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(54) **CONDENSED COMPOUND AND ORGANIC LIGHT-EMITTING DIODE INCLUDING THE SAME**

(71) Applicant: **SAMSUNG DISPLAY CO., LTD.**, Yongin-City (KR)

(72) Inventors: **Seok-Hwan HWANG**, Yongin-City (KR); **Young-Kook KIM**, Yongin-City (KR); **Jun-Ha PARK**, Yongin-City (KR); **Hye-Jin JUNG**, Yongin-City (KR); **Jin-O LIM**, Yongin-City (KR); **Eun-Young LEE**, Yongin-City (KR); **Jong-Woo KIM**, Yongin-City (KR); **Sang-Hyun HAN**, Yongin-City (KR); **Kwang-Hyun KIM**, Yongin-City (KR); **Eun-Jae JEONG**, Yongin-City (KR); **Soo-Yon KIM**, Yongin-City (KR)

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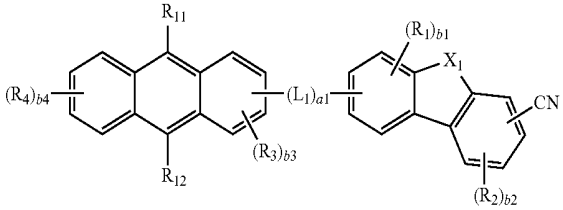
USPC **257/40**; 548/444; 549/460; 546/256; 546/276.7; 544/180; 549/43

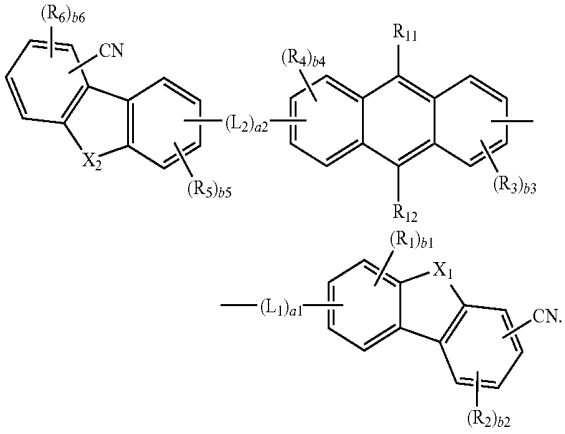
(57) **ABSTRACT**

Provided are a condensed compound and an organic light-emitting diode including the same, the condensed compound being represented by Formula 1 or 2:

<Formula 1>



<Formula 2>



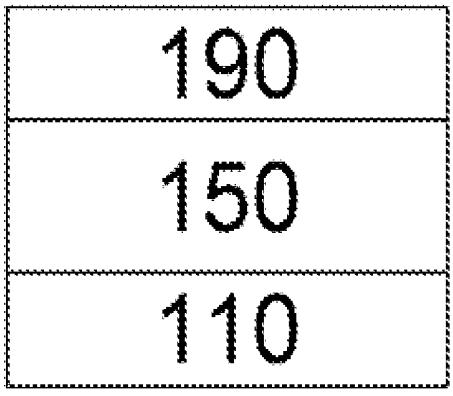
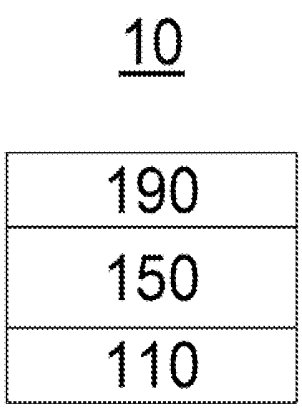


FIG. 1



CONDENSED COMPOUND AND ORGANIC LIGHT-EMITTING DIODE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Korean Patent Application No. 10-2013-0104401, filed on Aug. 30, 2013, in the Korean Intellectual Property Office, and entitled: "Condensed Compound and Organic Light-emitting Diode Including The Same," is incorporated by reference herein in its entirety.

BACKGROUND

[0002] 1. Field

[0003] One or more embodiments relate to a condensed compound and an organic light-emitting diode including the same.

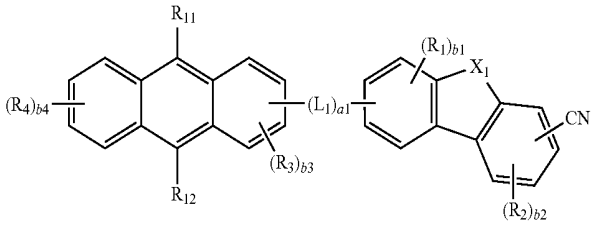
[0004] 2. Description of the Related Art

[0005] Organic light emitting diodes are self-emission diodes that may have wide viewing angles, a high contrast ratio, short response times, and excellent brightness, driving voltage, and response speed characteristics, and produce full-color images.

SUMMARY

[0006] Embodiments may be realized by providing a condensed compound for an organic light-emitting diode, the condensed compound being represented by Formula 1 or 2:

<Formula 1>



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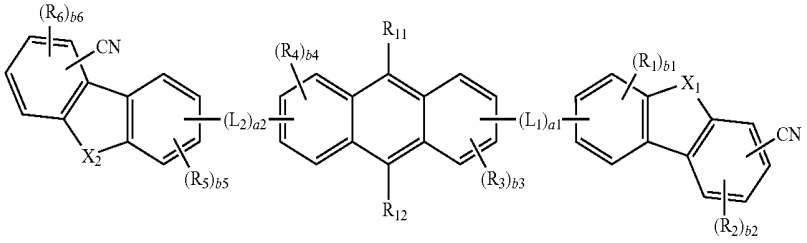


[0007] wherein:

[0008] X_1 is $N(R_{21})$, O, or S;

[0009] X_2 is $N(R_{22})$, O, or S;

[0010] L_1 and L_2 are each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_2-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_2-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_2-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic hetero-condensed polycyclic group;

[0011] a1 and a2 are each independently selected from 0, 1, 2, and 3;

[0012] R_1 to R_6, R_{11}, R_{12}, R_{21}, and R_{22} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and 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_2-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_2-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_2-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic hetero-condensed polycyclic group, $—N(Q_1)(Q_2)$, $—Si(Q_3)(Q_4)(Q_5)$, and $—B(Q_6)(Q_7)$;

[0013] b1 to b6 are each independently selected from 0, 1, 2, and 3;

[0014] at least one substitutent of the substituted C_3-C_{10} cycloalkylene, the substituted C_2-C_{10} heterocycloalkylene, the substituted C_3-C_{10} cycloalkenylene, the substituted C_2-C_{10} heterocycloalkenylene, the substituted C_6-C_{60} arylene, the substituted C_2-C_{60} heteroarylene, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic hetero-condensed polycyclic group, the substituted C_1-C_{60} alkyl, the substituted C_2-C_{60} alkenyl, the substituted C_2-C_{60} alkynyl, the substituted C_1-C_{60} alkoxy, the substituted C_3-C_{10} cycloalkyl, the substituted C_2-C_{10} heterocycloalkyl, the substituted C_3-C_{10} cycloalkenyl, the substituted C_2-C_{10} heterocycloalkenyl, the substituted C_6-C_{60} aryl, the substituted C_6-C_{60} aryloxy, the substituted C_6-C_{60} arylthio, the substituted C_2-C_{60} heteroaryl, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic hetero-condensed polycyclic group is selected from

[0015] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

[0016] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic hetero-condensed polycyclic group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$B(Q_{16})(Q_{17})$;

[0017] a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group;

[0018] a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} group, aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic hetero-condensed polycyclic group, —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, and —$B(Q_{26})(Q_{27})$; and

[0019] —$N(Q_{31})(Q_{32})$, —$Si(Q_{33})(Q_{34})(Q_{35})$, and —$B(Q_{36})(Q_{37})$; and

[0020] Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-$_{10}$ heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group.

[0021] Another aspect provides an organic light-emitting diode including: a first electrode; a second elecgtrode facing the first electrode; and an organic layer that is disposed between the first and second electrodes and includes an emission layer, wherein the organic layer includes at least one condensed compound described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Features will become apparent to those of skill in the art by describing in detail exemplary embdiments with reference to the attached drawings in which:

[0023] FIG. **1** illustrates a schematic view of an organic light-emitting diode according to an embodiment.

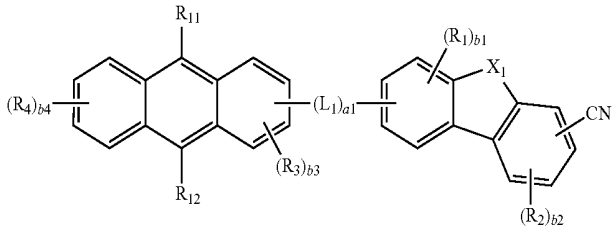
DETAILED DESCRIPTION

[0024] Example embodiments will now be described more fully hereinafter with reference to the accompanying drawings; however, they may be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure willl be thouough and complete,and will fully convey eemplayr implementations to those skilled in the art.

[0025] In the drawing figures, the dimensions of layers and regions may be exaggerated for clarity of illustration. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify th eindividual elements of the list.

[0026] A condensed compoound according to an embodiment is represented by Formula 1 or 2 below:

<Formula 1>



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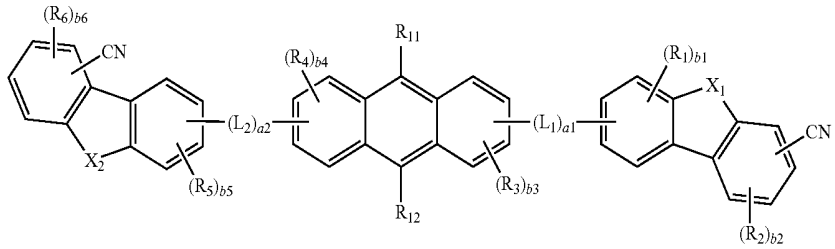
<Formula 2>



[0027] wherein in Formulae 1 and 2, X_1 is $N(R_{21})$, O, or S, and X_2 is $N(R_{22})$, O, or S. R_{21} and R_{22} may be understood by referring to a detailed description thereof provided below.

[0028] L_1 and L_2 in Formulae 1 and 2 may each independently be selected from

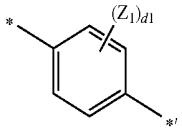
[0029] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrmidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene 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 carbazolylene group, a phenanthridinylene group, a acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group and an imidazopyrimidinylene group; and

[0030] a phenylene group, a pentalenylene group, an indenylene group, a naphthalene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluorantenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthilidinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group and an imidazopyrimidinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, a indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl

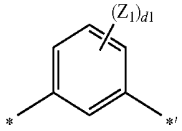
group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl group and an imidazopyrimidinyl group.

[0031] According to another embodiment, L_1 and L_2 in Formulae 1 and 2 may each independently be represented by one of Formulae 3-1 to 3-32 below:

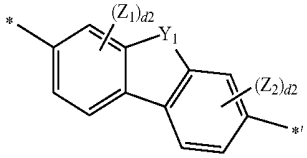
Formula 3-1



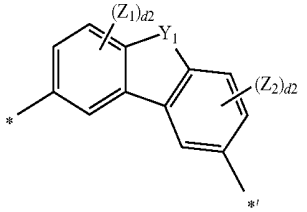
Formula 3-2



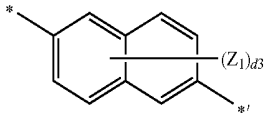
Formula 3-3



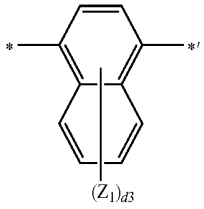
Formula 3-4



Formula 3-5



Formula 3-6



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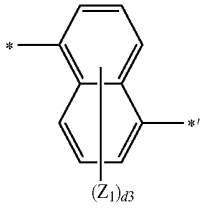

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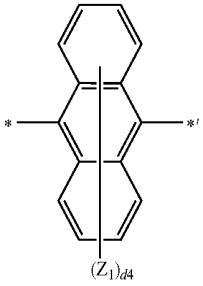
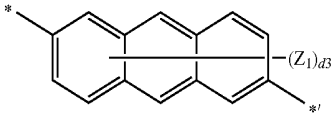
Formula 3-8



Formula 3-9



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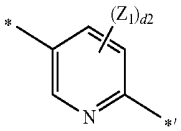
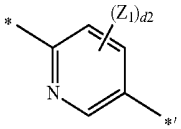
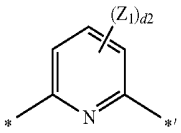


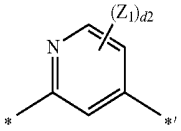
Formula 3-11



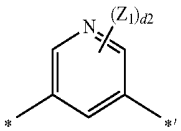
Formula 3-12



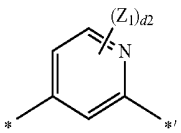
Formula 3-13



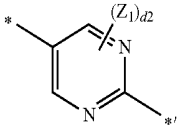
Formula 3-14



Formula 3-15



Formula 3-16



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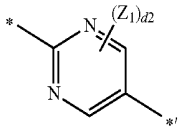
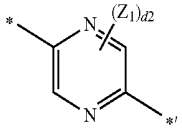
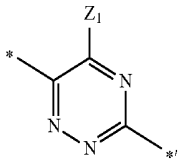
Formula 3-17



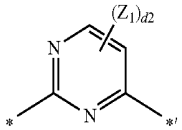
Formula 3-18



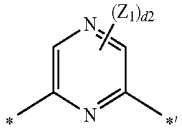
Formula 3-19



Formula 3-20



Formula 3-21



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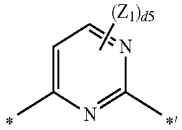
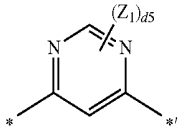
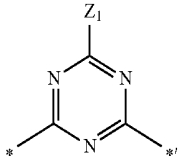


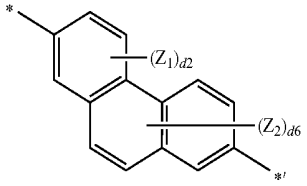
Formula 3-23



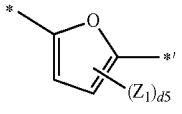
Formula 3-24



Formula 3-25



Formula 3-26



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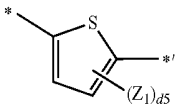
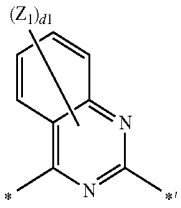
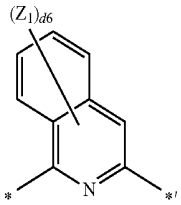
Formula 3-27



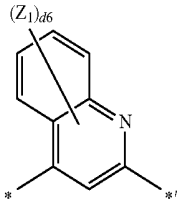
Formula 3-28



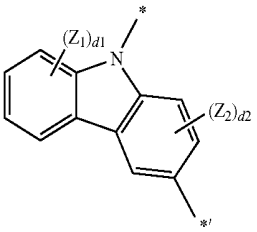
Formula 3-29



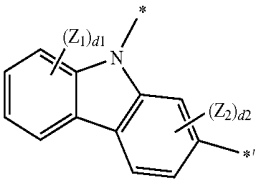
Formula 3-30



Formula 3-31



Formula 3-32



[0032] wherein in Formulae 3-1 to 3-32,

[0033] Y_1 is O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$;

[0034] Z_1 to Z_7 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquino-

linyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0035] d1 is selected from an integer of 1 to 4;

[0036] d2 is selected from an integer of 1 to 3;

[0037] d3 is selected from an integer of 1 to 6;

[0038] d4 is selected from an integer of 1 to 8;

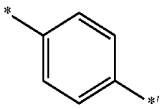
[0039] d5 is 1 or 2;

[0040] d6 is selected from an integer of 1 to 5; and

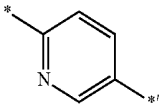
[0041] * and *' represent bonding sites in the condensed compound,

[0042] According to another embodiment, L_1 and L_2 in Formulae 1 and 2 may each independently be represented by one of Formulae 4-1 to 4-23 below:

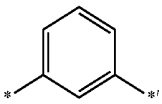
Formula 4-1



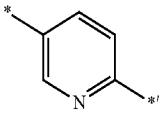
Formula 4-2



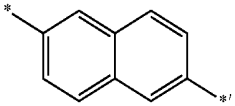
Formula 4-3



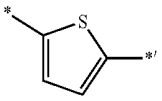
Formula 4-4



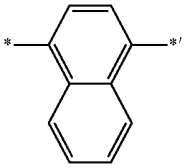
Formula 4-5



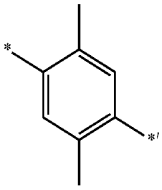
Formula 4-6



Formula 4-7



Formula 4-8



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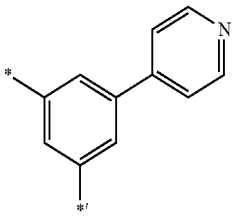
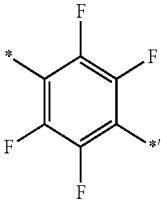
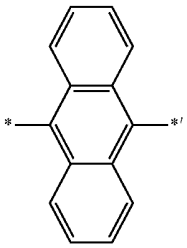
Formula 4-9



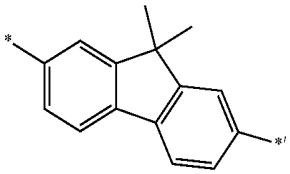
Formula 4-10



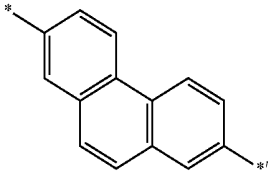
Formula 4-11



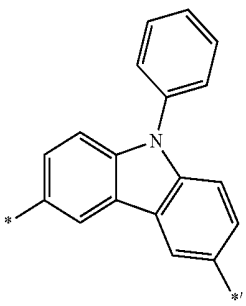
Formula 4-12



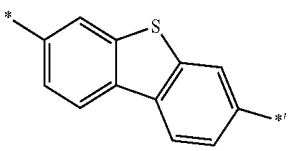
Formula 4-13



Formula 4-14



Formula 4-15



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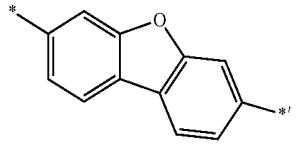
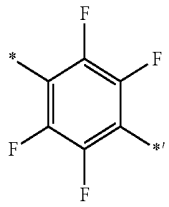
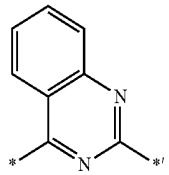
Formula 4-16



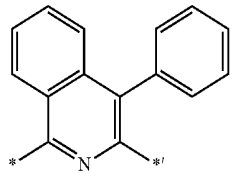
Formula 4-17



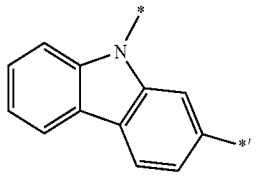
Formula 4-18



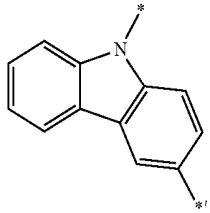
Formula 4-19



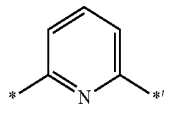
Formula 4-20



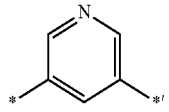
Formula 4-21



Formula 4-22



Formula 4-23



[0043] wherein * and *' represent bonding sites in the condensed compound.

[0044] a1 in Formulae 1 and 2 may be selected from 0, 1, 2, and 3. For example, a1 in Formulae 1 and 2 may be 0 or 1. When a1 in Formula 1 is 0, —$(L_1)_{a1}$— is a single bond. When a1 is 2 or more, a plurality of L_1s may be identical or different.

[0045] a2 in Formula 2 may be selected from 0, 1, 2, and 3. For example, a2 in formula 2 may be 0 or 1. When a2 in Formula 2 is 0, —$(L_2)_{a2}$— is a single bond. When a2 is 2 or more, a plurality of L_2s may be identical or different.

[0046] Regarding Formulae 1 and 2, when X_1 is $N(R_{21})$ or X_2 $N(R_{22})$, R_{21} and R_{22} may each independently be selected from

[0047] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl and an imidazopyrimidinyl group; and

[0048] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl and an imidazopyrimidinyl

group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoquinolinyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl and an imidazopyrimidinyl group.

[0049] According to an embodiment, regarding Formulae 1 and 2, when X_1 is $N(R_{21})$ or X_2 is $N(R_{22})$, R_{21} and R_{22} are each independently selected from

[0050] a phenyl group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0051] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group.

[0052] According to another embodiment, R_1 to R_6 in Formulae 1 and 2 may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $Si(Q_3)(Q_4)(Q_5)$ (wherein Q_3 to Q_5 may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group and a naphthyl group).

[0053] For example, R_1 to R_6 in Formulae 1 and 2 may each be hydrogen.

[0054] According to another embodiment, R_{11} and R_{12} in Formulae 1 and 2 may each independently be selected from

[0055] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

[0056] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0057] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0058] $Si(Q_3)(Q_4)(Q_5)$ (wherein Q_3 to Q_5 may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group and a naphthyl group).

[0059] According to another embodiment, regarding formulae 1 and 2,

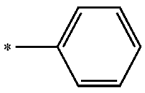
[0060] R_{21} and R_{22} may each independently be selected from Formulae 5-1 to 5-34 below;

[0061] R_1 to R_6 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl

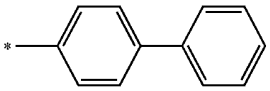
group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, and Formulae 5-1 to 5-34 below;

[0062] R_{11} and R_{12} may each independently be selected from a C_1-C_{20} alkyl group, (for example, a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group or a hexyl group), and Formulae 5-1 to 5-34 below:

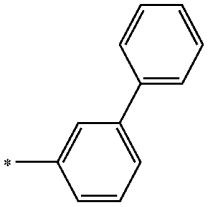
Formula 5-1



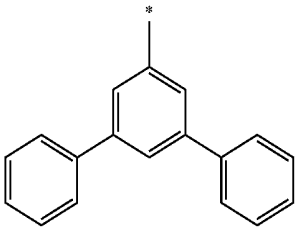
Formula 5-2



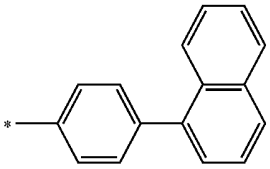
Formula 5-3



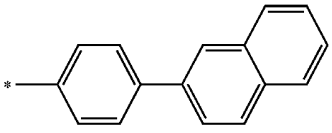
Formula 5-4



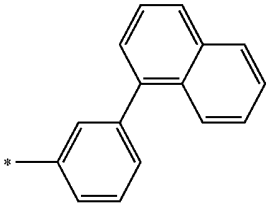
Formula 5-5



Formula 5-6



Formula5-7



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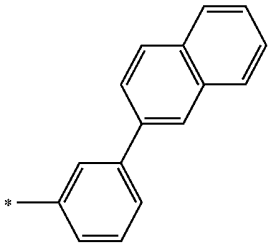
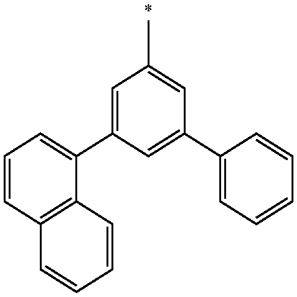
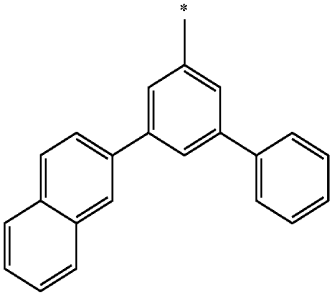
Formula 5-8



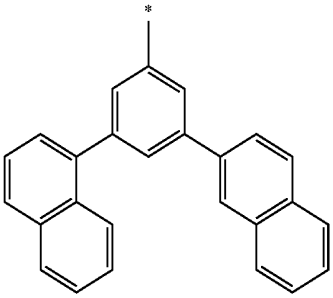
Formula 5-9



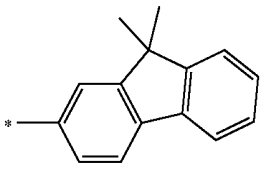
Formula 5-10



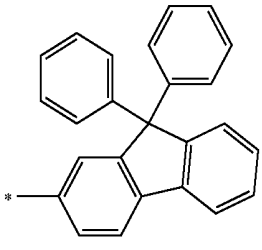
Formula 5-11



Formula 5-12



Formula 5-13



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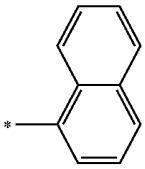
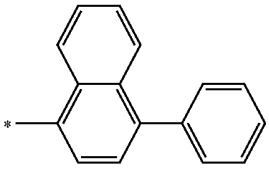
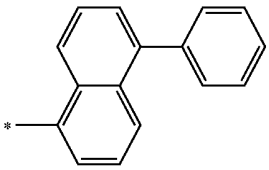
Formula 5-14



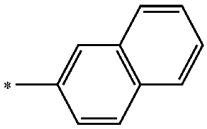
Formula 5-15



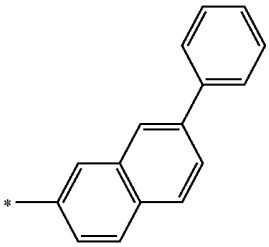
Formula 5-16



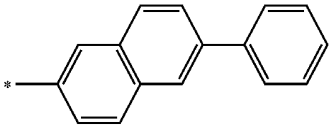
Formula 5-17



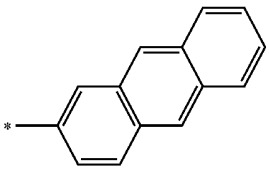
Formula 5-18



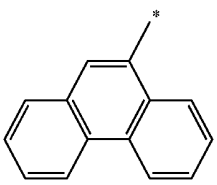
Formula 5-19



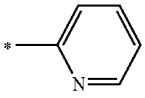
Formula 5-20



Formula 5-21



Formula 5-22



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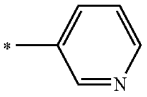
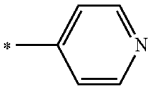
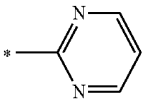
Formula 5-23



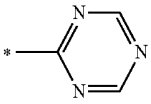
Formula 5-24



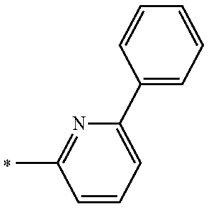
Formula 5-25



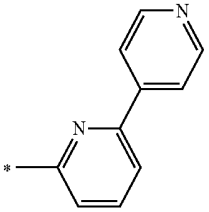
Formula 5-26



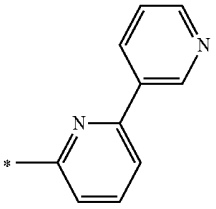
Formula 5-27



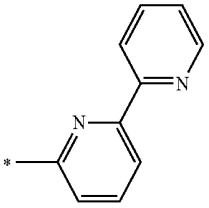
Formula 5-28



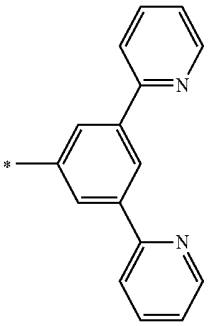
Formula 5-29



Formula 5-30



Formula 5-31



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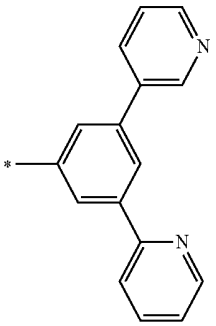
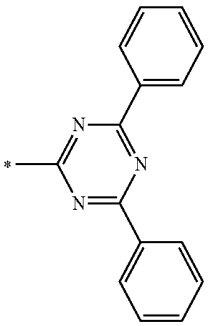
Formula 5-32



Formula 5-33



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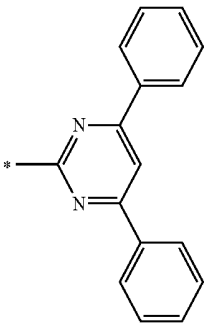
Formula 5-34

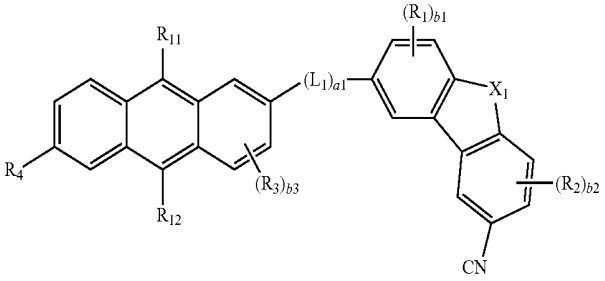


[0063] wherein * represents a bonding sites in the condensed compound.

[0064] b1 in Formulae 1 and 2 may be selected from 0, 1, 2, and 3. For example, b1 may be 0, 1, or 2. When b1 is 2 or more, a plurality of R_ts may be identical or different. b2 to b6 may be understood by referring to the description provided in connection with b1.

[0065] For example, the condensed compound represented by Formula 1 may be represented by one of Formulae 1-1 to 1-12 and 2-1 to 2-12:

<Formula 1-1>



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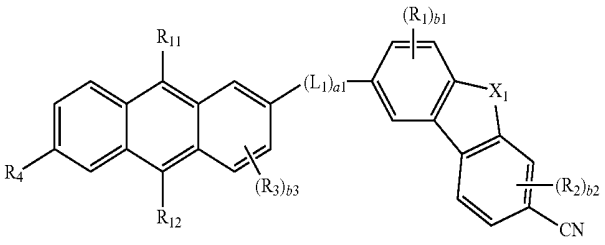

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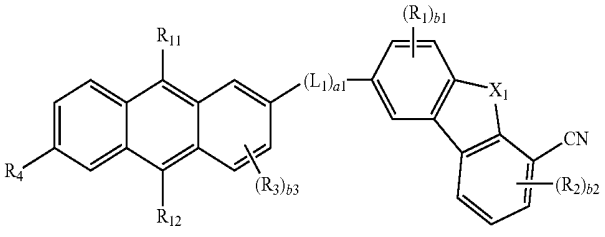

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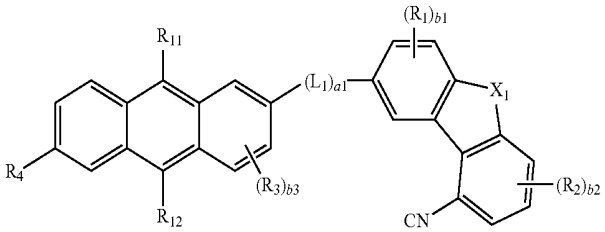

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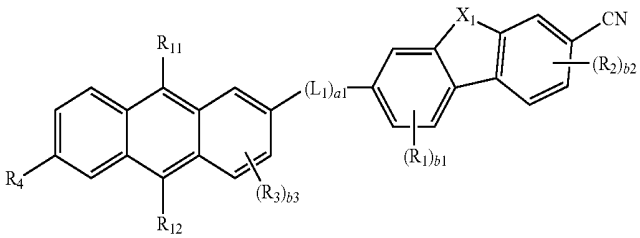

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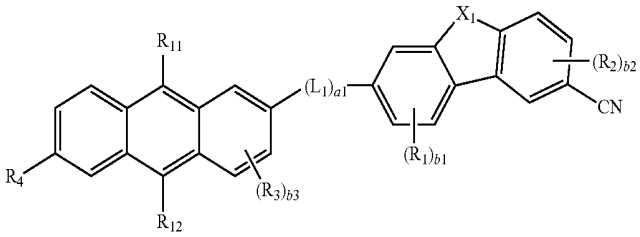
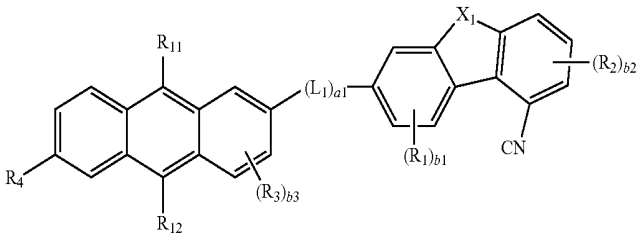


Formula 1-7>



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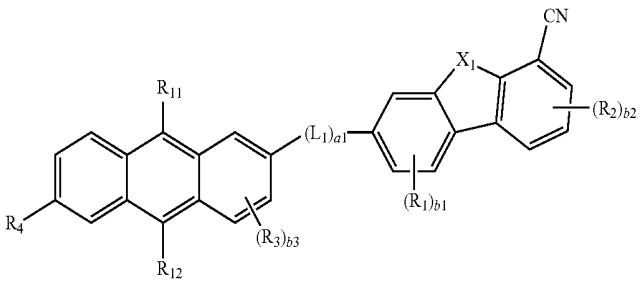

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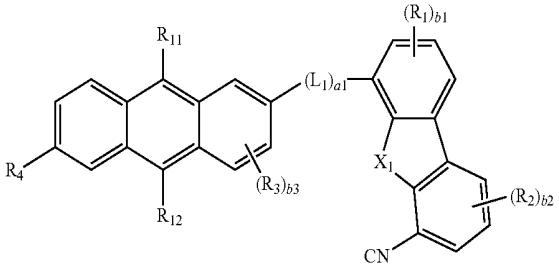

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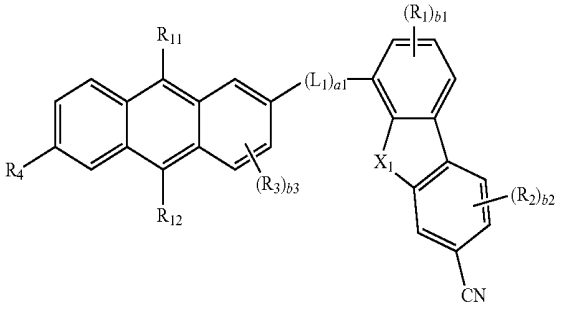

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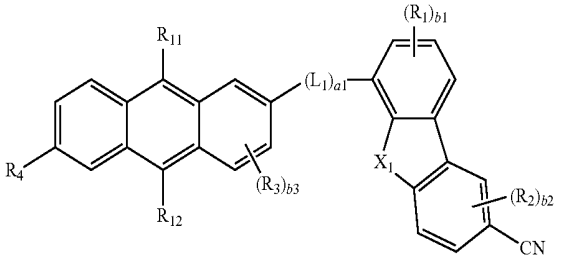

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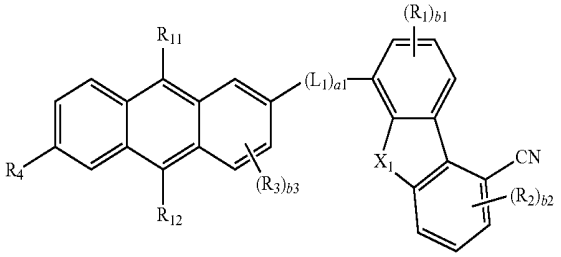

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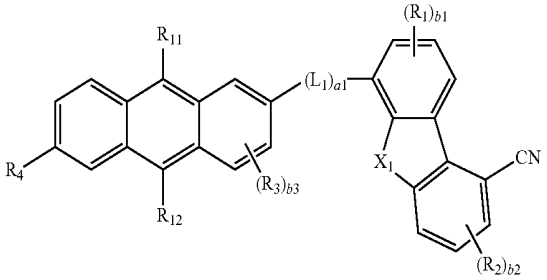

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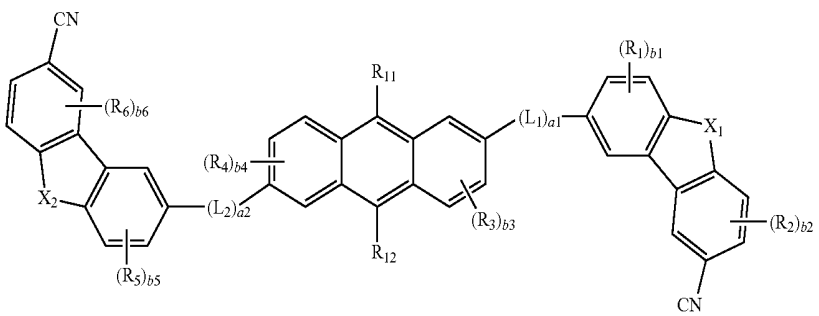

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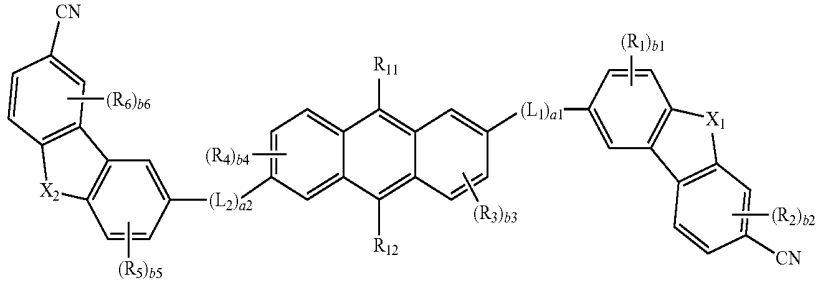

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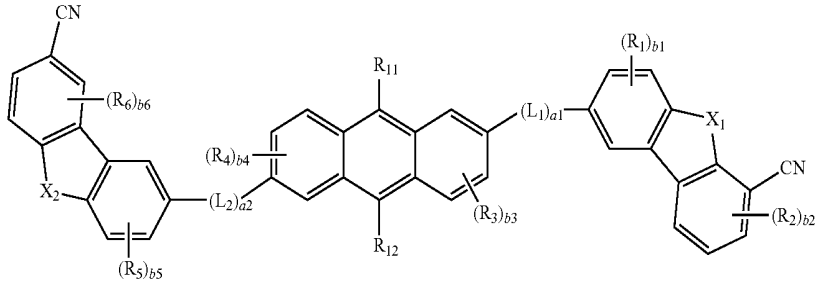

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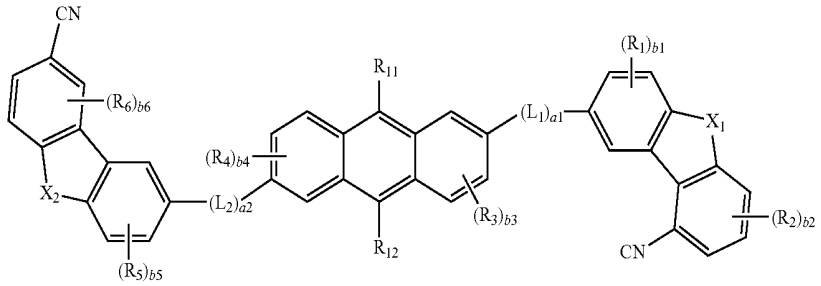

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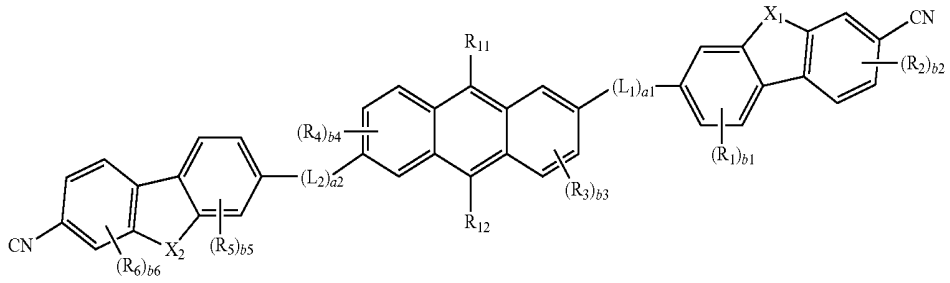

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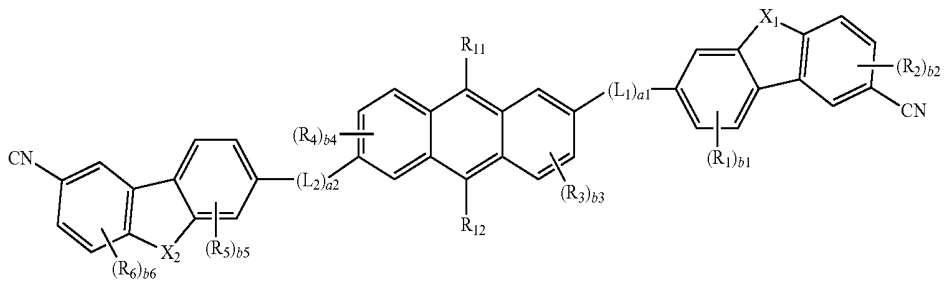

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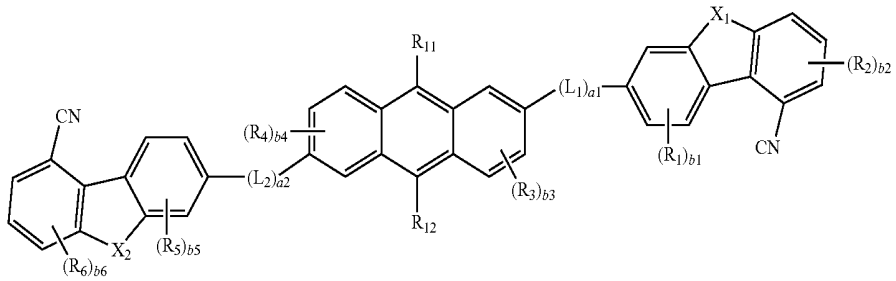

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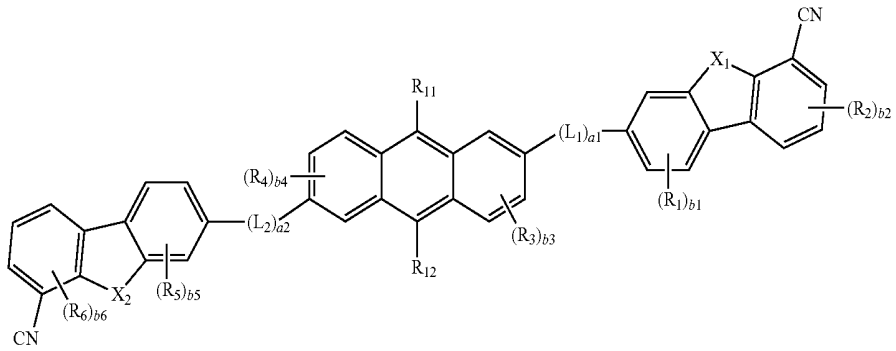

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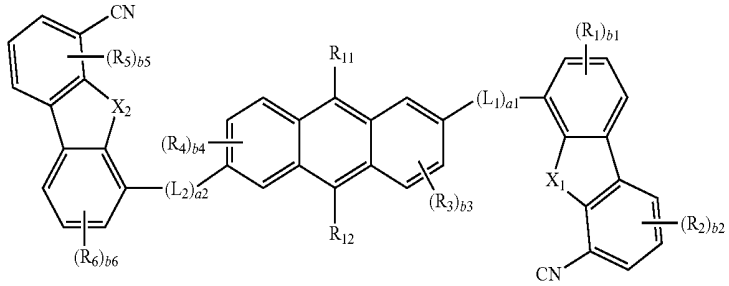

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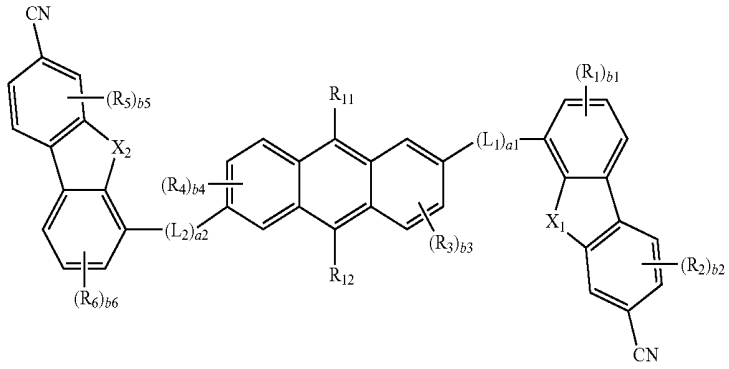

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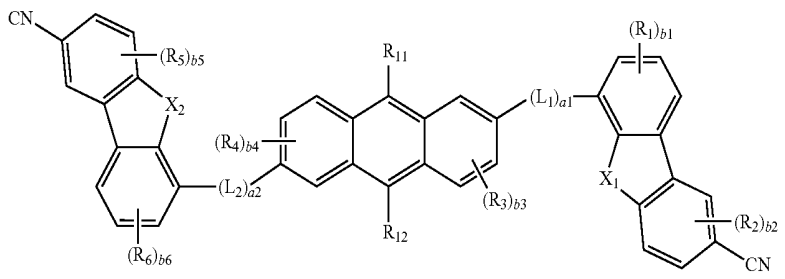

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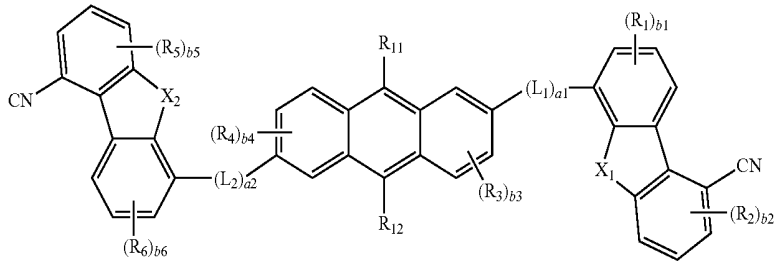


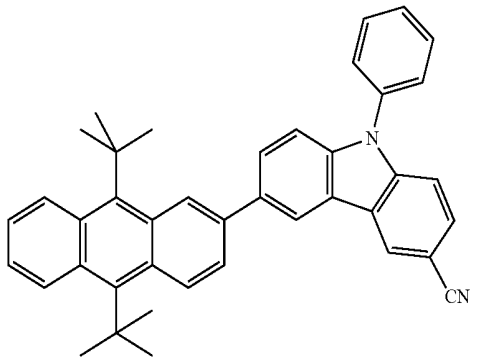
[0066] X_1, X_2, L_1, L_2, a1, a2, R_1 to R_6, R_{11}, R_{12}, and b1 to b6 in Formulae 1-1 to 1-12 and 2-1 to 2-12 may be understood by referring to the corresponding description provided herein.

[0067] According to an embodiment, the condensed compound may be represented by one of Formulae 1-1 to 1-12 and 2-1 to 2-12, L_1 and L_2 in Formulae 1-1 to 1-12 and 2-1 to 2-12 may each independently be one of Formulae 4-1 to 4-23; a1 and a2 may each independently be 0 or 1; R_{21} and R_{22} may each independently be selected from Formulae 5-1 to 5-34; R_1 to R_6 may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group and Formulae 5-1 to 5-34; R_{11} and R_{12} may each independently be selected from a C_1-C_{20} alkyl group and Formulae 5-1 to 5-34; and b1 to b6 may each independently be 0, 1, or 2.

[0068] According to another embodiment, the condensed compound represented by Formula 1 or Formula 2 may be represented by one of Formulae 1-1, 1-5, 1-9, 2-1, 2-5, and 2-9.

[0069] The condensed compound represented by Formula 1 or Formula 2 may be one of Compounds 1 to 119 below.

1



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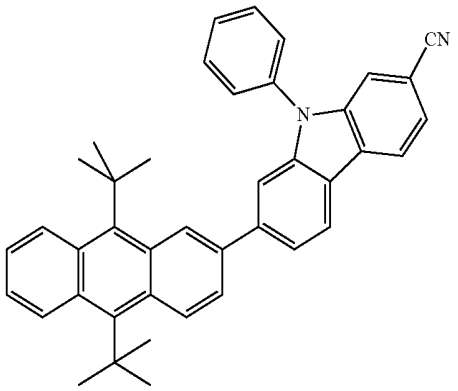

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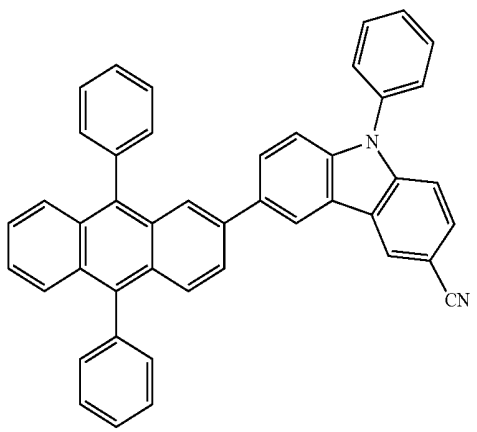

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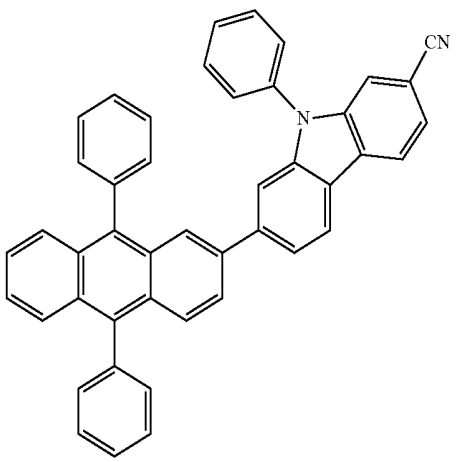

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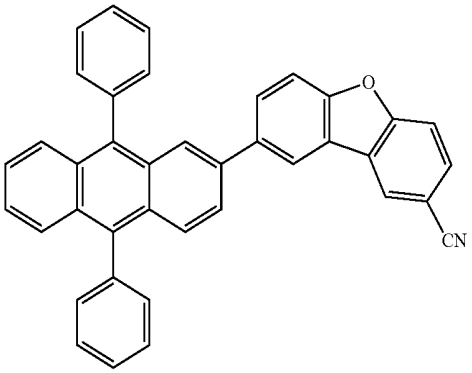

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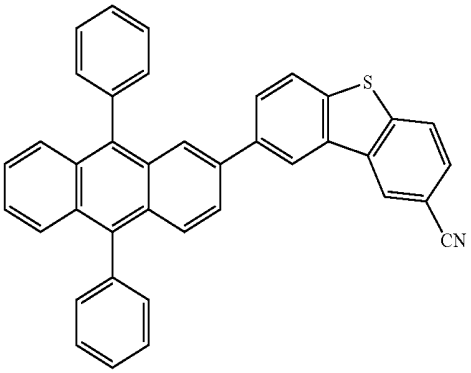

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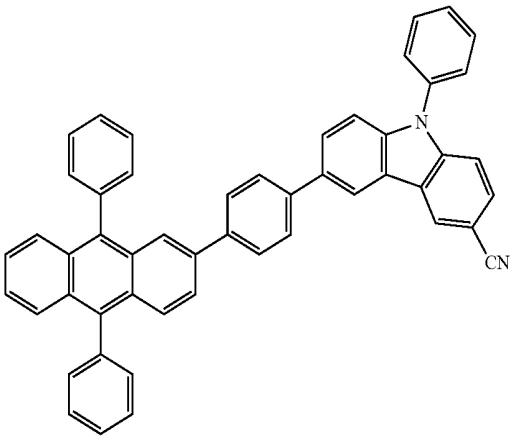

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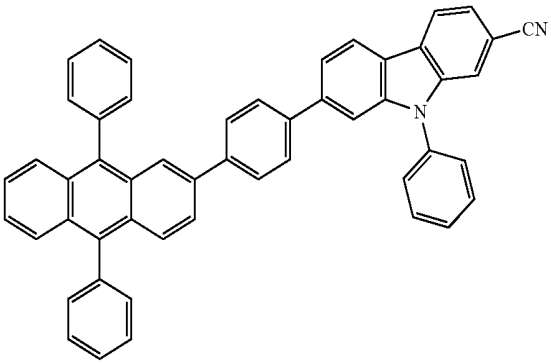

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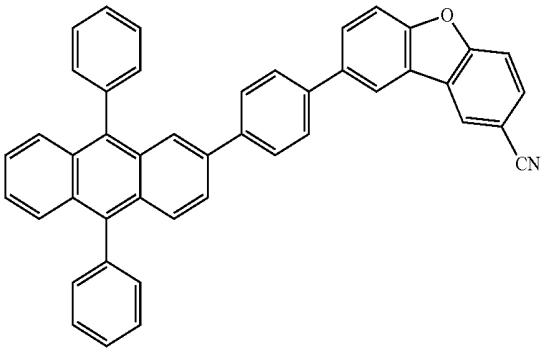

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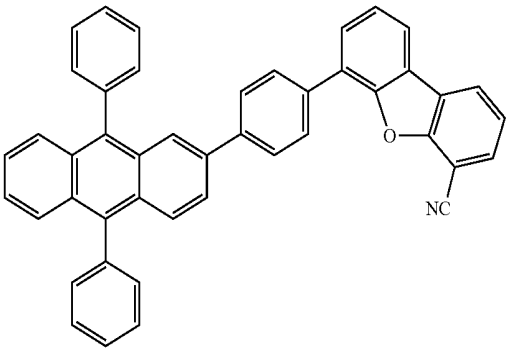

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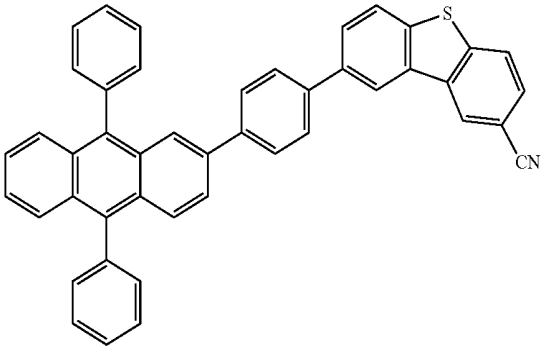

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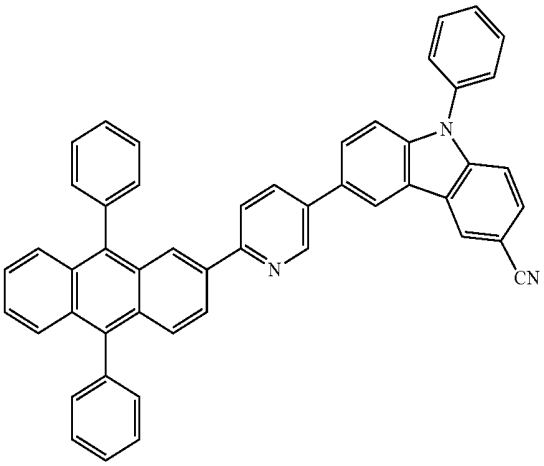

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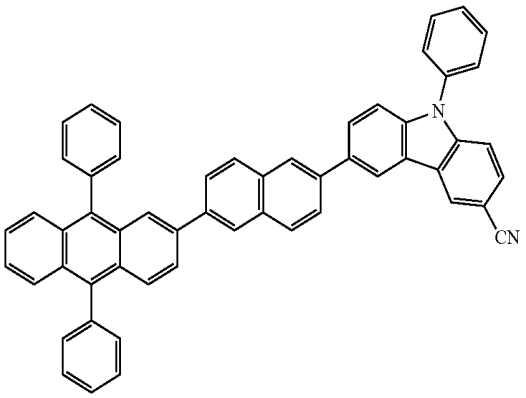

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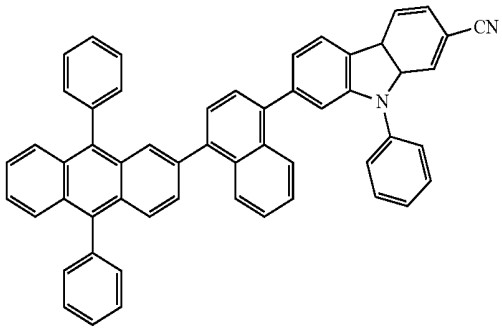

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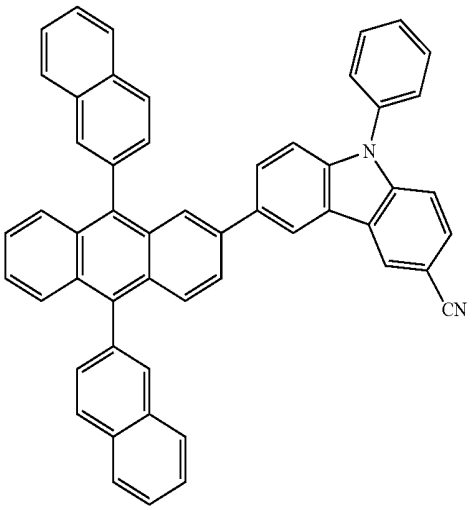

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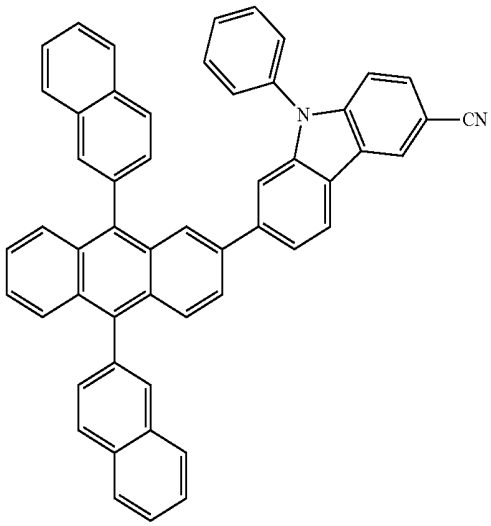

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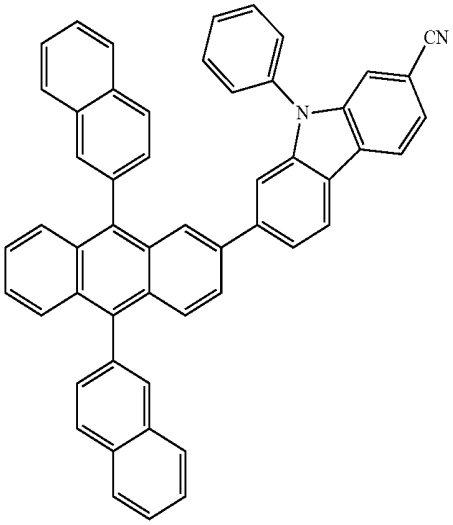

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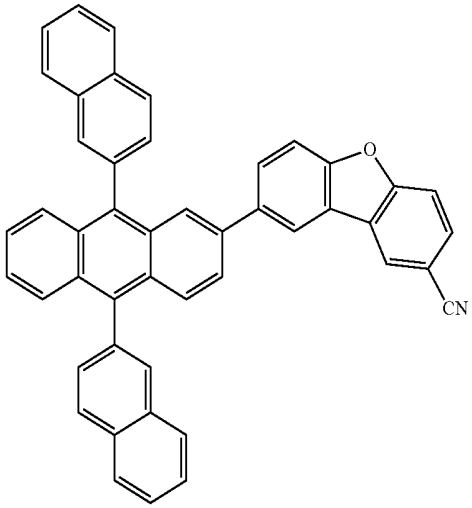

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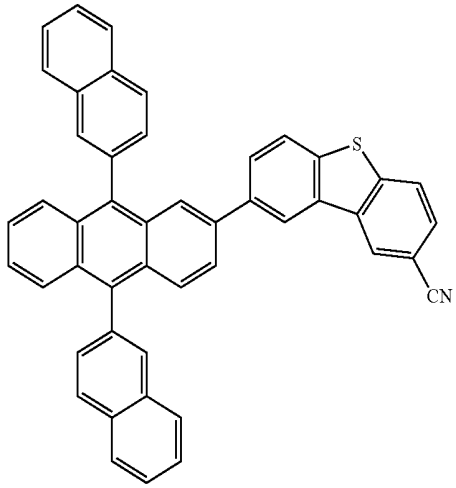

