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

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(57) **ABSTRACT**

Provided are a condensed cyclic compound and an organic light-emitting device including the same. The organic light-emitting device includes: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode and including an emission layer and at least one of the condensed cyclic compound.

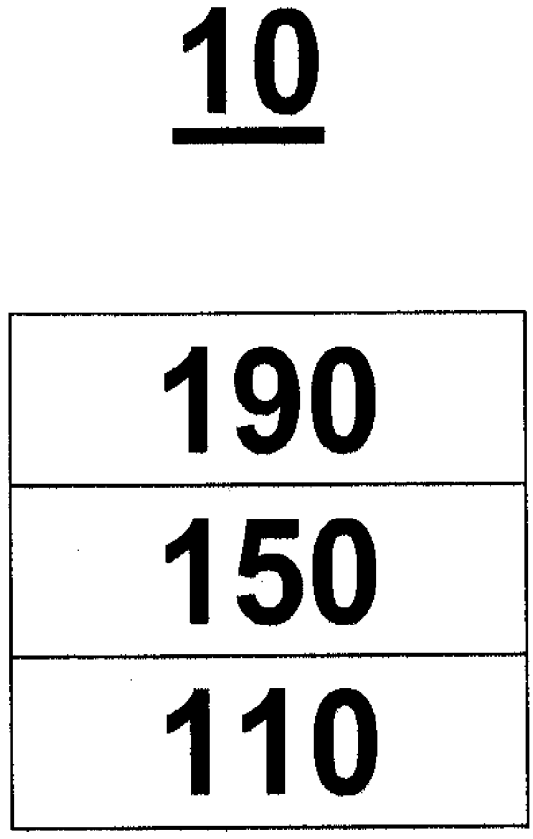


FIG. 1

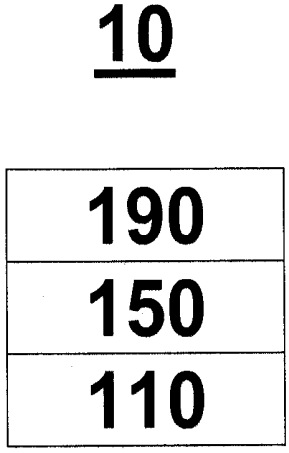


FIG. 2

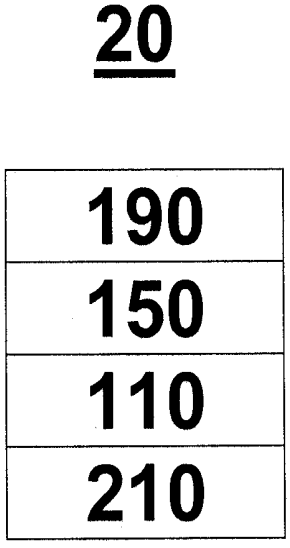


FIG. 3

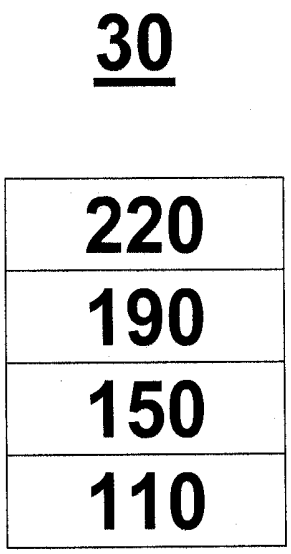
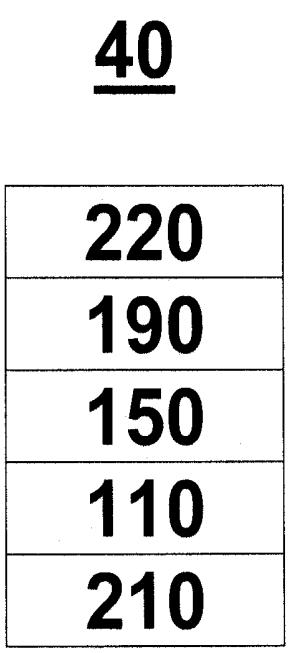


FIG. 4



CONDENSED CYCLIC COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2017-0140809, filed on Oct. 27, 2017, in the Korean Intellectual Property Office, the entire content of which is incorporated herein by reference.

BACKGROUND

1. Field

[0002] One or more embodiments relate to a condensed cyclic compound for an organic light-emitting device and an organic light-emitting device including the same.

2. Description of the Related Art

[0003] Organic light-emitting devices are self-emission devices that have wide viewing angles, high contrast ratios, short response times, and excellent characteristics in terms of brightness, driving voltage, and response speed, as compared to other devices in the art.

[0004] An example of such organic light-emitting devices 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 provided from the first electrode may move toward the emission layer through the hole transport region, and electrons provided from the second electrode may move toward the emission layer through the electron transport region. Carriers, such as holes and electrons, recombine in the emission layer to produce excitons. These excitons transit (or relax) from an excited state to a ground state, thereby generating light.

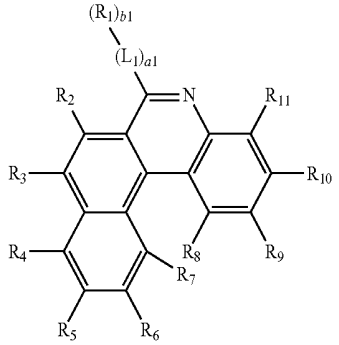
SUMMARY

[0005] Aspects of embodiments of the present disclosure provide a novel condensed cyclic compound and an organic light-emitting device including the same.

[0006] Additional aspects of embodiments will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0007] An aspect of an embodiment of the present disclosure provides a condensed cyclic compound represented by Formula 1 below:

Formula 1



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Formula 2

[0008] In Formulae 1 and 2,

[0009] L_1 and L_{11} may each independently be a substituted or unsubstituted C_3-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

[0010] a1 and a11 may each independently be 0, 1, 2, 3, 4, or 5,

[0011] when a1 is zero, L_1 may be a single bond, and when a11 is zero, L_{11} may be a single bond,

[0012] when a1 is two or more, two or more L_1(s) may be identical to or different from each other, and when a11 is two or more, two or more L_{21} (s) may be identical to or different from each other,

[0013] R_1 may be selected from —F, a fluorine-containing C_3-C_{60} carbocyclic group, and a fluorine-containing C_1-C_{60} heterocyclic group,

[0014] b1 may be 1, 2, 3, 4, or 5,

[0015] R_2 to R_{11} may each independently be selected from a group represented by Formula 2, hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$,

[0016] R_2 and R_3 are not linked to form a ring,

[0017] Ar_{11} may be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$,

[0018] c11 may be 1, 2, 3, or 4,

[0019] at least one substituent of the substituted C_3-C_{60} carbocyclic group, the substituted C_1-C_{60} heterocyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_2-C_{60} alkenyl group, the substituted C_2-C_{60} alkynyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the sub-

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

[0020] deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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;

[0021] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_{11})(Q_{12})(Q_{13})$, —$N(Q_{11})(Q_{12})$, —$B(Q_{11})(Q_{12})$, —$C(=O)(Q_{11})$, —$S(=O)_2(Q_{11})$, and —$P(=O)(Q_{11})(Q_{12})$;

[0022] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group;

[0023] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_{21})(Q_{22})(Q_{23})$, —$N(Q_{21})(Q_{22})$, —$B(Q_{21})(Q_{22})$, —$C(=O)(Q_{21})$, —$S(=O)_2(Q_{21})$, and —$P(=O)(Q_{21})(Q_{22})$; and

[0024] —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, —$B(Q_{31})(Q_{32})$, —$C(=O)(Q_{31})$, —$S(=O)_2(Q_{31})$, and —$P(=O)(Q_{31})(Q_{32})$, and

[0025] Q_1 to Q_3, Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0026] Another aspect of embodiments of the present disclosure provides an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode and including an emission layer and at least one of the condensed cyclic compound.

[0027] Another aspect of an embodiment of the present disclosure provides an electronic apparatus including a thin film transistor and the organic light-emitting device, wherein the thin film transistor includes a source electrode, a drain electrode, an active layer, and a gate electrode, and the first electrode of the organic light-emitting device is electrically coupled to or electrically connected to one of the source electrode and the drain electrode of the thin film transistor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] These and/or other aspects of embodiments will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

[0029] FIG. **1** is a schematic view of an organic light-emitting device according to an embodiment;

[0030] FIG. **2** is a schematic view of an organic light-emitting device according to an embodiment;

[0031] FIG. **3** is a schematic view of an organic light-emitting device according to an embodiment; and

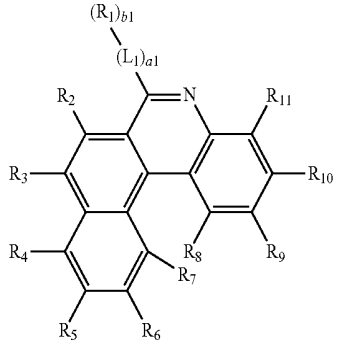
[0032] FIG. **4** is a schematic view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0033] Reference will now be made in more detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0034] A condensed cyclic compound according to an embodiment is represented by Formula 1 below:

Formula 1



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Formula 2

$$*-(L_{11})_{a11}-(Ar_{11})_{c11}.$$

[0035] In Formulae 1 and 2,

[0036] L_1 and L_{it} may each independently be a substituted or unsubstituted C_3-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group.

[0037] In one embodiment, L_1 and L_{11} may each independently be selected from:

[0038] a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a dibenzosilole group, a carbazole group, a quinoline group, an isoquinoline group, a benzocarbazole group, a dibenzocarbazole group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group; and

[0039] a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a dibenzosilole group, a carbazole group, a quinoline group, an isoquinoline group, a benzocarbazole group, a dibenzocarbazole group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, 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 biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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, a carbazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, and —$B(Q_{31})(Q_{32})$, and

[0040] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a phenyl group substituted with a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

[0041] For example, L_1 and L_{11} may each independently be selected from:

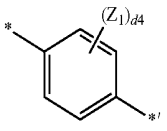
[0042] a benzene group, a naphthalene group, an anthracene group, a fluorene group, a spiro-bifluorene group, a pyridine group, a pyrimidine group, a pyrazine group, a triazine group, a quinoline group, an isoquinoline group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group; and

[0043] a benzene group, a naphthalene group, an anthracene group, a fluorene group, a spiro-bifluorene group, a pyridine group, a pyrimidine group, a pyrazine group, a triazine group, a quinoline group, an isoquinoline group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a cyano group, a C_1-C_{20} alkyl group, a phenyl group, a biphenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, a spiro-bifluorenyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a fluorenyl group,

[0044] but embodiments of the present disclosure are not limited thereto.

[0045] For example, L_1 and L_{it} may each independently be selected from groups represented by Formulae 3-1 to 3-33:

3-1



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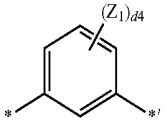

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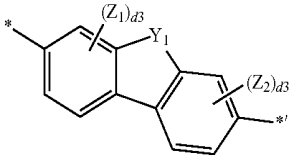

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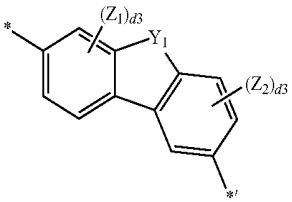

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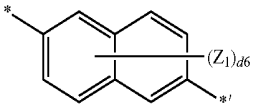

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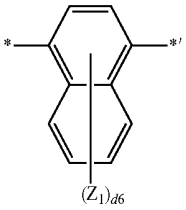

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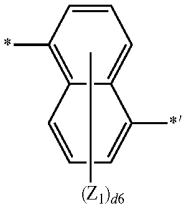

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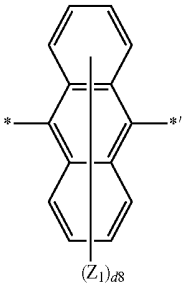

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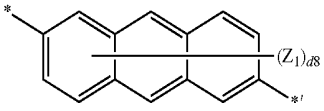

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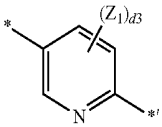
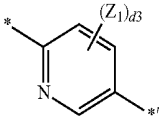


3-11



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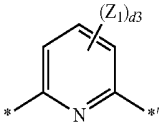

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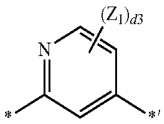

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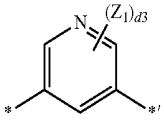

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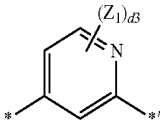

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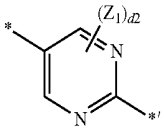

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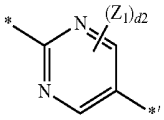

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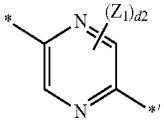

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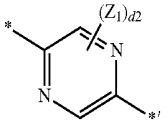

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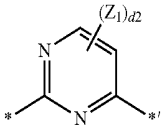

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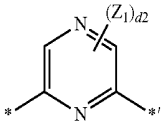

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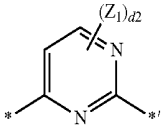

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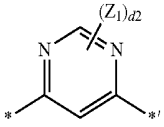

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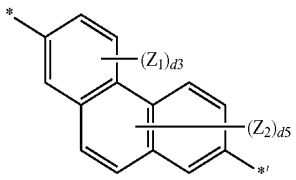

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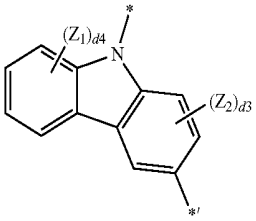

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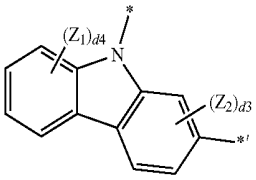

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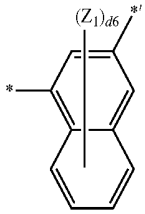

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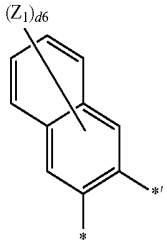

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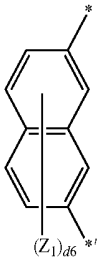

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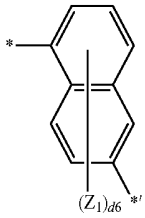

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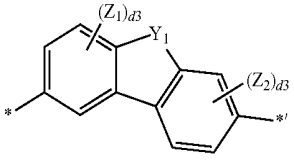

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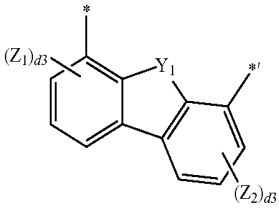

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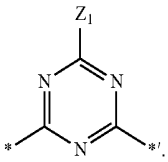


[0046] In Formulae 3-1 to 3-33,

[0047] Y_1 may be O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$,

[0048] Z_1 to Z_7 may each independently be selected from:

[0049] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, 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 biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spirobifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl 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, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and $—Si(Q_{31})(Q_{32})(Q_{33})$; and

[0050] a phenyl group substituted with a fluoro group (—F), but embodiments of the present disclosure are not limited thereto,

[0051] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group,

[0052] d2 may be an integer from 0 to 2,

[0053] d3 may be an integer from 0 to 3,

[0054] d4 may be an integer from 0 to 4,

[0055] d6 may be an integer from 0 to 6,

[0056] d8 may be an integer from 0 to 8, and

[0057] * and *' each indicate a binding site to a neighboring atom.

[0058] a1 and a11 in Formulae 1 and 2 may each independently be 0, 1, 2, 3, 4, or 5.

[0059] In one embodiment, a1 and a11 may each independently be 0, 1, 2, or 3, but embodiments of the present disclosure are not limited thereto.

[0060] For example, a1 and a11 may each independently be 0, 1, or 2.

[0061] When a1 is zero, *-$(L_1)_{a1}$-*' may be a single bond, and when a11 is zero, *-$(L_{11})_{a11}$-*' may be a single bond.

[0062] When a1 is two or more, two or more L_1(s) may be identical to or different from each other, and when a11 is two or more, two or more L_{21}(s) may be identical to or different from each other.

[0063] Ar_{11} in Formula 2 may be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$.

[0064] In one embodiment, Ar_{11} may be selected from:

[0065] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a thiophenyl group, a furanyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzonaphthofuranyl group, a dinaphthofuranyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a benzonaphthosilolyl group, a dinaphtho silolyl group, a benzimidazolyl group, a phenanthrolinyl group, and an imidazopyridinyl group;

[0066] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a thiophenyl group, a furanyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzonaphthofuranyl group, a dinaphthofuranyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a benzonaphthosilolyl group, a dinaphthosilolyl group, a benzimidazolyl group, a phenanthrolinyl group, and an imidazopyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, 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 biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a thiophenyl group, a furanyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzonaphthofuranyl group, a dinaphthofuranyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a benzonaphthosilolyl group, a dinaphthosilolyl group, a benzimidazolyl group, a phenanthrolinyl group, and an imidazopyridinyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, —$B(Q_{31})(Q_{32})$, —$C(=O)(Q_{31})$, —$S(=O)_2(Q_{31})$, and —$P(=O)(Q_{31})(Q_{32})$; and

[0067] —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$, but embodiments of the present disclosure are not limited thereto, and

[0068] Q_1 to Q_3 and Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a phenyl group substituted with at least one selected from a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

[0069] For example, Ar_{11} may be selected from:

[0070] a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

[0071] a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, —$B(Q_{31})(Q_{32})$, and —$P(=O)(Q_{31})(Q_{32})$; and

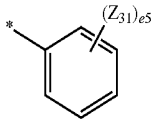
[0072] —$Si(Q_1)(Q_2)(Q_3)$, —$B(Q_1)(Q_2)$, and —$P(=O)(Q_1)(Q_2)$, and

[0073] Q_1 to Q_3 and Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group,

a phenyl group, a phenyl group substituted with a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0074] For example, Ar_{11} may be selected from —$B(Q_1)(Q_2)$, —$P(=O)(Q_1)(Q_2)$, and groups represented by Formulae 5-1 to 5-35:

5-1



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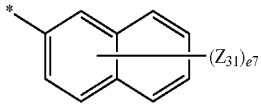

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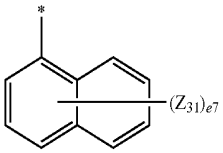

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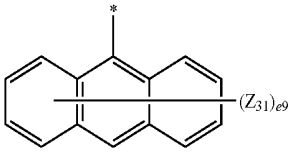

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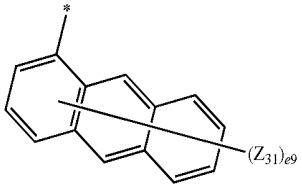

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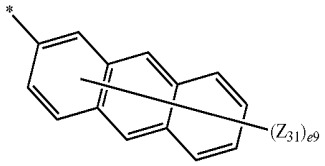

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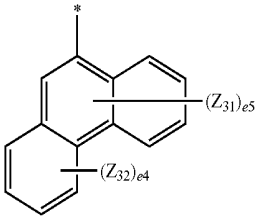

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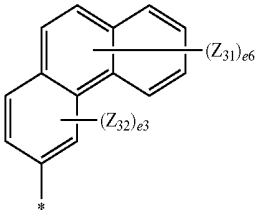

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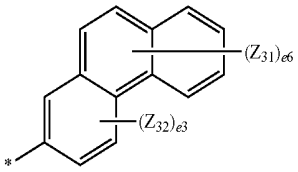

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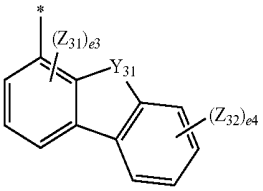

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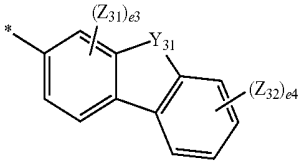

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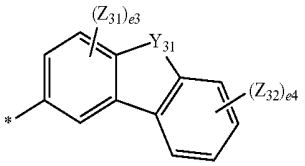

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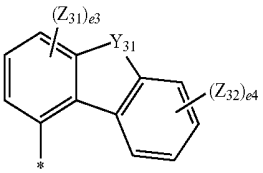

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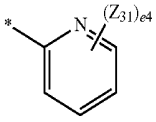

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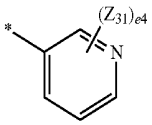

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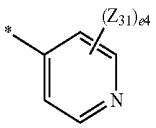

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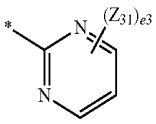

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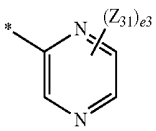

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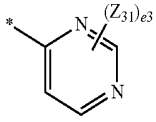

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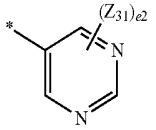

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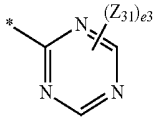

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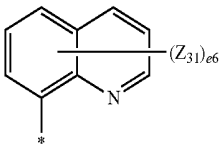

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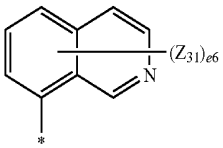

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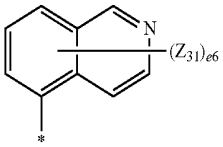

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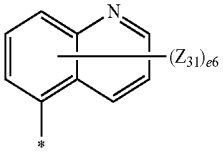

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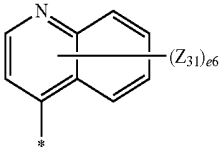

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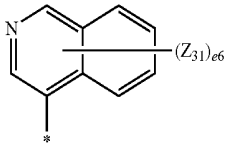

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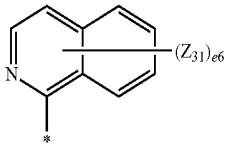

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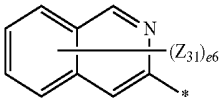

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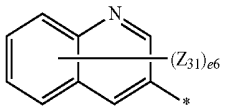

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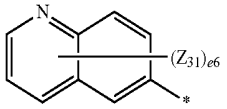

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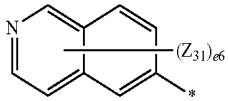

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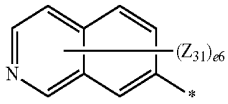

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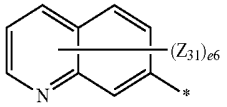

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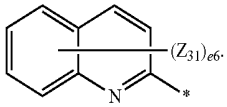


[0075] In Formulae 5-1 to 5-35,

[0076] Y_{31} may be O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$,

[0077] Z_{31} to Z_{37} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, 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 biphenyl group, a terphenyl 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 benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a pyridinyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a carbazolyl group, and $—Si(Q_{31})(Q_{32})(Q_{33})$,

[0078] Q_1, Q_2, and Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a phenyl group substituted with a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

[0079] e2 may be an integer from 0 to 2,

[0080] e3 may be an integer from 0 to 3,

[0081] e4 may be an integer from 0 to 4,

[0082] e5 may be an integer from 0 to 5,

[0083] e6 may be an integer from 0 to 6,

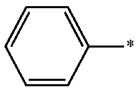
[0084] e7 may be an integer from 0 to 7,

[0085] e9 may be an integer from 0 to 9, and

[0086] * indicates a binding site to a neighboring atom.

[0087] For example, Ar_{11} may be selected from groups represented by Formulae 6-1 to 6-55.

6-1



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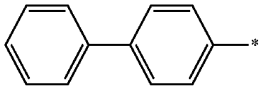

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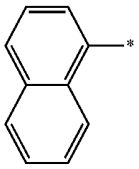

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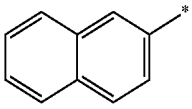

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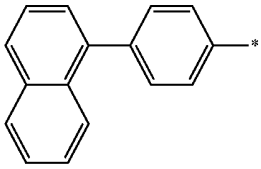

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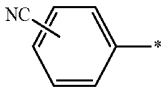

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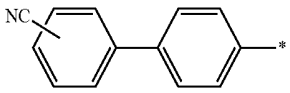

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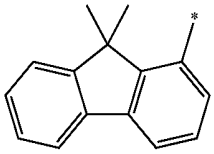

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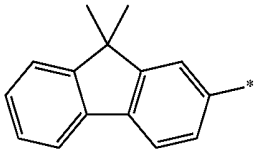

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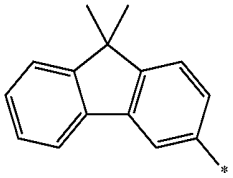

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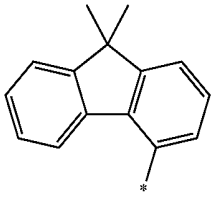

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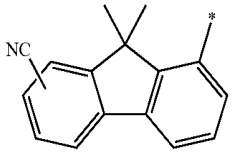

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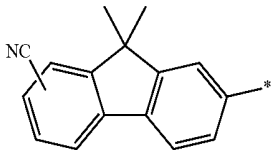

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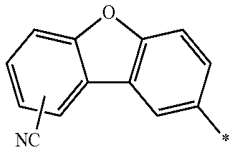

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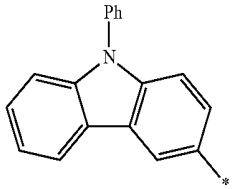

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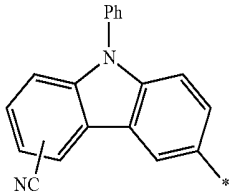

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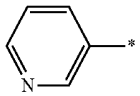

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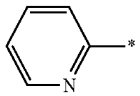

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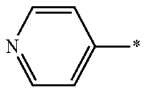

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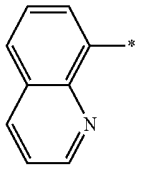

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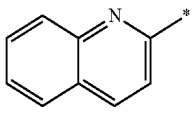

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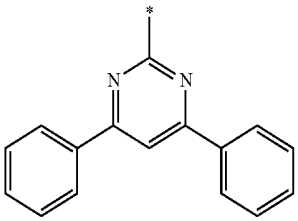

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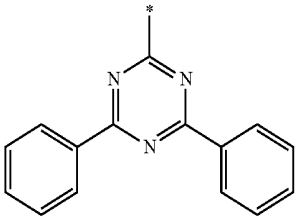

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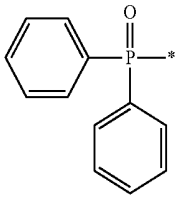

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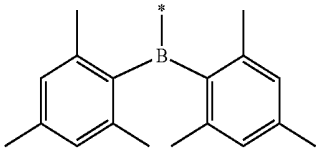

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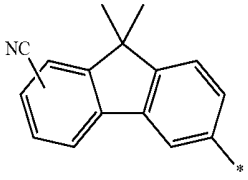

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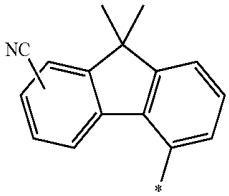

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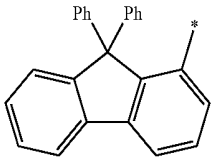

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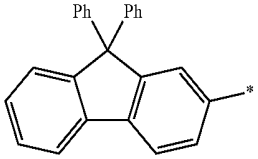

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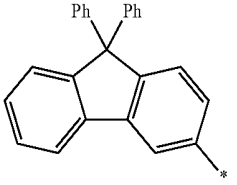

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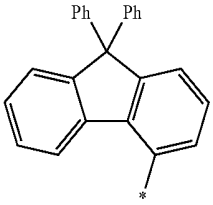

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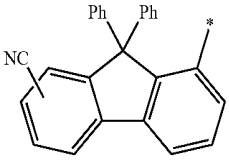

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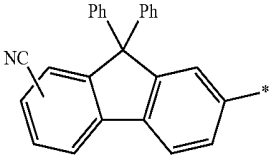

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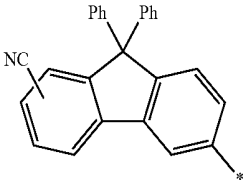

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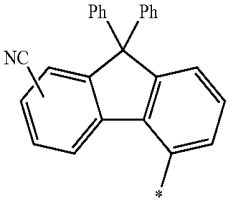

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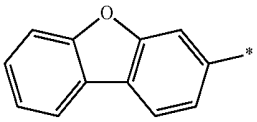

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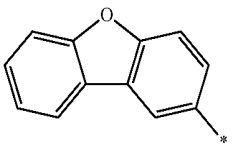

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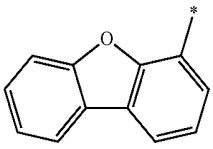

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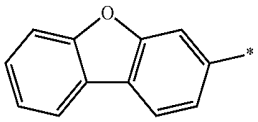

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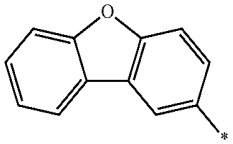

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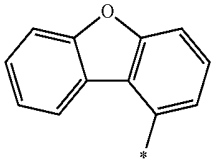

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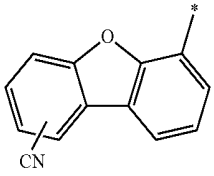

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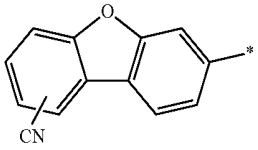

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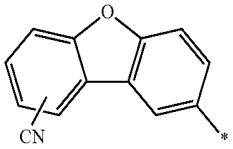

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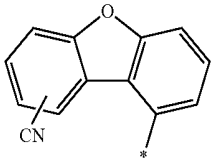

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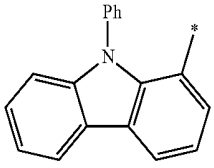

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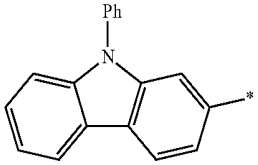

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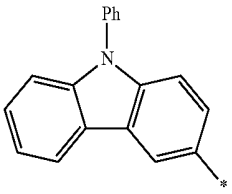

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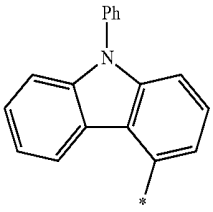

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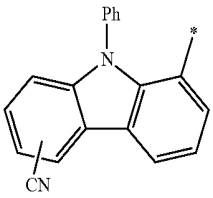

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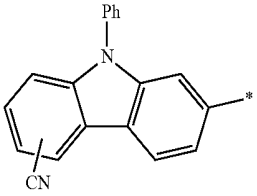

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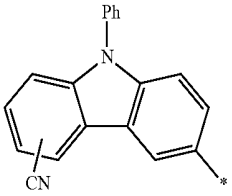

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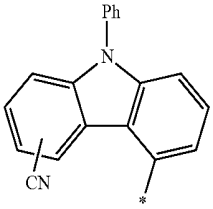

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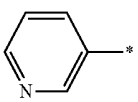

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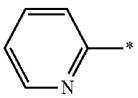

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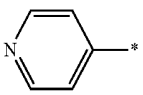

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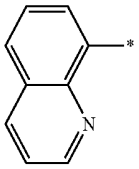

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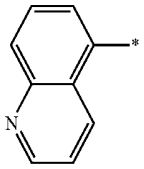

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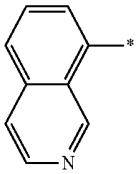

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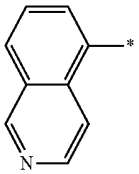

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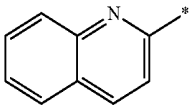

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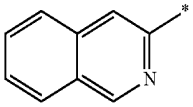

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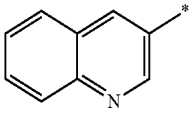

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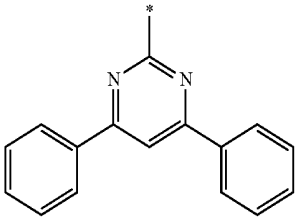

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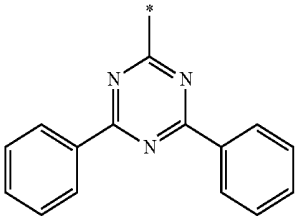

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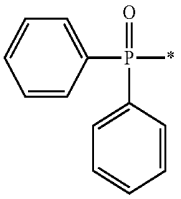

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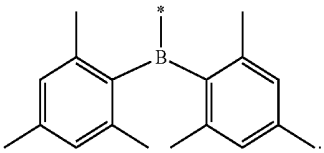


[0088] In Formulae 6-1 to 6-55, Ph indicates a phenyl group, and * indicates a binding site to a neighboring atom.

[0089] c11 in Formula 2 may be 1, 2, 3, or 4.

[0090] In one embodiment, c11 may be 1, 2, or 3, but embodiments of the present disclosure are not limited thereto.

[0091] R_1 in Formula 1 may be selected from —F, a fluorine-containing C_3-C_{60} carbocyclic group, and a fluorine-containing C_1-C_{60} heterocyclic group.

[0092] The fluorine-containing C_3-C_{60} carbocyclic group indicates a group in which a C_3-C_{60} carbocyclic group is substituted with at least one fluoro group (—F), or a C_3-C_{60} carbocyclic group substituted with a C_3-C_{60} carbocyclic group substituted with —F. For example, the fluorine-containing C_3-C_{60} carbocyclic group includes a fluorophenyl group and a fluorobiphenyl group.

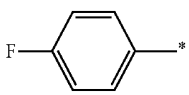
[0093] The fluorine-containing C_1-C_{60} heterocyclic group indicates a group in which a C_1-C_{60} heterocyclic group is substituted with at least one fluoro group (—F), or a C_1-C_{60} heterocyclic group substituted with a C_1-C_{60} heterocyclic group substituted with —F. For example, the fluorine-containing C_1-C_{60} heterocyclic group may include a fluoropyridinyl group and a 6-fluoro-2,2'-bipyridinyl group.

[0094] In one embodiment, R_1 may be selected from —F, a C_3-C_{10} cycloalkyl group substituted with —F, a C_1-C_{10} heterocycloalkyl group substituted with —F, a C_3-C_{10} cycloalkenyl group substituted with —F, a C_1-C_{10} heterocycloalkenyl group substituted with —F, a C_6-C_{60} aryl group substituted with —F, a C_6-C_{60} aryloxy group substituted with —F, a C_6-C_{60} arylthio group substituted with —F, a C_1-C_{60} heteroaryl group substituted with —F, a monovalent non-aromatic condensed polycyclic group substituted with —F, and a monovalent non-aromatic condensed heteropolycyclic group substituted with —F, but embodiments of the present disclosure are not limited thereto.

[0095] For example, R_1 may be selected from —F and a C_6-C_{60} aryl group substituted with —F.

[0096] For example, R_1 may be selected from —F and groups represented by Formulae 7-1 to 7-9:

7-1



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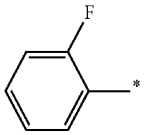

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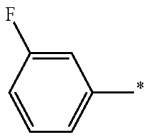

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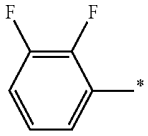

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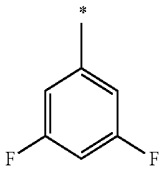

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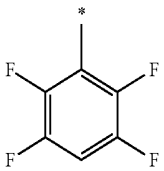

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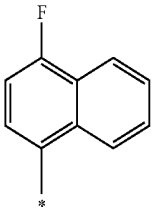

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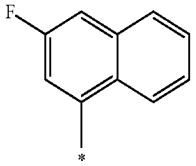

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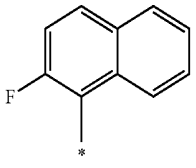


[0097] * in Formulae 7-1 to 7-9 indicates a binding site to a neighboring atom.

[0098] b1 in Formula 1 may be 1, 2, 3, 4, or 5.

[0099] In one embodiment, b1 may be 1, 2, or 3, but embodiments of the present disclosure are not limited thereto.

[0100] For example, b1 may be 1 or 2.

[0101] In Formula 1, R_2 to R_{11} may each independently be selected from a group represented by Formula 2, hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$, and

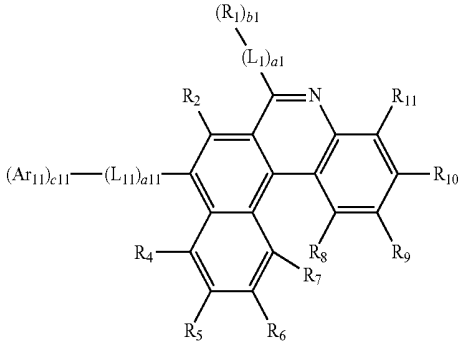
[0102] R_2 and R_3 are not linked to form a ring.

[0103] In one embodiment, at least one of R_2 to R_{11} in Formula 1 may be a group represented by Formula 2.

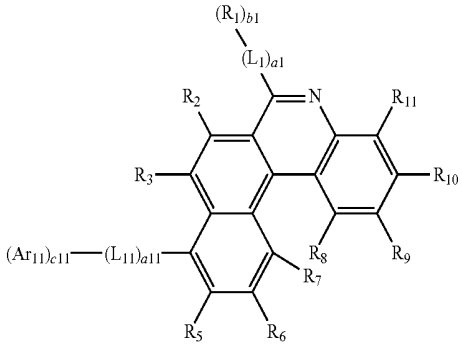
[0104] For example, at least one of R_3, R_4, and R_{10} may be a group represented by Formula 2.

[0105] In one embodiment, the group represented by Formula 1 may be represented by one of Formulae 1-1 to 1-3:

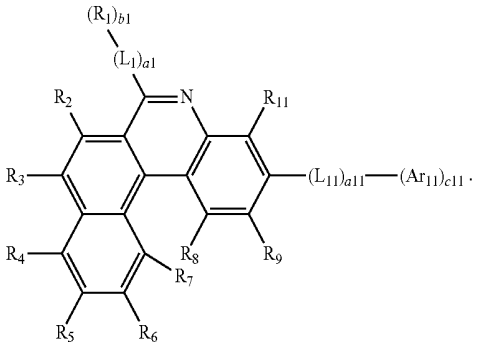
Formula 1-1



Formula 1-2



Formula 1-3



[0106] R_1 to R_{11}, b1, L_1, L_{11}, a1, a11, Ar_{11}, and c11 in Formulae 1-1 to 1-3 are the same as described herein.

[0107] For example, in Formula 1,

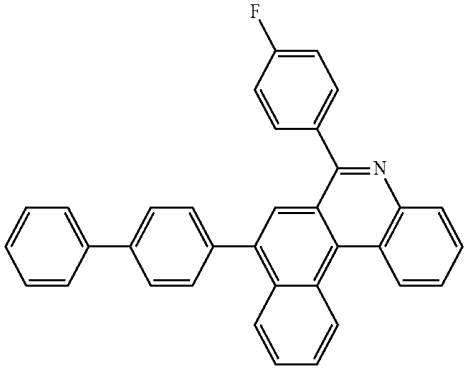
[0108] (i) R_3 may be a group represented by Formula 2, and R_2 and R_4 to R_{11} may each be hydrogen;

[0109] (ii) R_4 may be a group represented by Formula 2, and R_2, R_3, and R_5 to R_{11} may each be hydrogen; or

[0110] (iii) R_{10} may be a group represented by Formula 2, and R_2 to R_9 and R_{11} may each be hydrogen, but embodiments of the present disclosure are not limited thereto.

