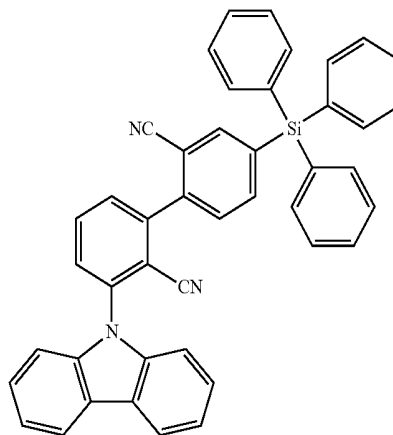
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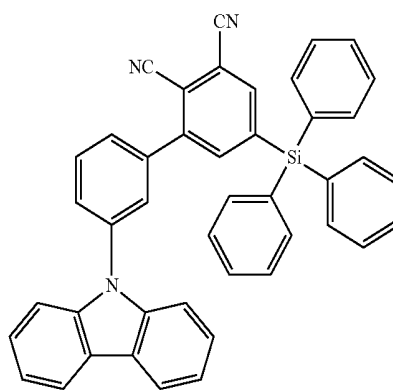
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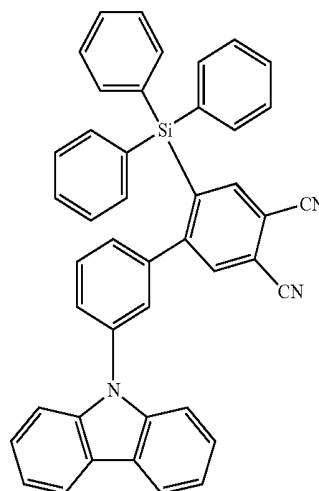
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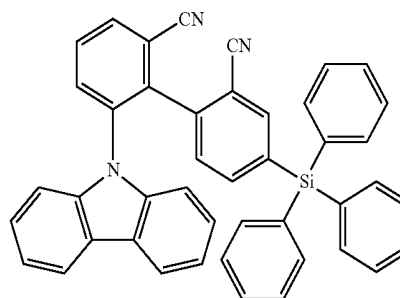


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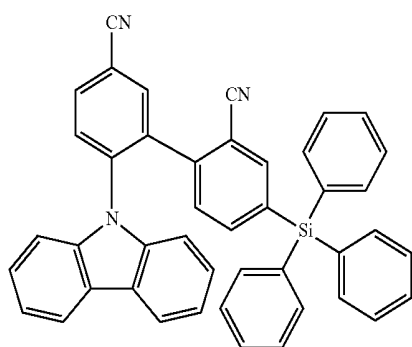
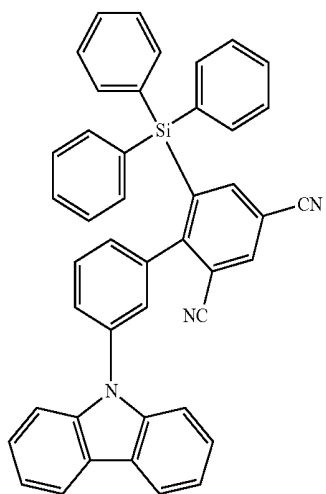
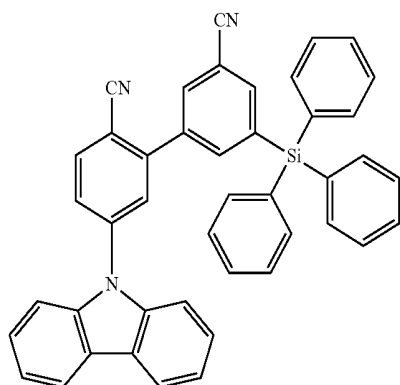
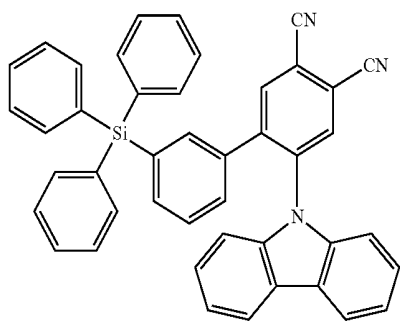
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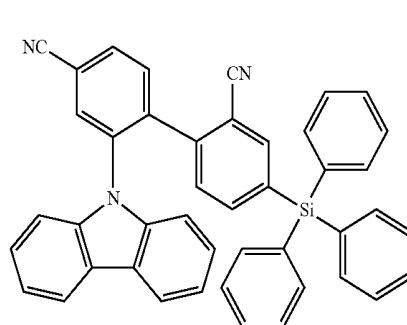
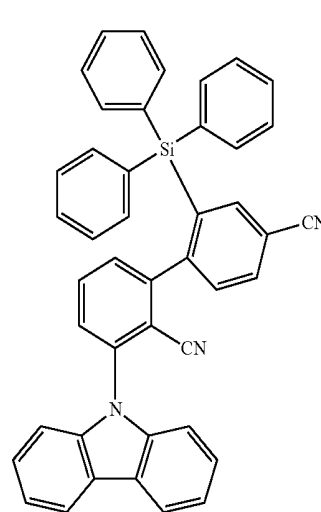
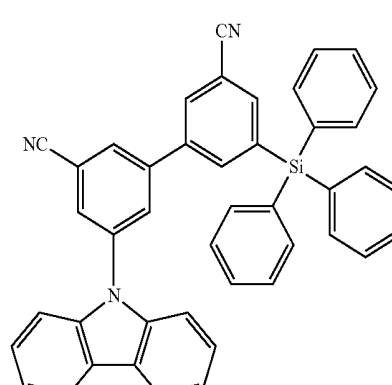
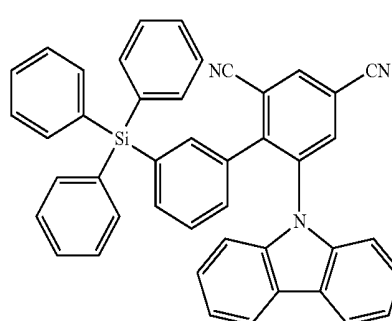
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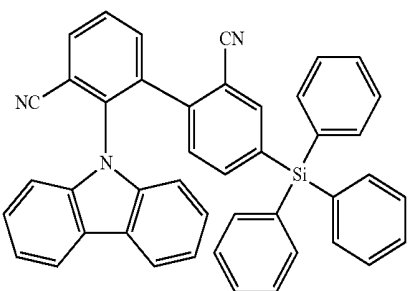
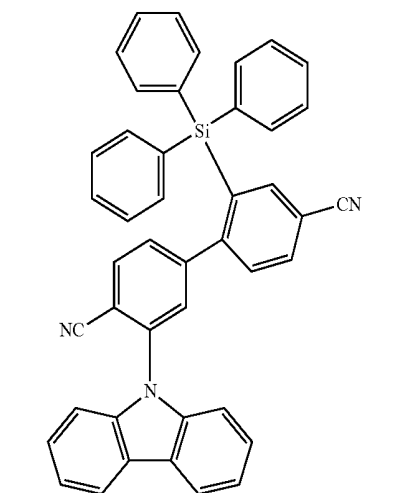
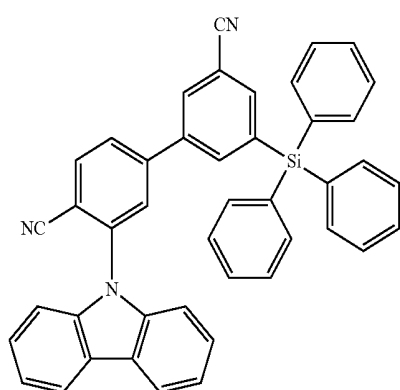
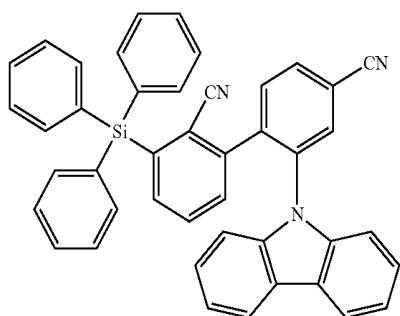
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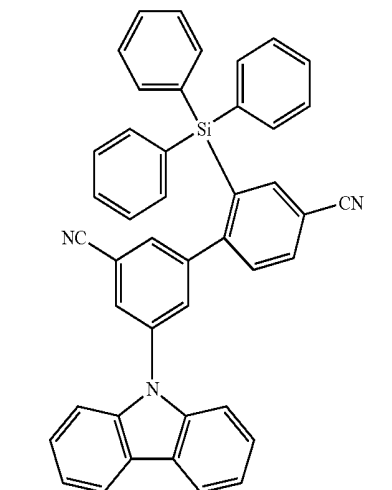
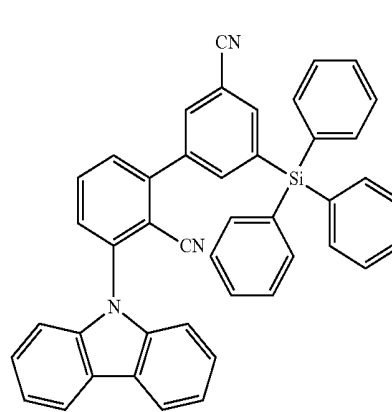
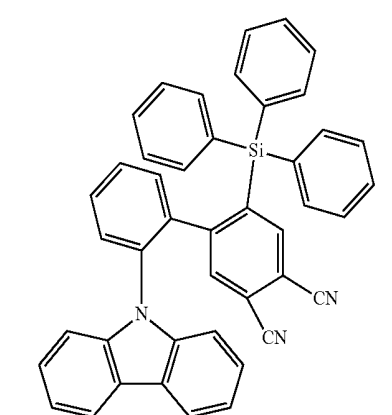
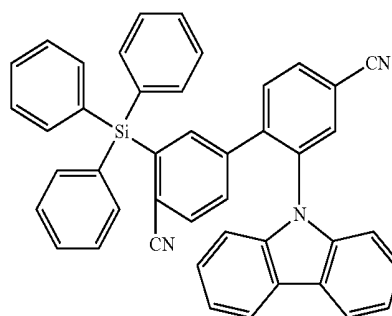
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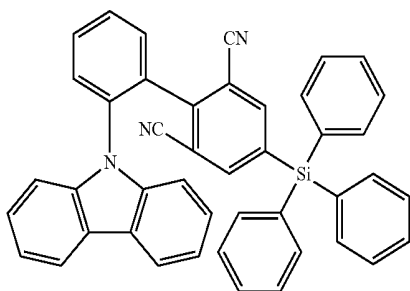
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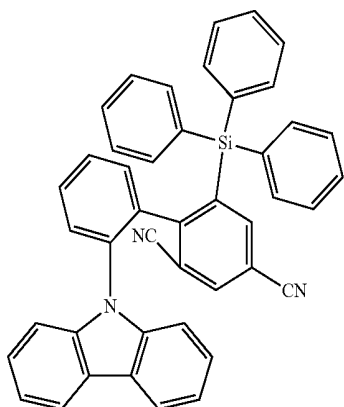
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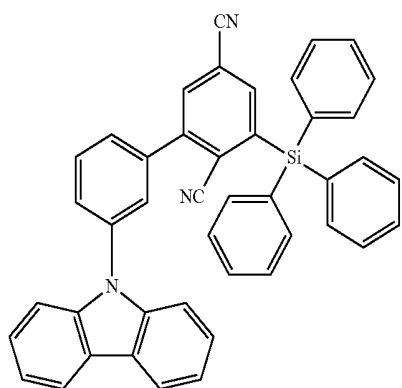
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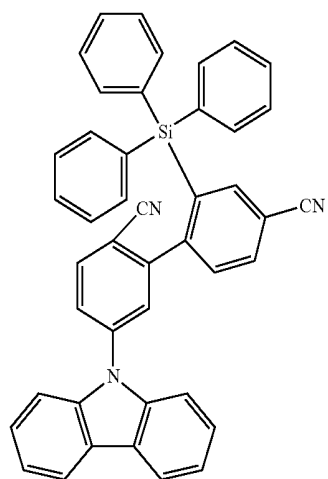
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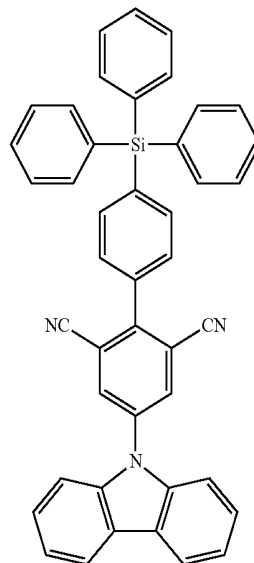


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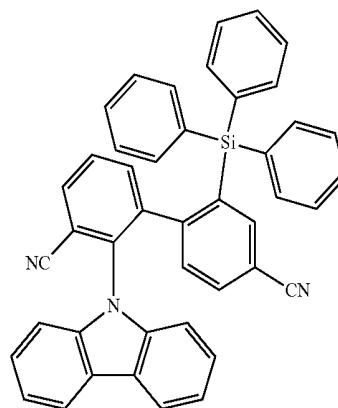


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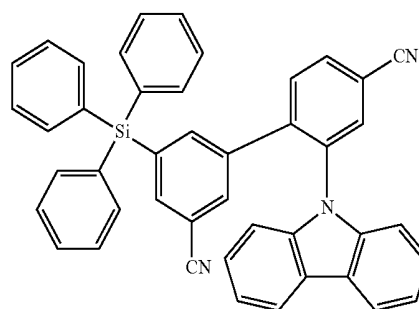
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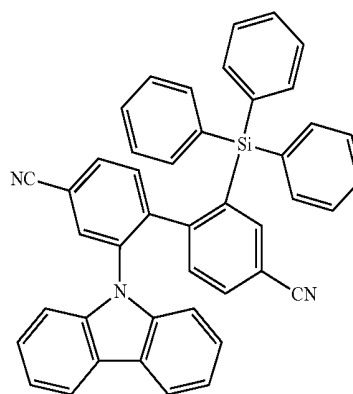
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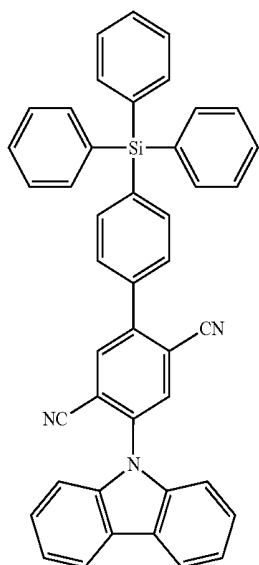


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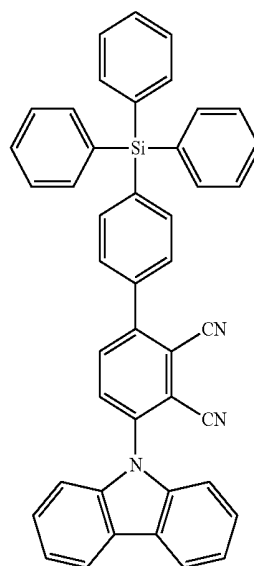
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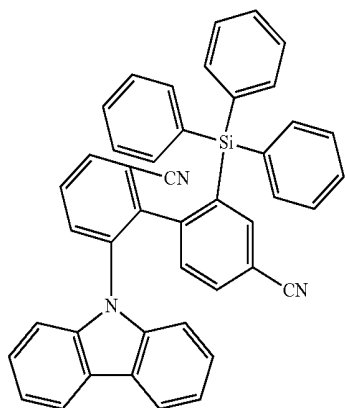
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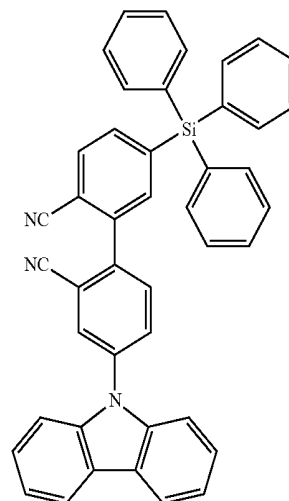
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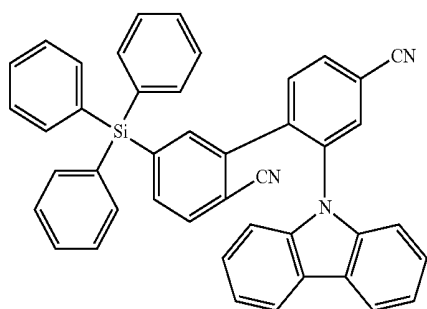


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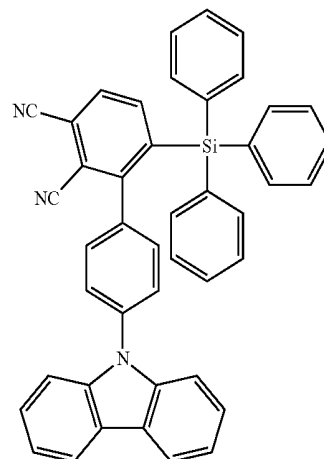
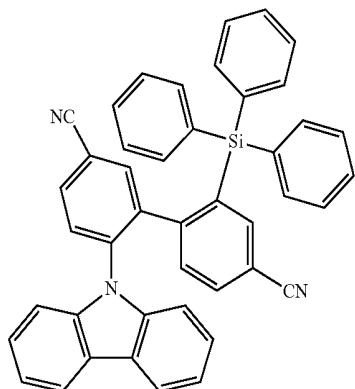
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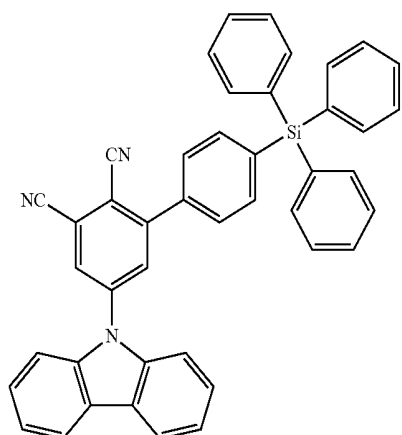
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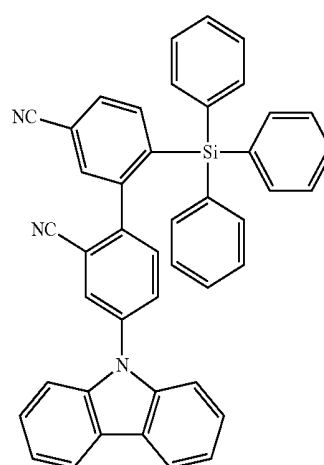
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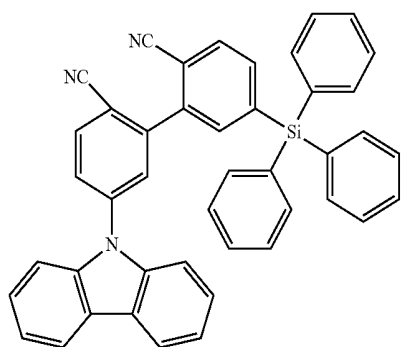
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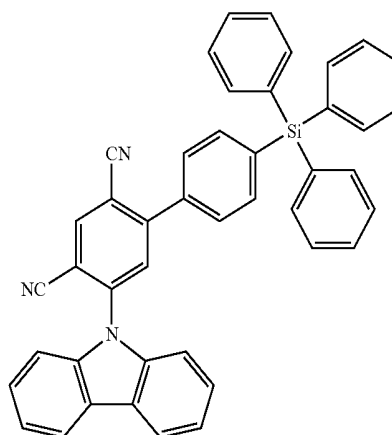
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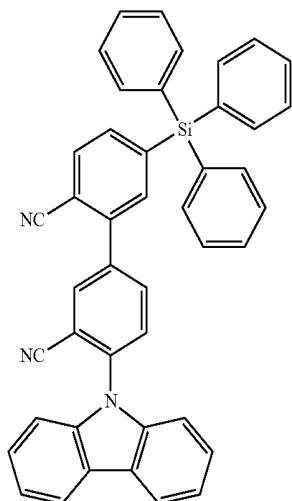
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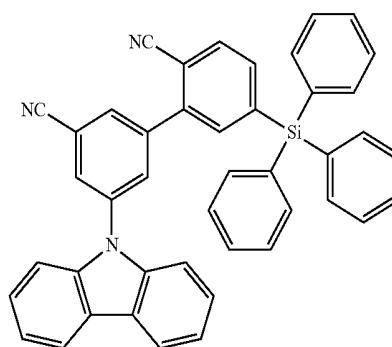
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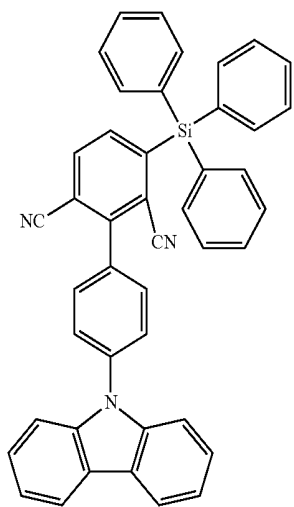
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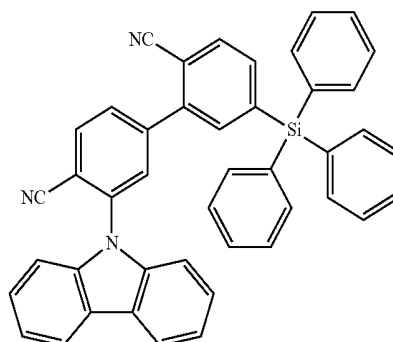


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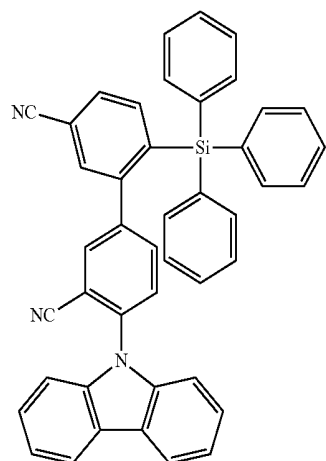


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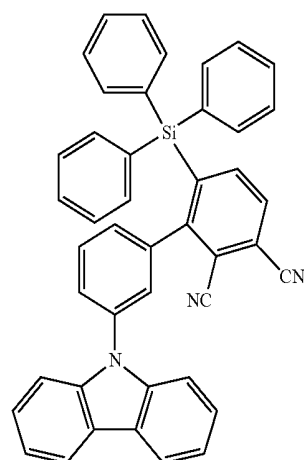
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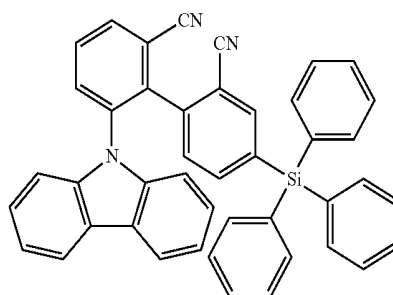
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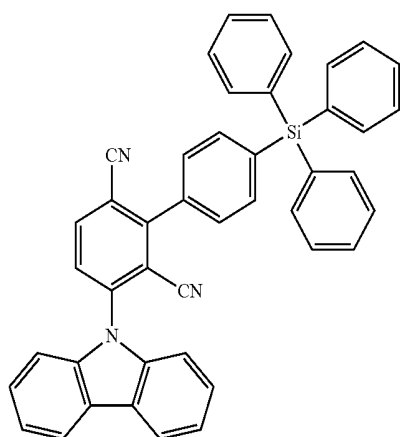
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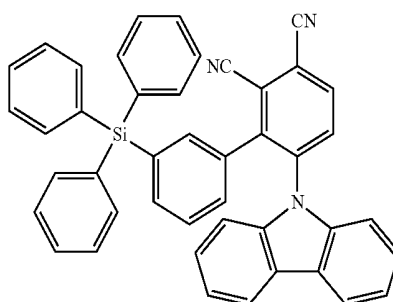
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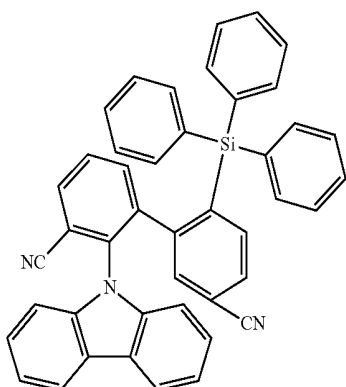


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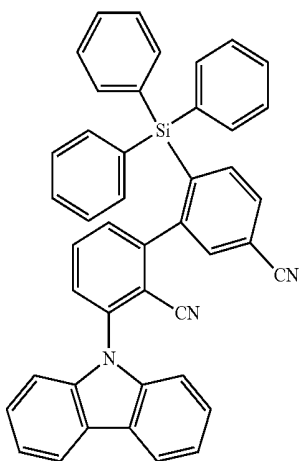


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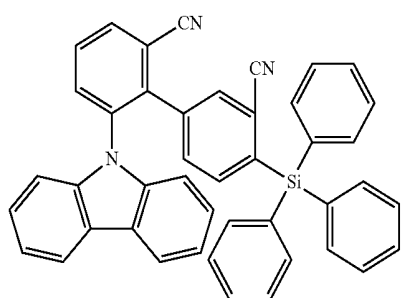
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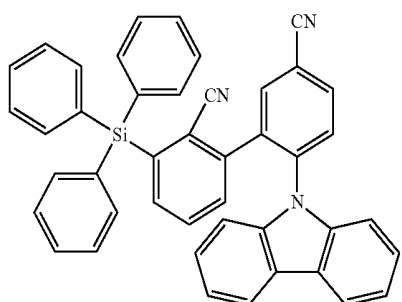
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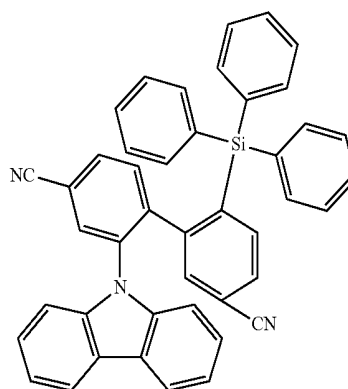


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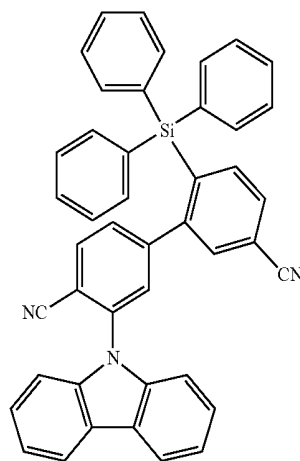


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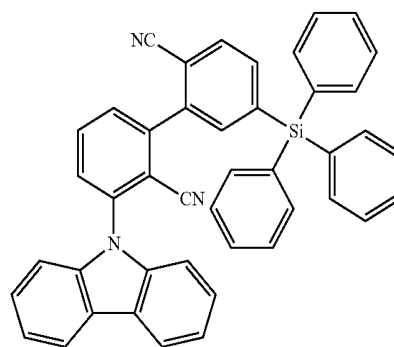
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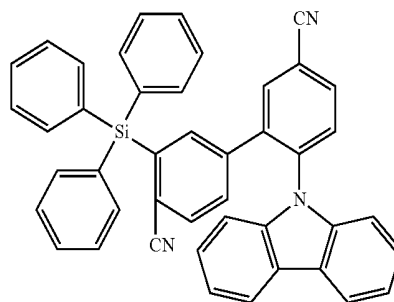
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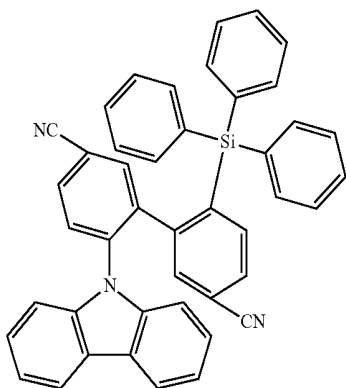


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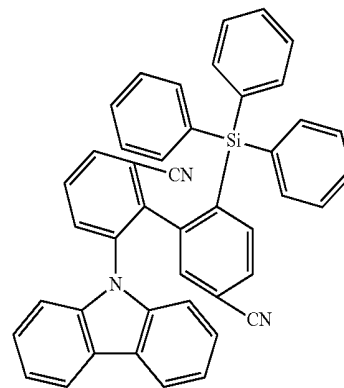
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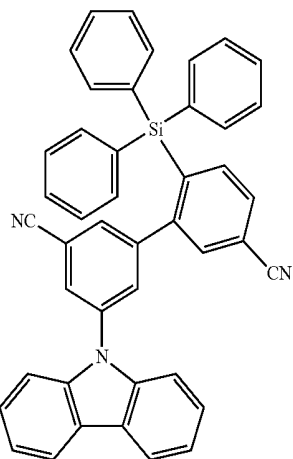
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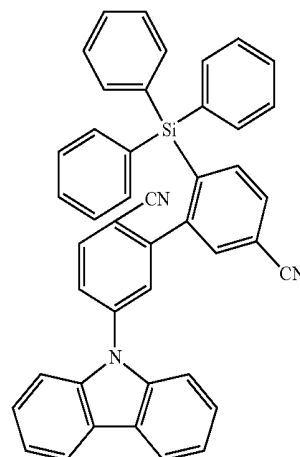


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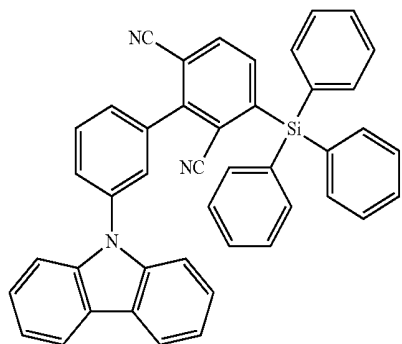
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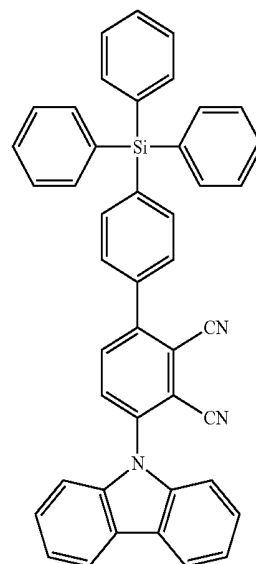
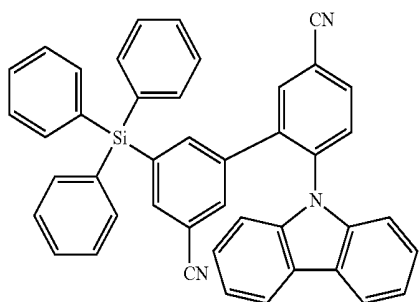


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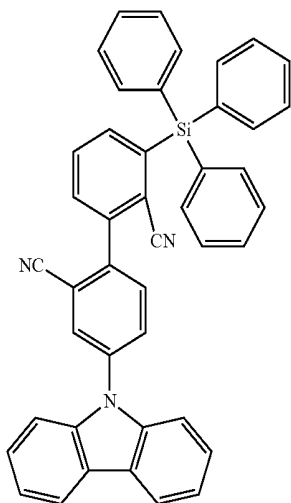
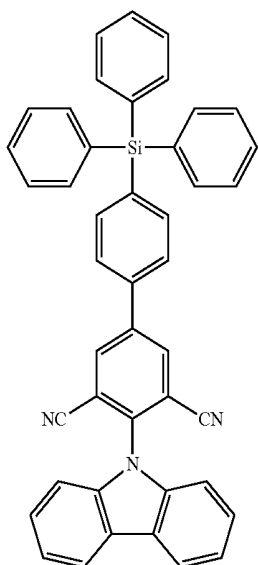
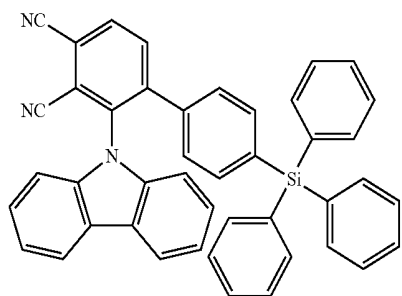
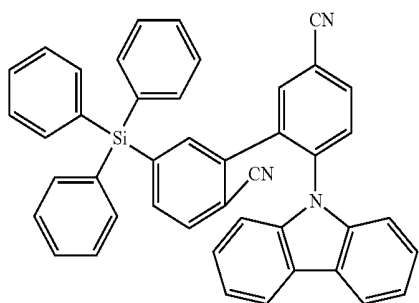


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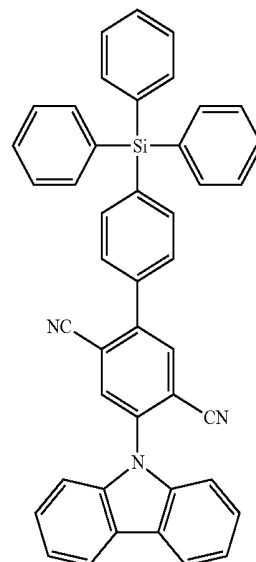
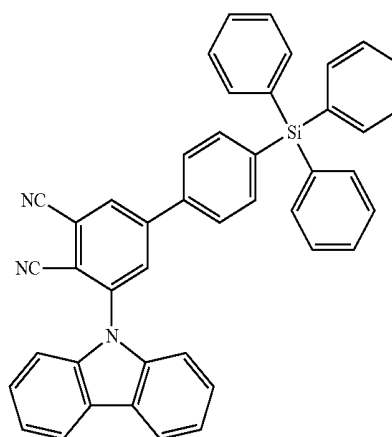
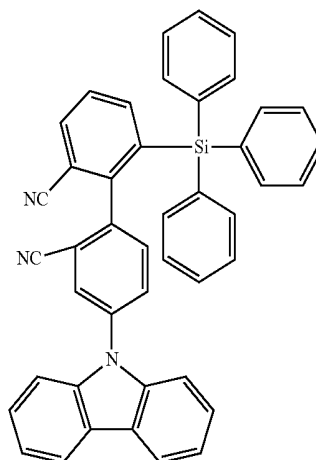
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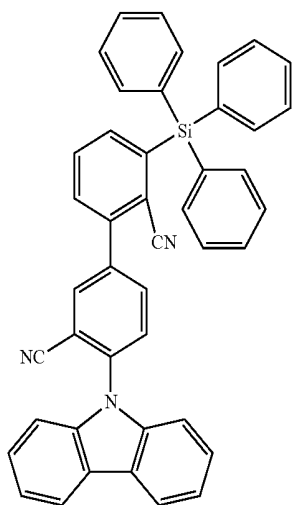
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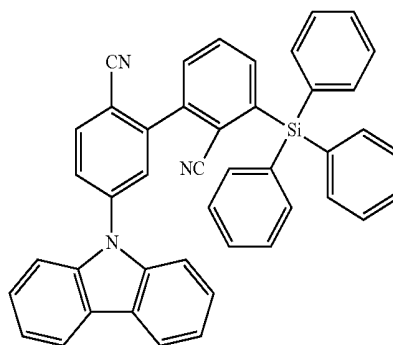


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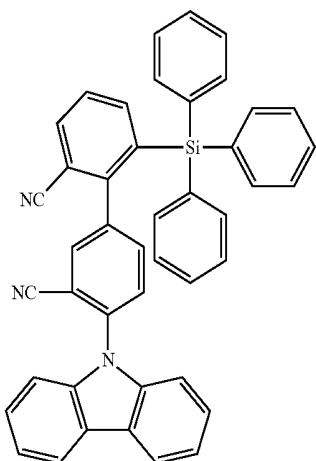


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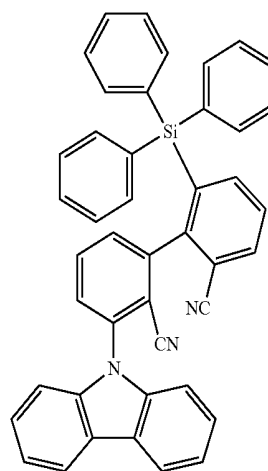
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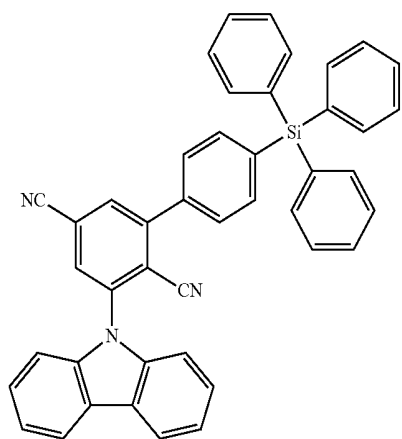
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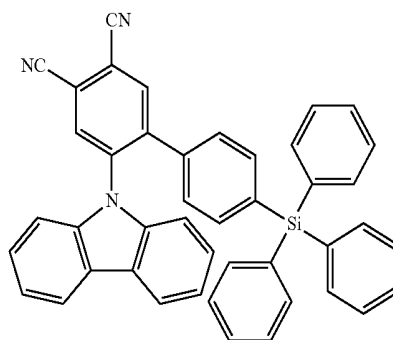
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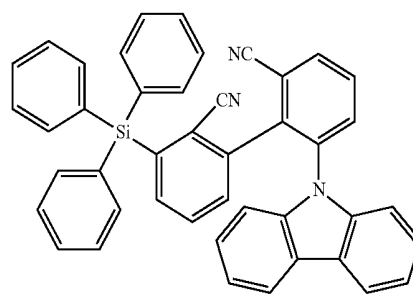
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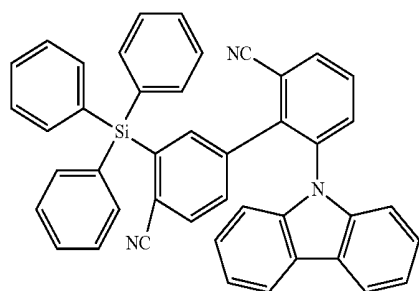
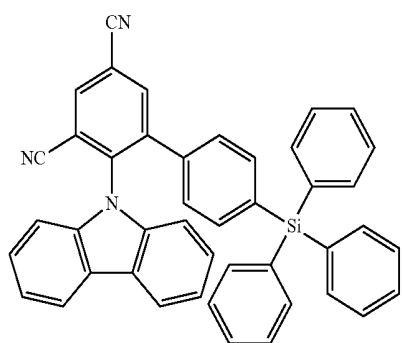
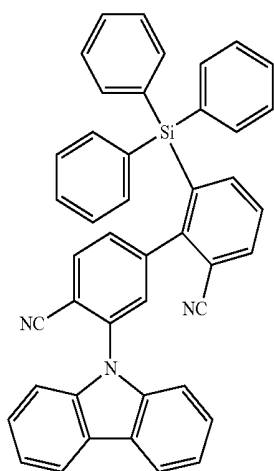
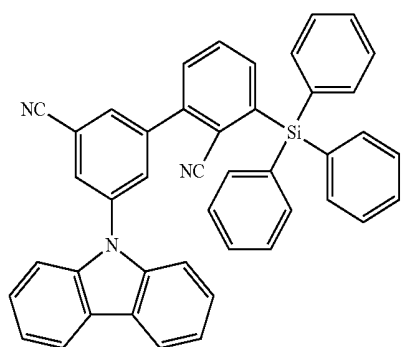


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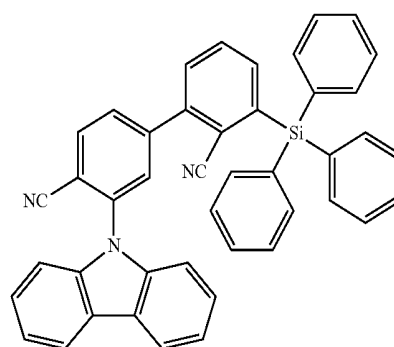
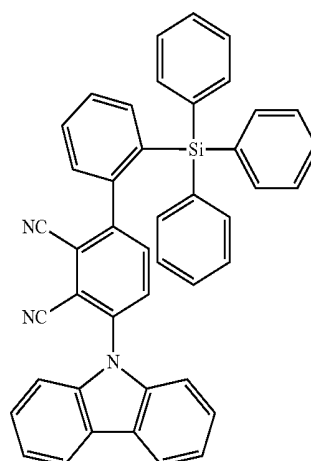
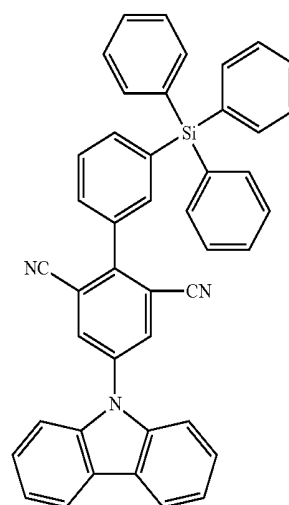


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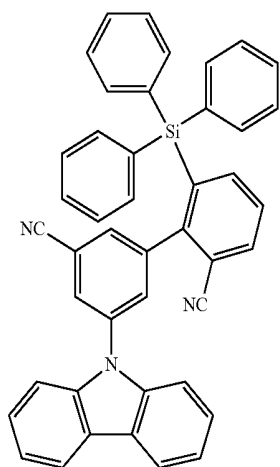
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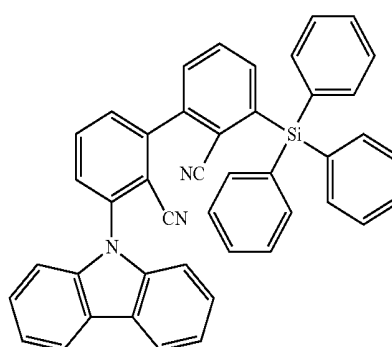


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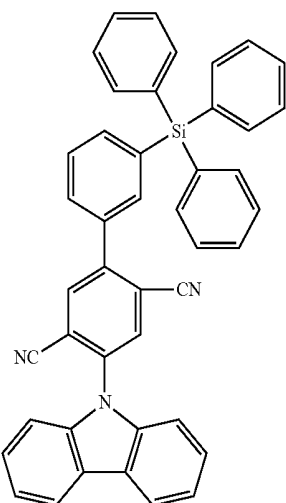


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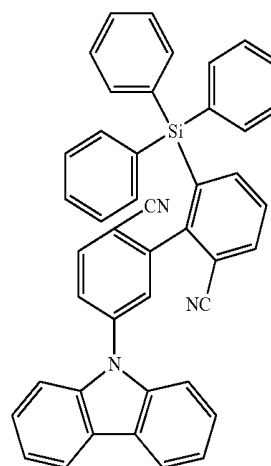
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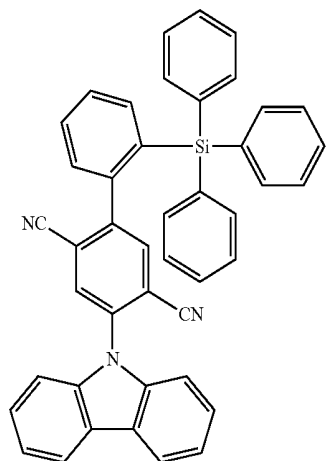
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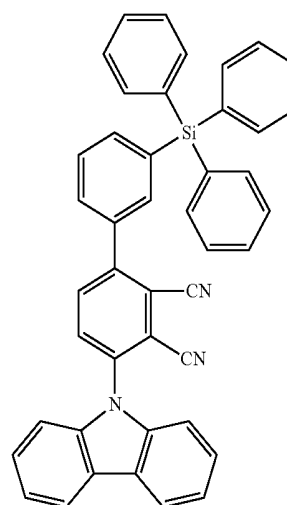
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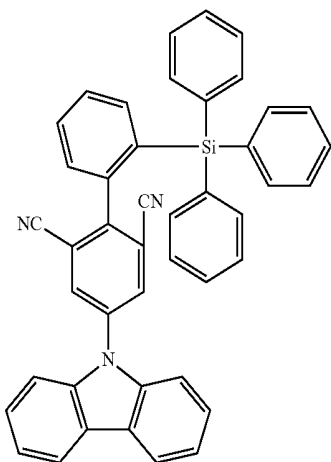


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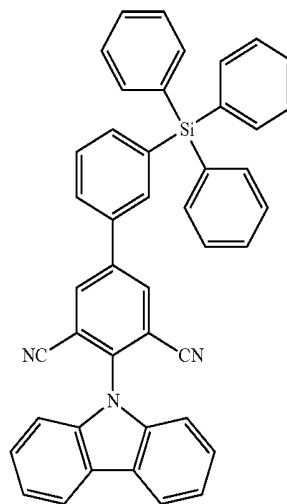
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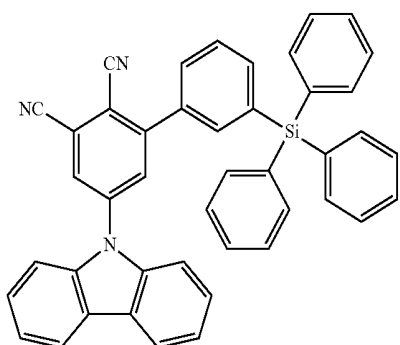


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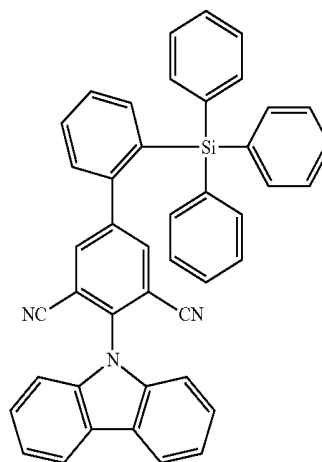
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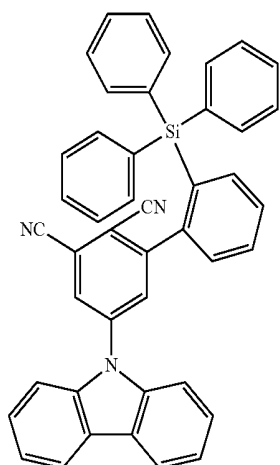
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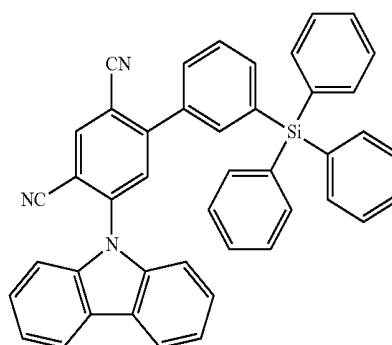
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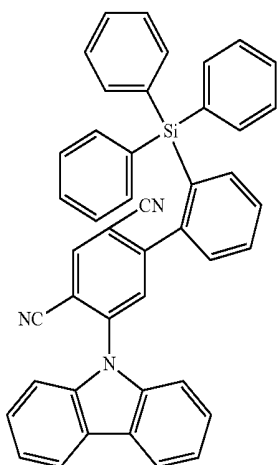


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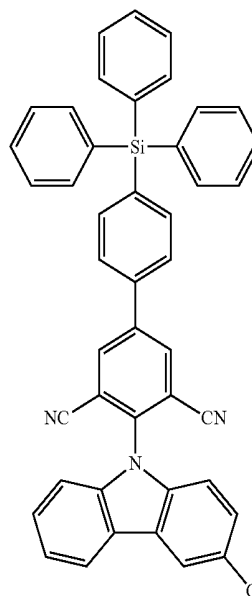
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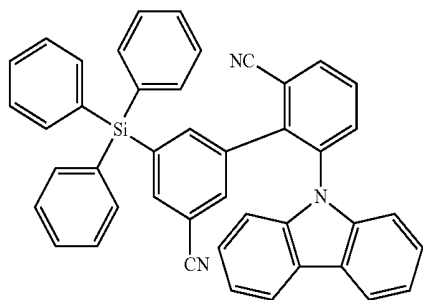


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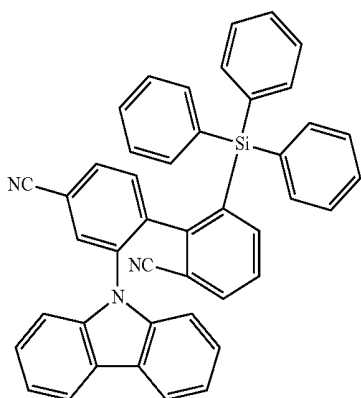
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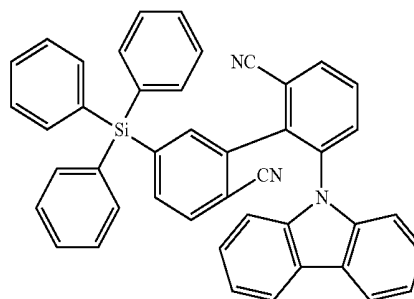
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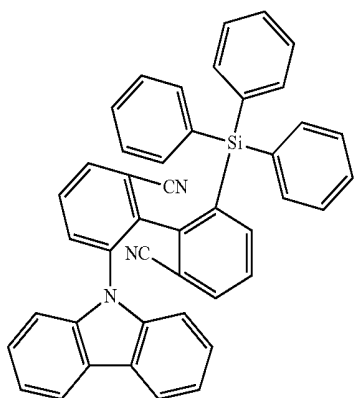
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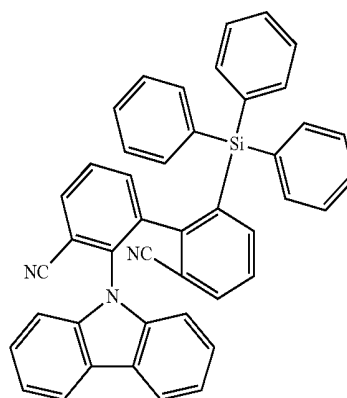
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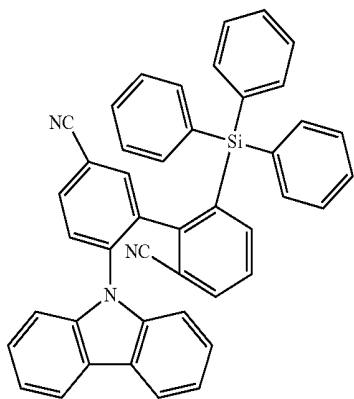


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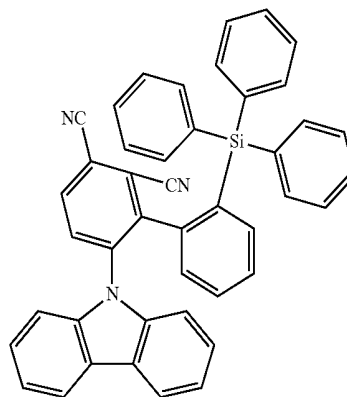
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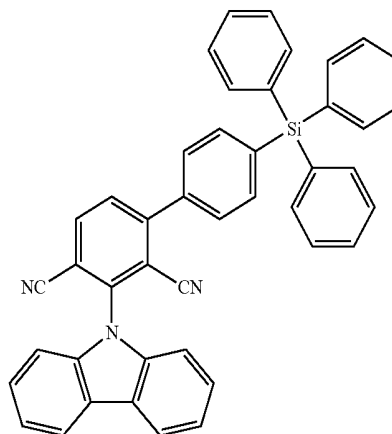
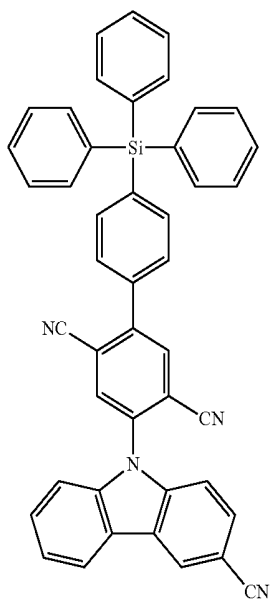
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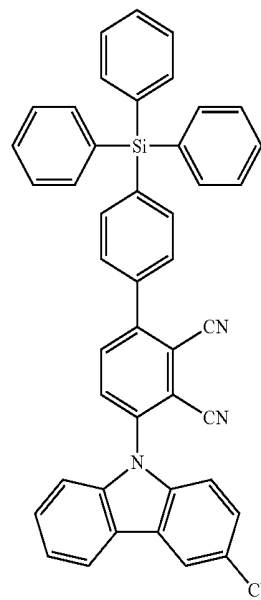
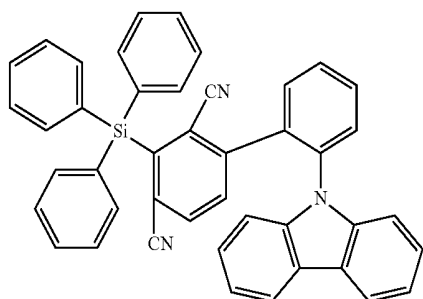
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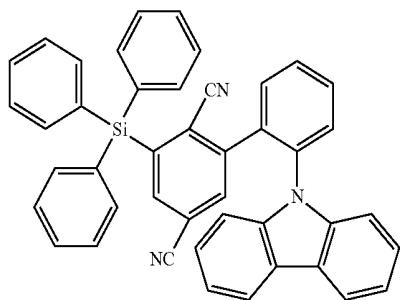
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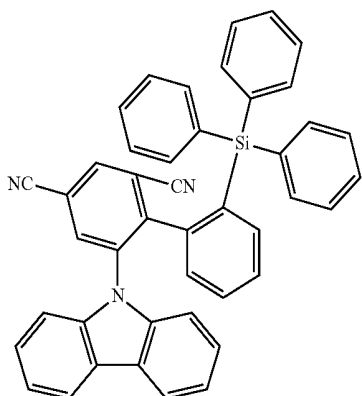
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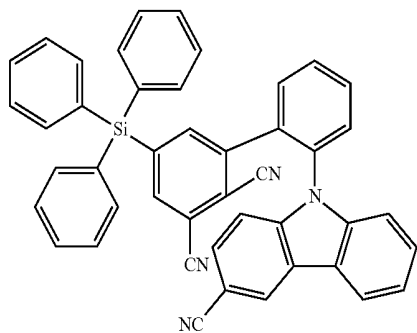
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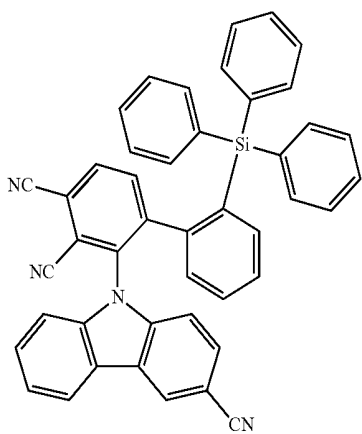
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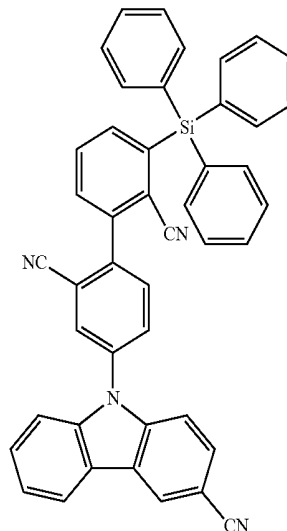


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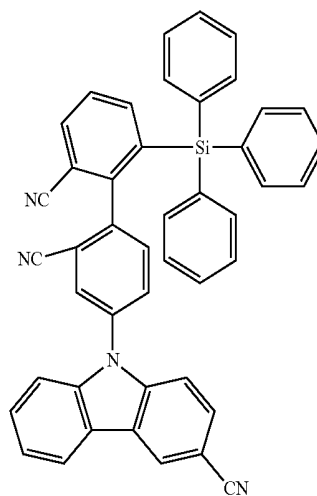


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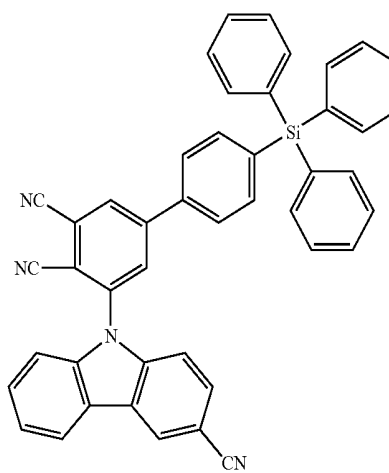
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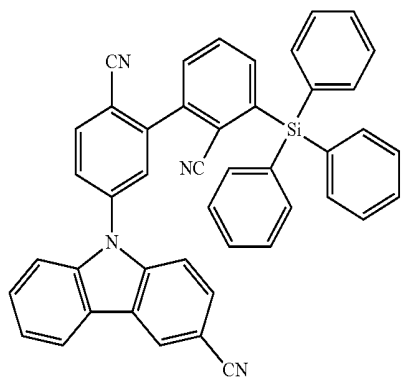


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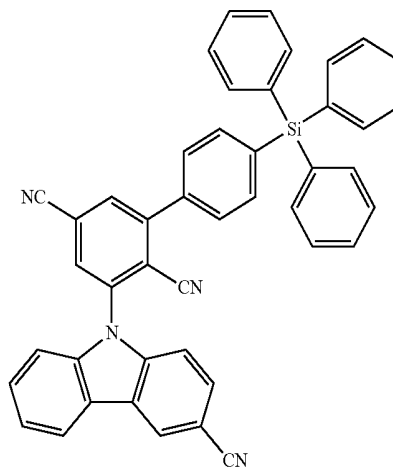
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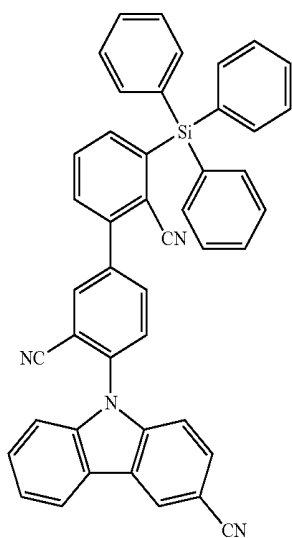
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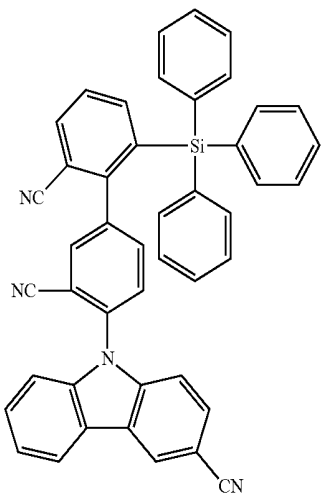
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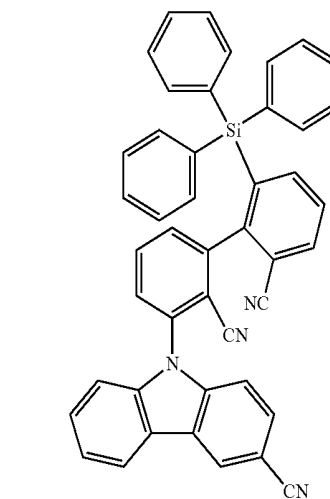


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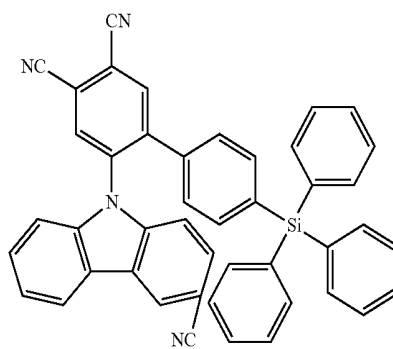
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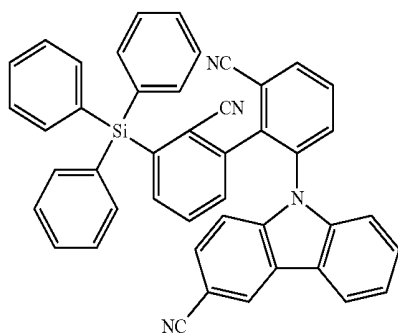
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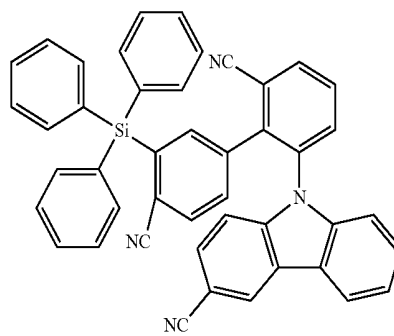


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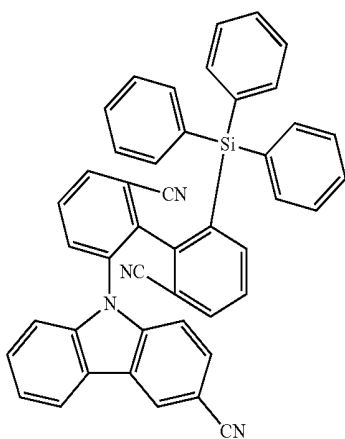
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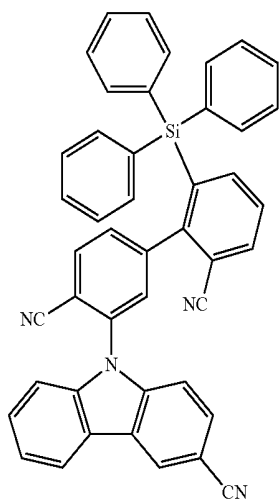
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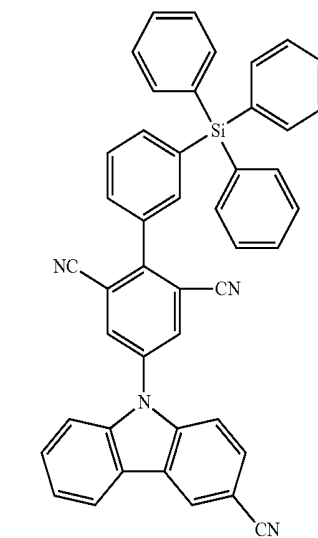
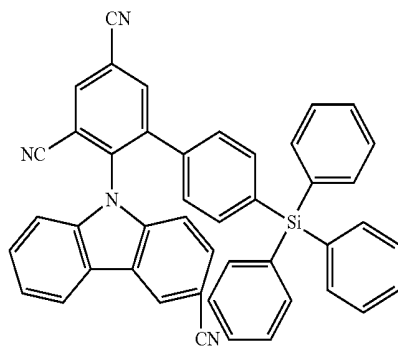
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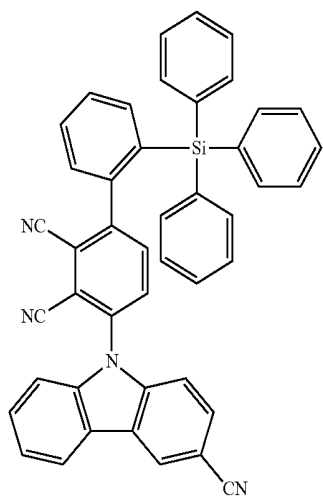


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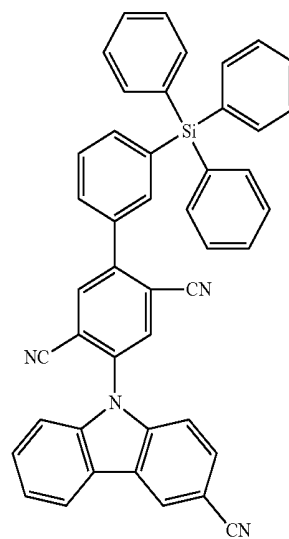


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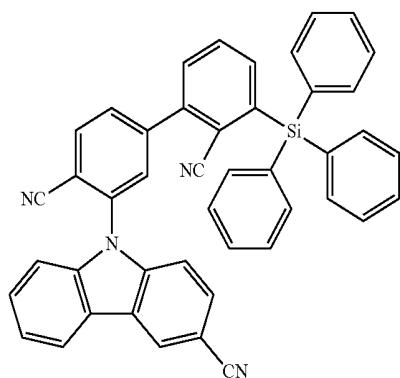


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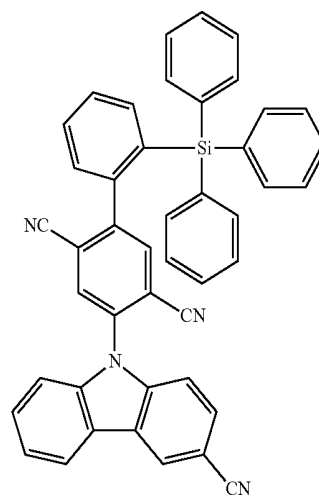
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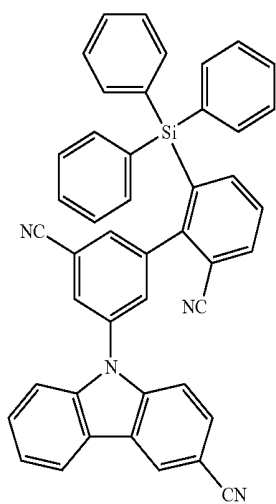
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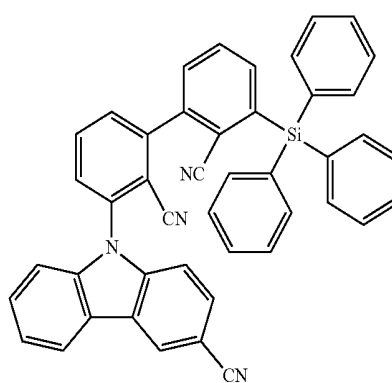
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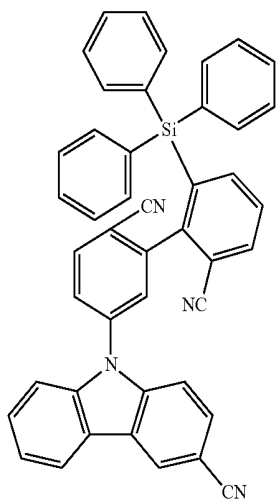


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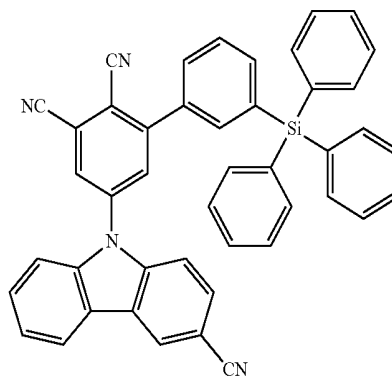
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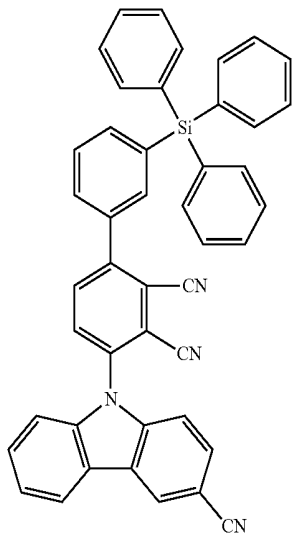
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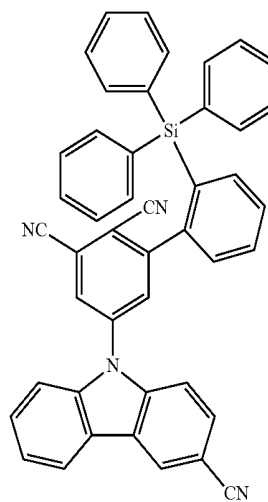


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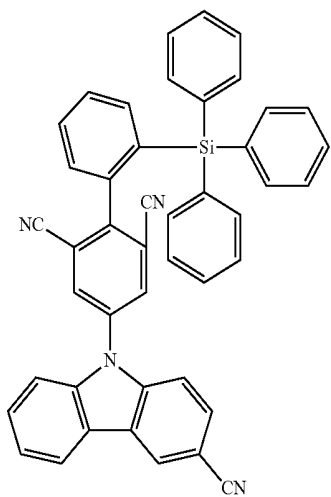
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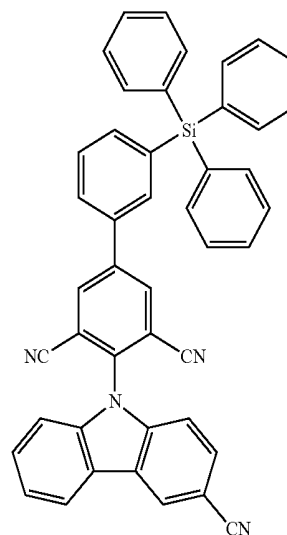
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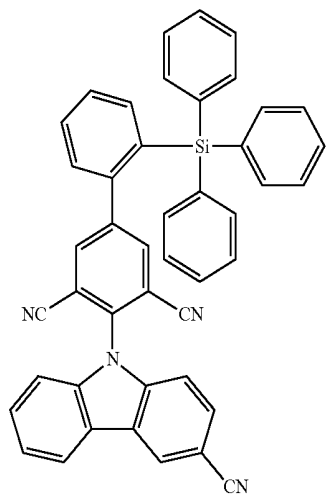
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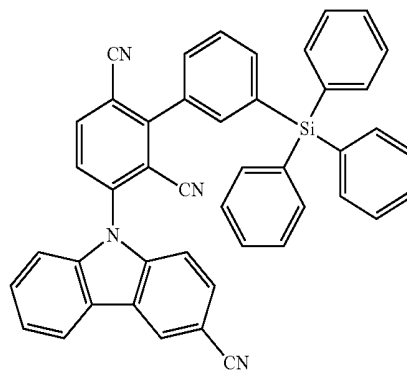


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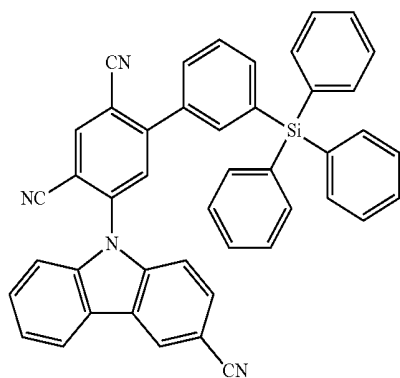


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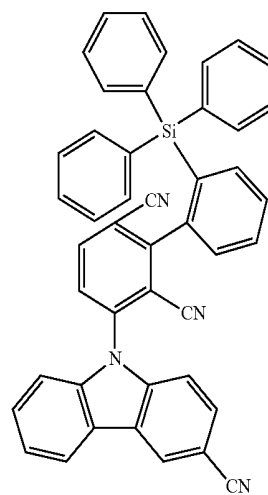
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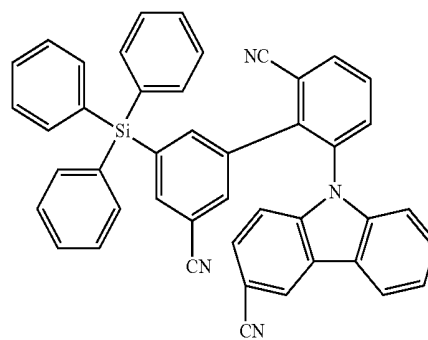
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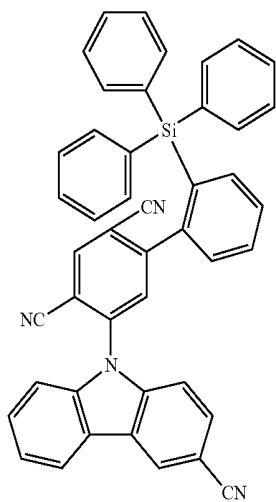
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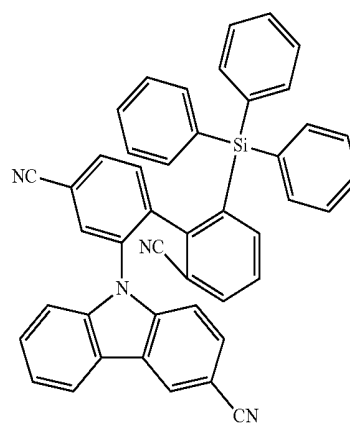
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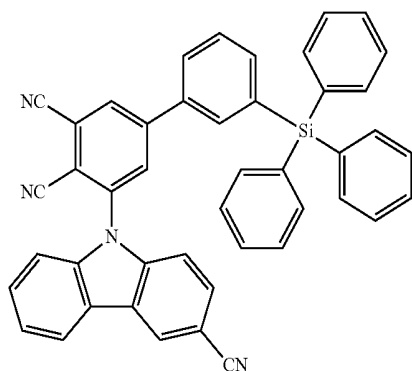