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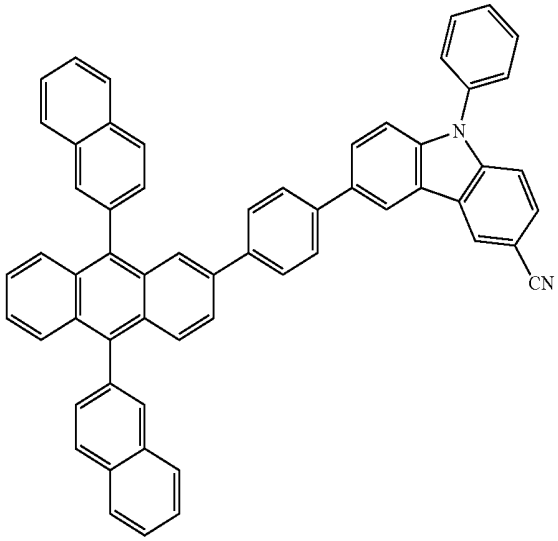

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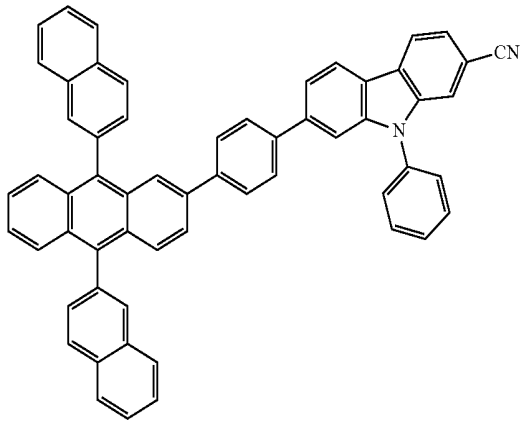

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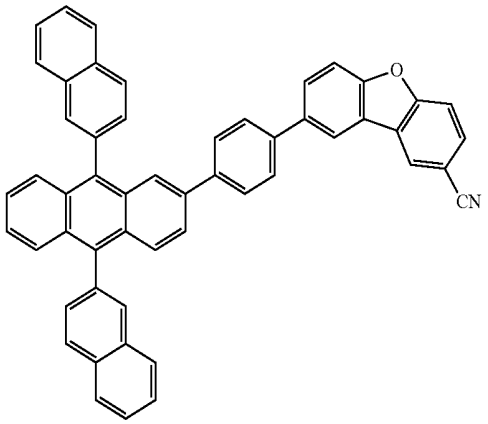

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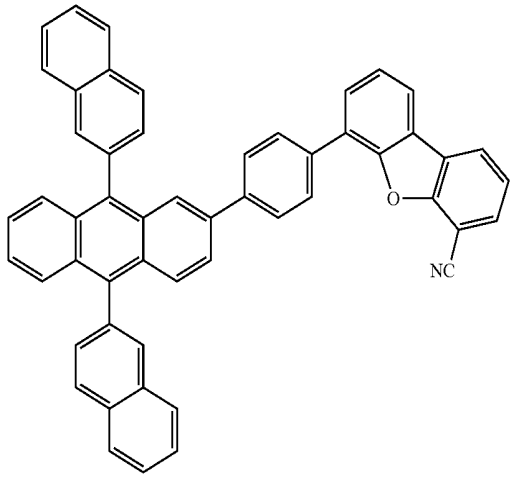

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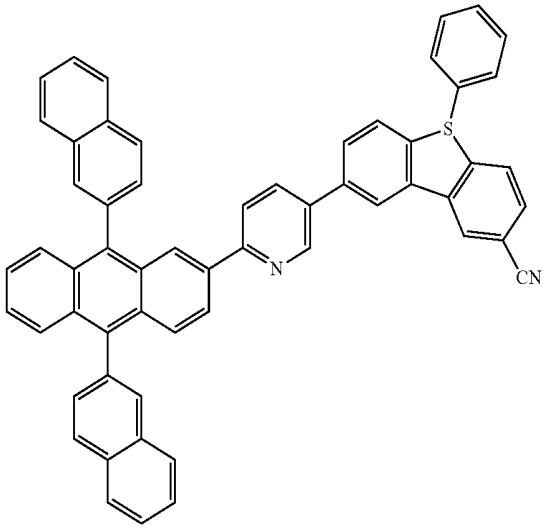

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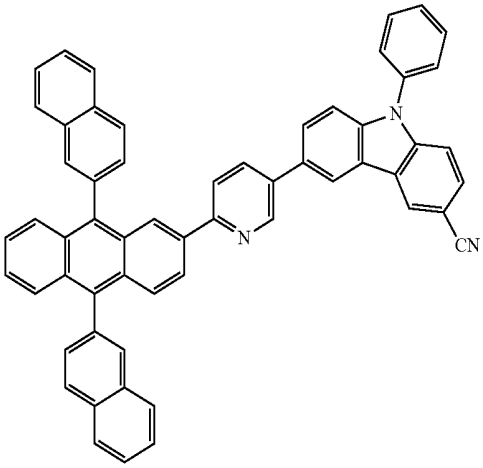

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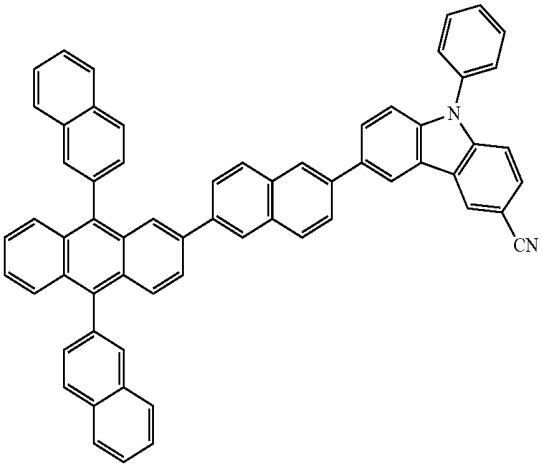

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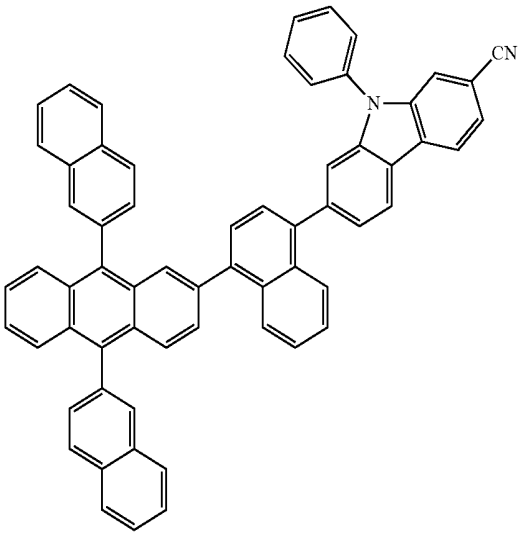

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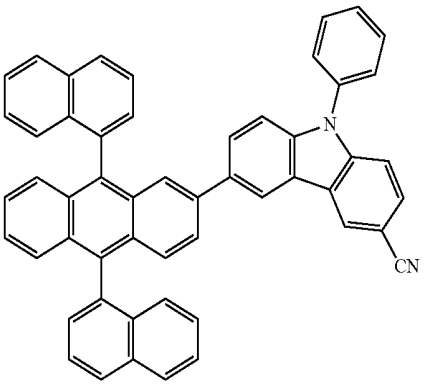

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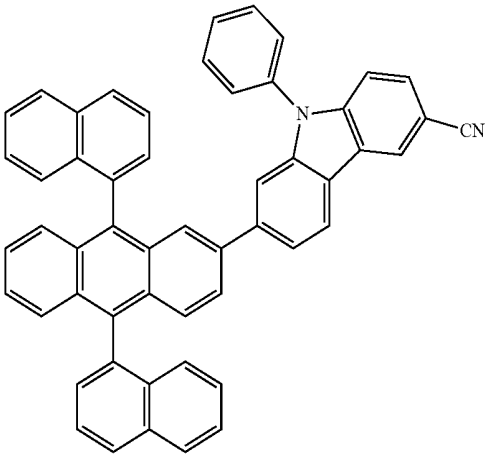

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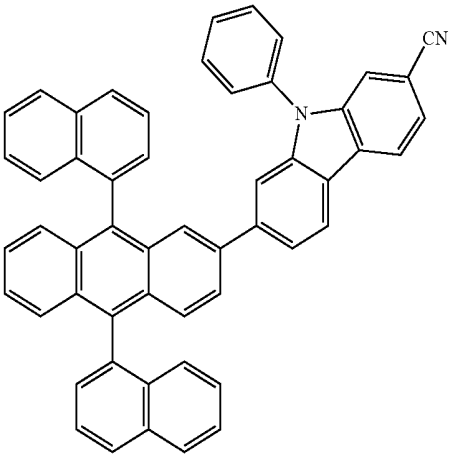

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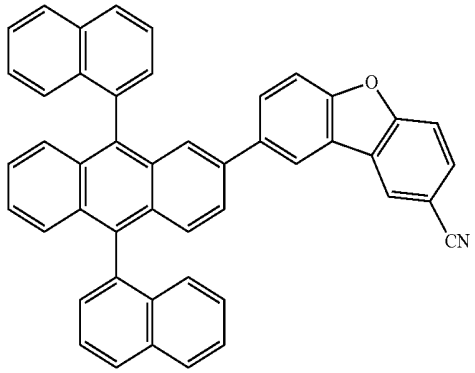

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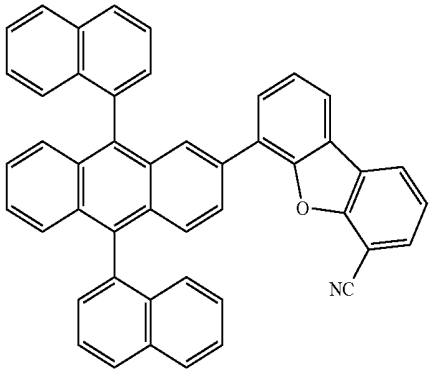

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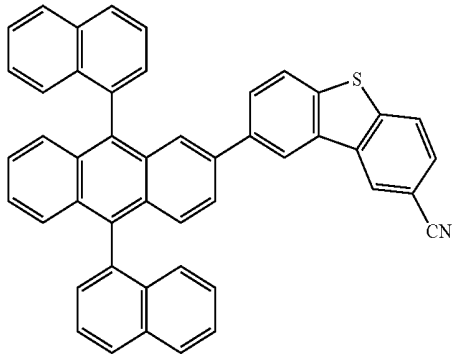

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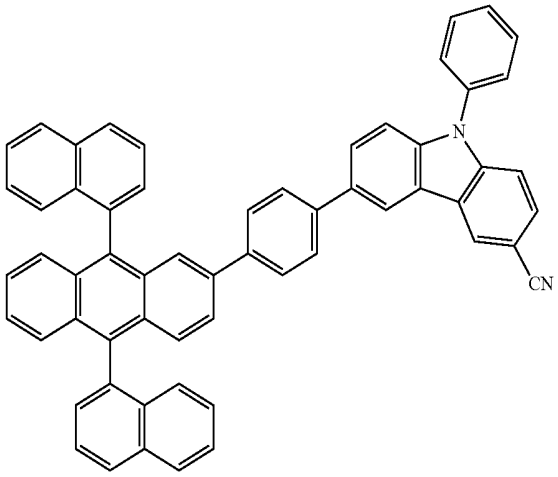

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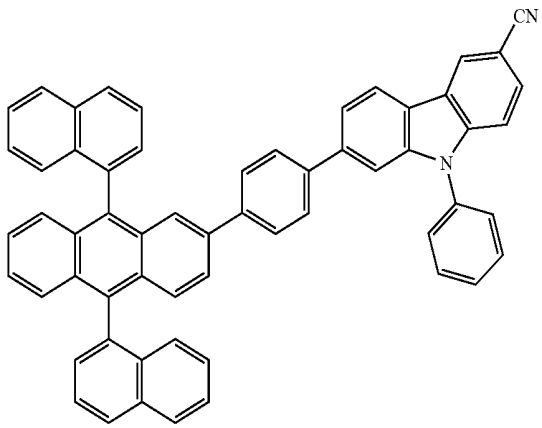

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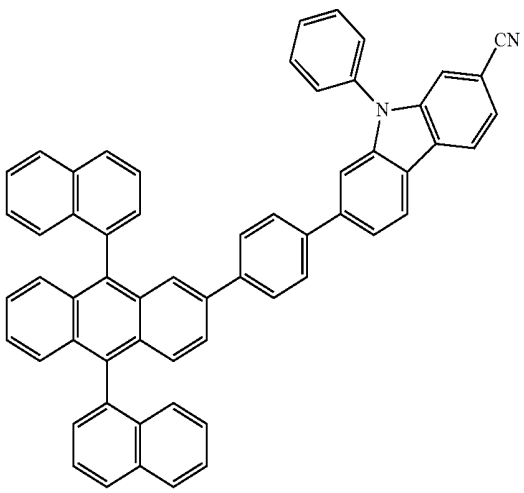

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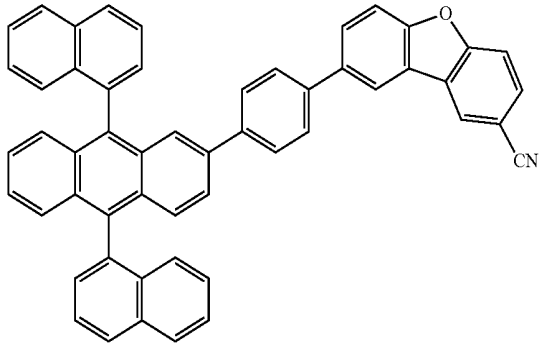

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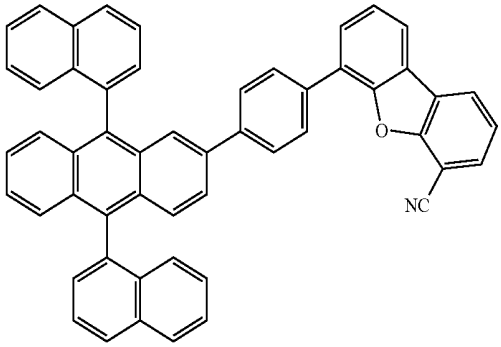

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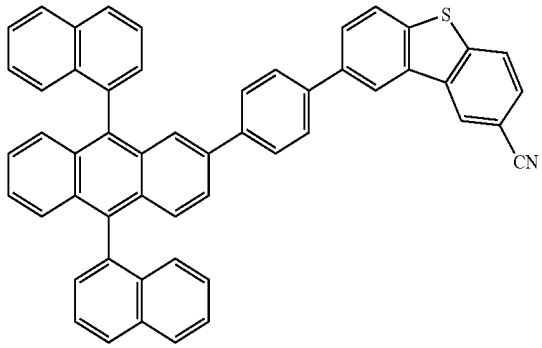

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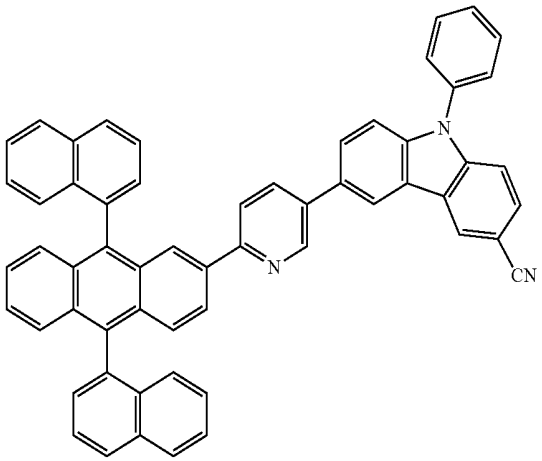

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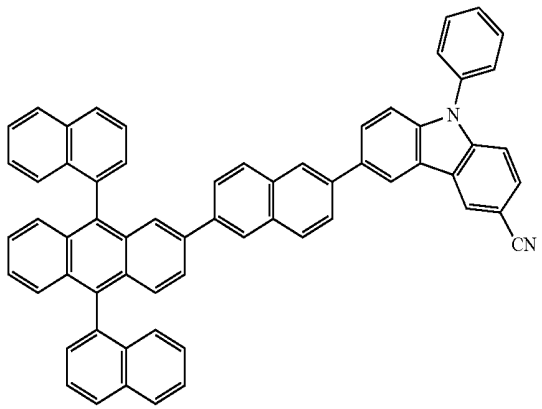

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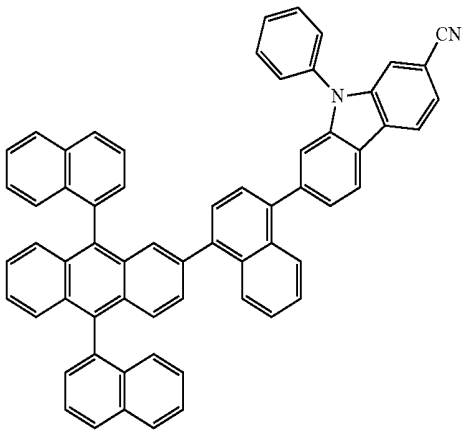

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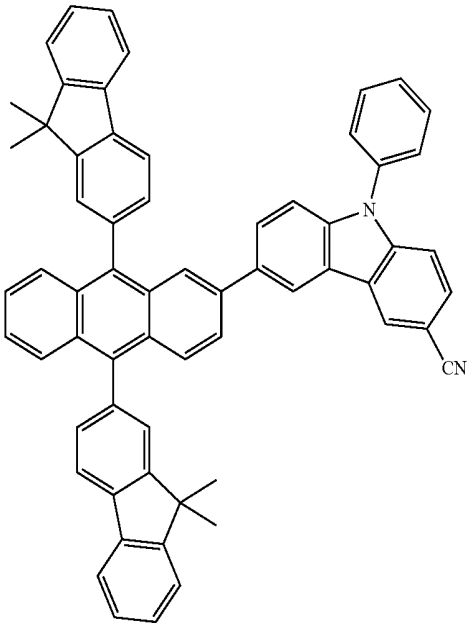

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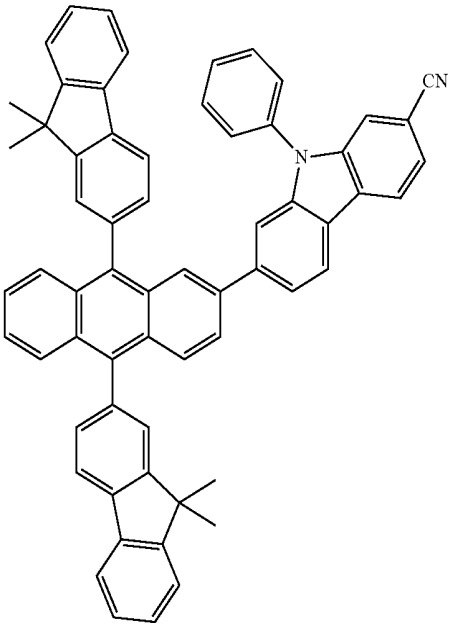

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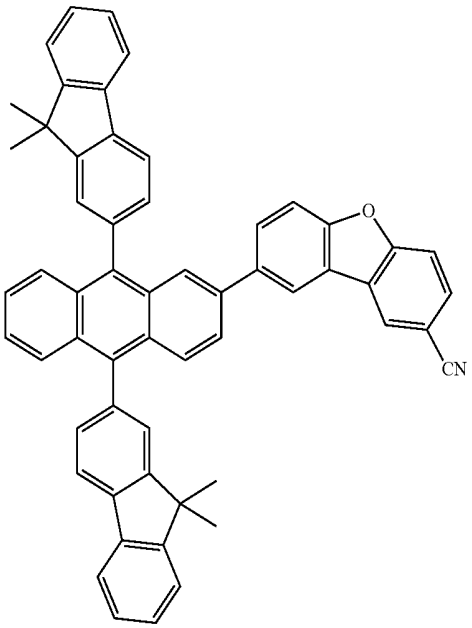

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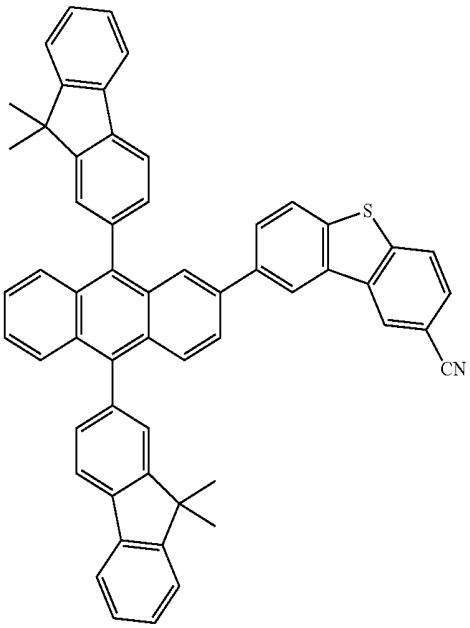

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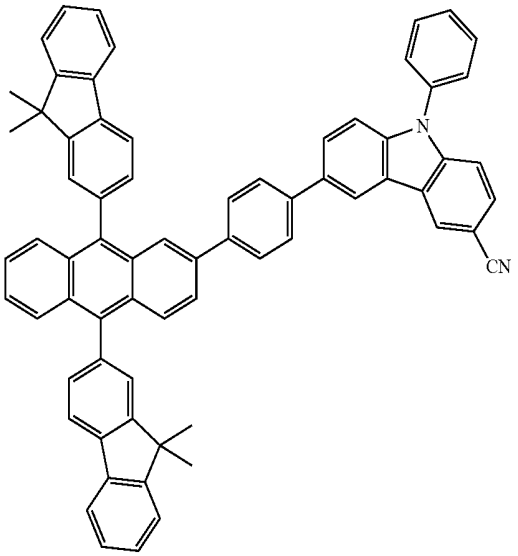

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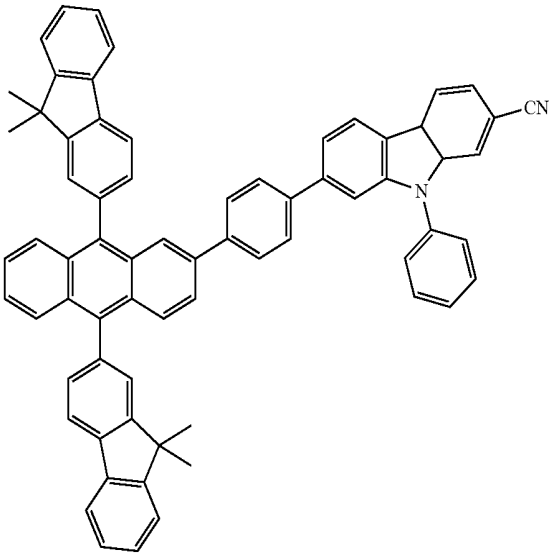

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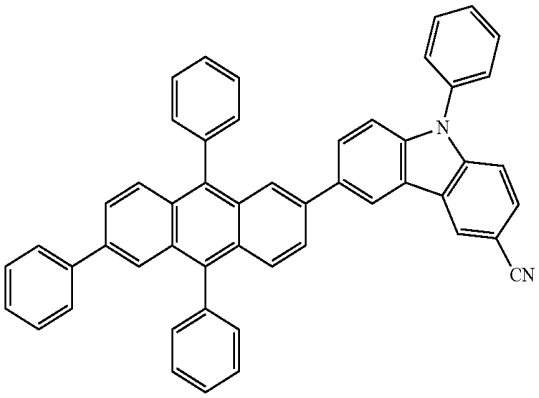

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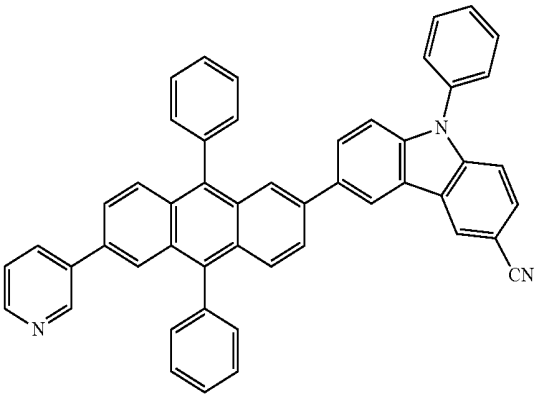

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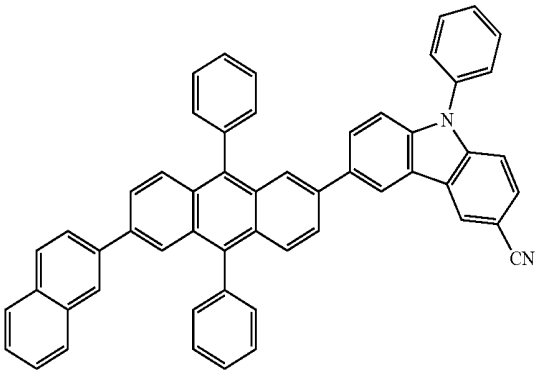

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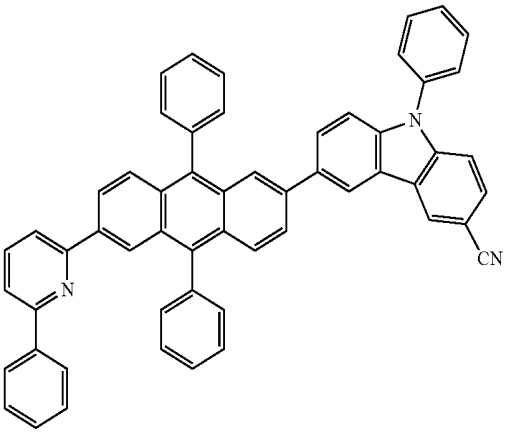

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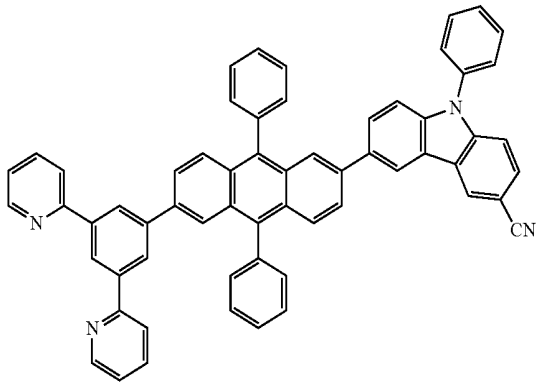

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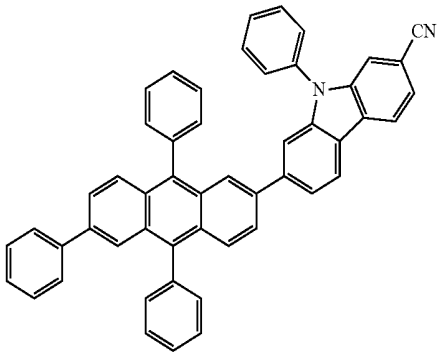

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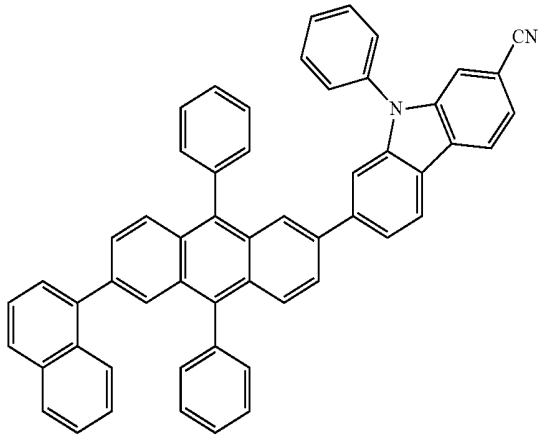

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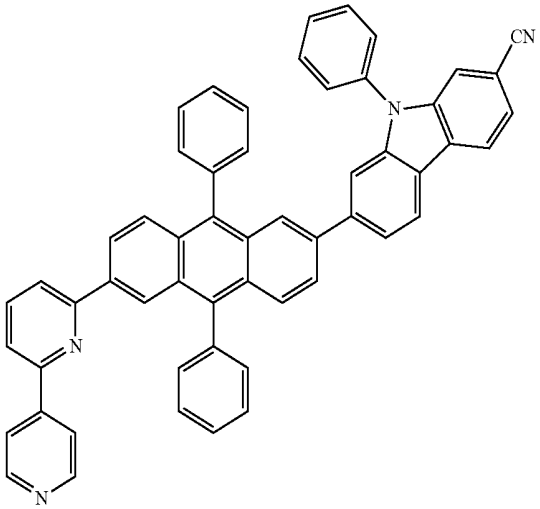

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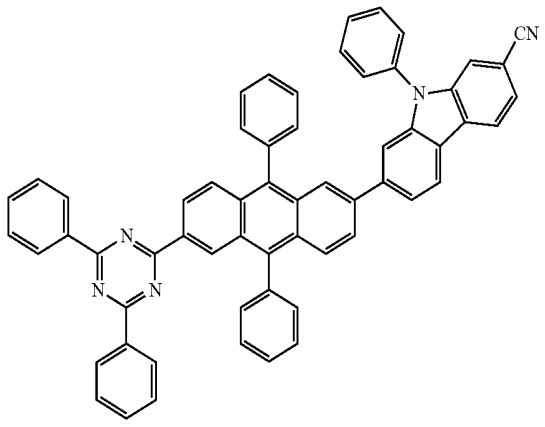

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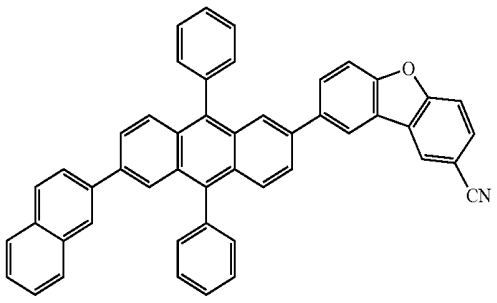

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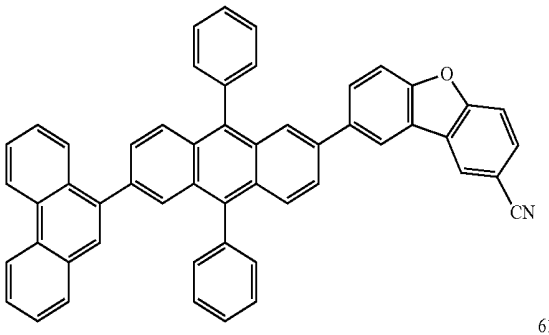

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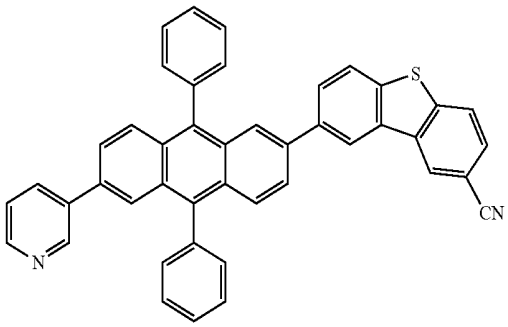

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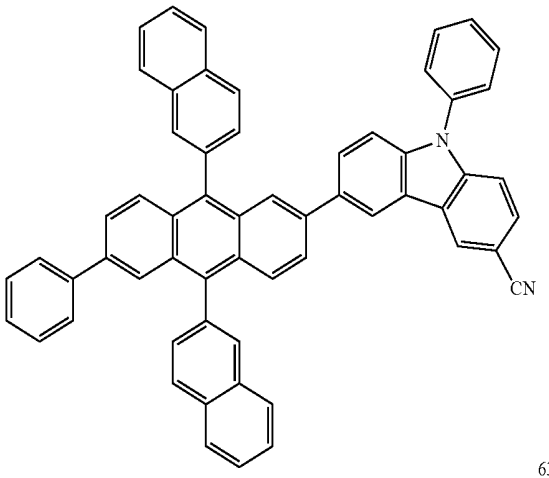

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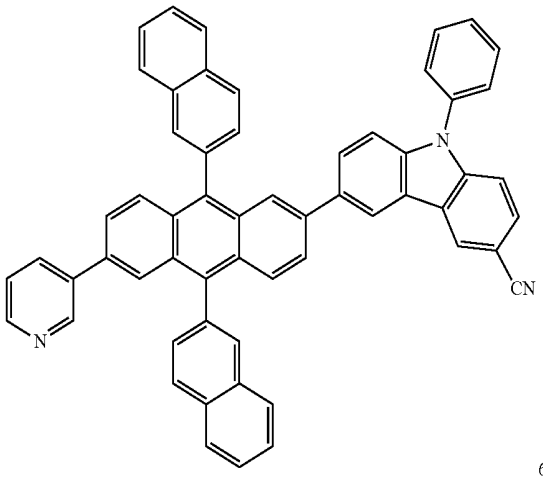

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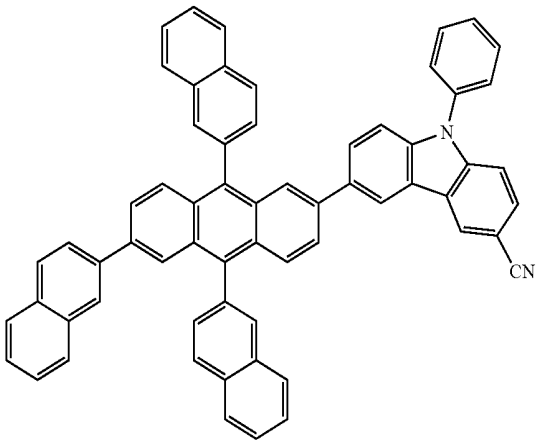

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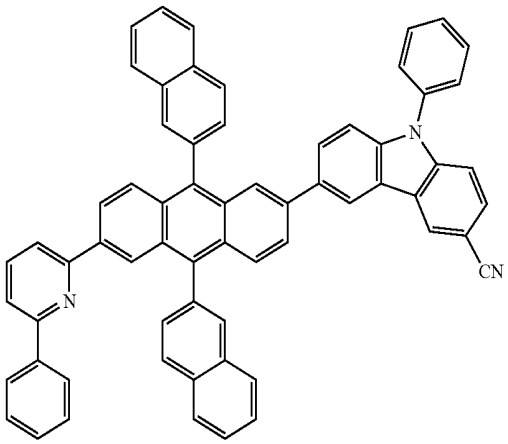

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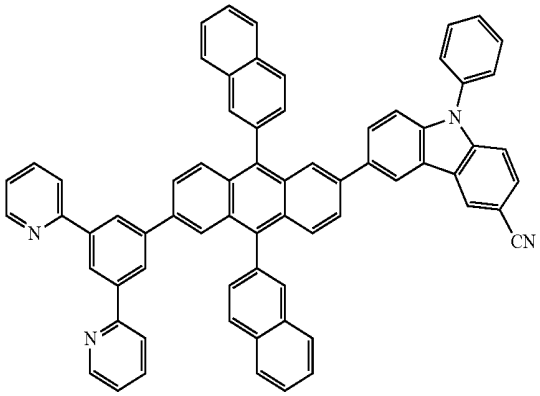

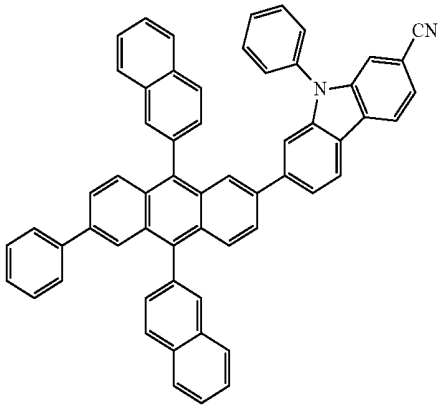

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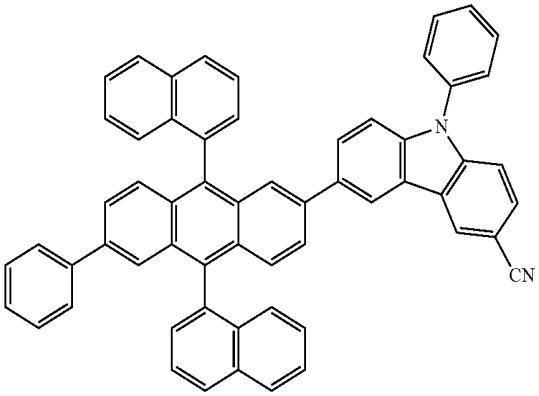

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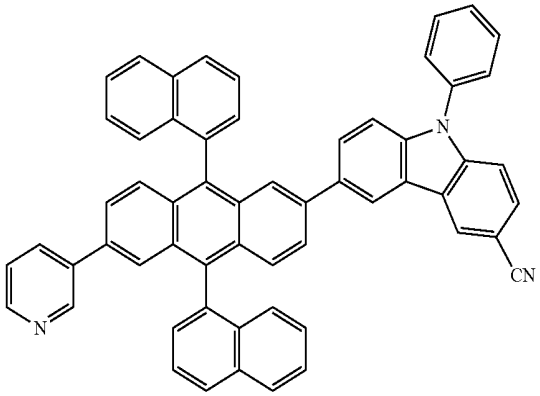

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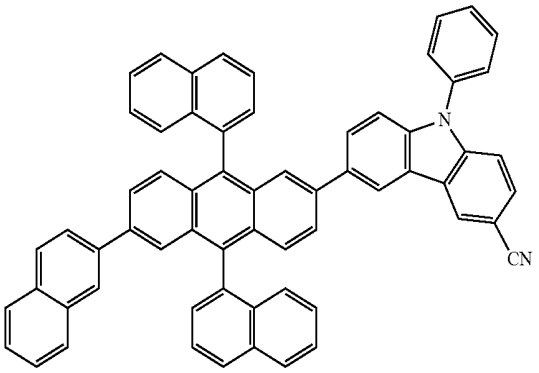

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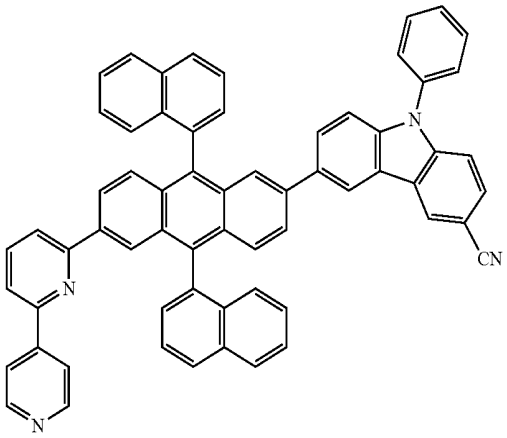

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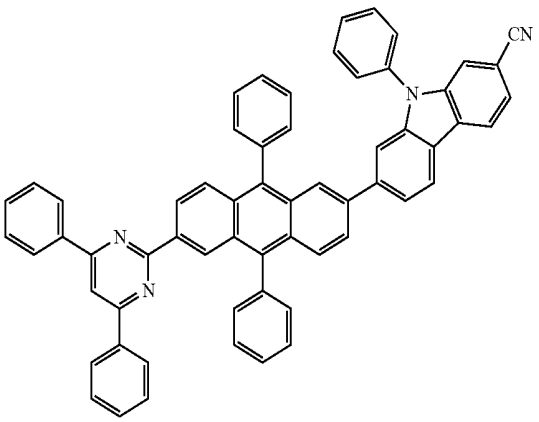

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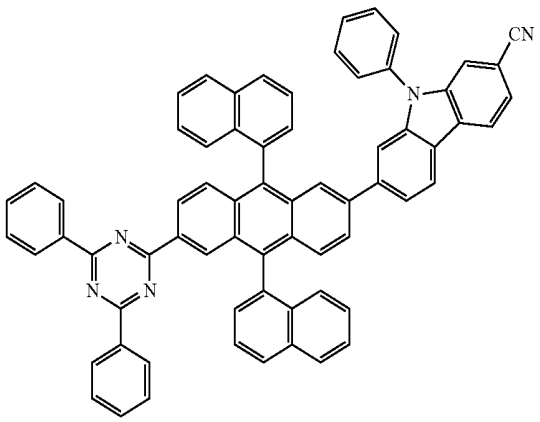

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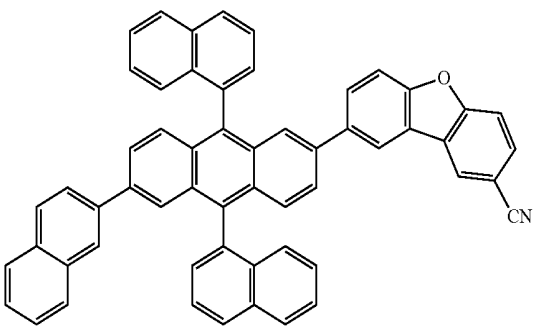

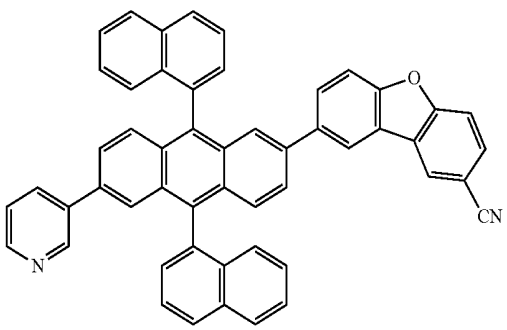

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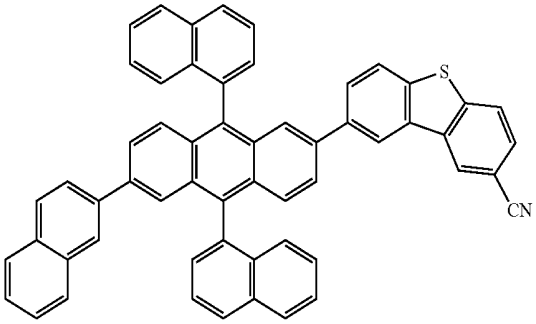

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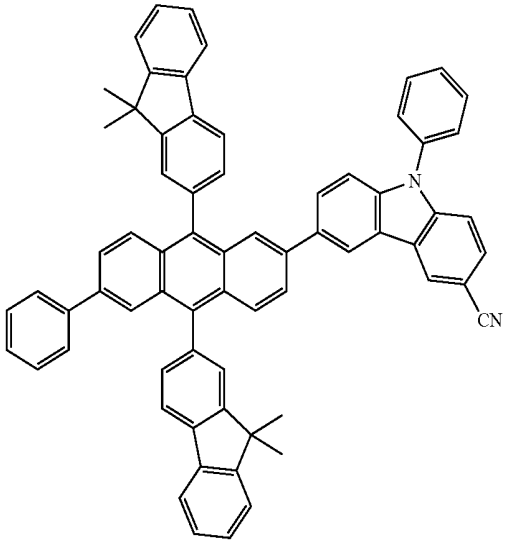

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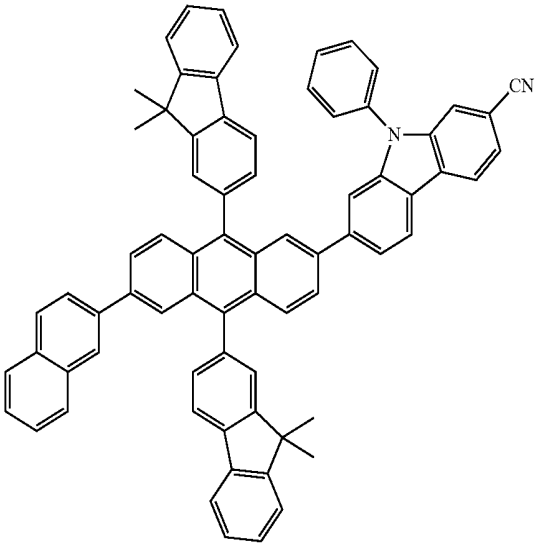

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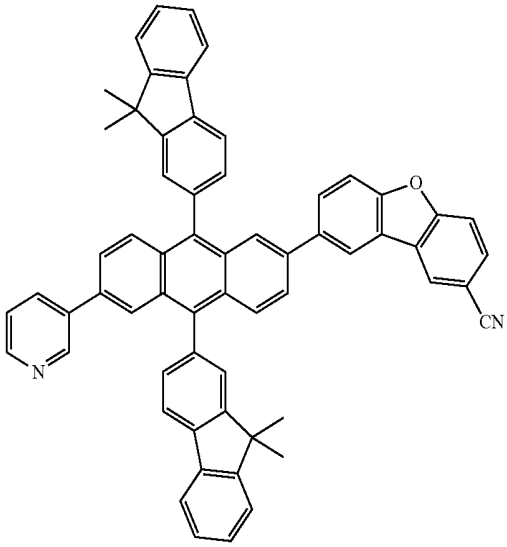

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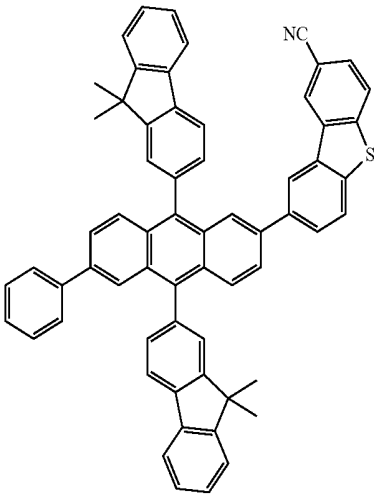

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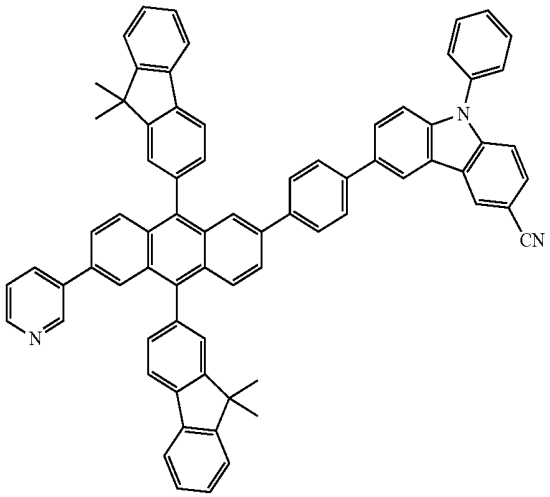

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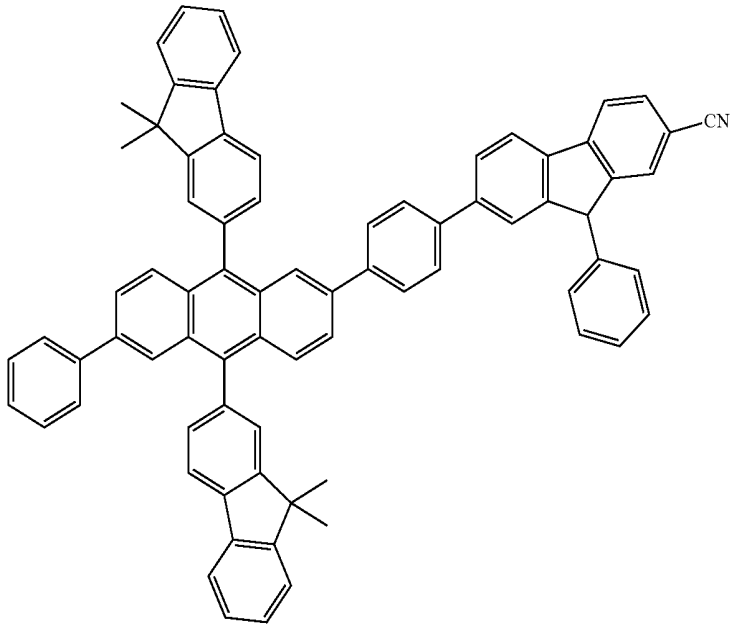

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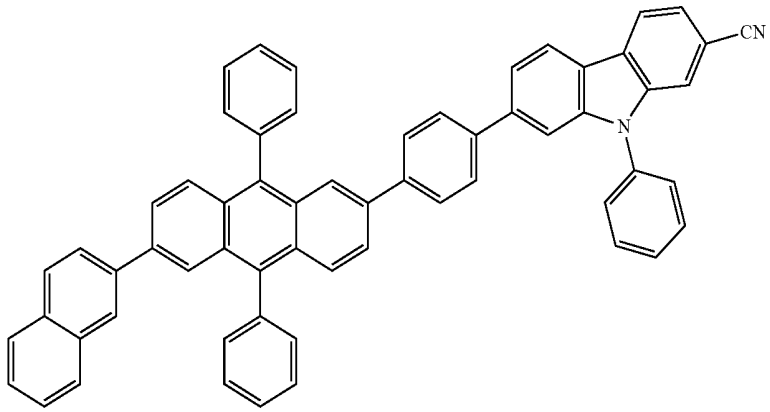

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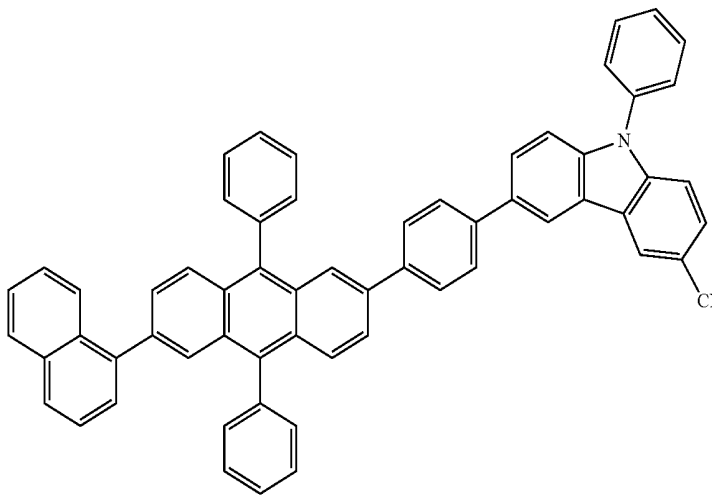

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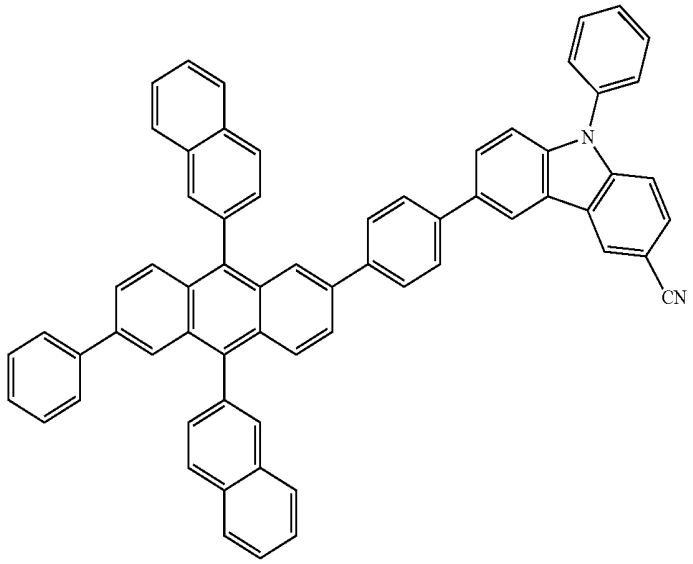

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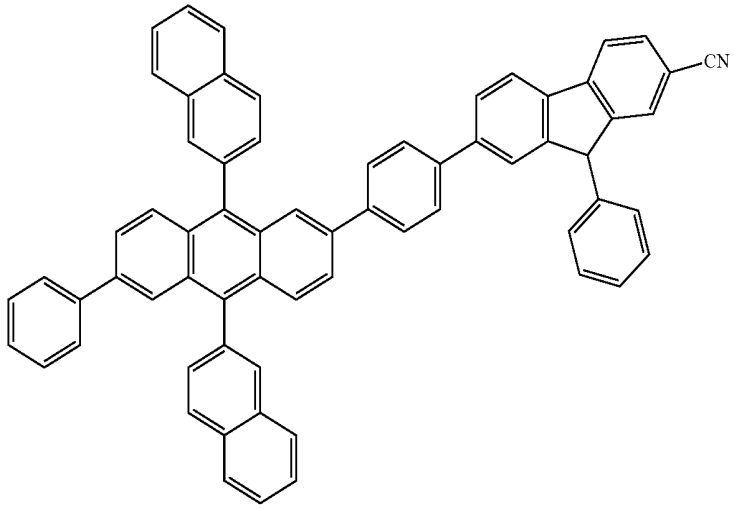

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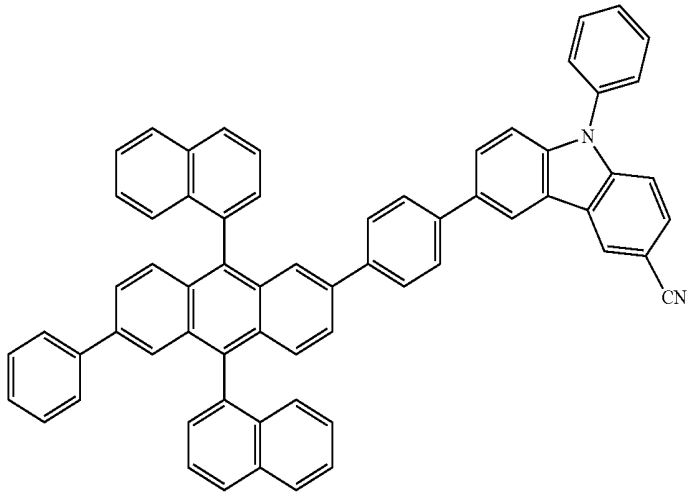

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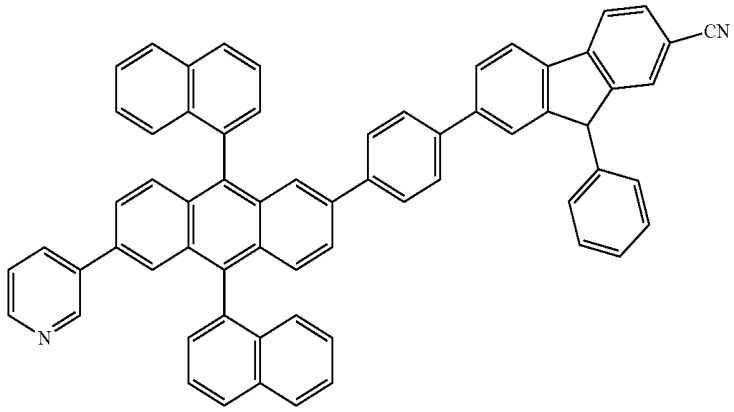

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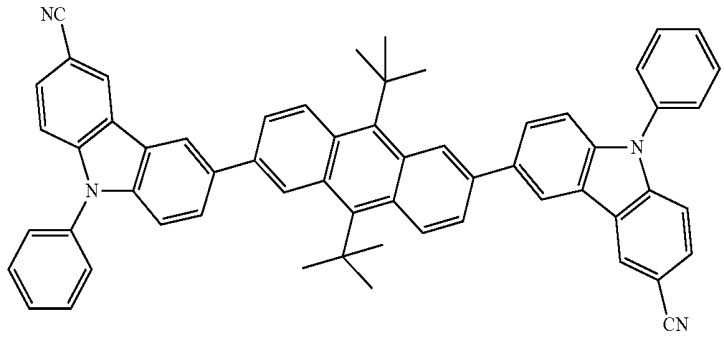

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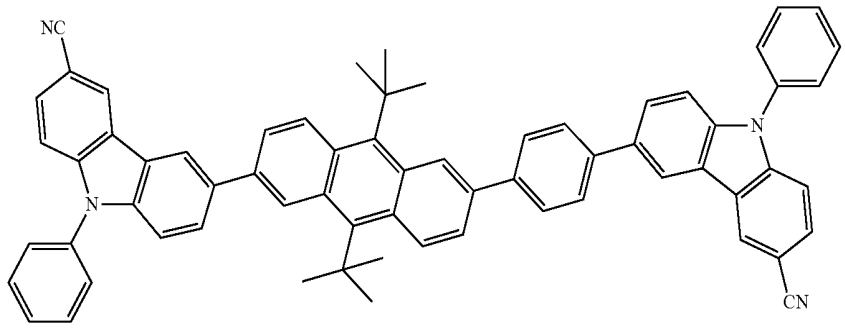

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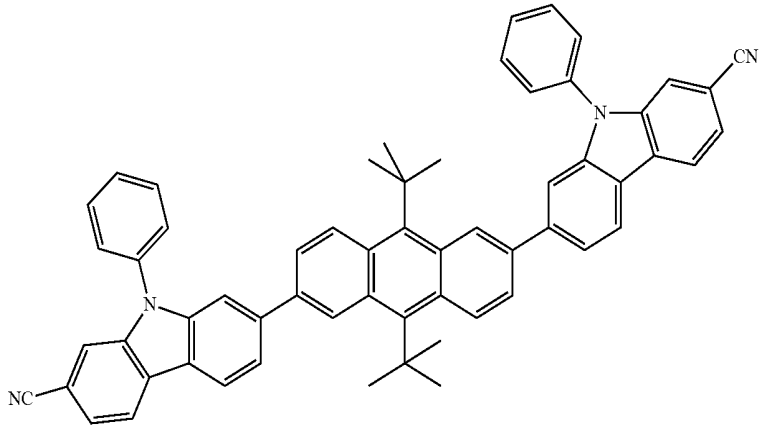

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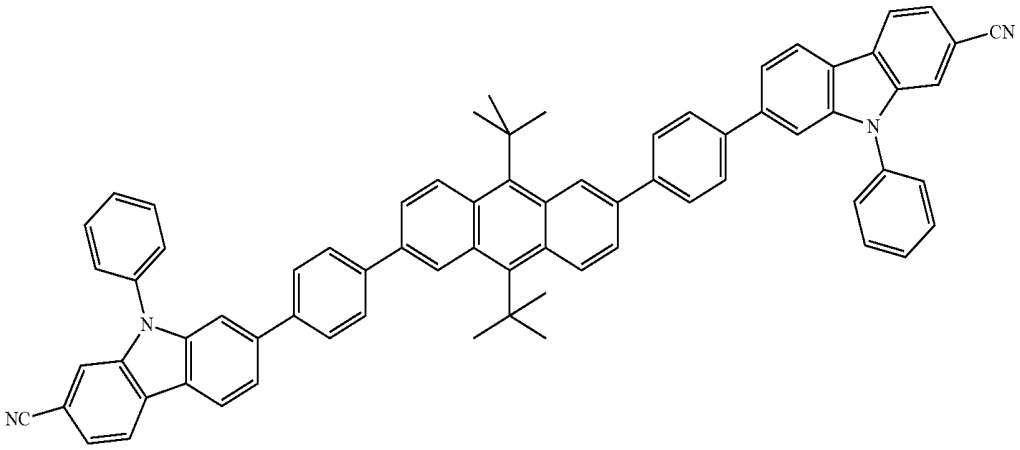

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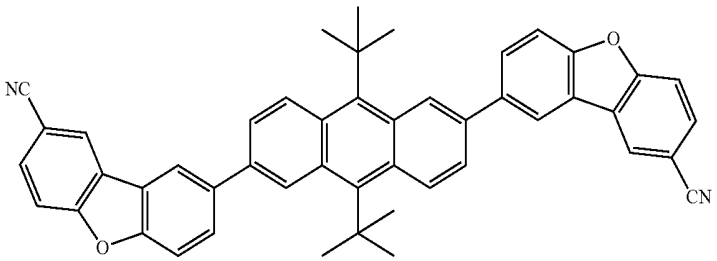