[0111] The condensed cyclic compound may be selected from Compounds 1 to 106:

1



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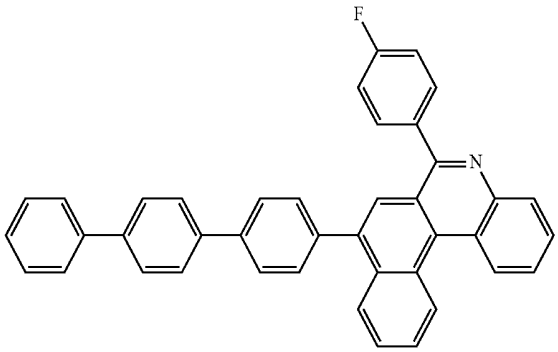

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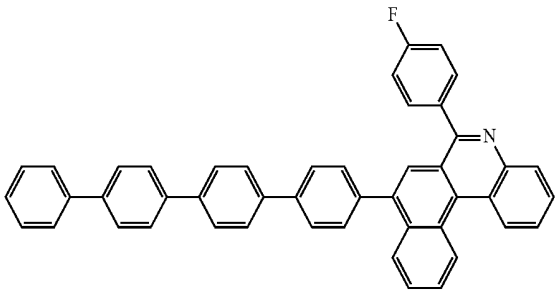

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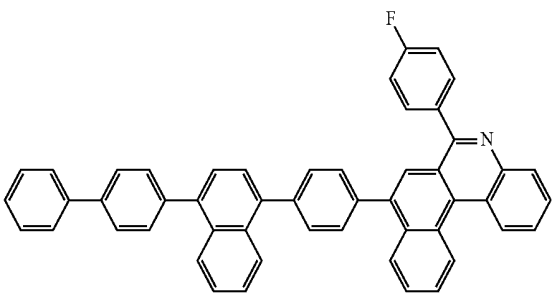

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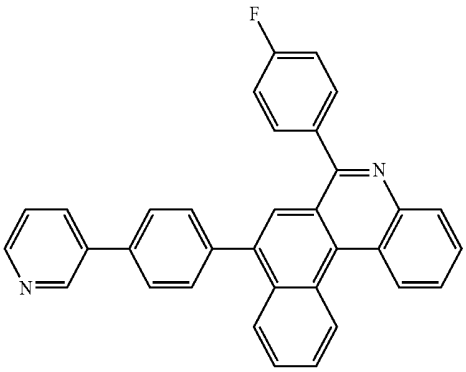

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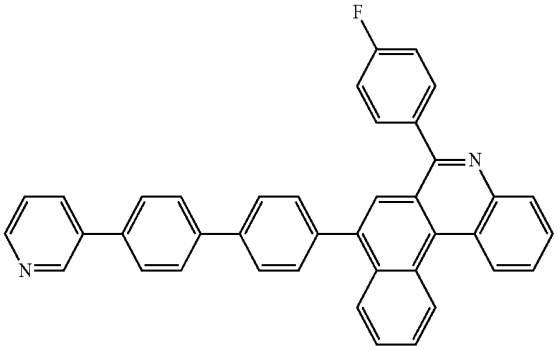

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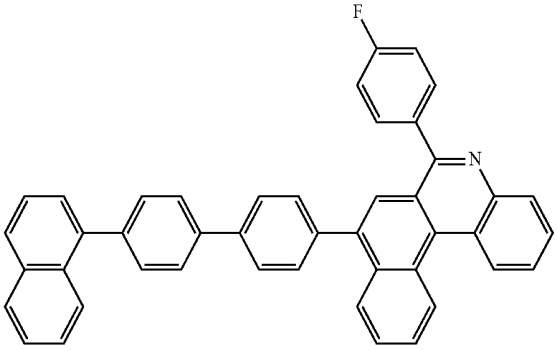

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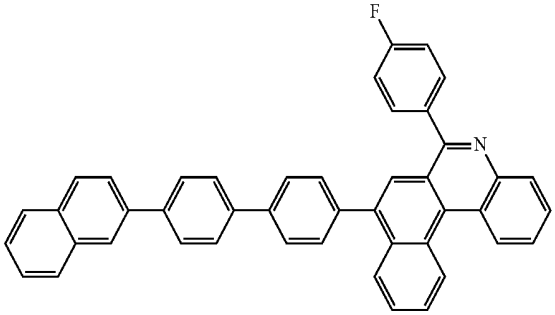

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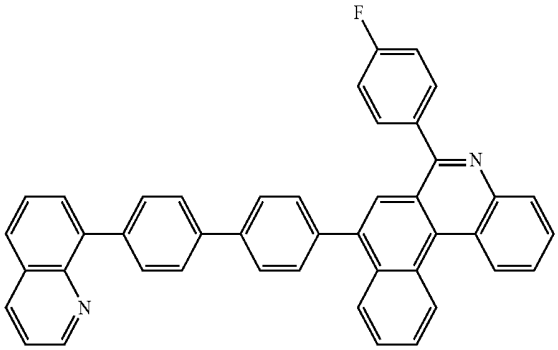

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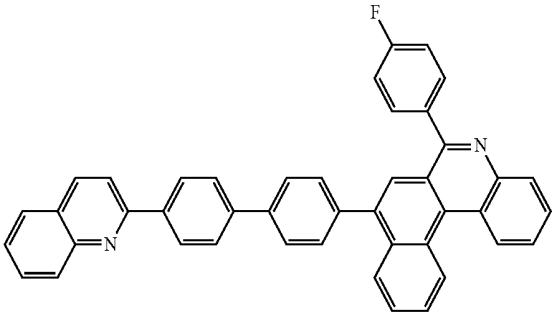

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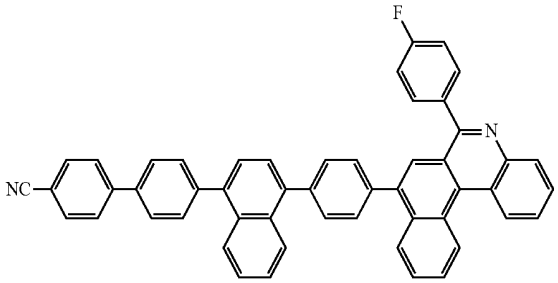

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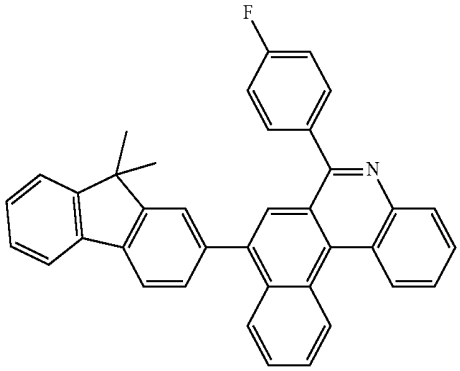

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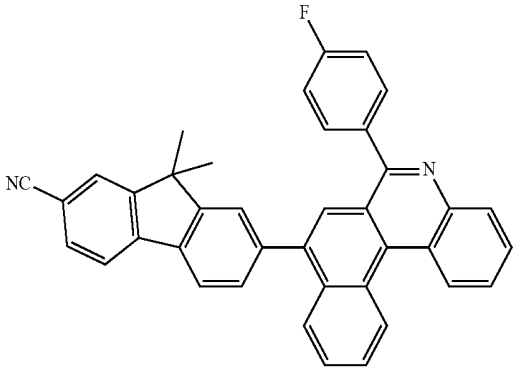

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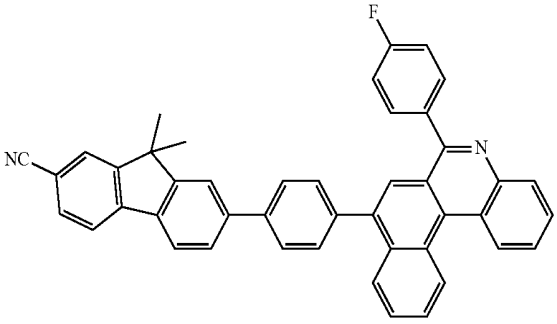

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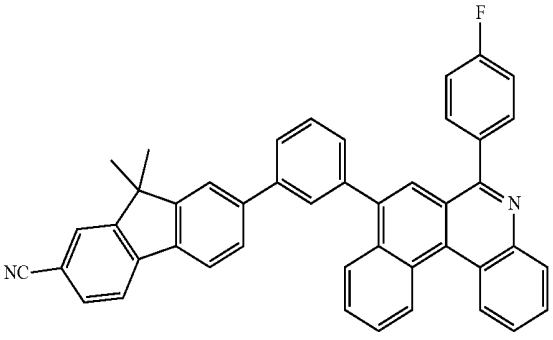

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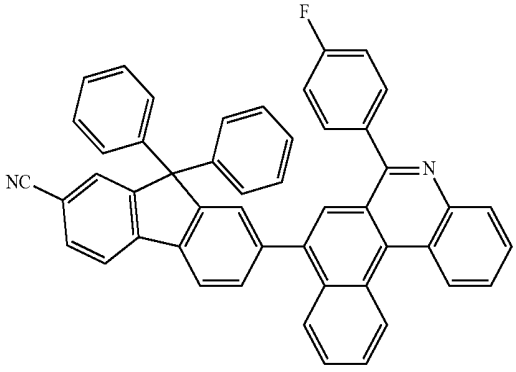

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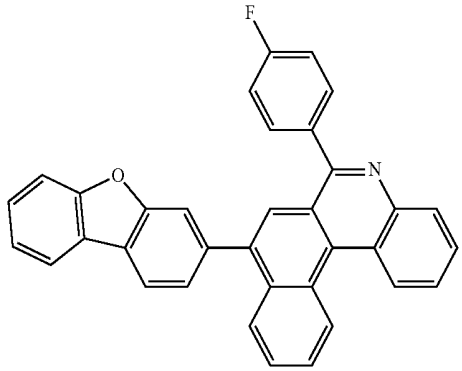

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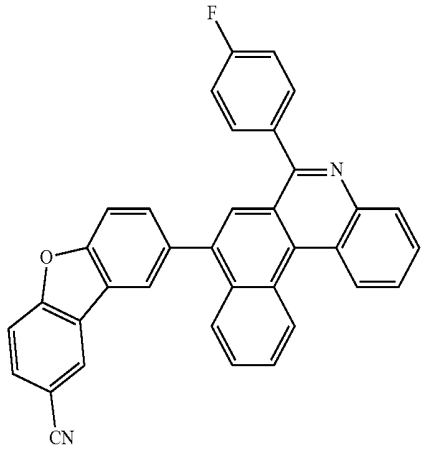

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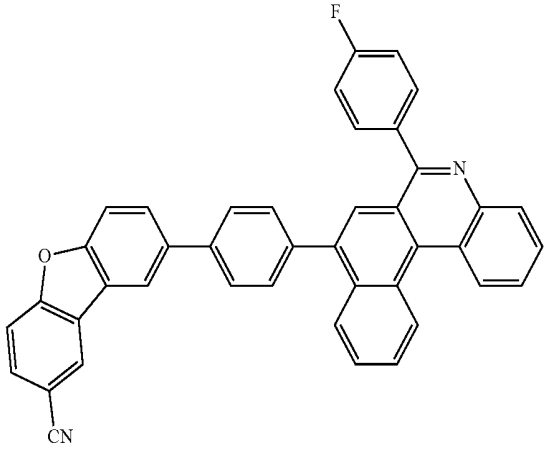

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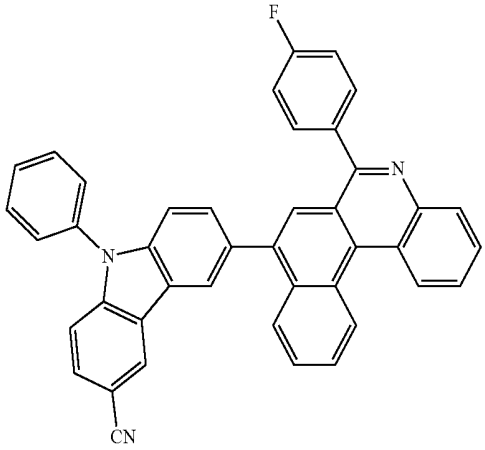

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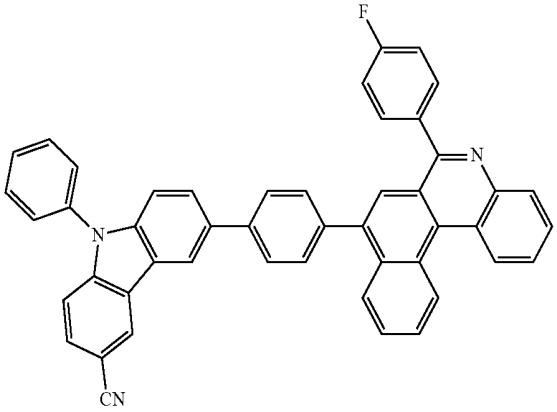

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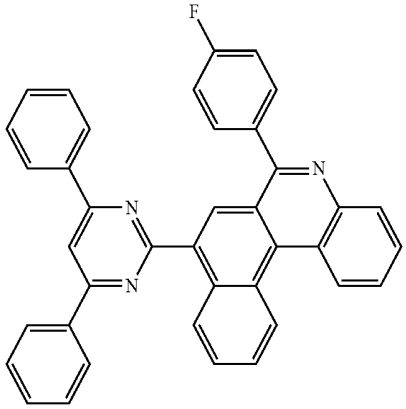

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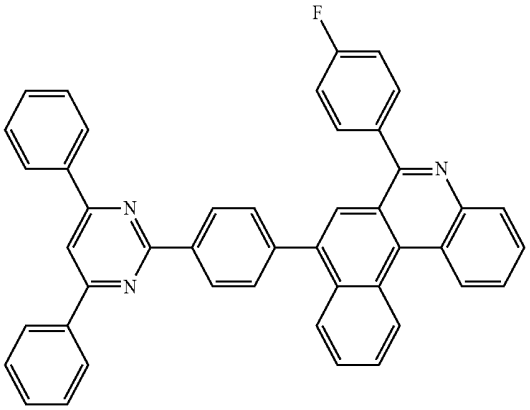

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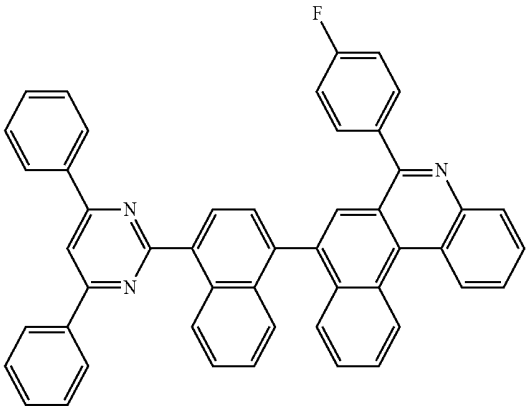

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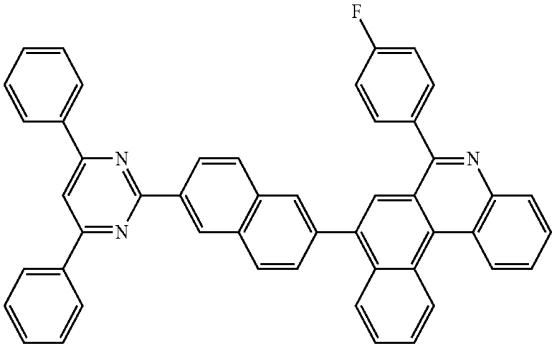

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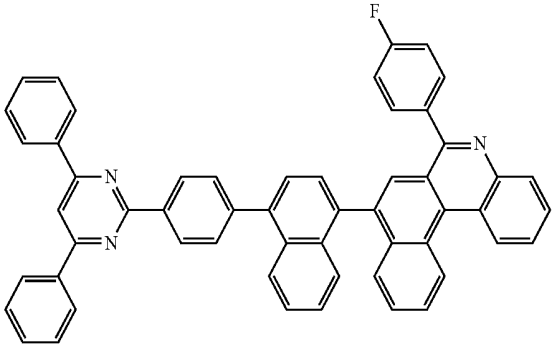

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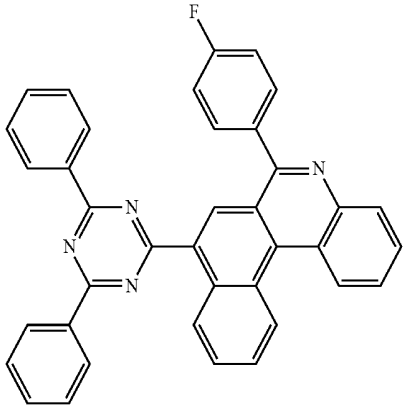

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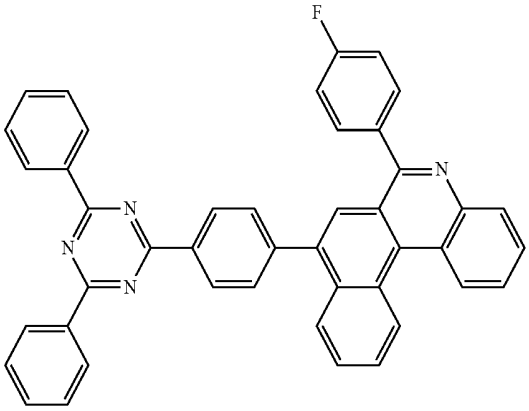

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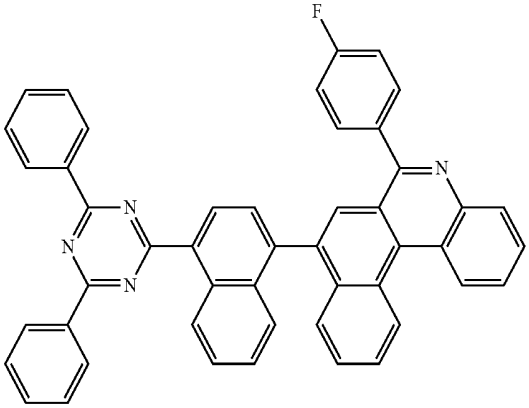

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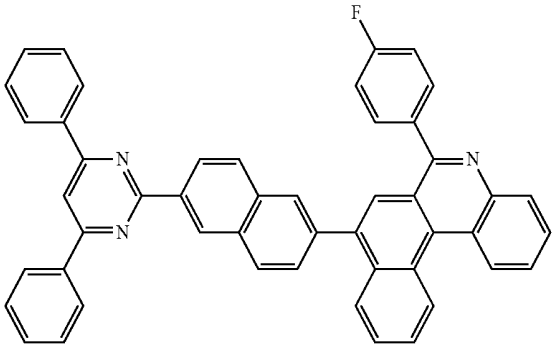

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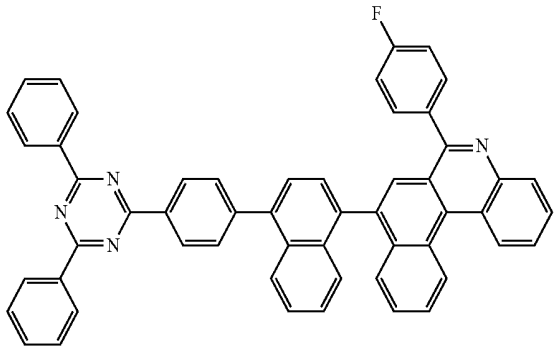

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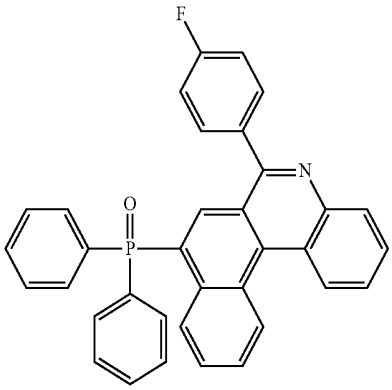

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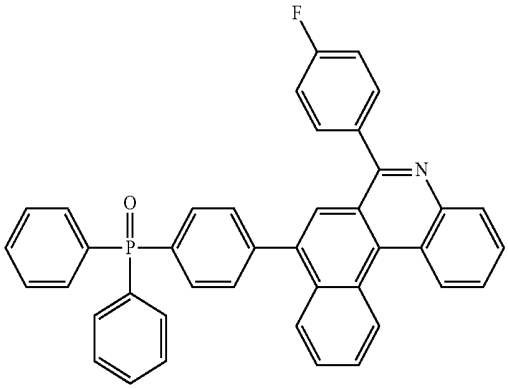

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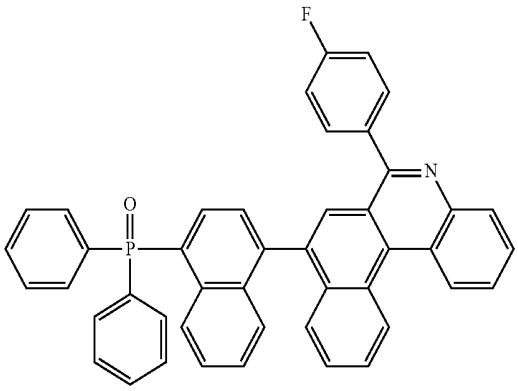

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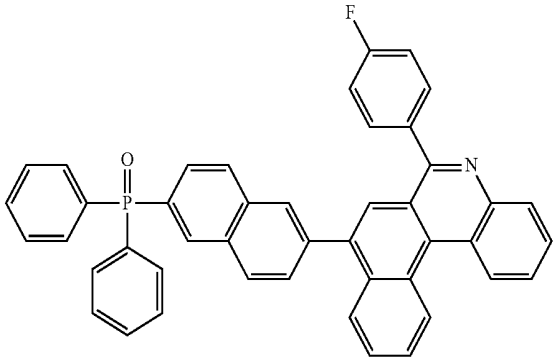

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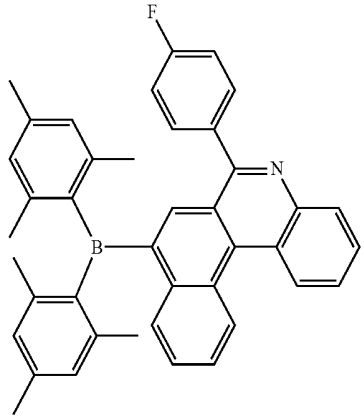

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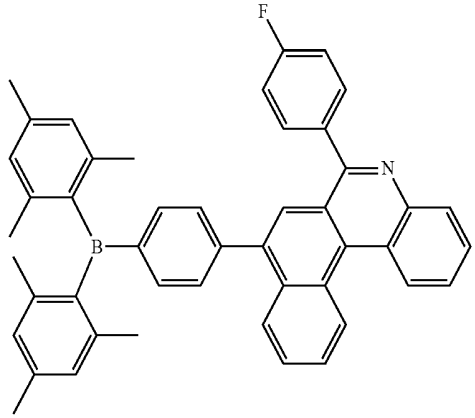

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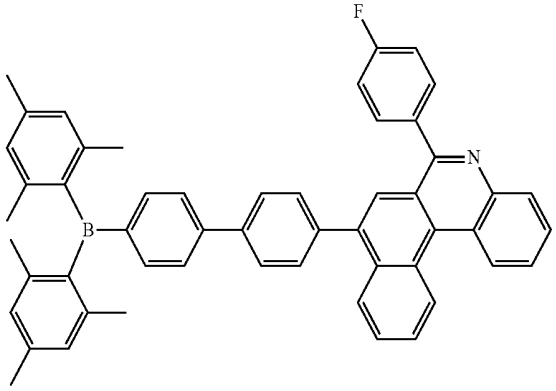

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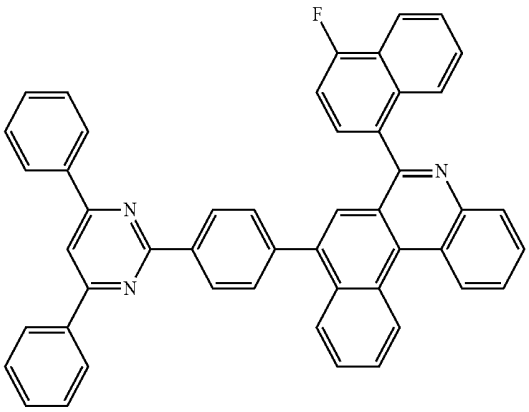

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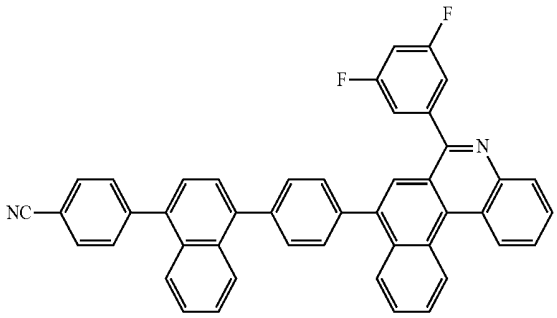

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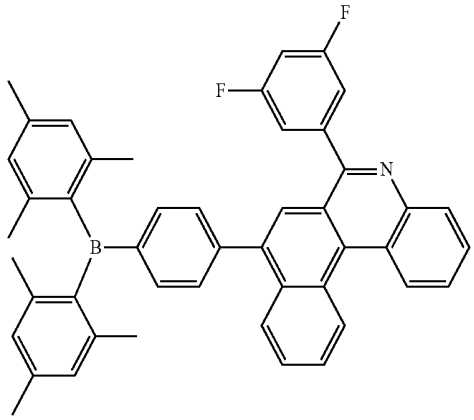

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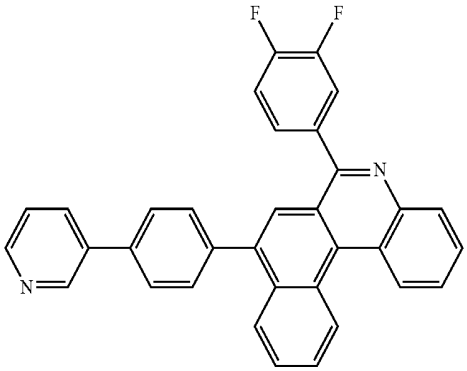

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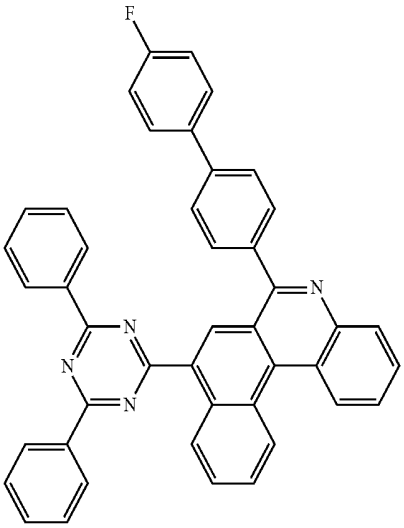

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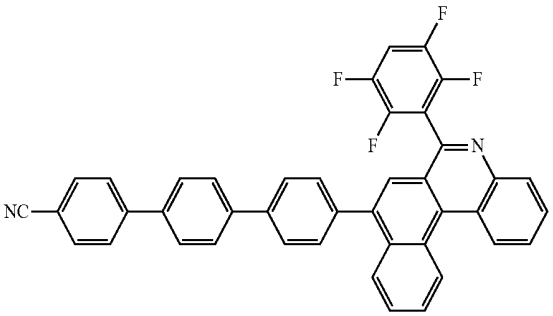

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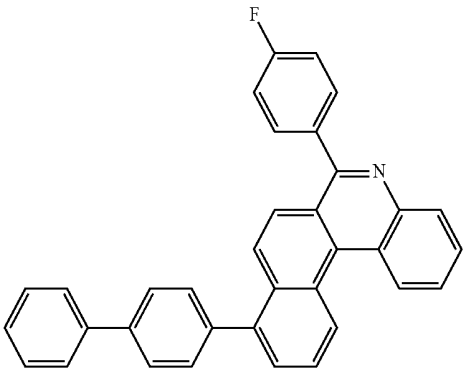

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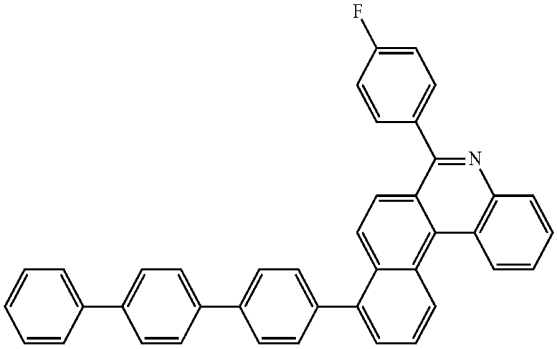

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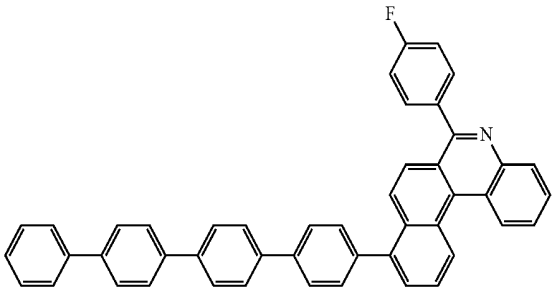

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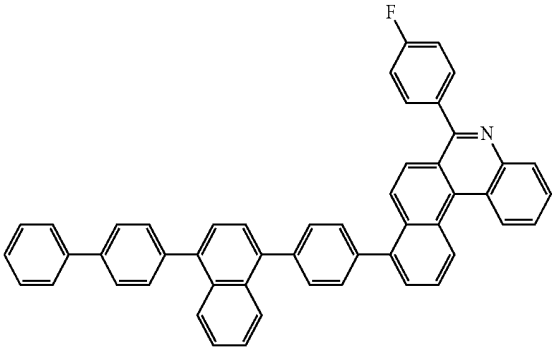

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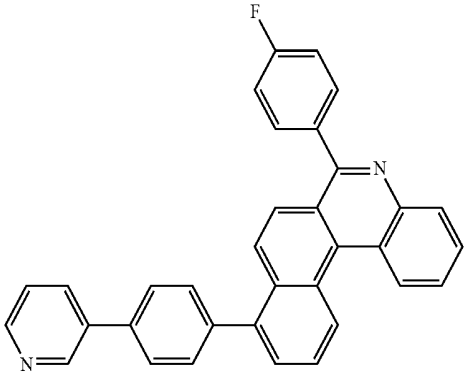

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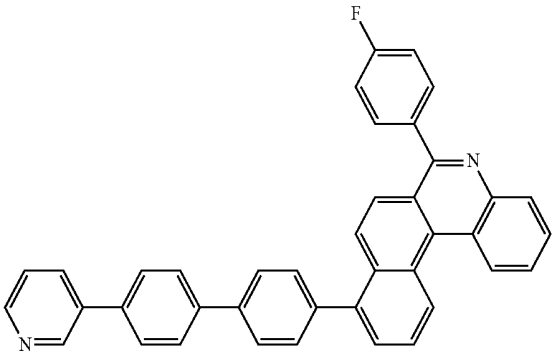

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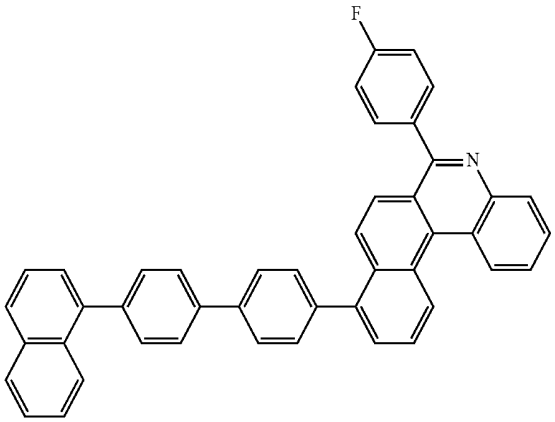

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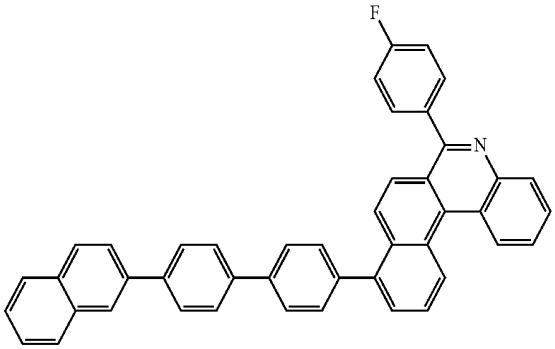

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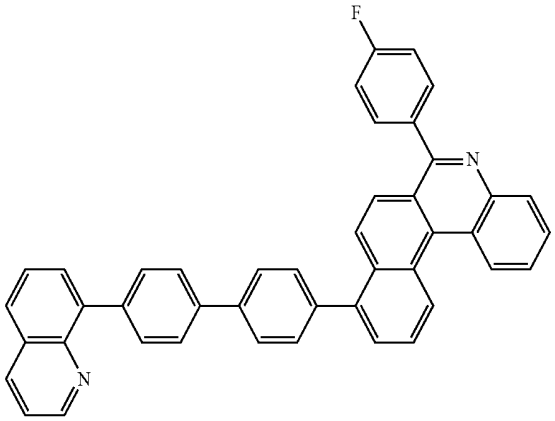

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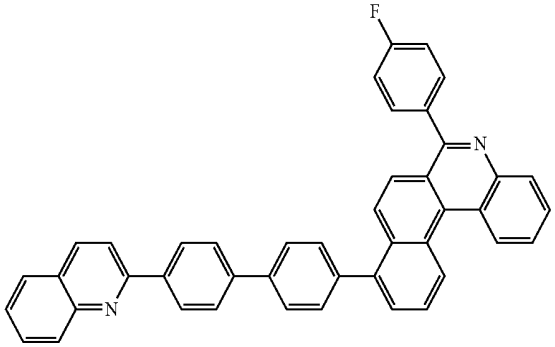

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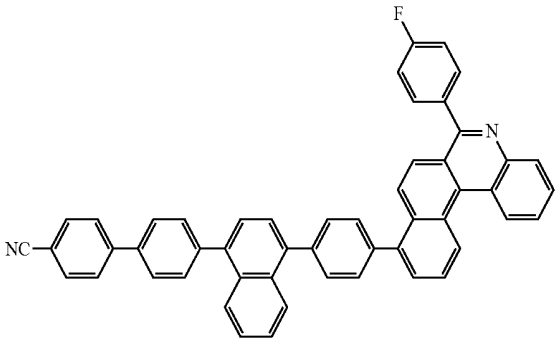

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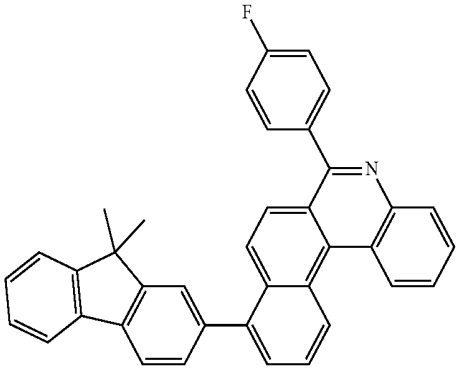

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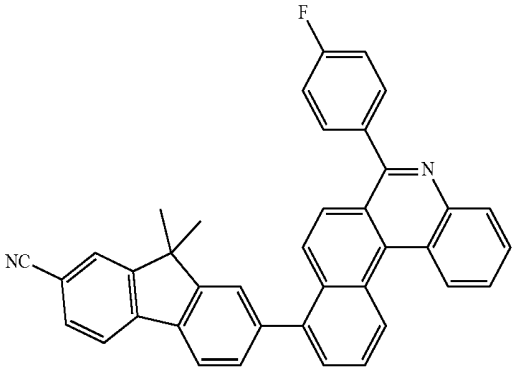

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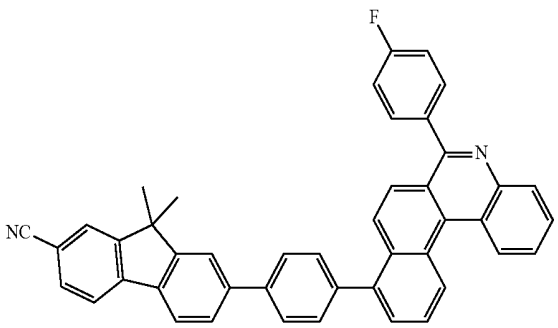

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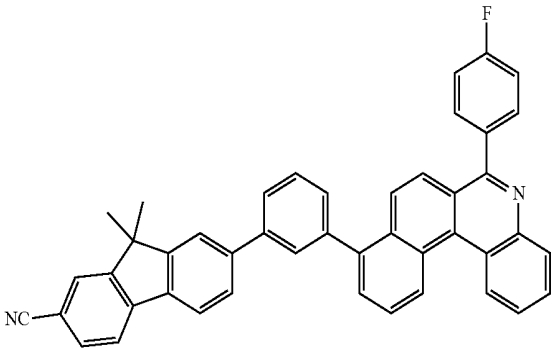

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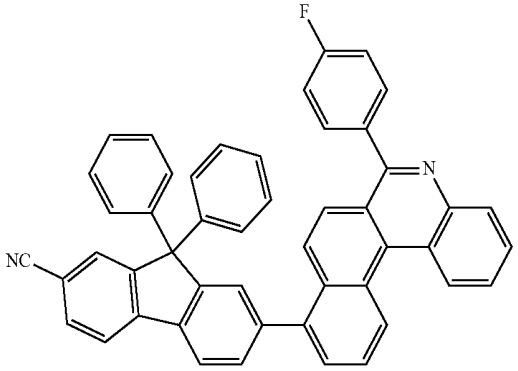

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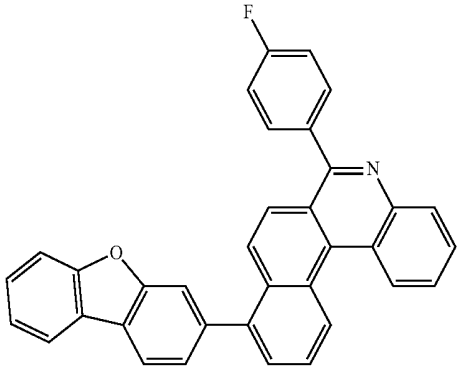

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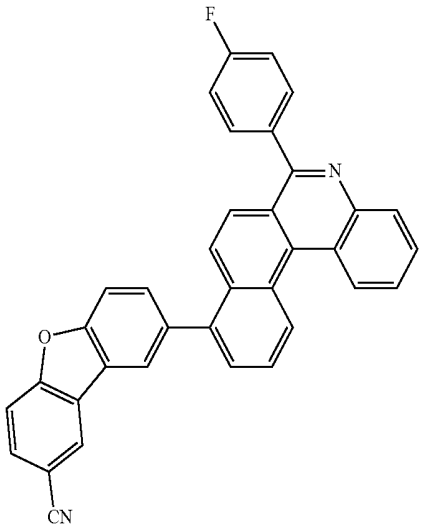

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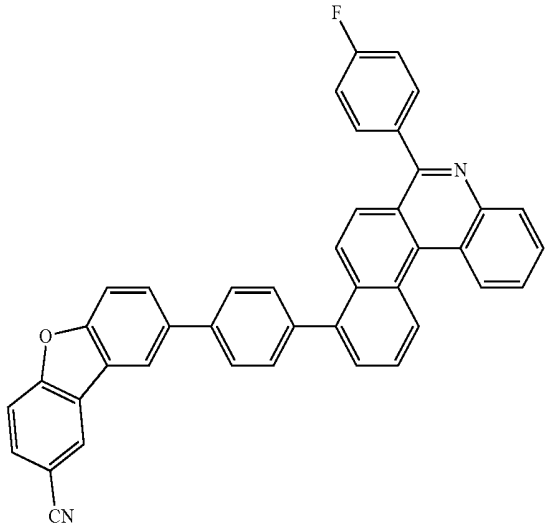

