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Kato et al.

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(54) **CONDENSED CYCLIC COMPOUND,
 COMPOSITION INCLUDING THE
 CONDENSED CYCLIC COMPOUND,
 ORGANIC LIGHT-EMITTING DEVICE
 INCLUDING THE CONDENSED CYCLIC
 COMPOUND, AND METHOD OF
 MANUFACTURING THE ORGANIC
 LIGHT-EMITTING DEVICE**

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 H01L 51/0074; H01L 51/0085; H01L
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 H01L 2251/5384
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 257/E51.001–E51.052;
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See application file for complete search history.

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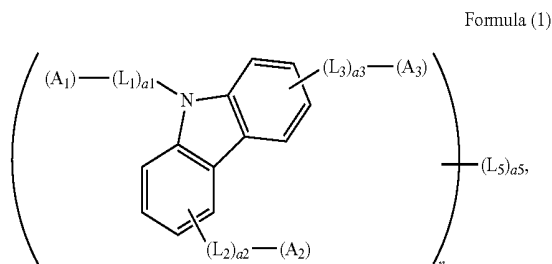
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(57) **ABSTRACT**

A condensed cyclic compound represented by Formula (1):



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

18 Claims, 1 Drawing Sheet

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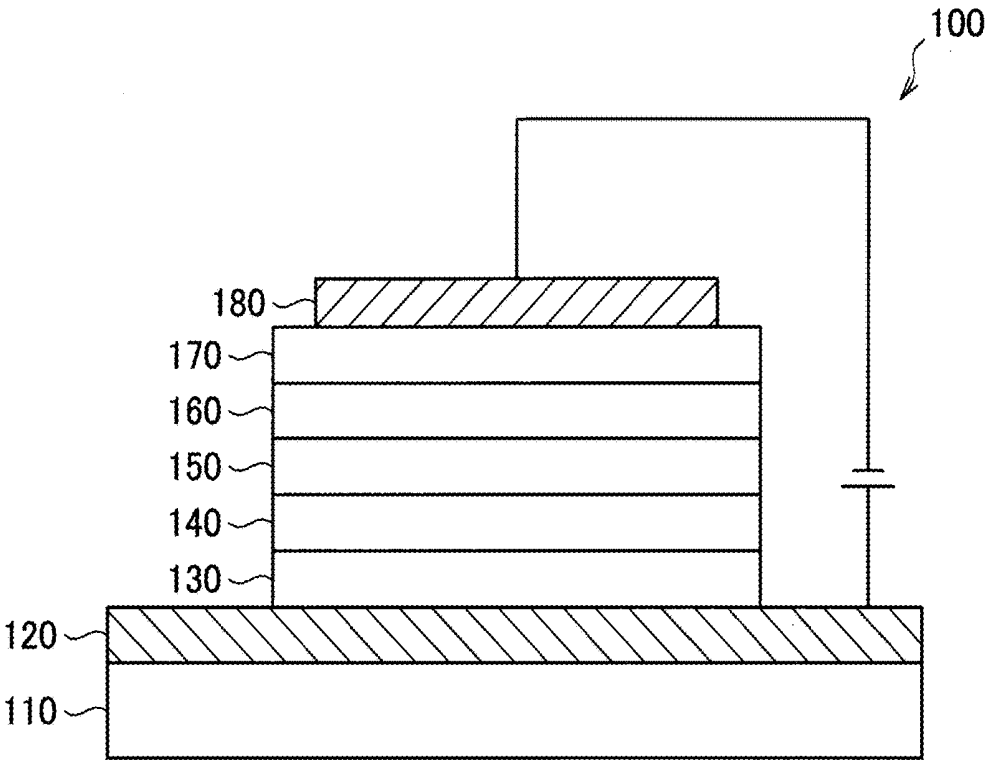
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**CONDENSED CYCLIC COMPOUND,
COMPOSITION INCLUDING THE
CONDENSED CYCLIC COMPOUND,
ORGANIC LIGHT-EMITTING DEVICE
INCLUDING THE CONDENSED CYCLIC
COMPOUND, AND METHOD OF
MANUFACTURING THE ORGANIC
LIGHT-EMITTING DEVICE**

**CROSS-REFERENCE TO RELATED
APPLICATION**

This application claims priority to Japanese Patent Application No. 2015-250531, filed on Dec. 22, 2015, in the Japanese Patent 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

One or more embodiments relate to a condensed cyclic compound, a composition including the condensed cyclic compound, an organic light-emitting device including the condensed cyclic compound, and a method of manufacturing the organic light-emitting device.

2. Description of the Related Art

Research efforts have recently been actively carried out to develop display apparatuses, mobile apparatuses, lighting apparatuses, or the like using organic light-emitting devices that are self-emission devices.

An organic light-emitting device has an organic layer including a light-emitting material. The light-emitting material is excited by recombination of holes and electrons in the organic layer, and light is generated when the excited light-emitting material transits from an excited state to a ground state.

Research efforts into various types of materials constituting the organic layer have been actively carried out to improve light emission efficiency, light emission lifespan, and driving voltage characteristics of the organic light-emitting device.

On the other hand, in order to manufacture a large-scale organic light-emitting device at a low cost, the use of solution coating instead of vacuum deposition in forming an organic layer is desired. Compared to vacuum deposition, the use of solution coating may increase use efficiency of a material for forming an organic layer and may facilitate the formation of a large-scale film without using expensive vacuum devices. Accordingly, solution coating is expected as an efficient method of manufacturing an organic light-emitting device.

SUMMARY

In an organic light-emitting device, a certain driving voltage is applied to an organic layer so as to inject holes and electrons into the organic layer. At this time, driving heat may be generated in the organic layer. An existing compound does not have a sufficient heat resistance to the driving heat. As a result, the existing compound included in the organic layer may be degraded by the driving heat. Thus, the organic light-emitting device does not have a satisfactory light emission lifespan.

In a solution coating method, after a solution in which an organic material is dissolved in a solvent is coated on a certain region to form a coating film, the solvent that

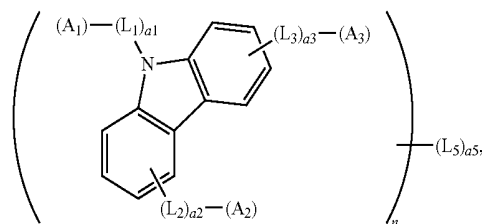
dissolves the organic material needs be removed by drying the coating layer by heat or the like. In such a solvent removing process, the organic material needs to have an excellent heat resistance so as to improve uniformity of the dried coating film. When a thickness of the dried coating film is not uniform, a stress may occur in a voltage applied to the manufactured organic light-emitting device. Thus, the organic light-emitting device may have an unsatisfactory light emission lifespan.

One or more embodiments include a condensed cyclic compound capable of improving thermal stability of an organic layer, and thus, capable of improving a light emission lifespan of an organic light-emitting device, a composition including the condensed cyclic compound, an organic light-emitting device including the condensed cyclic compound, and a method of manufacturing the organic light-emitting device.

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.

According to one or more embodiments, a condensed cyclic compound is represented by Formula (1):

Formula (1)



wherein, in Formula (1),

L_1 to L_3 and L_5 may each independently be selected from a single bond, $^*C(=O)^*$, $^*C(=S)^*$, $^*O^*$, $^*S^*$, $^*N(R_5)^*$, a substituted or unsubstituted C_2 - C_{60} alkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

* and * each indicate a binding site to a neighboring atom,

$a1$ to $a3$ and $a5$ may each independently be an integer from 1 to 10,

$(L_5)_{a5}$ may be an n -valent linking group or a single bond, wherein n may be a natural number greater than or equal to one,

when n is one, $(L_5)_{a5}$ may not exist,

when n is a natural number greater than or equal to two, at least one of $^*(L_1)_{a1}-(A_1)$, $^*(L_2)_{a2}-(A_2)$, and $^*(L_3)_{a3}-(A_3)$ may be linked to $(L_5)_{a5}$ or may be a single bond linked to $(L_5)_{a5}$,

i) A_1 to A_3 and R_5 may each independently be linked to $(L_5)_{a5}$;

ii) A_1 to A_3 and R_5 may be each independently a single bond linked to $(L_5)_{a5}$;

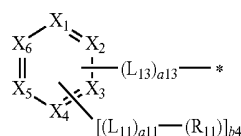
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iii) A_1 to A_3 and R_5 may each independently be a group represented by one of Formulae (2) to (5); or

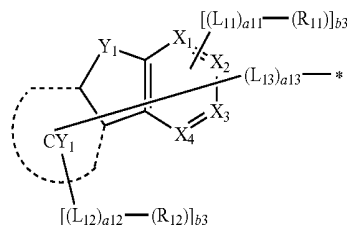
iv) A_1 to A_3 and R_5 may each independently be selected from a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl 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_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,

the group represented by $*(L_2)_{a2}-(A_2)$ may be linked to the third or fourth carbon of a carbazole core of Formula (1), the group represented by $*(L_3)_{a3}-(A_3)$ may be linked to the fifth or sixth carbon of the carbazole core of Formula (1), and $*$ in the group represented by $*(L_2)_{a2}-(A_2)$ and the group represented by $*(L_3)_{a3}-(A_3)$ indicates a binding site to a carbon atom of the carbazole core of Formula (1), and

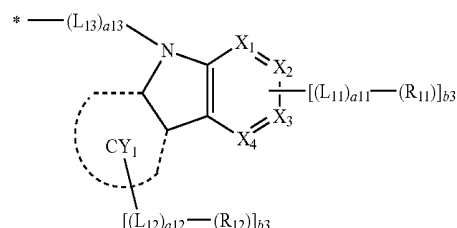
at least one of A_1 to A_3 may be selected from groups represented by Formulae (2) to (5), provided that, when i) n is 2, ii) $(L_5)_{a5}$ is a single bond, and iii) $*(L_3)_{a3}-(A_3)$ is a single bond linked to $(L_5)_{a5}$, A_2 is selected from groups represented by Formulae (2) to (5):



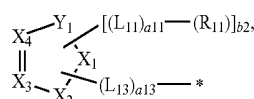
Formula (2)



Formula (3)



Formula (4)



Formula (5)

wherein, in Formulae (2) to (5),

X_1 may be N, carbon linked to $*(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_2 may be N, carbon linked to $*(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_3 may be N, carbon linked to $*(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_4 may be N, carbon linked to $*(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_5 may be N, carbon linked to $*(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , and X_6 may be N, carbon linked

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to $*(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , provided that X_1 to X_4 in Formula (4) are not carbon linked to L_{13} ,

Y_1 may be O, S, N(R_{13}), or C(R_{14})(R_{15}), and R_{14} and R_{15} may optionally be linked to form a saturated or unsaturated ring,

CY_1 may be a C_5 - C_{30} carbocyclic group or a C_2 - C_{30} heterocyclic group,

at least one of X_1 to X_6 in Formula (2) may be N,

in Formulae (3) and (4), at least one of X_1 to X_4 may be

N, or CY_1 may be a π electron-depleted nitrogen-containing C_2 - C_{30} heterocyclic group,

at least one of X_1 to X_4 in Formula (5) may be N,

L_{11} to L_{13} may each independently be selected from a single bond, a substituted or unsubstituted C_2 - C_{60} alkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

$a11$ to $a13$ may each independently be an integer selected from 1 to 10,

R_{11} to R_{15} may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, 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, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, and $-C(=O)(Q_1)$,

$b2$ may be an integer selected from 0 to 2,

$b3$ may be an integer selected from 0 to 3,

$b4$ may be an integer selected from 0 to 4,

$*$ indicates a binding site to a neighboring atom, and

at least one substituent of the substituted C_2 - C_{60} alkylene

group, the substituted C_3 - C_{10} cycloalkylene group, the substituted C_1 - C_{10} heterocycloalkylene group, the substituted C_3 - C_{10} cycloalkenylene group, the substituted C_1 - C_{10} heterocycloalkenylene group, the substituted C_6 - C_{60} arylene group, the substituted C_1 - C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted

tuted 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 in Formulae (1) to (5) may be selected from:

deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, 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, —NCS, 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(Q₁₁)(Q₁₂), and —C(=O)(Q₁₁);

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(Q₂₁)(Q₂₂), and —C(=O)(Q₂₁); and —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁),

wherein Q₁ to Q₃, Q₁₁ to Q₁₃, Q₂₁ to Q₂₃, and Q₃₁ to Q₃₃ may each independently be selected from hydrogen, deuterium, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphe-

nylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuran group, a phenyldibenzofuran group, a diphenyldibenzofuran group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, and a diphenyldibenzothiophenyl group.

According to an aspect of the present disclosure, an organic layer having excellent thermal stability and an organic light-emitting device having improved light emission lifespan may be provided.

According to one or more embodiments, a composition includes the condensed cyclic compound represented by Formula (1) and a liquid medium.

According to an aspect of the present disclosure, an organic layer having excellent thermal stability and an organic light-emitting device having improved light emission lifespan may be provided, and a composition suitable for solution coating may be provided.

According to one or more embodiments, an organic light-emitting device includes:

- 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 wherein the organic layer includes a layer including the condensed cyclic compound represented by Formula (1).

According to an aspect of the present disclosure, an organic layer having excellent thermal stability and an organic light-emitting device having improved light emission lifespan may be provided.

According to one or more embodiments, a method of manufacturing an organic light-emitting device including 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 wherein the organic layer includes a layer including the condensed cyclic compound represented by Formula (1), includes:

forming a layer including the condensed cyclic compound by solution coating using a composition including the condensed cyclic compound and a liquid medium.

According to an aspect of the present disclosure, an organic layer having excellent thermal stability and a large-sized organic light-emitting device having improved light emission lifespan may be provided.

BRIEF DESCRIPTION OF THE DRAWING

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

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. 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.

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.

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.

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.

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.

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.

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, of manufacturing techniques and/or tolerances, 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.

“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

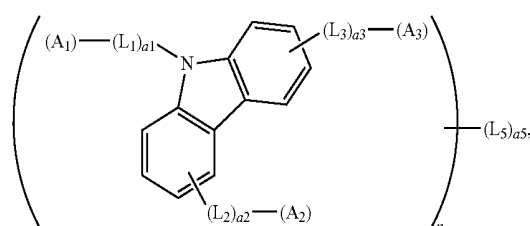
question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement system). For example, “about” can mean within one or more standard deviations, or within $\pm 30\%$, 20% , 10% , 5% of the stated value.

Hereinafter, embodiments are described in detail by referring to the attached drawings, and in the drawings, like reference numerals denote like elements, and a redundant explanation thereof will not be provided herein.

1. Condensed Cyclic Compound

A condensed cyclic compound according to an embodiment will be described. The condensed cyclic compound may be represented by Formula (1):

Formula (1)



wherein, in Formula (1),

L_1 to L_3 and L_5 may each independently be selected from a single bond, $^*C(=O)^*$, $^*C(S)^*$, $^*O^*$, $^*S^*$, $^*N(R_5)^*$ a substituted or unsubstituted C_2 - C_{60} alkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

* and * each indicate a binding site to a neighboring atom,

a_1 to a_3 and a_5 may each independently be an integer selected from 1 to 10,

$(L_5)_{a_5}$ may be an n -valent linking group or a single bond, wherein n may be a natural number greater than or equal to one,

when n is one, $(L_5)_{a_5}$ may not exist,

when n is a natural number greater than or equal to two, at least one of $^*(L_1)_{a_1}-(A_1)$, $^*(L_2)_{a_2}-(A_2)$, and $^*(L_3)_{a_3}-(A_3)$ may be linked to $(L_5)_{a_5}$ or may be a single bond linked to $(L_5)_{a_5}$,

i) A_1 to A_3 and R_5 may each independently be linked to $(L_5)_{a_5}$;

ii) A_1 to A_3 and R_5 may each independently be a single bond linked to $(L_5)_{a_5}$;

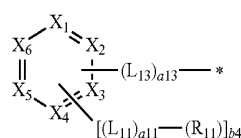
iii) A_1 to A_3 and R_5 may each independently be a group represented by one of Formulae (2) to (5); or

iv) A_1 to A_3 and R_5 may each independently be selected from a substituted or unsubstituted C_1 - C_{60} alkyl 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_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic con-

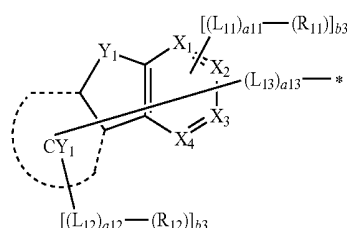
condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

the group represented by $^{*}-(L_2)_{a2}-(A_2)$ may be linked to the third or fourth carbon of a carbazole core of Formula (1), the group represented by $^{*}-(L_3)_{a3}-(A_3)$ may be linked to the fifth or sixth carbon of the carbazole core of Formula (1), and * in the group represented by $^{*}-(L_2)_{a2}-(A_2)$ and the group represented by $^{*}-(L_3)_{a3}-(A_3)$ indicates a binding site to a carbon atom of the carbazole of Formula (1), and

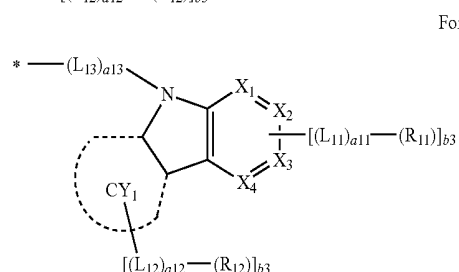
at least one of A_1 to A_3 may be selected from groups represented by Formulae (2) to (5), provided that, when, i) n is two, ii) $(L_5)_{a5}$ is a single bond, and iii) $^{*}-(L_3)_{a3}-(A_3)$ is a single bond linked to $(L_5)_{a5}$, A_2 is selected from groups represented by Formulae (2) to (5):



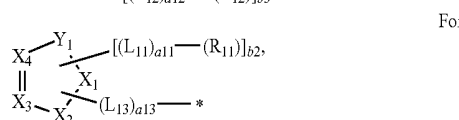
Formula (2)



Formula (3)



Formula (4)



Formula (5)

wherein, in Formulae (2) to (5),

X_1 may be N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_2 may be N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_3 may be N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_4 may be N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , X_5 may be N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , and X_6 may be N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L_{13} , provided that X_1 to X_4 in Formula (4) are not carbon linked to L_{13} ,

Y_1 may O, S, N(R_{13}), or C(R_{14})(R_{15}), and R_{14} and R_{15} may optionally be linked to form a saturated or unsaturated ring,

CY_1 may be a C_5 - C_{30} carbocyclic group or a C_2 - C_{30} heterocyclic group,

at least one of X_1 to X_6 in Formula (2) may be N,

in Formulae (3) and (4), at least one X_1 to X_4 may be N, or CY_1 may be a π electron-depleted nitrogen-containing C_2 - C_{30} heterocyclic group,

at least one of X_1 to X_4 in Formula (5) may be N,

L_{11} to L_{13} may each independently be selected from a single bond, a substituted or unsubstituted C_2 - C_{60} alkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

a_{11} to a_{13} may each independently be an integer selected from 1 to 10,

R_{11} to R_{15} may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, 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, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, and $-C(=O)(Q_1)$,

b_2 may be an integer selected from 0 to 2,

b_3 may be an integer selected from 0 to 3,

b_4 may be an integer selected from 0 to 4, and

* indicates a binding site to a neighboring atom.

The compound represented by Formula (1) may satisfy at least one of conditions (i) and (ii) below:

(i) the group represented by $^{*}-(L_2)_{a2}-(A_2)$ in Formula (1) is linked to the third or fourth carbon of the carbazole core of Formula (1), and the group represented by $^{*}-(L_3)_{a3}-(A_3)$ is linked to the fifth or sixth carbon of the carbazole core of Formula (1); and

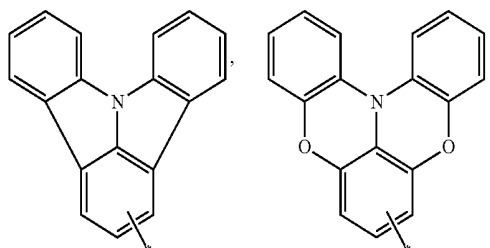
(ii) the group represented by $^{*}-(L_1)_{a1}-(A_1)$ in Formula (1) is linked to $(L_5)_{a5}$, is a single bond linked to $(L_5)_{a5}$, or does not include a π electron-depleted nitrogen-containing cyclic group.

L_1 to L_3 , L_5 , and L_{11} to L_{13} in Formulae (1) to (5) may each independently be selected from:

a single bond, $^{*}-C(=O)-^{*}$, $^{*}-C(=S)-^{*}$, and $^{*}-N(R_5)-^{*}$; and

a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a triazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a furanylene group, a thienylene group, an oxazolylene group, an isoxazolylene group, a thiazolylene group, an isothiazolylene

group, an oxadiazolylene group, an isoxadiazolylene group, a thiadiazolylene group, an isothiadiazolylene group, a pyrazolylene group, an indazolylene group, a purinylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoxazinolinylenylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoxazolylene group, a benzothiazolylene group, a benzimidazolylene group, an isoindolylene group, an indolylene group, a benzofuranylene group, a benzothiophenylene group, a carbazolylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a naphthobenzofuranylene group, a naphthobenzothiophenylene group, an imidazopyrimidinylene group, and an imidazopyridinylene group, each unsubstituted or substituted with at least one selected from deuterium, $-F$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, a cyano group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,



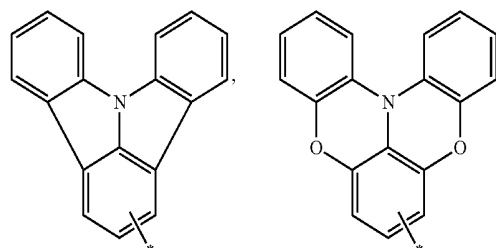
$-\text{Si}(Q_{31})(Q_{32})(Q_{33})$, $-\text{N}(Q_{31})(Q_{32})$, and $-\text{C}(=\text{O})(Q_{31})$, provided that L_{11} to L_{13} are not $^*-\text{C}(=\text{O})-^*$, $^*-\text{C}(=\text{S})-^*$, and $^*-\text{N}(R_5)-^*$.

For example, L_1 to L_3 in Formula (1) may each independently be selected from:

a single bond; and

a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, a furanylene group, a thienylene group, an isoindolylene group, an indolylene group, a benzofuranylene group, a benzothiophenylene group, a carbazolylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a naphthobenzofuranylene group, and a naphthobenzothiophenylene group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, a cyano group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl

group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,

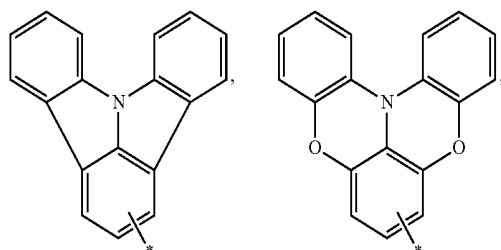


$-\text{Si}(Q_{31})(Q_{32})(Q_{33})$, $-\text{N}(Q_{31})(Q_{32})$, and $-\text{C}(=\text{O})(Q_{31})$, L_5 in Formula (1) may be selected from:

a single bond, $^*-\text{C}(=\text{O})-^*$, $^*-\text{C}(=\text{S})-^*$, and $^*-\text{N}(R_5)-^*$; and,

a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a triazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a furanylene group, a thienylene group, an oxazolylene group, an isoxazolylene group, a thiazolylene group, an isothiazolylene group, an oxadiazolylene group, an isoxadiazolylene group, a thiadiazolylene group, an isothiadiazolylene group, a pyrenylene group, an indenylene group, a purinylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoxazinolinylenylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoxazolylene group, a benzothiazolylene group, a benzimidazolylene group, an isoindolylene group, an indolylene group, a benzofuranylene group, a benzothiophenylene group, a carbazolylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a naphthobenzofuranylene group, a naphthobenzothiophenylene group, an imidazopyrimidinylene group, and an imidazopyridinylene group, each unsubstituted or substituted with at least one selected from deuterium, $-F$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, a cyano group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,

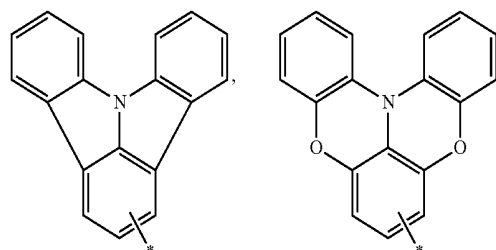
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—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁), and

L₁₁ to L₁₃ in Formulae (2) to (5) may each independently be selected from a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a triazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a furanylene group, a thienylene group, an oxazolylene group, an isoxazolylene group, a thiazolylene group, an isothiazolylene group, an oxadiazolylene group, an isoxadiazolylene group, a thiadiazolylene group, an isothiadiazolylene group, a pyra-

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—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁), but embodiments of the present disclosure are not limited thereto.

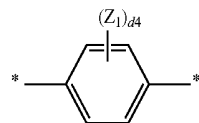
In one or more embodiments,

L₁ to L₃ in Formula (1) may each independently be selected from a single bond, groups represented by Formulae 6-1 to 6-3, and groups represented by Formulae 6-20 to 6-27,

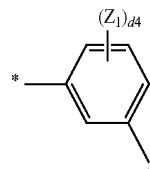
L₅ in Formula (1) may be selected from a single bond, *—C(=O)—*, *—C(=S)—*, *—N(R₅)—*, and groups represented by Formulae 6-1 to 6-27, and

L₁₁ to L₁₃ in Formulae (2) to (5) may each independently be selected from a single bond and groups represented by Formulae 6-1 to 6-27, but embodiments of the present disclosure are not limited thereto:

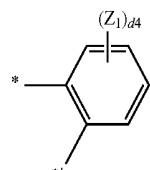
Formula 6-1



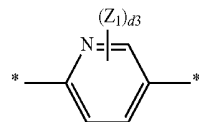
Formula 6-2



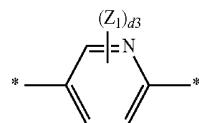
Formula 6-3



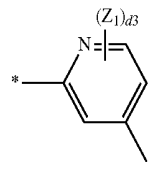
Formula 6-4



Formula 6-5

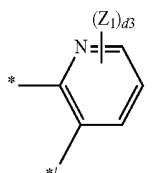
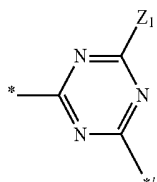
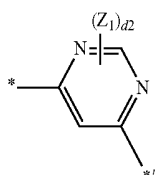
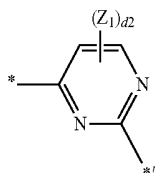
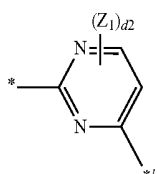
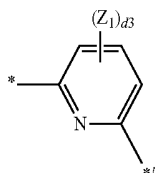
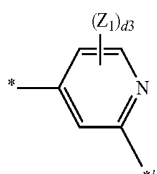
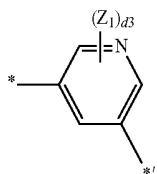


Formula 6-6



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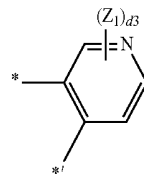


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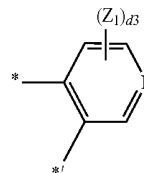
Formula 6-7

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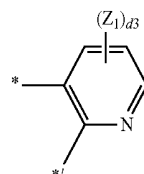
Formula 6-8

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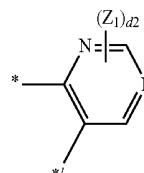
Formula 6-9

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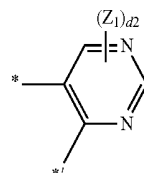
Formula 6-10

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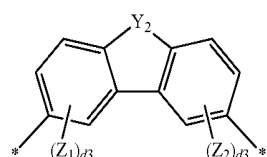
Formula 6-11

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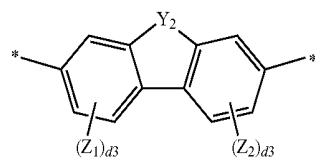
Formula 6-12

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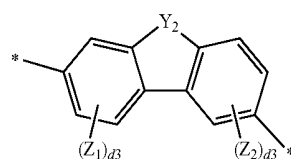
Formula 6-13

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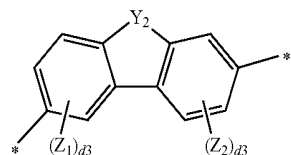


Formula 6-14

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65



Formula 6-15

Formula 6-16

Formula 6-17

Formula 6-18

Formula 6-19

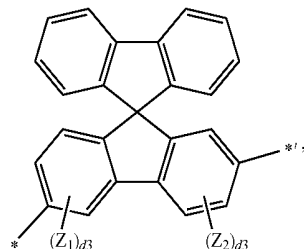
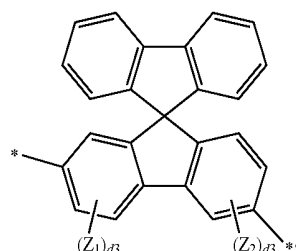
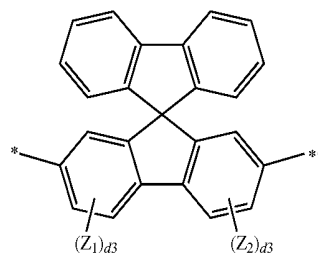
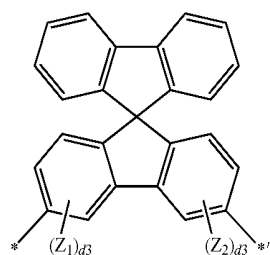
Formula 6-20

Formula 6-21

Formula 6-22

Formula 6-23

-continued



wherein, in Formulae 6-1 to 6-27,

Y_2 may be O, S, $C(Z_3)(Z_4)$, or $N(Z_5)$,

Z_1 to Z_5 may each independently be hydrogen, deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a trimethylsilyl group, or a triphenylsilyl group,

d_2 may be 1 or 2,

d_3 may be 1, 2, or 3,

d_4 may be 1, 2, 3, or 4, and

* and *' each indicate a binding site to a neighboring atom.

In one or more embodiments,

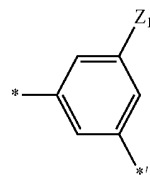
L_1 to L_3 in Formula (1) may each independently be selected from a single bond and a group represented by Formula 6(1),

L_5 in Formula (1) may be selected from a single bond, $*-C(=O)-*$, $*-C(=S)-*$, $*-N(R_5)-*$, and groups represented by Formulae 6(1) to 6(10),

L_{11} to L_{13} in Formulae (2) to (5) may each independently be selected from a single bond and groups represented by Formulae 6(1) to 6(9), but embodiments of the present disclosure are not limited thereto:

Formula 6-24

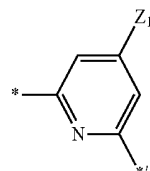
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Formula 6-25

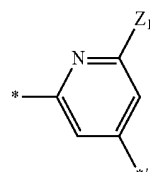
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Formula 6-26

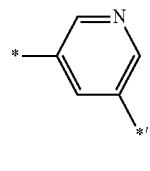
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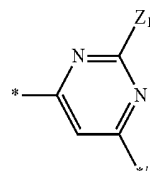
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Formula 6-27

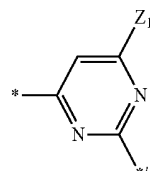
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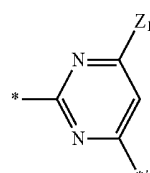
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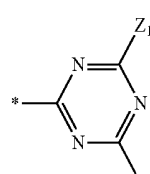
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Formula 6(1)

Formula 6(2)

Formula 6(3)

Formula 6(4)

Formula 6(5)

Formula 6(6)

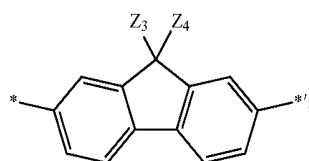
Formula 6(7)

Formula 6(8)

Formula 6(9)

19

-continued



Formula 6(10)

wherein Z_1 , Z_3 , and Z_5 in Formulae 6(1) to 6(10) may each independently be hydrogen, deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a trimethylsilyl group, or a triphenylsilyl group, and * and *' each indicate a binding site to a neighboring atom.

a_1 , a_2 , a_3 , a_5 , a_{11} , a_{12} , and a_{13} in Formulae (1) to (5) respectively indicate the number of groups L_1 , the number of groups L_2 , the number of groups L_3 , the number of groups L_5 , the number of groups L_{11} , the number of groups L_{12} , and the number of groups L_{13} and may each independently be selected from an integer from 1 to 5 or an integer from 1 to 3, but embodiments of the present disclosure are not limited thereto. When a_1 is two or more, two or more groups L_1 may be identical to or different from each other. This may be equally applied to each of a_2 to a_3 , a_5 , and a_{11} to a_{13} and each of L_2 to L_3 , L_5 , and L_{11} to L_{13} .

n may be a natural number from 1 to 10. For example, n may be 1, 2, 3, or 4, or may be 1 or 2, but embodiments of the present disclosure are not limited thereto.

In one or more embodiments, in Formula (1), 1) n may be one, or 2) n may be two and $(L_5)_{a_5}$ may be a group represented by $*-Ar_1-T_1-Ar_2-*'$, and Ar_1 , T_1 , and Ar_2 are the same as described in connection with L_5 , provided that Ar_1 and Ar_2 are not a single bond, $*-C(=O)-*$, $*-C(=S)-*$, $*-O-*'$, $*-S-*'$, or $*-N(R_5)-*$ but embodiments of the present disclosure are not limited thereto.

In one or more embodiments,

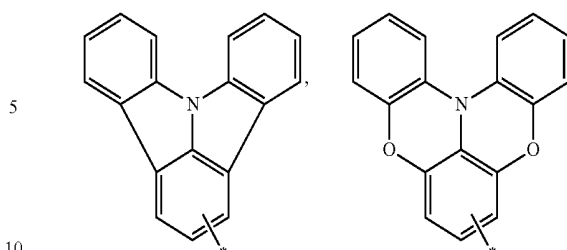
i) A_1 to A_3 and R_5 in Formula (1) may each independently be linked to $(L_5)_{a_5}$;

ii) A_1 to A_3 and R_5 in Formula (1) may each independently be a single bond linked to $(L_5)_{a_5}$;

iii) A_1 to A_3 and R_5 in Formula (1) may each independently be a group represented by one of Formulae (2) to (5); or

iv) A_1 to A_3 and R_5 in Formula (1) may each independently be selected from a phenyl group, an indenyl group, a naphthyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a furanyl group, a thienyl group, an isoindolyl group, an indolyl group, a benzofuranyl group, a benzothiophenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, and a naphthobenzothiophenyl group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,

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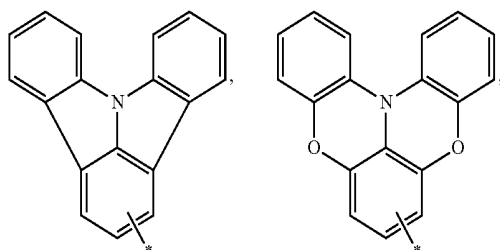
$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-C(=O)(Q_{31})$, and

R_{11} to R_{15} in Formulae (2) to (5) may each independently be selected from:

hydrogen, deuterium, $-F$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, a cyano group, a C_1 - C_{20} alkyl group, and C_1 - C_{20} alkoxy group; and

a phenyl group, an indenyl group, a naphthyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, an imidazolyl group, a pyrazolyl group, a triazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a furanyl group, a thienyl group, an oxazolyl group, an isoxazolyl group, a thiazolyl group, an isothiazolyl group, an oxadiazolyl group, an isoxadiazolyl group, a thiadiazolyl group, an isothiadiazolyl group, a pyranyl 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 benzothiazolyl group, a benzimidazolyl group, an isoindolyl group, an indolyl group, a benzofuranyl group, a benzothiophenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, an imidazopyrimidinyl group, and an imidazopyridinyl group, each unsubstituted or substituted with at least one selected from deuterium, $-F$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, $-NCS$, a cyano group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,

21



—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁), but embodiments of the present disclosure are not limited thereto.

At least one of A₁ to A₃ may be selected from groups represented by Formulae (2) to (5), provided that, when i) n is two, ii) (L₅)_{a5} is a single bond, and iii) *(L₃)_{a3}-(A₃) is a single bond linked to (L₅)_{a5}, A₂ is selected from groups represented by Formulae (2) to (5).

For example, A₂ in Formula (1) may be a group represented by one of Formulae (2) to (5), and none, one, or two of A₁ and A₃ may each independently be a group represented by one of Formulae (2) to (5).

In one or more embodiments, in Formula (1), A₂ may be a group represented by one of Formulae (2) to (5), and A₁ and A₃ may not be groups represented by Formulae (2) to (5).

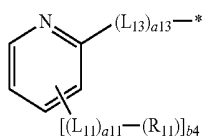
In one or more embodiments, in Formula (1), A₁ and A₂ may each independently be a group represented by one of Formulae (2) to (5), and A₃ may not be groups represented by Formulae (2) to (5).

In one or more embodiments, in Formula (1), A₂ and A₃ may each independently be a group represented by one of Formulae (2) to (5), and A₁ may not be groups represented by Formulae (2) to (5).

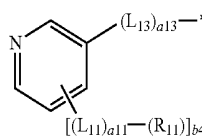
In one or more embodiments, in Formula (1), A₁ to A₃ may each independently be a group represented by one of Formulae (2) to (5).

In one or more embodiments, CY₁ in Formulae (3) and (4) may be a 6-membered cyclic group. For example, CY₁ may be a benzene group, a pyridine group, a pyrimidine group, a pyrazine group, or a pyridazine group, but embodiments of the present disclosure are not limited thereto.

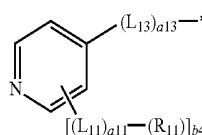
In one or more embodiments, the group represented by Formula (2) may be selected from groups represented by Formulae (2)-1 to (2)-7:



Formula (2)-1



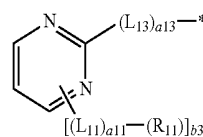
Formula (2)-2



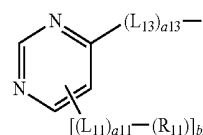
Formula (2)-3

22

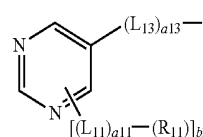
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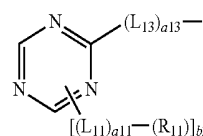
Formula (2)-4



Formula (2)-5



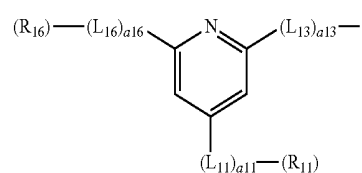
Formula (2)-6



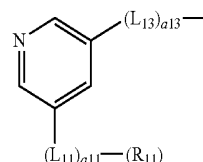
Formula (2)-7

wherein, in Formulae (2)-1 to (2)-7, L₁₁, L₁₃, a11, a13, R₁₁, and (L₁₁)_{a11}-(R₁₁) are each independently the same as described above, b4 may be an integer selected from 0 to 4, b3 may be an integer selected from 0 to 3, b2 may be an integer selected from 0 to 2, and * indicates a binding site to a neighboring atom.

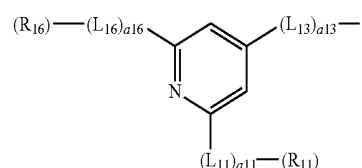
In one or more embodiments, the group represented by Formula (2) may be selected from groups represented by Formulae (2)-A to (2)-F:



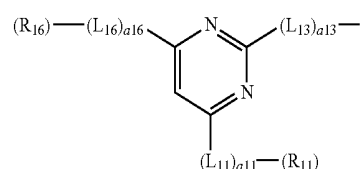
Formula (2)-A



Formula (2)-B



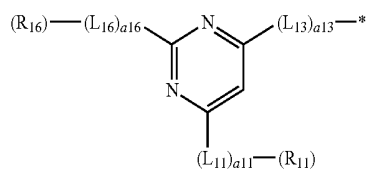
Formula (2)-C



Formula (2)-D

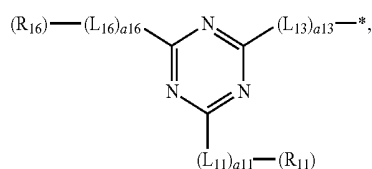
23

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Formula (2)-E

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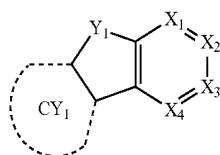
Formula (2)-F

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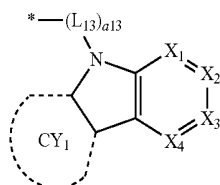
15

wherein, in Formulae (2)-A to (2)-F, L_{11} , L_{13} , $a11$, $a13$, R_{11} , and $(L_{11})_{a11}-(R_{11})$ are each independently the same as described above, L_{16} , $a16$, R_{16} , and $(L_{16})_{a16}-(R_{16})$ are each independently the same as described in connection with L_{11} , $a11$, R_{11} , and $(L_{11})_{a11}-(R_{11})$, and * indicates a binding site to a neighboring atom.

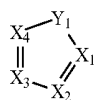
In one or more embodiments, a core represented by



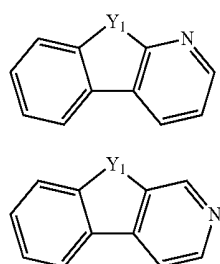
in Formula (3) may be selected from groups represented by Formulae 3-1 to 3-20, a core represented by



in Formula (4) may be selected from groups represented by Formulae 4-1 to 4-10, and a core represented by

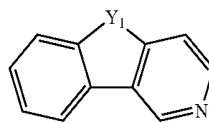


in Formula (5) may be selected from groups represented by Formulae 5-1 to 5-6:

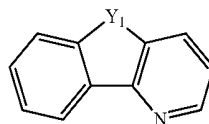
**24**

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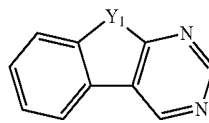
3-3



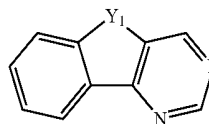
3-4



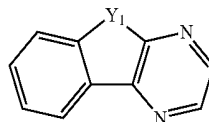
3-5



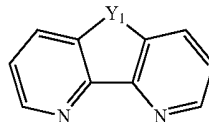
3-6



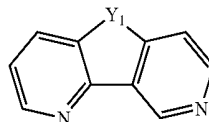
3-7



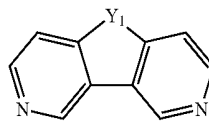
3-8



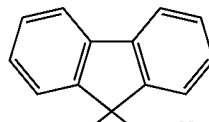
3-9



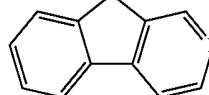
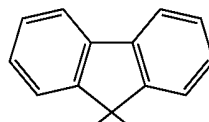
3-10



3-11

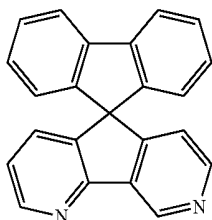
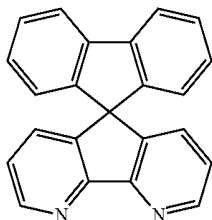
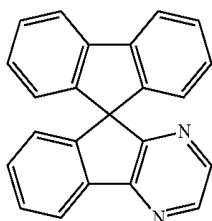
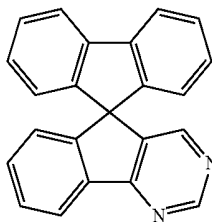
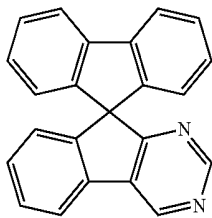
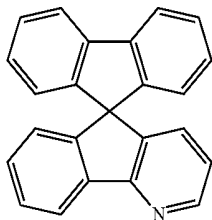
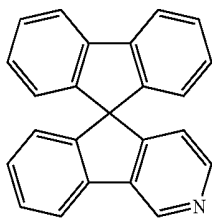


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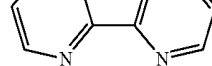
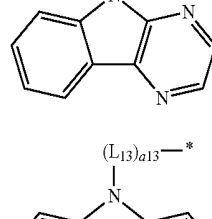
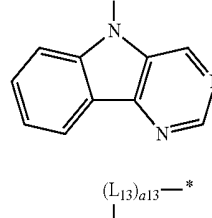
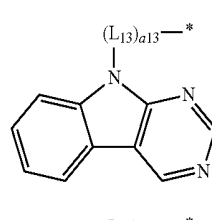
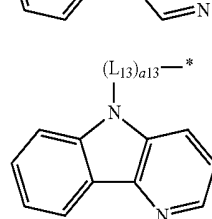
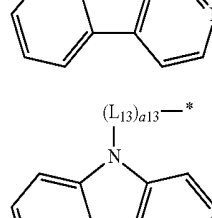
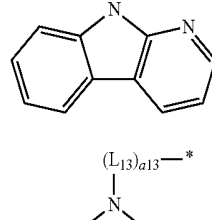
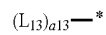
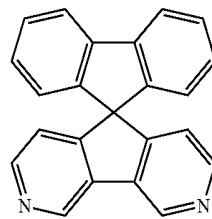
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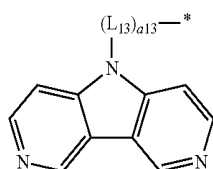
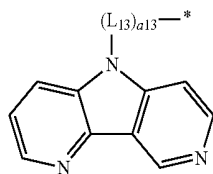
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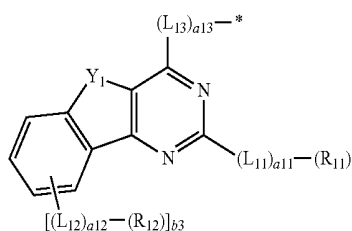
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wherein Y_1 in Formulae 3-1 to 3-20, 4-1 to 4-10, and 5-1 to 5-6 are the same as described above.

In one or more embodiments, the group represented by Formula (3) may be selected from groups represented by Formulae (3)-1 to (3)-11, and the group represented by Formula (4) may be selected from groups represented by Formulae (4)-1 and (4)-2, but embodiments of the present disclosure are not limited thereto:



Formula (3)-1

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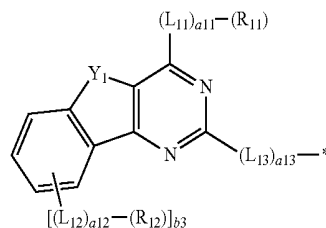
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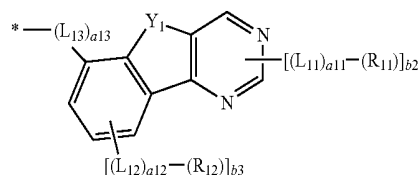
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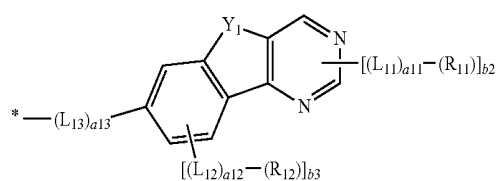
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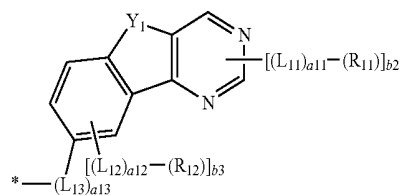
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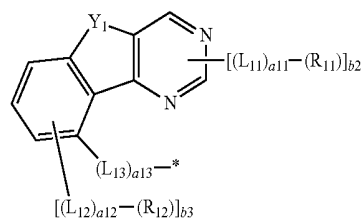
Formula (3)-3



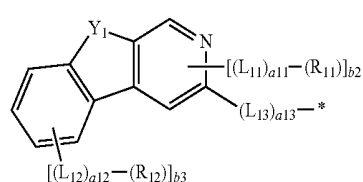
Formula (3)-4



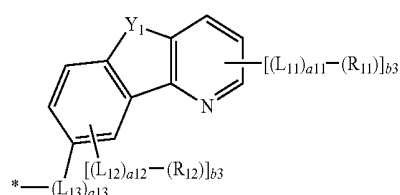
Formula (3)-5



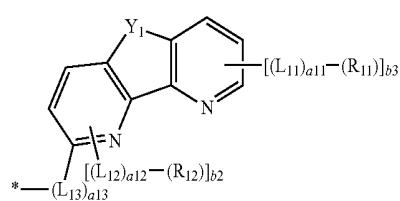
Formula (3)-6



Formula (3)-7



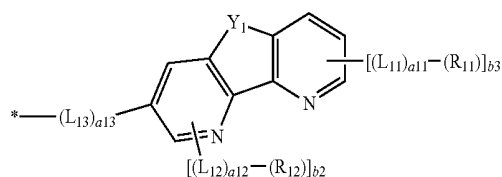
Formula (3)-8



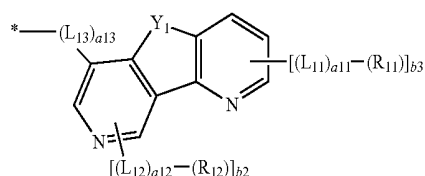
Formula (3)-9

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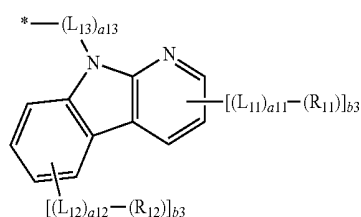
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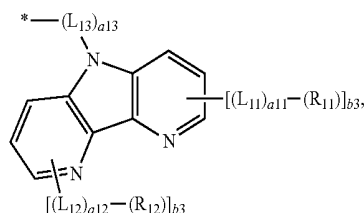
Formula (3)-10



Formula (3)-11



Formula (4)-1



Formula (4)-2

wherein, in Formulae (3)-1 to (3)-11, (4)-1, and (4)-2, L_{11} to L_{13} , a_{11} to a_{13} , R_{11} , R_{12} , and Y_1 are each independently the same as described above, b_2 may be an integer selected from 0 to 2, b_3 may be an integer selected from 0 to 3, and * indicates a binding site to a neighboring atom.