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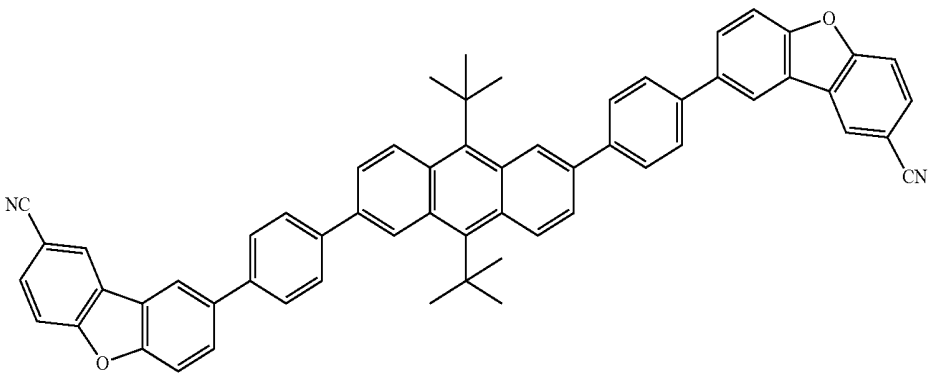

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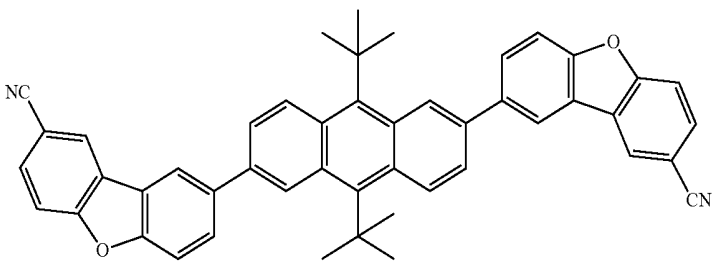

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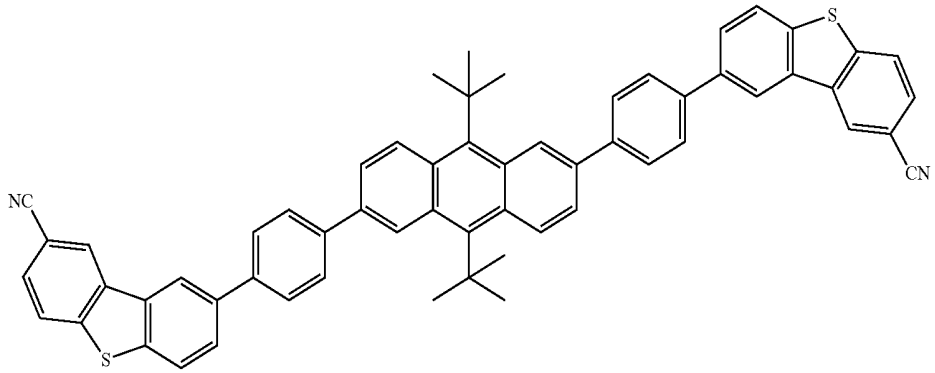

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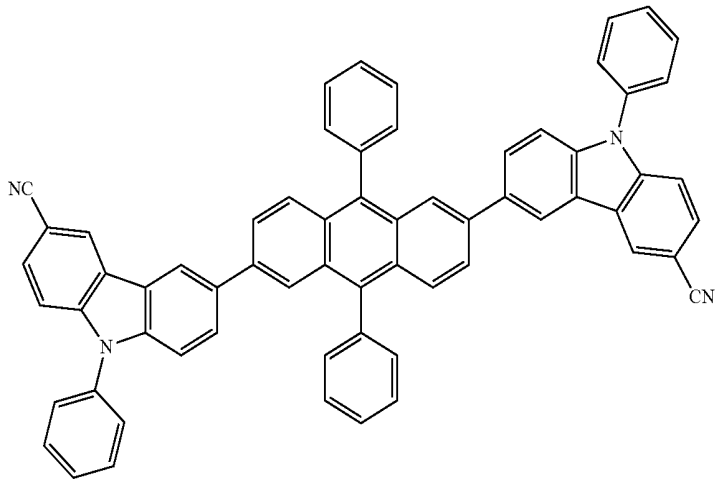

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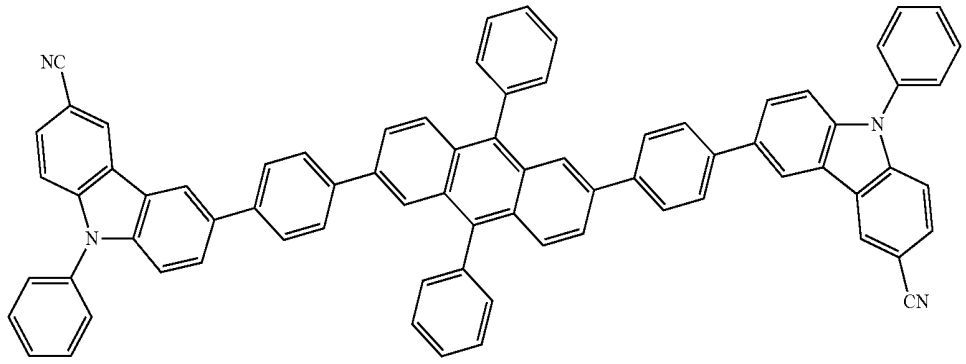

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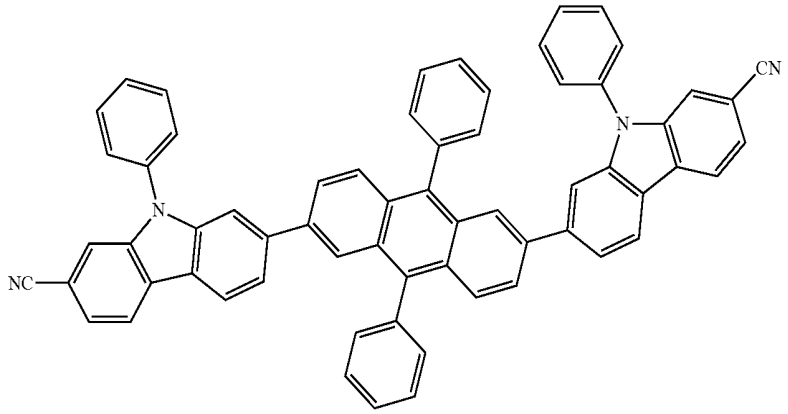

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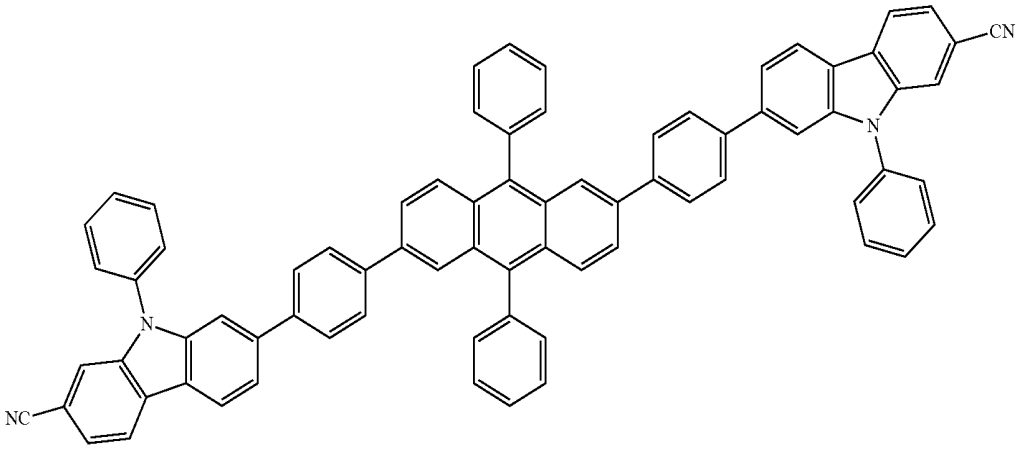

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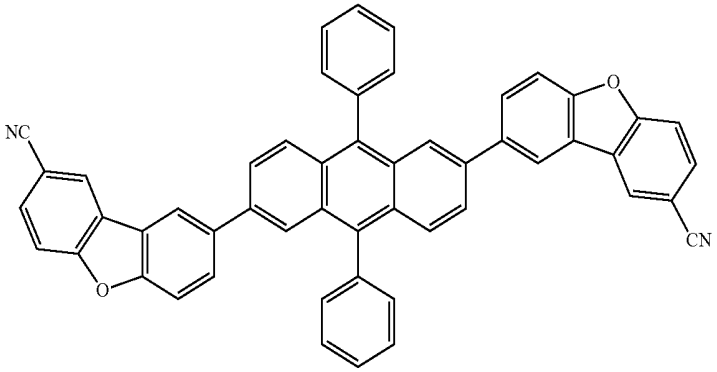

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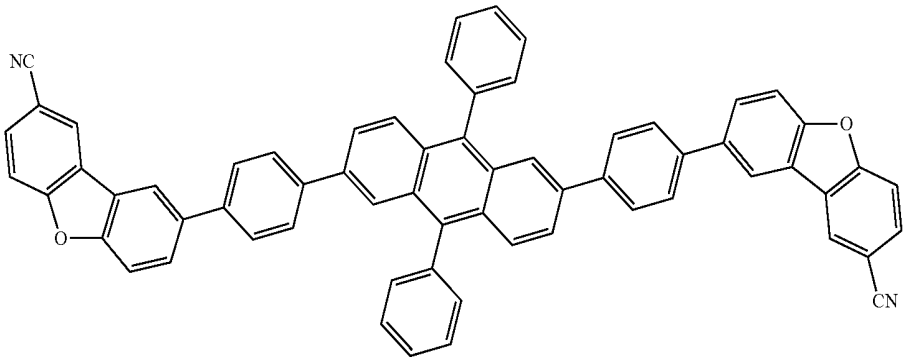

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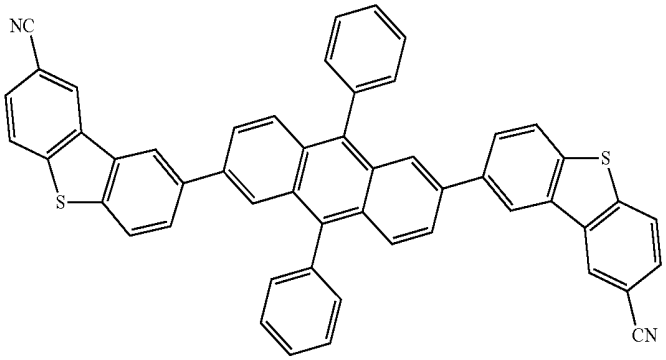

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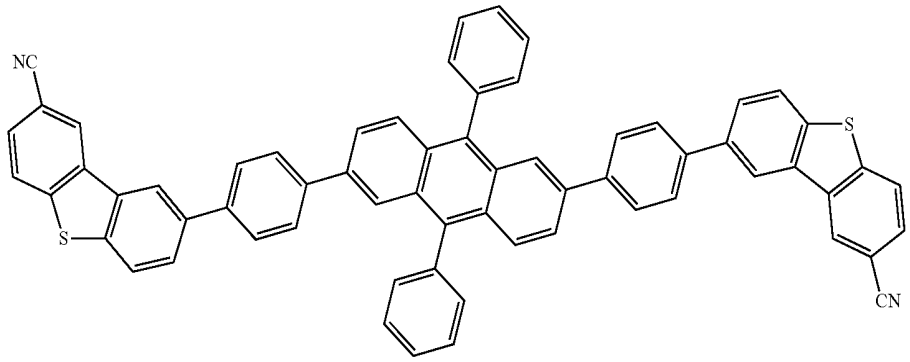

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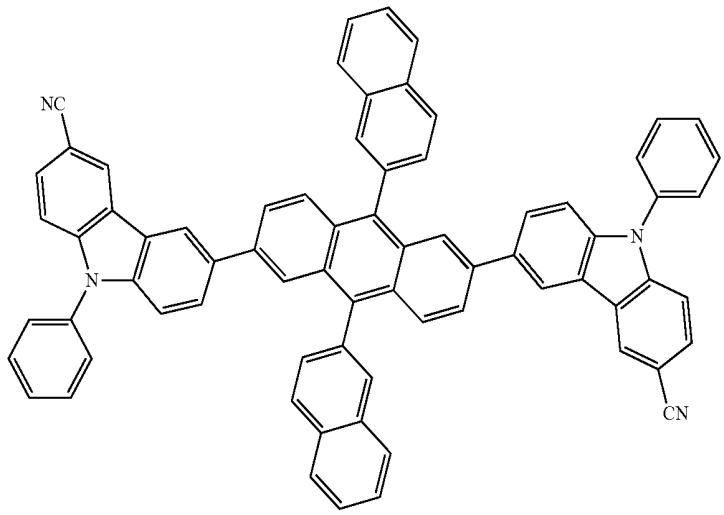

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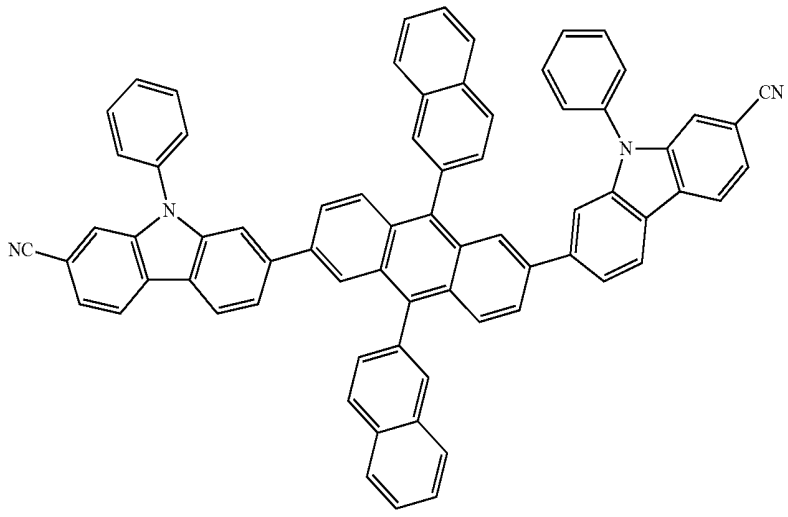

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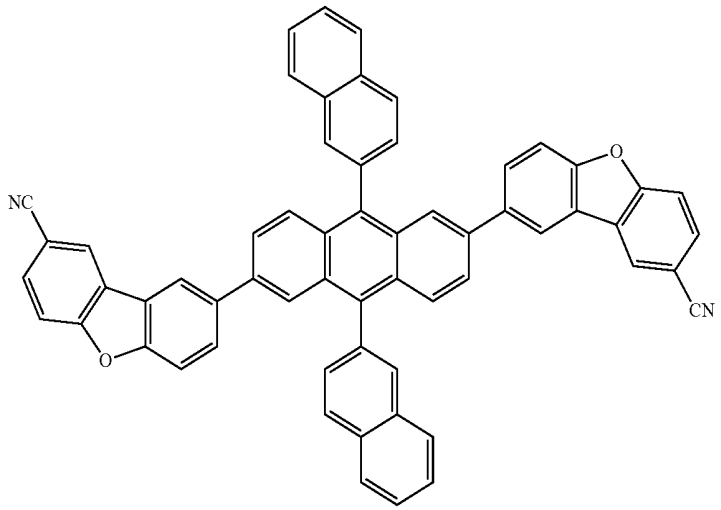

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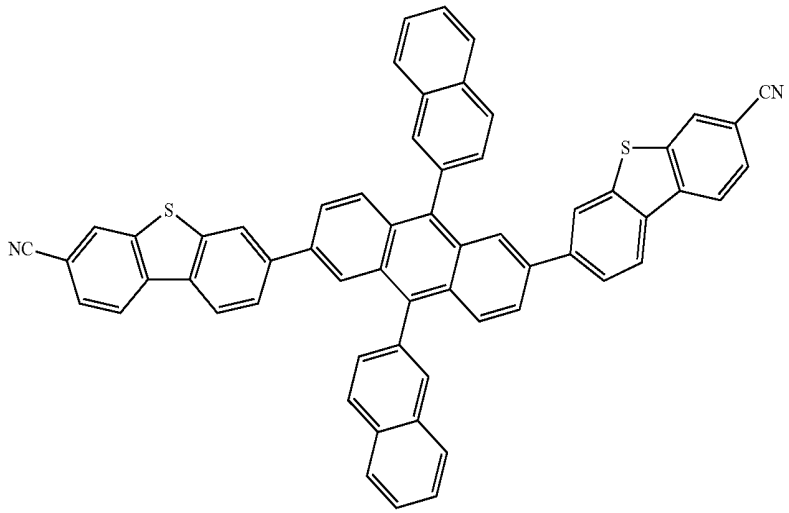

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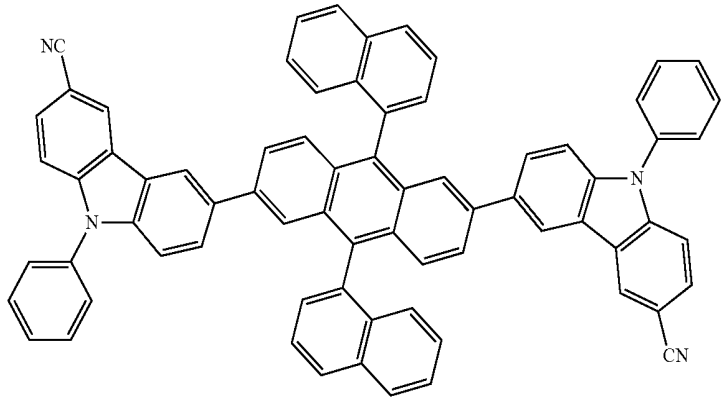

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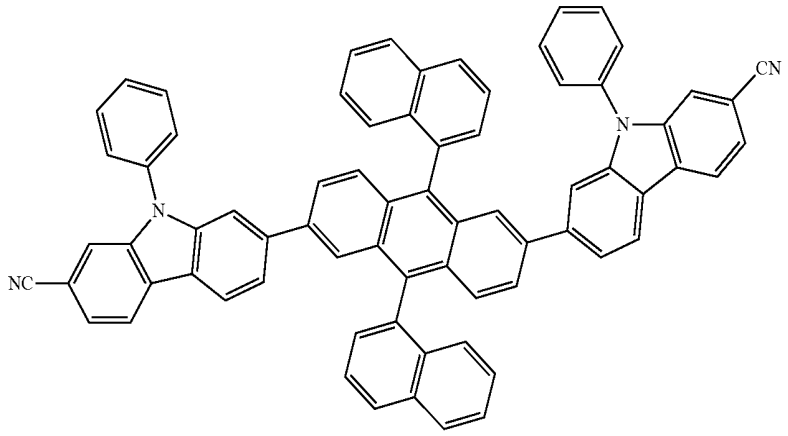


[0070] The condensed compound represented by Formula 1 or Formula 2 may be synthesized using an organic synthesis method. A synthesis method of the condensed compound may be determined by one of skill in the art in view of the following embodiments.

[0071] The condensed compound of Formula 1 or Formula 2 may be used between a pair of electrodes of an organic light-emitting diode. For example, the condensed compound may be included in an electron transport region, for example, an electron transport layer. Accordingly, an organic light-emitting diode according to an embodiment includes: a first electrode; a second electrode facing the first electrode; and an organic layer that is disposed between the first and second electrodes and includes an emission layer, wherein the organic layer includes at least one of the condensed compounds described above.

[0072] The expression "(an organic layer) includes at least one condensed compound" used herein includes a case in which "(an organic layer) includes one condensed compound of Formula 1 or Formula 2 and a case in which (an organic layer) includes two or more different condensed compounds of Formula 1 or Formula 2".

[0073] For example, the organic layer may include, as the condensed compound, only Compound 1. In this regard, Compound 1 may exist in an electron transport layer of the organic light-emitting diode. In another embodiment, the organic layer may include, as the condensed compound, Compound 1 and Compound 2. In this regard, Compound 1 and Compound 2 may exist in an identical layer (for example, Compound 1 and Compound 2 may both exist in an electron transport layer), or different layers (for example, Compound 1 may exist in an emission layer and Compound 2 may exist in an electron transport layer).

[0074] The organic layer includes i) a hole transport region that is disposed between the first electrode and the emission layer and includes at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and ii) an electron transport region that is disposed between the emission layer and the second electrode and includes at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer. The electron transport region may include a condensed compound represented by Formula 1 or Formula 2. For example, the electron transport region may include an electron transport layer including the condensed compound represented in Formula 1 or Formula 2.

[0075] The expression "organic layer" used herein refers to a single layer and/or a plurality of layers disposed between the first and second electrodes of an organic light-emitting diode. Each material of the "organic layer" is not limited to being an organic material.

[0076] FIG. **1** illustrates a schematic view of an organic light-emitting diode **10** according to an embodiment. The organic light-emitting diode **10** includes a first electrode **110**, an organic layer **150**, and a second electrode **190**.

[0077] Hereinafter, the structure of an organic light-emitting diode according to an embodiment and a method of manufacturing an organic light-emitting diode, according to an embodiment, will be described in connection with FIG. **1**.

[0078] In FIG. **1**, a substrate may be additionally disposed under the first electrode **110** or above the second electrode **190**. The substrate may be a glass substrate or a transparent plastic substrate, each with excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water repellency.

[0079] The first electrode **110** may be formed by depositing or sputtering a material for forming the first electrode **110** on the substrate. When the first electrode **110** is an anode, the material for the first electrode **110** may be selected from materials with a high work function to make holes be easily injected. The first electrode **110** may be a reflective electrode or a transmissive electrode. The material for the first electrode **110** may be a transparent and highly conductive material, and examples of such a material are indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), and zinc oxide (ZnO). When the first electrode **110** is a semi-transmissive electrode or a reflective electrode, a material for forming the first electrode **110** may include at least one of magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag).

[0080] The first electrode **110** may have a single-layer structure, or a multi-layer structure including, two or more layers. For example, the first electrode **110** may have a three-layered structure of ITO/Ag/ITO.

[0081] The organic layer **150** is disposed on the first electrode **110**. The organic layer **150** may include an emission layer.

[0082] The organic layer **150** may further include a hole transport region disposed between the first electrode **110** and the emission layer, and an electron transport region disposed between the emission layer and the second electrode **190**.

[0083] The hole transport region may include at least one selected from a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and the electron transport region may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

[0084] The hole transport region may have a single-layered structure formed using a single material, a single-layered structure formed using different materials, or a multi-layered structure having a plurality of layers formed using different materials.

[0085] For example, the hole transport region may have a single-layered structure formed using different materials, or a structure of hole injection layer/hole transport layer, a structure of hole injection layer/hole transport layer/buffer layer, a structure of hole injection layer/buffer layer, a structure of hole transport layer/buffer layer, or a structure of hole injection layer/hole transport layer/electron blocking layer, wherein layers of each structure are sequentially stacked from the first electrode **110** in this stated order.

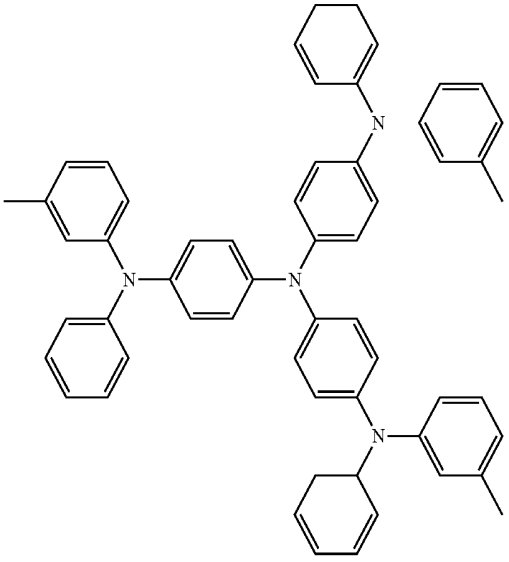
[0086] When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **110** by various methods, such as vacuum deposition, spin coating, casting, a Langmuir-Blodgett (LB) method, ink-jet printing, laser-printing, or laser-induced thermal imaging.

[0087] When a hole injection layer is formed by vacuum deposition, for example, the vacuum deposition may be performed at a deposition temperature of about 100 to about 500° C., at a vacuum degree of about 10^{-8} to about 10^{-3} torr, and at a deposition rate of about 0.01 to about 100 Å/sec in consideration of a compound for a hole injection layer to be deposited, and the structure of a hole injection layer to be formed.

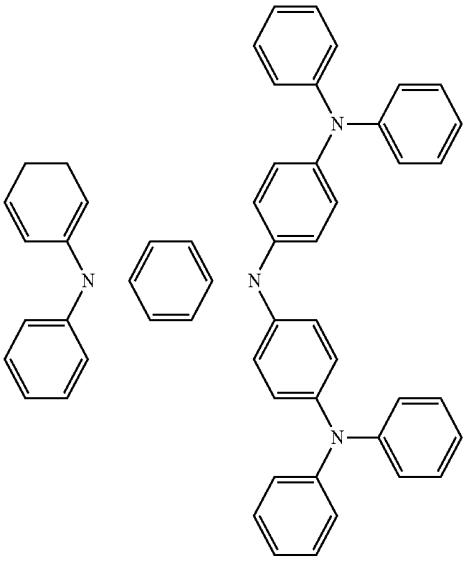
[0088] When a hole injection layer is formed by spin coating, the spin coating may be performed at a coating rate of about 2000 rpm to about 5000 rpm, and at a temperature of about 80° C. to 200° C. in consideration of a compound for a hole injection layer to be deposited, and the structure of a hole injection layer to be formed.

[0089] When the hole transport region includes a hole transport layer, the hole transport layer may be formed on the first electrode **110** or the hole injection layer by various methods, such as vacuum deposition, spin coating, casting, an LB method, ink-jet printing, laser-printing, or laser-induced thermal imaging. When the hole transport layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the hole transport layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0090] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, β-NPB, TPD, Spiro-TPD, Spiro-NPB, α-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), (polyaniline)/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, and a compound represented by Formula 202 below:



m-MTDATA



TDATA

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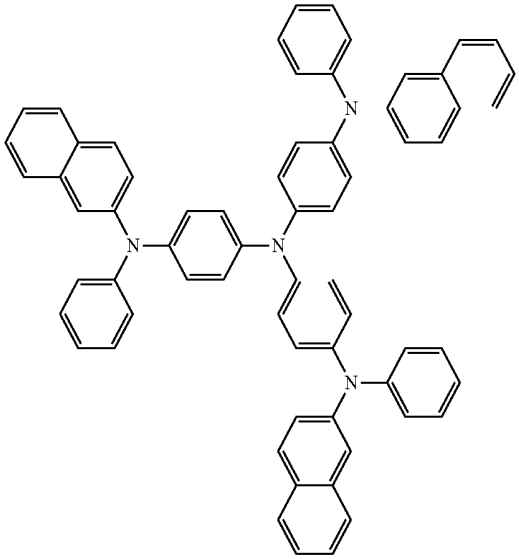

2-TNATA

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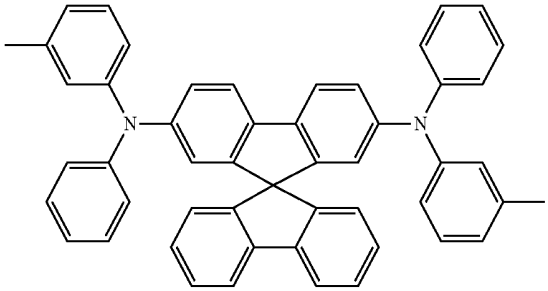
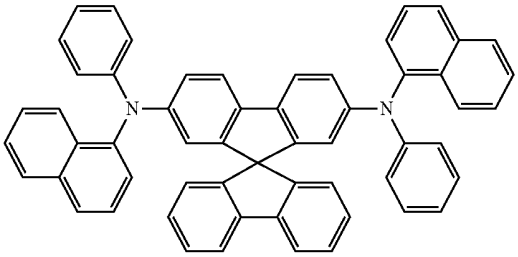
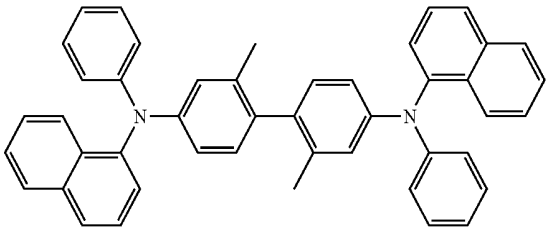
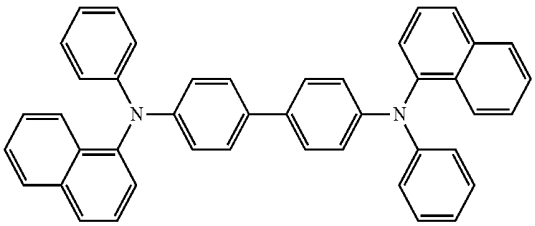


Spiro-TPD



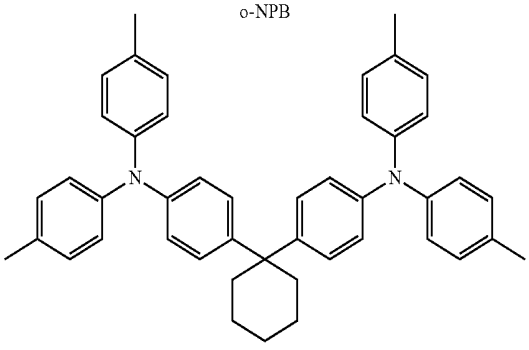
Spiro-NPB



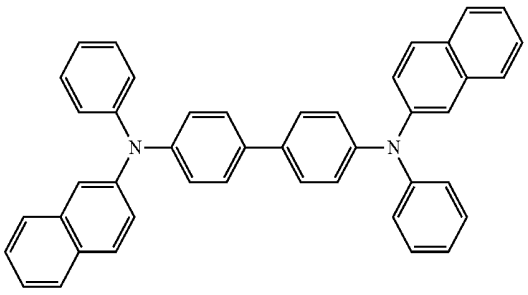


NPB

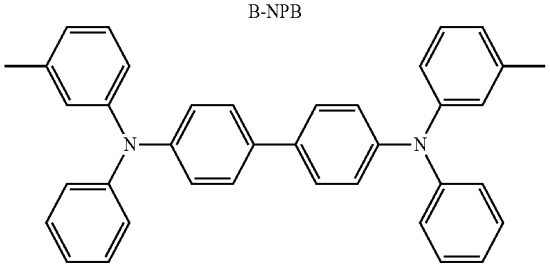
o-NPB



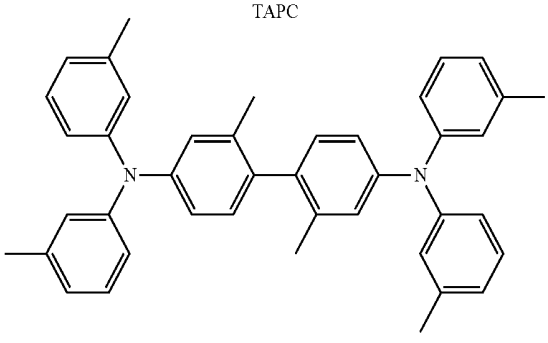
TAPC



B-NPB



TPD



HMTPD

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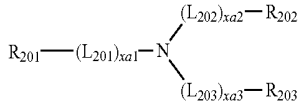
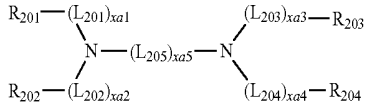


<Formula 202>



[0091] wherein in Formulae 201 and 202,

[0092] L_{201} to L_{205} may be understood by referring to the description provided herein in connection with L_1;

[0093] xa1 to xa4 may each independently be selected from 0, 1, 2, and 3;

[0094] xa5 may be selected from 1, 2, 3, 4, and 5; and

[0095] R_{201} to R_{205} may be understood by referring to the description provided herein in connection with R_{21}.

[0096] In Formulae 201 and 202,

[0097] L_{201} to L_{205} may each independently be selected from

[0098] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluoenylene group, a dibenzofluoenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group and a triazinylene group; and

[0099] a phenylene group, naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluoenylene group, a dibenzofluoenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group and a triazinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0100] xa1 to xa4 may each independently be 0, 1, or 2;

[0101] xa5 may be 1, 2, or 3; and

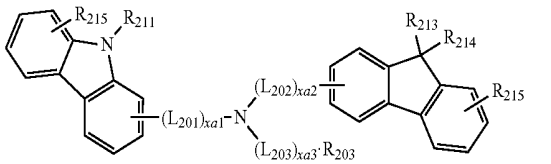
[0102] R_{201} to R_{205} are each independently selected from

[0103] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0104] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group.

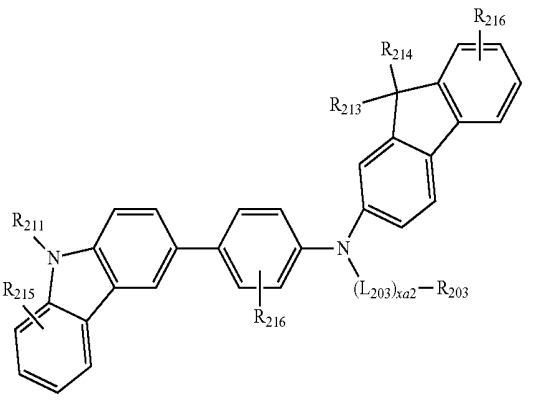
[0105] The compound represented by Formula 201 may be represented by Formula 201A:

<Formula 201A>



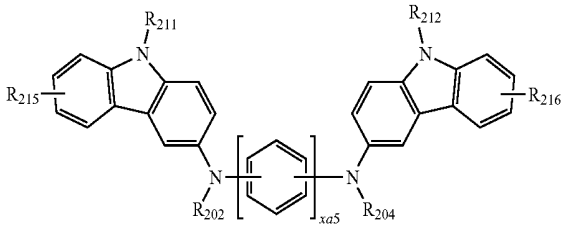
[0106] For example, the compound represented by Formula 201 may be represented by Formula 201A-1 below:

<Formula 201A-1>



[0107] For example, the compound represented by Formula 202 may be represented by Formula 202A below:

<Formula 202A>



[0108] L_{201} to L_{203}, xa1 to xa3, xa5, and R_{202} to R_{204} in Formulae 201A, 201A-1, and 202A are described above, R_{211} may be understood by referring to the description provided in connection with R_{203}, and R_{213} to R_{216} may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group and a monovalent non-aromatic hetero-condensed polycyclic group.

[0109] For example,

[0110] L_{201} to L_{203} in Formulae 201A, 201A-1, and 202A may each independently be selected from

[0111] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene group; and

[0112] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0113] xa1 to xa3 may each independently be 0 or 1;

[0114] R_{203}, R_{211}, and R_{212} may each independently be selected from

[0115] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0116] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0117] R_{213} and R_{214} are each independently selected from

[0118] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

[0119] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0120] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0121] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl

group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0122] R_{215} and R_{216} are each independently selected from

[0123] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group;

[0124] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0125] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

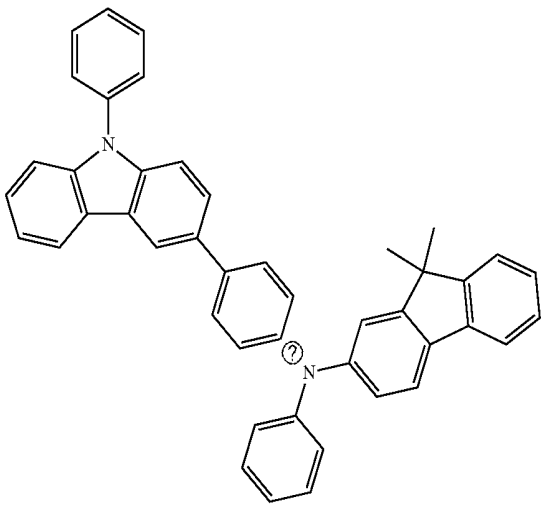
[0126] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0127] xa5 may be 1 or 2.

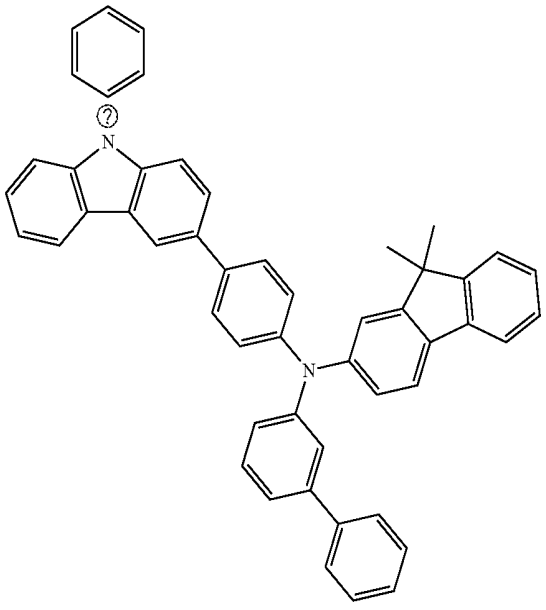
[0128] R_{213} and R_{214} in Formulae 201A and 201A-1 may bind to each other to form a saturated or unsaturated ring.

[0129] the compound represented by Formula 201 and the compound represented by Formula 202 may include compounds HT1 to HT20 illustrated below:

HT1



HT2



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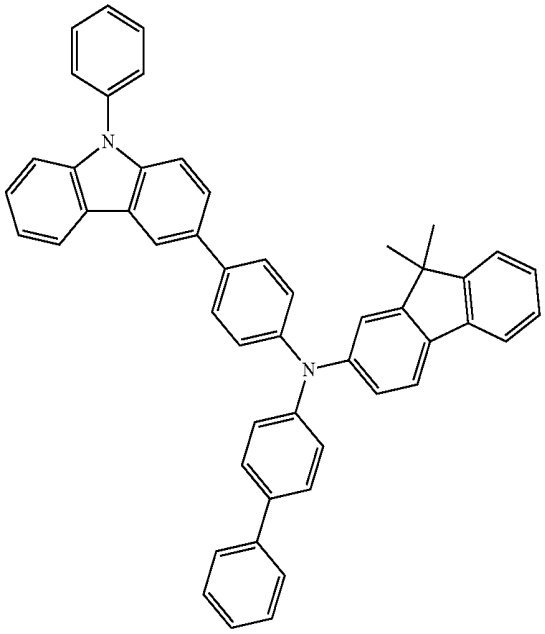
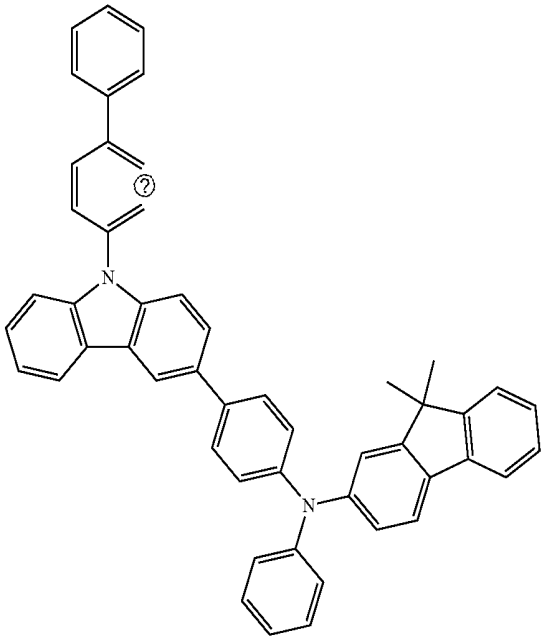
HT3

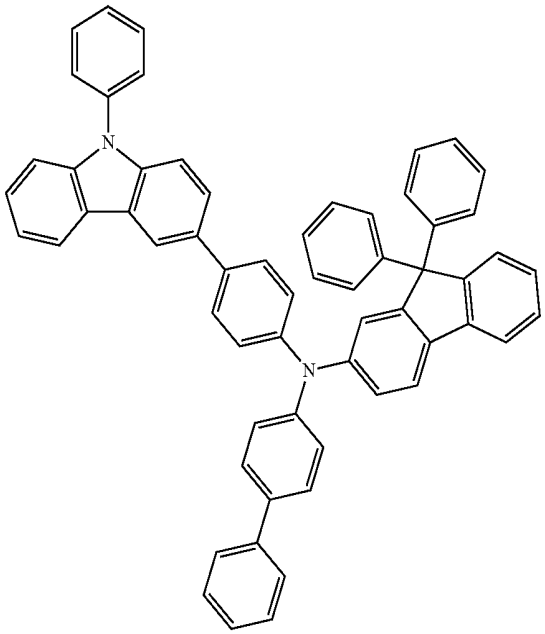


HT4

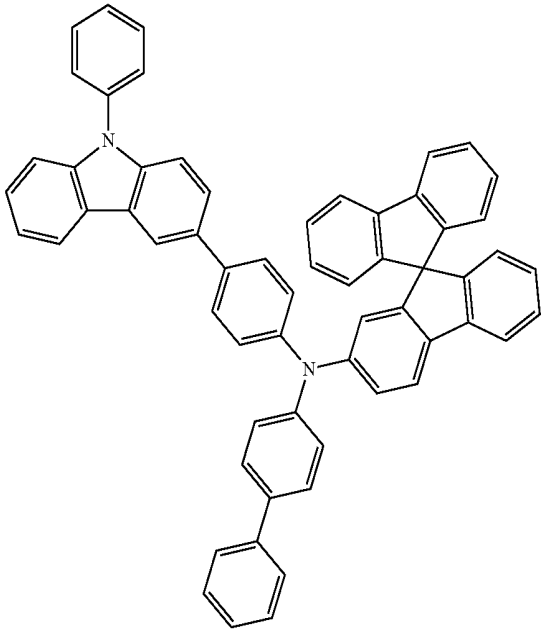


-continued

HT5



HT6



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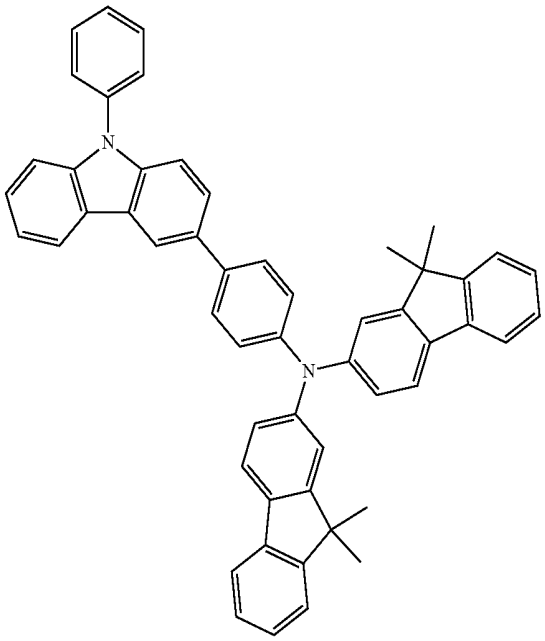
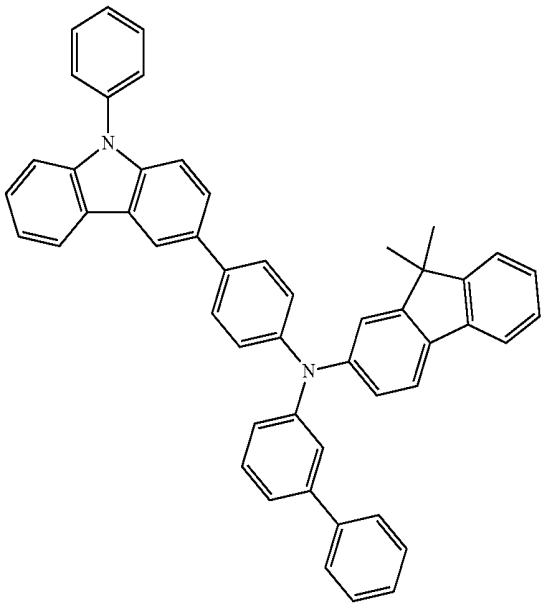
HT7



HT8



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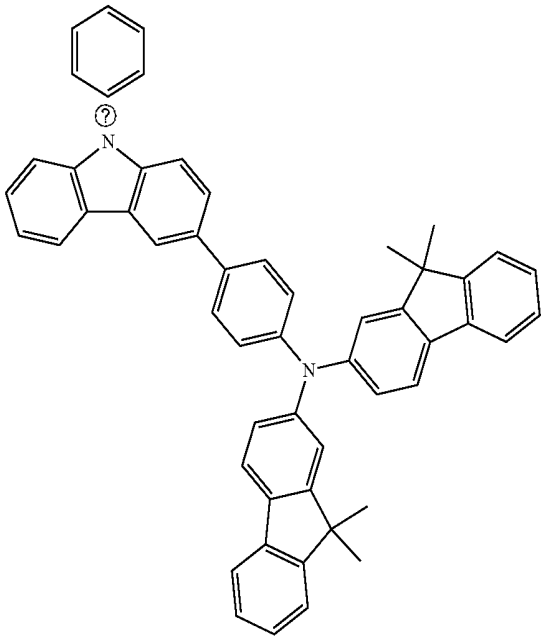
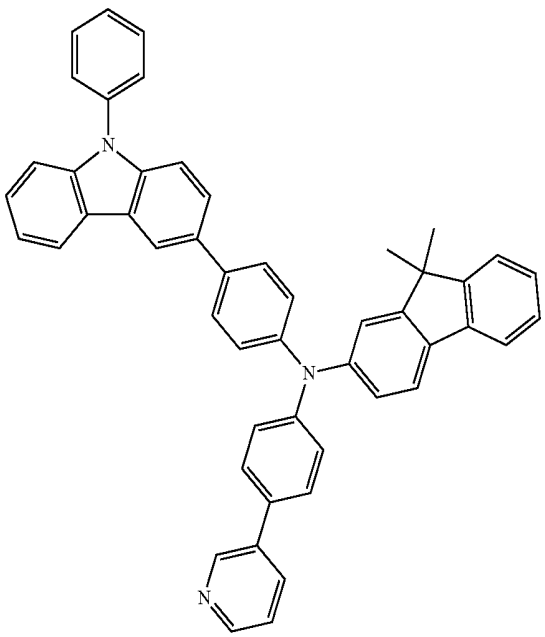
HT9



HT10



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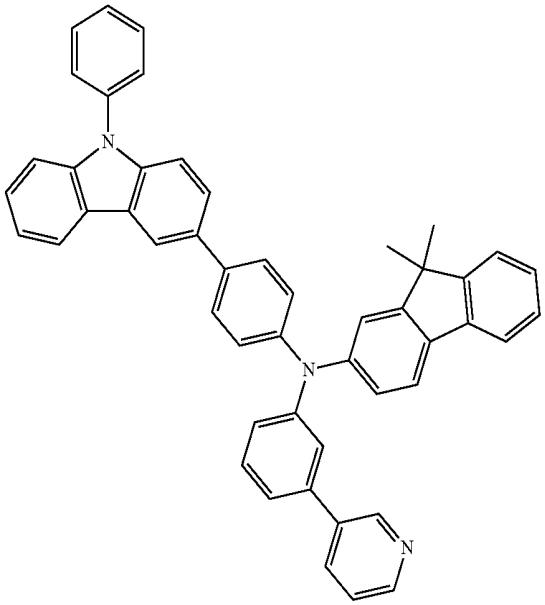
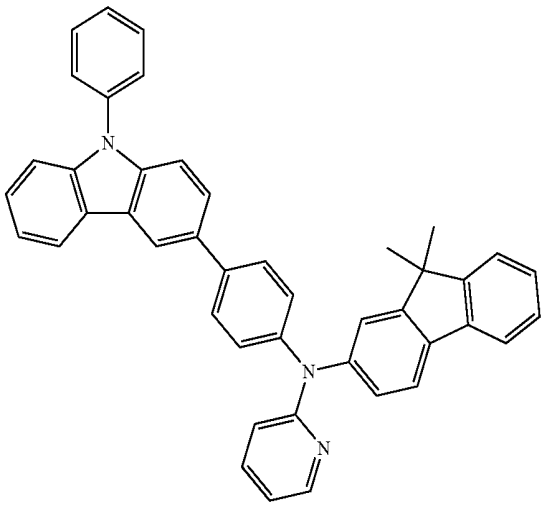
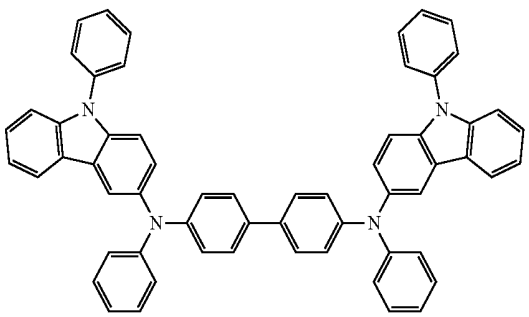
HT11



HT12



HT13



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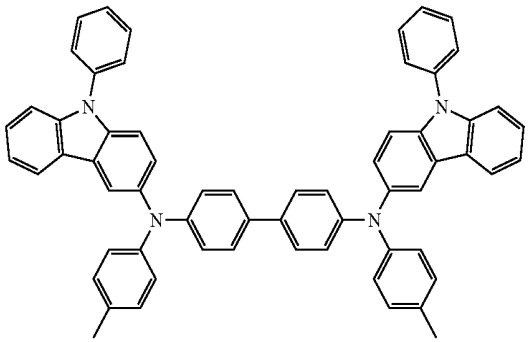
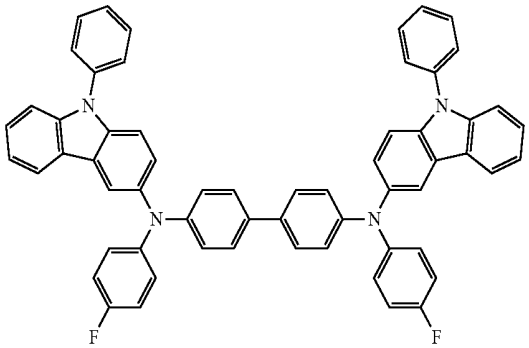
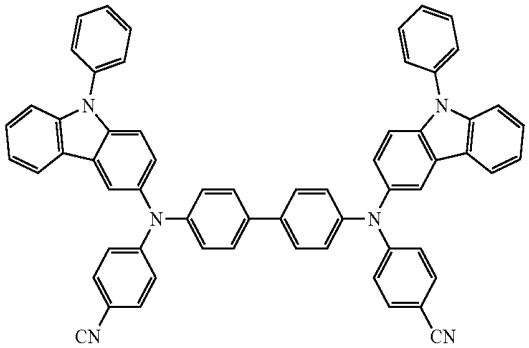
HT14



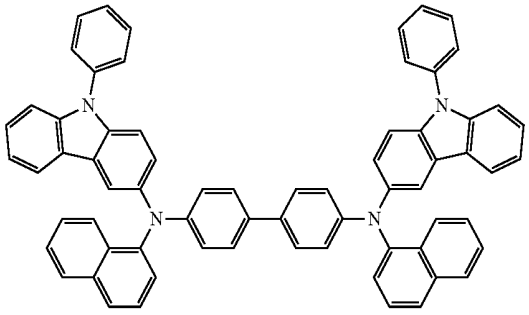
HT15



HT16



HT17



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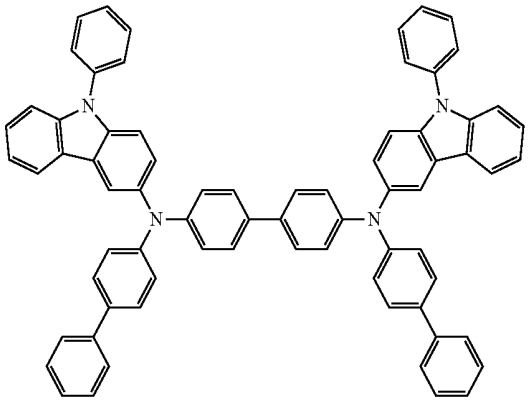
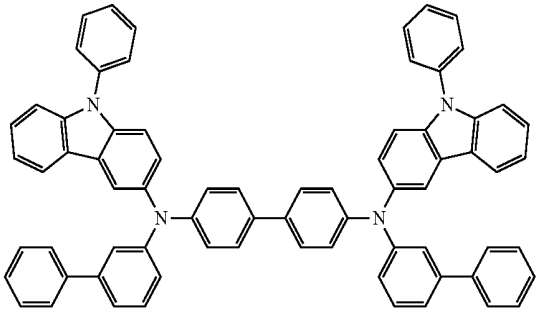
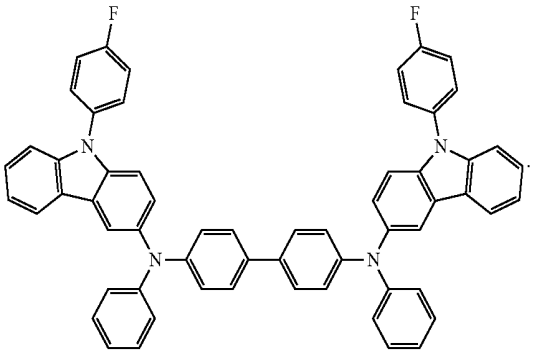
HT18



HT19



HT20



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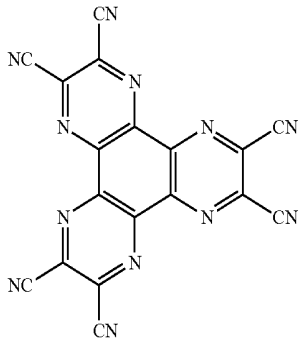
[0130] A thickness of the hole transport region may be in a range of about 100 Å to about 10000 Å, for example, about 100 Å to about 1000 Å. When the hole transport region includes a hole injection layer an a hole transport layer, a thickness of the hole injection layer may be in a range of about 100 Å to about 10000 Å, for example, about 100 Å to about 10000 ÅA, and a thickness of the hole transport layer may be in a range of about 50 Åto about 2000 Å, for example, about 100 Å to about 1500 Å. Maintaining the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer within these ranges may help provide satisfactory hole transporting characteristics without a substantial increase in driving voltage.

[0131] The hole transport region may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0132] The charge-generation material may be, for example, a p-dopant. Exemplary p-dopants include a quinone derivative, such as tetracyanoquinonedimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4-TCNQ); a metal oxide, such as a tungsten oxide or a molybdenum oxide; and a cyano group-containing compound, such as Compound HT-D1 illustrated below:

<Compound HT-D1>



<F4-TCNQ>

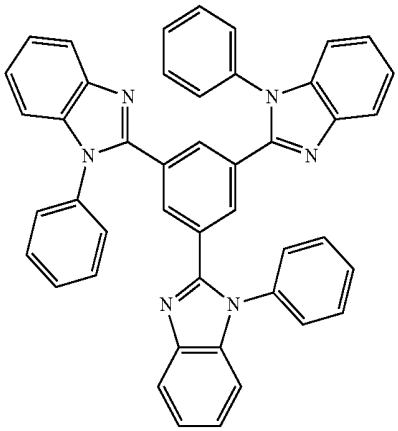
[0133] The hole transport region may further include, in addition to the hole injection layer and the hole transport layer, at least one of a buffer layer and an electron blocking layer. The buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, and a light-emission efficiency of a formed organic light-emitting diode may be improved. For use as a material of the buffer layer, materials of the hole transport region may be used. The electron blocking layer prevents injection of electrons from the electron transport region.

[0134] An emission layer is formed on the first electrode **110** or the hole transport region by various methods, such as vacuum deposition, spin coating, casting, an LB method, ink-jet printing, laser-printing, or laser-induced thermal imaging. When the emission layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the emission layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

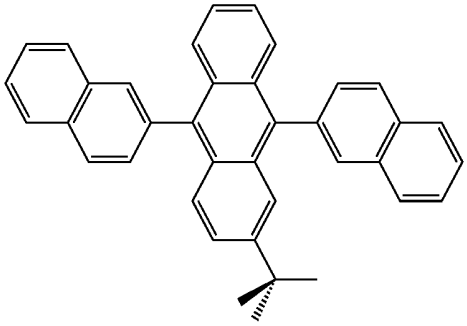
[0135] When the organic light-emitting diode **10** is a full color organic light-emitting diode, the emission layer may be patterned into, for example, a red emission layer, a green emission layer, and a blue emission layer, according to a sub-pixel. In some embodiments, the emission layer may have a stacked structure of a red emission layer, a green emission layer, and a blue emission layer, or may include a red-light emission material, a green-light emission material, and a blue-light emission material, which are mixed with each other in a single layer, to emit white light.

[0136] The emission layer may include a host and a dopant.

[0137] The host may include at least one selected from TPBi, TBADN, AND (also referred to as "DNA"), CBP, CDBP, and TCP.



TPBi



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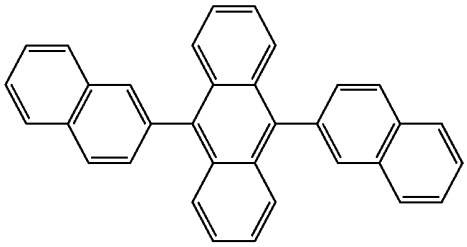
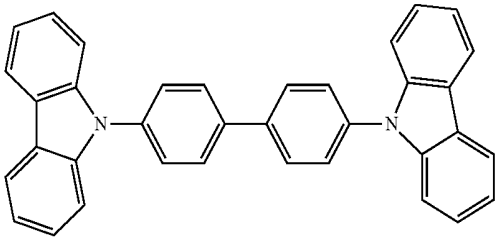
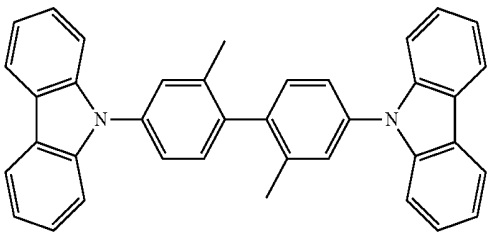


ADN



CBP



CDBP

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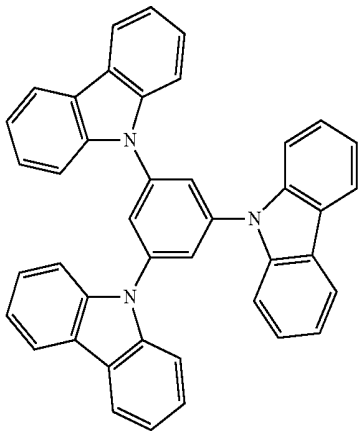


TCP

[0138] According to another embodiment, the host may include a compound represented by Formula 301 below.

$$Ar_{301}\text{-}[(L_{301})_{xb1}\text{-}R_{301}]_{xb2}$$ <Formula 301>

[0139] wherein in Formula 301,

[0140] Ar_{301} may be selected from

[0141] a naphthalene, a heptalene, a fluorenene, a spiro-fluorenene, a benzofluorenene, a dibenzofluorenene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene;

[0142] a naphthalene, a heptalene, a fluorenene, a spiro-fluorenene, a benzofluorenene, a dibenzofluorenene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monolavent non-aromatic condensed polycyclic group, a monolavent non-aromatic hetero-condensed polycyclic group and —$Si(Q_{301})(Q_{302})(Q_{303})$ (wherein Q_{301} to Q_{303} are each independently selected from hydrogen, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and a C_2-C_{60} heteroaryl group);

[0143] L_{301} may be understood by referring to the description provided in connection with L_{201};

[0144] R_{301} may be selected from

[0145] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

[0146] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a

pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

[0147] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0148] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a, fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

[0149] xb1 may be selected from 0, 1, 2, and 3; and

[0150] xb2 may be selected from 1, 2, 3, and 4.

[0151] In this regard, in Formula 301,

[0152] L_{301} may be selected from

[0153] a phenylene group, a naphthylene group, a fluorenyl group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group and a chrysenylene group; and

[0154] a phenylene group, a naphthylene group, a fluorenyl group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group and a chrysenylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a, fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group; and

[0155] R_{301} may be selected from

[0156] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

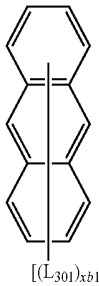
[0157] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group and a chrysenyl group;

[0158] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group; and

[0159] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group and a chrysenyl group.