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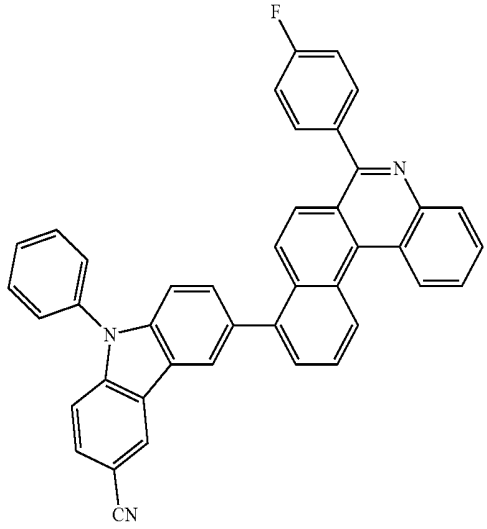

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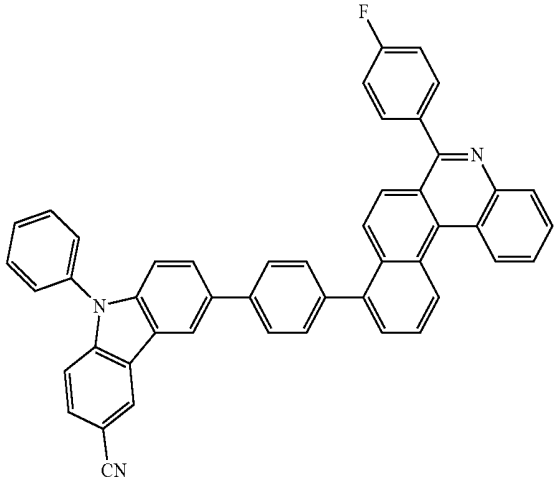

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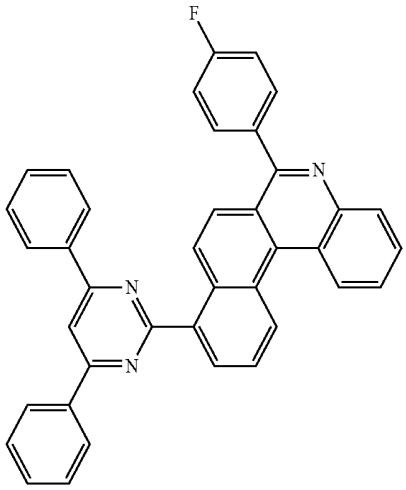

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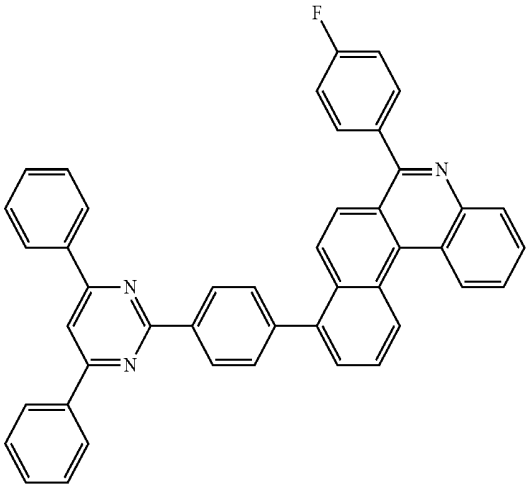

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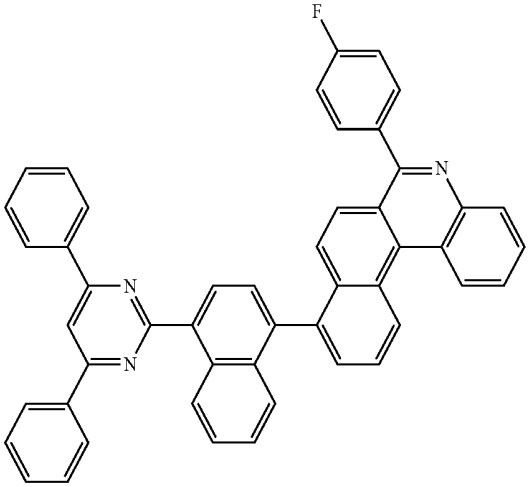

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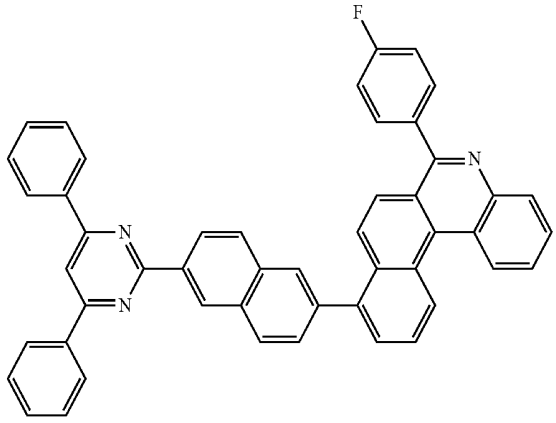

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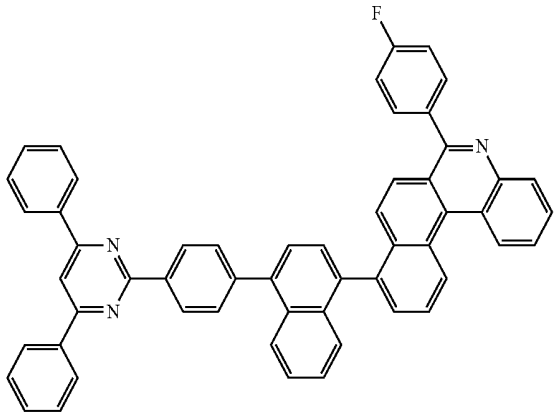

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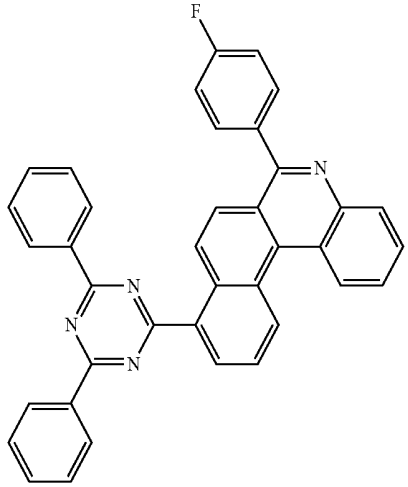

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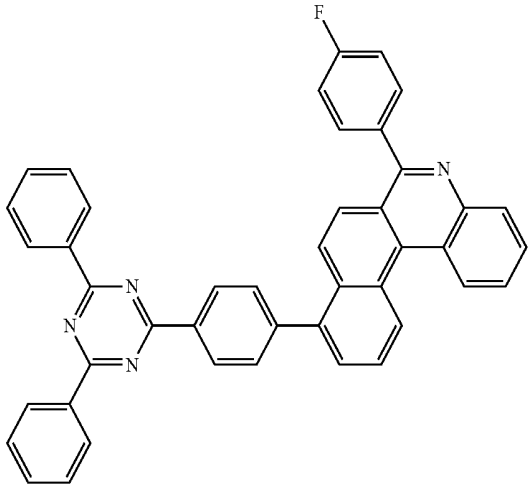

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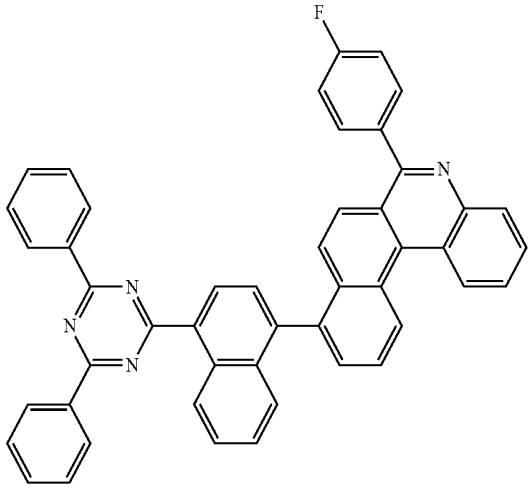

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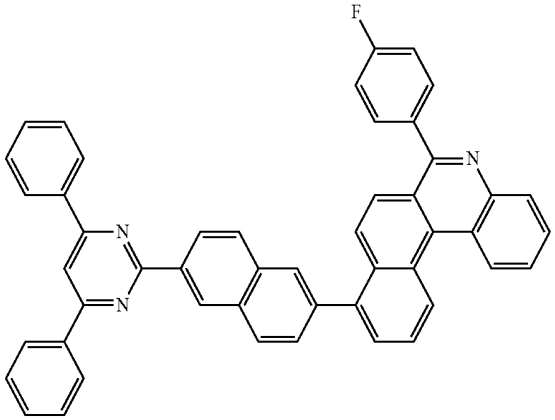

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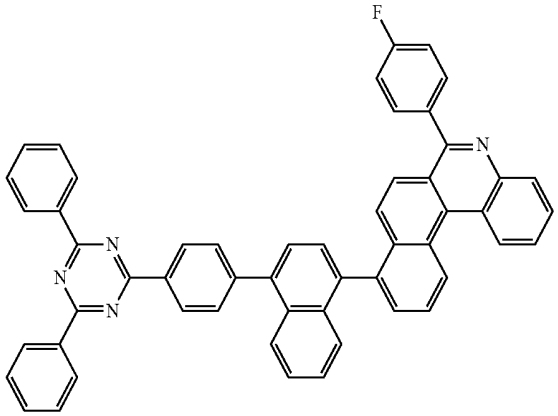

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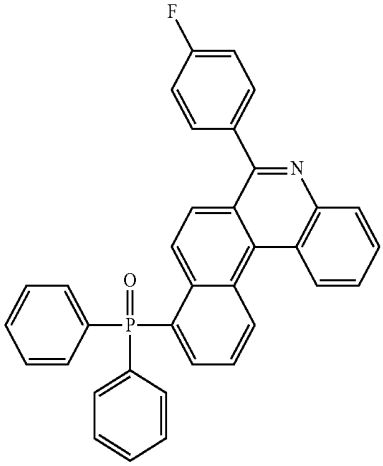

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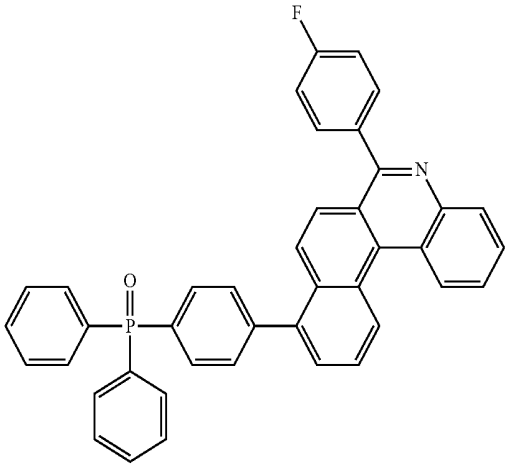

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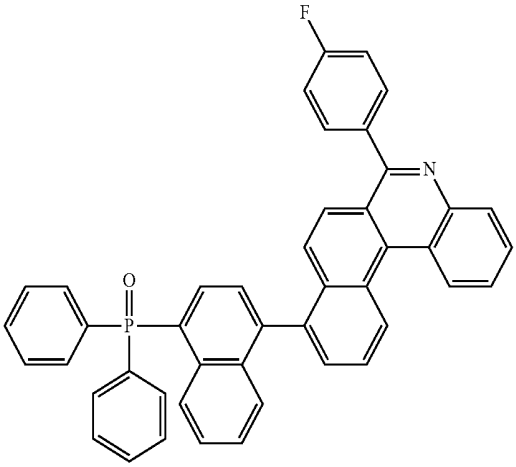

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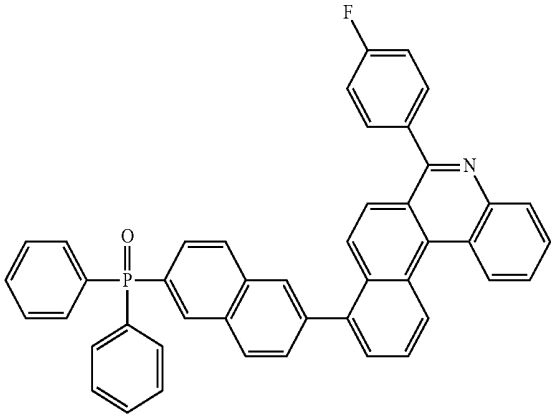

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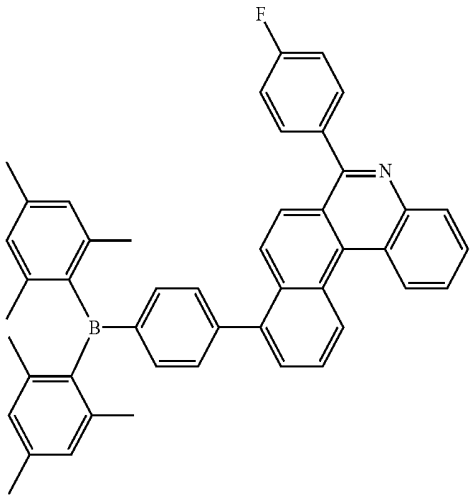

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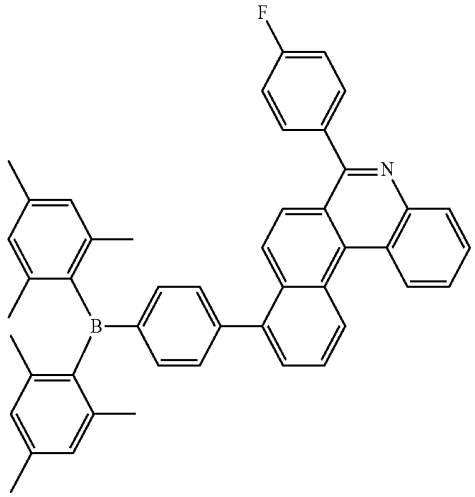

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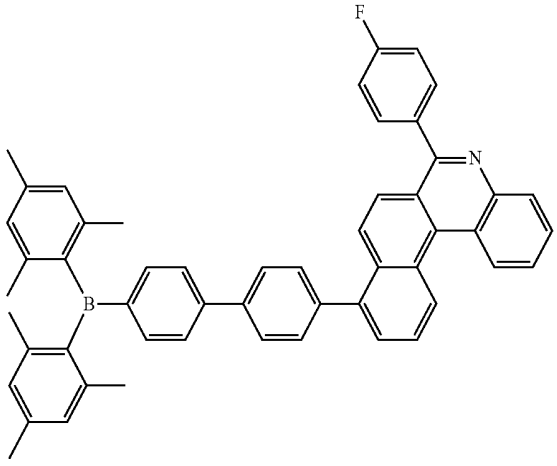

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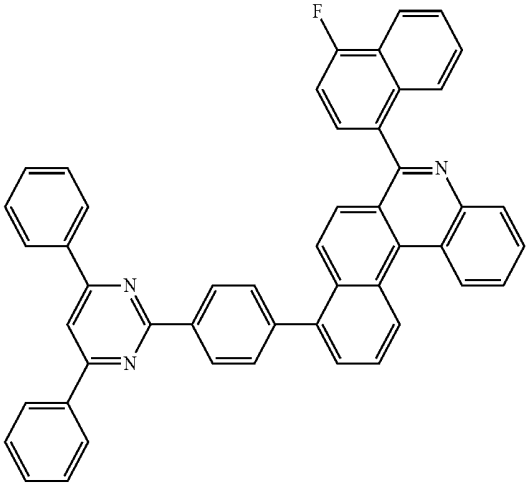

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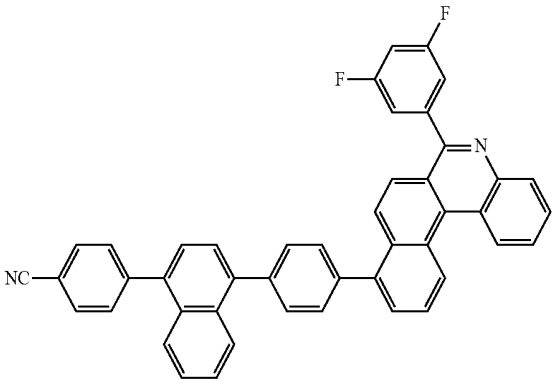

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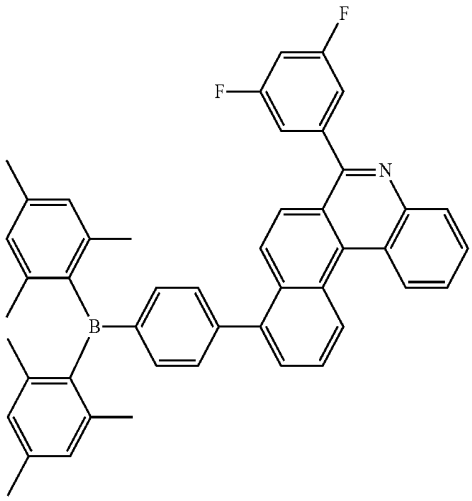

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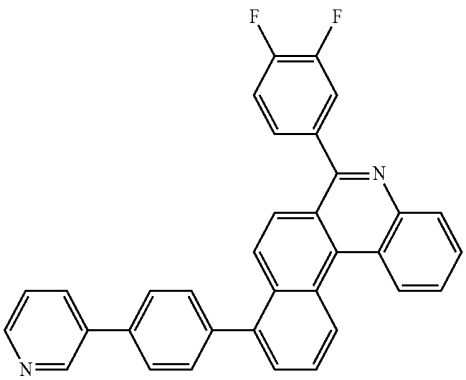

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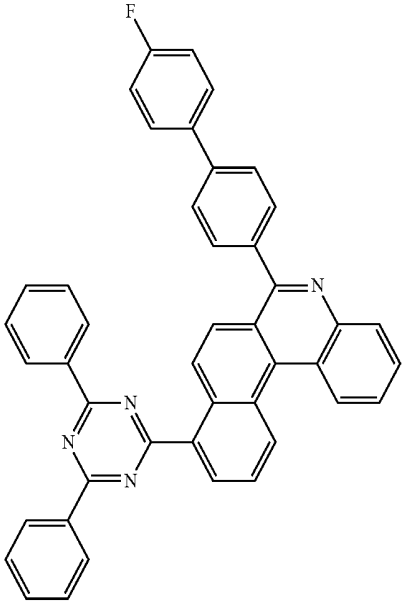

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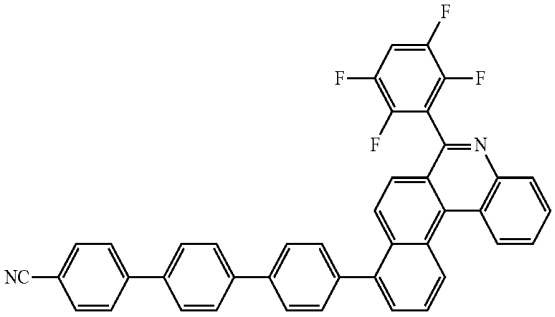

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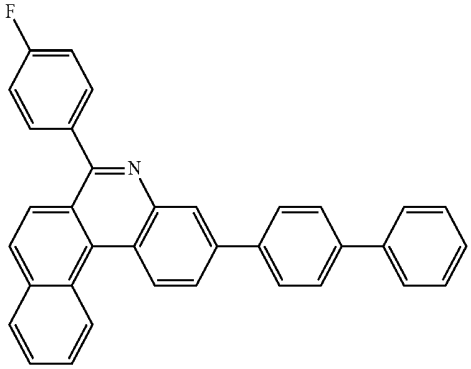

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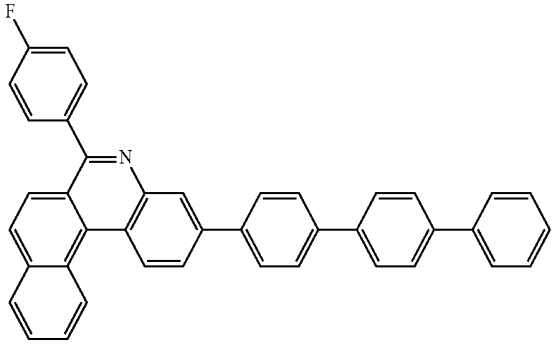

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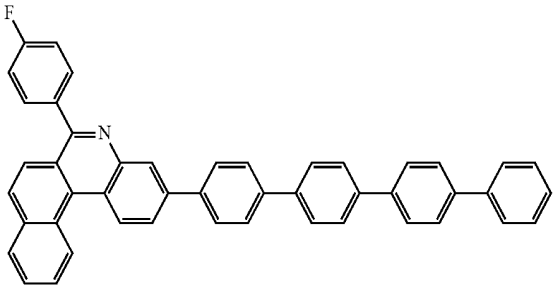

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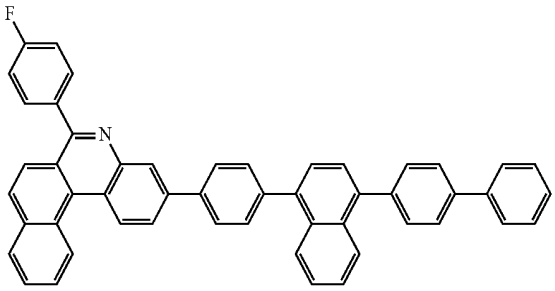

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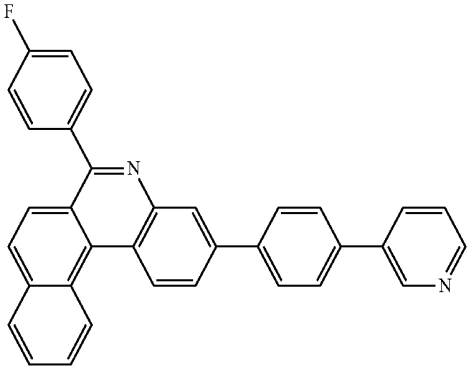

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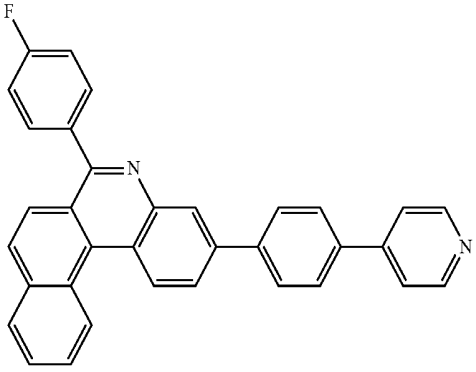

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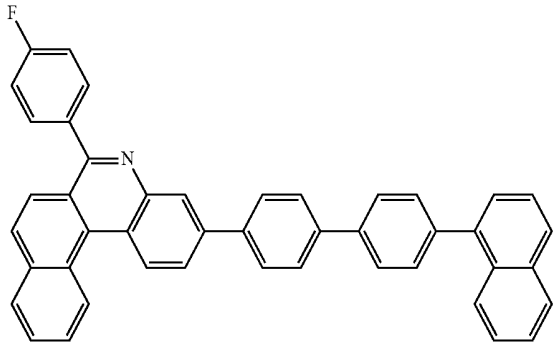

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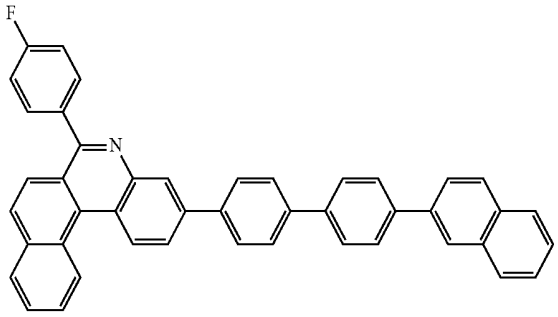

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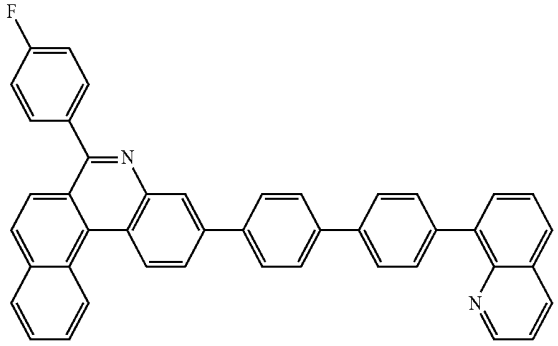

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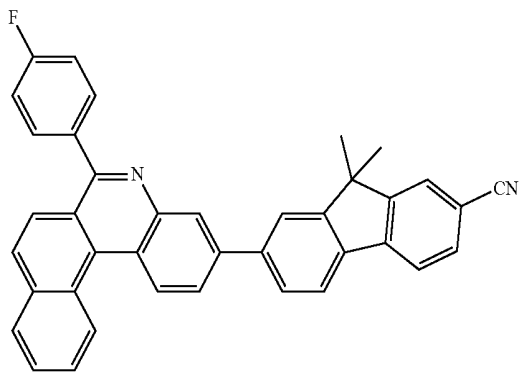

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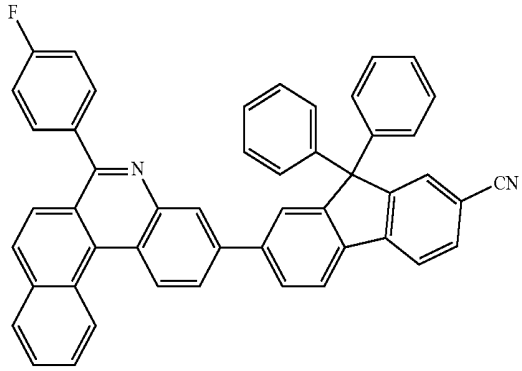

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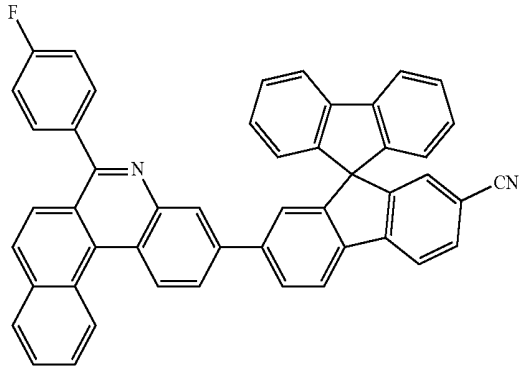

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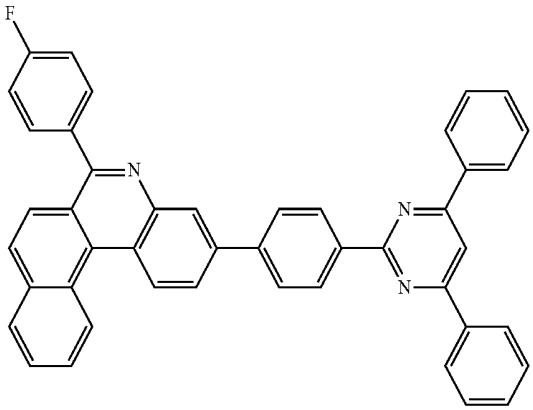

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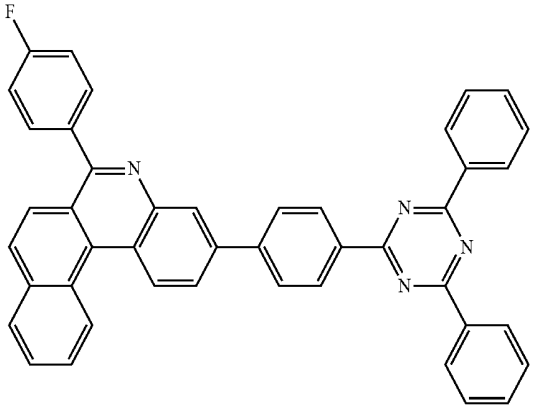

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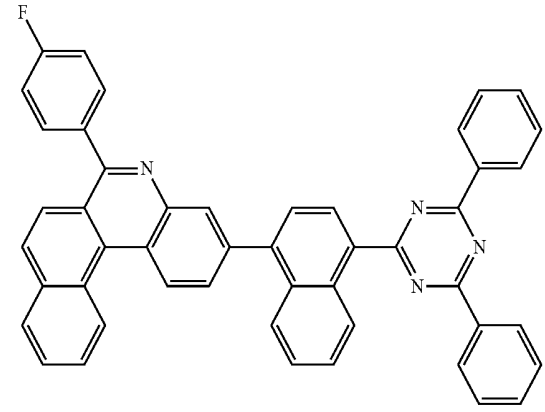

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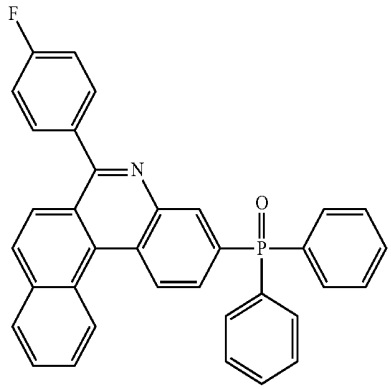

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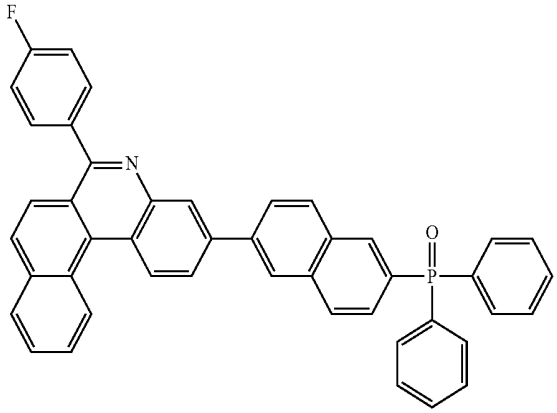

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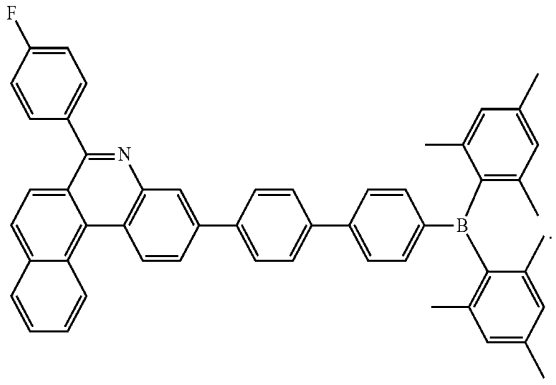


[0112] The condensed cyclic compound includes the structures of Formulae 1 and 2. For example, with the introduction of the nitrogen-containing condensed ring (for example, benzophenanthridine) core, the condensed cyclic compound has stability at high voltage and high temperature. Since at least one electron withdrawing group substituent is included in carbon neighboring to nitrogen in the core, excellent electron injection and transport effects are exhibited by a dipole-dipole interaction principle.

[0113] Also, in the condensed cyclic compound, since a substituent other than hydrogen is linked to another carbon other than the second carbon of the benzophenanthridine core, delocalization and orbital overlap of electrons increase, thereby increasing electron transport capability.

[0114] At least one condensed cyclic compound represented by Formula 1 may be used between a pair of electrodes constituting an organic light-emitting device. For example, the condensed cyclic compound may be included in at least one layer selected from a hole transport region, an electron transport region, and an emission layer. In one or more embodiments, the condensed cyclic compound of Formula 1 may be used as a material for a capping layer located outside a pair of electrodes of an organic light-emitting device.

[0115] Accordingly, provided is an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer, wherein the organic layer includes at least one condensed cyclic compound.

[0116] The expression "(an organic layer) includes at least one condensed cyclic compound" used herein may include a case in which "(an organic layer) includes identical compounds represented by Formula 1" and a case in which "(an organic layer) includes two or more different condensed cyclic compounds."

[0117] For example, in some embodiments, the first electrode is an anode and the second electrode is a cathode, and the organic layer includes a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode, and the hole transport region includes a hole injection layer, a hole transport layer, a buffer layer, an electron blocking layer, or any combination thereof, and the electron transport region includes a buffer layer, a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof.

[0118] In one embodiment, the electron transport region may include at least one of the condensed cyclic compounds.

[0119] In one or more embodiments, the electron transport region may include an electron transport layer and an electron injection layer, and the electron transport layer may include at least one condensed cyclic compound.

[0120] In one or more embodiments, the hole transport region may include a p-dopant, and the p-dopant may have a lowest unoccupied molecular orbital (LUMO) energy level (eV) of −3.5 eV or less.

[0121] For example, the p-dopant may include a cyano group-containing compound.

[0122] The host in the emission layer may include at least one selected from a pyrene-containing compound, an arylamine-based compound, and a styryl-based compound, but embodiments of the present disclosure are not limited thereto.

[0123] In the organic light-emitting device, the emission layer may be a first emission layer for emitting first color light,

[0124] between the first electrode and the second electrode, i) at least one second emission layer for emitting second color light may be further included, or ii) at least one second emission layer for emitting second color light and at least one third emission layer for emitting third color light may be further included,

[0125] a maximum emission wavelength of the first color light, a maximum emission wavelength of the second color light, and a maximum emission wavelength of the third color light are identical to or different from each other, and

[0126] the first color light and the second color light are emitted in the form of mixed light, or the first color light, the second color light, and the third color light are emitted in the form of mixed light.

[0127] The organic light-emitting device may further include at least one selected from a first capping layer disposed in a pathway along which light generated in an emission layer proceeds toward the outside through the first electrode and a second capping layer disposed in a pathway along which light generated in an emission layer proceeds toward the outside through the second electrode, and the at least one selected from the first capping layer and the second capping layer may include at least one condensed cyclic compound represented by Formula 1.

[0128] For example, the organic light-emitting device may have i) a stacked structure including a first electrode, an organic layer, a second electrode, and a second capping layer which are sequentially stacked in this stated order, ii) a stacked structure including a first capping layer, a first electrode, an organic layer, and a second electrode which are sequentially stacked in this stated order, or iii) a stacked structure including a first capping layer, a first electrode, an organic layer, a second electrode, and a second capping layer which are sequentially stacked in this stated order, and at least one selected from the first capping layer and the second capping layer may include the condensed cyclic compound.

[0129] In one embodiment, there is provided an electronic device including a thin film transistor and the organic light-emitting device, wherein the thin film transistor may include a source electrode, a drain electrode, an activation layer, and a gate electrode, and the first electrode of the organic light-emitting device may be electrically coupled with or electrically connected with at least one of the source electrode and the drain electrode of the thin film transistor.

[0130] The thin film transistor may include a source electrode, a drain electrode, an activation layer, and a gate electrode.

[0131] In one embodiment, there is provided an electronic device in which the first electrode of the organic light-emitting device is electrically coupled to or electrically connected to one of the source electrode and the drain electrode of the thin film transistor

[0132] The term "organic layer," as used herein, refers to a single layer and/or a plurality of layers disposed between the first electrode and the second electrode of the organic light-emitting device. A material included in the "organic layer" is not limited to an organic material.

Description of FIG. **1**

[0133] FIG. **1** is a schematic view of an organic light-emitting device **10** according to an embodiment. The organic light-emitting device **10** includes a first electrode **110**, an organic layer **150**, and a second electrode **190**.

[0134] Hereinafter, the structure of the organic light-emitting device **10** according to an embodiment and a method of manufacturing the organic light-emitting device **10** will be described in connection with FIG. **1**.

First Electrode **110**

[0135] 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 plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0136] 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 a first electrode may be selected from materials with a high work function to facilitate hole injection.

[0137] The first electrode **110** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. When the first electrode **110** is a transmissive electrode, a material for forming a first electrode may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), zinc oxide (ZnO), and any combinations thereof, but embodiments of the present disclosure are not limited thereto. In one or more embodiments, when the first electrode **110** is a semi-transmissive electrode or a reflectable electrode, a material for forming a first electrode may be selected from magnesium (Mg), silver (Ag), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), and any combinations thereof, but embodiments of the present disclosure are not limited thereto.

[0138] The first electrode **110** may have a single-layered structure, or a multi-layered structure including two or more layers. For example, the first electrode **110** may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode **110** is not limited thereto.

Organic Layer **150**

[0139] The organic layer **150** is disposed on the first electrode **110**. The organic layer **150** may include an emission layer.

[0140] The organic layer **150** may further include a hole transport region between the first electrode **110** and the emission layer, and an electron transport region between the emission layer and the second electrode **190**.

Hole Transport Region in Organic Layer **150**

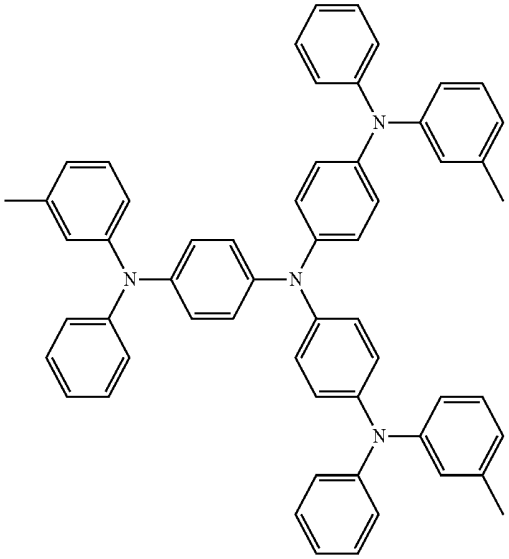
[0141] The hole transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0142] The hole transport region may include at least one layer selected from a hole injection layer, a hole transport layer, an emission auxiliary layer, and an electron blocking layer.

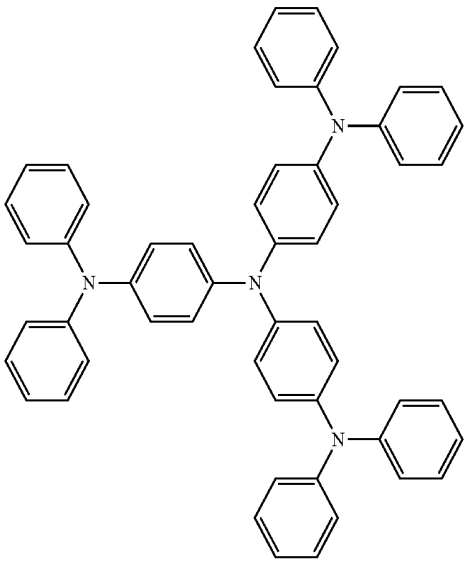
[0143] For example, the hole transport region may have a single-layered structure including a single layer including a

plurality of different materials, or a multi-layered structure having a hole injection layer/hole transport layer structure, a hole injection layer/hole transport layer/emission auxiliary layer structure, a hole injection layer/emission auxiliary layer structure, a hole transport layer/emission auxiliary layer structure, or a hole injection layer/hole transport layer/electron blocking layer structure, wherein for each structure, constituting layers are sequentially stacked from the first electrode **110** in this stated order, but the structure of the hole transport region is not limited thereto.