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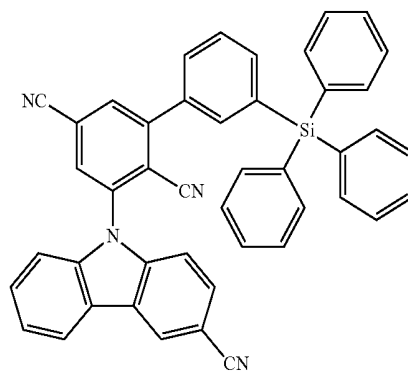


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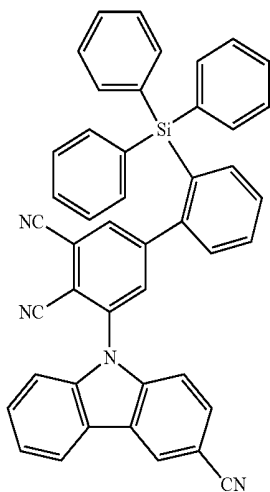
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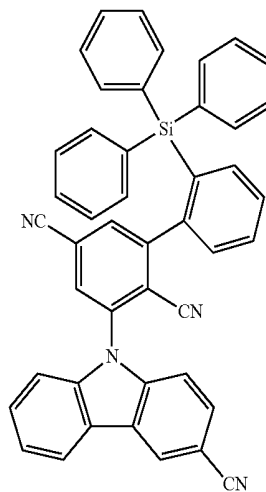
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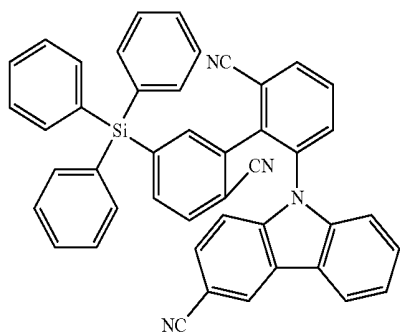
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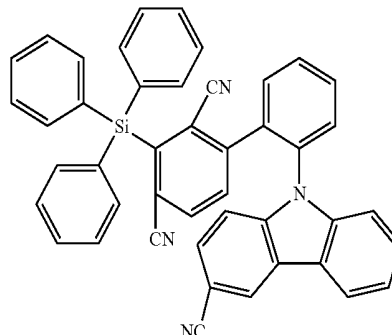
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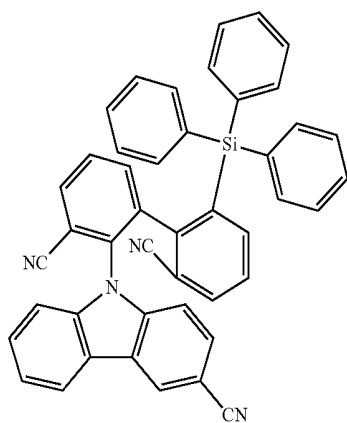
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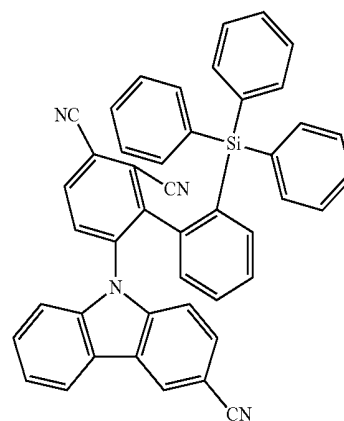
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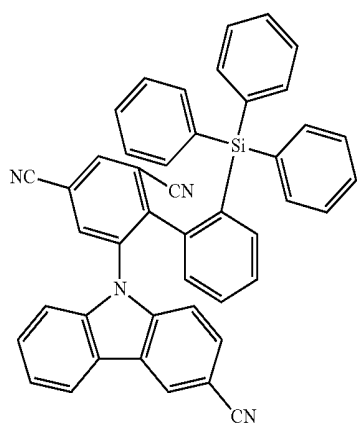
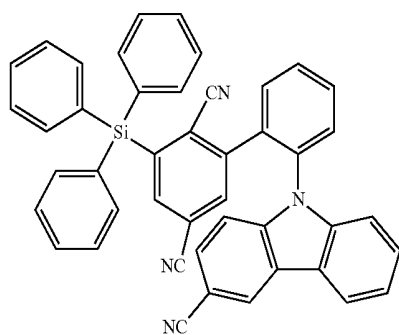
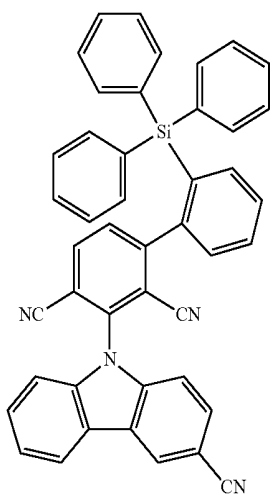
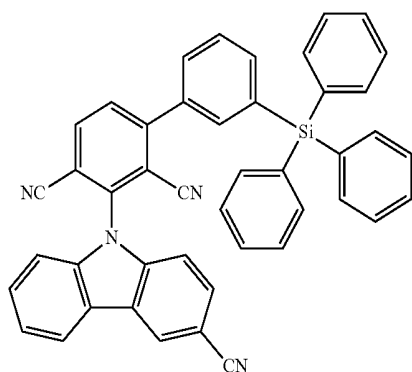
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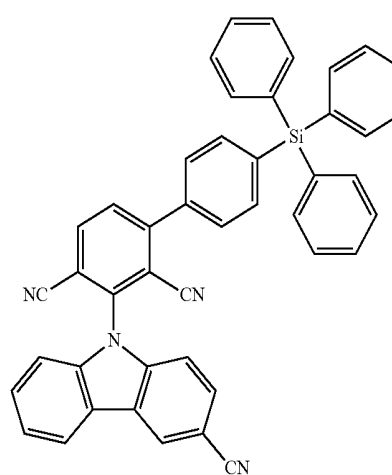
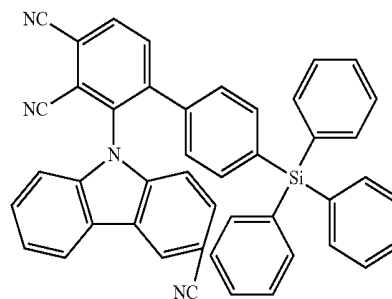
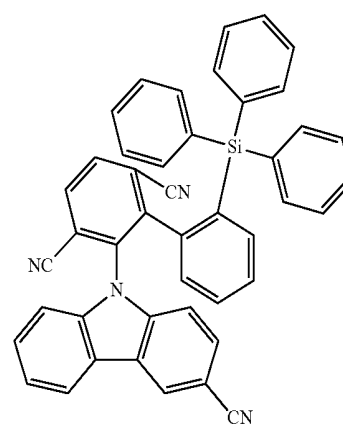
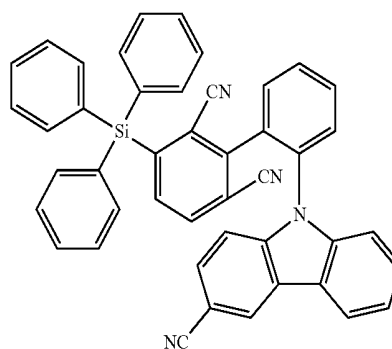
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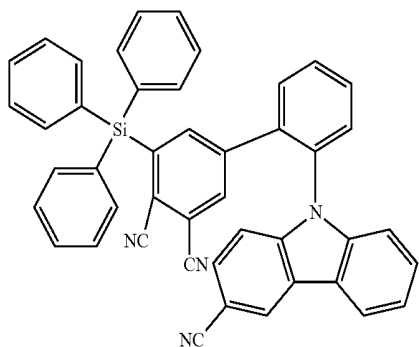
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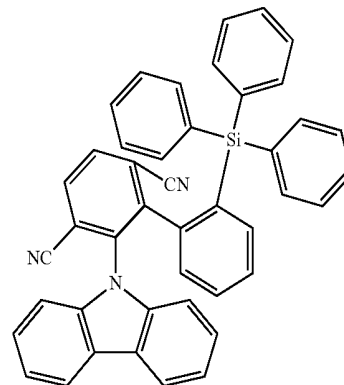


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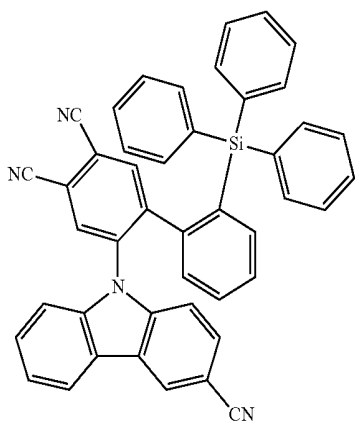
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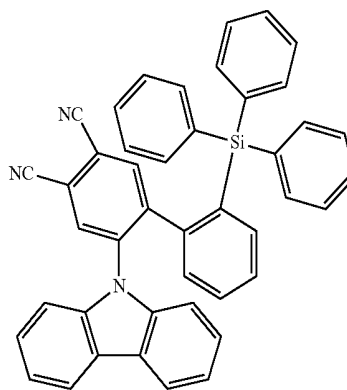


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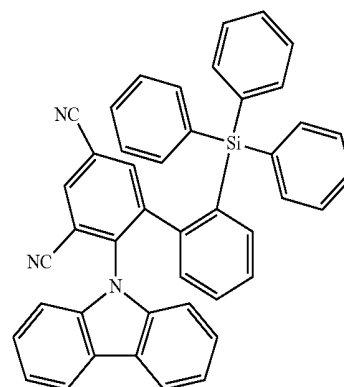
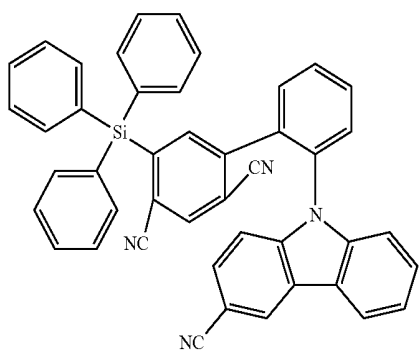


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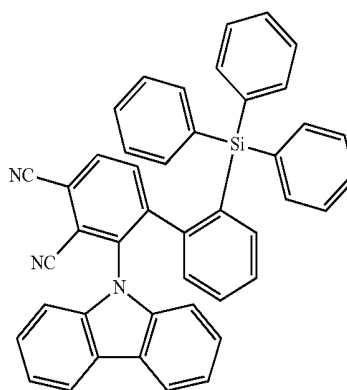
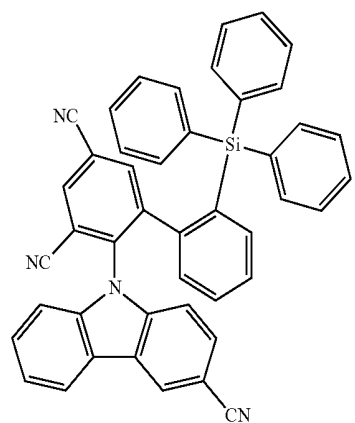
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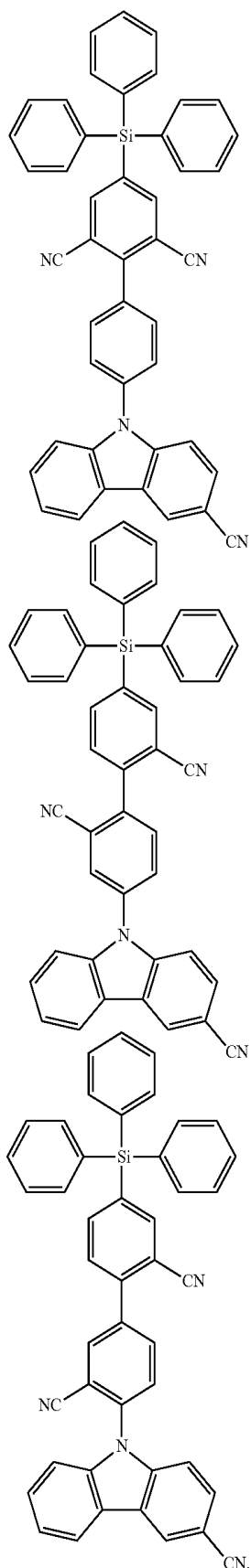


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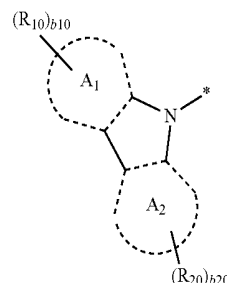


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[0092] The condensed cyclic compound represented by Formula 1 may have a structure in which



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moiety may be connected to a silyl group via $-(L_1)_{a1}$ - $(L_2)_{a2}$ - $(L_3)_{a3}$ -linker. Due to the steric hindrance induced by the silyl group substituted with Ar_1 to Ar_3 , a conjugation length may be shortened. Accordingly, the condensed cyclic compound represented by Formula 1 may have a relatively high triplet (Ti) energy level, thus having relatively excellent electron and hole transportability.

[0093] Also, the condensed cyclic compound represented by Formula 1 may essentially include a cyano group. Accordingly, the condensed cyclic compound represented by Formula 1 may have a high Ti energy level and excellent electron transportability.

[0094] Also, by controlling the position, at which a cyano group is substituted, in the condensed cyclic compound represented by Formula 1, the highest occupied molecular orbital (HOMO)/the lowest unoccupied molecular orbital (LUMO) energy level and electron and hole transportability may be controlled.

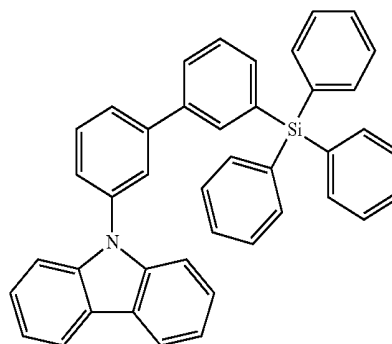
[0095] While not wishing to be bound by theory, it is understood that

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[0096] i) Compound A not including a cyano group may have deteriorated electron transportability, and

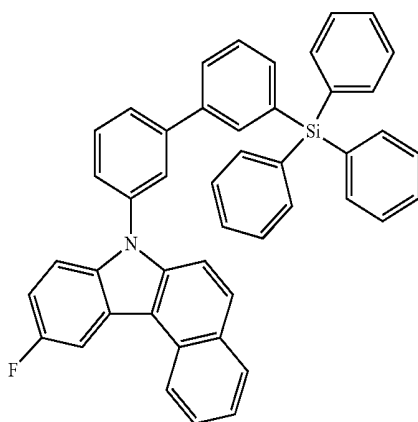
[0097] ii) when Compound B including a halogen group as a substituent corresponding to the cyano group is used in an organic light-emitting device, device lifespan may be deteriorated. It is known that device lifespan may be deteriorated when a halogen group is substituted in Appl. Phys. Lett. 109, 243302 (2016); doi: 10.1063/1.497205.

Compound A



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Compound B



[0098] As described above, the condensed cyclic compound represented by Formula 1 may have suitable electric characteristics for a material for organic light-emitting devices, e.g., a host material in an emission layer. Accordingly, an organic light-emitting device including the condensed cyclic compound may have high efficiency and/or a long lifespan.

[0099] For example, the HOMO, LUMO, T_1 , and singlet (S_1) energy levels of some of the compounds described above were evaluated by using Gaussian according to a density functional theory (DFT) method (structure optimization is performed at a degree of B3LYP, and 6-31G(d,p)). The results thereof are shown in Table 1.

TABLE 1

Compound No.	HOMO (electron volts, eV)	LUMO (eV)	T_1 (eV)	S_1 (eV)
505	-5.740	-1.931	3.005	3.226
83	-5.783	-1.208	3.13	3.923
65	-5.758	-1.384	3.09	3.839
66	-5.732	-1.279	3.107	3.905
67	-5.748	-1.165	3.115	3.929
68	-5.788	-1.333	3.12	3.923
82	-5.693	-1.082	3.119	3.954
57	-5.728	-1.076	3.126	-5.728
81	-5.77	-1.221	3.121	3.971
84	-5.764	-1.118	3.128	3.979
339	-6.201	-1.572	3.084	3.953
321	-6.164	-1.627	3.078	3.906
322	-6.142	-1.595	3.078	3.904
323	-6.157	-1.608	3.074	3.892
324	-6.214	-1.603	3.08	3.94
338	-6.112	-1.531	3.076	3.914
146	-6.143	-1.519	3.081	3.946
337	-6.196	-1.589	3.08	3.937
145	-6.173	-1.528	3.085	3.962
44	-5.624	-1.857	2.947	3.143
9	-5.581	-1.727	2.891	3.296
34	-5.589	-1.697	2.938	3.317
35	-5.556	-1.496	3.103	3.465
16	-5.615	-1.704	3.036	3.309
56	-5.527	-1.554	3.068	3.37
60	-5.529	-1.652	3.072	3.249
46	-5.59	-1.636	3.054	3.346
24	-5.587	-1.783	2.992	3.18
87	-5.467	-1.38	3.18	3.639
69	-5.398	-1.401	3.025	3.578
70	-5.356	-1.465	3.079	3.566
71	-5.383	-1.463	3.176	3.551
72	-5.414	-1.398	3.175	3.597

TABLE 1-continued

Compound No.	HOMO (electron volts, eV)	LUMO (eV)	T_1 (eV)	S_1 (eV)
86	-5.361	-1.423	3.176	3.518
61	-5.435	-1.331	3.169	3.684
85	-5.39	-1.475	3.18	3.609
88	-5.44	-1.341	3.178	3.766
302	-6.027	-1.885	3.088	3.544

[0100] Referring to Table 1, the compounds have excellent electric characteristics, e.g., a high T_1 energy level. Thus, the condensed cyclic compound represented by Formula 1 may be suitable for use as an emission layer material in an electronic device, e.g., an organic light-emitting device.

[0101] A method of synthesizing the condensed cyclic compound represented by Formula 1 may be apparent to one of ordinary skill in the art by referring to Synthesis Examples provided herein.

[0102] The condensed cyclic compound represented by Formula 1 may be suitable for use as an organic layer material of an organic light-emitting device, for example, an emission layer material, a hole transport region material, and/or an electron transport region material of the organic layer. In some embodiments, the condensed cyclic compound may be used as an emission layer material. In one or more embodiments, the condensed cyclic compound may be used as a hole transport region material, e.g., an electron blocking layer material. In one or more embodiments, the condensed cyclic compound may be used as an electron transport region material, e.g., a hole blocking layer material.

[0103] Accordingly, according to an aspect of another embodiment, an organic light-emitting device may include: a first electrode; a second electrode; and an organic layer disposed between the first electrode and the second electrode, wherein the organic layer includes an emission layer and at least one condensed cyclic compound represented by Formula 1.

[0104] As the organic light-emitting device has an organic layer including the condensed cyclic compound represented by Formula 1, the organic light-emitting device may have a low driving voltage, high efficiency, high luminance, high quantum efficiency, and long lifespan.

[0105] In an embodiment, in the organic light-emitting device,

[0106] the first electrode may be an anode, and the second electrode may be a cathode,

[0107] the organic layer may include a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,

[0108] wherein the hole transport region may include a hole injection layer, a hole transport layer, an electron blocking layer, or any combination thereof, and

[0109] the electron transport region may include a hole blocking layer, an electron transport layer, an electron injection layer, or a combination thereof, but embodiments are not limited thereto.

[0110] In an embodiment, the emission layer in the organic light-emitting device may include at least one condensed cyclic compound represented by Formula 1.

[0111] In an embodiment, the emission layer in the organic light-emitting device may include a host and a dopant, wherein the host may include at least one of the condensed cyclic compound represented by Formula 1, and the dopant may include a phosphorescent dopant or a fluorescent dopant. In some embodiments, the dopant may include a phosphorescent dopant (e.g., an organometallic compound represented by Formula 81 provided herein). The host may further include any suitable host, in addition to the condensed cyclic compound represented by Formula 1.

[0112] The emission layer may emit red light, green light, or blue light.

[0113] In an embodiment, the emission layer may include a phosphorescent dopant, but embodiments are not limited thereto.

[0114] In some embodiments, the condensed cyclic compound represented by Formula 1 may be included in a hole transport region of the organic light-emitting device.

[0115] In some embodiments, a hole transport region of the organic light-emitting device may include at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer, wherein at least one selected from the hole injection layer, the hole transport layer, and the electron blocking layer may include the condensed cyclic compound represented by Formula 1.

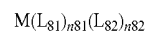
[0116] In some embodiments, the condensed cyclic compound represented by Formula 1 may be included in an electron transport region of the organic light-emitting device.

[0117] In some embodiments, a hole transport region of the organic light-emitting device may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer, wherein at least one selected from the hole blocking layer, the electron transport layer, and the electron injection layer, may include the condensed cyclic compound represented by Formula 1.

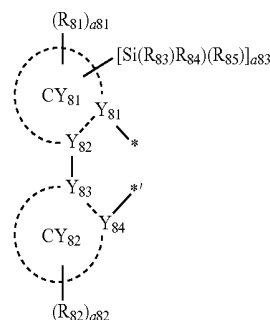
[0118] In an embodiment, a hole transport region of the organic light-emitting device may include an electron blocking layer, wherein the electron blocking layer may include the condensed cyclic compound represented by Formula 1. The electron blocking layer may be in a direct contact with the emission layer.

[0119] In an embodiment, an electron transport region of the organic light-emitting device may include a hole blocking layer, wherein the hole blocking layer may include the condensed cyclic compound represented by Formula 1. The hole blocking layer may be in a direct contact with the emission layer.

[0120] In one or more embodiments, the organic layer of the organic light-emitting device may further include an organometallic compound represented by Formula 81, in addition to the condensed cyclic compound represented by Formula 1.



Formula 81



Formula 81A

[0121] wherein, in Formulae 81 and 81A,

[0122] M may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), thulium (Tm), and rhodium (Rh),

[0123] L_{81} may be a ligand represented by Formula 81A, n_{81} may be an integer from 1 to 3; and when n_{81} is 2 or greater, at least two L_{81} groups may be identical to or different from each other,

[0124] L_{82} may be an organic ligand, n_{82} may be an integer from 0 to 4; and when n_{82} is 2 or greater, at least two L_{82} groups may be identical to or different from each other,

[0125] Y_{81} to Y_{84} may each independently be C or N,

[0126] Y_{81} and Y_{82} may be bound via a single bond or a double bond, Y_{83} and Y_{84} may be bound via a single bond or a double bond,

[0127] CY_{81} and CY_{82} may each independently be selected from a C_5 - C_{30} carbocyclic group and a C_2 - C_{30} heterocarbocyclic group,

[0128] CY_{81} and CY_{82} may optionally or additionally be bound via an organic linking group,

[0129] R_{81} to R_{85} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, — SF_5 , a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{81})(Q_{82})(Q_{83}), —N(Q_{84})(Q_{85}), —B(Q_{86})(Q_{87}), and —P(=O)(Q_{88})(Q_{89}),

[0130] a_{81} to a_{83} may each independently be an integer from 0 to 5,

[0131] when a_{81} is 2 or greater, at least two groups R_{81} may be identical to or different from each other,

[0132] when a82 is 2 or greater, at least two groups R₈₂ may be identical to or different from each other,

[0133] when a81 is 2 or greater, two adjacent groups R₈₁ may be optionally bound to form a saturated or unsaturated C₂-C₃₀ ring (e.g., a benzene ring, a cyclopentane ring, a cyclohexane ring, a cyclopentene ring, a cyclohexene ring, a norbornane ring, a (bicyclo[2.2.1]heptanes) ring, a naphthalene ring, a benzoindene ring, a benzoindole ring, a benzofuran ring, a benzothiophene ring, a pyridine ring, a pyrimidine ring, or a pyrazine ring), or a saturated or unsaturated C₂-C₃₀ ring substituted with at least one R₈₈ (e.g., a benzene ring, a cyclopentane ring, a cyclohexane ring, a cyclopentene ring, a cyclohexene ring, a norbornane ring, a (bicyclo[2.2.1]heptanes) ring, a naphthalene ring, a benzoindene ring, a benzoindole ring, a benzofuran ring, a benzothiophene ring, a pyridine ring, a pyrimidine ring, or a pyrazine ring, each substituted with at least one R₈₈),

[0134] when a82 is 2 or greater, two adjacent groups R₈₂ may be optionally bound to form a saturated or unsaturated C₂-C₃₀ ring (e.g., a benzene ring, a cyclopentane ring, a cyclohexane ring, a cyclopentene ring, a cyclohexene ring, a norbornane ring, a (bicyclo[2.2.1]heptanes) ring, a naphthalene ring, a benzoindene ring, a benzoindole ring, a benzofuran ring, a benzothiophene ring, a pyridine ring, a pyrimidine ring, or a pyrazine ring), or a saturated or unsaturated C₂-C₃₀ ring substituted with at least one R₈₉ (e.g., a benzene ring, a cyclopentane ring, a cyclohexane ring, a cyclopentene ring, a cyclohexene ring, a norbornane ring, a (bicyclo[2.2.1]heptanes) ring, a naphthalene ring, a benzoindene ring, a benzoindole ring, a benzofuran ring, a benzothiophene ring, a pyridine ring, a pyrimidine ring, or a pyrazine ring, each substituted with at least one R₈₉),

[0135] R₈₈ may be understood by referring to the descriptions for R₈₁ provided herein,

[0136] R₈₉ may be understood by referring to the descriptions for R₈₂ provided herein,

[0137] in Formula 81A, * and *¹ each indicate a binding site to M in Formula 81, and

[0138] at least one substituent of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q₉₁)(Q₉₂)(Q₉₃).

[0139] wherein Q₈₁ to Q₈₉ and Q₉₁ to Q₉₃ may each independently be selected from hydrogen, deuterium, a C₁-C₆₀ alkyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0140] In an embodiment, in Formula 81A, a83 may be 1 or 2, and

[0141] R₈₃ to R₈₅ may each independently be selected from

[0142] —CH₃, —CD₃, —CD₂H, —CDH₂, —CH₂CH₃, —CH₂CD₃, —CH₂CD₂H, —CH₂CDH₂, —CHDCH₃, —CHDCD₂H, —CHD₂CDH₂, —CHD₂CD₃, —CD₂CD₃, —CD₂CD₂H, and —CD₂CDH₂;

[0143] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0144] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C₁-C₁₀ alkyl group, and a phenyl group, but embodiments are not limited thereto.

[0145] In one or more embodiments, in Formula 81A,

[0146] Y₈₁ may be N, Y₈₂ and Y₈₃ may each be C, Y₈₄ may be N or C, and

[0147] CY₈₁ and CY₈₂ may each independently be selected from a cyclopentadiene group, a benzene group, a heptalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthylene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentacene group, a hexacene group, a pentacene group, a rubicene group, a coronene group, an ovalene group, a pyrrole group, an isoindole group, an indole group, an indazole group, a pyrazole group, an imidazole group, a triazole group, an oxazole group, an isoxazole group, an oxadiazole group, a thiazole group, an isothiazole group, a thiadiazole group, a purine group, a furan group, a thiophene group, a pyridine group, a pyrimidine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, a benzofuran group, a benzothiophene group, an iso-benzothiazole group, a benzoxazole group, an isobenzoxazole group, a benzocarbazole group, a dibenzocarbazole group, an imidazopyridine group, an imidazopyrimidine group, a dibenzofuran group, a dibenzothiophene group, a dibenzothiophene sulfone group, a carbazole group, a dibenzosilole group, and a 2,3-dihydro-1H-imidazole group.

[0148] In one or more embodiments, in Formula 81A, Y₈₁ may be N, Y₈₂ to Y₈₄ may each be C, CY₈₁ may be selected from 5-membered rings including two N atoms as ring-forming atoms, and CY₈₂ may be selected from a benzene

group, a naphthalene group, a fluorene group, a dibenzofuran group, and a dibenzothiophene group, but embodiments are not limited thereto.

[0149] In one or more embodiments, in Formula 81A, Y_{81} may be N, Y_{82} to Y_{84} may each be C, CY_{81} may be an imidazole group or a 2,3-dihydro-1H-imidazole group, and CY_{82} may be selected from a benzene group, a naphthalene group, a fluorene group, a dibenzofuran group, and a dibenzothiophene group, but embodiments are not limited thereto.

[0150] In one or more embodiments, in Formula 81A,

[0151] Y_{81} may be N, Y_{82} to Y_{84} may each be C,

[0152] CY_{81} may be selected from a pyrrole group, a pyrazole group, an imidazole group, a triazole group, an oxazole group, an isoxazole group, an oxadiazole group, a thiazole group, an isothiazole group, a thiadiazole group, a pyridine group, a pyrimidine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a benzimidazole group, an iso-benzothiazole group, a benzoxazole group, and an isobenzoxazole group, and

[0153] CY_{82} may be selected from a cyclopentadiene group, a benzene group, a naphthalene group, a fluorene group, a benzofluorene group, a dibenzofluorene group, a phenanthrene group, an anthracene group, a triphenylene group, a pyrene group, a chrysene group, a perylene group, a benzofuran group, a benzothiophene group, a benzocarbazole group, a dibenzocarbazole group, a dibenzofuran group, a dibenzothiophene group, a dibenzothiophene sulfone group, a carbazole group, and a dibenzosilole group.

[0154] In one or more embodiments, in Formula 81A,

[0155] R_{81} and R_{82} may each independently be selected from

[0156] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF₅, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;

[0157] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0158] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a

pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazoliny group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0159] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazoliny group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophe-

nyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

[0160] $-\text{B}(\text{Q}_{86})(\text{Q}_{87})$ and $-\text{P}(=\text{O})(\text{Q}_{88})(\text{Q}_{89})$,

[0161] wherein Q_{86} to Q_{89} may each independently be selected from

[0162] $-\text{CH}_3$, $-\text{CD}_3$, $-\text{CD}_2\text{H}$, $-\text{CDH}_2$, $-\text{CH}_2\text{CH}_3$, $-\text{CH}_2\text{CD}_3$, $-\text{CH}_2\text{CD}_2\text{H}$, $-\text{CH}_2\text{CDH}_2$, $-\text{CHDCH}_3$, $-\text{CHDCD}_2\text{H}$, $-\text{CHDCDH}_2$, $-\text{CHDCD}_3$, $-\text{CD}_2\text{CD}_3$, $-\text{CD}_2\text{CD}_2\text{H}$, and $-\text{CD}_2\text{CDH}_2$;

[0163] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0164] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C_1 - C_{10} alkyl group, and a phenyl group.

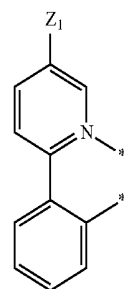
[0165] In one or more embodiments, in Formula 81A, at least one selected from groups R_{81} in the number of a81 and groups R_{82} in the number of a82 may be a cyano group.

[0166] In one or more embodiments, in Formula 81A, at least one of groups R_{82} in the number of a82 may be a cyano group.

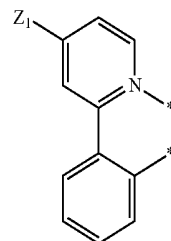
[0167] In one or more embodiments, in Formula 81A, at least one of groups R_{81} in the number of a81 and groups R_{82} in the number of a82 may be deuterium.

[0168] In one or more embodiments, in Formula 81, L_{82} may be selected from ligands represented by Formulae 3-1(1) to 3-1(60), 3-1(61) to 3-1(69), 3-1(71) to 3-1(79), 3-1(81) to 3-1(88), 3-1(91) to 3-1(98), and 3-1(101) to 3-1(114):

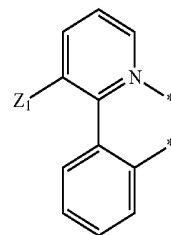
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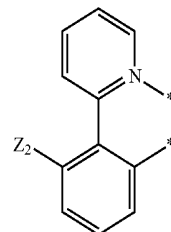
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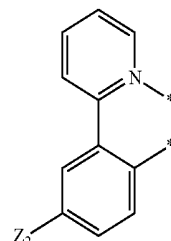
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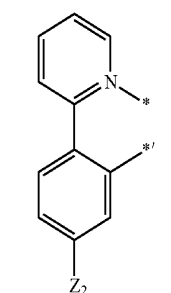
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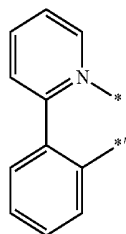
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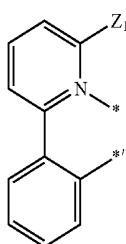
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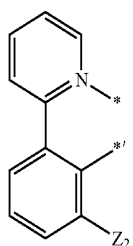


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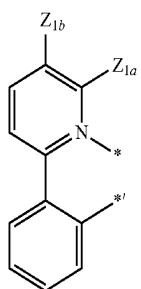


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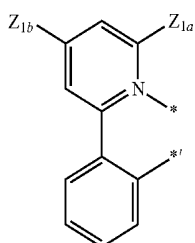
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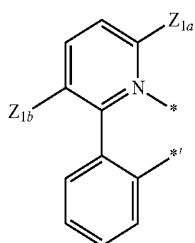
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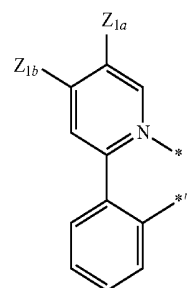
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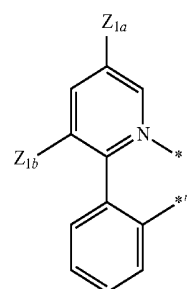
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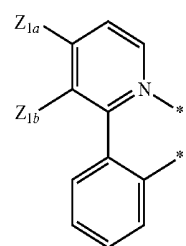


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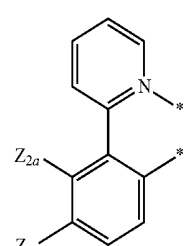


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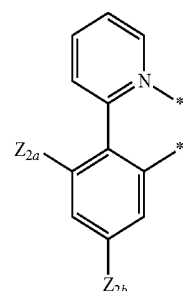
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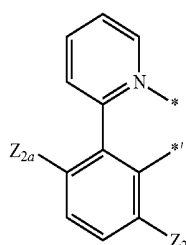
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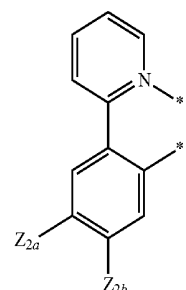
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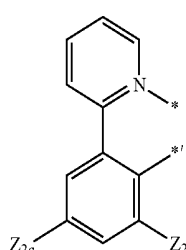
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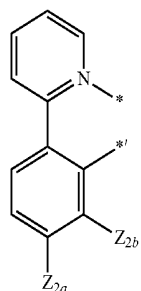


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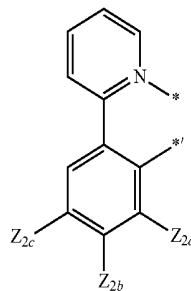
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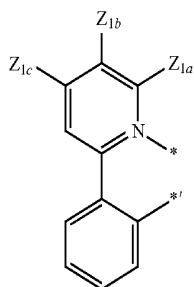


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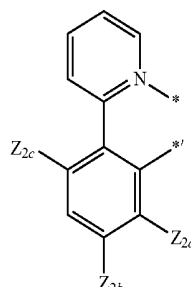
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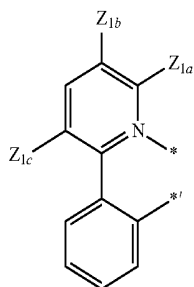
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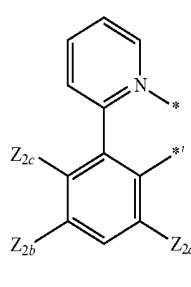
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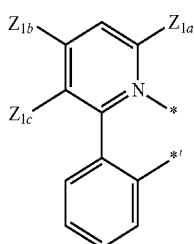
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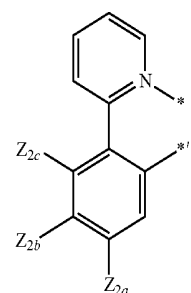
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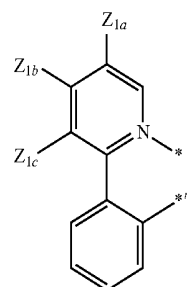
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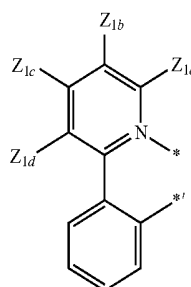
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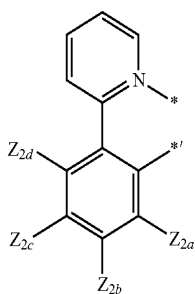


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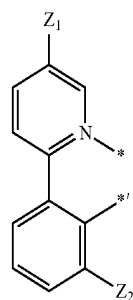
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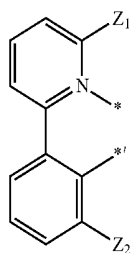


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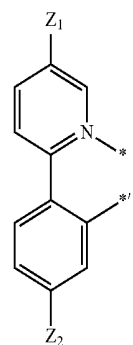
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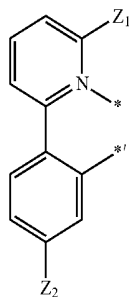
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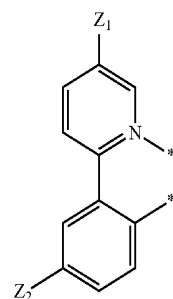
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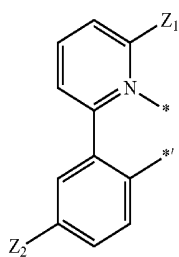
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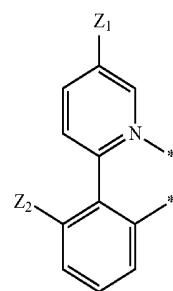
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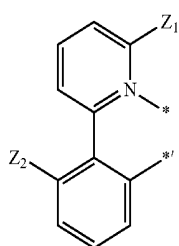
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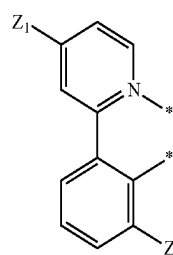
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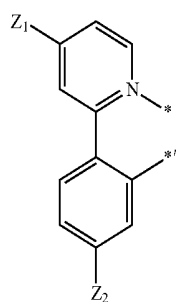


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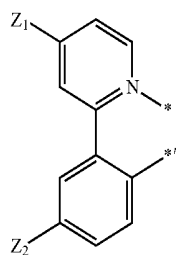


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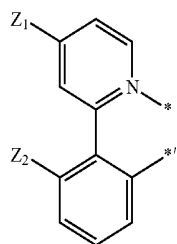
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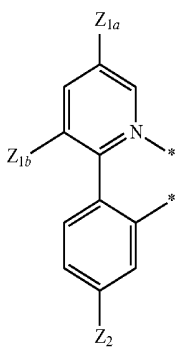
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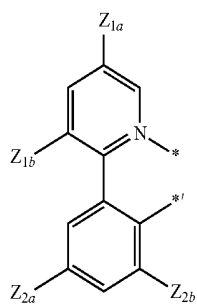
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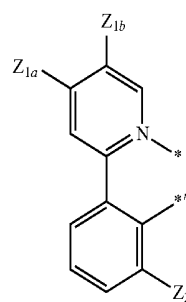


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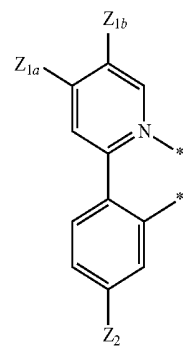


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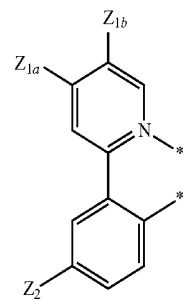
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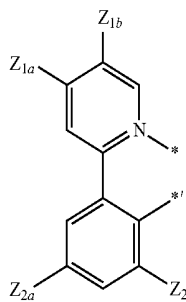
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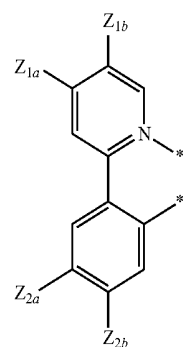
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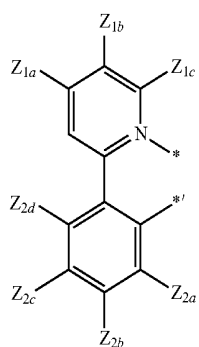


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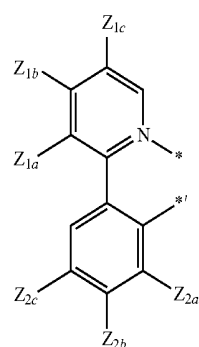
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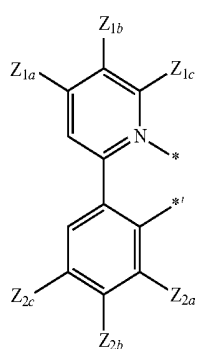


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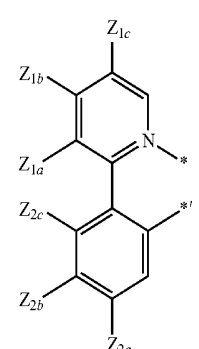
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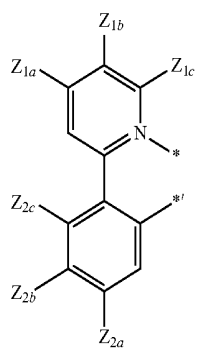
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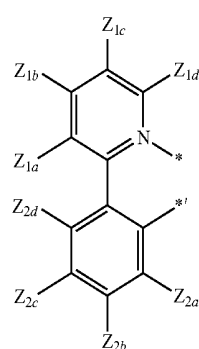
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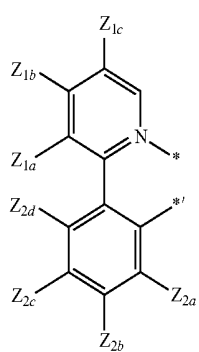
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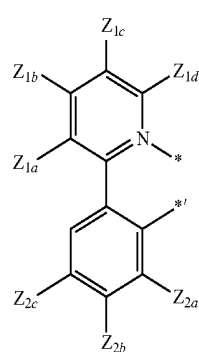
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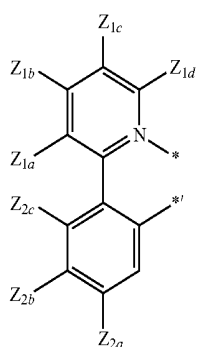


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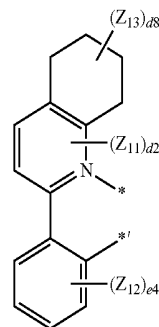
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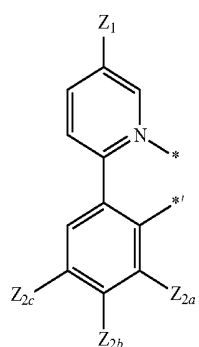


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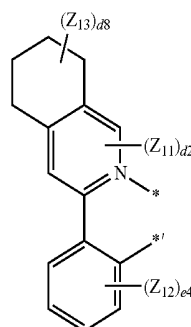
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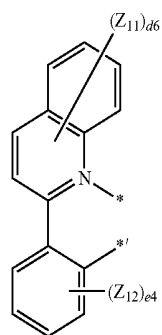
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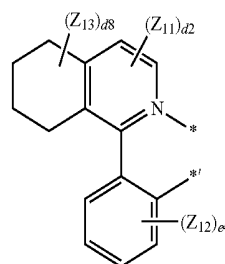
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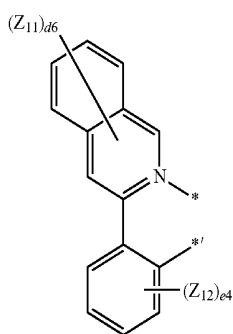
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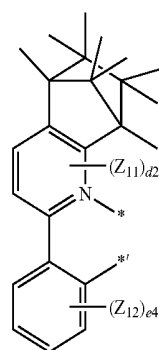
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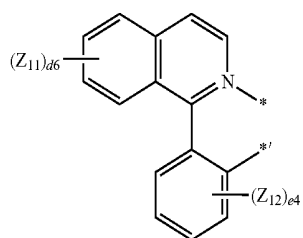
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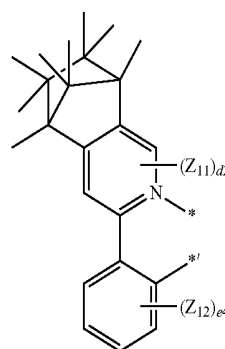
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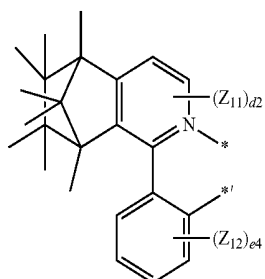


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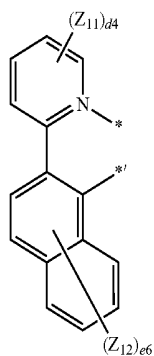


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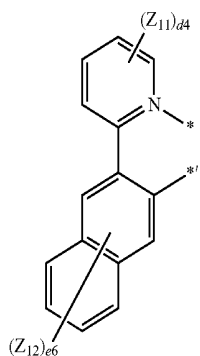
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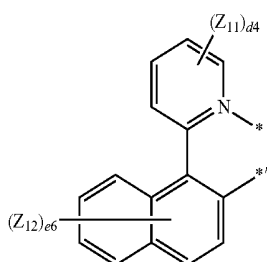
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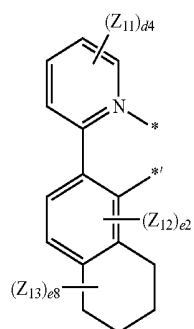
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3-1(72)

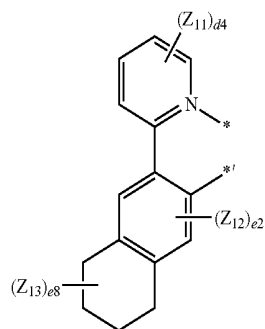


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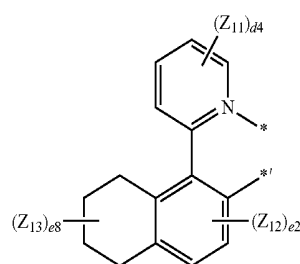


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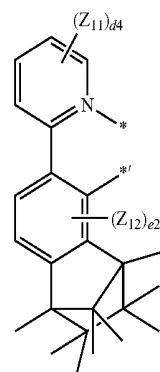
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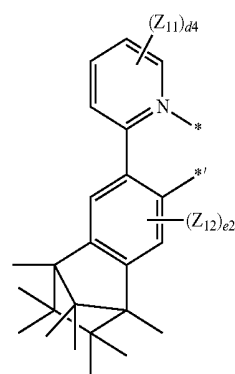
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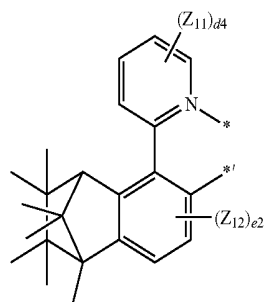
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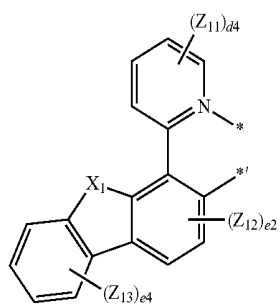


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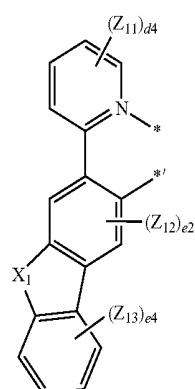
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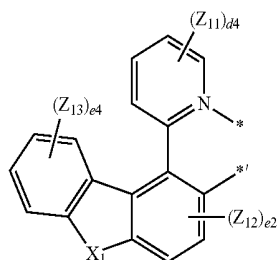


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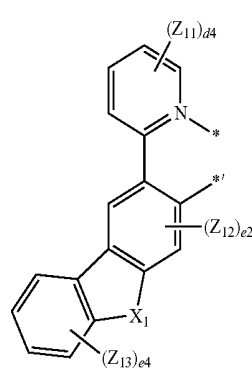
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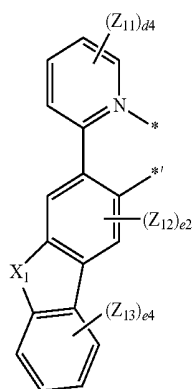
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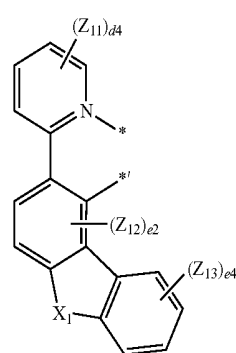
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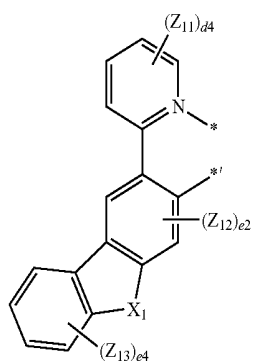
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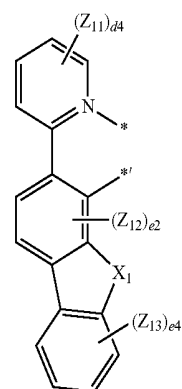
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3-1(87)

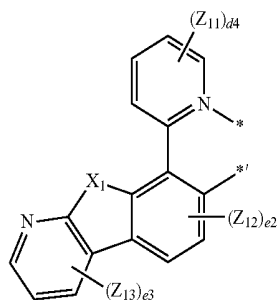


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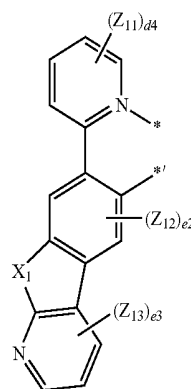
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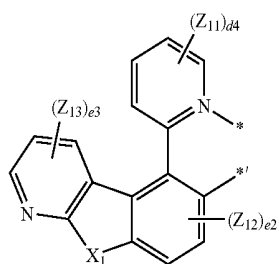


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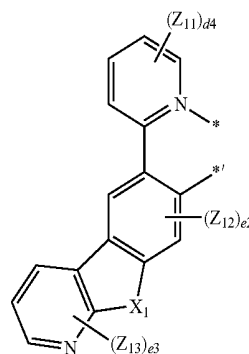
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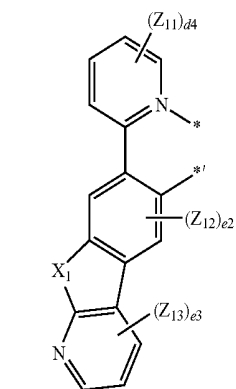
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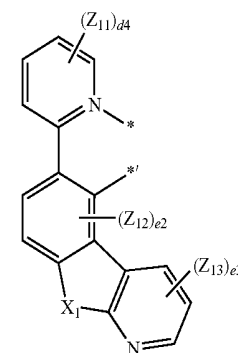
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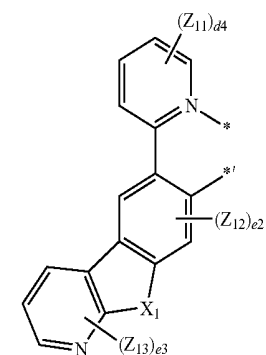
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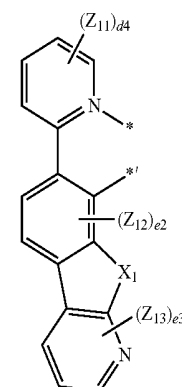
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3-1(97)

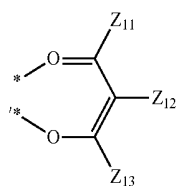


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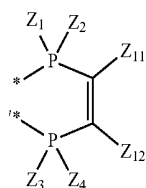


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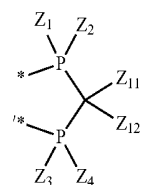
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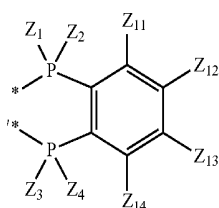
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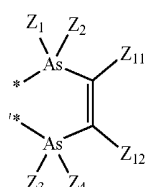
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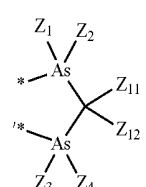
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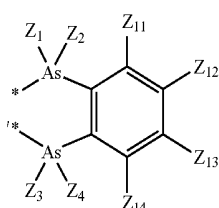
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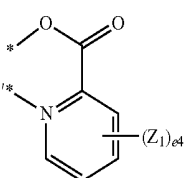
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3-1(106)

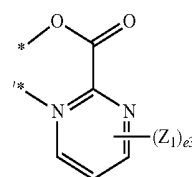


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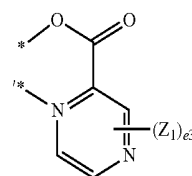


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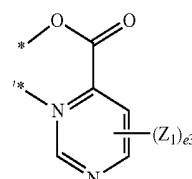
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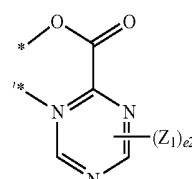
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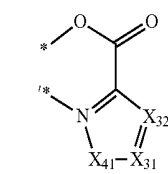
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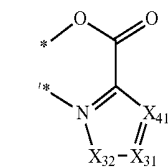
3-1(111)



3-1(112)



3-1(113)



3-1(114)

[0169] wherein, in Formulae 3-1(1) to 3-1(60), 3-1(61) to 3-1(69), 3-1(71) to 3-1(79), 3-1(81) to 3-1(88), 3-1(91) to 3-1(98), and 3-1(101) to 3-1(114),

[0170] X_1 may be O, S, $C(Z_{21})(Z_{22})$, or $N(Z_{23})$,

[0171] X_{31} may be N or $C(Z_{1a})$, X_{32} may be N or $C(Z_{1b})$,

[0172] X_{41} may be O, S, $N(Z_{1a})$, or $C(Z_{1a})(Z_{1b})$, and

[0173] Z_1 to Z_4 , Z_{1a} , Z_{1b} , Z_{1c} , Z_{1d} , Z_{2a} , Z_{2b} , Z_{2c} , Z_{2d} , Z_{11} to Z_{14} , and Z_{21} to Z_{23} may each independently be selected from

[0174] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF₅, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;

[0175] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro

group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0176] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiofenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiofenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0177] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiofenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiofenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a nor-

bornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiofenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiofenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

[0178] —B(Q₈₆)(Q₈₇) and —P(=O)(Q₈₈)(Q₈₉),

[0179] wherein Q₈₆ to Q₈₉ may each independently be selected from

[0180] —CH₃, —CD₃, —CD₂H, —CDH₂, —CH₂CH₃, —CH₂CD₃, —CH₂CD₂H, —CH₂CDH₂, —CHDCH₃, —CHDCH₂H, —CHDCHD₂, —CHDCHD₃, —CD₂CD₃, —CD₂CD₂H, and —CD₂CDH₂;

[0181] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0182] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C₁-C₁₀ alkyl group, and a phenyl group,

[0183] d2 and e2 may each independently be 0 or 2,

[0184] e3 may be an integer from 0 to 3,

[0185] d4 and e4 may each independently be an integer from 0 to 4,

[0186] d6 and e6 may each independently be an integer from 0 to 6,

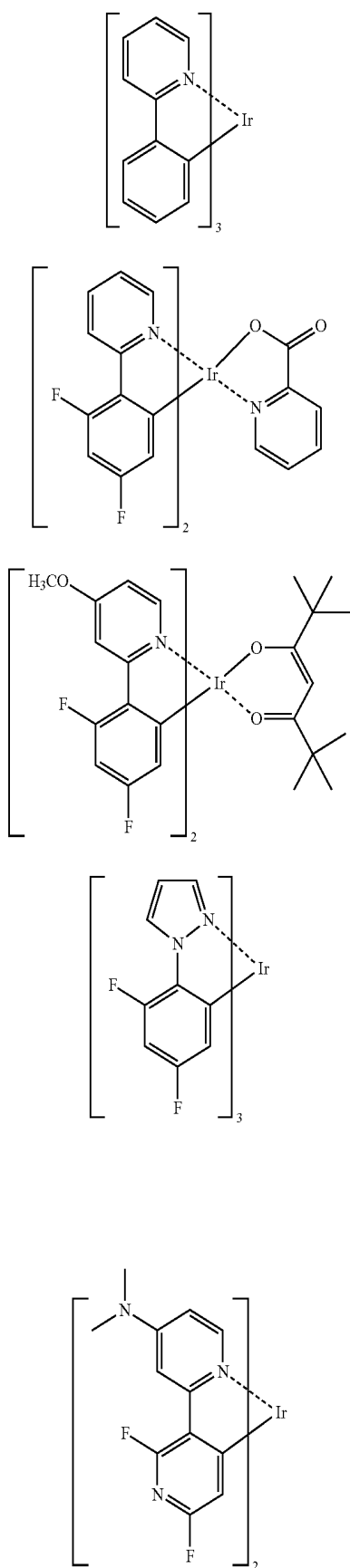
[0187] d8 and e8 may each independently be an integer from 0 to 8, and

[0188] * and *¹ each indicate a binding site to M in Formula 1.

[0189] In one or more embodiments, in Formula 81, M may be Ir, and a sum of n81 and n82 may be 3. In one or more embodiments, in Formula 81, M may be Pt, and a sum of n81 and n82 may be 2.

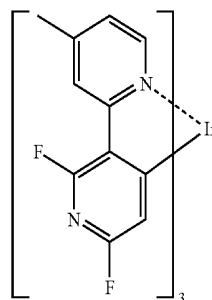
[0190] In one or more embodiments, the organometallic compound represented by Formula 81 may be neutral, and may not include ion pairs of cations and anions.

[0191] In one or more embodiments, the organometallic compound represented by Formula 81 may include at least one selected from Compounds PD1 to PD78 and Flr₆, but embodiments are not limited thereto:



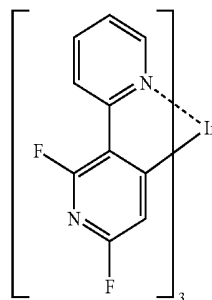
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PD1



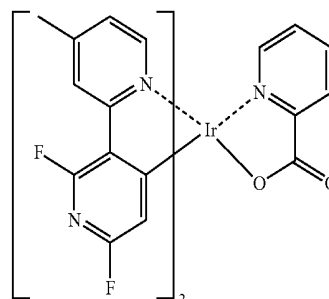
PD6

PD2



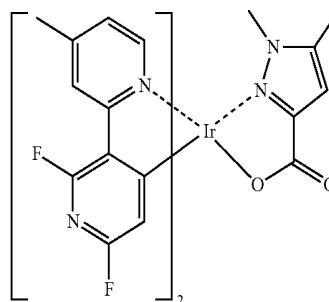
PD7

PD3



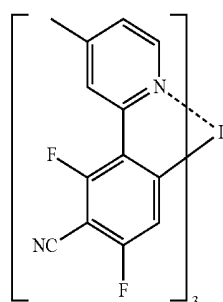
PD8

PD4



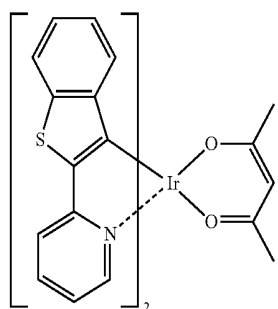
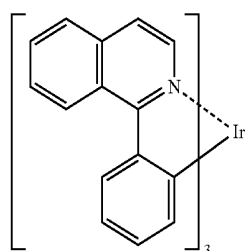
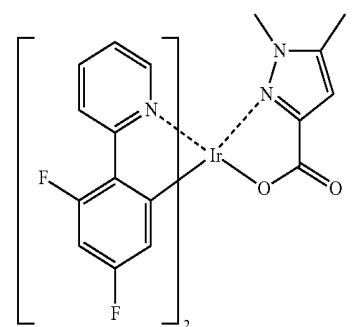
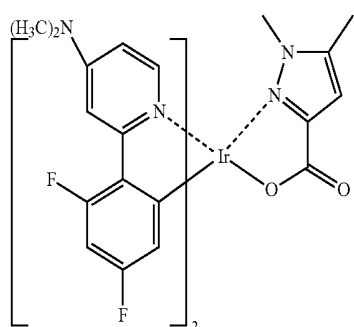
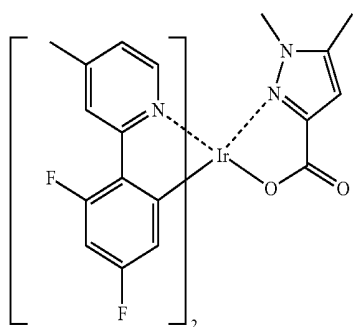
PD9

PD5



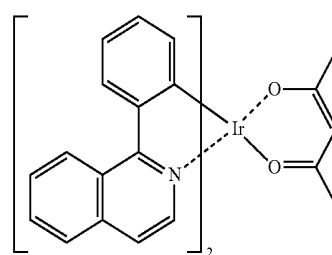
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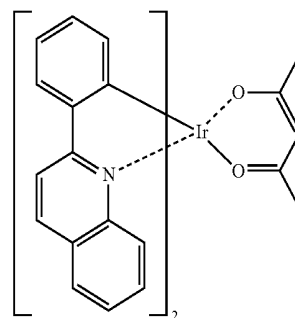
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PD11



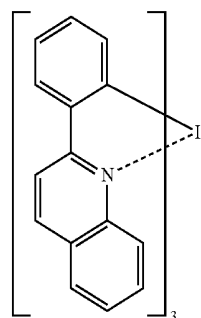
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PD12



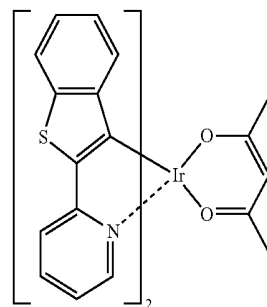
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PD13



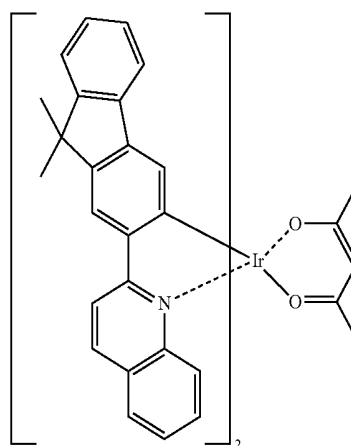
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PD14



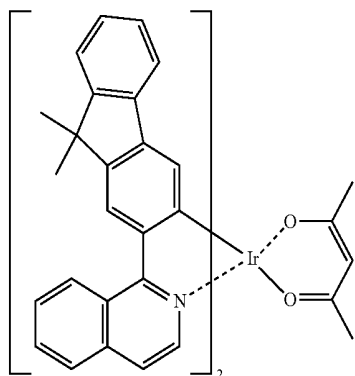
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PD15

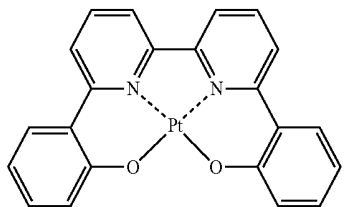


PD20

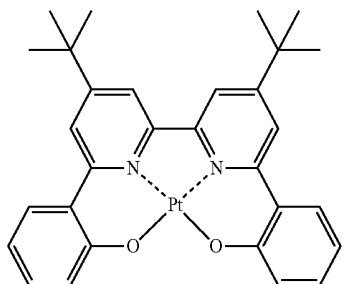
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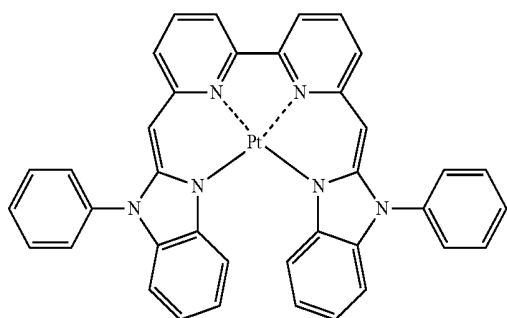
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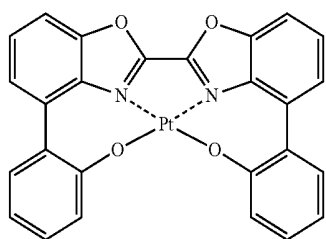
PD22



PD23

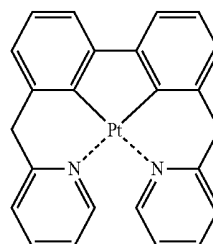


PD24

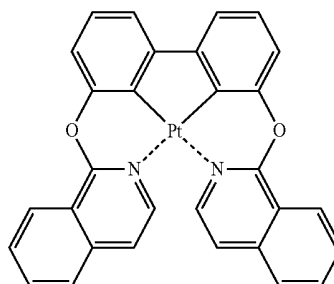


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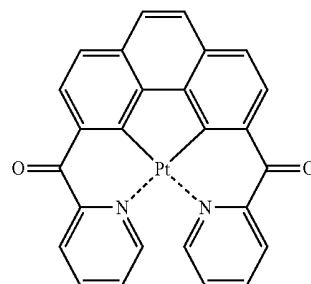
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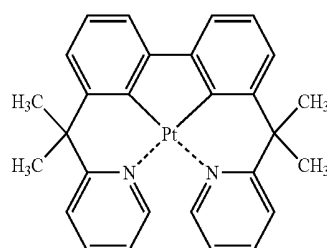
PD26



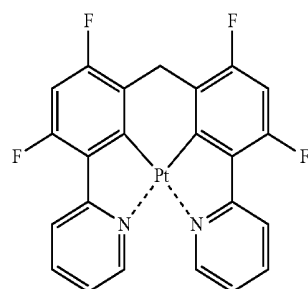
PD27



PD28

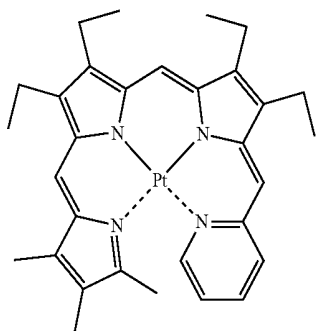
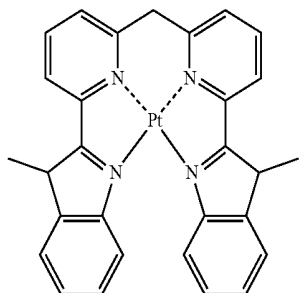
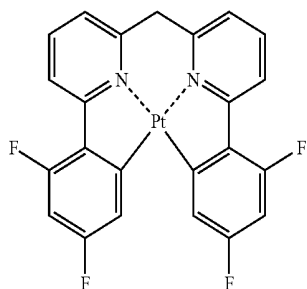
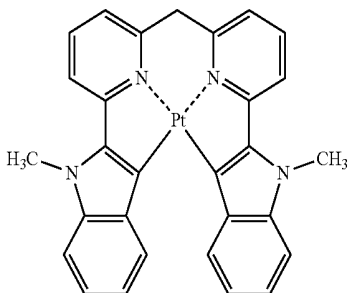
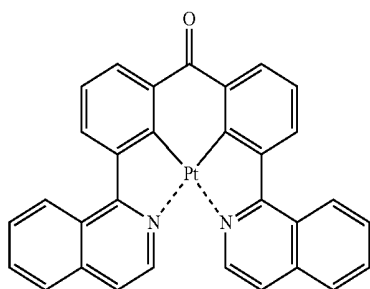


PD29



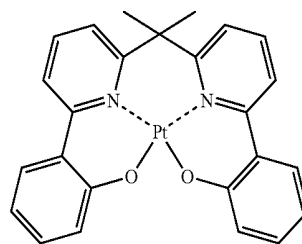
PD30

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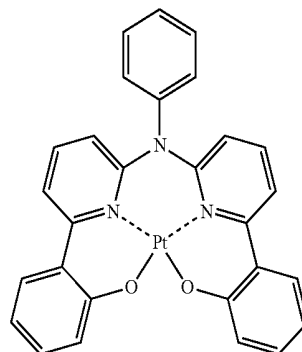
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PD31



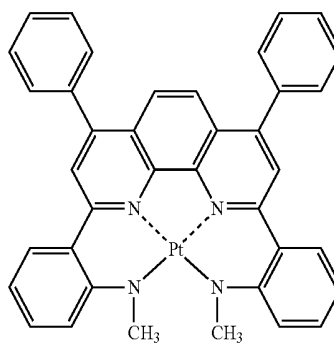
PD36

PD32



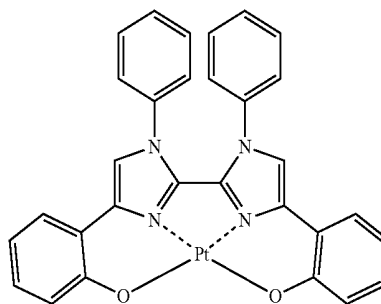
PD37

PD33



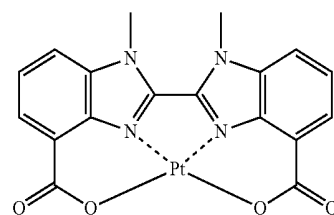
PD38

PD34



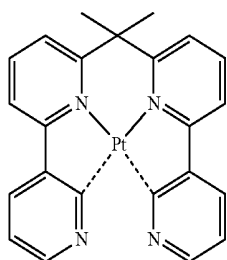
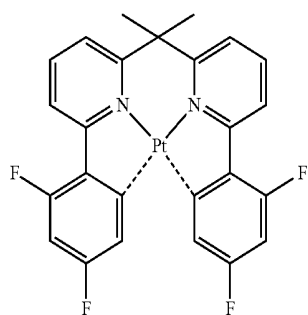
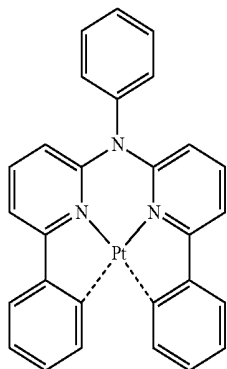
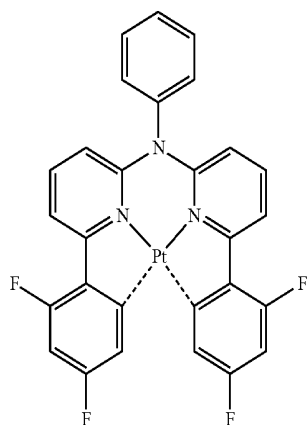
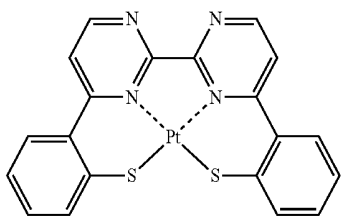
PD39

PD35



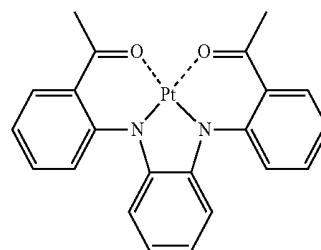
PD40

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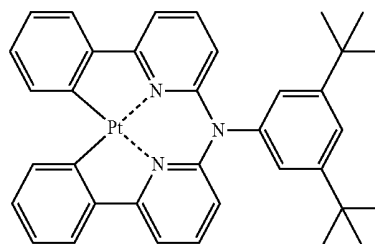
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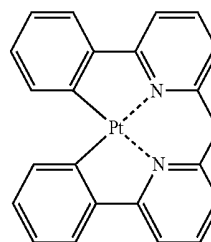
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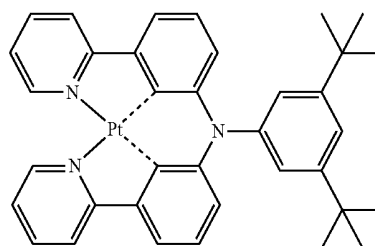
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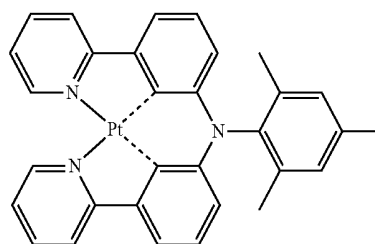
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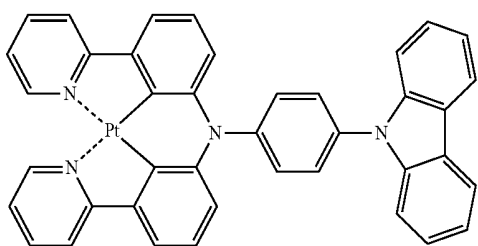
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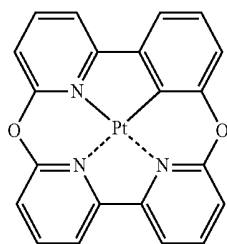


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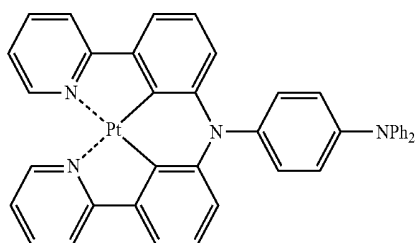
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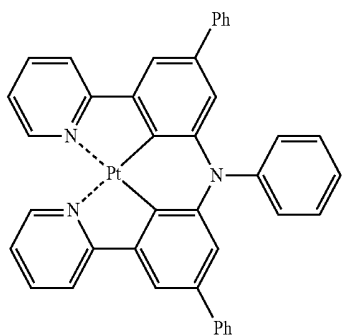
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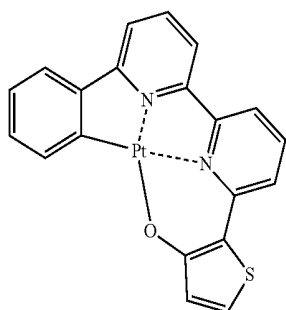
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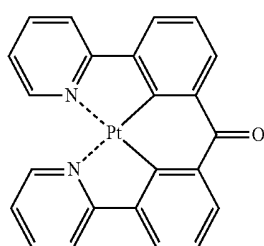
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PD55

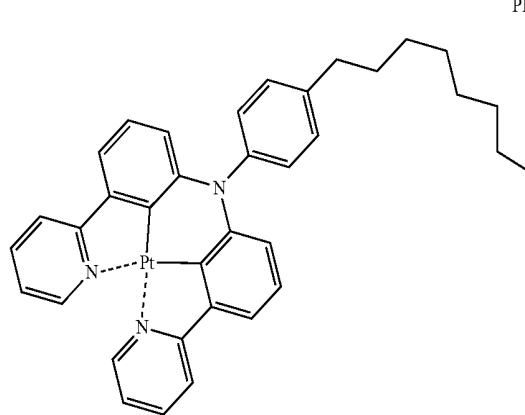


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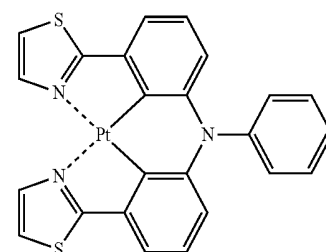


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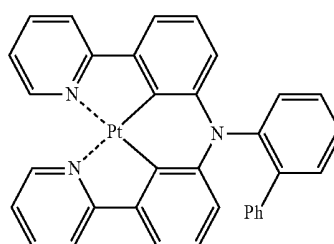
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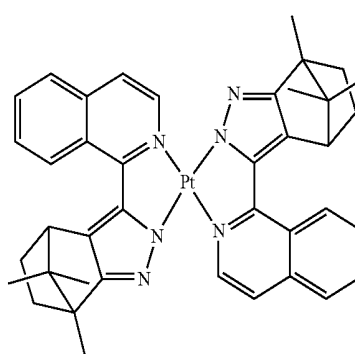
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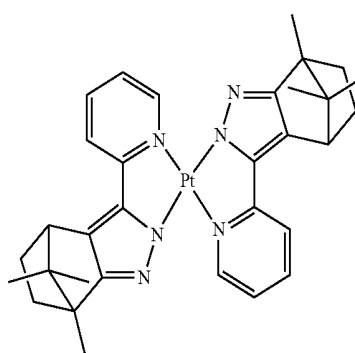
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PD60

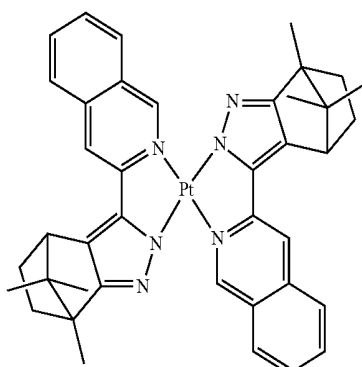


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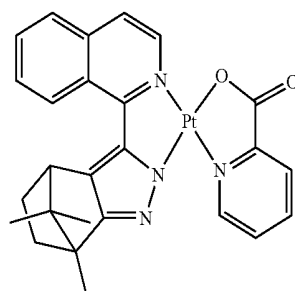
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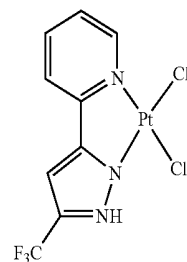
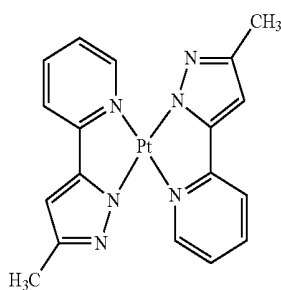
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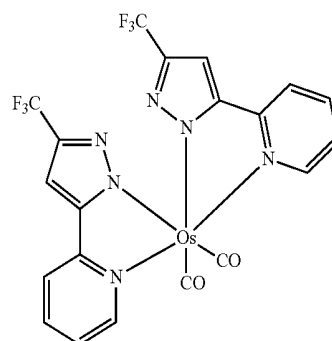
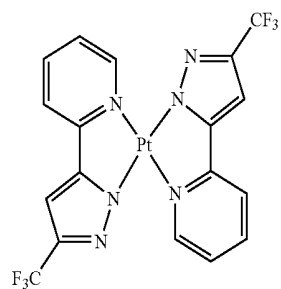
PD68

PD64



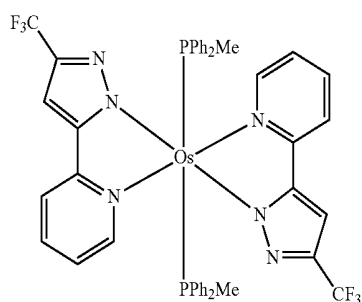
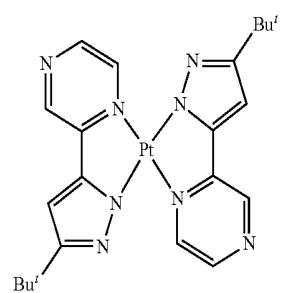
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PD65



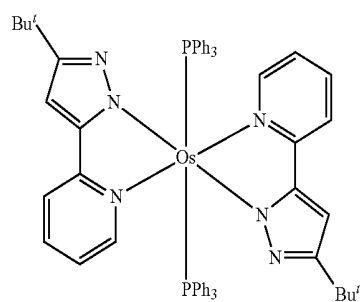
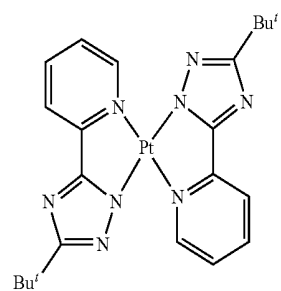
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PD66



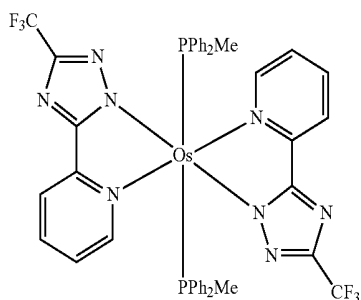
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PD67



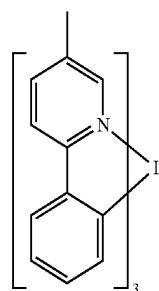
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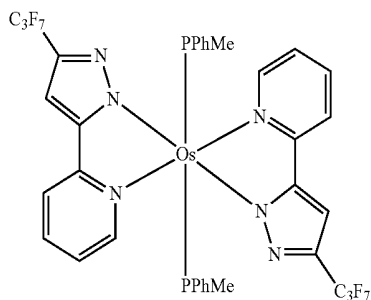


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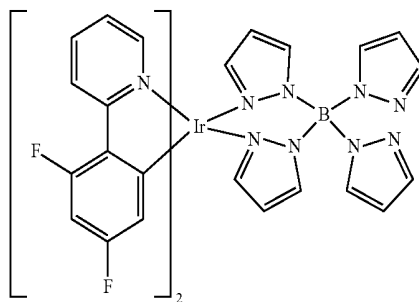
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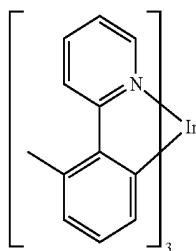
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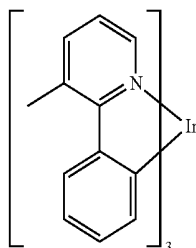
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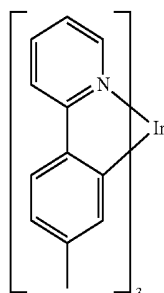
Flr6



PD75



PD76



PD77

[0192] As used herein, the expression “(for example, the organic layer) including at least one condensed cyclic compound” means that “(the organic layer) including a condensed cyclic compound represented by Formula 1, or at least two different condensed cyclic compounds represented by Formula 1”.