[0160] For example, the host may include a compound represented by Formula 301A below:

<Formula 301A>

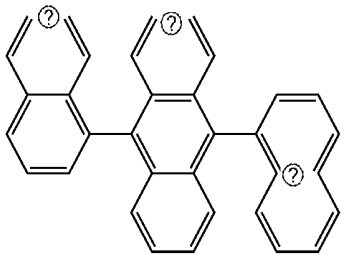


$[(L_{301})_{xb1}-R_{301}]_{xb2}$.

[0161] Substituents of Formula 301A are described above.

[0162] The compound represented by Formula 301 may include at least one of Compounds H1 to H42:

H1



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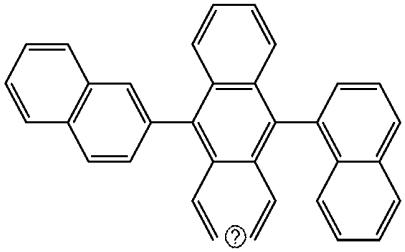
H2



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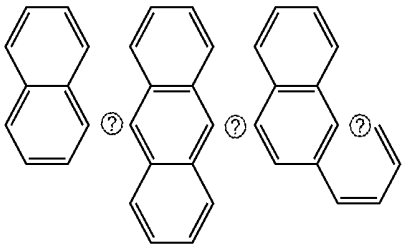

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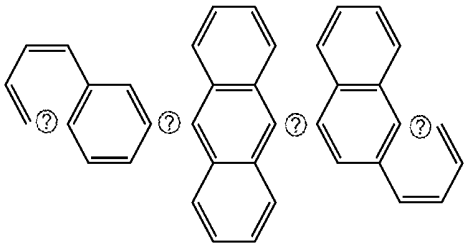

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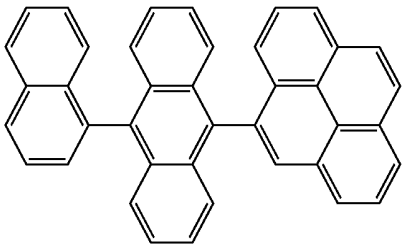

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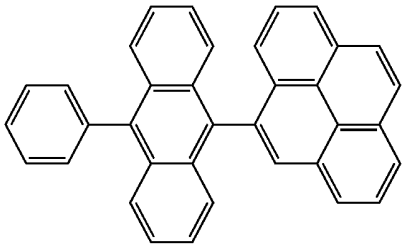

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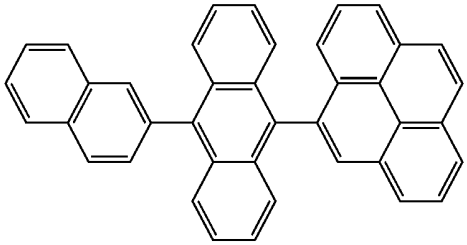

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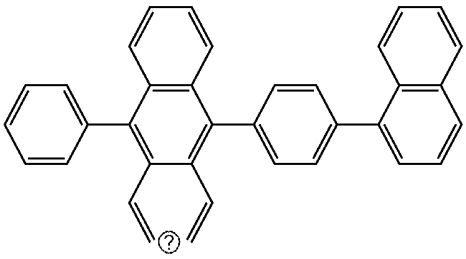

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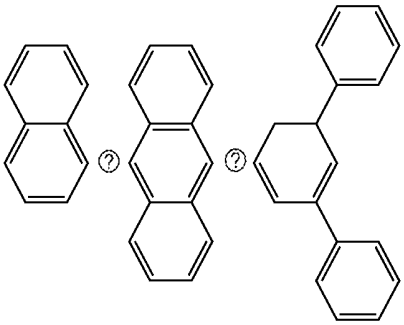

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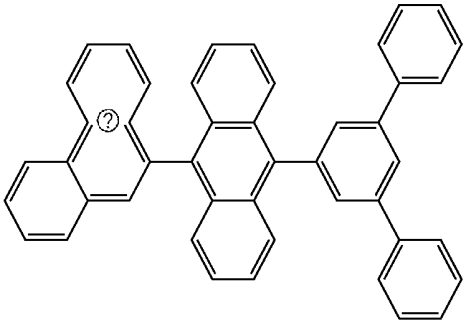

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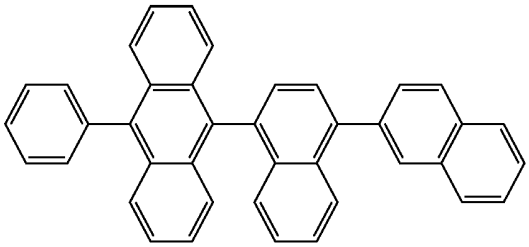

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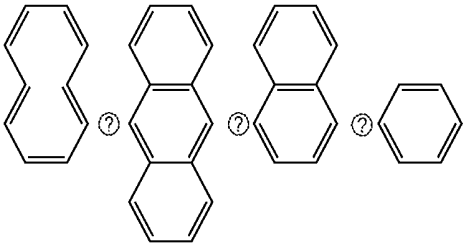

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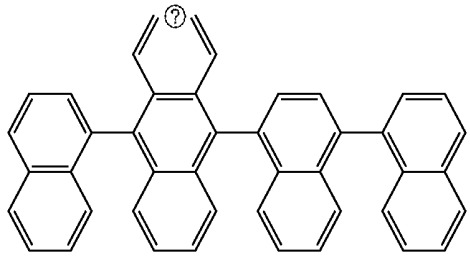

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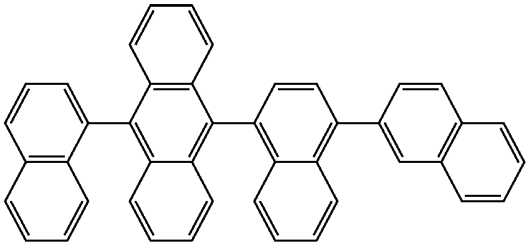

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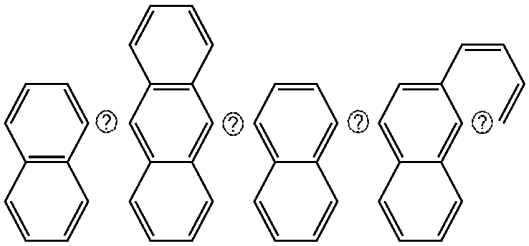

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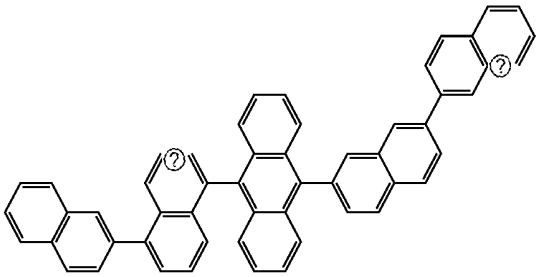

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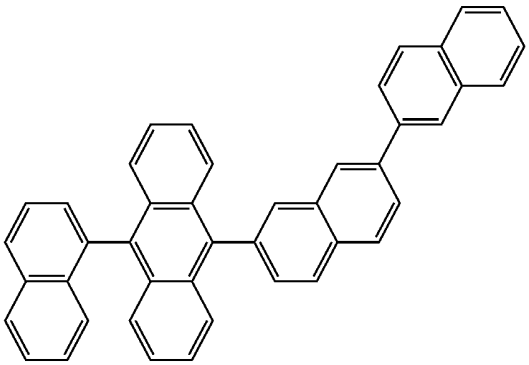

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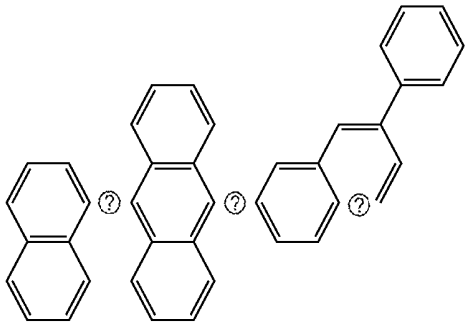

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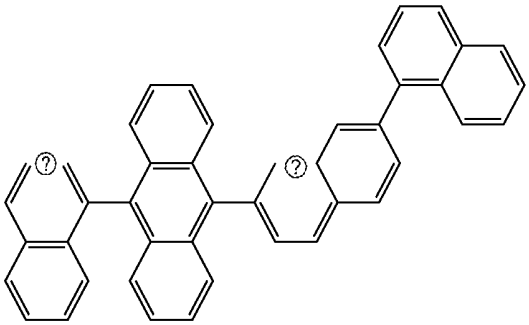

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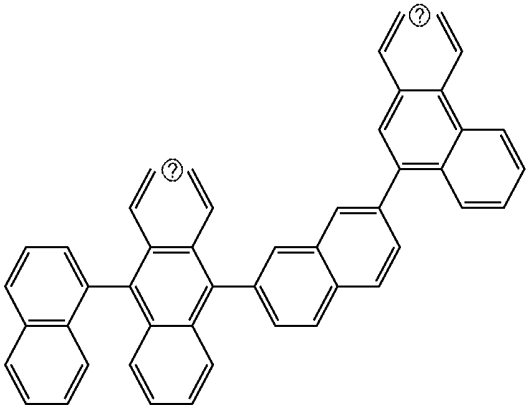

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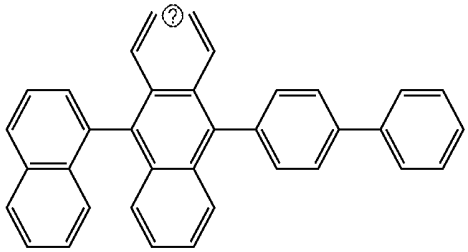

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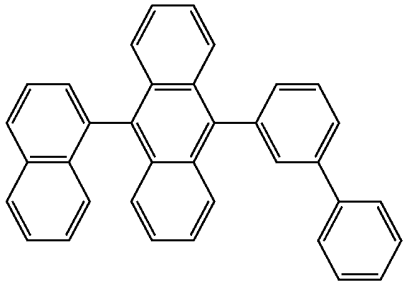

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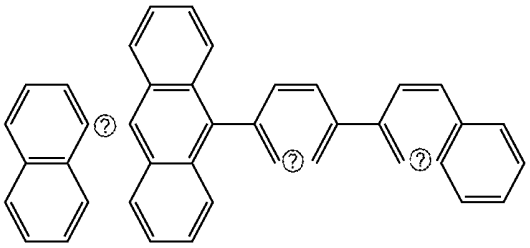

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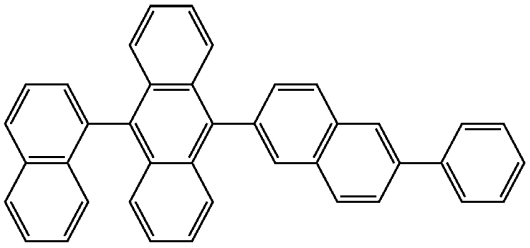

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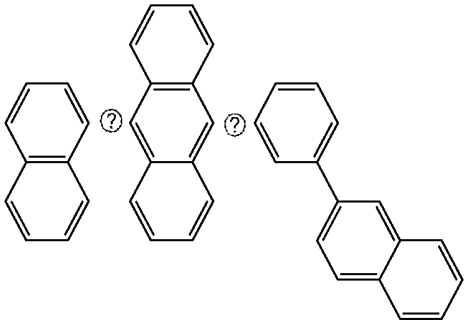

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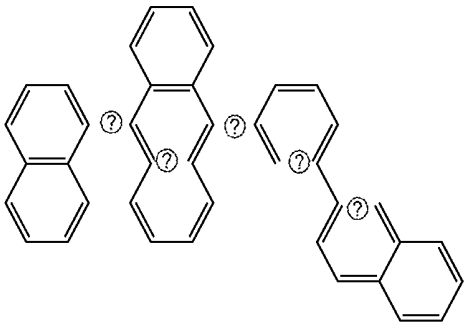

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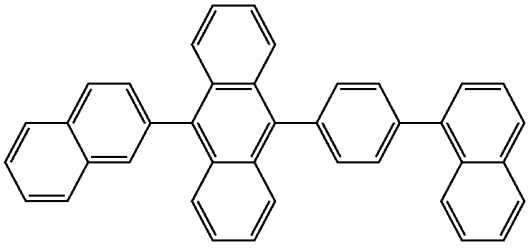

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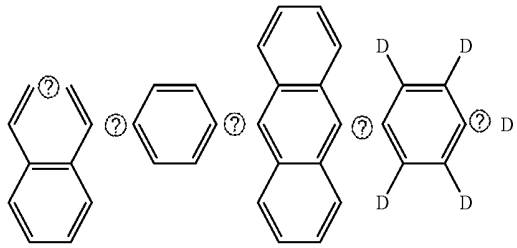

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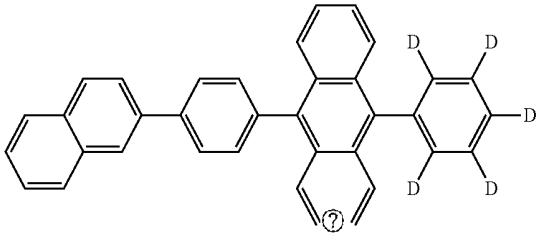

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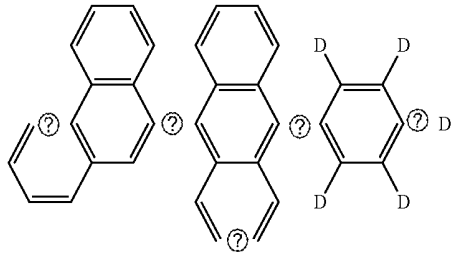

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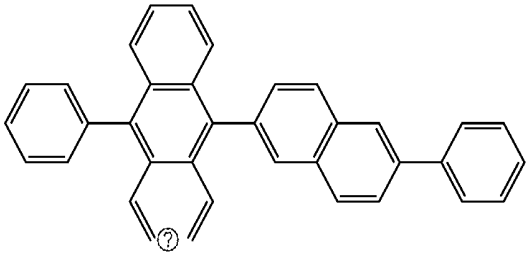

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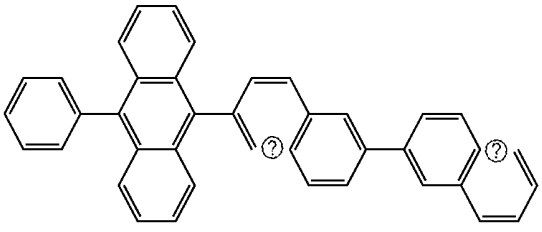

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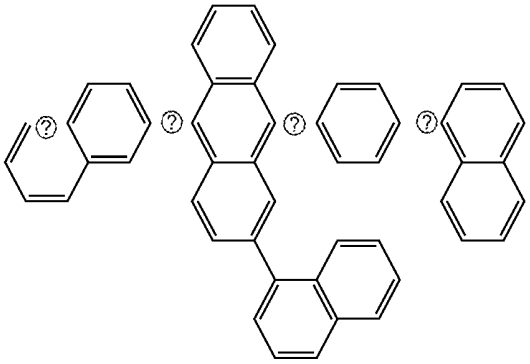
H33



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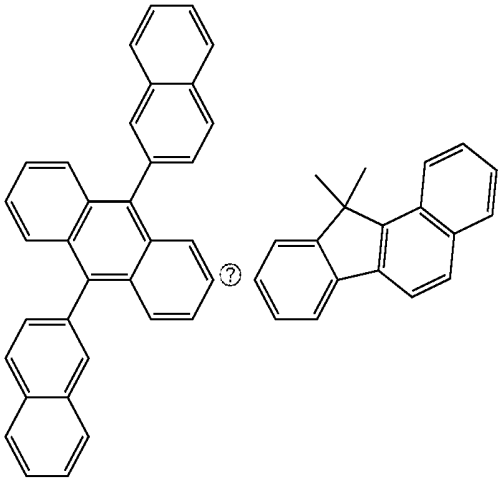
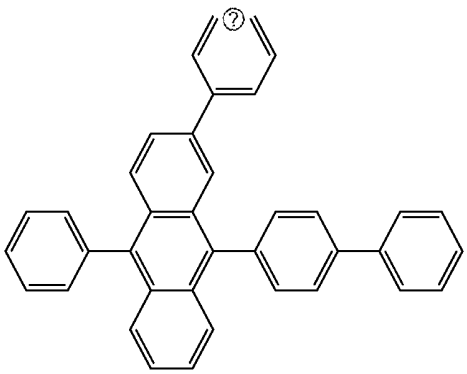


H35



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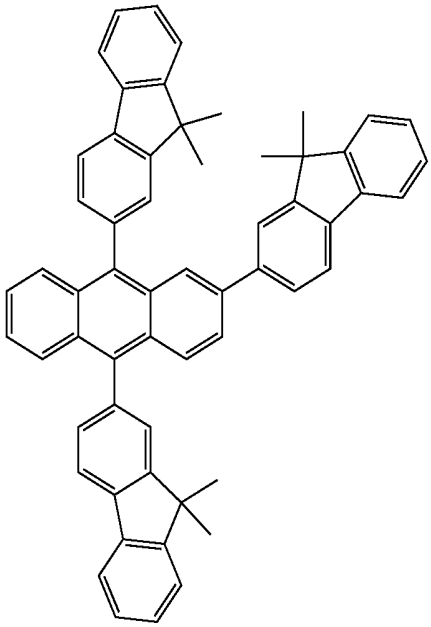

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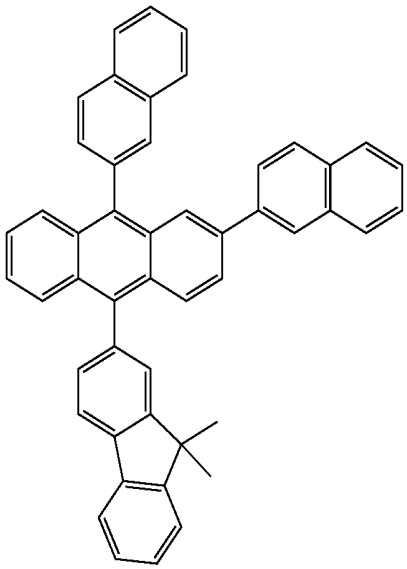

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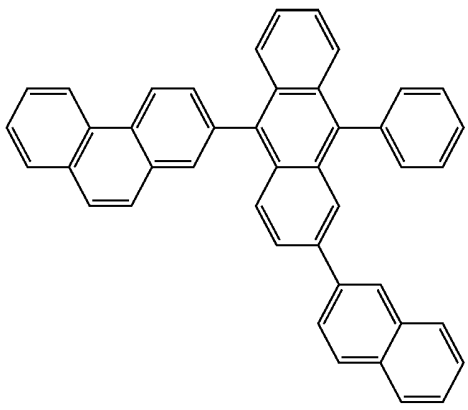

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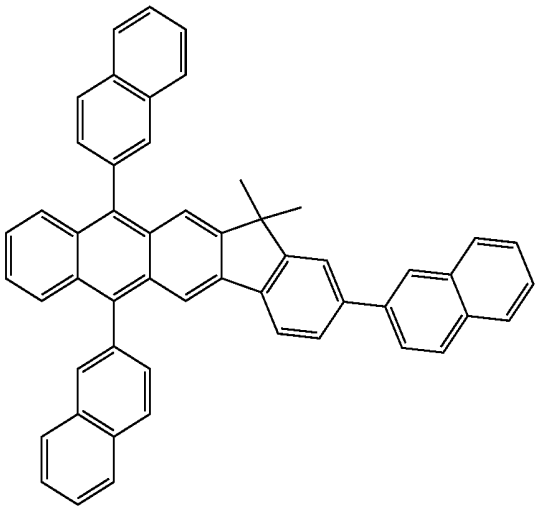

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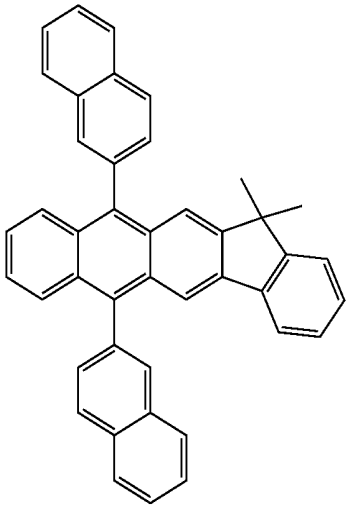

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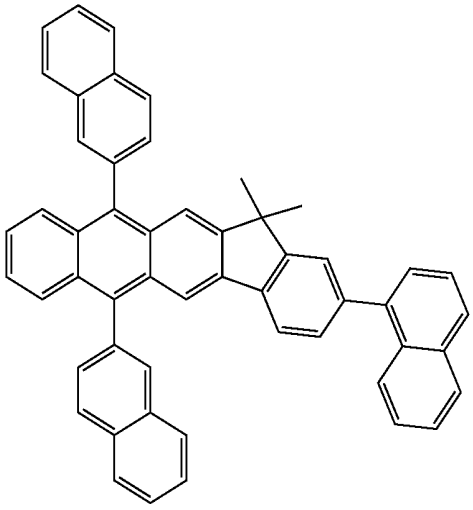

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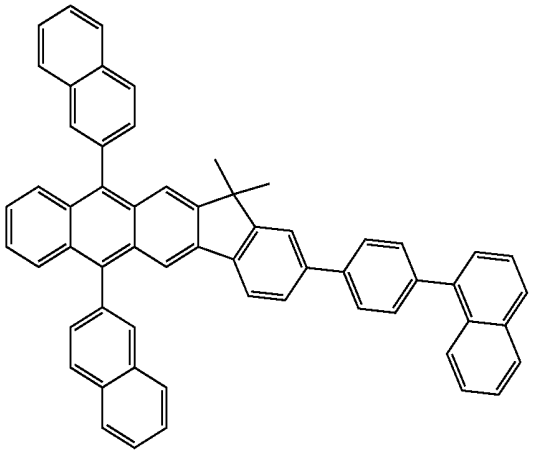
H42



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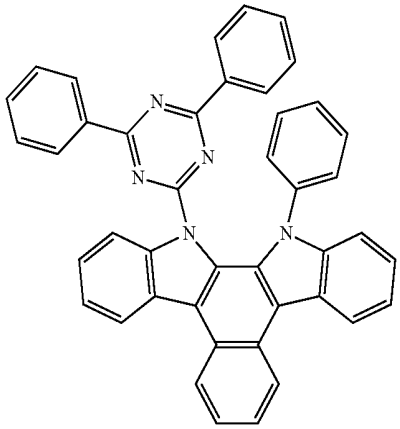
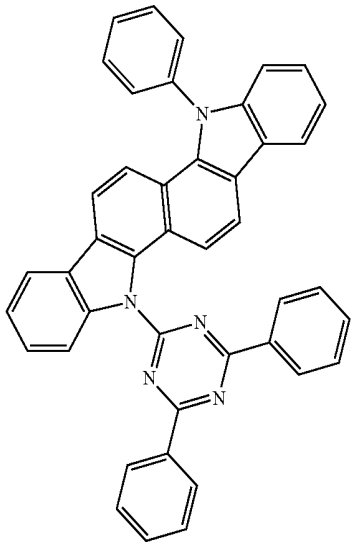
[0163] According to another embodiment, the host may include at least one of Compounds H43 to H49 below:

H43



H44



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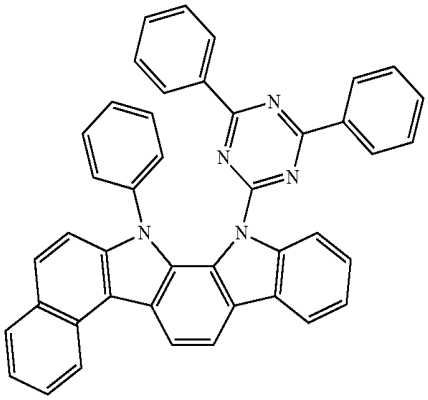
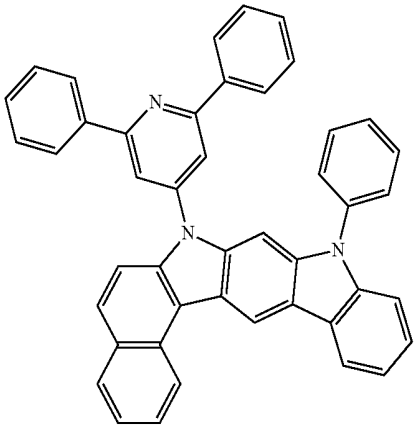
H45



H46



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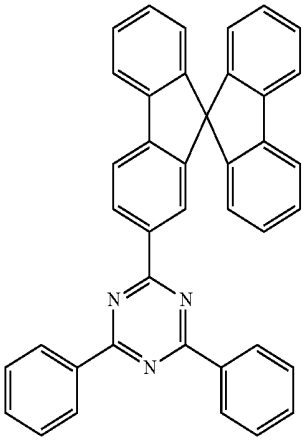
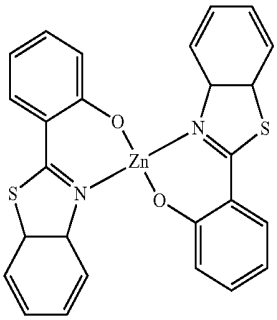


H48



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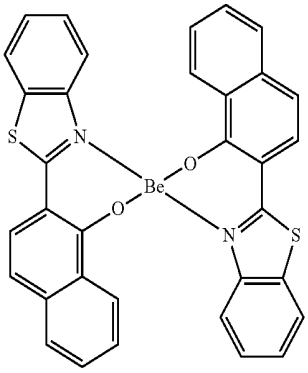
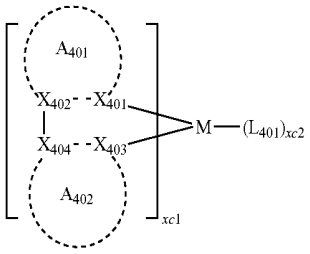
H49



[0164] The dopant may be at least one selected from a fluorescent dopant and a phosphorescent dopant.

[0165] The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:

<Formula 401>



[0166] wherein in Formula 401,

[0167] M may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), euroform (Eu), terbium (Tb), and thulium (TM);

[0168] X_{401} to X_{404} may each independently be nitrogen or carbon;

[0169] A_{401} and A_{402} rings may each independently be selected from a substituted or unsubstituted benzene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted fluorenene, a substituted or unsubstituted spiro-fluorenene, a substituted or unsubstituted indene, a substituted or unsubstituted pyrrol, a substituted or unsubstituted thiophene, a substituted or unsubstituted furan, a substituted or unsubstituted imidazole, a substituted or unsubstituted pyrazole, a substituted or unsubstituted thiazole, a substituted or unsubstituted isothiazole, a substituted or unsubstituted oxazole, a substituted or unsubstituted isoxazole, a substituted or unsubstituted pyridine, a substituted or unsubstituted pyrazine, a substituted or unsubstituted pyrimidine, a substituted or unsubstituted pyridazine, a substituted or unsubstituted quinoline, a substituted or unsubstituted isoquinoline, a substituted or unsubstituted benzoquinoline, a substituted or unsubstituted quinoxaline, a substituted or unsubstituted quinazoline, a substituted or unsubstituted carbazol, a substituted or unsubstituted benzoimidazole, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted isobenzothiophene, a substituted or unsubstituted benzooxazole, a substituted or unsubstituted isobenzooxazole, a substituted or unsubstituted triazole, a substituted or unsubstituted oxadia-

zole, a substituted or unsubstituted triazine, a substituted or unsubstituted dibenzofuran, and a substituted or unsubstituted dibenzothiophene; and

[0170] a substituent of at least one selected from the substituted benzene, substituted naphthalene, substituted fluorenene, substituted spiro-fluorenene, substituted indene, substituted pyrrol, substituted thiophene, substituted furan, substituted imidazole, substituted pyrazole, substituted thiazole, substituted isothiazole, substituted oxazole, substituted isoxazole, substituted pyridine, substituted pyrazine, substituted pyrimidine, substituted pyridazine, substituted quinoline, substituted isoquinoline, substituted benzoquinoline, substituted quinoxaline, substituted quinazoline, substituted carbazol, substituted benzoimidazole, substituted benzofuran, substituted benzothiophene, substituted isobenzothiophene, substituted benzooxazole, substituted isobenzooxazole, substituted triazole, substituted oxadiazole, substituted triazine, substituted dibenzofuran, and substituted dibenzothiophene may be selected from

[0171] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

[0172] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic hetero-condensed polycyclic group, $—N(Q_{401})(Q_{402})$, $—Si(Q_{403})(Q_{404})(Q_{405})$, and $—B(Q_{406})(Q_{407})$;

[0173] a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group and a monovalent non-aromatic hetero-condensed polycyclic group;

[0174] a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} group, aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic hetero-condensed polycyclic group, $—N(Q_{411})(Q_{412})$, $—Si(Q_{413})(Q_{414})(Q_{415})$, and $—B(Q_{416})(Q_{417})$; and

[0175] $—N(Q_{421})(Q_{422})$, $—Si(Q_{423})(Q_{424})(Q_{425})$, and $—B(Q_{426})(Q_{427})$; and

[0176] L_{401} is an organic ligand;

[0177] xc1 is 1, 2, or 3; and

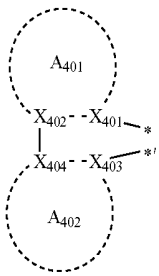
[0178] xc2 is 0, 1, 2, or 3.

[0179] L_{401} may be a monovalent, divalent, or trivalent organic ligand, For example, L_{401} may be selected from a halogen ligand (for example, Cl or F), a diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propandionate, 2,2,6,6-tetramethyl-3,5-heptandionate, or hexafluoracetonate), a carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazolecarboxylate, or benzoate), a carbon monooxide ligand, an isonitrile ligand, a cyano ligand, and a phosphorous ligand (for example, phosphine and phosphaite).

[0180] When A_{401} in Formula 401 has two or more substituents, the substituents of A_{401} may bind to each other to form a saturated or unsaturated ring.

[0181] When A_{401} in Formula 402 has two or more substituents, the substituents of A_{402} may bind to each other to form a saturated or unsaturated ring.

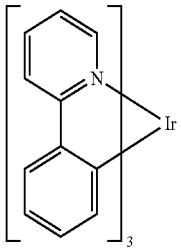
[0182] When xc1 in Formula 401 is two or more, a plurality of ligands



in Formula 401 may be identical or different. When xc1 in Formula 401 is two or more, A_{401} and A_{402} may be respectively directly connected to A_{401} and A_{402} of other neighboring ligands with or without a linker (for example, a C_1-C_5 alkylene group, or —N(R')— (wherein R' may be a C_1-C_{10} alkyl group or a C_6-C_{20} aryl group) or —C(═O)—) therebetween.

[0183] The phosphorescent dopant may include at least one of Compounds PD1 to PD74 below:

PD1



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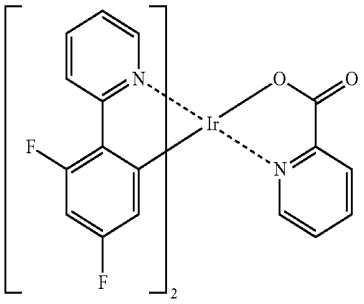
PD2



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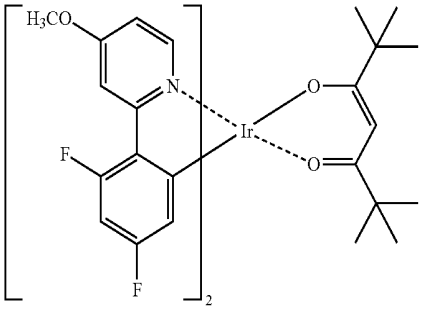

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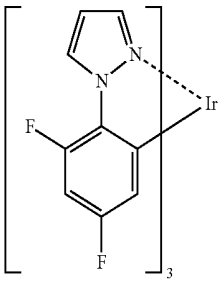

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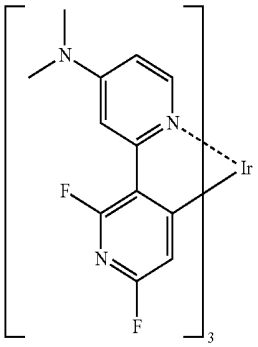

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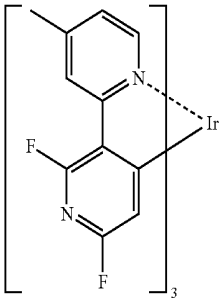

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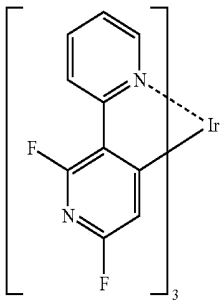

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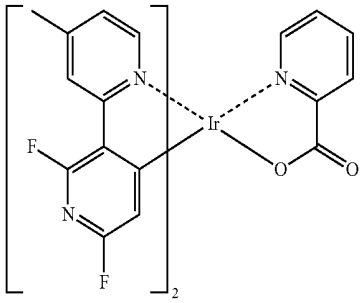

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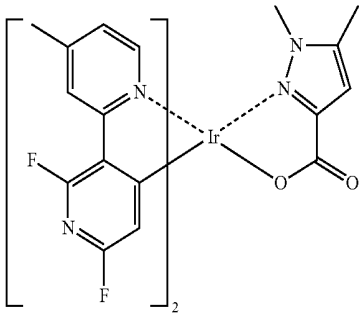

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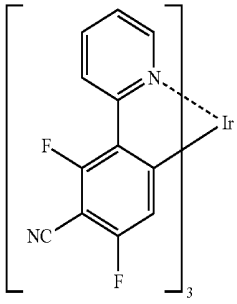

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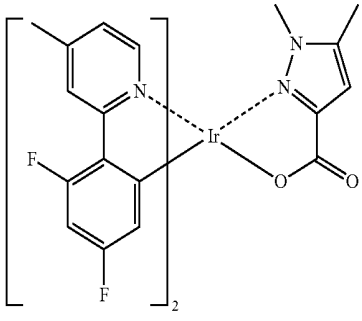

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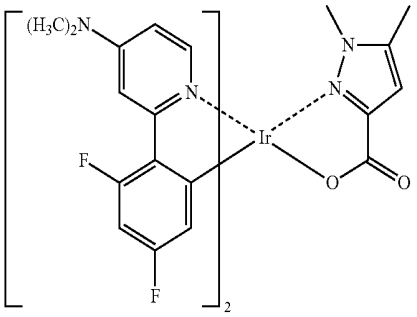

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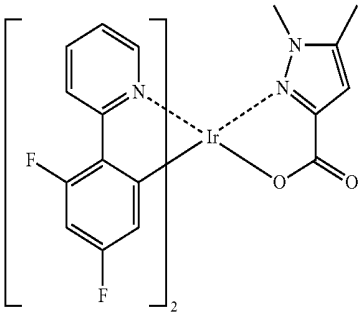

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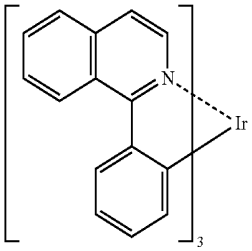

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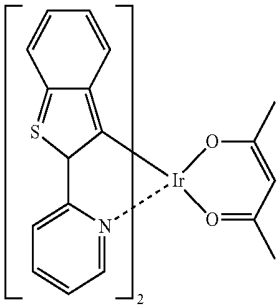

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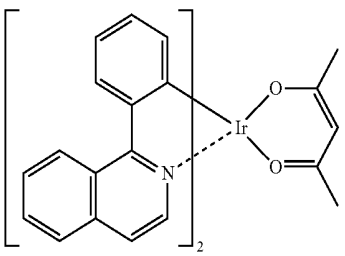

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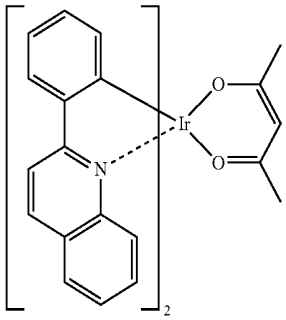
PD17



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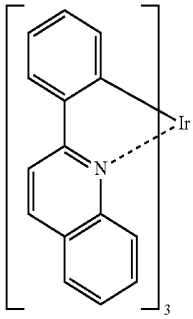

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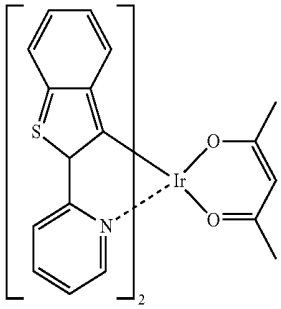

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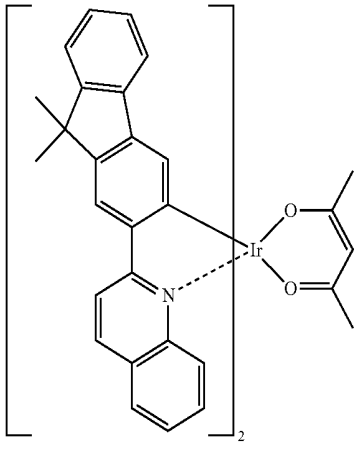

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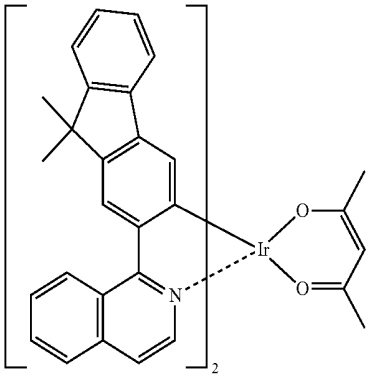

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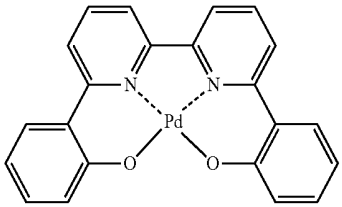

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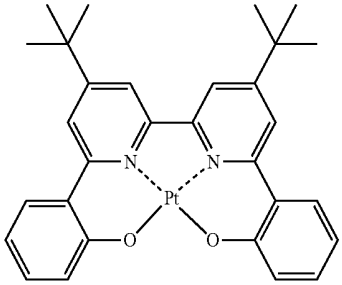
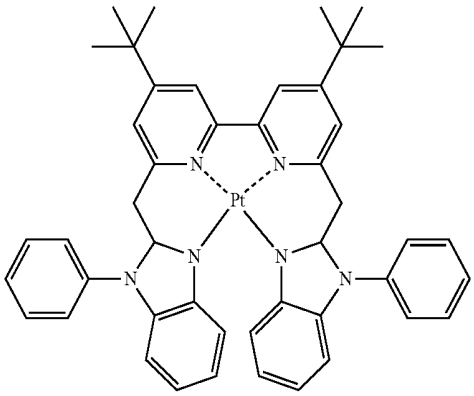
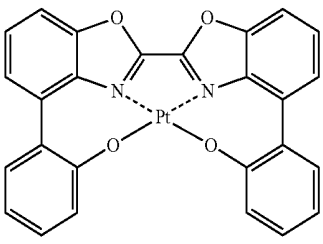


PD24



PD25



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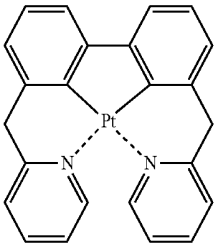

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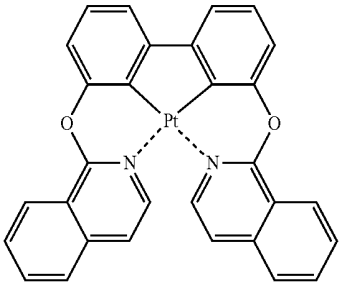

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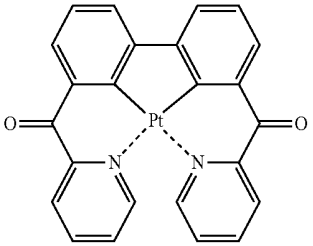

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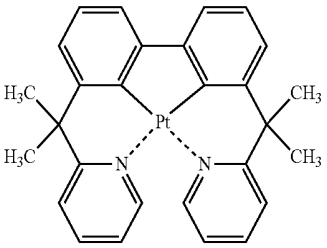

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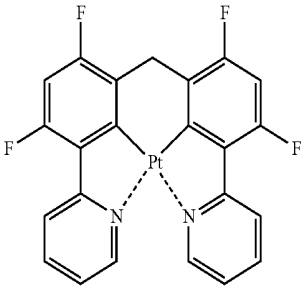

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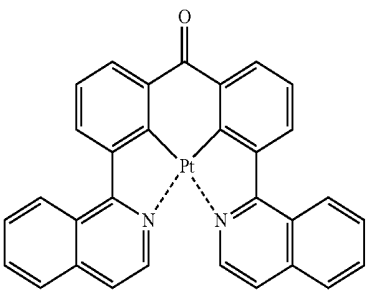

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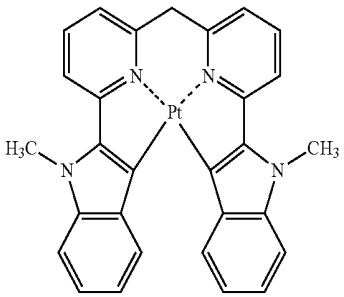

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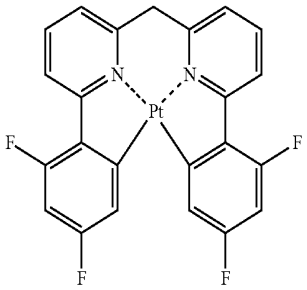

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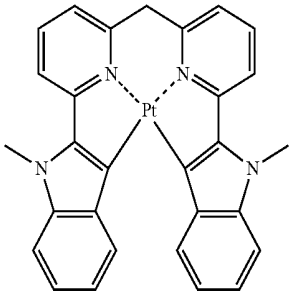

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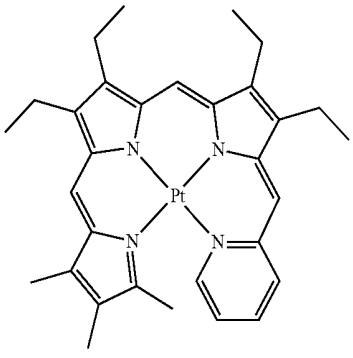

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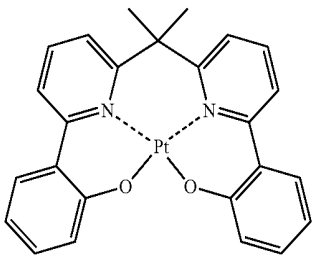

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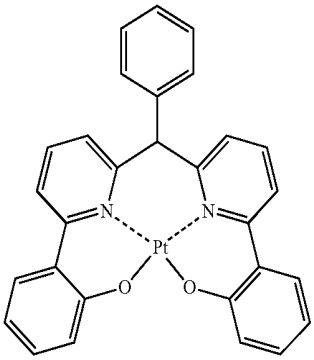

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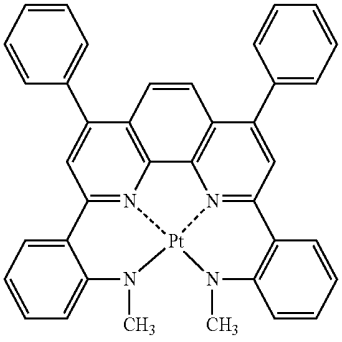

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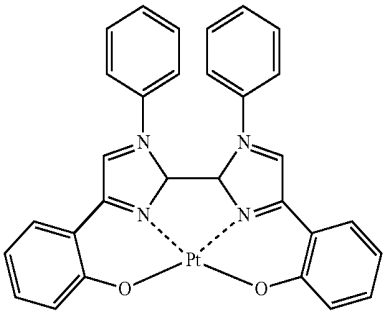

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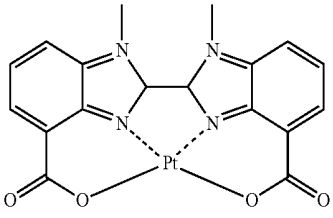

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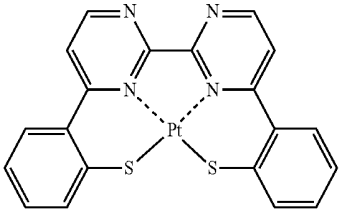

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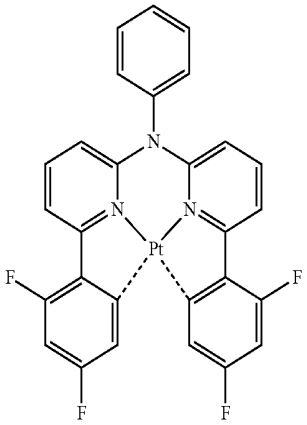

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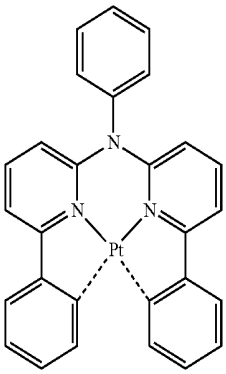

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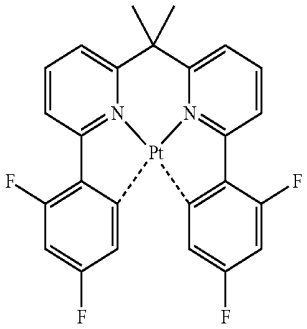

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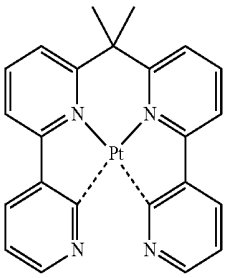

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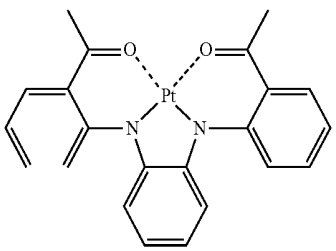

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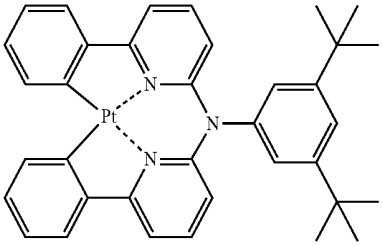

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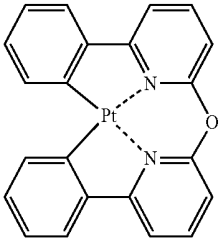

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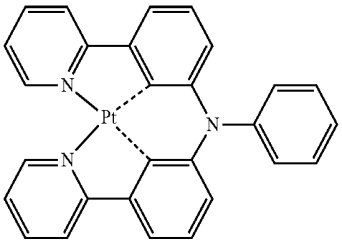

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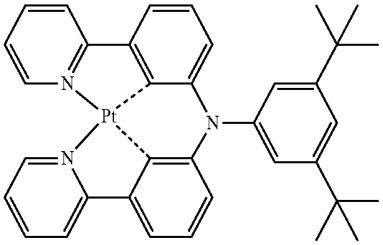

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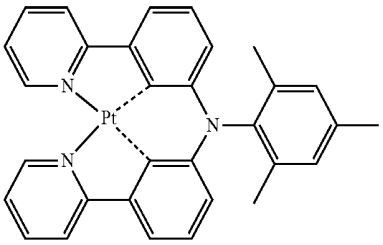

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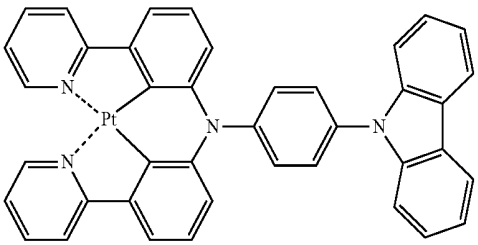

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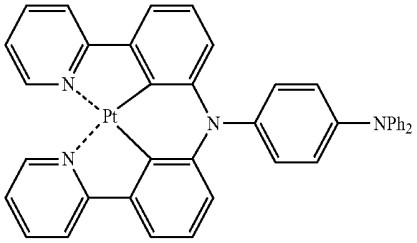

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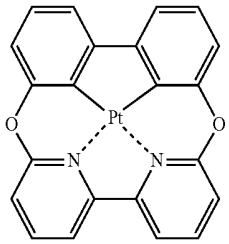

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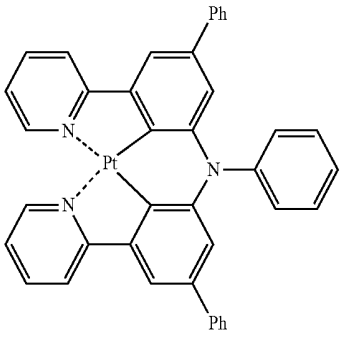

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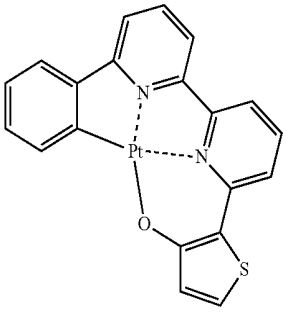

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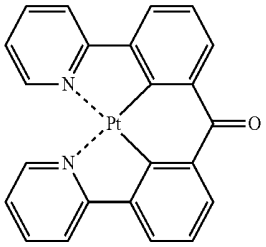

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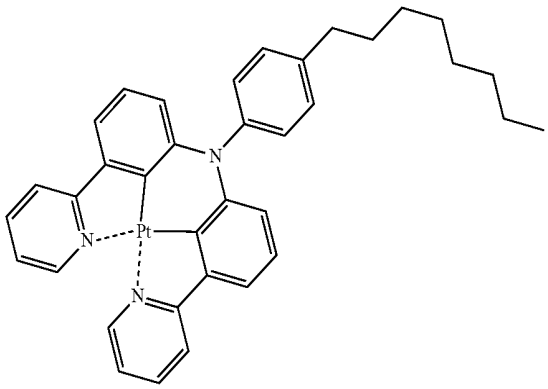

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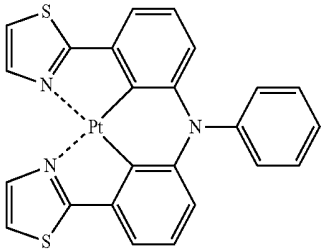

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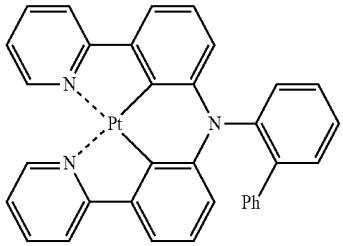

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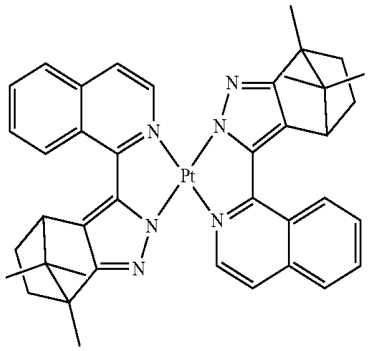

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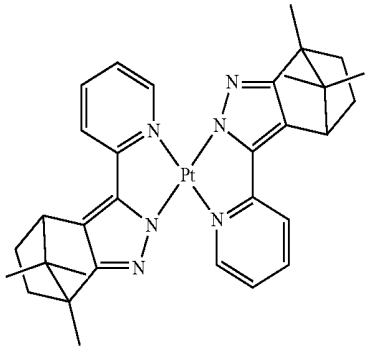

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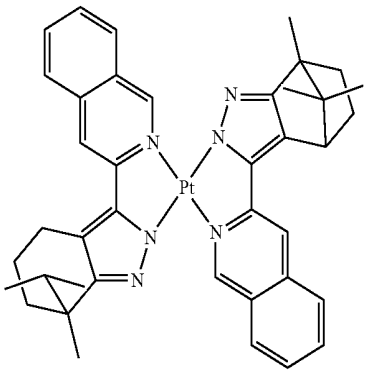

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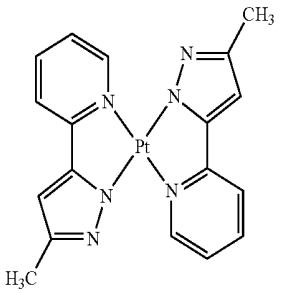

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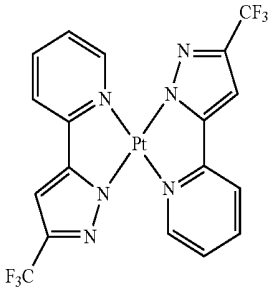

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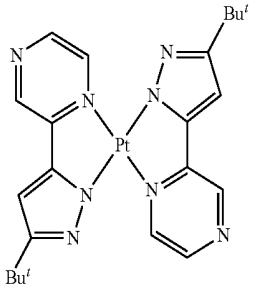

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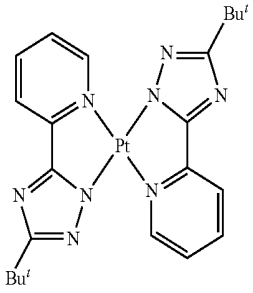

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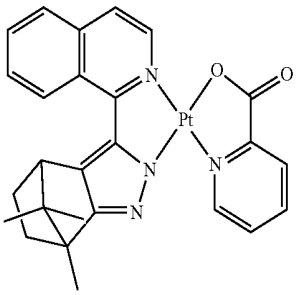

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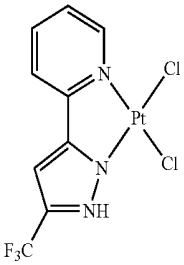

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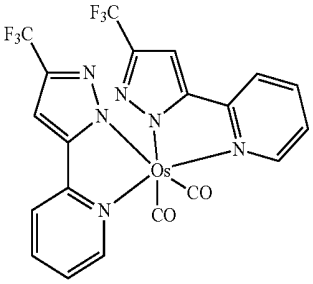

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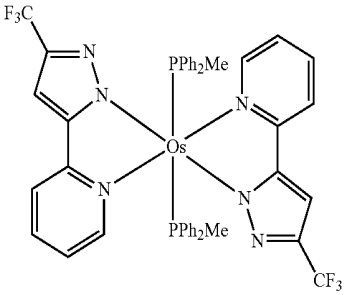

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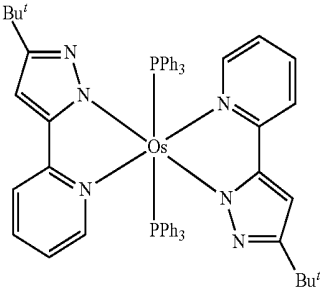

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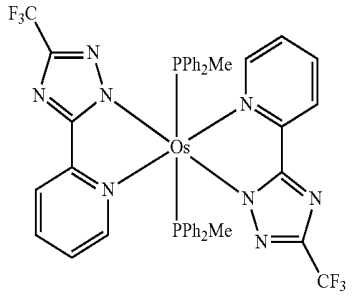
PD73



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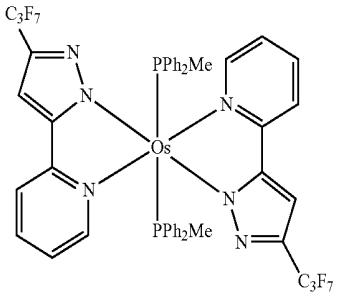
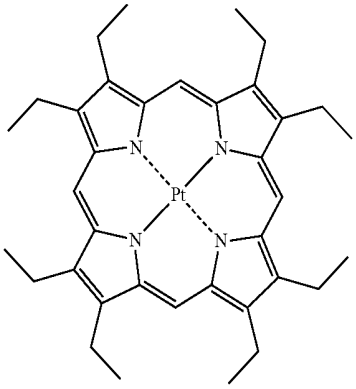
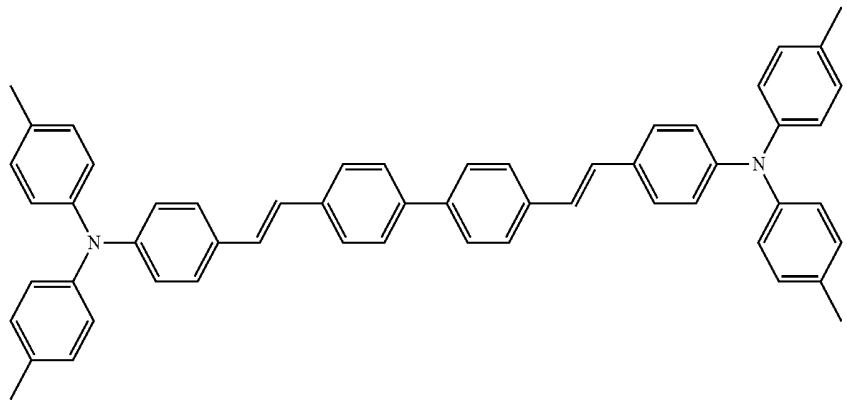


[0184] According to another embodiment, the phosphorescent dopant may include PtOEP:

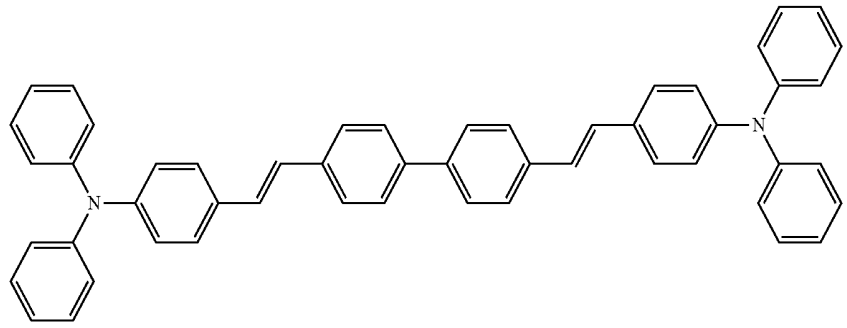


PtOEP

[0185] The fluorescent dopant may include at least one selected from DPAVBi, BDAVBi, TBPe, DCM, DCJTB, Coumarin 6, and C545T:



DPAVBi



BDAVBi

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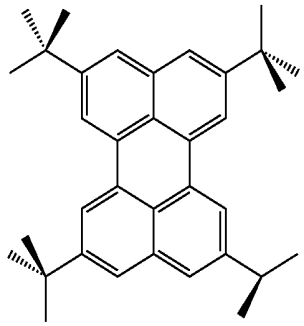
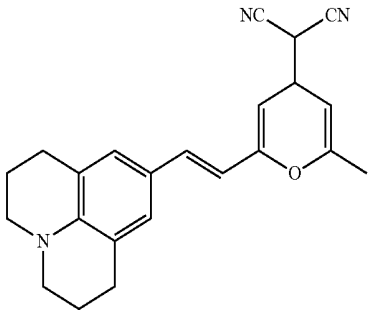
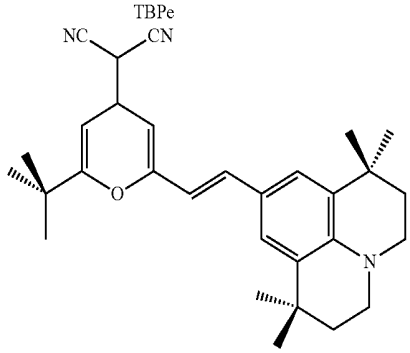
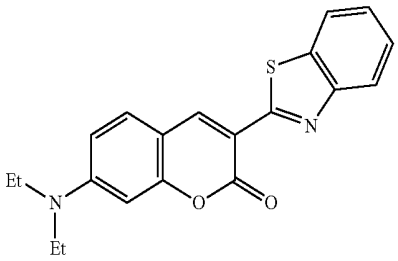




DCM

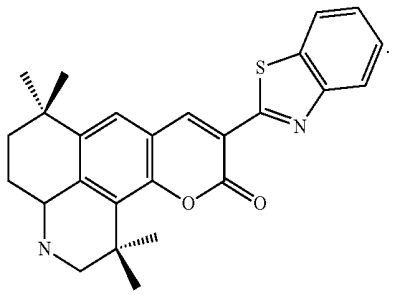
TBPe





Coumarin 6

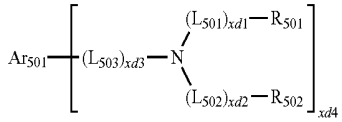
DCJTB



C545T

[0186] According to another embodiment, the fluorescent dopant may include a compound represented by Formula 501 below.