[0144] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB (NPD), β-NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-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, and a compound represented by Formula 202:



m-MTDATA



TDATA

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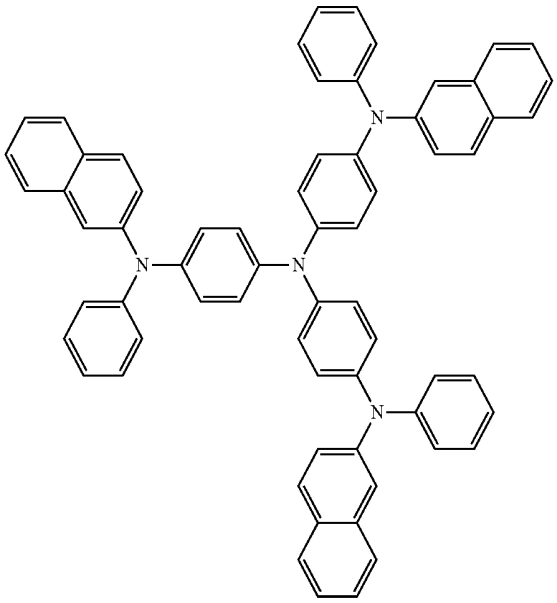
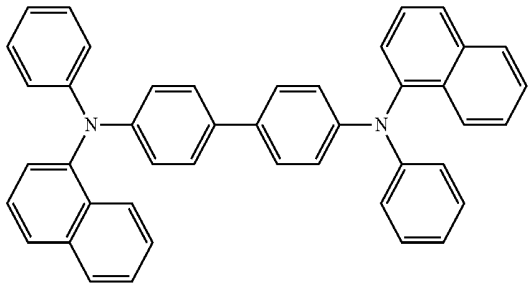
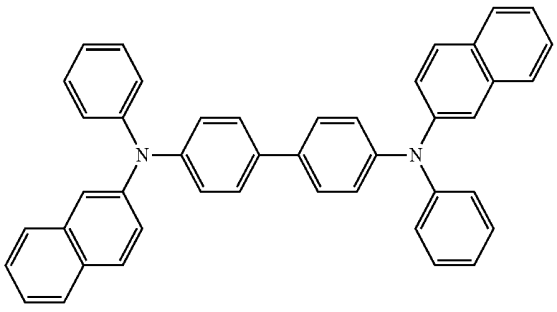


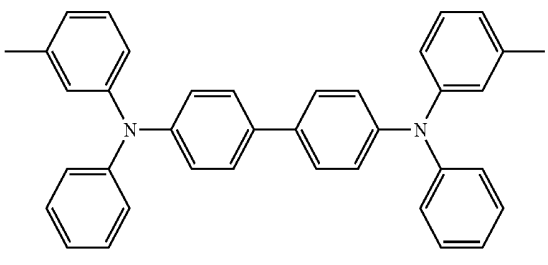
2-TNATA



NPB



β-NPB



TPD

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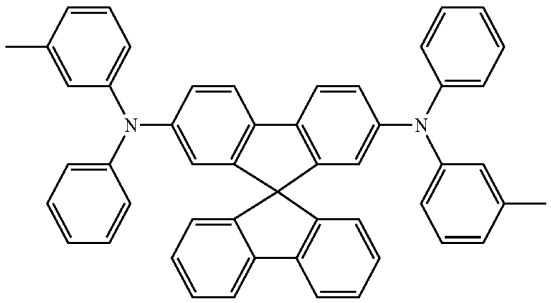
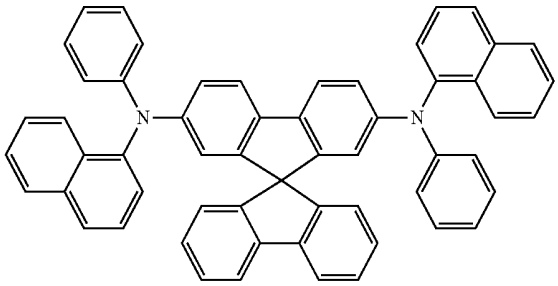
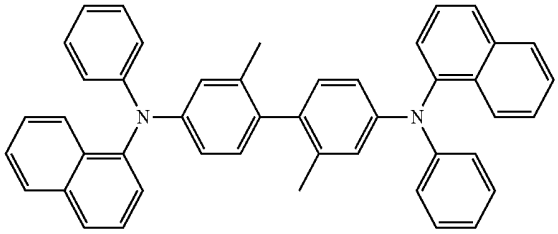


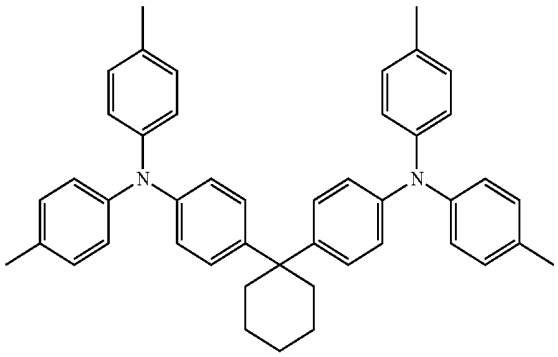
Spiro-TPD



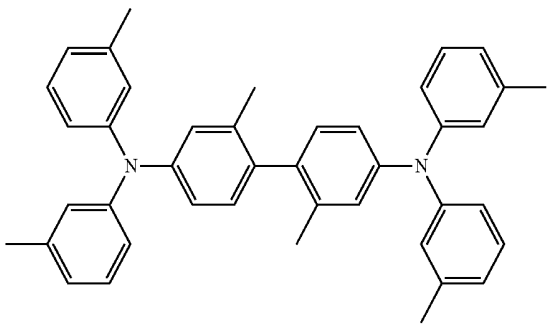
Spiro-NPB



methylated NPB



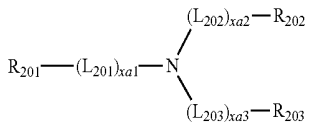
TAPC



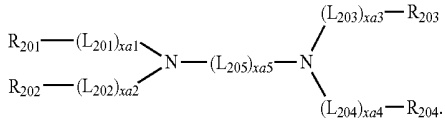
HMTPD

-continued

Formula 201



Formula 202



[0145] In Formulae 201 and 202,

[0146] L_{201} to L_{204} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0147] L_{205} may be selected from *—O—*', *—S—*', *—N(Q_{201})-*', a substituted or unsubstituted C_1-C_{20} alkylene group, a substituted or unsubstituted C_2-C_{20} alkenylene group, a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0148] xa1 to xa4 may each independently be an integer from 0 to 3,

[0149] xa5 may be an integer from 1 to 10, and

[0150] R_{201} to R_{204} and Q_{201} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0151] For example, in Formula 202, R_{201} and R_{202} may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group, and R_{203} and

[0152] R_{204} may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group.

[0153] In one or more embodiments, regarding Formulae 201 and 202,

[0154] L_{201} to L_{205} may each independently be selected from:

[0155] 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-bifluorenylene 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 thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group; and

[0156] 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-bifluorenylene 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 thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, 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 biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with —F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, and —$N(Q_{31})(Q_{32})$, and

[0157] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0158] In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

[0159] In one or more embodiments, xa5 may be 1, 2, 3, or 4.

[0160] In one or more embodiments, R_{201} to R_{204} and Q_{201} may each independently be selected from:

[0161] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and

[0162] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, 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 biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with —F, a pentalenyl group, an indenyl group, a naphthyl

group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$ and —$N(Q_{31})(Q_{32})$, and

[0163] Q_{31} to Q_{33} may be the same as described above.

[0164] In one or more embodiments, in Formula 201, at least one of R_{201} to R_{203} may each independently be selected from:

[0165] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

[0166] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, 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 biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with —F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

[0167] but embodiments of the present disclosure are not limited thereto.

[0168] In one or more embodiments, in Formula 202, i) R_{201} and R_{202} may be linked via a single bond and/or ii) R_{203} and R_{204} may be linked via a single bond.

[0169] In one or more embodiments, in Formula 202, at least one of R_{201} to R_{204} may be selected from:

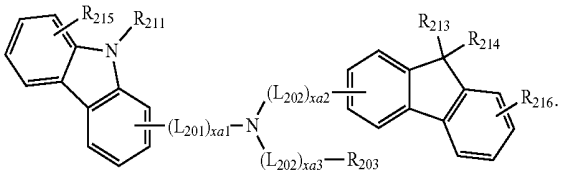
[0170] a carbazolyl group; and

[0171] a carbazolyl group substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, 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 biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with —F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,

[0172] but embodiments of the present disclosure are not limited thereto.

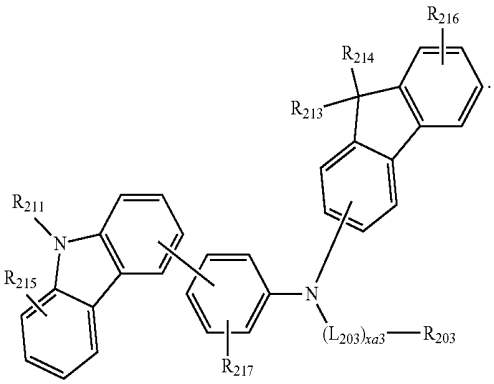
[0173] The compound represented by Formula 201 may be represented by Formula 201A:

Formula 201A



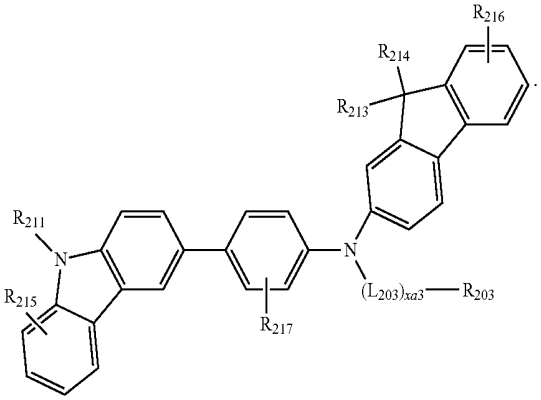
[0174] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A(1) below, but embodiments of the present disclosure are not limited thereto:

Formula 201A(1)



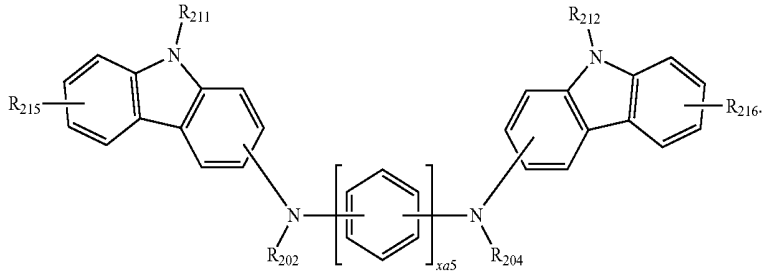
[0175] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A-1 below, but embodiments of the present disclosure are not limited thereto:

Formula 201A-1



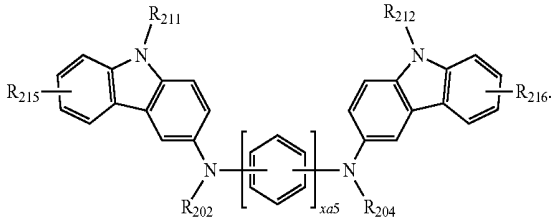
[0176] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A:

Formula 202A



[0177] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A-1:

Formula 202A-1



[0178] In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

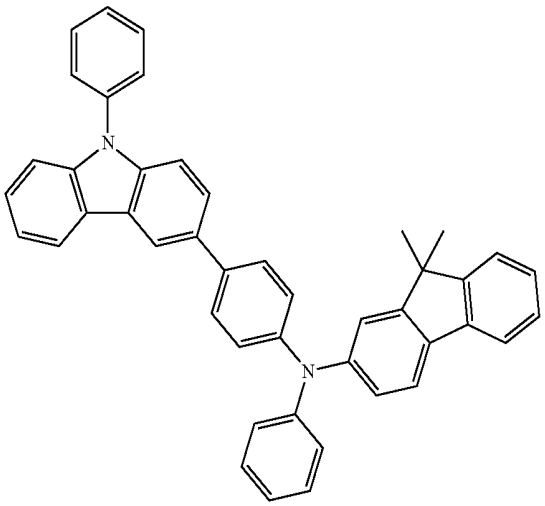
[0179] L_{201} to L_{203}, xa1 to xa3, xa5, and R_{202} to R_{204} may be the same as described above,

[0180] R_{211} and R_{212} may be understood by referring to the description provided herein in connection with R_{203}, and

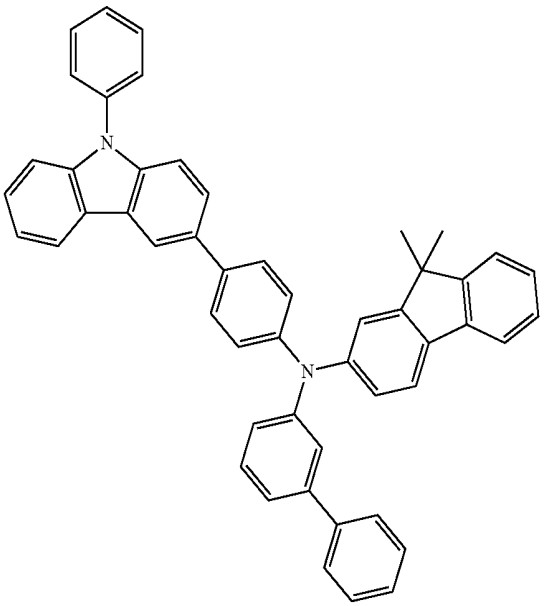
[0181] R_{213} to R_{217} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with —F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a 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 thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

[0182] The hole transport region may include at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:

HT1



HT2



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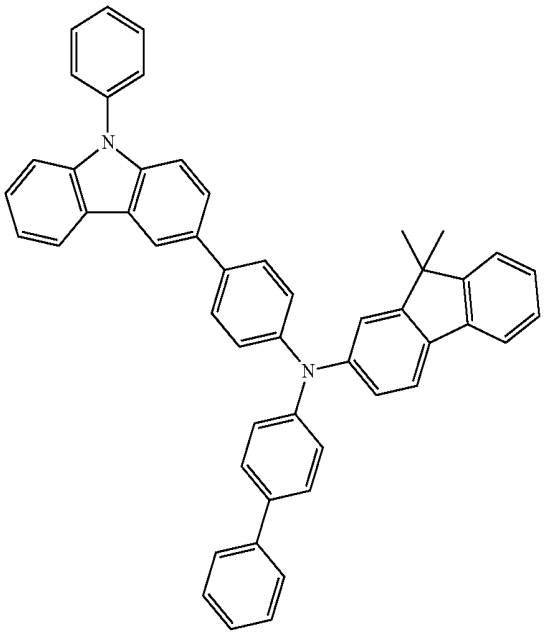

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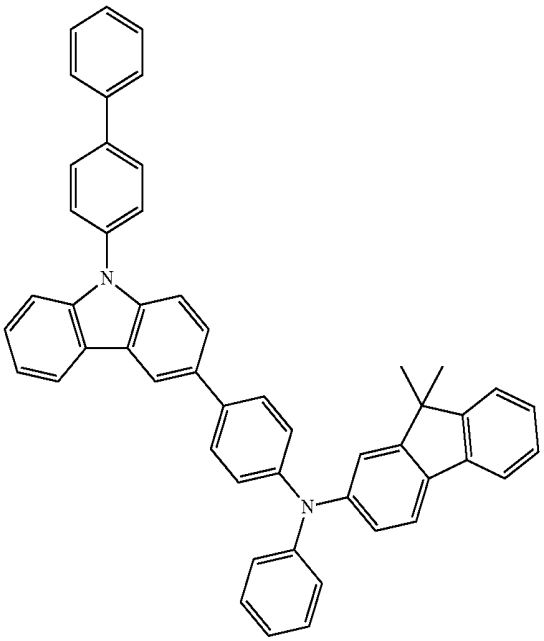

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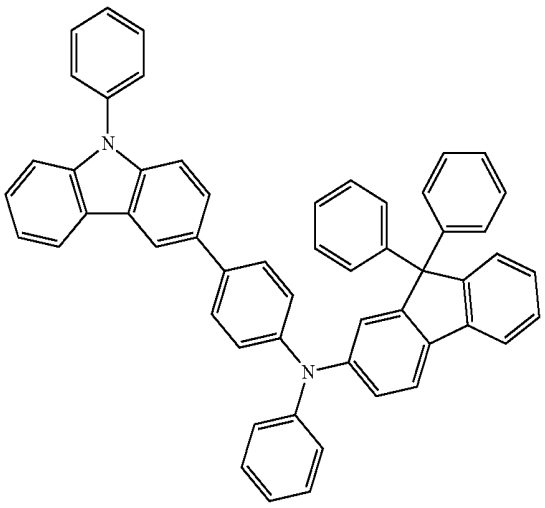

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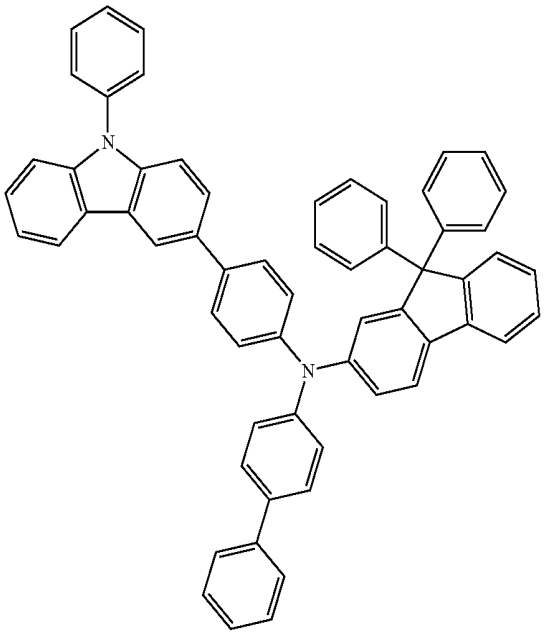

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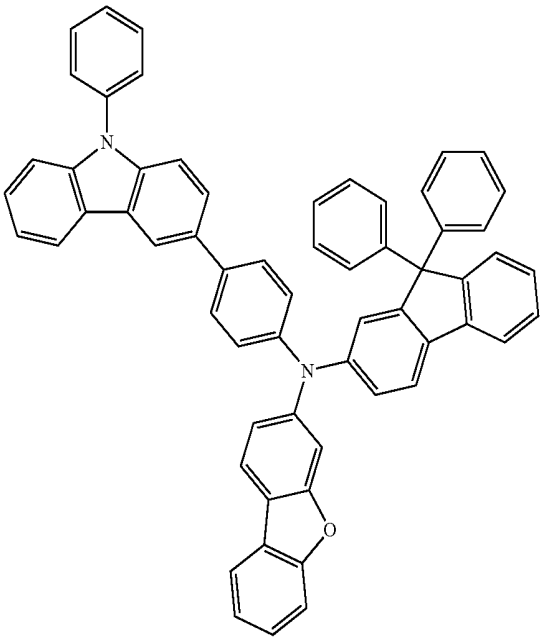

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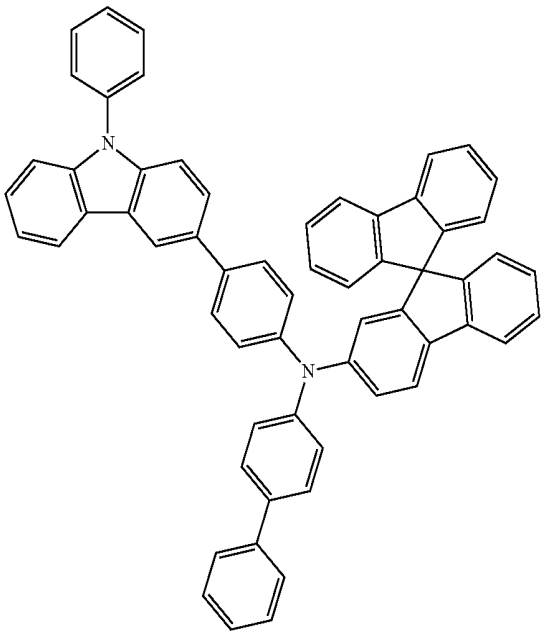

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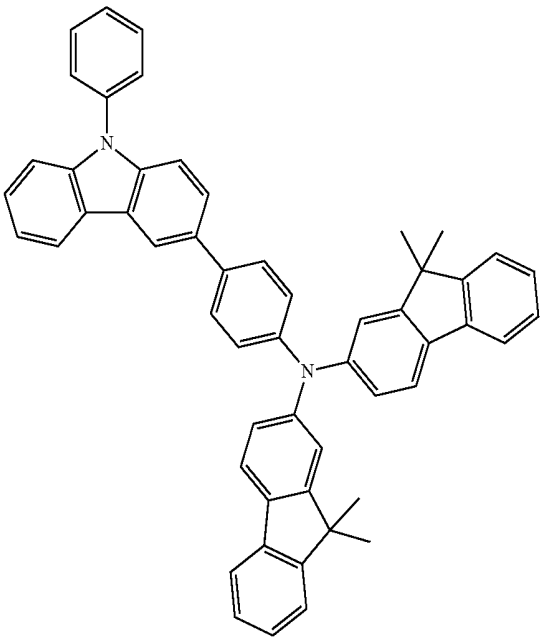

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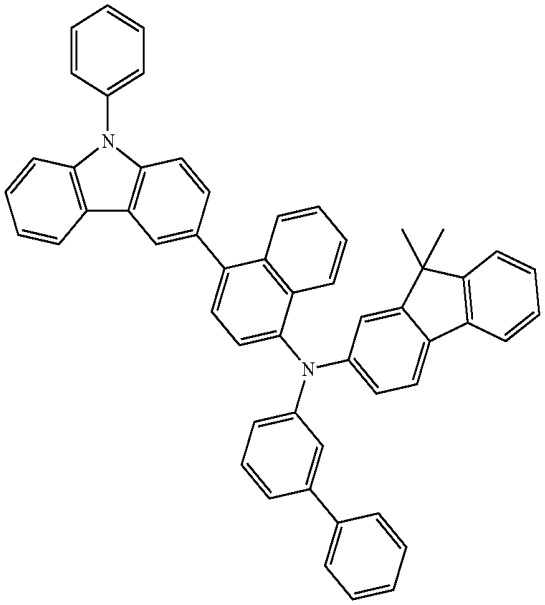

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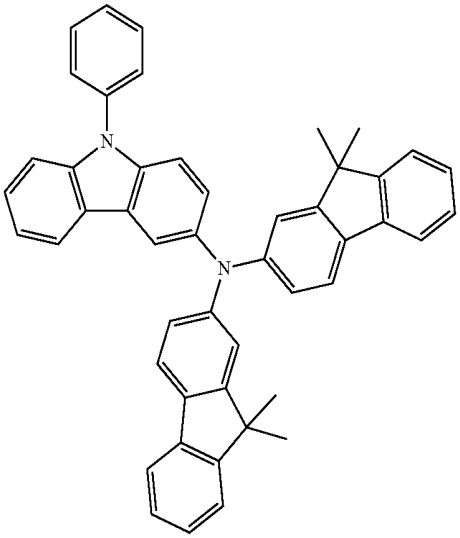

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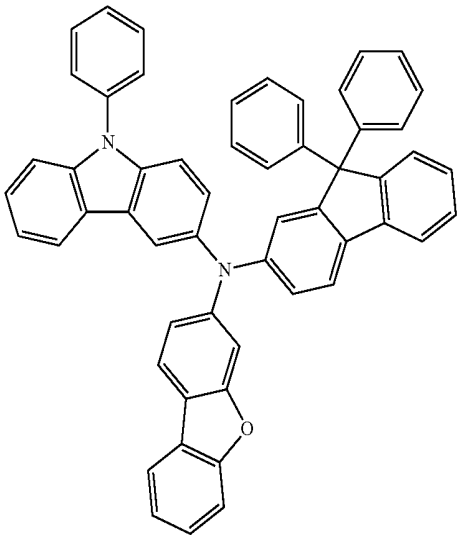

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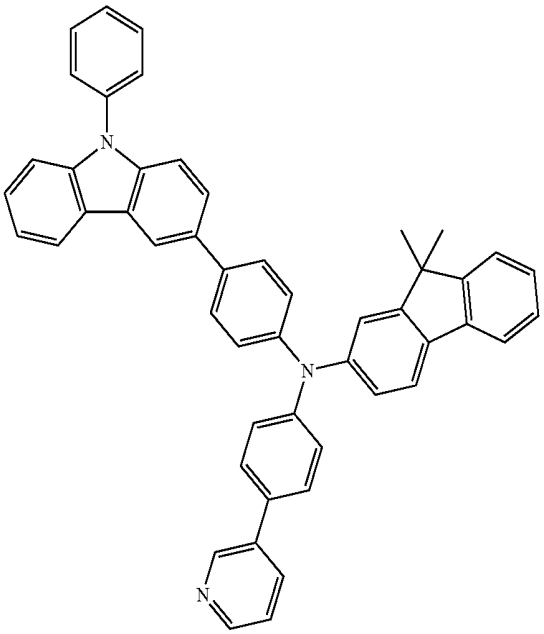

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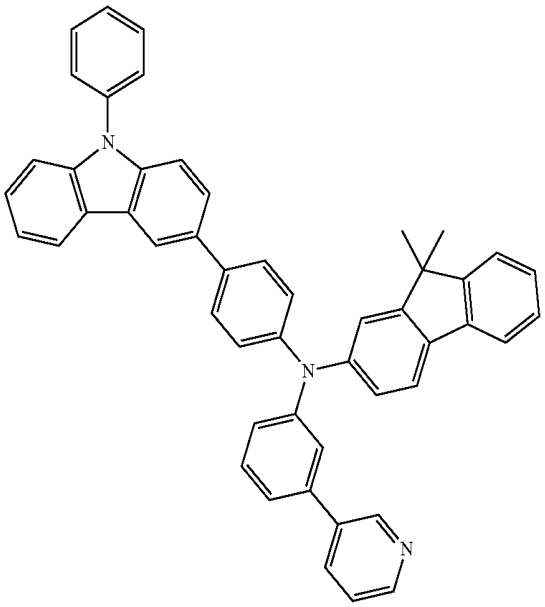

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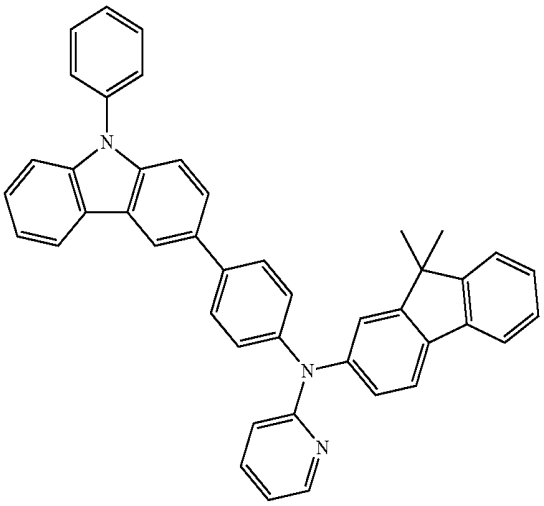

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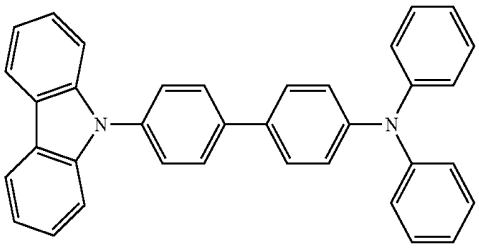

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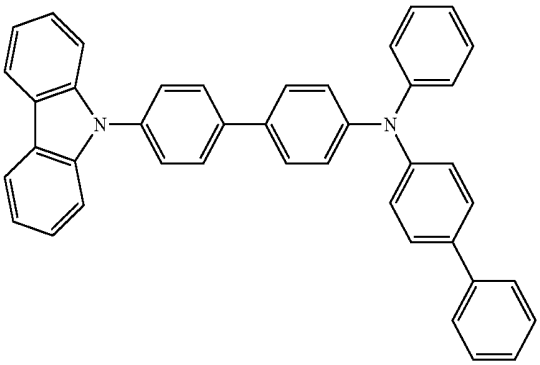

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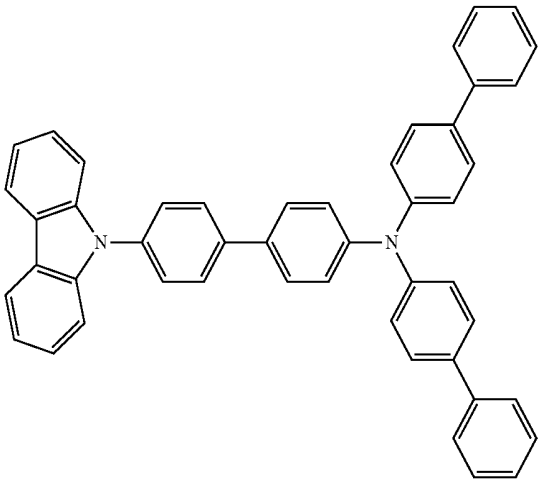

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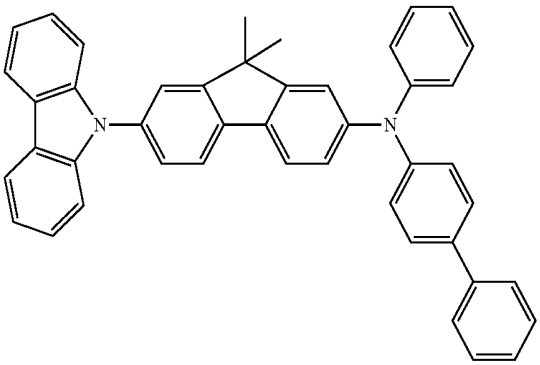

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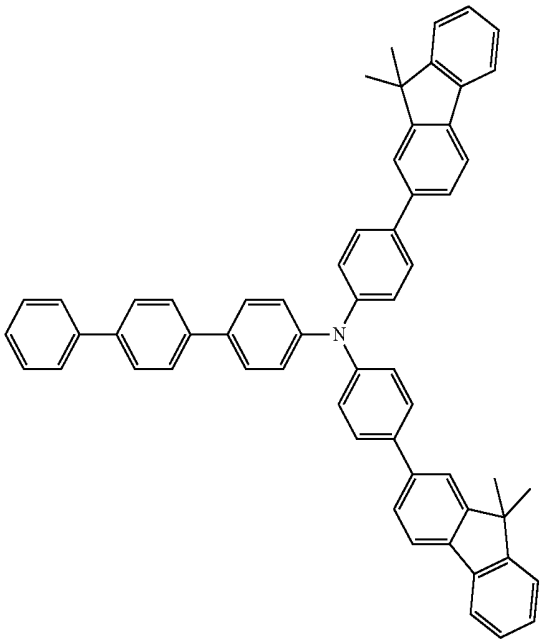
HT20



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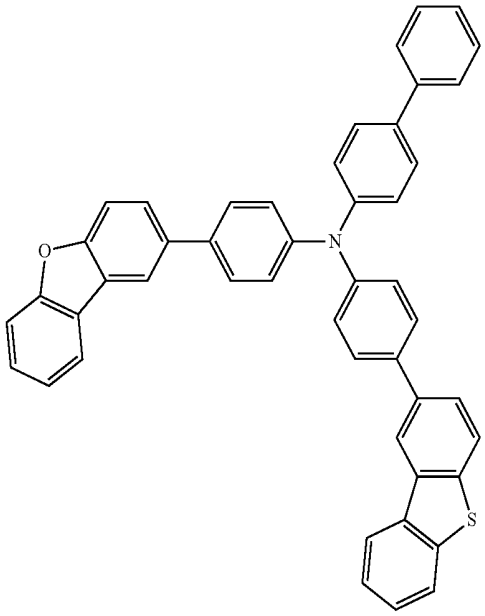

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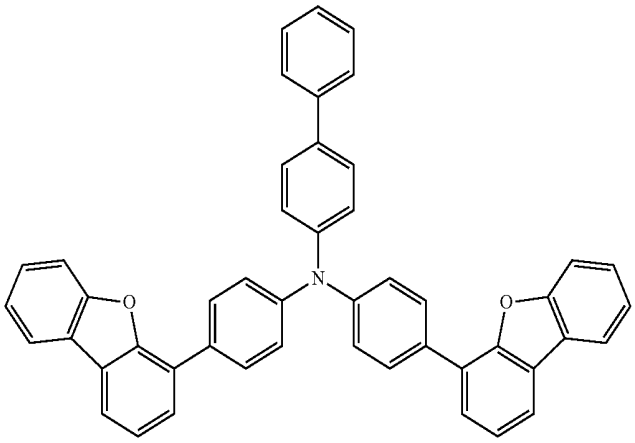

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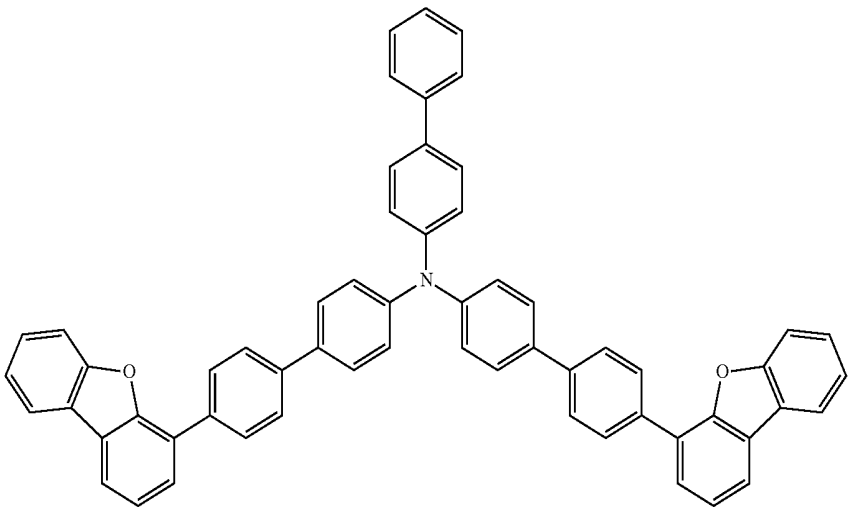

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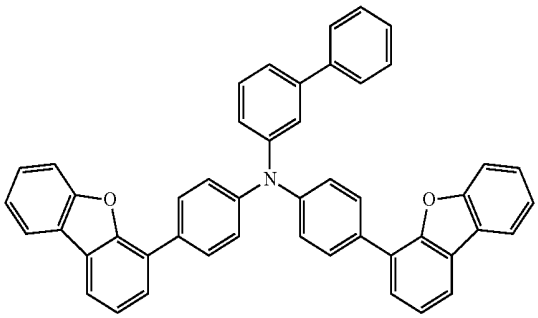

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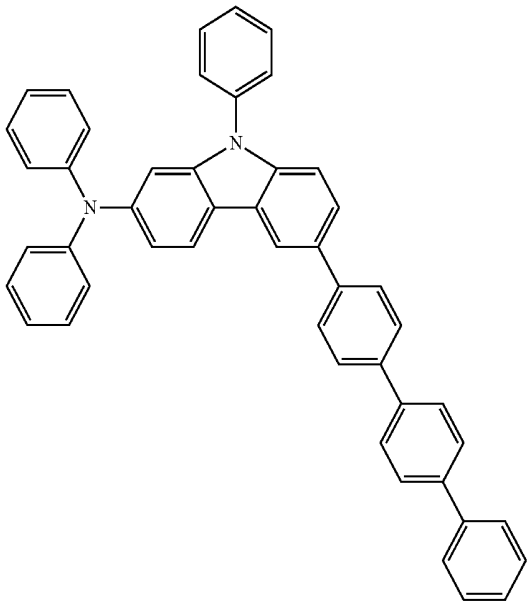

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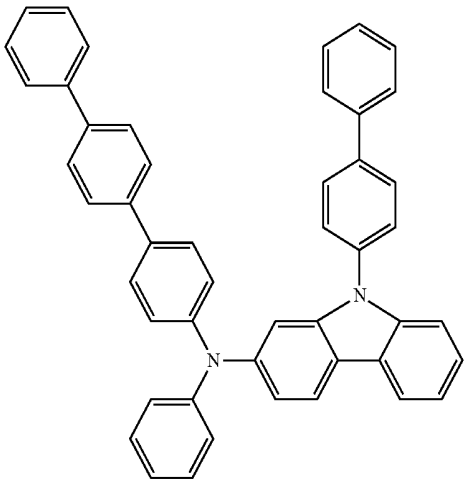

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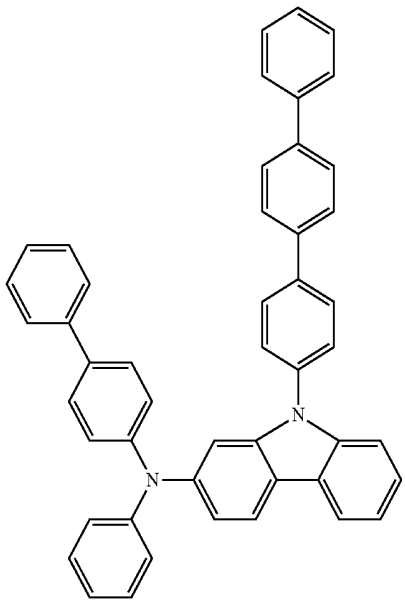

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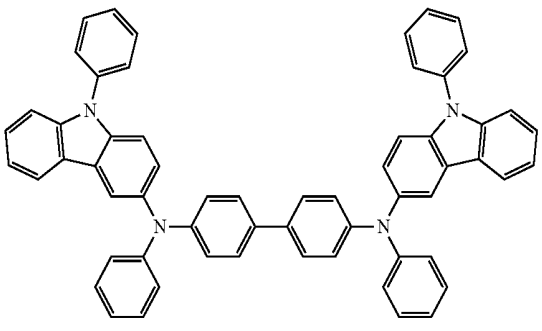

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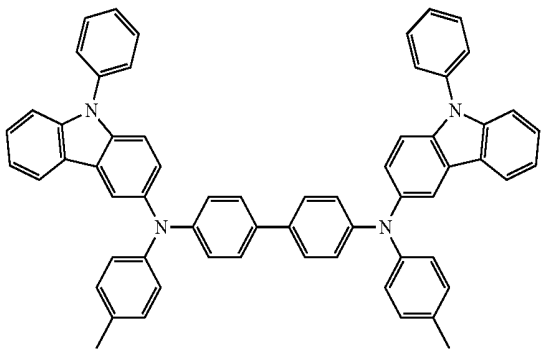

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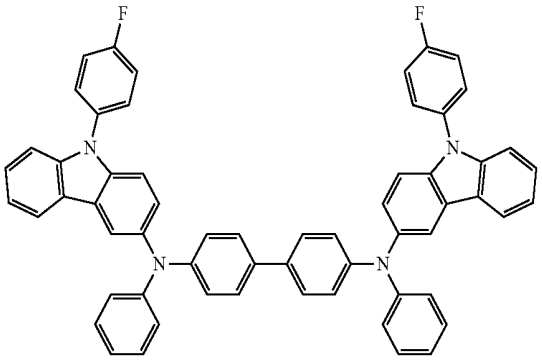