In one or more embodiments, in Formula (1), A_1 to A_3 , which are not groups represented by Formulae (2) to (5), may not include a π electron-depleted nitrogen-containing cyclic group.

Accordingly, four embodiments may be provided as follows:

First Embodiment

A_2 in Formula (1) may be selected from groups represented by Formulae (2) to (5),

i) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ in Formula (1) may each independently be linked to $(L_5)_{a5}$ or may be a single bond linked to $(L_5)_{a5}$, or

ii) in $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ of Formula (1),

L_1 and L_3 may each independently be a single bond, or may each independently be selected from a phenylene group, a fluorenylene group, a spiro-bifluorenylene group, a carbazolylene group, a dibenzofuranylene group, and a dibenzothiophenylylene group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzo-

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furanyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group, $-\text{Si}(Q_{31})(Q_{32})(Q_{33})$, $-\text{N}(Q_{31})(Q_{32})$, and $-\text{C}(=\text{O})(Q_{31})$, a_1 and a_3 may each independently be 1, 2, or 3, and

A_1 and A_3 may each independently be selected from a phenyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group, $-\text{Si}(Q_{31})(Q_{32})(Q_{33})$, $-\text{N}(Q_{31})(Q_{32})$, and $-\text{C}(=\text{O})(Q_{31})$.

Second Embodiment

A_1 and A_2 in Formula (1) may each independently be selected from groups represented by Formulae (2) to (5),

i) the group represented by $*(L_3)_{a3}-(A_3)$ in Formula (1) may be linked to $(L_5)_{a5}$ or may be a single bond linked to $(L_5)_{a5}$, or

ii) in $*(L_3)_{a3}-(A_3)$ of Formula (1),

L_3 may be a single bond, or may be selected from a phenylene group, a fluorenylene group, a spiro-bifluorenylene group, a carbazolylene group, a dibenzofuranylene group, and a dibenzothiophenylylene group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group, $-\text{Si}(Q_{31})(Q_{32})(Q_{33})$, $-\text{N}(Q_{31})(Q_{32})$, and $-\text{C}(=\text{O})(Q_{31})$, a_3 may be 1, 2, or 3, and

A_3 may be selected from a phenyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group, $-\text{Si}(Q_{31})(Q_{32})(Q_{33})$, $-\text{N}(Q_{31})(Q_{32})$, and $-\text{C}(=\text{O})(Q_{31})$.

Third Embodiment

A_2 and A_3 in Formula (1) may each independently be selected from groups represented by Formulae (2) to (5),

i) the group represented by $*(L_1)_{a1}-(A_1)$ in Formula (1) may be linked to $(L_5)_{a5}$ or may be a single bond linked to $(L_5)_{a5}$, or

ii) in $*(L_1)_{a1}-(A_1)$ of Formula (1),

L_1 may be a single bond, or may be selected from a phenylene group, a fluorenylene group, a spiro-bifluore-

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nylene group, a carbazolyne group, a dibenzofuranylene group, and a dibenzothiophenyne group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-C(=O)(Q_{31})$, a_1 may be 1, 2, or 3,

A_1 may be selected from a phenyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-C(=O)(Q_{31})$.

Fourth Embodiment

A_1 to A_3 in Formula (1) may each independently be selected from groups represented by Formulae (2) to (5).

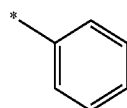
In one or more embodiments, in Formula (1),

1) A_2 may be selected from groups represented by Formulae (2) to (5), and i) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ may each independently be linked to $(L_5)_{a5}$; ii) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ may each independently be a single bond linked to $(L_5)_{a5}$; or iii) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ may each independently be selected from groups represented by Formulae 7-1 to 7-29,

2) A_1 and A_2 may each independently be selected from groups represented by Formulae (2) to (5), and i) the group represented by $*(L_3)_{a3}-(A_3)$ may be linked to $(L_5)_{a5}$; ii) the group represented by $*(L_3)_{a3}-(A_3)$ may be a single bond linked to $(L_5)_{a5}$; or iii) the group represented by $*(L_3)_{a3}-(A_3)$ may be selected from groups represented by Formulae 7-1 to 7-29,

3) A_2 and A_3 may each independently be selected from groups represented by Formulae (2) to (5), and i) the group represented by $*(L_1)_{a1}-(A_1)$ may be linked to $(L_5)_{a5}$; ii) the group represented by $*(L_1)_{a1}-(A_1)$ may be a single bond linked to $(L_5)_{a5}$; or iii) the group represented by $*(L_1)_{a1}-(A_1)$ may be selected from groups represented by Formulae 7-1 to 7-29, or

4) A_1 to A_3 may each independently be selected from groups represented by Formulae (2) to (5), and the groups represented by $*(L_{11})_{a11}-(R_{11})$ and $*(L_{12})_{a12}-(R_{12})$ in Formulae (2) to (5) may each independently be selected from groups represented by Formulae 7-1 to 7-57, but embodiments of the present disclosure are not limited thereto:



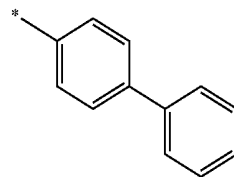
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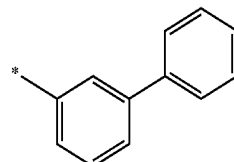
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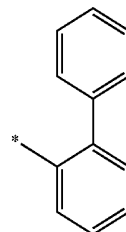
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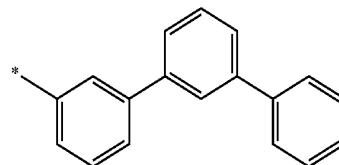
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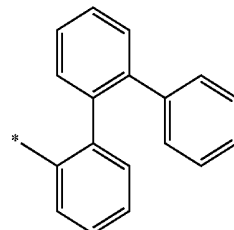
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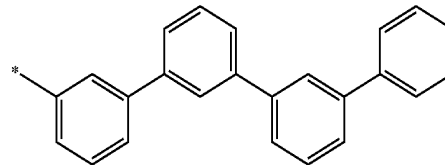
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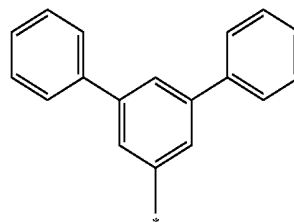
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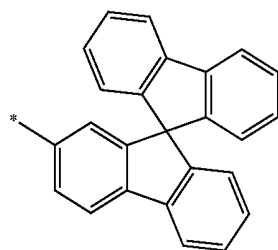
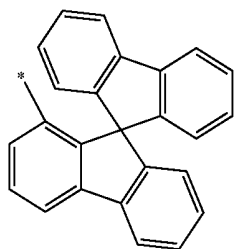
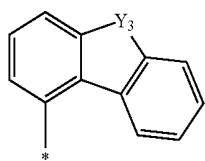
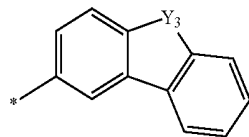
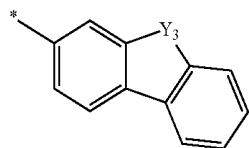
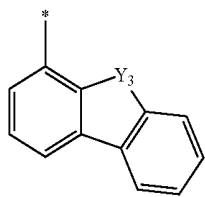
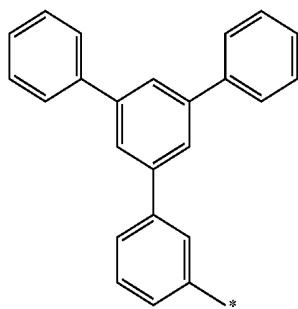


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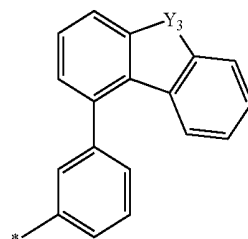
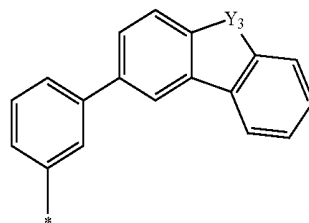
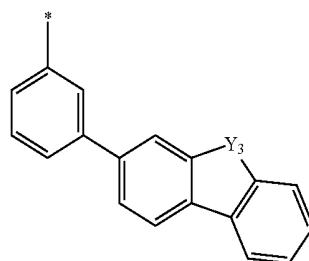
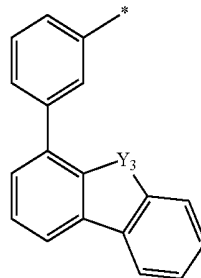
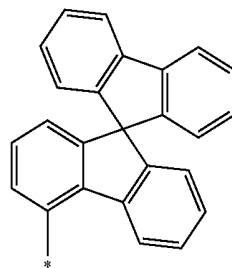
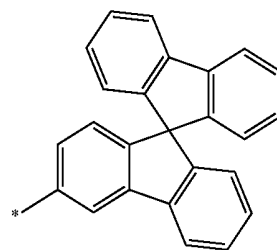
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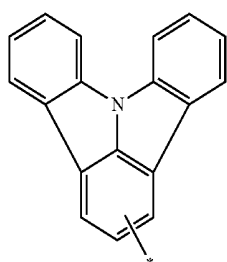
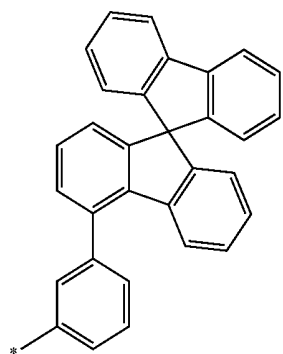
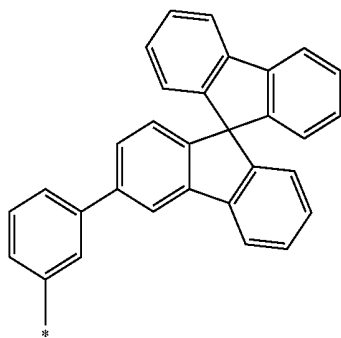
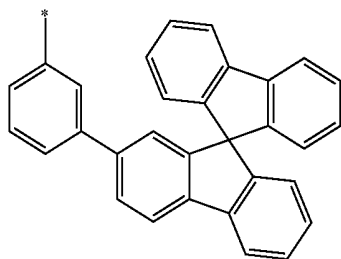
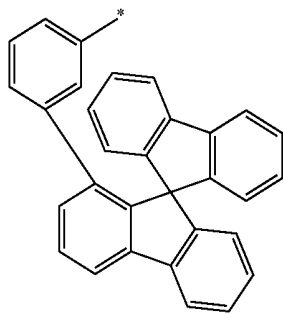
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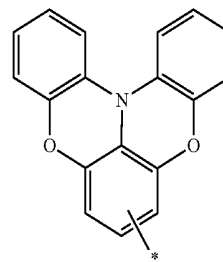
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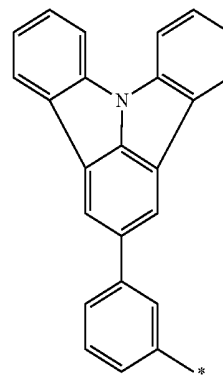


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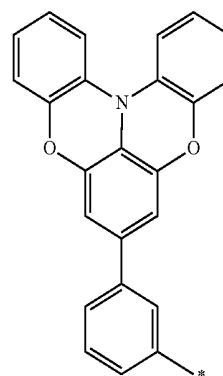
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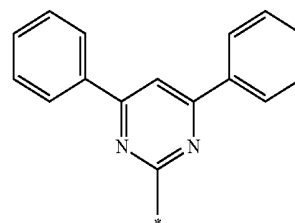
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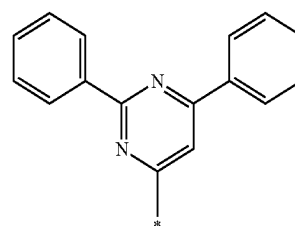
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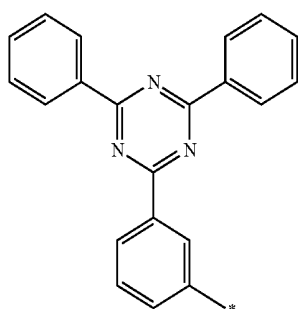
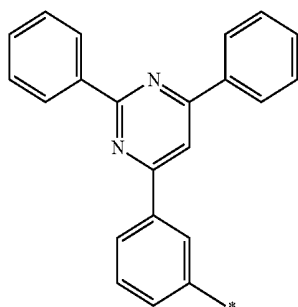
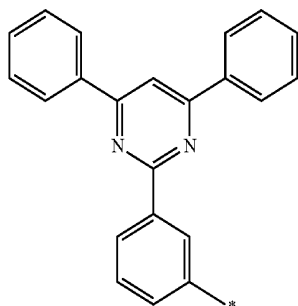
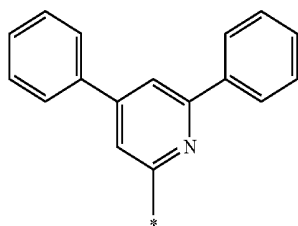
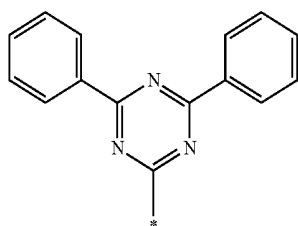
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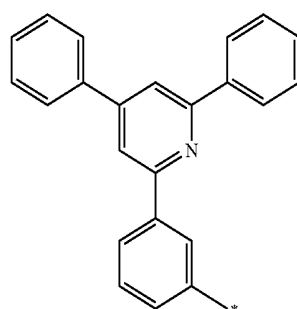
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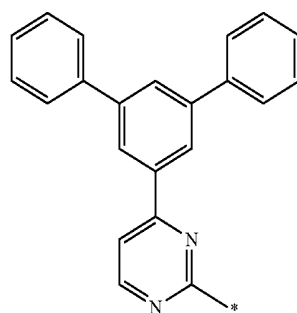
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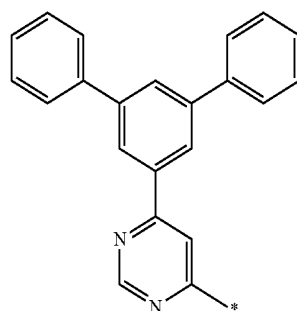
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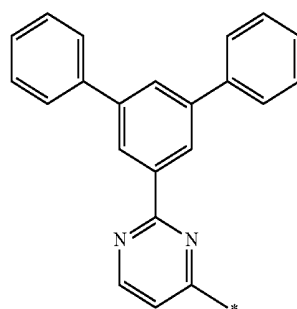


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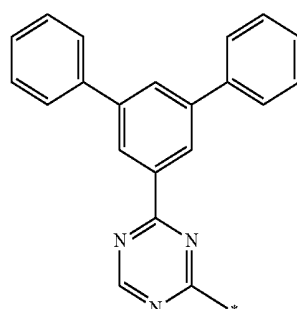


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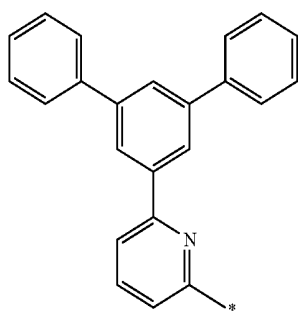
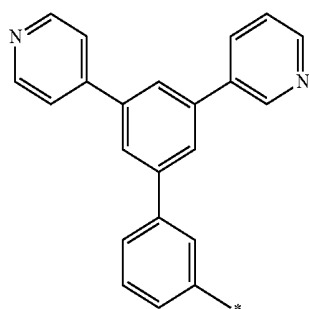
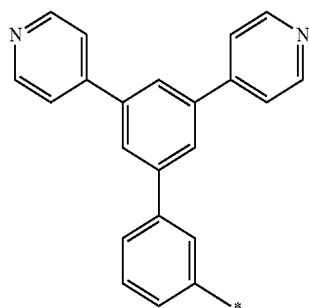
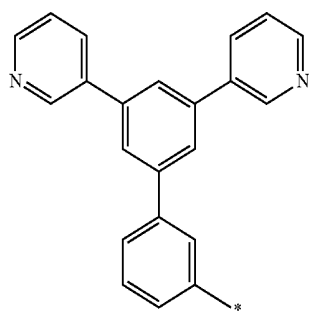
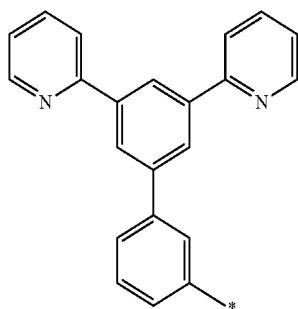
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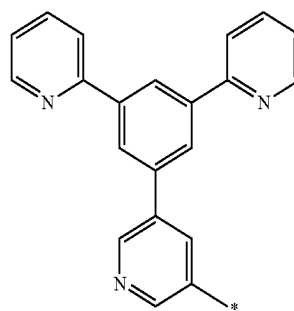
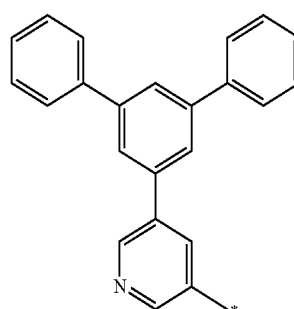
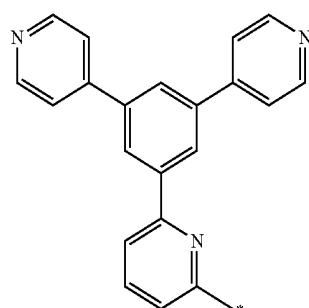
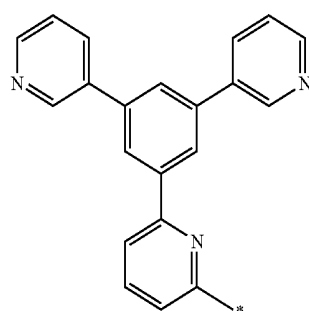
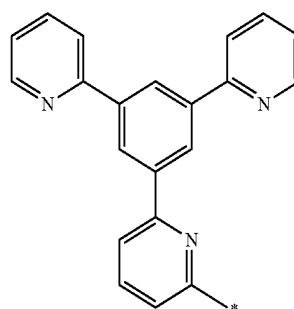
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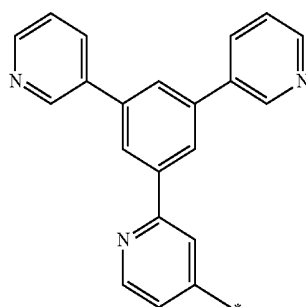
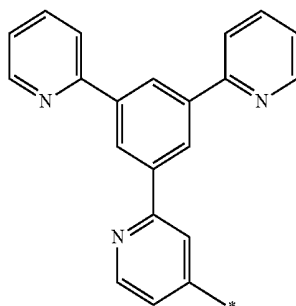
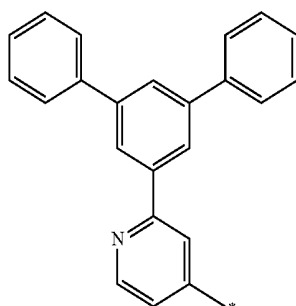
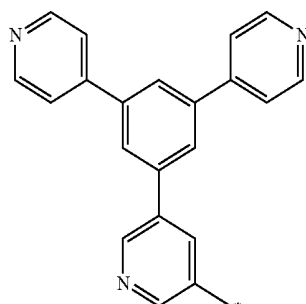
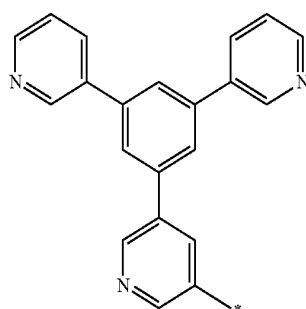
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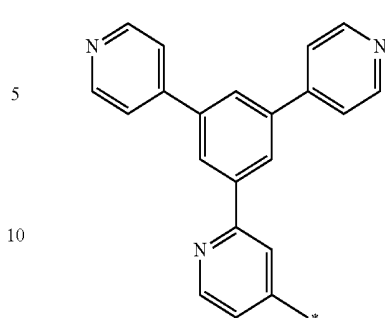
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15 wherein, in Formulae 7-1 to 7-57, Y_3 may be O, S,
 7-53 $C(Z_{13})(Z_{14})$, or $N(Z_{15})$, Z_{13} to Z_{15} may each independently
 be selected from $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl
 group, a C_1 - C_{20} alkoxy group, a phenyl group, and a
 20 biphenyl group, and * indicates a binding site to a neigh-
 boring atom.

The group represented by $*(L_2)_{a2}-(A_2)$ and the group
 represented by $*(L_3)_{a3}-(A_3)$ in Formula (1) may be linked
 to the carbazole core, such that a linking position of the
 25 group represented by $*(L_2)_{a2}-(A_2)$ and the carbazole core is
 asymmetric to a linking position of the group represented by
 $*(L_3)_{a3}-(A_3)$ and the carbazole core with respect to a
 reverse central axis passing through a nitrogen atom of the
 carbazole core of Formula (1).

7-54 30 When b2 to b4 in Formulae (2) to (5), (2)-1 to (2)-7, (3)-1
 to (3)-11, (4)-1, and (4)-2 are each two or more, two or more
 groups $*(L_{11})_{a11}-(R_{11})$ may be identical to or different from
 each other and two or more groups $*(L_{12})_{a12}-(R_{12})$ may be
 identical to or different from each other. Also, two or more
 35 neighboring groups selected from groups R_{11} and/or two or
 more neighboring groups selected from groups R_{12} may
 optionally be linked to form a C_2 - C_{10} carbocyclic group or
 a C_2 - C_{10} heterocyclic group, but embodiments of the present
 disclosure are not limited thereto.

40 The term "hydrogen atom" as used herein is a concept
 encompassing "deuterium atom" even when there is no
 7-55 special parallel representation of "deuterium atom", and
 each existing hydrogen atom may be an arbitrary number of
 deuterium atoms.

45 The condensed cyclic compound represented by Formu-
 lae (1) has excellent thermal stability due to a relatively high
 glass transition temperature. Thus, an organic light-emitting
 device including the condensed cyclic compound is rela-
 tively stable with respect to driving heat. Also, since deg-
 50 radation and deformation to the condensed cyclic compound
 caused by the driving heat of the organic light-emitting
 device are suppressed, the light emitting lifespan of the
 organic light-emitting device including the condensed cyclic
 compound may be improved.

7-56 55 Also, the condensed cyclic compound represented by
 Formula (1) may have, due to inclusion of azine-containing
 groups represented by Formulae (2) to (5), excellent electron
 transport and injection characteristics. Accordingly, the con-
 densed cyclic compound represented by Formula (1) is
 60 suitable for use in an organic light-emitting device.

Furthermore, solution coating described above is
 expected as a more efficient method of manufacturing an
 organic light-emitting device. An organic material appli-
 cable to solution coating is required to have a high solubility
 65 to a solvent and excellent film stability after coating.

The condensed cyclic compound represented by Formula
 (1) includes azine-containing groups represented by Formu-

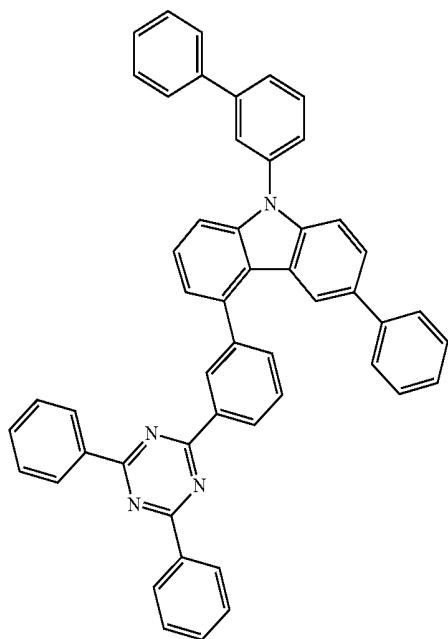
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lae (2) to (5) and has excellent solubility to a solvent. Also, as described above, the condensed cyclic compound represented by Formula (1) has a relatively high glass transition temperature (T_g), and degeneration and/or deformation thereof caused by heat generated when the solvent is removed after the formation of the coating film may be substantially prevented. Accordingly, the condensed cyclic compound may be easily applicable to solution coating. Furthermore, an organic layer formed by solution coating using a composition including the condensed cyclic com-

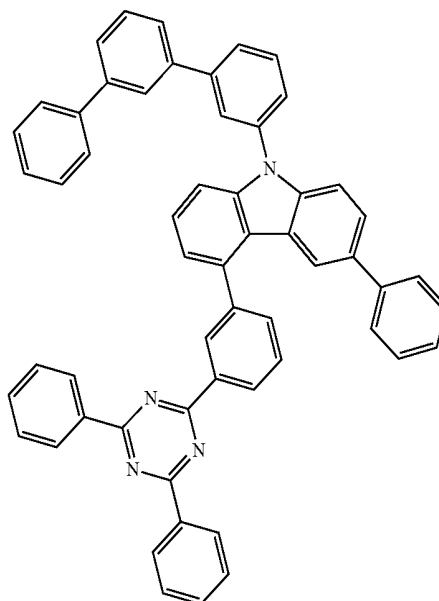
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pound has a uniform thickness, and thus, the surface of the organic layer is substantially flat. Therefore, an organic light-emitting device manufactured by solution coating using the composition including the condensed cyclic compound represented by Formula (1) has no application spot of a driving voltage and no light emission spot and has a long light emission lifespan.

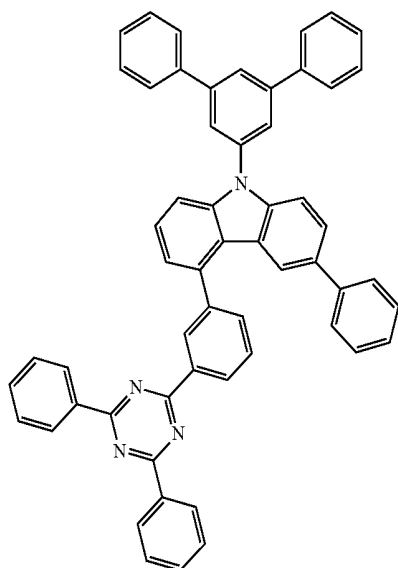
Examples of the condensed cyclic compound represented by Formula (1) are Compounds 1-1 to 1-126, but embodiments of the present disclosure are not limited thereto:



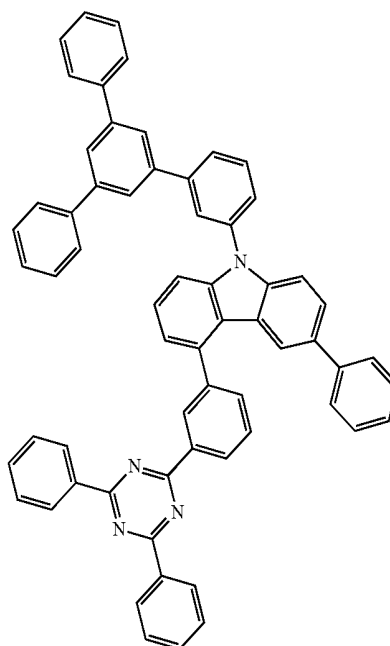
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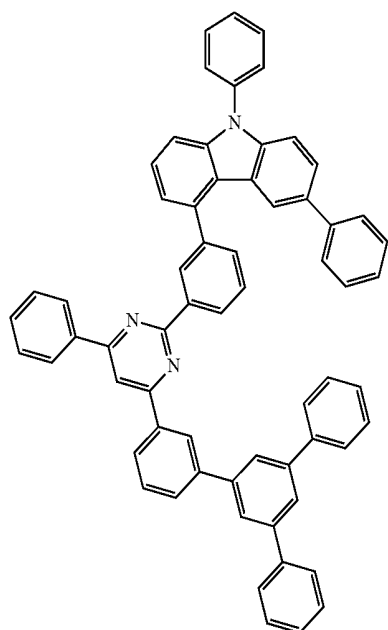


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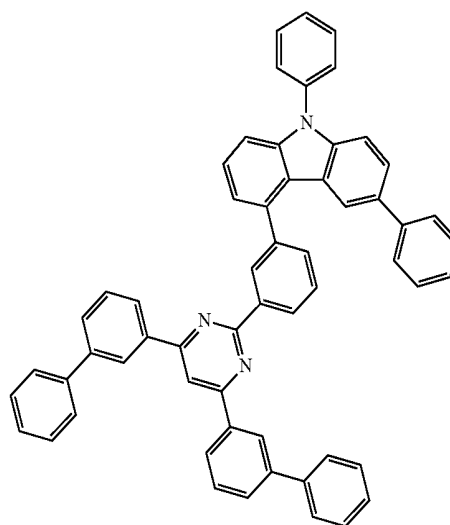
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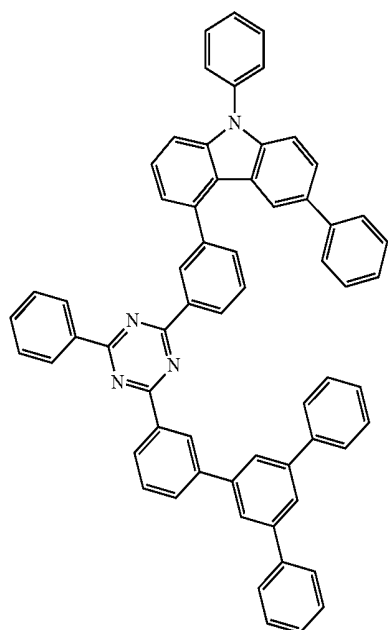
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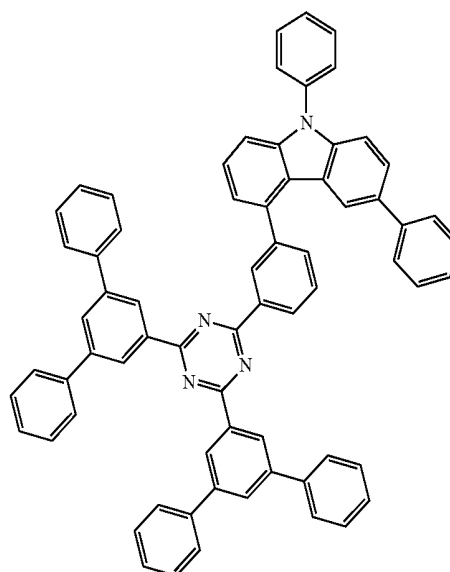


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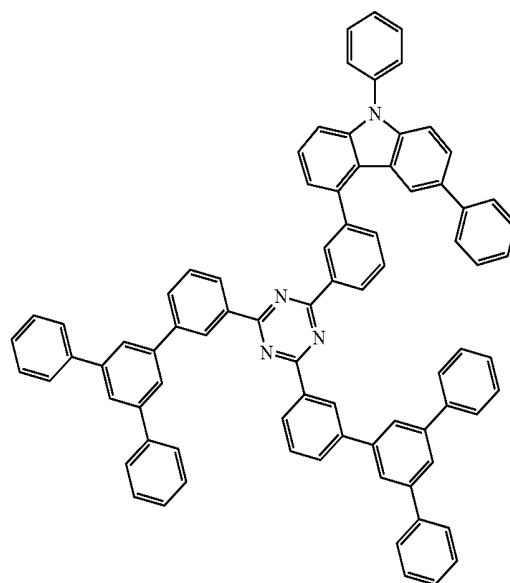
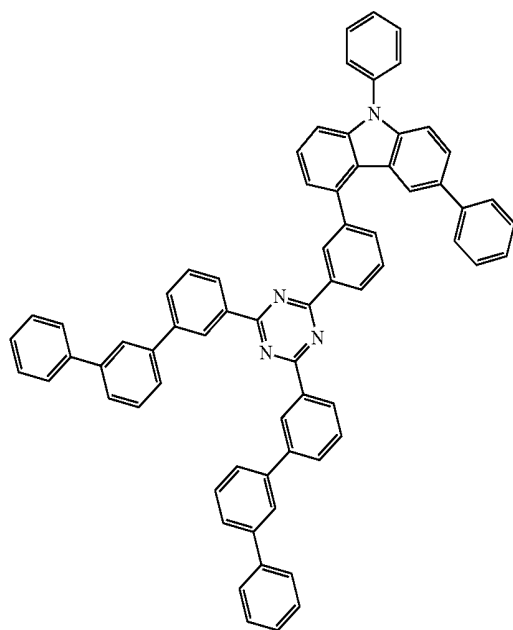
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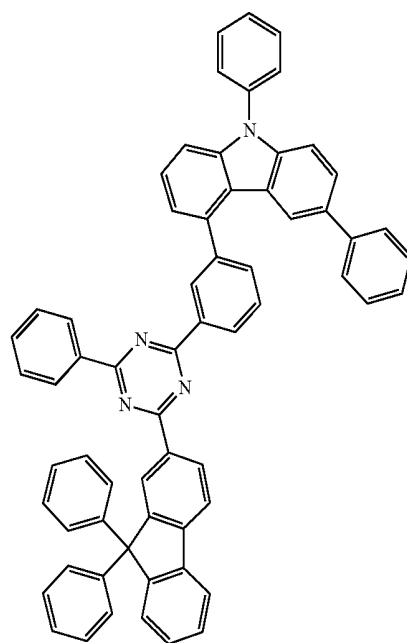
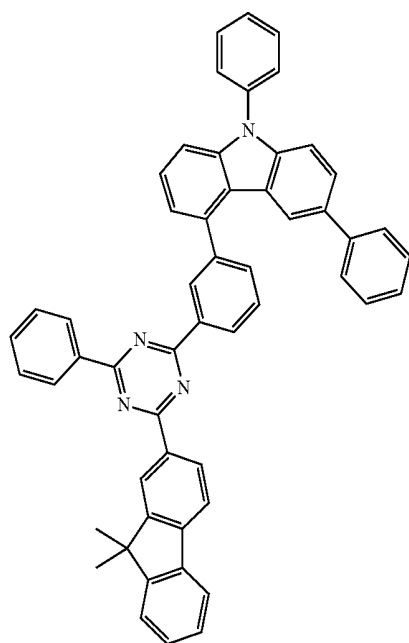
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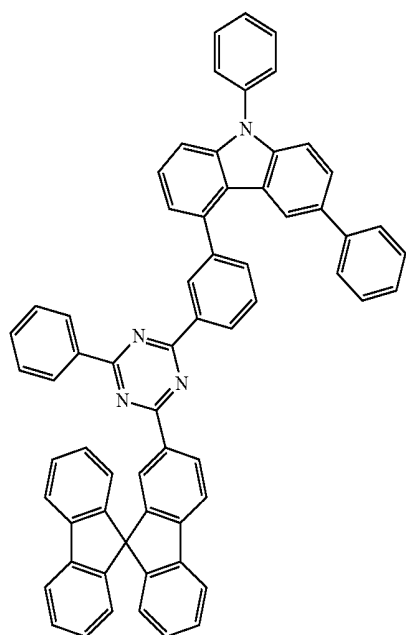
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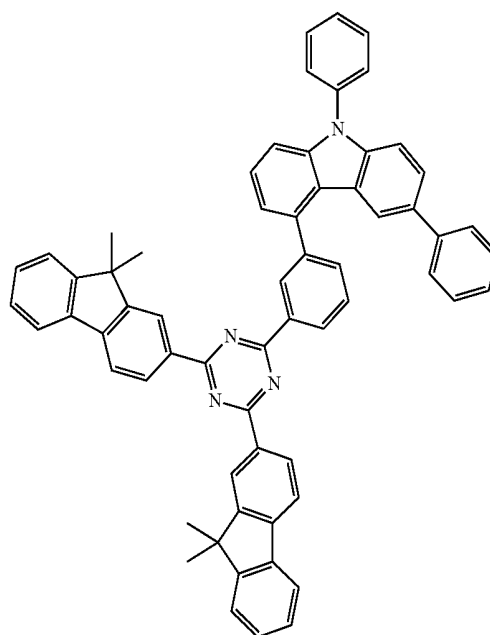
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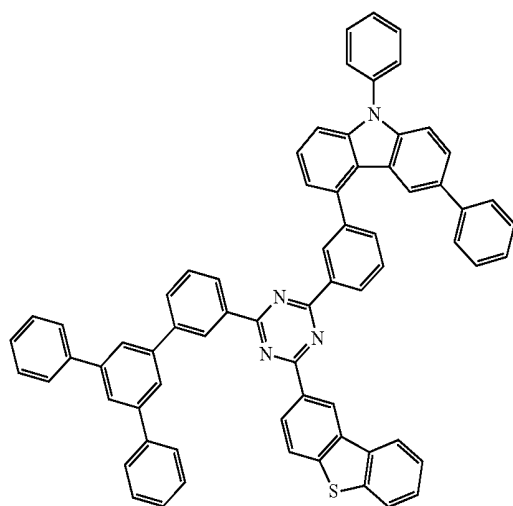


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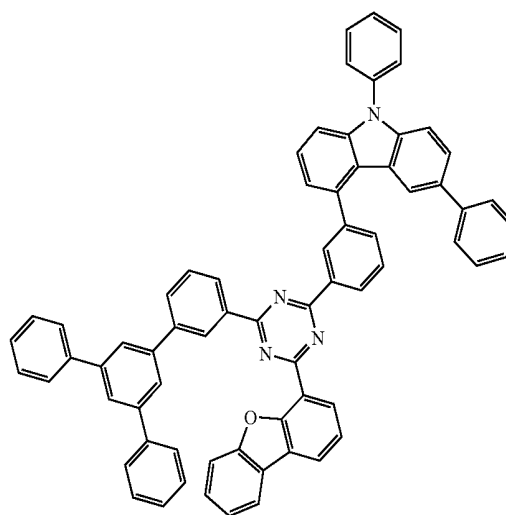
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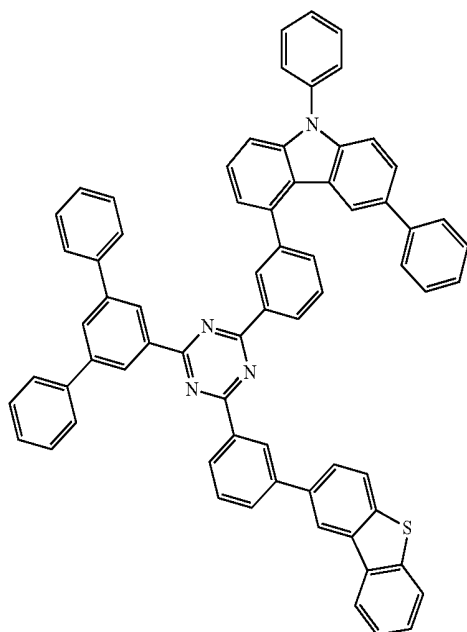


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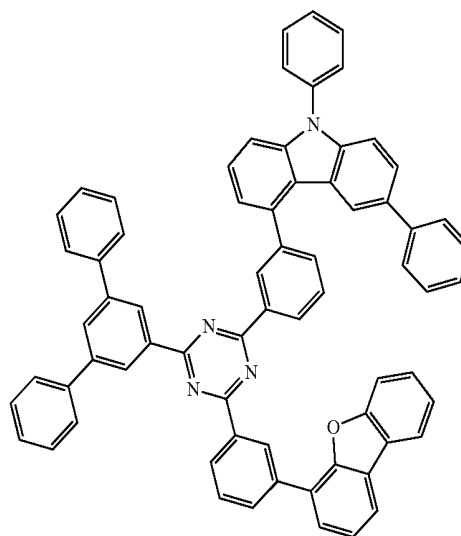
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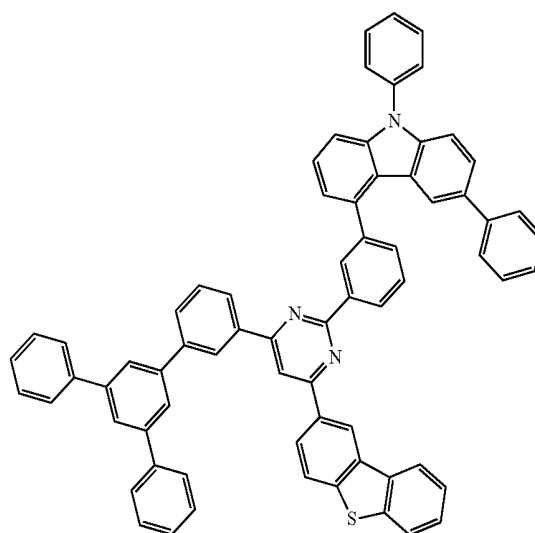
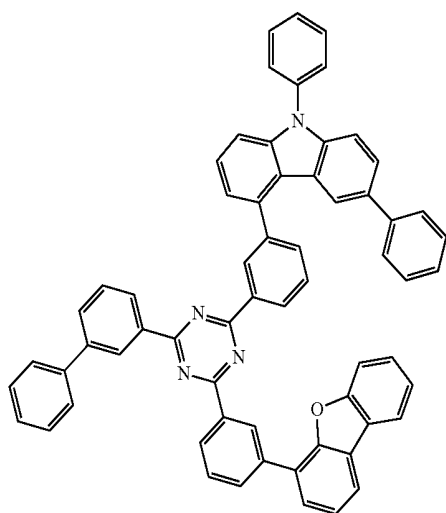
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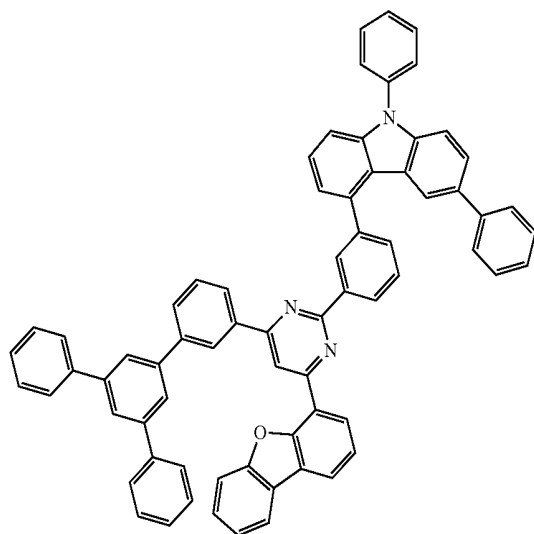
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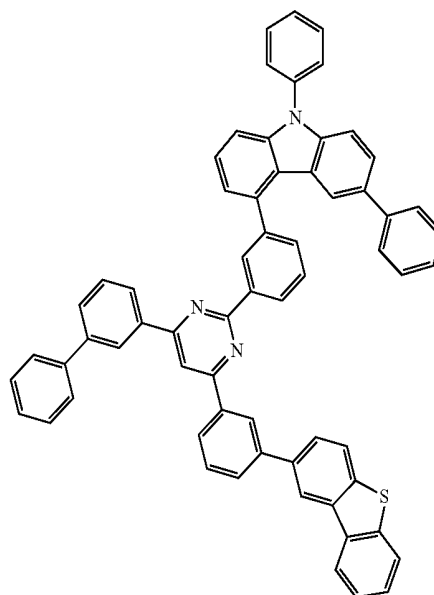
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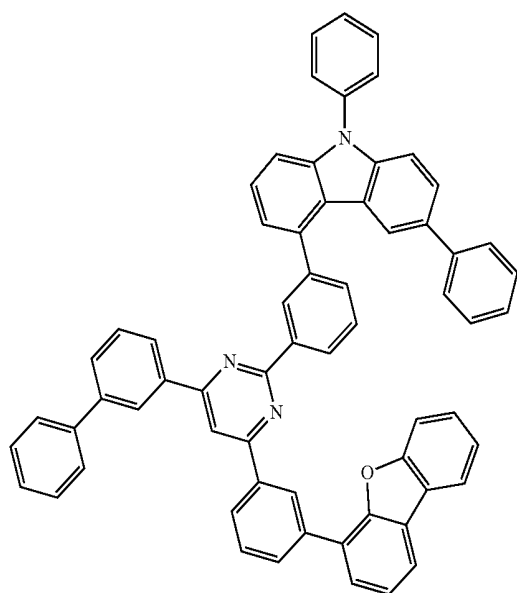


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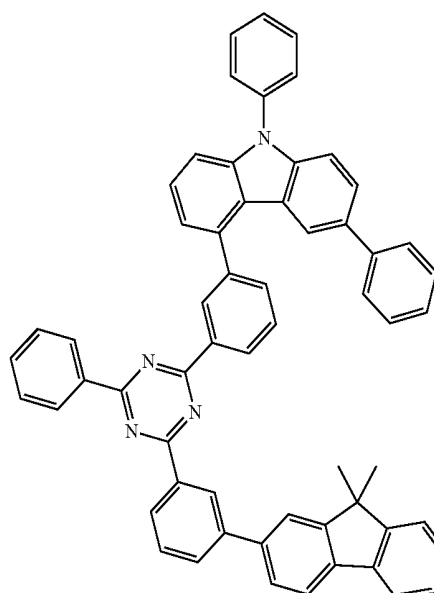
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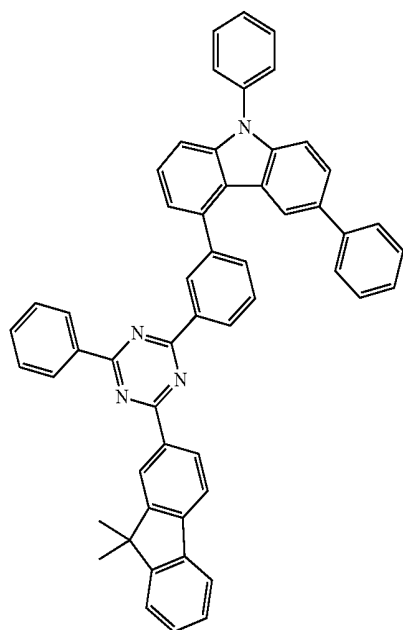


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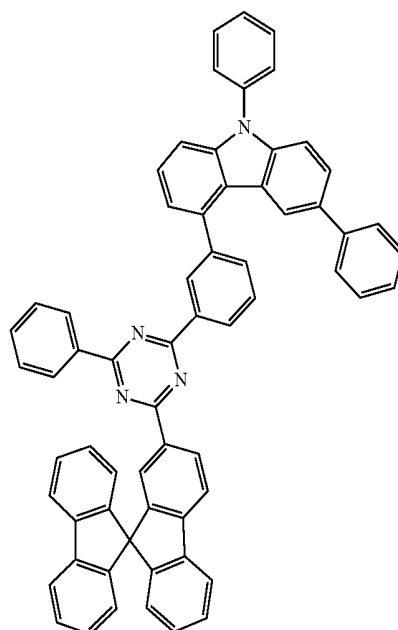
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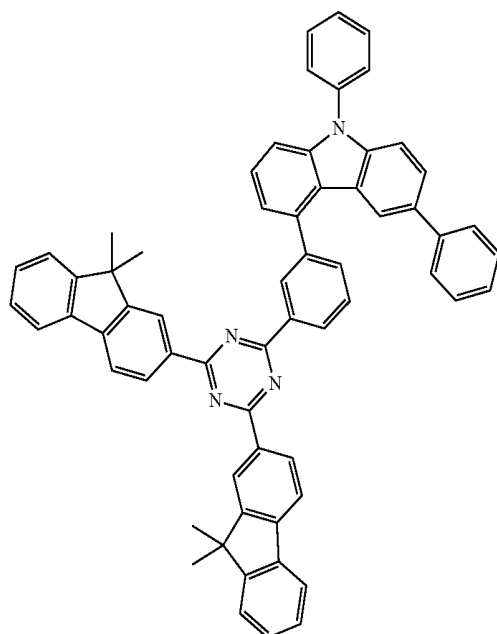


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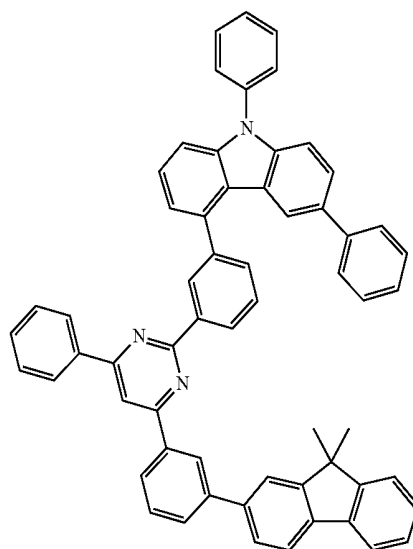
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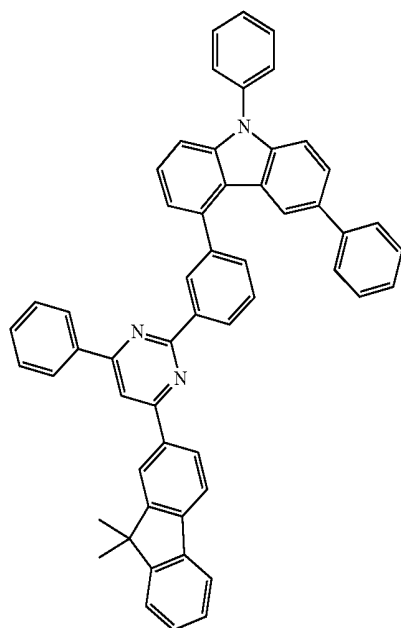