<Formula 501>



[0187] wherein in Formula 501,

[0188] Ar_{501} may be selected from

[0189] a naphthalene, a heptalene, a fluorenene, a spirofluorenene, a benzofluorenene, a dibenzofluorenene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene;

[0190] a naphthalene, a heptalene, a fluorenene, a spirofluorenene, a benzofluorenene, a dibenzofluorenene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic hetero-condensed polycyclic group, —$Si(Q_{501})(Q_{502})(Q_{503})$ (wherein Q_{501} to Q_{503} are each independently selected from a hydrogen, C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} aryl group, and a C_2-C_{60} heteroaryl group);

[0191] L_{501} to L_{503} may be understood by referring to the description provided herein in connection with L_{201};

[0192] R_{501} and R_{502} may each independently be selected from

[0193] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, a dibenzofuranyl group and a dibenzothiophenyl group; and

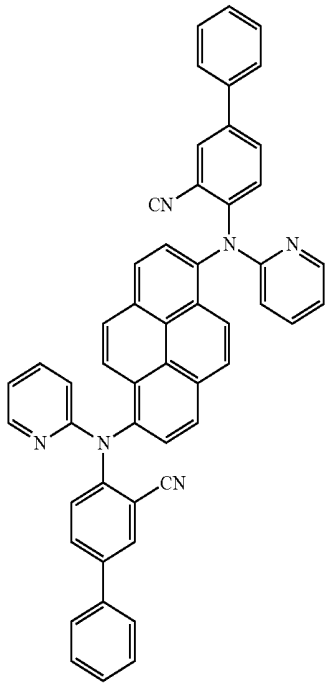
[0194] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group a dibenzofuranyl group and a dibenzothiophenyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, a dibenzofuranyl group and a dibenzothiophenyl group; and

[0195] xd1 to xd3 may each independently be selected from 0, 1, 2, and 3; and

[0196] xb4 may be selected from 1, 2, 3, and 4.

[0197] The fluorescent host may include at least one of Compounds FD1 to FD8 below;

FD4



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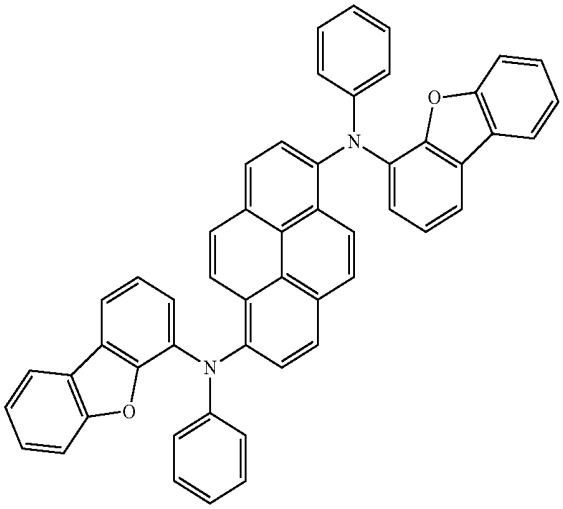
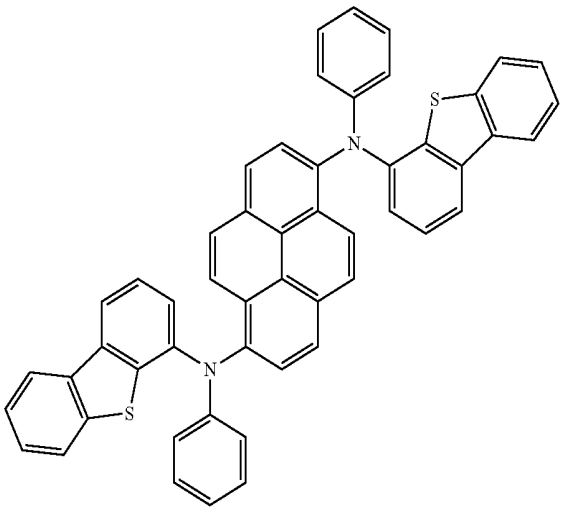
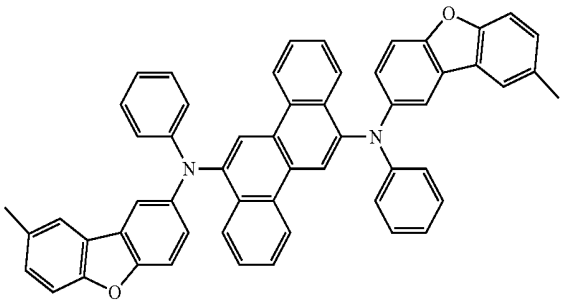
FD5



FD6



FD7



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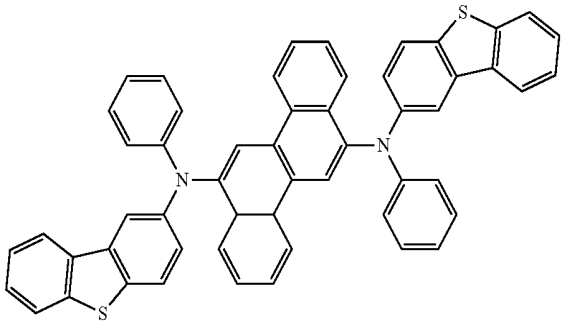
FD8



[0198] An amount of the dopant in the emission layer may be, for example, in a range of about 0.01 to about 15 parts by weight based on 100 parts by weight of the host.

[0199] A thickness of the emission layer may be in a range of about 100 Å to about 1000 Å, for example, about 200 Å to about 600 Å. Maintaining the thickness of the emission layer within this range may help provide excellent light-emission characteristics without a substantial increase in driving voltage.

[0200] Then, an electron transport region may be disposed on the emission layer.

[0201] The electron transport region may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

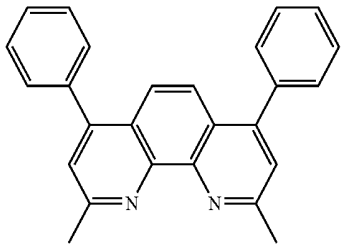
[0202] For example, the electron transport region may have a structure of electron transport layer/electron injection layer or a structure of hole blocking layer/electron transport layer/electron injection layer, wherein layers of each structure are sequentially stacked from the emission layer in the stated order.

[0203] According to an embodiment, the organic layer **150** of the organic light-emitting diode includes an electron transport region disposed between the emission layer and the second electrode **190**, wherein the electron transport region includes the condensed compound represented by Formula 1 or Formula 2.

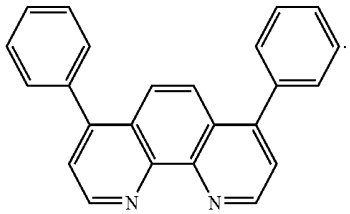
[0204] The electron transport region may include a hole blocking layer. The hole blocking layer may be formed, when the emission layer includes a phosphorescent dopant, to prevent diffusion of excitons or holes into an electron transport layer.

[0205] When the electron transport region includes a hole blocking layer, the hole blocking layer may be formed on the emission layer by various methods, such as vacuum deposition, spin coating casting, an LB method, ink-jet printing, laser-printing, or laser-induced thermal imaging. When the hole blocking layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the hole blocking layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0206] The hole blocking layer may include, for example, at least one of BCP and Bphen:



BCP



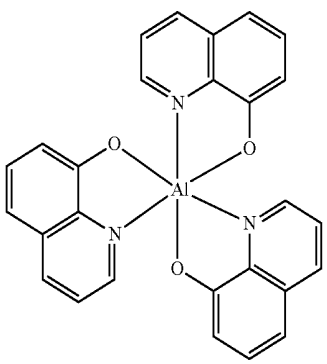
Bphen

[0207] A thickness of the hole blocking layer may be in a range of about 20 Å to about 1000 Å, for example, about 30 Å to about 300 Å. Maintaining the thickness of the hole blocking layer within these ranges may help provide the hole blocking layer with excellent hole blocking characteristics without a substantial increase in driving voltage.

[0208] The election transport region may include an electron transport layer. The electron transport layer may be formed on the emission layer or the hole blocking layer by various methods, such as vacuum deposition, spin coating casting, an LB method, ink-jet printing, laser-printing, or laser-induced thermal imaging. When an electron transport layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the electron transport layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0209] According to an embodiment, the organic layer **150** of the organic light-emitting diode includes an electron transport region disposed between the emission layer and the second electrode **190**, wherein the electron transport region includes an electron transport layer, and the electron transport layer includes the condensed compound represented by Formula 1 or Formula 2.

[0210] The electron transport layer may further include, in addition to the condensed compound represented by Formula 1 or Formula 2, at least one selected from BCP, Bphen, and Alq_3, Balq, TAZ, and NTAZ, which are illustrated below:



Alq_3

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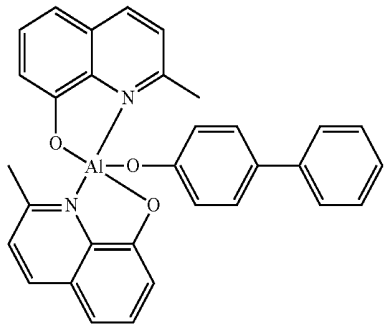
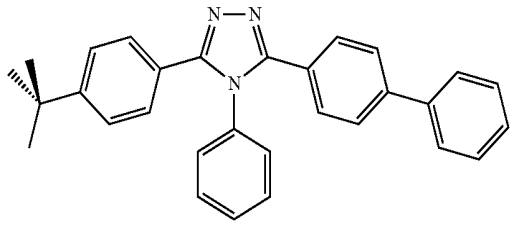
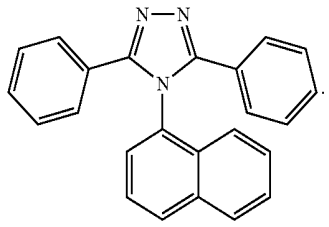


BAlq



TAZ



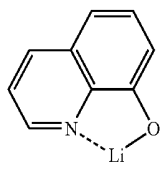
NTAZ

[0211] A thickness of the electron transport layer may be in a range of about 100 Å to about 1000 Å, for example, about 150 Å to about 500 Å. Maintaining the thickness of the electron transport layer within the range described above may help provide the electron transport layer with satisfactory electron transportation characteristics without a substantial increase in driving voltage.

[0212] Also, the electron transport layer may further include, in addition to the materials described above, a metal-containing material.

[0213] The metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2.

ET-D1



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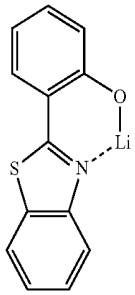
ET-D2



[0214] The electron transport region may include an electron injection layer that allows electrons to be easily provided from the second electrode **190**.

[0215] The electron injection layer may be formed on the electron transport layer by various methods, such as vacuum deposition, spin coating casting, an LB method, ink-jet printing, laser-printing, or laser-induced thermal imaging. When an electron injection layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the electron injection layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0216] The electron injection layer may include at least one selected from, LiF, NaCl, CsF, Li_2O, BaO, and LiQ.

[0217] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. Maintaining the thickness of the electron injection layer within the range described above may help provide the electron injection layer with satisfactory electron transportation characteristics without a substantial increase in driving voltage.

[0218] The second electrode **190** is disposed on the organic layer **150** having such a structure. The second electrode **190** may be a cathode that is an electron injection electrode, and in this regard, a material for forming the second electrode **190** may be a material having a low work function, and such a material may be metal, alloy, an electrically conductive compound, or a mixture thereof. Detailed examples of the second electrode **190** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag). According to another embodiment, the material for forming the second electrode **190** may be ITO or IZO. The second electrode **190** maybe a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

[0219] Hereinbefore, thee organic light-emitting diode has been described with reference to FIG. **1**; other implementations may have other structures.

[0220] A C_1-C_{60} alkyl group used herein refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and detailed examples thereof are a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a ter-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. A C_1-C_{60} alkylene group used herein refers to a divalent group having the same structure as the C_1-C_{60} alkyl group.

[0221] A C_1-C_{60} alkoxy group used herein refers to a monovalent group represented by —OA_{101} (wherein A_{101} is the C_1-C_{60} alkyl group), and detailed examples thereof are a methoxy group, an ethoxy group, and am isopropyloxy group.

[0222] A C_2-C_{60} alkenyl group used herein refers to a hydrocarbon group formed by substituting at least one carbon double bond in the middle or terminal of the C_2-C_{60} alkyl group, and detailed examples thereof are an ethenyl group, a prophenyl group and a butenyl group. A C_2-C_{60} alkenylene group used herein refers to a divalent group having the same structure as the C_2-C_{60} alkenyl group.

[0223] A C_2-C_{60} alkynyl group used herein refers to a hydrocarbon group formed by substituting at least one carbon triple bond in the middle or terminal of the C_2-C_{60} alkyl group, and detailed examples thereof are an ethynyl group and a propynyl group. A C_2-C_{60} alkynylene group used herein refers to a divalent group having the same structure as the C_2-C_{60} alkynyl group.

[0224] A C_3-C_{10} cycloalkyl group used herein refers to a monovalent hydrocarbon monocyclic group having 3 to 10 carbon atoms, and detailed examples thereof are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C_3-C_{10} cycloalkylene group used herein refers to a divalent group having the same structure as the C_3-C_{10} cycloalkyl group.

[0225] A C_2-C_{10} heterocycloalkyl group used herein refers to a monovalent monocyclic group having at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 2 to 10 carbon atoms, and detailed examples thereof are a tetrahydrofuranyl group and a tetrahydrothiophenyl group. A C_2-C_{10} heterocycloalkylene group used herein refers to a divalent group having the same structure as the C_2-C_{10} heterocycloalkyl group.

[0226] A C_3-C_{10} cycloalkenyl group used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one double bond in the ring thereof and does not have aromacity, and detailed examples thereof are a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C_3-C_{10} cycloalkenylene group used herein refers to a divalent group having the same structure as the C_3-C_{10} cycloalkenyl group.

[0227] A C_2-C_{10} heterocycloalkenyl group used herein refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom 2 to 10 carbon atoms, and at least one double bond in its ring. Detailed examples of the C_3-C_{10} heterocycloalkenyl are a 2,3-hydrofuranyl group and a 2,3-hydrothiophenyl group. A C_2-C_{10} heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C_2-C_{10} heterocycloalkenyl group.

[0228] A C_6-C_{60} aryl group used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and a C_6-C_{60} arylene group used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Detailed examples of the C_6-C_{60} aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6-C_{60} aryl group and the C_6-C_{60} arylene group each include two or more rings, the rings may be fused to each other.

[0229] A C_2-C_{60} heteroaryl group used herein refers to a monovalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom, and 2 to 60 carbon atoms. A C_2-C_{60} heteroarylene group used herein refers to a divalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom, and 2 to 60 carbon atoms. Detailed examples of the C_2-C_{60} heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_2-C_{60} heteroaryl group and the C_2-C_{60} heteroarylene group each include two or more rings, the rings may be fused to each other.

[0230] A C_6-C_{60} aryloxy group used herein indicates —OA_{102} (wherein A_{102} is the C_6-C_{60} aryl group), and a C_6-C_{60} arylthio group used herein indicates —SA_{103} (wherein A_{103} is the C_6-C_{60} aryl group).

[0231] A monovalent non-aromatic condensed polycyclic group (for example, having 6 80 carbon atoms) used herein refers to a monovalent group that has two or more rings condensed to each other, only carbon atoms as a ring-forming atom, and non-aromacity in the entire molecular structure. A detailed example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0232] A monovalent non-aromatic condensed heteropolycyclic group (for example, having 2 to 80 carbon atoms) used herein refers to a monovalent group that has two or more rings condensed to each other, has a heteroatom selected from N, O P, and S, other than carbon atoms, as a ring forming atom, and has non-aromacity in the entire molecular structure. Detailed examples of the monovalent non-aromatic condensed heteropolycyclic group are a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0233] The term "Ph" used herein refers to a phenyl group, the term "Me" used herein refers to a methyl group, the term "Et" used herein refers to an ethyl group, and the term "ter-Bu" or "But" used herein refers to tert-butyl.

[0234] Hereinafter, an organic light-emitting diode according to an embodiment will be described in detail with reference to Synthesis Examples and Examples. The wording "B was used instead of A" used in describing Synthesis Examples means that a molar equivalent of A was identical to a molar equivalent of B.

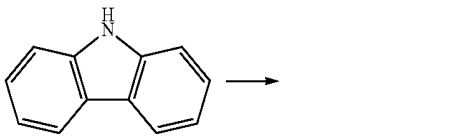
[0235] The following Examples and Comparative Examples are provided in order to highlight characteristics of one or more embodiments, but it will be understood that the Examples and Comparative Examples are not to be construed as limiting the scope of the embodiments, nor are the Comparative Examples to be construed as being outside the scope of the embodiments. Further, it will be understood that the embodiments are not limited to the particular details described in the Examples and Comparative Examples.

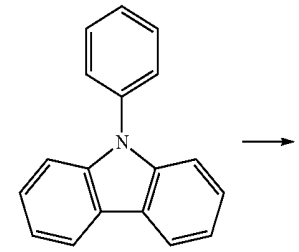
EXAMPLES

Synthesis Example 1

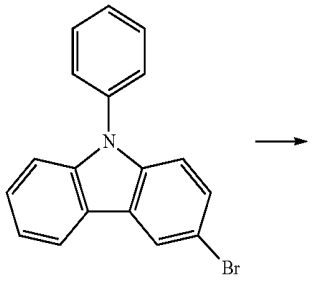
Synthesis of Compound 7

[0236]





I-1



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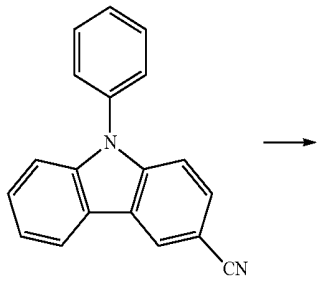

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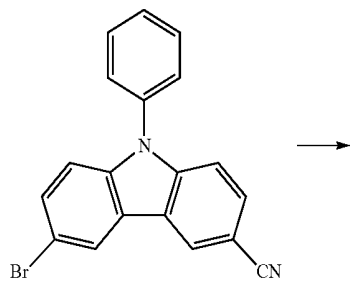

I-4

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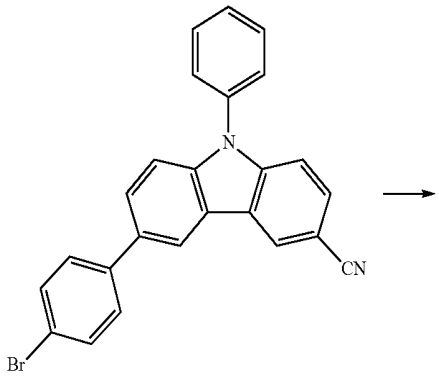

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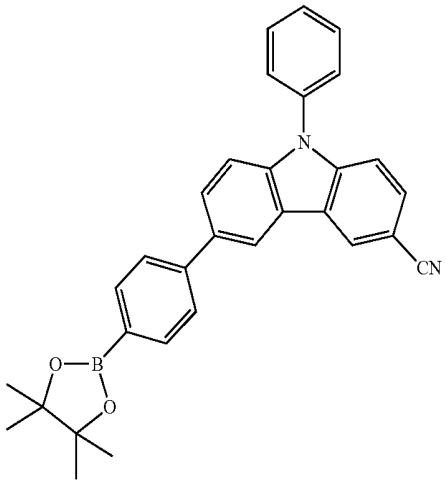

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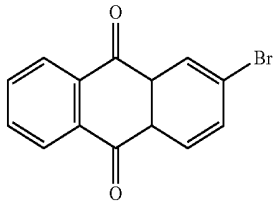

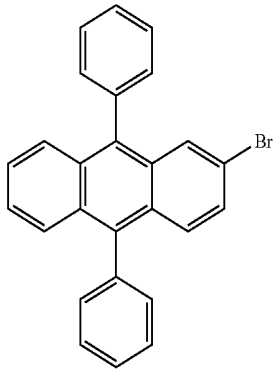

7-1

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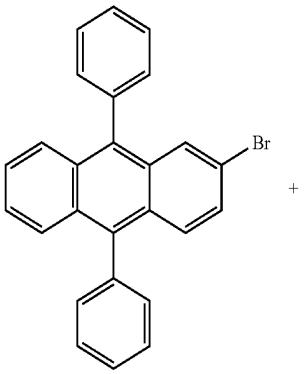
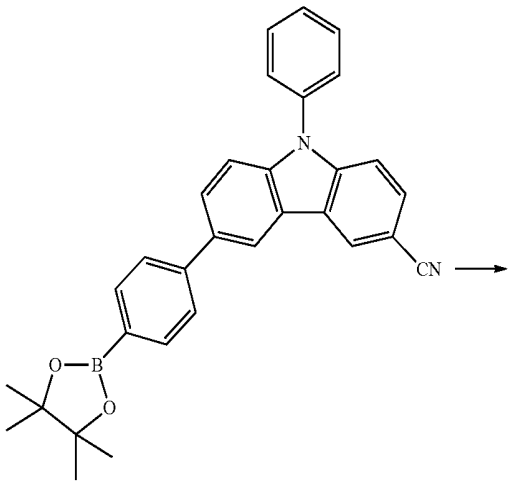
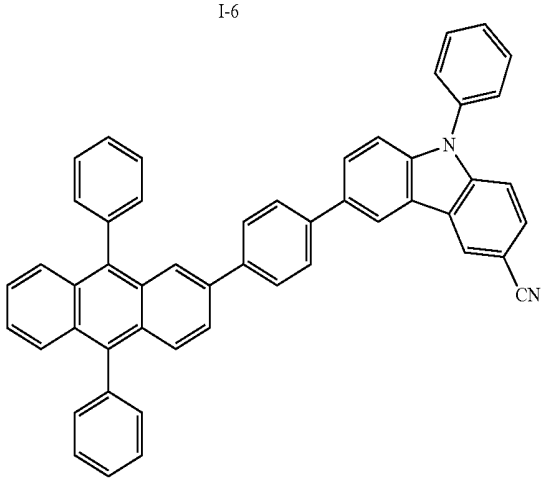


7-1



I-6



7

Synthesis of Intermediate I-1

[0237] 5.02 g (30 mmol) of 9H-carbazol, 4.71 g (30 mmol) of bromobenzene, 1.14 g (18 mmol) of copper powder, and 6.22 g (45 mmol) of K_2CO_3 were dissolved in 80 mL of o-dichlorobenzene, and then, the mixture was stirred at a temperature of 180° C. for 24 hours. The reaction solution was cooled to room temperature, 60 mL of water was added thereto, and then an extraction was perforated thereon three times using 50 mL of ethyl acetate. An organic layer obtained therefrom was dried using magnesium sulfate and then was dried to remove a solvent therefrom, and the obtained residual was separation-purified by using silica gel column chromatography to obtain 5.47 g of Intermediate I-1 (yield: 75%). The obtained compound was identified by LC-MS. $C_{18}H_{13}N$: M^+ 245.10

Synthesis of Intermediate I-2

[0238] 5.47 g (22.5 mmol) of Intermediate I-1 was completely dissolved in 80 mL of CH_2Cl_2, 4.00 g (22.5 mmol) of N-bromosuccinimide was added thereto, and the resultant solution was stirred at room temperature for 12 hours. 60 mL of water was added to the reaction solution, and then an extraction was performed thereon three times using 50 mL of CH_2Cl_2. An organic layer was dried using magnesium sulfate, a solvent was evaporated therefrom, and then, the resultant solution was re-crystallized using methanol to obtain 6.16 g (yield 85%) of Intermediate I-2. The obtained compound was identified by LC-MS. $C_{18}H_{12}BrN$:M^+ 321.0

Synthesis of Intermediate I-3

[0239] 6.16 g (19.1 mmol) of Intermediate I-2 and 2.57 g (28.7 mmol) of CuCN were dissolved in 70 mL of DMF, and then, the mixture was stirred at a temperature of 150° C. for 24 hours. The reaction solution was cooled at room temperature, and then, 60 mL of ammonia water and 60 mL of water were added thereto and then extracted three times using 50 mL of CH_2Cl_2. An organic layer obtained therefrom was dried using magnesium sulfate and then was dried to remove a solvent therefrom, and the obtained residual was separation-purified by using silica gel column chromatography to obtain 4.71 g (yield: 92%) of Intermediate I-3. The obtained compound was identified by LC-MS. $C_{19}H_{12}N_2$:M^+ 268.1.

Synthesis of Intermediate I-4

[0240] 4.71 g (17.6 mmol) of Intermediate I-3 was completely dissolved in 80 mL of CH_2Cl_2, 3.13 g (17.6 mmol) of N-bromosuccinimide was added thereto, and the resultant solution was stirred at room temperature for 8 hours. 60 mL of water was added to the reaction solution, and then an extraction was performed thereon three times using 50 mL of CH_2Cl_2. An organic layer was dried using magnesium sulfate, and then, a solvent was evaporated therefrom, and then, the resultant solution was re-crystallized using methanol to obtain 5.81 g (yield 95%) of Intermediate I-4. The obtained compound was identified by LC-MS. $C_{19}H_{11}BrN_2$:M^+ 346.0

Synthesis of Intermediate I-5

[0241] 5.81 g (16.7 mmol) of Intermediate I-4, 3.53 g (17.6 mmol) of 4-bromophenylboronic acid, 0.68 g (0.59 mmol) of $Pd(PPh_3)_4$, and 4.85 g (35.1 mmol) of K_2CO_3 were dissolved in 60 mL of THF and 30 mL of H_2O, and then, the resultant solution was stirred at a temperature of 80° C. for 12 hours. The reaction solution was cooled to room temperature, and then, extracted three times using 30 mL of water and 30 mL of ethyl acetate. An organic layer obtained therefrom was dried using magnesium sulfate, and then, the residual obtained by evaporating a solvent therefrom was separation-purified by using silica gel column chromatography to obtain 5.30 g (yield: 75%) of Compound I-6. The obtained compound was identified by LC-MS. $C_{25}H_{15}BrN_2$:M^+ 422.0

Synthesis of Intermediate I-6

[0242] 5.81 g (12.6 mmol) of Intermediate I-5, 0.46 g (0.63 mmol) of $Pd(dppf)_2Cl_2$, and 3.71 g (37.8 mmol) of KOAc were dissolved in 80 mL of DMSO, and then, the resultant solution was stirred at a temperature of 150° C. for 24 hours. The reaction solution was cooled to room temperature, 100 mL of water was added thereto, and then, the resultant reaction solution was extracted three times using 50 mL of CH_2Cl_2. An organic layer obtained therefrom was dried using magnesium sulfate and then was dried to remove a solvent therefrom, and the obtained residual was separation-purified by using silica gel column chromatography to obtain 4.15 g (yield: 70%) of Intermediate I-6. The obtained compound was identified by LC-MS. $C_{31}H_{27}BN_2O$:M^+ 470.2

Synthesis of Intermediate 7-1

[0243] 5.42 g (34.5 mmol) of bromobenzene was dissolved in 60 mL of THF, and then, 13.8 mL (34.5 mmol, 2.5 M in hexane) of nBuLi was slowly added thereto at a temperature of −78° C., and then, the resultant mixture was stirred for 1 hour, 4.33 g (15.0 mmol) of 2-bromo-4a, 9a-dihydro-anthraquinone was slowly dropped to the reaction solution and then, the resultant reaction solution was stirred at room temperature for 12 hours. 60 mL of water was added to the reaction solution, the resultant solution was extracted three times using 50 mL of ethyl acetate, and then, the obtained organic layer was dried using magnesium sulfate.

[0244] After a solvent was evaporated, 22.4 g (135 mmol) of KI and 21.3 g (165 mmol) of $Na_2H_2PO_2.H_2O$ dissolved in 50 mL of acetic acid were added to the obtained residual, and then, heated at a temperature of 120° C. for 1 hour. The reaction solution was cooled at room temperature, and then, 60 mL of water was added thereto, and filtered. The obtained residual was separation-purified by using silica gel column chromatography to obtain 5.05 g (yield: 82%) of Intermediate I-11. The obtained compound was identified by LC-MS. $C_{26}H_{17}Br$:M^+ ^{b} 408.0

Synthesis of Compound 7

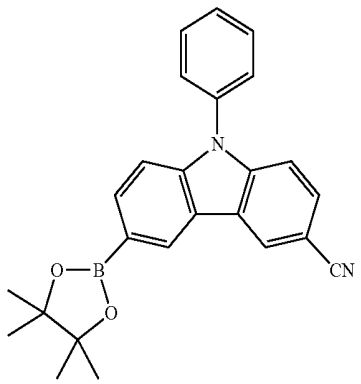
[0245] 6.97 g (yield: 62%) of Compound 7 was obtained in the same manner as used to synthesize Intermediate I-5, except that Intermediate 7-1 was used, instead of Intermediate I-4 and Intermediate I-6 was used instead of 4-bromophenylboronic acid. The obtained compound was identified by MS/FAB and 1H NMR. $C_{51}H_{32}N_2$ cal. 672.26, found 672.27

Synthesis Example 2

Synthesis of Compound 15

[0246]

I-7



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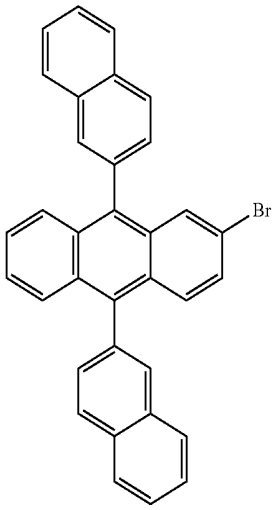
15-1



Synthesis of Intermediate I-7

[0247] 3.42 g (yield: 69%) of Intermediate I-7 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that Intermediate I-4 was used instead of Intermediate I-5. The obtained compound was identified by LC-MS. $C_{25}H_{23}BN_2O_2$:M^+ 394.2

Synthesis of Intermediate 15-1

[0248] 5.73 g (yield: 75%) of Intermediate 15-1 was obtained in the same manner as used to synthesize Intermediate 7-1 in Synthesis Example 1, except that 2-bromonaphthalene was used instead of bromobenzene. The obtained compounds was identified by LC-MS. $C_{34}H_{21}Br$:M^+ 508.0

Synthesis of Compound 15

[0249] 5.38 g (yield: 72%) of Compound 15 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate 15-1 and Intermediate I-7 were respectively used instead of Intermediate 7-I and Intermediate I-6. The obtained compound was identified by MS/FAB and ^1H NMR, and results thereof are shown in Table 1. $C_{53}H_{32}N_2$ cal. 696.26, found 696.28

Synthesis Example 3

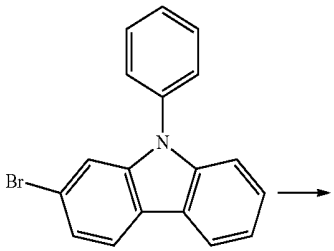
Synthesis of Compound 20

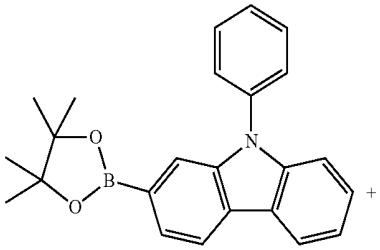
[0250] 4.38 g (yield: 70%) of Compound 15 was obtained to the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate 15-1 was used instead of Intermediate 7-1. The obtained compound was identified by MS/FAB and ^1H NMR. $C_{69}H_{36}N_2$ cal. 772.29, found 772.29

Synthesis Example 4

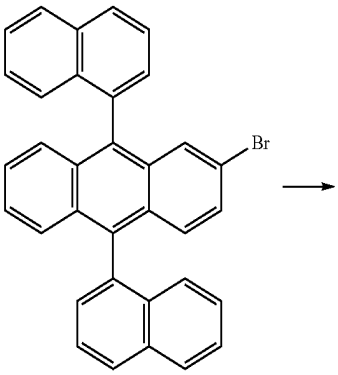
Synthesis of Compound 29

[0251]

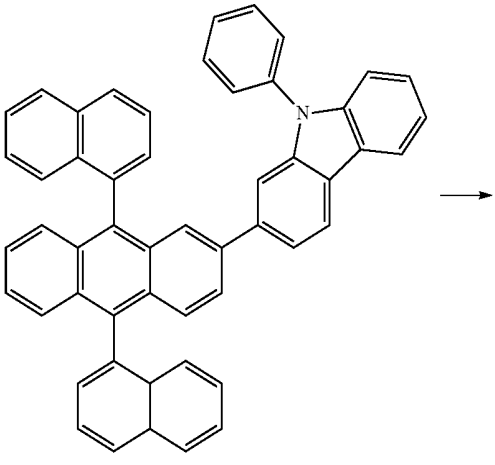




I-8



29-1



29-2

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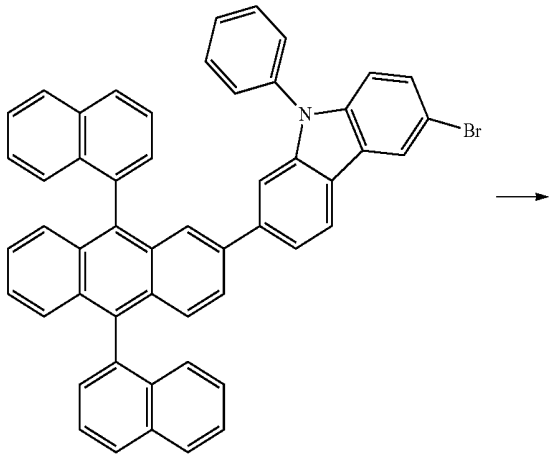
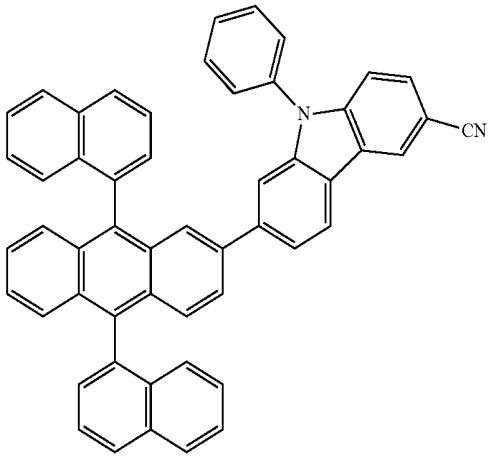


29-3



29

Synthesis of Intermediate I-8

[0252] 3.65 g (yield: 72%) of Intermediate I-8 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that 2-bromo-9-phenyl-9H-carbazol was used instead of Intermediate I-5. The obtained compound was identified by LC-MS. $C_{24}H_{24}BNO_2$:M^+ 369.2

Synthesis of Intermediate 29-1

[0253] 4.02 g (yield: 78%) of Intermediate 29-1 was obtained in the same manner as used to synthesize Intermediate 7-1 in Synthesis Example 1, except that 1-bromonaphthalene was used instead of bromobenzene. The obtained compound was identified by LC-MS. $C_{34}H_{21}Br$:M^+ 508.0

Synthesis of Intermediate 29-2

[0254] 3.72 g (yield: 70%) of Intermediate 29-2 was obtained in the same manner as used to synthesize Intermediate I-5 in Synthesis Example 1, except that Intermediate 29-1 was used instead of Intermediate I-4 and Intermediate I-8 was used instead of 4-bromophenylboronic acid. the obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{52}H_{33}N$ cal. 671.26, found 671.26

Synthesis of Intermediate 29-3

[0255] 2.41 g (yield: 58%) of Intermediate 29-3 was obtained in the same manner as used to synthesize Intermediate I-2 in Synthesis Example 1, except that Intermediate 29-2 was used instead of Intermediate I-1. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{52}H_{32}BrN$ cal. 749.17, found 749.18

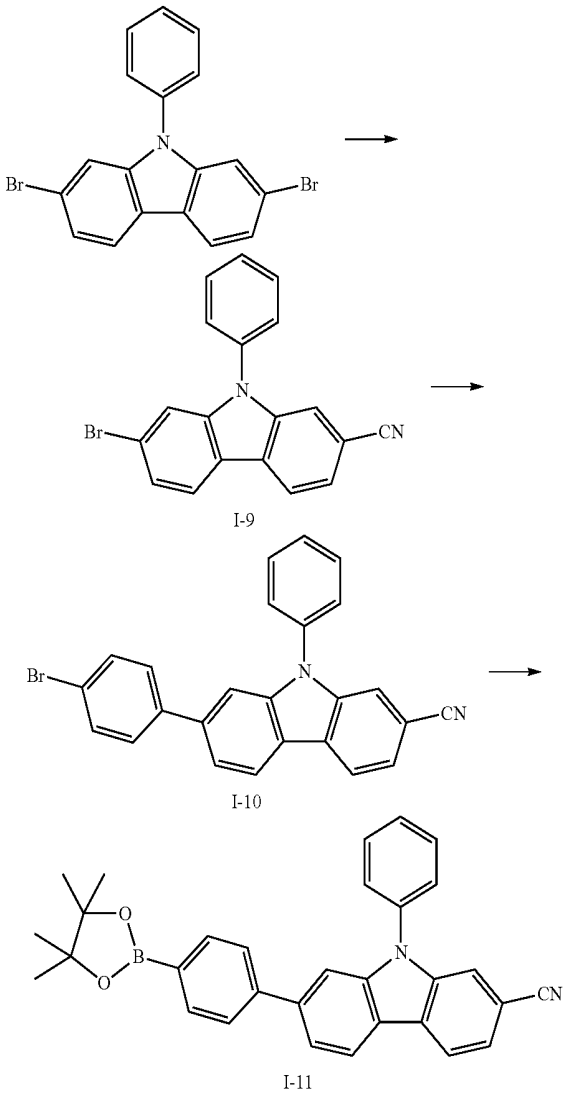
Synthesis of Compound 29

[0256] 1.82 g (yield: 81%) of Compound 29 was obtained in the same manner as used to synthesize Intermediate I-3 in Synthesis Example 1, except that Intermediate 29-3 was used instead of Intermediate I-2. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{53}H_{32}N_2$ cal. 696.26, found 696.27

Synthesis Example 5

Synthesis of Compound 36

[0257]



Synthesis of Intermediate I-9

[0258] 6.08 g (yield: 35%) of Intermediate I-9 was obtained in the same manner as used to synthesize Intermediate I-3 in Synthesis Example 1, except that 2,7-dibromo-9-phenyl-9H-carbazol was used instead of Intermediate I-2. The obtained compound was identified by LC-MS. $C_{19}H_{11}BrN_2$:M^+ 346.0

Synthesis of Intermediate I-10

[0259] 4.58 g (yield: 62%) of Intermediate I-10 was obtained in the same manner as used to synthesize Intermediate I-5 in Synthesis Example 1, except that Intermediate I-7 was used instead of Intermediate I-4. The obtained compound was identified by LC-MS. $C_{25}H_{15}BrN_2$:M^+ 422.0

Synthesis of Intermediate I-11

[0260] 3.83 g (yield: 75%) of Intermediate I-11 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that Intermediate I-10 was used instead of Intermediate I-5. The obtained compound was identified by LC-MS. $C_{31}H_{27}BN_2O_2$:M^+ 470.2

Synthesis of Compound 36

[0261] 3.55 g (yield: 72%) of Compound 36 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that intermediate 29-1 and Intermediate I-11 were respectively used instead of Intermediate 7-1 and intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{59}H_{36}N_2$ cal. 772.29, found 772.29

Synthesis Example 6

Synthesis of Compound 45

Synthesis of Intermediate I-12

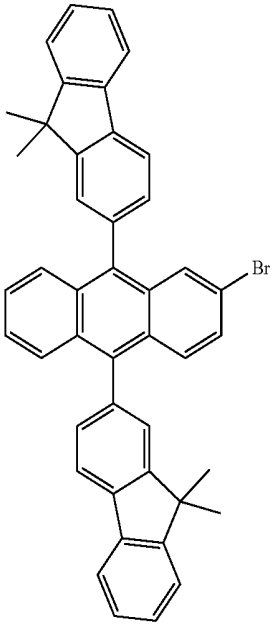
[0262] 4.52 g (yield: 52%) of Intermediate I-12 was obtained in the same manner as used to synthesize Intermediate I-3 in Synthesis Example 1, except that 2,8-dibromodibenzofuran was used instead of Intermediate I-2. The obtained compound was identified by LC-MS. $C_{13}H_6BrNO$: M^+ 270.9

Synthesis of Intermediate I-13

[0263] 3.44 g (yield: 65%) of Intermediate I-13 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that Intermediate I-12 was used instead of Intermediate I-5. The obtained compound was identified by LC-MS. $C_{19}H_{18}BNO_3$:M^+ 319.1

Synthesis of Intermediate 45-1

45-1



[0264] 43.88 g (yield: 76%) of Intermediate 45-1 was obtained in the same manner as used to synthesize Intermediate 7-1 in Synthesis Example 2, except dial 2-bromo-9,9-dimethyl-9H-fluorenene was used instead of bromobenzene. The obtained compound was identified by LC-MS. $C_4H_{23}Br$: M^+ 640.2

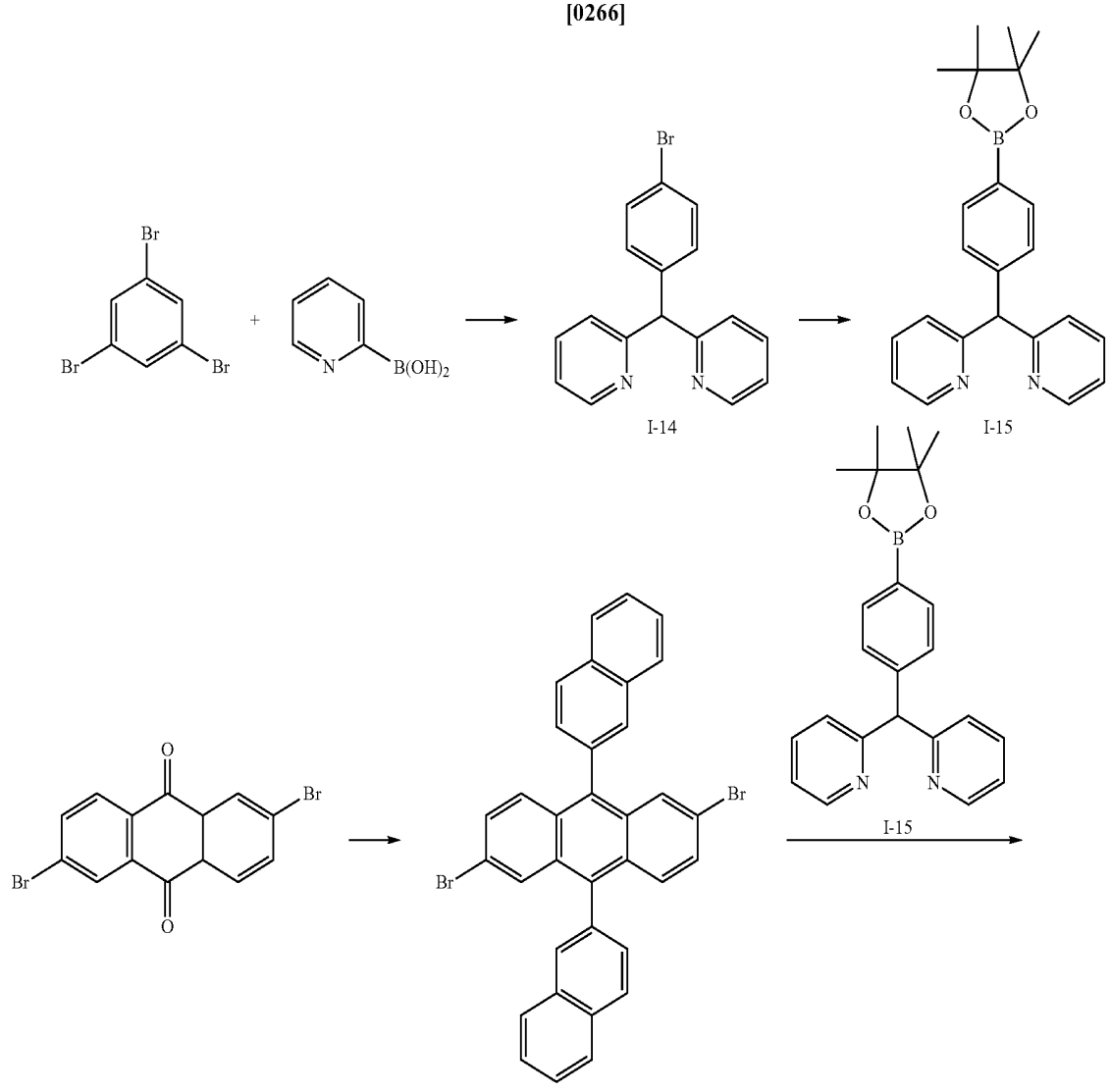
Synthesis of Compound 45

[0265] 3.56 g (yield: 78%) of Compound 45 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate 45-1 and Intermediate I-13 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{59}H_{36}N_2$ cal. 753.30, found 753.30

Synthesis Example 7

Synthesis of Compound 65

[0266]



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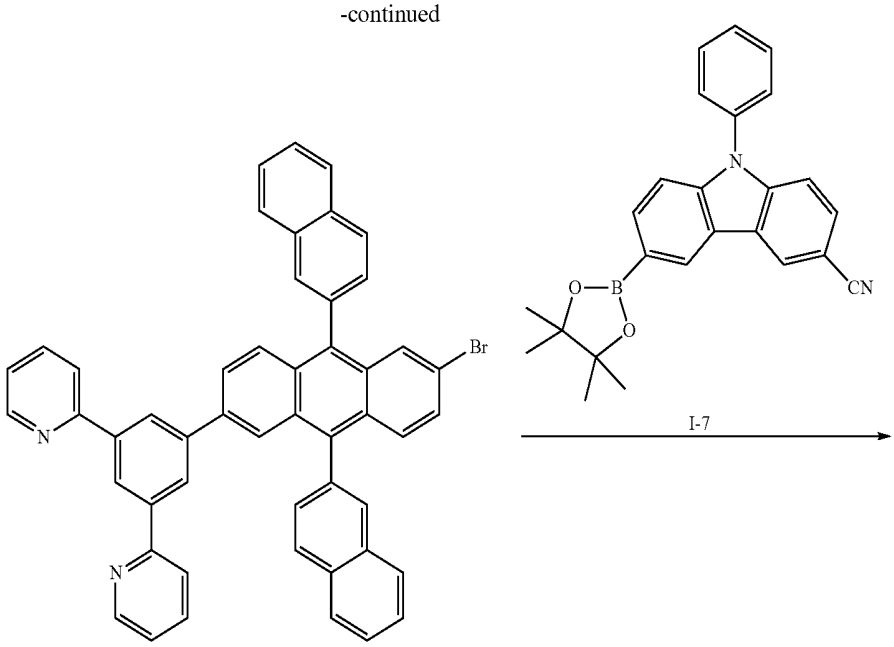
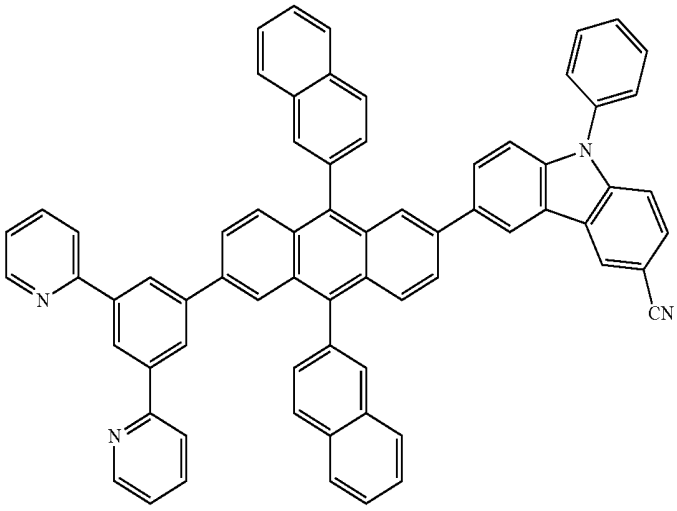


65-2



65

Synthesis of Intermediate I-14

[0267] 3.50 g (yield: 66%) of Intermediate I-14 was obtained in the same manner as used to synthesize Intermediate I-5 in Synthesis Example 1, except that 1,3,5-tribromobenzene was used instead of Intermediate I-4 and 2-pyridineboronic acid was used instead of 4-bromophenylboronic acid. The obtained compound was identified by LC-MS. $C_{16}H_{11}BrN_2$:M^+ 310.0

Synthesis of Intermediate I-15

[0268] 3.15 (yield: 78%) of Intermediate I-15 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that Intermediate I-14 was used instead of Intermediate I-5. The obtained compound was identified by LC-MS. $C_{22}H_{23}BN_2O_2$:M^+ 358.1

Synthesis of Intermediate 65-1

[0269] 3.42 g (yield: 61%) of Intermediate 65-1 was obtained in the same manner as used to synthesize Intermediate 7-1 in Synthesis Example 2, except that 2,6-dibromo-4a,9a-dihydro-anthraquinone was used instead of 2-bromo-4a,9a-dihydro-anthraquinone and 2-bromonaphthalene was used instead of bromobenzene. The obtained compound was identified by LC-MS. $C_{44}H_{20}Br_2$:M^+ 585.9

Synthesis of Intermediate 65-2

[0270] 3.05 g (yield: 71%) of Intermediate 52-2 was obtained in the same manner as used to synthesis Intermediate I-5 in Synthesis Example 1, except that Intermediate 52-1 was used instead of Intermediate I-4 and Intermediate I-15 was used instead of 4-bromophenylboronic acid. The obtained compound was identified by LC-MS. $C_{56}H_{31}BrN_2$:M^+ 738.1

Synthesis of Compound 65

[0271] 3.10 g (yield: 81%) of Compound 65 was obtained in the same manner as used to synthesize Compound 7 in

Synthesis Example 1, except that Intermediate 65-2 and Intermediate I-7 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{69}H_{42}N_4$ cal. 926.34, found 926.35

Synthesis Example 8

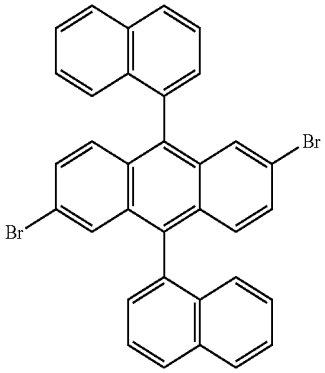
Synthesis of Compound 62

[0272] 3.20 g (yield: 65%) of Compound 62 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, 3-pyridineboronic acid was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{58}H_{35}N_8$ cal. 773.28, found 773.28

Synthesis Example 9

Synthesis of Compound 69

[0273]



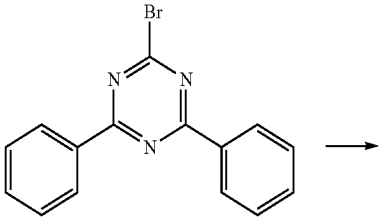
69-1

[0274] 3.18 g (yield: 71%) of Compound 69 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, 1-naphthylboronic acid was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{63}H_{38}N_2$ cal. 822.30, found 822.31

Synthesis Example 10

Synthesis of Compound 72

[0275]



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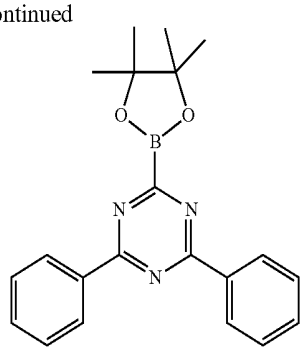
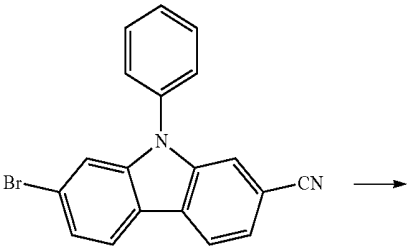


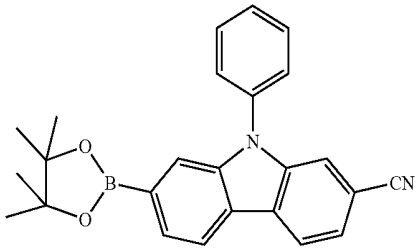
I-16

Synthesis of Intermediate I-16

[0276] 3.68 (yield: 79%) of Intermediate I-16 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that 2-bromo-4,6-diphenyl-1,3,5-triazine was used instead of Intermediate I-5. The obtained compound was identified by LC-MS. $C_{21}H_{22}BN_3O_2$:M^+ 359.1



I-9



I-17

Synthesis of Intermediate I-17

[0277] 3.10 g (yield: 82%) of Intermediate I-17 was obtained in the same manner as used to synthesize Intermediate I-6 in Synthesis Example 1, except that Intermediate I-9 was used instead of Intermediate I-5. The obtained compound was identified by LC-MS, $C_{25}H_{23}BN_2O_2$:M^+ 394.1

Synthesis of Compound 72

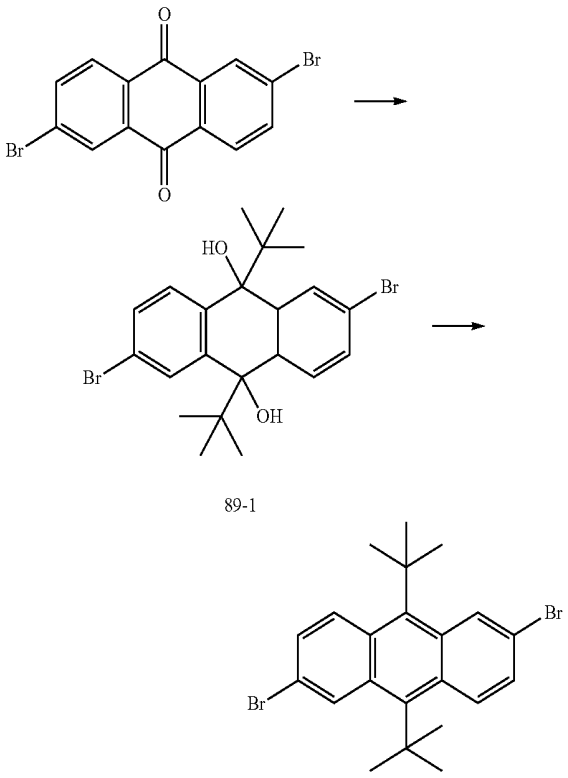
[0278] 4.03 g (yield: 73%) of Compound 72 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-1, 1-bromonaphthalene was used instead of 2-bromonaphthalene and Intermediate I-16

was used instead of Intermediate I-15, and in synthesizing Compound 65, Intermediate I-17 was used instead of Intermediate I-7. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{68}H_{41}N_5$ cal. 927.34, found 927.34

Synthesis Example 11

Synthesis of Compound 89

[0279]



Synthesis of Intermediate 89-1

[0280] In a nitrogen atmosphere, 2.9 g (10 mmol) of 2,6-dibromo-4a,9a-dihydro-anthraquinone was dissolved in 50 mL of purified tetrahydrofuran, and cooled to a temperature of −78° C., and then, 5 mL (2.0 M in diethyl ether) of t-butylmagnesium chloride was slowly added thereto. At the same temperature, the resultant solution was stirred for 30 minutes, and then a cooling diode was removed to raise a temperature thereof to room temperature. After stirring for one hour, when the reaction was terminated, the temperature was decreased to 0° C., and then, 10 mL of ammonium chloride aqueous solution teas slowly added thereto. Then, the resultant solution was extracted two times using 40 mL of diethyl ether, an organic layer obtained therefrom was dried using magnesium sulfate and filtered, and a solvent was evaporated therefrom. The obtained compound was identified by LC-MS. $C_{22}H_{28}Br_2O_2$:M^+ 482.0

Synthesis of Intermediate 89-2

[0281] A mixture of 2.6 g (5.39 mmol) of Intermediate 89-1, 10.7 g (53.9 mmol) of potassium iodide, 11.4 g (129 mmol) of sodium hypophosphate hydrate was refluxed in a mixed solution including 600 mL of ortho-dichloro benzene and 80 mL of an acetic acid for 24 hours. The reaction solution was cooled to room temperature, extracted using chloroform, and then, dehydrated using anhydrous magnesium sulfate, followed by compression to remove a solvent therefrom. The residual obtained therefrom was separation-purified by silica gel column chromatography to obtain 2.70 g (yield: 73%) of Intermediate 89-2. The obtained compound was identified by LC-MS. $C_{22}H_{26}Br_2$:M^+ 448.0

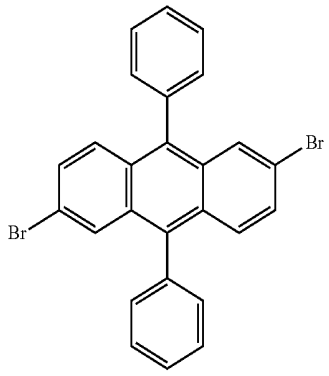
Synthesis of Compound 89

[0282] 4.40 g (yield: 75%) of Compound 89 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate 89-2 was used instead of Intermediate 7-1. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{72}H_{54}N_4$ cal. 974.43, found 974.43

Synthesis Example 12

Synthesis of Compound 96

[0283]



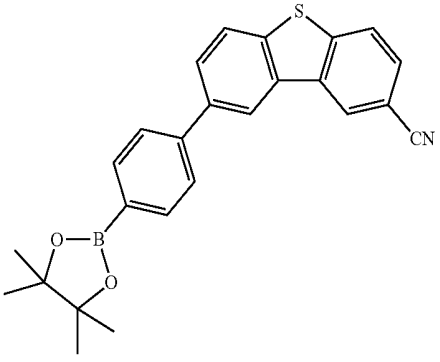
96-1

[0284] 3.05 g (yield: 65%) of Compound 96 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, Intermediate 96-1 and Intermediate I-7 were respectively used instead of Intermediate 65-1 and Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{64}H_{38}N_4$ cal. 862.31, found 862.32

Synthesis Example 13

Synthesis of Compound 103

[0285]



I-18

Synthesis of Intermediate I-18

[0286] Intermediate I-18 was obtained in the same manner as used to synthesize Intermediates I-2, I-3, I-4, I-5, and I-6 in Synthesis Example 1, except that 2,8-dibromodibenzothiophene was used instead of Intermediate I-1.