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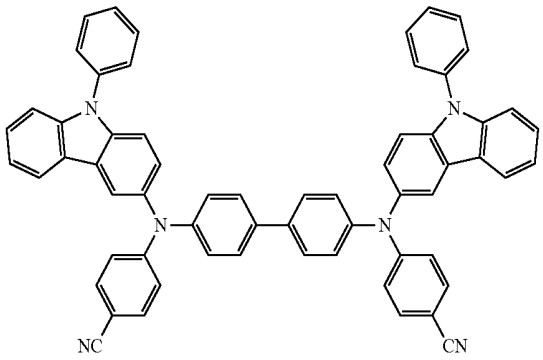

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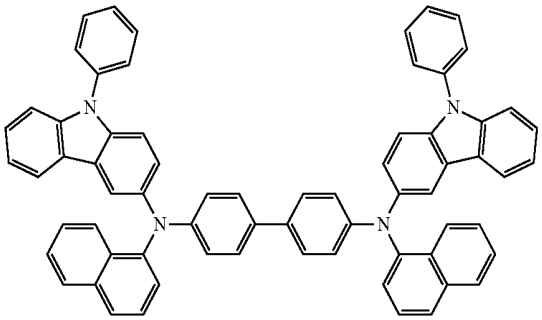
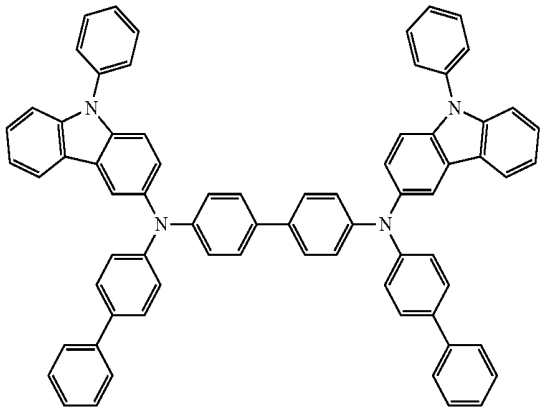


HT33



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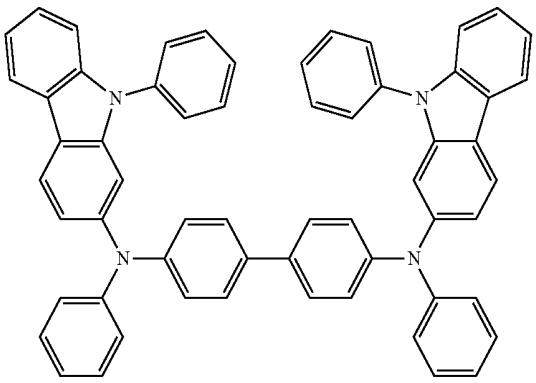

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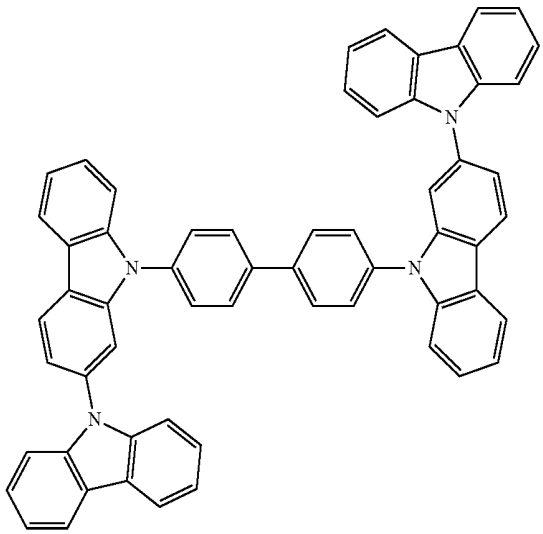

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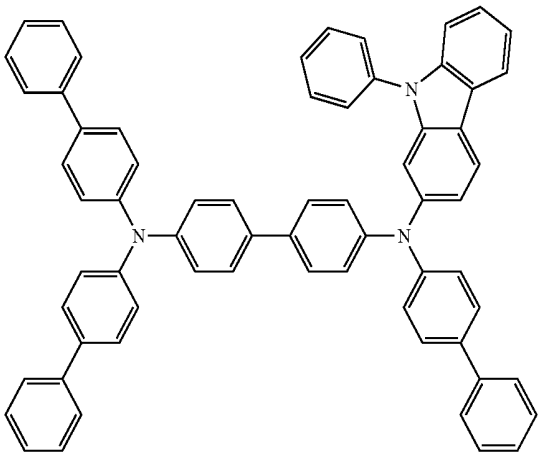

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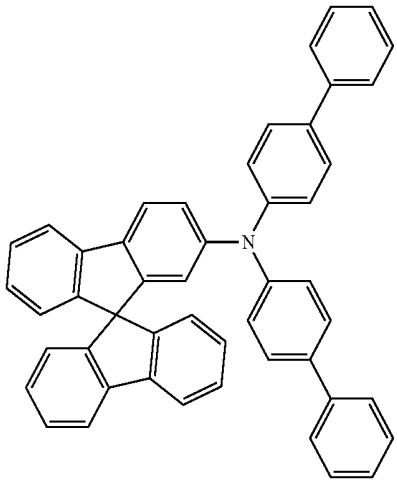
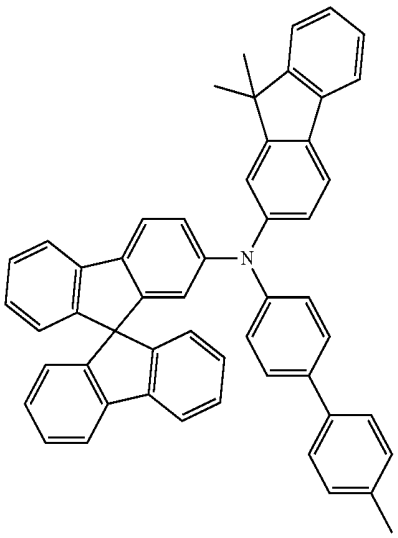
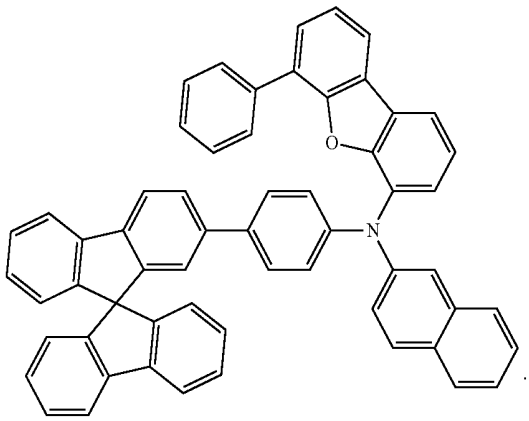


HT38



HT39



[0183] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region includes at least one selected from a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 9,000 Å, for example, about 100 Å to about 1,000 Å, and the thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, for example, about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, suitable or satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

[0184] The emission auxiliary layer may increase light-emission efficiency by compensating for an optical resonance distance according to the wavelength of light emitted by an emission layer, and the electron blocking layer may block the flow of electrons from an electron transport region. The emission auxiliary layer and the electron blocking layer may include the materials as described above.

[0185] [p-Dopant]

[0186] 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.

[0187] The charge-generation material may be, for example, a p-dopant.

[0188] In one embodiment, the p-dopant may have a lowest unoccupied molecular orbital (LUMO) energy level (eV) of −3.5 eV or less.

[0189] The p-dopant may include at least one selected from a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto.

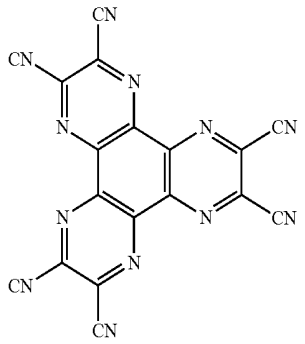
[0190] For example, the p-dopant may include at least one selected from a quinone derivative, such as tetracyanoquinodimethane (TCNQ) or 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ);

[0191] a metal oxide, such as tungsten oxide or molybdenum oxide;

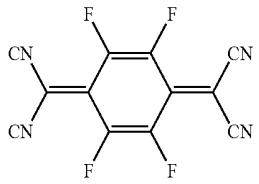
[0192] HAT-CN (1,4,5,8,9,12-hexaazatriphenylene-hexacarbonitrile); and

[0193] a compound represented by Formula 221 below:

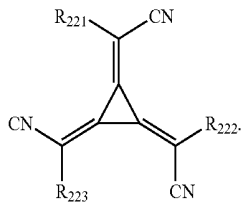
[0194] but embodiments of the present disclosure are not limited thereto:



HAT-CN



F4-TCNQ



Formula 221

[0195] In Formula 221,

[0196] R_{221} to R_{223} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, provided that at least one selected from R_{221} to R_{223} has at least one substituent selected from a cyano group, —F, —Cl, —Br, —I, a C_1-C_{20} alkyl group substituted with —F, a C_1-C_{20} alkyl group substituted with —Cl, a C_1-C_{20} alkyl group substituted with —Br, and a C_1-C_{20} alkyl group substituted with —I.

Emission Layer in Organic Layer **150**

[0197] When the organic light-emitting device **10** is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, or a blue emission layer, according to a sub-pixel. In one or more embodiments, the emission layer may have a stacked structure of two or more layers selected from a red emission layer, a green emission layer, and a blue emission layer, in which the two or more layers contact each other or are separated from each other. In one or more embodiments, the emission layer may include two or more materials selected from a red light-emitting material, a green light-emitting material, and a blue light-emitting material, in which the two or more materials are mixed with each other in a single layer to emit white light.

[0198] The emission layer may include a host and a dopant. The dopant may include at least one selected from a phosphorescent dopant and a fluorescent dopant.

[0199] An amount of the dopant in the emission layer may be in a range of about 0.01 parts by weight to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

[0200] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

Host in Emission Layer

[0201] In one or more embodiments, the host may further include a compound represented by Formula 301 below:

$$[Ar_{301}]_{xb11}-[(L_{301})_{xb1}-R_{301}]_{xb21}. \quad \text{Formula 301}$$

[0202] In Formula 301,

[0203] Ar_{3o1} may be a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

[0204] xb11 may be 1, 2, or 3,

[0205] L_{301} may each independently be selected from a substituted or unsubstituted

[0206] C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

[0207] xb1 may be an integer from 0 to 5,

[0208] R_{301} may be selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_{301})(Q_{302})(Q_{303})$, —$N(Q_{301})$

(Q_{302}), —$B(Q_{301})(Q_{302})$, —$C(=O)(Q_{301})$, —$S(=O)_2(Q_{301})$, and —$P(=O)(Q_{301})(Q_{302})$,

[0209] xb21 may be an integer from 1 to 5, and

[0210] Q_{301} to Q_{303} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

[0211] In one embodiment, Ar_{301} in Formula 301 may be selected from:

[0212] a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, and a dibenzothiophene group; and

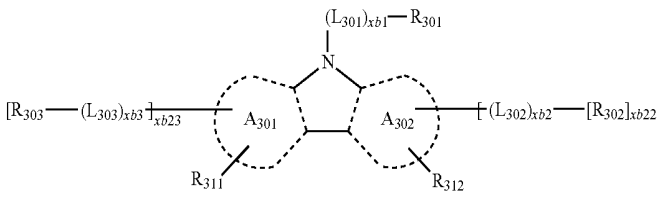
[0213] a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, —$B(Q_{31})(Q_{32})$, —$C(=O)(Q_{31})$, —$S(=O)_2(Q_{31})$, and —$P(=O)(Q_{31})(Q_{32})$, and

[0214] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

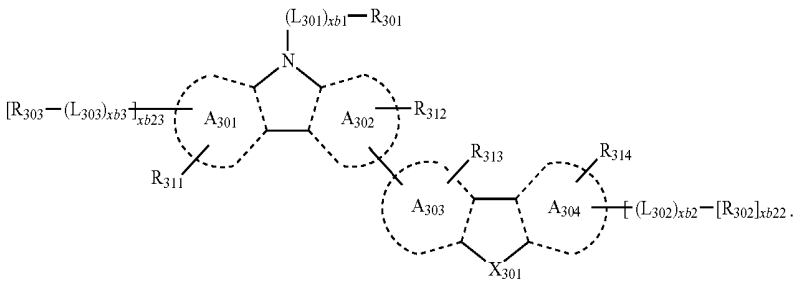
[0215] In Formula 301, when xb11 is two or more, two or more of Ar_{301}(s) may be linked via a single bond.

[0216] In one or more embodiments, the compound represented by Formula 301 may be represented by Formula 301-1 or 301-2:

Formula 301-1



Formula 301-2



[0217] In Formulae 301-1 and 301-2,

[0218] A_{301} to A_{304} may each independently be selected from a benzene group, a naphthalene group, a phenanthrene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a pyridine group, a pyrimidine group, an indene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, an indole group, a carbazole group, a benzocarbazole group, a dibenzocarbazole group, a furan group, a benzofuran group, a dibenzofuran group, a naphthofuran group, a benzonaphthofuran group, a dinaphthofuran group, a thiophene group, a benzothiophene group, a dibenzothiophene group, a naphthothiophene group, a benzonaphthothiophene group, and a dinaphthothiophene group,

[0219] X_{301} may be O, S, or N-[$(L_{304})_{xb4}$-R_{304}],

[0220] R_{311} to R_{314} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, —$B(Q_{31})(Q_{32})$, —$C(=O)(Q_{31})$, —$S(=O)_2(Q_{31})$, and —$P(=O)(Q_{31})(Q_{32})$,

[0221] xb22 and xb23 may each independently be 0, 1, or 2,

[0222] L_{301}, xb1, R_{301}, and Q_{31} to Q_{33} may be the same as described above,

[0223] L_{302} to L_{304} may each independently be the same as described in connection with L_{301},

[0224] xb2 to xb4 may each independently be the same as described in connection with xb1, and

[0225] R_{302} to R_{304} may each independently be the same as described in connection with R_{301}.

[0226] For example, in Formulae 301, 301-1, and 301-2, L_{301} to L_{304} may each independently be selected from:

[0227] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene

group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group; and

[0228] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an azacarbazolyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, —$B(Q_{31})(Q_{32})$, —$C(=O)(Q_{31})$, —$S(=O)_2(Q_{31})$, and —$P(=O)(Q_{31})(Q_{32})$, and

[0229] Q_{31} and Q_{33} may be the same as described above.

[0230] In one embodiment, in Formulae 301, 301-1, and 301-2, R_{301} to R_{304} may each independently be selected from:

[0231] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

[0232] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br,

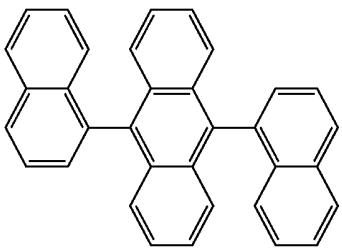
—I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an azacarbazolyl group, $—Si(Q_{31})(Q_{32})(Q_{33})$, $—N(Q_{31})(Q_{32})$, $—B(Q_{31})(Q_{32})$, $—C(=O)(Q_{31})$, $—S(=O)_2(Q_{31})$, and $—P(=O)(Q_{31})(Q_{32})$, and

[0233] Q_{31} and Q_{33} may be the same as described above.

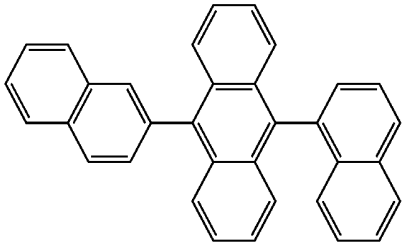
[0234] In one or more embodiments, the host may include an alkaline earth metal complex. For example, the host may be selected from a Be complex (for example, Compound H55), a Mg complex, and a Zn complex.

[0235] The host may include at least one selected from 9,10-di(2-naphthyl)anthracene (ADN), 2-methyl-9,10-bis(naphthalen-2-yl)anthracene (MADN), 9,10-di-(2-naphthyl)-2-t-butyl-anthracene (TBADN), 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP), 1,3-di-9-carbazolylbenzene (mCP), 1,3,5-tri(carbazol-9-yl)benzene (TCP), and Compounds H1 to H55, but embodiments of the present disclosure are not limited thereto:

H1



H2



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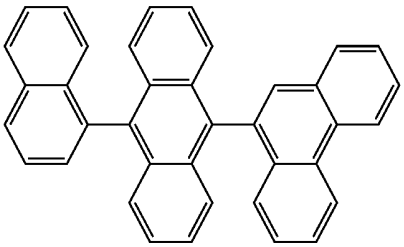

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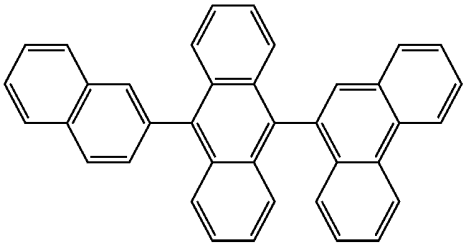

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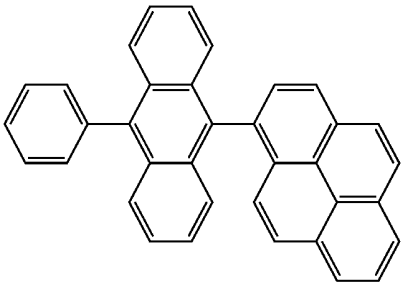

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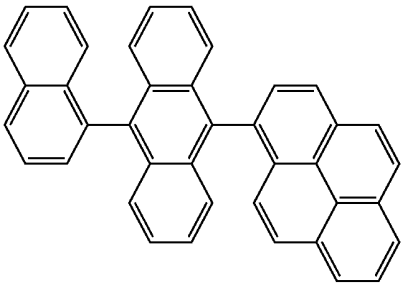

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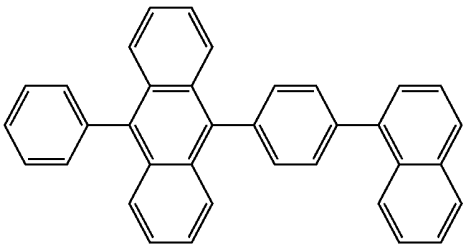

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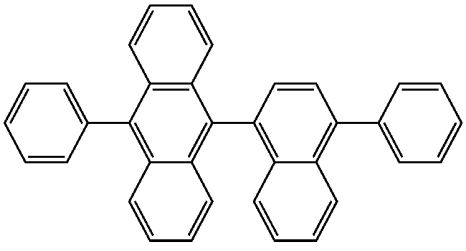

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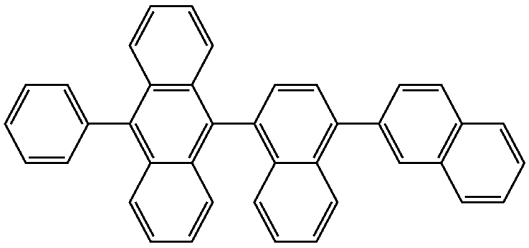

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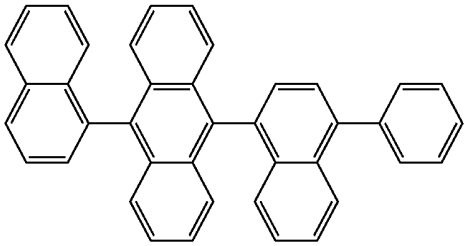

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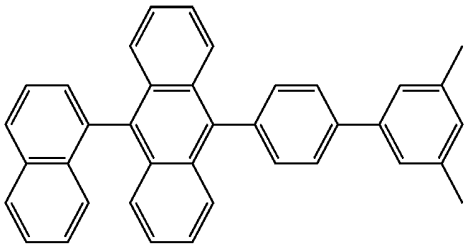

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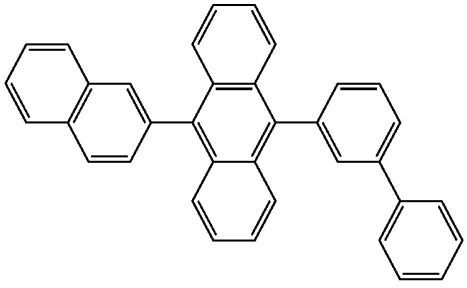

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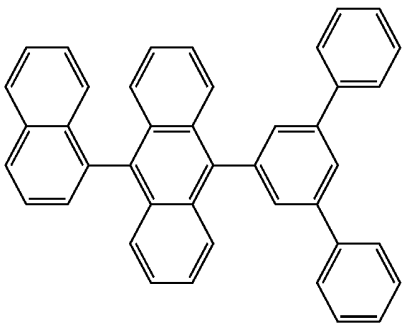

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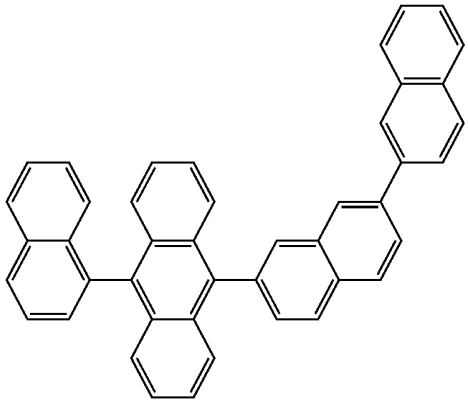

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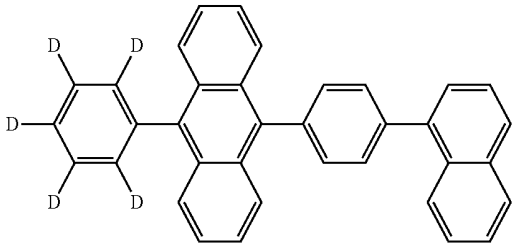

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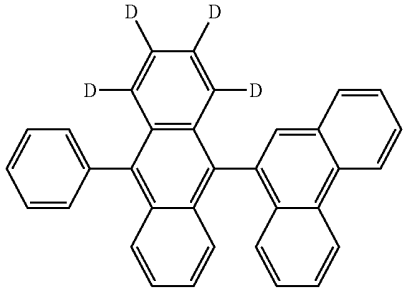

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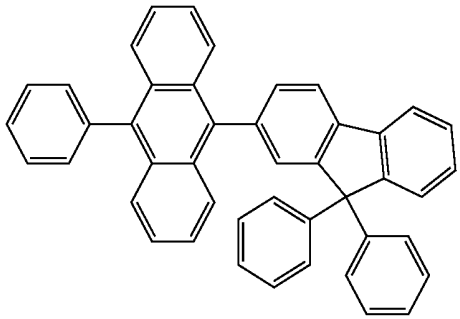

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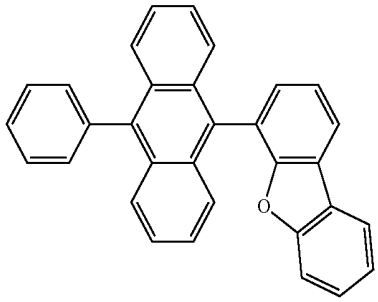

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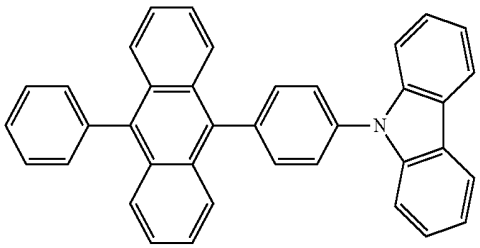
H19



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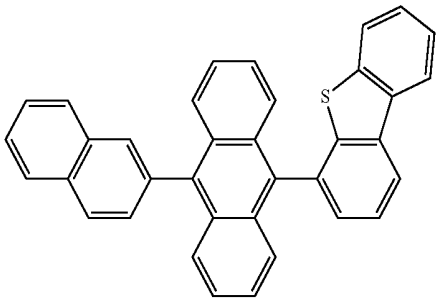

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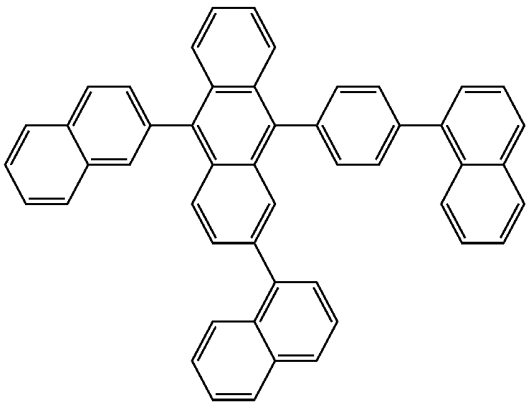

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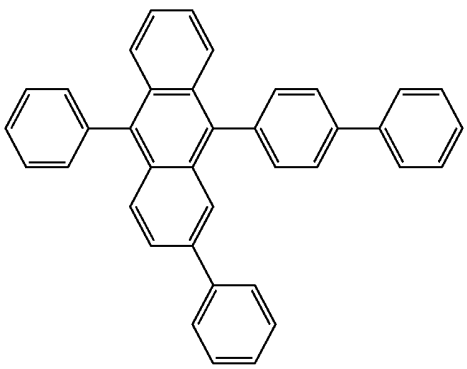

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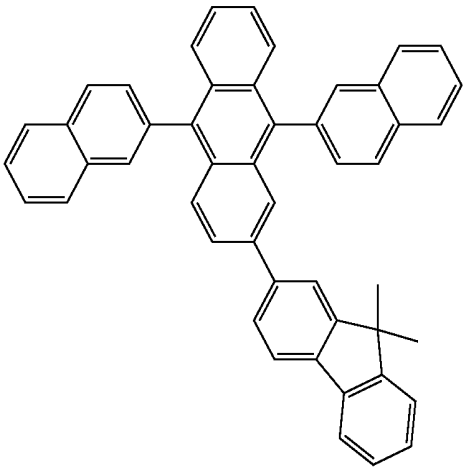
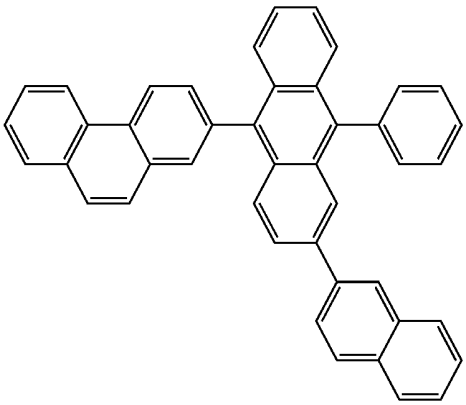
H23



H24



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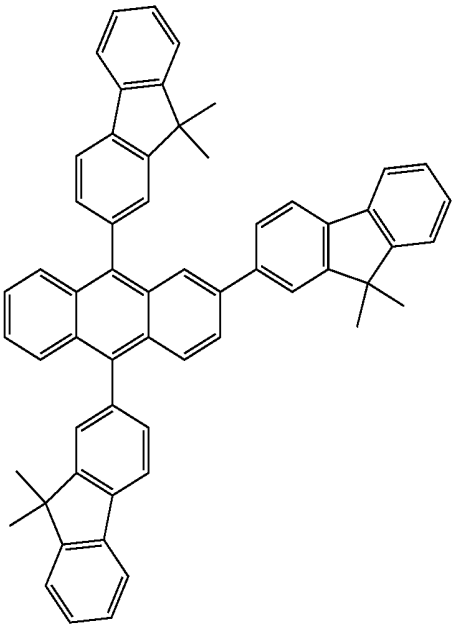

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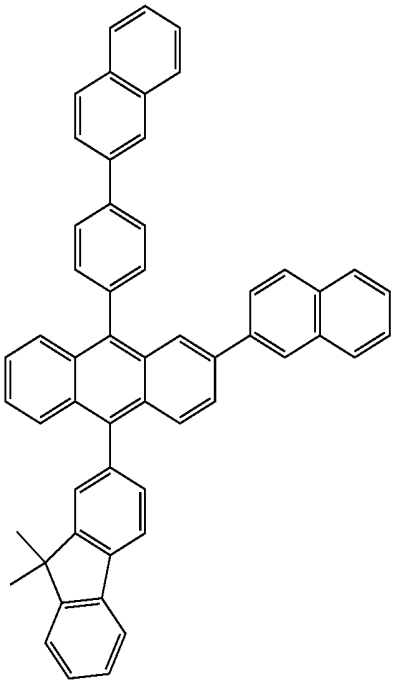

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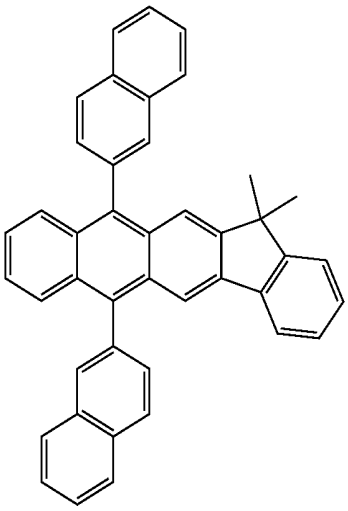

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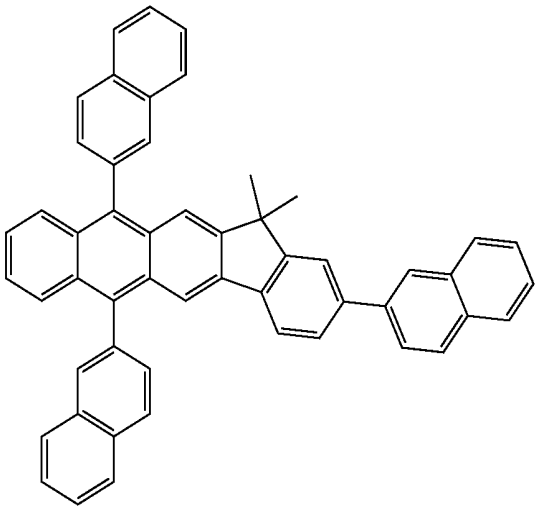

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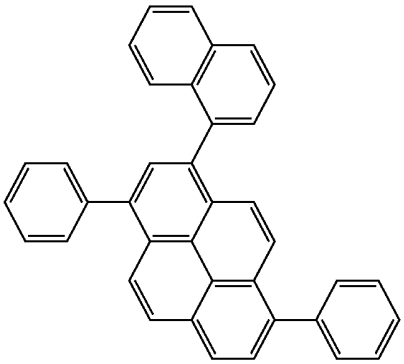

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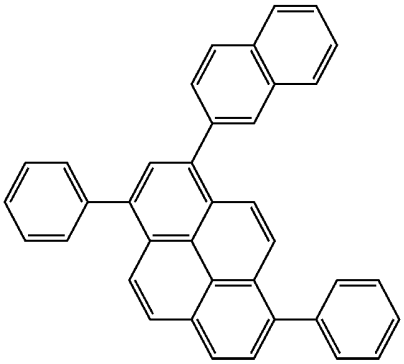

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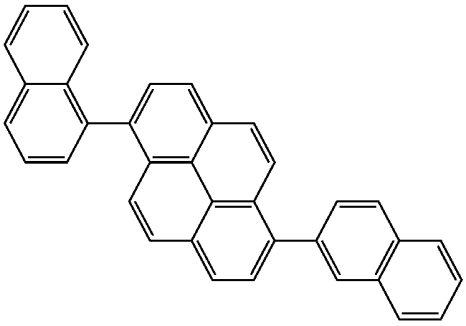

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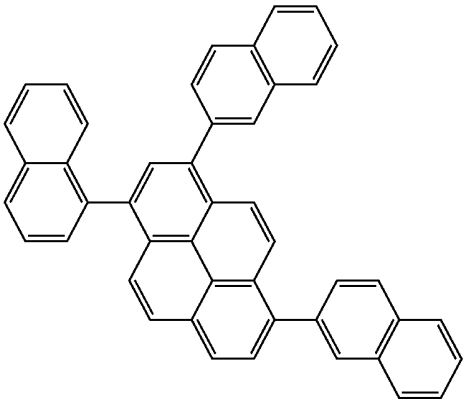

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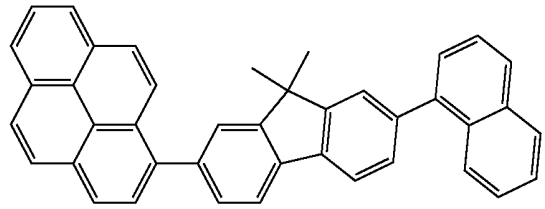

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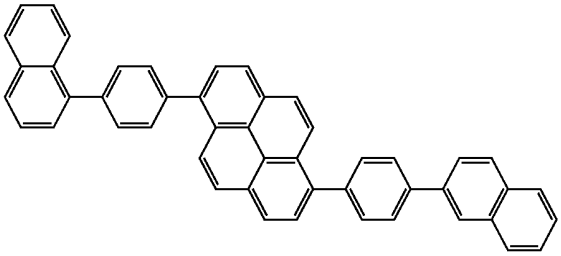

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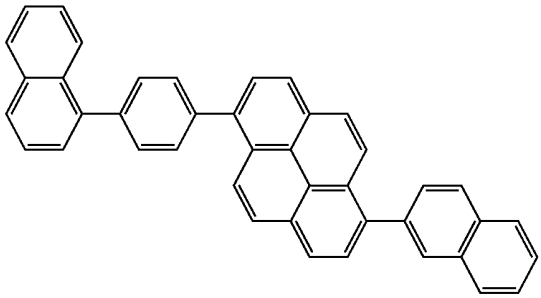

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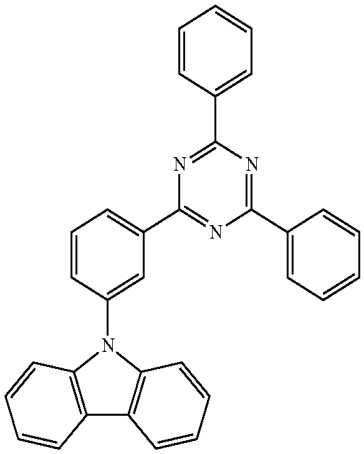

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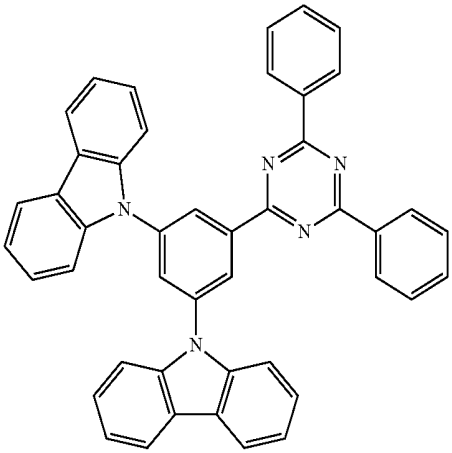

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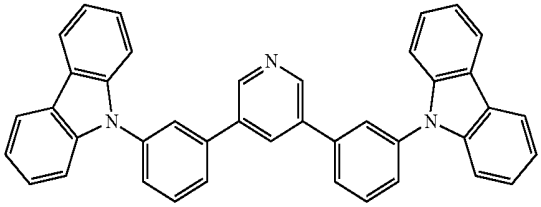

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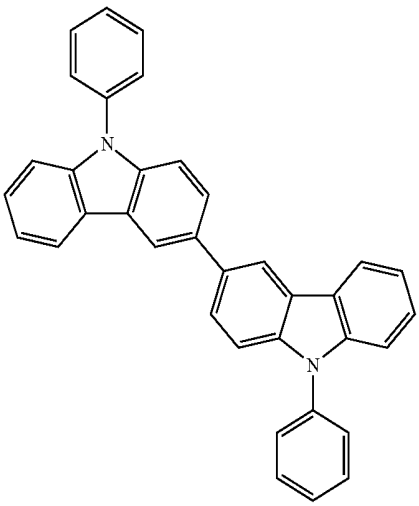

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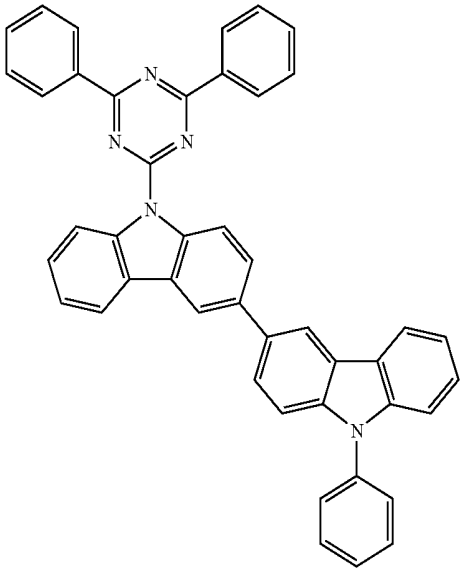

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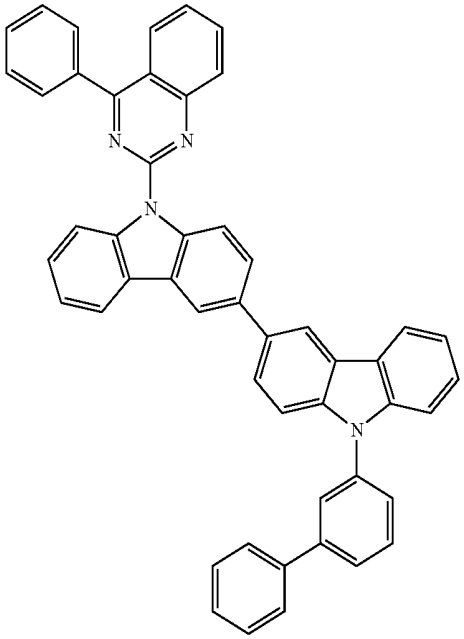

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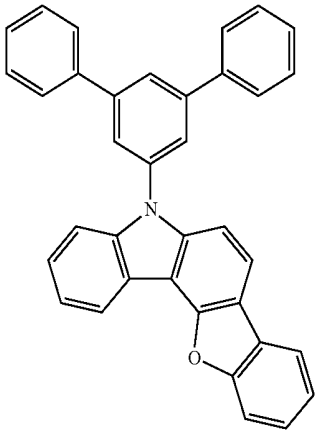

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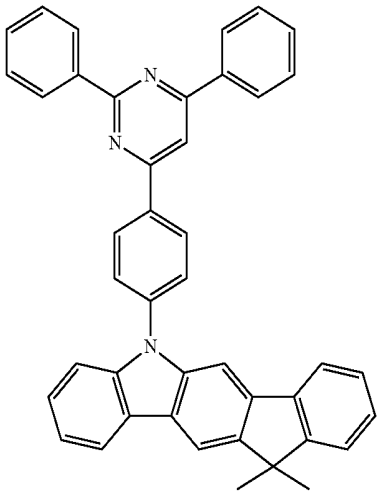

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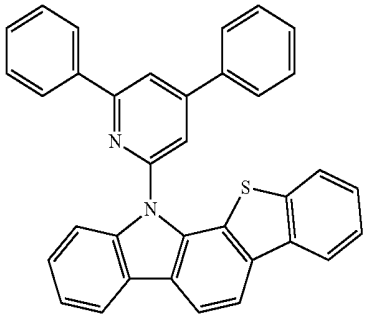

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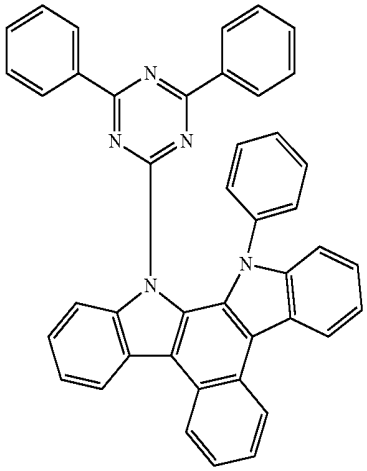