[0193] For example, the organic layer may include Compound 1 only as the condensed cyclic compound. In this embodiment, Compound 1 may be included in the emission layer of the organic light-emitting device. In some embodiments, Compounds 1 and 2 may be included in the organic layer as the condensed cyclic compounds. In this embodiment, Compounds 1 and 2 may be present in the same layer (for example, Compounds 1 and 2 may be both present in an emission layer), or in different layers (for example, Compound 1 may be present in an emission layer, and Compound 2 may be present in a hole blocking layer).

[0194] The first electrode may be an anode, which is a hole injection electrode, and the second electrode may be a cathode, which is an electron injection electrode. In some embodiments, the first electrode may be a cathode, which is an electron injection electrode, and the second electrode may be an anode, which is a hole injection electrode.

[0195] The term “organic layer” as used herein refers to a single and/or a plurality of layers between the first electrode and the second electrode in an organic light-emitting device. The “organic layer” may include not only organic compounds but also organometallic complexes including metals.

[0196] The FIG. illustrates a schematic cross-sectional view of an organic light-emitting device 10 according to an embodiment. Hereinafter, a structure of an organic light-emitting device according to one or more embodiments and a method of manufacturing the organic light-emitting device will be described with reference to the FIGURE. The organic light-emitting device 10 may include a first electrode 11, an organic layer 15, and a second electrode 19, which may be sequentially layered in this stated order.

[0197] A substrate may be additionally disposed under the first electrode 11 or on the second electrode 19. The substrate

may be a conventional substrate used in organic light-emitting devices, e.g., a glass substrate or a transparent plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water repellency.

[0198] The first electrode **11** may be formed by vacuum-depositing or sputtering, onto the substrate, a material for forming the first electrode **11**. The first electrode **11** may be an anode. The material for forming the first electrode **11** may be selected from materials with a high work function for easy hole injection. The first electrode **11** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

[0199] The material for forming the first electrode **11** may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO₂), and zinc oxide (ZnO). In some embodiments, the material for forming the first electrode **11** may be a metal, such as magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag).

[0200] The first electrode **11** may have a single-layered structure or a multi-layered structure including a plurality of layers. In some embodiments, the first electrode **11** may have a triple-layered structure of ITO/Ag/ITO, but embodiments are not limited thereto.

[0201] The organic layer **15** may be on the first electrode **11**.

[0202] The organic layer **15** may include a hole transport region, an emission layer, and an electron transport region.

[0203] The hole transport region may be disposed between the first electrode **11** and the emission layer.

[0204] The hole transport region may include at least one selected from a hole injection layer, a hole transport layer, an electron blocking layer, and a buffer layer.

[0205] The hole transport region may include a hole injection layer only or a hole transport layer only. In some embodiments, the hole transport region may include a hole injection layer and a hole transport layer which are sequentially stacked on the first electrode **11**. In some embodiments, the hole transport region may include a hole injection layer, a hole transport layer, and an electron blocking layer, which are sequentially stacked on the first electrode **11**.

[0206] When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **11** by using one or more suitable methods, such as vacuum deposition, spin coating, casting, and Langmuir-Blodgett (LB) deposition.

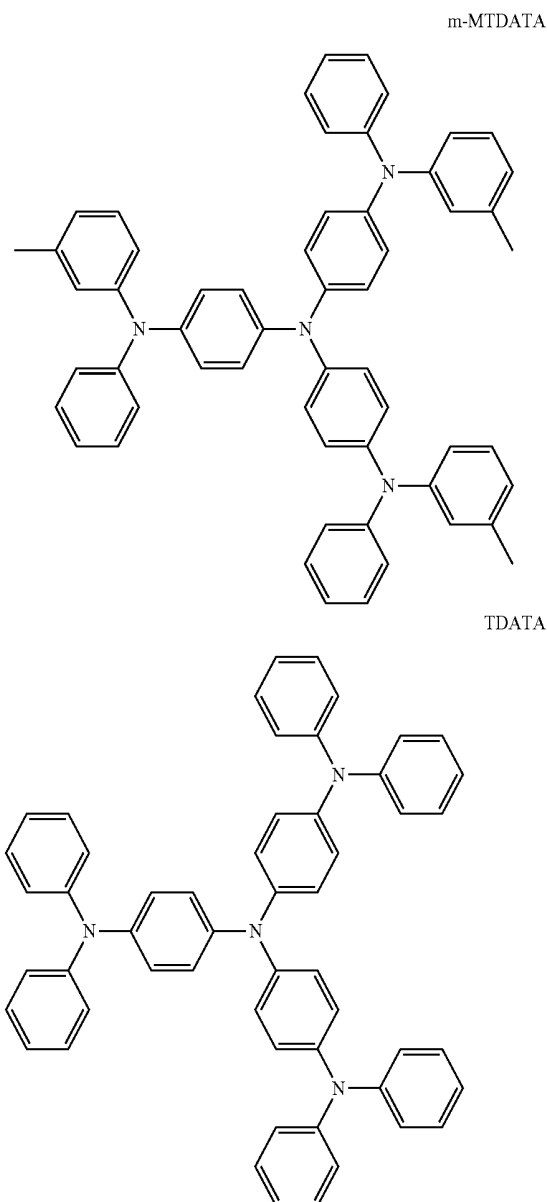
[0207] When a hole injection layer is formed by vacuum deposition, for example, the vacuum deposition may be performed at a deposition temperature in a range of about 100° C. to about 500° C., at a vacuum degree in a range of about 10⁻⁸ torr to about 10⁻³ torr, and at a deposition rate in a range of about 0 Angstroms per second (Å/sec) to about 100 Å/sec, though the conditions may vary depending on a compound that is used as a hole injection material and a structure and thermal properties of a desired hole injection layer, but conditions for the vacuum deposition are not limited thereto.

[0208] When a hole injection layer is formed by spin coating, the spin coating may be performed at a coating rate in a range of about 2,000 revolutions per minute (rpm) to about 5,000 rpm, and at a temperature in a range of about 80° C. to 200° C., to facilitate removal of a solvent after the spin coating, though the conditions may vary depending on

a compound that is used as a hole injection material and a structure and thermal properties of a desired hole injection layer, but conditions for the spin coating are not limited thereto.

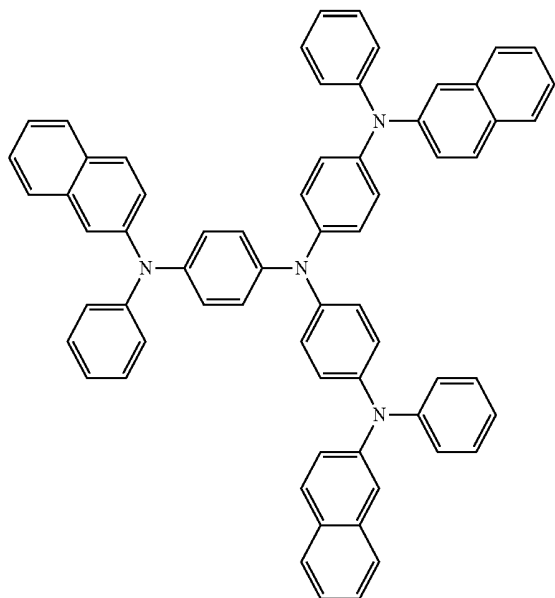
[0209] The conditions for forming a hole transport layer and an electron blocking layer may be inferred from the conditions for forming the hole injection layer.

[0210] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, β-NPB, TPD, spiro-TPD, spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrene sulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), (polyaniline)/poly(4-styrene sulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202:



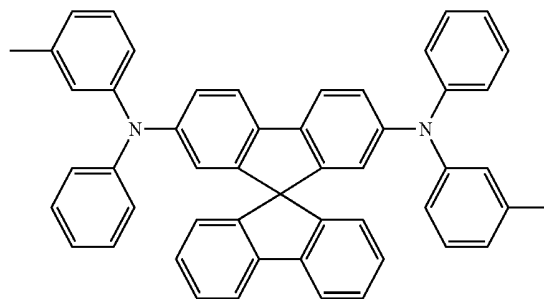
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2-TNATA

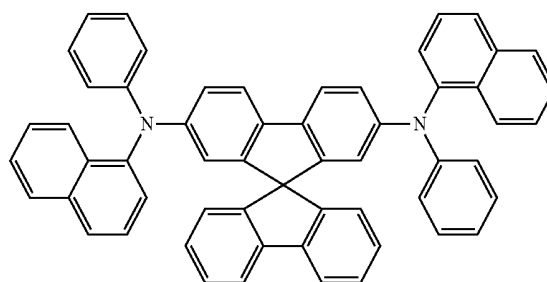


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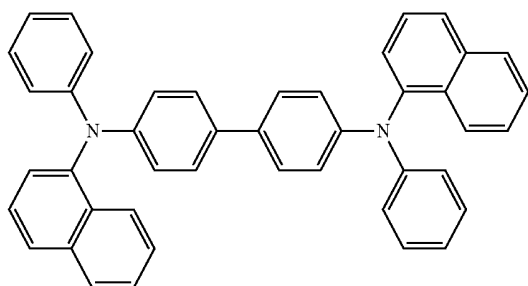
Spiro-TPD



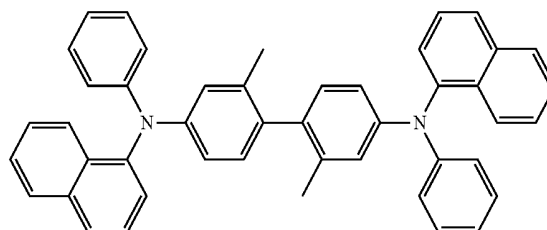
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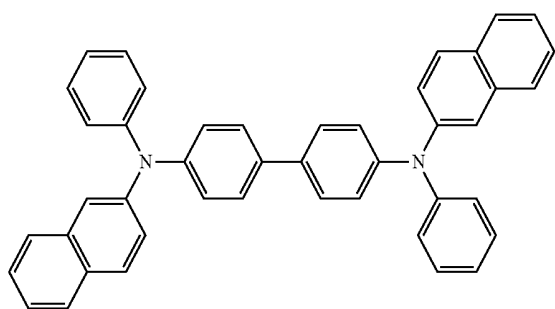
NPB



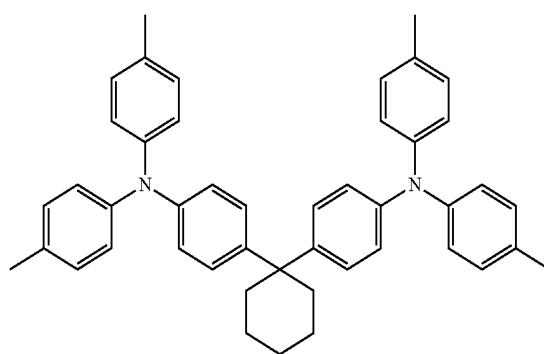
methylated NPB



β -NPB

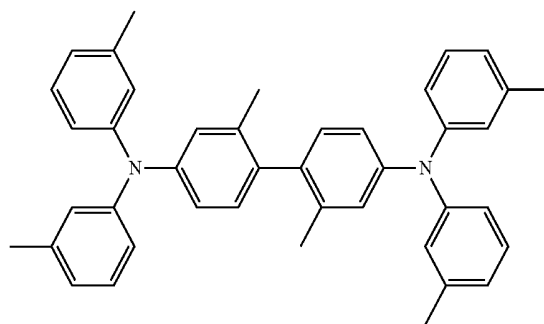
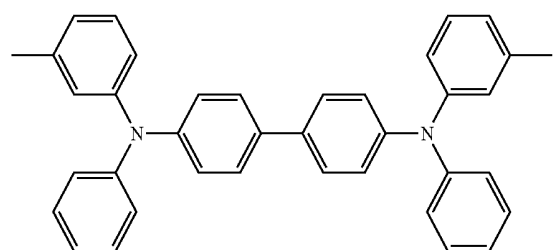


TAPC



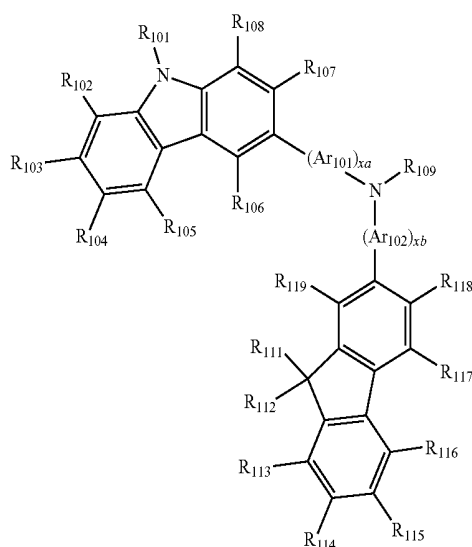
HMTPD

TPD

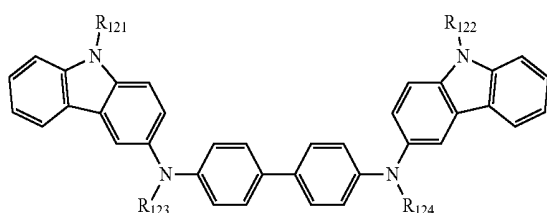


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Formula 201



Formula 202



[0211] wherein, in Formula 201, Ar₁₀₁ and Ar₁₀₂ may each independently be selected from

[0212] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group; and

[0213] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy

group, a C₃-C₁₀ cycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0214] In Formula 201, xa and xb may each independently be an integer from 0 to 5. In some embodiments, xa and xb may each independently be an integer from 0, 1, and 2.

[0215] In some embodiments, xa may be 1, and xb may be 0, but embodiments are not limited thereto.

[0216] In Formulae 201 and 202, R₁₀₁ to R₁₀₈, R₁₁₁ to R₁₁₉, and R₁₂₁ to R₁₂₄ may each independently be selected from

[0217] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group (e.g., a methyl group, an ethyl group, a propyl group, a butyl group, pentyl group, or a hexyl group), and a C₁-C₁₀ alkoxy group (e.g., a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group);

[0218] a C₁-C₁₀ alkyl group and a C₁-C₁₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0219] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group; and

[0220] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, and a C₁-C₁₀ alkoxy group, but embodiments are not limited thereto.

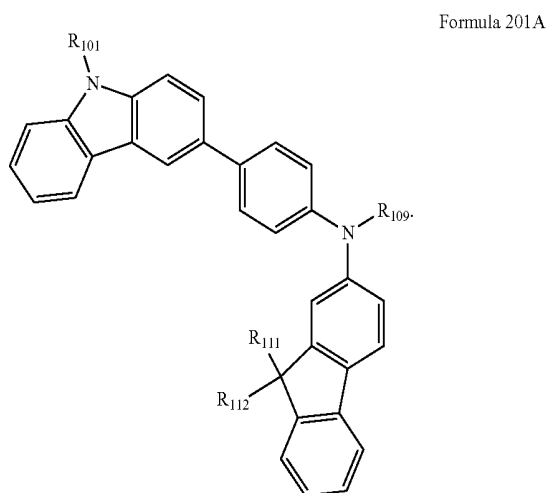
[0221] In Formula 201, R₁₀₉ may be selected from

[0222] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group; and

[0223] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a

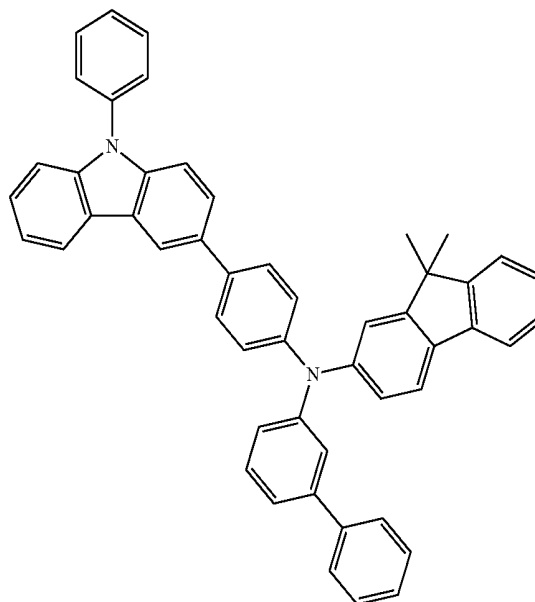
phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group.

[0224] In some embodiments, the compound represented by Formula 201 may be represented by Formula 201A, but embodiments are not limited thereto:



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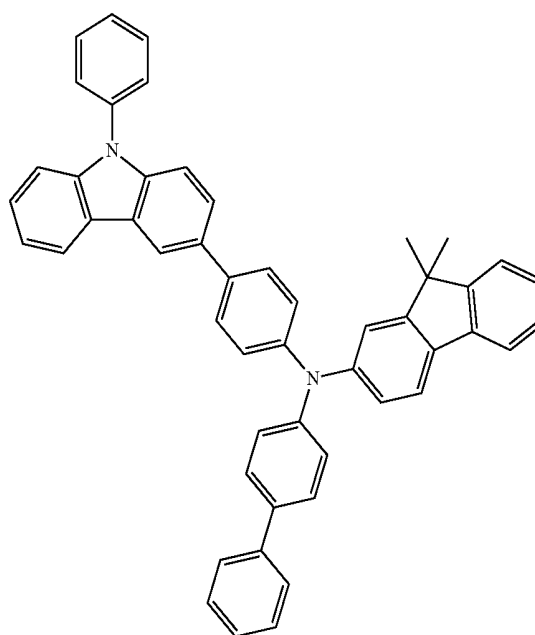
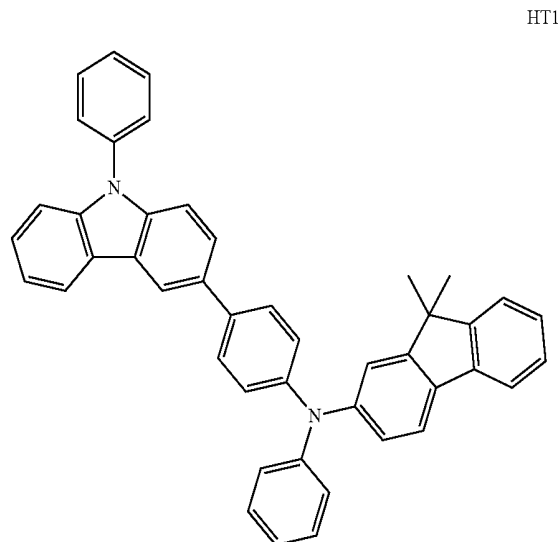
HT2



[0225] R_{101} , R_{111} , R_{112} , and R_{109} in Formula 201A may be understood by referring to the descriptions for those provided herein.

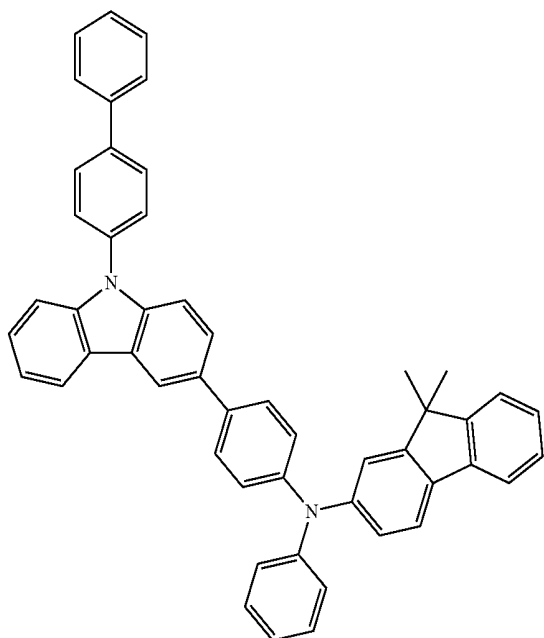
HT3

[0226] In some embodiments, the compounds represented by Formulae 201 and 202 may include Compounds HT1 to HT20, but embodiments are not limited thereto:



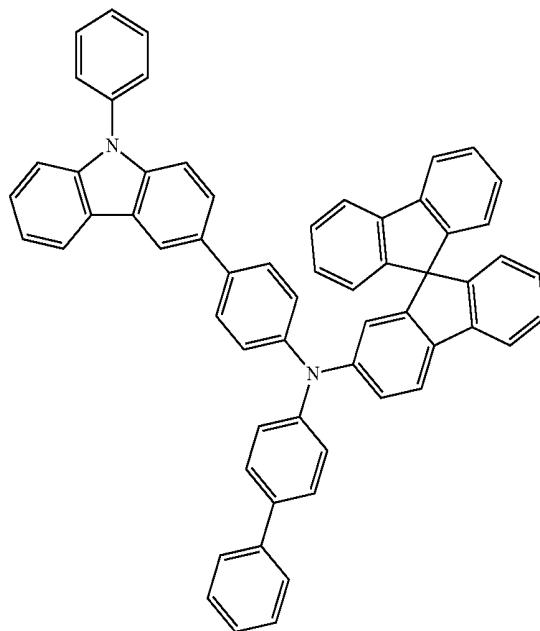
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HT4

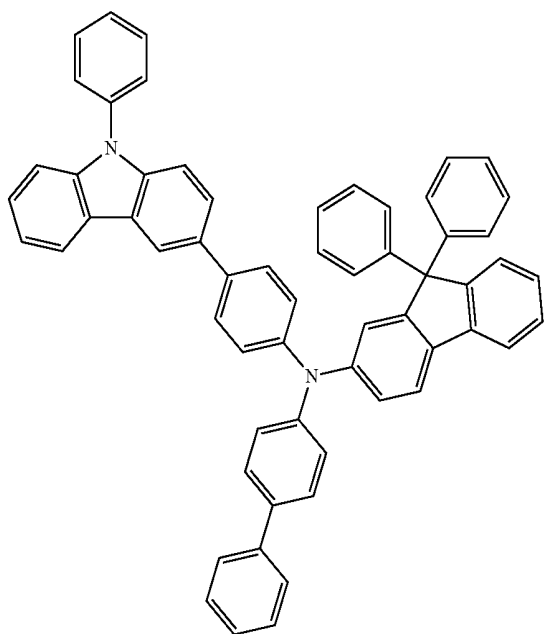


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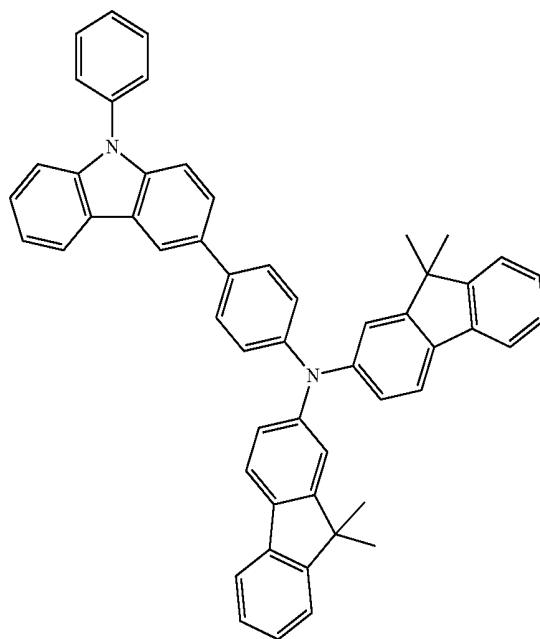
HT6



HT5

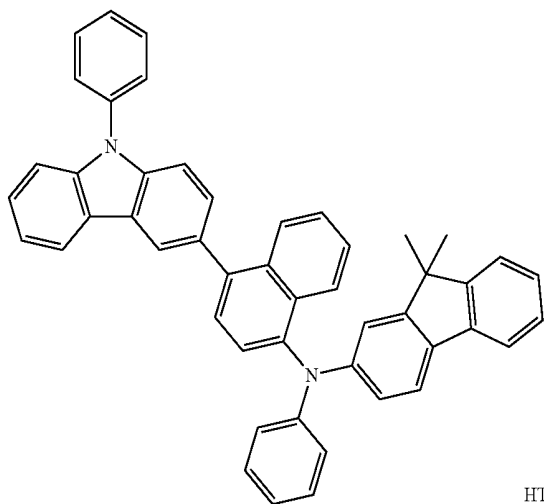


HT7

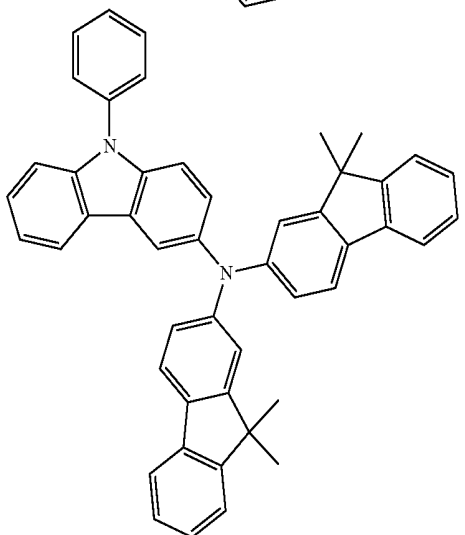


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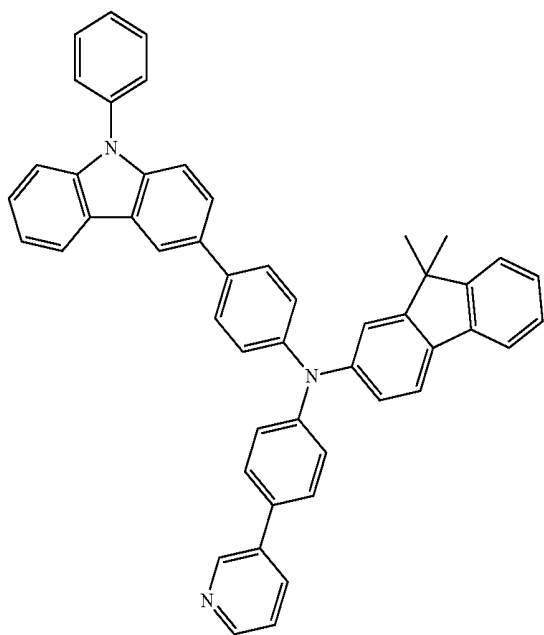
HT8



HT9

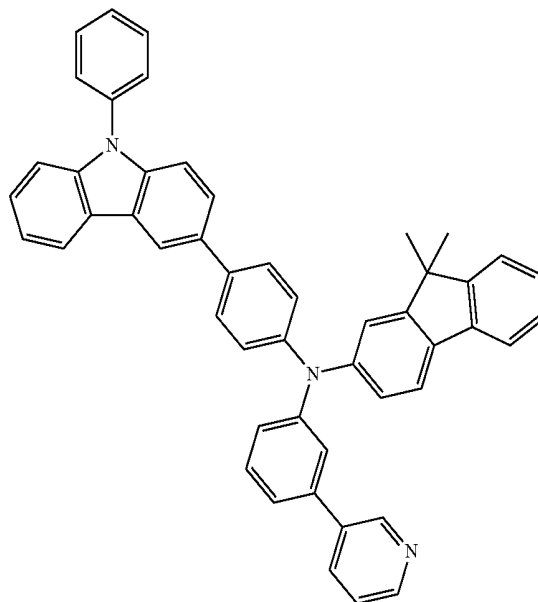


HT10

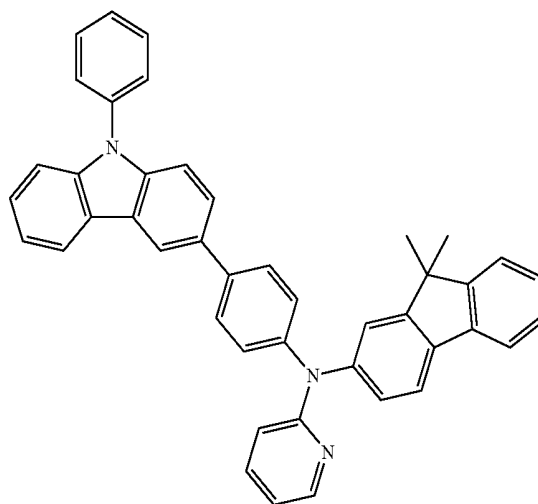


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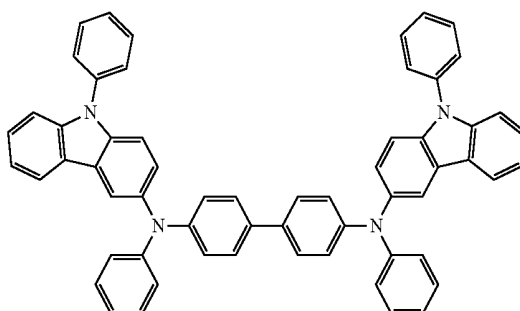
HT11



HT12

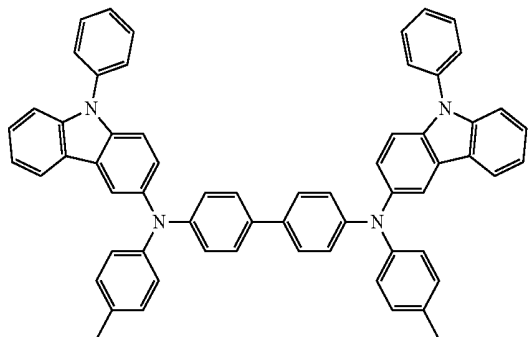


HT13

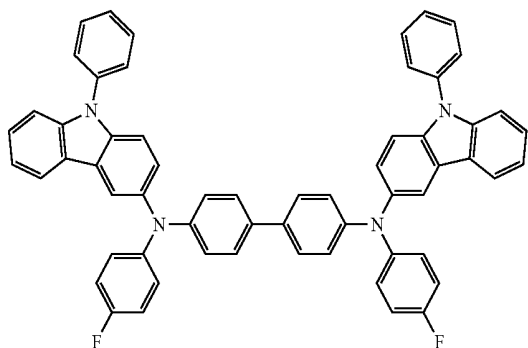


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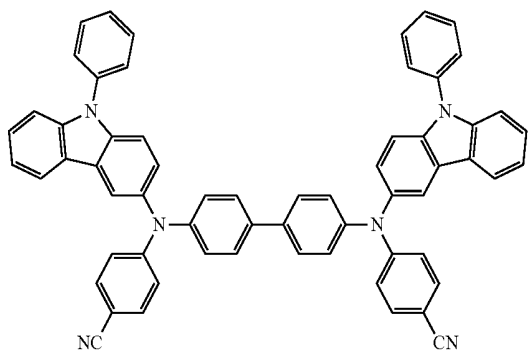
HT14



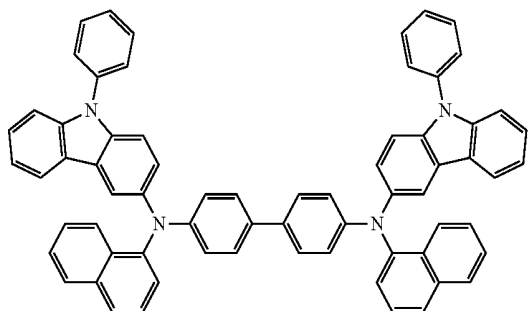
HT15



HT16

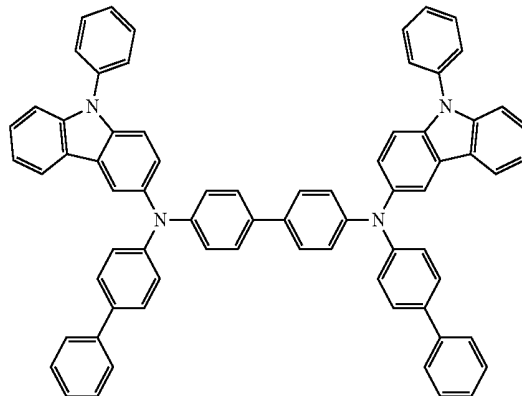


HT17

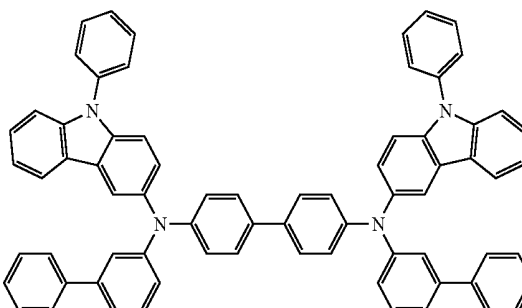


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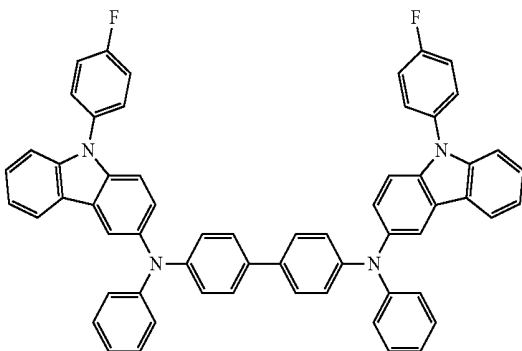
HT18



HT19



HT20



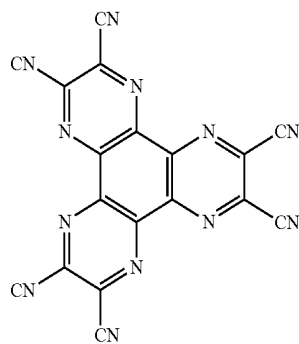
[0227] The thickness of the hole transport region may be in a range of about 100 (Angstroms) Å to about 10,000 Å, and in some embodiments, about 100 Å to about 1,000 Å. When the hole transport region includes at least one selected from a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, and in some embodiments, about 100 Å to about 1,000 Å, and the thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, and in some embodiments, about 100 Å to about 1,500 Å.

[0228] While not wishing to be bound by theory, it is understood that when the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within any of these ranges, excellent hole transport characteristics may be obtained without a substantial increase in driving voltage.

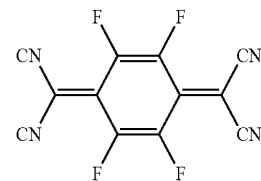
[0229] The hole transport region may include a charge generating material as well as the aforementioned materials,

to improve conductive properties of the hole transport region. The charge generating material may be substantially homogeneously or non-homogeneously dispersed in the hole transport region.

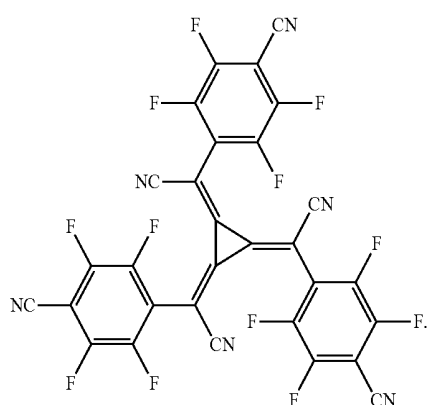
[0230] The charge generating material may include, for example, a p-dopant. The p-dopant may include one of a quinone derivative, a metal oxide, and a compound containing a cyano group, but embodiments are not limited thereto. For example, non-limiting examples of the p-dopant include a quinone derivative, such as tetracyanoquinodimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinodimethane (F4-TCNQ); a metal oxide, such as a tungsten oxide or a molybdenum oxide; and a compound containing a cyano group, such as Compound HT-D1 or Compound HT-D2, but embodiments are not limited thereto:



HT-D1



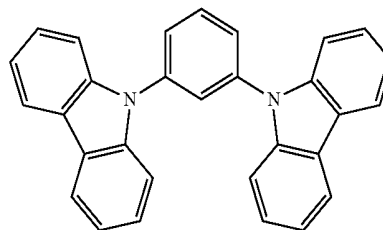
F4-TCNQ



HT-D2

ditions for forming the emission layer may be generally similar to the those conditions for forming a hole injection layer, though the conditions may vary depending on a compound that is used.

[0234] The hole transport region may further include an electron blocking layer. The electron blocking layer may include any suitable known material, e.g., mCP, but embodiments are not limited thereto:



mCP

[0235] The thickness of the electron blocking layer may be in a range of about 50 Å to about 1,000 Å, and in some embodiments, about 70 Å to about 500 Å. While not wishing to be bound by theory, it is understood that when the thickness of the electron blocking layer is within any of these ranges, excellent electron blocking characteristics may be obtained without a substantial increase in driving voltage.

[0236] When the organic light-emitting device 10 is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and a blue emission layer. In some embodiments, the emission layer may have a structure in which the red emission layer, the green emission layer, and/or the blue emission layer are layered to emit white light. In some embodiments, the structure of the emission layer may vary.

[0237] The emission layer may include the condensed cyclic compound represented by Formula 1.

[0238] In some embodiments, the emission layer may include the condensed cyclic compound represented by Formula 1 only.

[0239] In some embodiments, the emission layer may include:

[0240] the condensed cyclic compound represented by Formula 1,

[0241] i) the second compound (e.g., a compound represented by Formula H-1);

[0242] ii) the organometallic compound represented by Formula 81; or

[0243] iii) any combination of i) and ii).

[0244] The condensed cyclic compound represented by Formula 1, the second compound, and the organometallic compound represented by Formula 81 may be understood by referring to the descriptions for those provided herein.

[0245] When the emission layer includes the host and the dopant, an amount of the dopant may be selected from a range of about 0.01 parts to about 20 parts by weight based on about 100 parts by weight of the emission layer, but embodiments are not limited thereto. While not wishing to be bound by theory, it is understood that when the amount of the dopant is within this range, light emission without quenching may be realized.

[0246] When the emission layer includes the condensed cyclic compound represented by Formula 1 and the second

[0231] The hole transport region may further include a buffer layer.

[0232] The buffer layer may compensate for an optical resonance distance depending on a wavelength of light emitted from the emission layer to improve the efficiency of an organic light-emitting device.

[0233] An emission layer may be formed on the hole transport region by using one or more suitable methods, such as vacuum deposition, spin coating, casting, or LB deposition. When the emission layer is formed by vacuum deposition or spin coating, vacuum deposition and coating with

compound, a weight ratio of the condensed cyclic compound represented by Formula 1 to the second compound may be in a range of about 1:99 to about 99:1, for example, about 70:30 to about 30:70. In some embodiments, a weight ratio of the condensed cyclic compound represented by Formula 1 to the second compound may be in a range of about 60:40 to about 40:60.

[0247] While not wishing to be bound by theory, it is understood that when the weight ratio of the condensed cyclic compound represented by Formula 1 to the second compound in the emission layer is within any of these ranges, the charge transport balance may be efficiently achieved in the emission layer.

[0248] The thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, and in some embodiments, about 200 Å to about 600 Å. While not wishing to be bound by theory, it is understood that when the thickness of the emission layer is within any of these ranges, improved luminescence characteristics may be obtained without a substantial increase in driving voltage.

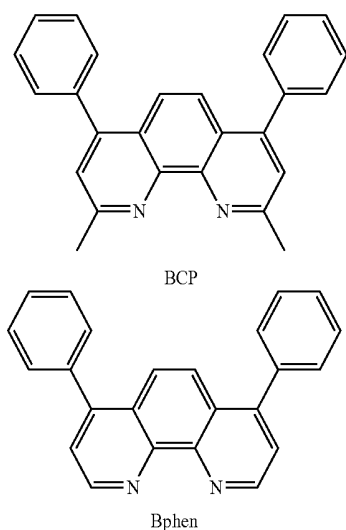
[0249] Next, an electron transport region may be formed on the emission layer.

[0250] The electron transport region may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

[0251] In some embodiments, the electron transport region may have a hole blocking layer/an electron transport layer/an electron injection layer structure or an electron transport layer/an electron injection layer structure, but embodiments are not limited thereto. The electron transport layer may have a single-layered structure or a multi-layered structure including two or more different materials.

[0252] The conditions for forming a hole blocking layer, an electron transport layer, and an electron injection layer may be inferred based on the conditions for forming the hole injection layer.

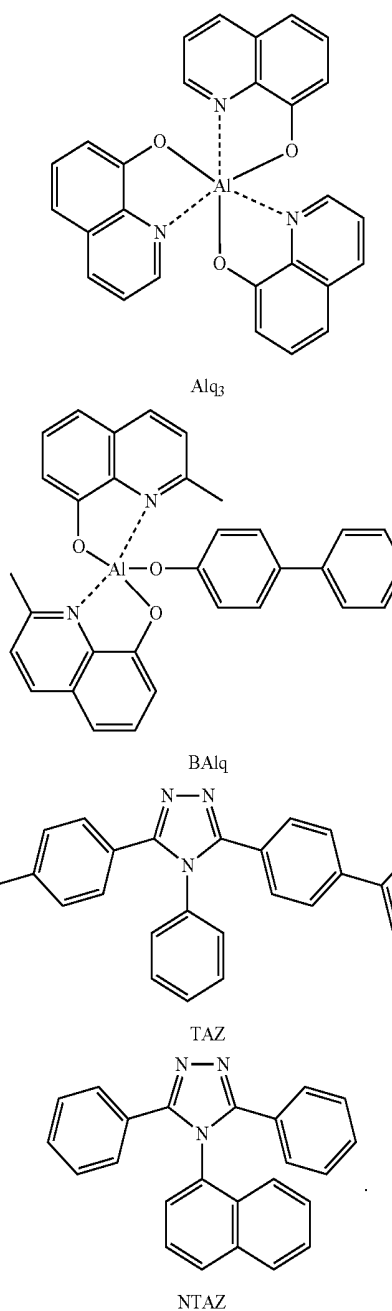
[0253] When the electron transport region includes a hole blocking layer, the hole blocking layer, for example, may include at least one of BCP and Bphen, but embodiments are not limited thereto:



[0254] The hole blocking layer may include the condensed cyclic compound represented by Formula 1.

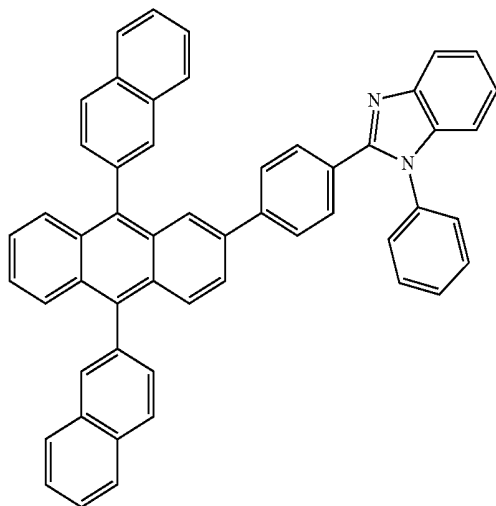
[0255] The thickness of the hole blocking layer may be in a range of about 20 Å to about 1,000 Å, and in some embodiments, about 30 Å to about 300 Å. While not wishing to be bound by theory, it is understood that when the thickness of the hole blocking layer is within any of these ranges, excellent hole blocking characteristics may be obtained without a substantial increase in driving voltage.

[0256] The electron transport layer may further include at least one selected from BCP, BPhen, Alq₃, BAq, TAZ, and NTAZ:

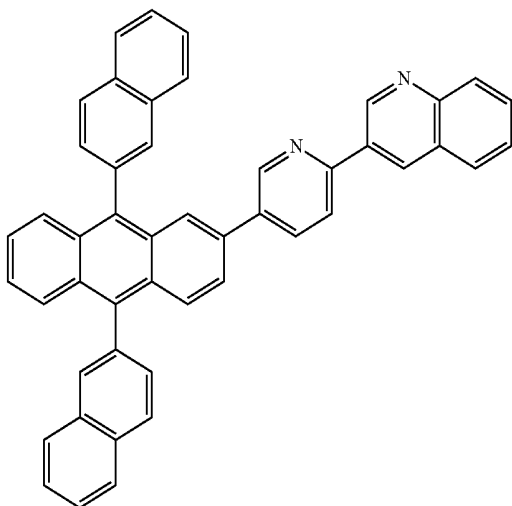


[0257] In some embodiments, the electron transport layer may include at least one selected from Compounds ET1, ET2, and ET3, but embodiments are not limited thereto:

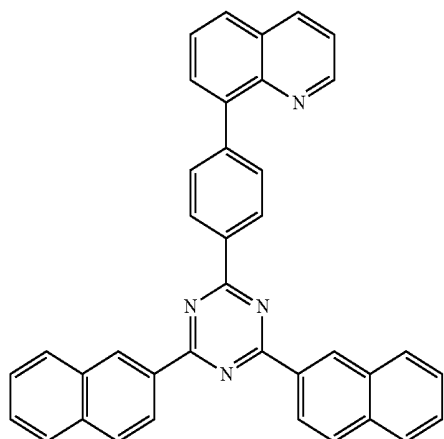
ET1



ET2



ET3



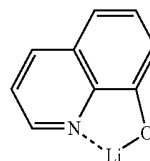
[0258] The thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, and in some embodiments, about 150 Å to about 500 Å. While not wishing to be bound by theory, it is understood that when the thickness of the electron transport layer is within any of

these ranges, excellent electron transport characteristics may be obtained without a substantial increase in driving voltage.

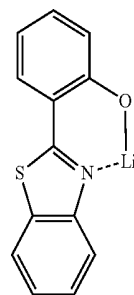
[0259] The electron transport layer may further include a material containing metal, in addition to the materials described above.

[0260] The material containing metal may include a L_1 complex. The L_1 complex may include, e.g., Compound ET-D1 (lithium 8-hydroxyquinolate, LiQ) or Compound ET-D2:

ET-D1



ET-D2



[0261] The electron transport region may include an electron injection layer that facilitates electron injection from the second electrode 19.

[0262] The electron injection layer may include at least one selected from LiQ, LiF, NaCl, CsF, Li_2O , and BaO.

[0263] The thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. While not wishing to be bound by theory, it is understood that when the thickness of the electron injection layer is within any of these ranges, excellent electron injection characteristics may be obtained without a substantial increase in driving voltage.

[0264] The second electrode 19 may be on the organic layer 15. The second electrode 19 may be a cathode. A material for forming the second electrode 19 may be a material with a relatively low work function, such as a metal, an alloy, an electrically conductive compound, and a mixture thereof. Examples of the material for forming the second electrode 19 may include lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, ITO or IZO may be used to form a transmissive second electrode 19 to manufacture a top emission light-emitting device. In some embodiments, the material for forming the second electrode 19 may vary.

[0265] Hereinbefore the organic light-emitting device 10 has been described with reference to the FIGURE, but embodiments are not limited thereto.

[0266] The term “ C_1 - C_{60} alkyl group” as used herein refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms.

[0267] Examples thereof include a methyl group, an ethyl group, a propyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a

hexyl group. The term “C₁-C₆₀ alkylene group” as used herein refers to a divalent group having substantially the same structure as the C₁-C₆₀ alkyl group.

[0268] The term “C₁-C₆₀ alkoxy group” as used herein refers to a monovalent group represented by —OA₁₀₁ (wherein A₁₀₁ is a C₁-C₆₀ alkyl group). Examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group.

[0269] The term “C₂-C₆₀ alkenyl group” as used herein refers to a group formed by including at least one carbon-carbon double bond in the middle or at the terminus of the C₂-C₆₀ alkyl group. Examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term “C₂-C₆₀ alkenylene group” as used herein refers to a divalent group having substantially the same structure as the C₂-C₆₀ alkenyl group.

[0270] The term “C₂-C₆₀ alkynyl group” as used herein refers to a group formed by including at least one carbon-carbon triple bond in the middle or at the terminus of the C₂-C₆₀ alkyl group. Examples thereof include an ethynyl group and a propenyl group. The term “C₂-C₆₀ alkynylene group” as used herein refers to a divalent group having substantially the same structure as the C₂-C₆₀ alkynyl group.

[0271] The term “C₃-C₁₀ cycloalkyl group” as used herein refers to a monovalent monocyclic saturated hydrocarbon group including 3 to 10 carbon atoms. Examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term “C₃-C₁₀ cycloalkylene group” as used herein refers to a divalent group having substantially the same structure as the C₃-C₁₀ cycloalkyl group.

[0272] The term “C₁-C₁₀ heterocycloalkyl group” as used herein refers to a monovalent monocyclic group including at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom and 1 to 10 carbon atoms. Examples thereof include a tetrahydrofuran group and a tetrahydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkylene group” as used herein refers to a divalent group having substantially the same structure as the C₁-C₁₀ heterocycloalkyl group.

[0273] The term “C₃-C₁₀ cycloalkenyl group” as used herein refers to a monovalent monocyclic group including 3 to 10 carbon atoms and at least one carbon-carbon double bond in its ring, wherein the molecular structure as a whole is non-aromatic. Examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term “C₃-C₁₀ cycloalkenylene group” as used herein refers to a divalent group having substantially the same structure as the C₃-C₁₀ cycloalkenyl group.

[0274] The term “C₁-C₁₀ heterocycloalkenyl group” as used herein refers to a monovalent monocyclic group including at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom, 1 to 10 carbon atoms, and at least one double bond in its ring. Examples of the C₂-C₁₀ heterocycloalkenyl group include a 2,3-dihydrofuran group and a 2,3-dihydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkylene group” as used herein refers to a divalent group having substantially the same structure as the C₁-C₁₀ heterocycloalkenyl group.

[0275] The term “C₆-C₆₀ aryl group” as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. The term “C₆-C₆₀ arylene group” as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms.

Examples of the C₆-C₆₀ aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C₆-C₆₀ aryl group and a C₆-C₆₀ arylene group each include at least two rings, the at least two rings may be fused.

[0276] The term “C₁-C₆₀ heteroaryl group” as used herein refers to a monovalent group having a carbocyclic aromatic system having at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom and 1 to 60 carbon atoms. The term “C₁-C₆₀ heteroarylene group” as used herein refers to a divalent group having a carbocyclic aromatic system having at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 1 to 60 carbon atoms. Examples of the C₁-C₆₀ heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C₁-C₆₀ heteroaryl group and the C₁-C₆₀ heteroarylene group each include at least two rings, the at least two rings may be fused.

[0277] The term “C₆-C₆₀ aryloxy group” as used herein refers to a group represented by —OA₁₀₂ (where A₁₀₂ is a C₆-C₆₀ aryl group). The term “C₆-C₆₀ arylthio group” as used herein refers to a group represented by —SA₁₀₃ (where A₁₀₃ is a C₆-C₆₀ aryl group).

[0278] The term “monovalent non-aromatic condensed polycyclic group” as used herein refers to a monovalent group having two or more rings condensed and only carbon atoms (for example, the number of carbon atoms may be in a range of 8 to 60) as ring-forming atoms, wherein the molecular structure as a whole is non-aromatic. Examples of the non-aromatic condensed polycyclic group include a fluorenyl group. The term “divalent non-aromatic condensed polycyclic group” as used herein refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed polycyclic group.

[0279] The term “monovalent non-aromatic condensed heteropolycyclic group” as used herein refers to a monovalent group having at least two rings condensed and a heteroatom selected from N, O, P, Si, and S as well as carbon atoms (for example, the number of carbon atoms may be in a range of 1 to 60) as ring-forming atoms, wherein the molecular structure as a whole is non-aromatic. Examples of the monovalent non-aromatic condensed heteropolycyclic group include a carbazolyl group. The term “divalent non-aromatic condensed heteropolycyclic group” as used herein refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0280] In the present specification, at least one substituent of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0281] deuterium, —CD₃, —CD₂H, —CDH₂, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof,

a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;

[0282] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from deuterium, —CD₃, —CD₂H, —CDH₂, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —N(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇);

[0283] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0284] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —CD₃, —CD₂H, —CDH₂, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₂₁)(Q₂₂)(Q₂₃), —N(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇); and

[0285] —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

[0286] wherein, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted

C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

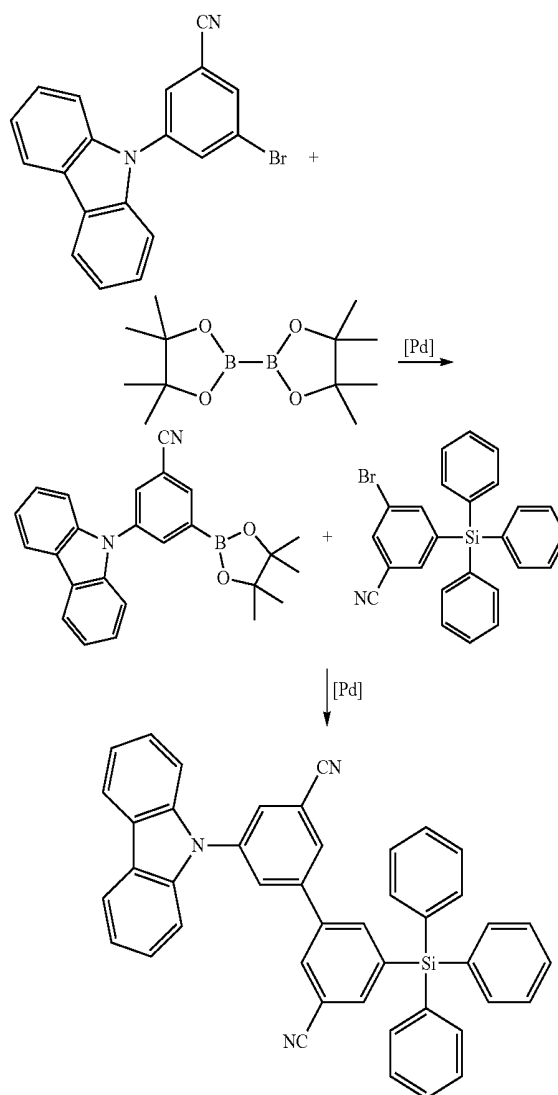
[0287] The symbols * and ** as used herein, unless defined otherwise, refer to a binding site to an adjacent atom in the formula.

[0288] Hereinafter, a compound and an organic light-emitting device according to an embodiment will be described in detail with reference to Synthesis Examples and Examples, however, the present disclosure is not limited thereto. The wording “B was used instead of A” used in describing Synthesis Examples means that an identical molar equivalent of B was used in place of A.

EXAMPLES

Synthesis Example 1: Synthesis of Compound 505

[0289]



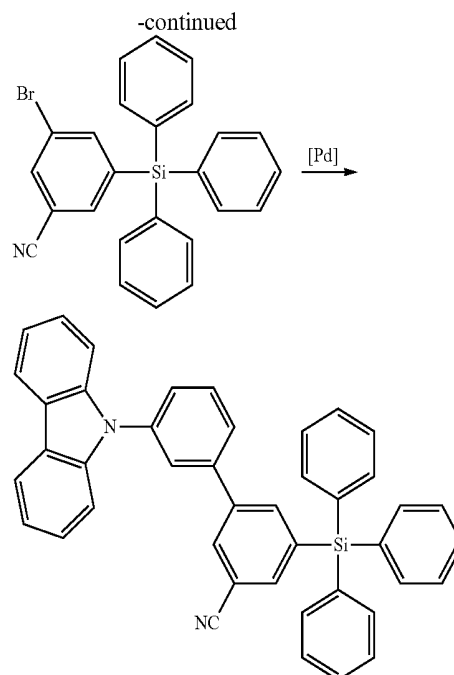
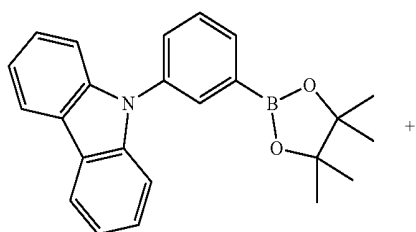
[0290] 13.21 grams (g), 38.04 millimoles (mmol) of 3-bromo-5-(9H-carbazol-9-yl)benzotrile, 14.49 g (57.07 mmol) of bis(pinacolato)diboron, 1.55 g (1.90 mmol) of PdCl₂(dppf), and 11.20 g (114.13 mmol) of KOAc were mixed with 127 milliliters (mL) of dimethyl formamide (DMF). The mixture was then heated and stirred in a sealed tube at a temperature of 100° C. for 18 hours. The resulting product was cooled to room temperature and diluted by adding 700 mL of ethyl acetate. The solid content was removed therefrom using a Celite filter. Subsequently, the resultant was washed three times using 600 mL of H₂O. The water was removed from the solution using MgSO₄, and the organic solvent was removed therefrom using a rotary evaporator. Silica hot-filtration was performed thereon using 400 mL of toluene, and then extraction was performed using additional 400 mL of toluene. Subsequently, the solution was concentrated to 100 mL, followed by addition of 600 mL of MeOH and stirring at room temperature for 4 hours. The formed solid content was subjected to filtration, followed by vacuum-drying, thereby obtaining 9.0 g of 3-(9H-carbazol-9-yl)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzotrile. This compound was used in the following reaction without any additional purification.

[0291] 3.14 g (7.96 mmol) of 3-(9H-carbazol-9-yl)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzotrile, 4.56 g (10.35 mmol) of 3-bromo-5-(triphenylsilyl)benzotrile, 0.46 g (0.40 mmol) of Pd(PPh₃)₄, and 7.78 g (23.89 mmol) of Cs₂CO₃ were mixed with 35 mL of 1,4-dioxane, followed by heating and stirring at a temperature of 160° C. for 18 hours. The resulting product was cooled to room temperature and diluted by adding 200 mL of ethyl acetate. The solid content was removed therefrom using a Celite filter. Subsequently, the resultant was washed three times using 200 mL of H₂O. Then, water was removed from the solution using MgSO₄, followed by filtration using 300 g of silica gel and removing the solvent therefrom using a rotary evaporator. The solid content was dissolved using 100 mL of methylene chloride, and the solvent was substituted using 20 mL of ethyl acetate, thereby obtaining a solid content. Then, 3.65 g of Compound 505 was obtained by vacuum-drying. The obtained Compound 505 was identified using liquid chromatography-mass spectrometry (LC-MS).

[0292] C₄₄H₂₉N₃Si: M+ 627.27

Synthesis Example 2: Synthesis of Compound 21

[0293]

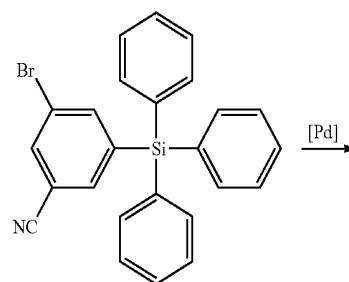
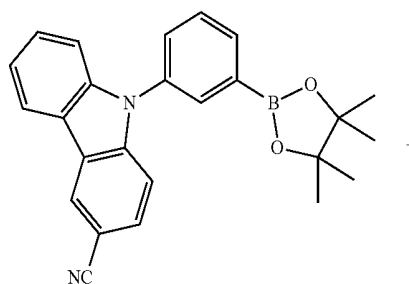


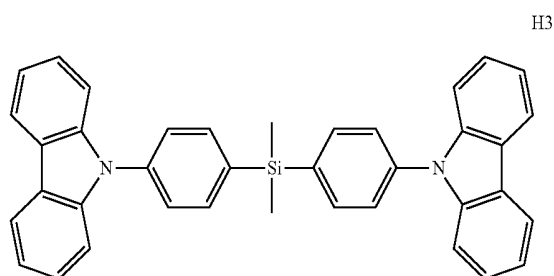
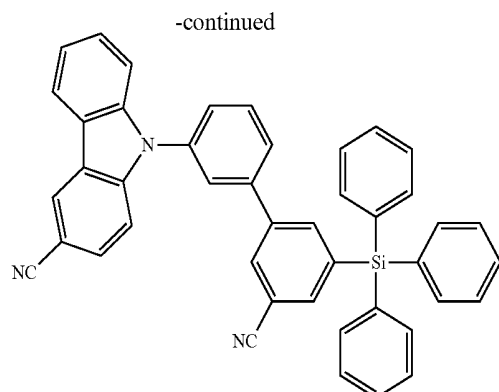
[0294] Compound 21 was prepared in substantially the same manner as in Synthesis Example 1, except that 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole was used instead of 3-(9H-carbazol-9-yl)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzotrile. The obtained Compound 21 was identified using LC-MS.

[0295] C₄₃H₃₀N₂Si: M+ 602.26

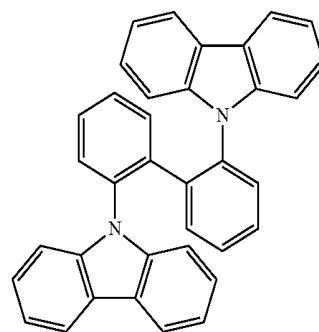
Synthesis Example 3: Synthesis of Compound 277

[0296]





H13



ET3

[0297] Compound 277 was prepared in substantially the same manner as in Synthesis Example 1, except that 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole-3-carbonitrile was used instead of 3-(9H-carbazol-9-yl)-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzonitrile. The obtained Compound 277 was identified using LC-MS.

[0298] $C_{44}H_{29}N_3Si$: M+ 627.18

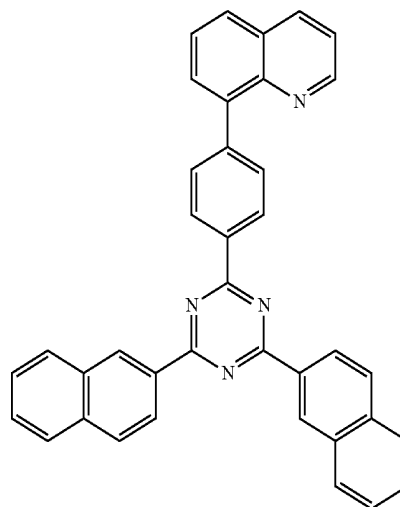
Example 1

[0299] As a first electrode (an anode), a glass substrate having an ITO electrode deposited thereon at a thickness of 1,500 Å was washed with distilled water in the presence of ultrasound waves. Once the washing with distilled water was complete, ultrasound wave washing was performed on the substrate using a solvent, such as iso-propyl alcohol, acetone, or methanol. Subsequently, the substrate was dried, transferred to a plasma washer, washed for 5 minutes using oxygen plasma, and mounted in a vacuum depositor.

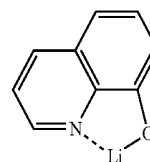
[0300] Compound HT3 was vacuum-deposited on the ITO electrode of the glass substrate to form a hole injection layer having a thickness of 100 Å, and Compound HT13 was deposited on the hole injection layer to form a hole transport layer having a thickness of 1,300 Å, thereby forming a hole transport region.