Synthesis of Compound 103

[0287] 3.76 g (yield: 75%) of Compound 103 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, Intermediate 96-1 and Intermediate I-18 were respectively used instead of Intermediate 65-1 and Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{64}H_{36}N_2S_2$ cal. 896.23, found 896.24

Synthesis Example 14

Synthesis of Compound 104

[0288] 3.89 g (yield: 70%) of Compound 104 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, Intermediate I-7 was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{72}H_{42}N_4$ cal. 962.34, found 962.34

Synthesis Example 15

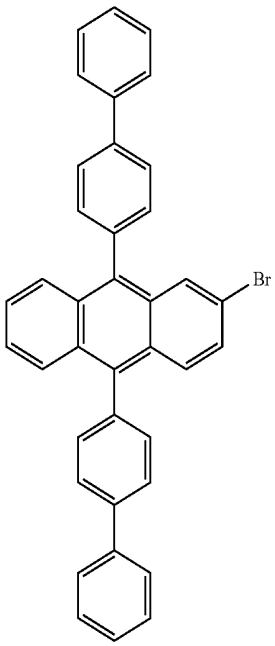
Synthesis of Compound 109

[0289] 3.31 g (yield: 72%) of Compound 109 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, Intermediate 69-1 and Intermediate I-17 were respectively used instead of Intermediate 65-1 and Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{72}H_{42}N_4$ cal. 962.34, found 962.34

Synthesis Example 16

Synthesis of Compound 112

[0290]



112-1

[0291] 2.85 g (yield: 74%) of Compound 112 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate 112-1 and Intermediate I-7 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{57}H_{36}N_2$ cal. 748.29, found 748.30

Synthesis Example 17

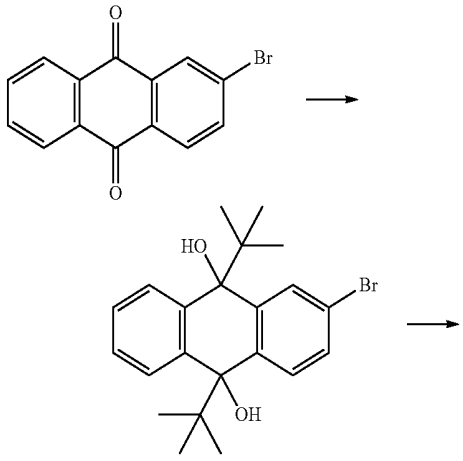
Synthesis of Compound 116

[0292] 3.08 g (yield: 69%) of Compound **116** was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate 112-1 and Intermediate I-11 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR. $C_{63}H_{40}N_2$ cal. 824.32, found 824.32

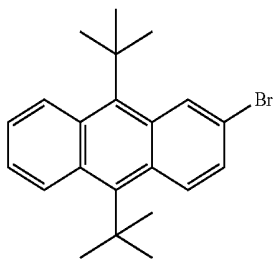
Synthesis Example 18

Synthesis of Compound 1

[0293]



1-1



1-2

Synthesis of Intermediate I-2

[0294] Intermediate 1-2 was prepared in the same manner as used to synthesize Intermediate 89-1 and 89-2 in Synthesis Example 11, except that 2-bromo-4a,9a-dihydro-anthraquinone was used instead of 2,6-dibromo-4a,9a-dihydro-anthraquinone.

Synthesis of Compound 1

[0295] 4.02 g (yield: 75%) of Compound 1 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate I-2 and Intermediate I-7 were respectively used instead of Intermediate 7-2 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 19

Synthesis of Compound 5

[0296] 3.77 g (yield: 64%) of Compound 5 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate I-13 was used instead of Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 20

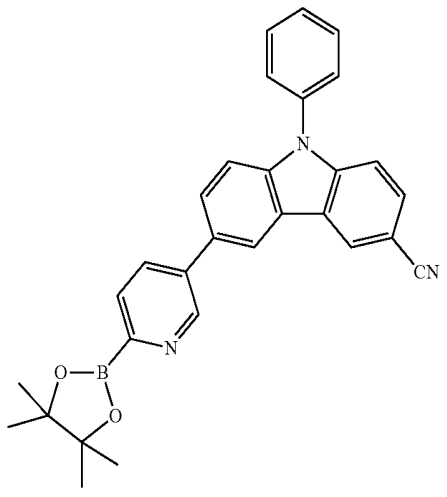
Synthesis of Compound 8

[0297] 2.87 g (yield: 62%) of Compound 8 was obtained in the same manner as used to synthesis Compound 7 in Synthesis Example 1, except that Intermediate I-11 was used instead of Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 21

Synthesis of Compound 12

[0298]



I-19

Synthesis of Intermediate I-19

[0299] Intermediate I-19 was synthesized in the same manner as used to synthesize Intermediates I-5 and I-6 in Synthesis Example 1, except that in synthesizing Intermediate I-5, 5-bromo-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl) pyridine was used instead of 4-bromophenylboronic acid.

Synthesis of Compound 12

[0300] 3.02 g (yield: 71%) of Compound 12 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 1, except that Intermediate I-9 was used instead of Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 22

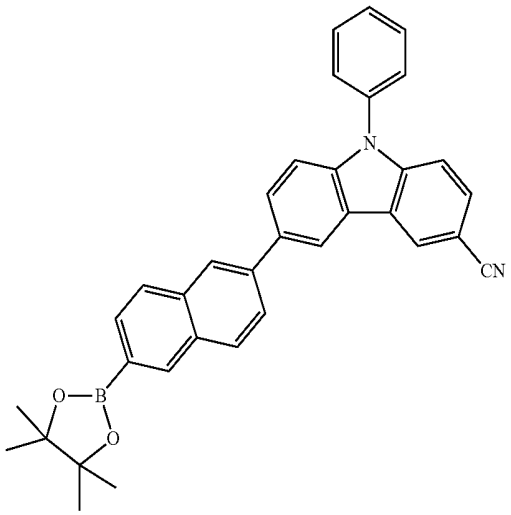
Synthesis of Compound 24

[0301] 3.88 g (yield: 75%) of Compound 24 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 24, except that Intermediate 15-2 and Intermediate I-18 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 23

Synthesis of Compound 26

[0302]



I-20

Synthesis of Intermediate I-20

[0303] Intermediate I-19 was synthesized in the same manner as used to synthesize Intermediates I-5 and I-6 in Synthesis Example 1, except that in synthesizing Intermediate I-5, 1-(2-bromonaphthalen-6-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane was used instead of 4-bromophenylboronic acid.

Synthesis of Compound 26

[0304] 3.44 g (yield: 63%) of Compound 26 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 24, except that Intermediate 15-2 and Intermediate I-20 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 24

Synthesis of Compound 43

[0305] 4.00 g (yield: 78%) of Compound 43 was obtained in the same manner as used to synthesize Compound 7 in Synthesis Example 43, except that Intermediate 45-1 and Intermediate I-7 were respectively used instead of Intermediate 7-1 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 25

Synthesis of Compound 49

[0306] 3.89 g (yield: 69%) of Compound 49 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-1, bromobenzene was used instead of 2-bromonaphthalene, and in synthesizing Intermediate 65-2, phenylboronic acid was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 26

Synthesis of Compound 52

[0307] 4.00 g (yield: 74%) of Compound 52 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-1, bromobenzene was used instead of 2-bromonaphthalene, and in synthesizing Intermediate 65-2, 2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-6-phenylpyridine was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 27

Synthesis of Compound 58

[0308] 3.46 g (yield: 62%) of Compound 58 was obtained is the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-1, bromobenzene was used instead of 2-bromonaphthalene, in synthesizing Intermediate 65-2, 2-naphthylboronic acid was used instead of Intermediate I-15, and in synthesizing Compound 65, Intermediate I-13 was used instead of Intermediate I-7. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 28

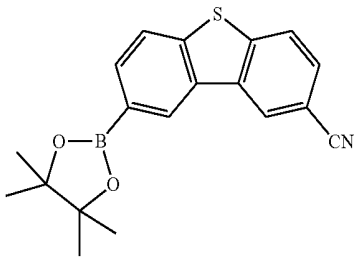
Synthesis of Compound 64

[0309] 4.03 g (yield: 79%) of Compound 64 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-2, 2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-6-phenylpyridine was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 29

Synthesis of Compound 79

[0310]



I- 21

Synthesis of Intermediate I-21

[0311] Intermediate I-12 was synthesized in the same manner as used to synthesize Intermediates I-12 and I-13 in Synthesis Example 6, except that 2,8-dibromodibenzothiophene was used instead of 2,8-dibromodibenzofuran.

Synthesis of Compound 79

[0312] 3.22 g (yield: 70%) of Compound 79 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-1, 2-bromo-9,9-dimethyl-9H-fluorenene was used instead of 2-bromonaphthalene, in synthesizing Intermediate 65-2, phenylboronic acid was used instead of Intermediate I-15, and in synthesizing Compound 65, Intermediate I-21 was used instead of Intermediate I-7, the Synthesis Example 7. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 30

Synthesis of Compound 83

[0313] 3.79 g (yield: 72%) of Compound 83 was obtained is the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 65-1, bromobenzene was used instead of 2-bromonaphthalene, in synthesizing Intermediate 65-2, 1-naphthylboronic acid was used instead of Intermediate I-15, and in synthesizing Compound 65, Intermediate I-6 was used instead of Intermediate I-7. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 31

Synthesis of Compound 92

[0314] 3.89 g (yield: 70%) of Compound 104 was obtained in the same manner as in Synthesis Example 7, except that in synthesizing Intermediate 6589, Intermediate I-7 was used instead of Intermediate I-15. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 32

Synthesis of Compound 94

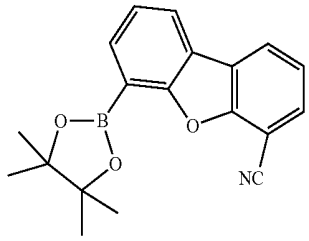
[0315] 3.25 f (yield: 74%) of Compound 94 was obtained in the same manner as in Example 11, except that in synthesiz-

ing Compound 89, Intermediate I-21 was used instead of Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

Synthesis Example 33

Synthesis of Compound 110

[0316]



I-22

Synthesis of Intermediate I-22

[0317] Intermediate I-22 was synthesized in the same manner as used to synthesize Intermediates I-12 and I-13 in Synthesis Example 6, except that 4,6-dibromodibenzofuran was used instead of 2,8-dibromodibenzofuran.

Synthesis of Compound 110

[0318] 3.75 g (yield: 75%) of Compound 110 was obtained in the same manner as in Synthesis Example 11, except that in synthesizing Compound 89, Intermediate 69-1 and Intermediate I-22 were respectively used instead of Intermediate 89-2 and Intermediate I-6. The obtained compound was identified by MS/FAB and ^{1}H NMR.

[0319] ^{1}H NMR and MS/FAB results of the synthesized compounds are shown in Table 1 below.

[0320] Synthesis methods for compounds other than those listed in Table 1 may be determined by one of skill in the art by referring to the synthetic paths and source materials of Synthesis Examples 1 to 33.

TABLE 1

		MS/FAB	
Compound	^{1}H NMR ($CDCl_3$, 400 MHz)	Found	calc.
1	8.32-8.30 (m, 1H), 8.27-8.25 (m, 1H), 8.13-8.09 (m, 3H), 7.84 (d, 1H), 7.68-7.62 (m, 2H), 7.57-7.54 (m, 2H), 7.52-7.40 (m, 6H), 7.34-7.25 (m, 2H), 1.54 (s, 9H), 1.51 (s, 9H)	556.30	556.29
5	8.45-8.43 (m, 1H), 8.40-8.38 (m, 1H), 7.93-7.83 (m, 3H), 7.81-7.75 (m, 6H), 7.71-7.69 (m, 1H), 7.65-7.62 (m, 2H), 7.57-7.46 (m, 5H), 7.41-7.25 (m, 4H)	521.18	521.18
7	8.35-8.32 (m, 1H), 8.22-8.20 (m, 1H), 7.97-7.93 (m, 5H), 7.85-7.77 (m, 6H), 7.71-7.69 (m, 2H), 7.63-7.61 (m, 2H), 7.57-7.46 (m, 9H), 7.41-7.25 (m, 6H)	672.27	672.26
8	8.03-7.93 (m, 5H), 7.91-7.89 (m, 1H), 7.88-7.84 (m, 2H), 7.82-7.76 (m, 6H), 7.74-7.67 (m, 2H), 7.60-7.45 (m, 10H), 7.41-7.27 (m, 6H)	672.26	672.26
12	8.68-8.66 (m, 1H), 8.62-8.60 (m, 1H), 8.38-8.36 (m, 1H), 8.31-8.26 (m, 2H), 8.14 (d, 1H), 8.09 (dd, 1H), 7.92 (d, 1H), 7.81-7.77 (m, 4H), 7.71-7.62 (m, 3H), 7.57-7.46 (m, 9H), 7.41-7.26 (m, 7H)	673.26	673.25
15	8.31-8.29 (m, 1H), 8.27-8.24 (m, 1H), 8.17-8.15 (m, 1H), 8.07-8.05 (m, 1H), 7.98-7.96 (m, 1H), 7.96-7.83 (m, 10H), 7.76-7.68(m, 3H), 7.65-7.46 (m, 10H), 7.40-7.25 (m, 4H)	696.28	696.26
20	8.31-8.29 (m, 1H), 8.21-8.19 (m, 1H), 8.08-8.06 (m, 2H), 8.00-7.98 (m, 1H), 7.96-7.88 (m, 12H) 7.85-7.79 (m, 2H), 7.75-7.73(m, 1H), 7.70-7.46 (m, 12H), 7.40-7.25 (m, 4H)	772.29	772.29
24	8.40-8.35 (m, 2H), 8.12-7.89 (m, 5H), 7.95-7.88 (m, 10H), 7.85-7.74 (m, 5H), 7.71-7.65 (m, 3H), 7.62-7.54 (m, 4H), 7.40-7.32 (m, 2H)	713.22	713.22
26	8.33-8.30 (m, 3H), 8.27-8.25 (m, 1H), 8.07-8.05 (m, 1H), 8.01-7.88 (m, 14H), 7.83-7.79 (m, 2H), 7.76-7.68 (m, 2H), 7.65-7.45 (m, 11H), 7.40-7.25 (m, 5H)	822.31	822.30
29	8.50-8.48 (m, 1H), 8.39-8.37 (m, 1H), 8.31-8.29 (m, 1H), 8.21-8.19 (m, 1H), 7.97-7.95 (m, 1H), 7.90-7.79 (m, 6H), 7.72-7.68 (m, 4H), 7.63 (dd, 1H), 7.59-7.44 (m, 7H), 7.37-7.25 (m, 7H), 6.96-6.93 (m, 2H)	696.27	696.26
36	8.39-8.37 (m, 1H), 8.16 (d, 1H), 8.03-7.89 (m, 13H), 7.76-7.69 (m, 5H), 7.60-7.50 (m, 7H), 7.46-7.44 (m, 1H), 7.37-7.27 (m, 6H), 6.98-7.94 (m, 2H)	772.29	772.29

TABLE 1-continued

Compound	^{1}H NMR ($CDCl_3$, 400 MHz)	MS/FAB Found	MS/FAB calc.
43	8.21-8.19 (m, 1H), 8.15-8.13 (m, 1H), 7.98-7.96 (m, 1H), 7.93-7.88 (m, 5H), 7.86-7.79 (m, 5H), 7.75-7.69 (m, 3H), 7.63 (dd, 1H), 7.52-7.47 (m, 4H), 7.45-7.25 (m, 7H), 7.15-7.09 (m, 4H), 1.61 (s, 12H)	828.36	828.35
45	8.45-8.43 (m, 1H), 8.40-8.38 (m, 1H), 7.94-7.68 (m, 15H), 7.63 (d, 1H), 7.43-7.30 (m, 5H), 7.15-7.09 (m, 4H), 1.60 (s, 12H)	753.31	753.30
49	8.32-8.30 (m, 1H), 8.26-8.24 (m, 1H), 8.07-8.04 (m, 1H), 7.94-7.90 (m, 2H), 7.86-7.71 (m, 9H), 7.65-7.60 (m, 3H), 7.53-7.46 (m, 10H), 7.42-7.37 (m, 3H), 7.32-7.25 (m, 2H)	672.27	672.26
52	8.70-8.68 (m, 2H), 8.45-8.43 (m, 1H), 8.34-8.27 (m, 4H), 8.24-8.22 (m, 1H), 8.13-8.01 (m, 5H), 7.97-7.83 (m, 10H), 7.75-7.69 (m, 5H), 7.65-7.46 (m, 10H), 7.34-7.26 (m, 4H)	926.35	926.34
58	8.45-8.43 (m, 1H), 8.41-8.39 (m, 1H), 8.25-8.23 (m, 1H), 8.07 (d, 1H), 7.98 (d, 1H), 7.96-7.75 (m, 14H), 7.64-7.56 (m, 3H), 7.53-7.48 (m, 5H), 7.41-7.37 (m, 2H)	647.23	647.22
62	8.89-8.87 (m, 1H), 8.55-8.53 (m, 1H), 8.31-8.25 (m, 3H), 8.09-7.96 (m, 4H), 7.97-7.83 (m, 11H), 7.74 (dd, 1H), 7.65-7.46 (m, 12H), 7.34-7.26 (m, 2H)	773.29	773.28
64	8.83-8.81 (m, 1H), 8.39-8.06 (m, 9H), 7.97-7.90 (m, 10H), 7.86-7.47 (m, 16H), 7.41-7.38 (m, 1H), 7.32-7.25 (m, 2H)	849.32	849.31
65	8.70-8.66 (m, 2H), 8.44 (t, 1H), 8.35-8.33 (m, 2H), 8.30-8.27 (m, 2H), 8.24-8.22 (m, 1H), 8.13-8.01 (m, 5H), 7.97-7.63 (m, 10H), 7.75-7.69 (m, 5H), 7.65-7.45 (m, 10H), 7.34-7.25 (m, 4H)	926.34	926.34
69	8.41-8.38 (m, 2H), 8.31-8.25 (m, 3H), 8.19-8.17 (m, 2H), 8.07-8.05 (m, 1H), 8.01-7.90 (m, 5H) 7.86-7.82 (m, 5H), 7.73-7.68 (m, 6H), 7.65-7.57 (m, 4H), 7.52-7.46 (m, 4H), 7.36-7.25 (m, 4H), 6.96-6.94 (m, 2H)	822.31	822.30
72	8.90-8.88 (m, 1H), 8.73-8.68 (m, 5H), 8.43-8.39 (m, 3H), 8.23 (d, 1H), 8.04-7.93 (m, 4H), 7.89-7.80 (m, 4H), 7.72-7.68 (m, 4H), 7.63-7.51 (m, 11H), 7.42-7.27 (m, 6H), 6.96-6.94 (m, 2H)	927.34	927.34
79	8.60-8.58 (m, 1H), 8.35-8.33 (m, 1H), 8.12 (d, 1H), 8.02 (d, 1H), 7.95-7.74 (m, 15H), 7.69-7.67 (m, 1H), 7.51-7.47 (m, 2H), 7.43-7.36 (m, 3H), 7.33-7.28 (m, 2H), 7.15-7.09 (m, 4H), 1.61 (s, 12H)	845.32	845.31
83	8.32-8.30 (m, 1H), 8.21-8.17 (m, 2H), 7.97-7.96 (m, 1H), 7.93-7.79 (m, 14H), 7.96-7.61 (m, 4H), 7.53-7.46 (m, 10H), 7.41-7.37 (m, 2H), 7.34-7.28 (m, 3H), 7.02-7.00 (m, 1H)	798.31	798.30
89	8.31-8.29 (m, 1H), 8.23-8.21 (m, 2H), 8.15-8.13 (m, 2H), 7.94-7.91 (m, 4H), 7.85-7.82 (m, 2H), 7.74-7.70 (m, 4H), 7.65-7.58 (m, 8H), 7.52-7.46 (m, 8H), 7.34-7.25 (m, 5H), 1.59 (s, 18H)	974.43	974.43
92	8.41-8.39 (m, 2H), 8.30-8.27 (m, 2H), 8.24-8.20 (m, 2H), 7.86 (dd, 2H), 7.76-7.72 (m, 4H), 7.64-7.56 (m, 6H), 1.58 (s, 18H)	672.29	672.28
94	8.55-8.53 (m, 2H), 8.38-8.35 (m, 2H), 8.18-8.11 (m, 4H), 8.03-8.01 (m, 2H), 7.81 (dd, 2H), 7.68 (dd, 2H), 7.60-7.56 (m, 4H), 1.59 (s, 18H)	704.24	704.23
96	8.31-8.28 (m, 2H), 8.25-8.22 (m, 2H), 8.05-8.02 (m, 2H), 7.91 (dd, 2H), 7.86-7.80 (m, 6H), 7.72 (dd, 2H), 7.65-7.59 (n, 4H), 7.53-7.46 (m, 12H), 7.41-7.37 (m, 2H), 7.34-7.25 (m, 4H).	862.32	862.31
103	8.35-8.30- (m, 4H), 8.11 (dd, 2H), 8.03-7.91 (m, 8H), 7.85-7.76 (m, 12H), 7.69-7.63 (m, 4H), 7.53-7.48 (m, 4H), 7.41-7.37 (m, 2H)	896.24	896.23
104	8.31-8.29 (m, 2H), 8.27-8.25 (m, 2H), 8.22-8.19 (m, 2H), 8.07-8.05 (m, 2H), 7.97-7.91 (m, 10H), 7.65-7.63 (m, 2H), 7.74-7.71 (m, 2H), 7.65-7.46 (m, 16H), 7.34-7.25 (m, 4H)	962.35	962.34
109	8.41-8.39 (m, 1H), 8.24-8.22 (m, 2H), 8.04-7.93 (m, 7H), 7.89-7.80 (m, 6H), 7.72-7.68 (m, 6H), 7.60-7.51 (m, 12H), 7.38-7.27 (m, 6H), 6.98-6.94 (m, 2H)	962.34	962.34

TABLE 1-continued

Compound	^{1}H NMR ($CDCl_3$, 400 MHz)	MS/FAB Found	MS/FAB calc.
110	8.41-8.35 (m, 6H), 8.14-8.08 (m, 4H), 7.94-7.90 (m, 6H), 7.64-7.62 (m, 2H), 7.72-7.68 (m, 4H), 7.59-7.55 (m, 4H), 7.48-7.44 (n, 2H), 7.36-7.32 (m, 2H), 6.98-6.94 (m, 2H)	812.25	812.25
112	8.31-8.29 (m, 1H), 8.27-8.25 (m, 1H), 8.05-8.03 (m, 1H), 7.90-7.71 (m, 12H), 7.67-7.59 (m, 7H), 7.53-7.46 (m, 8H), 7.42-7.25 (m, 6H)	748.30	748.29
116	8.03-7.95 (m, 5H), 7.91-7.89 (m, 1H), 7.85-7.71 (m, 14H), 7.67-7.65 (m, 1H), 7.62-7.56 (m, 5H), 7.54-7.49 (m, 8H), 7.42-7.27 (m, 6H)	824.32	824.32

Example 1

[0321] An ITO glass substrate (a product of Corning Co., Ltd) including an ITO layer having a thickness of 15 Ω/cm^2 (1200 Å) was cut to a size of 50 mm×50 mm×0.7 mm, sonicated using isopropyl alcohol and pure water each for 5 minutes, and cleaned by the exposure to ultraviolet rays for 30 minutes and then to ozone. Then, the ITO glass substrate was mounted on a vacuum deposition apparatus.

[0322] 2-TNATA was deposited on the ITO layer acting as an anode to form a hole injection layer having a thickness of 600 Å, NPB was deposited on the hole injection layer to form a hole transport layer having a thickness of 300 Å, and then, ADN(host) and DPAVBi(dopant) were co-deposited at a weight ratio of 98:2 on the emission layer to form an emission layer having a thickness of 300 Å.

[0323] Thereafter, Compound 7 was deposited on the emission layer to form an electron transport layer having a thickness of 300 Å, LiF was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and Al was deposited on the electron injection layer to form a cathode having a thickness of 3000 Å, thereby completing the manufacture of an organic light-emitting diode.

Example 2

[0324] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 15 was used instead of Compound 7.

Example 3

[0325] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 20 was used instead of Compound 7.

Example 4

[0326] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 24 was used instead of Compound 7.

Example 5

[0327] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 29 was used instead of Compound 7.

Example 6

[0328] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 36 was used instead of Compound 7.

Example 7

[0329] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 45 was used instead of Compound 7.

Example 8

[0330] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 52 was used instead of Compound 7.

Example 9

[0331] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 62 was used instead of Compound 7.

Example 10

[0332] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 69 was used instead of Compound 7.

Example 11

[0333] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 72 was used instead of Compound 7.

Example 12

[0334] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 78 was used instead of Compound 7.

Example 13

[0335] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 89 was used instead of Compound 7.

Example 14

[0336] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 96 was used instead of Compound 7.

Example 15

[0337] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 103 was used instead of Compound 7.

Example 16

[0338] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 104 was used instead of Compound 7.

Example 17

[0339] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 109 was used instead of Compound 7.

Example 18

[0340] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 110 was used instead of Compound 7.

Example 19

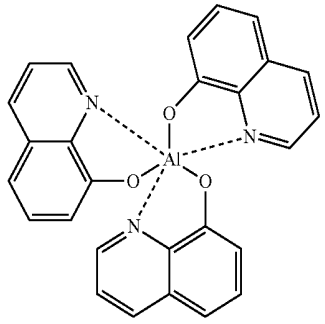
[0341] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 112 was used instead of Compound 7.

Example 20

[0342] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound 117 was used instead of Compound 7.

Comparative Example 1

[0343] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Alq_3 was used instead of Compound 7.

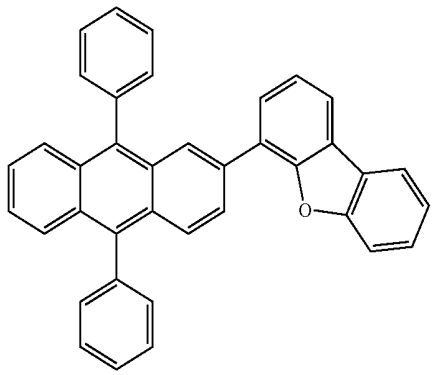


Alq3

Comparative Example 2

[0344] An organic light-emitting diode was manufactured in the same manner as in Example 1, except that in forming an electron transport layer, Compound A was used instead of Compound 7.

<Compound A>



Evaluation Example 1

[0345] The driving voltage, current density, brightness, efficiency, and half-lifespan of the organic light-emitting diodes manufactured according to Examples 1 to 20, and Comparative Examples 1 and 2 were measured using a Keithley SMU 236 and a brightness photometer PR650, and results thereof are shown in Table 2. The half-lifespan is a period of time that is taken until the brightness of the organic light-emitting diode reduces down to 50% of the initial brightness.

TABLE 2

	Electron transport layer	Driving voltage (V)	Current Density (mA/cm^2)	Brightness (cd/m^2)	Efficiency (cd/A)	Emission color	Half lifespan (hr @100 mA/cm^2)
Example 1	Compound 7	5.41	50	3130	6.26	Blue	463
Example 2	Compound 15	5.32	50	3065	6.13	Blue	457
Example 3	Compound 20	5.36	50	3230	6.46	Blue	478

TABLE 2-continued

	Electron transport layer	Driving voltage (V)	Current Density (mA/cm^2)	Brightness (cd/m^2)	Efficiency (cd/A)	Emission color	Half lifespan (hr @100 mA/cm^2)
Example 4	Compound 24	5.16	50	3310	6.62	Blue	338
Example 5	Compound 29	5.27	50	3215	6.43	Blue	416
Example 6	Compound 36	5.21	50	3190	6.38	Blue	434
Example 7	Compound 45	5.35	50	3280	6.56	Blue	321
Example 8	Compound 52	4.98	50	3530	7.06	Blue	345
Example 9	Compound 62	5.03	50	3570	7.14	Blue	382
Example 10	Compound 69	5.25	50	3045	6.09	Blue	439
Example 11	Compound 72	5.06	50	2980	5.96	Blue	395
Example 12	Compound 83	5.26	50	3110	6.22	Blue	438
Example 13	Compound 89	5.38	50	3055	6.11	Blue	377
Example 14	Compound 96	5.23	50	3105	6.21	Blue	465
Example 15	Compound 103	5.04	50	3200	6.40	Blue	355
Example 16	Compound 104	5.10	50	3130	6.26	Blue	471
Example 17	Compound 109	5.13	50	3090	6.18	Blue	420
Example 18	Compound 110	5.16	50	3050	6.10	Blue	367
Example 19	Compound 112	5.33	50	2940	5.88	Blue	409
Example 20	Compound 117	5.29	50	3020	6.04	Blue	425
Comparative Example 1	Alq_3	7.35	50	2065	4.13	Blue	145
Comparative Example 2	Compound A	6.75	50	2335	4.67	Blue	183

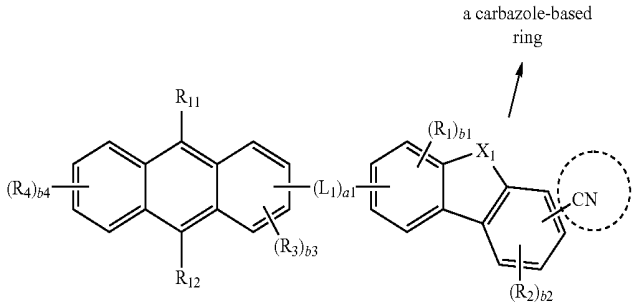
[0346] From Table 2, it was confirmed that the driving voltage, current density, brightness, efficiency, and half-lifespan of the organic light-emitting diodes manufactured according to Examples 1 to 20 are higher than the driving voltage, current density, brightness, efficiency, and half-lifespan of the organic light-emitting diodes manufactured according to Comparative Examples 1 and 2.

[0347] As described above, an organic light-emitting diode including a condensed compound according to an embodiment may have a low driving voltage, high efficiency, high brightness, and long lifespan.

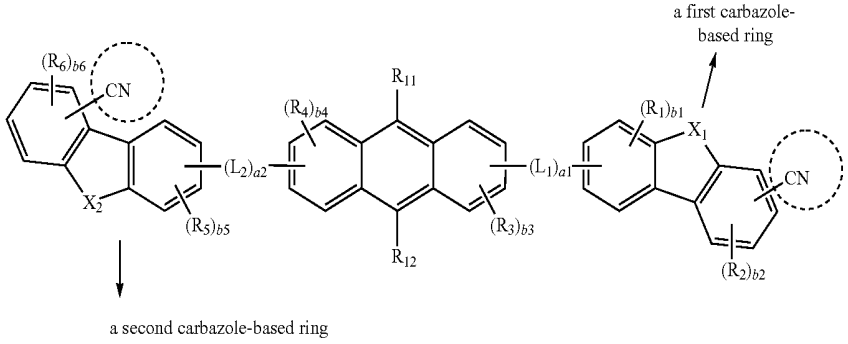
[0348] By way of summation and review, an organic light-emitting diode may include a first electrode disposed on a substrate, and a hole transport region, an emission layer, an electron transport region, and a second electrode, which are sequentially disposed on the first electrode. Holes injected from the first electrode may pass via the hole transport region and migrate toward the emission layer, and electrons injected from the second electrode may pass via the electron transport region toward the emission layer. The holes and the electrons are recombined with each other in the emission layer to generate excitons. Then, the excitons are transitioned from an excited state to a ground state, thereby generating light.

[0349] Formula 1 includes a "carbazole-based ring" substituted with CN (cyano) (see Formula 1' below), and Formula 2 includes a "first carbazole-based ring" and a "second carbazole-based ring", each of which is substituted with CN (cyano) (see Formula 2' below).

<Formula 1'>



<Formula 2'>



[0350] Since Formulae 1 and 2 include a "carbazole-based ring" substituted with CN, an intermolecular binding force may be enhanced. Accordingly, an organic light-emitting diode including at least one of a compound represented by Formula 1 or at least one of a compound represented by Formula 2 may have a long lifespan

[0351] Also, Formulae 1 and 2 include a "carbazole-based ring" substituted with CN, and X_1 and X_2, which are heteroatoms of the "carbazole-based ring," may offset electron pulling effects of CN. Accordingly, the compound represented by Formula 1 and the compound represented by Formula 2 may have excellent thermal stability. An organic light-emitting diode including at least one of a compound represented by Formula 1 or at least one of a compound represented by Formula 2 may have a long lifespan

[0352] Without wishing to be bound by any theories, it believed that since Formulae 1 and 2 include a "carbazole-based ring", though the "carbazole-based ring" is substituted with CN, which has a strong electron withdrawing characteristic, electron-trapping may be reduced or not occur, and a diode including the same may have a long lifespan. For example, in the case of a compound having the same structure as Formula 1 except that "phenanthroline" is employed instead of the "carbazole-based ring", due to the inclusion of both CN and "phenanthroline", each of which has a high electron withdrawing characteristic, electron-trapping may occur, and the lifespan of the organic light-emitting diode may be decreased.

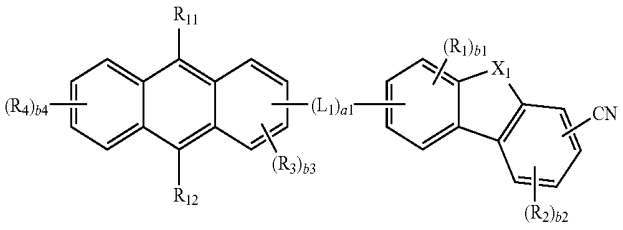
[0353] Accordingly, an organic light-emitting diode including the condensed compound represented by Formula 1 or Formula 2 may have a low driving voltage, high efficiency, high brightness, and long lifespan.

[0354] Example embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. In some instances, as would be apparent to one of skill in the art as of the filing of the present application, features, characteristics, and/or elements described in connection with a particular embodiment may be used singly or in combination with features, characteristics, and/or elements described in connection with other embodiments unless otherwise specifically indicated. Accordingly, it will be understood by those of skill in the art that various changes in form and details may be made without departing from the spirit and scope of the present invention as set forth in the following claims.

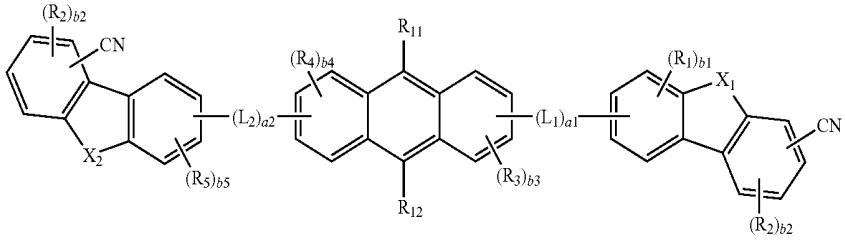
What is claimed is:

1. A condensed compound for an organic light-emitting diode, the condensed compound being represented by Formula 1 or 2:

<Formula 1>



<Formula 2>



wherein:

X_1 is $N(R_{21})$, O, or S;

X_2 is $N(R_{22})$, O, or S;

L_1 and L_2 are each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_2-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_2-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6C_{60} arylene group, a substituted or unsubstituted C_2-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed poylcyclic group, and a substituted or unsubstituted divalent non-aromatic hetero-condensed polycyclic group;

a1 and a2 are each independently selected from 0, 1, 2, and 3;

R_1 to R_6, R_{11}, R_{12}, R_{21}, and R_{22} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and 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_2-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_2-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 unsubsti-

tuted C_6-C_{60} arylthio group, a substituted or unsubstituted C_2-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic hetero-condensed polycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, and —$B(Q_6)(Q_7)$;

b1 to b6 are each independently selected from 0, 1, 2, and 3;

at least one substitutent of the substituted C_3-C_{10} cycloalkylene, the substituted C_2-C_{10} heterocycloalkylene, the substituted C_3-C_{10} cycloalkenylene, the substituted C_2-C_{10} heterocycloalkenylene, the substituted C_6-C_{60} arylene, the substituted C_2-C_{60} heteroarylene, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic hetero-condensed polycyclic group, the substituted C_1-C_{60} alkyl, the substituted C_2-C_{60} alkenyl, the substituted C_2-C_{60} alkynyl, the substituted C_1-C_{60} alkoxy, the substituted C_3-C_{10} cycloalkyl, the substituted C_2-C_{10} heterocycloalkyl, the substituted C_3-C_{10} cycloalkenyl, the substituted C_2-C_{10} heterocycloalkenyl, the substituted C_6-C_{60} aryl, the substituted C_6-C_{60} aryloxy, the substituted C_6-C_{60} arylthio, the substituted C_2-C_{60} heteroaryl, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic hetero-condensed polycyclic group is selected from

a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

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

a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group;

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

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

Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-$_{10}$ heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_2-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_2-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group.

2. The condensed compound as claimed in claim **1**, wherein L_1 and L_2 are each independently selected from

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spirofluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene grooup, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrmidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene 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 carbazolylene group, a phenanthridinylene group, a acridinylene group, a phenanthrolinylene group, a phenzinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzo-

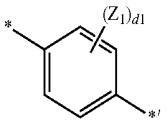
furanylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group and an imidazopyrimidinylene group; and

a phenylene group, a pentalenylene group, an indenylene group, a naphthalene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spirofluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluorantenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthilidinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group and an imidazopyrimidinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, a indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl group, and an imidazopyrimidinyl group.

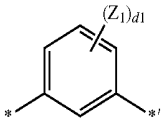
3. The condensed compound as claimed in claim **1**, wherein:

L_1 and L_2 are each independently selected from Formulae 3-1 to 3-32:

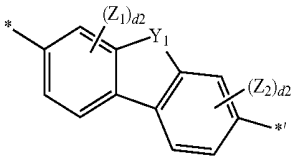
Formula 3-1



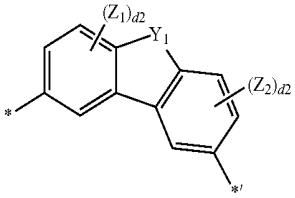
Formula 3-2



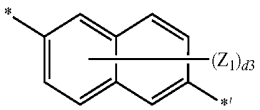
Formula 3-3



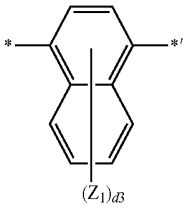
Formula 3-4



Formula 3-5



Formula 3-6



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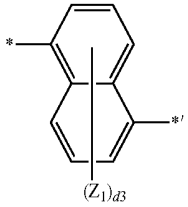
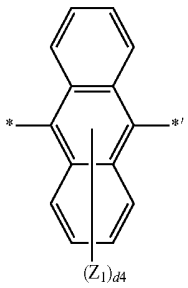
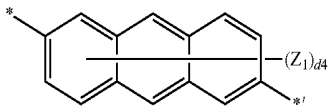
Formula 3-7



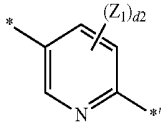
Formula 3-8



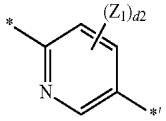
Formula 3-9



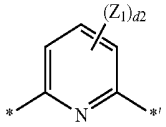
Formula 3-10



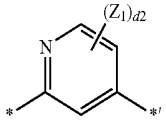
Formula 3-11



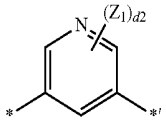
Formula 3-12



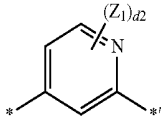
Formula 3-13



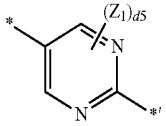
Formula 3-14



Formula 3-15



Formula 3-16



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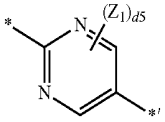
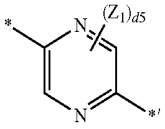
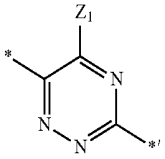
Formula 3-17



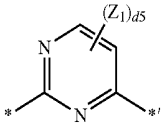
Formula 3-18



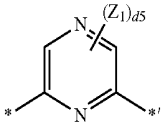
Formula 3-19



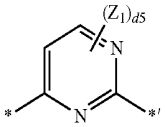
Formula 3-20



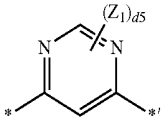
Formula 3-21



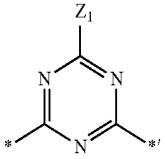
Formula 3-22



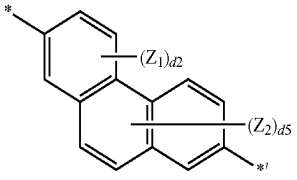
Formula 3-23



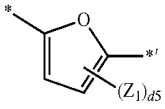
Formula 3-24



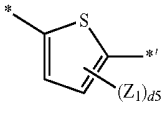
Formula 3-25



Formula 3-26



Formula 3-27



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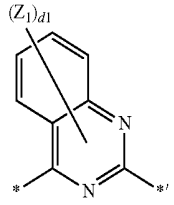
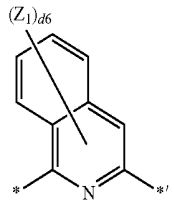
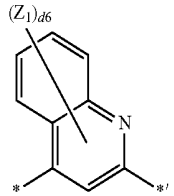
Formula 3-28



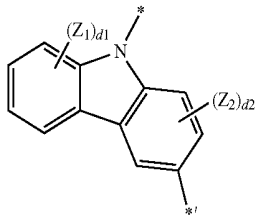
Formula 3-29



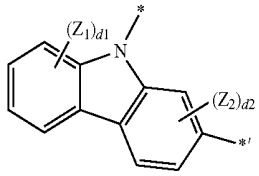
Formula 3-30



Formula 3-31



Formula 3-32



Y_1 is O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$;

Z_1 to Z_7 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group,

d1 is selected from an integer of 1 to 4;

d2 is selected from an integer of 1 to 3;

d3 is selected from an integer of 1 to 6;

d4 is selected from an integer of 1 to 8;

d5 is 1 or 2;

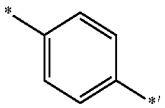
d6 is selected from an integer of 1 to 5; and

* and *' represent bonding sites in the condensed compound.

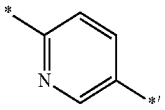
4. The condensed compound as claimed in claim **1**, wherein:

L_1 and L_2 are each independently selected from Formulae 4-1 to 4-23:

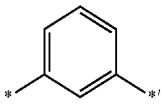
Formula 4-1



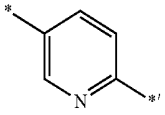
Formula 4-2



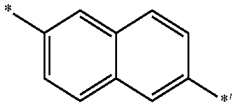
Formula 4-3



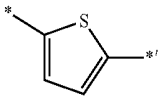
Formula 4-4



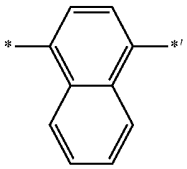
Formula 4-5



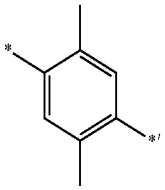
Formula 4-6



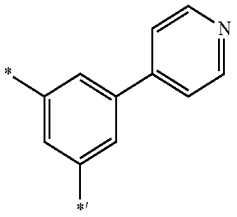
Formula 4-7



Formula 4-8



Formula 4-9



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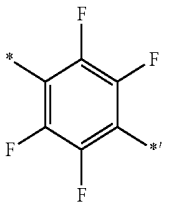
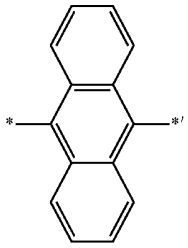
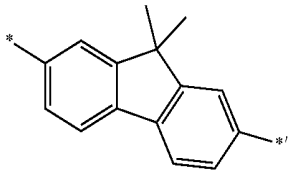
Formula 4-10



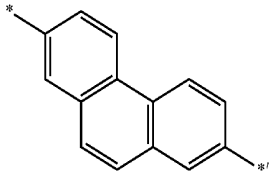
Formula 4-11



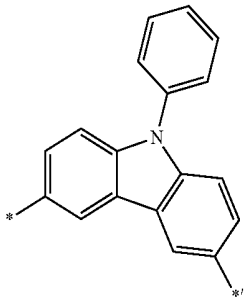
Formula 4-12



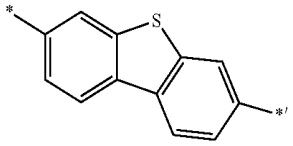
Formula 4-13



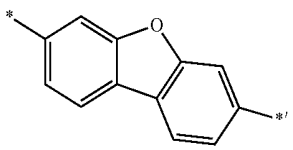
Formula 4-14



Formula 4-15



Formula 4-16



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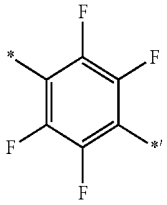
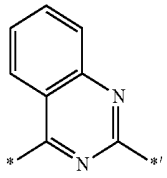
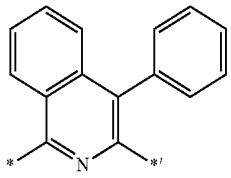
Formula 4-17



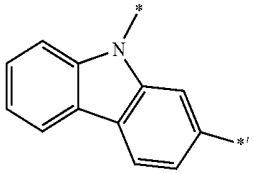
Formula 4-18



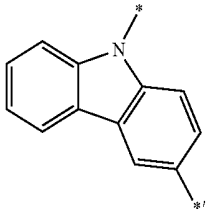
Formula 4-19



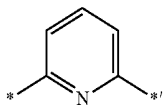
Formula 4-20



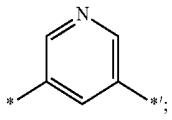
Formula 4-21



Formula 4-22



Formula 4-23



and * and *' represent bonding sites in the condensed compound.

5. The condensed compound as claimed in claim **1**, wherein:

a1 in Formula 1 is 0 or 1, and

a1 and a2 in Formula 2 are each independently 0 or 1.

6. The condensed compound as claimed in claim **1**, wherein:

X_1 is $N(R_{21})$,

X_2 is $N(R_{22})$, and

R_{21} and R_{22} are each independently selected from

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group,

a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl group and an imidazopyrimidinyl group; and

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl group and an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, a indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoquinolinyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazolpyridinyl and an imidazopyrimidinyl group.

7. The condensed compound as claimed in claim **1**, wherein:

X_1 is $N(R_{21})$,

X_2 is $N(R_{22})$, and

R_{21} and R_{22} are each independently selected from

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group,

an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group.

8. The condensed compound as claimed in claim **1**, wherein R_1 to R_6 are each independently selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, and $Si(Q_3)(Q_4)(Q_5)$, Q_3 to Q_5 each independently being selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group and a naphthyl group.

9. The condensed compound as claimed in claim **1**, wherein:

R_{11} and R_{12} are each independently selected from a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

$Si(Q_3)(Q_4)(Q_5)$, Q_3 to Q_5 each independently being selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group and a naphthyl group.

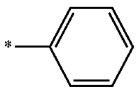
10. The condensed compound as claimed in claim **1**, wherein:

R_{21} and R_{22} are each independently selected from Formulae 5-1 to 5-34;

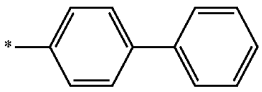
R_1 to R_6 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group and Formulae 5-1 to 5-34; and

R_{11} and R_{12} are each independently selected from Formulae 5-1 to 5-34:

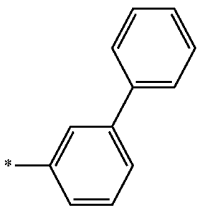
Formula 5-1



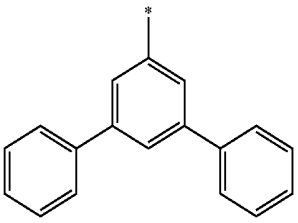
Formula 5-2



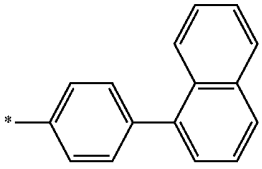
Formula 5-3



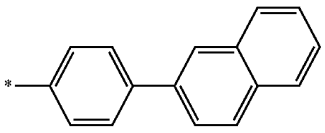
Formula 5-4



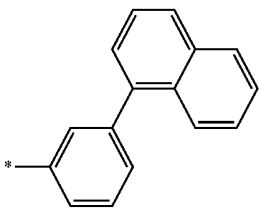
Formula 5-5



Formula 5-6



Formula 5-7



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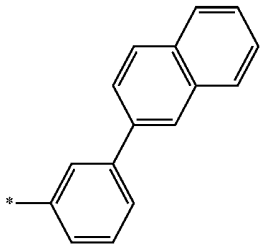
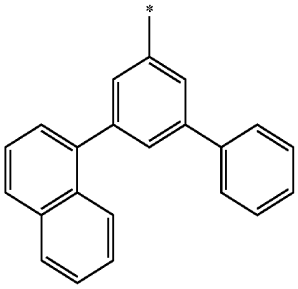
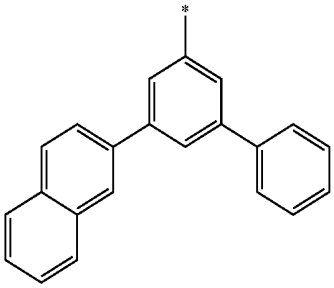
Formula 5-8



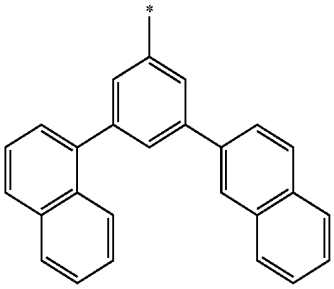
Formula 5-9



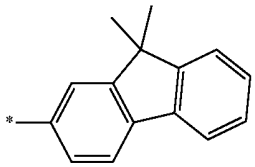
Formula 5-10



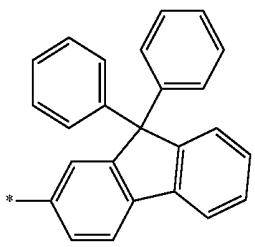
Formula 5-11



Formula 5-12



Formula 5-13



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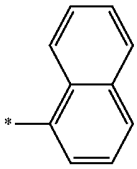
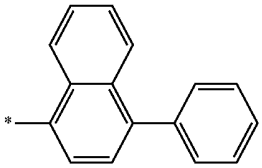
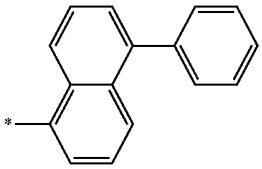
Formula 5-14



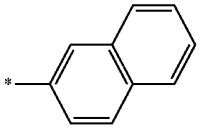
Formula 5-15



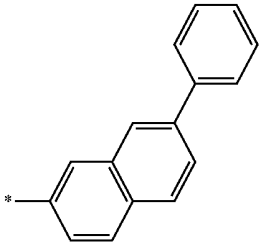
Formula 5-16



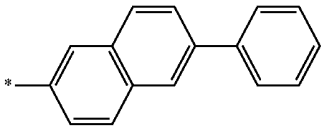
Formula 5-17



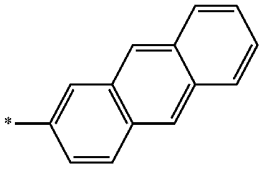
Formula 5-18



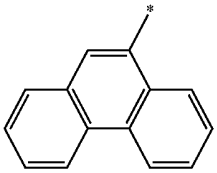
Formula 5-19



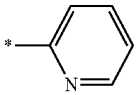
Formula 5-20



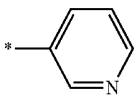
Formula 5-21



Formula 5-22



Formula 5-23



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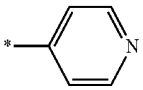
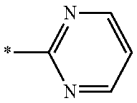
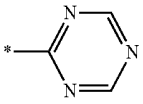
Formula 5-24



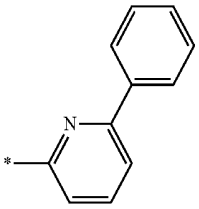
Formula 5-25



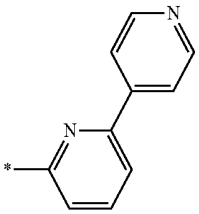
Formula 5-26



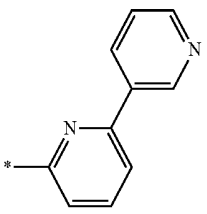
Formula 5-27



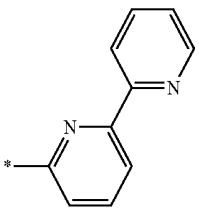
Formula 5-28



Formula 5-29



Formula 5-30



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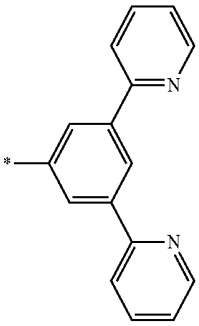
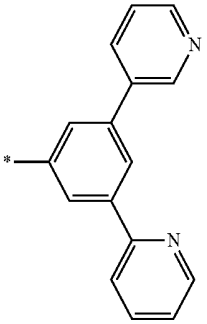
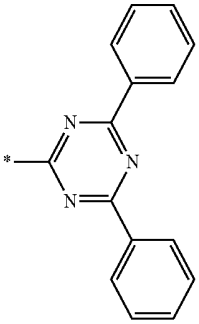
Formula 5-31



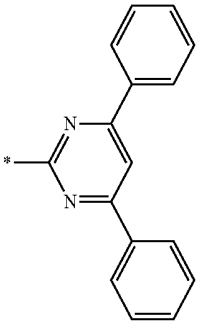
Formula 5-32



Formula 5-33



Formula 5-34

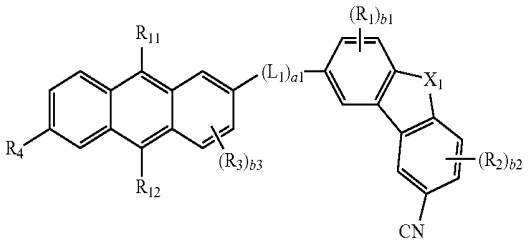


and * represents a bonding site in the condensed compound.