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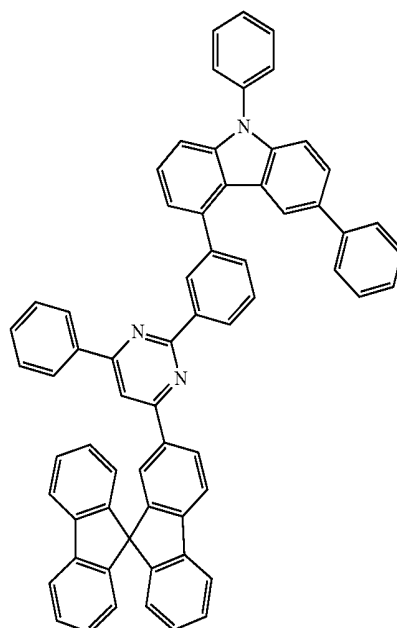
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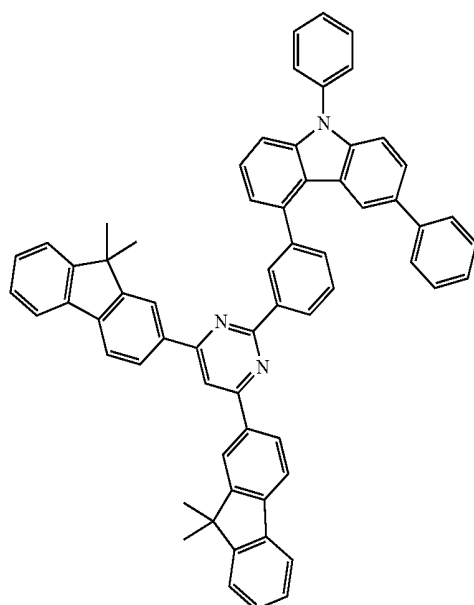


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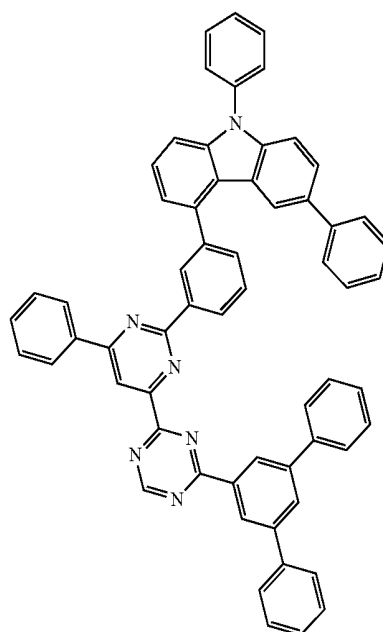
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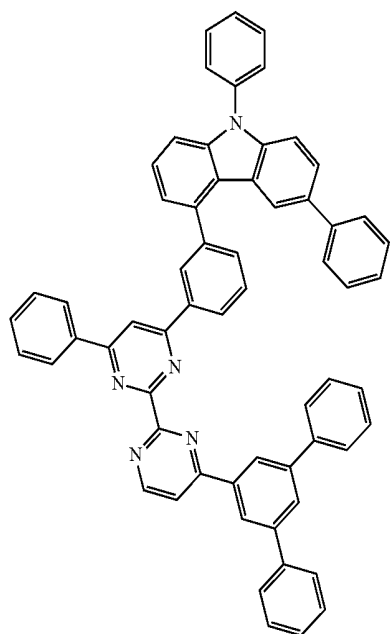
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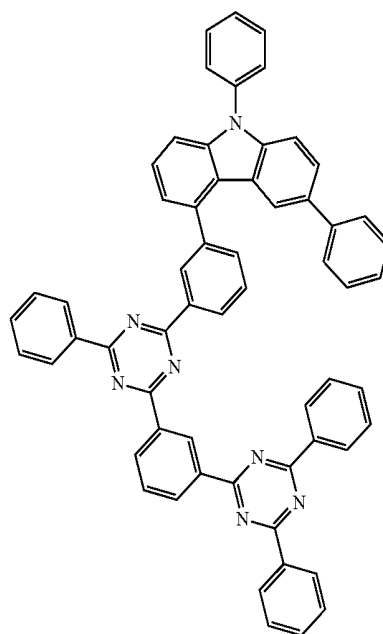


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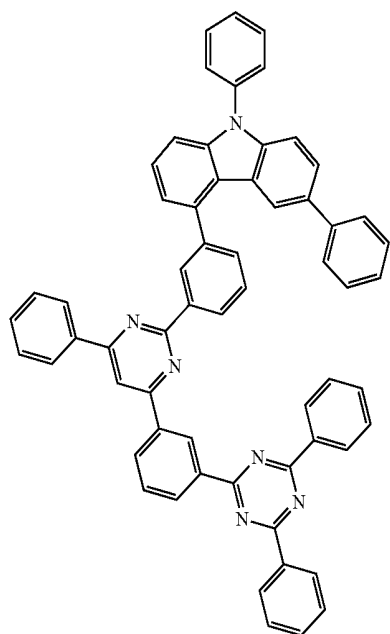
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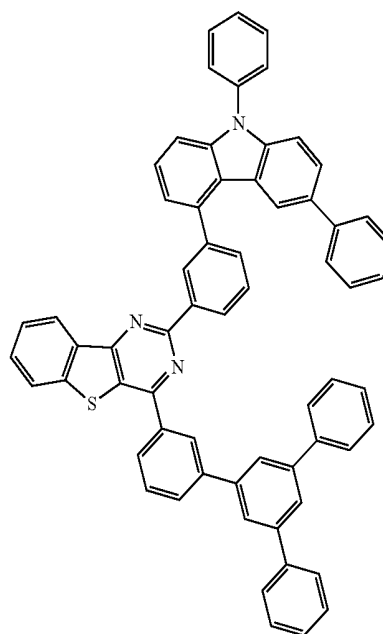


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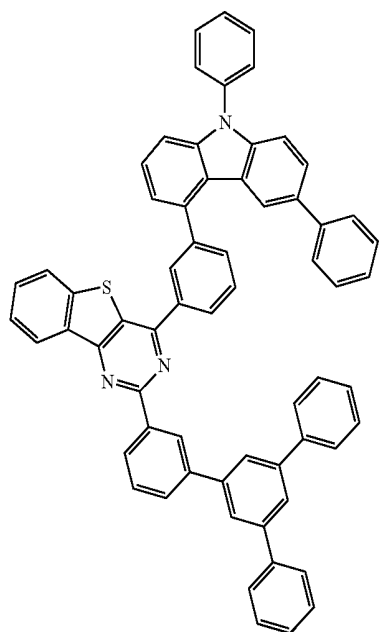
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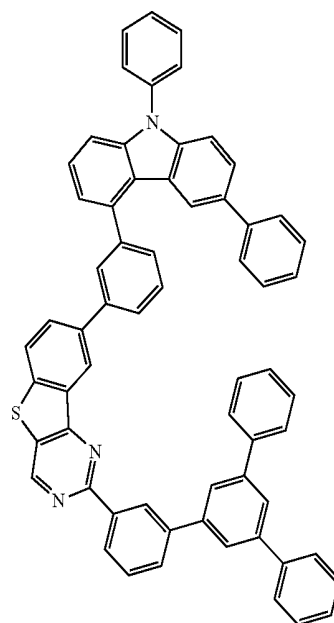


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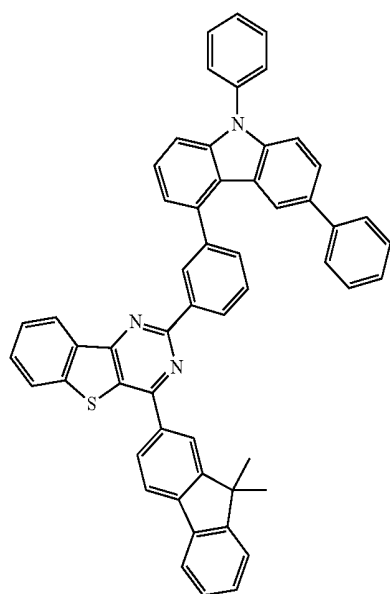
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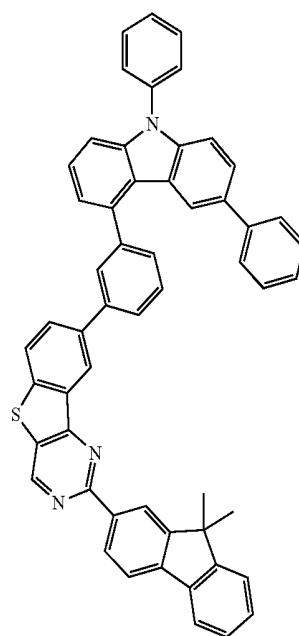


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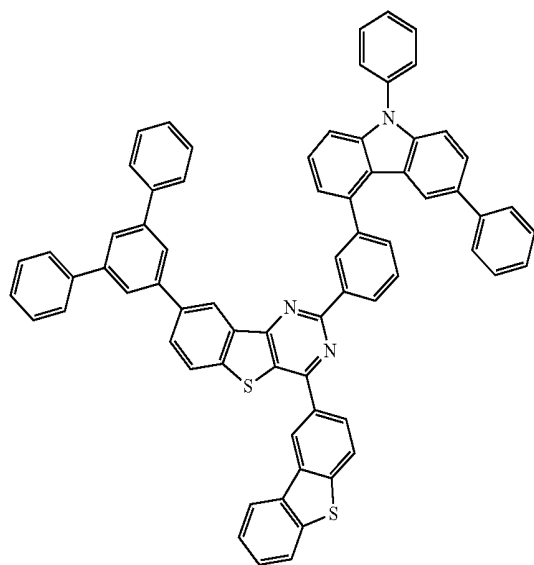
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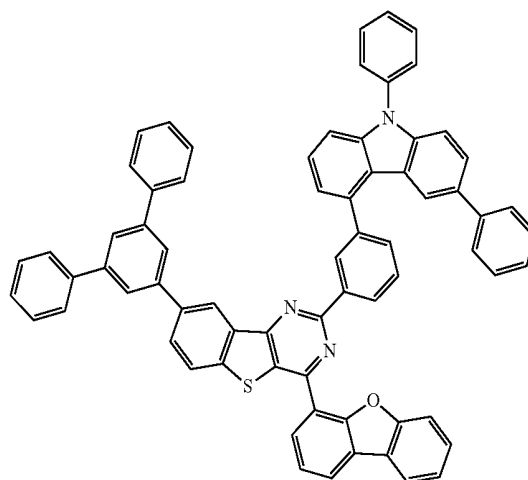
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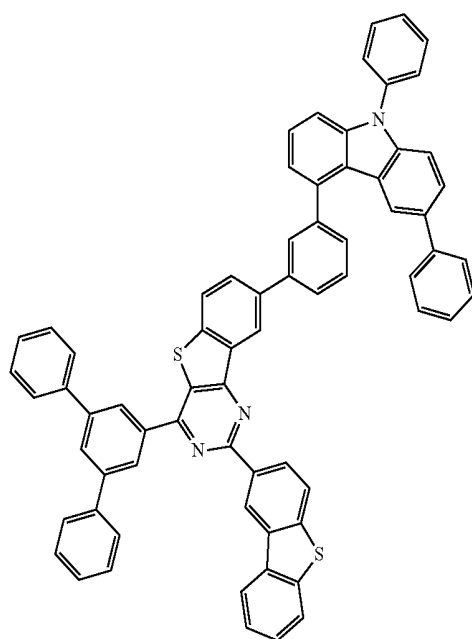


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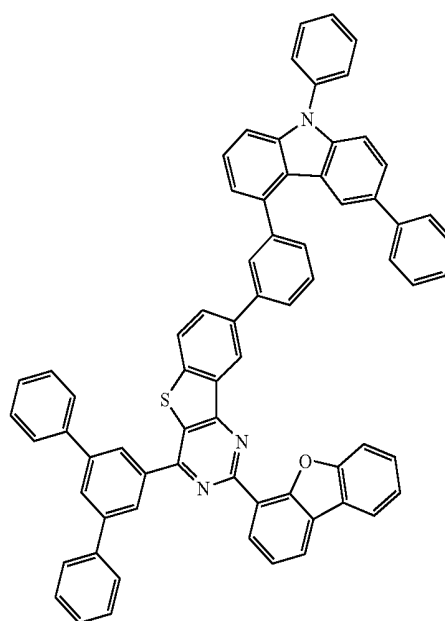
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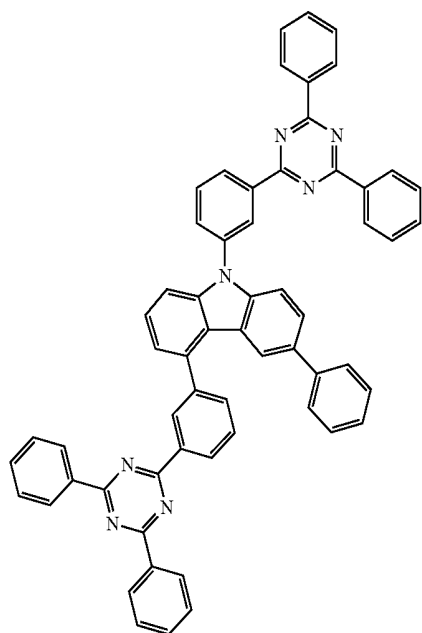
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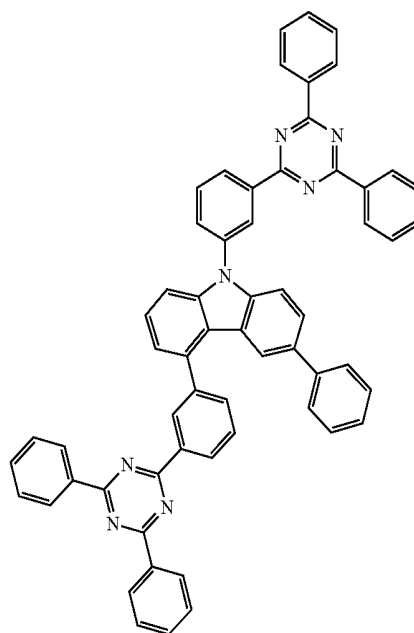
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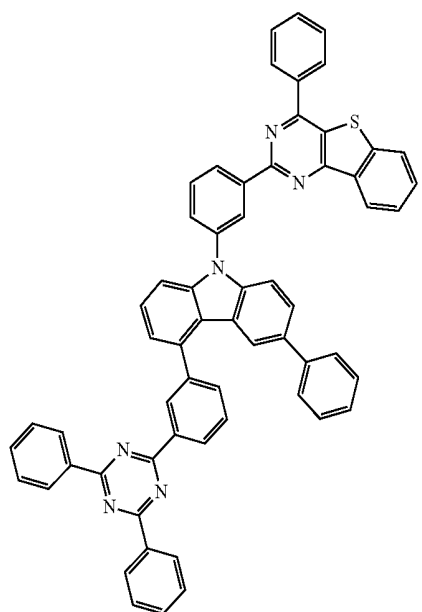


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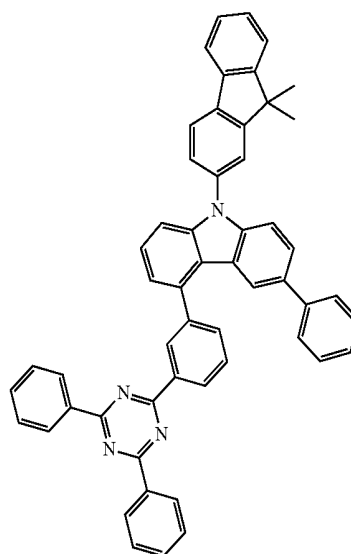
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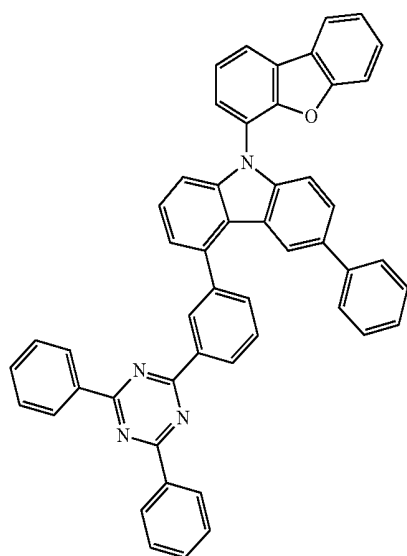
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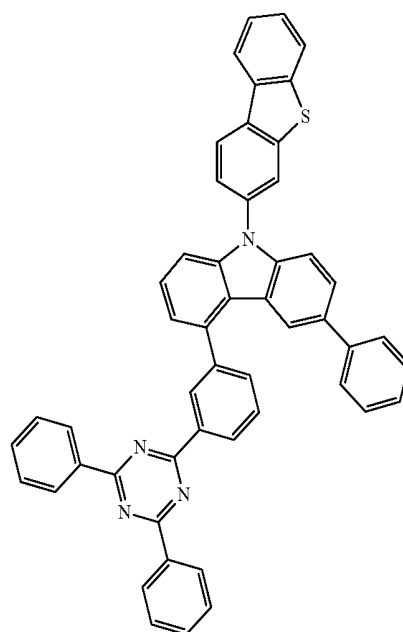
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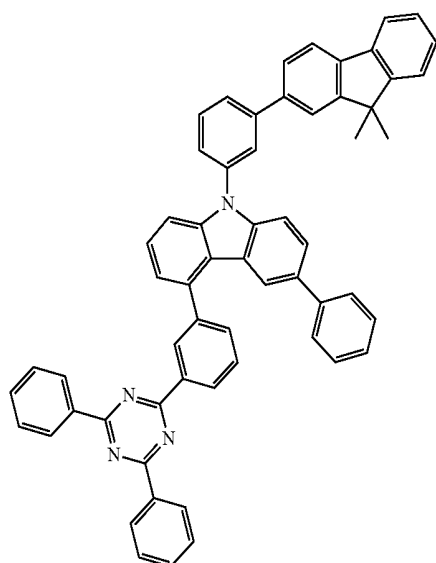
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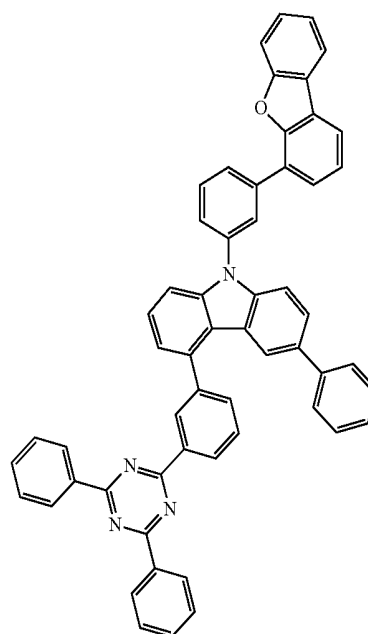


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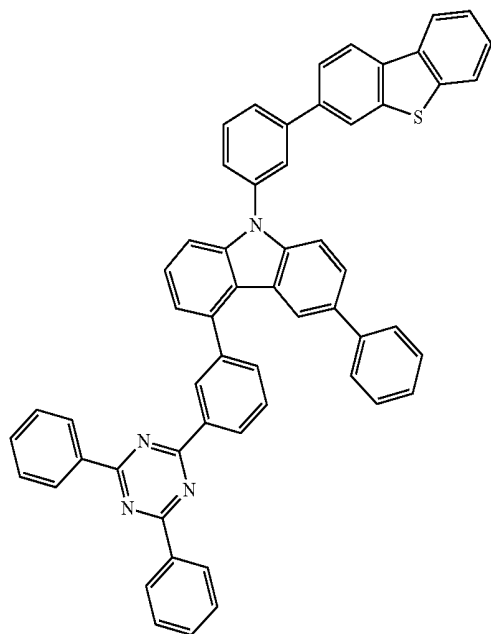
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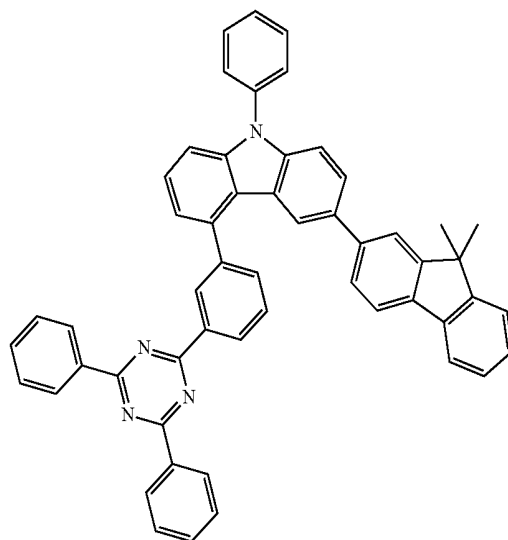
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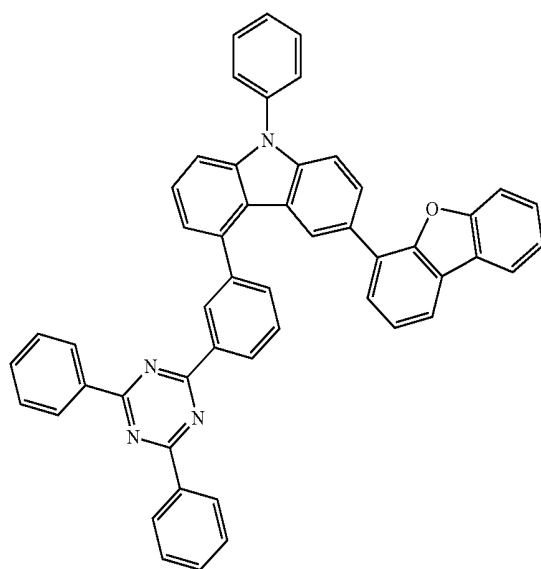


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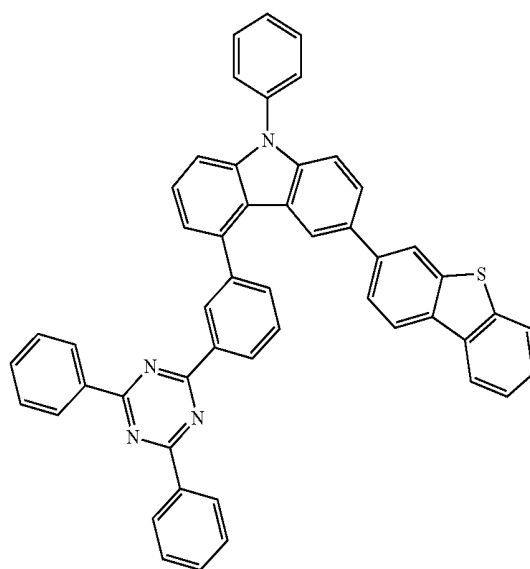
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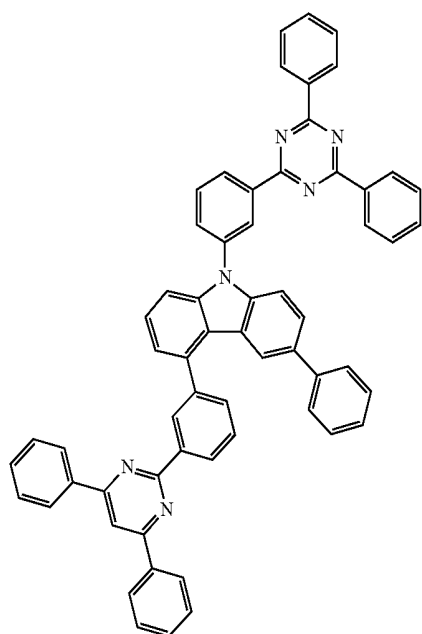
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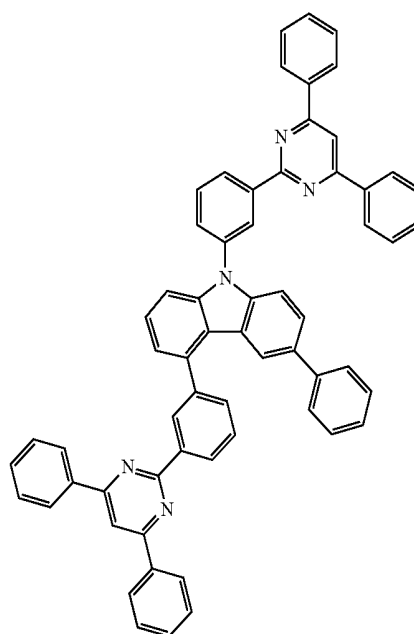


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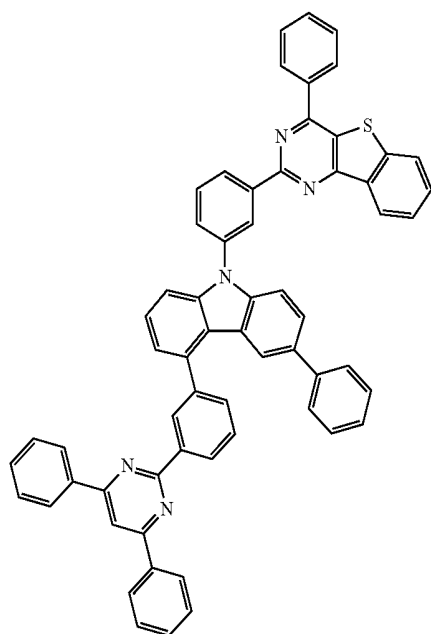
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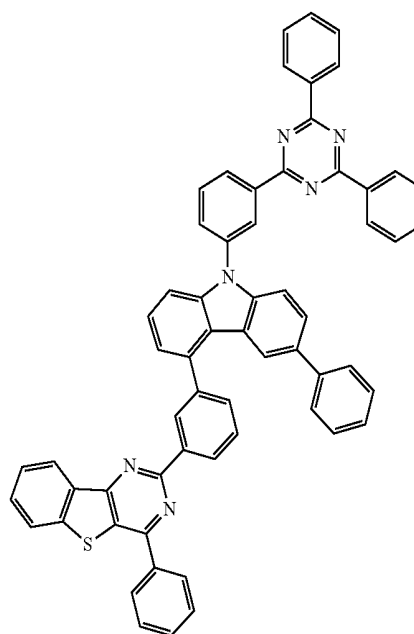
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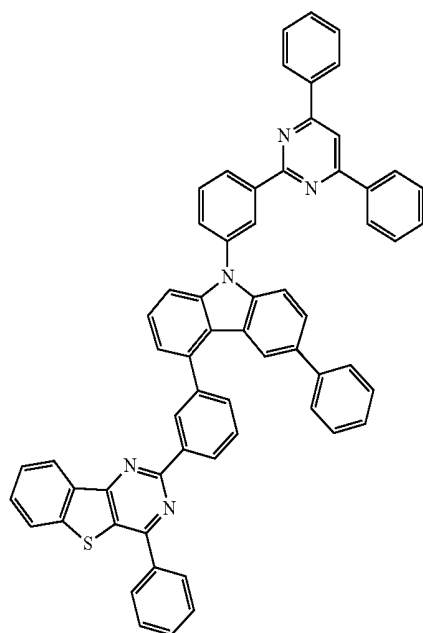


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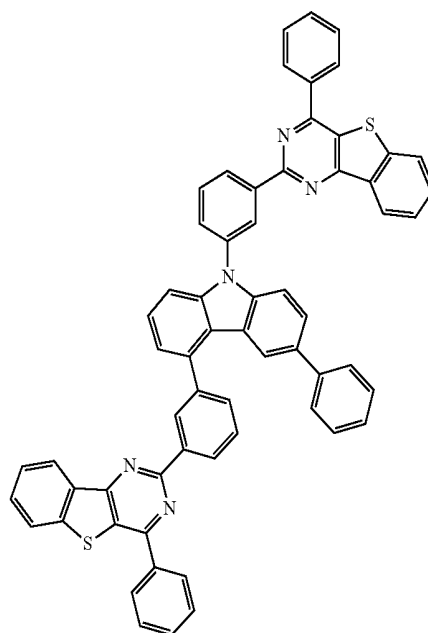
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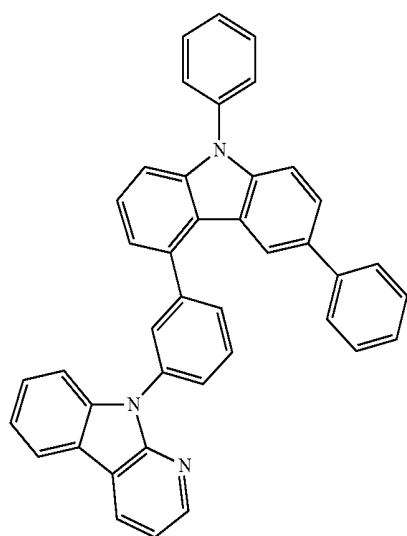


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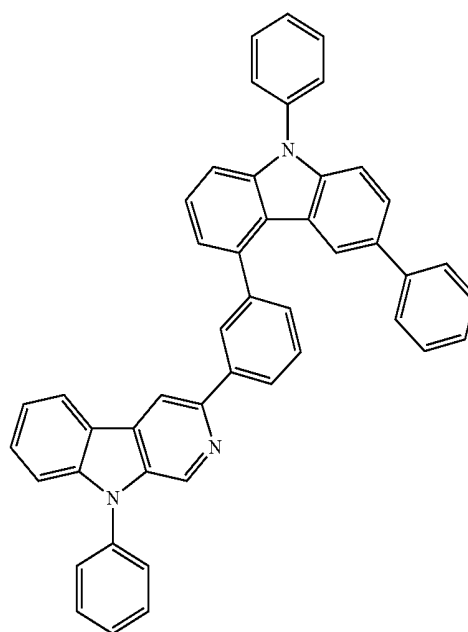
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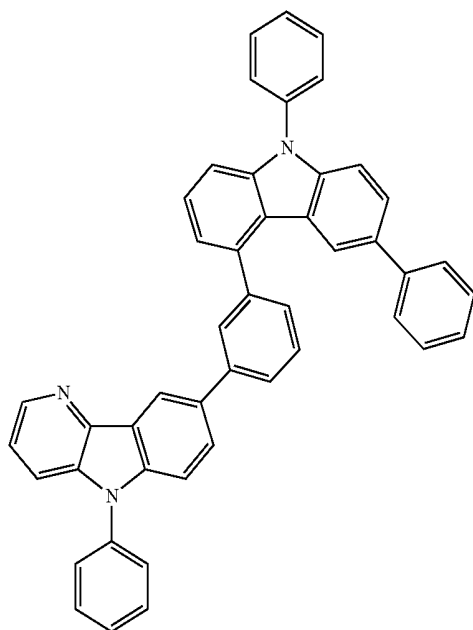


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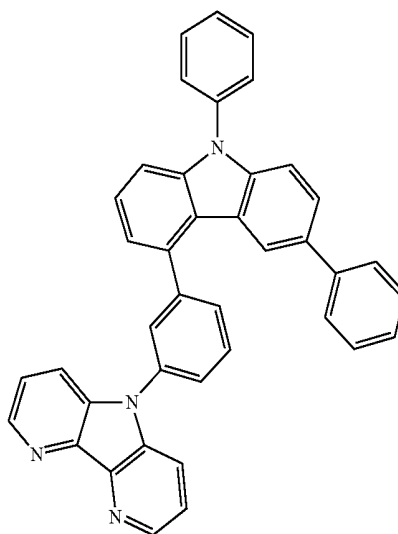
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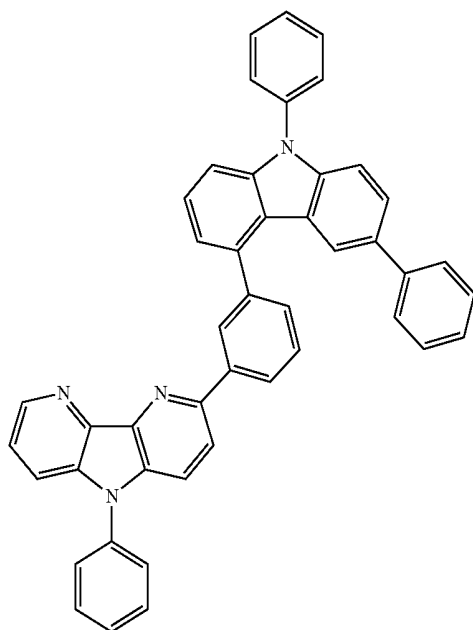


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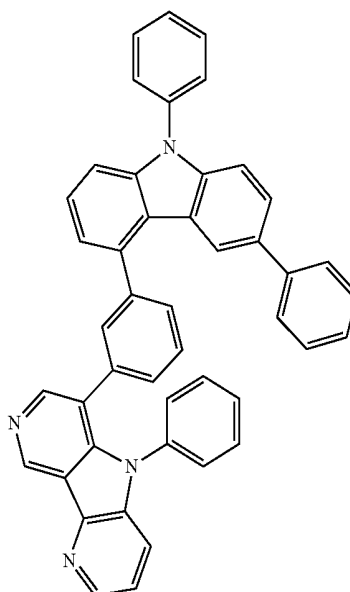
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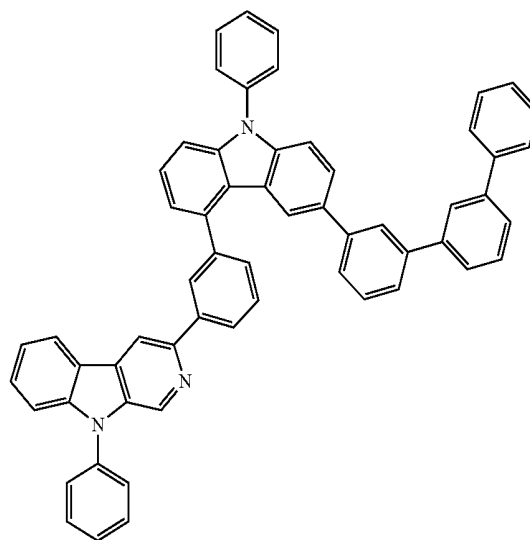
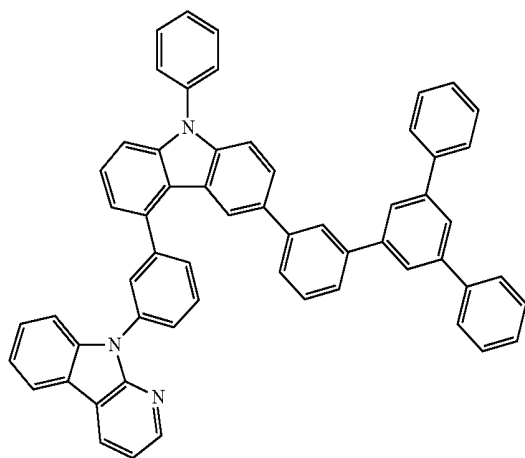
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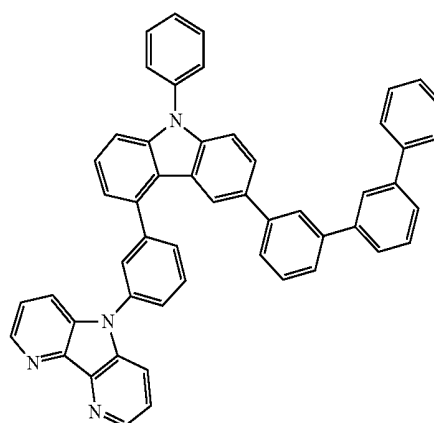
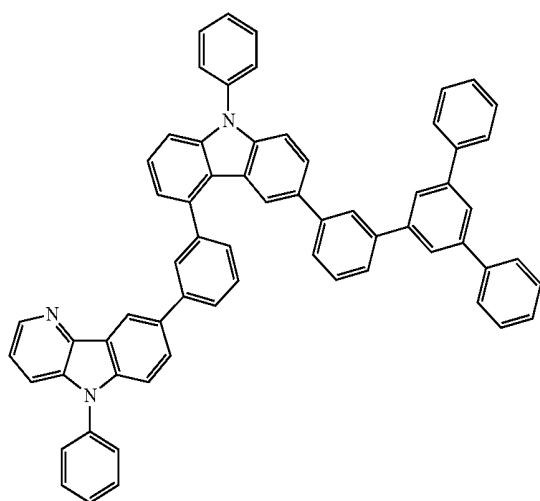
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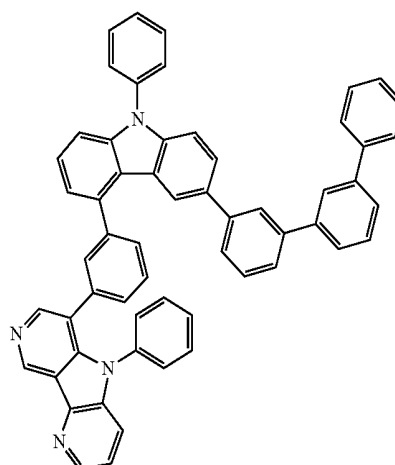
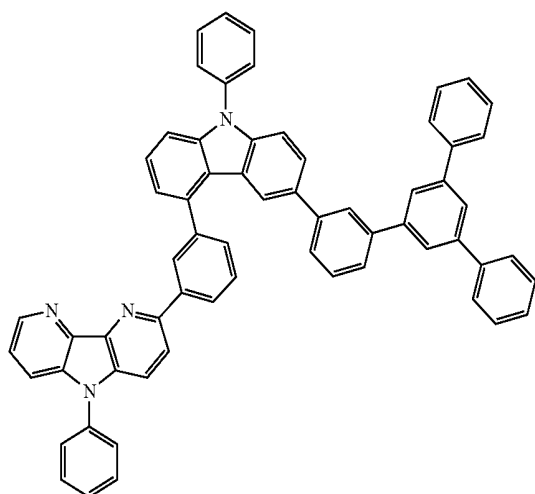
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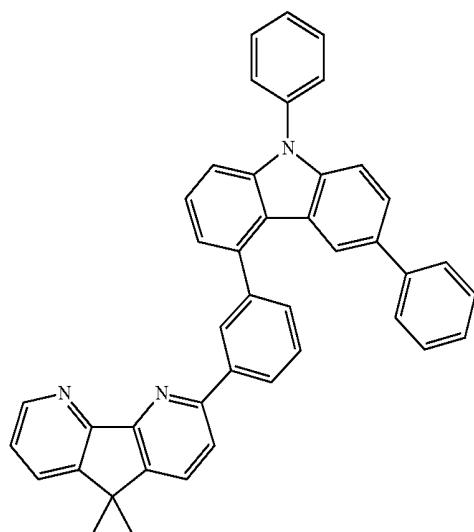
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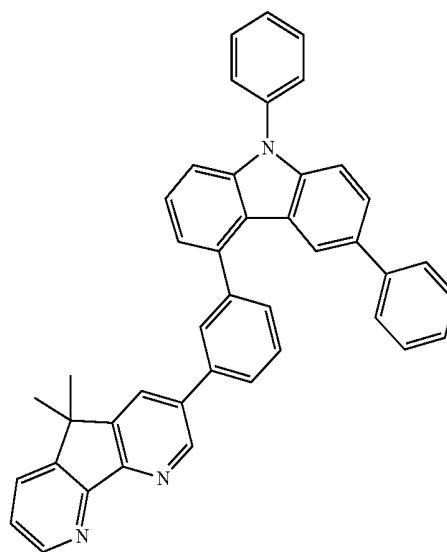
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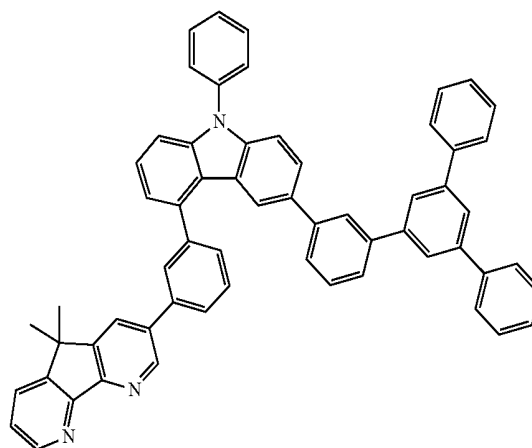
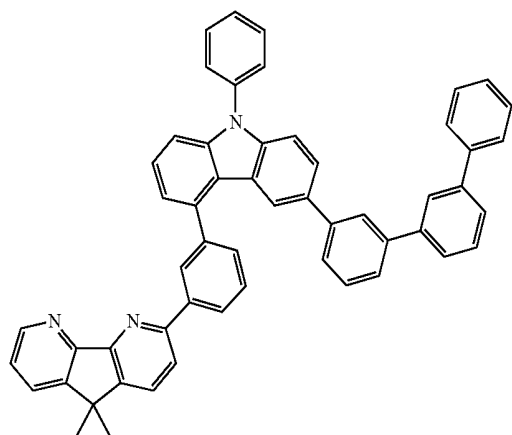
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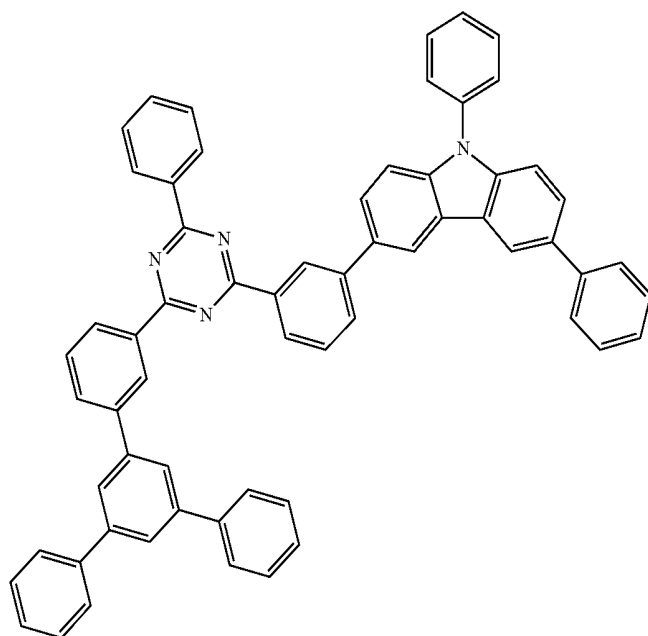


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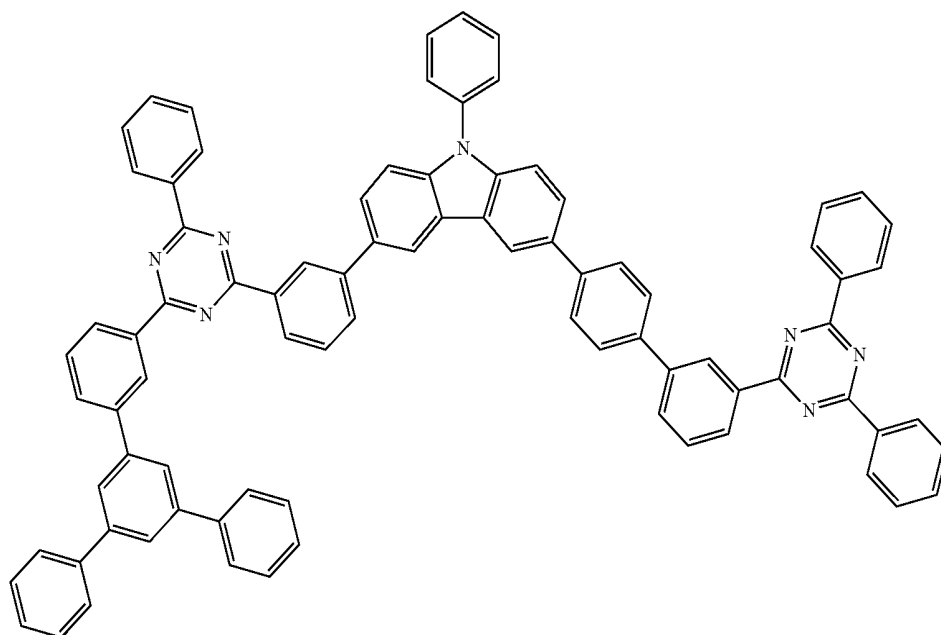


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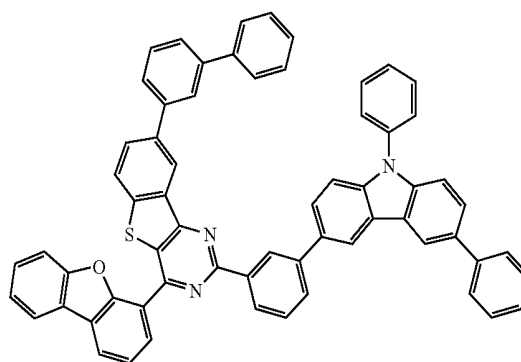
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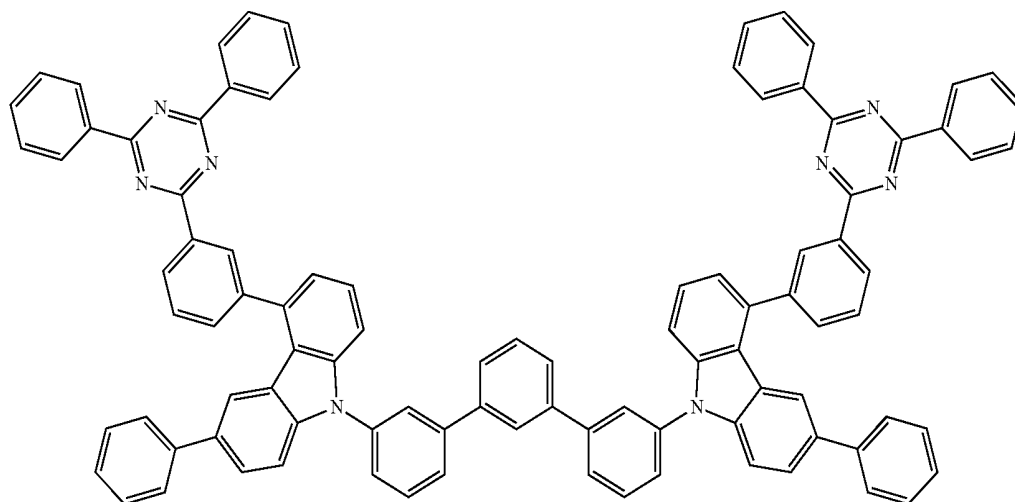