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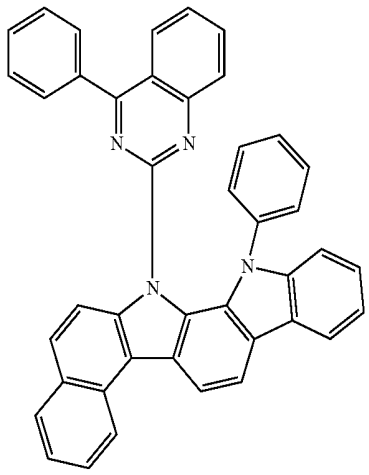

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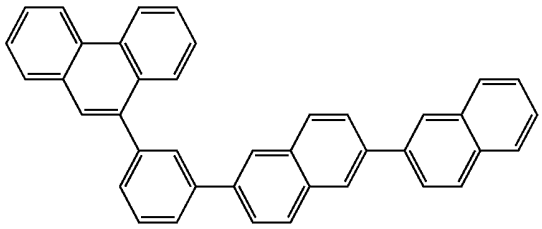

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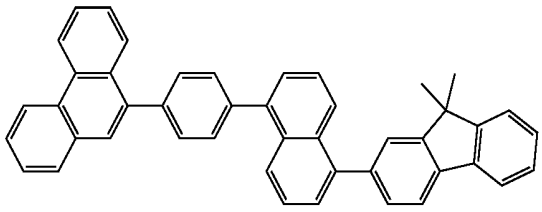

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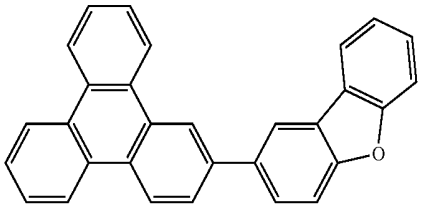

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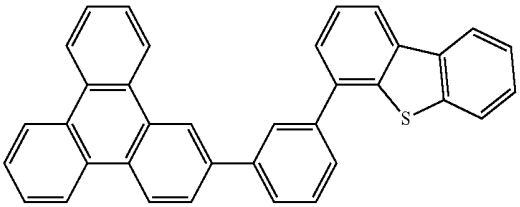

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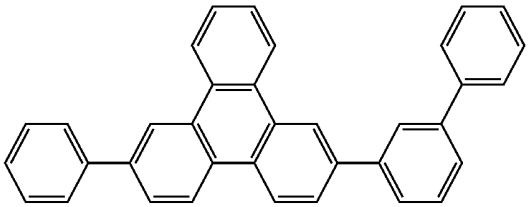

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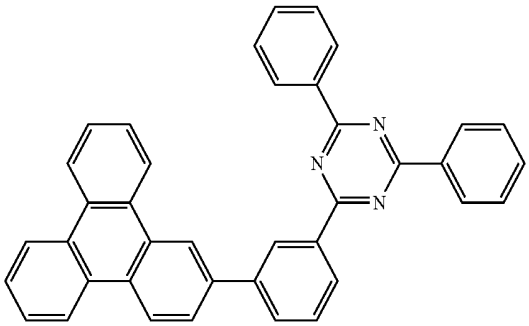

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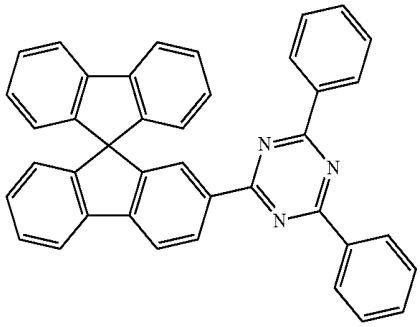

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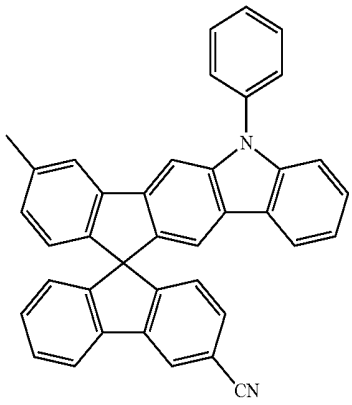

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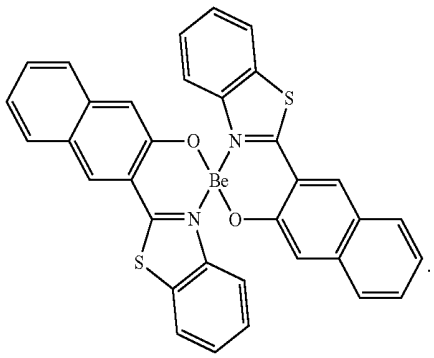

Phosphorescent Dopant Included in Emission Layer in Organic Layer **150**

[0236] The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:

Formula 401

$$M(L_{401})_{xc1}(L_{402})_{xc2}$$

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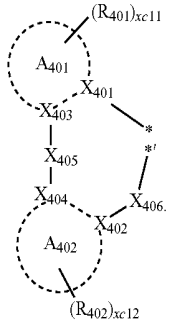
Formula 402



[0237] In Formulae 401 and 402,

[0238] M may be selected from iridium (Ir), platinum (Pt), palladium (Pd), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), rhodium (Rh), and thulium (Tm),

[0239] L_{401} may be selected from ligands represented by Formula 402, and xc1 may be 1, 2, or 3, wherein, when xc1 is two or more, two or more L_{401}(s) may be identical to or different from each other,

[0240] L_{402} may be an organic ligand, and xc2 may be an integer from 0 to 4, wherein, when xc2 is two or more, two or more L_{402}(s) may be identical to or different from each other,

[0241] X_{401} to X_{404} may each independently be nitrogen or carbon,

[0242] X_{401} and X_{403} may be linked via a single bond or a double bond, and X_{402} and X_{404} may be linked via a single bond or a double bond,

[0243] A_{401} and A_{402} may each independently be selected from a C_5-C_{60} carbocyclic group or a C_1-C_{60} heterocyclic group,

[0244] X_{405} may be a single bond, *—O—*', *—S—*', *—C(=O)—*', *—N(Q_{411})-*', *—C(Q_{411})(Q_{412})-', *—C(Q_{411})=C(Q_{412})-*', *—C(Q_{411})=', or *=C=*', wherein Q_{411} and Q_{412} may each independently be hydrogen, deuterium, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group,

[0245] X_{406} may be a single bond, O, or S,

[0246] R_{401} and R_{402} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{20} alkyl group, a substituted or unsubstituted C_1-C_{20} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{401})(Q_{402})(Q_{403}), —N(Q_{401})(Q_{402}), —B(Q_{401})(Q_{402}), —C(=O)(Q_{401}), —S(=O)$_2$(Q_{401}), and —P(=O)(Q_{401})(Q_{402}), wherein Q_{401} to Q_{403} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a C_6-C_{20} aryl group, and a C_1-C_{20} heteroaryl group,

[0247] xc11 and xc12 may each independently be an integer from 0 to 10, and

[0248] * and *' in Formula 402 each indicate a binding site to M in Formula 401.

[0249] In one embodiment, in Formula 402, A_{401} and A_{402} may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, an indene group, a pyrrole group, a thiophene group, a furan(furan) group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a quinoxaline group, a quinazoline group, a carbazole group, a benzimidazole group, a benzofuran group, a benzothiophene group, an isobenzothiophene group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a dibenzofuran group, and a dibenzothiophene group.

[0250] In one or more embodiments, in Formula 402, i) X_{401} may be nitrogen, and X_{402} may be carbon, or ii) X_{401} and X_{402} may each be nitrogen concurrently (e.g., at the same time).

[0251] In one or more embodiments, R_{402} and R_{402} in Formula 401 may each independently be selected from:

[0252] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

[0253] a C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a phenyl group, a naphthyl group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, and a norbornenyl group;

[0254] a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

[0255] a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl

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

[0256] —$Si(Q_{401})(Q_{402})(Q_{403})$, —$N(Q_{401})(Q_{402})$, —$B(Q_{401})(Q_{402})$, —$C(=O)(Q_{401})$, —$S(=O)_2(Q_{401})$, and —$P(=O)(Q_{401})(Q_{402})$, and

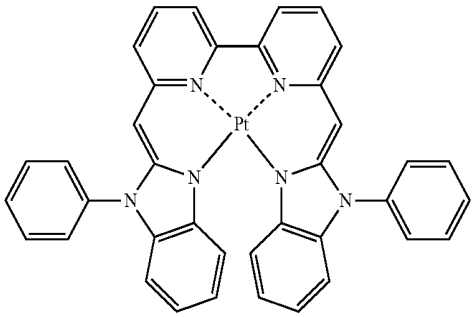
[0257] Q_{401} to Q_{403} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, and a naphthyl group, but are not limited thereto.

[0258] In one or more embodiments, when xc1 in Formula 401 is two or more, two A_{401}(s) in two or more L_{401}(s) may optionally be linked via X_{407}, which is a linking group, or two A_{402}(s) in two or more L_{401}(s) may optionally be linked via X_{408}, which is a linking group (see Compounds PD1 to PD4 and PD7). X_{407} and X_{408} may each independently be a single bond, *—O—*', *—S—*', *—C(=O)—*', *—N(Q_{413})-*', *—C(Q_{413})(Q_{414})-*' or *—C(Q_{413})=C(Q_{414})-*' (wherein Q_{413} and Q_{414} may each independently be hydrogen, deuterium, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group), but embodiments of the present disclosure are not limited thereto.

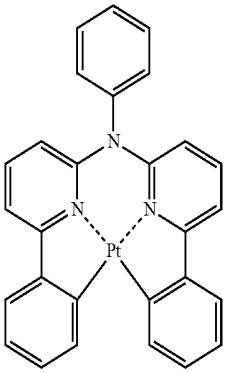
[0259] L_{402} in Formula 401 may be a monovalent, divalent, or trivalent organic ligand. For example, L_{402} may be selected from halogen, diketone (for example, acetylacetonate), carboxylic acid (for example, picolinate), —C(=O), isonitrile, —CN, and a phosphorus-containing material (for example, phosphine and phosphite), but embodiments of the present disclosure are not limited thereto.

[0260] In one or more embodiments, the phosphorescent dopant may be selected from, for example, Compounds PD1 to PD25, but embodiments of the present disclosure are not limited thereto:

PD1



PD2



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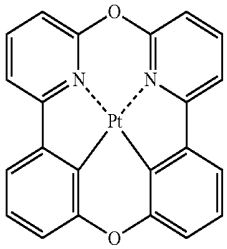
PD3



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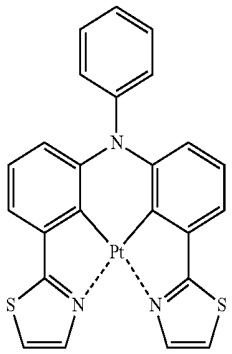

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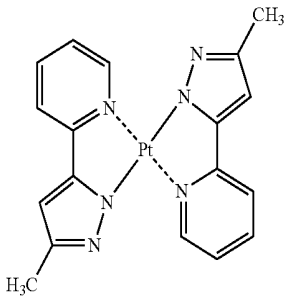

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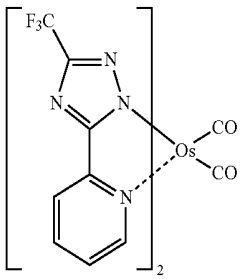
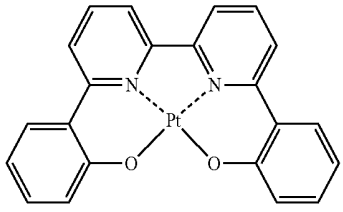


PD7



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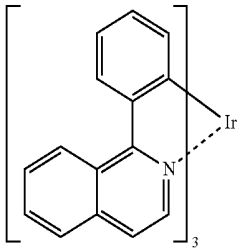

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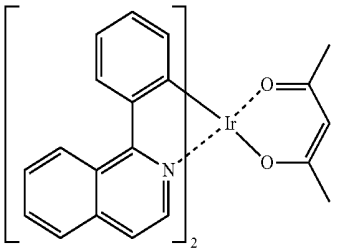

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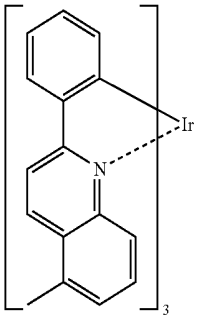

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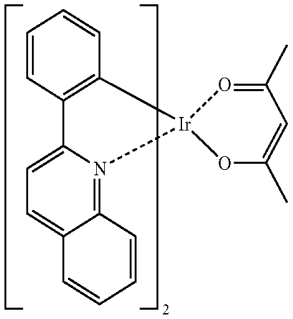

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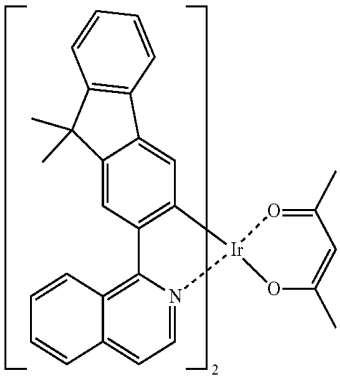

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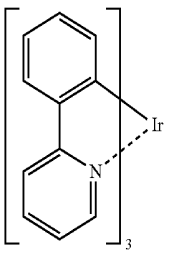

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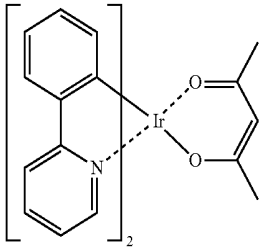

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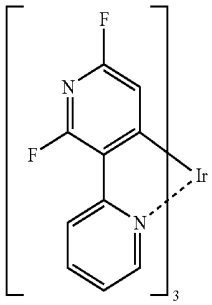

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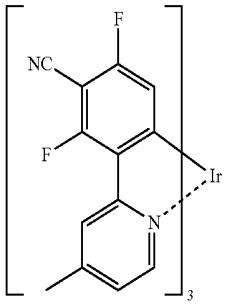

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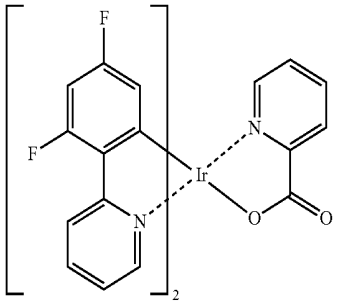

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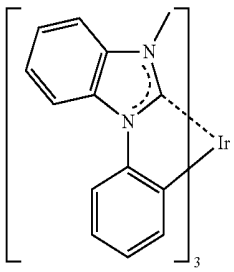

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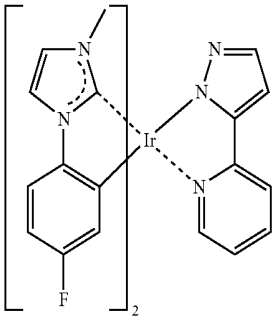

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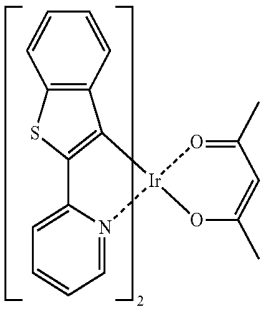

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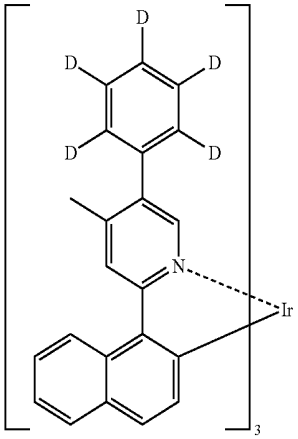

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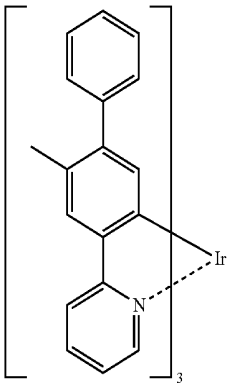

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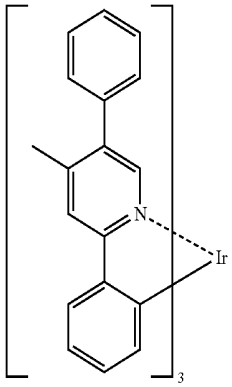

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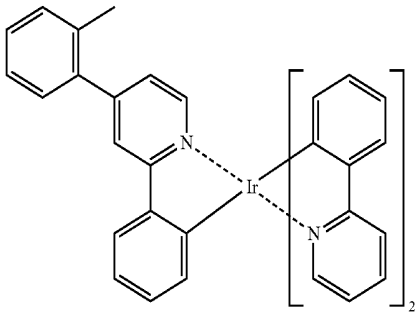

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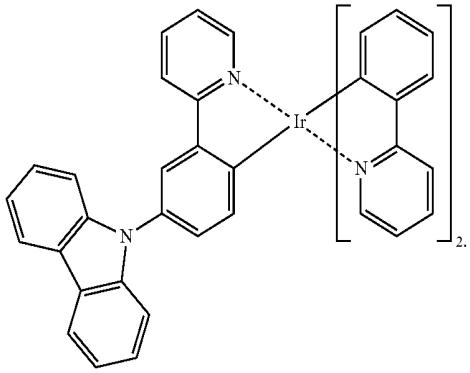
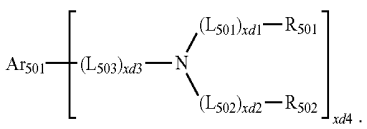


Fluorescent Dopant in Emission Layer

[0261] The fluorescent dopant may include an arylamine compound or a styrylamine compound.

[0262] The fluorescent dopant may include a compound represented by Formula 501 below:

Formula 501



[0263] In Formula 501,

[0264] Ar_{501} may be a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

[0265] L_{501} to L_{503} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0266] xd1 to xd3 may each independently be an integer of 0 to 3,

[0267] R_{501} and R_{502} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and

[0268] xd4 may be an integer of 1 to 6.

[0269] In one embodiment, Ar_{501} in Formula 501 may be selected from:

[0270] a naphthalene group, a heptalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, and an indenophenanthrene group; and

[0271] a naphthalene group, a heptalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, and an indenophenanthrene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0272] In one or more embodiments, L_{501} to L_{503} in Formula 501 may each independently be selected from:

[0273] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group; and

[0274] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

[0275] In one or more embodiments, R_{501} and R_{502} in Formula 501 may each independently be selected from:

[0276] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and

[0277] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl

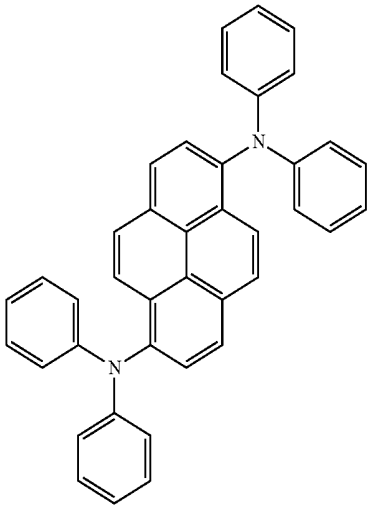
group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group and —$Si(Q_{31})(Q_{32})(Q_{33})$, and

[0278] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

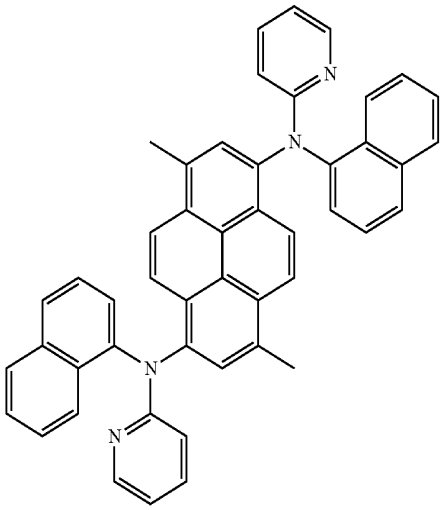
[0279] In one or more embodiments, xd4 in Formula 501 may be 2, but embodiments of the present disclosure are not limited thereto.

[0280] For example, the fluorescent dopant may be selected from Compounds FD1 to FD22:

FD1



FD2



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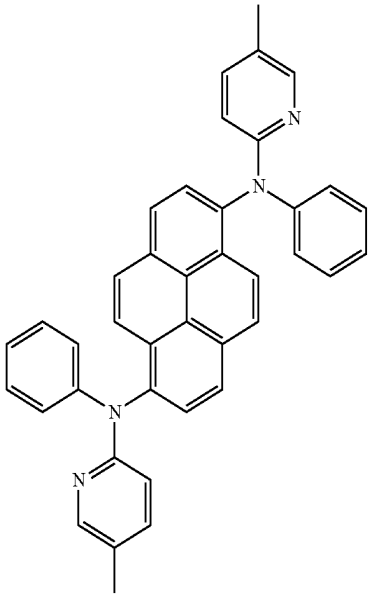
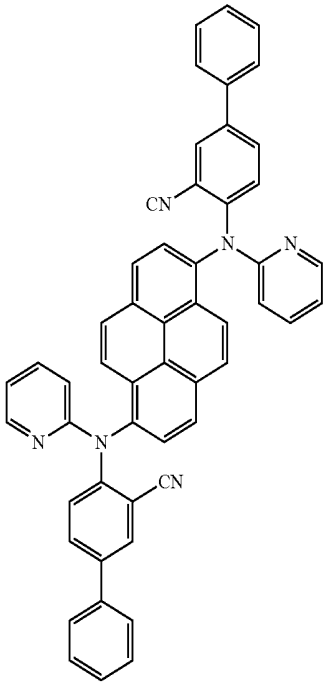
FD3



FD4



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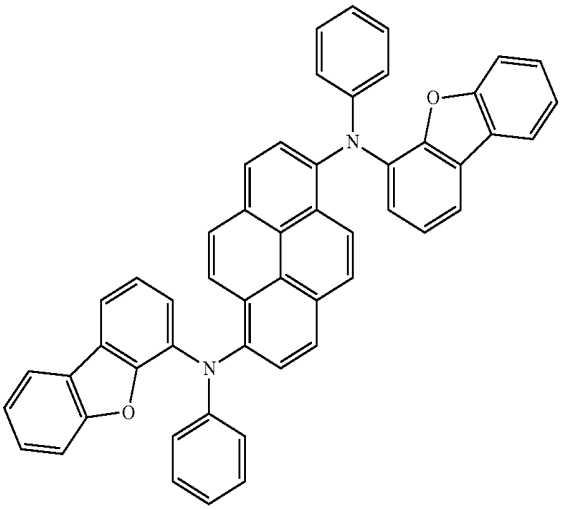
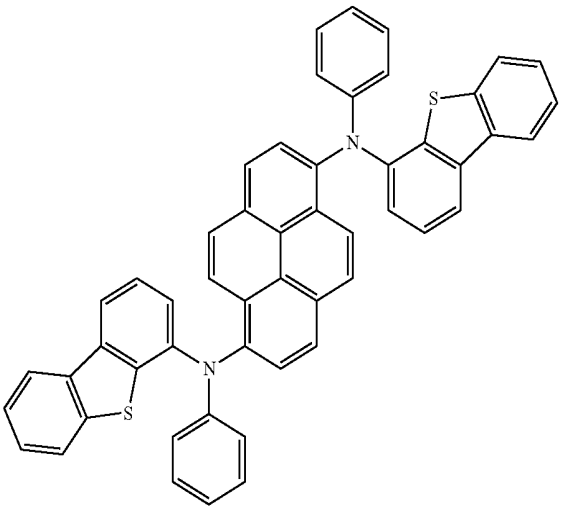
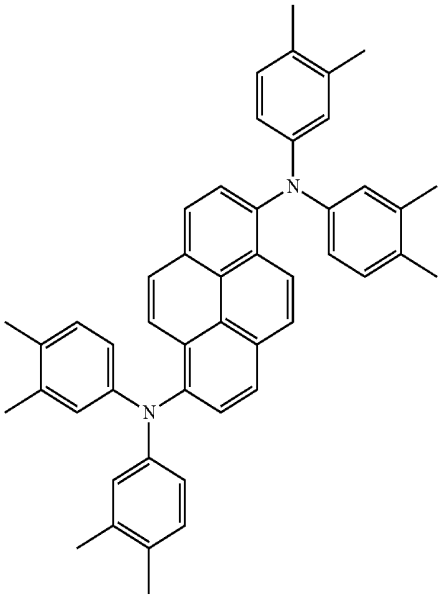
FD5



FD6



FD7



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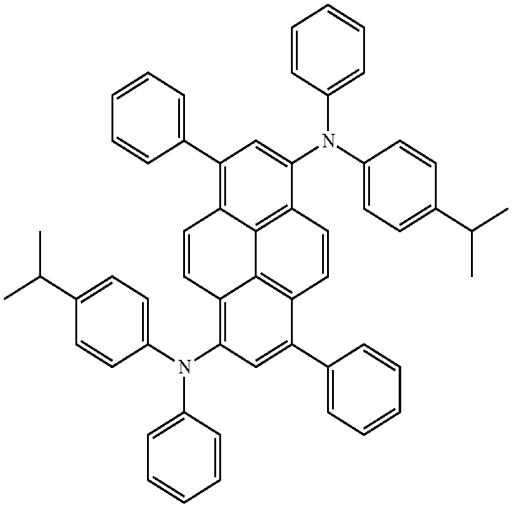
FD8



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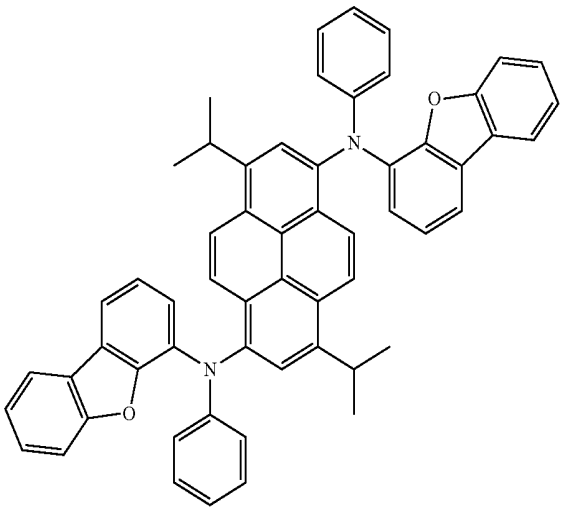

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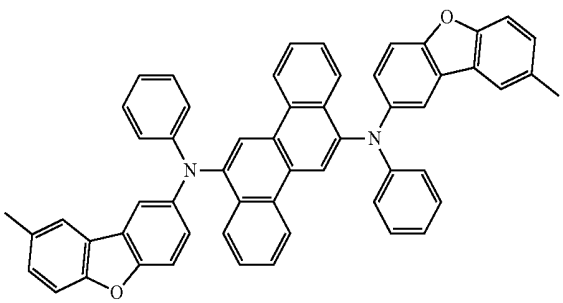

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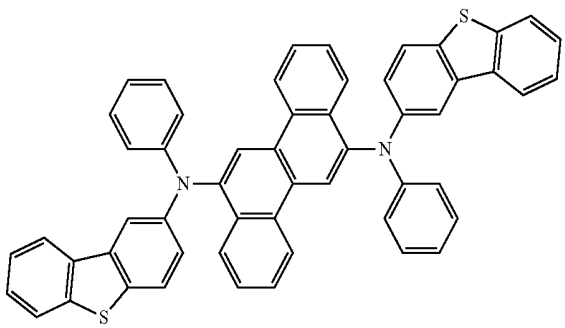
FD11



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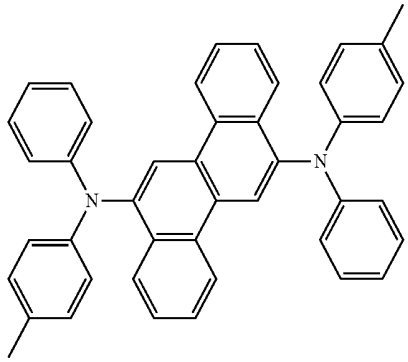
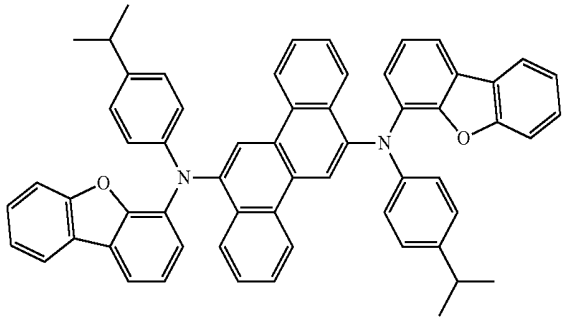
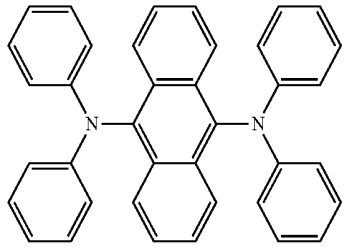


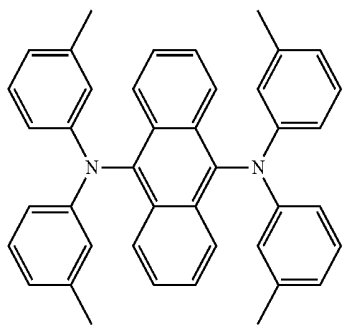
FD13



FD14



FD15



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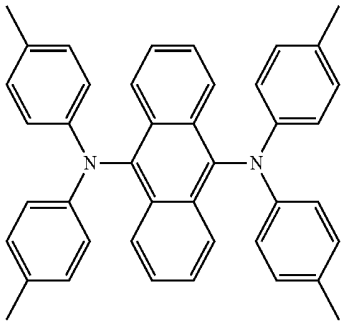
FD16



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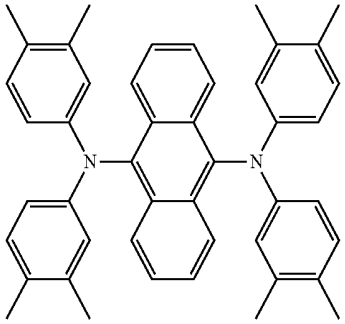
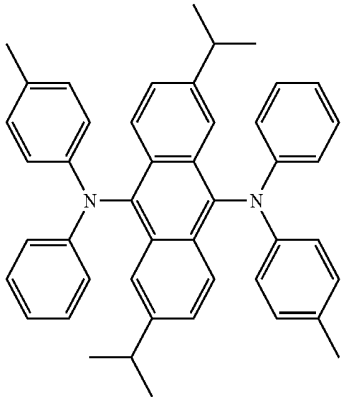


FD18



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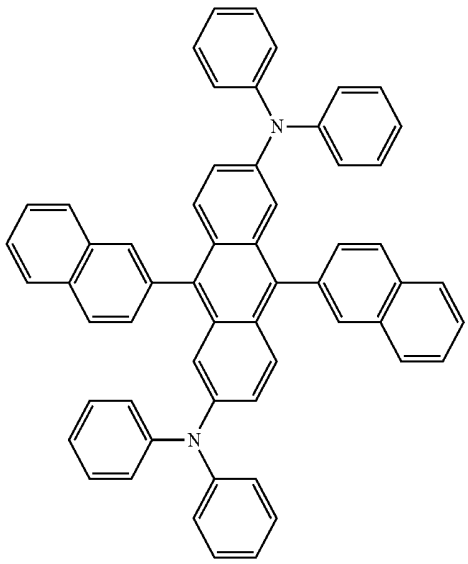

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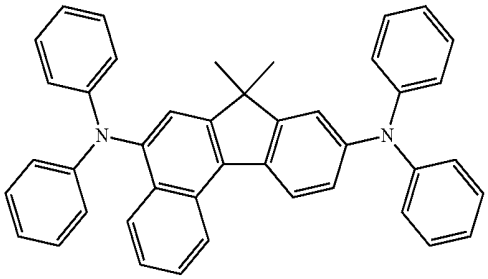
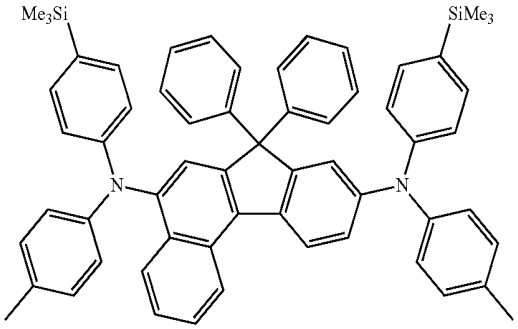
FD20



FD21



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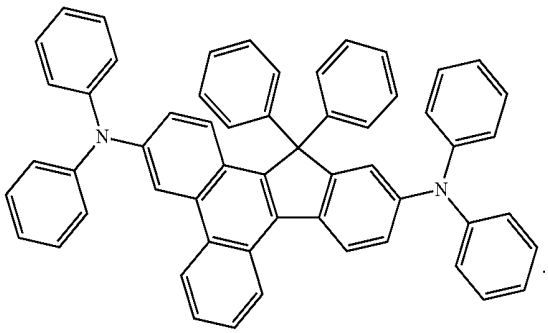
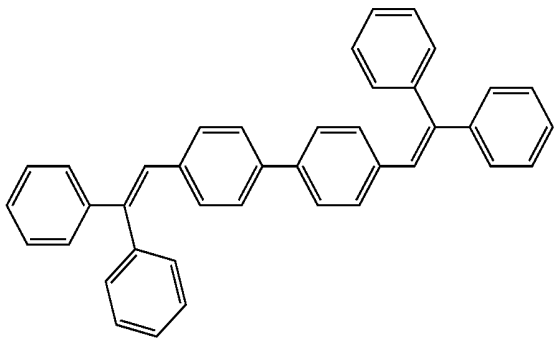


[0281] In one or more embodiments, the fluorescent dopant may be selected from the following compounds, but embodiments of the present disclosure are not limited thereto:



DPVBi

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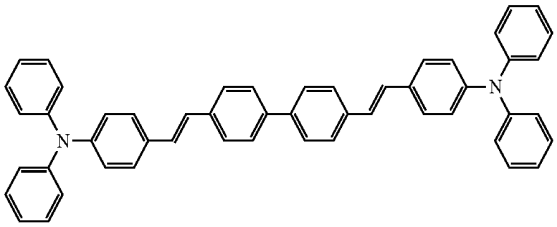
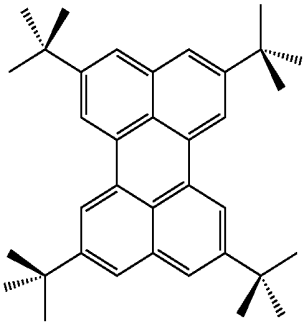
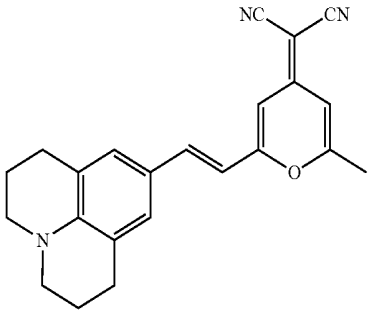


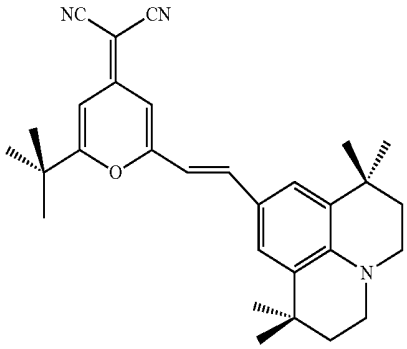
DPAVBi



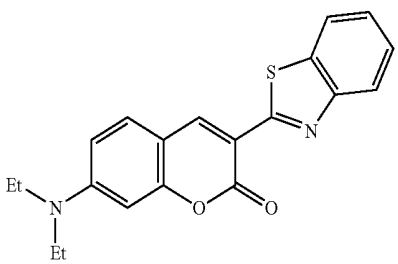
TBPe



DCM

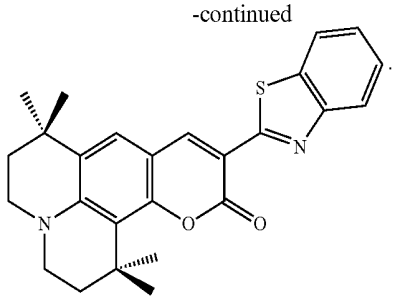


DCJTB



Coumarin 6

-continued



C545T

Electron Transport Region in Organic Layer **150**

[0282] The electron transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0283] The electron transport region may include at least one selected from a buffer layer, a hole blocking layer, an electron control layer, an electron transport layer, and an electron injection layer, but embodiments of the present disclosure are not limited thereto.

[0284] For example, the electron transport region may have an electron transport layer/electron injection layer structure, a hole blocking layer/electron transport layer/electron injection layer structure, an electron control layer/electron transport layer/electron injection layer structure, or a buffer layer/electron transport layer/electron injection layer structure, wherein for each structure, constituting layers are sequentially stacked from an emission layer. However, embodiments of the structure of the electron transport region are not limited thereto.

[0285] The electron transport region may include a compound represented by Formula 1.

[0286] In one embodiment, the electron transport region (for example, a buffer layer, a hole blocking layer, an electron control layer, or an electron transport layer in the electron transport region) may include a metal-free compound containing at least one π electron-depleted nitrogen-containing ring.

[0287] The term "π electron-depleted nitrogen-containing ring," as used herein, refers to a C_1-C_{60} heterocyclic group having at least one *—N=*' moiety as a ring-forming moiety.

[0288] For example, the "π electron-depleted nitrogen-containing ring" may be i) a 60-membered to 7-membered heteromonocyclic group having at least one *—N=*' moiety, ii) a heteropolycyclic group in which two or more 5-membered to 7-membered heteromonocyclic groups each having at least one *—N=*' moiety are condensed with each other (e.g., combined together), or iii) a heteropolycyclic group in which at least one of 5-membered to 7-membered heteromonocyclic groups, each having at least one *—N=*' moiety, is condensed with at least one C_5-C_{60} carbocyclic group.

[0289] Examples of the π electron-depleted nitrogen-containing ring include an imidazole, a pyrazole, a thiazole, an isothiazole, an oxazole, an isoxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, an indazole, a purine, a quinoline, an isoquinoline, a benzoquinoline, a phthalazine, a naphthyridine, a quinoxaline, a quinazoline, a cinnoline, a phenanthridine, an acridine, a phenanthroline, a phenazine, a benzimidazole, an isobenzothiazole, a benzoxazole, an isobenzoxazole, a triazole, a tetrazole, an oxadiazole, a triazine, thiadiazol, an imidazopyridine, an imidazopyrimidine, and an azacarbazole, but are not limited thereto.

[0290] For example, the electron transport region may include a compound represented by Formula 601:

$$[Ar_{601}]_{xe11}\text{-}[(L_{601})_{xe1}\text{-}R_{601}]_{xe21}. \qquad \text{Formula 601}$$

[0291] In Formula 601,

[0292] Ar_{601} may be a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

[0293] xe11 may be 1, 2, or 3,

[0294] L_{601} may each independently be selected from a substituted or unsubstituted

[0295] C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0296] xe1 may be an integer from 0 to 5,

[0297] R_{601} may be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_{601})(Q_{602})(Q_{603})$, —$C(=O)(Q_{601})$, —$S(=O)_2(Q_{601})$, and —$P(=O)(Q_{601})(Q_{602})$,

[0298] Q_{601} to Q_{603} may each independently be a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and

[0299] xe21 may be an integer from 1 to 5.