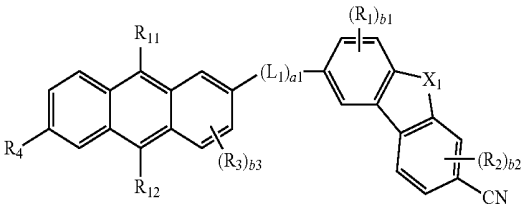
11. The condensed compound as claimed in claim **1**, wherein:

the condensed compound is represented by any one of Formulae 1-1 to 1-12 and 2-1 to 2-12:

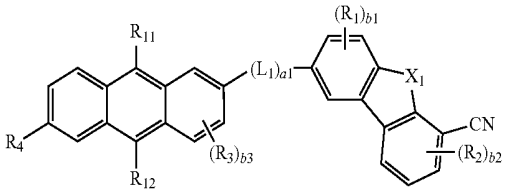
<Formula 1-1>



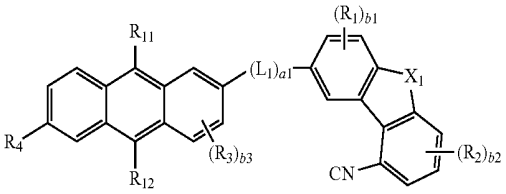
<Formula 1-2>



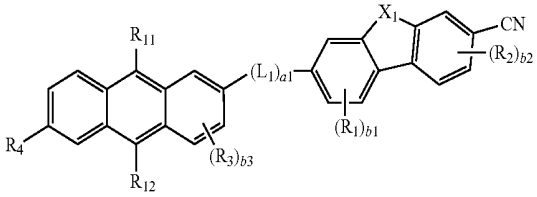
<Formula 1-3>



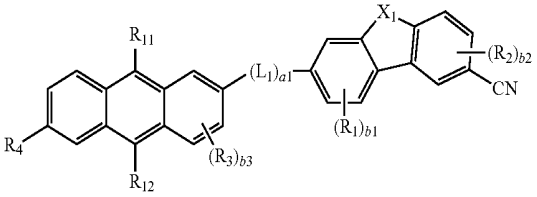
<Formula 1-4>



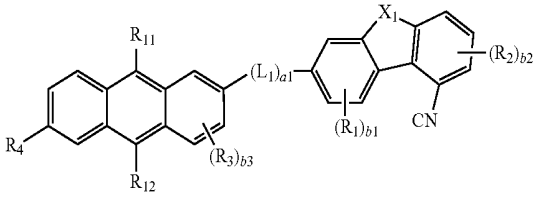
<Formula 1-5>



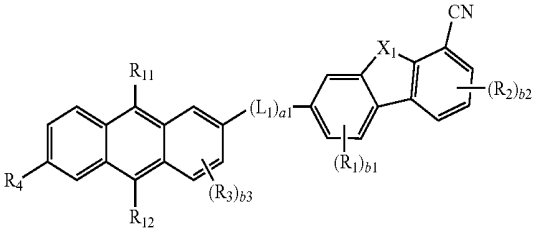
<Formula 1-6>



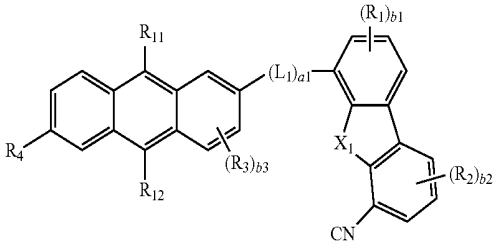
<Formula 1-7>



<Formula 1-8>



<Formula 1-9>



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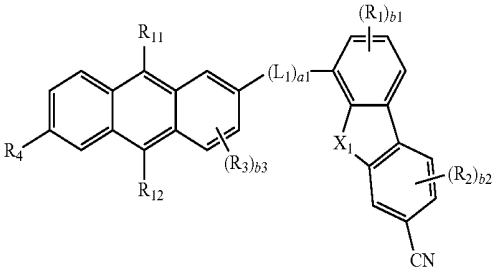
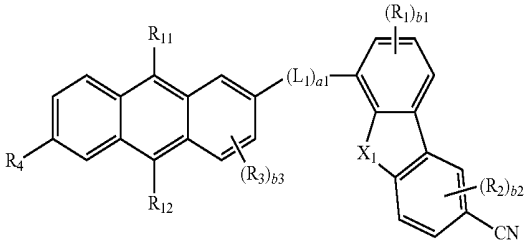
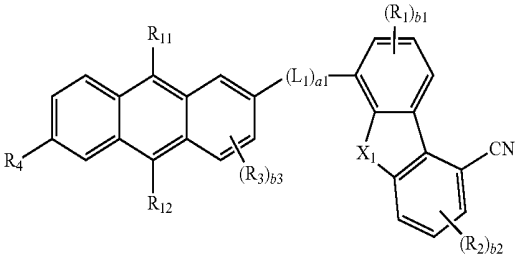


<Formula 1-11>



<Formula 1-12>



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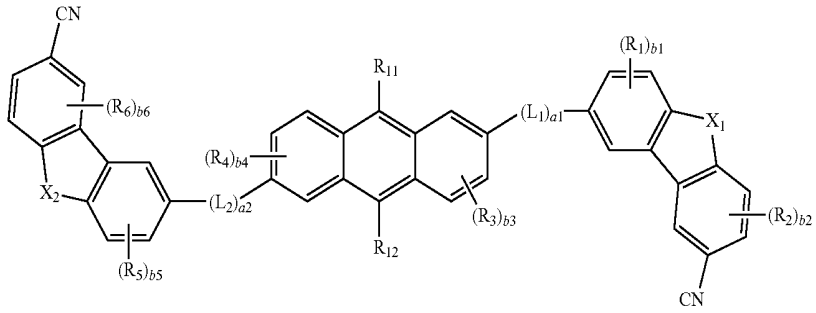
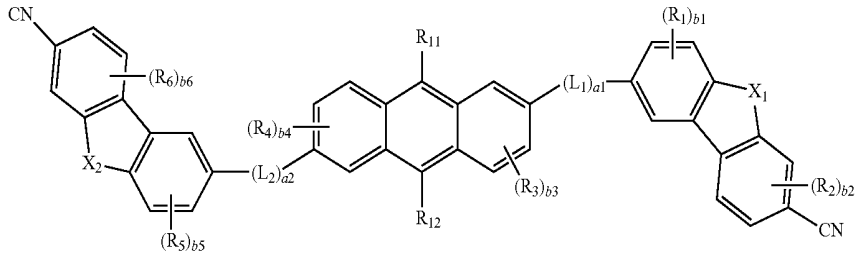
<Formula 2-1>



<Formula 2-2>



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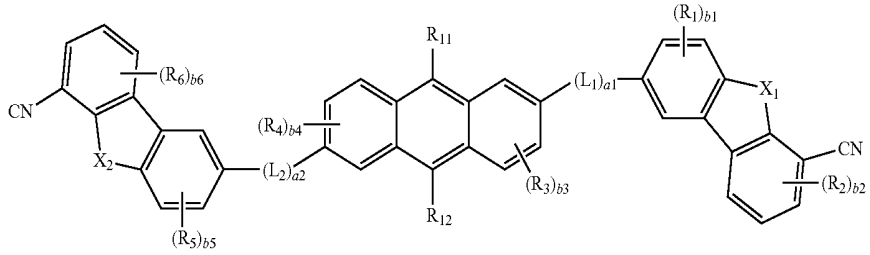
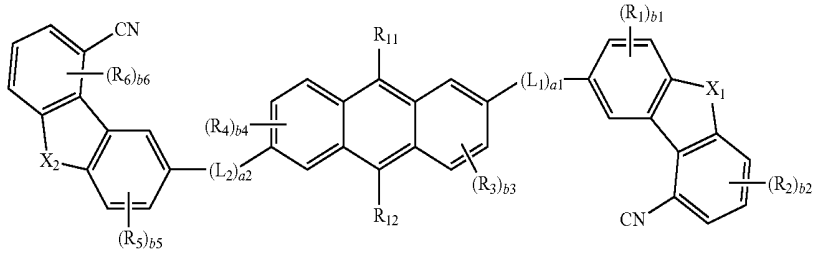
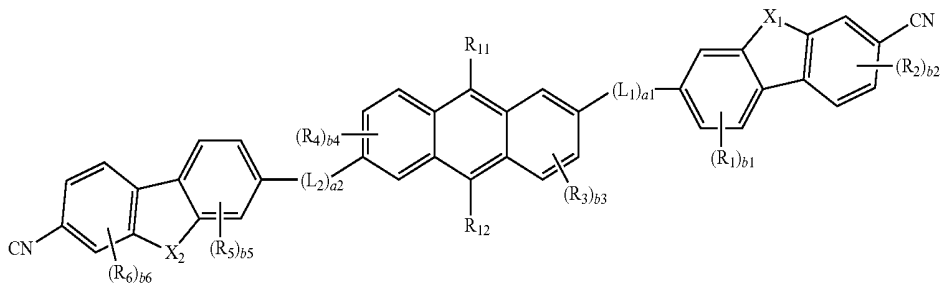


<Formula 2-4>



<Formula 2-5>



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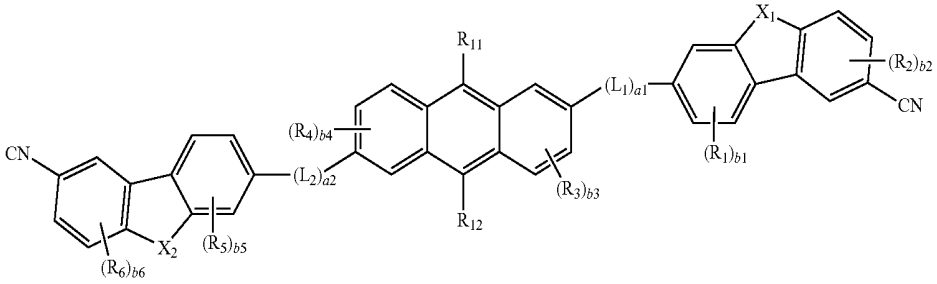

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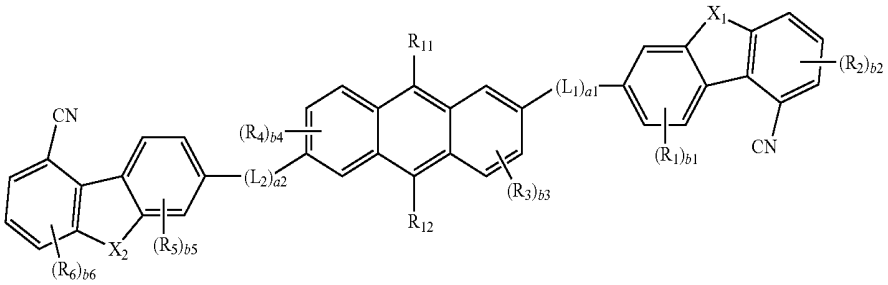
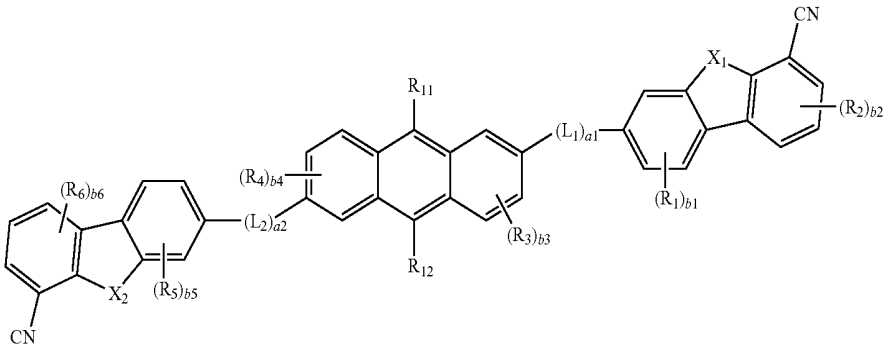
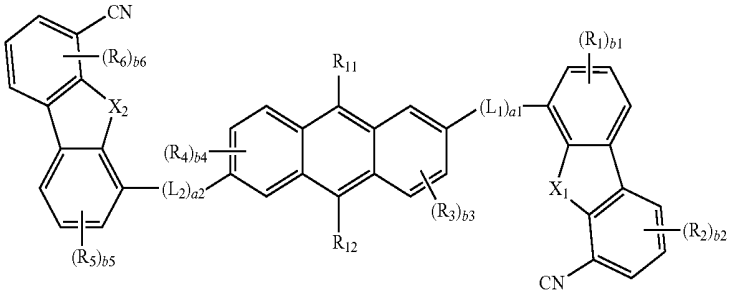


<Formula 2-8>



<Formula 2-9>



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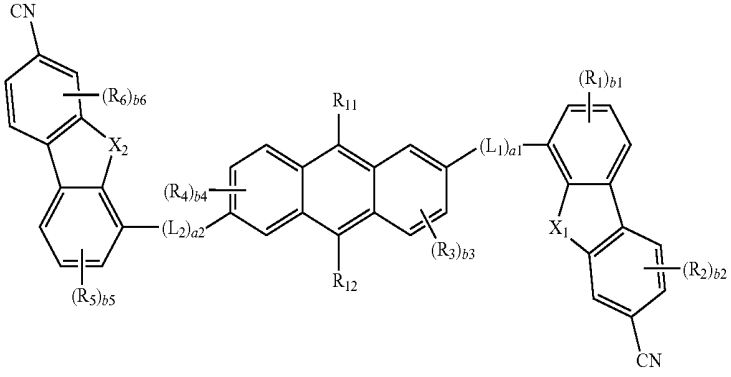

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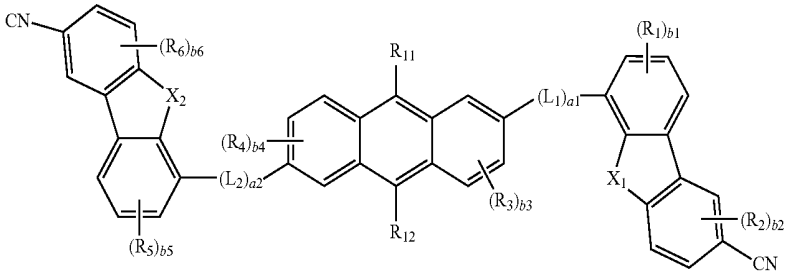
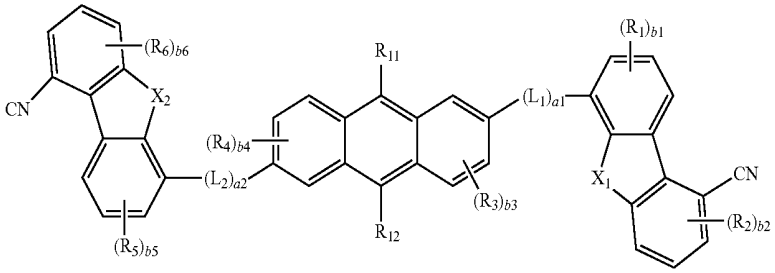
<Formula 2-11>



<Formula 2-12>



X_1, X_2, L_1, a1, a2, R_1 to R_6, R_{11}, R_{12}, and b1 to b6 are as defined in claim **1**.

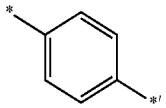
12. The condensed compound as claimed in claim **11**, wherein:

a1 in Formulae 1-1 to 1-12 is 0 or 1, and

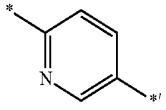
a1 and a2 in Formulae 2-1 to 2-12 are each independently 0 or 1;

L_1 and L_2 are each independently represented by one of Formulae 4-1 to 4-23:

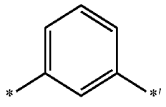
Formula 4-1



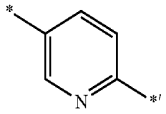
Formula 4-2



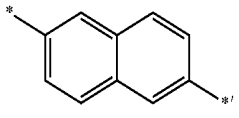
Formula 4-3



Formula 4-4



Formula 4-5



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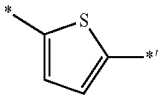
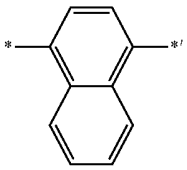
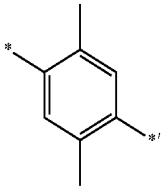
Formula 4-6



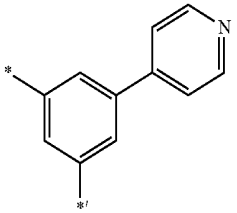
Formula 4-7



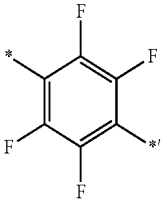
Formula 4-8



Formula 4-9



Formula 4-10



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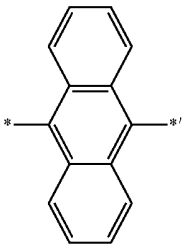
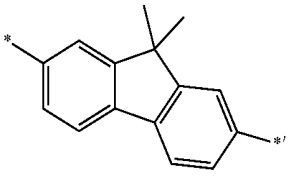
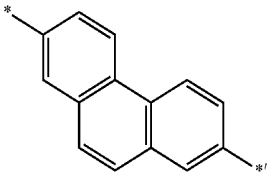
Formula 4-11



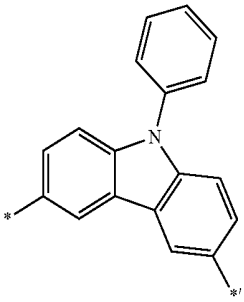
Formula 4-12



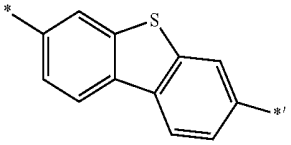
Formula 4-13



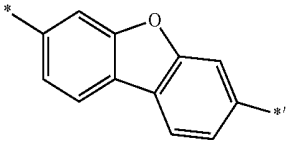
Formula 4-14



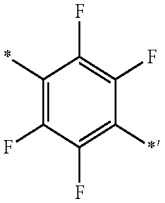
Formula 4-15



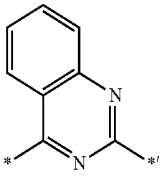
Formula 4-16



Formula 4-17



Formula 4-18



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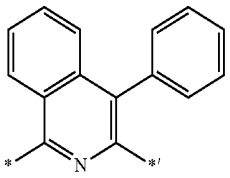
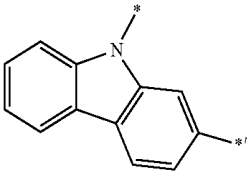
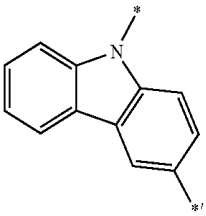
Formula 4-19



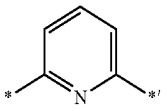
Formula 4-20



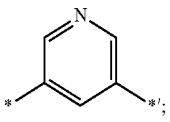
Formula 4-21



Formula 4-22



Formula 4-23



and * and *' represent bonding sites in the condensed compound.

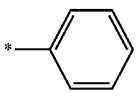
13. The condensed compound as claimed in claim **11**, wherein:

R_{21} and R_{22} are each independently selected from Formulae 5-1 to 5-34;

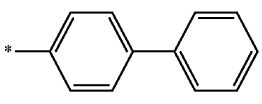
R_1 to R_6 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, and Formulae 5-1 to 5-34; and

R_{11} and R_{12} are each independently selected from Formulae 5-1 to 5-34:

Formula 5-1



Formula 5-2



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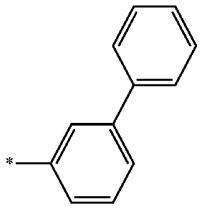
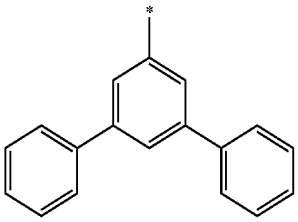
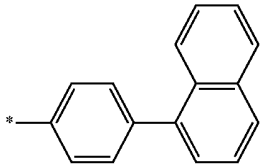
Formula 5-3



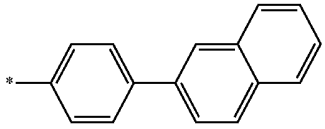
Formula 5-4



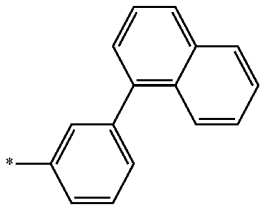
Formula 5-5



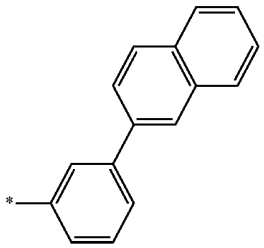
Formula 5-6



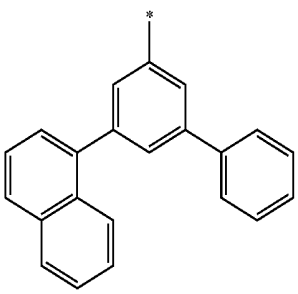
Formula 5-7



Formula 5-8



Formula 5-9



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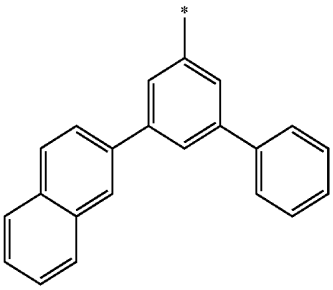
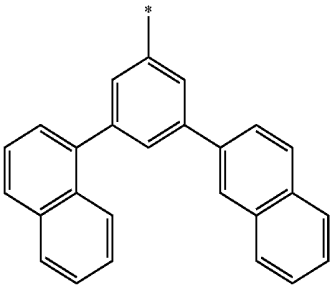
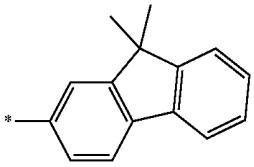
Formula 5-10



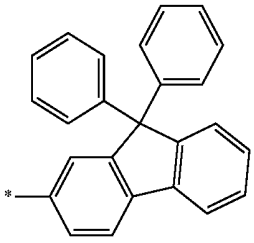
Formula 5-11



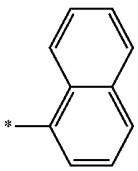
Formula 5-12



Formula 5-13



Formula 5-14



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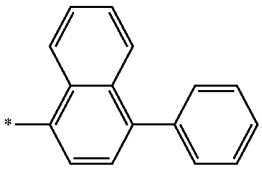
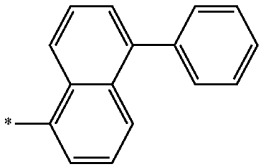


Formula 5-16



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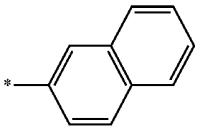
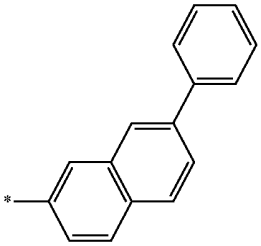


Formula 5-18



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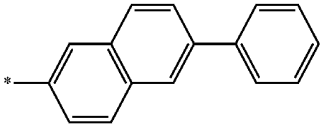

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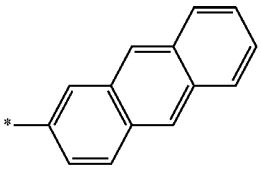

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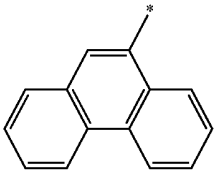

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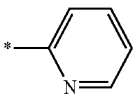

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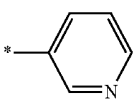

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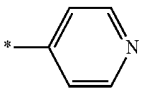

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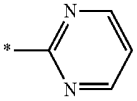

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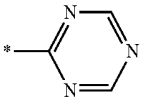

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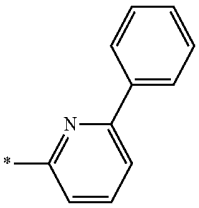

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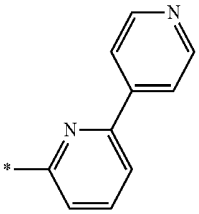

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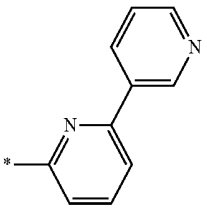

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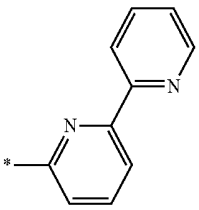

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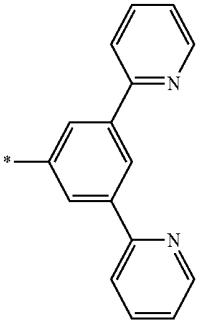

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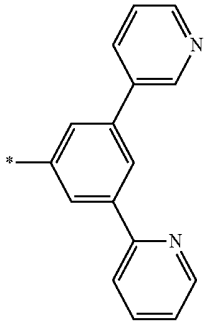
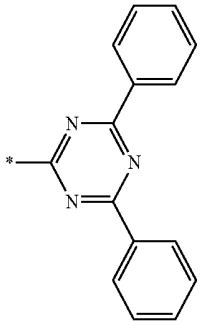


Formula 5-33



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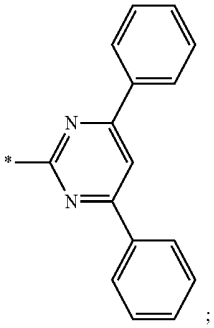
Formula 5-34



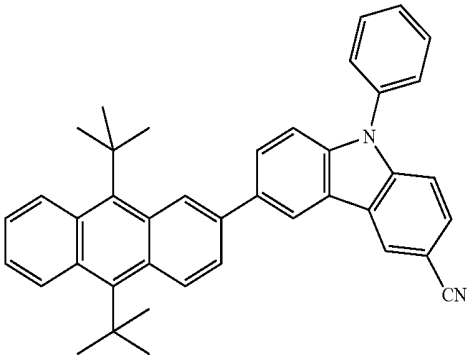
;

and * represents a bonding site in the condensed compound.

14. The condensed compound as claimed in claim **11**, wherein the condensed compound is represented by any one of Formulae 1-1, 1-5, 1-9, 2-1, 2-5, and 2-9.

15. The condensed compound as claimed in claim **1**, wherein the condensed compound is one of Compounds 1 to 119:

1



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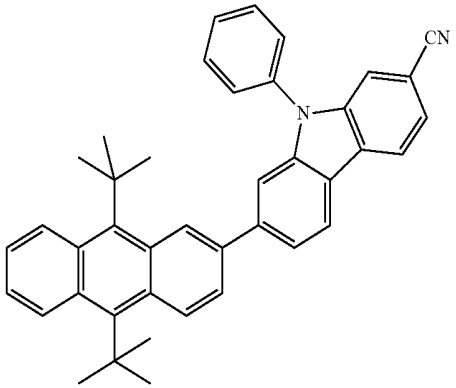

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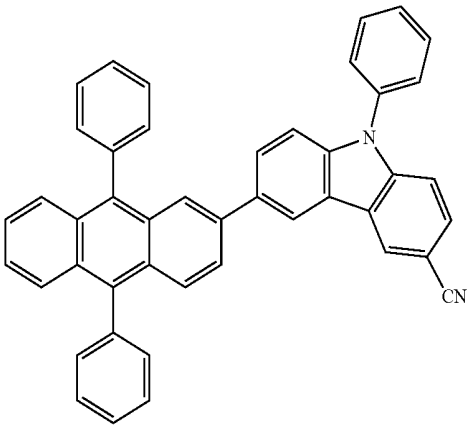

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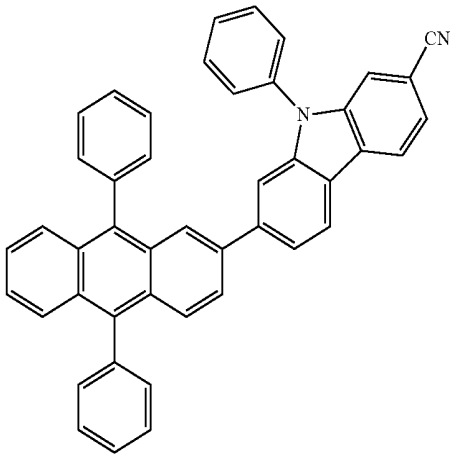

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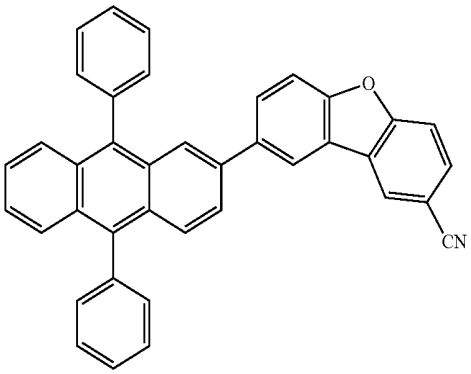

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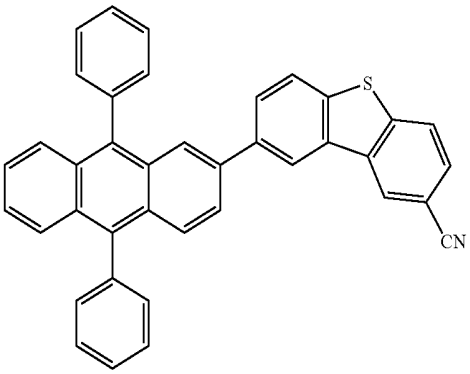

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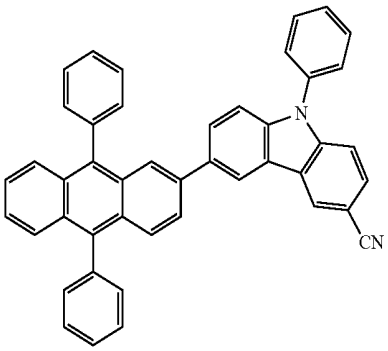

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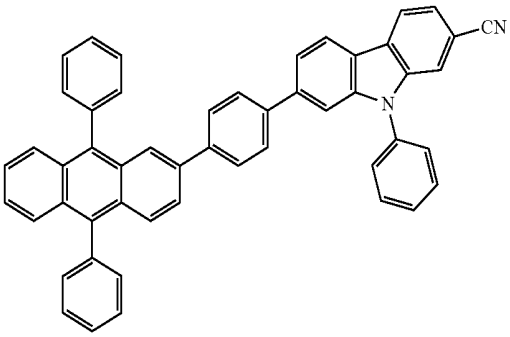

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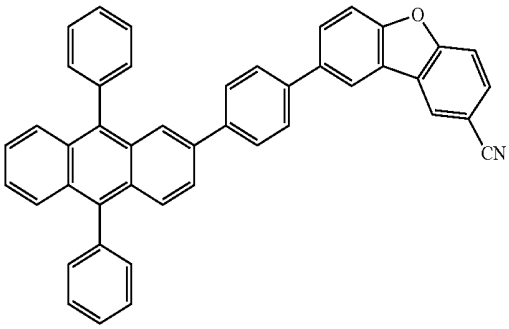

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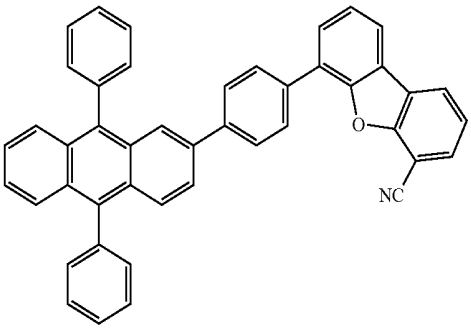

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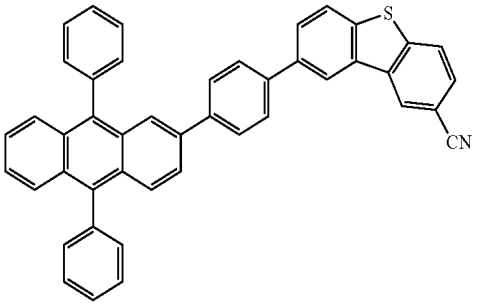

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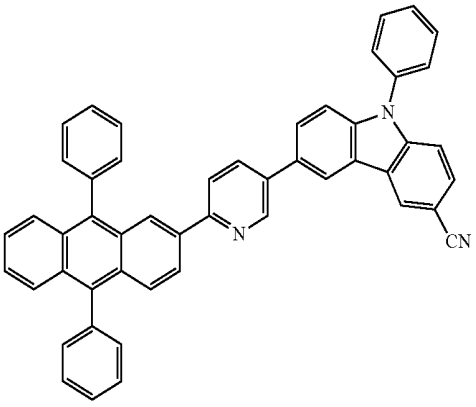

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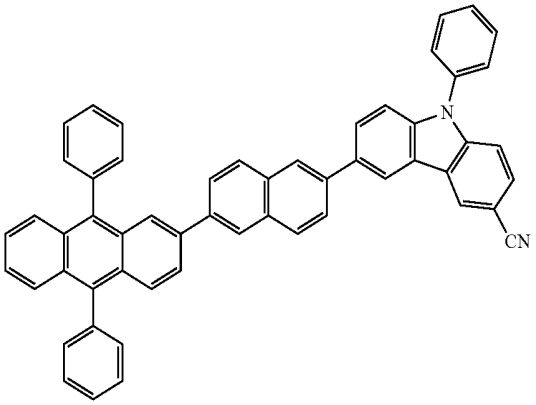

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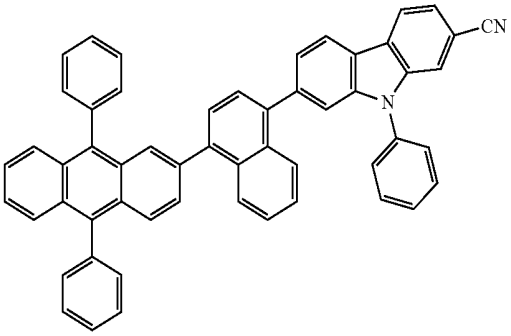

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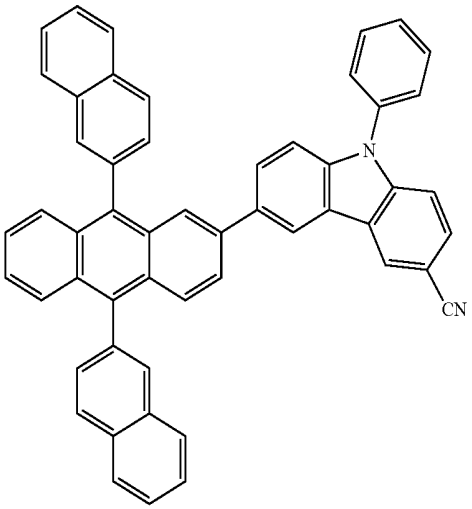

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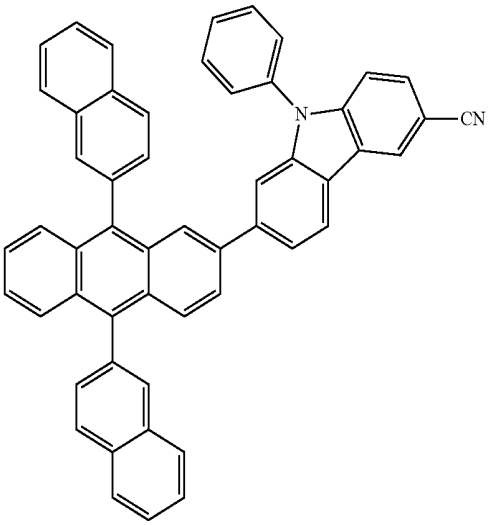

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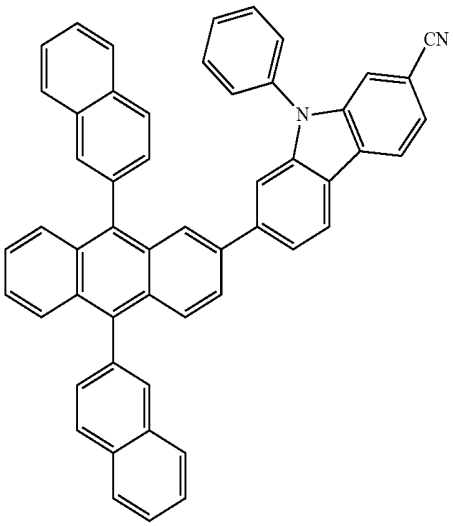

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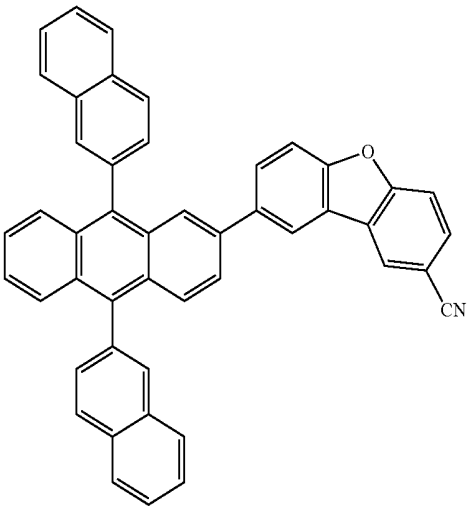

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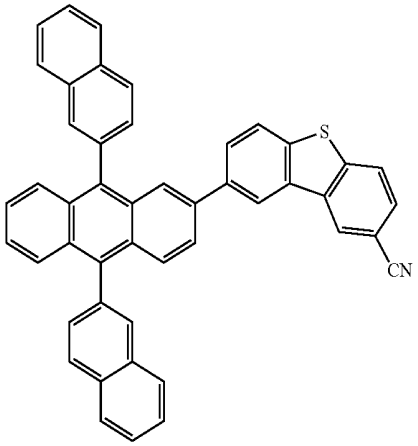

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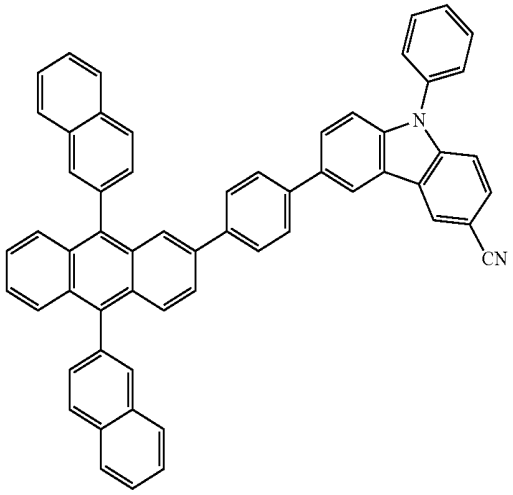

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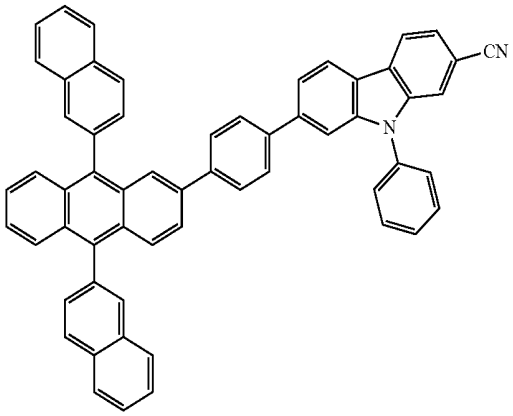

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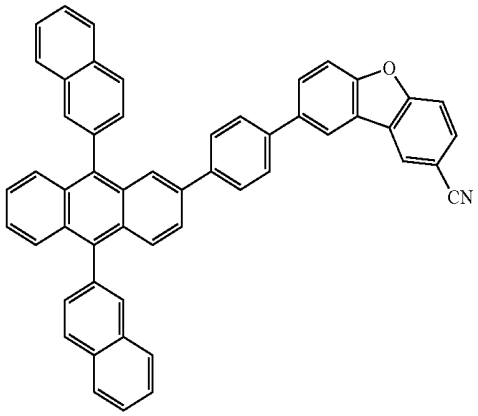

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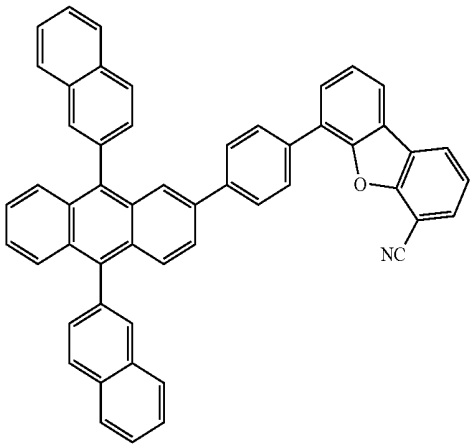

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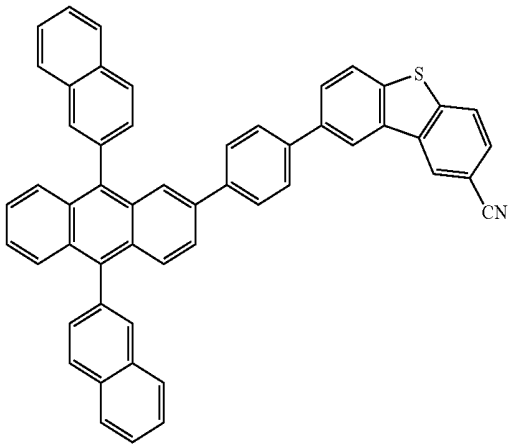

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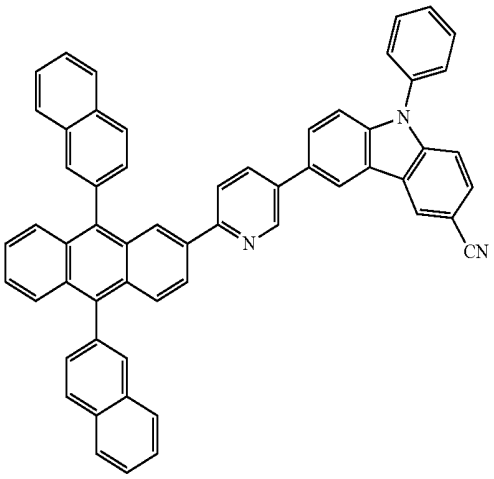

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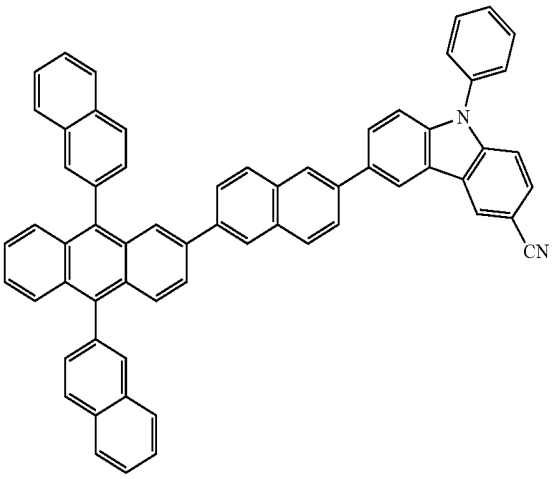

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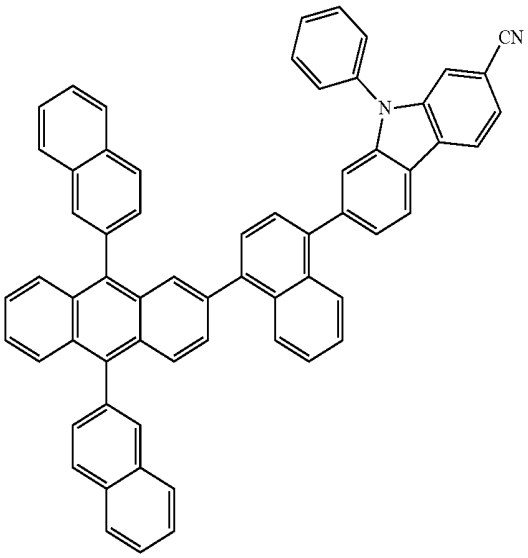

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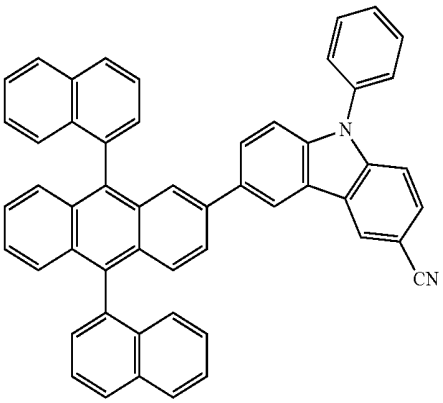

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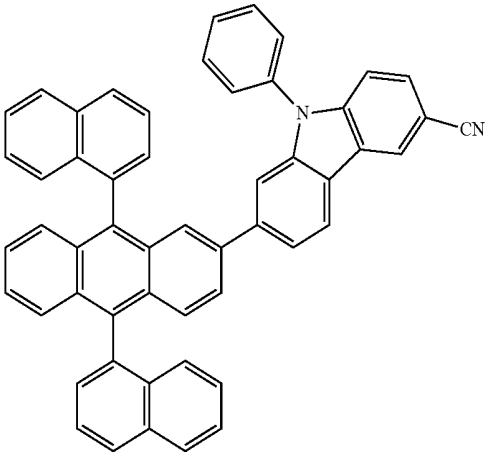

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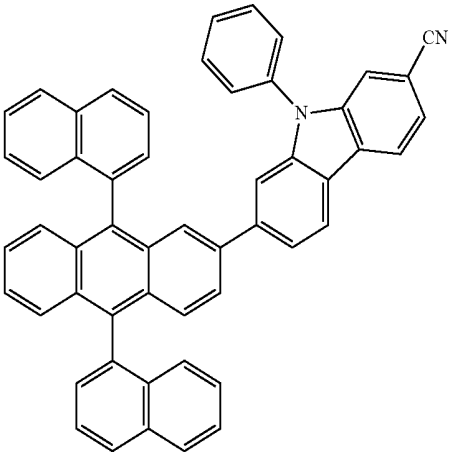

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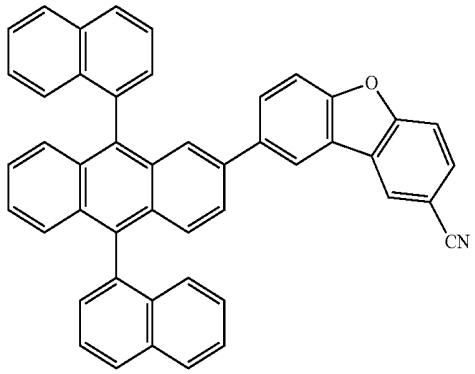

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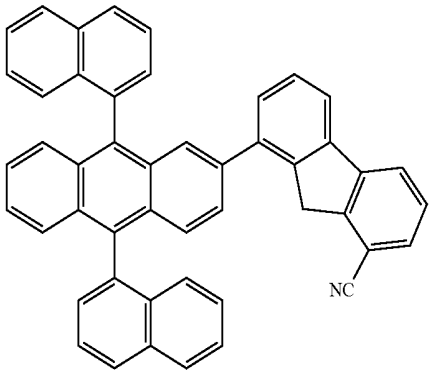

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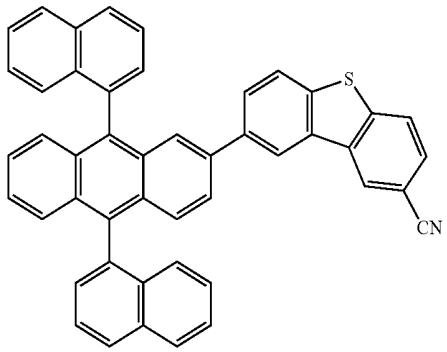

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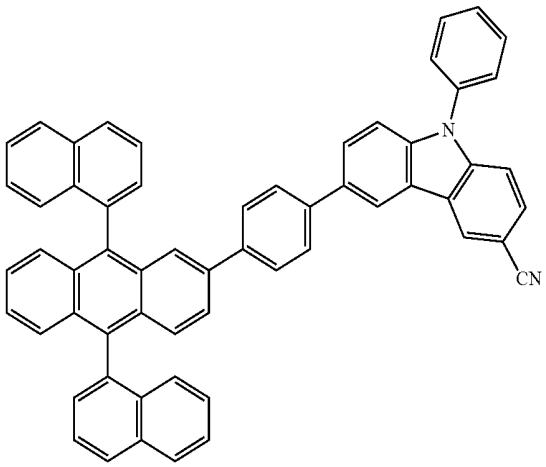

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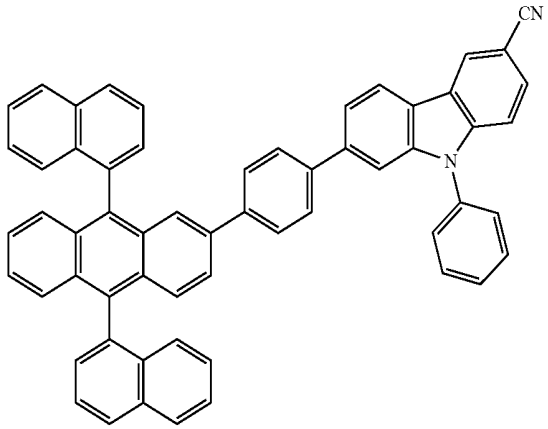

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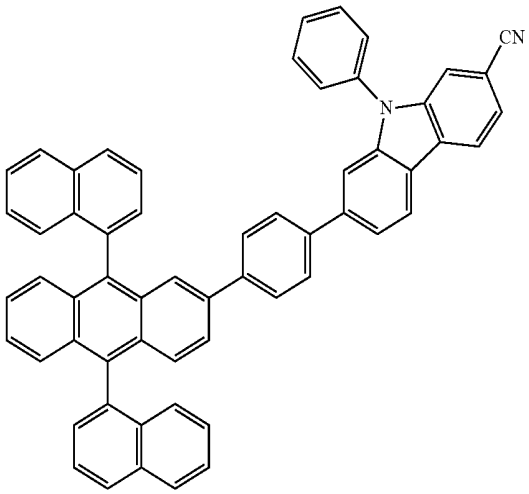

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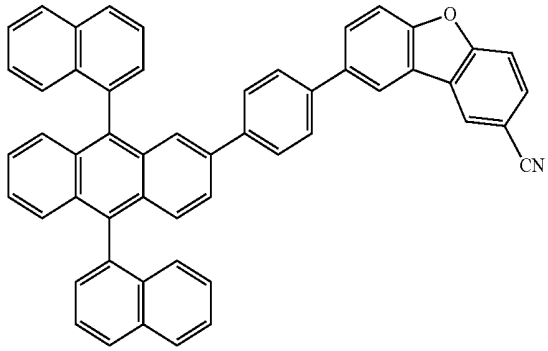

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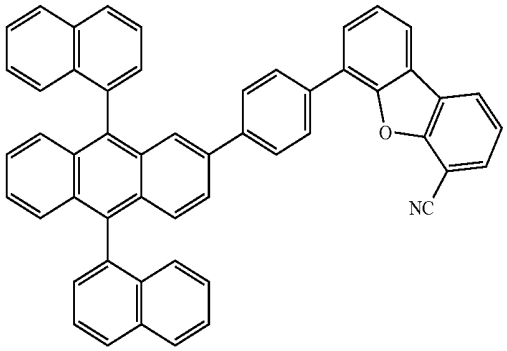

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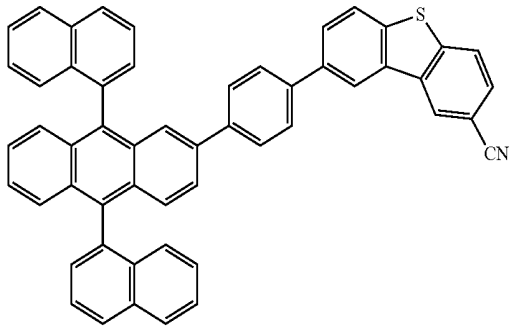

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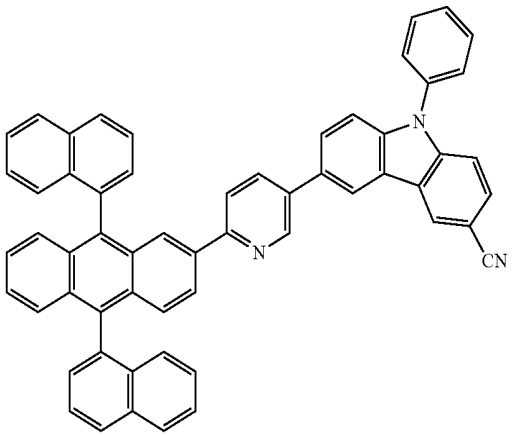

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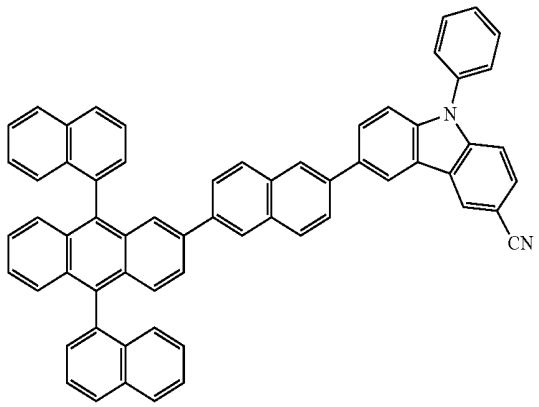

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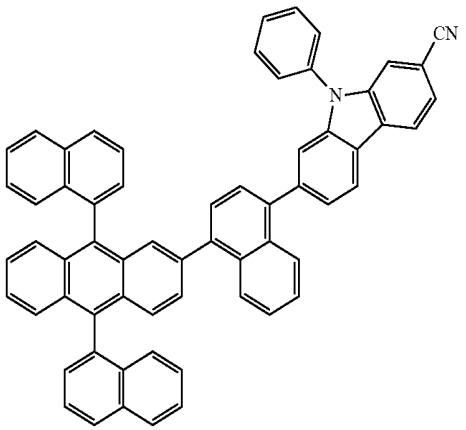

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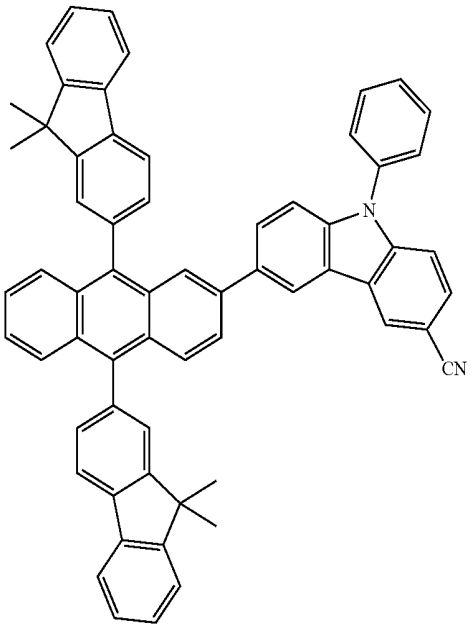

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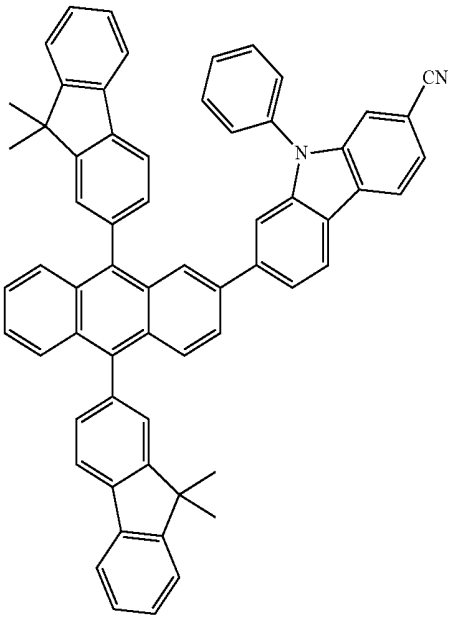

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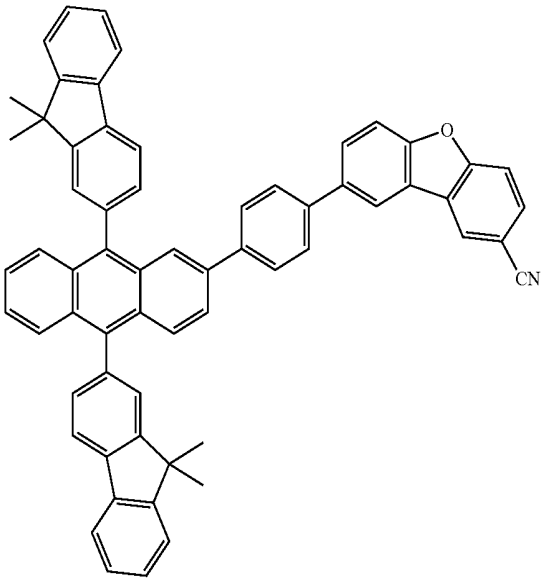

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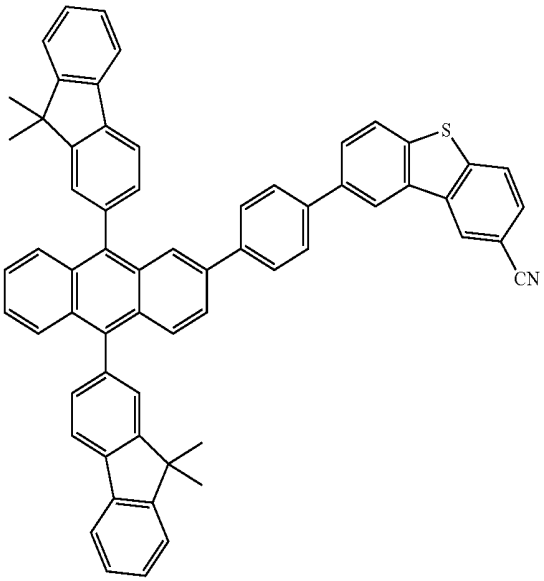

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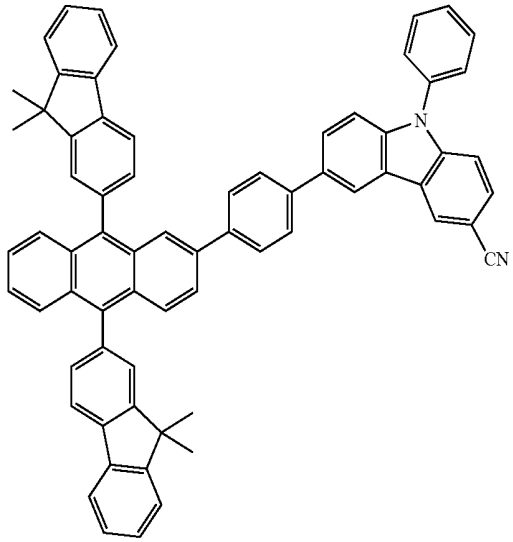

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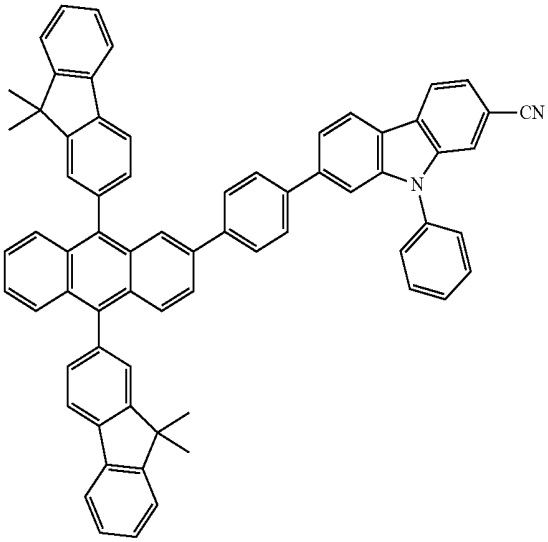

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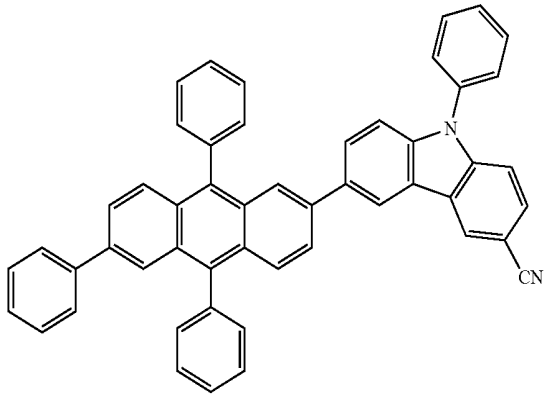

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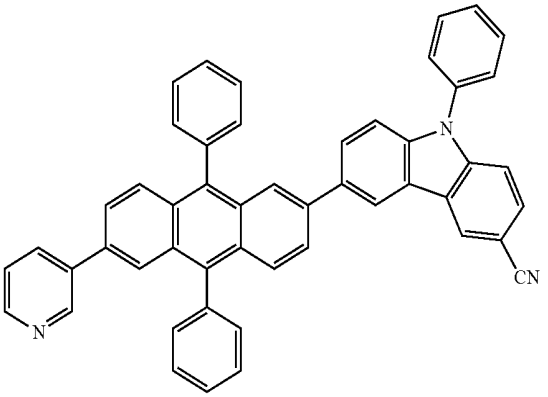

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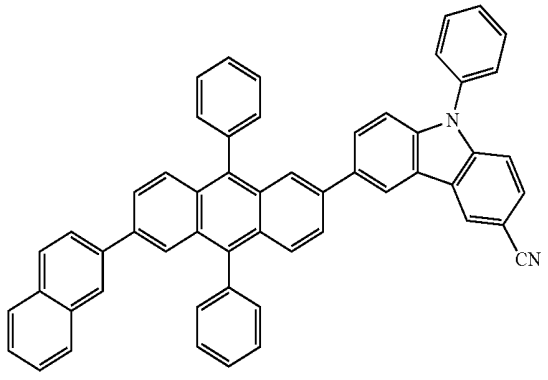

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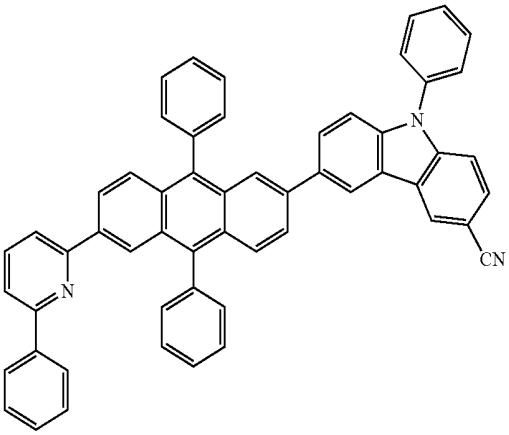

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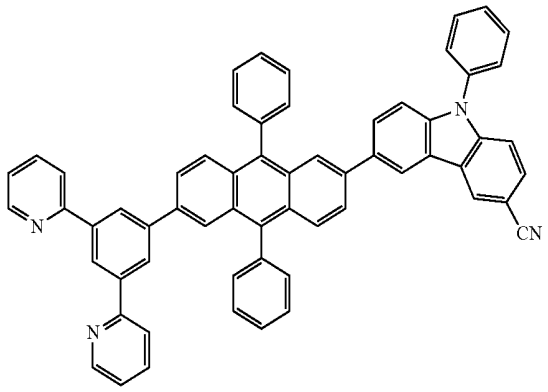

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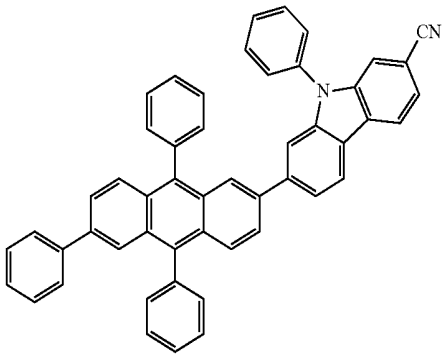

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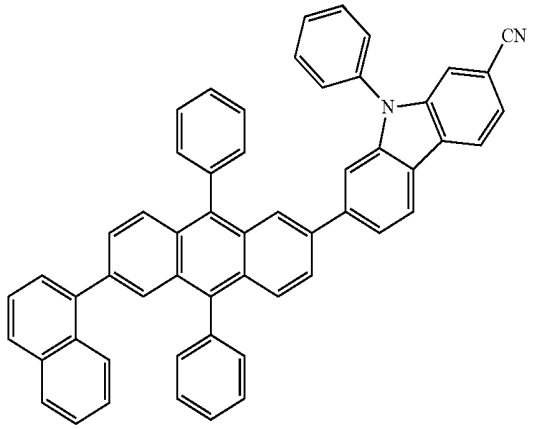

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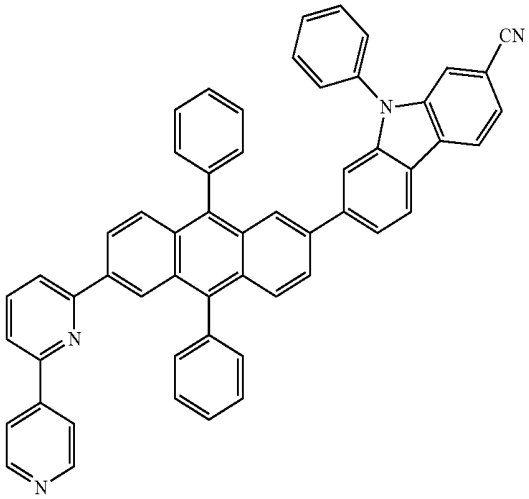

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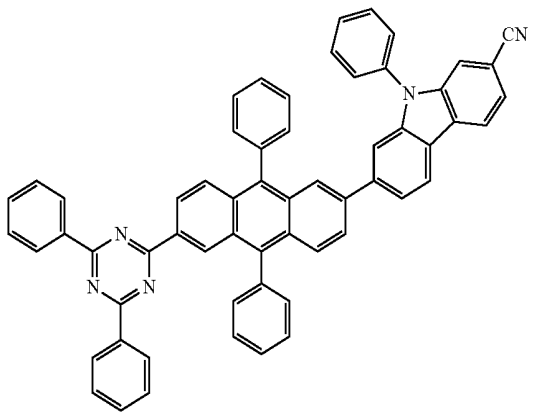