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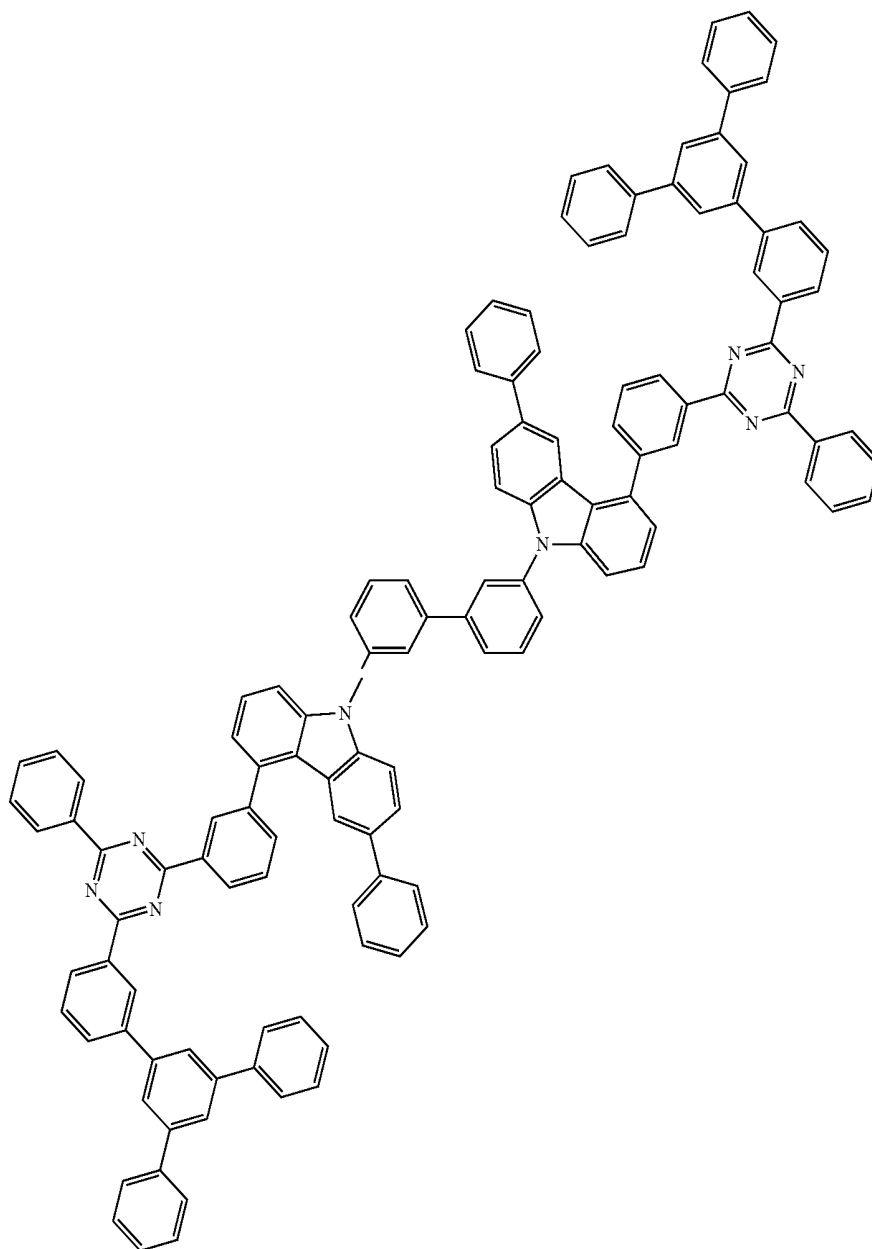
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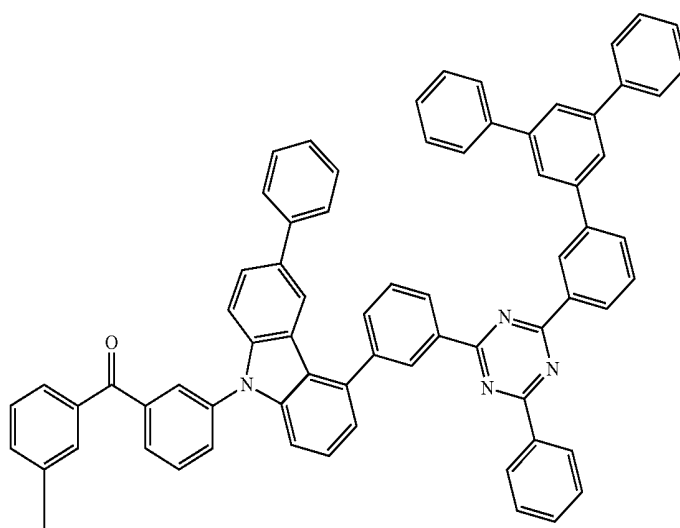
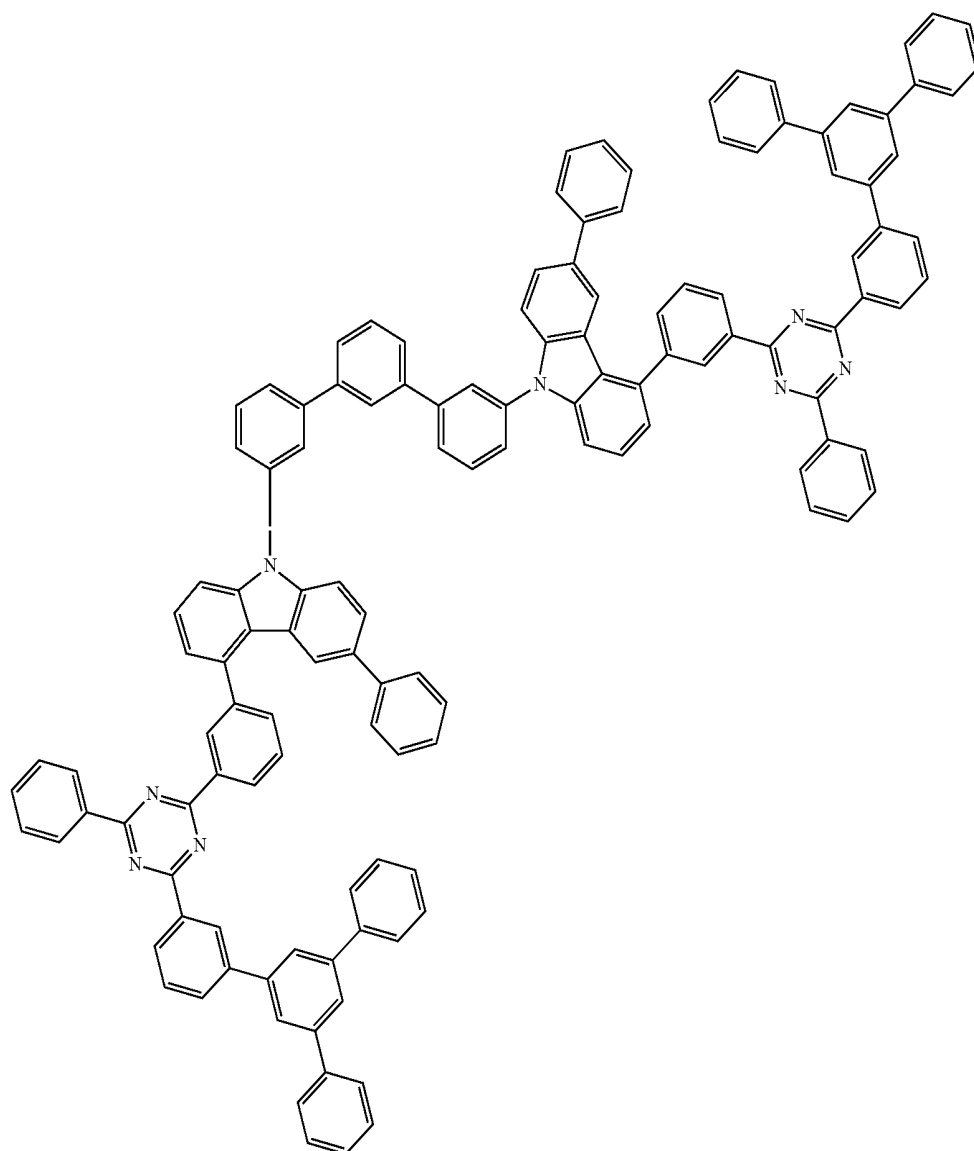
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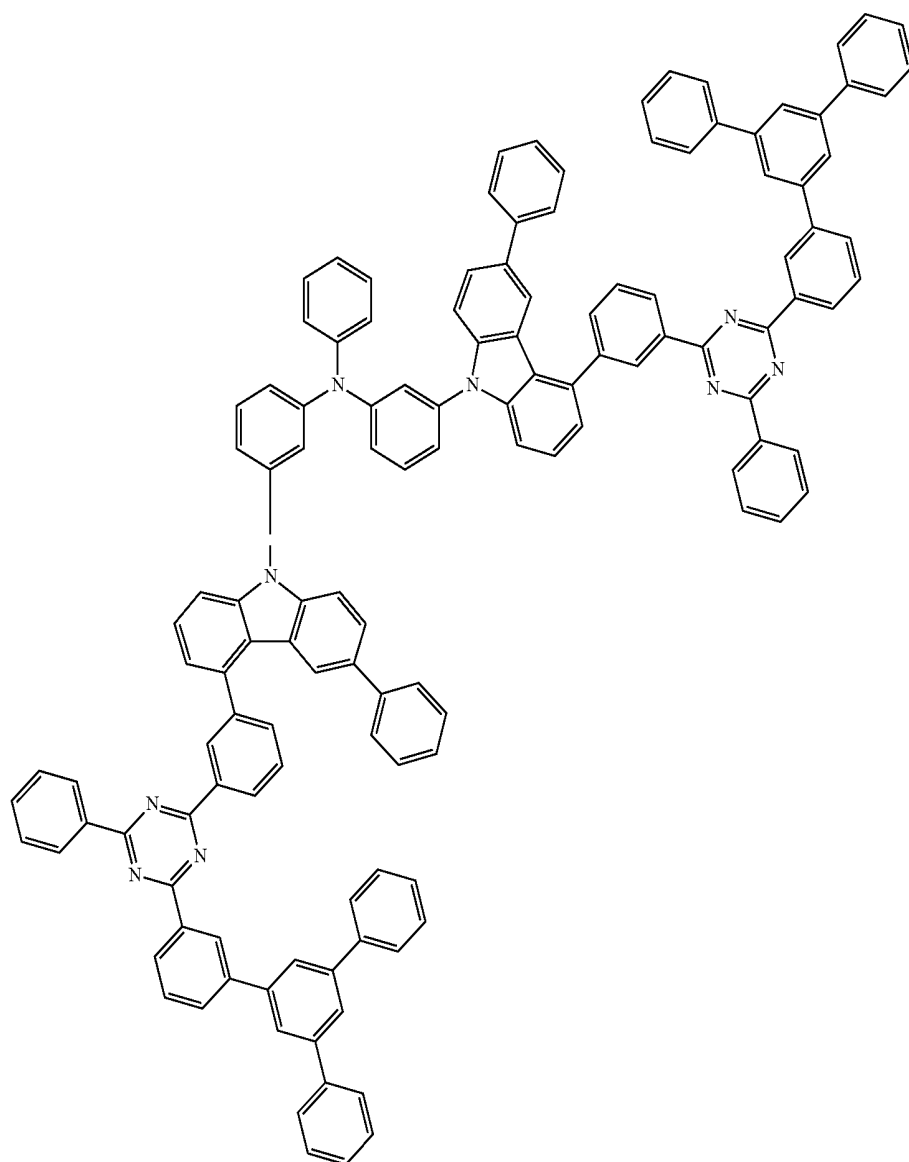
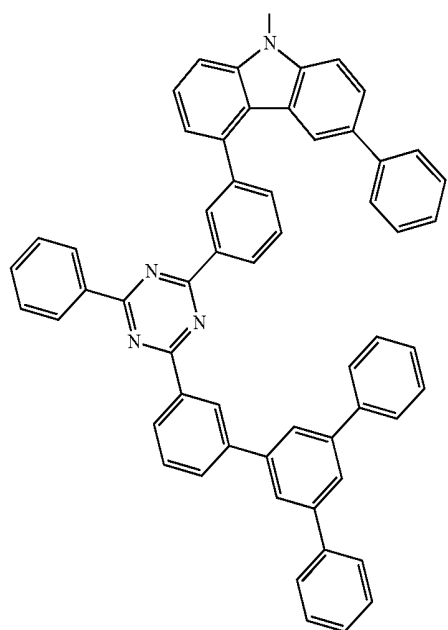
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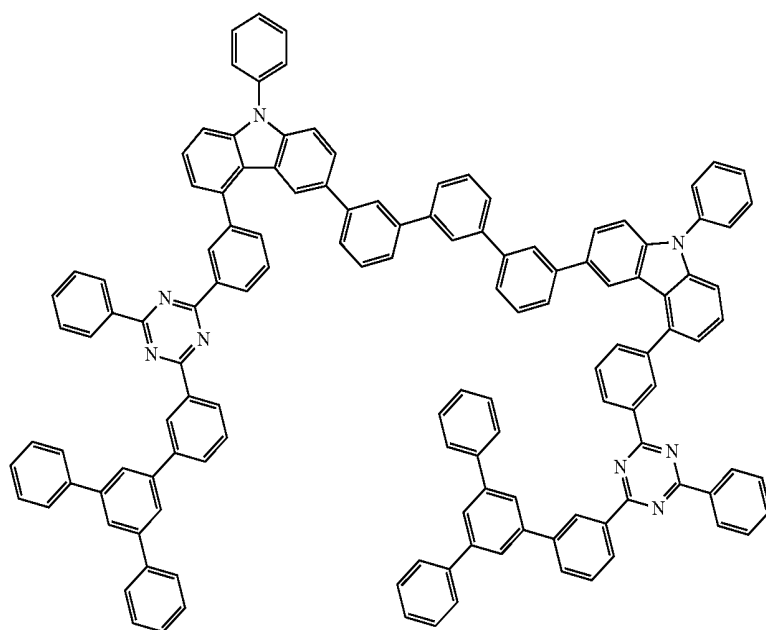
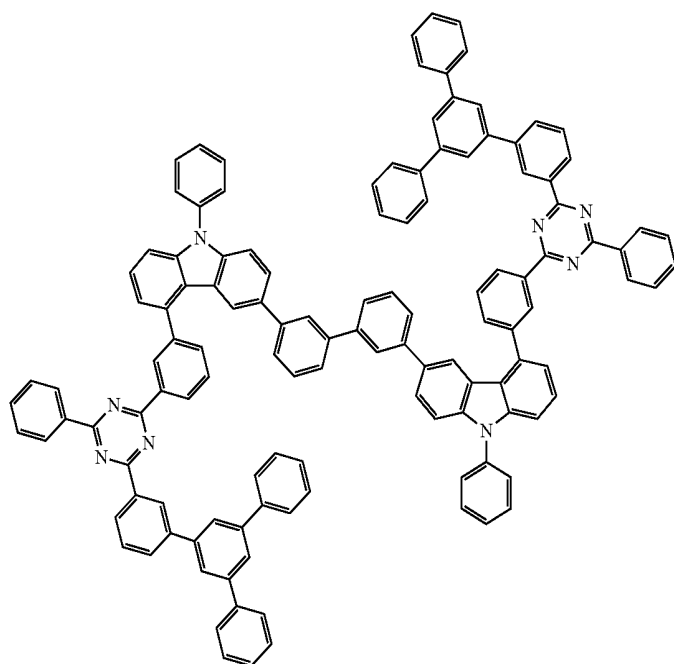


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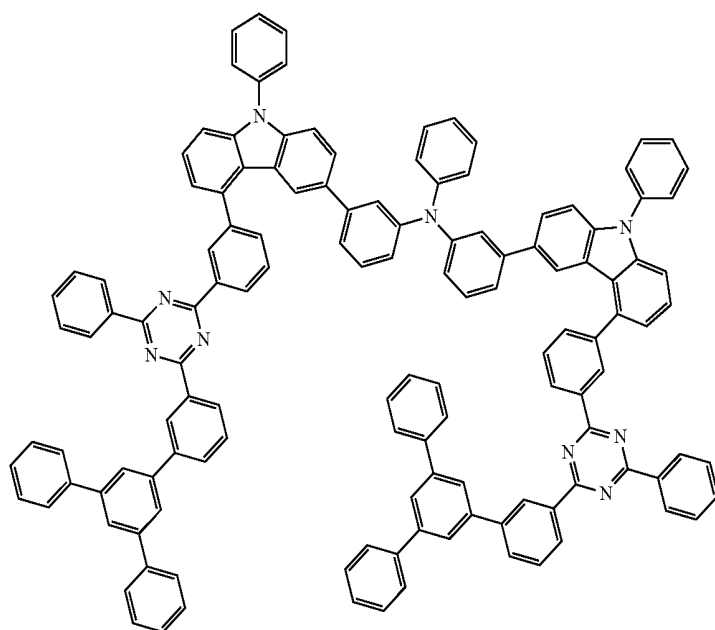
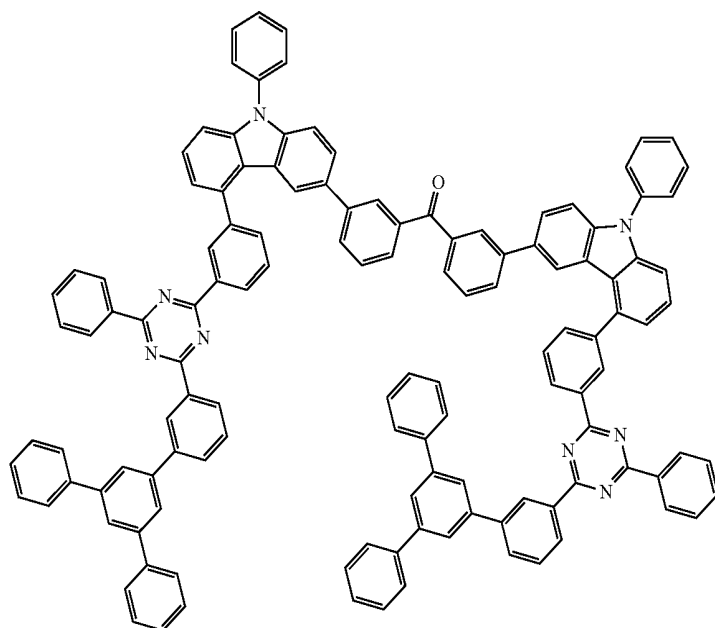
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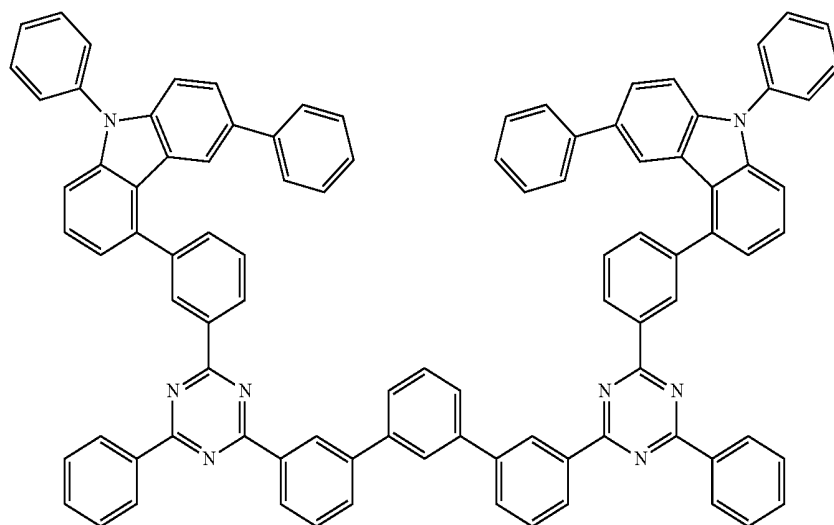
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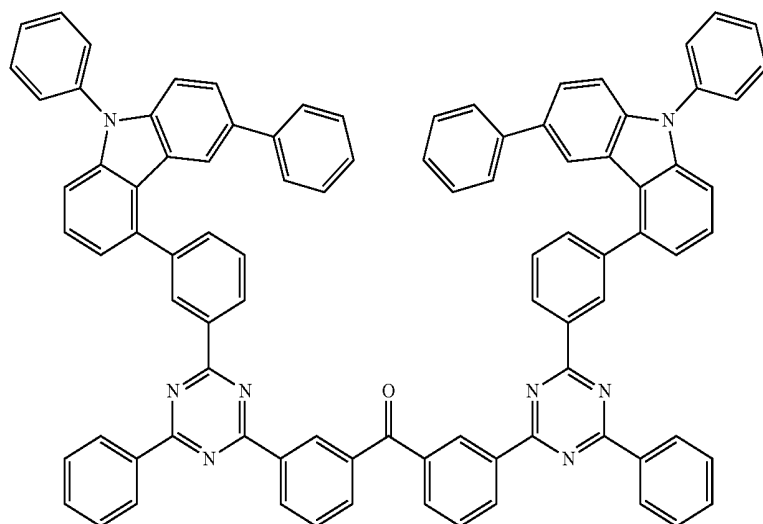
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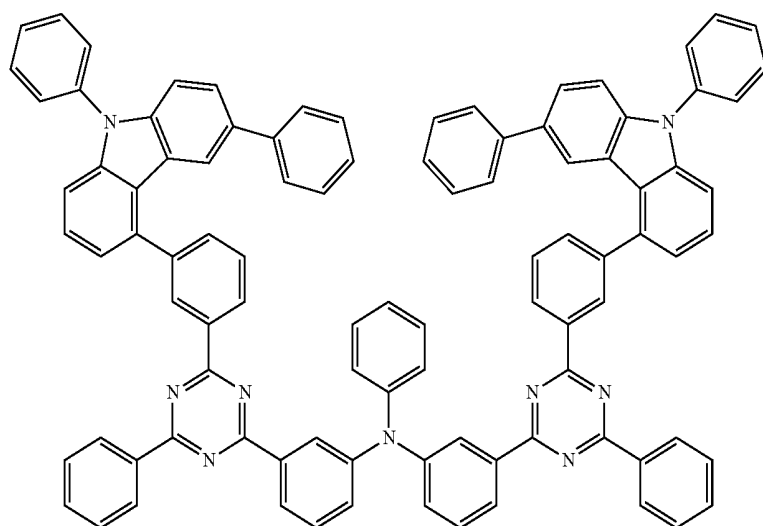
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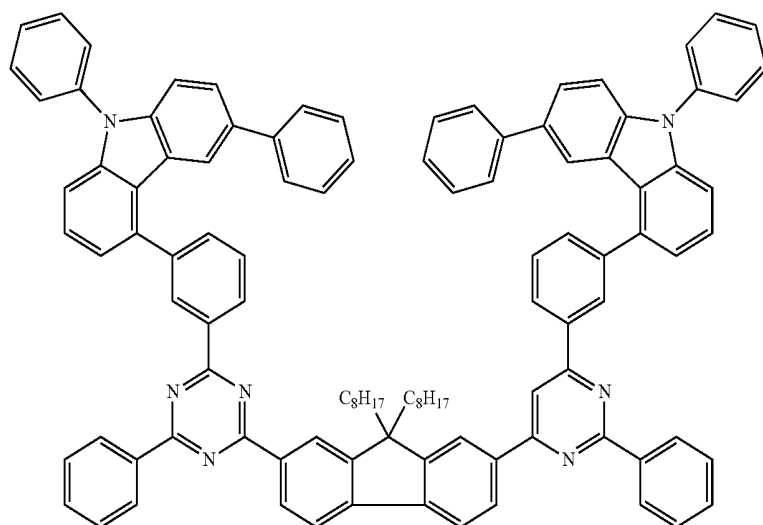


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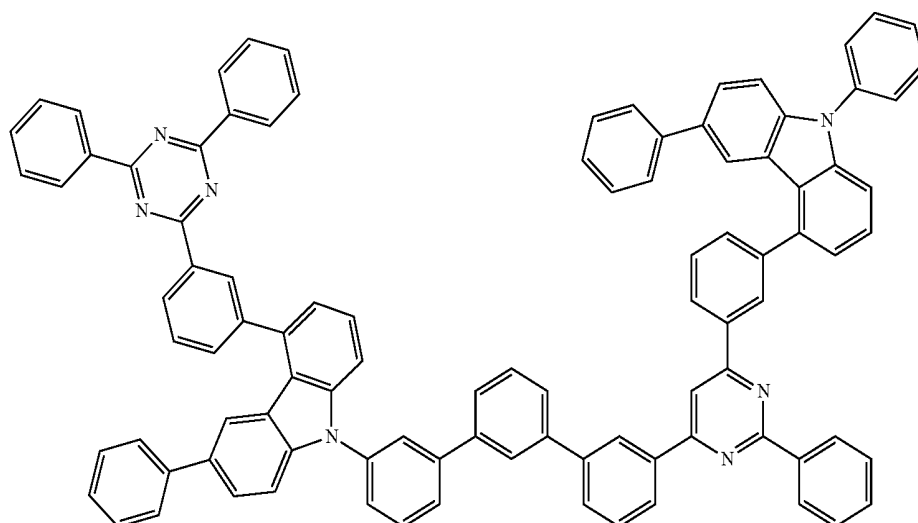
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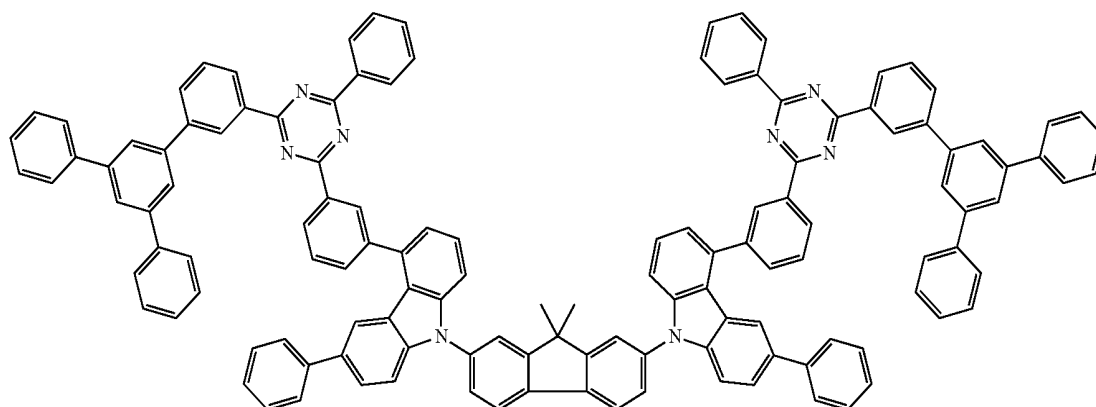
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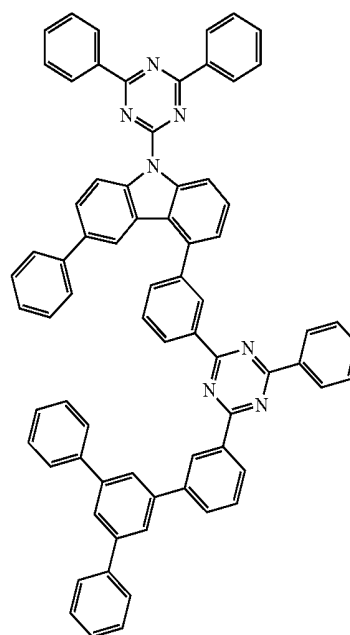
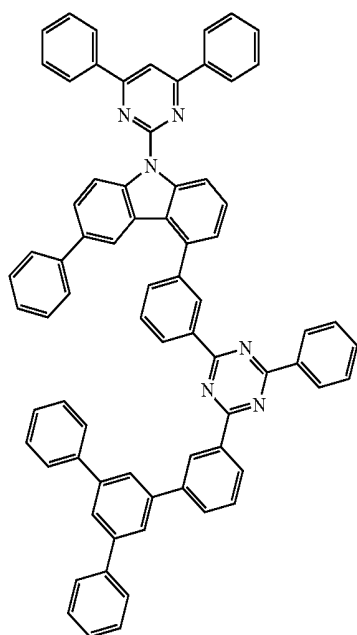


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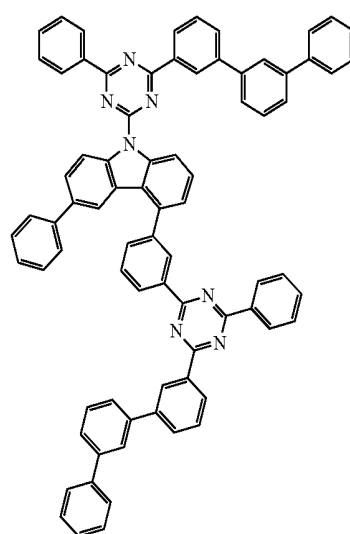
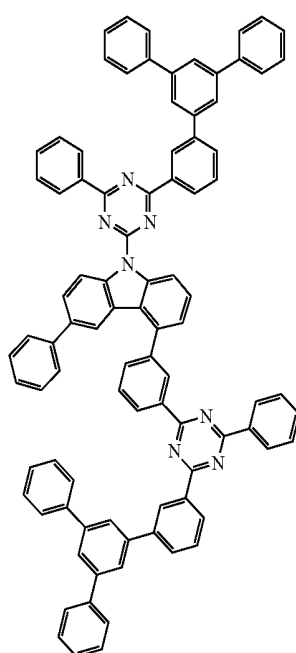
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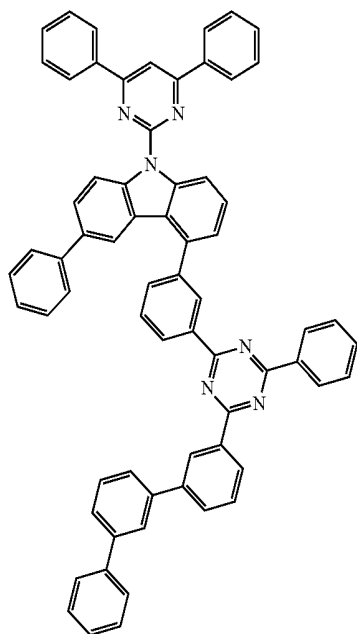


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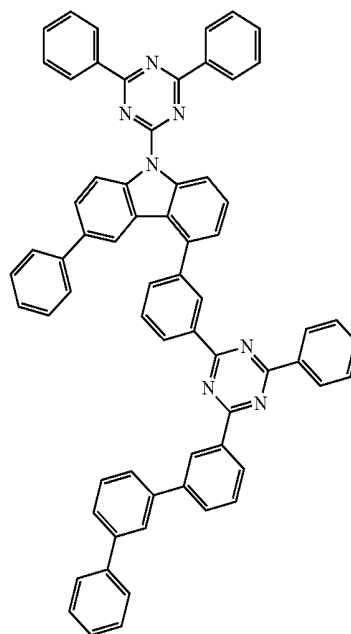


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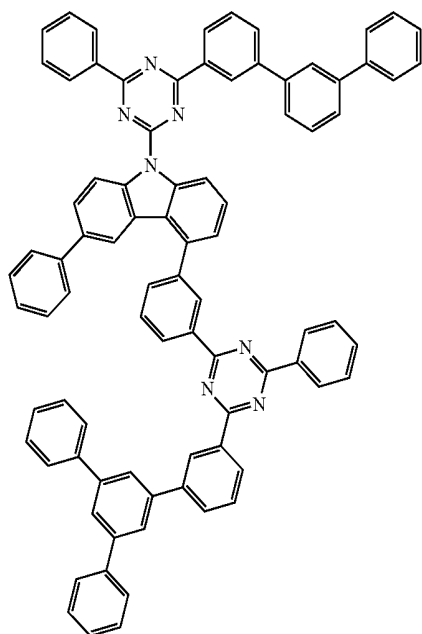


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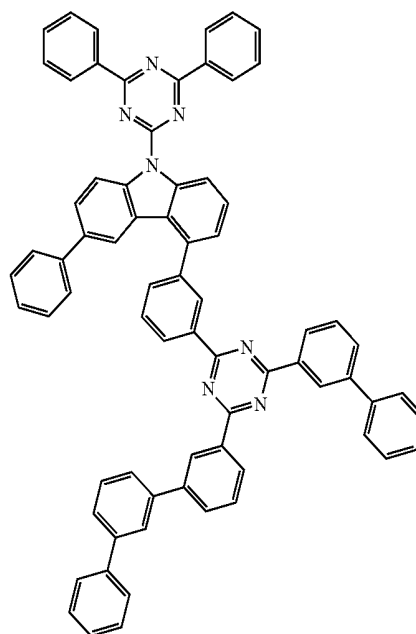
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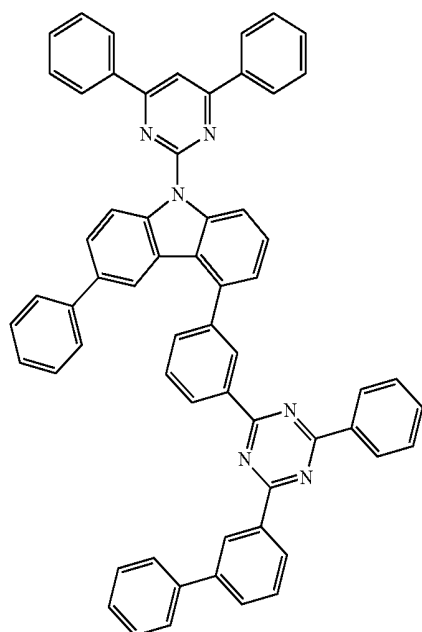


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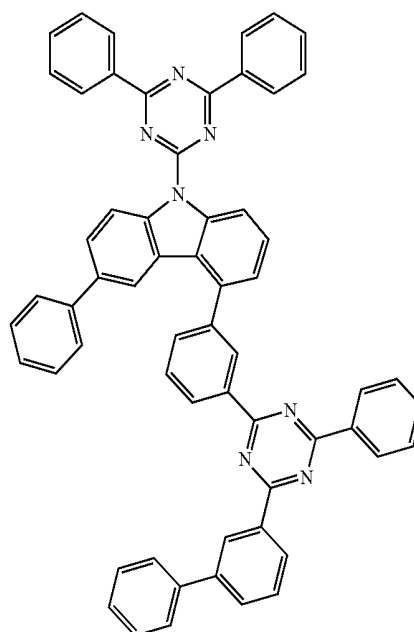
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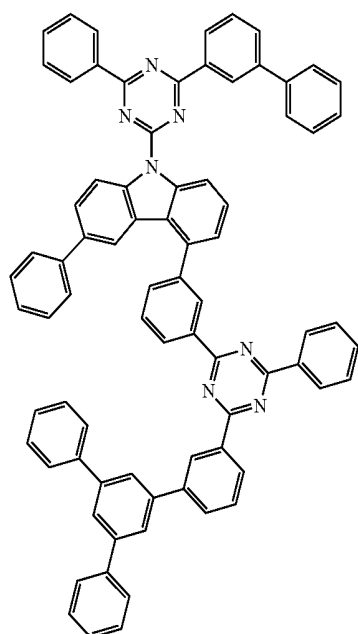
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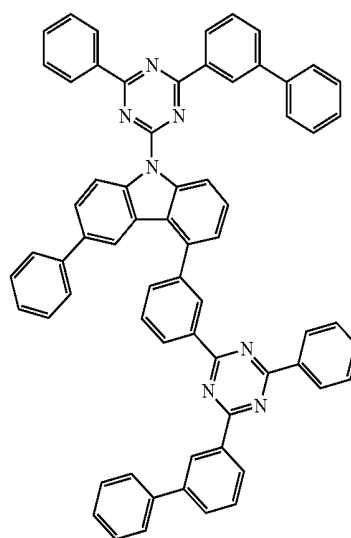
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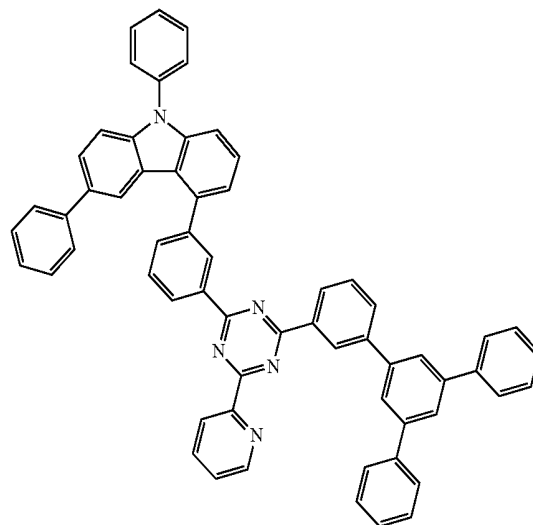
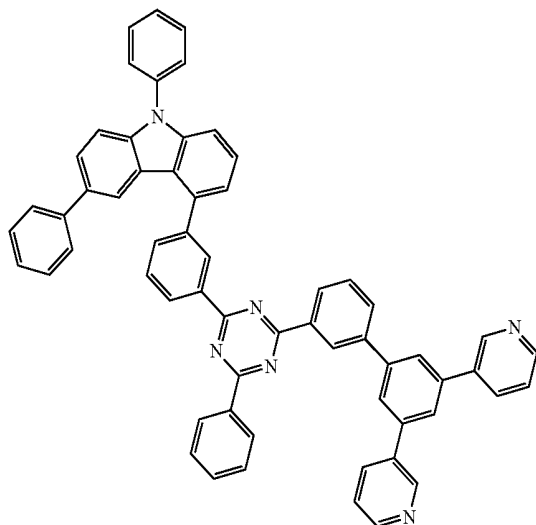
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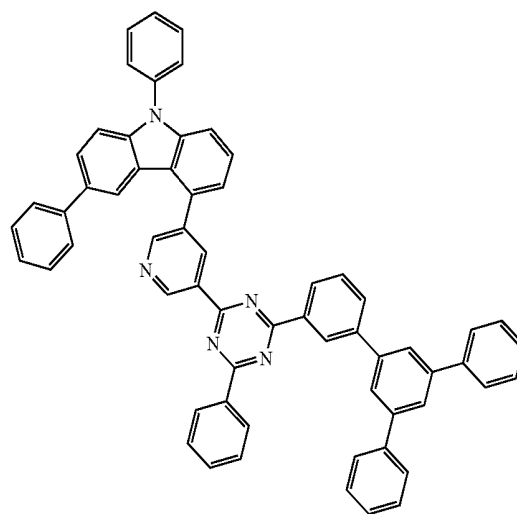
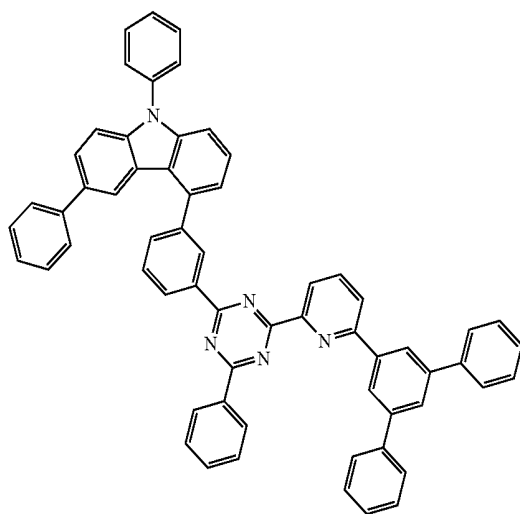
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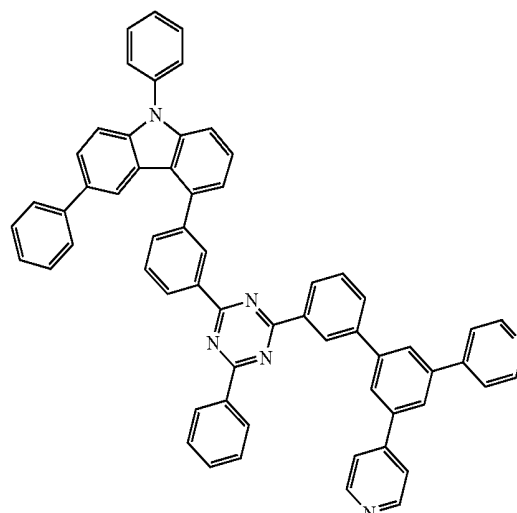
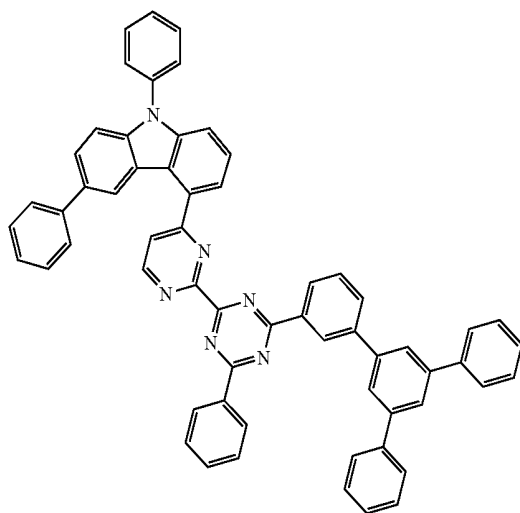
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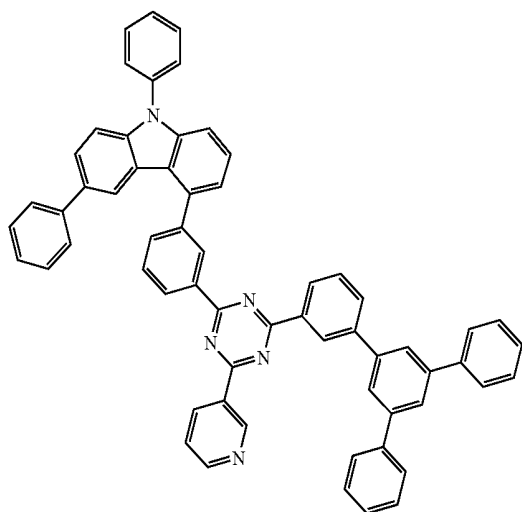


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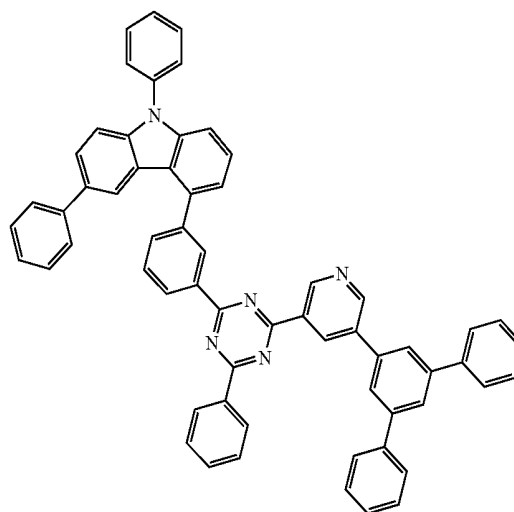
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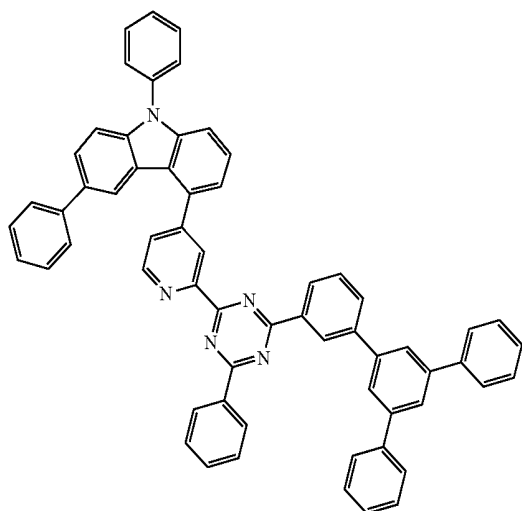
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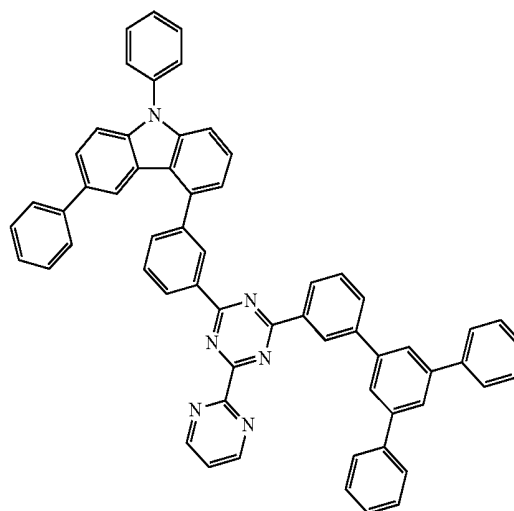
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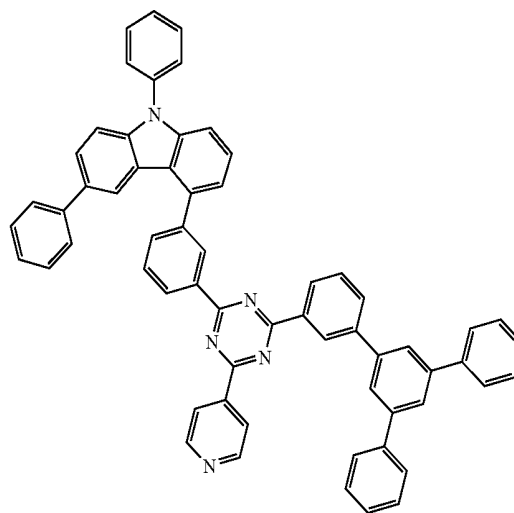
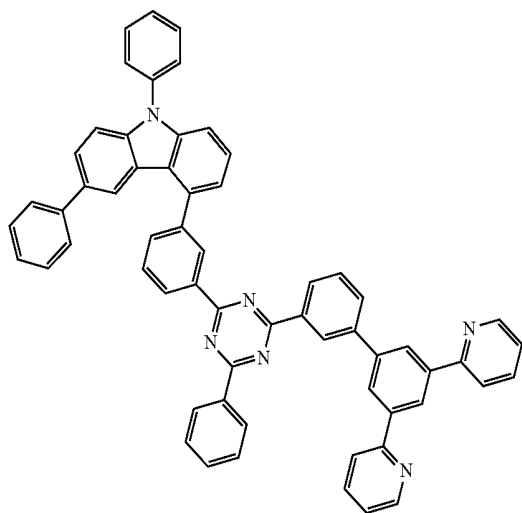
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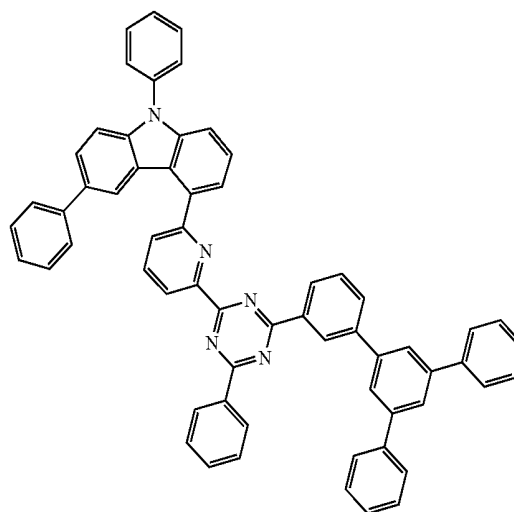
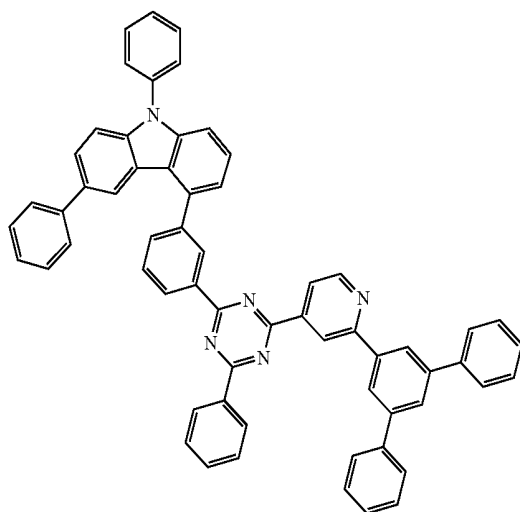


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1-124





The condensed cyclic compound represented by Formula (1) may have a glass transition temperature of about 120° C. or higher, for example, 125° C. or higher, and for example, 145° C. or higher. The glass transition temperature may be measured by a method defined in JIS K 7121 or ISO 3146 corresponding thereto. In the following examples, the glass transition temperature was measured by a scanning calorimetric measurement method.

In the condensed cyclic compound represented by Formula (1), a solubility to toluene or xylene at 1 atm and 25° C. may be 1.0 wt % or more, for example, 2.0 wt % or more, and for example, 3.0 wt % or more.

An organic light-emitting device including the condensed cyclic compound represented by Formula (1) may have an improved light emission lifespan. Also, when a film including the condensed cyclic compound is formed by solution coating using a composition including the condensed cyclic compound represented by Formula (1), the film may have a uniform thickness.

The condensed cyclic compound may be synthesized using a known organic synthesis method. More specific synthesis methods may be understood in connection with the following examples by those of ordinary skill in the art.

2. Material for Forming Organic Light-Emitting Device

In one or more embodiments, the material for forming the organic light-emitting device includes the condensed cyclic compound represented by Formula (1). The condensed cyclic compound is applicable as the material for forming the organic light-emitting device. Also, since the condensed

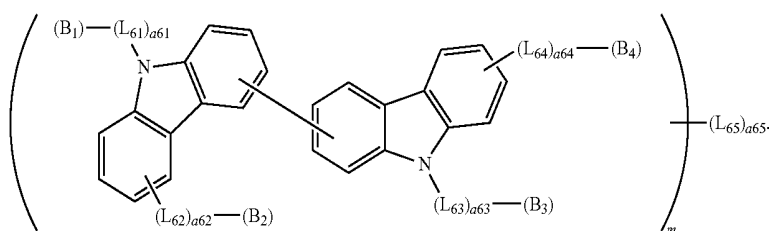
cyclic compound has electron transport and injection capabilities, the condensed cyclic compound may be used as materials for forming the electron transport layer, the electron injection layer, and the emission layer.

When the material for forming the organic light-emitting device is a material for forming the emission layer, the condensed cyclic compound represented by Formula (1), which is included in the material for forming the emission layer, may be a host material. In this case, the material for forming the emission layer may include only one condensed cyclic compound represented by Formula (1), or may include two or more different condensed cyclic compounds represented by Formula (1). Various modifications may be made to the material for forming the emission layer. For example, the material for forming the emission layer may include i) only Compound 1-7 as the condensed cyclic compound represented by Formula (1) or ii) a mixture of Compounds 1-5 and 1-7 as the condensed cyclic compound represented by Formula (1). In this regard, the material for forming the organic light-emitting device may further include a hole transport compound.

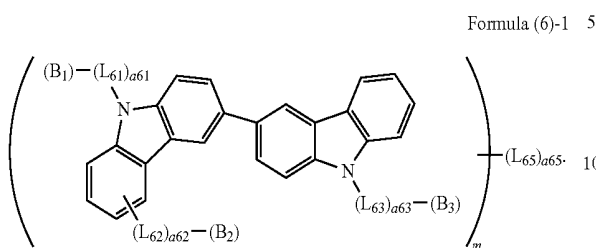
For use as the hole transport compound, a known hole injection material, a known hole transport material, or a known host material may be used. For example, a carbazole-containing compound or a bicarbazole-containing compound may be used. A linking position between two carbazole groups in the bicarbazole-containing compound may be variously changed to, for example, 3, 4-, 3, 3-, 3, 2-, 3, 1-, 2, or 2-.