[0300] In one embodiment, at least one of Ar_{601}(s) in the number of xe11 and R_{601}(s) in the number of xe21 may include the π electron-depleted nitrogen-containing ring.

[0301] In one embodiment, ring Ar_{601} in Formula 601 may be selected from:

[0302] a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a qui-

noxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a thiadiazole group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group; and

[0303] a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a thiadiazole group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, $—Si(Q_{31})(Q_{32})(Q_{33})$, $—S(=O)_2(Q_{31})$, and $—P(=O)(Q_{31})(Q_{32})$, and

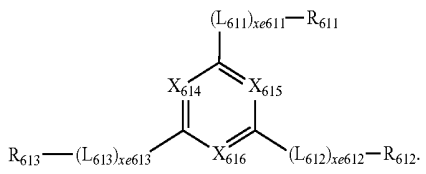
[0304] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0305] When xe11 in Formula 601 is two or more, two or more Ar_{601}(s) may be linked via a single bond.

[0306] In one or more embodiments, Ar_{601} in Formula 601 may be an anthracene group.

[0307] In one or more embodiments, a compound represented by Formula 601 may be represented by Formula 601-1:

Formula 601-1



[0308] In Formula 601-1,

[0309] X_{614} may be N or $C(R_{614})$, X_{615} may be N or $C(R_{615})$, X_{616} may be N or $C(R_{616})$, and at least one selected from X_{614} to X_{616} may be N,

[0310] L_{611} to L_{613} may each independently be the same as described in connection with L_{601},

[0311] xe611 to xe613 may each independently be the same as described in connection with xe1,

[0312] R_{611} to R_{613} may each independently be the same as described in connection with R_{601}, and

[0313] R_{614} to R_{616} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0314] In one embodiment, L_{601} and L_{611} to L_{613} in Formulae 601 and 601-1 may each independently be selected from:

[0315] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group; and

[0316] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group,

a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group;

[0317] but embodiments of the present disclosure are not limited thereto.

[0318] In one or more embodiments, xe1 and xe611 to xe613 in Formulae 601 and 601-1 may each independently be 0, 1, or 2.

[0319] In one or more embodiments, in Formulae 601 and 601-1, R_{601} and R_{611} to R_{613} may each independently be selected from:

[0320] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group;

[0321] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

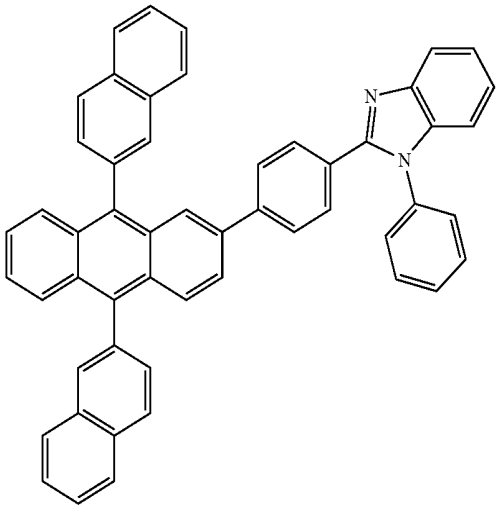
[0322] —$S(=O)_2(Q_{601})$ and —$P(O)(Q_{601})(Q_{602})$, and

[0323] Q_{601} and Q_{602} may be the same as described above.

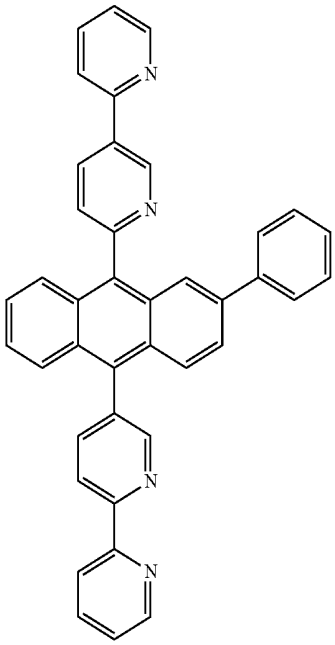
[0324] The electron transport region may include at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:

-continued

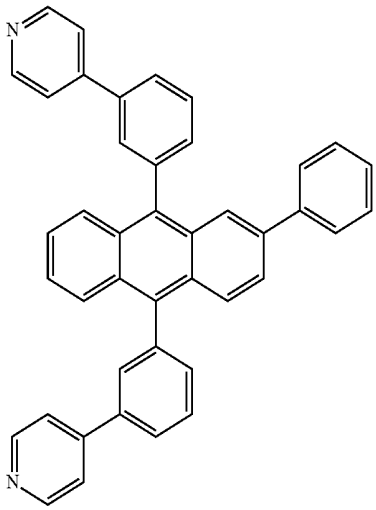
ET1



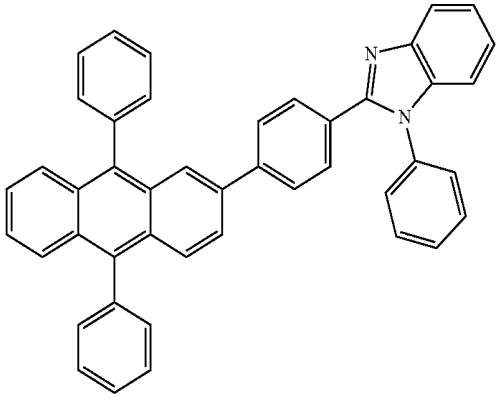
ET2



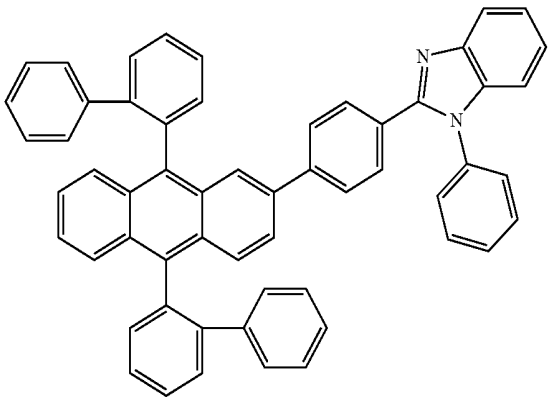
ET3



ET4



ET5



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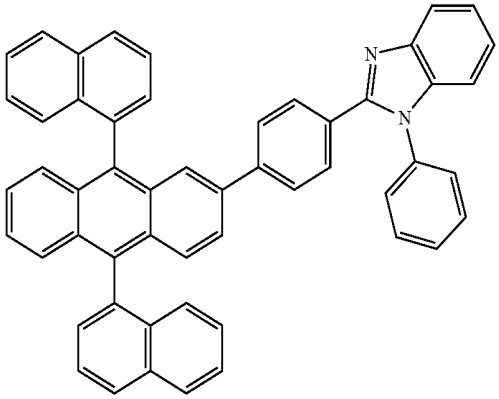

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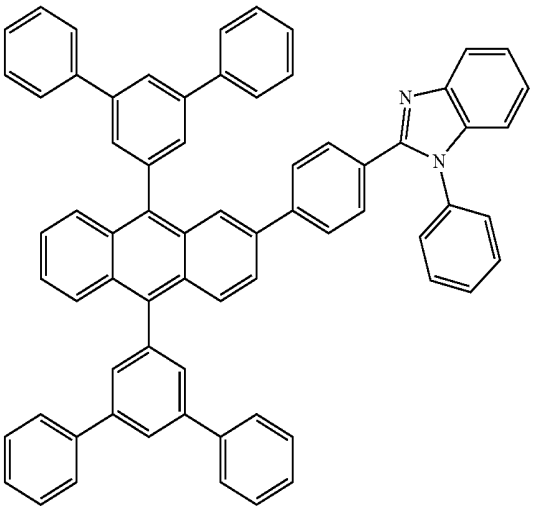

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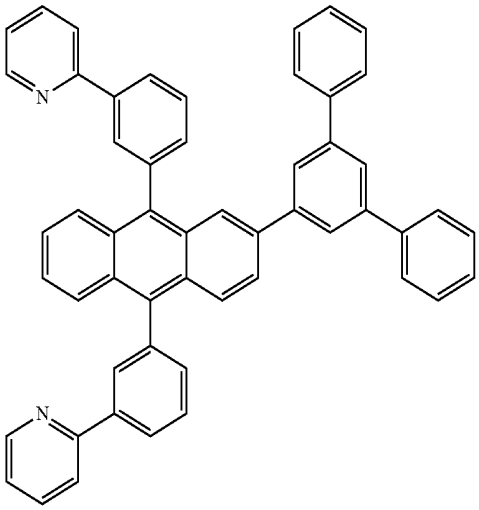

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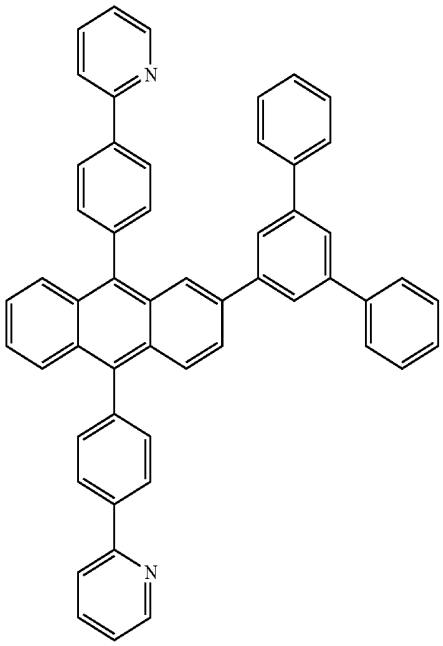

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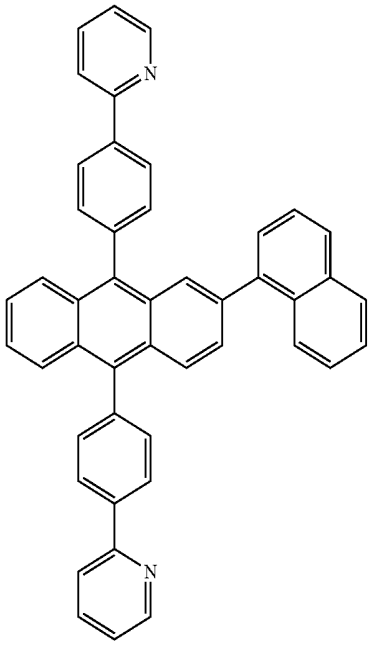

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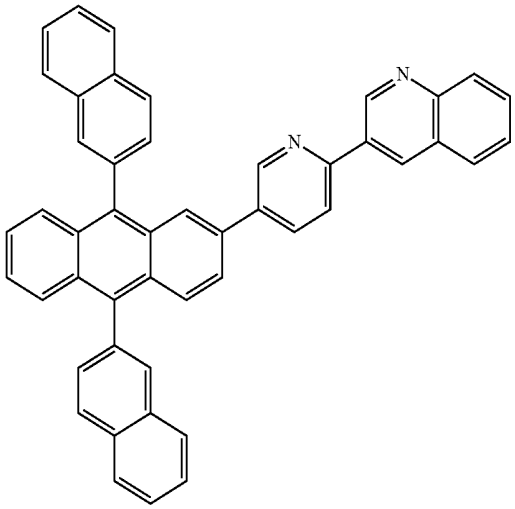

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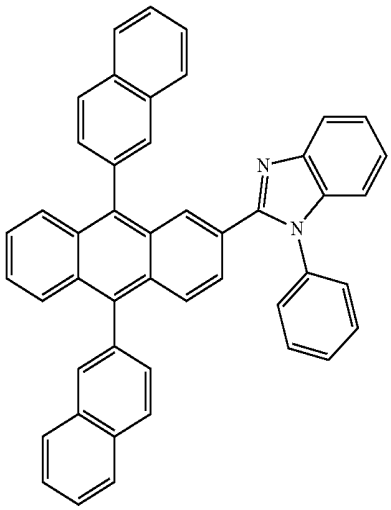

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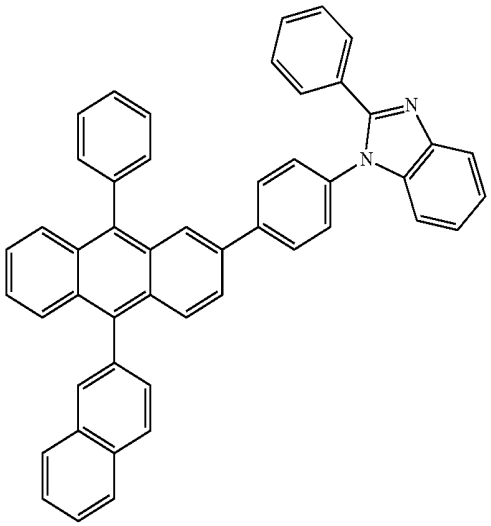

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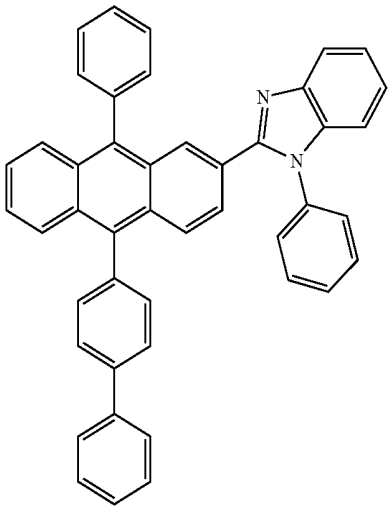

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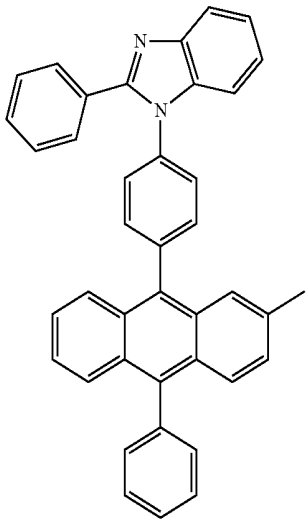

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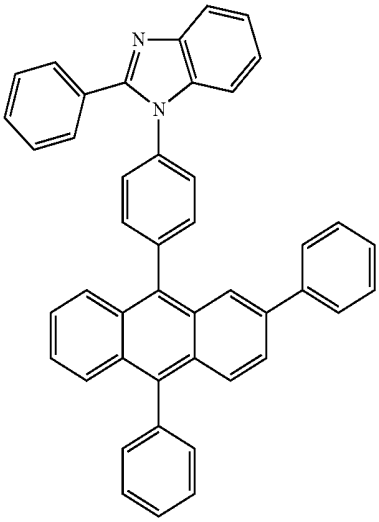

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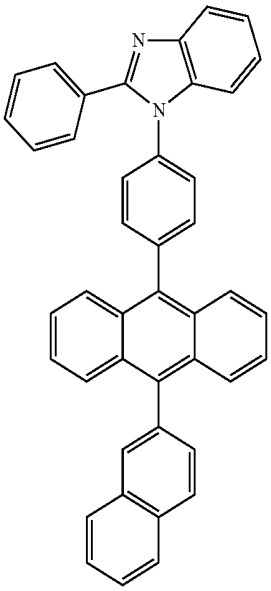

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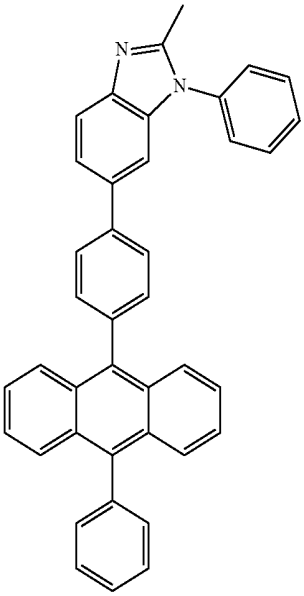

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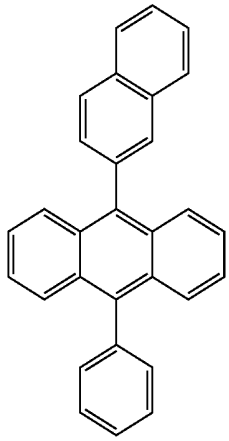

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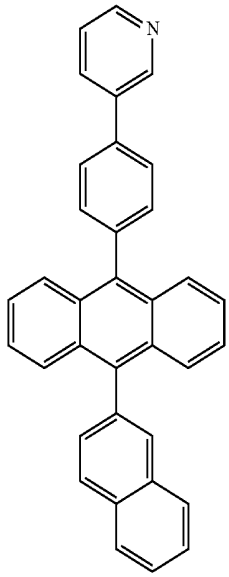

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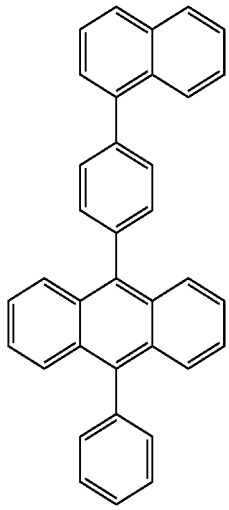

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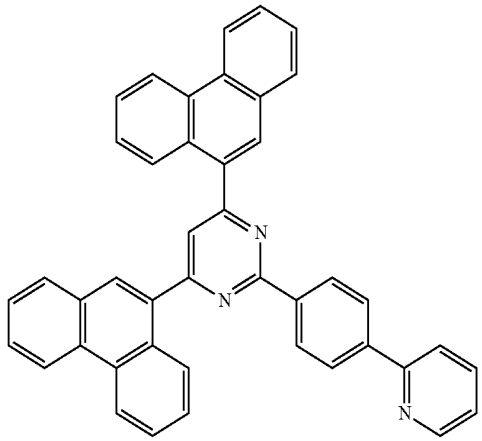

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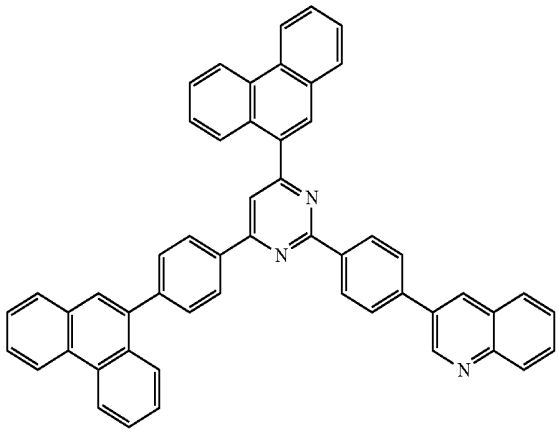

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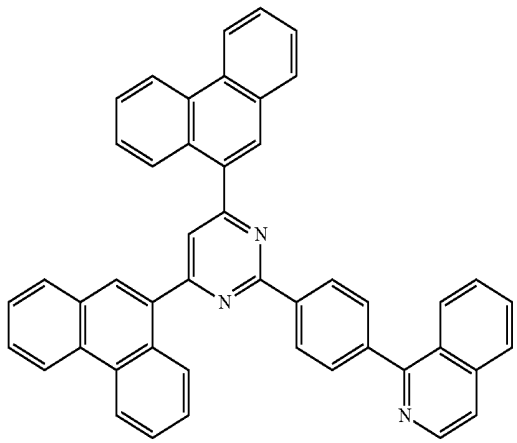

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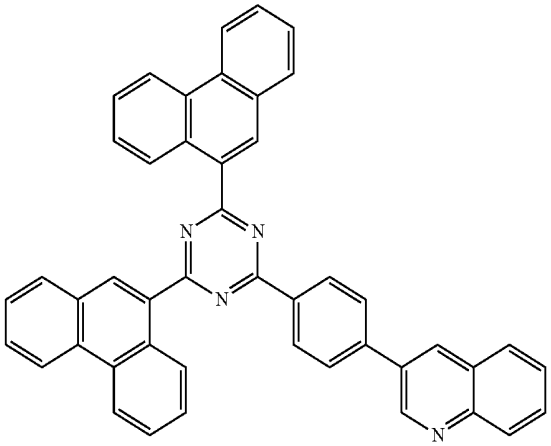

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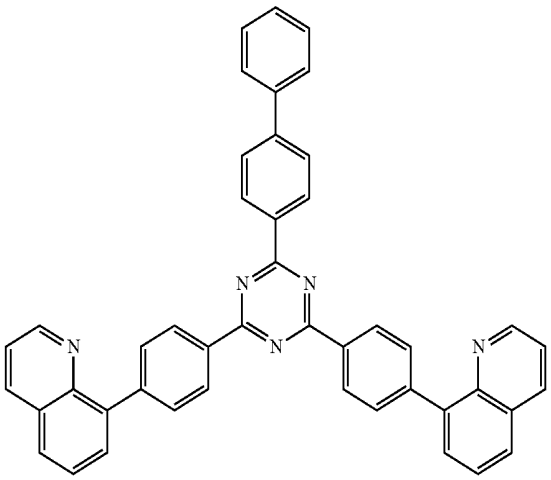

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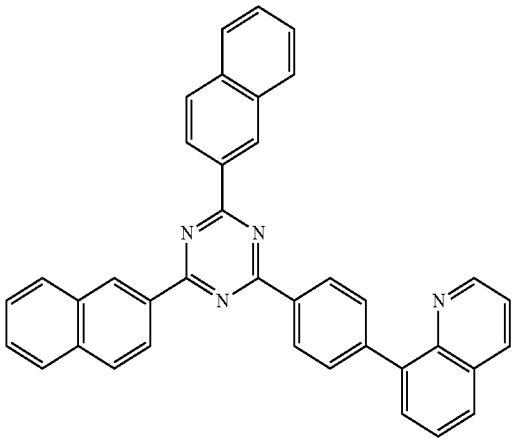

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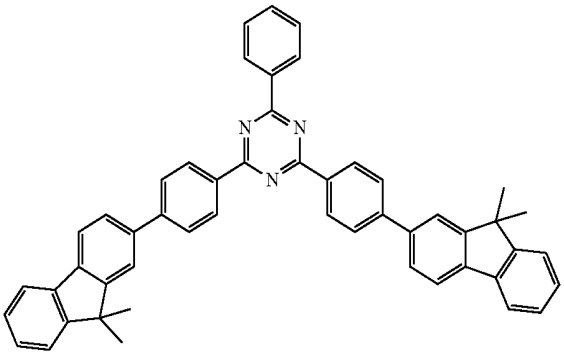

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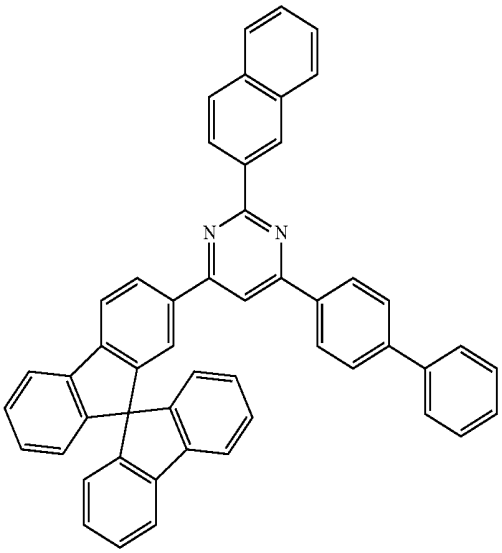

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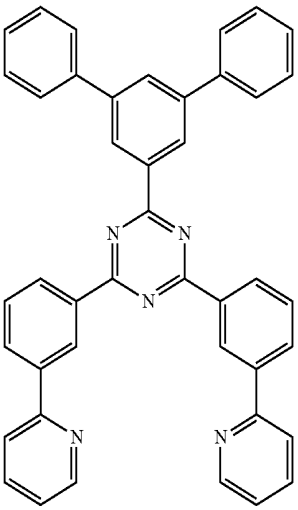

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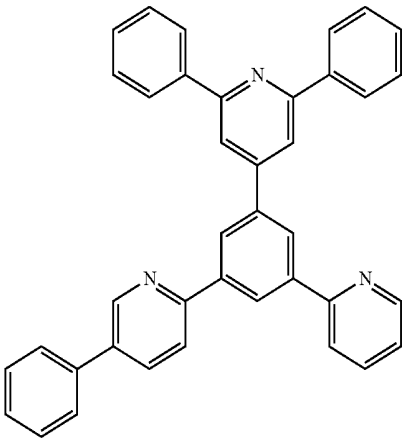

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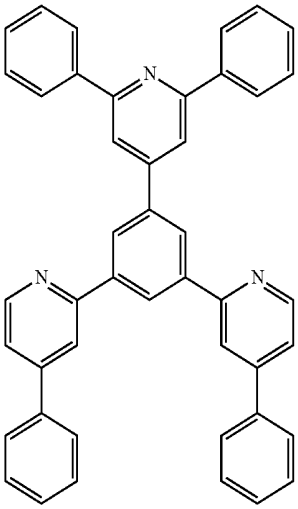

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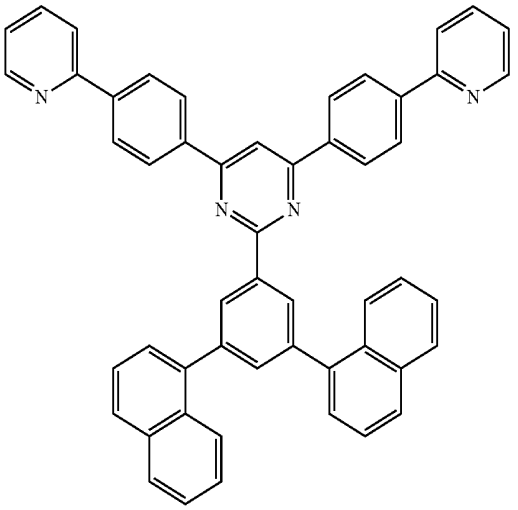

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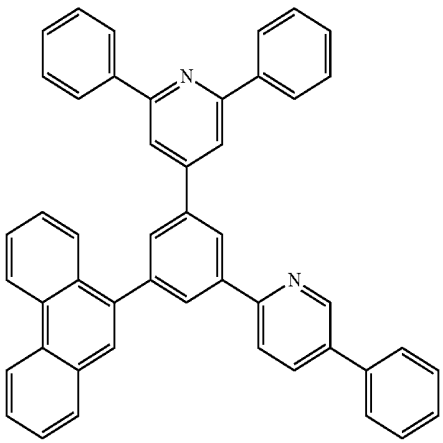

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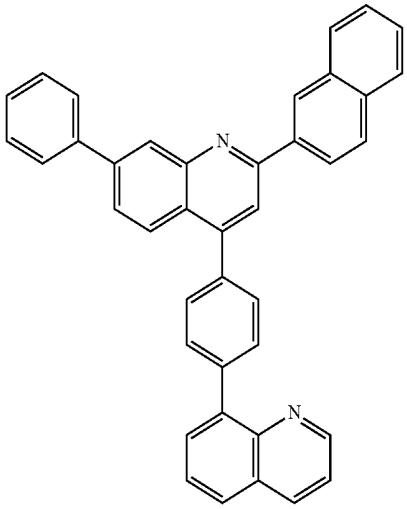

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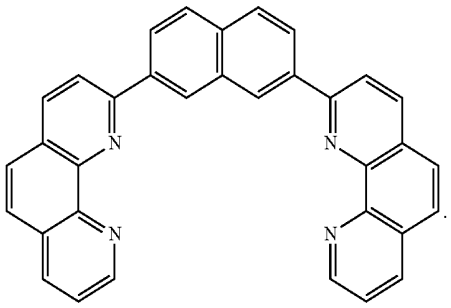
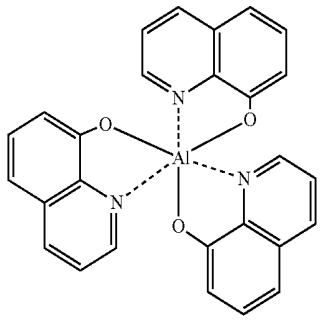
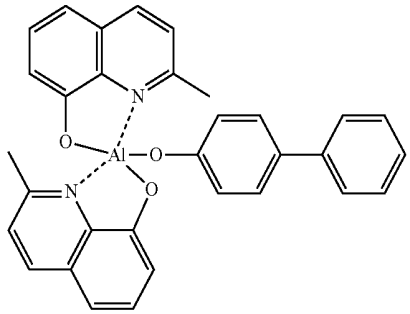


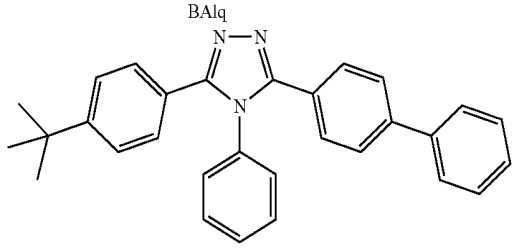
[0325] In one or more embodiments, the electron transport region may include at least one selected from 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), Alq_3, BAlq, 3-(biphenyl-4-yl)-5-(4-tert-butylphenyl)-4-phenyl-4H-1,2,4-triazole (TAZ), and NTAZ:



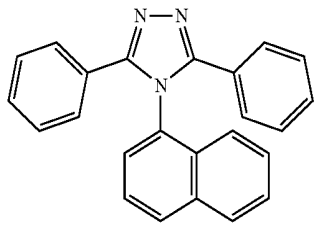
Alq_3



BAlq



TAZ



NTAZ

[0326] Thicknesses of the buffer layer, the hole blocking layer, and the electron control layer may each be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. When the thicknesses of the buffer layer, the hole blocking layer, and the electron control layer are within these ranges, the electron blocking layer may have excellent electron blocking characteristics or electron control characteristics without a substantial increase in driving voltage.

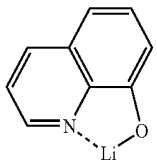
[0327] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within the range described above, the electron transport layer may have suitable or satisfactory electron transport characteristics without a substantial increase in driving voltage.

[0328] The electron transport region (for example, the electron transport layer in the electron transport region) may further include, in addition to the materials described above, a metal-containing material.

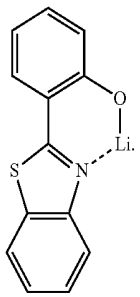
[0329] The metal-containing material may include at least one selected from alkali metal complex and alkaline earth-metal complex. The alkali metal complex may include a metal ion selected from a Li ion, a Na ion, a K ion, a Rb ion, and a Cs ion, and the alkaline earth-metal complex may include a metal ion selected from a Be ion, a Mg ion, a Ca ion, a Sr ion, and a Ba ion. A ligand coordinated with the metal ion of the alkali metal complex or the alkaline earth-metal complex may be selected from a hydroxy quinoline, a hydroxy isoquinoline, a hydroxy benzoquinoline, a hydroxy acridine, a hydroxy phenanthridine, a hydroxy phenyloxazole, a hydroxy phenylthiazole, a hydroxy diphenyloxadiazole, a hydroxy diphenylthiadiazol, a hydroxy phenylpyridine, a hydroxy phenylbenzimidazole, a hydroxy phenylbenzothiazole, a bipyridine, a phenanthroline, and a cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0330] For example, 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



ET-D2



[0331] The electron transport region may include an electron injection layer that facilitates injection of electrons from the second electrode **190**. The electron injection layer may directly contact the second electrode **190**.

[0332] The electron injection layer may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0333] The electron injection layer may include an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combinations thereof.

[0334] The alkali metal may be selected from Li, a Na, K, Rb, and Cs. In one embodiment, the alkali metal may be Li, a Na, or Cs. In one or more embodiments, the alkali metal may be Li or Cs, but embodiments of the present disclosure are not limited thereto.

[0335] The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

[0336] The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

[0337] The alkali metal compound, the alkaline earth-metal compound, and the rare earth metal compound may be selected from oxides and halides (for example, fluorides, chlorides, bromides, or iodides) of the alkali metal, the alkaline earth-metal, and the rare earth metal.

[0338] The alkali metal compound may be selected from alkali metal oxides, such as Li_2O, Cs_2O, or K_2O, and alkali metal halides, such as LiF, NaF, CsF, KF, LiI, NaI, CsI, or KI. In one embodiment, the alkali metal compound may be selected from LiF, Li_2O, NaF, LiI, NaI, CsI, and KI, but embodiments of the present disclosure are not limited thereto.

[0339] The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO, $Ba_xSr_{1-x}O$ ($0<x<1$), or $Ba_xCa_{1-x}O$ ($0<x<1$). In one embodiment, the alkaline earth-metal compound may be selected from BaO, SrO, and CaO, but embodiments of the present disclosure are not limited thereto.

[0340] The rare earth metal compound may be selected from YbF_3, ScF_3, ScO_3, Y_2O_3, Ce_2O_3, GdF_3, and TbF_3. In one embodiment, the rare earth metal compound may be selected from YbF_3, ScF_3, TbF_3, YbI_3, ScI_3, and TbI_3, but embodiments of the present disclosure are not limited thereto.

[0341] The alkali metal complex, the alkaline earth-metal complex, and the rare earth metal complex may include an ion of alkali metal, alkaline earth-metal, and rare earth metal as described above, and a ligand coordinated with a metal ion of the alkali metal complex, the alkaline earth-metal complex, or the rare earth metal complex may be selected from hydroxy quinoline, hydroxy isoquinoline, hydroxy benzoquinoline, hydroxy acridine, hydroxy phenanthridine, hydroxy phenyloxazole, hydroxy phenylthiazole, hydroxy diphenyloxadiazole, hydroxy diphenylthiadiazol, hydroxy phenylpyridine, hydroxy phenylbenzimidazole, hydroxy phenylbenzothiazole, bipyridine, phenanthroline, and cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0342] The electron injection layer may include (e.g., consist of) an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combinations thereof, as described above. In one or more embodiments, the electron injection layer may further include an organic material. When the electron injection layer further includes an organic material, an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combinations thereof may be homogeneously or non-homogeneously dispersed in a matrix including the organic material.

[0343] 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. When the thickness of the electron injection layer is within the range described above, the electron injection layer may have suitable or satisfactory electron injection characteristics without a substantial increase in driving voltage.

Second Electrode **190**

[0344] The second electrode **190** may be disposed on the organic layer **150** having such a structure. The second electrode **190** may be a cathode which is an electron injection electrode, and in this regard, a material for forming the second electrode **190** may be selected from metal, an alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function.

[0345] The second electrode **190** may include at least one selected from lithium (Li), silver (Ag), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), ITO, and IZO, but embodiments of the present disclosure are not limited thereto. The second electrode **190** may be a transmissive electrode, a semi-transmissive electrode, or a reflective electrode.

[0346] The second electrode **190** may have a single-layered structure, or a multi-layered structure including two or more layers.

[0347] [Description of FIGS. **2** to **4**]

[0348] An organic light-emitting device **20** of FIG. **2** includes a first capping layer **210**, a first electrode **110**, an organic layer **150**, and a second electrode **190** which are sequentially stacked in this stated order, an organic light-emitting device **30** of FIG. **3** includes a first electrode **110**, an organic layer **150**, a second electrode **190**, and a second capping layer **220** which are sequentially stacked in this stated order, and an organic light-emitting device **40** of FIG. **4** includes a first capping layer **210**, a first electrode **110**, an organic layer **150**, a second electrode **190**, and a second capping layer **220**.

[0349] Regarding FIGS. **2** to **4**, the first electrode **110**, the organic layer **150**, and the second electrode **190** may be understood by referring to the description presented in connection with FIG. **1**.

[0350] In the organic layer **150** of each of the organic light-emitting devices **20** and **40**, light generated in an emission layer may pass through the first electrode **110**, which is a semi-transmissive electrode or a transmissive electrode, and the first capping layer **210** toward the outside, and in the organic layer **150** of each of the organic light-emitting devices **30** and **40**, light generated in an emission layer may pass through the second electrode **190**, which is a semi-transmissive electrode or a transmissive electrode, and the second capping layer **220** toward the outside.

[0351] The first capping layer **210** and the second capping layer **220** may increase external luminescent efficiency according to the principle of constructive interference.

[0352] The first capping layer **210** and the second capping layer **220** may each independently be an organic capping layer including an organic material, an inorganic capping layer including an inorganic material, or a composite capping layer including an organic material and an inorganic material.

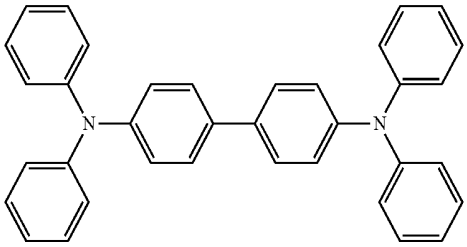
[0353] At least one selected from the first capping layer **210** and the second capping layer **220** may each independently include at least one material selected from carbocyclic compounds, heterocyclic compounds, amine-based compounds, porphyrine derivatives, phthalocyanine derivatives, a naphthalocyanine derivatives, alkali metal com-

plexes, and alkaline earth-based complexes. The carbocyclic compound, the heterocyclic compound, and the amine-based compound may be optionally substituted with a substituent containing at least one element selected from O, N, S, Se, Si, F, Cl, Br, and I. In one embodiment, at least one selected from the first capping layer **210** and the second capping layer **220** may each independently include an amine-based compound.

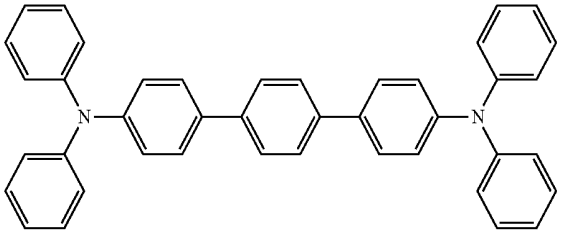
[0354] In one embodiment, at least one selected from the first capping layer **210** and the second capping layer **220** may each independently include the compound represented by Formula 201 or the compound represented by Formula 202.

[0355] In one or more embodiments, at least one selected from the first capping layer **210** and the second capping layer **220** may each independently include a compound selected from Compounds HT28 to HT33 and Compounds CP1 to CP5, but embodiments of the present disclosure are not limited thereto:

CP1



CP2



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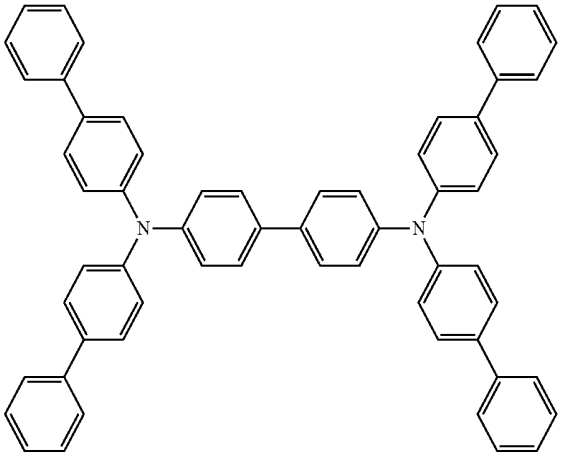

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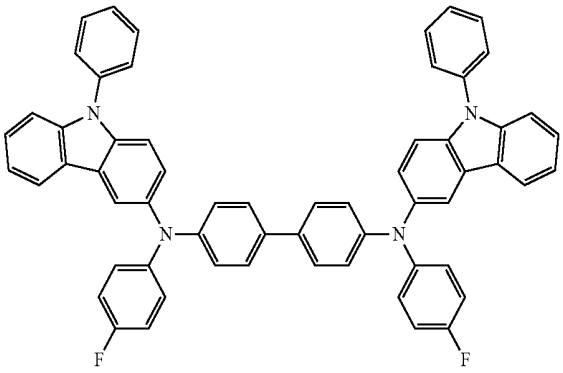
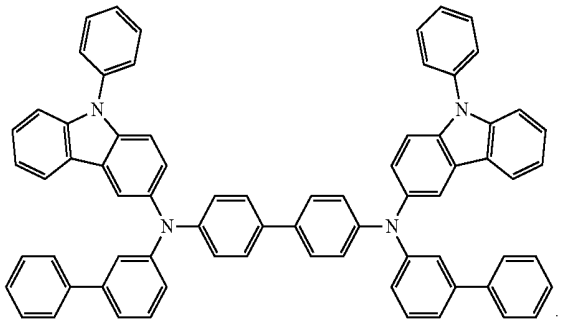
CP4



CP5



[0356] Hereinbefore, the organic light-emitting device according to an embodiment has been described in connection with FIGS. **1-4**. However, embodiments of the present disclosure are not limited thereto.