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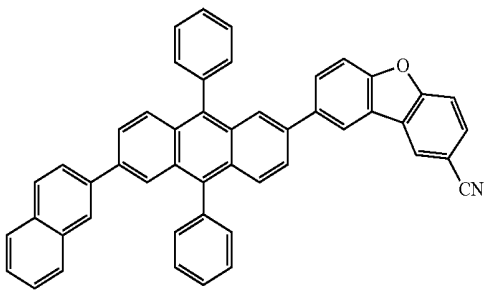

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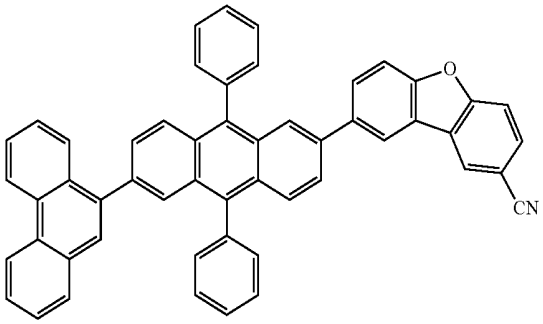

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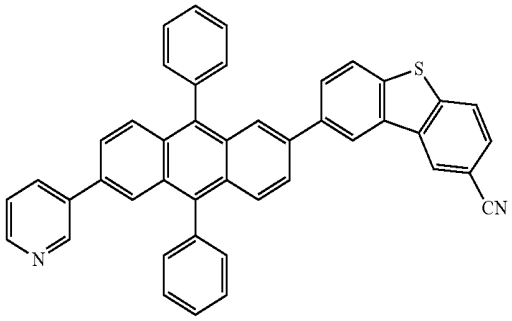

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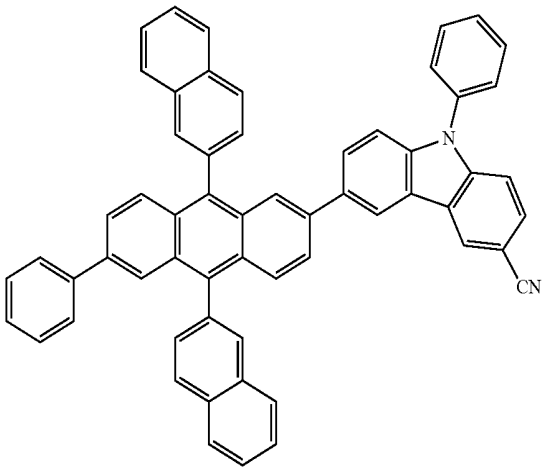

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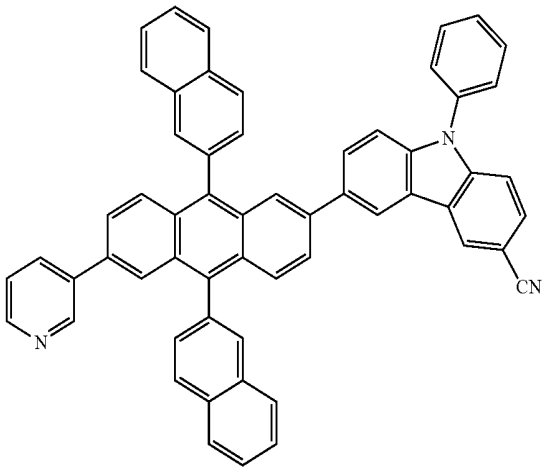

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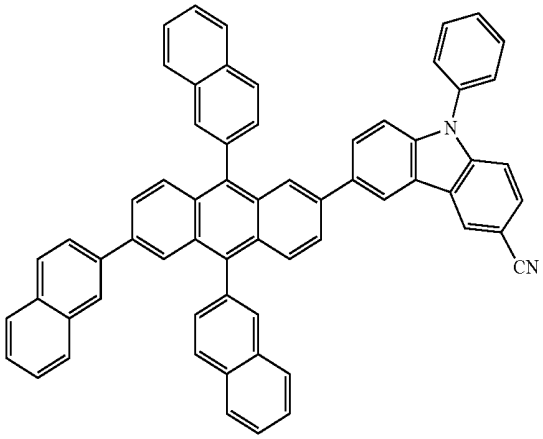

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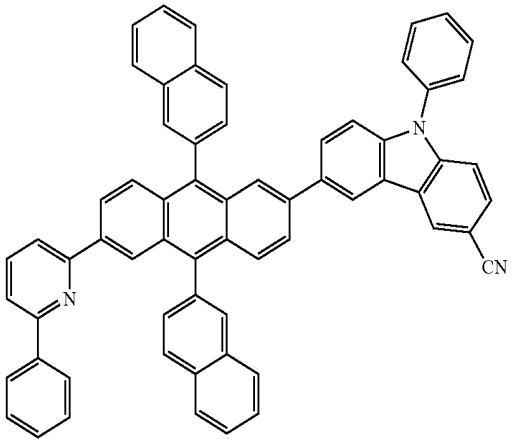

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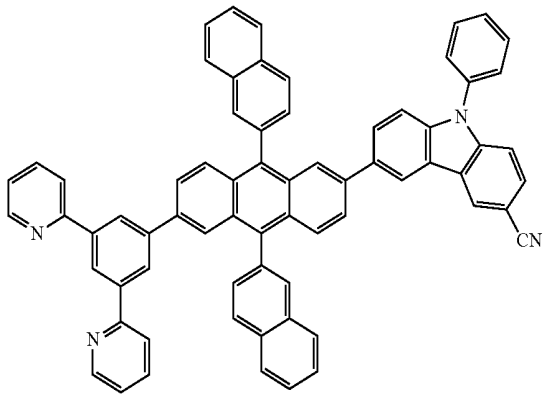

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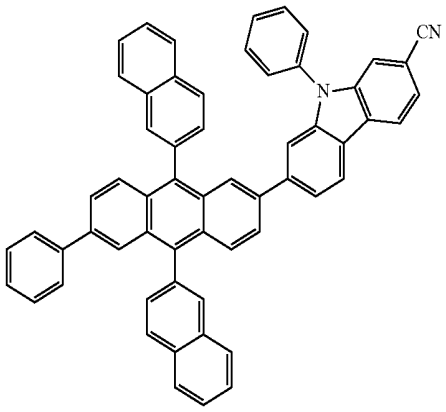

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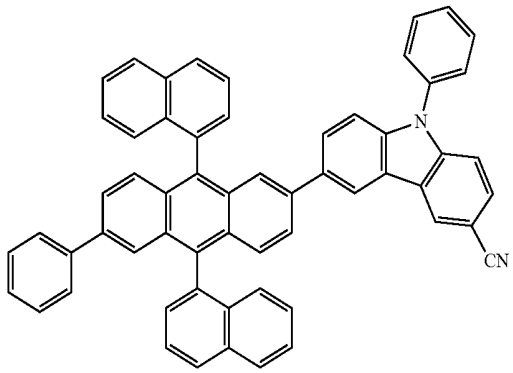

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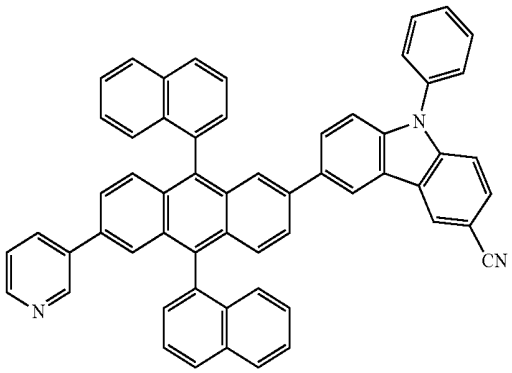

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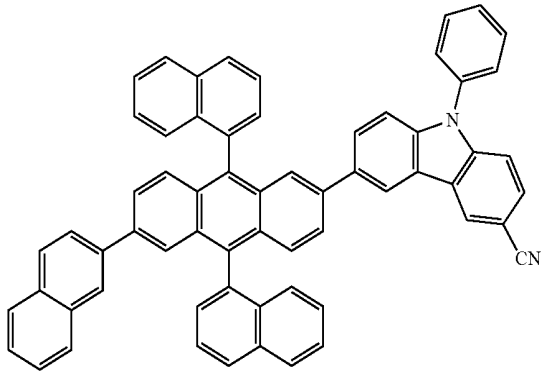

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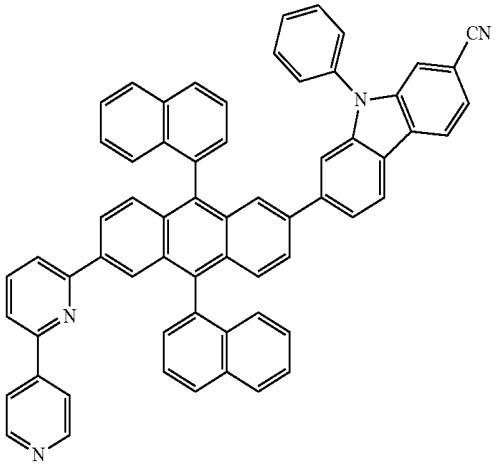

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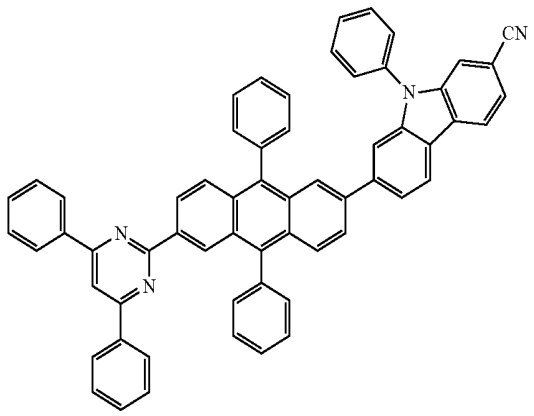

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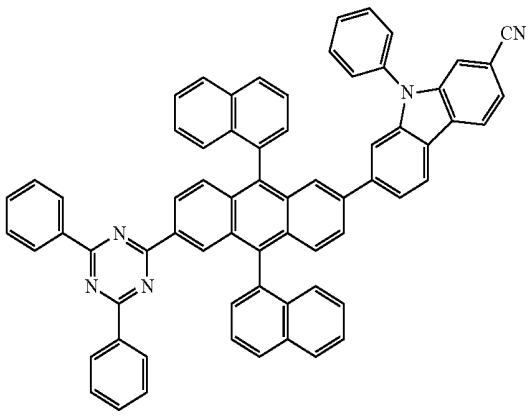

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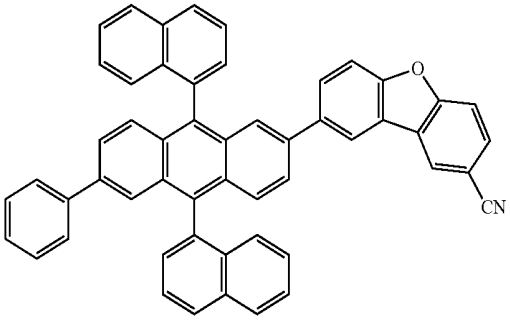

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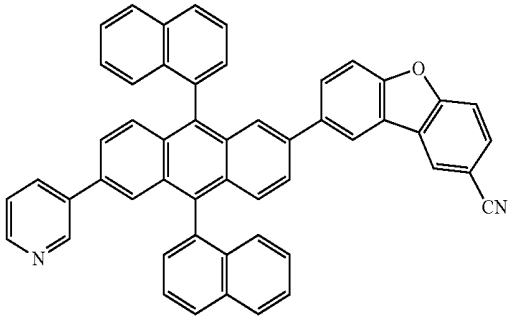

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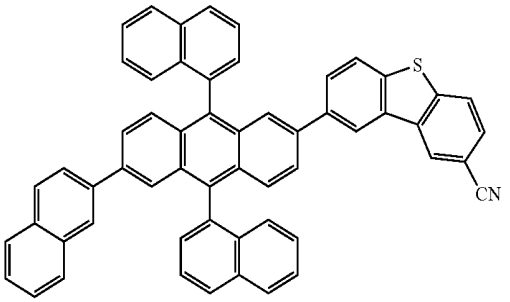

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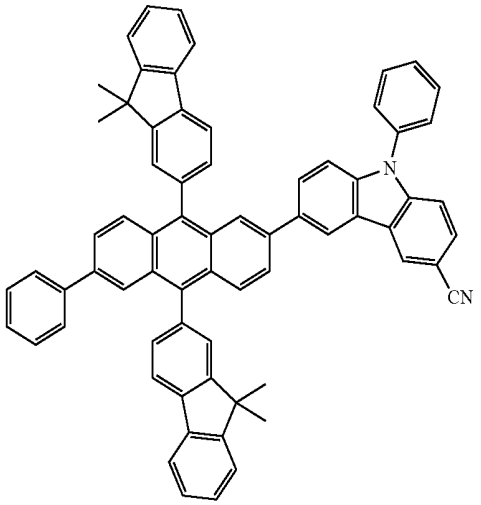

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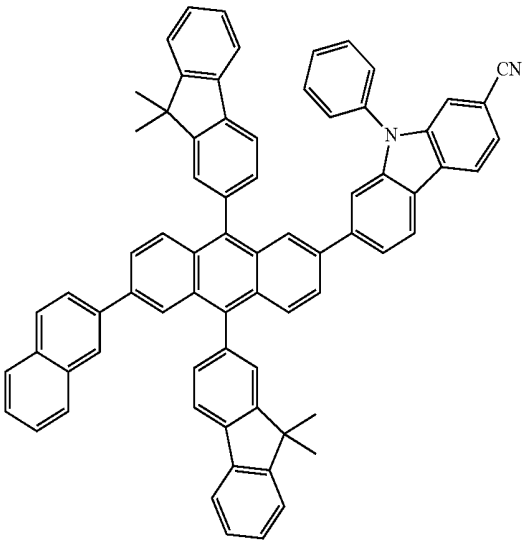

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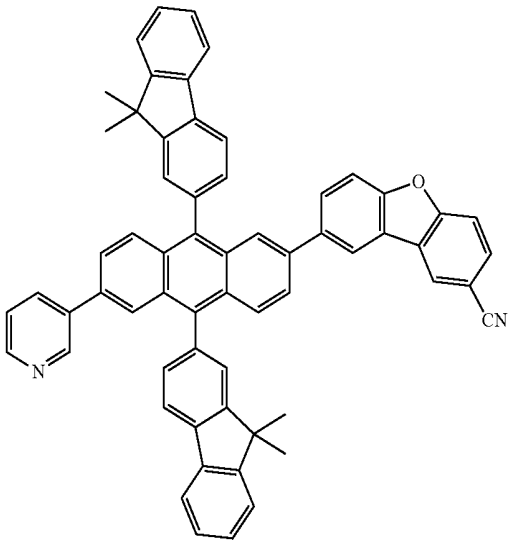

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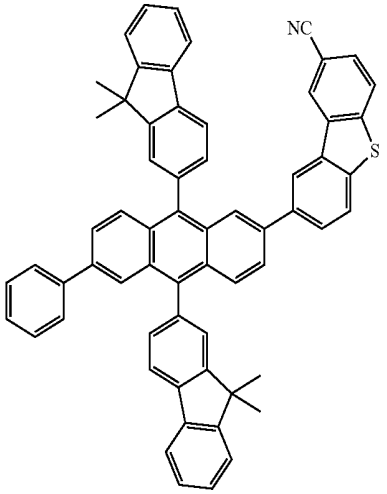

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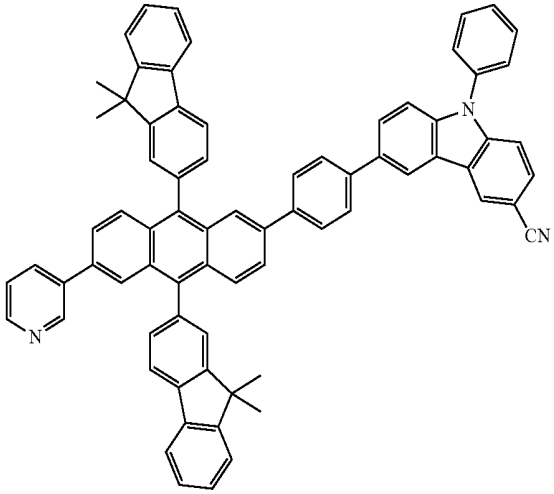

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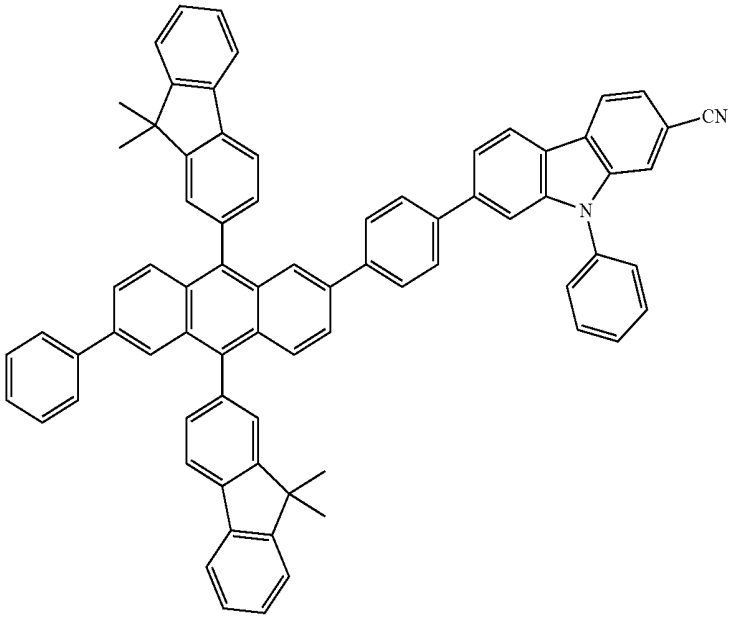

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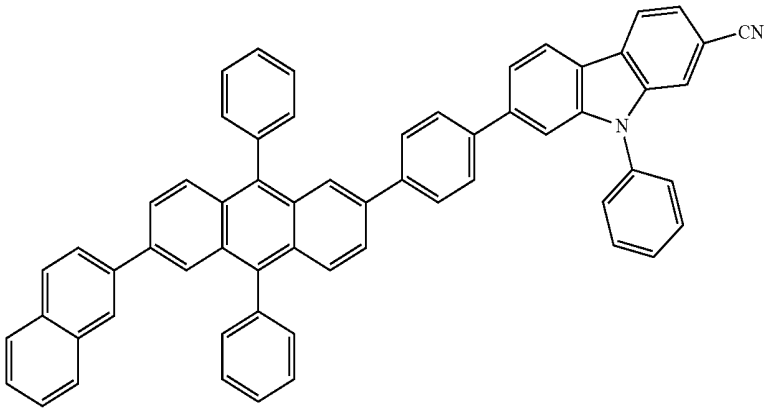

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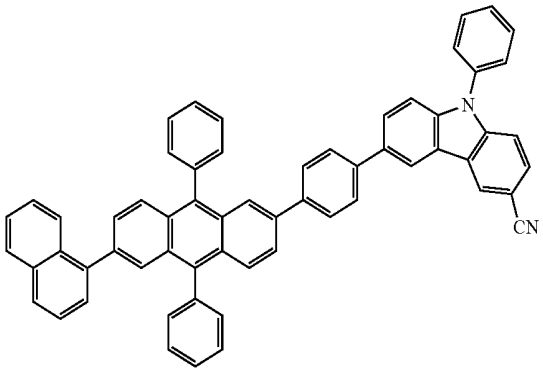

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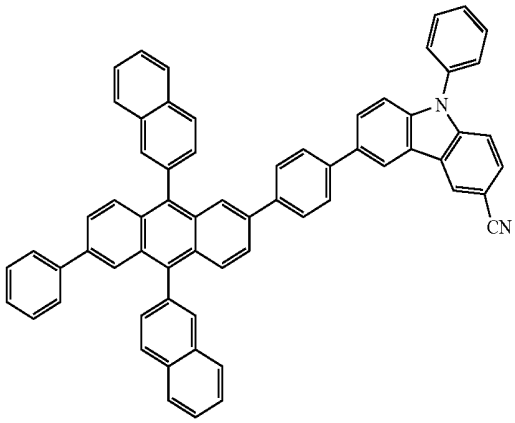

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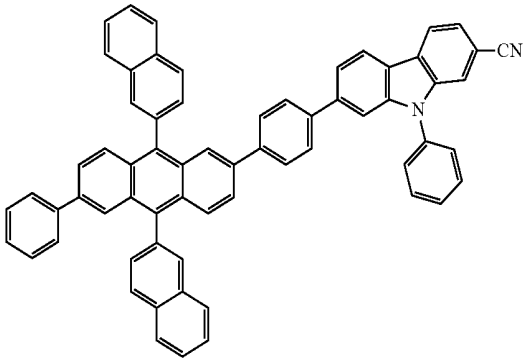

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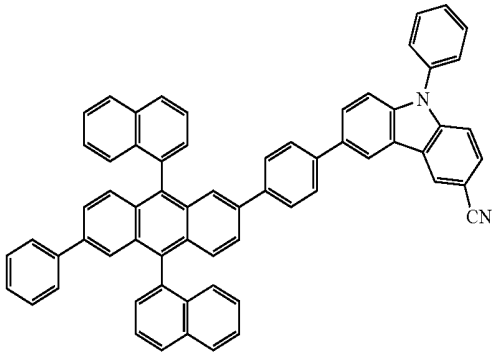

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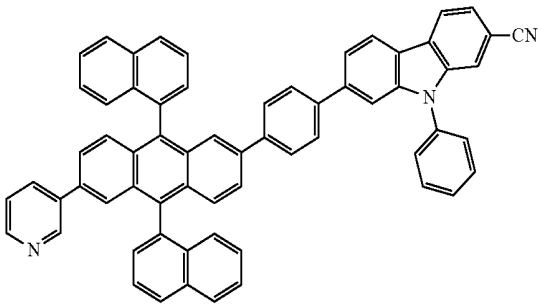

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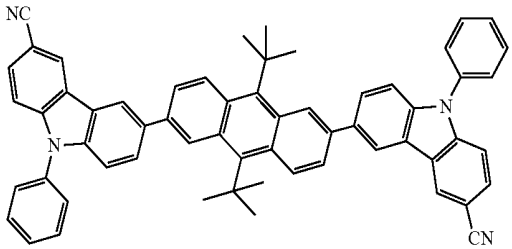

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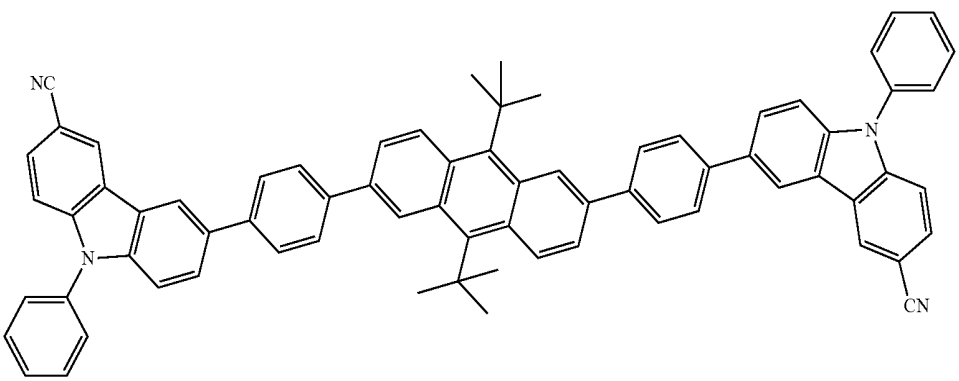

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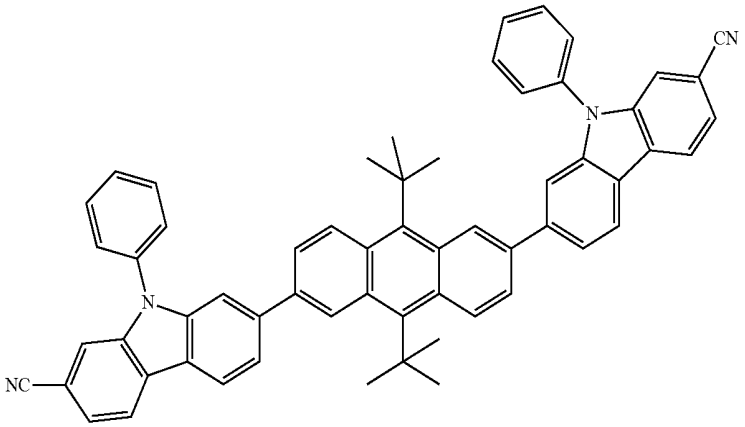

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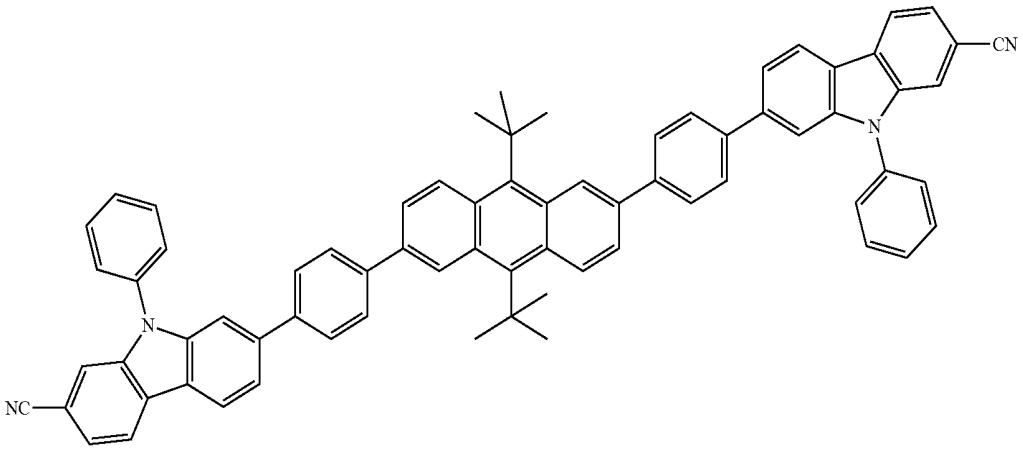

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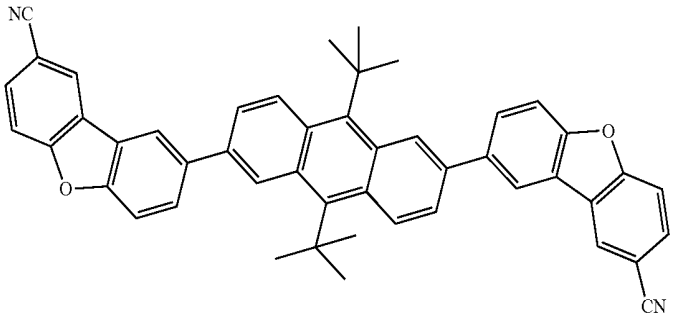

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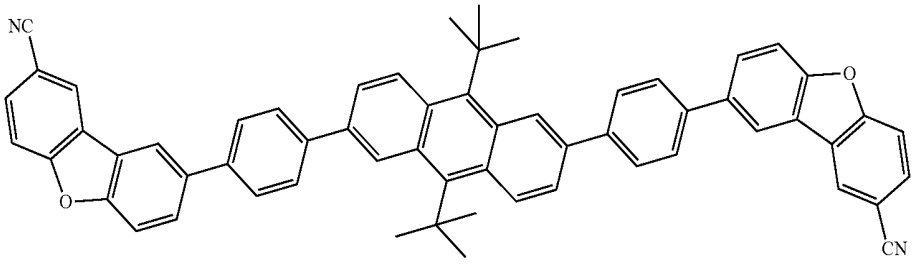

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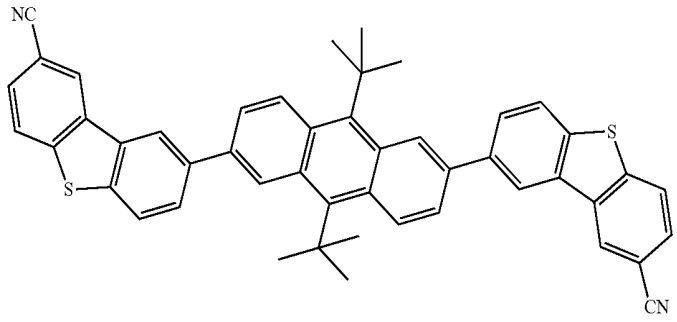

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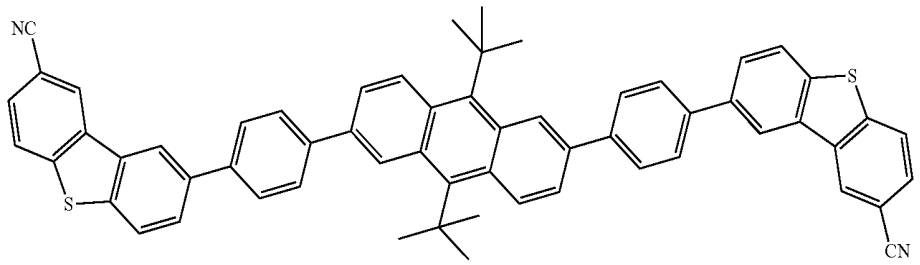

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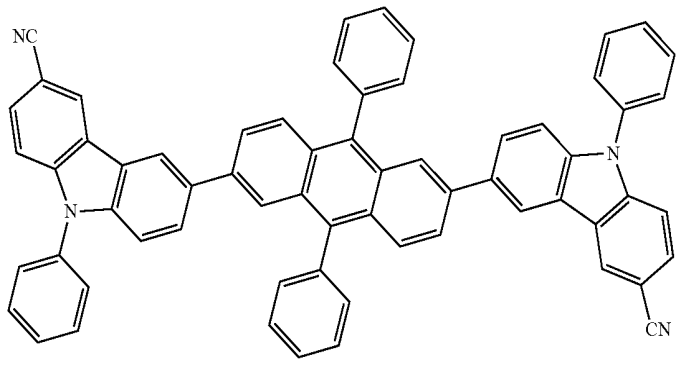

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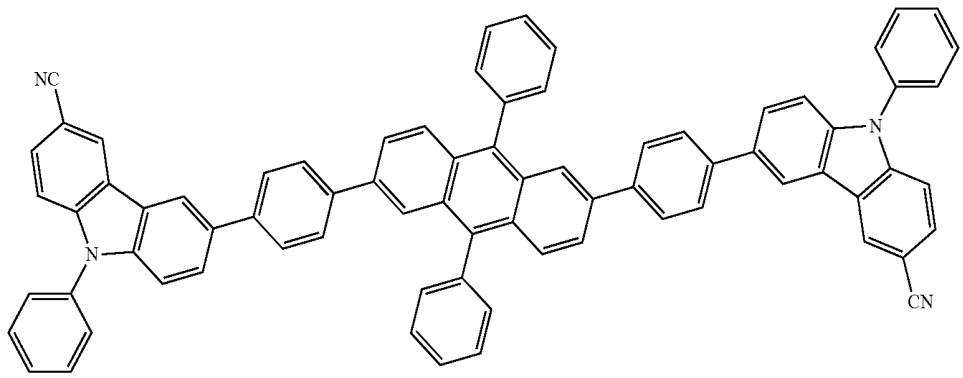

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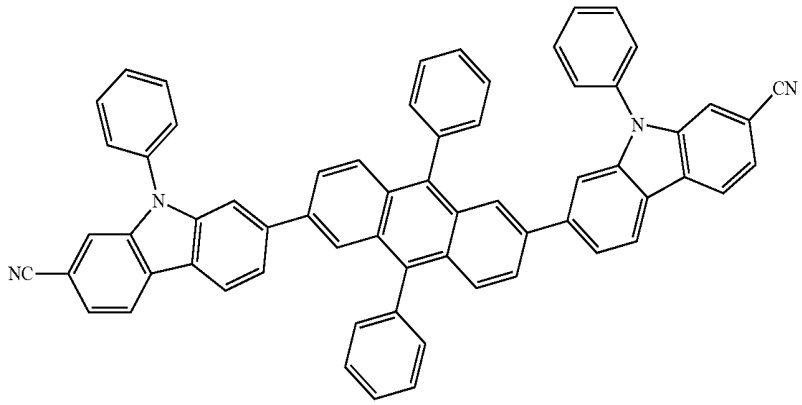

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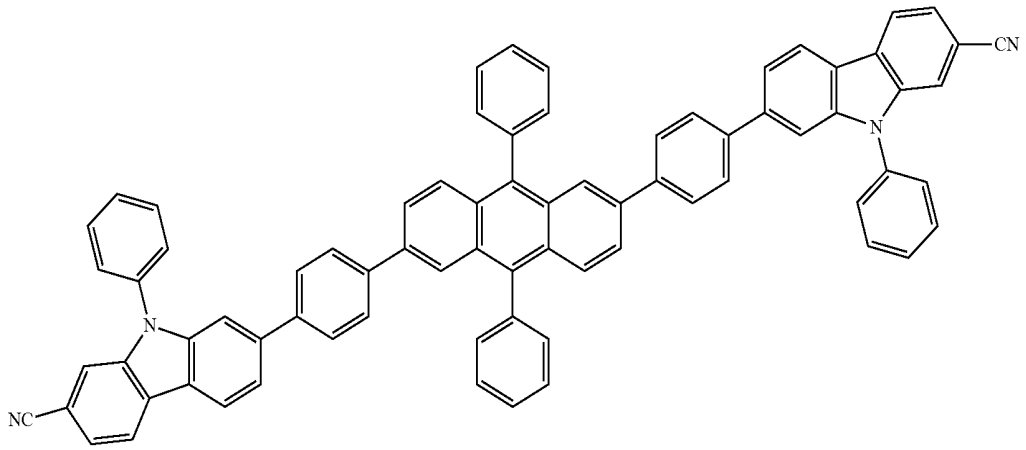

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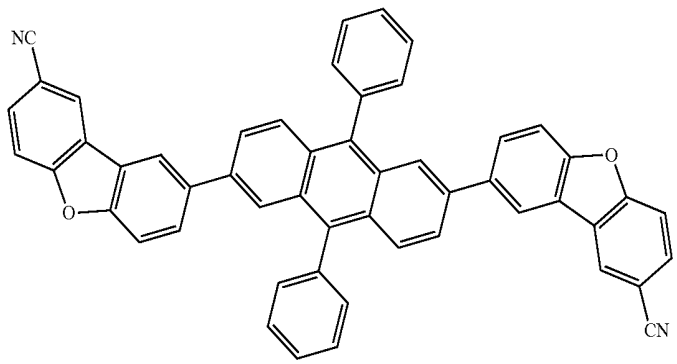

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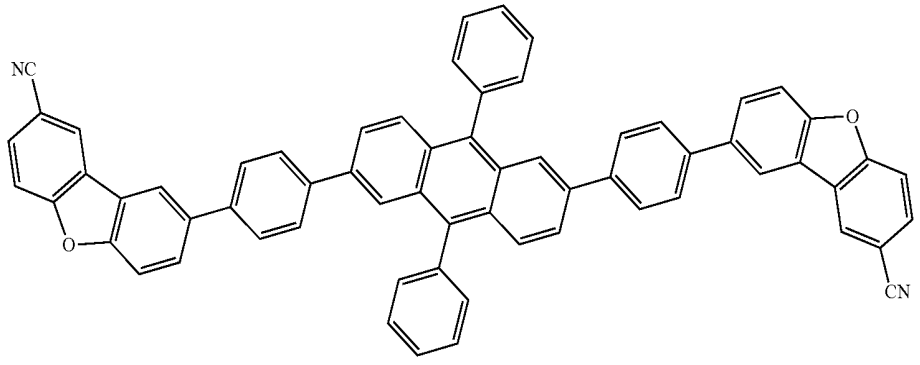

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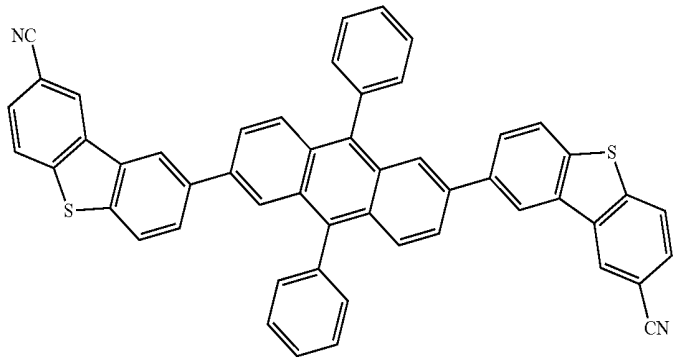

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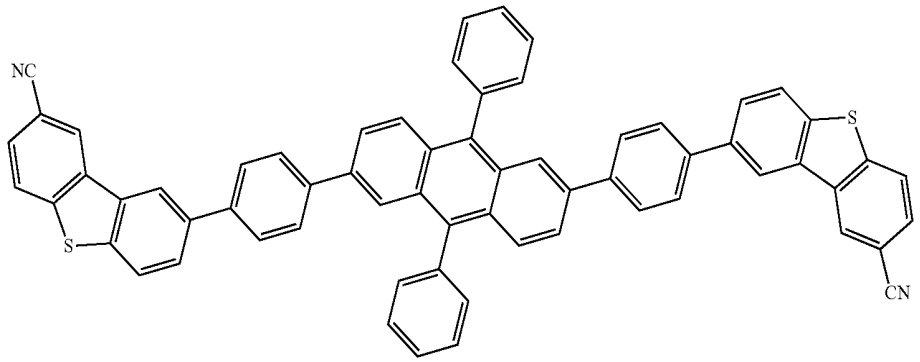

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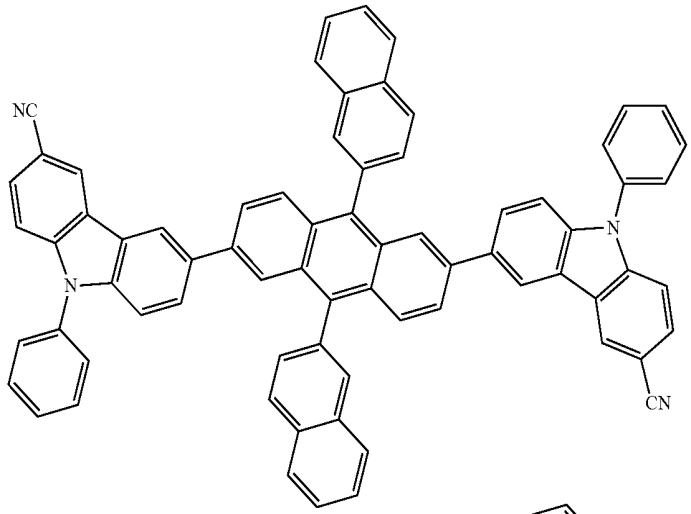

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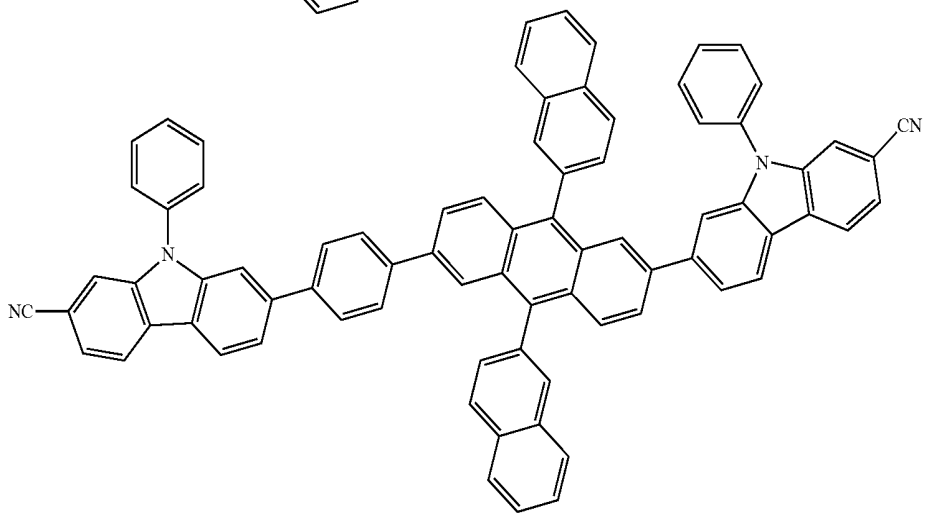

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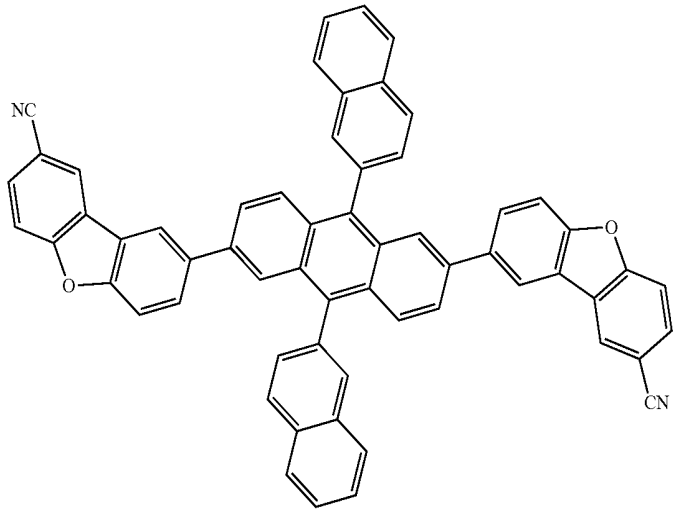

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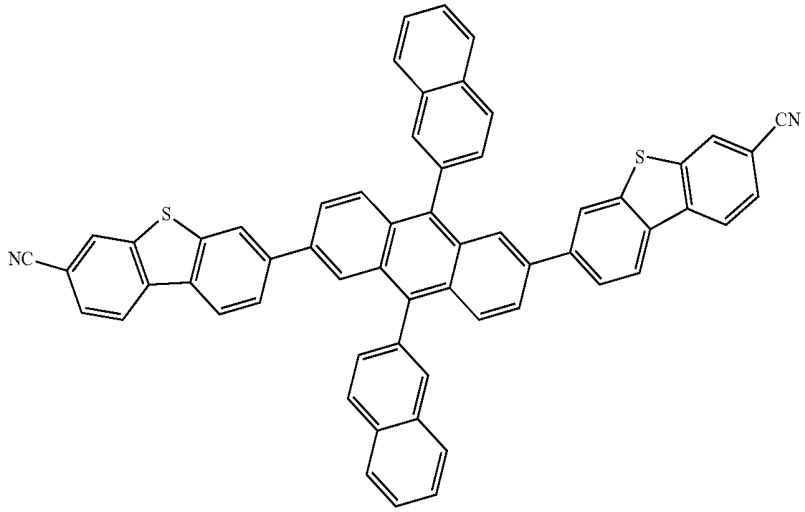

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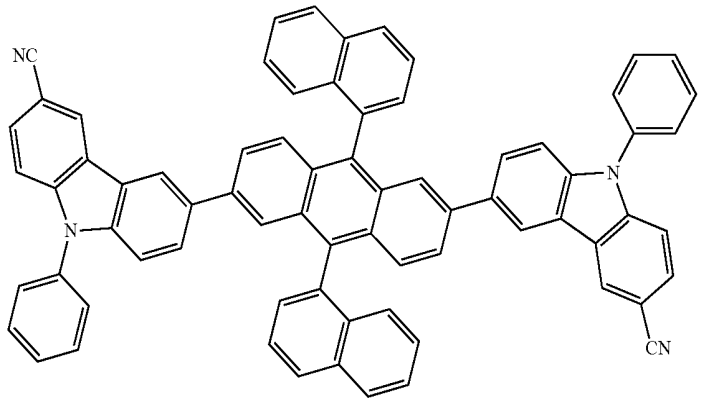

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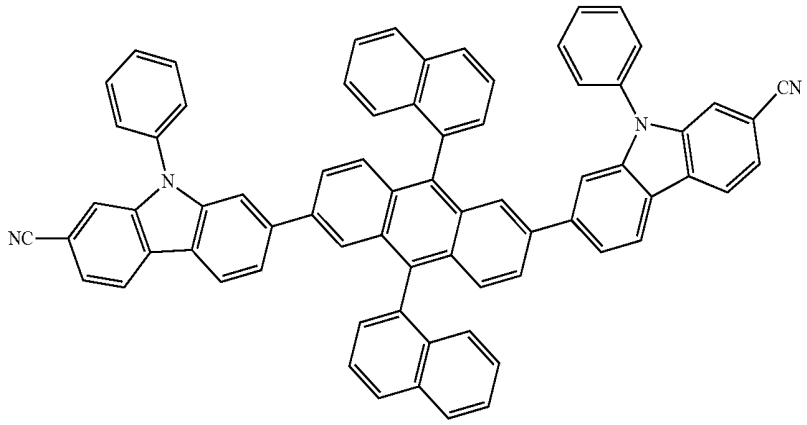

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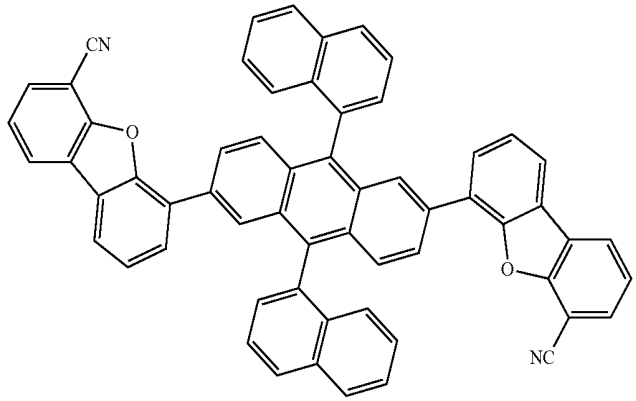

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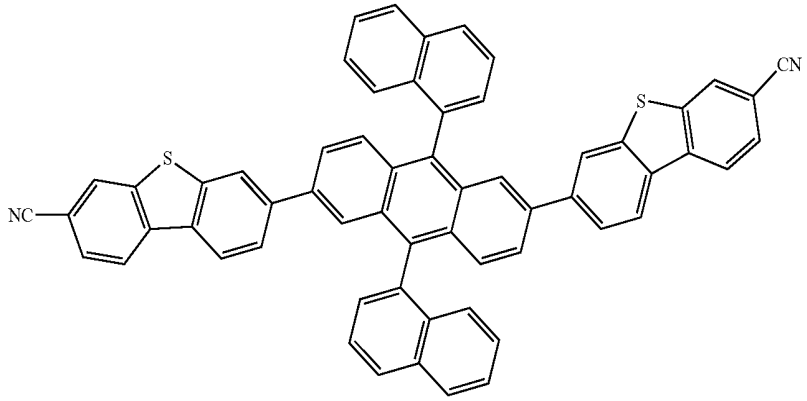

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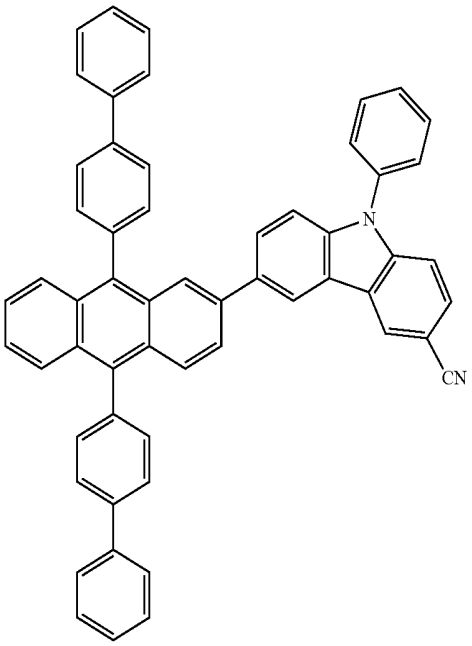

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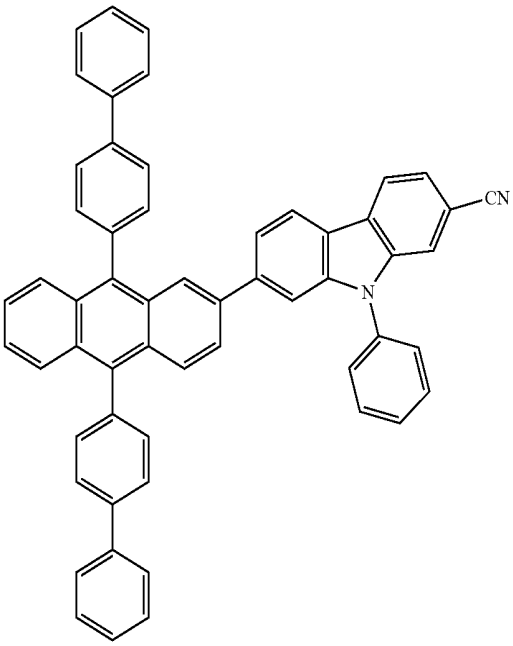

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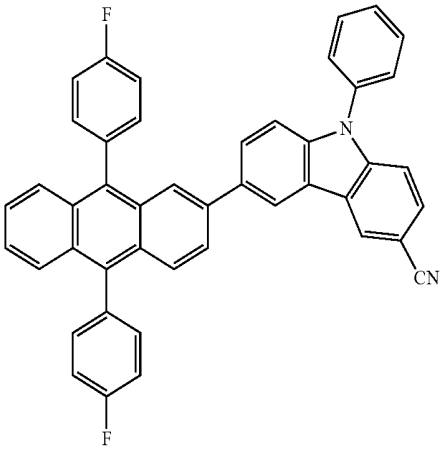

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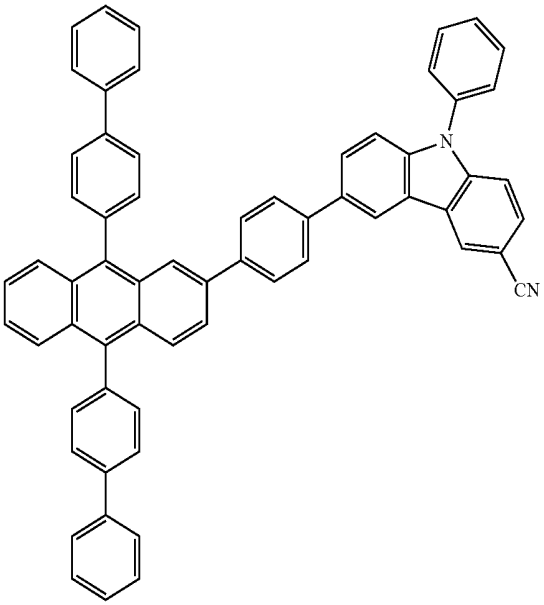

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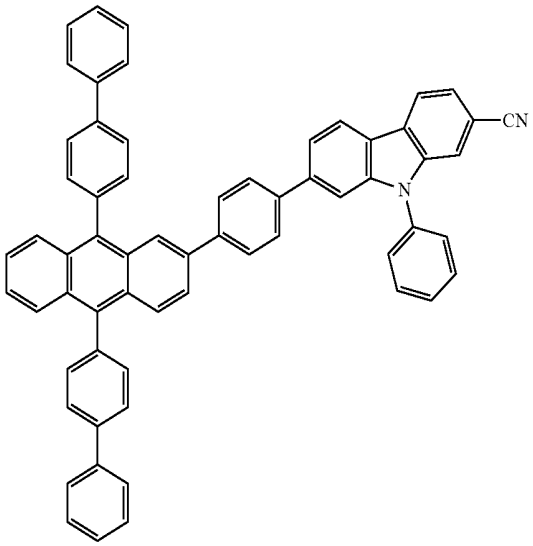

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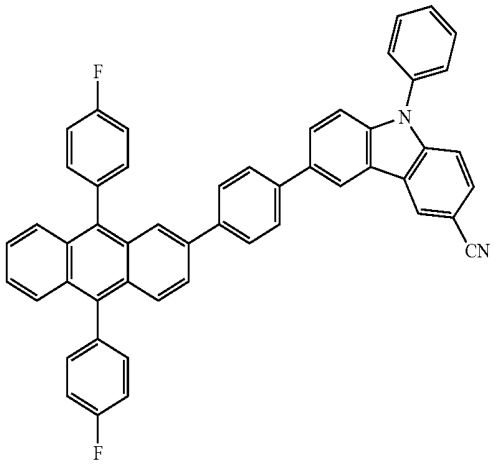

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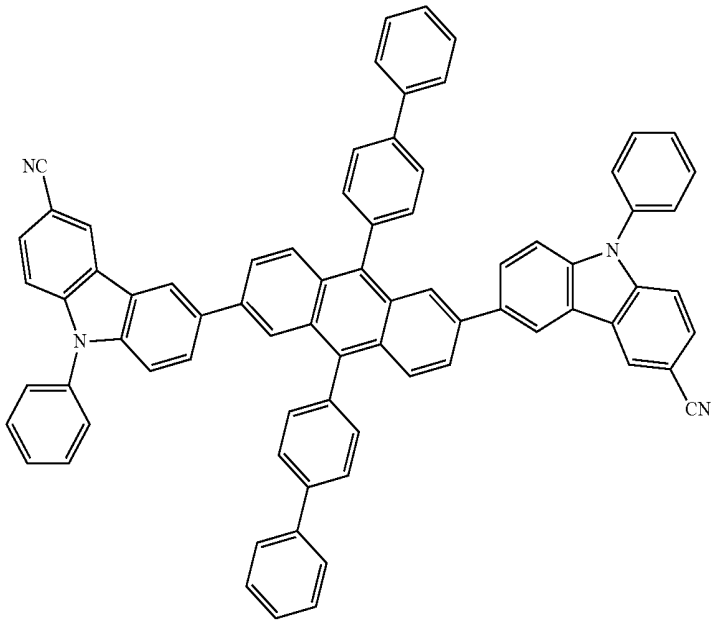

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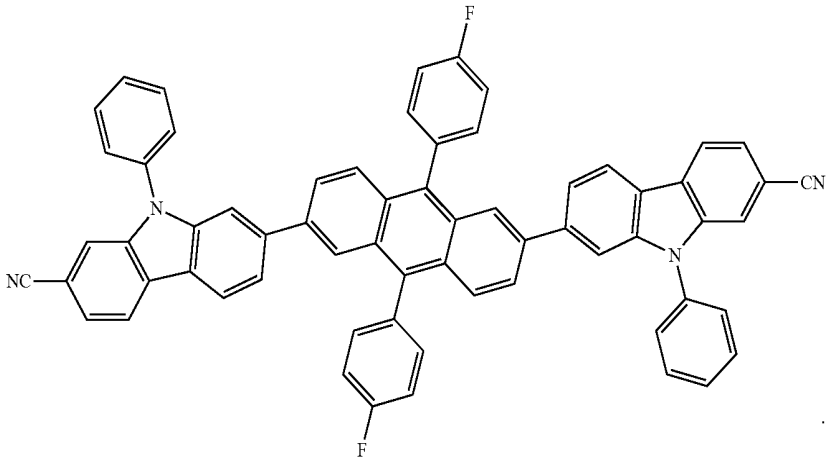


16. An organic light-emitting diode comprising: a first electrode; a second electrode facing the first electrode; and an organic layer that is disposed between the first and second electrodes and includes an emission layer, wherein the organic layer includes at least one condensed compound as claimed in claim **1**.

17. The organic light-emitting diode as claimed in claim **16**, wherein the organic layer includes:

a hole transport region that is disposed between the first electrode and the emission layer and includes at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and

an electron transport region, that is disposed between the emission layer and the second electrode and includes at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

18. The organic light-emitting diode as claimed in claim **17**, wherein the electron transport region includes the condensed compound.

19. The organic light-emitting diode as claimed in claim **18**, wherein:

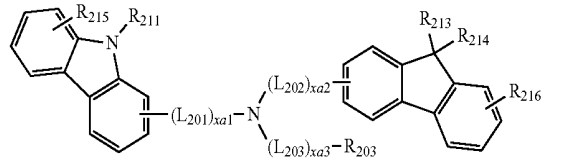
the electron transport region includes an electron transport layer, and

the electron transport layer includes the condensed compound.

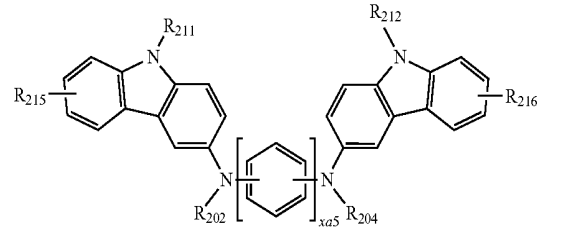
20. The organic light-emitting diode as claimed in claim **17**, wherein:

the hole transport region includes at least one of a compound represented by Formula 201A and a compound represented by Formula 202A:

<Formula 201A>



<Formula 202A>



L_{201} to L_{203} are each independently selected from

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group and a triazinylene group; and

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluoenylene group, a dibenzofluoenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group and a triazinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoindolyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

xa1 to xa3 may each independently 0 or 1;

R_{203}, R_{211}, and R_{212} are each independently selected from

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

R_{213} and R_{214} are each independently selected from

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

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

zofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

R_{215} and R_{216} are each independently selected from

a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof,

a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group;

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid and a salt thereof, a sulfonic acid and a salt thereof, a phosphoric acid and a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group and a triazinyl group; and

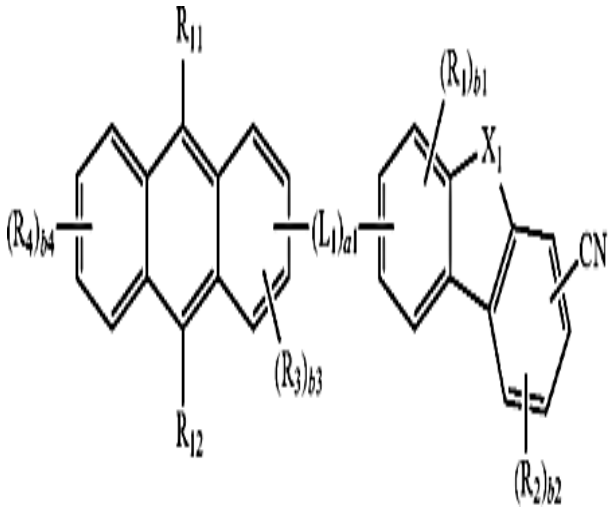
xa5 1 or 2.

* * * * *

专利名称(译)	缩合化合物和包括其的有机发光二极管		
公开(公告)号	US20150069355A1	公开(公告)日	2015-03-12
申请号	US14/447333	申请日	2014-07-30
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	HWANG SEOK HWAN KIM YOUNG KOOK PARK JUN HA JUNG HYE JIN LIM JIN O LEE EUN YOUNG KIM JONG WOO HAN SANG HYUN KIM KWANG HYUN JEONG EUN JAE KIM SOO YON		
发明人	HWANG, SEOK-HWAN KIM, YOUNG-KOOK PARK, JUN-HA JUNG, HYE-JIN LIM, JIN-O LEE, EUN-YOUNG KIM, JONG-WOO HAN, SANG-HYUN KIM, KWANG-HYUN JEONG, EUN-JAE KIM, SOO-YON		
IPC分类号	H01L51/00		
CPC分类号	H01L51/0058 H01L51/0072 H01L51/0052 H01L51/5072 H01L51/0067 H01L51/0074 H01L51/5056 H01L51/0073 C07D209/88 C07D307/91 C07D333/76 C07D401/04 C07D401/10 C07D401/14 C07D403/10 C07D405/10 C07D409/10 C07D209/82 H01L51/0059 H01L51/0062		
优先权	1020130104401 2013-08-30 KR		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供一种缩合化合物和包含该化合物的有机发光二极管，该缩合化合物由式1或2表示：


R11
(R1)b1
X1
(R4)b4
(L1)a1
CN
(R3)b3
R12
(R2)b2