[0301] Subsequently, Compound 505 (host) and Compound PD97 (dopant, 10 percent by weight (weight %)) were deposited on the hole transport region to form an emission layer having a thickness of about 300 Å.

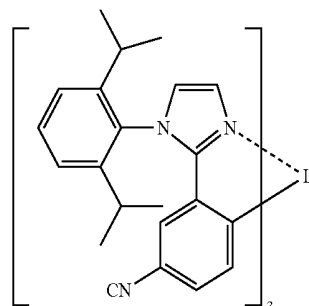
[0302] BCP was vacuum deposited on the emission layer to form a hole blocking layer having a thickness of about 50 Å. Compound ET3 and LiQ were then co-deposited on the hole blocking layer to form an electron transport layer having a thickness of about 250 Å. Next, LiQ was deposited on the electron transport layer to form an electron injection layer having a thickness of about 5 Å, and then, aluminum (Al) second electrode (a cathode) having a thickness of 1,000 Å was formed on the electron injection layer, thereby completing the manufacture of an organic light-emitting device.



LiQ



PD79



[0313] Referring to Table 2, it was found that the organic light-emitting devices of Examples 1 to 3 had similar or better driving voltage, current efficiency, luminescence efficiency, and lifespan characteristics, as compared with the organic light-emitting devices of Comparative Examples 1 and 2.

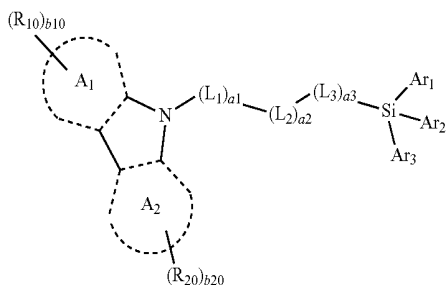
[0314] As apparent from the foregoing description, the condensed cyclic compound according to embodiments has excellent electric characteristics and thermal stability. Accordingly, an organic light-emitting device including the condensed cyclic compound may have a low driving voltage, high efficiency, high power, high quantum yield, and long lifespan.

[0315] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

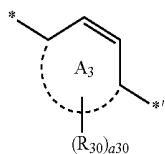
[0316] While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present description as defined by the following claims.

What is claimed is:

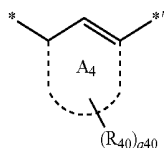
1. A condensed cyclic compound represented by Formula 1:



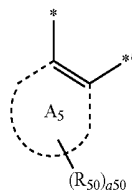
Formula 1



Formula 2



Formula 3



Formula 4

wherein in Formulae 1 to 4,

Ar₁ to Ar₃ are each independently -(L₄)_{a4}-(R₆₀)_{a60},

L₁ to L₄ are each independently a group represented by one selected from Formulae 2 to 4,

a₁ and a₃ are each independently an integer from 1 to 3, a₂ and a₄ are each independently an integer from 0 to 3, rings A₁ to A₅ are each independently a C₅-C₆₀ carbocyclic group or a C₂-C₆₀ heterocyclic group,

R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ are each independently selected from hydrogen, deuterium, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —N(Q₄)(Q₅), and —B(Q₆)(Q₇),

wherein at least one selected from R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ is a cyano group,

b₁₀, b₂₀, b₃₀, b₄₀, b₅₀, and b₆₀ are each independently an integer from 1 to 10, and

at least one substituent of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;

a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ hetero-

cycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —N(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇);

a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₂₁)(Q₂₂)(Q₂₃), —N(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇); and

—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇);

wherein Q₁ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazine group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

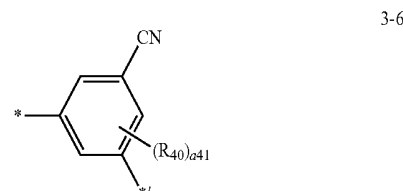
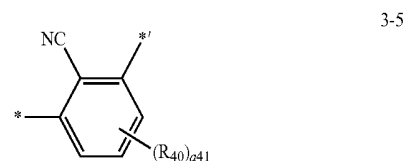
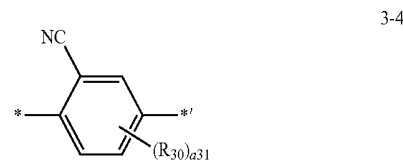
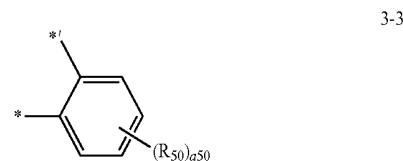
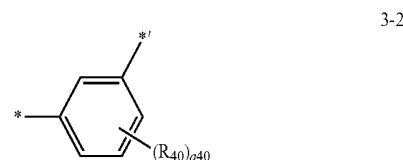
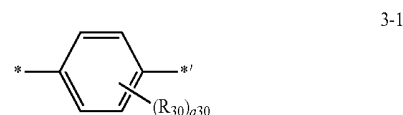
2. The condensed cyclic compound of claim 1, wherein a₄ is 1, 2, or 3.

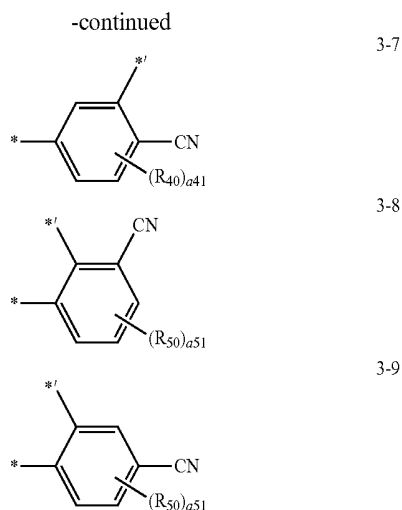
3. The condensed cyclic compound of claim 1, wherein rings A₁ and A₅ are each independently selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, an indene group, a pyrrole group, a thiophene group, a furan group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a quinoxaline group, a quinazoline group, a carbazole group, a benzimidazole group, a benzofuran group, a benzothiothiophene group, an isobenzothiothiophene group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a dibenzofuran group, and a dibenzothiothiophene group.

4. The condensed cyclic compound of claim 1, wherein rings A₁ and ring A₂ are each independently selected from a benzene group, a naphthalene group, a fluorene group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a carbazole group, a triazine group, a dibenzofuran group, and a dibenzothiothiophene group.

5. The condensed cyclic compound of claim 1, wherein rings A₃ to A₅ are each a benzene group.

6. The condensed cyclic compound of claim 1, wherein L₁ to L₃ are each independently a group represented by one selected from Formulae 3-1 to 3-9:





wherein, in Formulae 3-1 to 3-9,

R_{30} , R_{40} , R_{50} , a_{30} , a_{40} , and a_{50} are each as defined in claim 1,

a_{30} , a_{40} , and a_{50} are each independently an integer from 1 to 4, and

a_{31} , a_{41} , and a_{51} are each independently an integer from 1 to 3.

7. The condensed cyclic compound of claim 1, wherein R_{10} , R_{20} , R_{30} , R_{40} , R_{50} , and R_{60} are each independently selected from

hydrogen, deuterium, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, and a triazinyl group;

a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluo-ranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pyrrolyl group, an imidazolyl group, a pyrazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl

group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoxazolyl group, a benzimidazolyl group, a furanyl group, a benzofuranyl group, a thiophenyl group, a benzothiophenyl group, a thiazolyl group, an isothiazolyl group, a benzothiazolyl group, an isoxazolyl group, an oxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, imidazopyridimidinyl group, and an imidazopyridinyl group; and

a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluo-ranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pyrrolyl group, an imidazolyl group, a pyrazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoxazolyl group, a benzimidazolyl group, a furanyl group, a benzofuranyl group, a thiophenyl group, a benzothiophenyl group, a thiazolyl group, an isothiazolyl group, a benzothiazolyl group, an isoxazolyl group, an oxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, imidazopyridimidinyl group, and an imidazopyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a phthalazinyl group, a quinoxalinyl group, a cinnolinyl group, and a quinazolinyl group, and

at least one selected from R_{10} , R_{20} , R_{30} , R_{40} , R_{50} , and R_{60} is a cyano group,

8. The condensed cyclic compound of claim 1, wherein R_{10} , R_{20} , R_{30} , R_{40} , R_{50} , and R_{60} are each independently selected from

hydrogen, deuterium, a cyano group, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group;

a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

a cyclopentyl group, a cyclohexyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, and

at least one selected from R₁₀, R₂₀, R₃₀, R₄₀, R₅₀, and R₆₀ is a cyano group,

9. The condensed cyclic compound of claim 1, wherein the number of cyano groups comprised in the condensed cyclic compound represented by Formula 1 is 1 to 5.

10. The condensed cyclic compound of claim 1, wherein

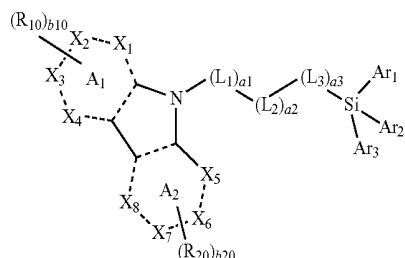
(i) at least one selected from R₁₀ and R₂₀ is a cyano group, and R₃₀, R₄₀, and R₅₀ are each independently a cyano group,

(ii) at least one selected from R₃₀, R₄₀, and R₅₀ is a cyano group, and R₁₀ and R₂₀ are each independently a cyano group, or

(iii) R₆₀ is a cyano group.

11. The condensed cyclic compound of claim 1, wherein at least one selected from R₁₀ and R₂₀ and at least one selected from R₃₀, R₄₀, and R₅₀ are each a cyano group.

12. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound represented by Formula 1 is represented by Formula 10:



Formula 10

wherein, in Formula 10,

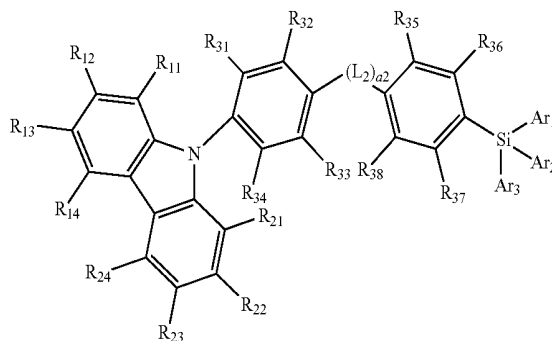
A₁, A₂, R₁₀, R₂₀, b₁₀, b₂₀, L₁, L₂, L₃, a₁, a₂, a₃, and Ar₁ to Ar₃ are each as defined in claim 1,

X₁ to X₄ are each independently selected from carbon (C) and nitrogen (N), and

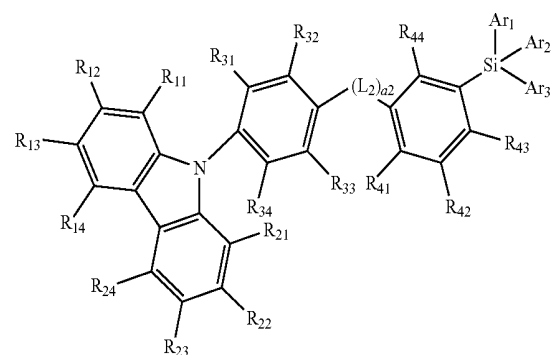
X₅ to X₈ are each independently selected from C and N.

13. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound represented by Formula 1 is represented by one of Formulae 10-1 to 1-9:

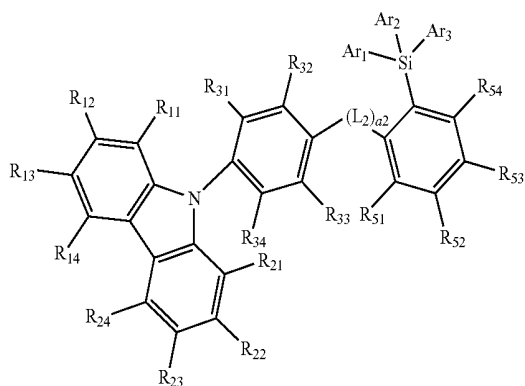
Formula 10-1



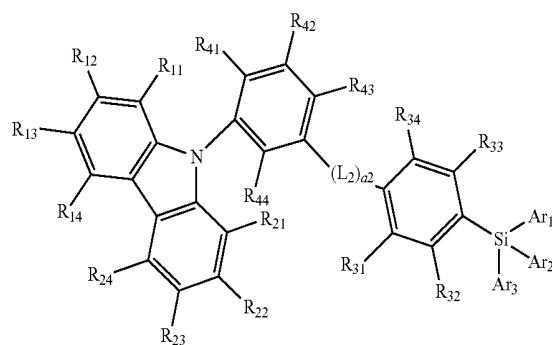
Formula 10-2



Formula 10-3

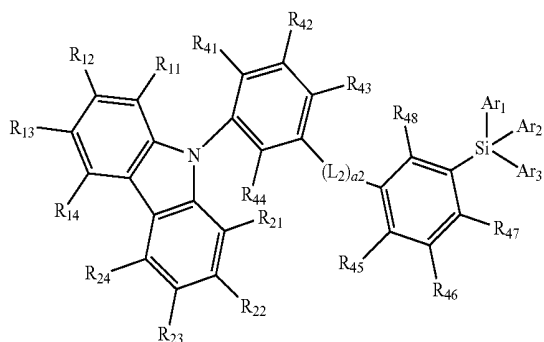


Formula 10-4

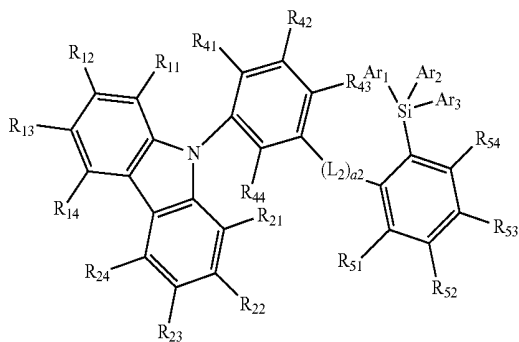


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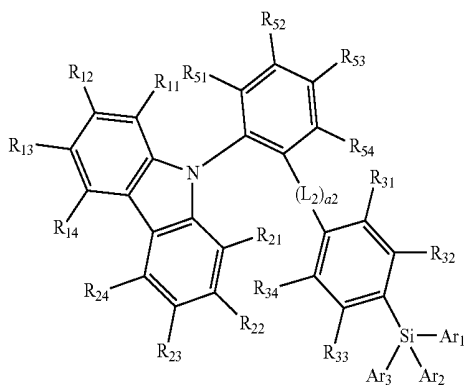
Formula 10-5



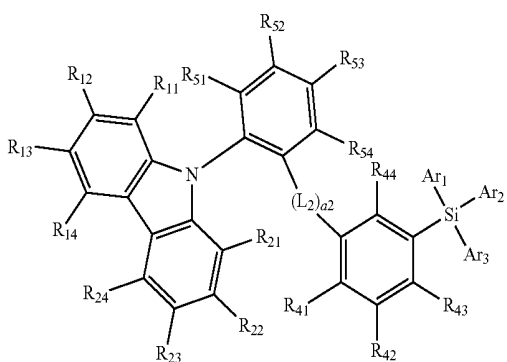
Formula 10-6



Formula 10-7

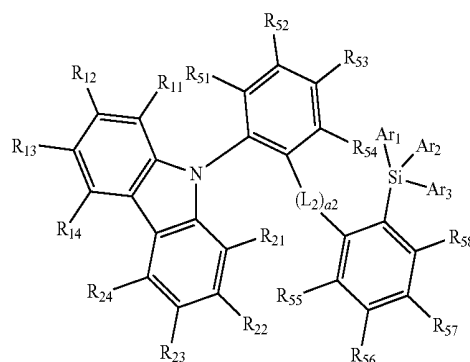


Formula 10-8



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Formula 10-9



wherein, in Formulae 10-1 to 10-9,

L_2 , a_2 , and Ar_1 to Ar_3 are each as defined in claim 1,

R_{11} to R_{14} are each independently defined the same as R_{10} in claim 1,

R_{21} to R_{24} are each independently defined the same as R_{20} in claim 1,

R_{31} to R_{38} are each independently defined the same as R_{30} in claim 1,

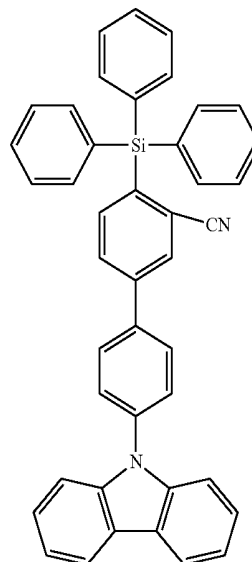
R_{41} to R_{48} are each independently defined the same as R_{40} in claim 1,

R_{51} to R_{58} are each independently defined the same as R_{50} in claim 1, and

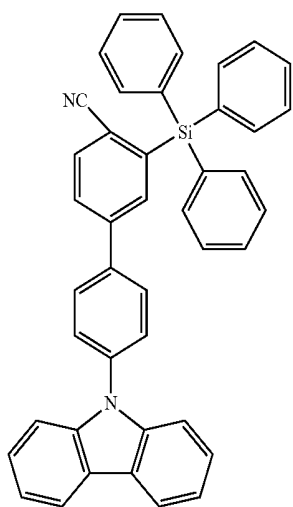
at least one selected from R_{11} to R_{14} , R_{21} to R_{24} , R_{31} to R_{38} , R_{41} to R_{48} , R_{51} to R_{58} , and R_{60} is a cyano group.

14. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound represented by Formula 1 is selected from Compounds 1 to 671:

1

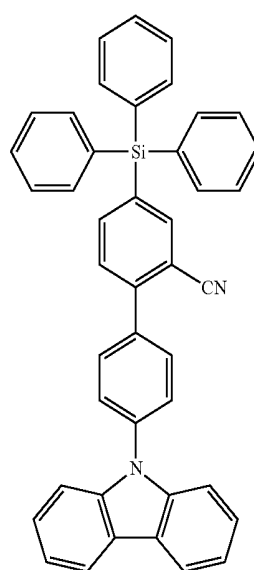


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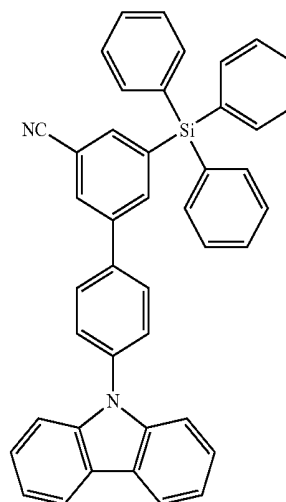
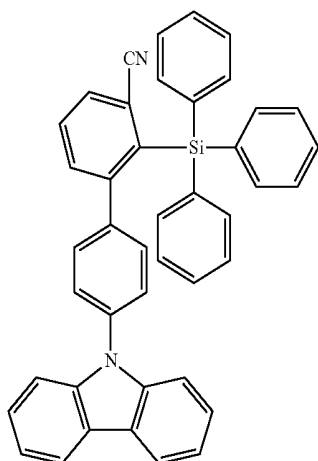
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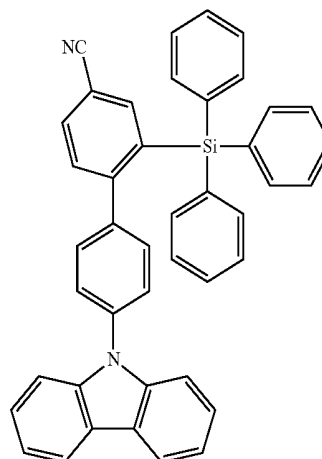
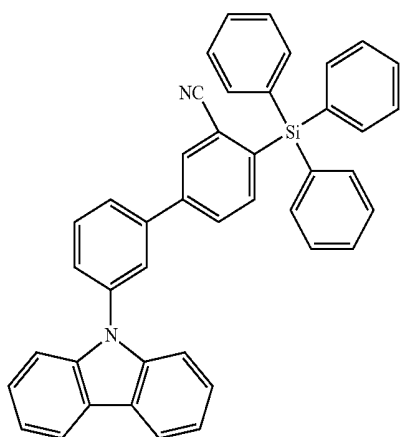
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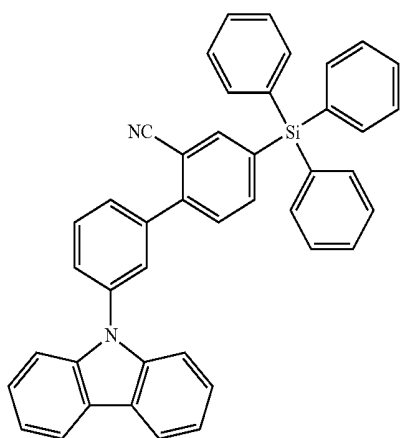
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4



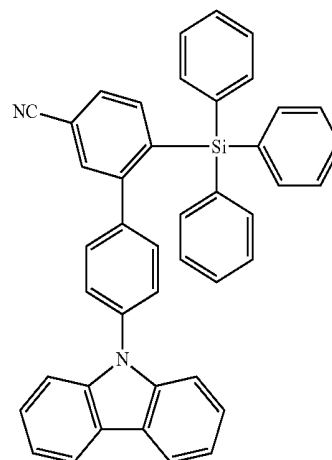
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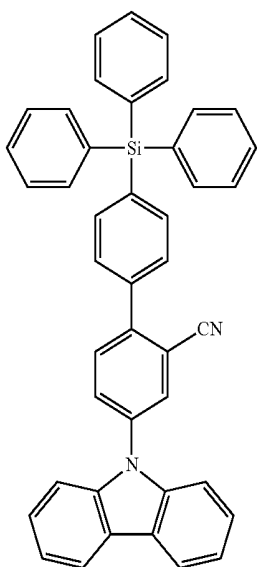
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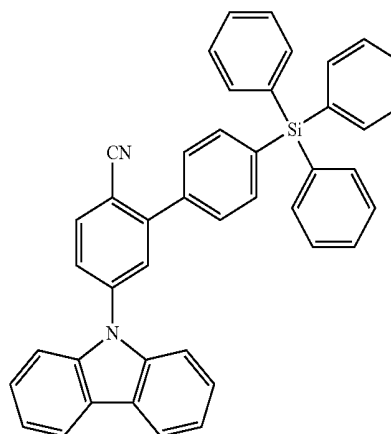


11

9

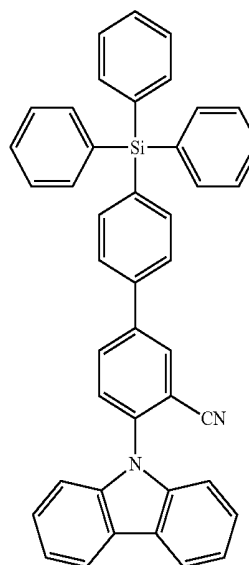
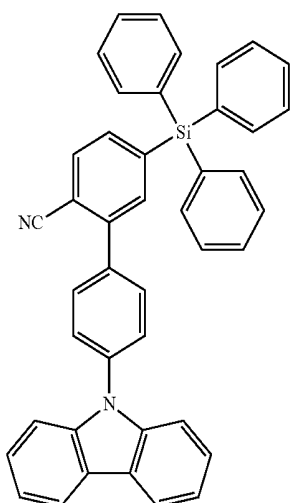


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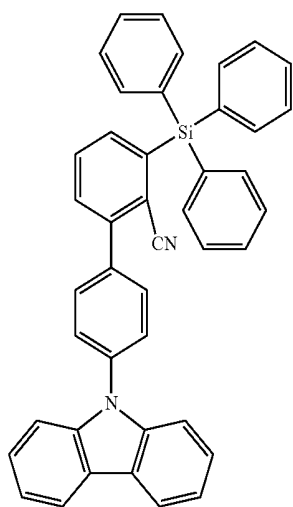


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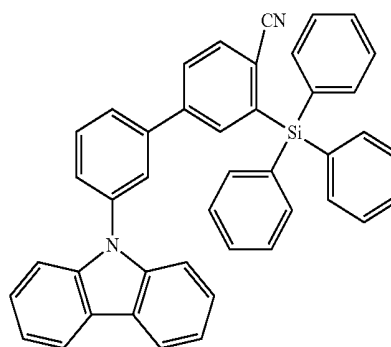


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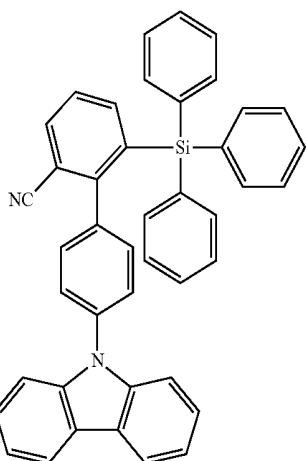


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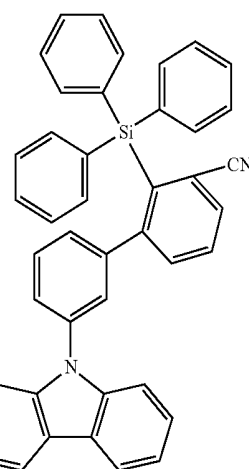
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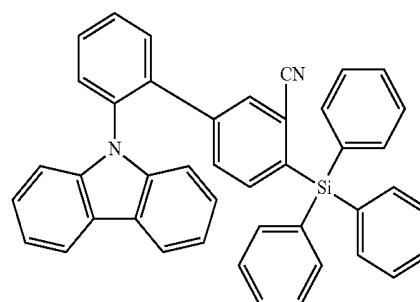
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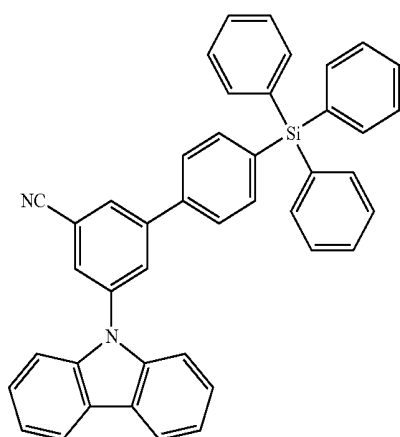
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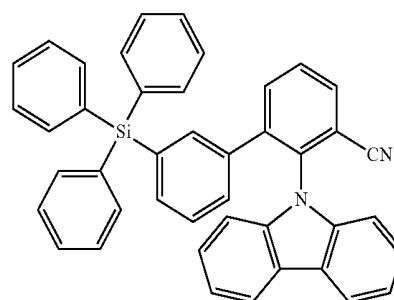
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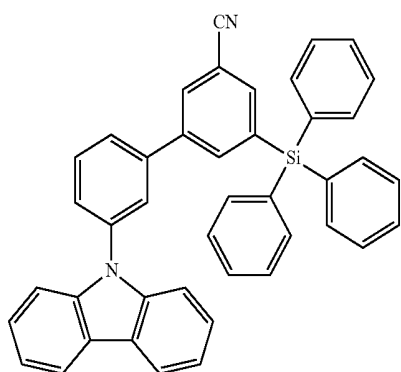


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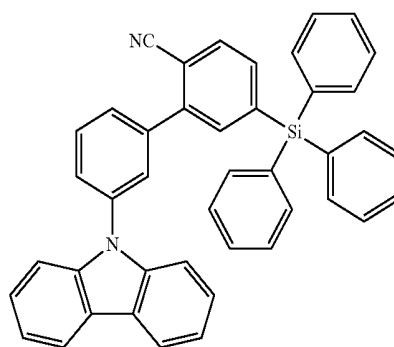
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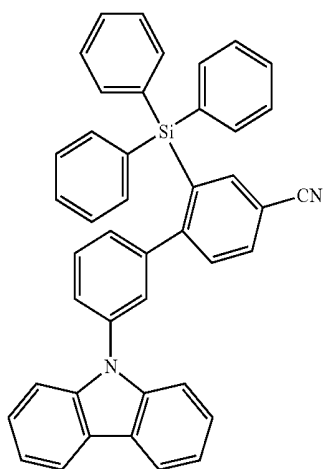
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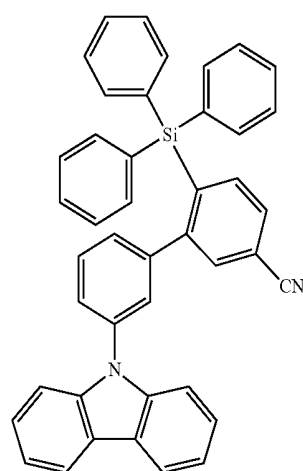


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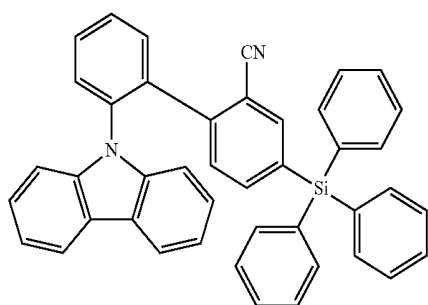
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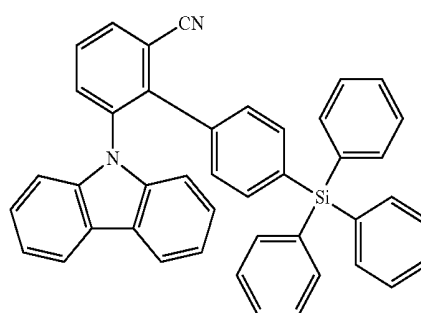
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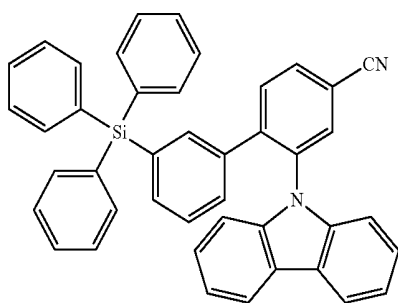
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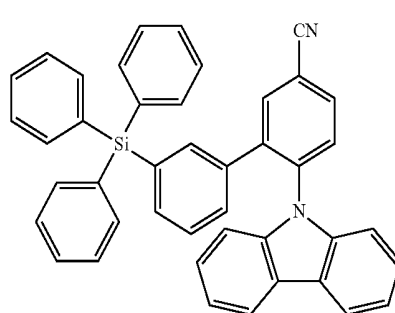
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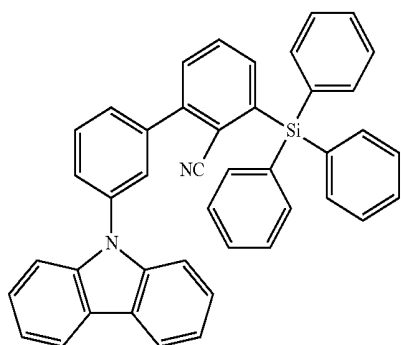
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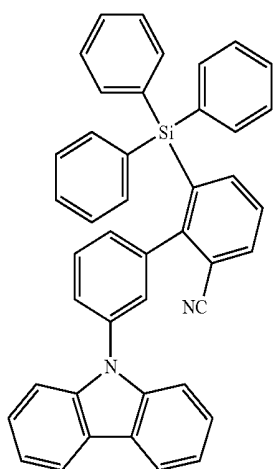
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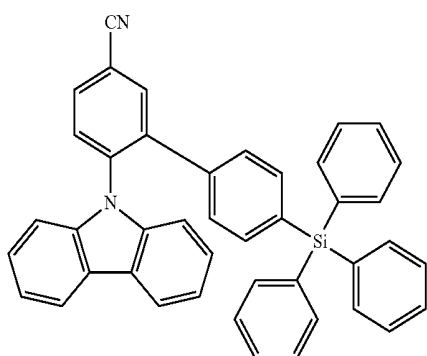
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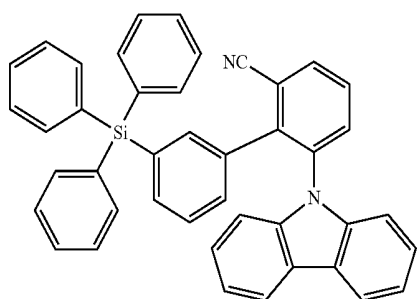
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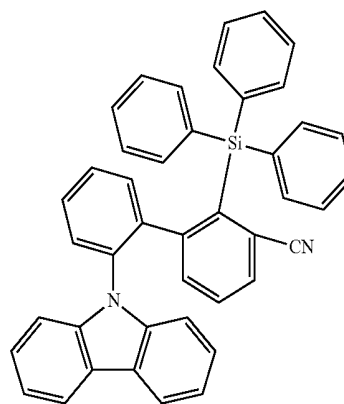


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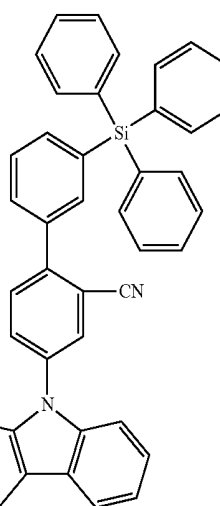


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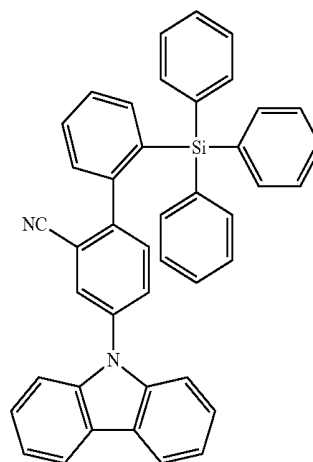
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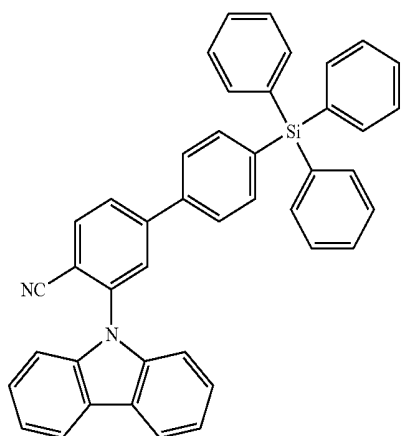


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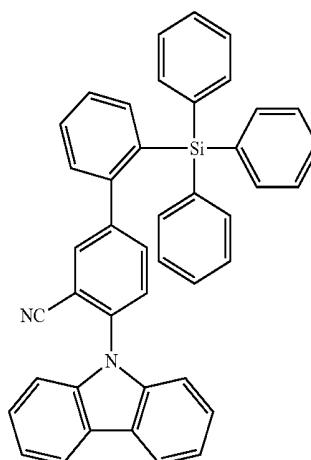
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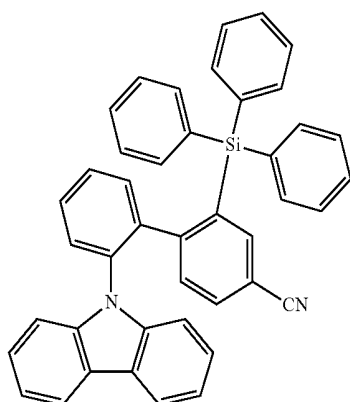
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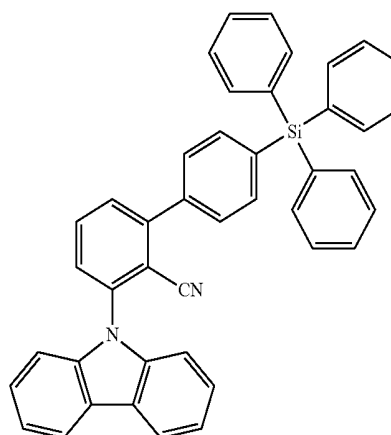


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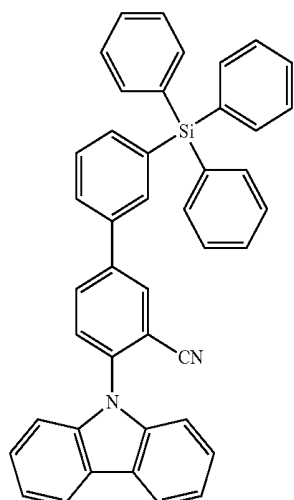


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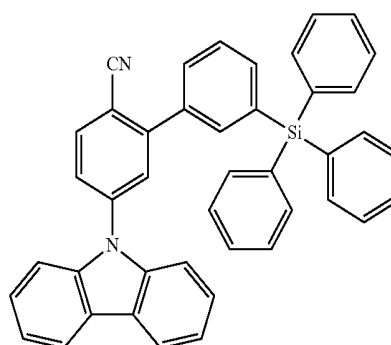


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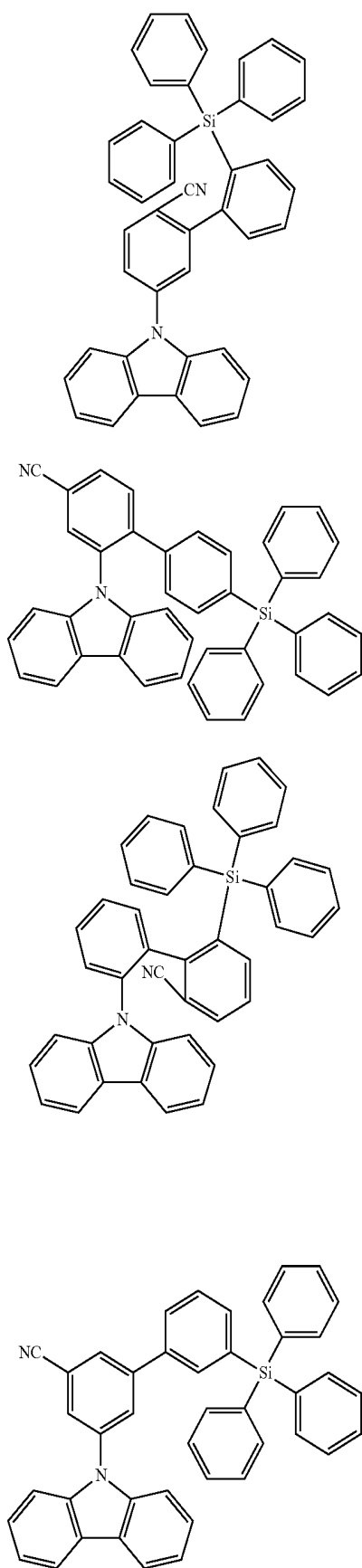
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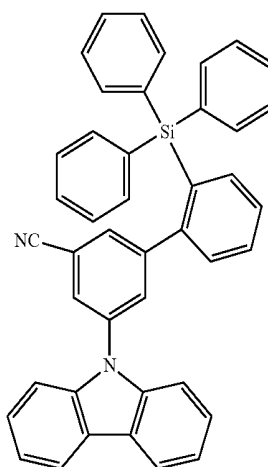
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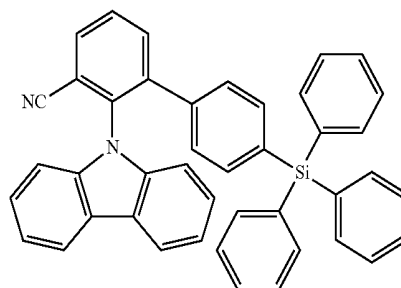
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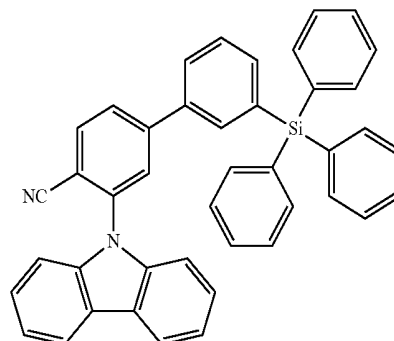
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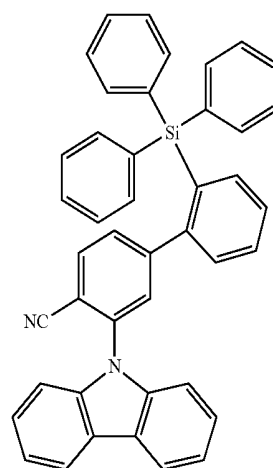
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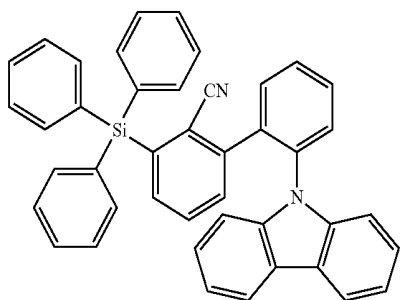


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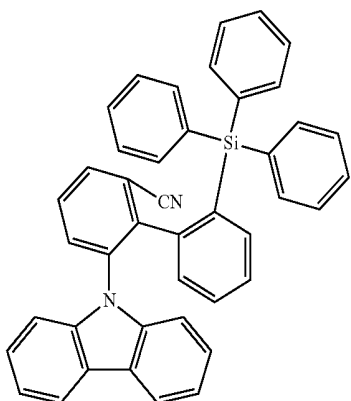
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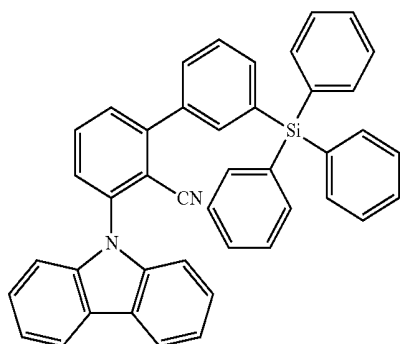
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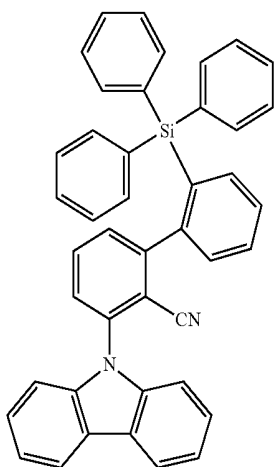
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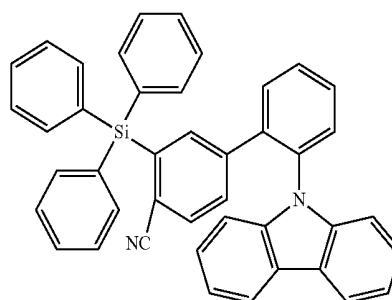


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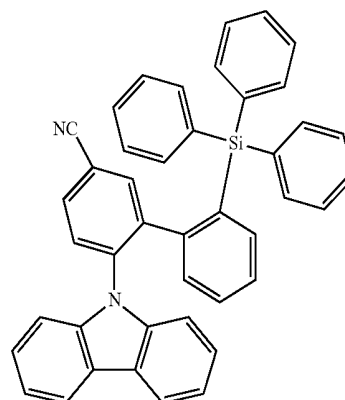


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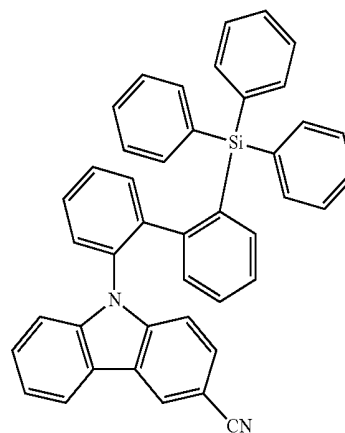
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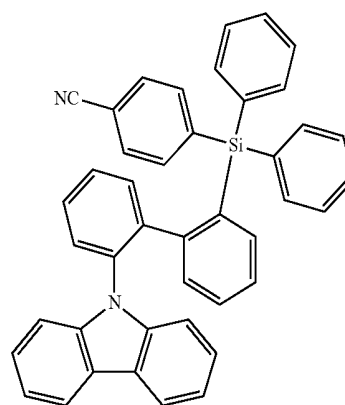
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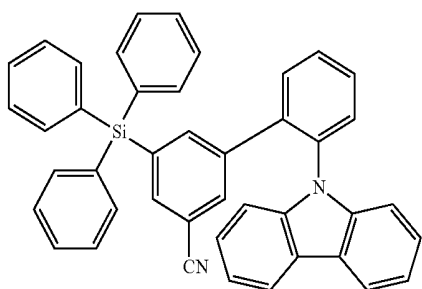


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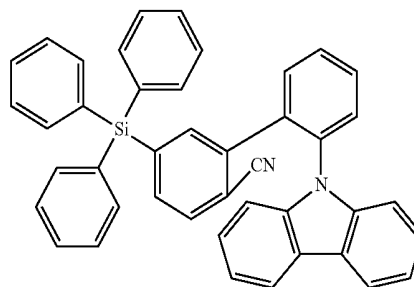
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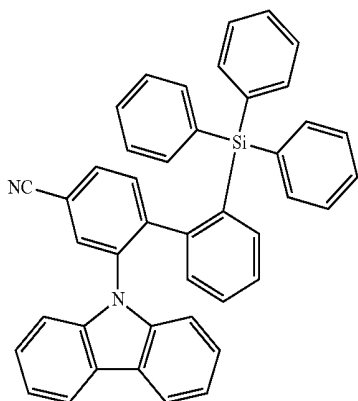
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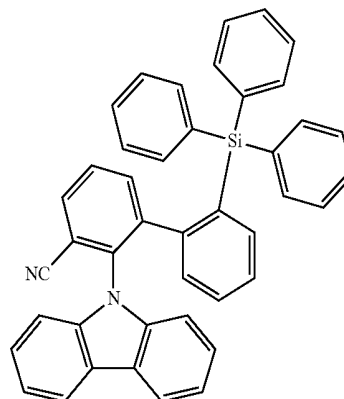
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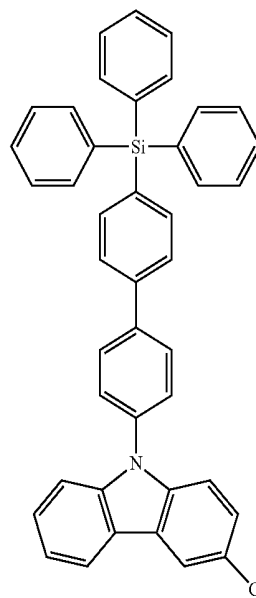
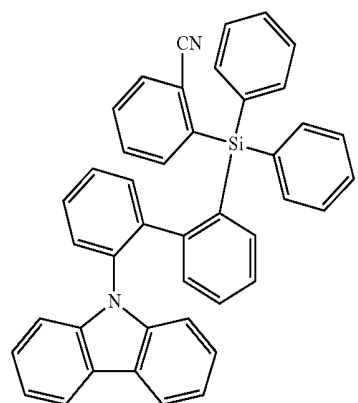
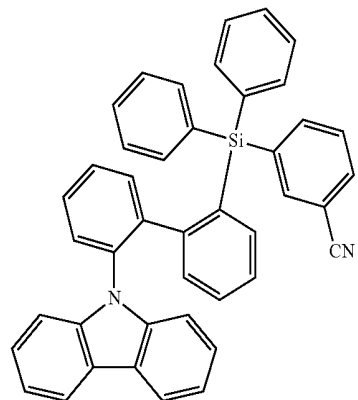
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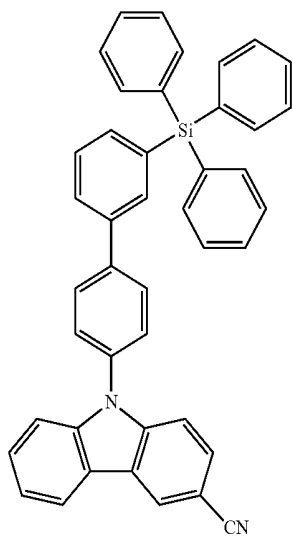


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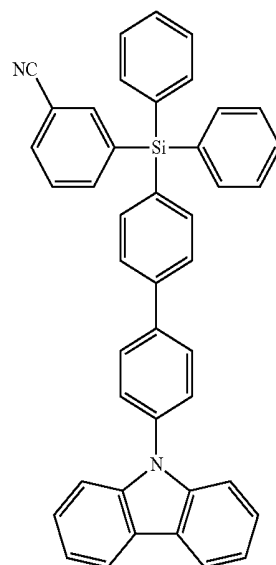


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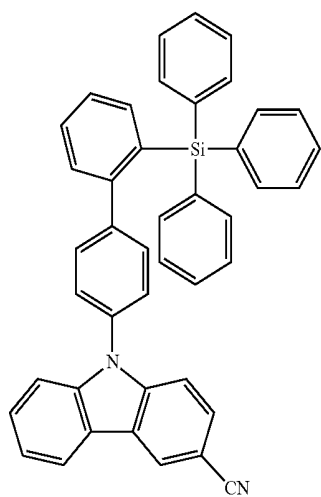


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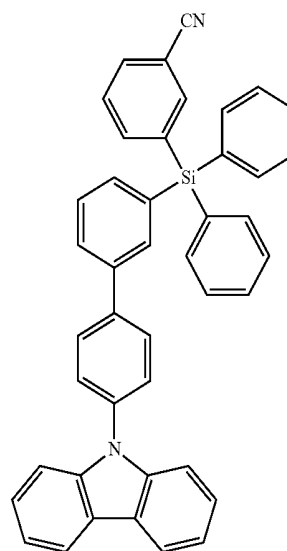
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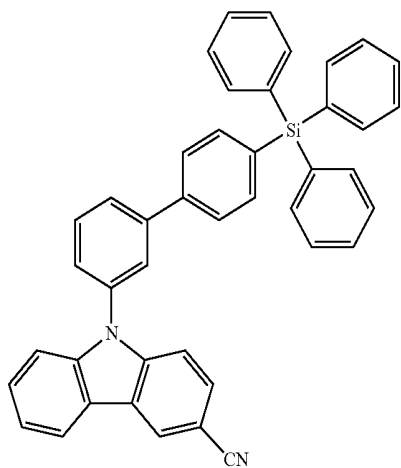
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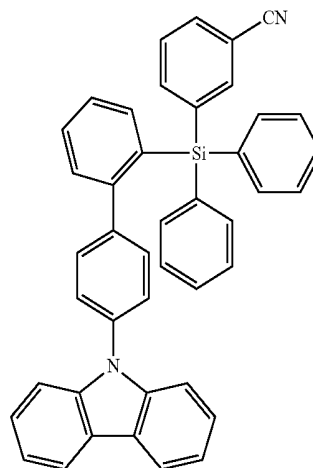
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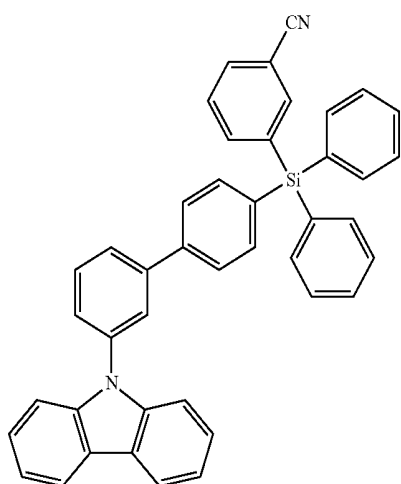


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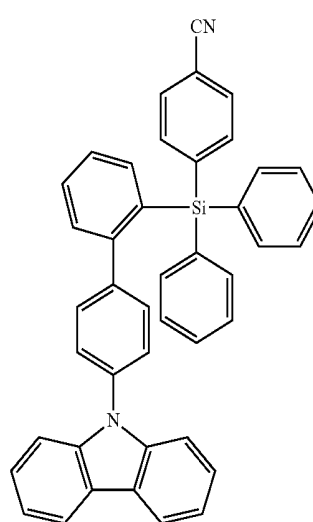
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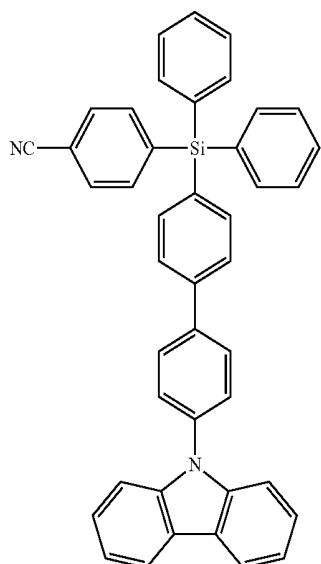
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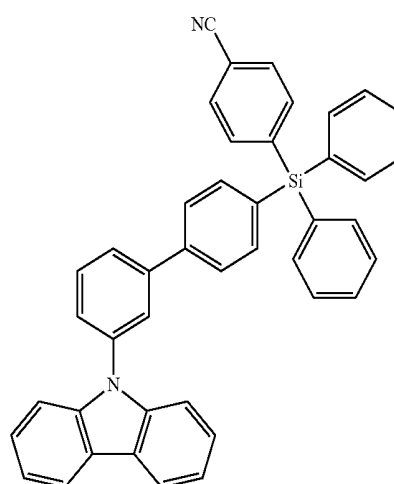


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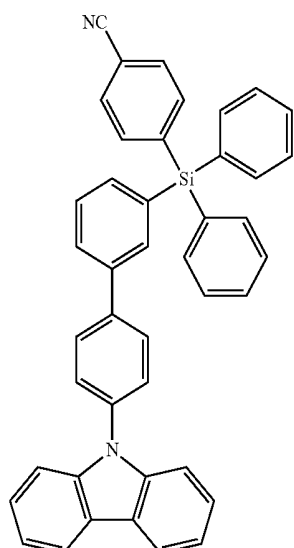
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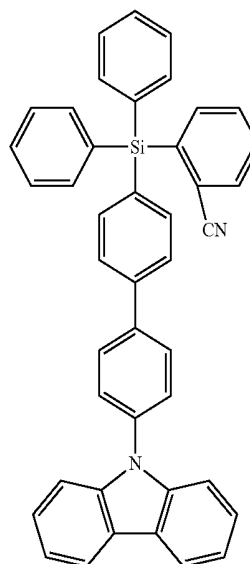
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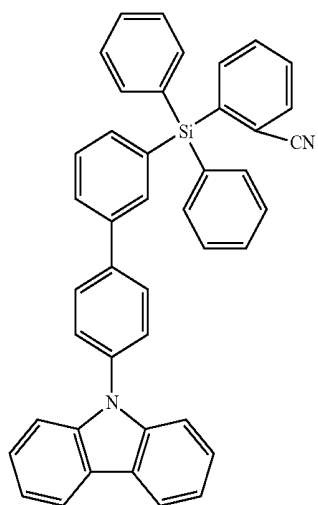
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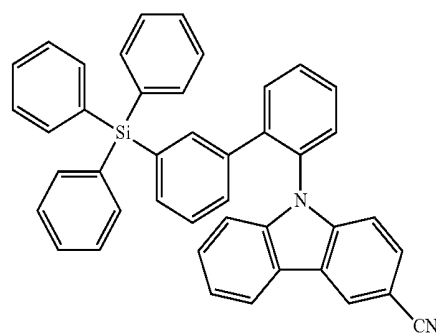
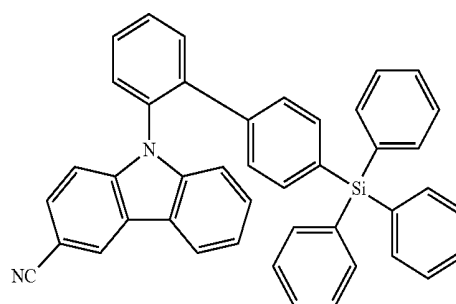
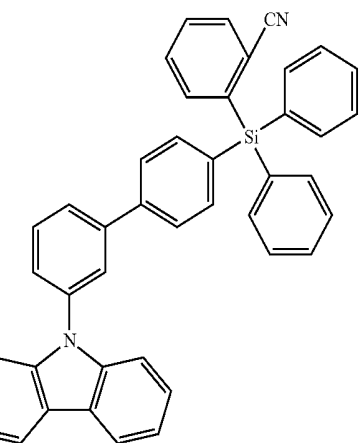
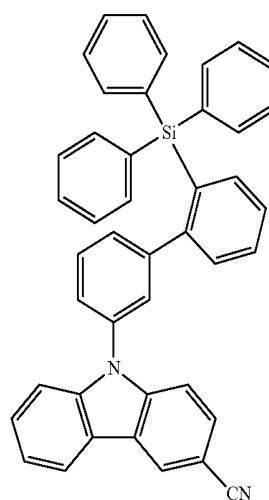
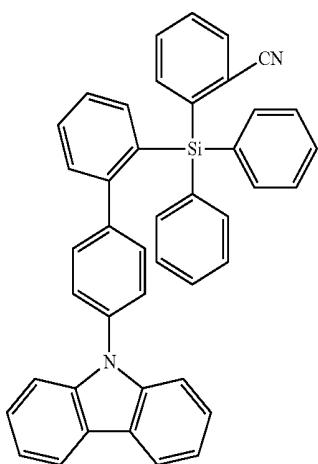
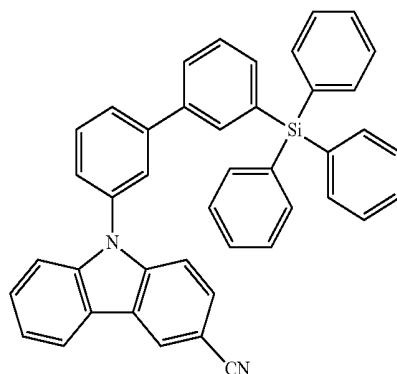
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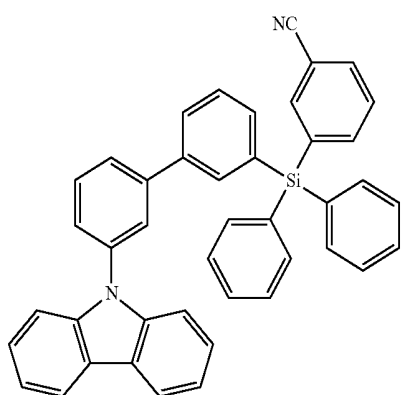
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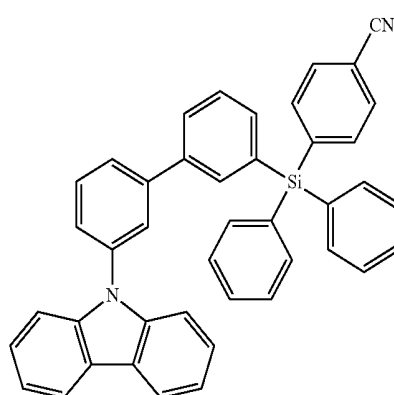


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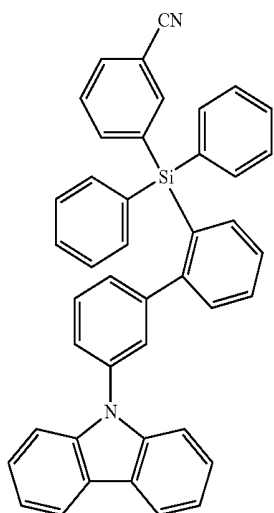
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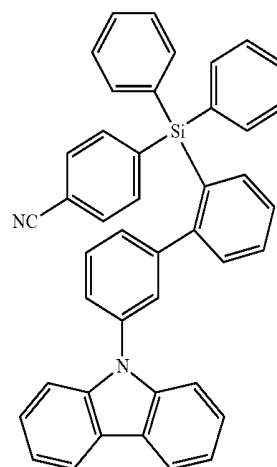


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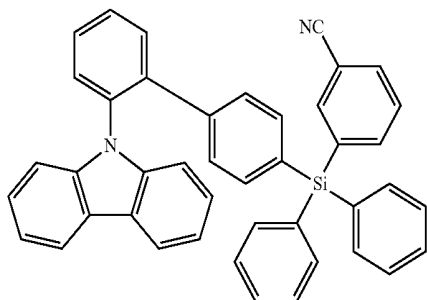
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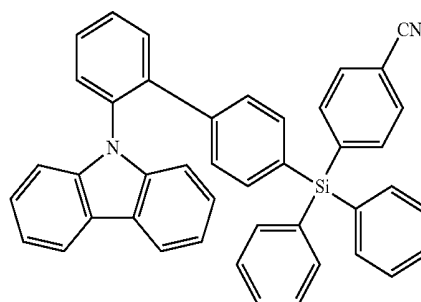
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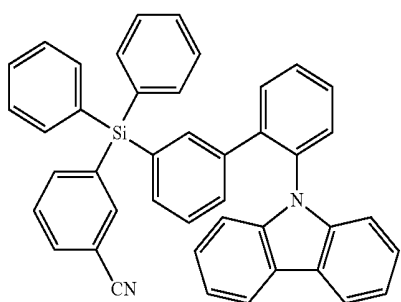
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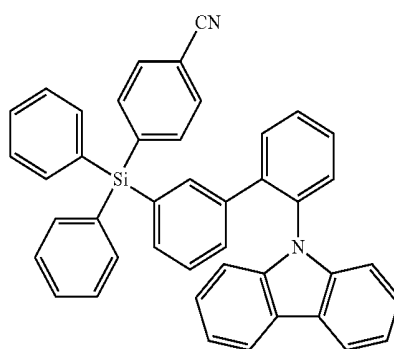
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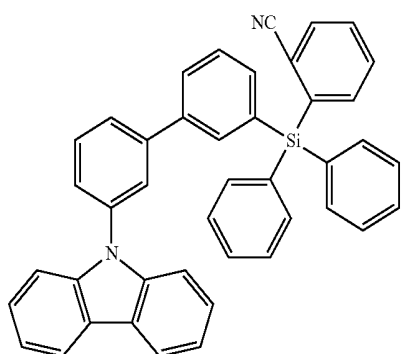
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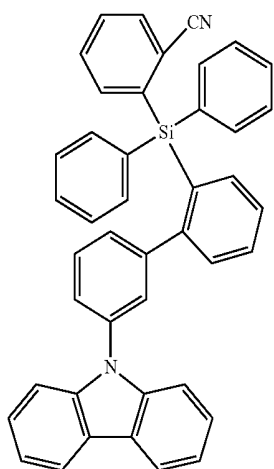
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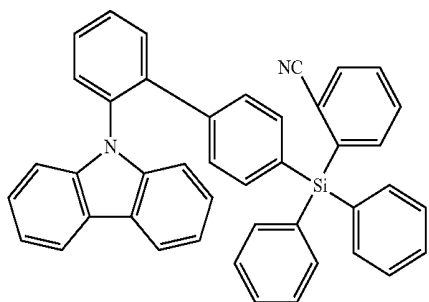
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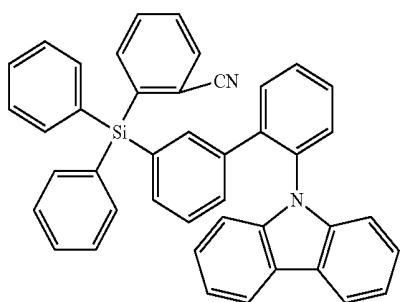
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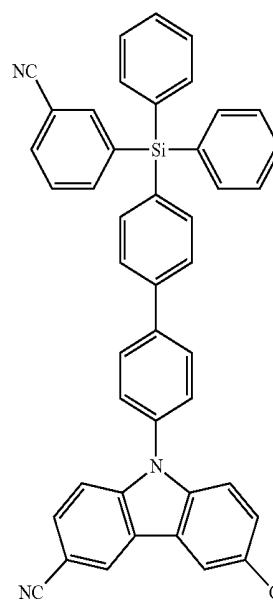


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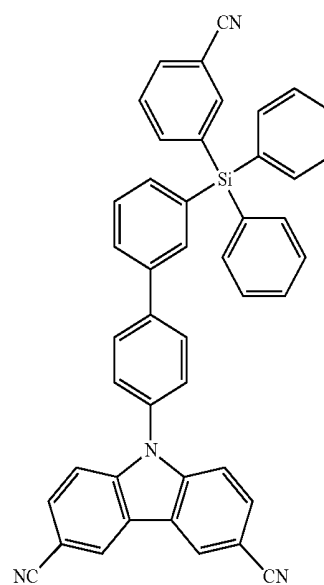


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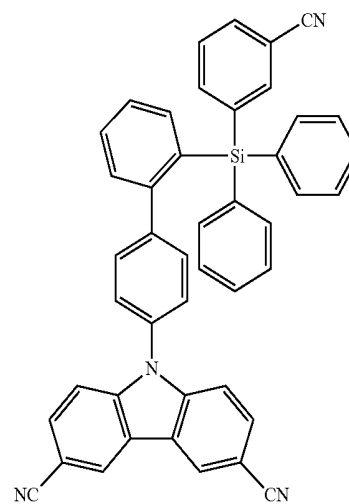
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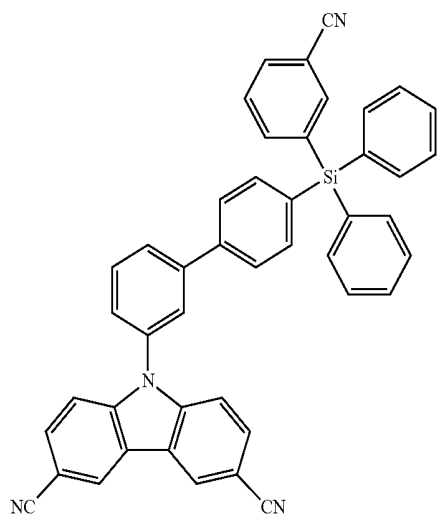


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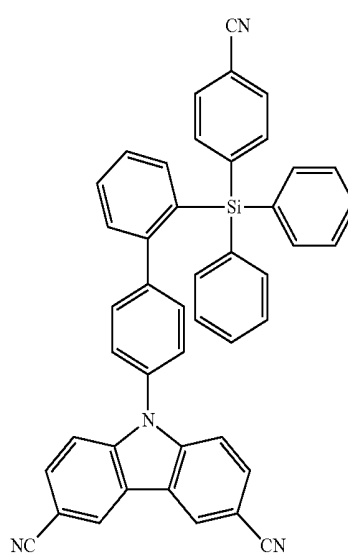
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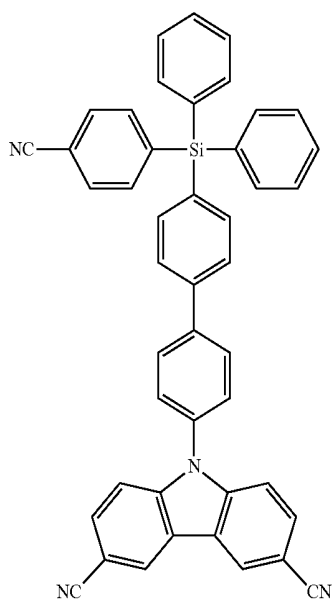
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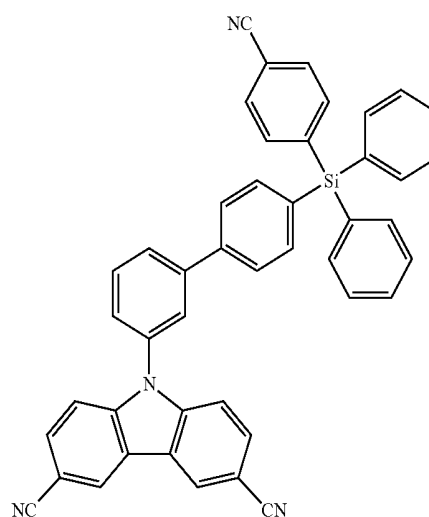


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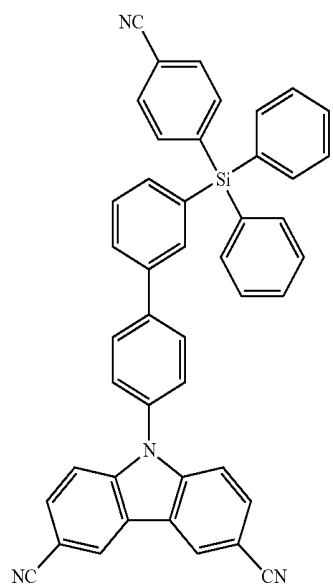
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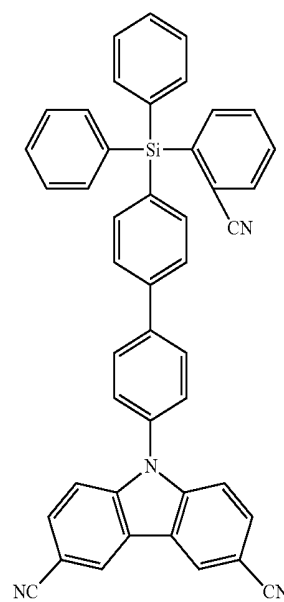
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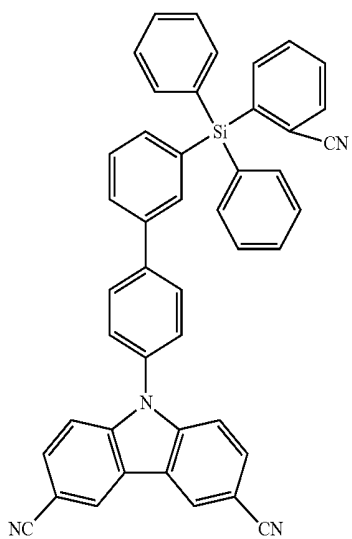


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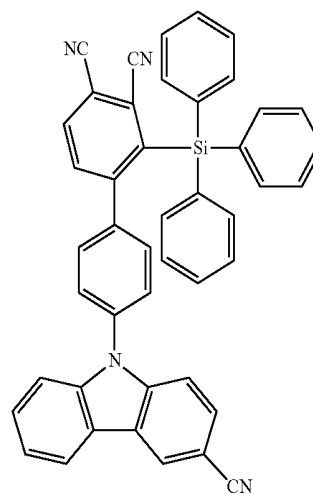
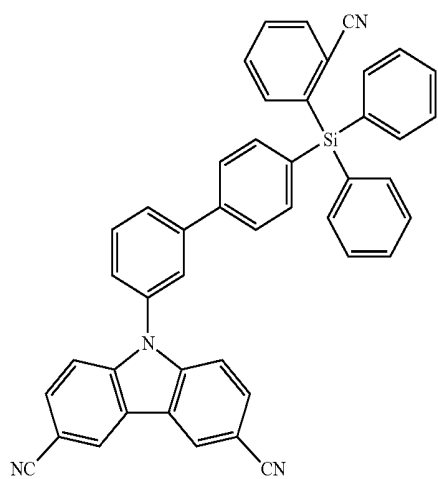
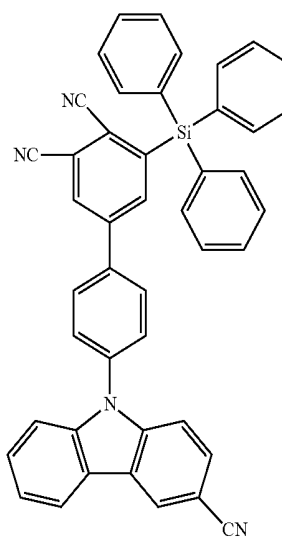
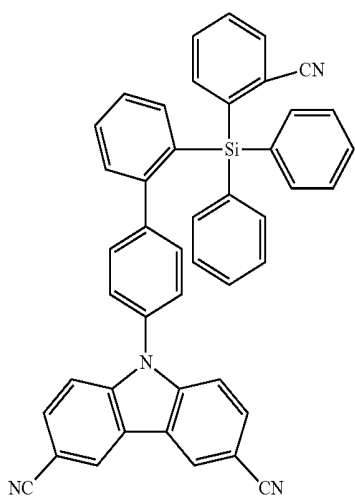
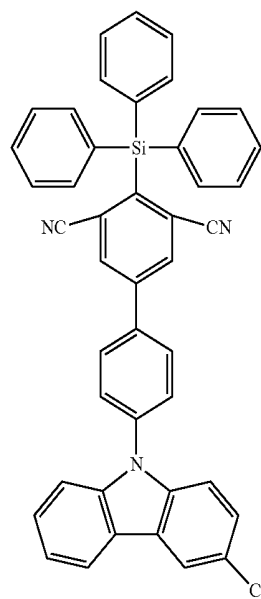