For example, the hole transport compound may be a compound represented by Formula (6):

Formula (6)



In one or more embodiments, the hole transport compound may be a compound represented by Formula (6)-1:



In Formulae (6) and (6)-1,

L_{61} to L_{65} may each independently be selected from a single bond, $^*C(=O)^*$, $^*C(=S)^*$, $^*O^*$, $^*S^*$, $^*N(R_{65})^*$, a substituted or unsubstituted C_2-C_{60} alkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent π electron-depleted nitrogen-free non-aromatic condensed heteropolycyclic group,

* and * each indicate a binding site to a neighboring atom,

a_{61} to a_{65} may each independently be an integer from 1 to 10,

$(L_{65})_{a_{65}}$ may be an m -valent linking group or a single bond, wherein m may be a natural number greater than or equal to one,

when m is one, $(L_{65})_{a_{65}}$ may not exist,

when m is two or more, at least one of groups represented by $^*(L_{61})_{a_{61}}(B_1)$, $^*(L_{62})_{a_{62}}(B_2)$, $^*(L_{63})_{a_{63}}(B_3)$, and $^*(L_{64})_{a_{64}}(B_4)$ may be linked to $(L_{65})_{a_{65}}$, or may be a single bond linked to $(L_{65})_{a_{65}}$,

i) B_1 to B_4 and R_{65} may each independently be linked to $(L_{65})_{a_{65}}$,

ii) B_1 to B_4 and R_{65} may each independently be a single bond linked to $(L_{65})_{a_{65}}$, or

iii) B_1 to B_4 and R_{65} may each independently be selected from hydrogen, deuterium, a substituted or unsubstituted C_1-C_{60} alkyl 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 π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, and $-C(=O)(Q_1)$, provided that B_1 and B_2 are not hydrogen, deuterium, a substituted or unsubstituted C_1-C_{60} alkyl group, or a substituted or unsubstituted C_1-C_{60} alkoxy group, and

at least one substituent of the substituted C_2-C_{60} alkylene group, the substituted C_3-C_{10} cycloalkylene group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenylene group, the substituted C_6-C_{60} arylene group, the substituted π electron-depleted nitrogen-free C_1-C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent π electron-depleted nitrogen-free non-aromatic condensed heteropolycyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} aryl group, the substituted π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group may be selected from:

deuterium and a C_1-C_{60} alkyl group;

a C_3-C_{10} cycloalkyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group;

a C_3-C_{10} cycloalkyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, a C_3-C_{10} cycloalkyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, and $-C(=P)(Q_{21})$; and

$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-C(=O)(Q_{31})$,

wherein Q_1 to Q_3 , Q_{21} to Q_{23} , and Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, and a diphenyldibenzothiophenyl group.

In one or more embodiments, all of B_1 to B_3 in Formulae (6) and (6)-1 may not be hydrogen, deuterium, a substituted or unsubstituted C_1-C_{60} alkyl group, or a substituted or unsubstituted C_1-C_{60} alkoxy group.

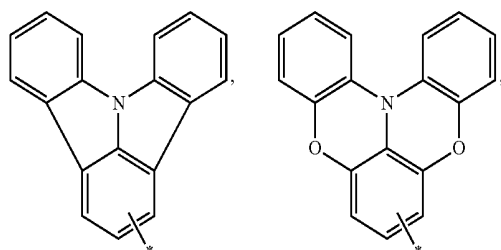
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In one or more embodiments, all of B_1 to B_4 in Formula (6) may not be hydrogen, deuterium, a substituted or unsubstituted C_1 - C_{60} alkyl group, or a substituted or unsubstituted C_1 - C_{60} alkoxy group.

For example, L_{61} to L_{65} in Formulae (6) and (6)-1 may each independently be selected from:

a single bond, $*-C(=O)-*$, $*-C(=S)-*$, and $*-N(R_{65})-*$; and

a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, a furanylene group, a thienylene group, an isoindolylenylene group, an indolylenylene group, a benzofuranylene group, a benzothiophenylene group, a carbazolylenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a naphthobenzofuranylene group, and a naphthobenzothiophenylene group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazoyl group, a phenylcarbazoyl group, a biphenylcarbazoyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,



$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-C(=O)(Q_{31})$.

In one or more embodiments, in Formulae (6) and (6)-1, L_{61} to L_{64} may each independently be selected from a single bond, groups represented by Formulae 6-1 to 6-3, and groups represented by Formulae 6-20 to 6-27, and

L_{65} may be selected from a single bond, $*-C(=O)-*$, $*-C(=S)-*$, $*-N(R_5)-*$, groups represented by Formulae 6-1 to 6-3, and groups represented by Formulae 6-20 to 6-27.

a_{61} , a_{62} , a_{63} , a_{64} , and a_{65} in Formulae (6) and (6)-1 respectively indicate the number of groups L_{61} , the number of groups L_{62} , the number of groups L_{63} , the number of groups L_{64} , and the number of groups L_{65} and may each independently be an integer from 1 to 5 or an integer from 1 to 3, but embodiments of the present disclosure are not limited thereto. When a_{61} is two or more, two or more groups L_{61} may be identical to or different from each other. This may be equally applied to a_{62} to a_{65} and L_{62} to L_{65} .

m in Formulae (6) and (6)-1 may be a natural number from 1 to 10. For example, m may be 1, 2, 3, or 4, or m may be 1 or 2, but embodiments of the present disclosure are not limited thereto.

In one or more embodiments, in Formulae (6) and (6)-1, m may be one, or 2) m may be two, $(L_{65})_{a_{65}}$ may be a group represented by $*-Ar_{61}-T_{61}-Ar_{62}-*$, and Ar_{61} , T_{61} ,

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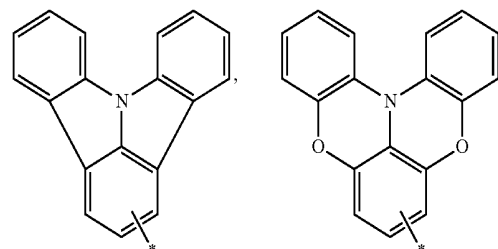
and Ar_{62} are each independently the same as described in connection with L_{65} in Formula (6), provided that Ar_{61} and Ar_{62} are not a single bond, $*-C(=O)-*$, $*-C(=S)-*$, $*-O-*$, $*-S-*$, or $*-N(R_{65})-*$, but embodiments of the present disclosure are not limited thereto.

In one or more embodiments,

i) B_1 to B_3 and R_{65} in Formulae (6) and (6)-1 may each independently be linked to $(L_{65})_{a_{65}}$,

ii) B_1 to B_3 and R_{65} in Formulae (6) and (6)-1 may each independently be a single bond, or

iii) B_1 to B_3 and R_{65} in Formulae (6) and (6)-1 may each independently be selected from a phenyl group, an indenyl group, a naphthyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a furanyl group, a thienyl group, an isoindolyl group, an indolyl group, a benzofuranyl group, a benzothiophenyl group, a carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazoyl group, a naphthobenzofuranyl group, and a naphthobenzothiophenyl group, each unsubstituted or substituted with at least one selected from deuterium, $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazoyl group, a phenylcarbazoyl group, a biphenylcarbazoyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,



$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-C(=O)(Q_{31})$.

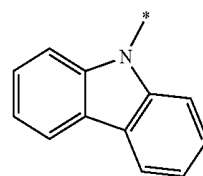
B_4 in Formula (6) may be hydrogen, deuterium, or a C_1 - C_{20} alkyl group, or B_4 in Formulae (6) and (6)-1 are the same as described in connection with B_1 in Formulae (6) and (6)-1.

In one or more embodiments,

i) $*(L_{61})_{a_{61}}-(B_1)$, $*(L_{62})_{a_{62}}-(B_2)$, and $*(L_{63})_{a_{63}}-(B_3)$ in Formulae (6) and (6)-1 may each independently be linked to $(L_{65})_{a_{65}}$,

ii) $*(L_{61})_{a_{61}}-(B_1)$, $*(L_{62})_{a_{62}}-(B_2)$, and $*(L_{63})_{a_{63}}-(B_3)$ in Formulae (6) and (6)-1 may each independently be a single bond linked to $(L_{65})_{a_{65}}$, or

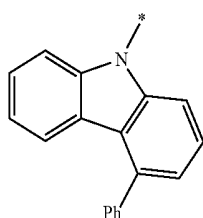
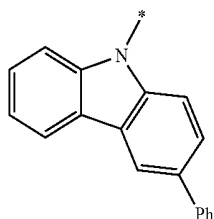
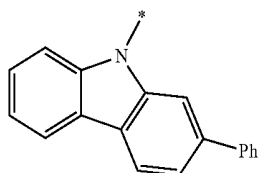
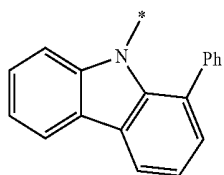
iii) $*(L_{61})_{a_{61}}-(B_1)$, $*(L_{62})_{a_{62}}-(B_2)$, and $*(L_{63})_{a_{63}}-(B_3)$ in Formulae (6) and (6)-1 may each independently be selected from the group represented by Formulae 7-1 to 7-29 and groups represented by Formulae 8-1 to 8-7:



8-1

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-continued



116

-continued

8-2

5

10

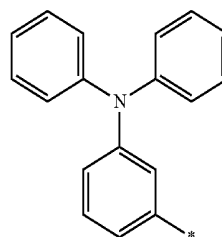
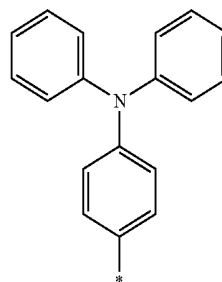
8-3

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8-4

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8-6

8-7

wherein, in Formulae 8-1 to 8-7, Ph indicates a phenyl group and * indicates a binding site to a neighboring atom.

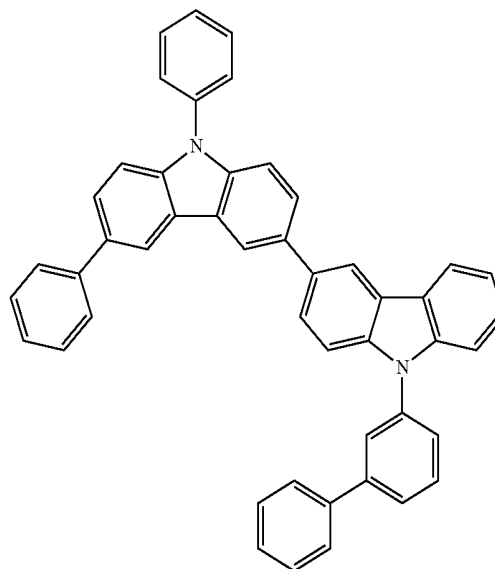
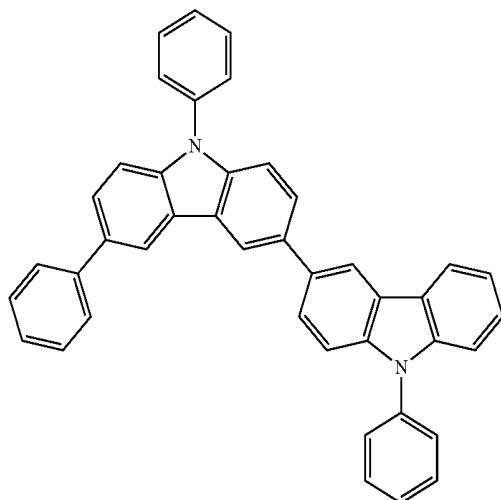
The group represented by $*(L_{64})_{a64}-(B_4)$ in Formula (6) may be hydrogen, deuterium, or a C_1 - C_{20} alkyl group. In one or more embodiments, the group represented by $*(L_{64})_{a64}-(B_4)$ is the same as described in connection with $*(L_{61})_{a61}-(B_1)$.

A hole transport compound represented by Formula (6) (for example, Formula (6)-1) may not include a π electron-depleted nitrogen-containing cyclic group (for example, a pyridine group, a pyrimidine group, a triazine group, a quinoline group, or the like).

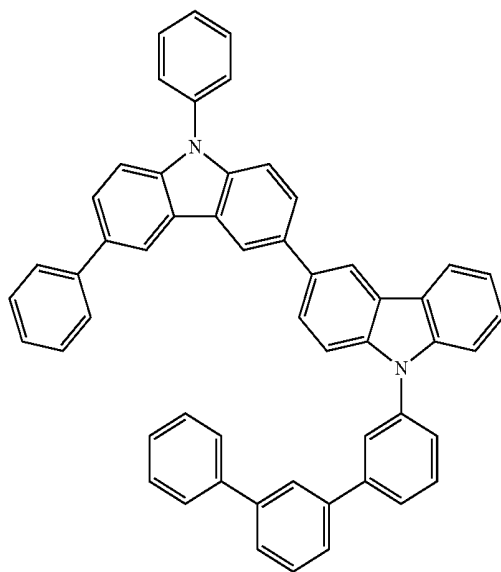
Examples of the hole transport compound represented by Formula (6) (for example, Formula (6)-1) may include Compounds 6-1 to 6-52, but embodiments of the present disclosure are not limited thereto:

6-1

6-2

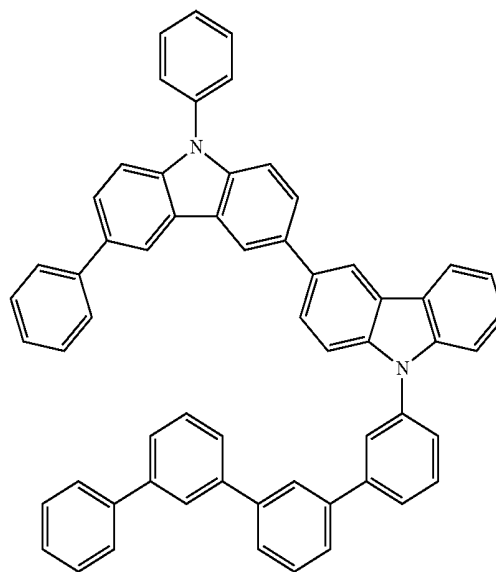


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6-3

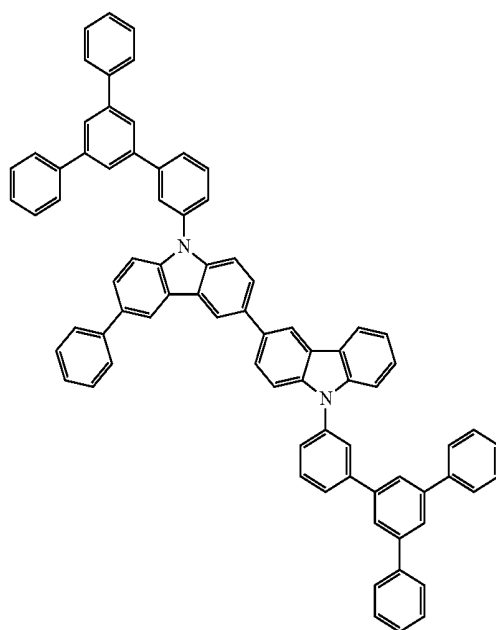
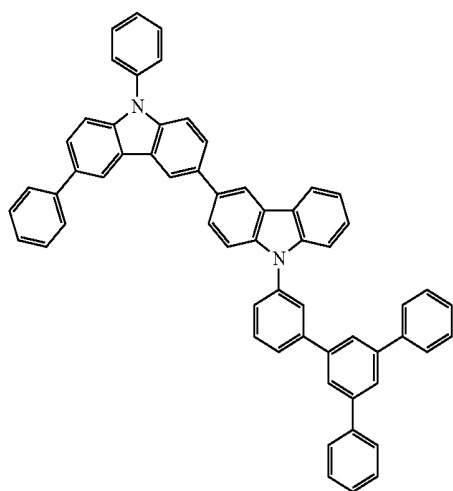
118

6-4



6-5

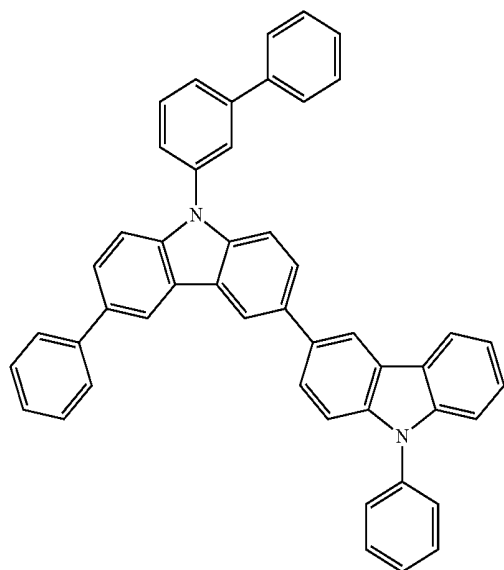
6-6



119

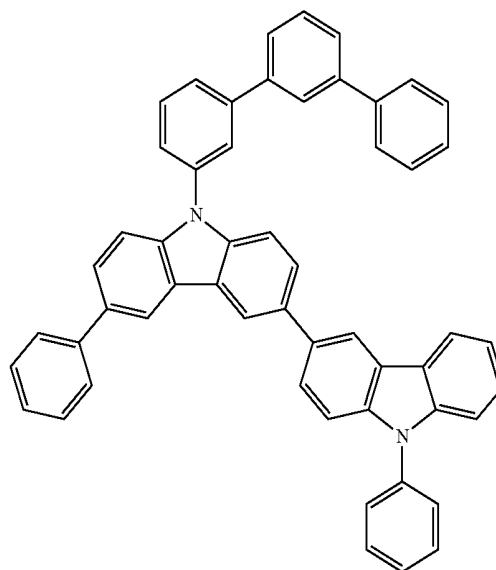
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6-7

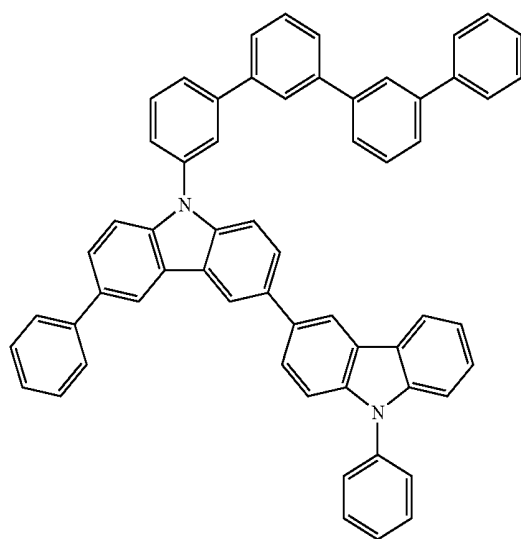


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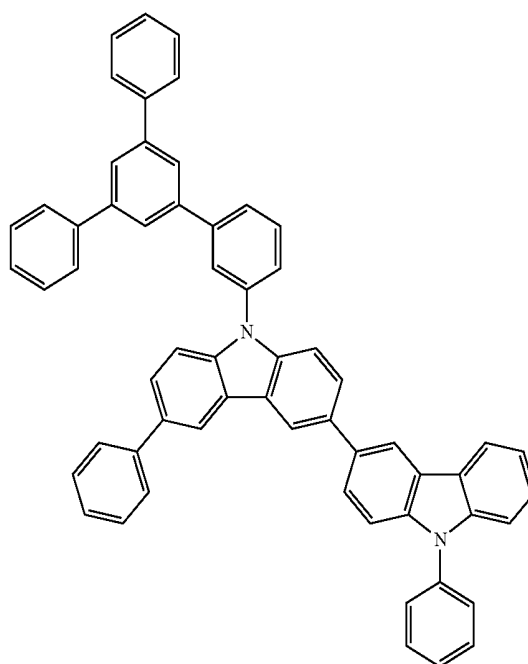
6-8



6-9



6-10



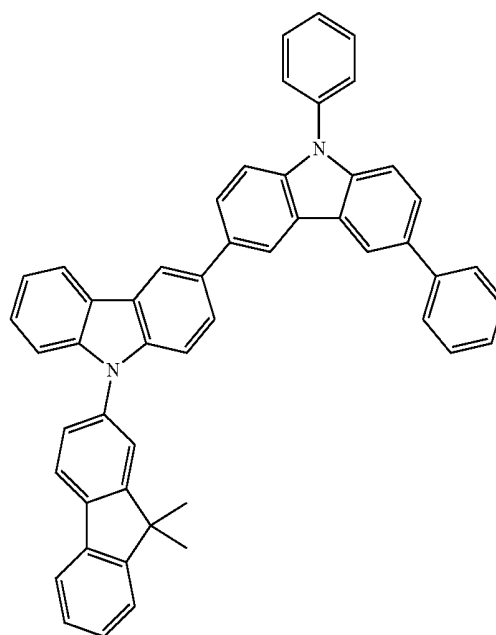
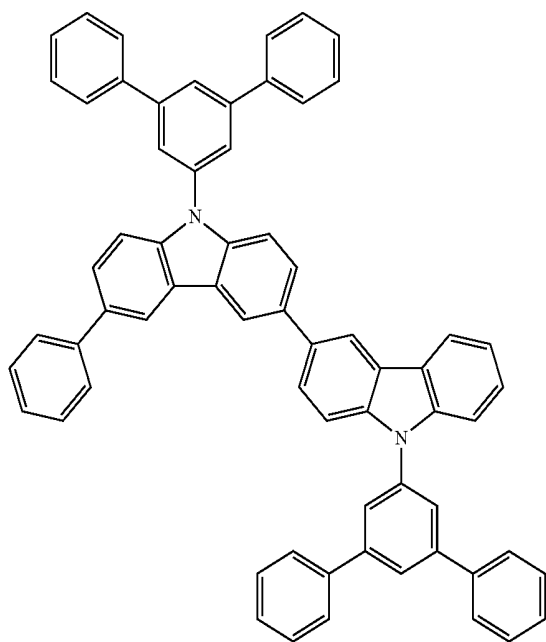
121

122

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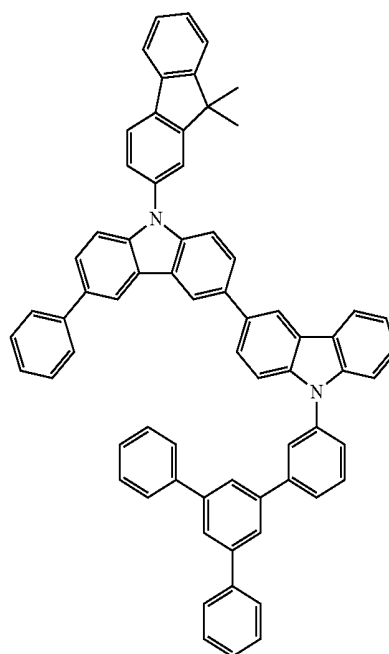
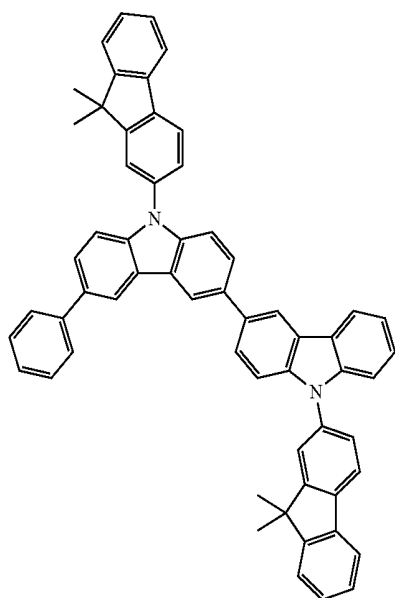
6-11

6-12

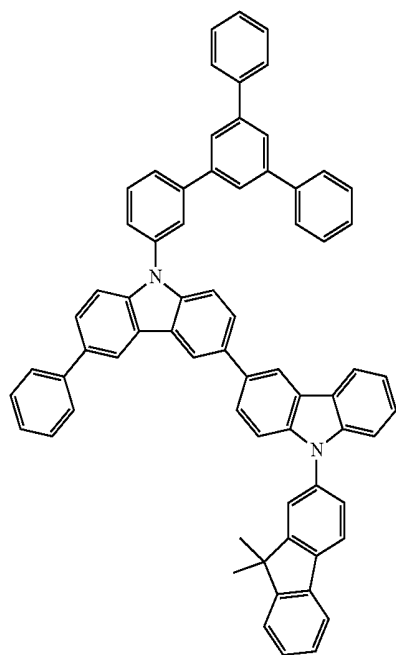


6-13

6-14

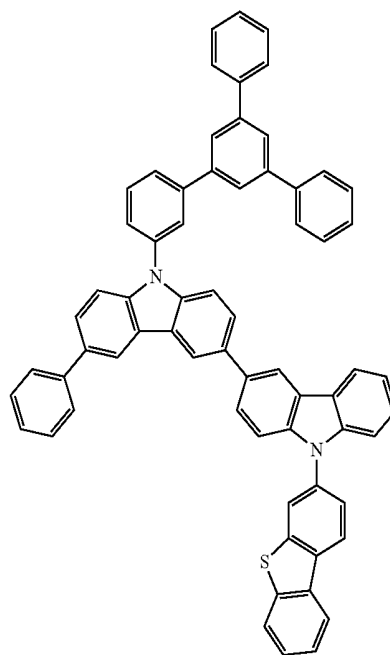


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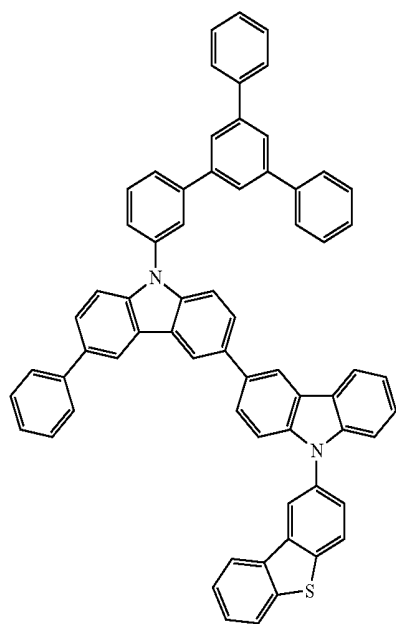
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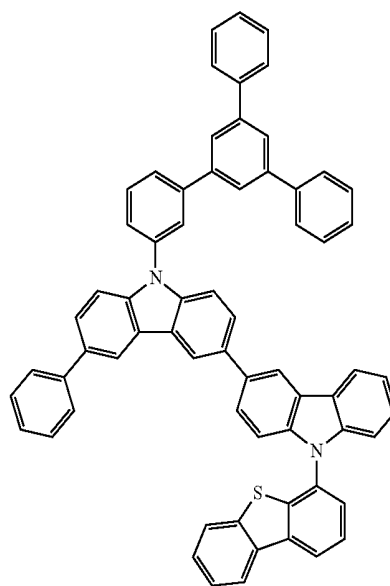


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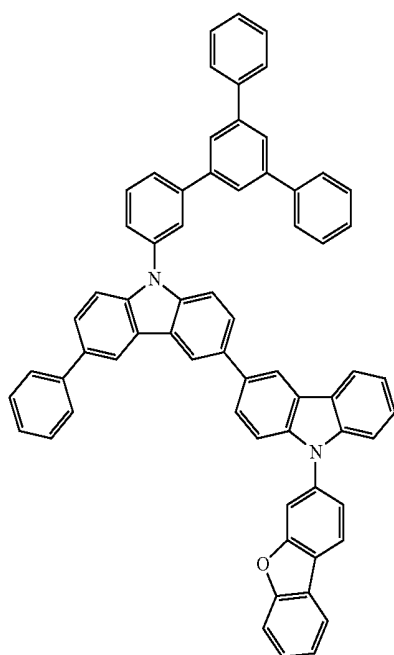
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6-18

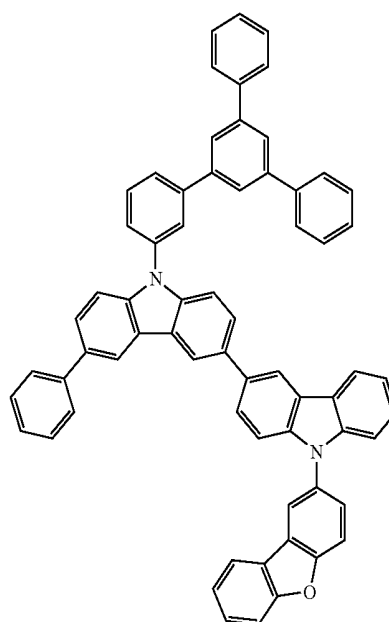


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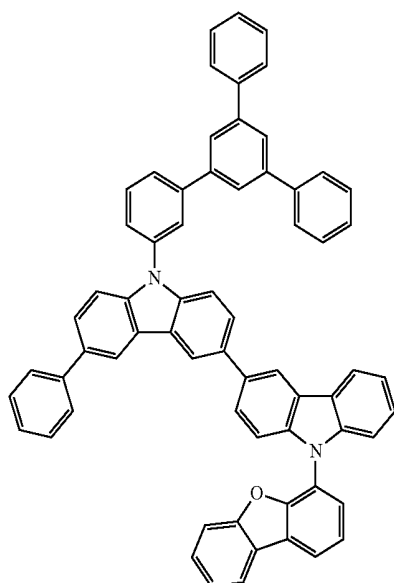
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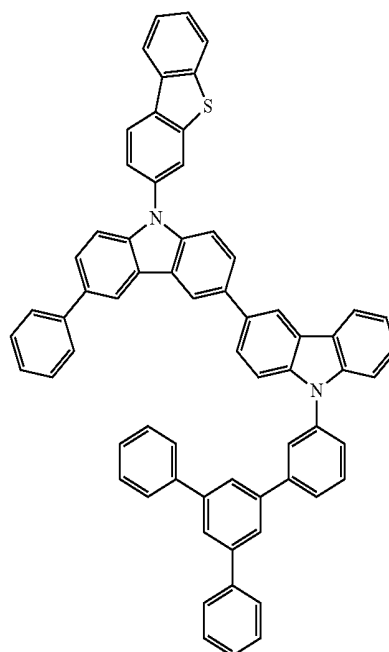


6-20

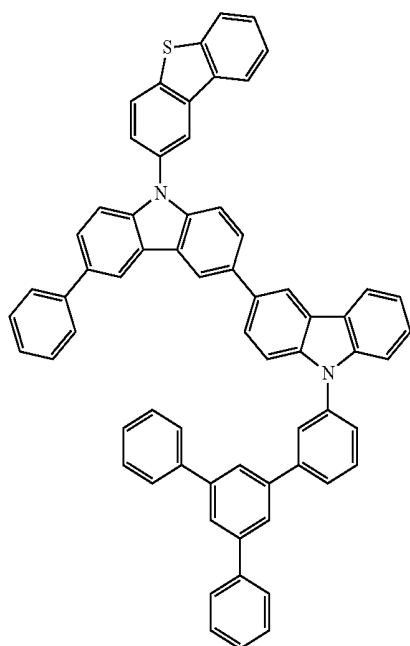
6-21



6-22

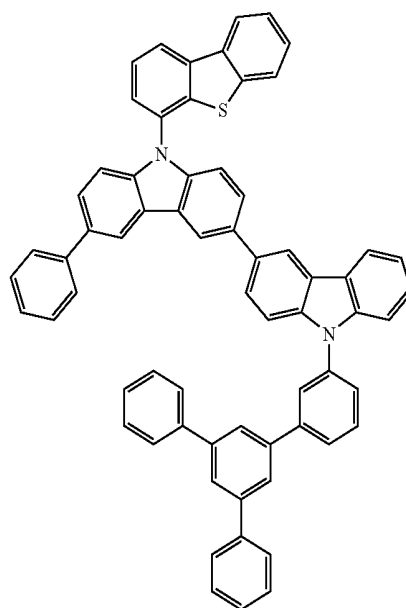


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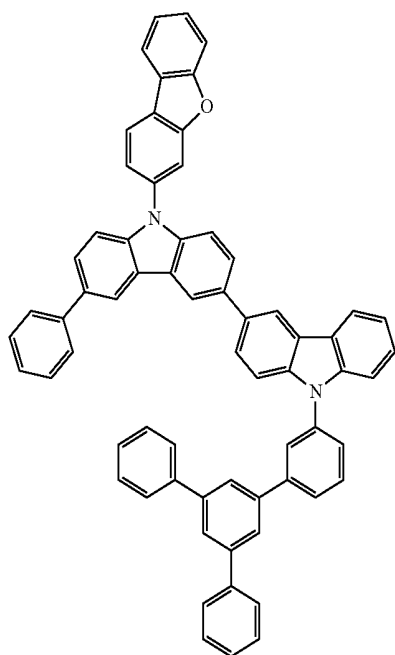
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6-23

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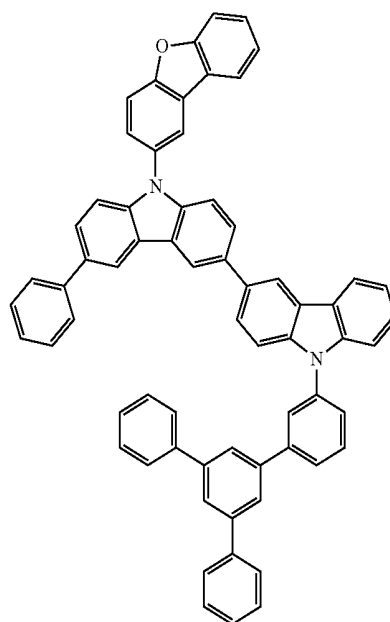


6-24

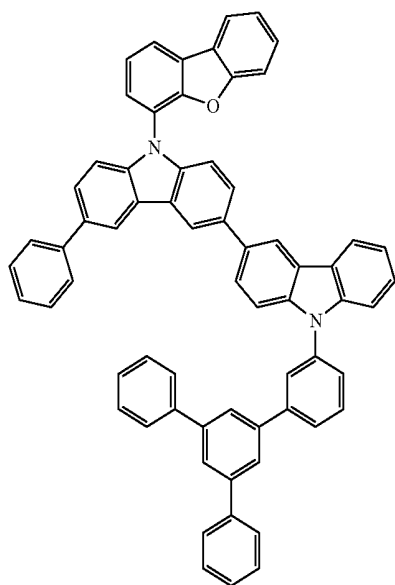
6-25



6-26

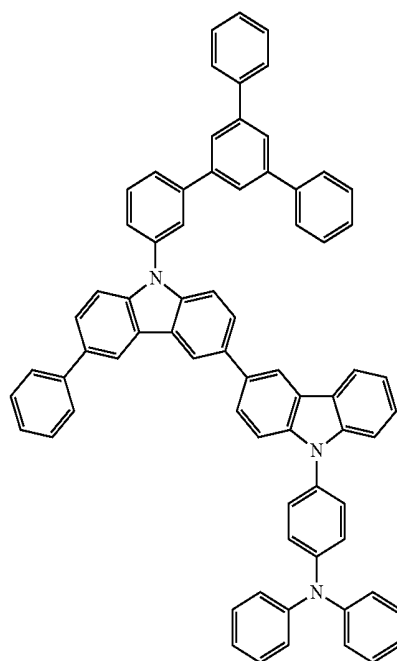


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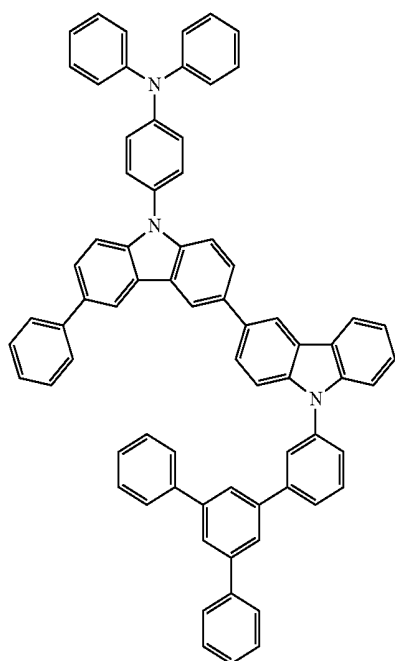
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6-27

130

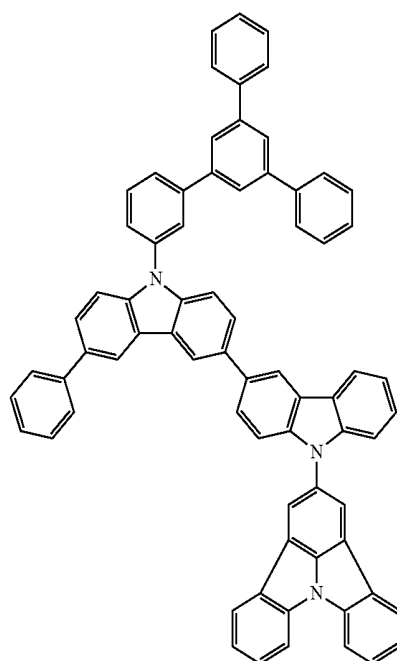


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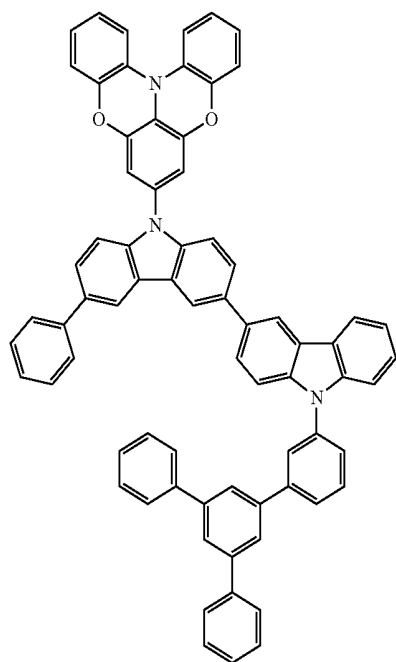
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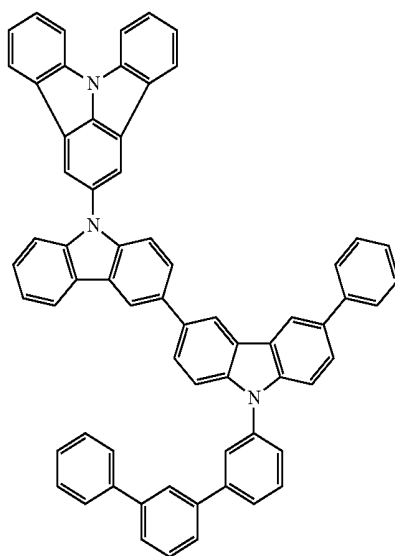
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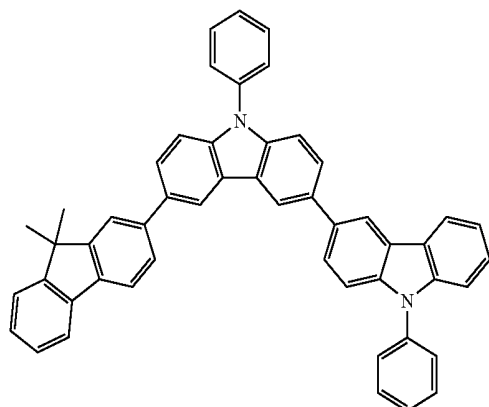
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6-31

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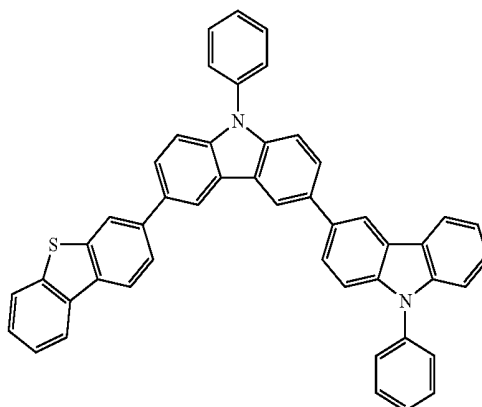


6-32

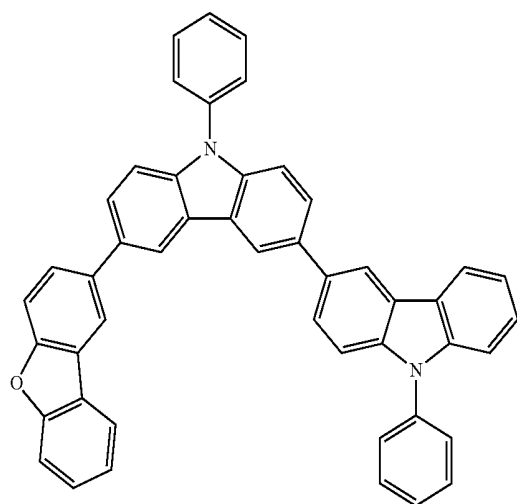
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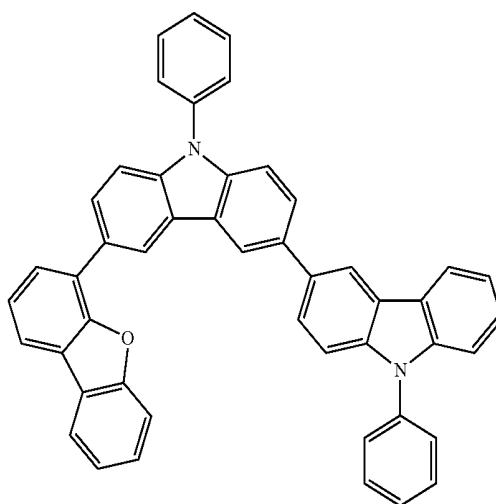
6-34



6-35



6-36

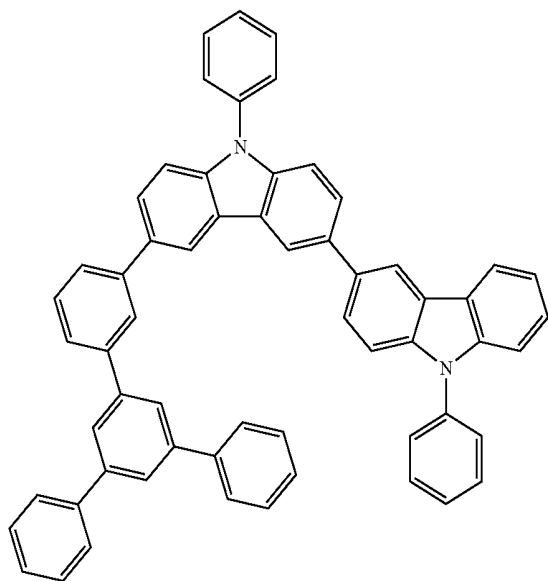


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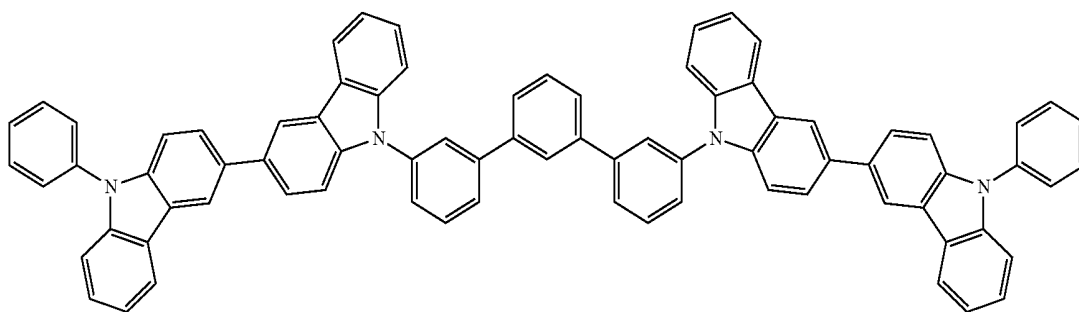
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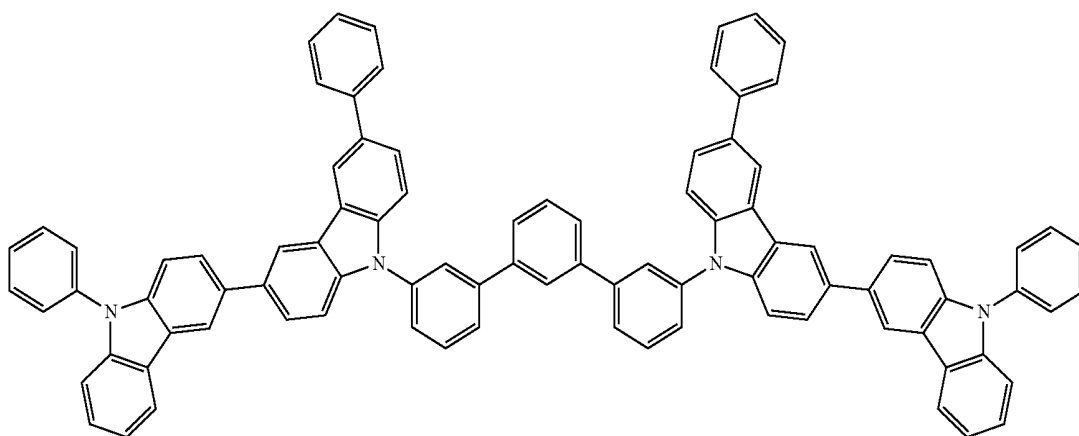
6-37



6-38



6-39

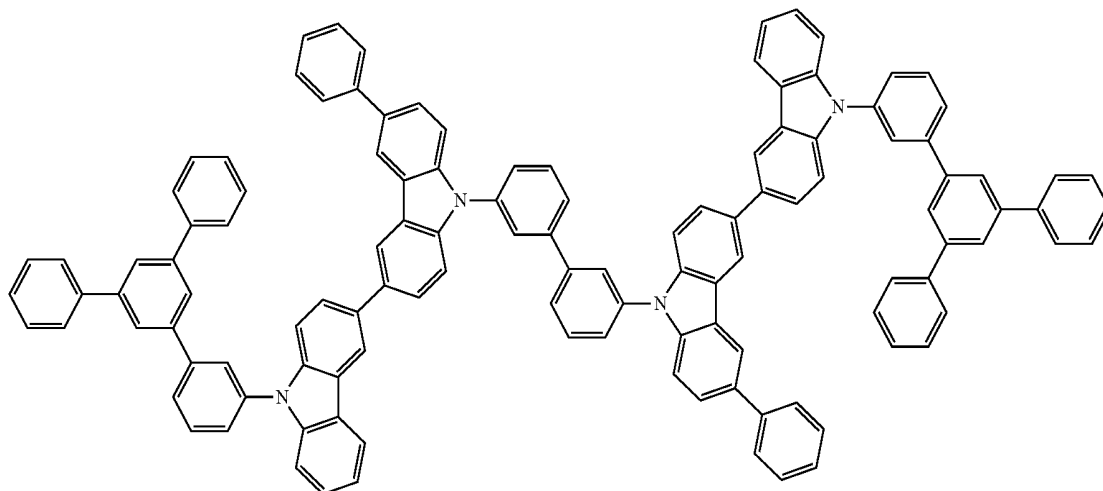


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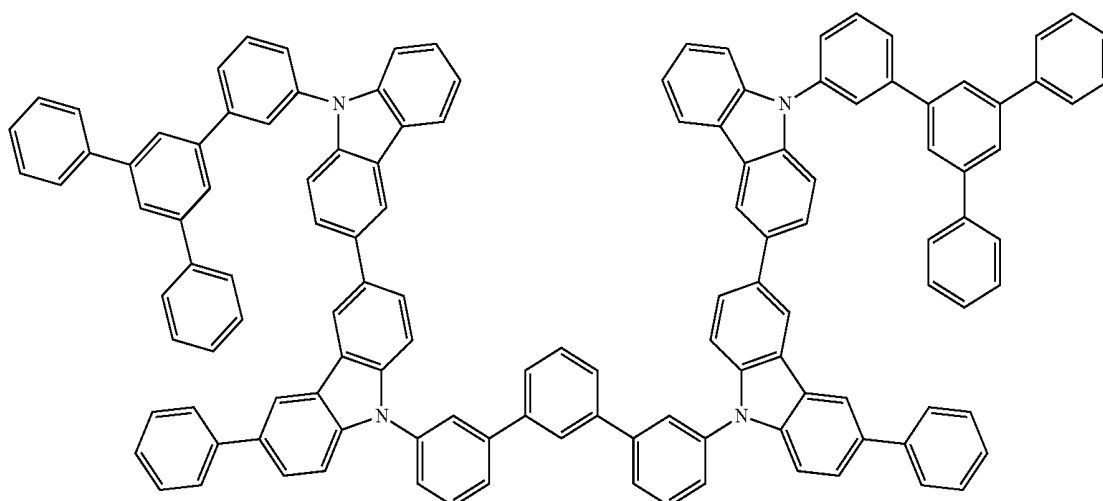
136