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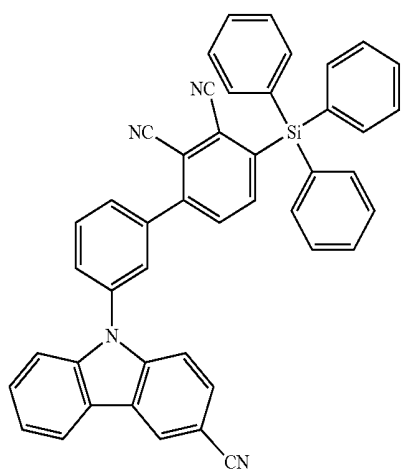
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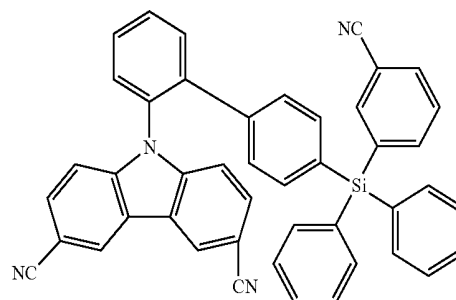


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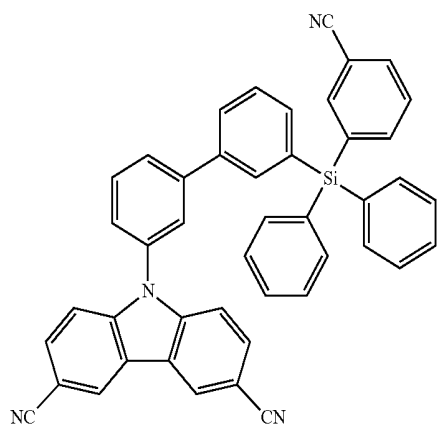


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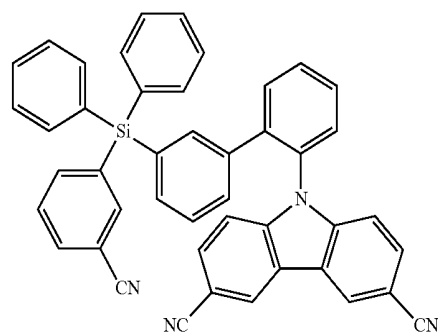
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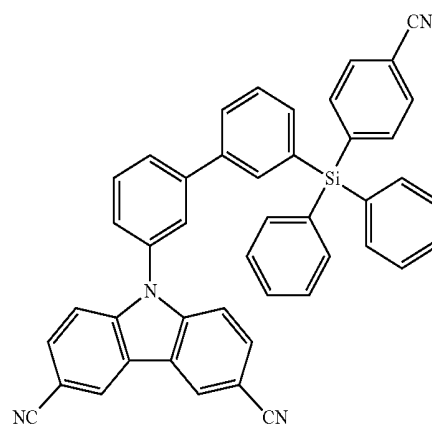
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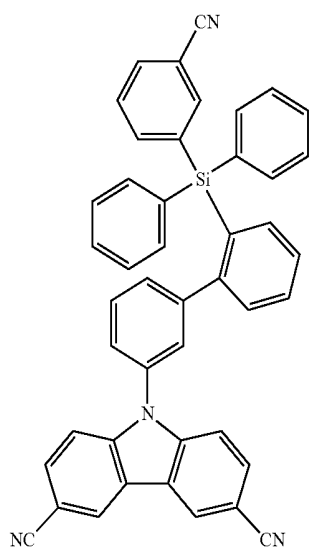
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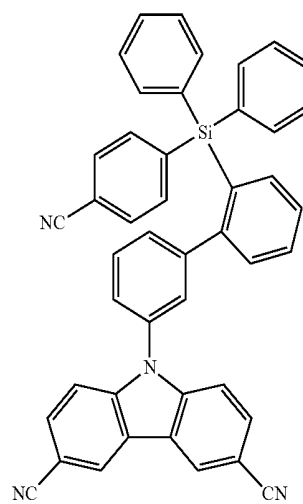
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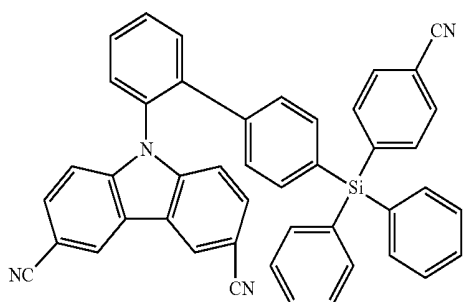


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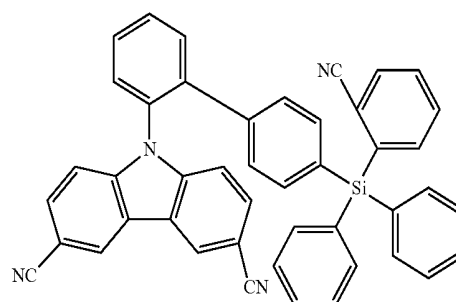
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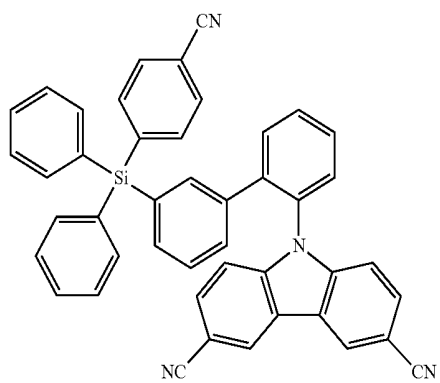
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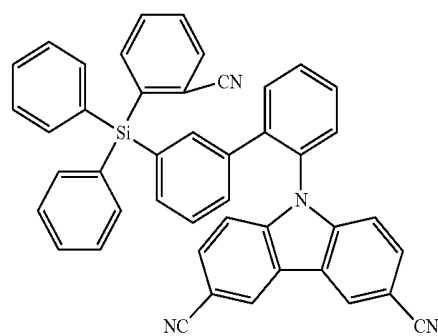


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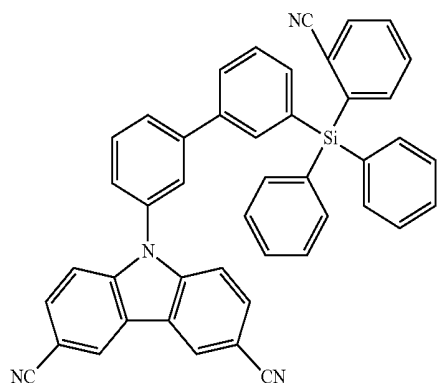
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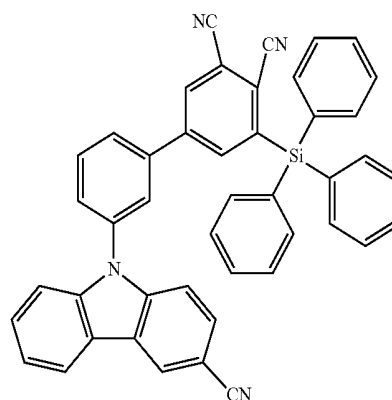
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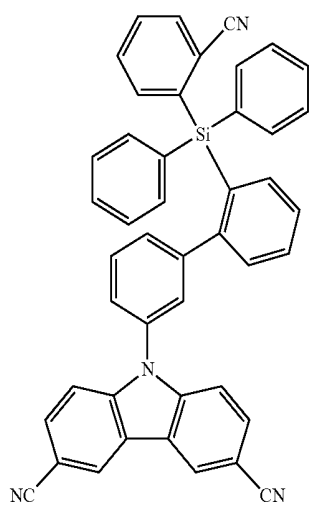
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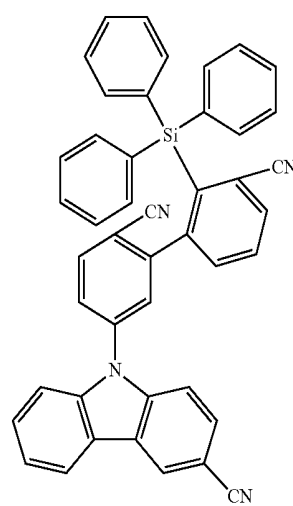
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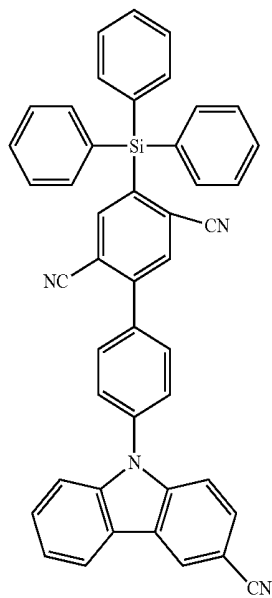
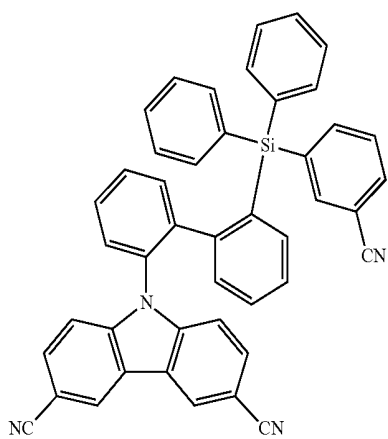
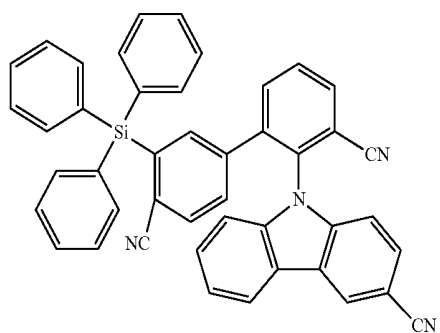
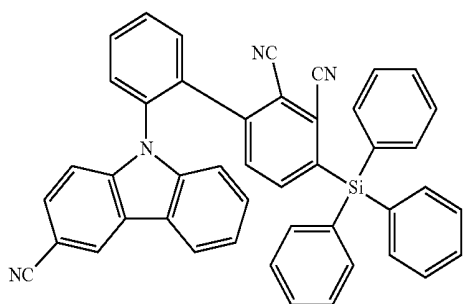
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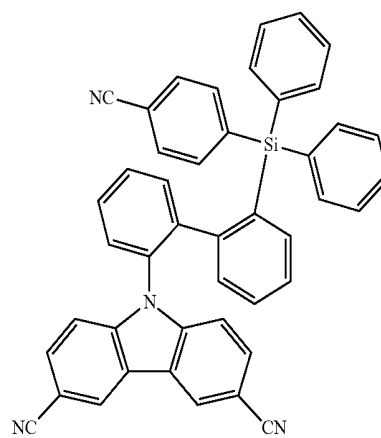
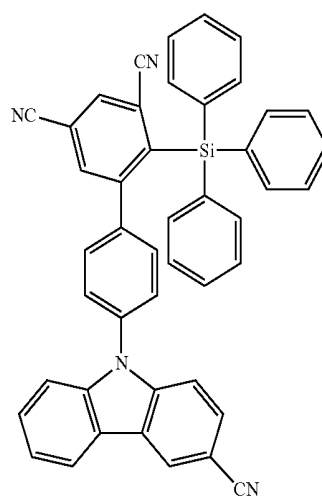
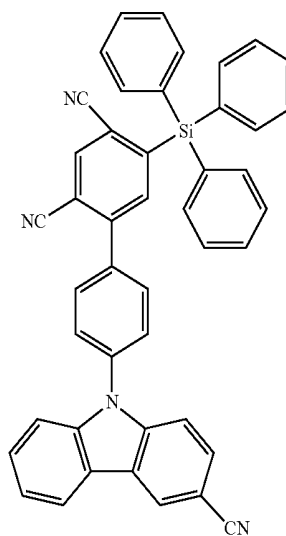
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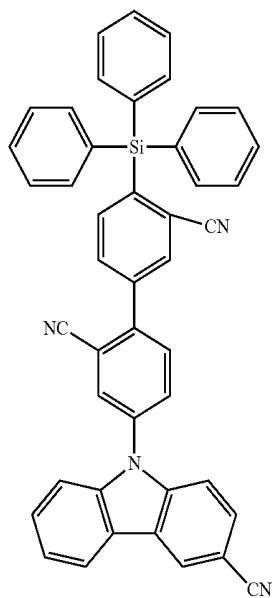
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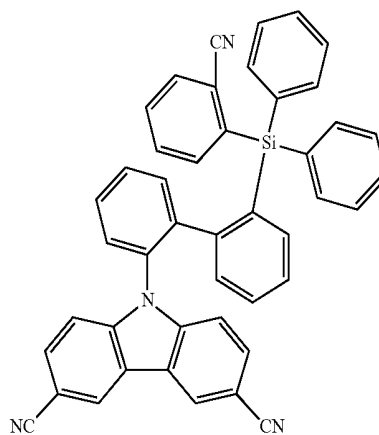


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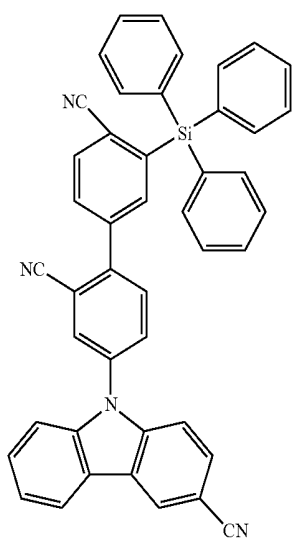


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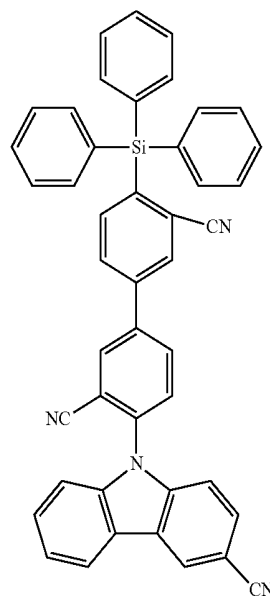
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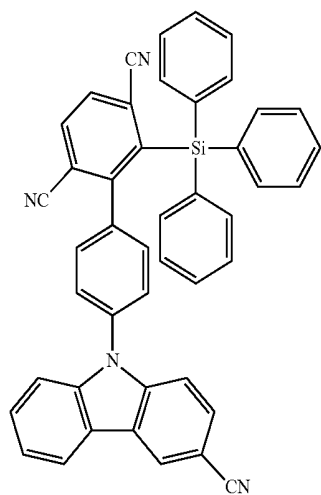
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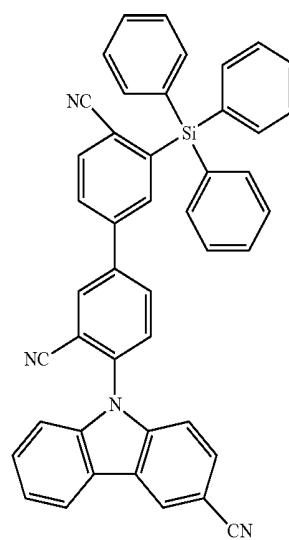
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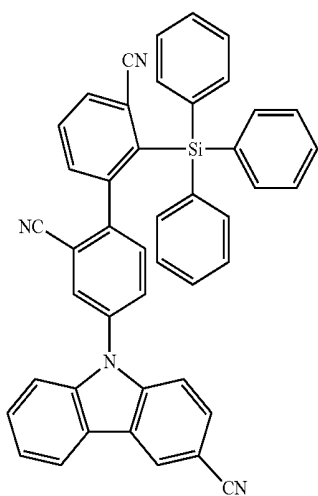


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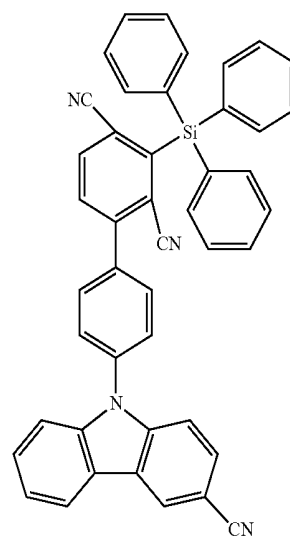
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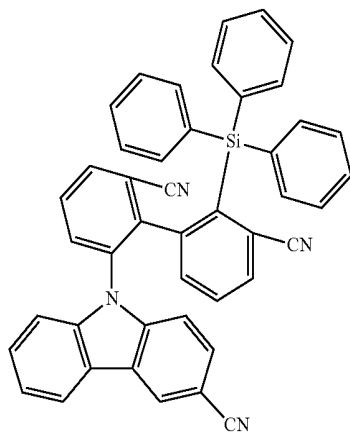
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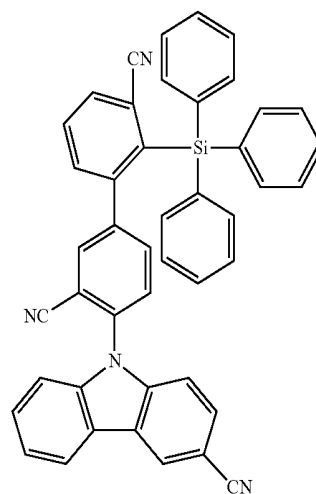
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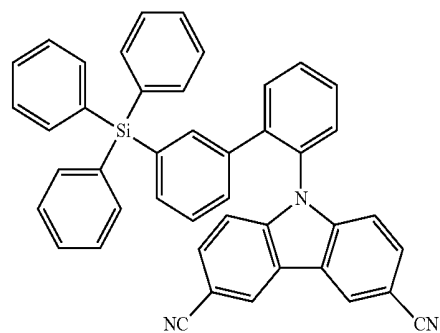
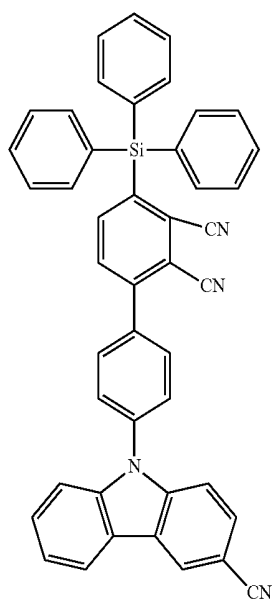


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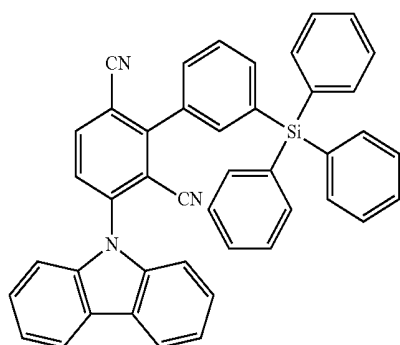
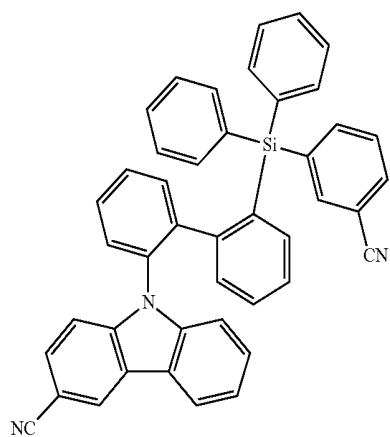
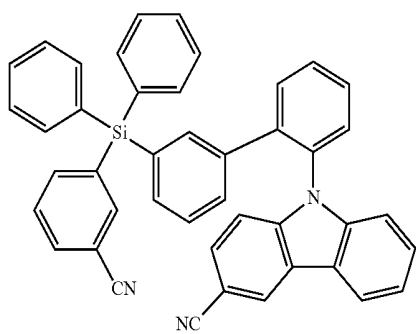
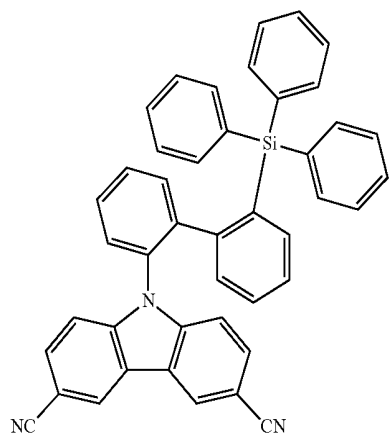
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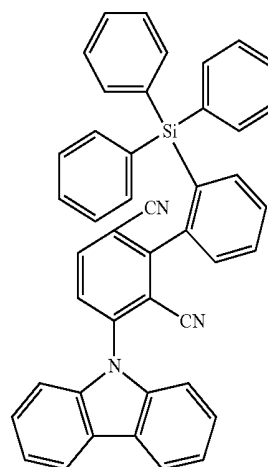
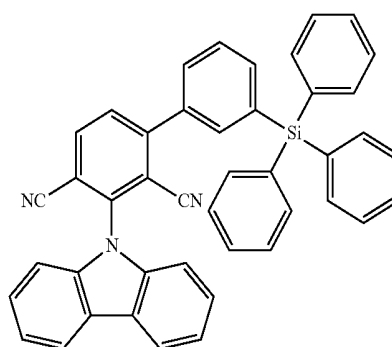
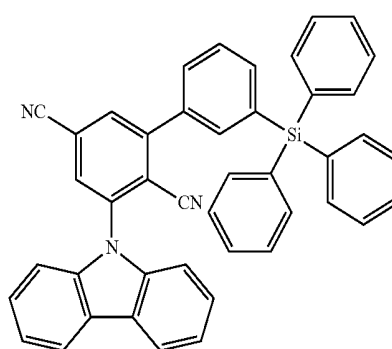
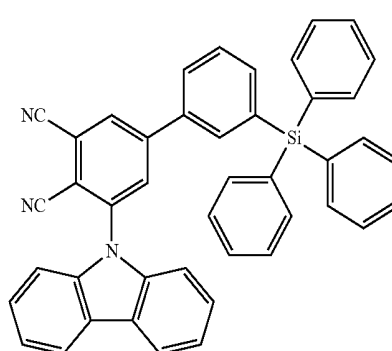
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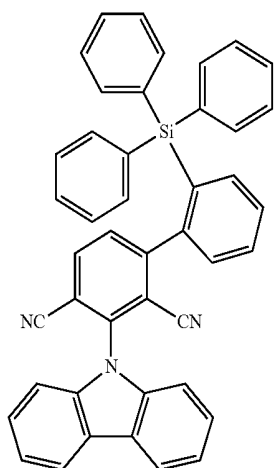
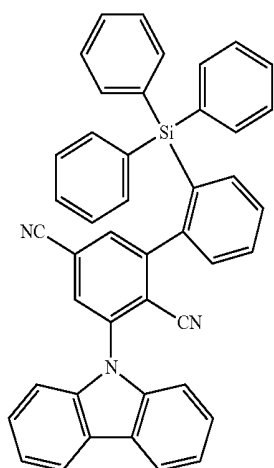
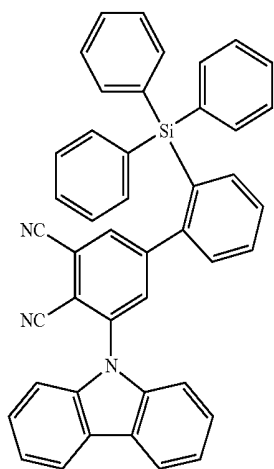
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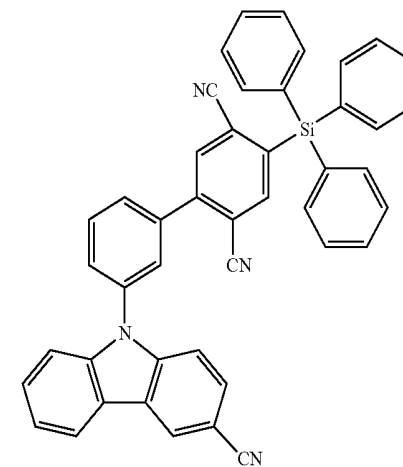
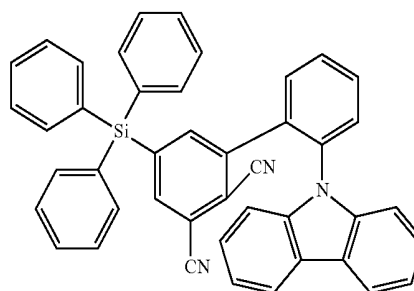
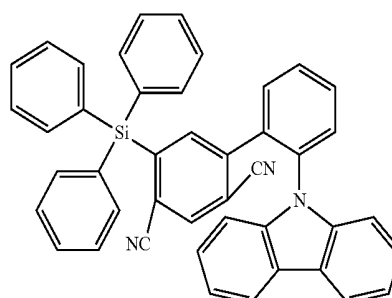
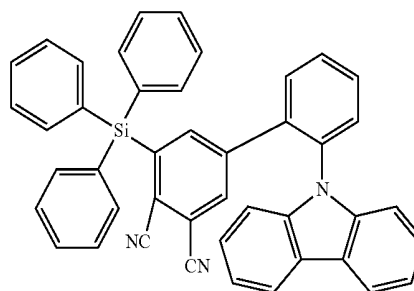
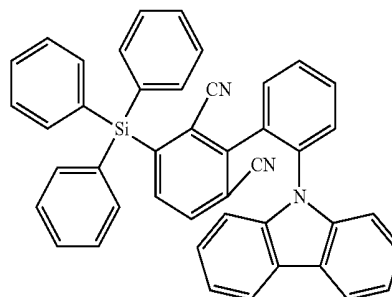
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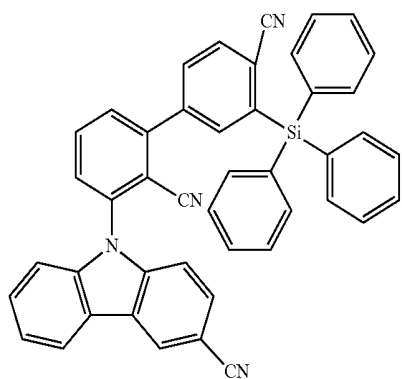
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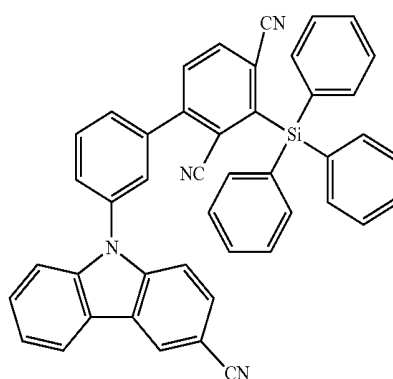
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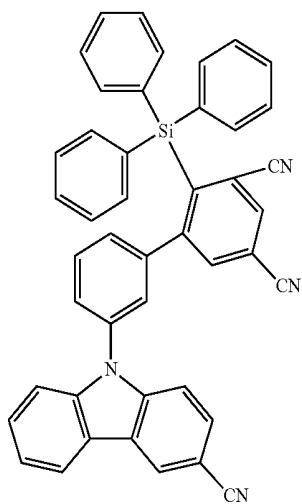
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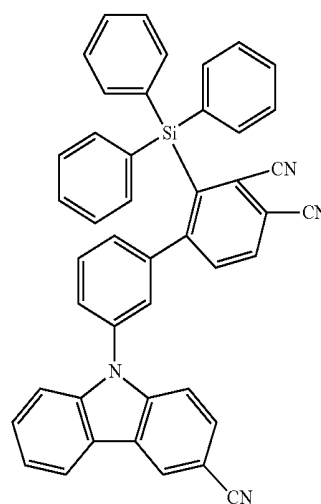
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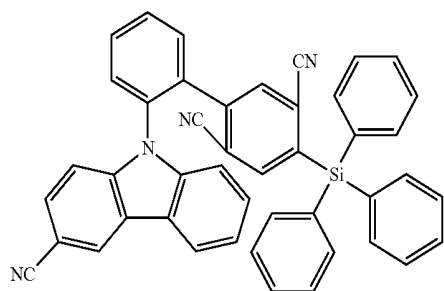
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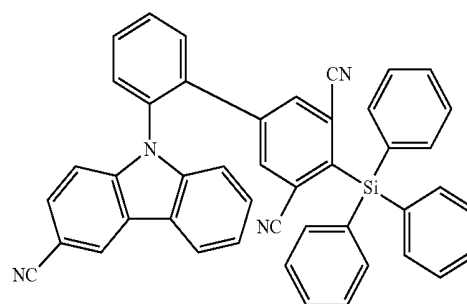
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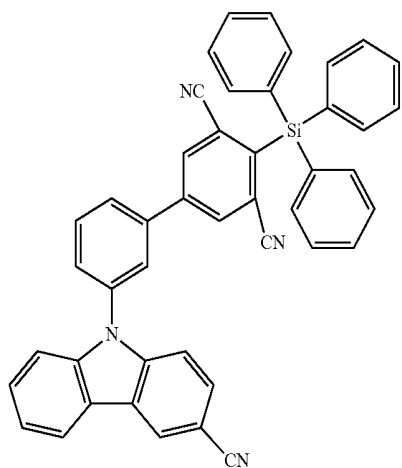
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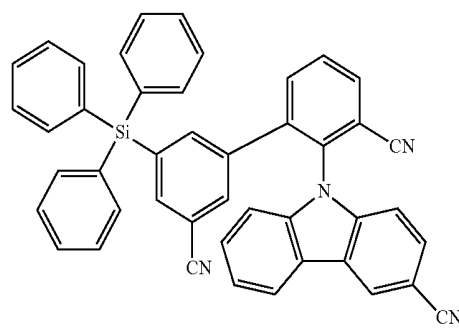
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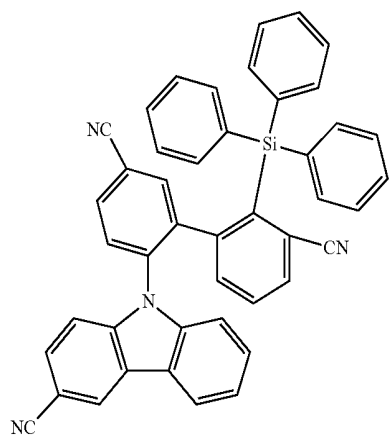
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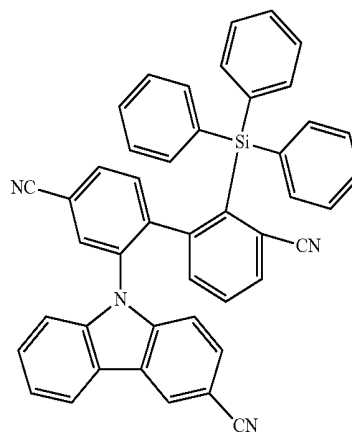


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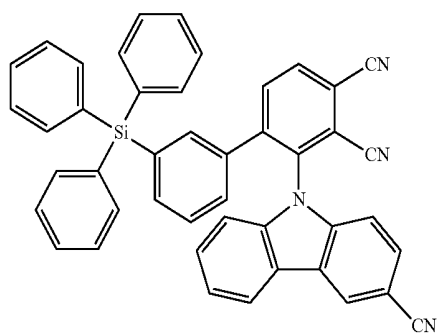


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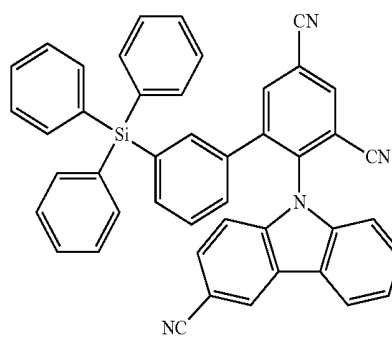
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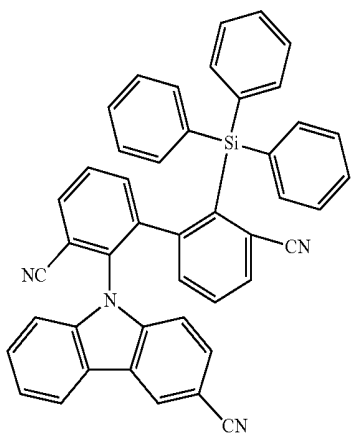
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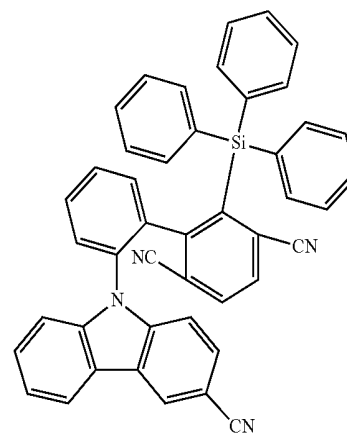
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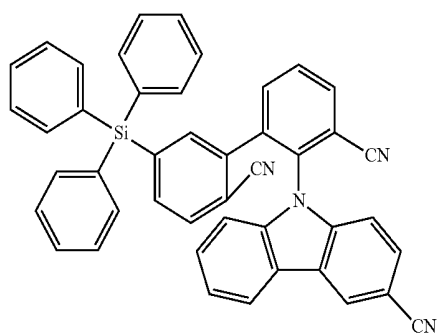
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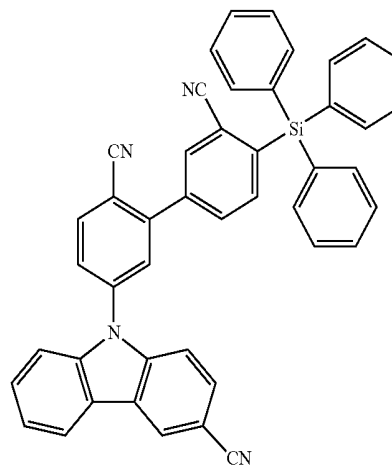
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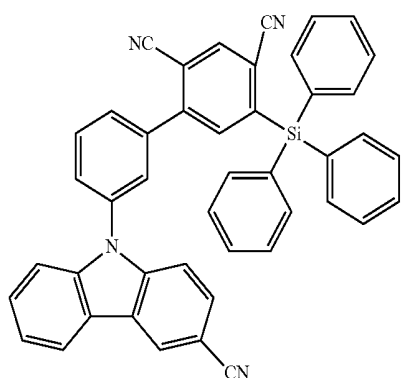


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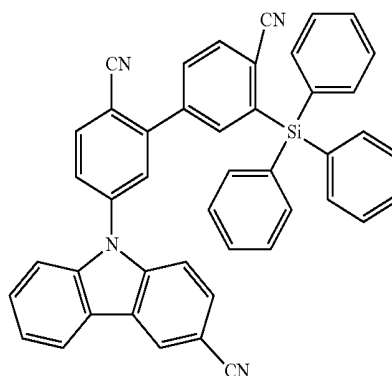
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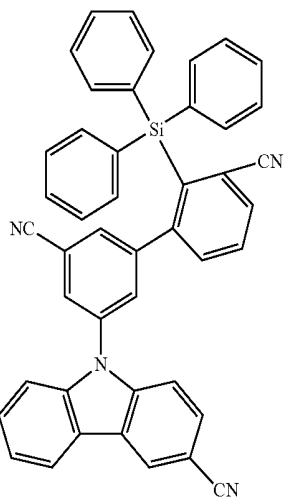
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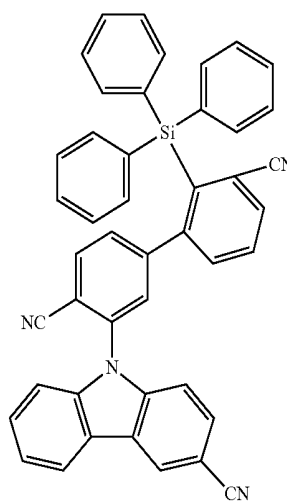


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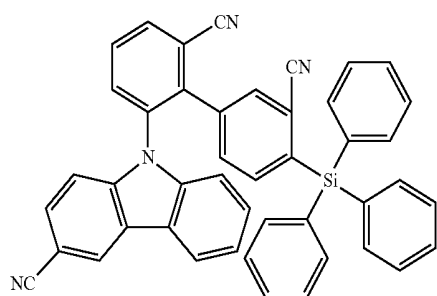
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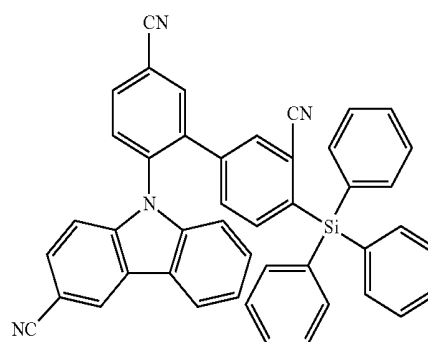
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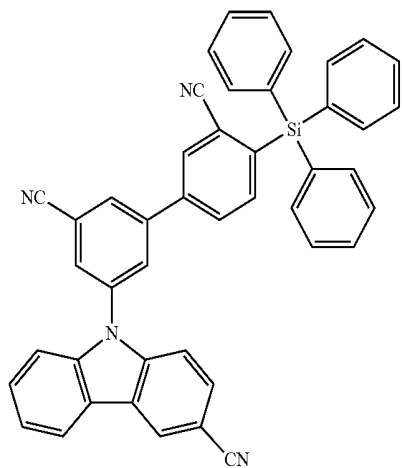
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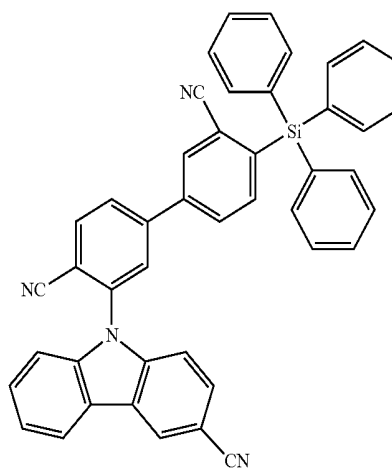
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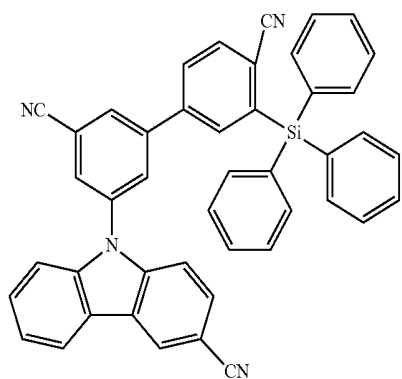
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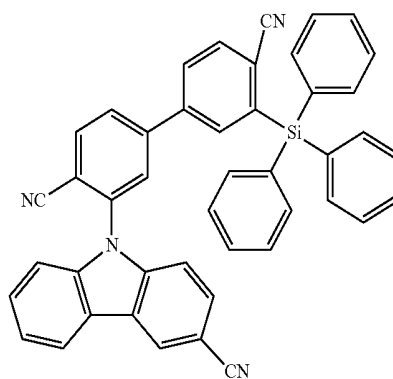


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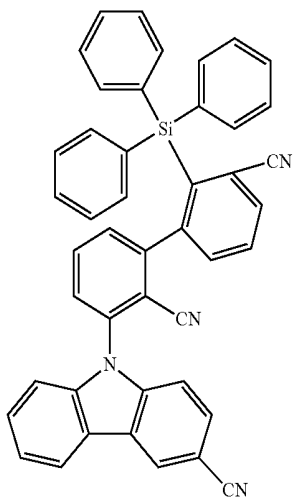


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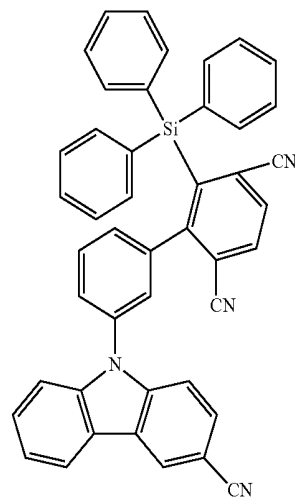
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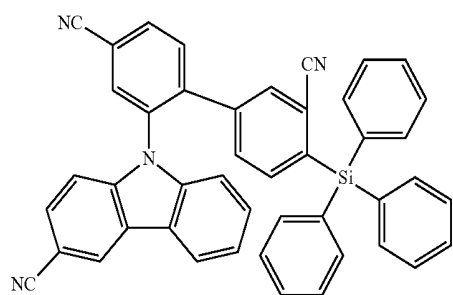
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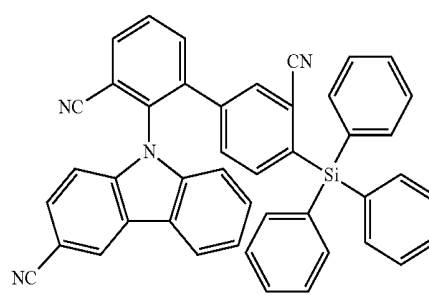
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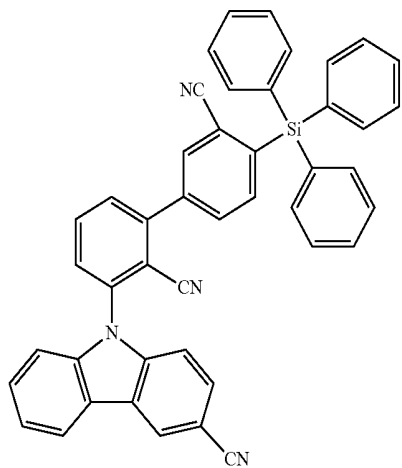
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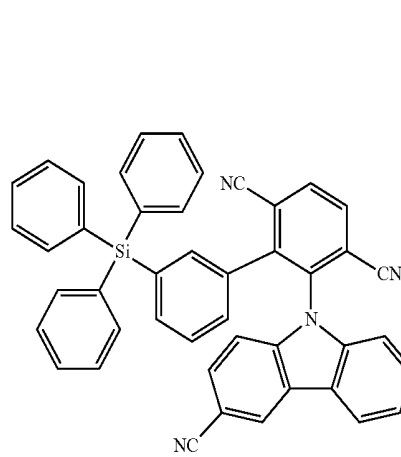
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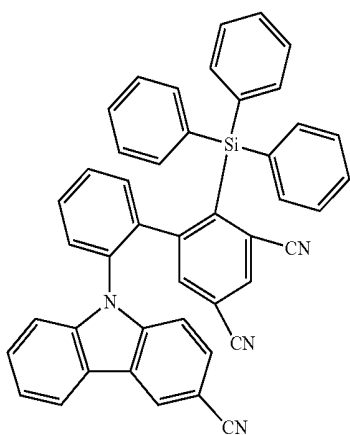


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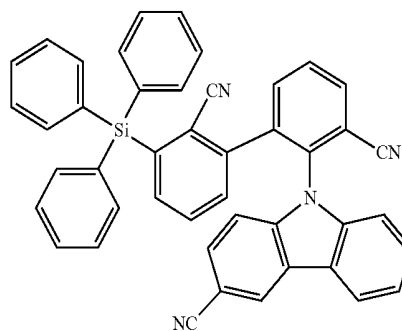
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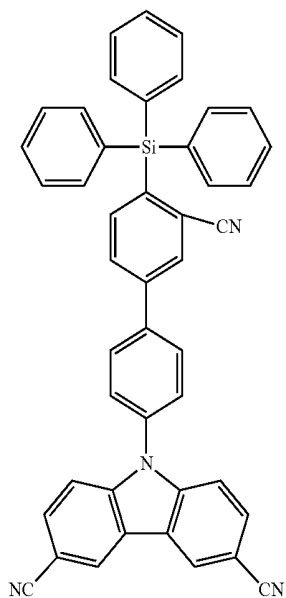
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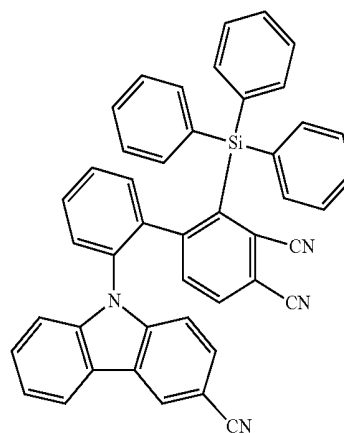


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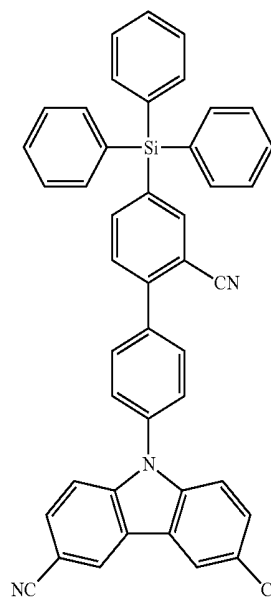
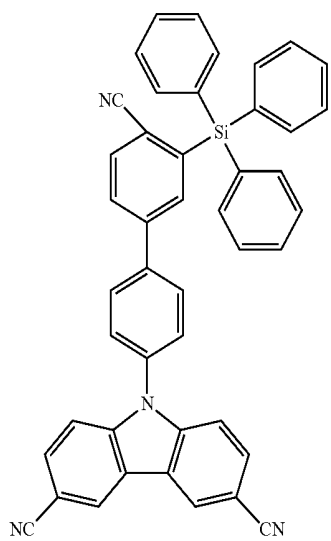


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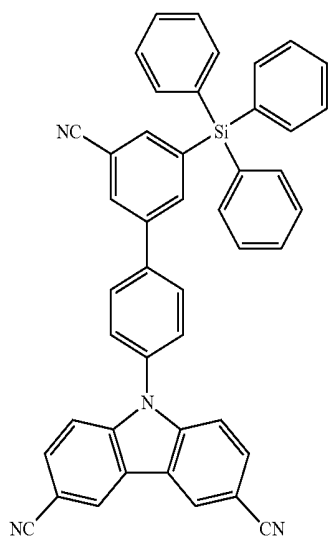


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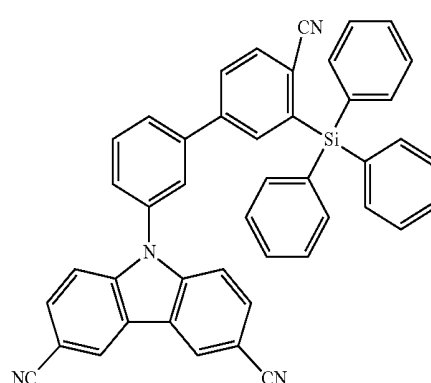
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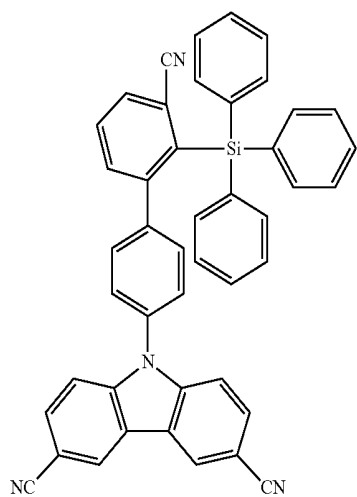
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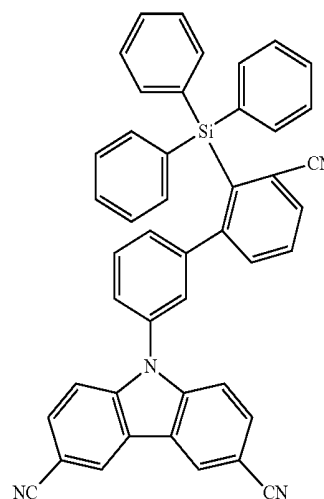
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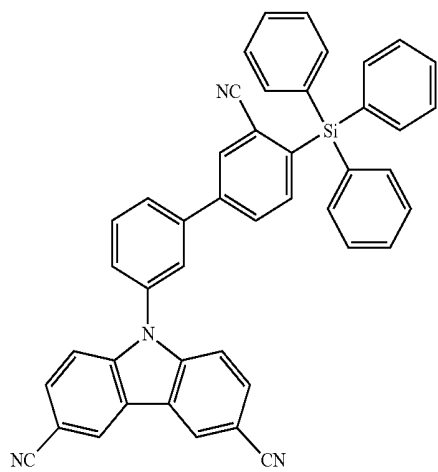
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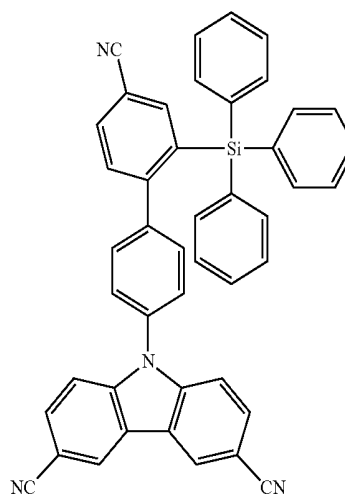
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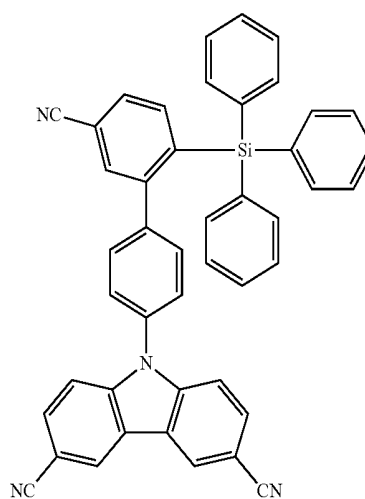
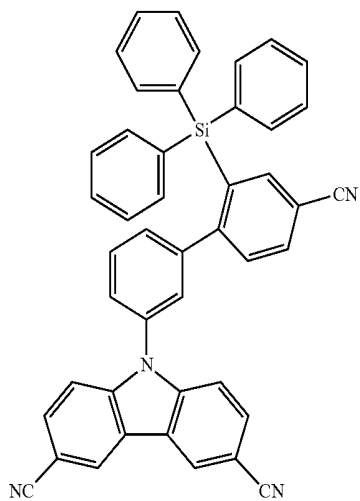
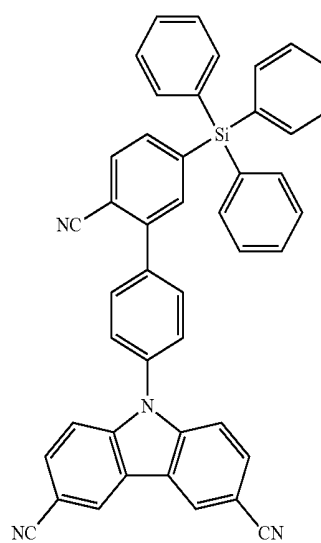
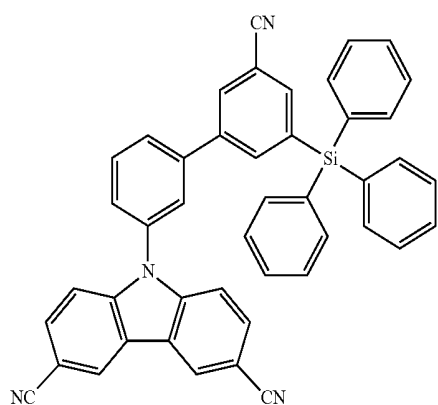
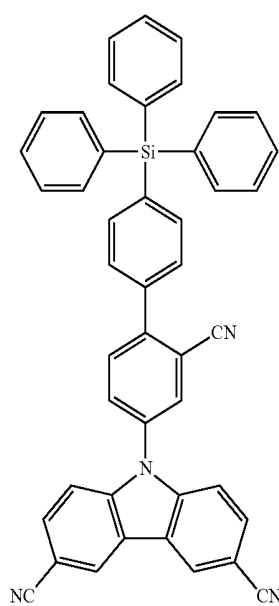
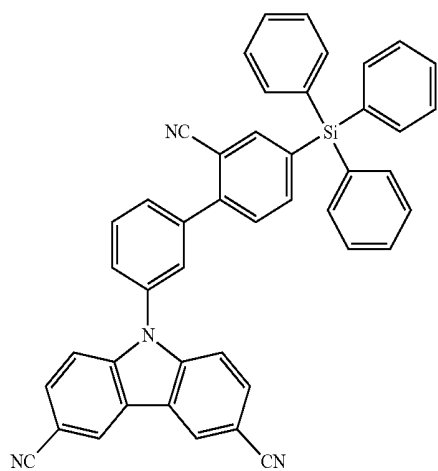
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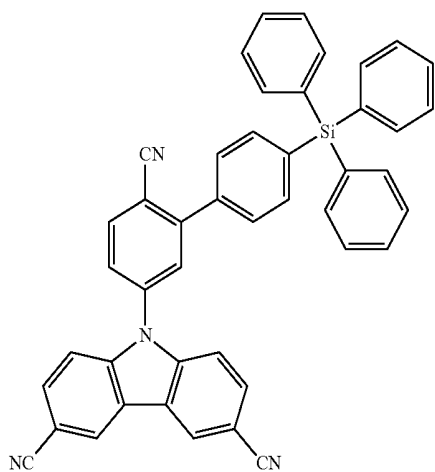
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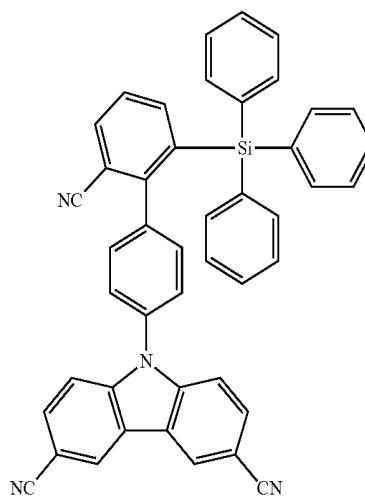


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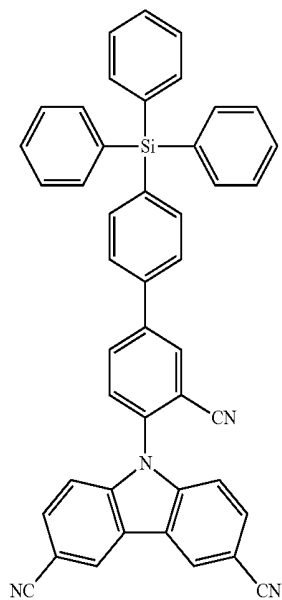
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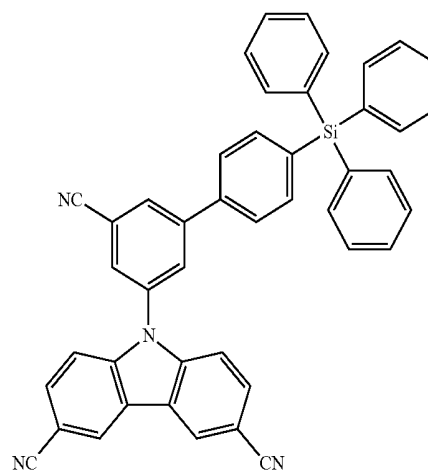


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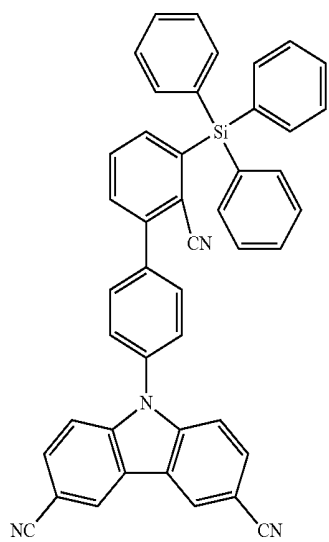
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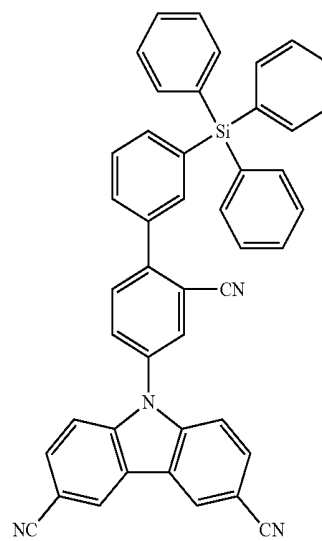
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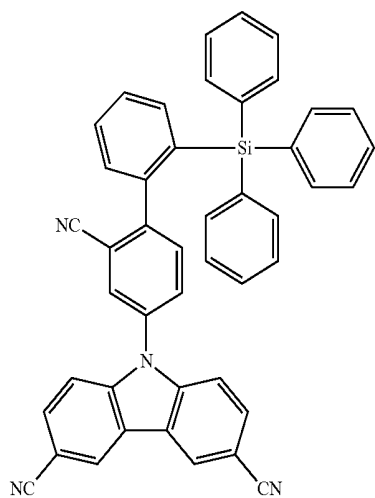
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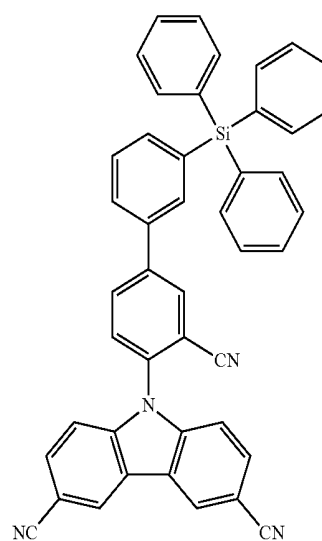


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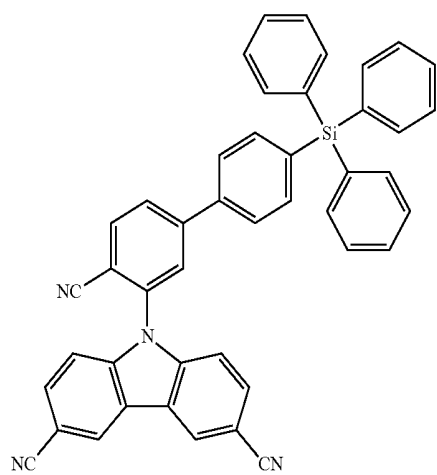


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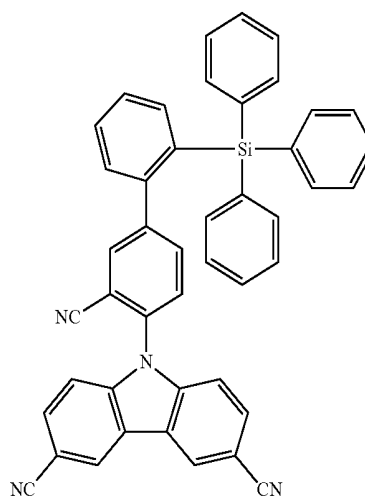
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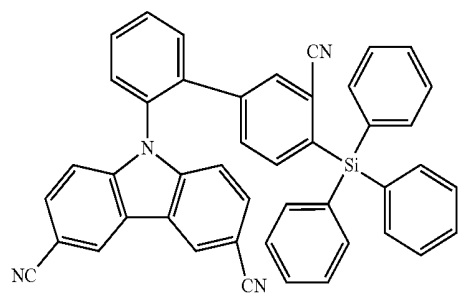
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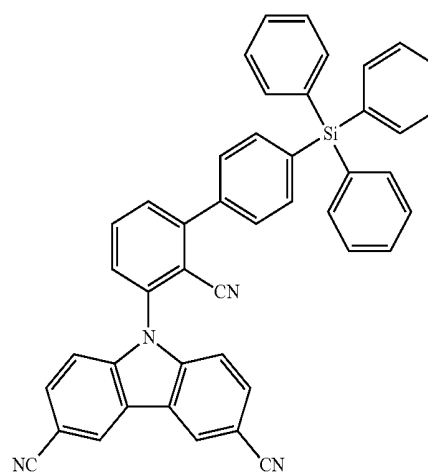
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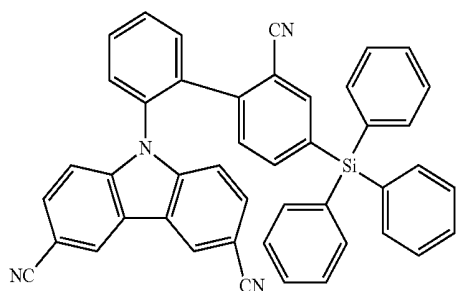


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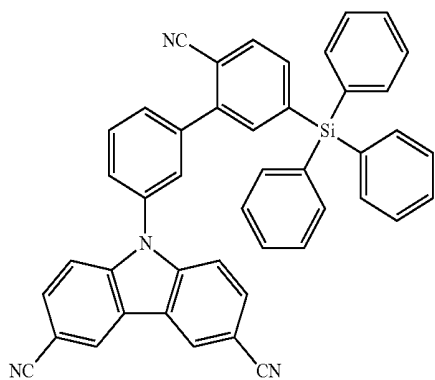


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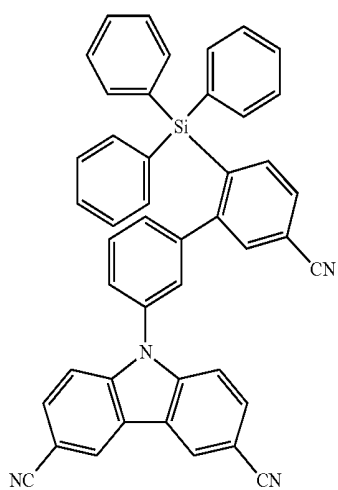
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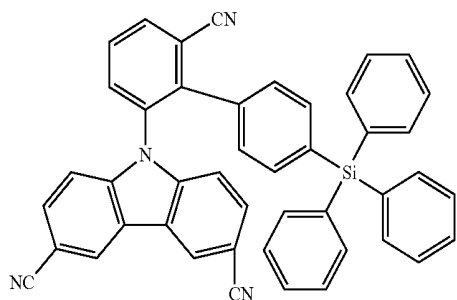
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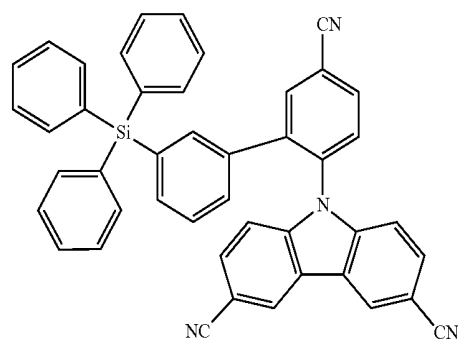


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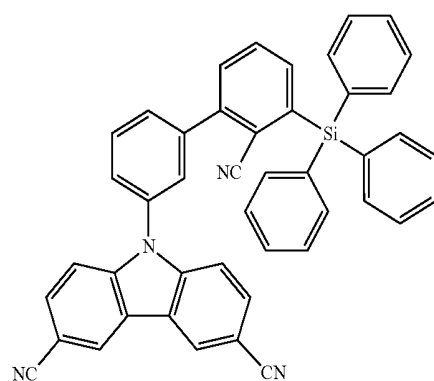


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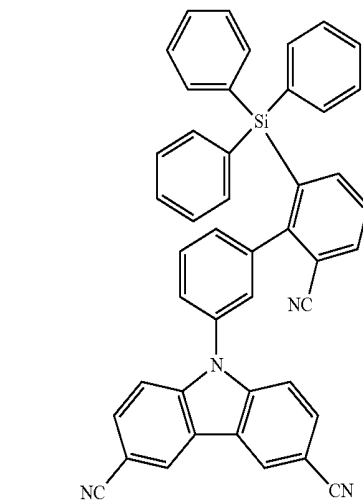
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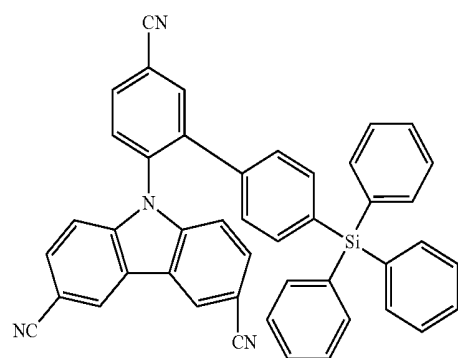
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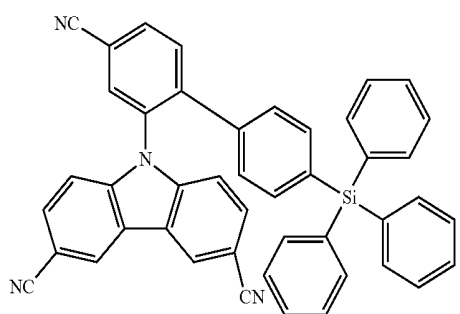
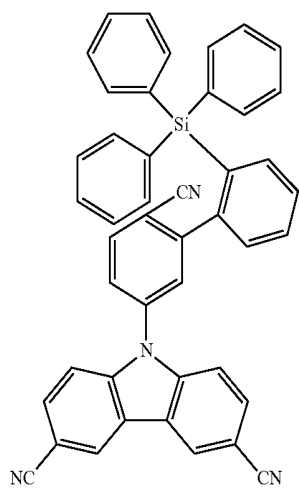
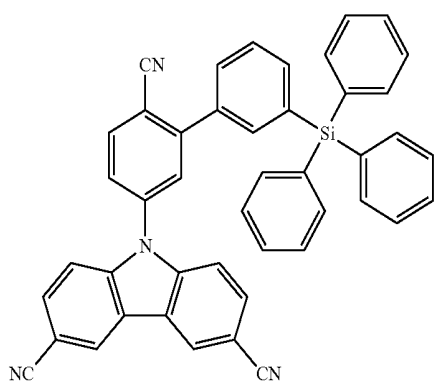
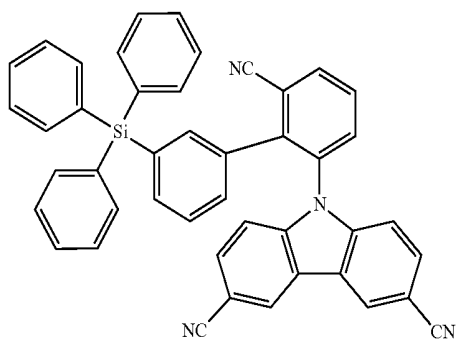


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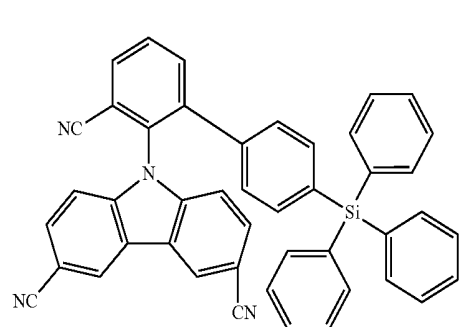
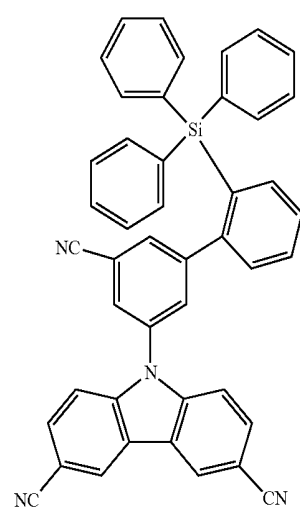
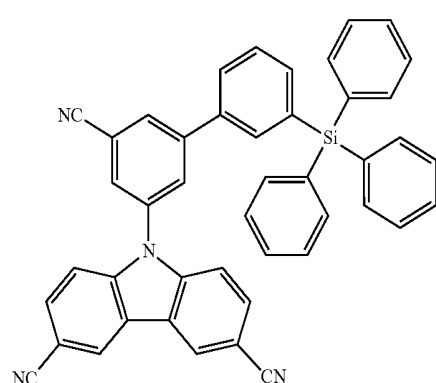
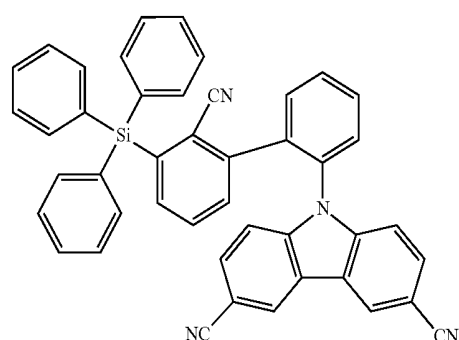


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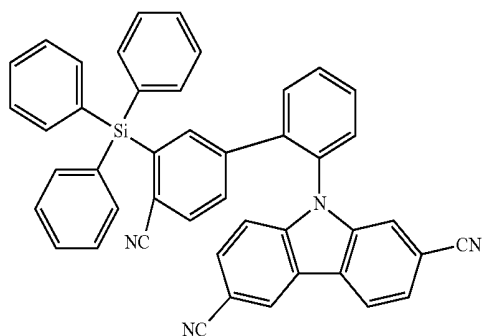


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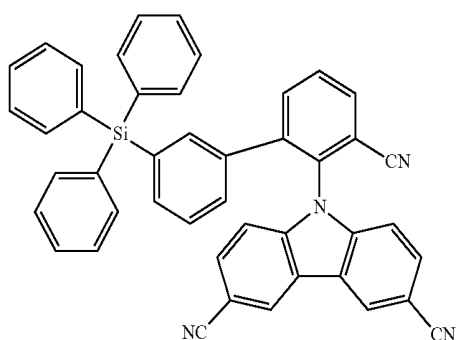


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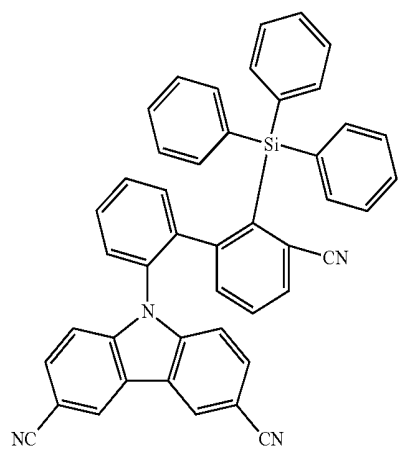
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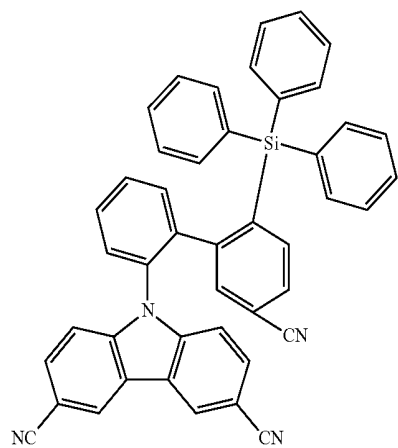
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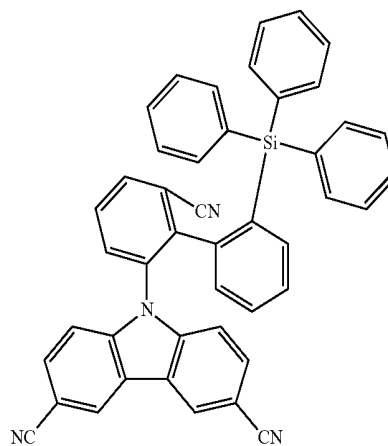


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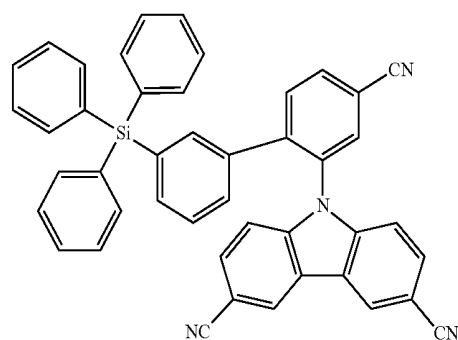


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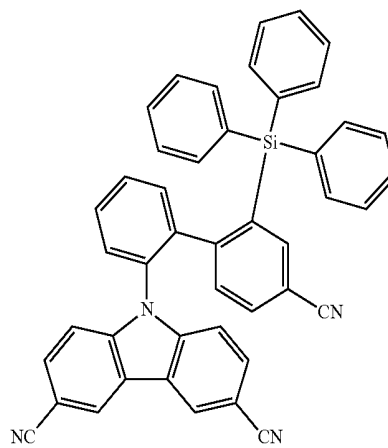
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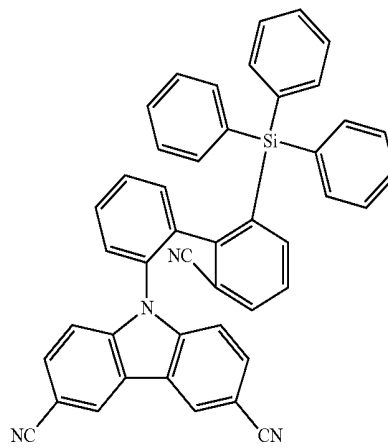
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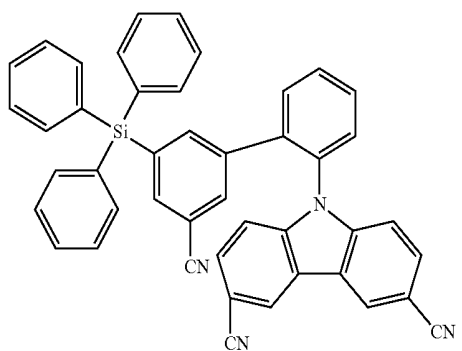
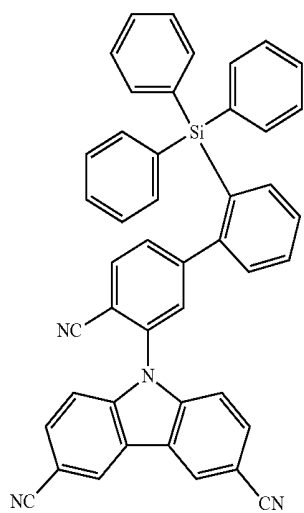
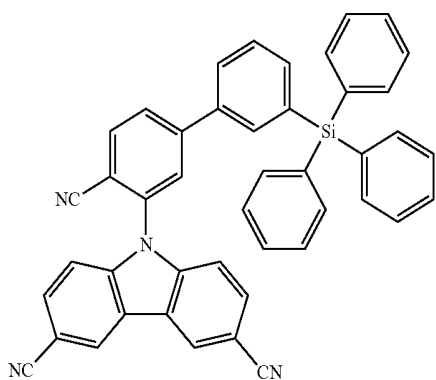
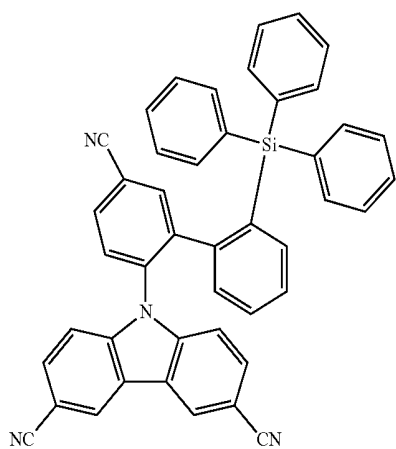
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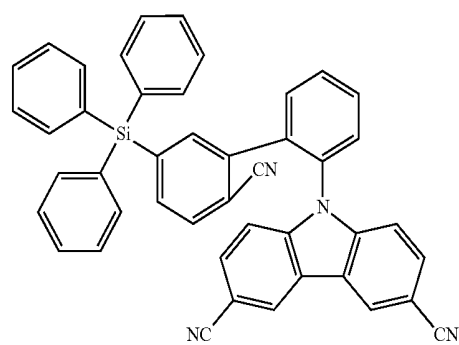
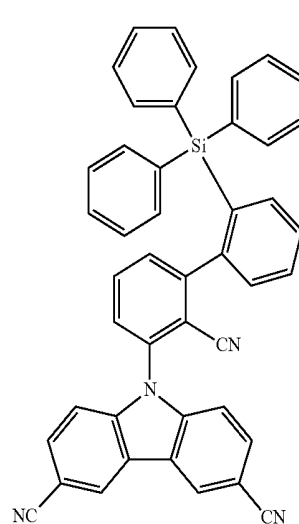
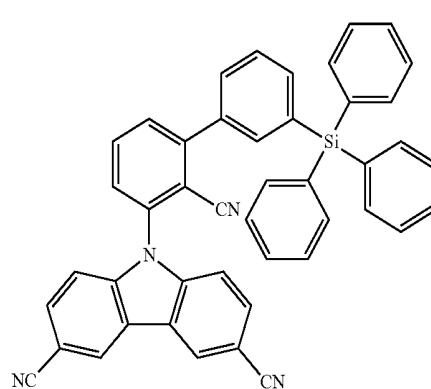
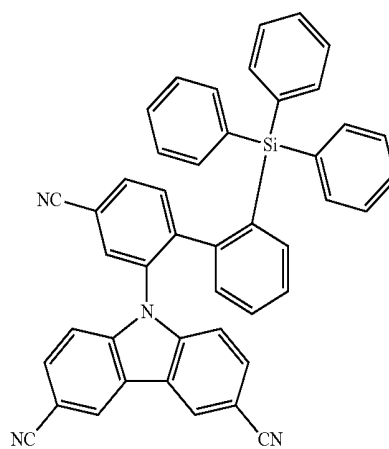
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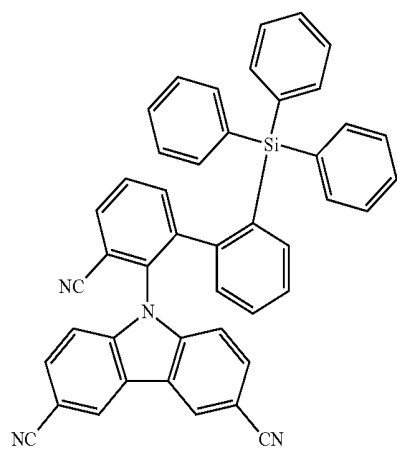
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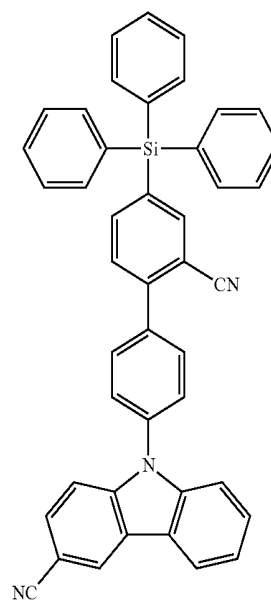
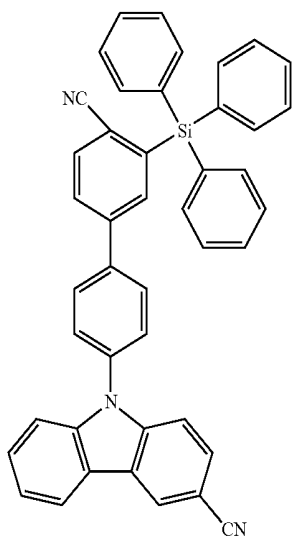
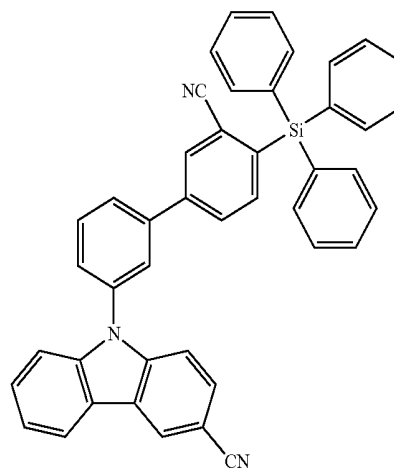
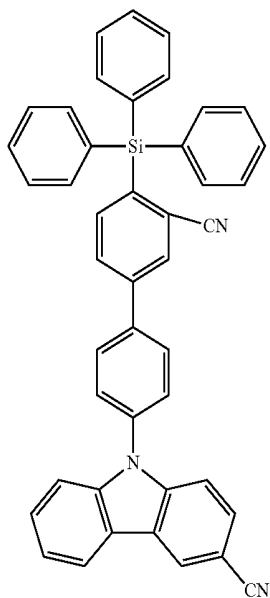
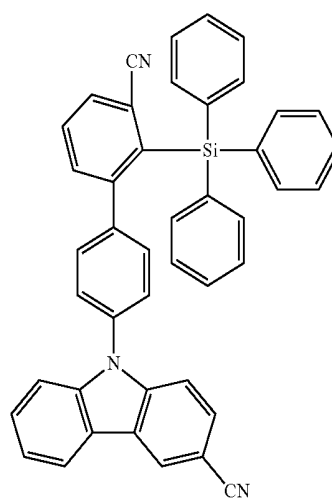
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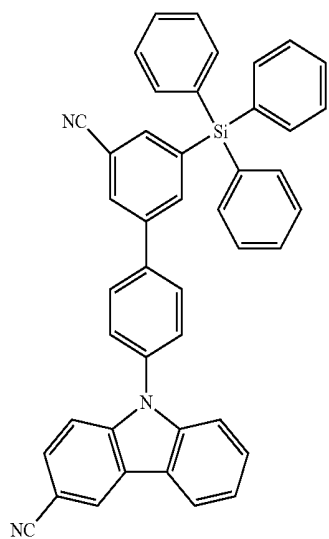
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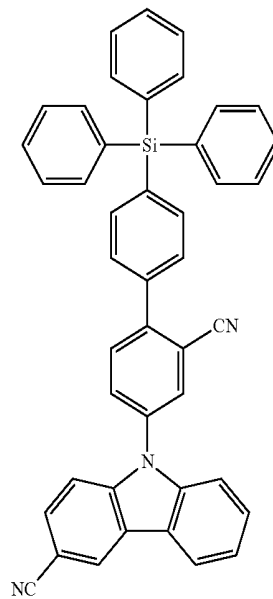
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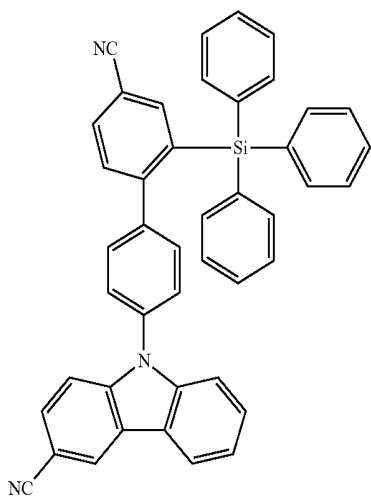
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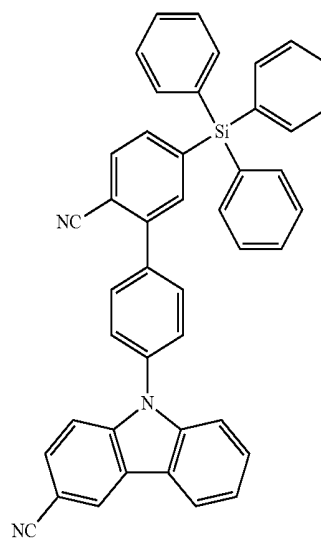
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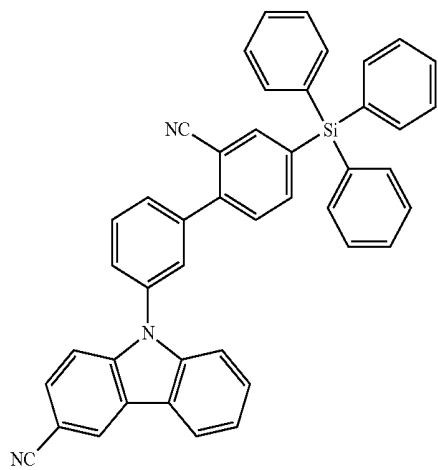
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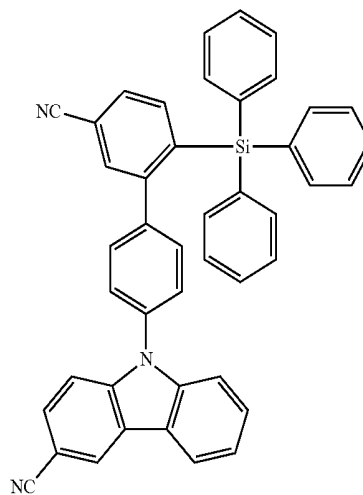
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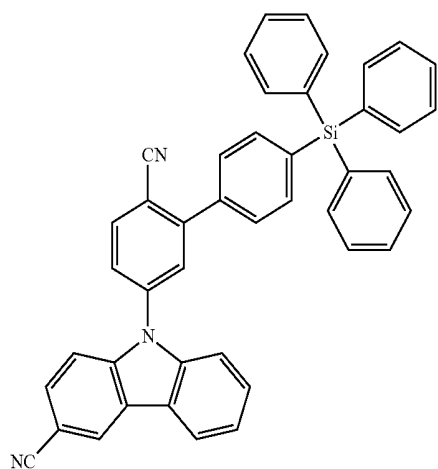
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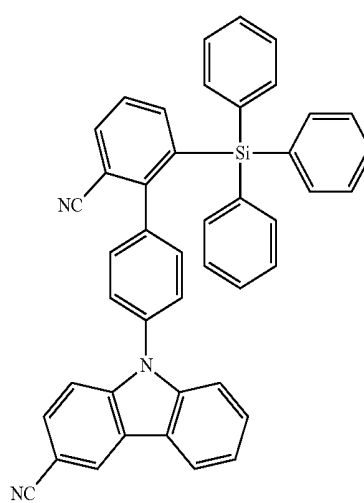


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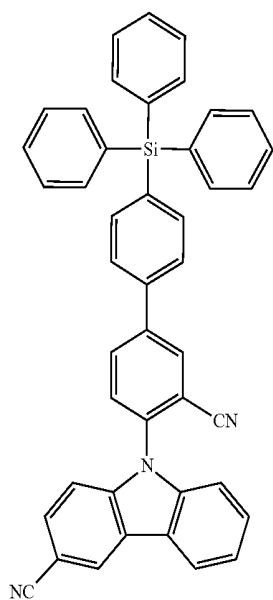
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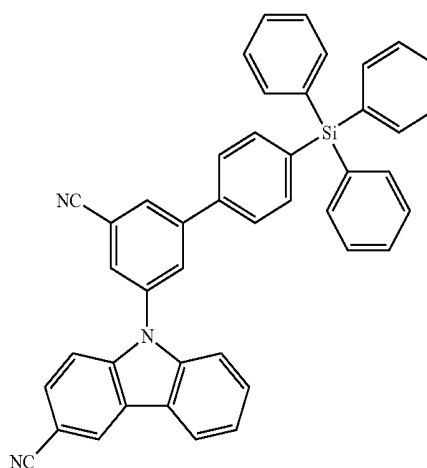


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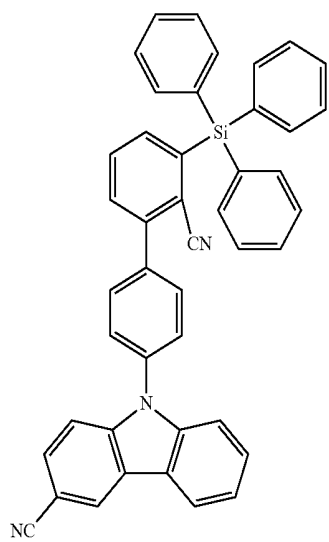
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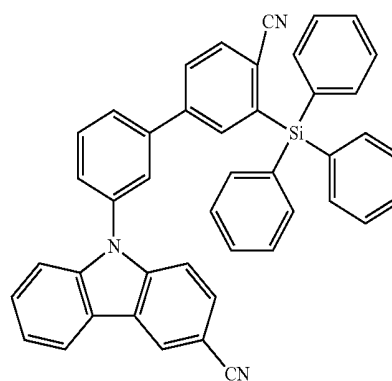
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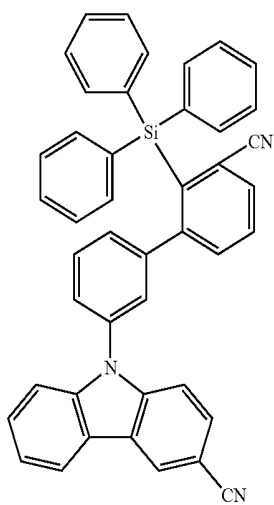
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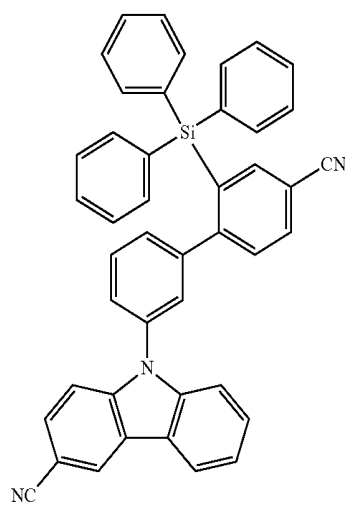


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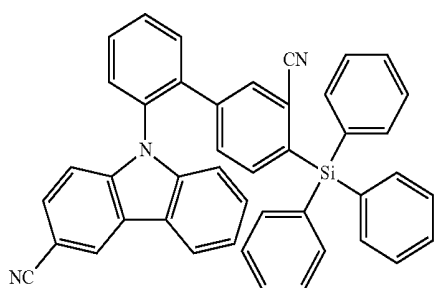


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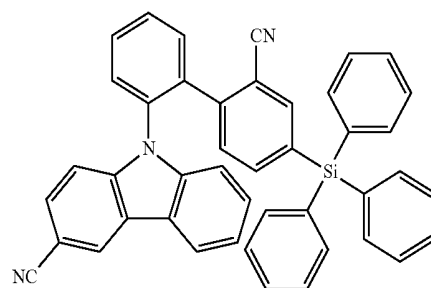
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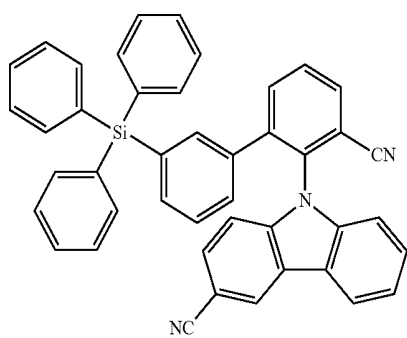
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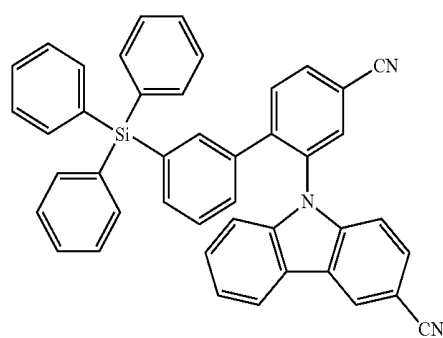
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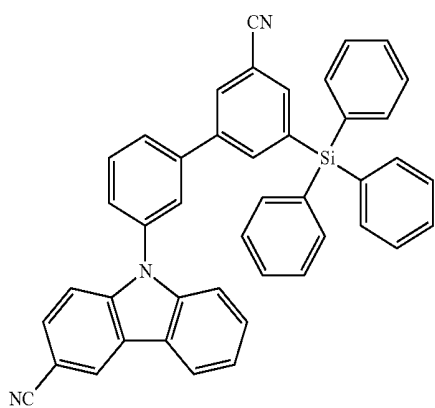
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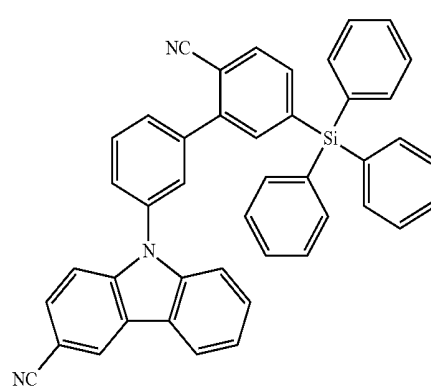
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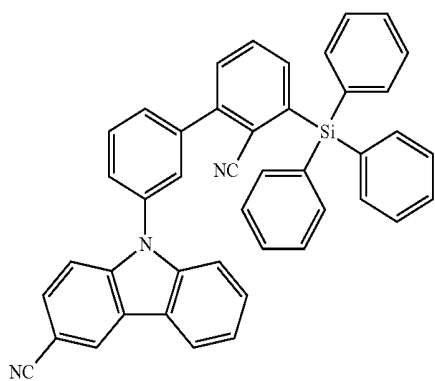
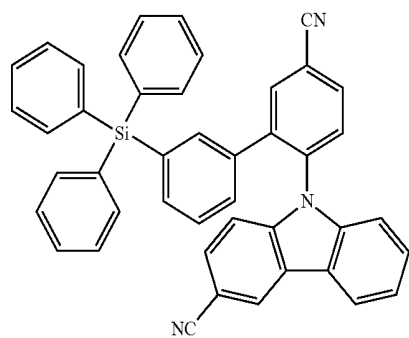
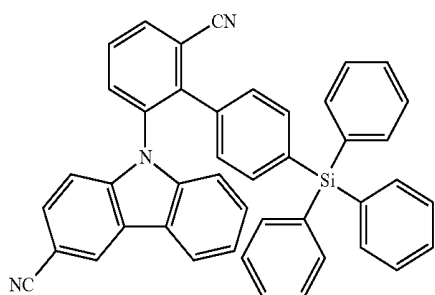
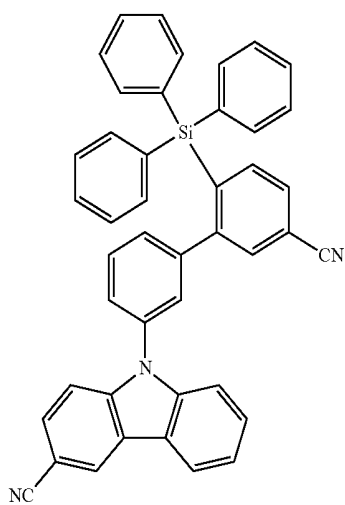


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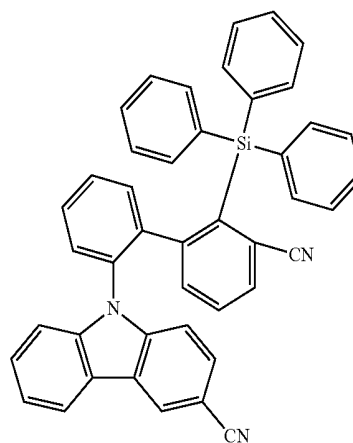
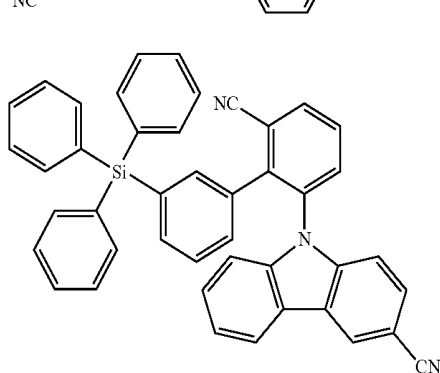
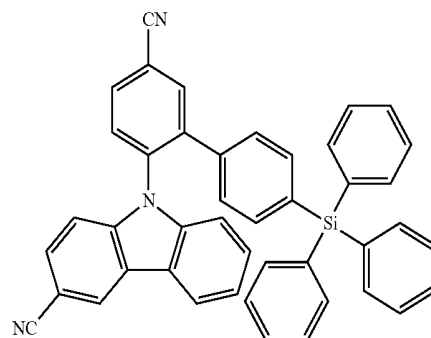
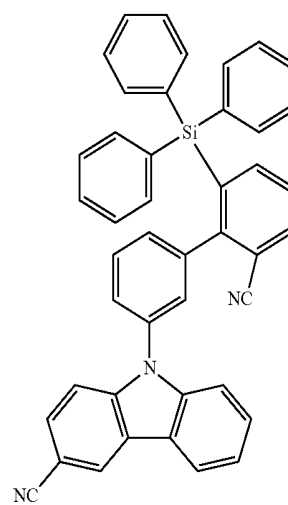


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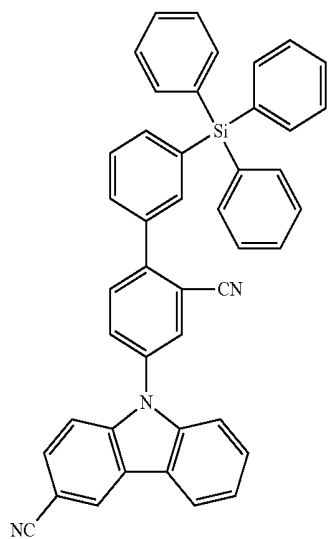
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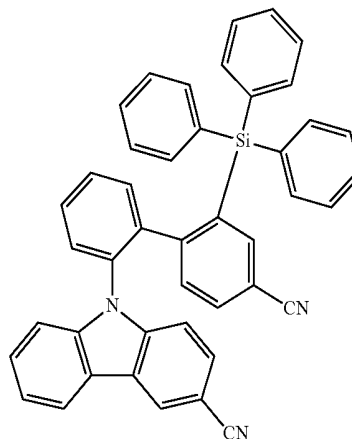
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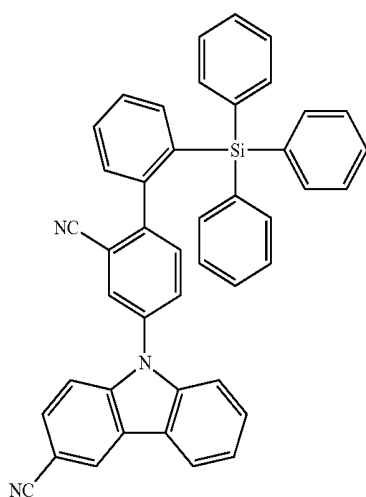
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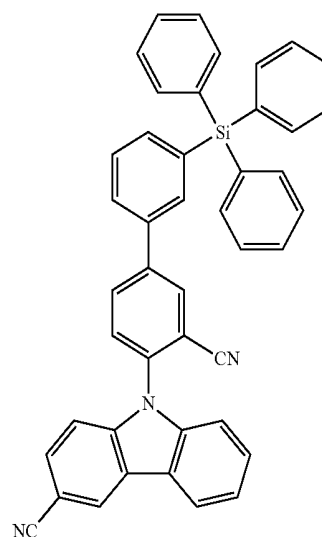
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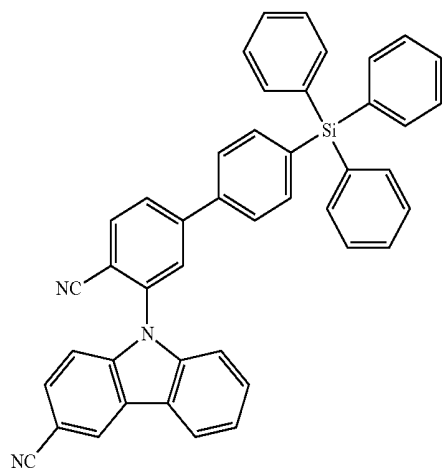
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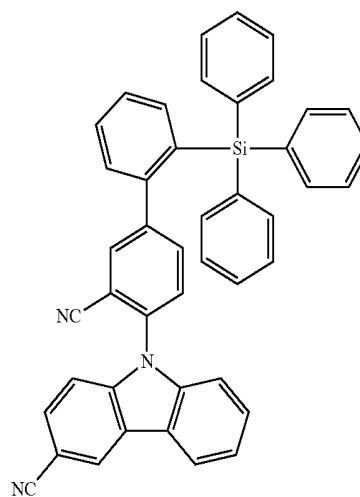
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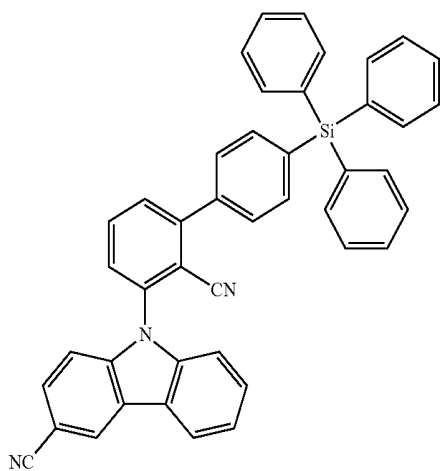
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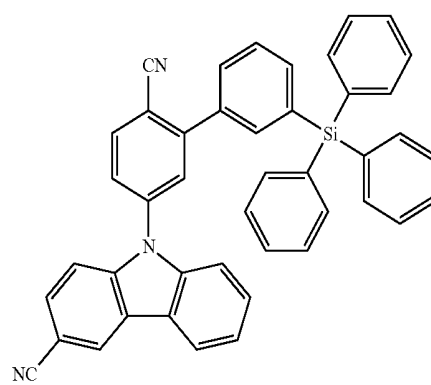
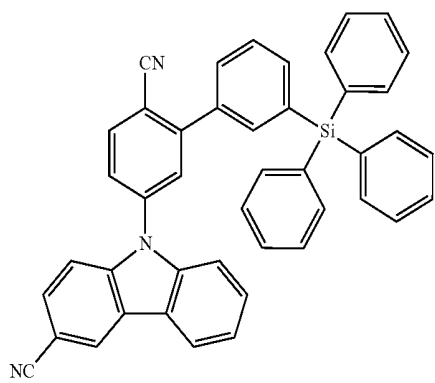
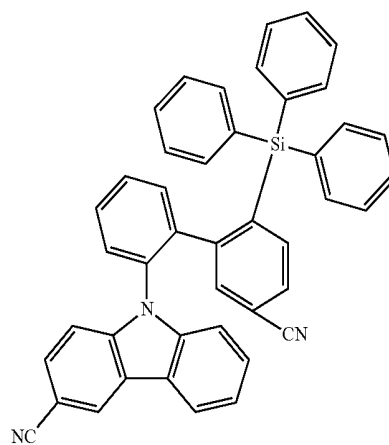
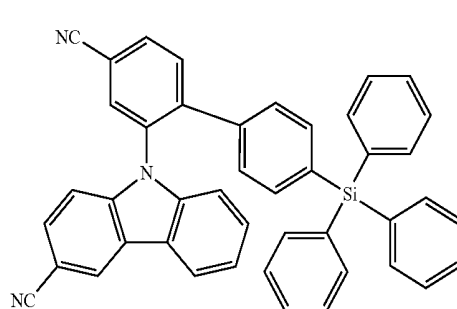
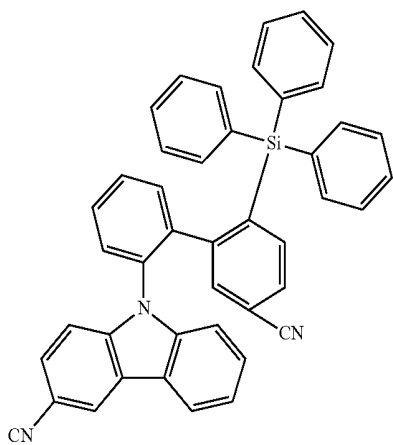
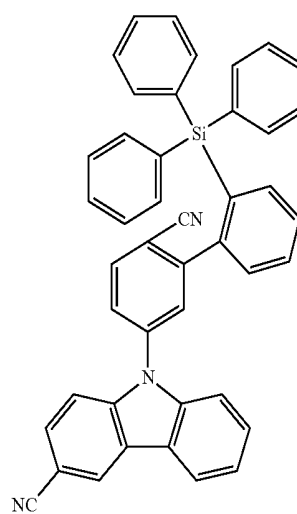
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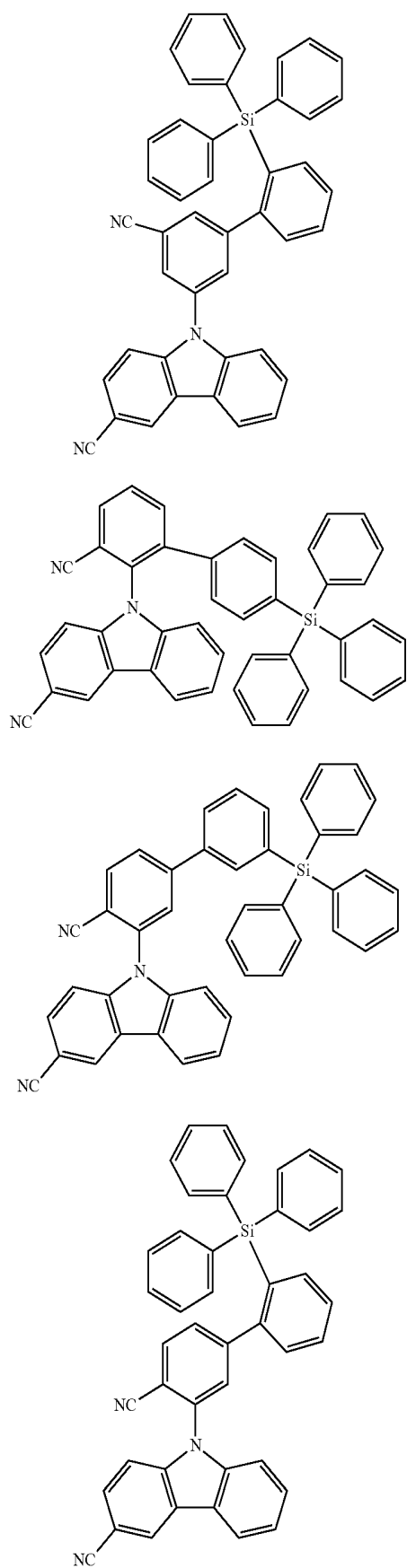
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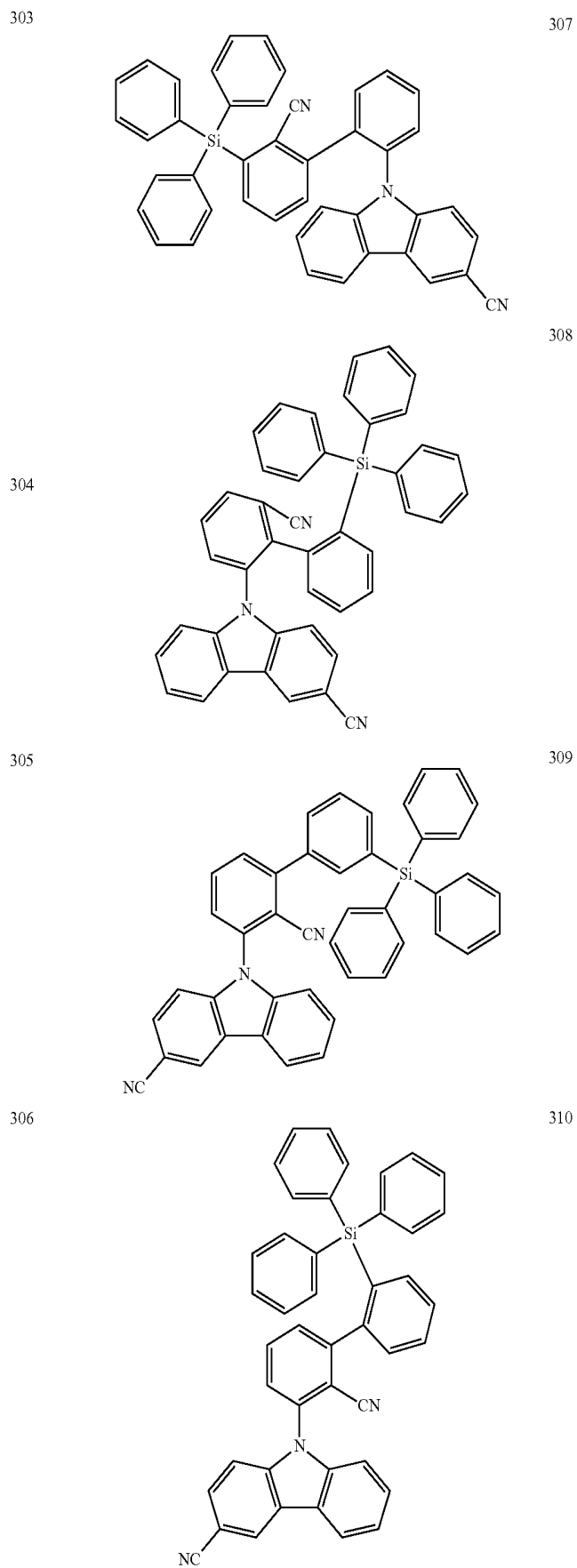
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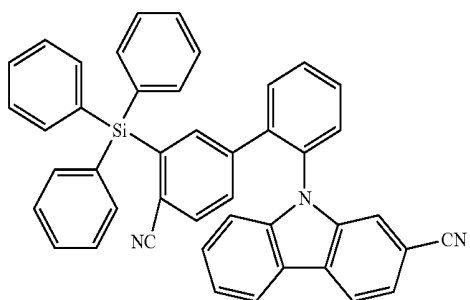
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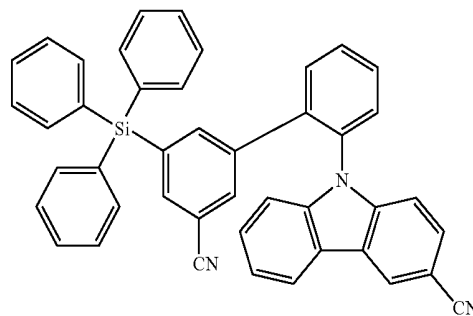


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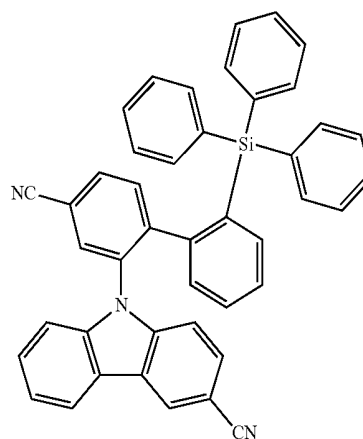
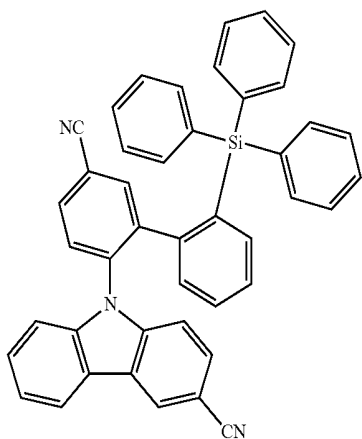
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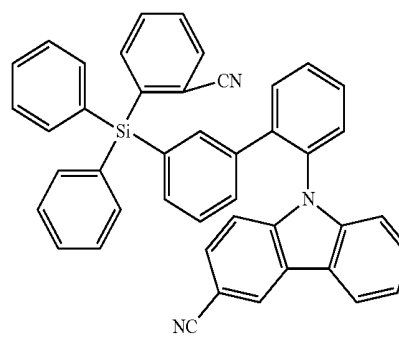
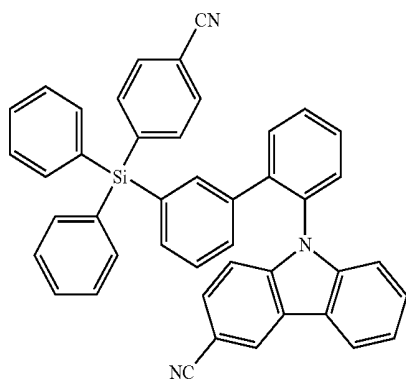
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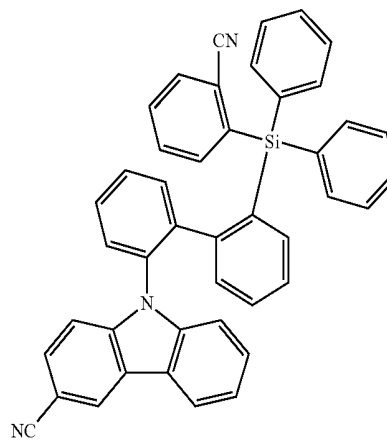
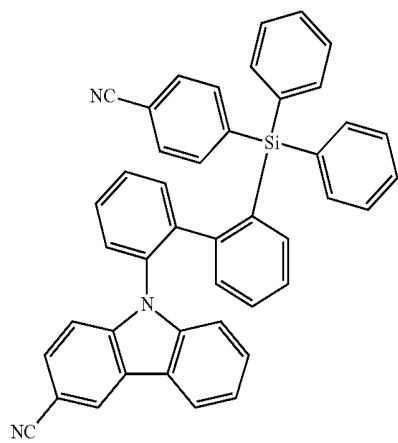
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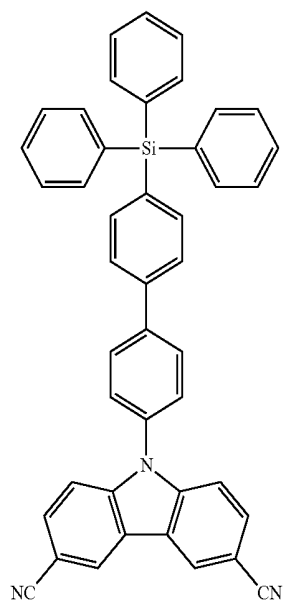
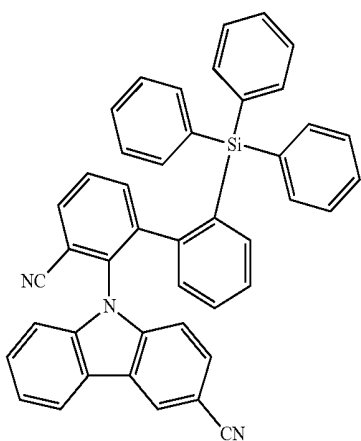
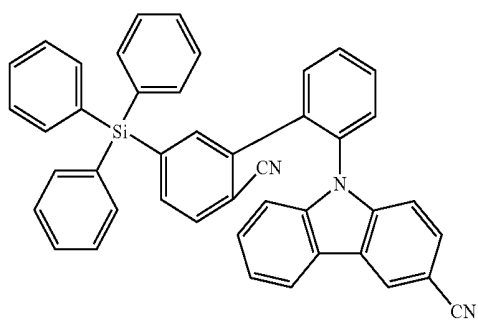


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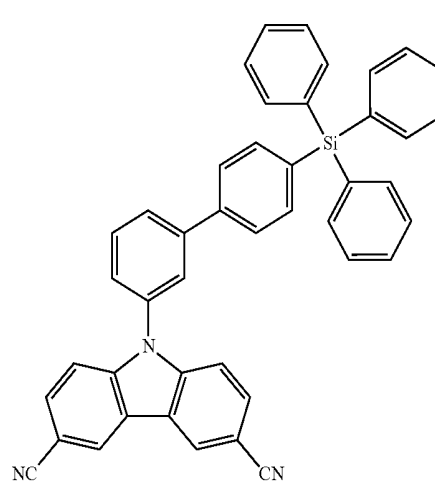
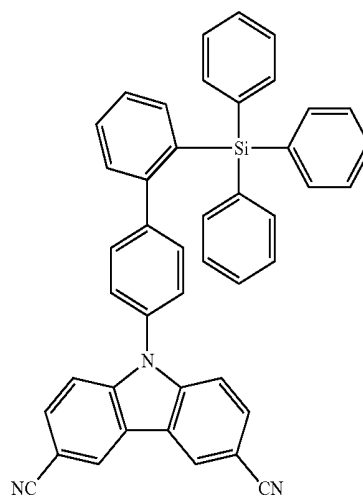
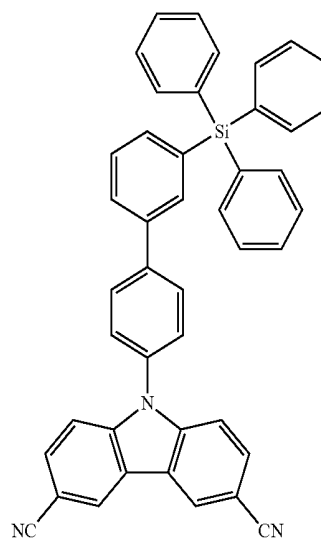
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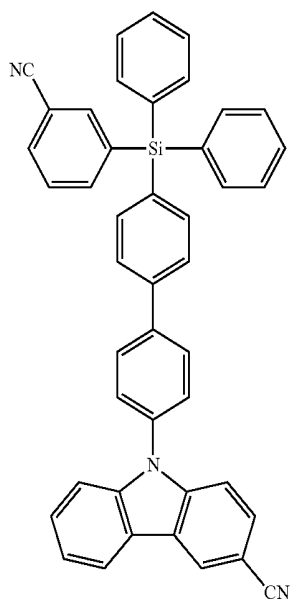
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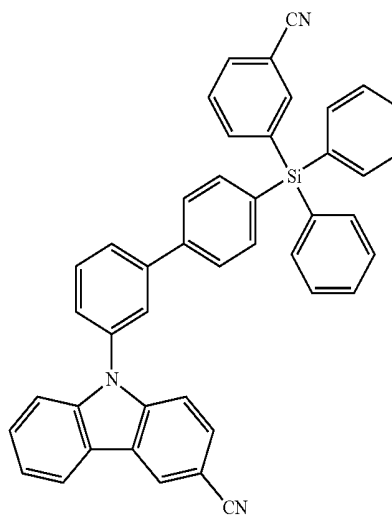


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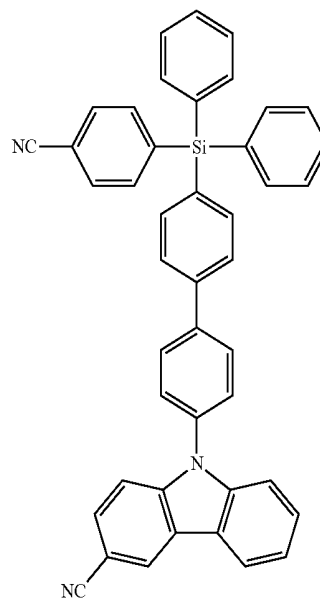
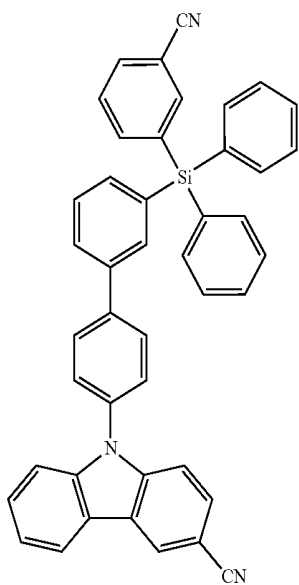
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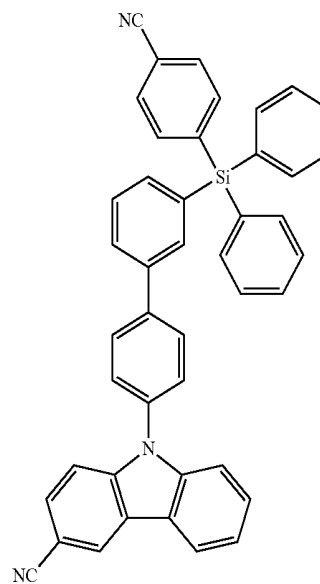
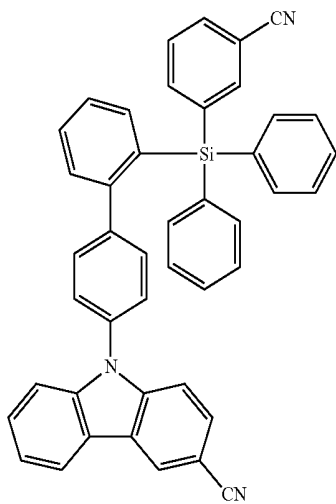
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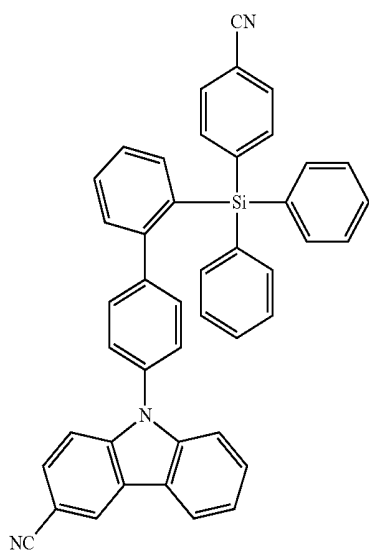
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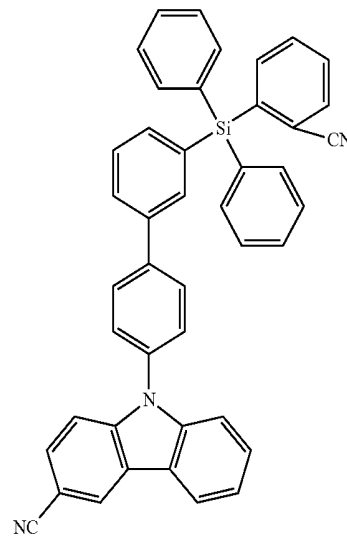
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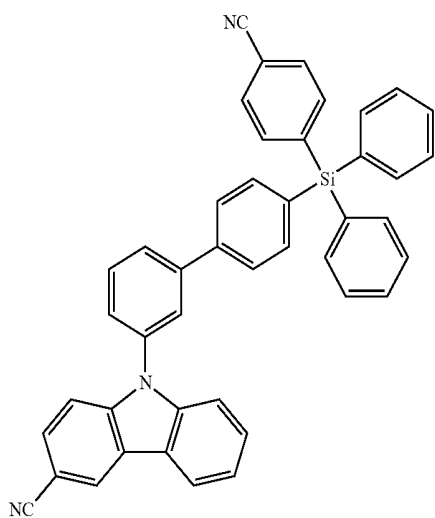
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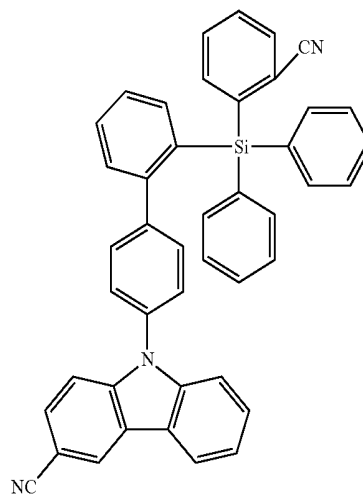
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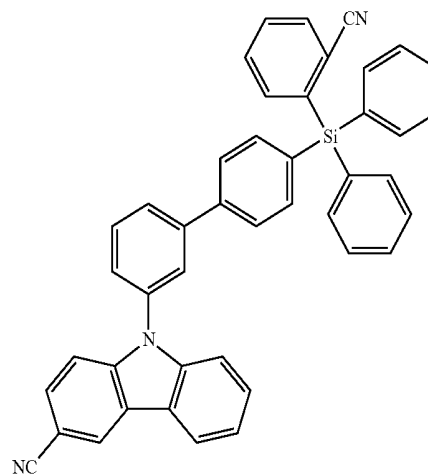
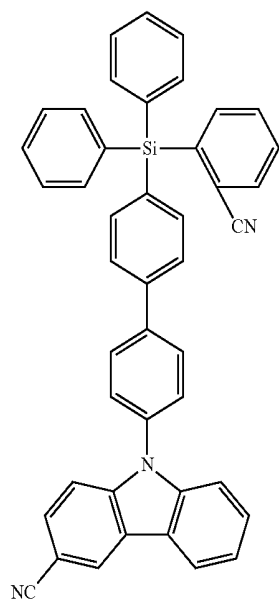


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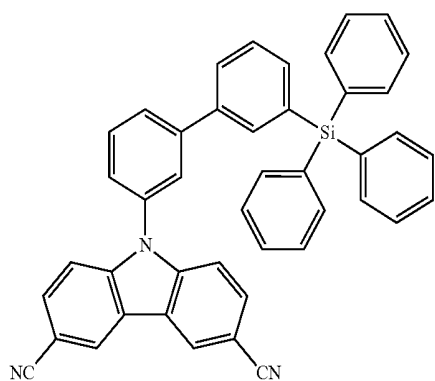


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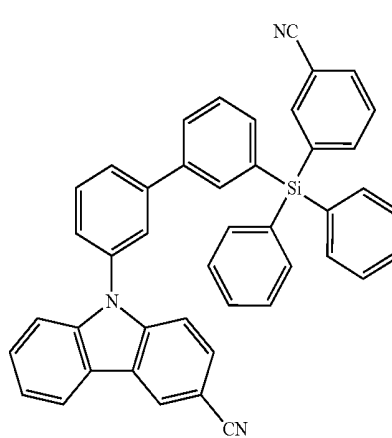
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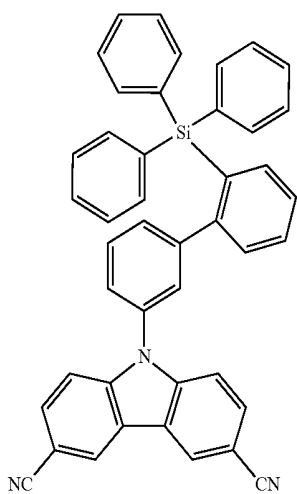
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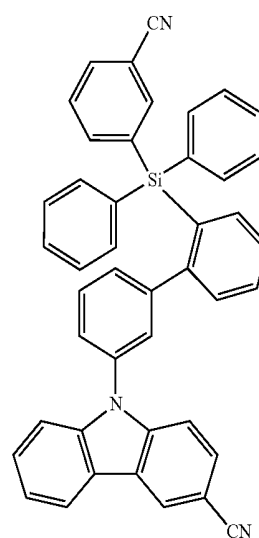
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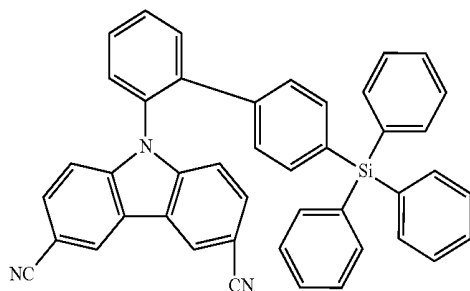


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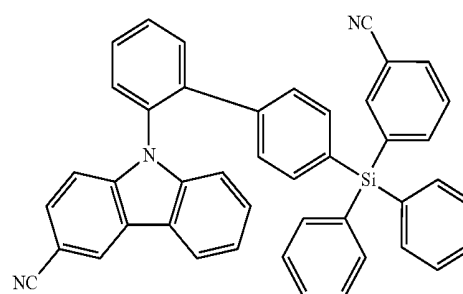
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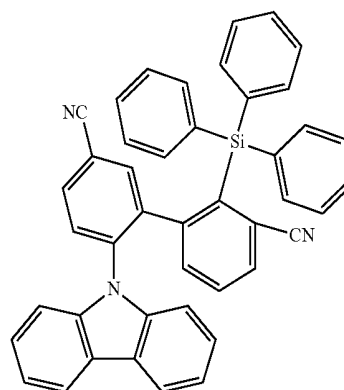
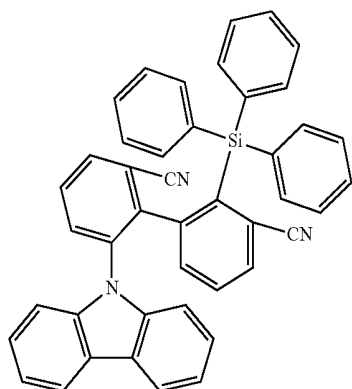
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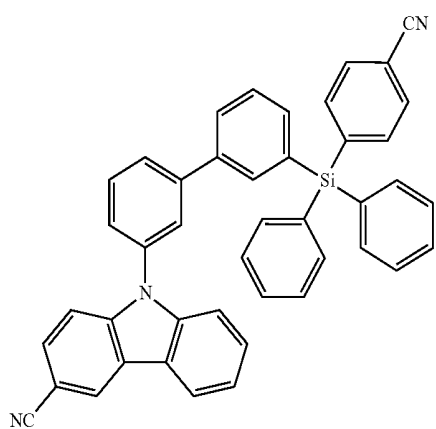
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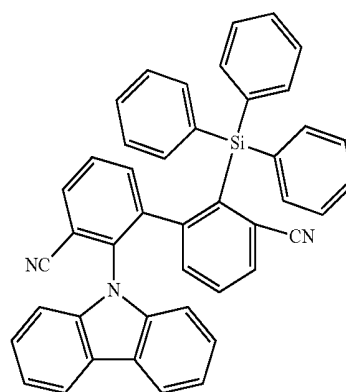
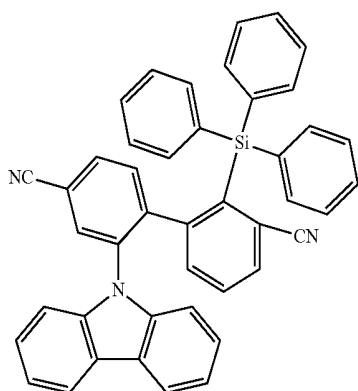
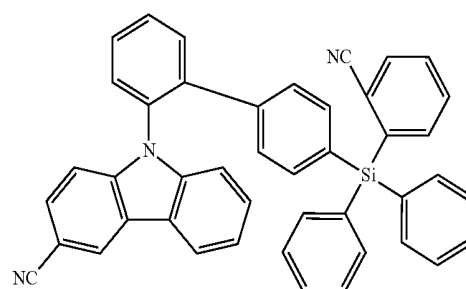
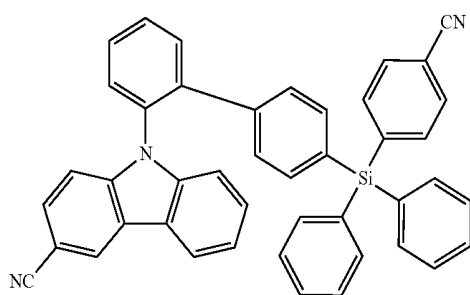
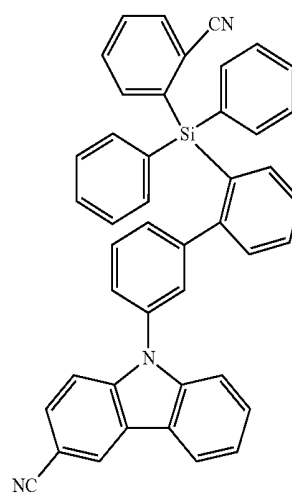
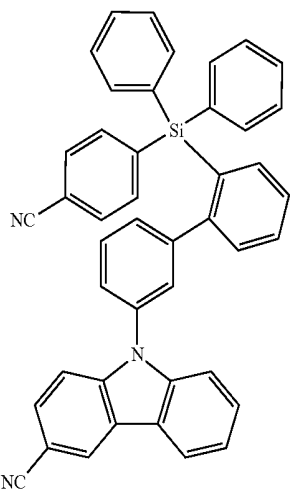
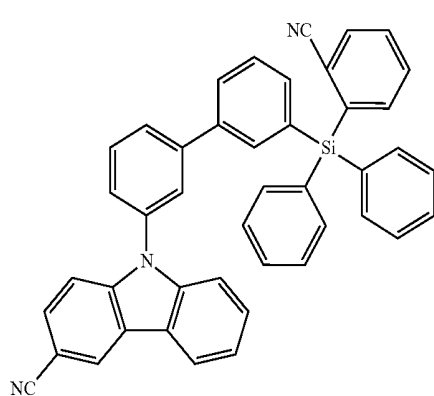
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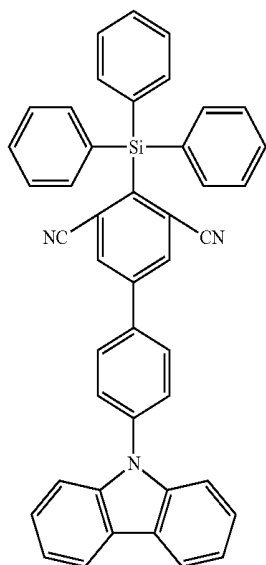
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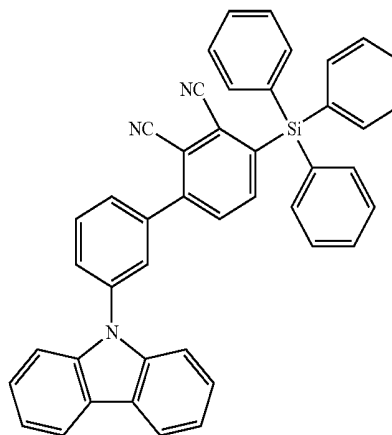


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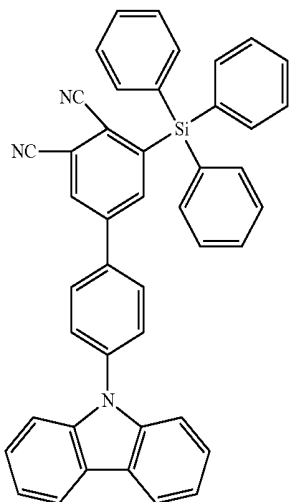


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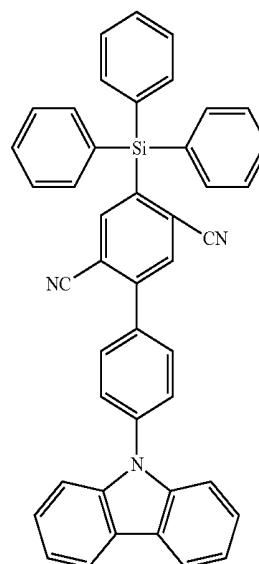
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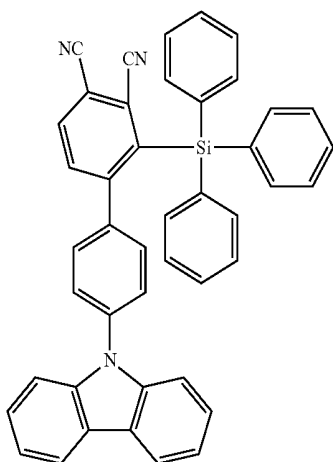
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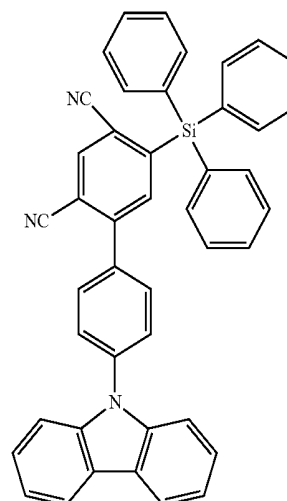
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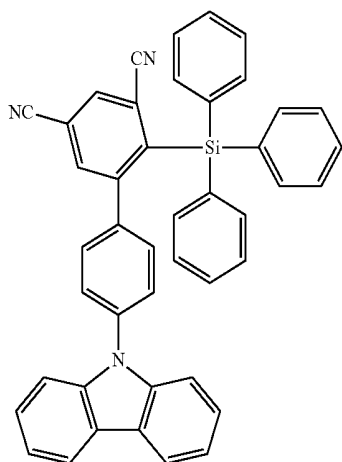


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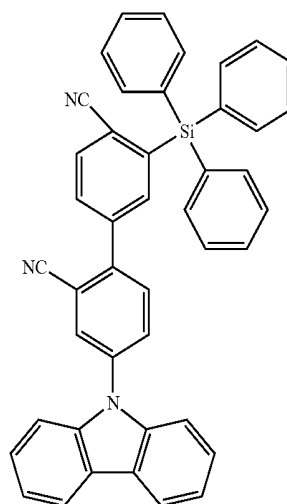
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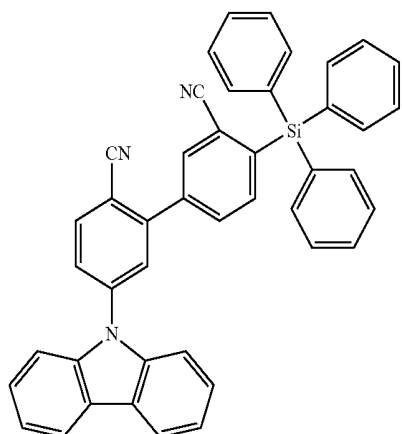
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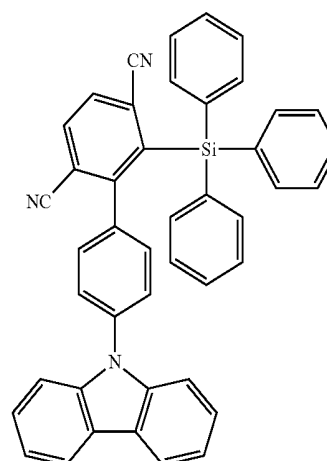


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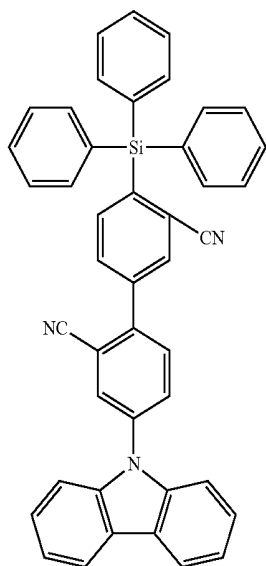
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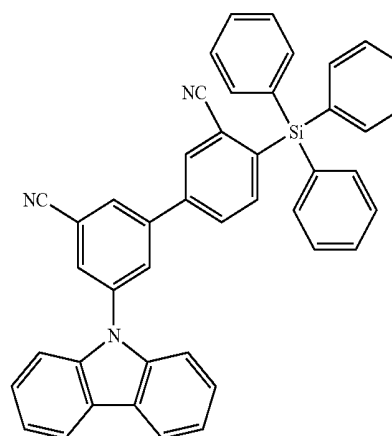
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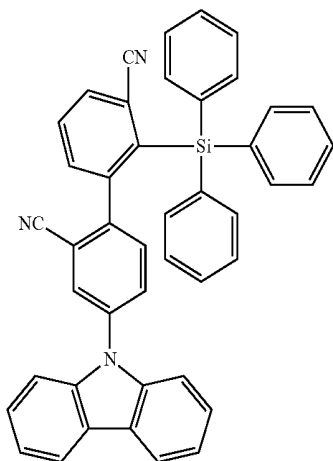
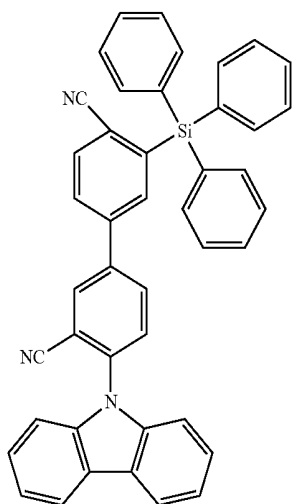
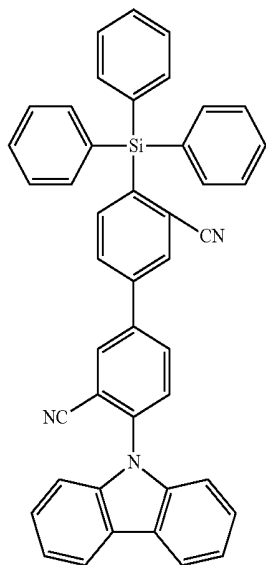
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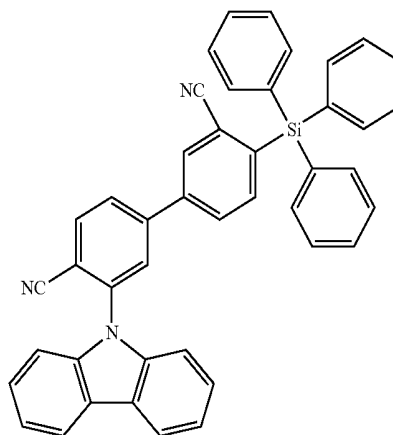


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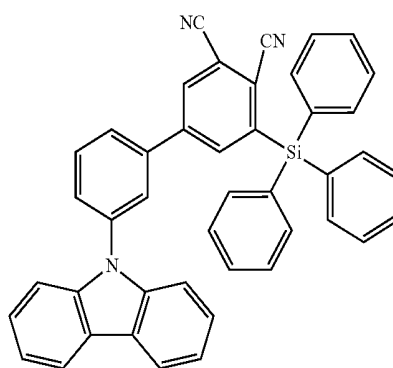
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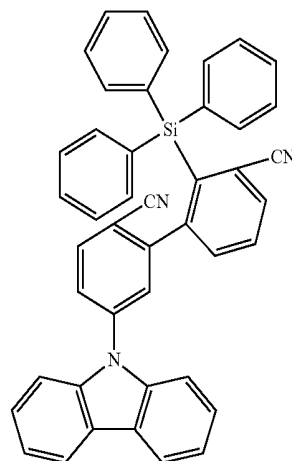
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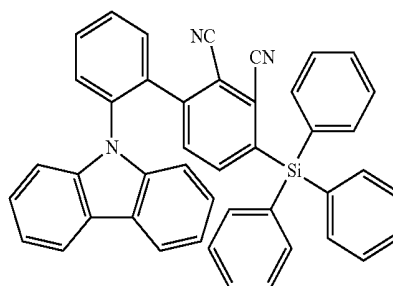
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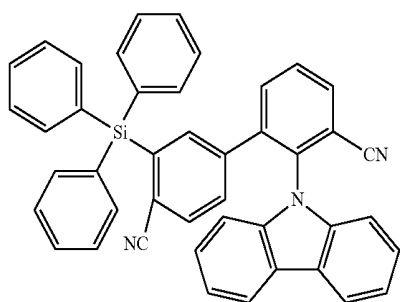
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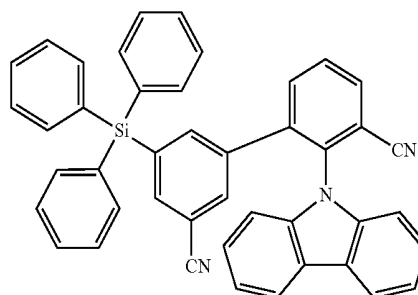


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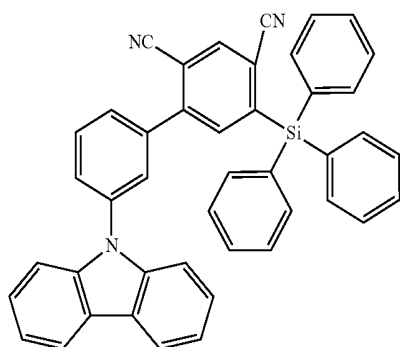


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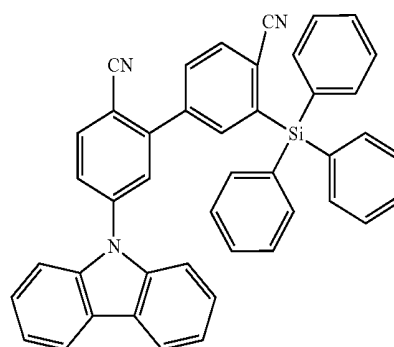
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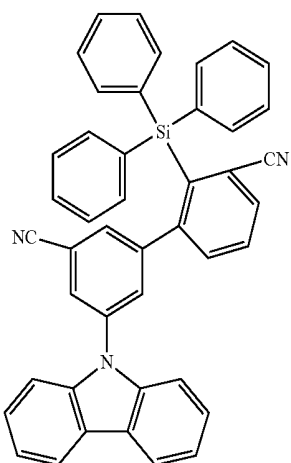
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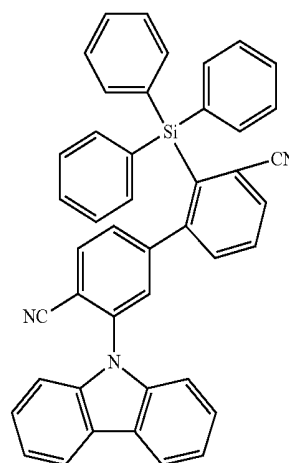
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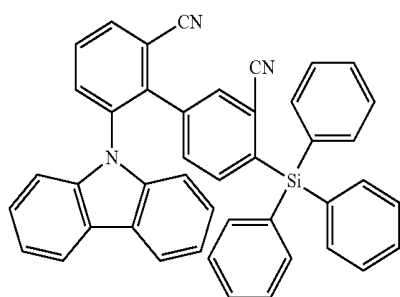
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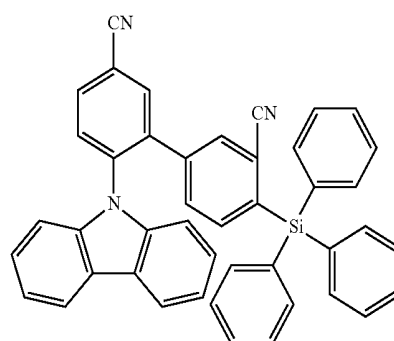
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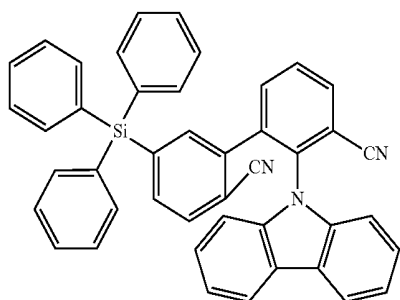