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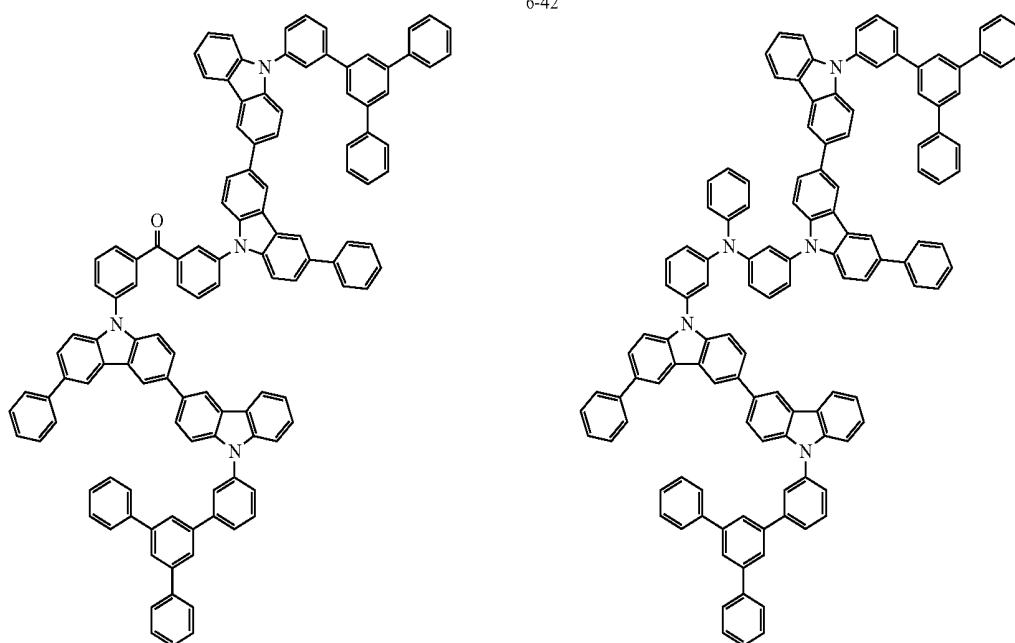


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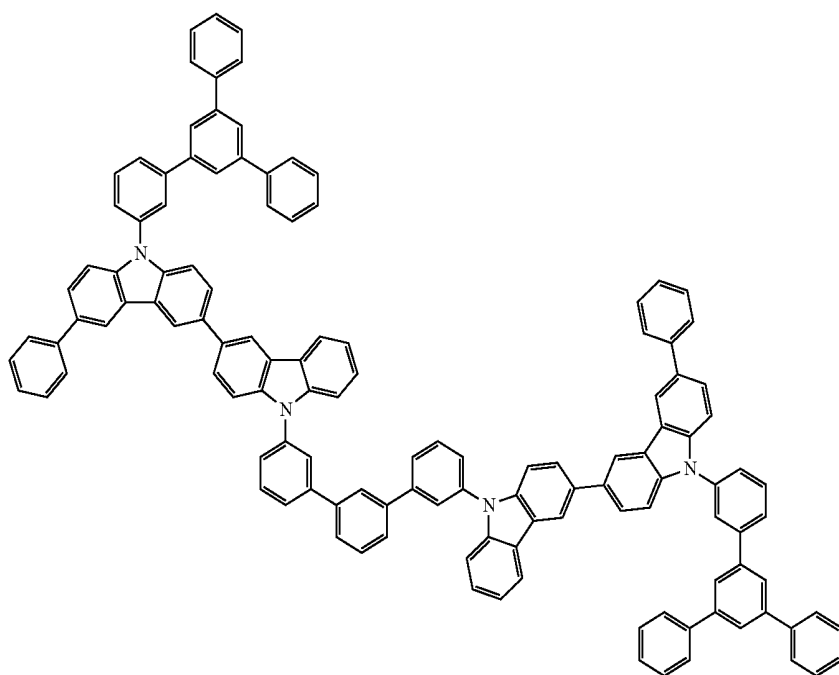
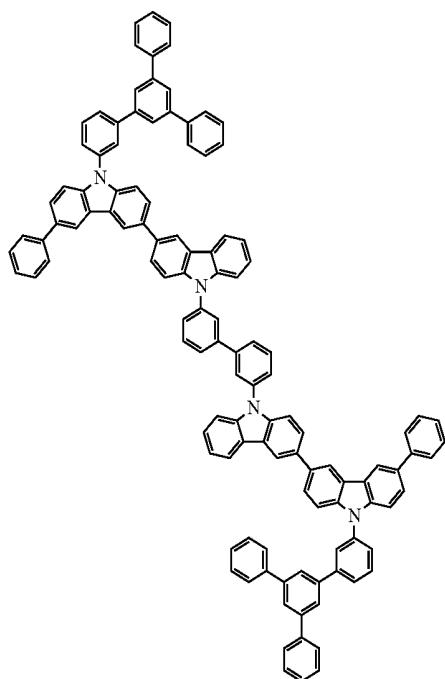


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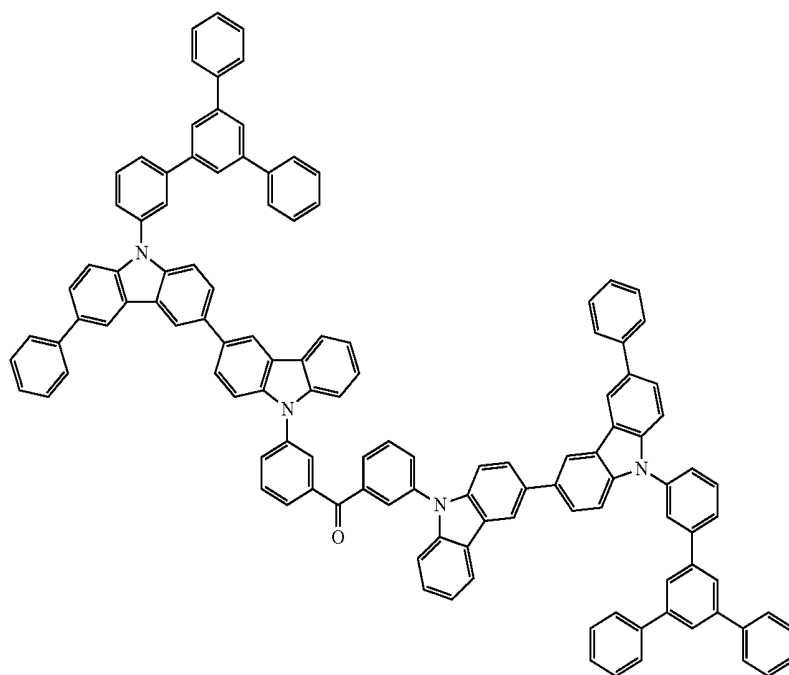
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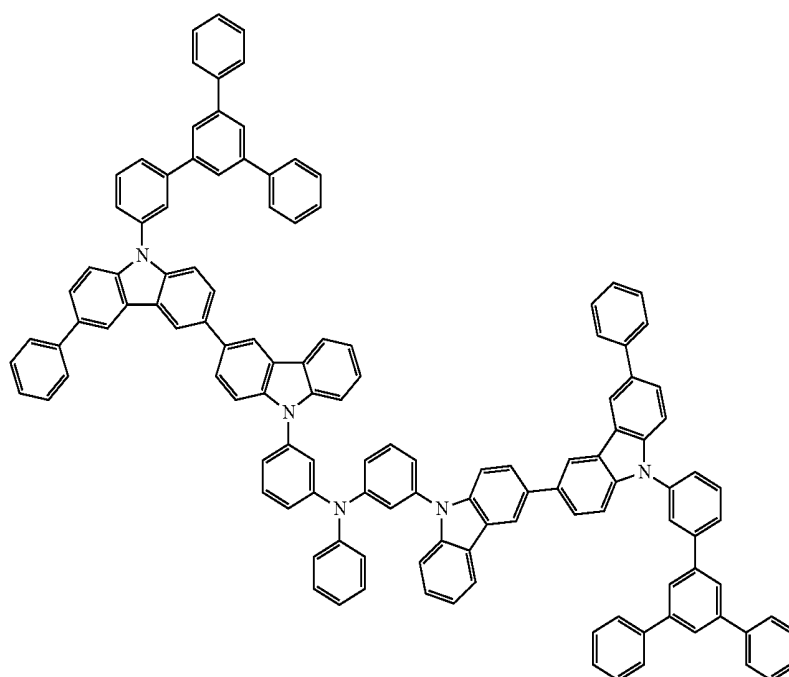
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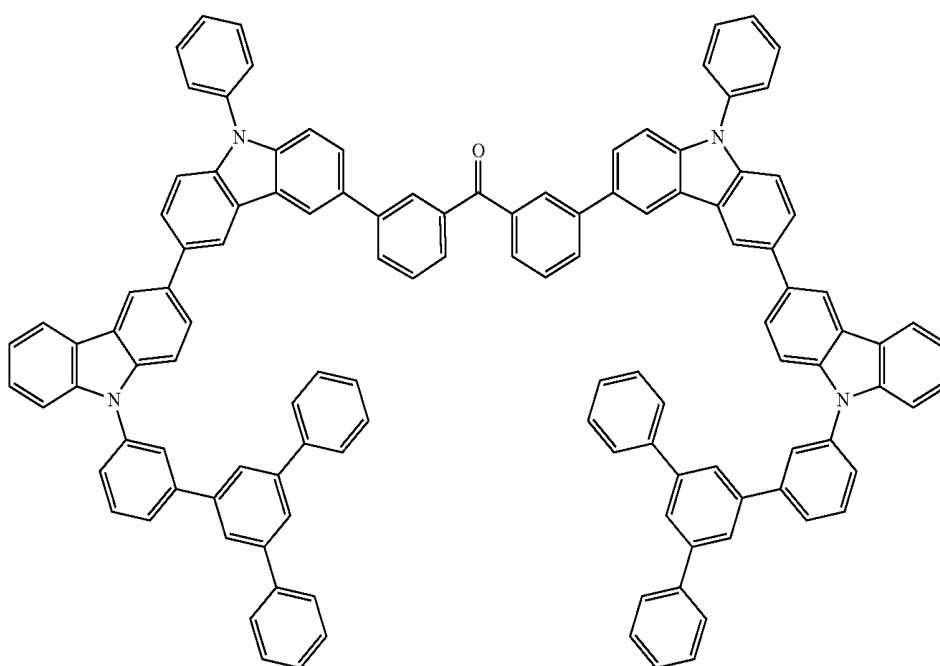
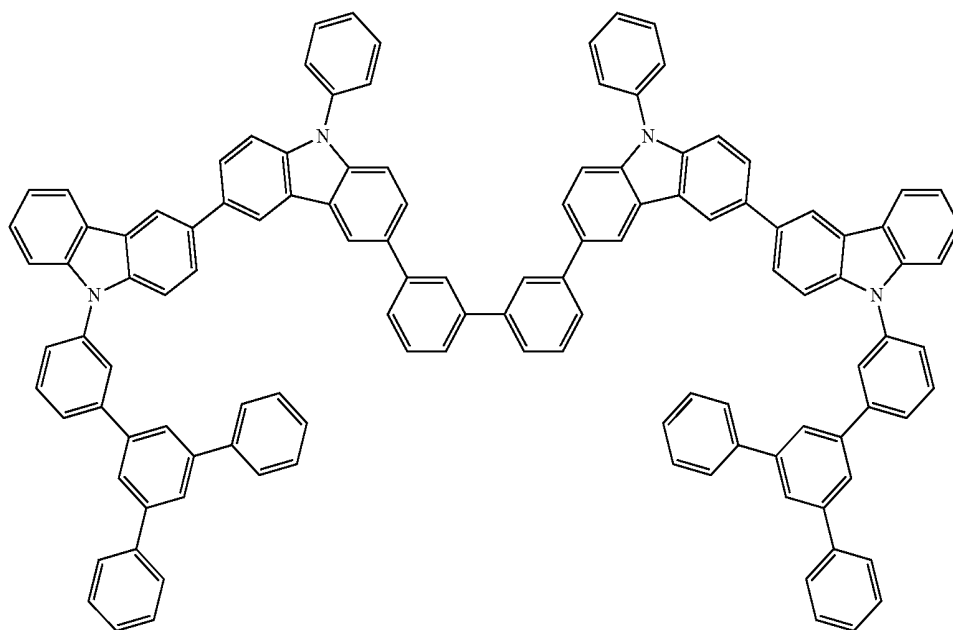


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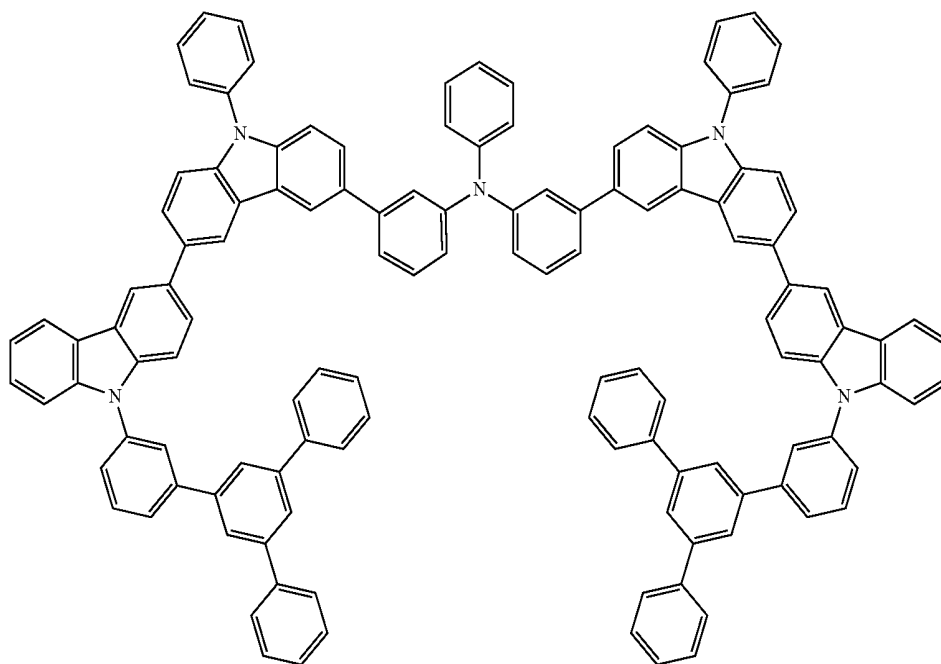
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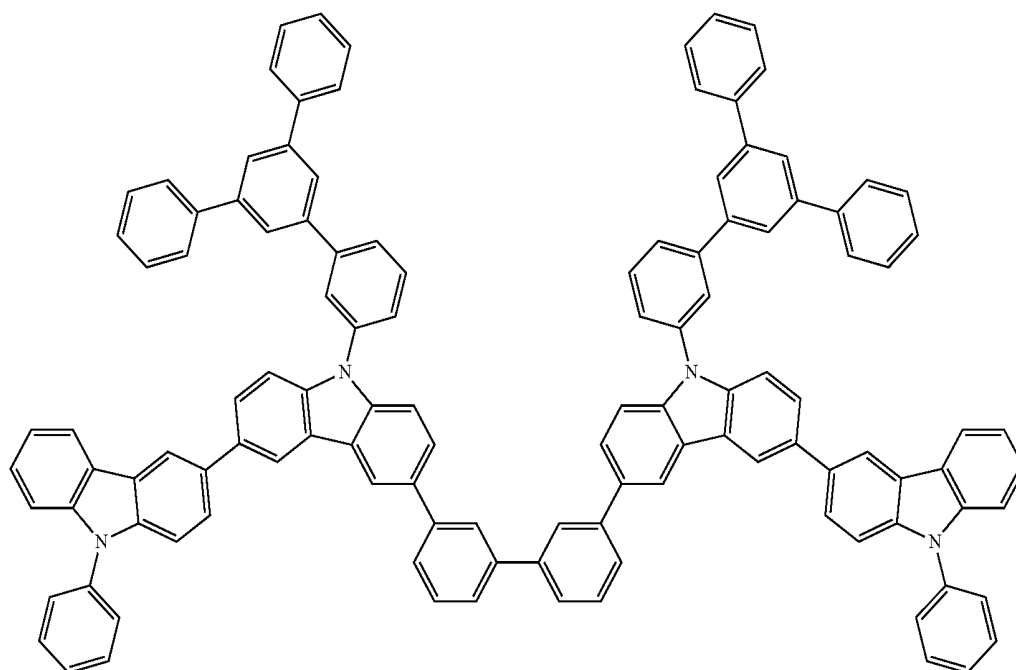
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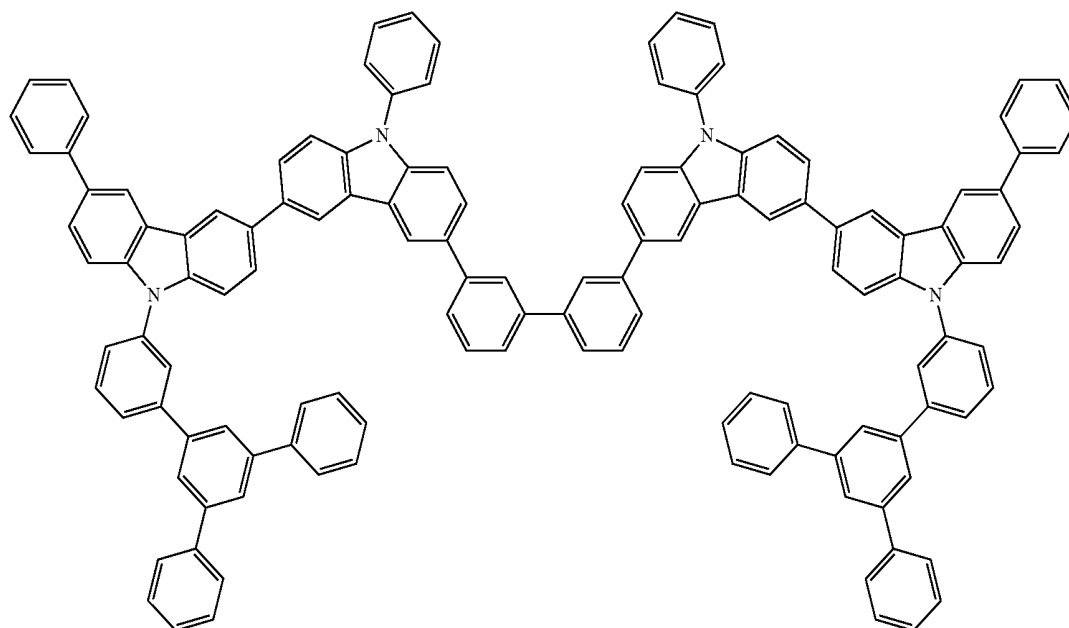


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The bicarbazole-containing compound represented by Formula (6) (for example, (6)-1) may have excellent thermal stability due to a relatively high glass transition temperature. Also, the bicarbazole-containing compound may also have a relatively high solubility to the solvent.

An amount ratio of the condensed cyclic compound represented by Formula (1) to the hole transport compound represented by Formula (6) among the materials for forming the organic light-emitting device may be in a range of 100:0 to 1:99, for example, 95:5 to 5:95. In one or more embodiments, an amount ratio of the condensed cyclic compound represented by Formula (1) to the hole transport compound represented by Formula (6) among the materials for forming the organic light-emitting device may be in a range of 80:20 to 20:80, for example, 70:30 to 30:70. While not wishing to be bound by theory, it is understood that when the amount ratio is within this range, effective balance between holes and electrons in the organic light-emitting device may be achieved.

When the material for forming the organic light-emitting device is a material for forming the emission layer, the material for forming the organic light-emitting device may further include a light-emitting material (for example, a phosphorescent dopant or a fluorescent dopant) to be described below.

3. Composition for Manufacturing Organic Light-Emitting Device

The composition for manufacturing the organic light-emitting device may be used for forming each layer of the organic light-emitting device through solution coating.

The composition for manufacturing the organic light-emitting device may include the condensed cyclic compound represented by Formula (1) and a liquid medium.

The liquid medium may be a liquid medium (for example, a solvent or the like) that dissolves the material for forming the organic light-emitting device as described above. That is, the composition for manufacturing the organic light-emitting device may be a solution composition.

Examples of the liquid medium may include toluene, xylene, ethylbenzene, diethylbenzene, mesitylene, propylbenzene, cyclohexylbenzene, dimethoxybenzene, anisole, ethoxy toluene, phenoxytoluene, iso-propylbiphenyl, dimethylanisole, phenyl acetate, a phenyl propionic acid, methyl benzoate, and ethyl benzoate, but embodiments of the present disclosure are not limited thereto.

In the composition for manufacturing the organic light-emitting device, a concentration of the material for forming the organic light-emitting device may be adjusted according to a purpose thereof.

4. Organic Light-Emitting Device

An organic light-emitting device **100** according to an embodiment will be described in connection with the FIGURE. The FIGURE is a schematic view of the organic light-emitting device **100** according to an embodiment.

The organic light-emitting device **100** illustrated in the FIGURE includes a substrate **110**, a first electrode **120** disposed on the substrate **110**, a hole injection layer **130** disposed on the first electrode **120**, a hole transport layer **140** disposed on the hole injection layer **130**, an emission layer **150** disposed on the hole transport layer **140**, an electron transport layer **160** disposed on the emission layer **150**, an electron injection layer **170** disposed on the electron transport layer **160**, and a second electrode **180** disposed on the electron injection layer **170**.

The condensed cyclic compound represented by Formula (1) may be included in any organic layer disposed between the first electrode **120** and the second electrode **180**. For example, the condensed cyclic compound may be included in the emission layer **150** as a host material.

The organic layer including the condensed cyclic compound represented by Formula (1) may be formed by vacuum deposition or solution coating. In one or more embodiments, the organic layer including the condensed cyclic compound may be formed by solution coating. The organic layer including the condensed cyclic compound may be formed by using solution coating, such as spin coating, casting, micro gravure coating, gravure coating, bar coating,

roll coating, wire bar coating, dip coating, spray coating, screen-printing, flexographic-printing, offset-printing, and ink-jet printing. The solvent used in solution coating may be selected from any solvents capable of dissolving the condensed cyclic compound represented by Formula (1).

Film-forming methods of forming layers other than the organic layer including the condensed cyclic compound represented by Formula (1) are not particularly limited. For example, a film may be formed by vacuum deposition or solution coating.

For use as the substrate **110**, any substrate that is used in general organic light-emitting devices may be used. For example, the substrate **110** may be a glass substrate, a semiconductor substrate such as a silicon substrate, or a transparent plastic substrate.

The first electrode **120** is disposed on the substrate **110**. The first electrode **120** may be an anode. A material for forming the first electrode **120** may be a material having a high work function, and such a material may be a metal, an alloy, or an electrically conductive compound. For example, the first electrode **120** may be a transmissive electrode using indium tin oxide (ITO) ($\text{In}_2\text{O}_3\text{—SnO}_2$), indium zinc oxide ($\text{In}_2\text{O}_3\text{—ZnO}$), tin oxide (SnO_2), or zinc oxide (ZnO), each having excellent transparent and electrically conductive properties. In one or more embodiments, the first electrode **120** may be a reflective electrode in which magnesium (Mg), aluminum (Al), or the like is additionally laminated on the transmissive electrode.

The hole injection layer **130** is disposed on the first electrode **120**. The hole injection layer **130** is a layer that facilitates hole injection from the first electrode **120** to the hole transport layer **140**. A thickness of the hole injection layer **130** may be in a range of about 10 nanometers (nm) to about 1,000 nm, for example, about 10 nm to about 500 nm, or for example, about 10 nm to about 100 nm.

The hole injection layer **130** may include a known hole injection material. Examples of the hole injection material may include poly(ether ketone)-containing triphenylamine (TPAPEK), 4-isopropyl-4"-methyltriphenylborate (PPBI), N,N"-diphenyl-N,N"-bis[4-(phenyl-m-tolyl-amino)-phenyl]-biphenyl-4,4"-diamine (DNTPD), copper phthalocyanine, 4,4",4"-tris(3-methylphenylphenylamino)triphenylamine (m-MTDATA), N,N"-di(1-naphthyl)-N,N"-diphenylbenzidine (NPB), 4,4",4"-tris(diphenylamino)triphenylamine (TDATA), 4,4",4"-tris(N,N-2-naphthylphenylamino)triphenylamine (2-TNATA), polyaniline/dodecylbenzene sulfonic acid, poly(3,4-ethylenedioxythiophene)/poly(4-styrene sulfonate) (PEDOT/PSS), and polyaniline/10-camphor sulfonic acid.

The hole transport layer **140** is disposed on the hole injection layer **130**. The hole transport layer **140** is a layer that transports holes to the emission layer **150**. A thickness of the hole transport layer **140** may be in a range of about 10 nm to about 150 nm, for example, about 10 nm to about 100 nm.

The hole transport layer **140** may include a known hole transport material. The hole transport material may be 1,1-bis[(di-4-tolylamino)phenyl]cyclohexene (TAPC), N-phenylcarbazole, polyvinylcarbazole, N,N"-bis(3-methylphenyl)-N,N"-diphenyl-[1,1-biphenyl]-4,4"-diamine (TPD), 4,4",4"-tris(N-carbazolyl)triphenylamine (TCTA), N,N"-di(1-naphthyl)-N,N"-diphenylbenzidine (NPB), or (poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(4,4'-(N-(4-sec-butylphenyl)diphenylamine))] (TFB).

The emission layer **150** is disposed on the hole transport layer **140**. The emission layer **150** is a layer that emits fluorescence and/or phosphorescence. The emission layer

150 may be formed using vacuum deposition, spin coating, and/or ink-jet printing. A thickness of the emission layer **150** may be in a range of about 10 nm to about 60 nm, for example, about 10 nm to about 50 nm, or for example, about 10 nm to about 40 nm. For use as the light-emitting material of the emission layer **150**, a known light-emitting material may be used. In one or more embodiments, the light-emitting material included in the emission layer **150** may be a light-emitting material (for example, a phosphorescent dopant) that may emit light (that is, phosphorescence) from triplet excitons. When the light-emitting material is a phosphorescent material, the light emission lifespan of the organic light-emitting device **100** may be further improved.

The emission layer **150** may be formed by solution coating using the condensed cyclic compound represented by Formula (1) as the material for forming the organic light-emitting device (for example, using a composition including the condensed cyclic compound represented by Formula (1) and a liquid medium). The use of solution coating may improve the light emission lifespan of the organic light-emitting device **100** and may achieve efficient film formation of the large-area emission layer **150** including the condensed cyclic compound.

In one or more embodiments, the emission layer **150** may include a host, and the host may include the condensed cyclic compound represented by Formula (1). The emission layer **150** may be formed by solution coating using a composition including the condensed cyclic compound represented by Formula (1) and the liquid medium.

In one or more embodiments, the emission layer **150** may include a host, and the host may include the condensed cyclic compound represented by Formula (1) and the hole transport compound represented by Formula (6) (for example, Formula (6)-1). The emission layer **150** may be formed by solution coating using a composition including the condensed cyclic compound represented by Formula (1), the hole transport compound represented by Formula (6) (for example, Formula (6)-1), and the liquid medium.

In one or more embodiments, the emission layer **150** may include a host and a dopant. The host may include the condensed cyclic compound represented by Formula (1), and the dopant may include a fluorescent dopant or a phosphorescent dopant (for example, a phosphorescent dopant). The emission layer **150** may be formed by solution coating using a composition including the condensed cyclic compound represented by Formula (1), the dopant, and the liquid medium.

In one or more embodiments, the emission layer **150** may include a host and a dopant. The host may include the condensed cyclic compound represented by Formula (1) and the hole transport compound represented by Formula (6) (for example, Formula (6)-1), and the dopant may include a fluorescent dopant or a phosphorescent dopant (for example, a phosphorescent dopant). The emission layer **150** may be formed by solution coating using a composition including the condensed cyclic compound represented by Formula (1), the hole transport compound represented by Formula (6) (for example, Formula (6)-1), the dopant, and the liquid medium.

In the embodiments, the host may include only one condensed cyclic compound represented by Formula (1), or may include two or more different condensed cyclic compounds represented by Formula (1). Various modifications may be made to the host. For example, the host may include i) only Compound 1-7 as the condensed cyclic compound represented by Formula (1) or ii) a mixture of Compounds 1-5 and 1-7 as the condensed cyclic compound represented by Formula (1).

When the composition for manufacturing the organic light-emitting device is formed in a certain region (for example, the emission layer **150**), a film may be formed by providing the composition on the hole transport layer **140** and removing at least a part of the liquid medium in the composition. The process of removing a part of the liquid medium may include a thermal treatment. The temperature and time of the thermal treatment may vary depending on a material included in the composition for manufacturing the organic light-emitting device.

When another organic layer of the organic light-emitting device **100** includes the condensed cyclic compound represented by Formula (1), the emission layer **150** may include a known material.

For example, the emission layer **150** may include, as the known host material, tris(8-quinolinato)aluminium (Alq_3), 4,4"-bis(carbazol-9-yl)biphenyl (CBP), poly(n-vinyl carbazole) (PVK), 9,10-di(naphthalene)anthracene (ADN), 4,4", 4"-tris(N-carbazolyl)triphenylamine (TCTA), 1,3,5-tris(N-phenyl-benzimidazol-2-yl)benzene (TPBI), 3-tert-butyl-9, 10-di(naphth-2-yl)anthracene (TBADN), distyrylarylene (DSA), or 4,4"-bis(9-carbazole) 2,2-dimethyl-biphenyl (dm-CBP).

The emission layer **150** may include, as the dopant material, a perylene and a derivative thereof, rubrene and a derivative thereof, coumarin and a derivative thereof, 4-dicyanomethylene-2-(p-dimethylaminostyryl)-6-methyl-4H-pyran (DCM) and a derivative thereof, an iridium (Ir) complex such as bis[2-(4,6-difluorophenyl)pyridinato]picolinate iridium (III) (Flrpic), bis(1-phenylisoquinoline) (acetylacetonate)iridium (III) ($\text{Ir}(\text{pic})_2(\text{acac})$), tris(2-phenylpyridine)iridium (III) ($\text{Ir}(\text{ppy})_3$), and tris (2-(3-p-xylyl) phenyl)pyridine iridium(III), an osmium (Os) complex, or a platinum complex.

Also, the emission layer **150** may include a quantum dot as the light-emitting material. The quantum dot may have a single core structure including Group II-VI semiconductors, Group III-V semiconductors, or Group IV-IV semiconductors, or a core/shell structure in which Group II-VI semiconductors are capped in the single core structure. A nanoparticle of the quantum dot may have a diameter of about 1 nm to about 20 nm, for example, about 1 nm to about 10 nm, but embodiments of the present disclosure are not limited thereto.

In the core or core/cap structure, the quantum dot corresponding to the core may use any type of semiconductor. For example, the Group II-VI semiconductors are a combination of at least one of Group IIB elements and at least one of group VIB elements in the periodic table. The Group II-VI semiconductors may be CdS, CdSe, CdTe, ZnSe, ZnS, PbS, PbSe, HgS, HgSe, HgTe, CdHgTe, or $\text{CdSe}_x\text{Te}_{1-x}$ (wherein x is a real number of $0 < x < 1$). Also, the group III-V semiconductors may be GaAs, InAs, or InP.

In the core/shell structure, the shell refers to a semiconductor quantum dot that is linked to a core semiconductor quantum dot to form a coating layer on a surface of a core semiconductor. Compared with the single core structure, the core/shell structure may obtain excellent light emission efficiency. The shell may have a band gap that is higher than that of the core semiconductor and may act as a passivation layer that protects the core semiconductor from the outside. The shell may include Group II-VI semiconductors having a high band gap. For example, the shell may include ZnS, CdS, or ZnSe. In the combination of these core/shell structures, when the core includes CdSe or CdS, the shell may

include ZnS, and when the core includes CdSe, the shell may include CdS or ZnSe. In this way, various combinations may be used without limitations.

An amount of the dopant may be in a range of about 0.01 parts to 20 parts by weight, for example, about 0.1 parts to 20 parts by weight, based on 100 parts by weight of the emission layer **150**. While not wishing to be bound by theory, it is understood that when the amount of the dopant is within this range, effective light emission may be achieved without concentration quenching.

The electron transport layer **160** is disposed on the emission layer **150**. The electron transport layer **160** is a layer that has an electron transport function. The electron transport layer **160** may be formed using vacuum deposition, spin coating, or ink-jet printing. The electron transport layer **160** may have a thickness of about 15 nm to about 80 nm, for example, about 30 nm to about 60 nm.

The electron transport layer **160** may include a known electron transport material. The electron transport material may be tris(8-quinolinato)aluminium (Alq_3), or a nitrogenous aromatic ring-containing compound. For example, the nitrogenous aromatic ring-containing compound may be a pyridine ring-containing compound such as 1,3,5-tri[(3-pyridyl)-phen-3-yl]benzene, a triazine ring-containing compound such as 2,4,6-tris(3"-(pyridin-3-yl)biphenyl-3-yl)-1, 3,5-triazine, or an imidazole ring-containing compound such as 2-(4-(N-phenylbenzimidazol-1-yl-phenyl)-9,10-dinaphthylanthracene).

The electron transport layer **160** may further include, in addition to the organic compounds described above, a metal-containing compound such as (8-quinolinato)lithium (Liq).

The electron injection layer **170** is disposed on the electron transport layer **160**. The electron injection layer **170** is a layer that has a function of facilitating injection of electrons from the second electrode **180**. The electron injection layer **170** may be formed using vacuum deposition or the like. The electron injection layer **170** may have a thickness of about 0.3 nm to about 9 nm, for example, about 1 nm to about 5 nm.

For use as the material for forming the electron injection layer **170**, a known electron injection material may be used. The electron injection material may be a lithium compound such as (8-quinolinato)lithium (Liq) and lithium fluoride (LiF), sodium chloride (NaCl), cesium fluoride (CsF), lithium oxide (Li_2O), or barium oxide (BaO), but embodiments of the present disclosure are not limited thereto.

The second electrode **180** is disposed on the electron injection layer **170**. The second electrode **180** may be a cathode. A material for forming the second electrode **180** may be a material having a low work function, and such a material may be a metal, an alloy, or an electrically conductive compound. For example, the second electrode **180** may be a reflective electrode using a metal such as lithium (Li), magnesium (Mg), aluminum (Al), and calcium (Ca), or an alloy using aluminum-lithium (Al—Li), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). Also, the second electrode **180** may be a transmissive electrode using a thin film including the metal material and having a thickness of about 20 nm or less, for example, about 10 nm or less, or a transparent, electrically conductive film such as ITO ($\text{In}_2\text{O}_3\text{—SnO}_2$) and IZO ($\text{In}_2\text{O}_3\text{—ZnO}$).

An embodiment of the organic light-emitting device **100** has been described in connection with the FIGURE. The organic light-emitting device **100** may have, due to inclusion of an organic layer including the condensed cyclic compound represented by Formula (1), an improved light emission lifespan.

The stacked structure of the organic light-emitting device **100** is not limited to the above-described embodiments. The organic light-emitting device **100** may have another known stacked structure. For example, at least one of the hole injection layer **130**, the hole transport layer **140**, the electron transport layer **160**, and the electron injection layer **170** in the organic light-emitting device **100** may be omitted, or another layer such as a resonant auxiliary layer, a buffer layer, a hole blocking layer, or an electron blocking layer may be added to the organic light-emitting device **100**. In this way, various modifications may be made thereto. Also, each layer of the organic light-emitting device **100** may be variously modified. For example, each layer of the organic light-emitting device **100** has a single layer or multiple layers.

For example, the organic light-emitting device **100** may further include a hole blocking layer between the emission layer **150** and the electron transport layer **160** so as to prevent excitons or holes from diffusing into the electron transport layer **160**. For example, the hole blocking layer may include an oxazole (oxadiazole) derivative, a triazole derivative, or a phenanthroline derivative.

The term “C₁-C₆₀ alkyl group” as used herein refers to a linear or branched saturated aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and non-limiting 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 the same structure as the C₁-C₆₀ alkyl group.

The term “C₁-C₆₀ alkoxy group” as used herein refers to a monovalent group represented by -OA₁₀₁ (wherein A₁₀₁ is the C₁-C₆₀ alkyl group), and non-limiting examples thereof include a methoxy group, an ethoxy group, and an isopropoxy (iso-propoxy) group.

The term “C₂-C₆₀ alkenyl group” as used herein refers to a hydrocarbon group formed by including at least one carbon-carbon double bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and 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 the same structure as the C₂-C₆₀ alkenyl group.

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

The term “C₃-C₁₀ cycloalkyl group” as used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and non-limiting 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 the same structure as the C₃-C₁₀ cycloalkyl group.

The term “C₁-C₁₀ heterocycloalkyl group” as used herein refers to a monovalent saturated monocyclic group having at least one heteroatom selected from N, O, P, Si and S as a ring-forming atom and 1 to 10 carbon atoms, and non-limiting examples thereof include a tetrahydrofuranlyl group and a tetrahydrothiophenyl group. The term “C₁-C₁₀ hetero-

cycloalkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkyl group.

The term “C₃-C₁₀ cycloalkenyl group” as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and which is not aromatic, and non-limiting 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 the same structure as the C₃-C₁₀ cycloalkenyl group.

The term “C₁-C₁₀ heterocycloalkenyl group” as used herein refers to a monovalent monocyclic group that has 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 carbon-carbon double bond in its ring. Examples of the C₂-C₁₀ heterocycloalkenyl group are a 2,3-dihydrofuranlyl group and a 2,3-dihydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkenyl group.

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, and 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. Non-limiting 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 the C₆-C₆₀ arylene group each include two or more rings, the rings may be fused to each other.

The term “C₁-C₆₀ heteroaryl group” as used herein refers to a monovalent group having a heterocyclic aromatic system that has 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 heterocyclic aromatic system that has at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom, and 1 to 60 carbon atoms. Non-limiting 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 two or more rings, the rings may be fused to each other.

The term “C₆-C₆₀ aryloxy group” as used herein refers to -OA₁₀₂ (wherein A₁₀₂ is the C₆-C₆₀ aryl group), and a C₆-C₆₀ arylthio group as used herein indicates -SA₁₀₃ (wherein A₁₀₃ is the C₆-C₆₀ aryl group).

The term “monovalent non-aromatic condensed polycyclic group” as used herein refers to a monovalent group having two or more rings condensed to each other, only carbon atoms (for example, the number of carbon atoms may be in a range of 8 to 60) as a ring-forming atom, and which is not aromatic in the entire molecular structure. Non-limiting examples of the monovalent 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 the same structure as the monovalent non-aromatic condensed polycyclic group.

The term “monovalent non-aromatic condensed heteropolycyclic group” as used herein refers to a monovalent group having two or more rings condensed to each other, a

heteroatom selected from N, O, P, Si, and S, other than carbon atoms (for example, the number of carbon atoms may be in a range of 2 to 60), as a ring-forming atom, and which is not aromatic in the entire molecular structure. Non-limiting 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 the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

At least one substituent of the substituted C₂-C₆₀ alkylene group, the substituted C₃-C₁₀ cycloalkylene group, the substituted C₁-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₁-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, 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, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, 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, —NCS, 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(Q₁₁)(Q₁₂), and —C(=O)(Q₁₁);

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(Q₂₁)(Q₂₂), and —C(=O)(Q₂₁); and

—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂)₃₂, and —C(=O)(Q₃₁);

wherein Q₁₁ to Q₁₃, Q₂₁ to Q₂₃, and Q₃₁ to Q₃₃ may each independently be selected from hydrogen, deuterium, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, and a diphenyldibenzothiophenyl group.

When a group containing a specified number of carbon atoms is substituted with any of the groups listed in the preceding paragraph, the number of carbon atoms in the resulting “substituted” group is defined as the sum of the carbon atoms contained in the original (unsubstituted) group and the carbon atoms (if any) contained in the substituent. For example, when the term “substituted C₁-C₃₀ alkyl” refers to a C₁-C₃₀ alkyl group substituted with C₆-C₃₀ aryl group, the total number of carbon atoms in the resulting aryl substituted alkyl group is C₇-C₆₀.

The term “biphenyl group” as used herein refers to a monovalent group in which two benzene groups are linked via a single bond.

The term “terphenyl group” as used herein refers to a monovalent group in which three benzene groups are linked via a single bond.

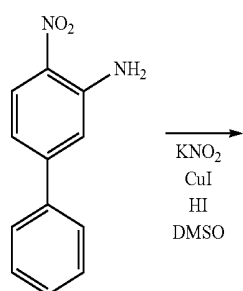
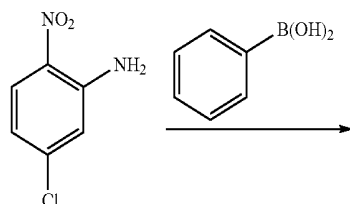
* and *[†] used herein, unless defined otherwise, each refers to a binding site to a neighboring atom in a corresponding formula.

Hereinafter, a compound and an organic light-emitting device according to embodiments are described in detail with reference to Synthesis Examples and Examples. However, the organic light-emitting device is not limited thereto. The wording “B was used instead of A” used in describing Synthesis Examples means that an amount of A used was identical to an amount of B used, in terms of a molar equivalent.

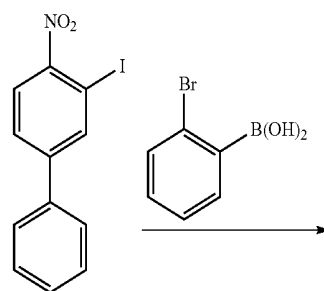
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EXAMPLE

1. Synthesis

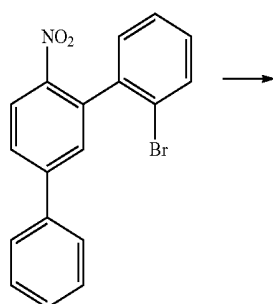
Synthesis Example 1: Synthesis of Compound 1-7



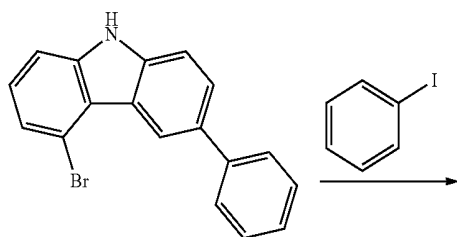
Intermediate a-1



Intermediate a-2



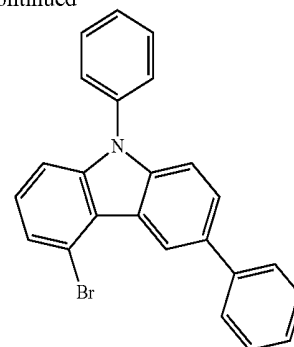
Intermediate a-3



Intermediate a-4

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-continued



Intermediate a

Synthesis of Intermediate a
(5-phenyl-2-nitroaniline)

190.10 grams (g) (1.10 moles, mol) of 5-chloro-2-nitroaniline, 161.05 g (1.32 mol, 1.2 equivalents, eq) of a phenylboronic acid, 2.2 liters (L) of 2 M potassium carbonate (aqueous solution, aq), and 2.2 L of toluene were stirred in a nitrogen atmosphere. The obtained resultant mixture was purged with nitrogen (N₂) for 20 minutes, 63.56 g (55 mmol, 0.05 eq) of tetrakis-triphenylphosphine palladium(0) was added thereto, and the mixture was heated under reflux for 6 hours. After the reaction was completed, the resultant obtained therefrom was cooled and 500 milliliters (mL) of water was added thereto. The extraction process was performed thereon three times by using 500 mL of toluene, and washing thereof was performed by using 500 mL of water and 500 mL of brine, each operation twice. Drying thereof was performed by using sodium sulfate. The resultant obtained therefrom was filtered and concentrated to obtain 410.2 g of a crude product. The crude product was dissolved in toluene. The resultant mixture was adsorbed on 800 g of amine modified silica gel in about twice amount (an eluent was ethyl acetate/toluene=1/5 (volume to volume, v/v)), and column purification was performed thereon in 2,870 g of amine modified silica gel 7 times, thereby completing the preparation of Intermediate a-1 (yellow solid) (synthesized amount: 210 g, yield: 89%, purity (GC): 98%).

Synthesis of Intermediate a-2
(3-Iodo-4-nitro-1,1'-biphenyl)

221.31 g (1.03 mol) of Intermediate a-1 (5-phenyl-2-nitroaniline), (185.3 g, 2.18 mol, 2.1 eq) of potassium nitrite (KNO₂), 187.0 g (0.982 mol, 1 eq) of copper iodide (I), and 2.5 L of dimethylsulfoxide (DMSO) were stirred in a nitrogen atmosphere. The resultant mixture obtained therefrom was heated to a temperature of 60° C., and 1,976 g (8.5 mol, 8.23 eq) of a 55% hydriodic acid was added by drops for 30 minutes. The resultant was then stirred at a temperature of 60° C. for 30 minutes and cooled by removing the heating source and ice cooling. The reaction was quenched by adding 3 L of an aqueous solution containing 1,078 g of potassium carbonate to the reactant. A separation process was performed thereon by adding 2.5 L of diethyl ether thereto. The extraction process was performed thereon four times by using 2.0 L of diethyl ether, and the washing thereof was performed by using 3.0 L of water, 3.0 L of a sodium thiosulfate aqueous solution, and 2.0 L of brine, each operation twice. Drying thereof was performed by using sodium

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sulfate. The resultant obtained therefrom was filtered and concentrated to obtain 312.1 g of a crude product. The crude product was dissolved in dichloromethane. The resultant mixture was adsorbed on 624 g of silica gel in about twice amount (an eluent=dichloromethane/hexane=1/10 (v/v)), and column purification was performed thereon by using 1,433 g of silica gel 5 times, thereby completing the preparation of Intermediate a-2 (yellow crystal) (synthesized amount: 292 g, yield: 85%, purity (GC): 98%).

Synthesis of Intermediate a-3 (2-bromo-6'-nitro-1,1':3',1-terphenyl)

20.0 g (61.43 mmol) of Intermediate a-2 (3-iodo-4-nitro-1,1"-biphenyl) and 12.8 g (6,373 mmol) of an o-bromophenyl boronic acid was dissolved in an N₂ bubbled toluene/DME mixture solvent (86 mL/86 mL), and 1.42 g (1.23 mmol) of tetrakis-triphenylphosphine palladium (0) and 86 mL of 2 M sodium carbonate (aq) were sequentially added thereto, and the mixture was heated under reflux for 10 hours. The resultant obtained therefrom was cooled to room temperature and an extraction process was performed thereon twice by using 150 mL of pure water and 200 mL of toluene. An organic layer obtained therefrom was washed by using 200 mL of brine, and dried by using sodium sulfate. The resultant was filtered and concentrated to obtain 23.2 g of a crude product. Column purification was performed on the crude product by using 700 g of silica gel (hexane/toluene (=1/1 (v/v)) eluent). The vacuum drying was performed thereon at a temperature of 40° C. for 16 hours, thereby completing the preparation of Intermediate a-3 (light yellow viscous liquid) (synthesized amount: 18.2 g, yield: 83%, purity (HPLC): 99.5%).

Synthesis of Intermediate a-4 (5-bromo-3-phenyl-9H-carbazole)

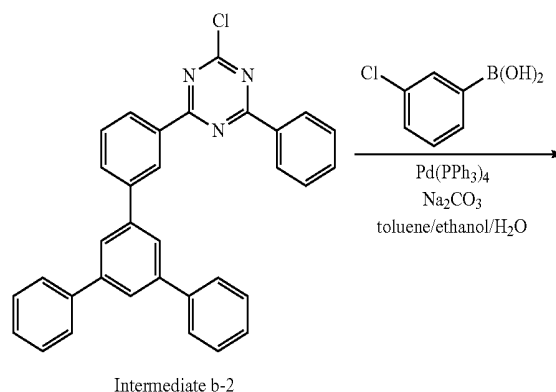
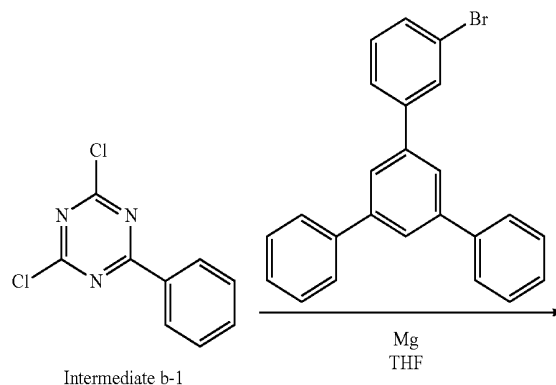
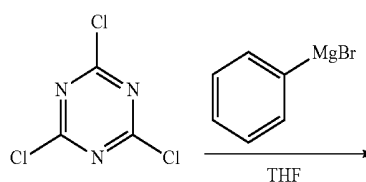
18.15 g (51.24 mmol) of Intermediate a-3 (2-bromo-6'-nitro-1,1":3",1-terphenyl) was dissolved in 110 mL of o-dichlorobenzene in an inert atmosphere, and 32.0 g (122.0 mmol) of triphenylphosphine was added thereto. The resultant mixture was stirred at a temperature of 180° C. for 20 hours. The outside temperature and pressure were adjusted to 80° C. and 1 Torr or less, and the solvent was removed to obtain 54.9 g of a viscous crude product. A mixed solution of hexane/toluene (=1/1 (v/v)) was added thereto to precipitate a target object. The target object was separated by filtration under reduced pressure and washed by using a mixed solution of hexane/toluene (=1/1 (v/v)). The filtrate obtained therefrom was concentrated to obtain 45.0 g of a crude product. The column purification was performed on the crude product by using 900 g of silica gel (hexane/toluene (=1/1 (v/v)) eluent), and a solvent was removed to obtain 14.1 g of a light yellow viscous liquid. 50 mL of hexane was added to the light yellow viscous liquid, and the resultant mixture was heated and stirred at a temperature of 60° C. A precipitate collected therefrom was dried under reduced pressure for 15 hours, thereby completing the preparation of Intermediate a-4 (light yellow solid) (synthesized amount: 13.5 g, yield: 81%, purity (HPLC): 99.1%).