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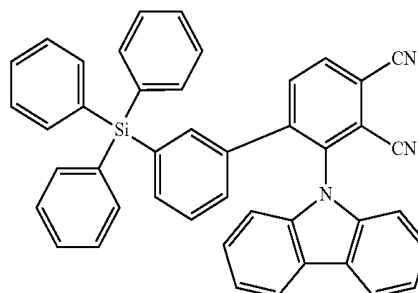
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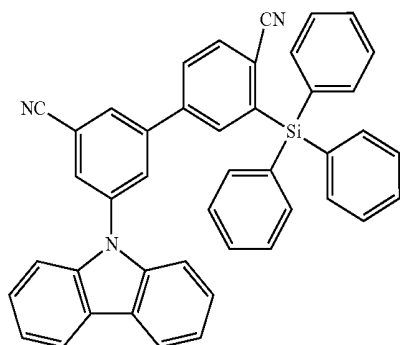


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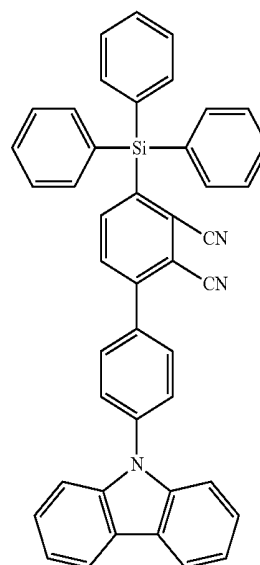
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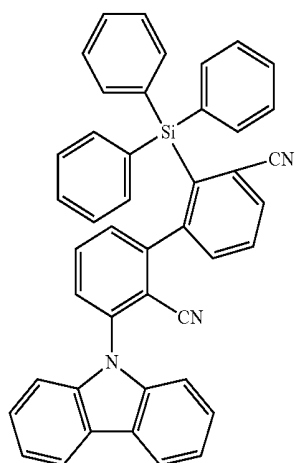
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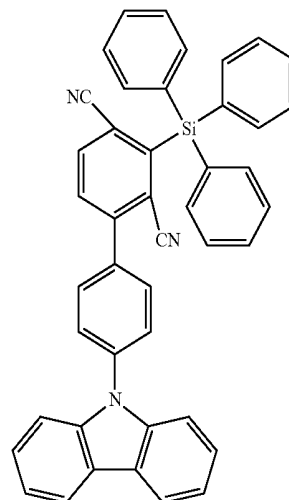
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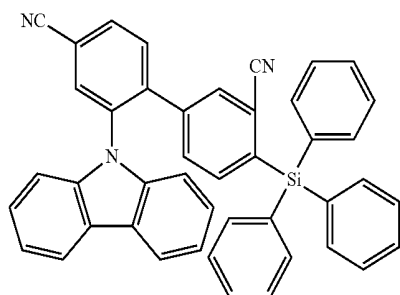
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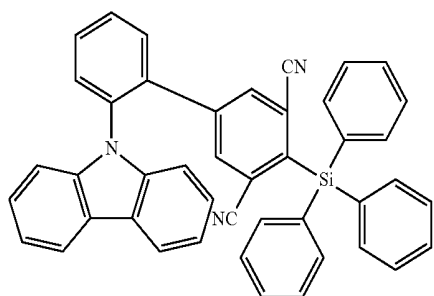
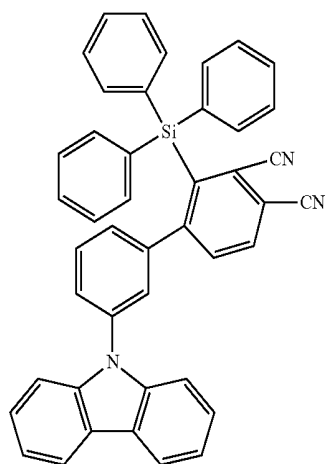
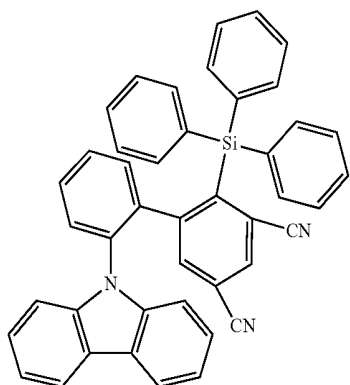
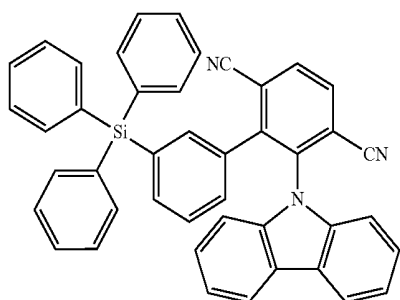


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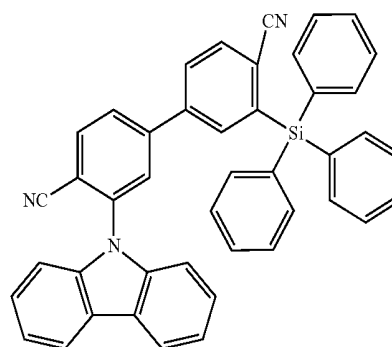
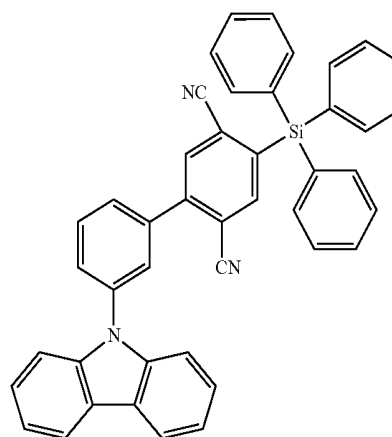
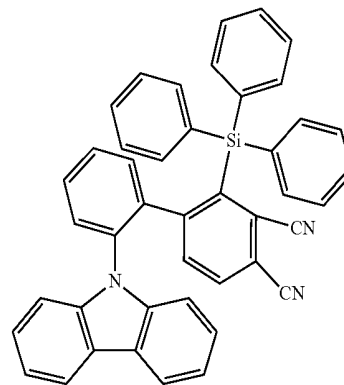
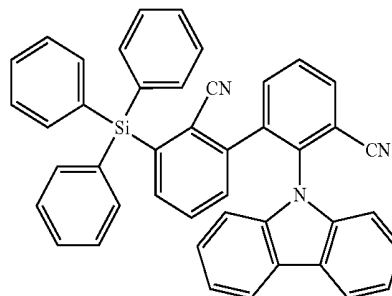


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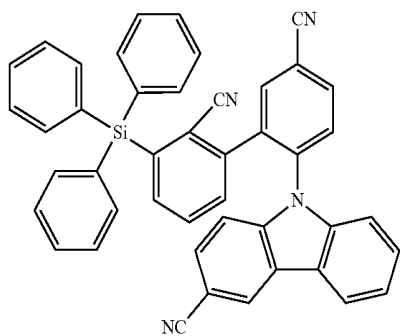
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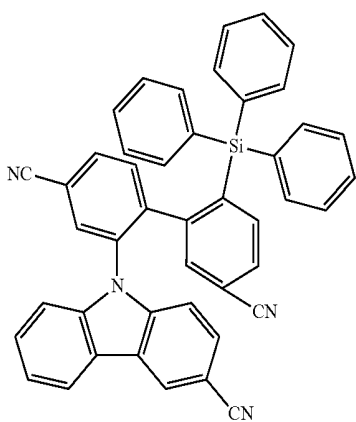
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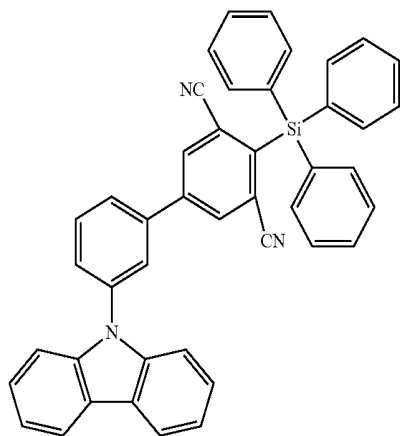
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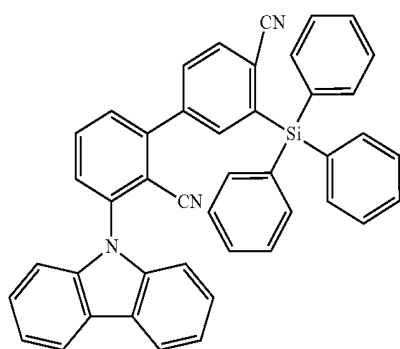
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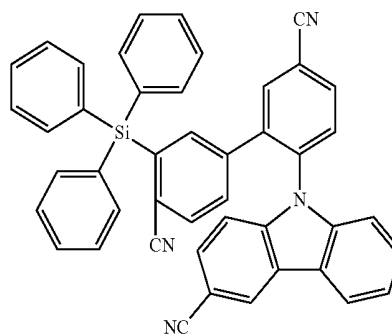


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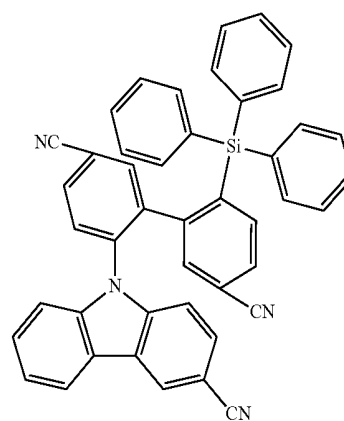


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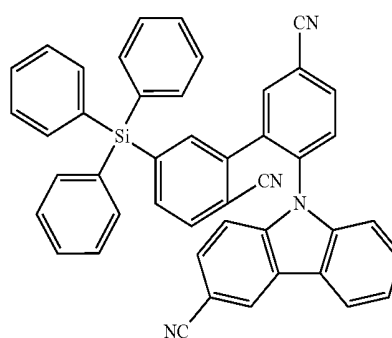
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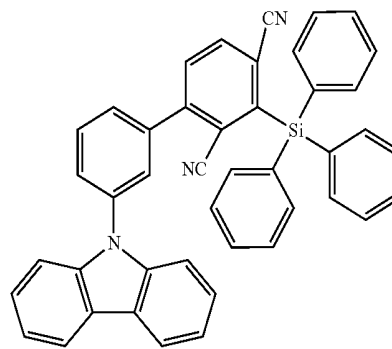
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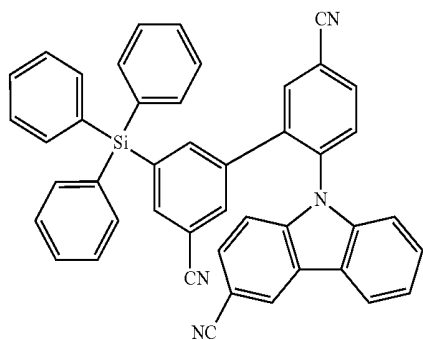


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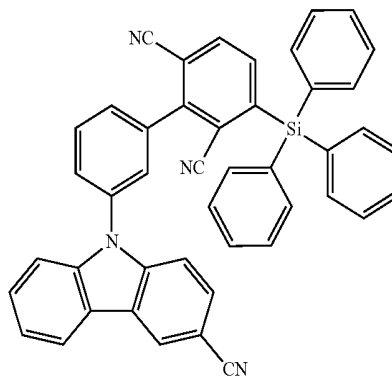
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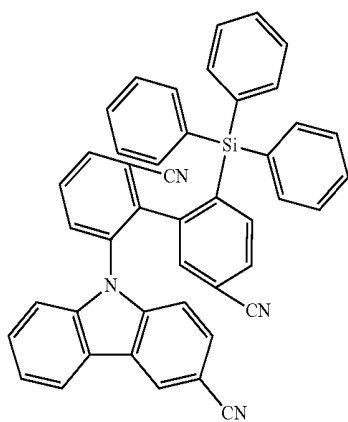
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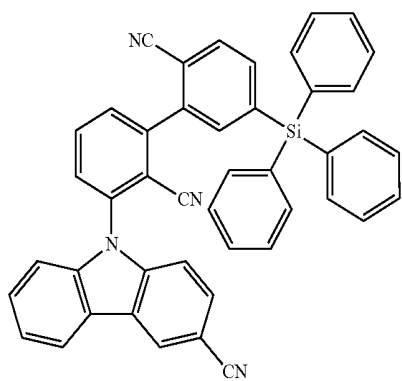
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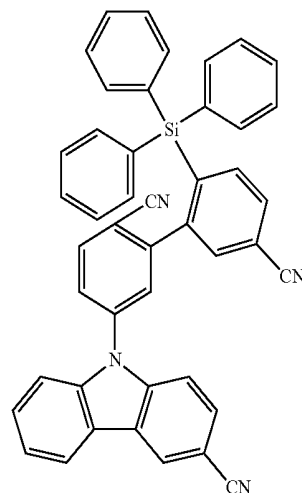


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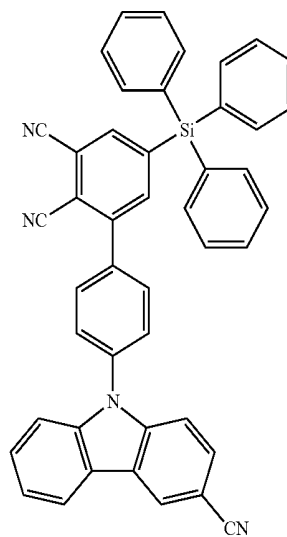
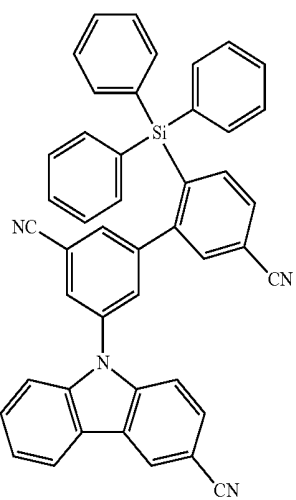
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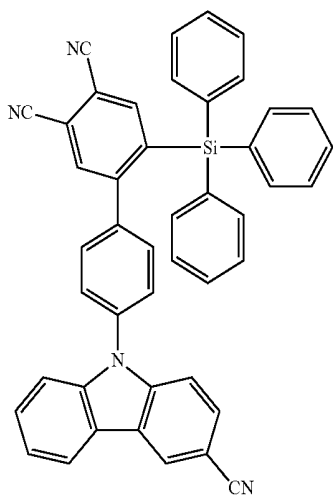
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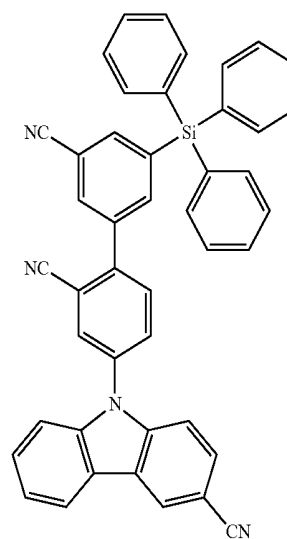


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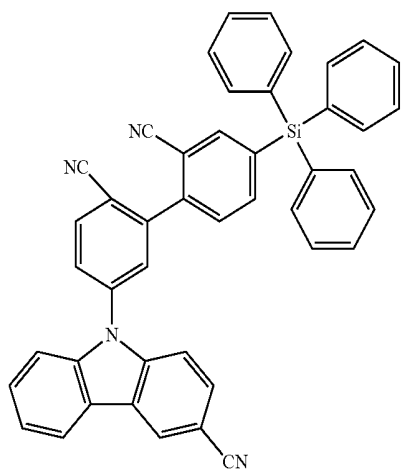
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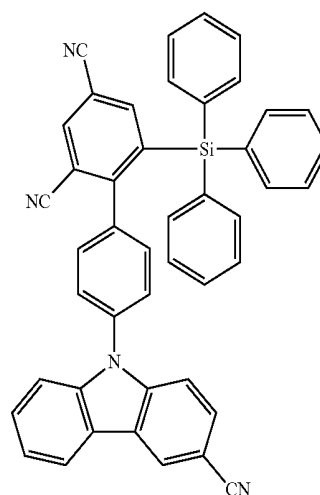


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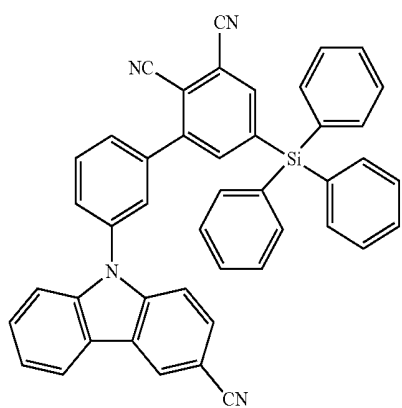
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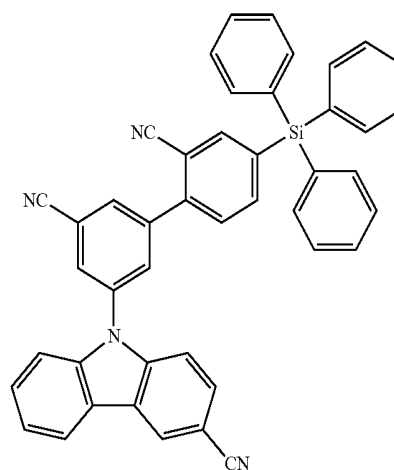
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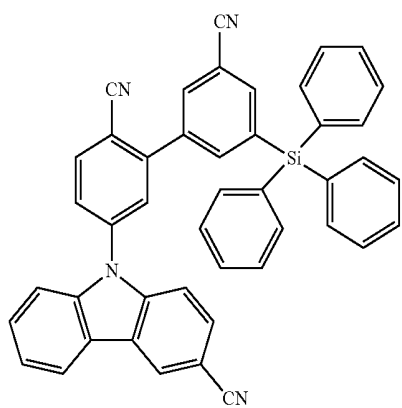
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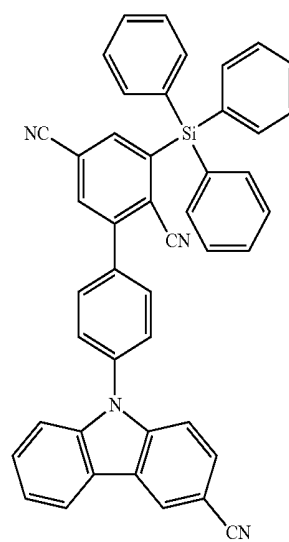
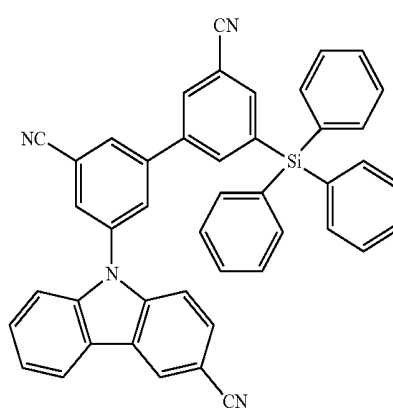
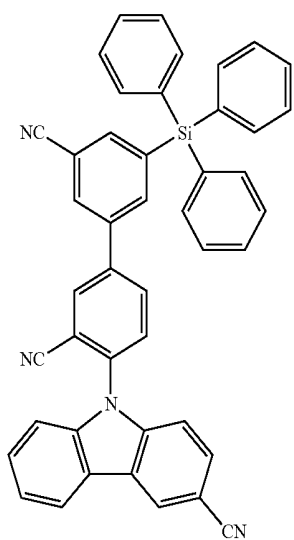
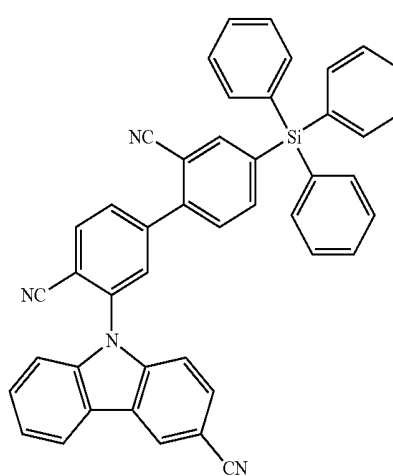
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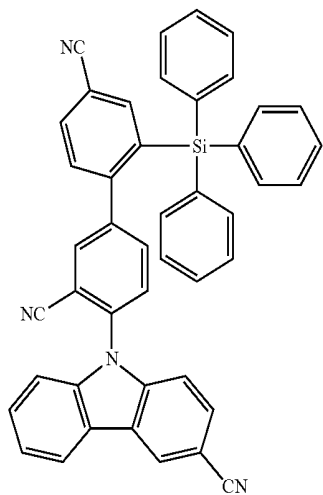
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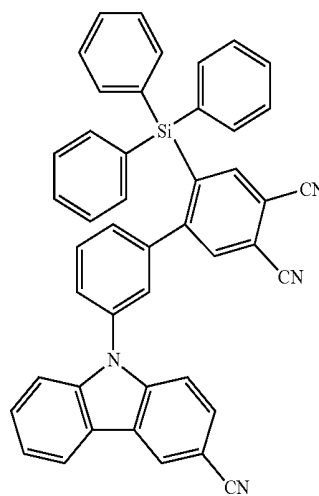


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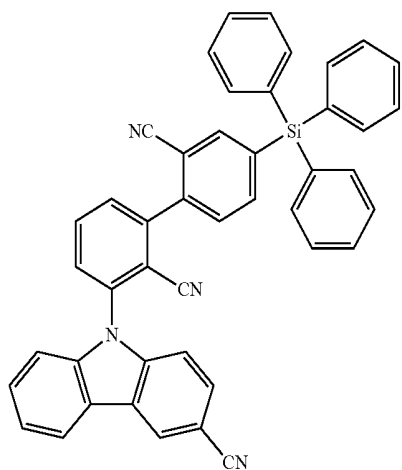


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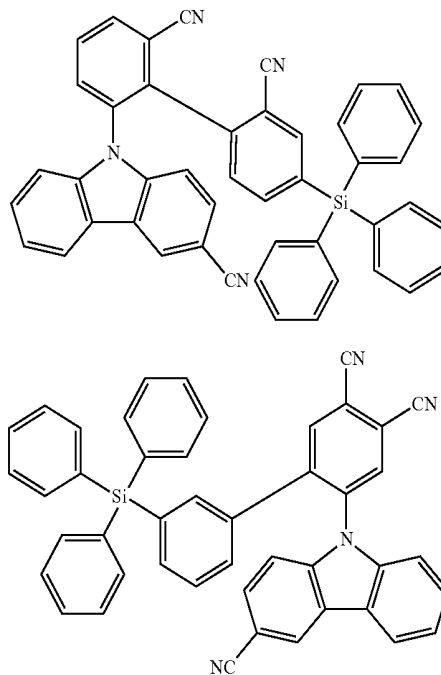
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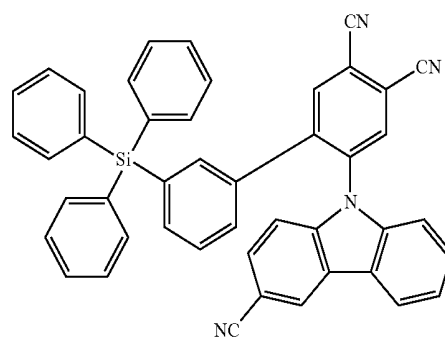
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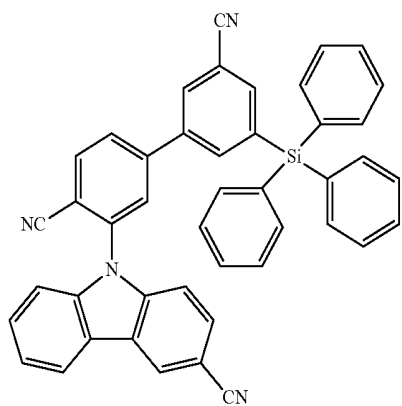
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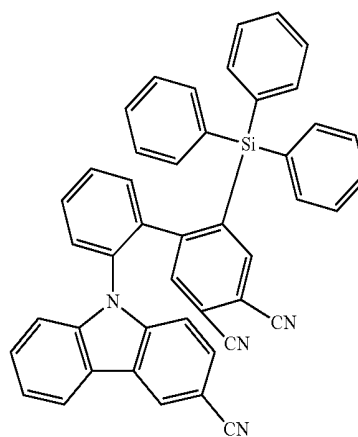
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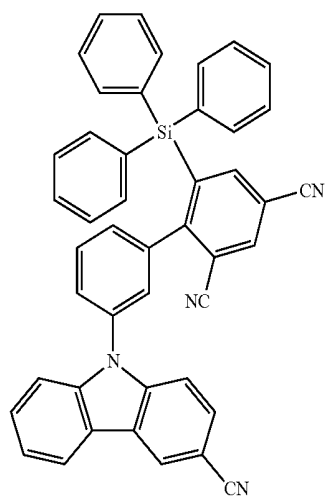


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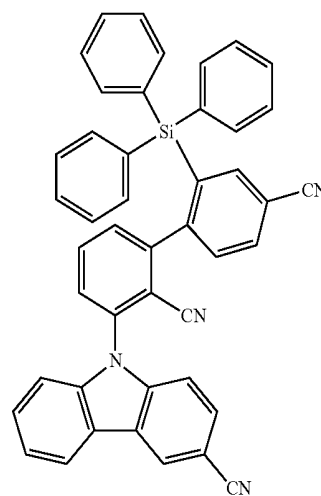
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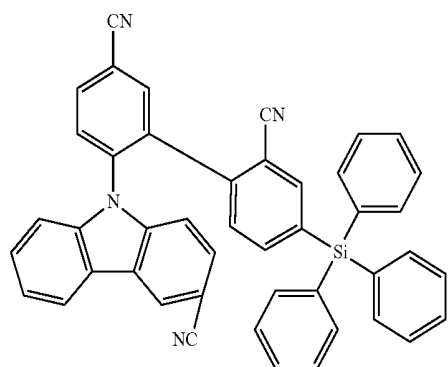


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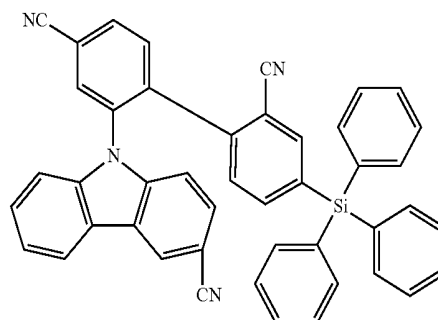
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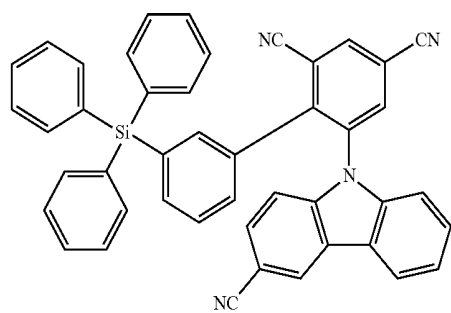
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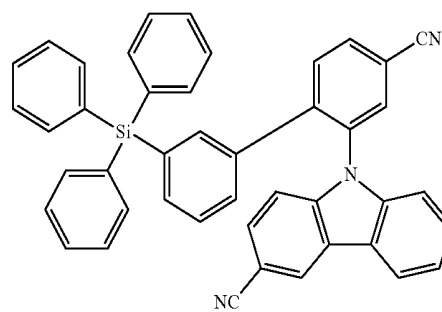
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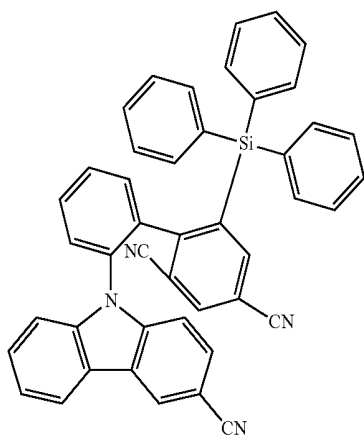
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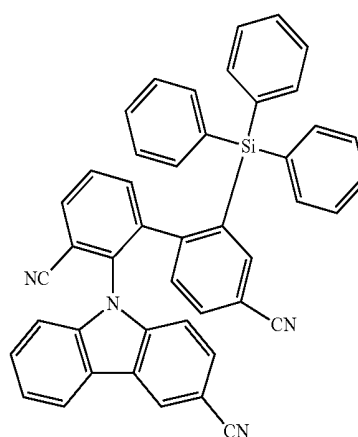
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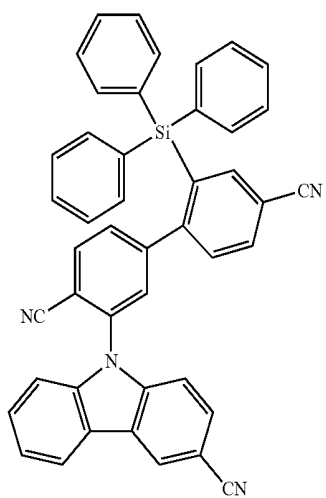


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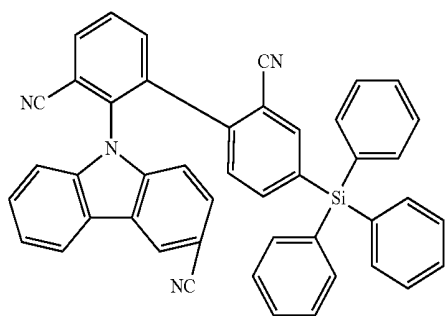


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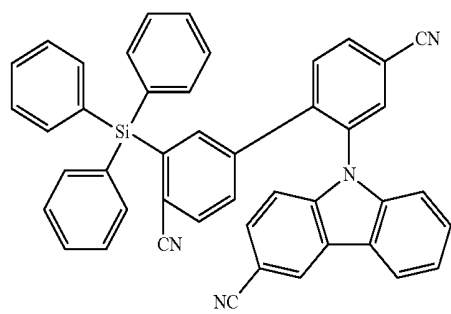
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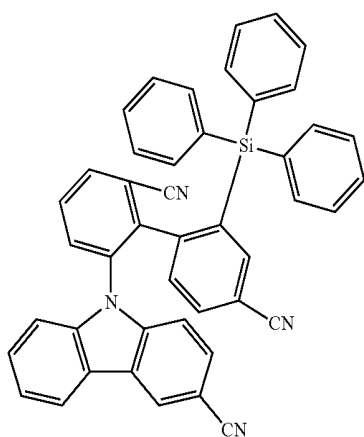
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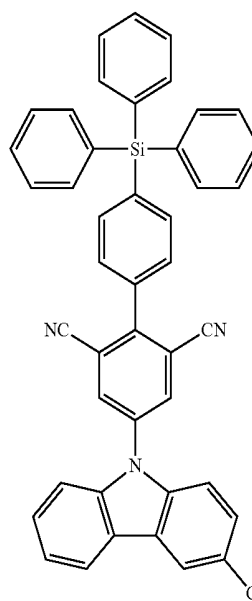


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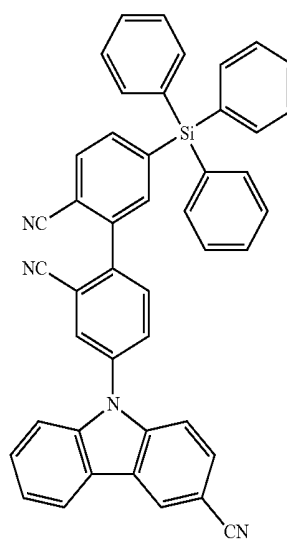


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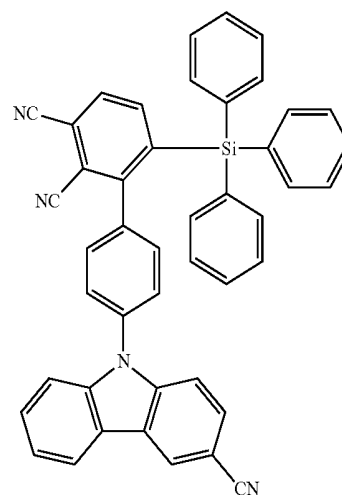
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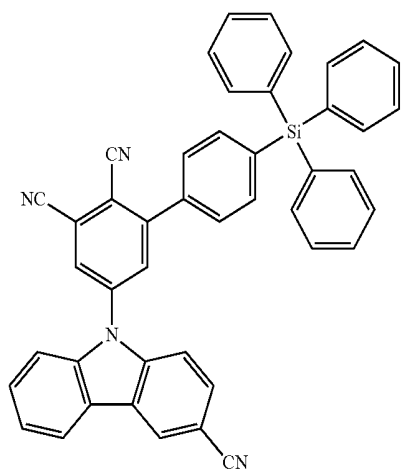


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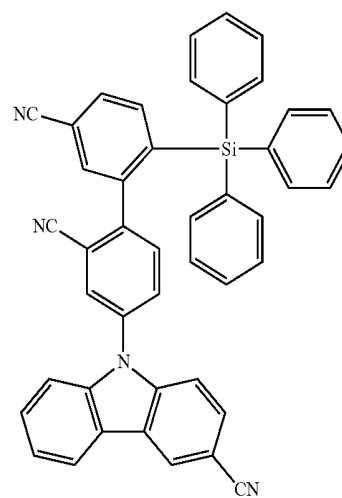
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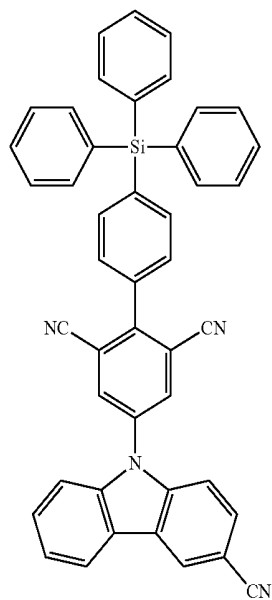
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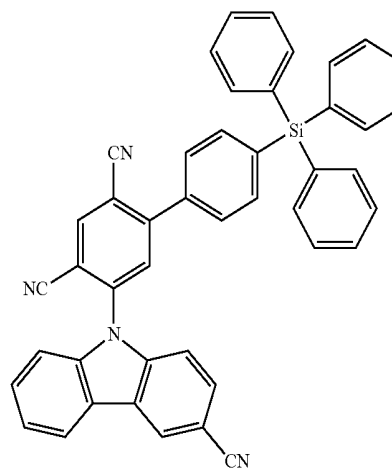


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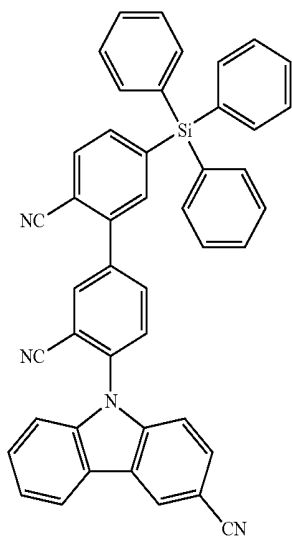
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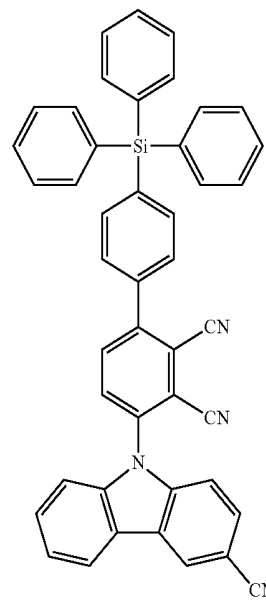
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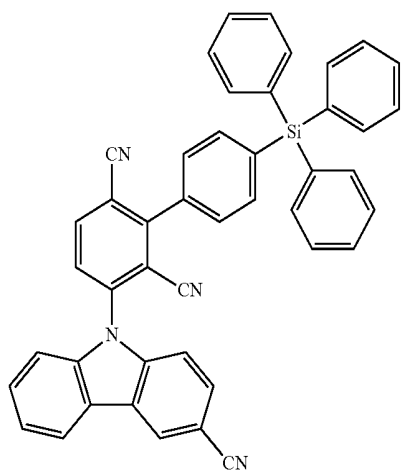
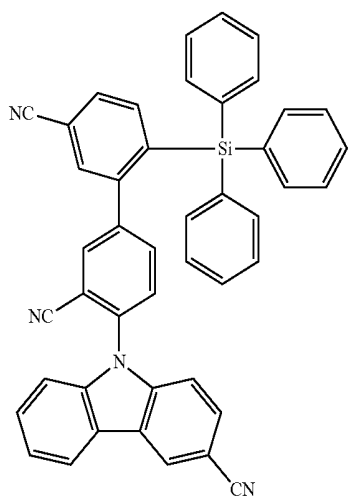
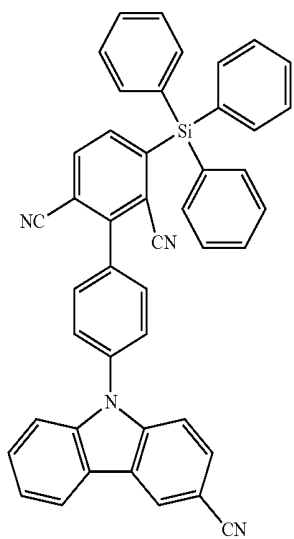


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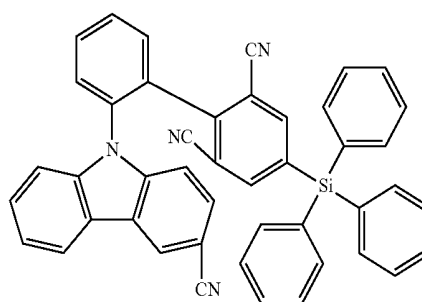
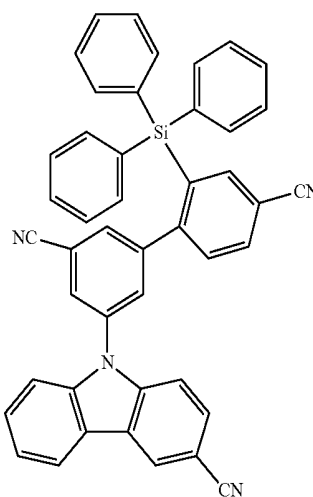
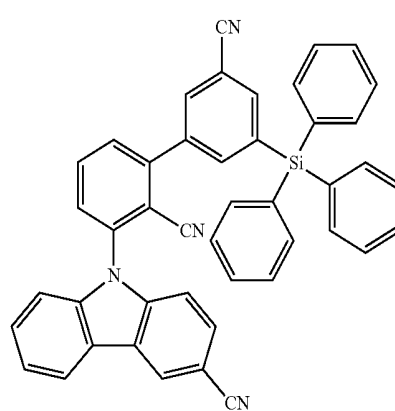
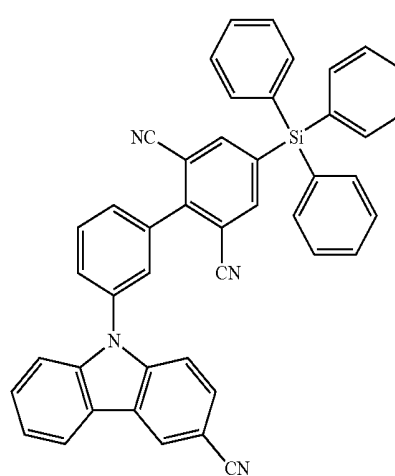


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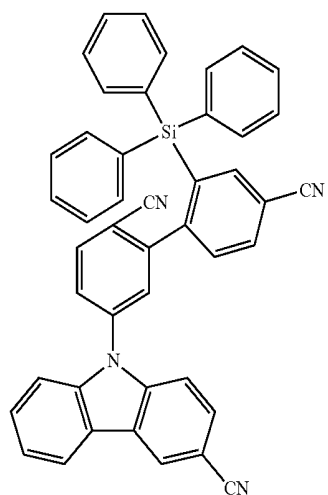
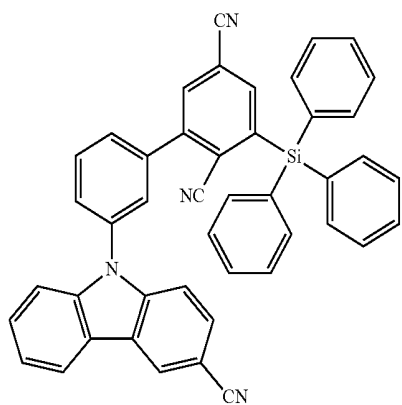
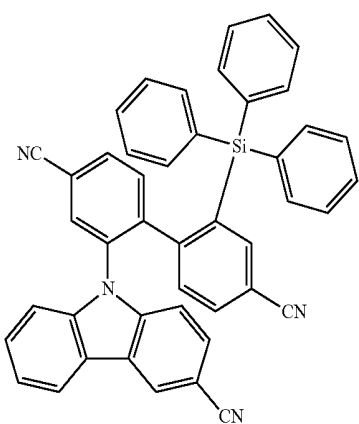
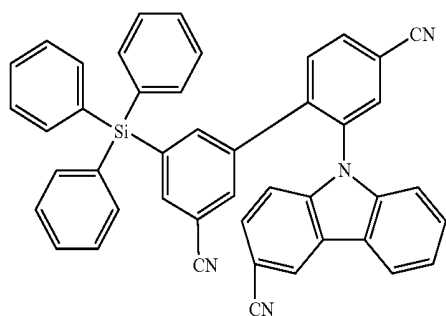
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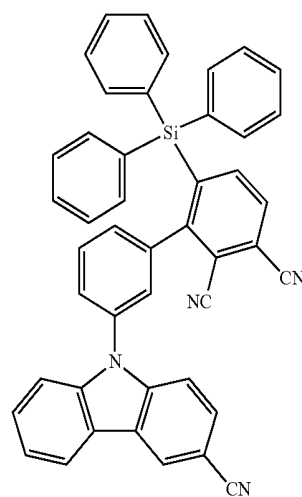
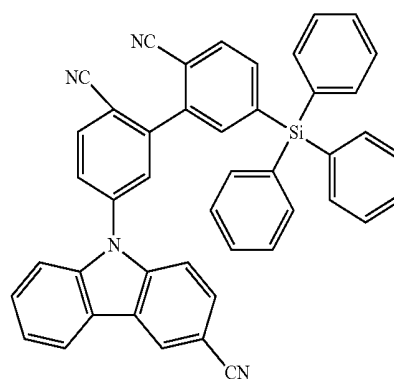
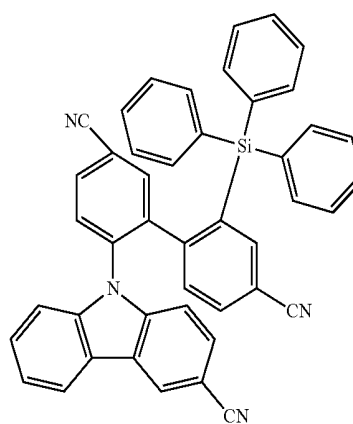
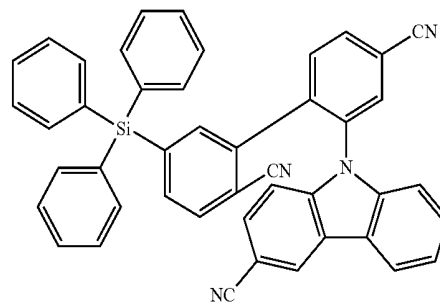
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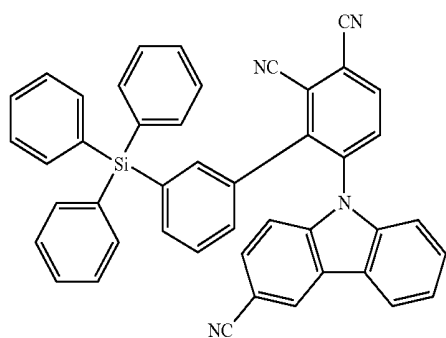
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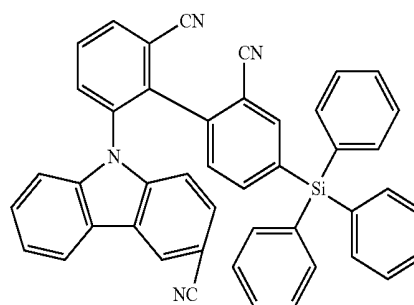


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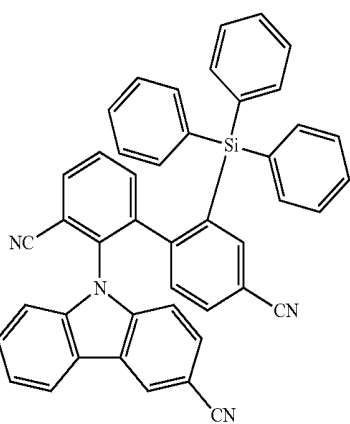


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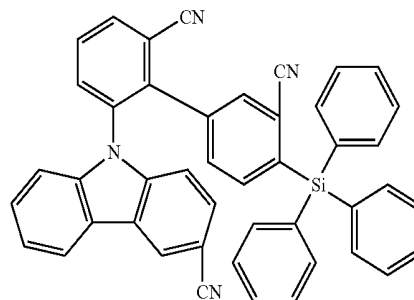
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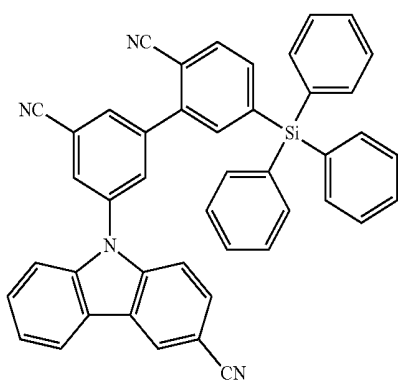
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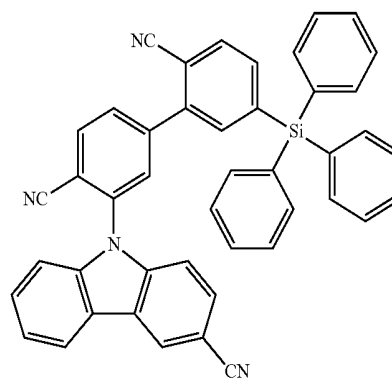
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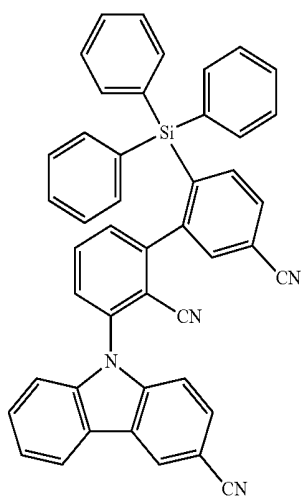
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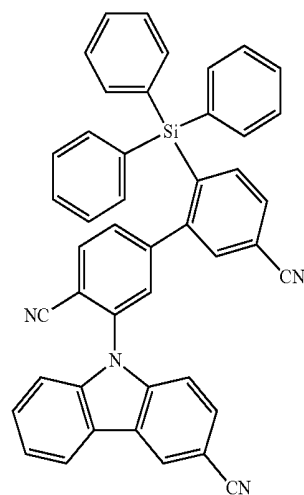
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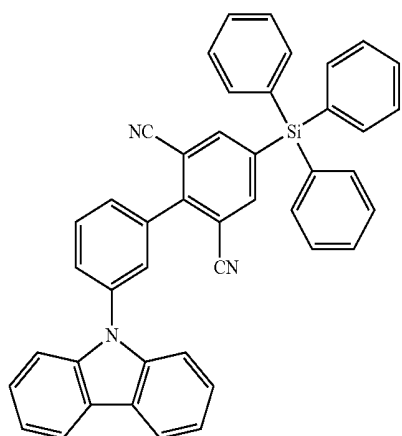


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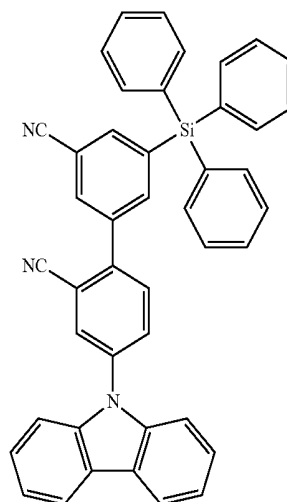
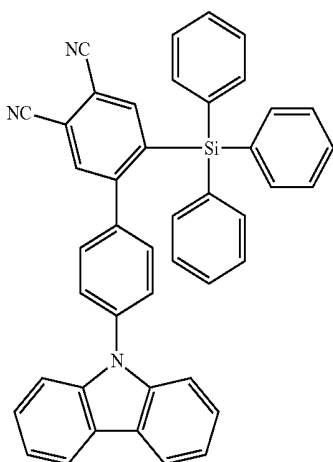
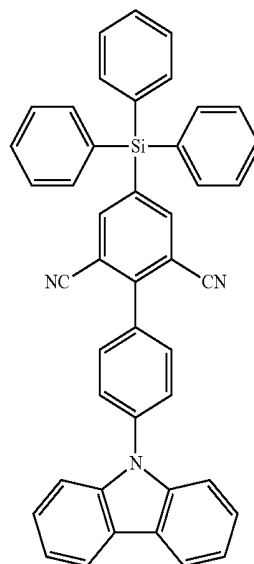
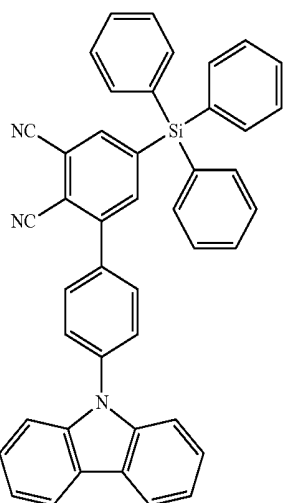
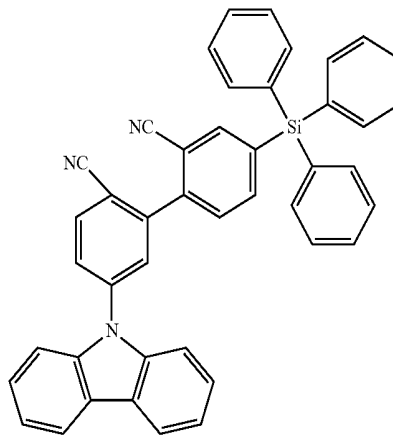


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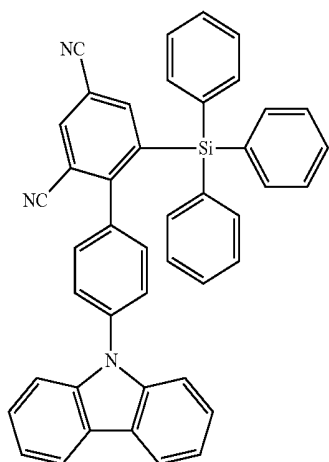
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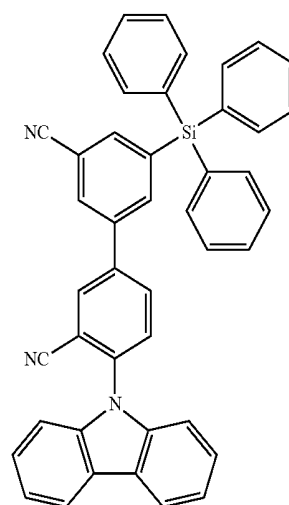


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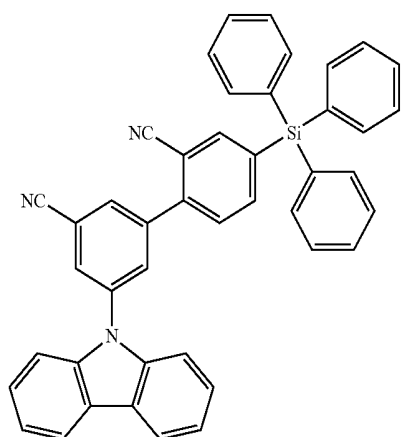


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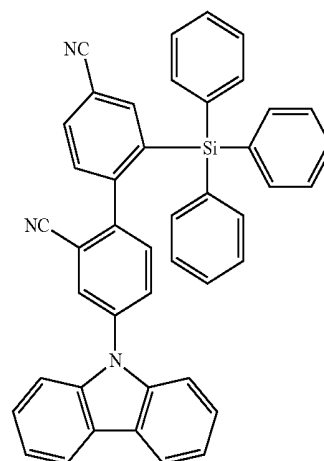
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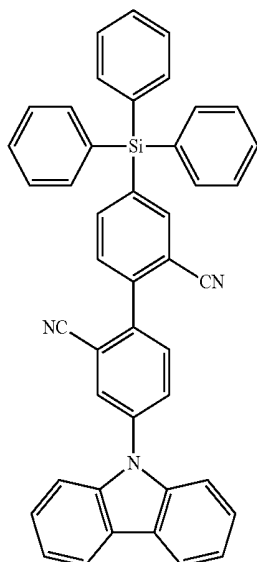
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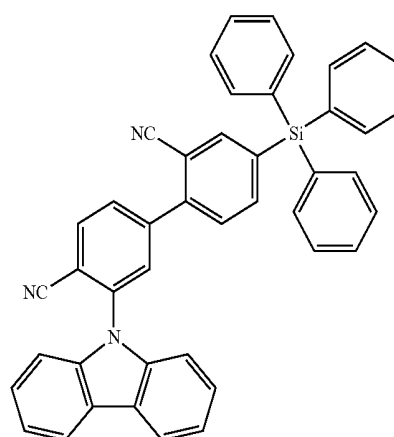
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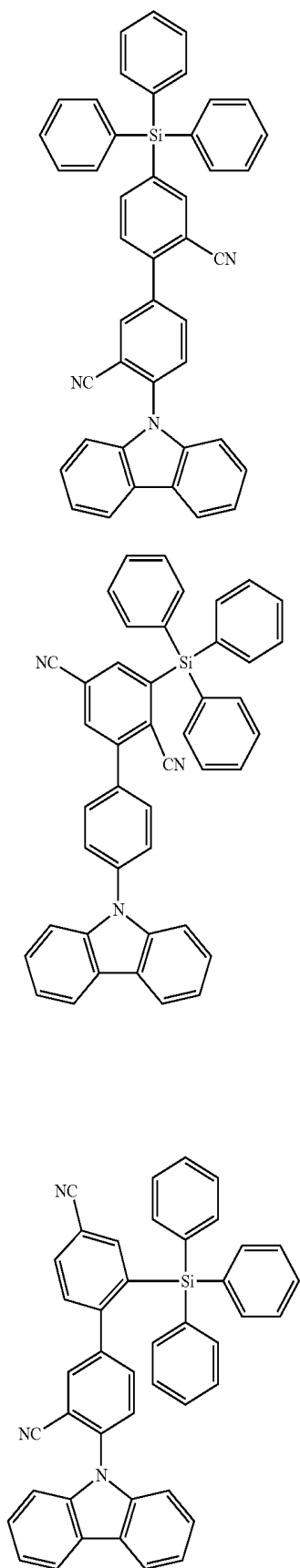


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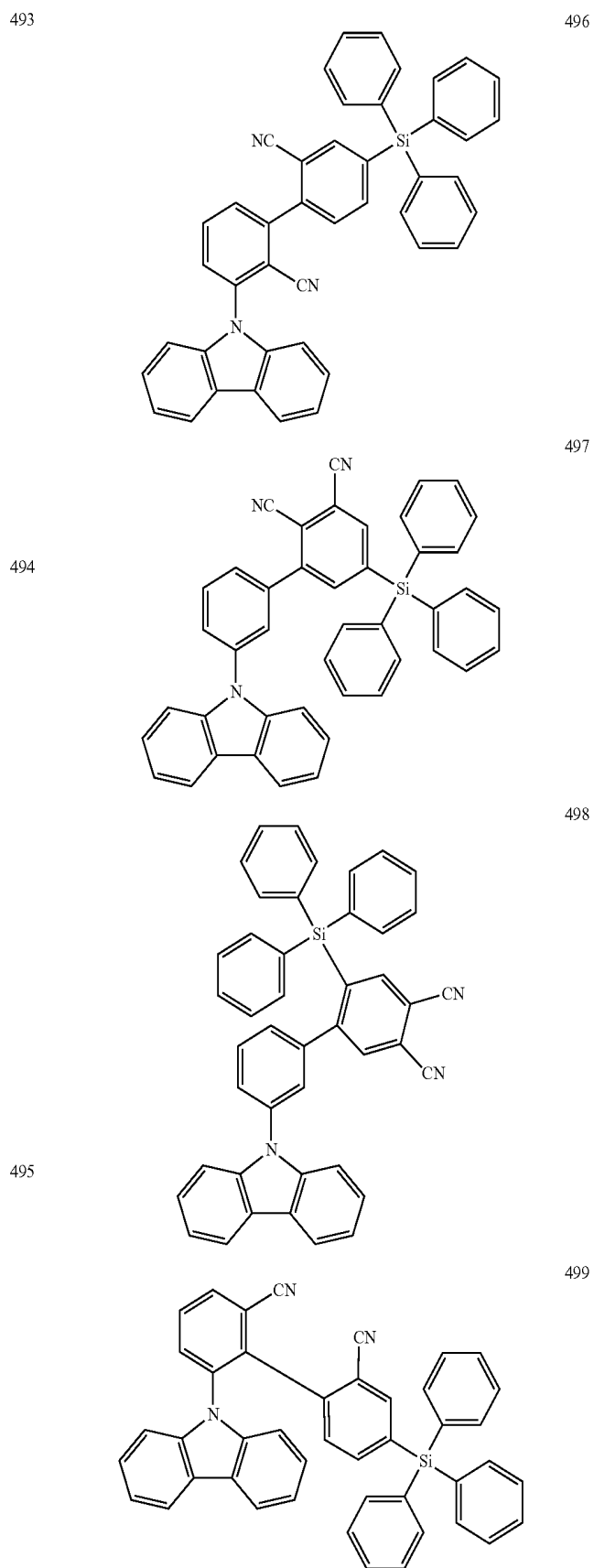


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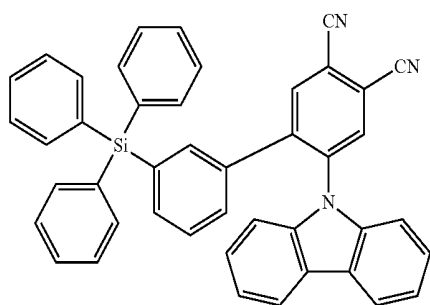
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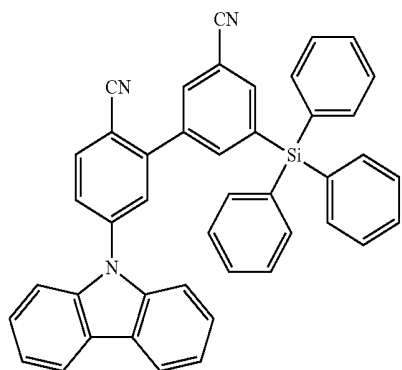
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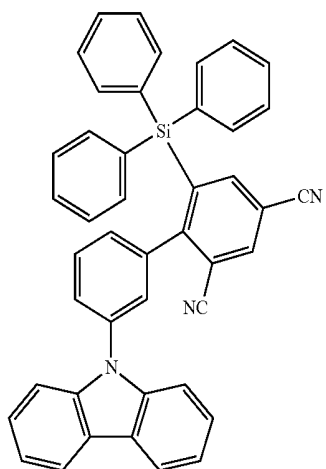
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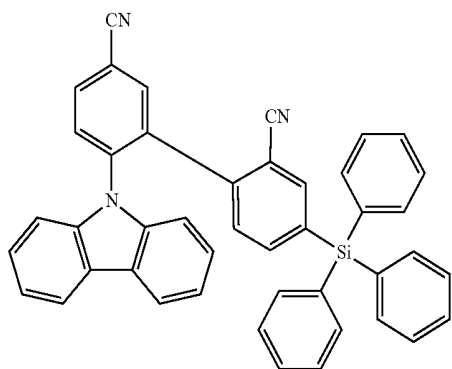
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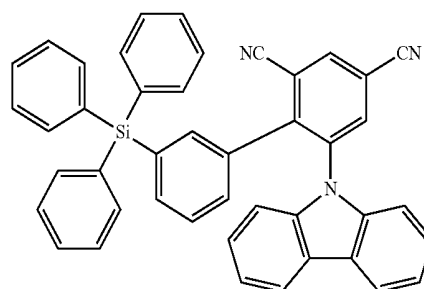


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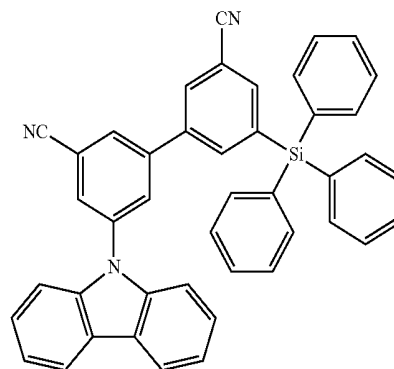


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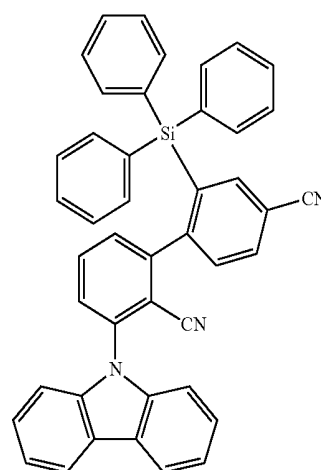
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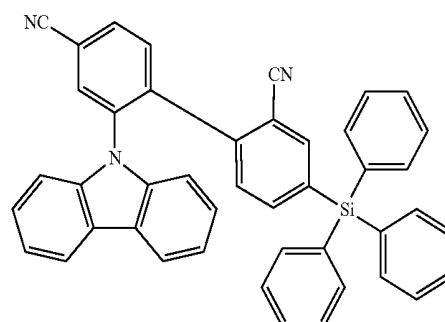
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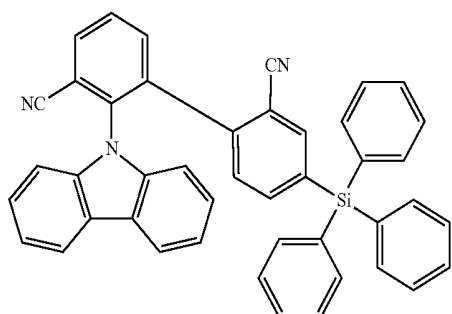
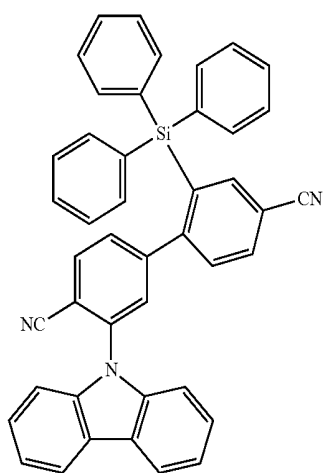
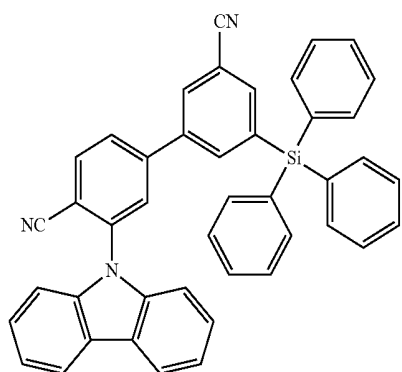
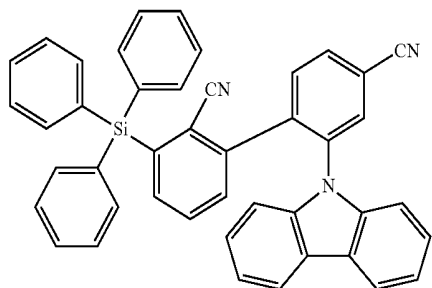


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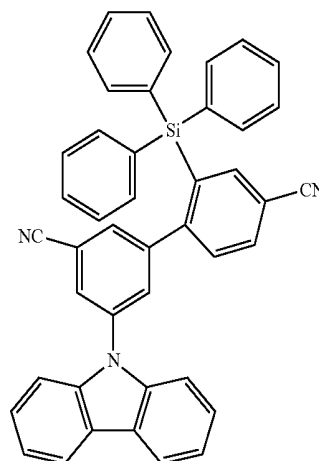
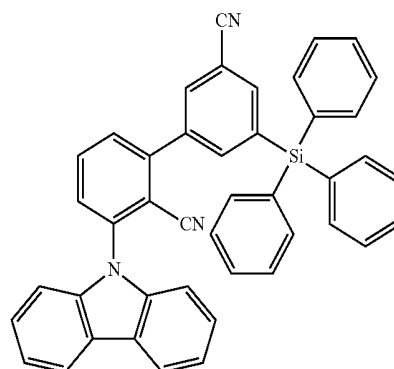
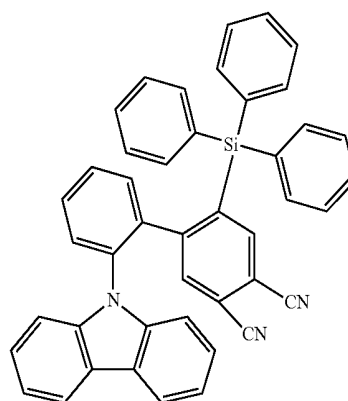
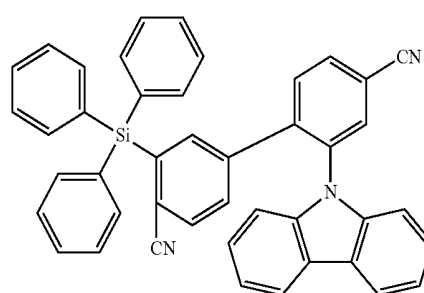


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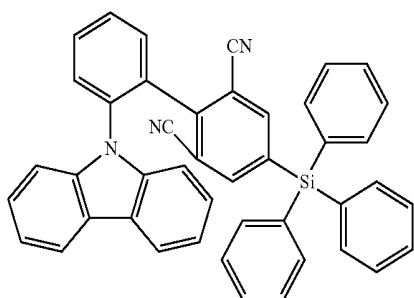
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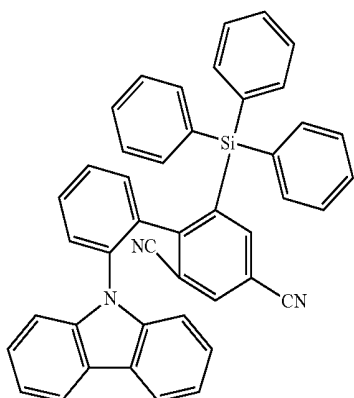
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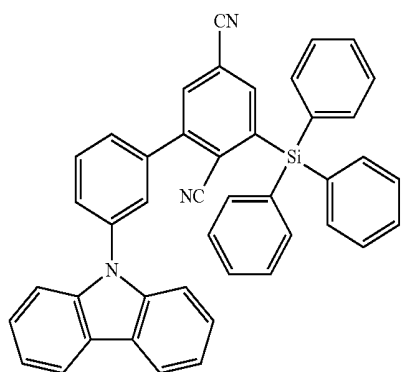
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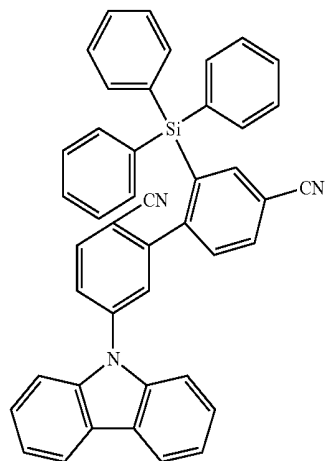
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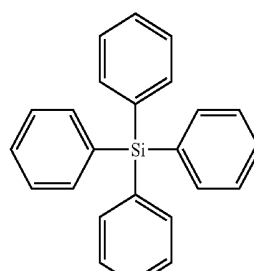


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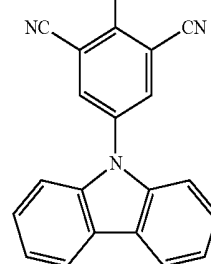


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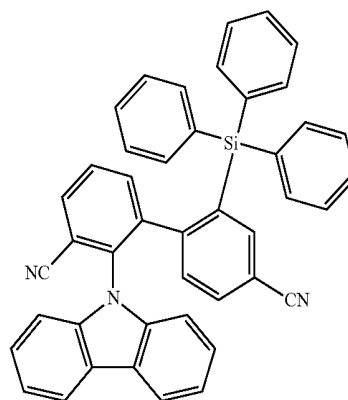
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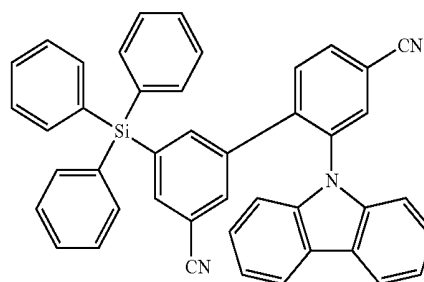
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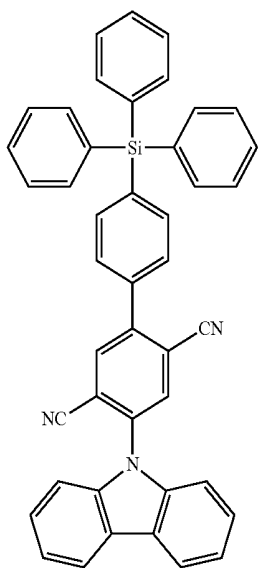


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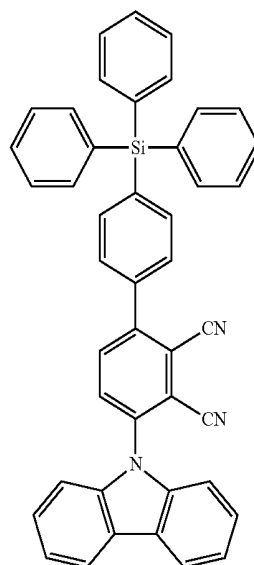
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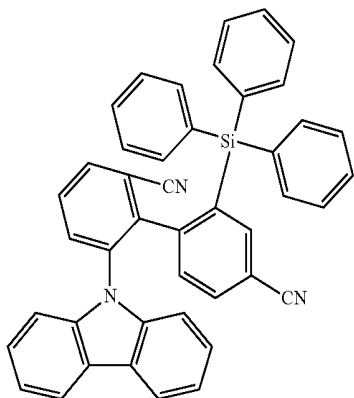
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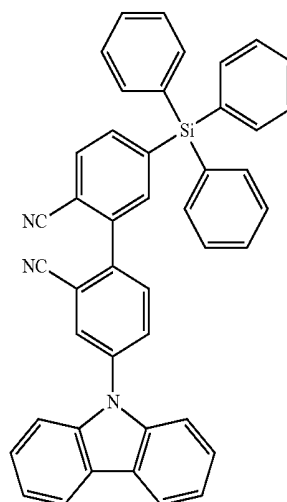
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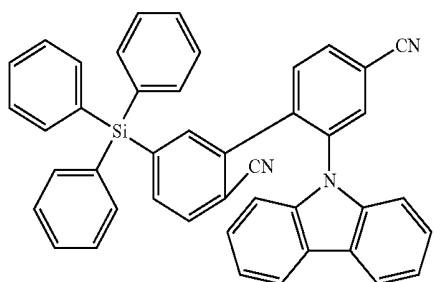


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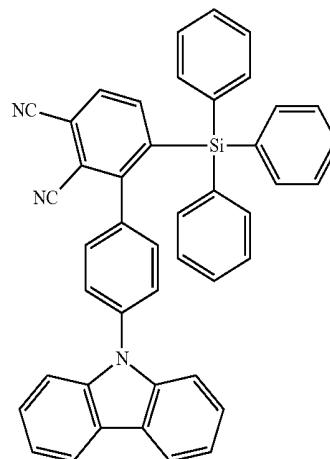
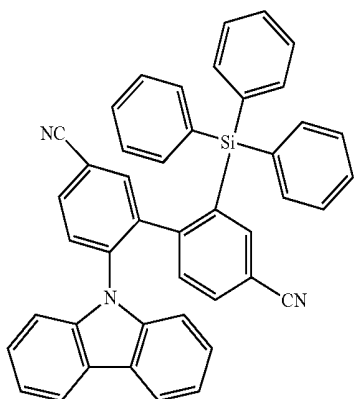
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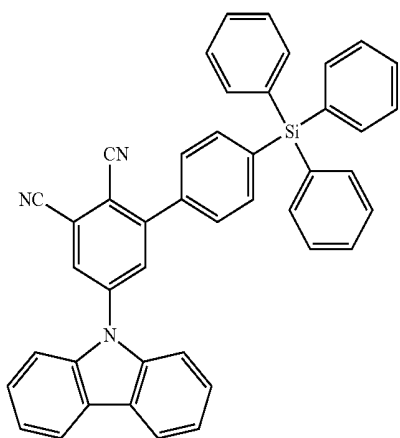
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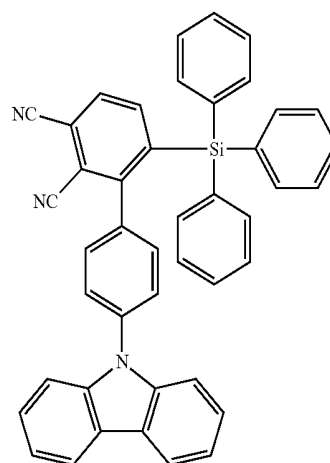
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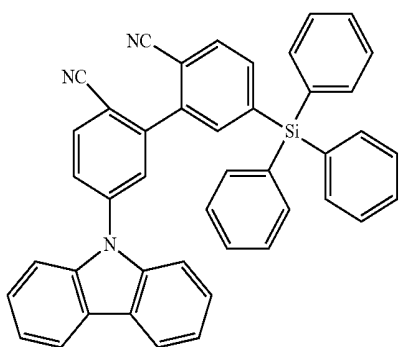
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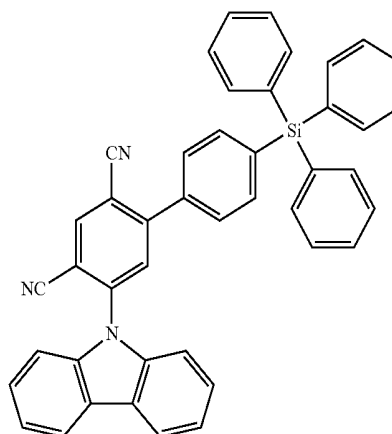
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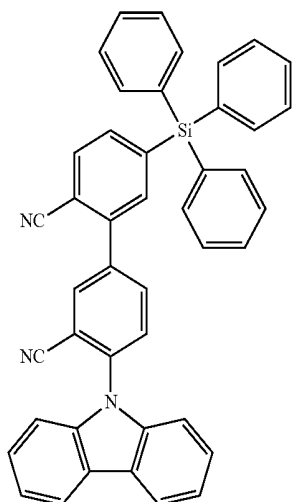
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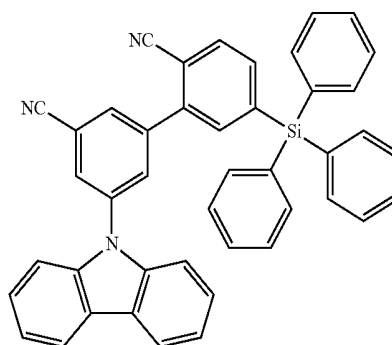
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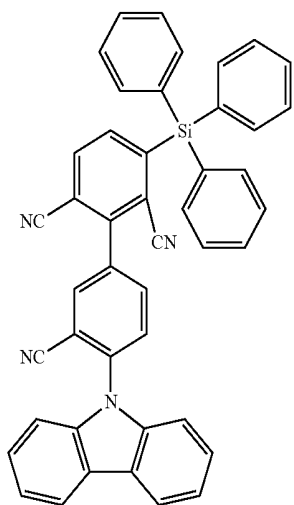
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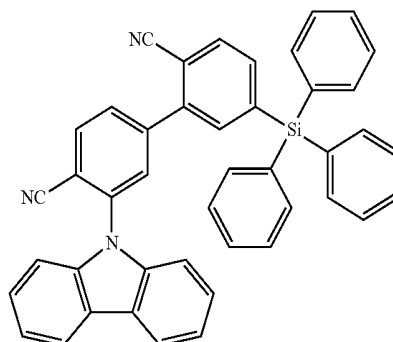


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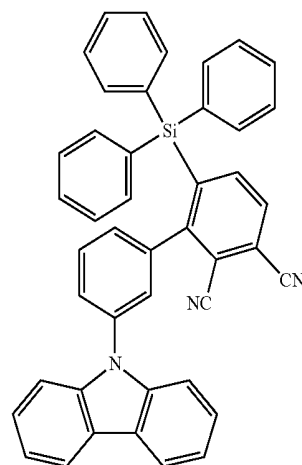
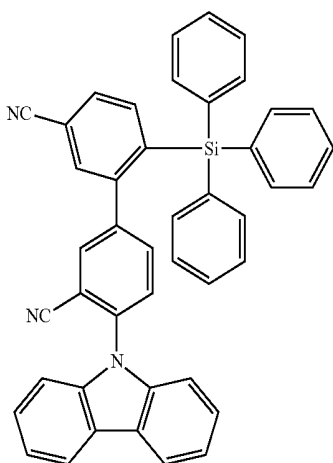
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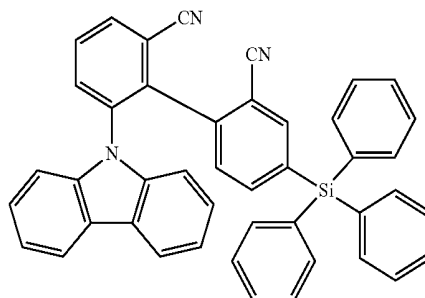
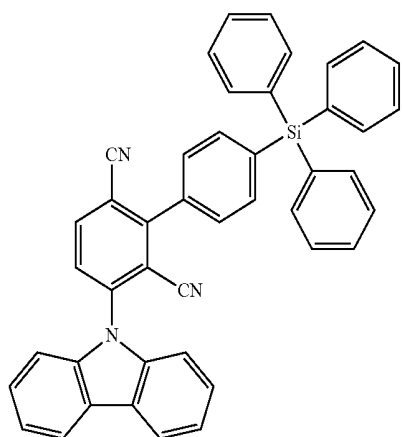
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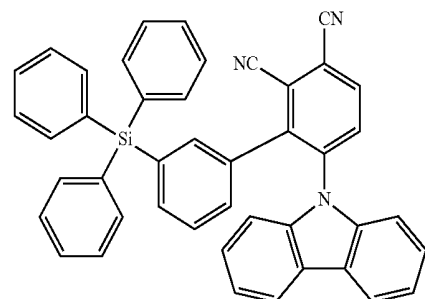


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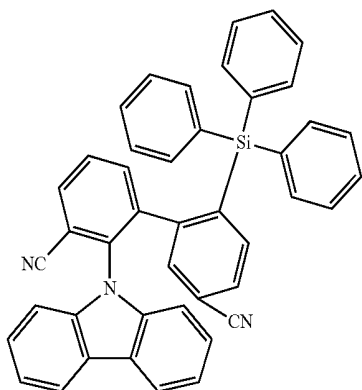
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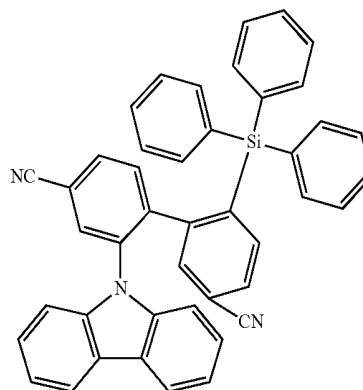


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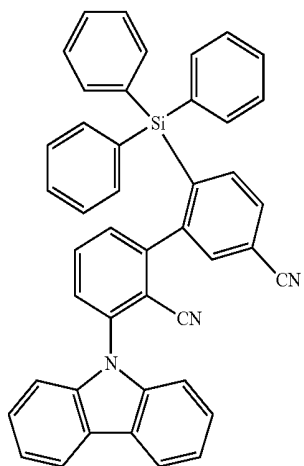
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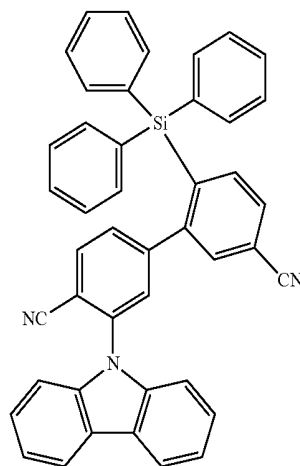


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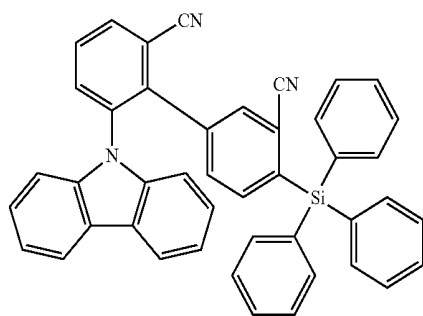
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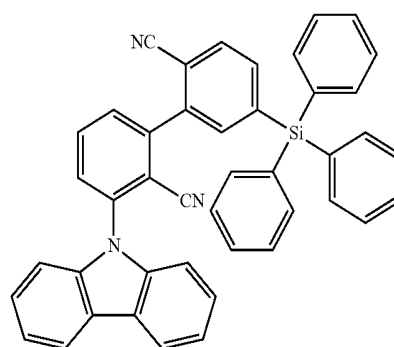
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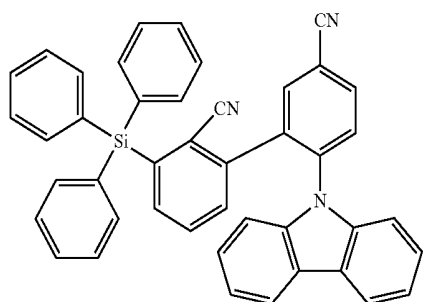
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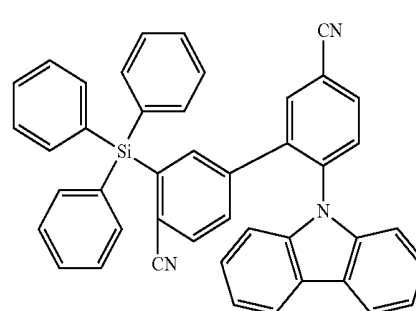
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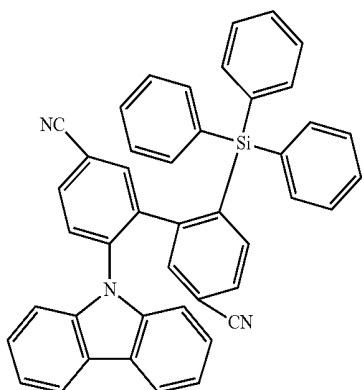
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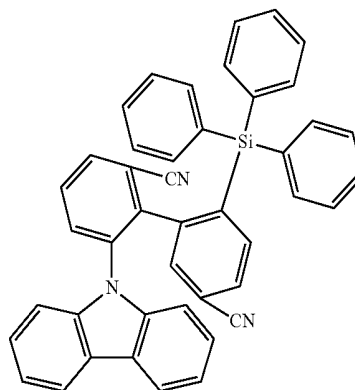


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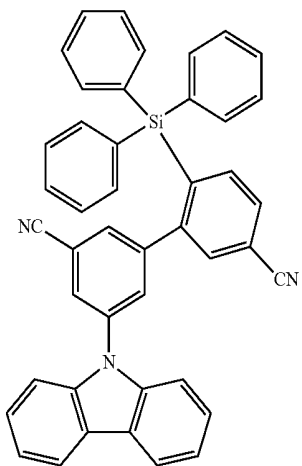
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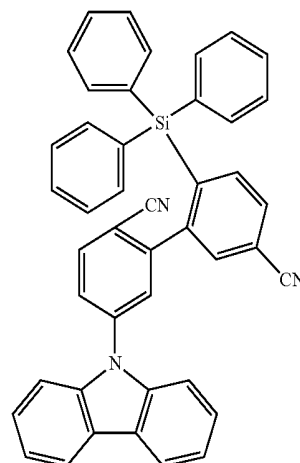


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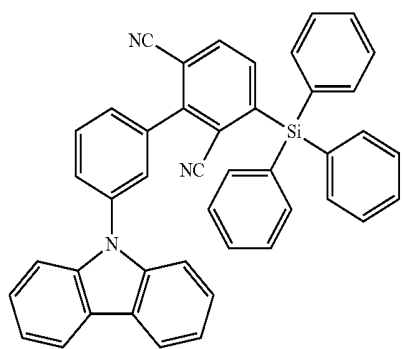
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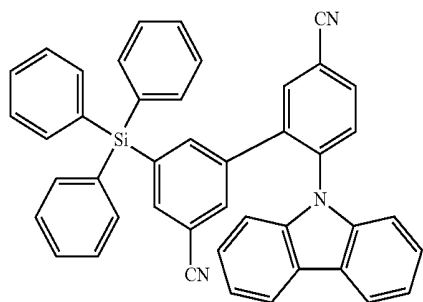
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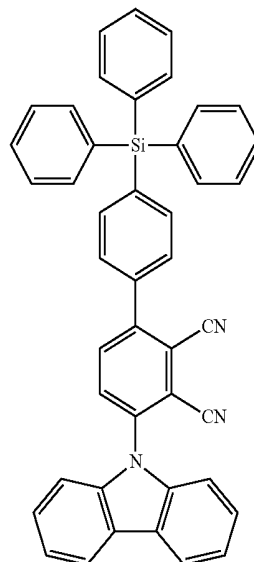
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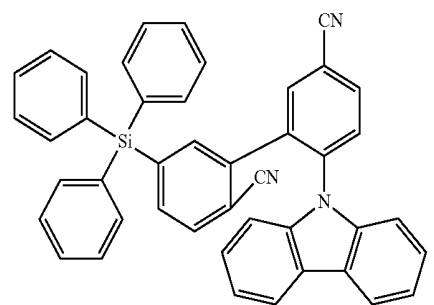
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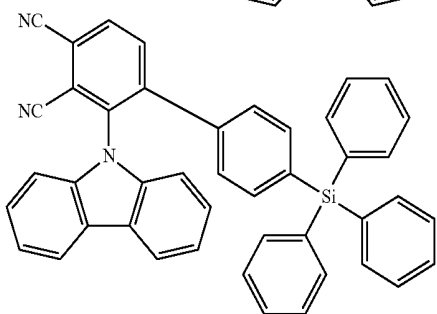
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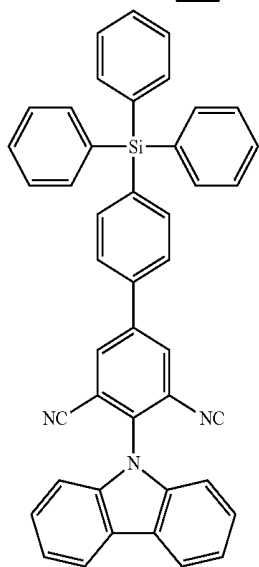
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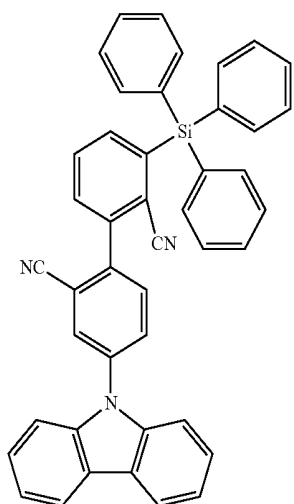
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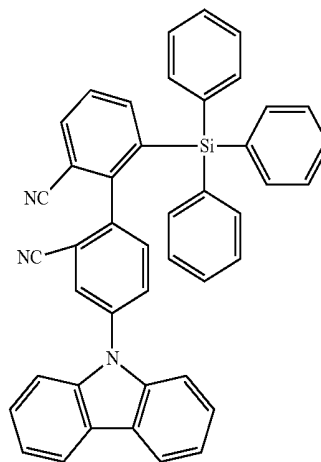


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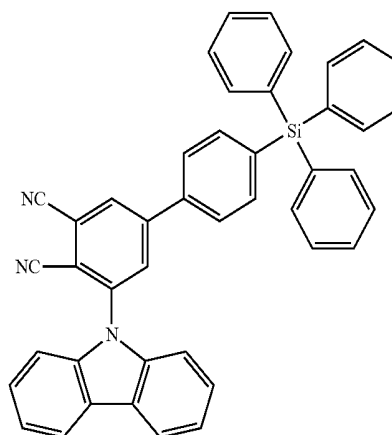


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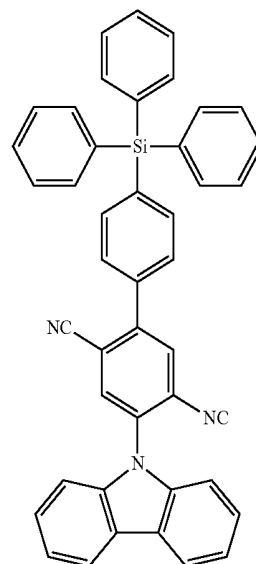
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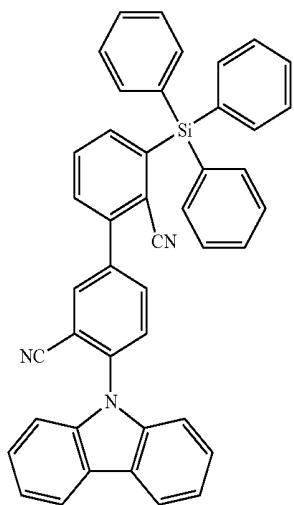


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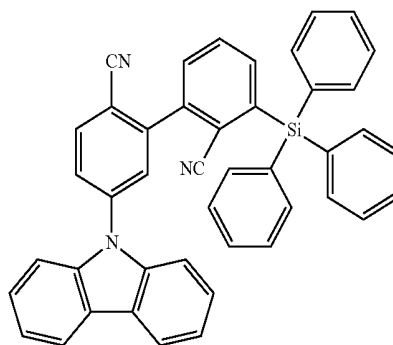
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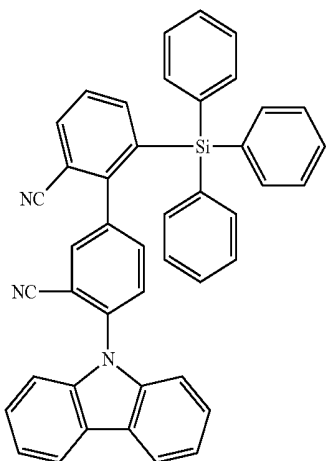


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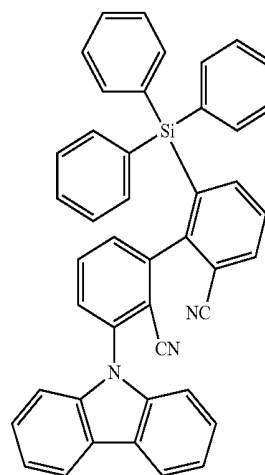
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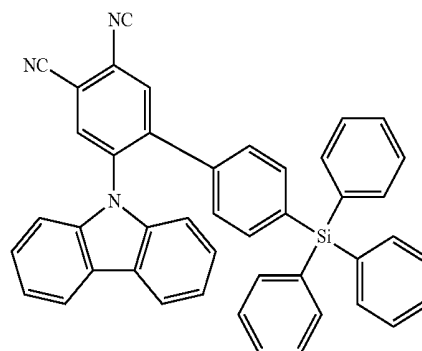
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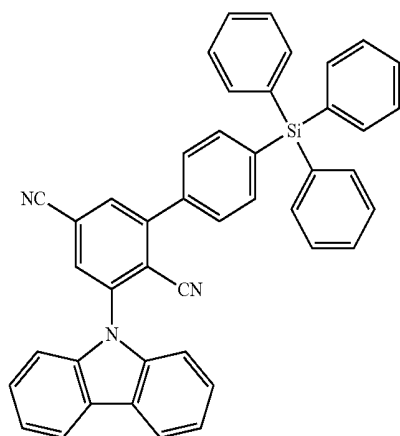
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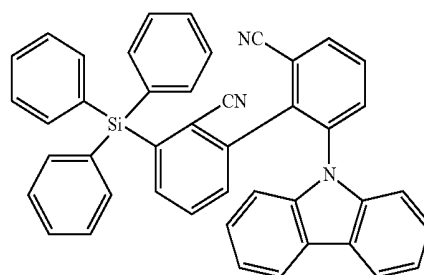
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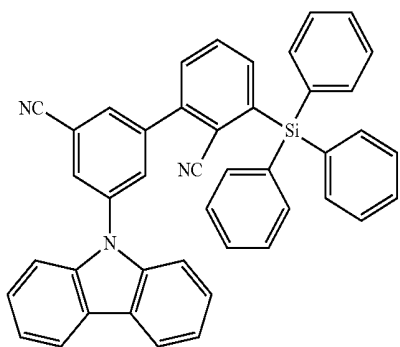


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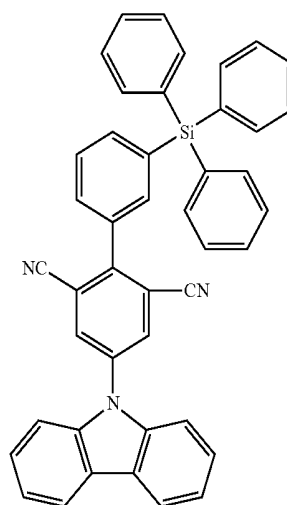
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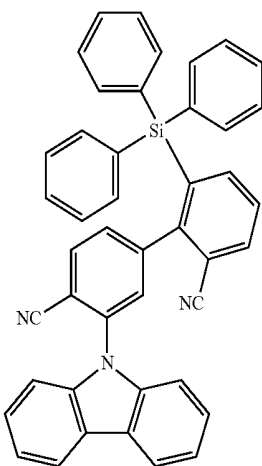
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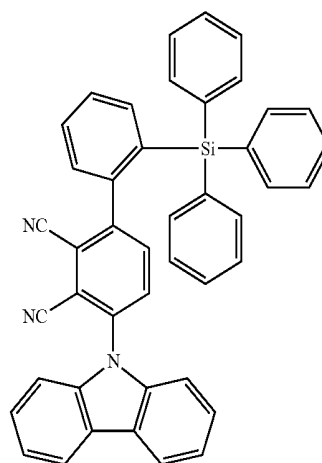
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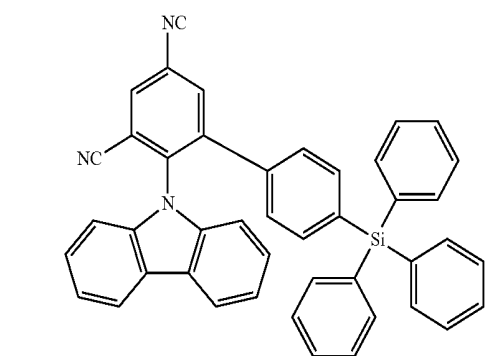


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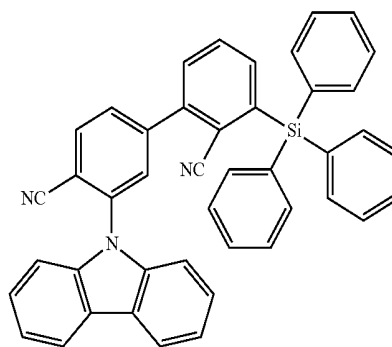
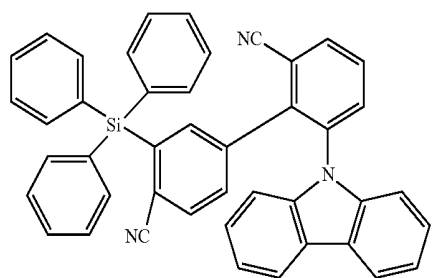
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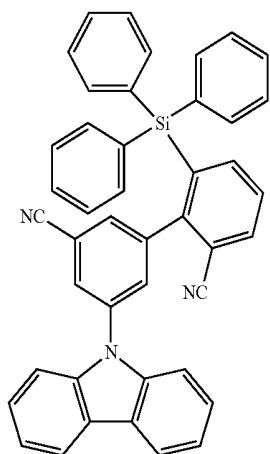
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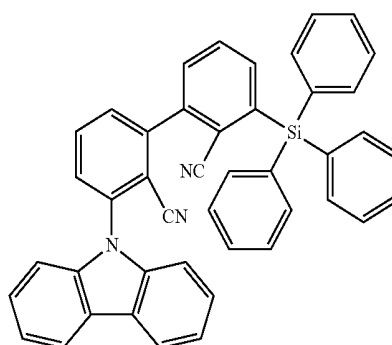


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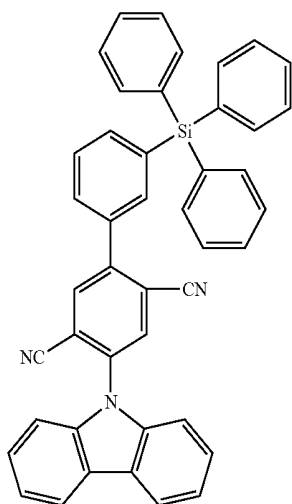


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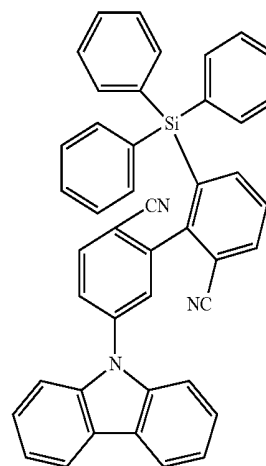
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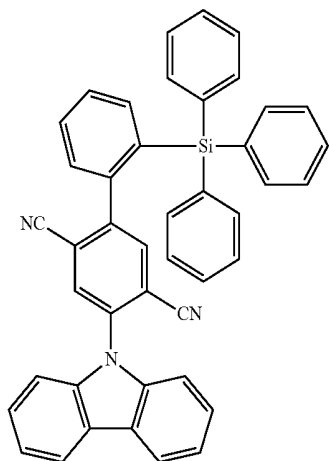
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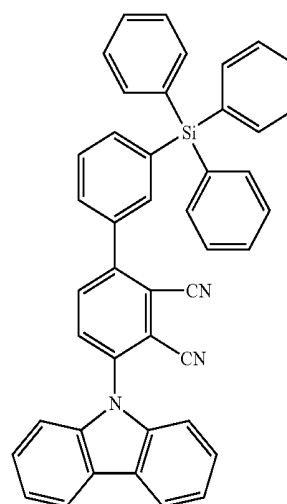
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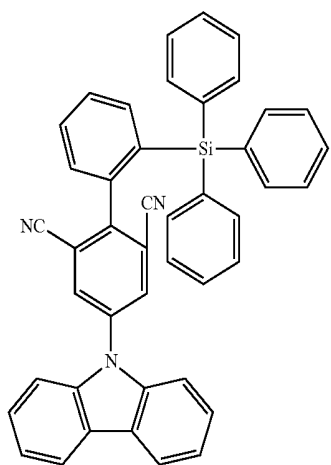


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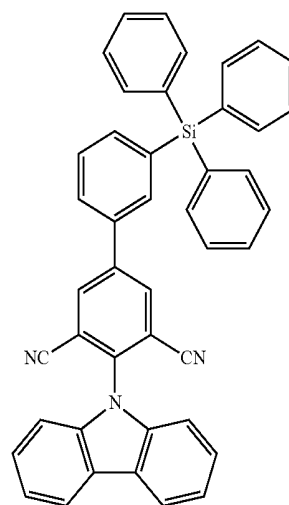
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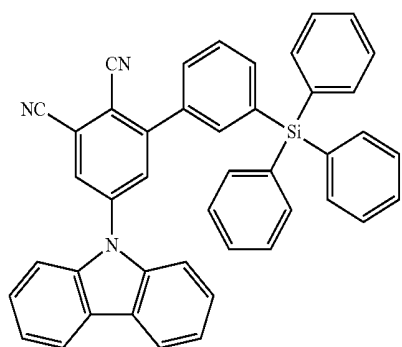


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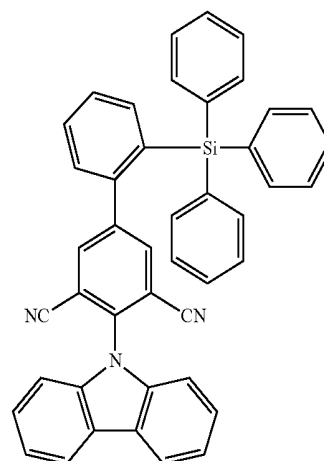


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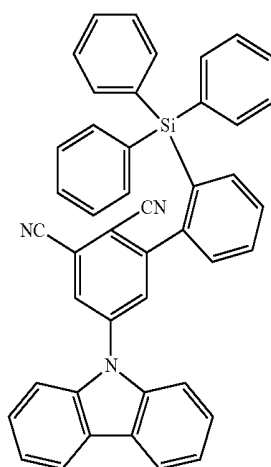


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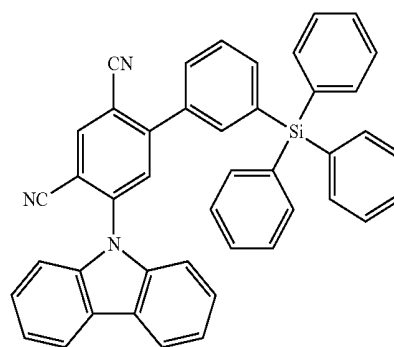
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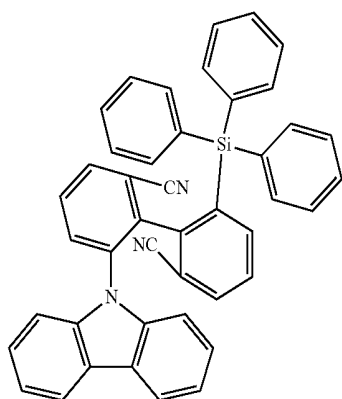
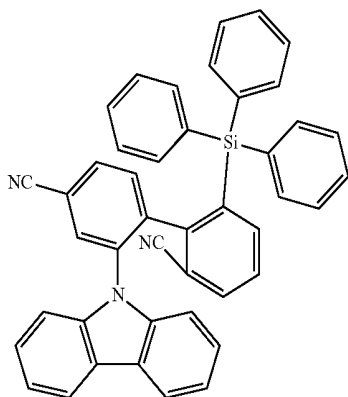
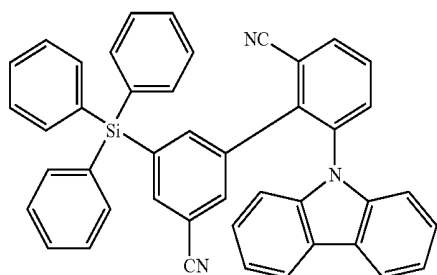
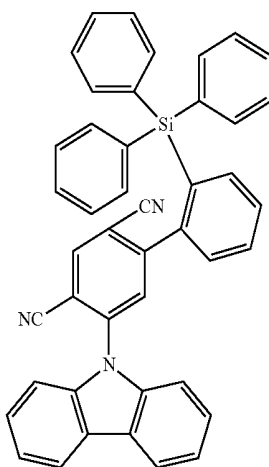
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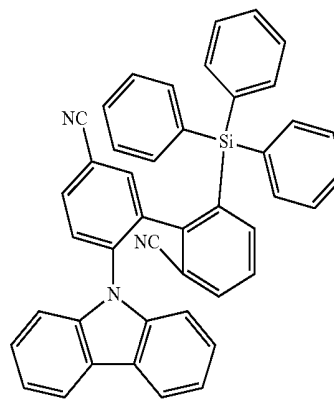
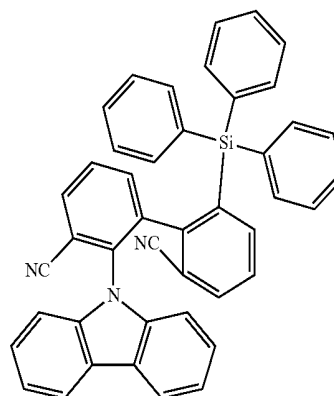
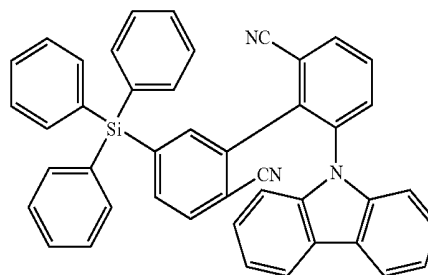
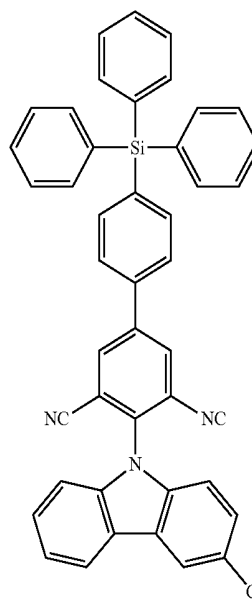
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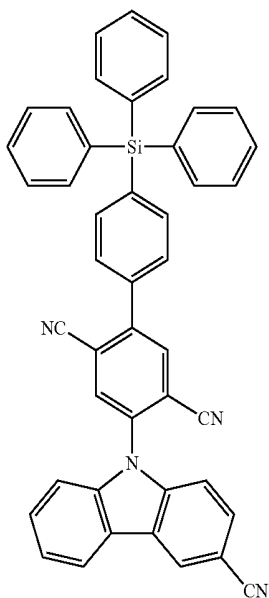
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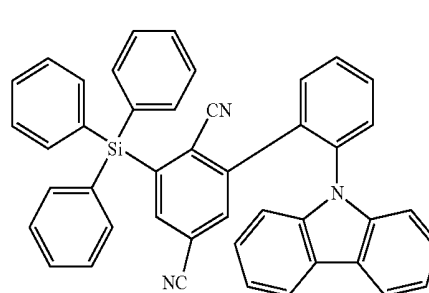
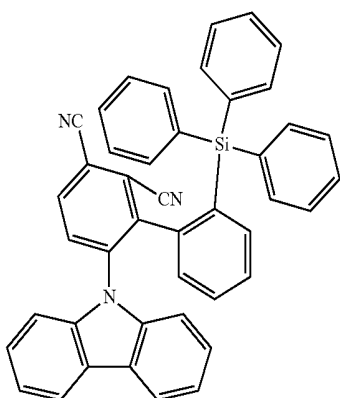
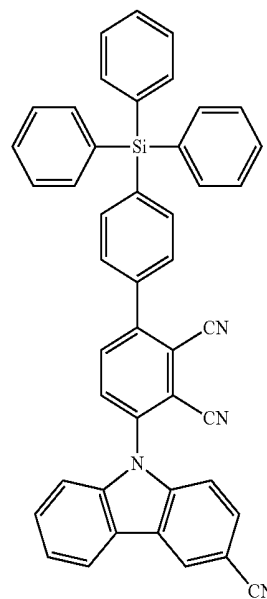
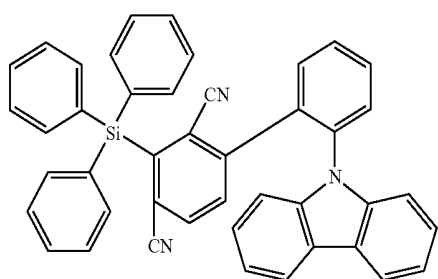
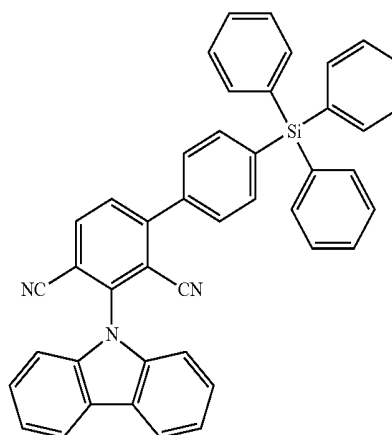
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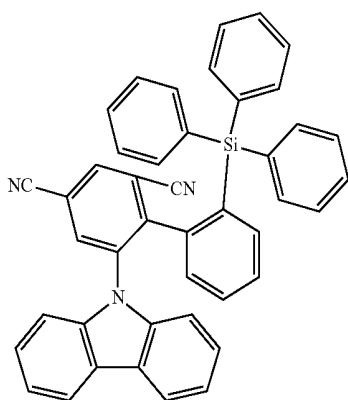
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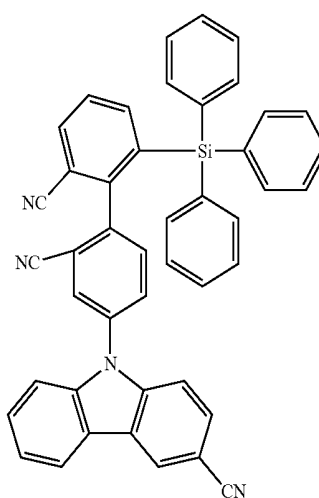


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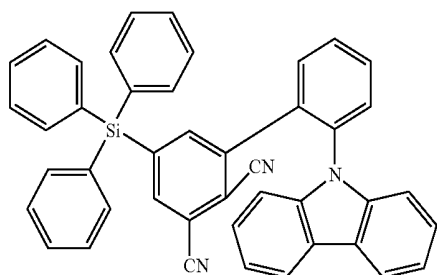


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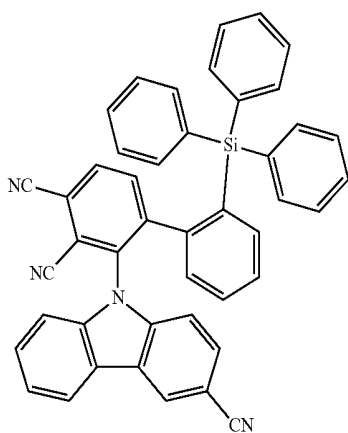
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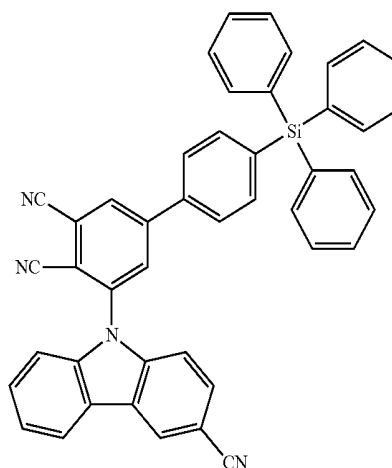
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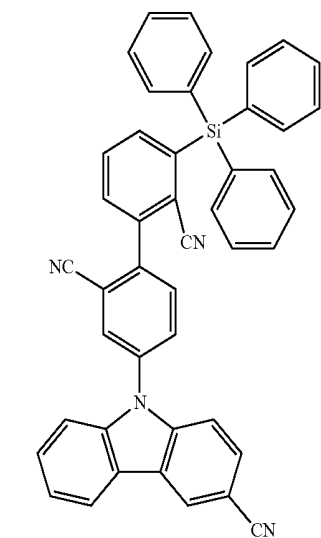
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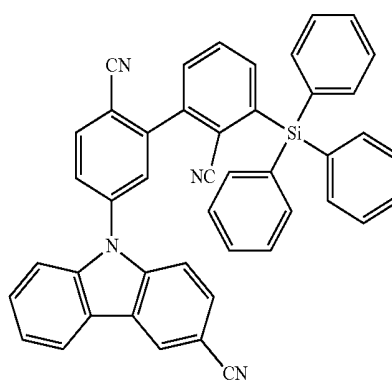
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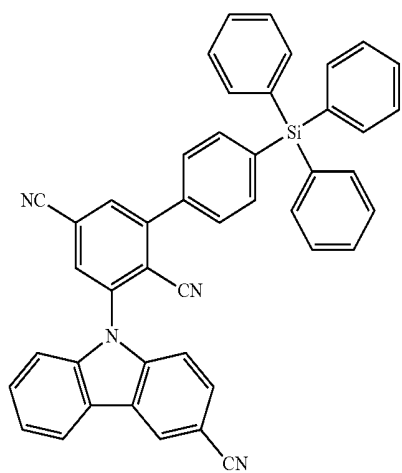
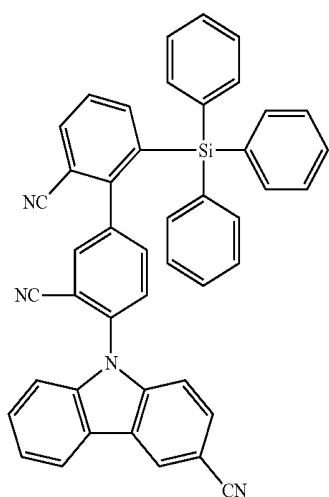
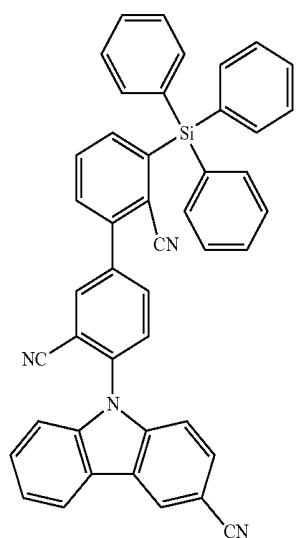


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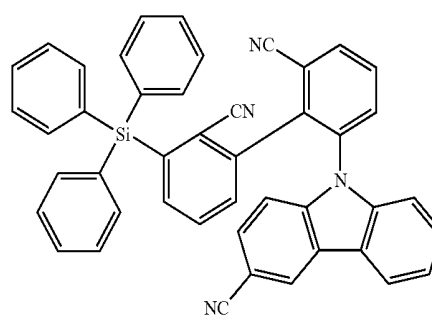
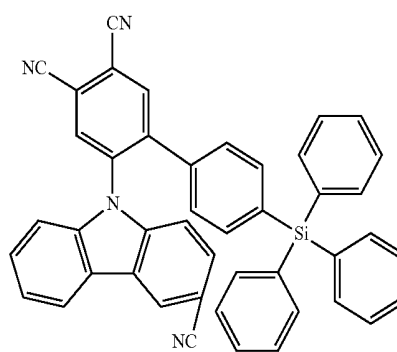
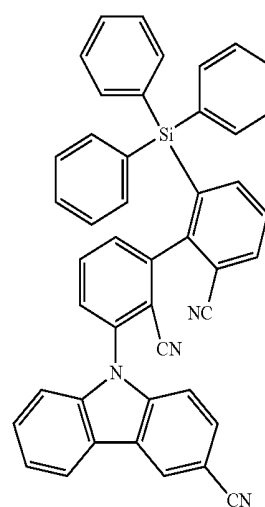
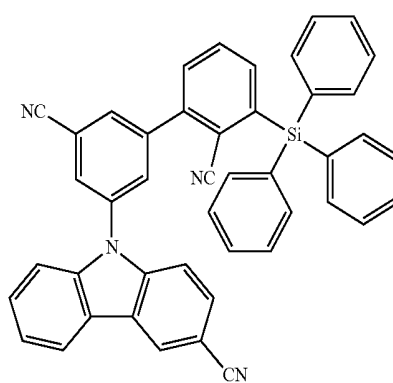


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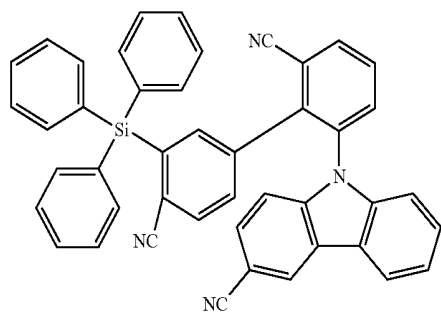
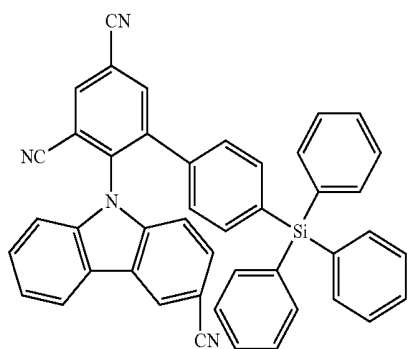
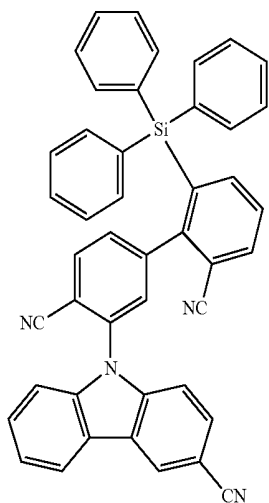
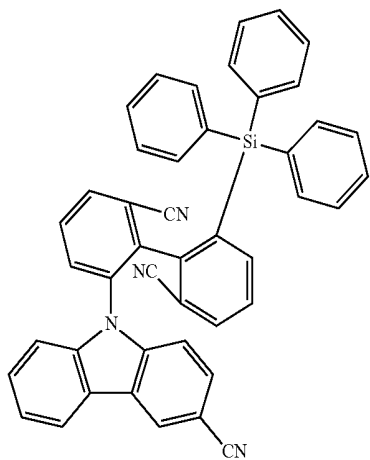
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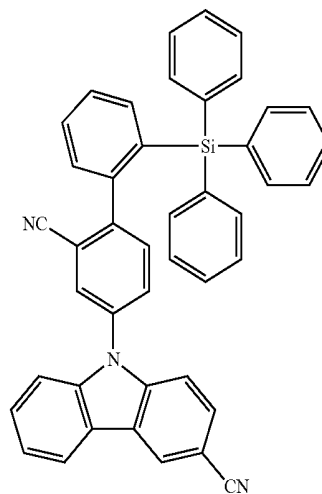
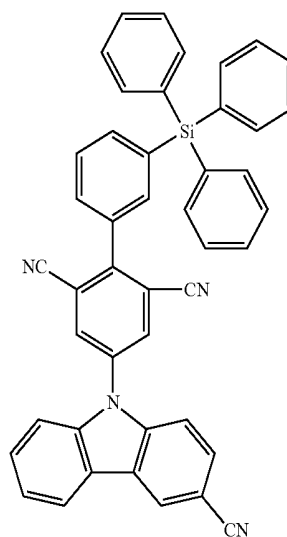
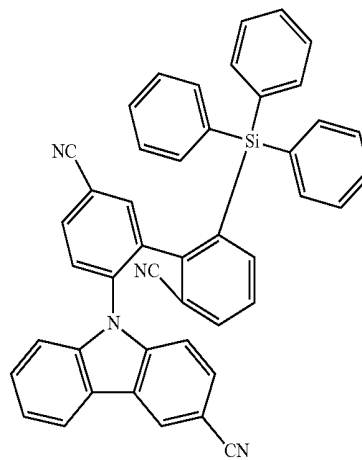
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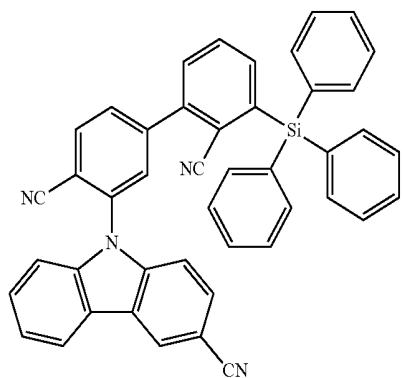
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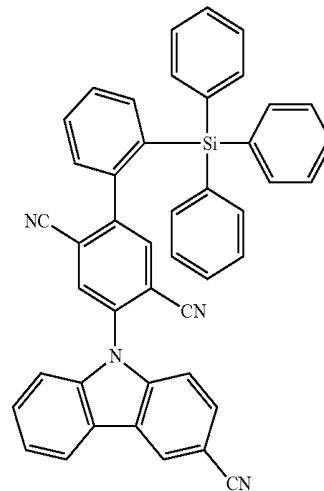
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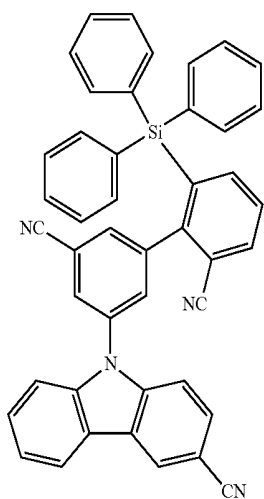
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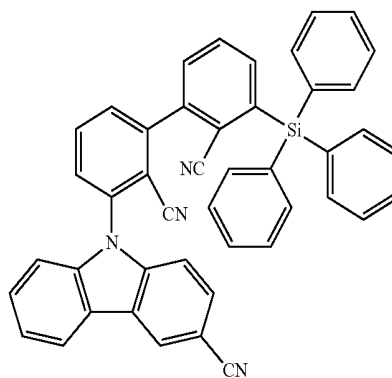
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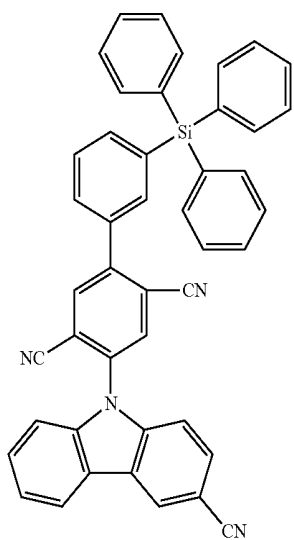
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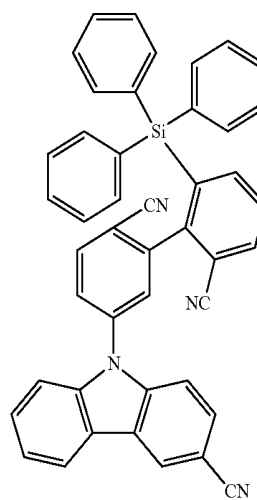
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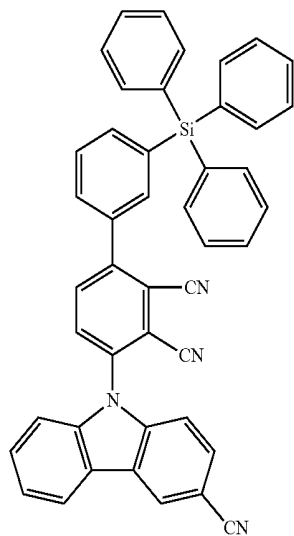
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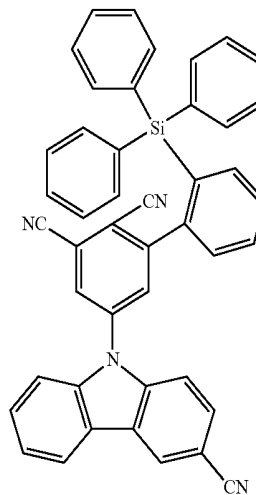


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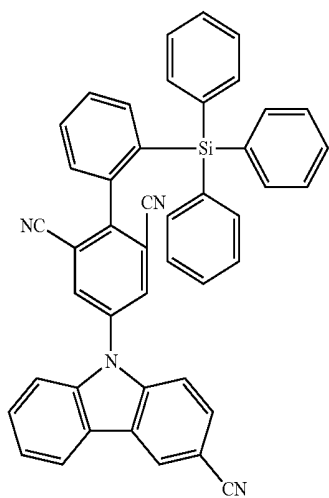


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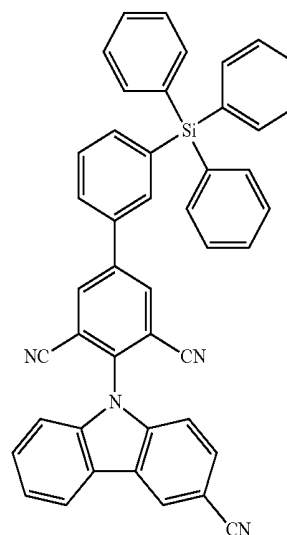
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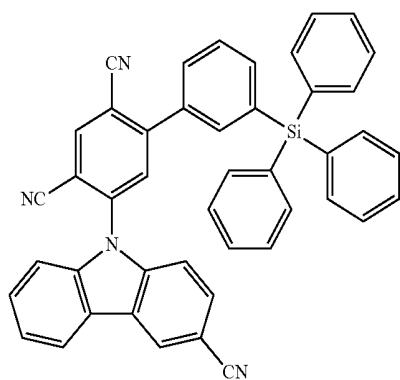
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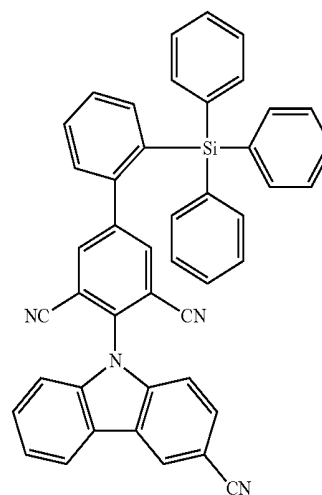
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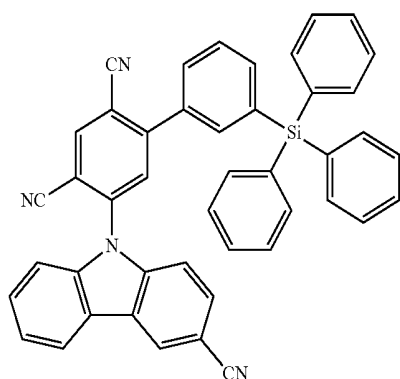


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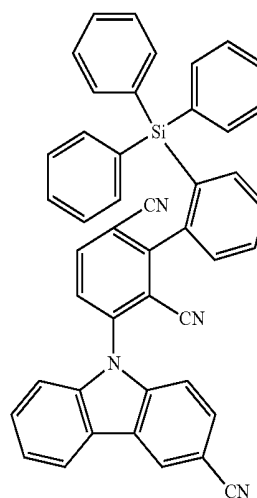


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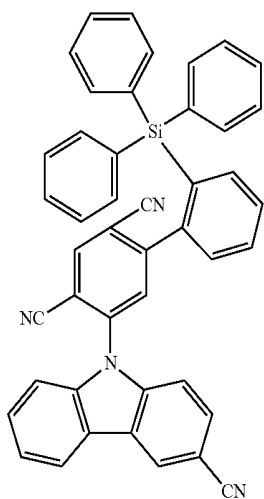
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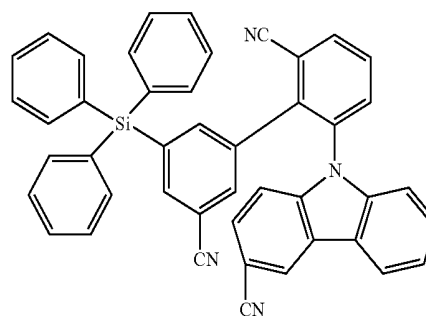
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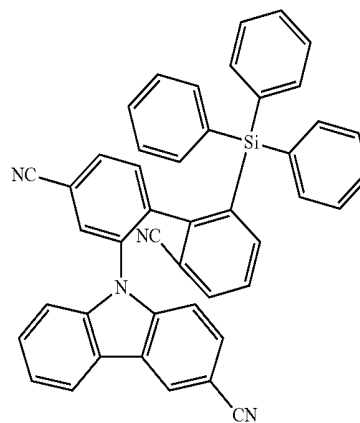
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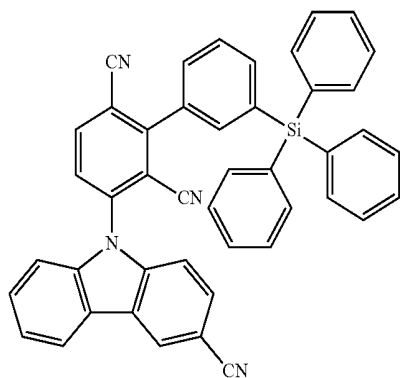
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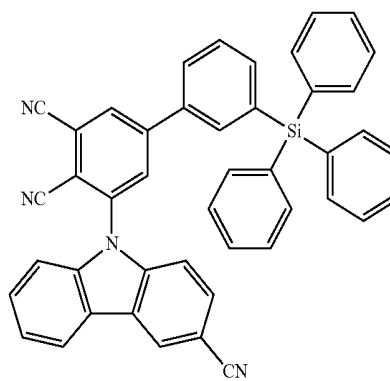
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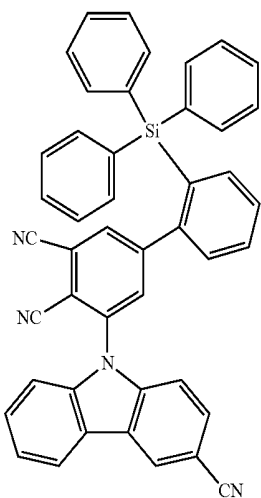
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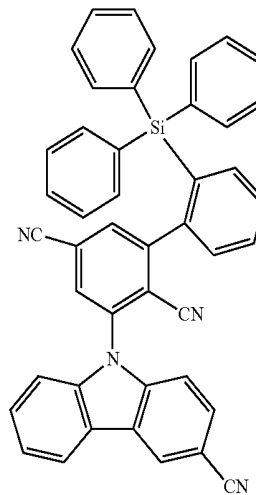


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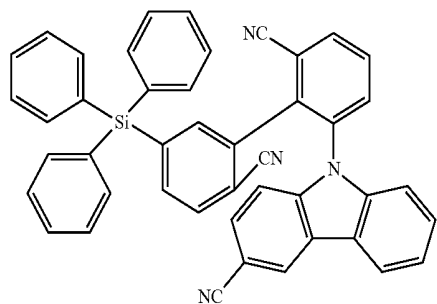


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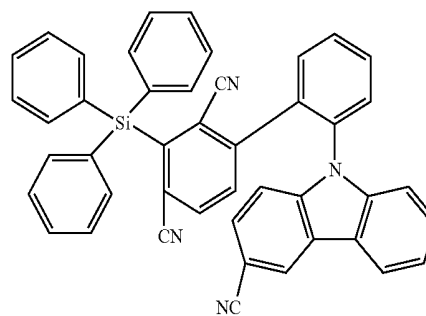
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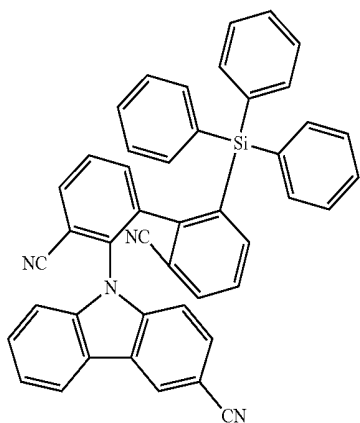
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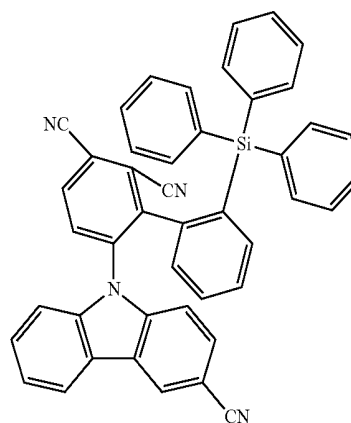
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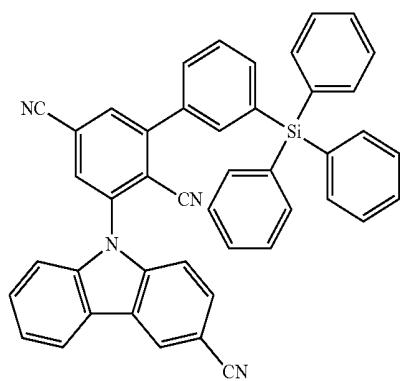
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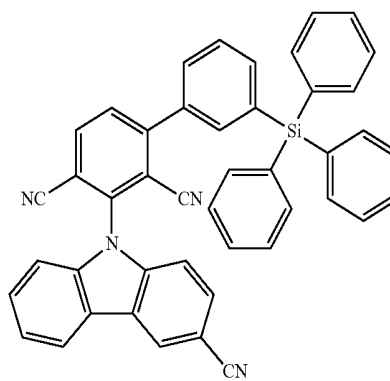
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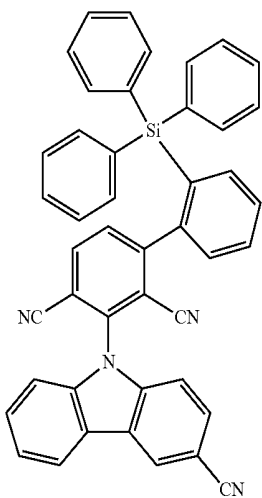


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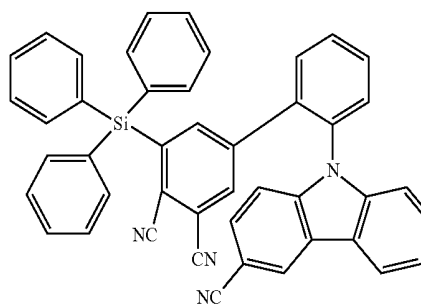
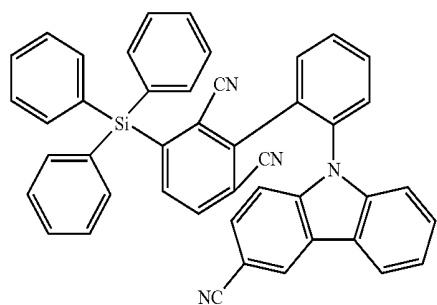
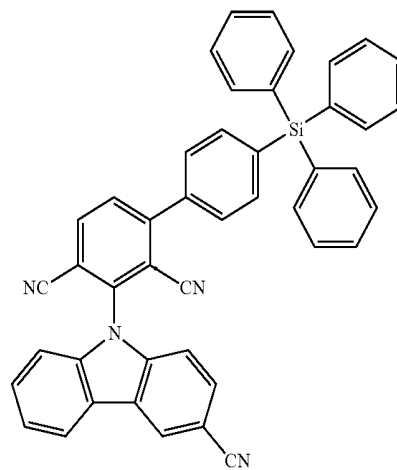
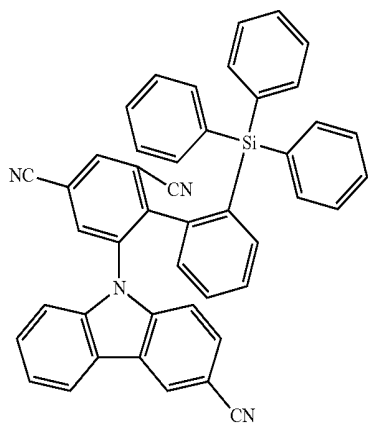
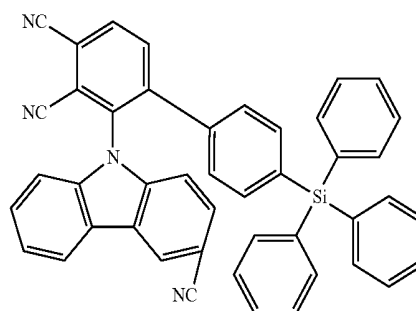
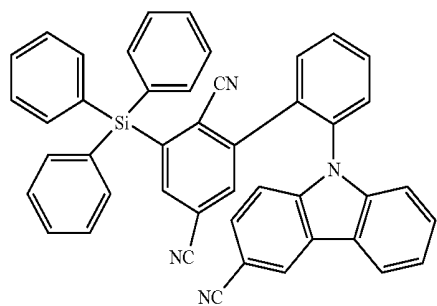
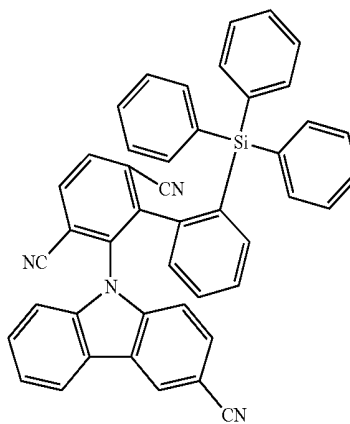


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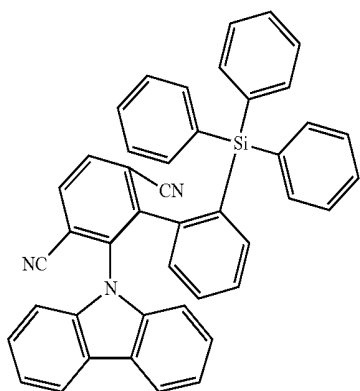
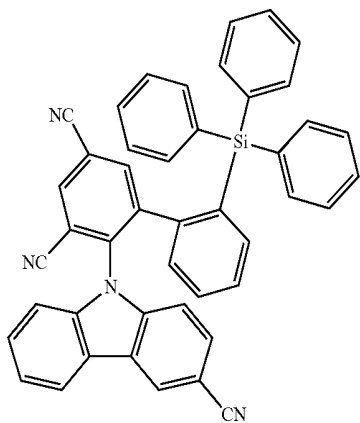
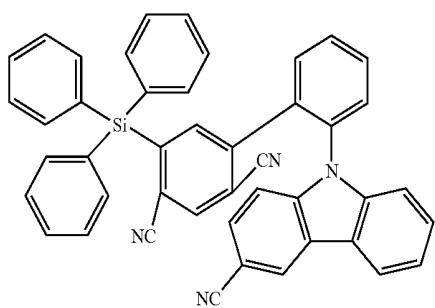
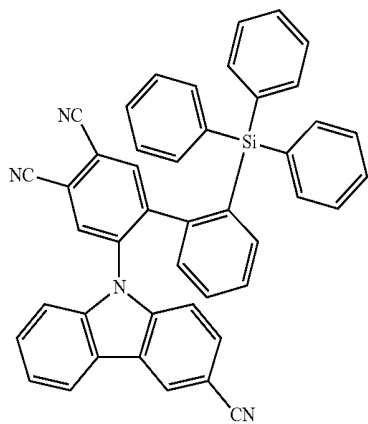
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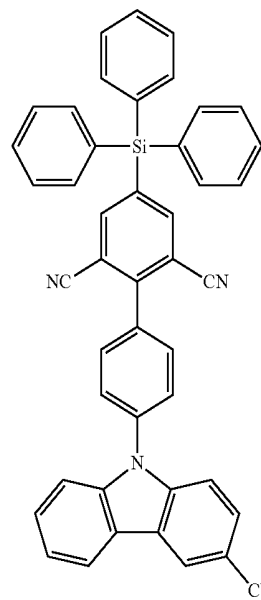
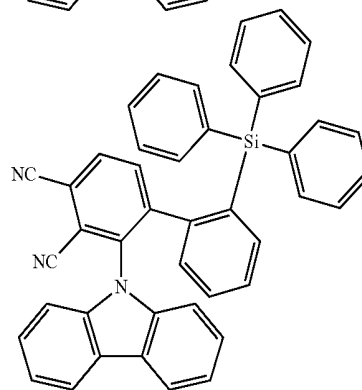
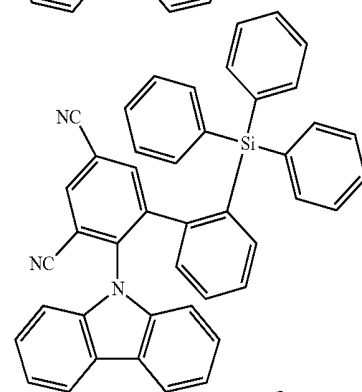
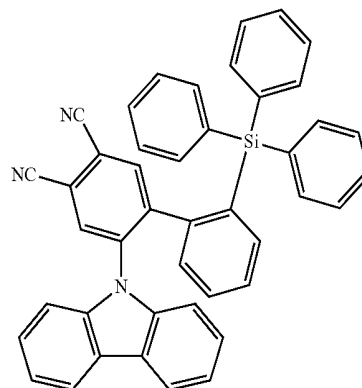
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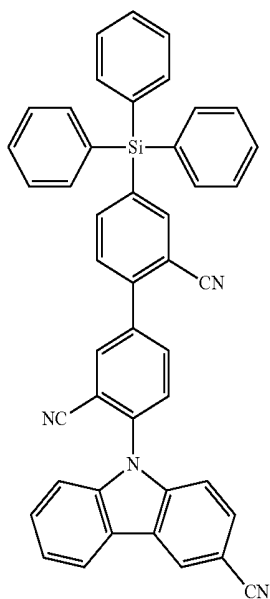
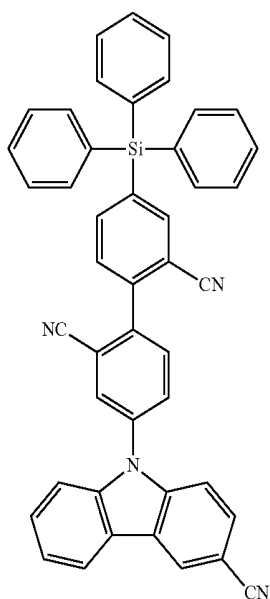
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15. An organic light-emitting device comprising:

a first electrode;

a second electrode; and

an organic layer disposed between the first electrode and the second electrode, wherein the organic layer comprises an emission layer and at least one condensed cyclic compound represented by Formula 1 of claim 1.

16. The organic light-emitting device of claim 15, wherein the first electrode is an anode, and the second electrode is a cathode,

the organic layer comprises a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,

wherein the hole transport region comprises at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer, and

wherein the electron transport region comprises at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

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17. The organic light-emitting device of claim 15, wherein the emission layer comprises the condensed cyclic compound represented by Formula 1.**18.** The organic light-emitting device of claim 17, wherein the emission layer further comprises a dopant, and wherein the dopant comprises a phosphorescent dopant.**19.** The organic light-emitting device of claim 16, wherein the hole transport region comprises the condensed cyclic compound represented by Formula 1.**20.** The organic light-emitting device of claim 16, wherein the electron transport region comprises the condensed cyclic compound represented by Formula 1.

* * * * *

专利名称(译)	稠合环状化合物和包括该稠合环状化合物的有机发光装置		
公开(公告)号	US20200044168A1	公开(公告)日	2020-02-06
申请号	US16/299549	申请日	2019-03-12
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD. 三星SDI CO. , LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD. 三星SDI CO. , LTD.		
[标]发明人	KIM SANGMO KWON EUNSUK KIM JONGSOO SON JHUNMO LEE DONGSEON JEON SOONOK CHUNG YEONSOOK JUNG YONGSIK		
发明人	KIM, SANGMO KWON, EUNSUK KIM, JONGSOO SON, JHUNMO LEE, DONGSEON JEON, SOONOK CHUNG, YEONSOOK JUNG, YONGSIK		
IPC分类号	H01L51/00 C07F7/08		
CPC分类号	H01L51/0094 H01L51/5092 C07F7/0812 H01L51/5056 H01L51/5096 H01L51/5072 H01L51/5016 H01L51/5088 H01L51/0072 H01L51/0085		
优先权	1020180089505 2018-07-31 KR		
外部链接	Espacenet USPTO		

摘要(译)

式1表示的稠合环状化合物：其中，在式1中，组和变量与规范中描述的相同。