Synthesis of Intermediate a (5-bromo-3,9-diphenyl-9H-carbazole)

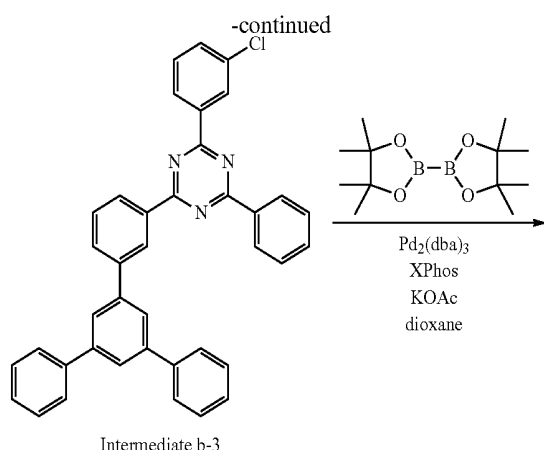
13.46 g (41.78 mmol) of Intermediate a-4 (5-bromo-3-phenyl-9H-carbazole) and 9.50 g (46.57 mmol) iodobenzene were mixed with 41 mL of 1,4-dioxane, and 0.40 g (2.09

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mmol) of CuI, 0.96 g (8.41 mmol) of trans-1,2-diaminocyclohexane, and 2.02 g (21.02 mmol) of tert-BuONa were sequentially added thereto. The resultant mixture was stirred at a temperature of 105° C. for 20 hours. The resultant mixture was cooled to room temperature, filtered under reduced pressure by using 10 g of celite, and washed by using dioxane. A solvent was removed from a filtrate obtained therefrom to thereby obtain 25.30 g of a crude product. The crude product was dissolved in dichloromethane and adsorbed on 100 g of silica gel, and the solvent was evaporated. Column purification was performed thereon by using 400 g of the adsorbed silica gel and a hexane/toluene (=1/1 (v/v)) eluent, the solvent was removed therefrom, and the residue was vacuum-dried, thereby completing the preparation of Intermediate a (colorless solid) (synthesized amount: 14.6 g, yield: 88%, purification (HPLC): 99.0%).



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Synthesis of Intermediate b-1 (2,4-dichloro-6-phenyl-1,3,5-triazine)

30.0 g (162.7 mmol) of a cyanuric acid was added to a 2-L round bottom flask and an atmosphere inside the flask was evacuated and purged with argon three times by using a vacuum pump. Then, 975 mL of dry toluene was added to the flask, and the resultant mixture was cooled to a temperature of 0° C. by using an ice bath. 29.5 g (162.3 mmol) of phenyl magnesium bromide and 54.2 mL of a dry diethyl ether solution were added by drops thereto in an argon atmosphere. A resultant obtained therefrom was gradually heated to room temperature and stirred for 2 hours. The reaction was quenched by using 200 mL of 6 normal (N) HCl (aq) at a temperature of 0° C., and an extraction process

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was performed thereon by using toluene. An organic layer collected therefrom was dried by using MgSO_4 and concentrated in vacuum to obtain a crude product. The crude product was dissolved in tetrahydrofuran (THF) and poured into 200 mL of excess methanol, and a reprecipitation process was repeated twice. A crude product obtained therefrom was dissolved in THF and poured into 100 mL of hexane. The resultant obtained by reprecipitation was vacuum-dried at a temperature of 40° C. for 5 hours, thereby completing the preparation of Intermediate b-1 (off-white solid) (synthesized amount: 33.4 g, yield: 60%, purity (HPLC): 98.7%).

Synthesis of Intermediate b-2 (2-chloro-4-phenyl-6-(5'-phenyl-[1,1':3',1''-terphenyl]-3-yl)-1,3,5-triazine)

1.83 g (75.3 mmol) of Mg was added to a 300-mL round bottom flask and the atmosphere inside the flask was ventilated with argon three times by using a vacuum pump. 30 mL of dry THF was added to the flask, and the resultant mixture was cooled to a temperature of -78° C. by using a dry ice ethanol bath. 29.0 g (75.3 mmol) of 3-bromo-5'-phenyl-1,1':3',1''-terphenyl and 166 mL of a dry THF solution were added by drops thereinto in an argon atmosphere. The resultant obtained therefrom was gradually heated to room temperature and stirred for 30 minutes. The resultant mixture was slowly added by drops into 196 mL of a dry THF solution containing 20.4 g (90.3 mmol) of 2,4-dichloro-6-phenyl-1,3,5-triazine at a temperature of 0° C. The resultant obtained therefrom was gradually heated to room temperature and stirred for 2 hours. After the reaction was finished at a temperature of 0° C., the reactant was extracted by using toluene. An organic layer obtained therefrom was dried by using Na_2SO_4 and the solvent was evaporated in vacuum. A crude product obtained therefrom was dissolved in THF and poured into excess methanol, and reprecipitation thereof was repeated twice. The resultant obtained therefrom was dried at a temperature of 40° C. in vacuum for 5 hours, thereby completing the preparation of Intermediate b-2 (off-white solid) (synthesized amount: 25.9 g, yield: 69%, purity (HPLC): 96.8%).

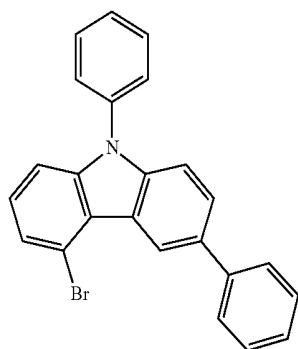
Synthesis of Intermediate b-3 (2-(3-chlorophenyl)-4-phenyl-6-(5'-phenyl-[1,1':3',1''-terphenyl]-3-yl)-1,3,5-triazine)

19.5 g (39.3 mmol) of Intermediate b-3, 6.15 g (39.3 mmol) of a (3-chlorophenyl)boronic acid, 0.91 g (0.79 mmol) of $\text{Pd}(\text{PPh}_3)_4$, and 12.5 g (118 mmol) of sodium carbonate were dissolved in 160 mL of toluene and mixed with 80 mL of ethanol and 160 mL of deionized water in a 500-mL round bottom flask. The obtained mixture was refluxed for 2 hours in an argon atmosphere. After the reaction, the resultant mixture was poured into 300 mL of pure water, a precipitate was filtered, and washing thereof was performed by using methanol. A crude solid obtained therefrom was dissolved in toluene and poured into excess methanol. The resultant obtained by reprecipitation was dried at a temperature of 40° C. in vacuum for 5 hours, thereby completing the preparation of Intermediate b-3 (synthesized amount: 21.0 g, yield: 93%, purity (HPLC): 97.1%).

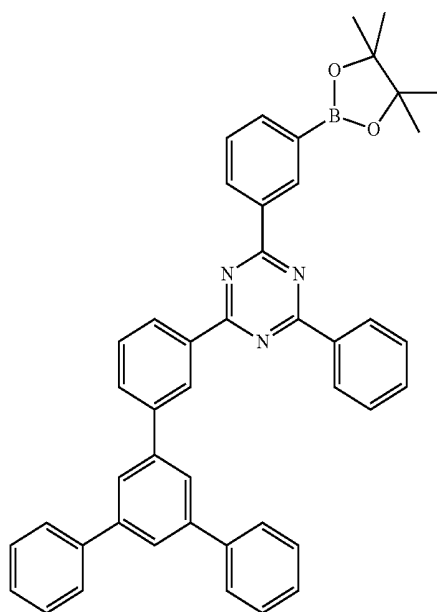
161

Synthesis of Intermediate b (2-phenyl-4-(5'-phenyl-[1,1':3',1''-terphenyl]-3-yl)-6-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-1,3,5-triazine)

20.0 g (35.0 mmol) of Intermediate b-3, 17.8 g (69.9 mmol) of bis-(pinacolate)-diboron, 1.60 g (1.75 mmol) of $\text{Pd}_2(\text{dba})_3$, 1.67 g (3.50 mmol) of XPhos, and 10.3 g (105 mmol) of potassium acetate were mixed with 350 mL of 1,4-dioxane in a round bottom flask, and the obtained mixture was refluxed in an argon atmosphere for 2 hours. After the reaction, the resultant mixture was filtered by using celite and concentrated by using a rotary evaporator. A crude product obtained therefrom was purified by Si-gel column chromatography (a toluene/hexane mixture was used as an eluent and a mixture ratio was gradually mixed from 1/4 to 1/0 (only toluene), thereby completing the preparation of Intermediate b (white solid) (synthesized amount: 18.0 g, yield: 78%, purity (HPLC): 99.9%).



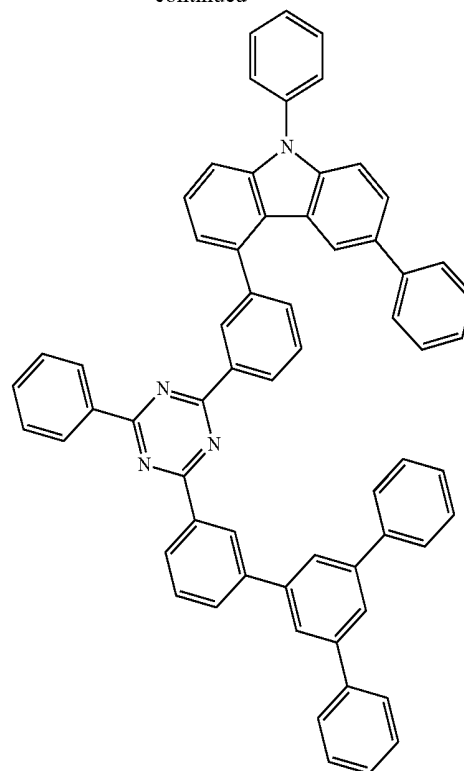
Intermediate a



Intermediate b

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-continued



Compound 1-7

Synthesis of Compound 1-7

In an argon atmosphere, 2.20 g (5.52 mmol) of Intermediate a, 3.30 g (4.97 mmol) of Intermediate b, 0.078 g (0.11 mmol) of dichlorobis(triphenylphosphine)dipalladium, 55 mL of dioxane, and 28 mL of a 0.5 N sodium carbonate aqueous solution were added to a reaction vessel, and the mixture was stirred at a temperature of 90° C. for 8 hours. After the reaction was completed, the resultant mixture was cooled to room temperature and filtered by using celite. An organic layer obtained therefrom was concentrated and purified by column chromatography, thereby completing the preparation of Compound 1-7 (synthesized amount: 2.97 g, yield: 69.9%) (the structure thereof was identified by LC-MS). A measurement of a glass transition temperature (Tg) was performed based on JIS K 7121 by using SII DSC6220 (manufactured by Seiko Instruments Inc.).

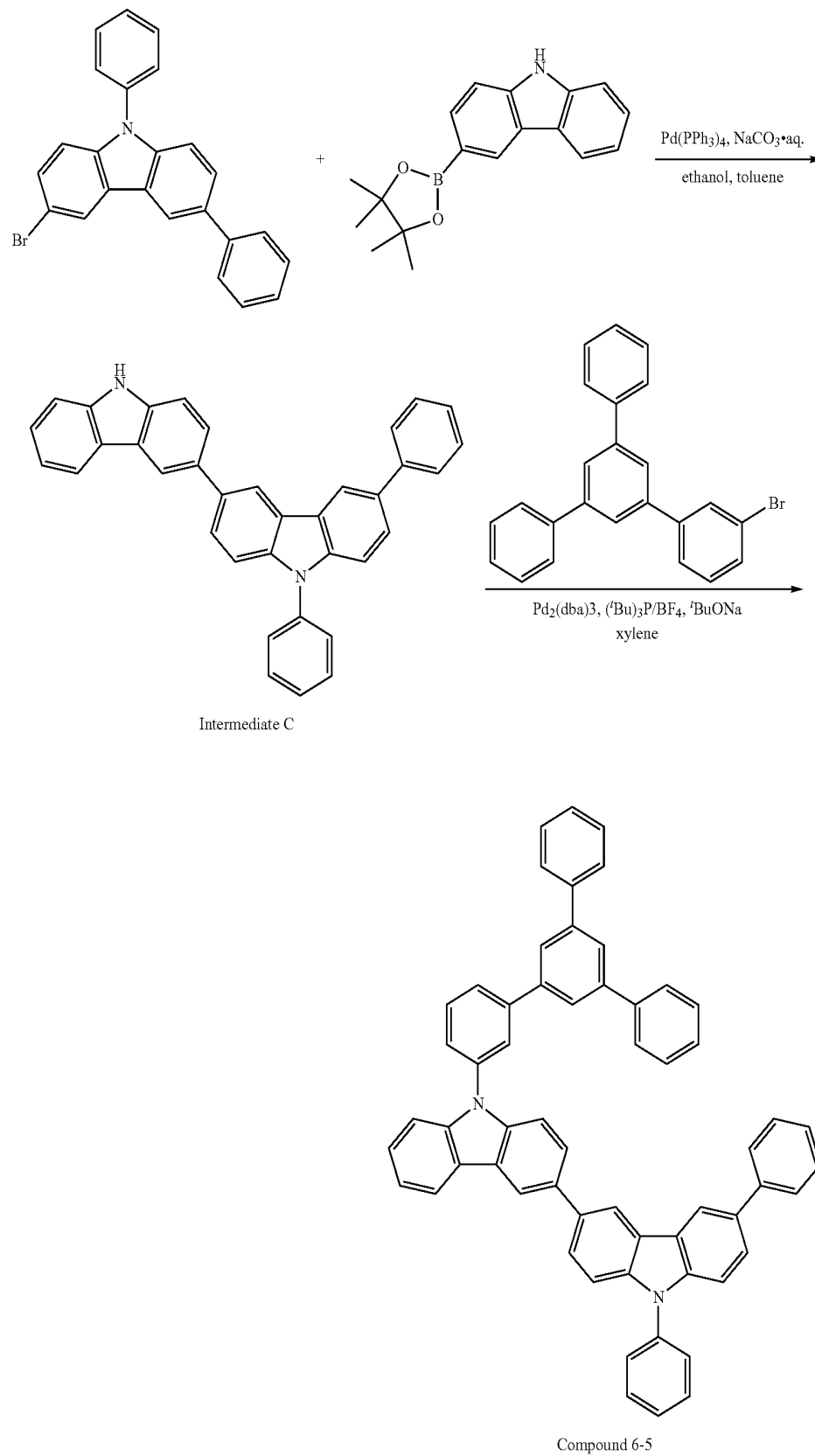
LC-MS, calcd for $\text{C}_{63}\text{H}_{42}\text{N}_4=855$, found $m/z=855$ ($\text{M}+\text{H}^+$).

Tg: 145.5° C.

Solubility (xylene)>10 wt %

Synthesis Example 2: Synthesis of Compound 6-5

Compound 6-5 was synthesized according to the Reaction Scheme below.



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Synthesis of Intermediate c

In an argon atmosphere, 6.8 g (17.1 mmol) of 3-bromo-6,9-diphenylcarbazole, 5.0 g (17.1 mmol) of 3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-9H-carbazole, 52 mL of toluene, 17 mL of ethanol, and 25 mL of a 2 N sodium carbonate aqueous solution (Na_2CO_3 aq.) were mixed and stirred. Then, 0.60 g (0.51 mmol) of tetrakis(triphenylphosphine) palladium ($\text{Pd}(\text{PPh}_3)_4$) was added thereto, and the reaction mixture was refluxed for 8 hours. After the reaction was completed, the resultant mixture was cooled to room temperature, extracted by using toluene/water, and purified by column chromatography, thereby completing the preparation of Intermediate c (synthesized amount: 3.0 g, yield: 36%).

Synthesis of Compound 6-5

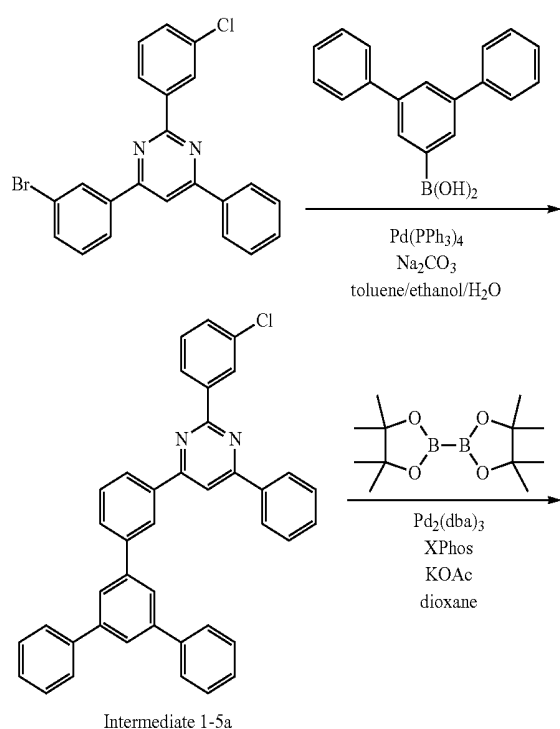
In an argon atmosphere, 3.0 g (6.19 mmol) of Intermediate c and 2.64 g (6.85 mmol) of 3-bromo-5"-phenyl-1,1":3",1"-terphenyl were mixed with 26 mL of dehydrated xylene. Then, 0.120 g (0.130 mmol) of tris(dibenzylideneacetone)dipalladium ($\text{Pd}_2(\text{dba})_3$), 0.150 g (0.520 mmol) of tri-tert-butylphosphine tetrafluoroborate ($(\text{tBu})_3\text{P}/\text{BF}_4$), and 0.90 g (9.37 mmol) of sodium-*t*-butoxide (tBuONa) were added thereto, and the reaction mixture was refluxed for 8 hours. The resultant mixture was cooled to room temperature, filtered by using celite, and extracted by using toluene and a saturated saline solution, and purified by column chromatography, thereby completing the preparation of Compound 6-5 (light yellow solid) (synthesized amount: 2.0 g, yield: 41%) (the structure thereof was identified by LC-MS).

LCMS, calcd for $\text{C}_{60}\text{H}_{40}\text{N}_2=789$, found $m/z=789$ ($\text{M}+\text{H}^+$).

Tg: 156.6° C.

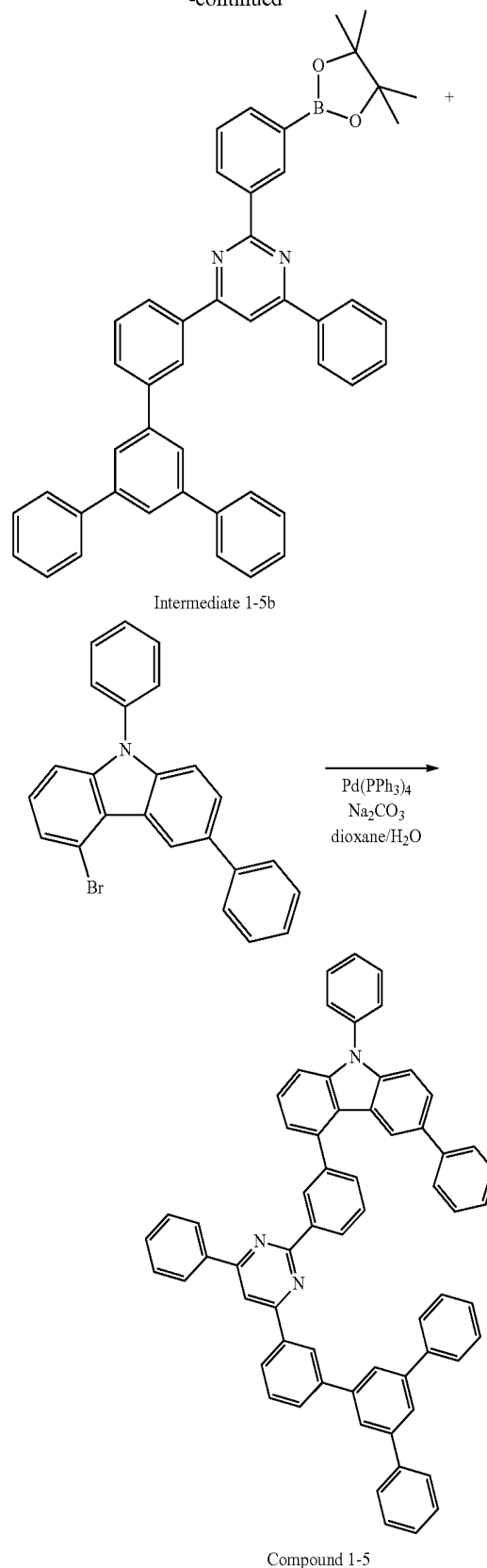
Solubility (xylene)>10 wt %

Synthesis Example 3: Synthesis of Compound 1-5



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-continued



Synthesis of Intermediate 1-5a

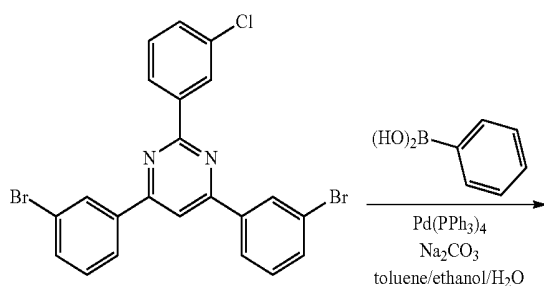
20.0 g (47.4 mmol) of 4-(3-bromophenyl)-2-(3-chlorophenyl)-6-phenylpyrimidine, 20.3 g (56.9 mmol) of a 5'-m-

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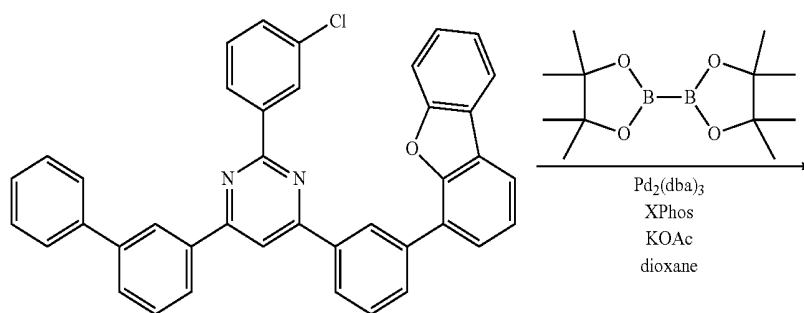
terphenyl boronic acid, 0.91 g (0.79 mmol) of $\text{Pd}(\text{PPh}_3)_4$, and 12.5 g (118 mmol) of sodium carbonate were dissolved in 160 mL of toluene, 250 mL of ethanol, and 200 mL of deionized water in a 200-mL round bottom flask, and the reaction mixture was refluxed for 3 hours in an argon atmosphere. After the reaction, the mixture was poured into 300 mL of pure water, a precipitate was filtered therefrom, and washing thereof was performed by using methanol. A crude solid obtained therefrom was dissolved in toluene, and excess methanol was poured thereinto. A resultant obtained by reprecipitation was dried at a temperature of 40° C. in vacuum for 5 hours, thereby completing the preparation of Intermediate 1-5a (white solid) (synthesized amount: 20.3 g, yield: 75%, purity (HPLC): 99.6%).

Synthesis of Intermediate 1-5b

Intermediate 1-5b (synthesized amount: 20.0 g, yield: 85%, purity (HPLC): 99.9%) was synthesized in the same



Intermediate 1-23a



Intermediate 1-23b

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manner as in Synthesis of Intermediate b of Synthesis Example 2, except that Intermediate 1-5a was used instead of Intermediate b-3.

Synthesis of Compound 1-5

Compound 1-5 (synthesized amount: 3.3 g, yield: 40%, purity (HPLC): 99.95%) was synthesized in the same manner as in Synthesis of Compound 1-7 of Synthesis Example 1, except that Intermediate 1-5b was used instead of Intermediate b.

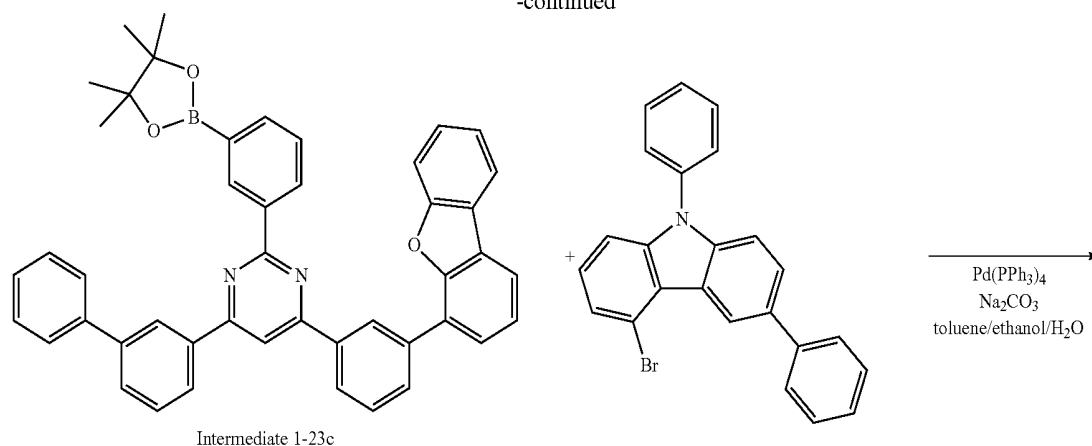
LCMS, calcd for $\text{C}_{64}\text{H}_{43}\text{N}_3$ =854.07, found m/z =854.3 ($\text{M}+\text{H}^+$).

Synthesis Example 4: Synthesis of Compound 1-23

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-continued



Synthesis of Intermediate 1-23a

Intermediate 1-23a (synthesized amount: 25.1 g, yield: 70%, purity (HPLC): 99.0%) was synthesized in the same manner as in Synthesis of Intermediate 1-5a of Synthesis Example 3, except that 4,6-bis(3-bromophenyl)-2-(3-chlorophenyl)pyrimidine and a phenyl boronic acid were each used instead of 4-(3-bromophenyl)-2-(3-chlorophenyl)-6-phenylpyrimidine and a 5'-m-terphenylboronic acid.

Synthesis of Intermediate 1-23b

Intermediate 1-23b (synthesized amount: 20.3 g, yield: 84%, purity (HPLC): 99.6%) was synthesized in the same manner as in Synthesis of Intermediate 1-5a of Synthesis Example 3, except that Intermediate 1-23a and a dibenzo-

50 furane-4-boronic acid were each used instead of 4-(3-bromophenyl)-2-(3-chlorophenyl)-6-phenylpyrimidine and a 5'-m-terphenylboronic acid.

Synthesis of Intermediate 1-23c

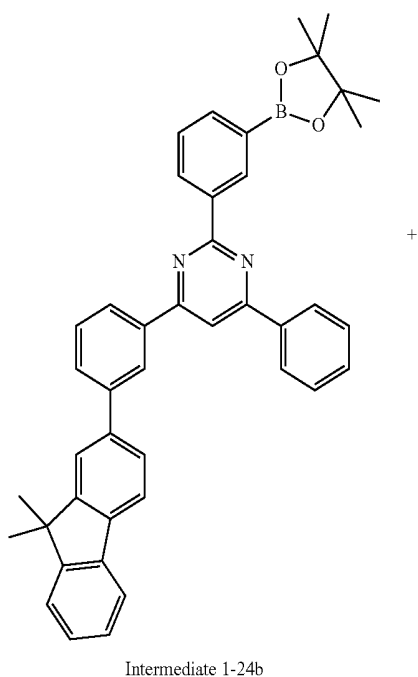
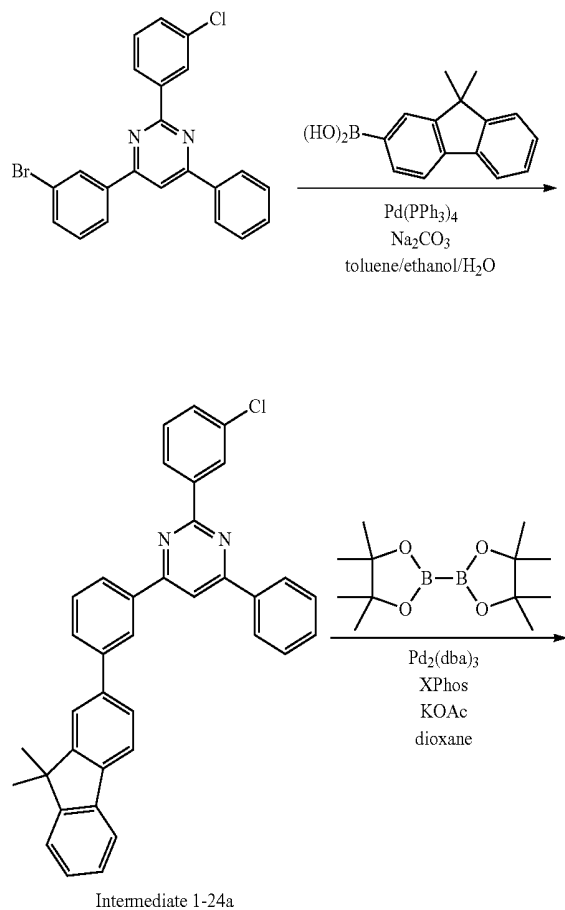
55 Intermediate 1-23c (synthesized amount: 15.0 g, yield: 85%, purity (HPLC): 99.9%) was synthesized in the same manner as in Synthesis of Intermediate b of Synthesis Example 2, except that Intermediate 1-23b was used instead of Intermediate b-3.

Synthesis of Compound 1-23

60 Compound 1-23 (synthesized amount: 8.0 g, yield: 64%, purity (HPLC): 99.94%) was synthesized in the same manner as in Synthesis of Compound 1-7 of Synthesis Example 1, except that Intermediate 1-23c was used instead of Intermediate b.

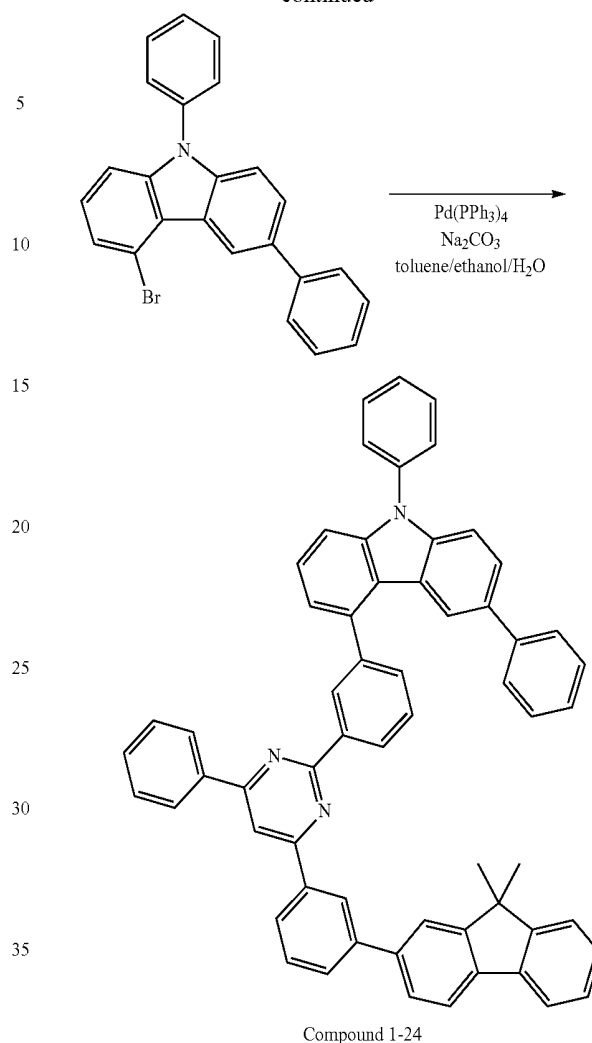
171

Synthesis Example 5: Synthesis of Compound 1-24



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-continued



Synthesis of Intermediate 1-24a

Intermediate 1-23b (synthesized amount: 20.30 g, yield: 75%, purity (HPLC): 99.6%) was synthesized in the same manner as in Synthesis of Intermediate 1-5a of Synthesis Example 3, except that a 9,9"-dimethylfluorene-3-boronic acid was used instead of the 5'-m-terphenylboronic acid.

Synthesis of Intermediate 1-24b

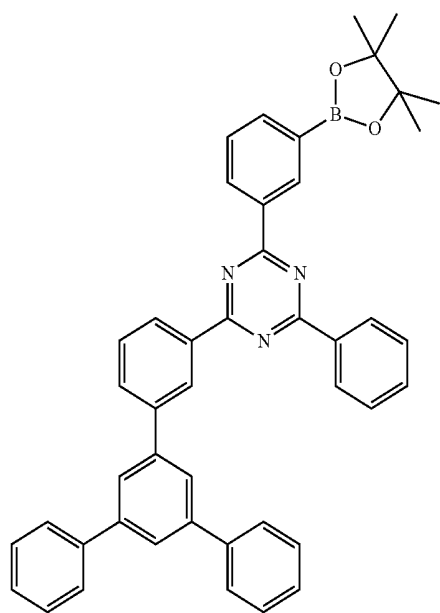
Intermediate 1-24b (synthesized amount: 23.89 g, yield: 85%, purity (HPLC): 99.9%) was synthesized in the same manner as in Synthesis of Intermediate b of Synthesis Example 2, except that Intermediate 1-24a was used instead of Intermediate b-3.

Synthesis of Compound 1-24

Compound 1-24 (synthesized amount: 8.02 g, yield: 72%, purity (HPLC): 99.92%) was synthesized in the same manner as in Synthesis of Compound 1-7 of Synthesis Example 1, except that Intermediate 1-24b was used instead of Intermediate b.

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Synthesis Example 6: Synthesis of Compound 1-79

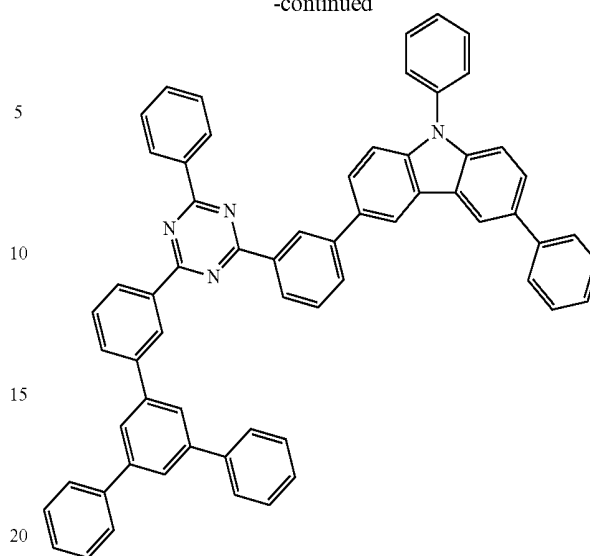


Intermediate b

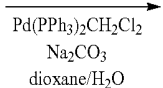
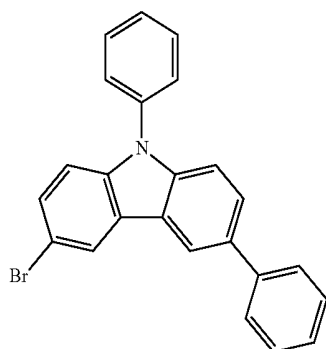
+

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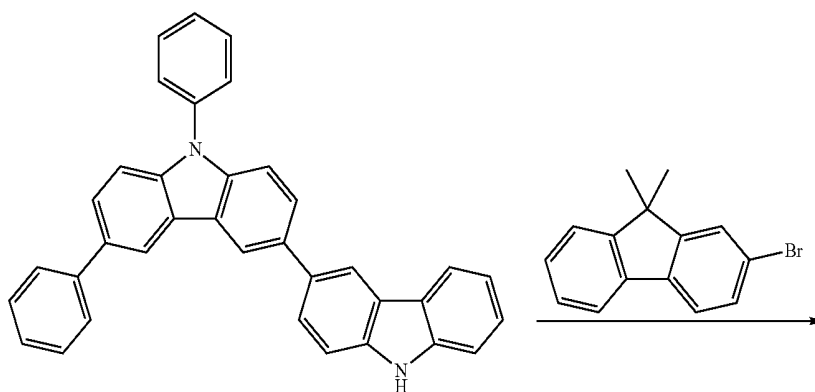
Compound 1-79



Compound 1-79 (synthesized amount: 3.0 g, yield: 68%, purity (HPLC): 99.97%) was synthesized in the same manner as in Synthesis of Compound 1-7 of Synthesis Example 1, except that 3-bromo-6,9-diphenyl-9H-carbazole was used instead of Intermediate a.

LCMS, calcd for $\text{C}_{63}\text{H}_{42}\text{N}_4$ =855.06, found m/z =855.3 ($\text{M}+\text{H}^+$).

Synthesis Example 7: Synthesis of Compound 6-12

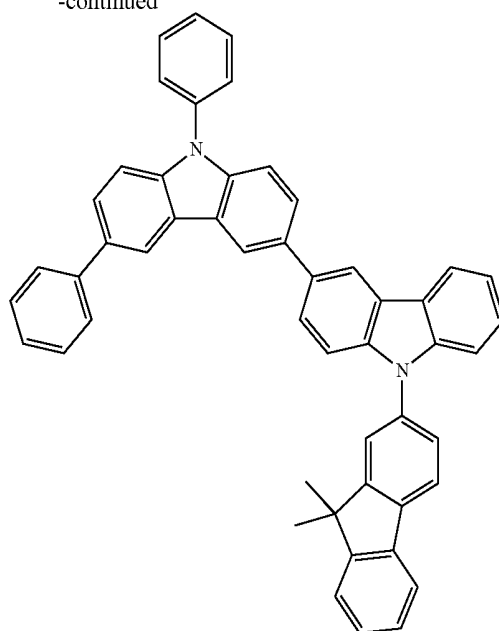


Intermediate C

175

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-continued



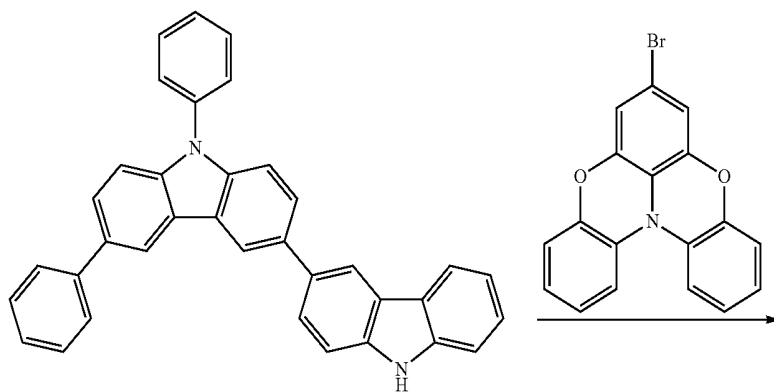
Compound 6-12

Compound 6-12 (synthesized amount: 1.19 g, yield: 43%,
 purity (HPLC): 99.89%) was synthesized in the same man-
 ner as in Synthesis of Compound 6-5 of Synthesis Example
 2, except that 2-bromo-9,9"-dimethylfluorene was used
 instead of 3-bromo-5"-phenyl-1,1":3",1"-terphenyl.

40

LCMS, calcd for $C_{51}H_{53}N_2=676.86$, found $m/z=677.3$
 ($M+H^+$).

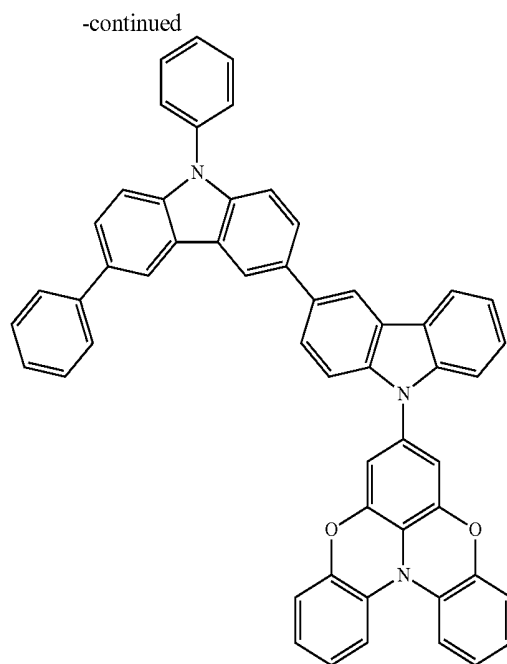
Synthesis Example 8: Synthesis of Compound 6-31



Intermediate C

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Compound 6-31

Compound 6-31 (synthesized amount: 1.0 g, yield: 55%, purity (HPLC): 99.93%) was synthesized in the same manner as in Synthesis of Compound 6-5 of Synthesis Example 2, except that 7-bromobenzo[5,6][1,4]oxazino[2,3,4-kl]phenoxazine was used instead of 3-bromo-5"-phenyl-1,1":3", 1"-terphenyl.

2. Manufacture of Organic Light-Emitting Device

An organic light-emitting device was manufactured by the following processes.

Example 1

Poly(3,4-ethylene dioxothiophene)/poly(4-styrene sulfonate) (PEDOT/PSS) (manufactured by Sigma-Aldrich) were spin-coated on an ITO glass substrate, on which a stripe type ITO layer as a first electrode (anode) was deposited to a thickness of 150 nanometers (nm), and then dried to form a hole injection layer having a thickness of 30 nm.

A mixture containing 1 wt % of poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(4,4'-(N-(4-sec-butylphenyl)diphenylamine)] (TFB) (manufactured by Sigma-Aldrich) in xylene was spin-coated on the hole injection layer and dried, and then, a thermal treatment was performed at a temperature of 230° C. for 1 hour to form a hole transport layer having a thickness of 30 nm.

A mixture containing Compounds 1-7 and 6-5 (host) and tris(2-(3-p-xylyl)phenyl)pyridine iridium (III) (dopant) in toluene was spin-coated on the hole transport layer, and then, dried to form an emission layer having a thickness of 30 nm. A weight ratio of Compound 1-7 to Compound 6-5 was 3:7, and an amount of tris(2-(3-p-xylyl)phenyl)pyridine iridium (III) was 10 wt % based on 100 wt % of the emission layer.

(8-quinolate)lithium (Liq) and KLET-03 (available from Chemi-pro) were co-deposited on the emission layer in a vacuum deposition apparatus to form an electron transport layer having a thickness of 50 nm, lithium fluoride (LiF) was deposited on the electron transport layer in a vacuum deposition apparatus to form an electron injection layer having a thickness of 1 nm, and aluminum (Al) was deposited on the electron injection layer in a vacuum deposition apparatus to form a second electrode (cathode) having a thickness of 100 nm, thereby completing the manufacture of an organic light-emitting device.

Example 2

An organic light-emitting device of Example 2 was manufactured in the same manner as in Example 1, except that only Compound 1-7 was used as a host material, without using Compound 6-5.

Examples 3 and 4

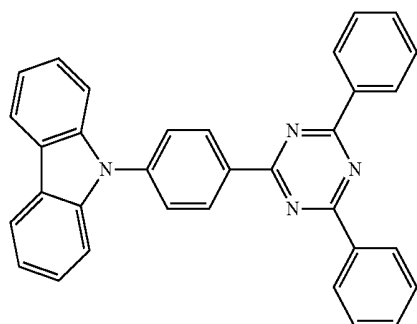
Organic light-emitting devices of Examples 3 and 4 were manufactured in the same manner as in Example 1, except that Compounds 6-12 and 6-31 were each used instead of Compound 6-5 as a host material.

Comparative Example 1

An organic light-emitting device of Comparative Example 1 was manufactured in the same manner as in Example 1, except that Compounds h-1 and CBP were each used instead of Compounds 1-7 and 6-5 as a host material. Compound h-1 in Table 1 is as follows. Letters described in the materials for the host in Table 1 refer to the numbered Compounds described above.

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Compound h-1



3. Evaluation Results

A. Evaluation of Film-Forming Property

A TBF layer was formed on an ITO glass substrate, on which an ITO layer was deposited to a thickness of 150 nm, in the same manner as in Example 1. Then, a mixture containing 1 wt % of Compounds 1-7 and 6-5 in xylene (weight ratio of Compound 1-7 to Compound 6-5=3:7) was spin-coated on the TBF layer and dried to form a laminated film having a thickness of 30 nm.

The laminated film was thermally treated at a temperature of 125° C. Then, the surface of the laminated film was observed through an optical microscope and the surface state of the laminated film was evaluated based on the following criteria.

○: a uniform state having no defect

Δ: a state in which several dark spots are observed, but a device can be manufactured

X: a state in which continuity of a film cannot be secured and a device cannot be manufactured

B. Evaluation of Organic Light-Emitting Device

The current efficiency and light emission lifespan of the organic light-emitting devices manufactured according to Examples 1 to 4 and Comparative Example 1 were evaluated by the following methods.

Each of the organic light-emitting devices was turned on to emit light by applying a certain voltage thereto by using a DC constant voltage power supply (source meter manufactured by KEYENCE). While the light emission of the organic light-emitting device was measured by a luminance meter (SR-3 manufactured by Topcom), a current gradually increased and a current density was measured when luminance was 6,000 candelas per square meter (cd/m²) and current efficiency was calculated from the current density measured when the current was left constant.

Also, the light emission lifespan (T₈₀) indicates an amount of time that lapsed when luminance measured by a luminance meter gradually decreased and was 80% of initial luminance (100%).

Evaluation results are shown in Table 1. The current efficiency and light emission lifespan in Table 1 are relative values when a current efficiency value and a light emission lifespan value of Comparative Example 1 are assumed to be 100.

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TABLE 1

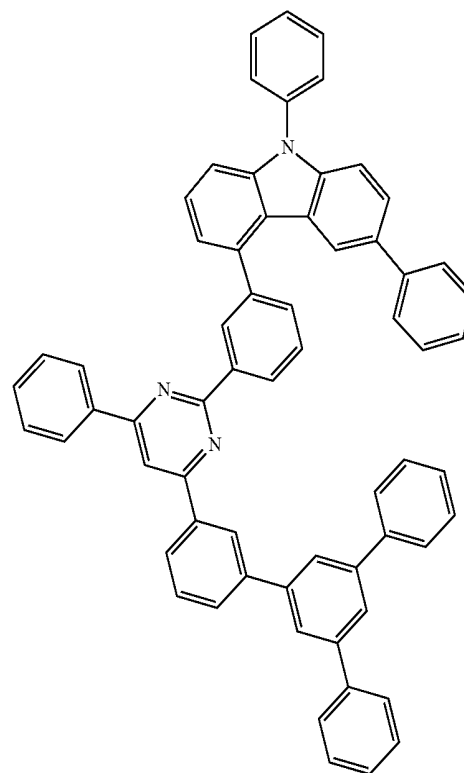
	Host material	Film-forming property	Current efficiency	Light emission lifespan (T ₈₀) (at 6,000 cd/m ²)
5				
Example 1	1-7:6-5	○	150	260
Example 2	1-7	○	130	180
Example 3	1-7:6-12	○	148	280
Example 4	1-7:6-31	○	153	195
Comparative Example 1	h-1:CBP	Δ	100	100

From the results shown in Table 1, it may be confirmed that the organic light-emitting devices of Examples 1 to 4, which each include the compound represented by Formula (1) as the host material, have equal or higher current efficiency and have a considerably improved light emission lifespan, compared to those of Comparative Example 1. Also, it may be confirmed that, since Compound 1-7 has a glass transition temperature (T_g) of 125° C. or higher and is soluble in a hydrocarbon-based solvent such as toluene or xylene, the compound represented by Formula (1) is suitable as a material for forming an organic light-emitting device for solution coating.

4. Measurement of Glass Transition Temperature and Measurement of Solubility

Examples 5 to 8

The glass transition temperature (T_g) and solubility of Compounds 1-5, 1-23, 1-24, and 1-79 were measured. In measuring the solubility, xylene was used as a solvent. The glass transition temperature (T_g) and solubility of each compound is written under each compound number.

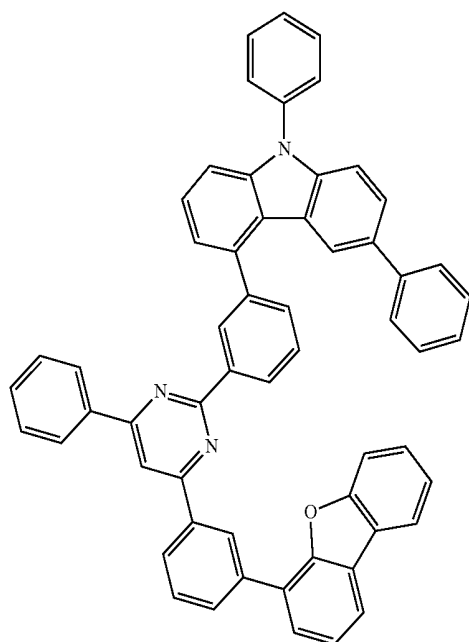


T_g = 143° C.
> 10wt%

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-continued

1-23

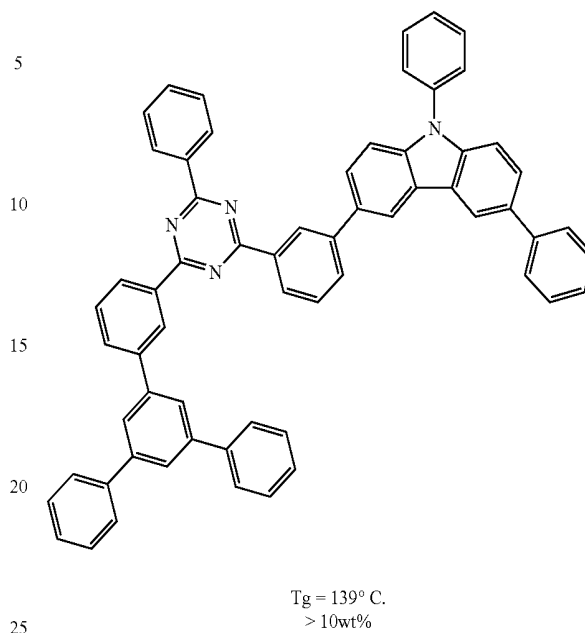


T_g = 137° C.
> 10wt%

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-continued

1-79



T_g = 139° C.
> 10wt%

From the above, it may be confirmed that Compounds 1-5, 1-23, 1-24, and 1-79 have excellent heat resistance and solubility, and thus, are suitable as a material for forming an organic light-emitting device for solution coating.

By using the condensed cyclic compound described above, the thermal stability of the organic layer may be improved, and thus, the light emission lifespan of the organic light-emitting device may be improved.

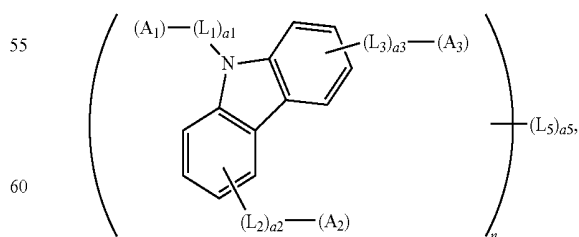
It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

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 disclosure as defined by the following claims.

What is claimed is:

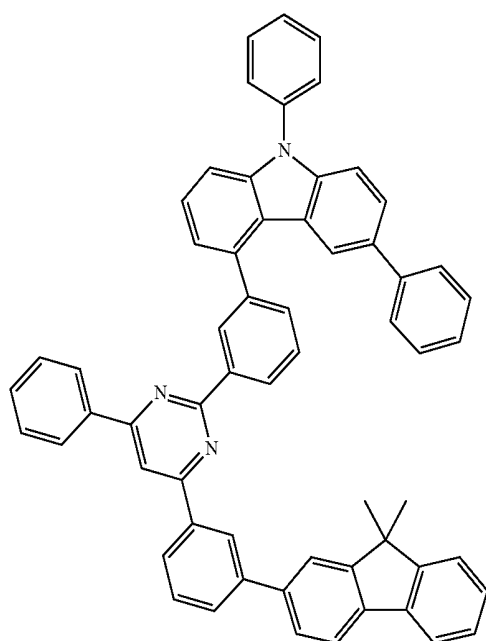
1. A condensed cyclic compound represented by Formula (1):

Formula (1)



wherein, in Formula (1),

L₁ to L₃ are each independently selected from a single bond, a substituted or unsubstituted C₂-C₆₀ alkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl-



T_g = 144° C.
> 10wt%

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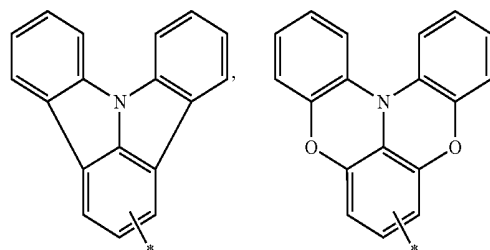
lene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

L₅ is selected from:

a single bond, *—C(=O)—*, *—C(=S)—*, and *—N(R₅)—*;

a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a triazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a furanylene group, a thienylene group, an oxazolylene group, an isoxazolylene group, a thiazolylene group, an isothiazolylene group, an oxadiazolylene group, an isoxadiazolylene group, a thiadiazolylene group, an isothiadiazolylene group, a pyrenylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoxazolylene group, a benzothiazolylene group, a benzimidazolylene group, an isoindolylene group, an indolylene group, a benzofuranylene group, a benzothienophenylene group, a benzocarbazolylene group, a naphthobenzofuranylene group, a naphthobenzothienophenylene group, an imidazopyrimidinylene group, and an imidazopyridinylene group, each unsubstituted or substituted with at least one selected from deuterium, —F, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,

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—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁), and

* and *' each indicate a binding site to a neighboring atom,

a1 to a3 and a5 are each independently an integer selected from 1 to 10,

(L₅)_{a5} is an n-valent linking group or a single bond, wherein n is a natural number greater than or equal to one,

when n is one, (L₅)_{a5} does not exist,

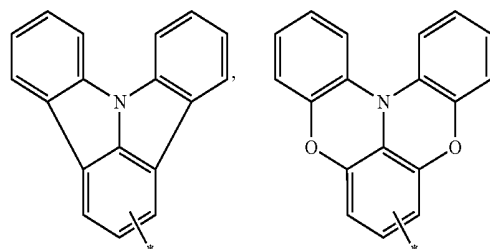
when n is a natural number greater than or equal to two, at least one of *(L₁)_{a1}-(A₁), *(L₂)_{a2}-(A₂), and *(L₃)_{a3}-(A₃) is linked to (L₅)_{a5} or is a single bond linked to (L₅)_{a5},

i) A₁ to A₃ and R₅ are each independently linked to (L₅)_{a5};

ii) A₁ to A₃ and R₅ are each independently a single bond linked to (L₅)_{a5};

iii) A₁ to A₃ and R₅ are each independently a group represented by one of Formulae (2) to (5); or

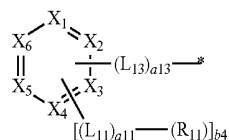
iv) A₁ to A₃ and R₅ are each independently selected from a phenyl group, an indenyl group, a naphthyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a furanyl group, a thienyl group, an isoindolyl group, an indolyl group, a benzofuranyl group, a benzothiophenyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, and a naphthobenzothiophenyl group, each unsubstituted or substituted with at least one selected from deuterium, —CD₃, —CD₂H, —CDH₂, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group,



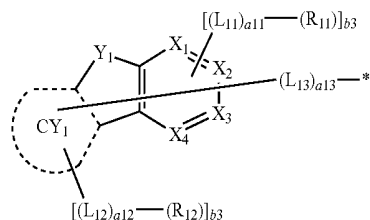
a group represented by *(L₂)_{a2}-(A₂) is linked to a third or fourth carbon of a carbazole core of Formula (1), a group represented by *(L₃)_{a3}-(A₃) is linked to a fifth or sixth carbon of the carbazole core of Formula (1), and * in the group represented by *(L₂)_{a2}-(A₂) and the group represented by *(L₃)_{a3}-(A₃) indicates a binding site to a carbon atom of the carbazole core of Formula (1), and

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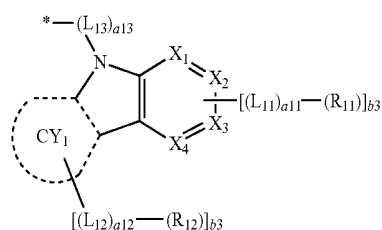
provided that, A₂ is a group represented by one of Formulae (2) to (5) and A₃ is not a group represented by one of Formulae (3) and (4):



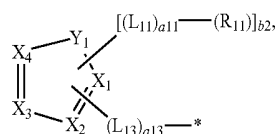
Formula (2)



Formula (3)



Formula (4)



Formula (5)

wherein, in Formulae (2) to (5),

X₁ is N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L₁₃, X₂ is N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L₁₃, X₃ is N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L₁₃, X₄ is N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L₁₃, X₅ is N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L₁₃, X₆ is N, carbon linked to $^{*}-(L_{11})_{a11}-(R_{11})$, or carbon linked to L₁₃, provided that X₁ to X₄ in Formula (4) are not carbon linked to L₁₃, Y₁ is O, S, N(R₁₃), or C(R₁₄)(R₁₅), and R₁₄ and R₁₅ are optionally linked to form a saturated or unsaturated ring,

CY₁ is a C₅-C₃₀ carbocyclic group or a C₂-C₃₀ heterocyclic group,

at least one of X₁ to X₆ in Formula (2) is N,

in Formulae (3) and (4), at least one of X₁ to X₄ is N, or CY₁ is a π electron-depleted nitrogen-containing C₂-C₃₀ heterocyclic group,

at least one of X₁ to X₄ in Formula (5) is N,

L₁₁ to L₁₃ are each independently selected from a single bond, a substituted or unsubstituted C₁-C₆₀ alkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

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a11 to a13 are each independently an integer selected from 1 to 10,

R₁₁ to R₁₅ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, 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(Q₁)(Q₂), and —C(=O)(Q₁), provided that R₁₁ in Formula (2) is selected from 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,

b2 is an integer from 0 to 2,

b3 is an integer from 0 to 3,

b4 is an integer from 01 to 4,

indicates a binding site to a neighboring atom, and

wherein the group represented by $^{*}-(L_{2})_{a2}-(A_2)$ and the group represented by $^{*}-(L_{3})_{a3}-(A_3)$ are linked to the carbazole core, such that a linking position of the group represented by $^{*}-(L_{2})_{a2}-(A_2)$ and the carbazole core is asymmetric to a linking position of the group represented by $^{*}-(L_{3})_{a3}-(A_3)$ and the carbazole core with respect to a reverse central axis passing through a nitrogen atom of the carbazole core of Formula (1), and at least one substituent of the substituted C₂-C₆₀ alkylene group, the substituted C₃-C₁₀ cycloalkylene group, the substituted C₁-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₁-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, 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 substi-

tuted 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 in Formulae (1) to (5) is selected from:

deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, 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, —NCS, 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(Q₁₁)(Q₁₂), and —C(=O)(Q₁₁);

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(Q₂₁)(Q₂₂), and —C(=O)(Q₂₁); and

—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁),

wherein Q₁ to Q₃, Q₁₁ to Q₁₃, Q₂₁ to Q₂₃, and Q₃₁ to Q₃₃ are each independently selected from hydrogen, deuterium, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a

phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuran group, a phenyldibenzofuran group, a diphenyldibenzofuran group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, and a diphenyldibenzothiophenyl group.

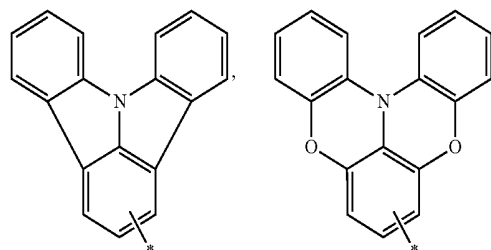
2. The condensed cyclic compound of claim 1, wherein L₁ to L₃ are each independently selected from:

a single bond; and

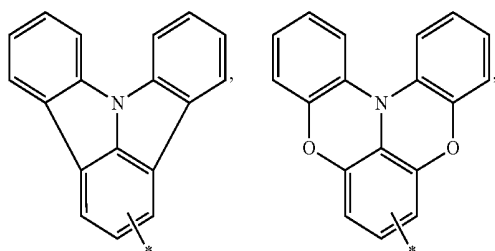
a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, a furanylene group, a thienylene group, an isoindolylene group, an indolylene group, a benzofuranylene group, a benzothiophenylene group, a carbazolylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a naphthobenzofuranylene group, and a naphthobenzothiophenylene group, each unsubstituted or substituted with at least one selected from deuterium, —CD₃, —CD₂H, —CDH₂, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuran group, a phenyldibenzofuran group, a diphenyldibenzofuran group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,

—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁), and

L₁₁ to L₁₃ are each independently selected from a phenylene group, an indenylene group, a naphthylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a triazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a furanylene group, a thienylene group, an oxazolylene group, an isoxazolylene group, a thiaz-



olylene group, an isothiazolylene group, an oxadiazolylene group, an isoxadiazolylene group, a thiadiazolylene group, an iso-thiadiazolylene group, a pyranylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoxazolylene group, a benzothiazolylene group, a benzimidazolylene group, an isoindolylene group, an indolylene group, a benzofuranylene group, a benzothienophenylene group, a carbazolylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a naphthobenzofuranylene group, a naphthobenzothiophenylene group, an imidazopyrimidinylene group, and an imidazopyridinylene group, each unsubstituted or substituted with at least one selected from deuterium, —F, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,



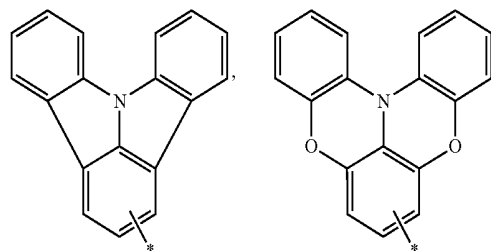
—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁).

3. The condensed cyclic compound of claim 1, wherein (L₅)_{a5} is a group represented by *—Ar₁-T₁-Ar₂—*, and n is two, and

Ar₁, T₁, and Ar₂ are the same as described in connection with L₅ in claim 1, provided that Ar₁ and Ar₂ are not a single bond, *—C(=O)—, *—C(=S)—, *—O—, *—S—, or *—N(R₅)—.

4. The condensed cyclic compound of claim 1, wherein R₁₁ to R₁₅ are each independently selected from: hydrogen, deuterium, —F, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, a cyano group, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group; and a phenyl group, an indenyl group, a naphthyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a

pyrenyl group, a chrysenyl group, a pyrrolyl group, an imidazolyl group, a pyrazolyl group, a triazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a furanyl group, a thienyl group, an oxazolyl group, an isoxazolyl group, a thiazolyl group, an isothiazolyl group, an oxadiazolyl group, an isoxadiazolyl group, a thiadiazolyl group, an isothiadiazolyl group, a pyranlyl 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 benzothiazolyl group, a benzimidazolyl group, an isoindolyl group, an indolyl group, a benzofuranyl group, a benzothiophenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, an imidazopyrimidinyl group, and an imidazopyridinyl group, each unsubstituted or substituted with at least one selected from deuterium, —F, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, —NCS, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a biphenyl group, a phenylpyridinyl group, a phenylpyrimidinyl group, a phenyltriazinyl group, a diphenylpyridinyl group, a diphenylpyrimidinyl group, a diphenyltriazinyl group, a pyridinylphenyl group, a dipyridinylphenyl group, a pyrimidinylphenyl group, a dipyrimidinylphenyl group, a triazinylphenyl group, a ditriazinylphenyl group, a fluorenyl group, a spiro-bifluorenyl group, a dimethylfluorenyl group, a diphenylfluorenyl group, a carbazolyl group, a phenylcarbazolyl group, a biphenylcarbazolyl group, a dibenzofuranyl group, a phenyldibenzofuranyl group, a diphenyldibenzofuranyl group, a dibenzothiophenyl group, a phenyldibenzothiophenyl group, a diphenyldibenzothiophenyl group,



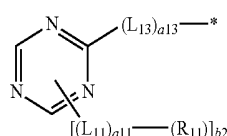
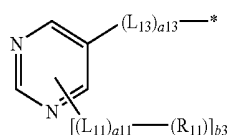
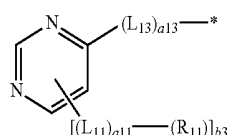
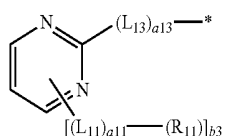
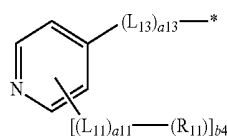
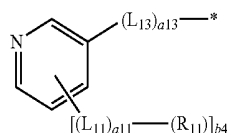
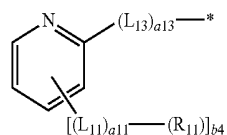
—Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), and —C(=O)(Q₃₁).

5. The condensed cyclic compound of claim 1, wherein n is two and (L₅)_{a5} is a divalent linking group.

6. The condensed cyclic compound of claim 1, wherein CY₁ in Formulae (3) and (4) is a benzene group, a pyridine group, a pyrimidine group, a pyrazine group, or a pyridazine group.

7. The condensed cyclic compound of claim 1, wherein the group represented by Formula (2) is selected from groups represented by Formulae (2)-1 to (2)-7:

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wherein, in Formulae (2)-1 to (2)-7,

L_{11} , L_{13} , a_{11} , a_{13} , and R_{11} are each independently the same described in claim 1,

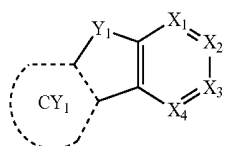
b_4 is an integer selected from 1 to 4,

b_3 is an integer selected from 0 to 3,

b_2 is an integer selected from 0 to 2, and

indicates a binding site to a neighboring atom.

8. The condensed cyclic compound of claim 1, wherein a core represented by

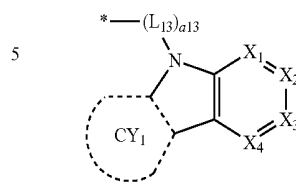


in Formula (3) is selected from groups represented by Formulae 3-1 to 3-20,

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a core represented by

Formula (2)-1



Formula (2)-2

10

in Formula (4) is selected from groups represented by Formulae 4-1 to 4-10, and

a core represented by

Formula (2)-3

15



Formula (2)-4

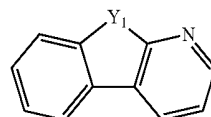
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in Formula (5) is selected from groups represented by Formulae 5-1 to 5-6:

Formula (2)-5

25

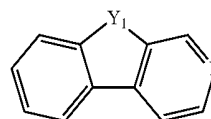
3-1



Formula (2)-6

30

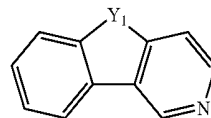
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Formula (2)-7

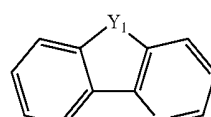
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3-3



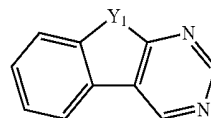
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3-4



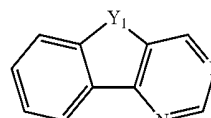
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3-5



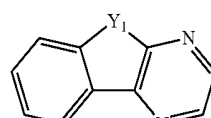
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3-6



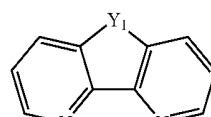
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3-7



60

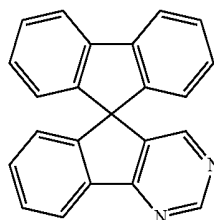
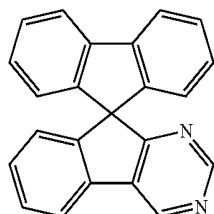
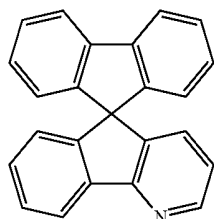
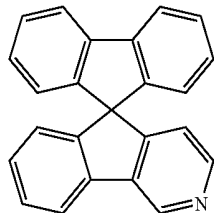
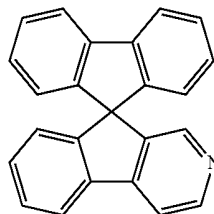
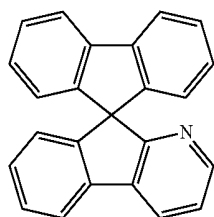
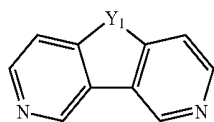
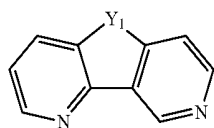
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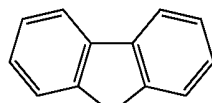
193

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**194**

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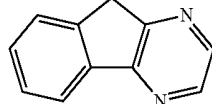
3-9



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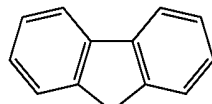
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3-11

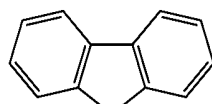
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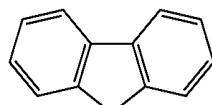
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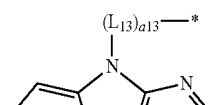
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3-14

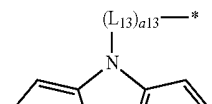
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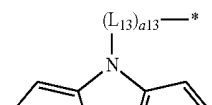
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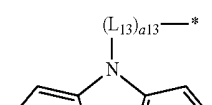
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4-1

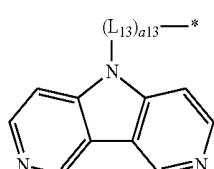
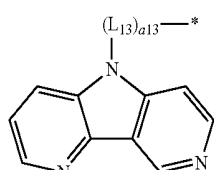
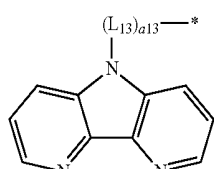
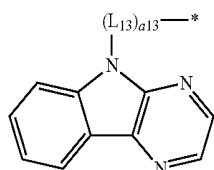
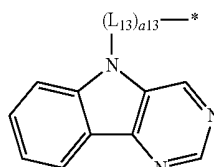
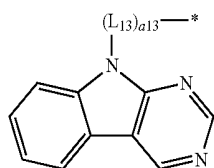
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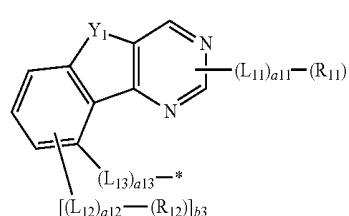
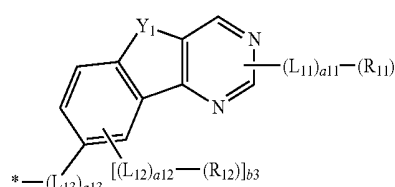
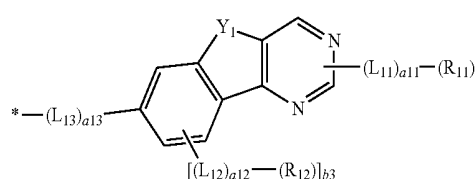
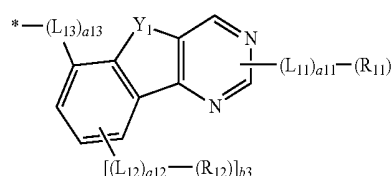
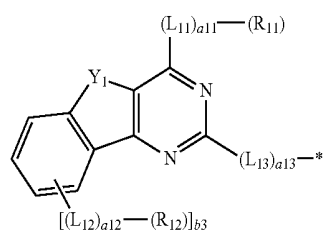
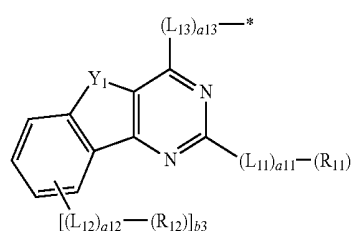
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5-6

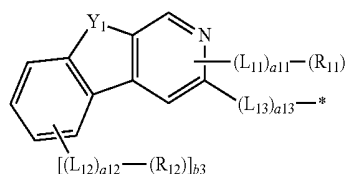
wherein Y_1 in Formulae 3-1 to 3-20, 4-1 to 4-10, and 5-1 to 5-6 are the same as described in claim 1.

9. The condensed cyclic compound of claim 1, wherein the group represented by Formula (3) is selected from groups represented by Formulae (3)-1 to (3)-11, and the group represented by Formula (4) is selected from groups represented by Formulae (4)-1 and (4)-2:

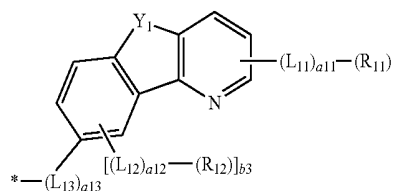


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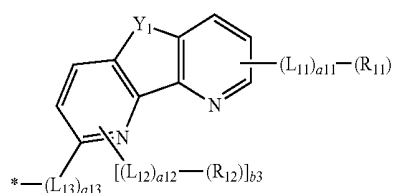
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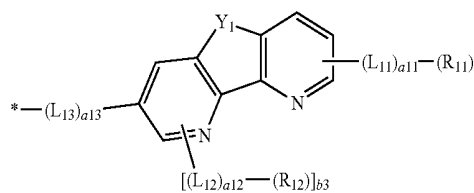
Formula (3)-7



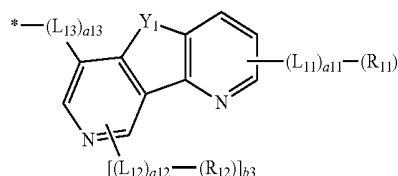
Formula (3)-8



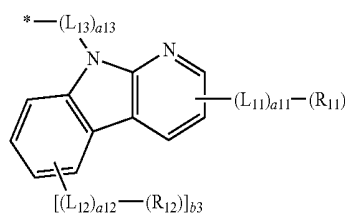
Formula (3)-9



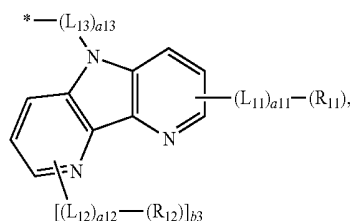
Formula (3)-10



Formula (3)-11



Formula (4)-1



Formula (4)-2

wherein, in Formulae (3)-1 to (3)-11, (4)-1, and (4)-2, L_{11} to L_{13} , a_{11} to a_{13} , R_{11} , R_{12} , and Y_1 are each independently the same as described in claim 1, b_2 is an integer selected from 0 to 2, b_3 is an integer selected from 0 to 3, and indicates a binding site to a neighboring atom.

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10. The condensed cyclic compound of claim 1, wherein, in Formula (1),

1) A_2 is selected from groups represented by Formulae (2) to (5), and

- 5 i) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ are each independently linked to $(L_5)_{a5}$;
- 10 ii) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ are a single bond linked to $(L_5)_{a5}$; or
- 15 iii) the groups represented by $*(L_1)_{a1}-(A_1)$ and $*(L_3)_{a3}-(A_3)$ are each independently selected from groups represented by Formulae 7-1 to 7-29,

2) A_1 and A_2 are each independently selected from groups represented by Formulae (2) to (5), and

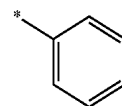
- 15 i) the group represented by $*(L_3)_{a3}-(A_3)$ is linked to $(L_5)_{a5}$;
- 20 ii) the group represented by $*(L_3)_{a3}-(A_3)$ is a single bond linked to $(L_5)_{a5}$; or
- 25 iii) the group represented by $*(L_3)_{a3}-(A_3)$ is selected from groups represented by Formulae 7-1 to 7-29,

3) A_2 is selected from groups represented by Formulae (2) to (5) and A_3 is selected from groups represented by Formulae (2) and (5), and

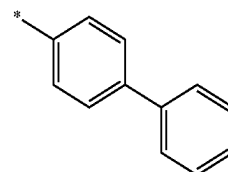
- 25 i) the group represented by $*(L_1)_{a1}-(A_1)$ is linked to $(L_5)_{a5}$;
- 30 ii) the group represented by $*(L_1)_{a1}-(A_1)$ is a single bond linked to $(L_5)_{a5}$; or
- 35 iii) the group represented by $*(L_1)_{a1}-(A_1)$ is selected from groups represented by Formulae 7-1 to 7-29, or

4) A_1 and A_2 are each independently selected from Formulae (2) to (5) and A_3 is selected from groups represented by Formulae (2) and (5), and

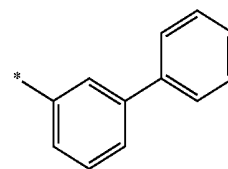
the groups represented by $*(L_{11})_{a11}-(R_{11})$ and $*(L_{12})_{a12}-(R_{12})$ in Formulae (2) to (5) are each independently selected from groups represented by Formulae 7-1 to 7-57:



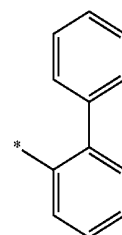
7-1



7-2



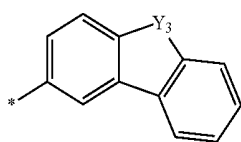
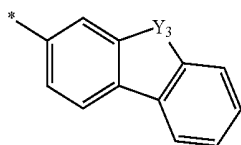
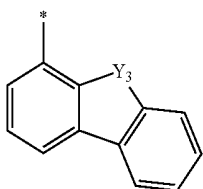
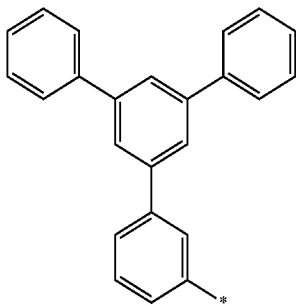
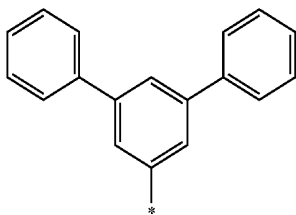
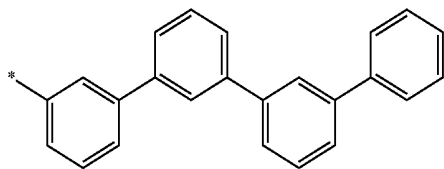
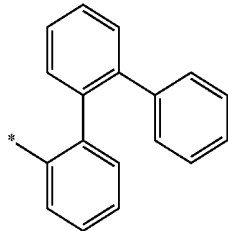
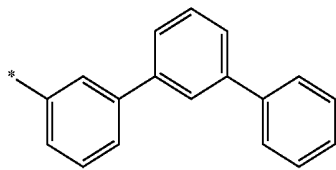
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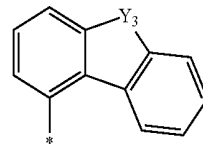
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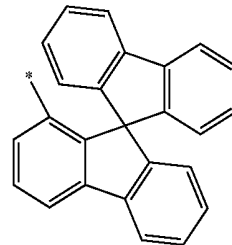
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7-6

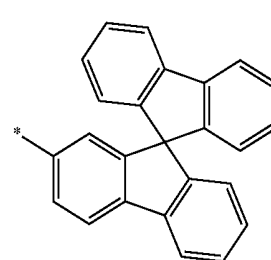
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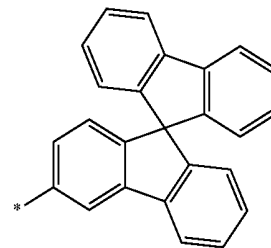
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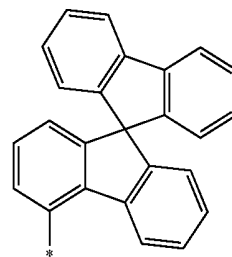
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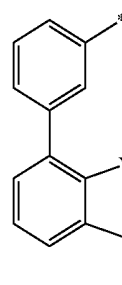
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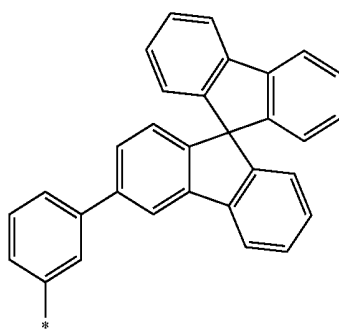
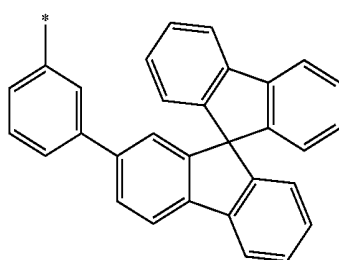
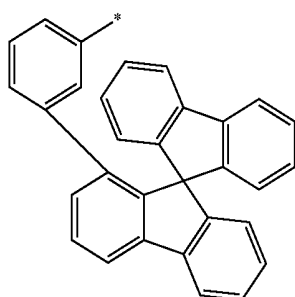
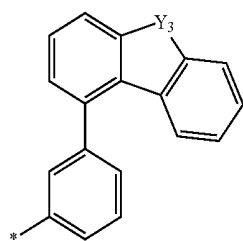
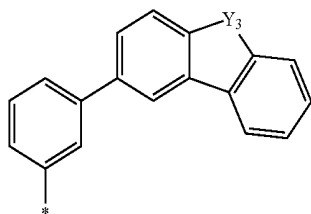
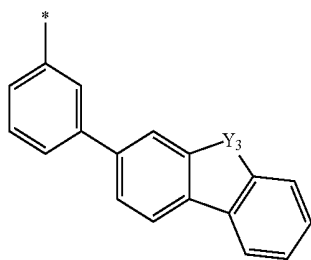
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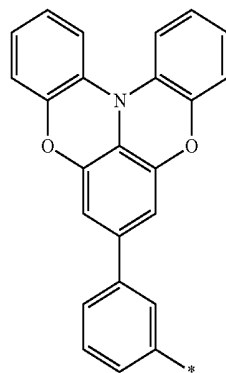
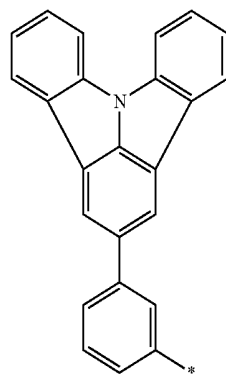
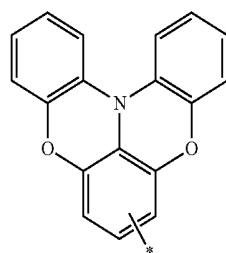
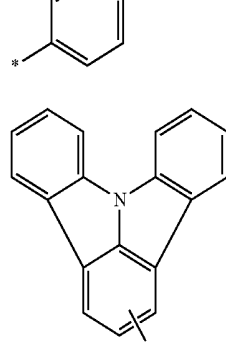
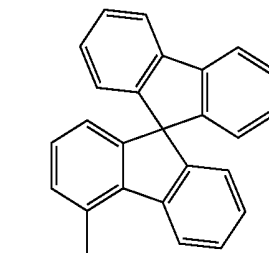
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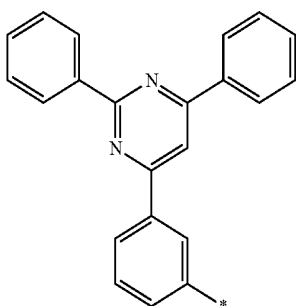
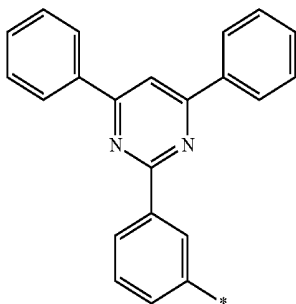
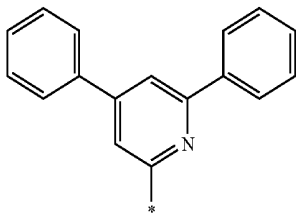
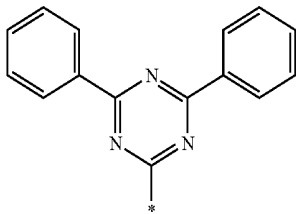
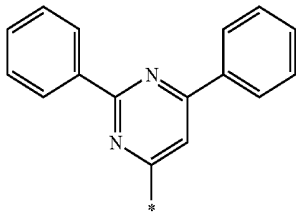
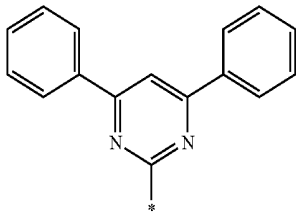
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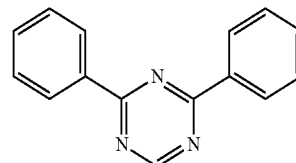
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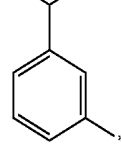
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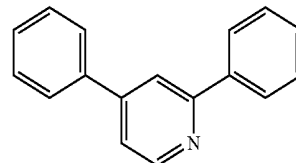


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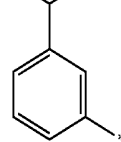


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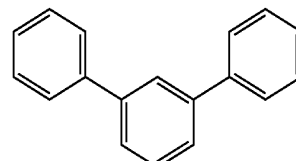
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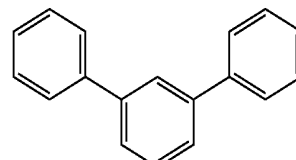
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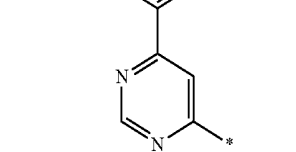
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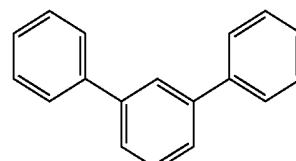
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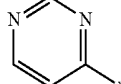
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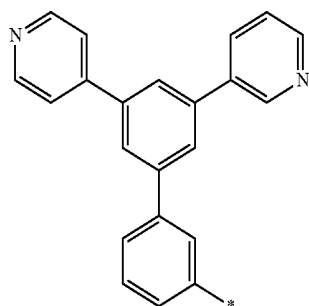
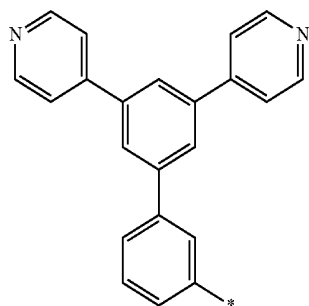
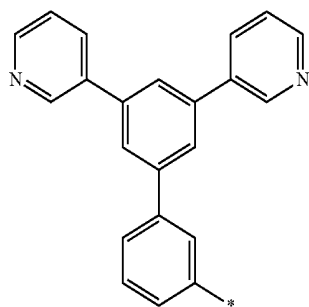
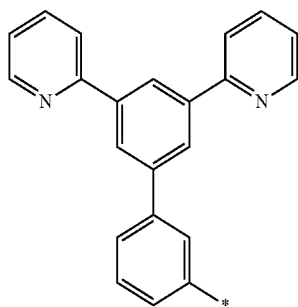
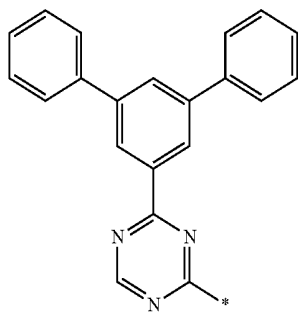
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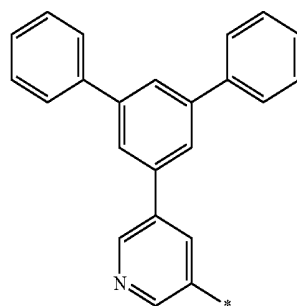
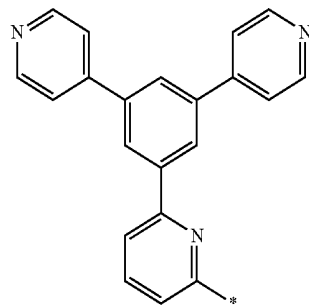
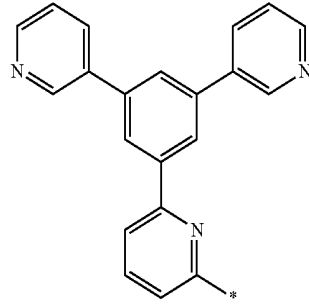
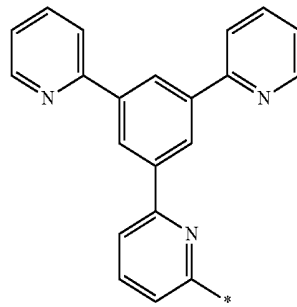
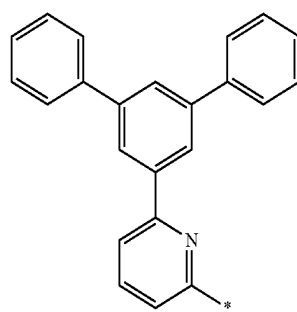
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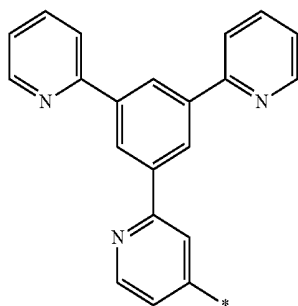
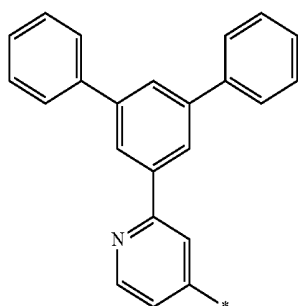
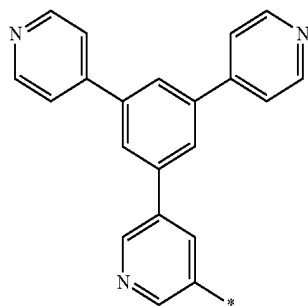
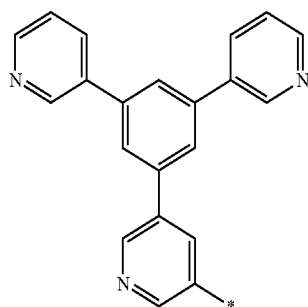
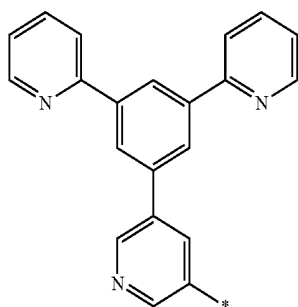
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**208**

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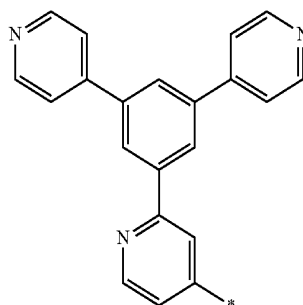
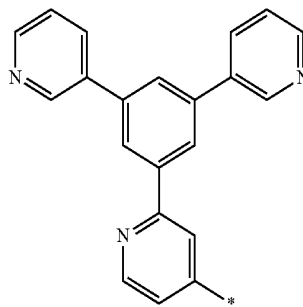
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wherein, in Formulae 7-1 to 7-57,

Y_3 is O, S, $C(Z_{13})(Z_{14})$, or $N(Z_{15})$,

Z_{13} to Z_{15} are each independently selected from $-CD_3$, $-CD_2H$, $-CDH_2$, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, and a biphenyl group, and

indicates a binding site to a neighboring atom.

11. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound has a glass transition temperature of about 125° C. or higher.

12. The condensed cyclic compound of claim 1, wherein a solubility of the condensed cyclic compound to toluene or xylene at 1 atmosphere and 25° C. is about 1 percent by weight or more.

13. A composition comprising:

the condensed cyclic compound of claim 1; and
a liquid medium.

14. An organic light-emitting device comprising:
a first electrode;
a second electrode; and

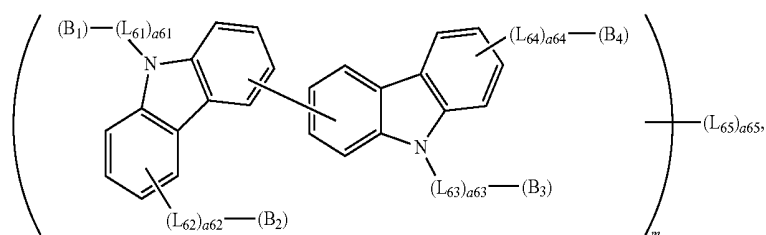
an organic layer disposed between the first electrode and the second electrode,

wherein the organic layer comprises an emission layer, and

wherein the organic layer comprises a layer comprising the condensed cyclic compound of claim 1.

15. The organic light-emitting device of claim 14, wherein the layer comprising the condensed cyclic compound is the emission layer.

16. The organic light-emitting device of claim 15, wherein the emission layer further comprises a condensed cyclic compound represented by Formula (6):



wherein, in Formula (6),

L_{61} to L_{65} are each independently selected from a single bond, $*-C(=O)-*$, $*-C(=S)-*$, $*-O-*$, $*-N(R_{65})-*$, a substituted or unsubstituted C_2-C_{60} alkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent π electron-depleted nitrogen-free non-aromatic condensed heteropolycyclic group,

and $*$ each indicate a binding site to a neighboring atom, a_{61} to a_{65} are each independently an integer selected from 1 to 10,

$(L_{65})_{a_{65}}$ is an m -valent linking group or a single bond, wherein m is a natural number greater than or equal to one,

when m is one, $(L_{65})_{a_{65}}$ does not exist,

when m is a natural number greater than or equal to two, at least one of groups represented by $*(L_{61})_{a_{61}}-(B_1)$, $*(L_{62})_{a_{62}}-(B_2)$, $*(L_{63})_{a_{63}}-(B_3)$, and $*(L_{64})_{a_{64}}-(B_4)$ is linked to $(L_{65})_{a_{65}}$ or is a single bond linked to $(L_{65})_{a_{65}}$,

i) B_1 to B_4 and R_{65} are each independently linked to $(L_{65})_{a_{65}}$;

ii) B_1 to B_4 and R_{65} are a single bond linked to $(L_{65})_{a_{65}}$; or

iii) B_1 to B_4 and R_{65} are each independently selected from hydrogen, deuterium, a substituted or unsubstituted C_1-C_{60} alkyl 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 π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(Q_1)(Q_2)(Q_3)$, $-\text{N}(Q_1)(Q_2)$, and $-\text{C}(=O)(Q_1)$, provided that B_1 and B_2 are not hydrogen, deuterium, a substituted or unsubstituted C_1-C_{60} alkyl group, or a substituted or unsubstituted C_1-C_{60} alkoxy group, and

at least one substituent of the substituted C_2-C_{60} alkylene group, the substituted C_3-C_{10} cycloalkylene group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenylene group, the substituted C_6-C_{60} arylene group, the substituted π electron-depleted nitrogen-free C_1-C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent π electron-depleted nitrogen-free non-aromatic condensed heteropolycyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} aryl group, the substituted π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group is selected from:

deuterium and a C_1-C_{60} alkyl group;

a C_3-C_{10} cycloalkyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group;

a C_3-C_{10} cycloalkyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, a C_3-C_{10} cycloalkyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a π electron-depleted nitrogen-free C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a π electron-depleted nitrogen-free C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a π electron-depleted nitrogen-free monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(Q_{21})(Q_{22})(Q_{23})$, $-\text{N}(Q_{21})(Q_{22})$, and $-\text{C}(=O)(Q_{21})$; and

$-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, and $-\text{C}(=\text{O})$
(Q_{31}),

wherein Q_1 to Q_3 , Q_{21} to Q_{23} , and Q_{31} to Q_{33} are each
independently selected from a C_1 - C_{20} alkyl group, a
 C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, 5
a fluorenyl group, a spiro-bifluorenyl group, a dimeth-
ylfluorenyl group, a diphenylfluorenyl group, a carba-
zolyl group, a phenylcarbazolyl group, a biphenylcar-
bazolyl group, a dibenzofuranyl group, a
phenyldibenzofuranyl group, a diphenyldibenzofuranyl 10
group, a dibenzothiophenyl group, a phenyldibenzoth-
iophenyl group, and a diphenyldibenzothiophenyl
group.

17. The organic light-emitting device of claim 15, wherein
the emission layer further comprises a phosphorescent dop- 15
ant.

18. A method of manufacturing 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 20
emission layer, and wherein the organic layer comprises a
layer comprising the condensed cyclic compound of claim 1,
the method comprising:

forming the layer comprising the condensed cyclic com-
pound by solution coating using a composition com- 25
prising the condensed cyclic compound and a liquid
medium.

* * * * *

专利名称(译)	稠合环状化合物，包括该稠合环状化合物的组合物，包括该稠合环状化合物的有机发光器件以及制造该有机发光器件的方法		
公开(公告)号	US10597403	公开(公告)日	2020-03-24
申请号	US15/388957	申请日	2016-12-22
[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.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD.		
[标]发明人	KATO FUMIAKI INAYAMA SATOSHI ISHII NORIHITO SHIBATA KATSUNORI ITO MITSUNORI		
发明人	KATO, FUMIAKI INAYAMA, SATOSHI ISHII, NORIHITO SHIBATA, KATSUNORI ITO, MITSUNORI		
IPC分类号	H01L51/54 C07D405/14 C07D403/10 H01L51/00 C09K11/02 C09K11/06 C07D498/06 H01L51/50		
CPC分类号	H01L51/0072 H01L51/0073 C07D403/10 C09K11/025 C07D498/06 C07D405/14 H01L51/0067 H01L51/5016 H01L51/0085 H01L2251/5384 C07D403/14 C07D498/04		
代理机构(译)	康托科尔伯恩LLP		
优先权	2015250531 2015-12-22 JP		
其他公开文献	US20170174705A1		
外部链接	Espacenet		

摘要(译)

式(1)表示的稠环化合物：其中，在公式(1)，组和变量与规范中所述相同。

Formula (1)