[0357] Layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region may be formed in a certain region by using one or more suitable methods selected from vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, ink-jet printing, laser-printing, and laser-induced thermal imaging.

[0358] When layers constituting the hole transport region, the emission layer, and layers constituting the electron transport region are formed by vacuum deposition, the deposition conditions may vary according to a compound that is used to form the hole injection layer, and the structure and thermal characteristics of the hole injection layer. For example, the deposition conditions may include a deposition temperature of about 100° C. to about 500° C., a vacuum pressure of about 10^{-8} torr to about 10^{-3} torr, and a deposition rate of about 0.01 Å/sec to about 0 Å/sec.

[0359] When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by spin coating, the spin coating may be performed at a coating speed of about 2,000 rpm to about 5,000 rpm and at a heat treatment temperature of about 80° C. to about 200° C. by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

General Definition of Some of the Substituents

[0360] The term "C_1-C_{60} alkyl group," as used herein, refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms, and

examples thereof include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. The term "C_1-C_{60} alkylene group," as used herein, refers to a divalent group having substantially the same structure as the C_1-C_{60} alkyl group.

[0361] The term "C_2-C_{60} alkenyl group," as used herein, refers to a hydrocarbon group having at least one carbon-carbon double bond at a main chain (e.g., in the middle) or at the terminus of the C_2-C_{60} alkyl group, and examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term "C_2-C_{60} alkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C_2-C_{60} alkenyl group.

[0362] The term "C_2-C_{60} alkynyl group," as used herein, refers to a hydrocarbon group having at least one carbon-carbon triple bond at a main chain (e.g., in the middle) or at the terminus of the C_2-C_{60} alkyl group, and examples thereof include an ethynyl group, and a propynyl group. The term "C_2-C_{60} alkynylene group," as used herein, refers to a divalent group having substantially the same structure as the C_2-C_{60} alkynyl group.

[0363] The term "C_1-C_{60} alkoxy group," as used herein, refers to a monovalent group represented by —OA_{101} (wherein A_{101} is the C_1-C_{60} alkyl group), and examples thereof include a methoxy group, an ethoxy group, and an isopropyloxy group.

[0364] The term "C_3-C_{10} cycloalkyl group," as used herein, refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term "C_3-C_{10} cycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the C_3-C_{10} cycloalkyl group.

[0365] The term "C_1-C_{10} heterocycloalkyl group," as used herein, refers to a monovalent monocyclic group having at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom and 1 to 10 carbon atoms, and examples thereof include a 1,2,3,4-oxatriazolidinyl group, a tetrahydrofuranyl group, and a tetrahydrothiophenyl group. The term "C_1-C_{10} heterocycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the C_1-C_{10} heterocycloalkyl group.

[0366] The term "C_3-C_{10} cycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity (e.g., the ring and/or the entire group is not aromatic), and examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term "C_3-C_{10} cycloalkenylene group," as used herein. refers to a divalent group having substantially the same structure as the C_3-C_{10} cycloalkenyl group.

[0367] The term "C_1-C_{10} heterocycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, 1 to 10 carbon atoms, and at least one double bond in its ring. Non-limiting examples of the C_1-C_{10} heterocycloalkenyl group include a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuranyl group, and a 2,3-dihydrothiophenyl group. The term "C_1-C_{10} heterocycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C_1-C_{10} heterocycloalkenyl group.

[0368] The term "C_6-C_{60} aryl group," as used herein, refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and the term "C_6-C_{60} arylene group," as used herein, refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Non-limiting examples of the C_6-C_{60} aryl group include 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 (e.g., combined together).

[0369] The term "C_1-C_{60} heteroaryl group," as used herein, refers to a monovalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms.

[0370] The term "C_1-C_{60} heteroarylene group," as used herein, refers to a divalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms. Non-limiting examples of the C_1-C_{60} heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1-C_{60} heteroaryl group and the C_1-C_{60} heteroarylene group each include two or more rings, the rings may be condensed with each other (e.g., combined together).

[0371] The term "C_6-C_{60} aryloxy group," as used herein, refers to —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).

[0372] The term "monovalent non-aromatic condensed polycyclic group," as used herein, refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed with each other (e.g., combined together), only carbon atoms as ring-forming atoms (e.g., the ring itself is only formed from carbon atoms), and no aromaticity in its entire molecular structure (e.g., the entire group and/or molecule is not aromatic). An example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. The term "divalent non-aromatic condensed polycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed polycyclic group.

[0373] The term "monovalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a monovalent group (for example, having 1 to 60 carbon atoms) having two or more rings condensed to each other, at least one heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure (e.g., the entire group and/or molecule is not aromatic). An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. The term "divalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0374] The term "C_5-C_{60} carbocyclic group," as used herein, refers to a monocyclic or polycyclic group having 5 to 60 carbon atoms in which a ring-forming atom is a carbon

atom only (e.g., the ring itself is only formed from carbon atoms). The C_5-C_{60} carbocyclic group may be an aromatic carbocyclic group or a non-aromatic carbocyclic group. The C_5-C_{60} carbocyclic group may be a ring, such as benzene, a monovalent group, such as a phenyl group, or a divalent group, such as a phenylene group. In one or more embodiments, depending on the number of substituents coupled to or connected to the C_5-C_{60} carbocyclic group, the C_5-C_{60} carbocyclic group may be a trivalent group or a quadrivalent group.

[0375] The term "C_1-C_{60} heterocyclic group," as used herein, refers to a group having substantially the same structure as the C_1-C_{60} carbocyclic group, except that as a ring-forming atom, at least one heteroatom selected from N, O, Si, P, and S is used in addition to carbon (the number of carbon atoms may be in a range of 1 to 60).

[0376] At least one substituent of the substituted C_5-C_{60} carbocyclic group, the substituted C_1-C_{60} heterocyclic group, the substituted C_3-C_{10} cycloalkylene group, the substituted C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted C_1-C_{10} heterocycloalkenylene group, the substituted C_6-C_{60} arylene group, the substituted C_1-C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_2-C_{60} alkenyl group, the substituted C_2-C_{60} alkynyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} aryl group, the substituted C_6-C_{60} aryloxy group, the substituted C_6-C_{60} arylthio group, the substituted C_1-C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0377] deuterium (-D), —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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;

[0378] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—Si(Q_{11})(Q_{12})(Q_{13})$, $—N(Q_{11})(Q_{12})$, $—B(Q_{11})(Q_{12})$, $—C(=O)(Q_{11})$, $—S(=O)_2(Q_{11})$, and $—P(=O)(Q_{11})(Q_{12})$,

[0379] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0380] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—Si(Q_{21})(Q_{22})(Q_{23})$, $—N(Q_{21})(Q_{22})$, $—B(Q_{21})(Q_{22})$, $—C(=O)(Q_{21})$, $—S(=O)_2(Q_{21})$, and $—P(=O)(Q_{21})(Q_{22})$; and

[0381] $—Si(Q_{31})(Q_{32})(Q_{33})$, $—N(Q_{31})(Q_{32})$, $—B(Q_{31})(Q_{32})$, $—C(=O)(Q_{31})$, $—S(=O)_2(Q_{31})$, and $—P(=O)(Q_{31})(Q_{32})$, and

[0382] Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0383] The term "Ph," as used herein, refers to a phenyl group, the term "Me," as used herein, refers to a methyl group, the term "Et," as used herein, refers to an ethyl group, the term "ter-Bu" or "Bu^t," as used herein, refers to a tert-butyl group, and the term "OMe," as used herein, refers to a methoxy group.

[0384] The term "biphenyl group," as used herein, refers to "a phenyl group substituted with a phenyl group." In other words, the "biphenyl group" is a substituted phenyl group having a C_6-C_{60} aryl group as a substituent.

[0385] The term "terphenyl group," as used herein refers to "a phenyl group substituted with a biphenyl group." In other words, the "terphenyl group" is a phenyl group having, as a substituent, a C_6-C_{60} aryl group substituted with a C_6-C_{60} aryl group.

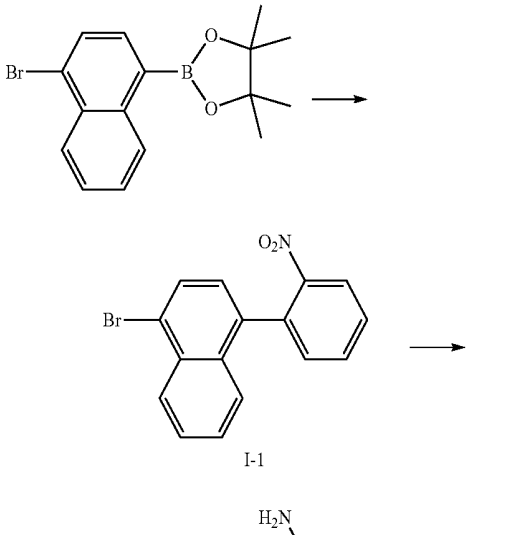
[0386] * and *' used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

[0387] Hereinafter, a compound according to embodiments and an organic light-emitting device according to embodiments will be described in more detail with reference to Synthesis Examples and Examples. The wording "B was used instead of A" used in describing Synthesis Examples refers to that an identical (or substantially identical) molar equivalent of B was used in place of A. A synthesis method of the condensed cyclic compound represented by Formula 1 will be apparent to those of ordinary skill in the art by referring to the following examples. The following examples, however, do not limit the present disclosure.

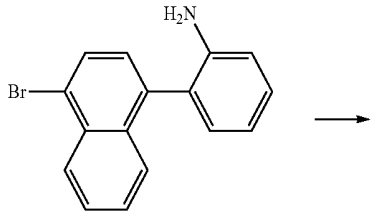
EXAMPLES

Synthesis Example 1: Synthesis of Compound 3

[0388]



I-1



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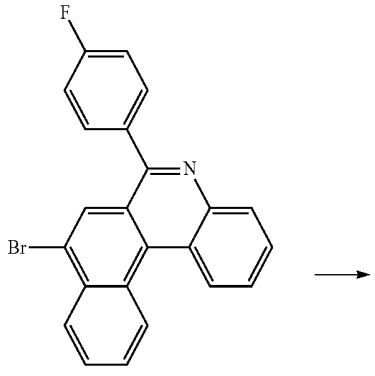

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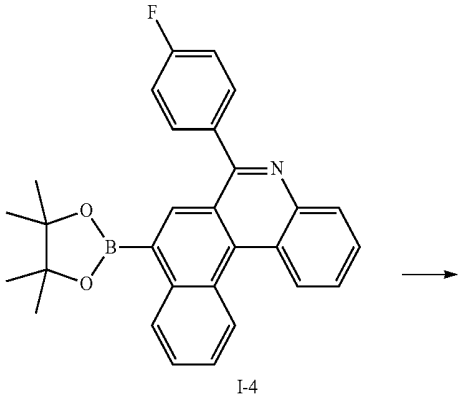

I-4

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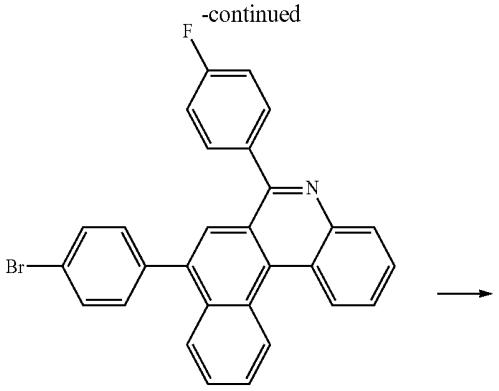
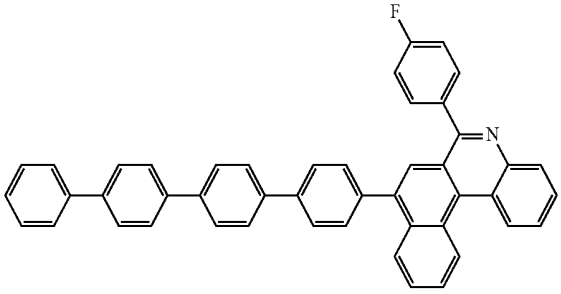


I-5



3

Synthesis of Intermediate I-1

[0389] 3.32 g (10.0 mmol) of 2-(4-bromonaphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane, 2.02 g (10.0 mmol) of 1-bromo-2-nitrobenzene, 0.58 g (0.50 mmol) of $Pd(PPh_3)_4$, 0.16 g (0.5 mmol) of tetrabutylammonium bromide (TBAB), and 3.18 g (30.0 mmol) of Na_2CO_3 were dissolved in 60 mL of a mixed solution of toluene/ethanol/H_2O (3/3/1) and stirred at a temperature of 80° C. for 16 hours. The reaction solution was cooled to room temperature, and an organic layer was extracted therefrom three times by using 60 mL of water and 60 mL of diethylether. The extracted organic layer was dried by using magnesium sulfate, and a solvent was evaporated therefrom. Then, a residue obtained therefrom was separated and purified by silica gel column chromatography to obtain 2.68 g (yield: 82%) of Intermediate I-1. The obtained compound was identified by LC-MS.

[0390] $C_{16}H_{10}BrNO_2$: M+1 327.0.

Synthesis of Intermediate I-2

[0391] 3.27 g (10.0 mmol) of Intermediate I-1, 3.56 g (30 mmol) of tin, and 5 mL (50 mmol, conc. 36.5%) of hydrochloric acid were dissolved in 60 mL of ethanol and stirred at a temperature of 100° C. for 8 hours. The reaction solution was cooled to room temperature and filtered under reduced pressure to obtain a filtrate. A solution in which 3 g of sodium hydroxide was dissolved in 10 mL of water was added to the filtrate, and an organic layer was extracted therefrom three times by using 60 mL of water and 60 mL of dichloromethane. The extracted organic layer was dried by using magnesium sulfate, and a solvent was evaporated therefrom. Then, a residue obtained therefrom was separated and purified by silica gel column chromatography to obtain 2.67 g (yield: 90%) of Intermediate I-2. The obtained compound was identified by LC-MS.

[0392] $C_{16}H_{12}BrN$: M+1 297.0.

Synthesis of Intermediate I-3

[0393] 2.97 g (10 mmol) of Intermediate I-2 and 2.48 g (20 mmol) of 4-fluorobenzaldehyde were dissolved in 30 mL of trifluoroacetic acid and stirred at a temperature of 130° C. for 3 days in a sealed tube. The reaction solution was cooled to room temperature and quenched by using $NaHCO_3$. Then, an organic layer was extracted therefrom three times by using 60 mL of water and 60 mL of dichloromethane. The extracted organic layer was dried by using magnesium sulfate, and a solvent was evaporated therefrom. Then, a residue obtained therefrom was separated and purified by silica gel column chromatography to obtain 2.01 g (yield: 50%) of Intermediate I-3. The obtained compound was identified by LC-MS.

[0394] $C_{23}H_{13}BrFN$: M+1 401.0.

Synthesis of Intermediate I-4

[0395] 4.01 g (10 mmol) of Intermediate I-3 was dissolved in 50 mL of THF, and 4 mL of nBuLi (**2.5**M in hexane) was added thereto at a temperature of −78° C. After 1 hour, 2.0 mL (10 mmol) of 2-isopropoxy-4,4,5,5-tetramethyl-1,3,2-dioxaborolane at the same temperature. The reaction solution was stirred at room temperature for 5 hours, and water was added thereto. Then, the reaction product was washed three times by 30 mL of diethyl ether. The washed diethyl ether layer was dried by using $MgSO_4$ under reduced pressure. Then, the product was separated and purified by silica gel column chromatography to obtain 3.46 g (yield: 77%) of Intermediate I-4. The obtained compound was identified by LC-MS.

[0396] $C_{16}H_{19}BO_2$: M+1 449.2.

Synthesis of Intermediate I-5

[0397] 4.49 g (10.0 mmol) of Intermediate I-4, 3.38 g (12.0 mmol) of 1-bromo-4-iodobenzene, 0.58 g (0.50 mmol) of $Pd(PPh_3)_4$, 0.16 g (0.5 mmol) of tetrabutylammonium bromide (TBAB), and 3.18 g (30.0 mmol) of Na_2CO_3 were dissolved in 60 mL of a mixed solution of toluene/ethanol/H_2O (3/3/1) and stirred at a temperature of 80° C. for 16 hours. The reaction solution was cooled to room temperature, and an organic layer was extracted therefrom three times by using 60 mL of water and 60 mL of diethylether. The extracted organic layer was dried by using magnesium sulfate, and a solvent was evaporated therefrom. Then, a residue obtained therefrom was separated and purified by silica gel column chromatography to obtain 3.82 g (yield: 80%) of Intermediate I-5. The obtained compound was identified by LC-MS.

[0398] $C_{29}H_{17}BrFN$: M+1 477.0.

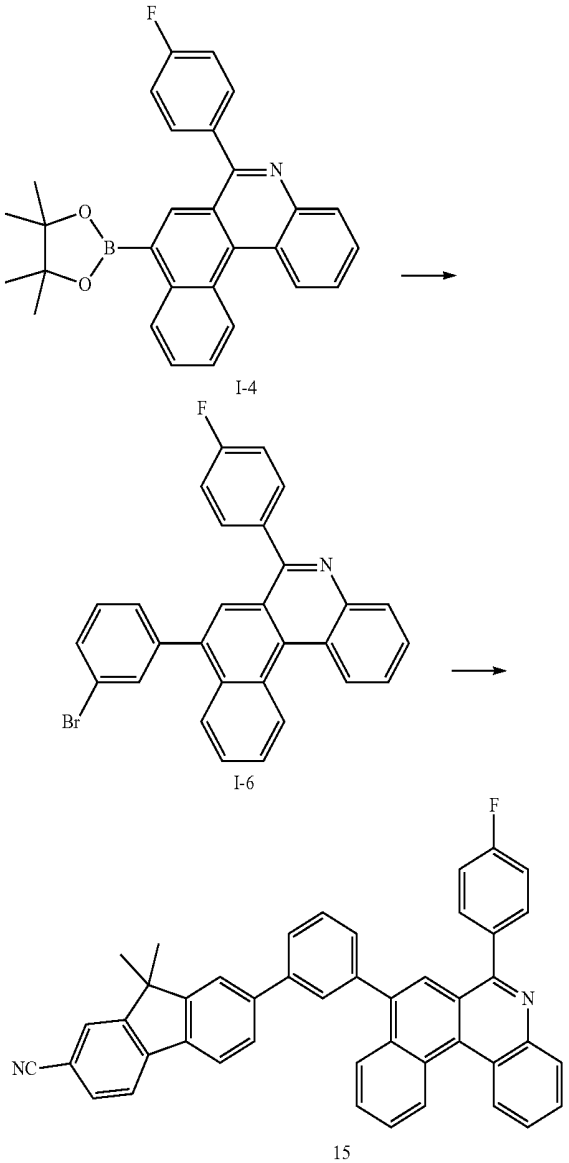
Synthesis of Compound 3

[0399] 4.77 g (10 mmol) of Intermediate I-5, 3.56 g (10 mmol) of 2-([1,1':4',1"-terphenyl]-4-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane, 0.58 g (0.5 mmol) of $Pd(PPh_3)_4$, and 4.14 g (30 mmol) of K_2CO_3 were dissolved in 60 mL of a mixed solution of tetrahydrofuran (THF)/H_2O (volume ratio of 2/1) and stirred at a temperature of 80° C. for 16 hours. The reaction solution was cooled to room temperature, and 40 mL of water was added thereto. Then, an organic layer was extracted therefrom three times by using 50 mL of ethyl ether. The extracted organic layer was dried by using magnesium sulfate, and a solvent was evaporated therefrom. Then, a residue obtained therefrom was separated and purified by silica gel column chromatography to obtain 4.08 g (yield: 65%) of Compound 3. The obtained compound was identified by mass spectrometry/fast atom bombardment (MS/FAB) and ^1H nuclear magnetic resonance spectroscopy (NMR).

[0400] $C_{47}H_{30}FN$ cal. 627.24, found 627.25.

Synthesis Example 2: Synthesis of Compound 15

[0401]



Synthesis of Intermediate I-6

[0402] 3.43 g (yield: 72%) of Intermediate I-6 was obtained in substantially the same manner as in Synthesis of Intermediate I-5, except that 1-bromo-3-iodobenzene was used instead of 1-bromo-4-iodobenzene. The obtained compound was identified by LC-MS.

[0403] $C_{29}H_{17}BrFN$: M+1 477.0.

Synthesis of Compound 15

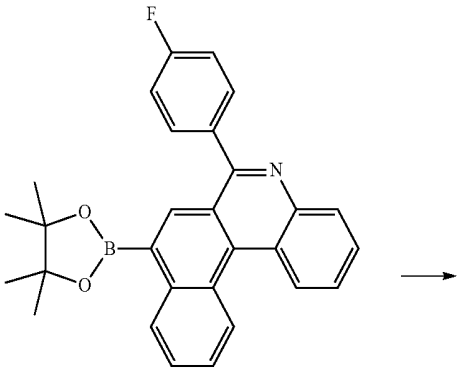
[0404] 4.13 g (yield: 67%) of Compound 15 was obtained in substantially the same manner as in Synthesis of Compound 3, except that Intermediate I-6 was used instead of Intermediate I-5, and 9,9-dimethyl-7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-9H-fluorene-2-carbonitrile was used instead of 2-([1,1':4',1"-terphenyl]-4-yl)-4,4,5,5-tetram-

ethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

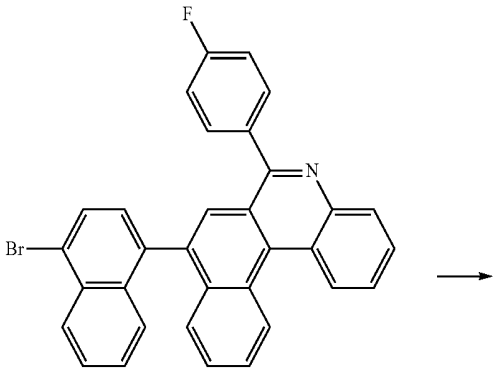
[0405] $C_{45}H_{29}FN_2$ cal. 616.23, found 616.22.

Synthesis Example 3: Synthesis of Compound 29

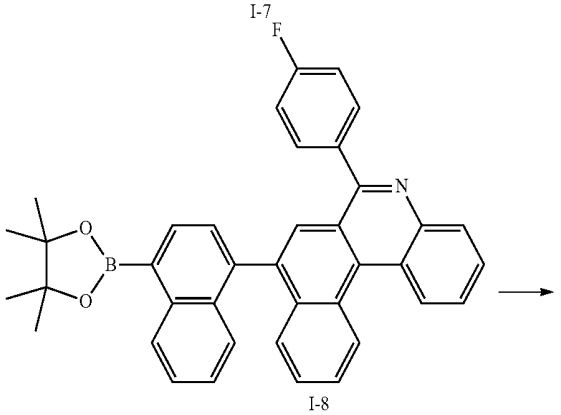
[0406]



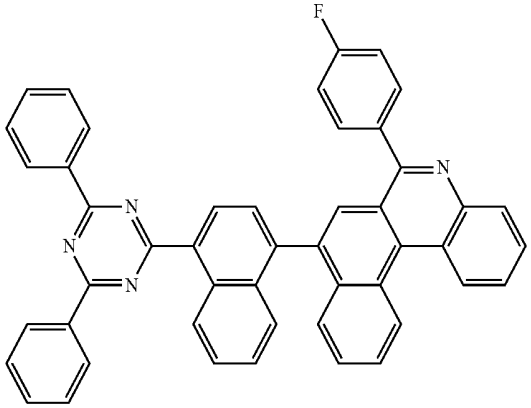
I-4



I-7



I-8



29

Synthesis of Intermediate I-7

[0407] 2.90 g (yield: 55%) of Intermediate I-7 was obtained in substantially the same manner as in Synthesis of Intermediate I-5, except that 1,4-dibromonaphthalene was used instead of 1-bromo-4-iodobenzene. The obtained compound was identified by LC-MS.

[0408] $C_{33}H_{19}BrFN$: M+1 527.1.

Synthesis of Intermediate I-8

[0409] 4.37 g (yield: 76%) of Intermediate I-8 was obtained in substantially the same manner as in Synthesis of Intermediate I-4, except that Intermediate I-7 was used instead of Intermediate I-3. The obtained compound was identified by LC-MS.

[0410] $C_{39}H_{31}BrFNO_2$: M+1 575.2.

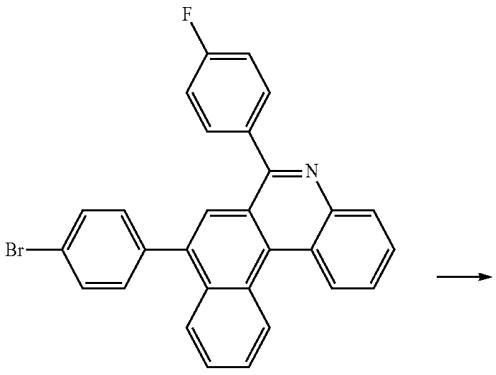
Synthesis of Compound 29

[0411] 4.90 g (yield: 72%) of Compound 29 was obtained in substantially the same manner as Synthesis of Compound 3, except that Intermediate I-8 was used instead of Intermediate I-5, and 2-chloro-4,6-diphenyl-1,3,5-triazine was used instead of 2-([1,1': 4',1"-terphenyl]-4-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

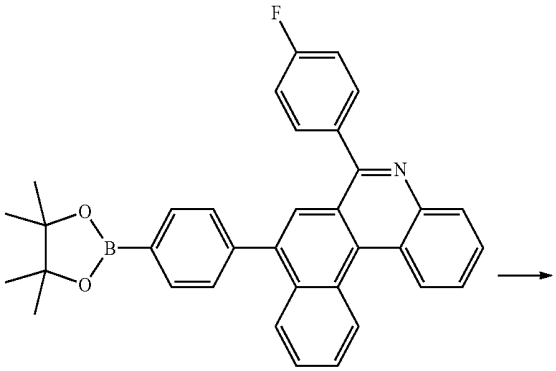
[0412] $C_{48}H_{29}FN_4$ cal. 680.24, found 680.23.

Synthesis Example 4: Synthesis of Compound 38

[0413]



I-5



I-9

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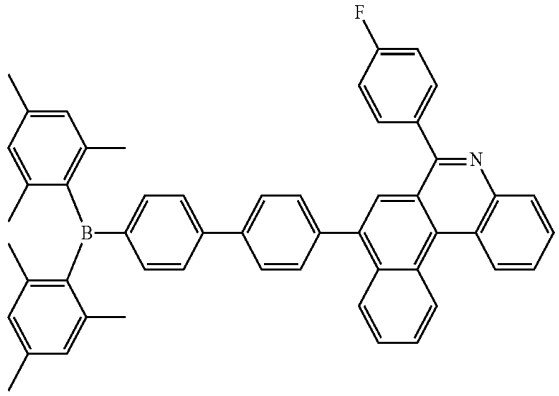


38

Synthesis of Intermediate I-9

[0414] 3.99 g (yield: 76%) of Intermediate I-9 was obtained in substantially the same manner as in Synthesis of Intermediate I-4, except that Intermediate I-5 was used instead of Intermediate I-3. The obtained compound was identified by LC-MS.

[0415] $C_{35}H_{29}BFNO_2$: M+1 525.2.

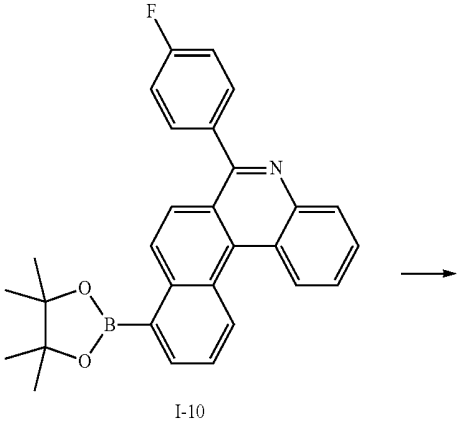
Synthesis of Compound 38

[0416] 5.06 g (yield: 70%) of Compound 38 was obtained in substantially the same manner as in Synthesis of Compound 3, except that Intermediate I-9 was used instead of Intermediate I-5, and (4-bromophenyl)dimesitylborane was used instead of 2-([1,1':4',1"-terphenyl]-4-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

[0417] $C_{53}H_{43}BFN$ cal. 723.35, found 723.36.

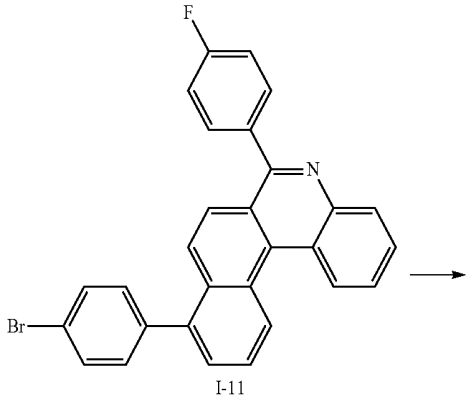
Synthesis Example 5: Synthesis of Compound 50

[0418]

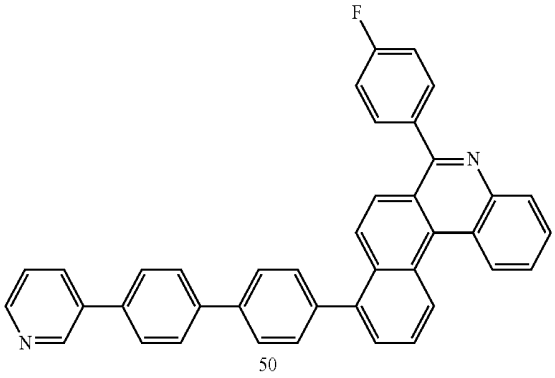


I-10

-continued



I-11



50

Synthesis of Intermediate I-10

[0419] 2.95 g (yield: 68%) of Intermediate I-10 was obtained in substantially the same manner as in Synthesis of Intermediate I-4, except that 2-(5-bromonaphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane was used instead of 2-(4-bromonaphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by LC-MS.

[0420] $C_{28}H_{22}BFNO_2$: M+1 434.2.

Synthesis of Intermediate I-11

[0421] 3.67 g (yield: 77%) of Intermediate I-11 was obtained in substantially the same manner as in Synthesis of Intermediate I-5, except that Intermediate I-10 was used instead of Intermediate I-4. The obtained compound was identified by LC-MS.

[0422] $C_{29}H_{17}BrFN$: M+1 477.1.

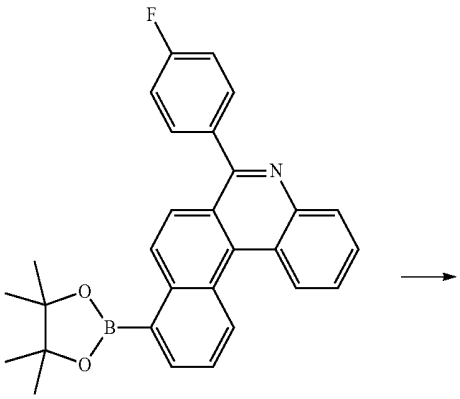
Synthesis of Compound 50

[0423] 3.75 g (yield: 68%) of Compound 50 was obtained in substantially the same manner as in Synthesis of Compound 3, except that Intermediate I-11 was used instead of Intermediate I-5, and (4-(pyridin-3-yl)phenyl)boronic acid was used instead of 2-([1,1':4',1"-terphenyl]-4-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

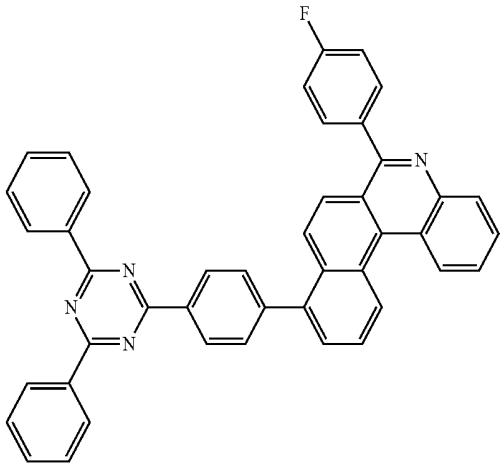
[0424] $C_{40}H_{25}FN_2$ cal. 552.20, found 552.20.

Synthesis Example 6: Synthesis of Compound 72

[0425]



I-10



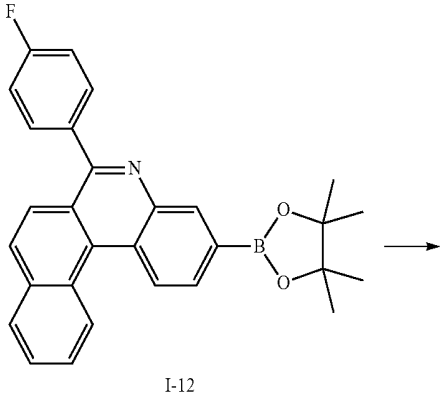
72

[0426] 4.79 g (yield: 76%) of Compound 72 was obtained in substantially the same manner as in Synthesis of Compound 50, except that Intermediate I-10 was used instead of Intermediate I-11, and 2-(4-bromophenyl)-4,6-diphenyl-1,3,5-triazine was used instead of (4-(pyridin-3-yl)phenyl)boronic acid. The obtained compound was identified by MS/FAB and ^{1}H NMR.

[0427] $C_{44}H_{27}FN_4$ cal. 630.22, found 630.21.

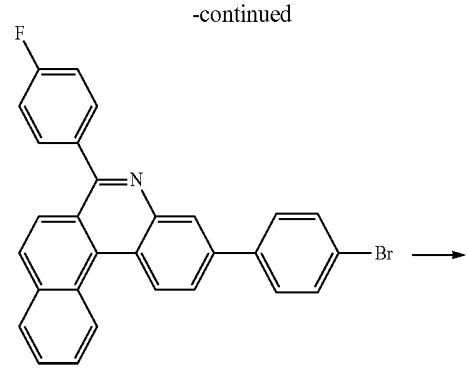
Synthesis Example 7: Synthesis of Compound 92

[0428]

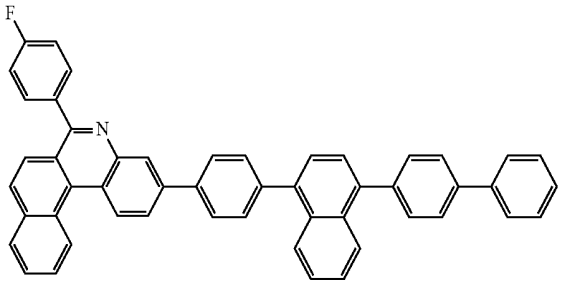


I-12

-continued



I-13



92

Synthesis of Intermediate I-12

[0429] 3.23 g (yield: 72%) of Intermediate I-12 was obtained in substantially the same manner as in Synthesis of Intermediate I-4, except that 4,4,5,5-tetramethyl-2-(naphthalen-1-yl)-1,3,2-dioxaborolane was used instead of 2-(4-bromonaphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane, and 1,4-dibromo-2-nitrobenzene was used instead of 1-bromo-2-nitrobenzene. The obtained compound was identified by LC-MS.

[0430] $C_{29}H_{25}BFNO_2$: M+1 449.2.

Synthesis of Intermediate I-13

[0431] 3.48 g (yield: 73%) of Intermediate I-13 was obtained in substantially the same manner as in Synthesis of Intermediate I-5, except that Intermediate I-12 was used instead of Intermediate I-4. The obtained compound was identified by LC-MS.

[0432] $C_{29}H_{17}BrFN$: M+1 477.1.

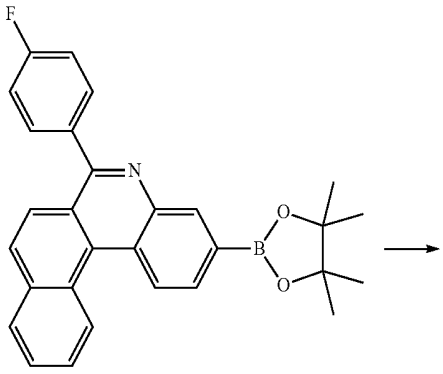
Synthesis of Compound 92

[0433] 4.81 g (yield: 71%) of Compound 92 was obtained in substantially the same manner as in Synthesis of Compound 3, except that Intermediate I-13 was used instead of Intermediate I-5, and 2-(4-([1,1'-biphenyl]-4-yl)naphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane was used instead of 2-([1,1':4',1"-terphenyl]-4-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

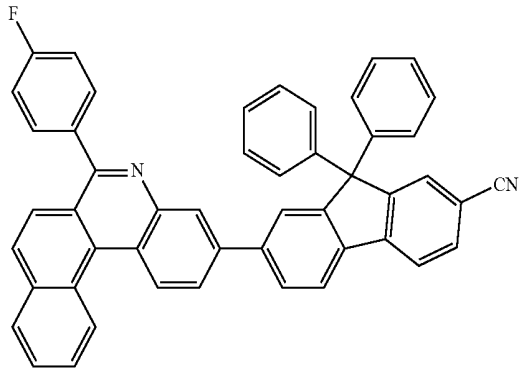
[0434] $C_{51}H_{32}FN$ cal. 677.25, found 6.

Synthesis Example 8: Synthesis of Compound 99

[0435]



I-12



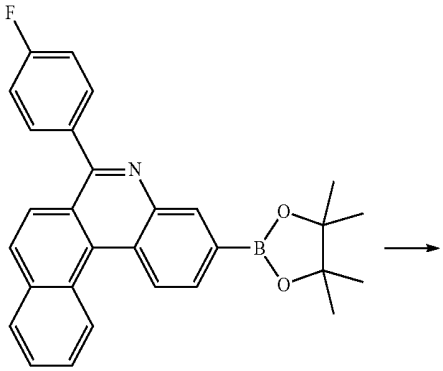
99

[0436] 4.45 g (yield: 67%) of Compound 99 was obtained in substantially the same manner as in Synthesis of Compound 92, except that Intermediate I-12 was used instead of Intermediate I-13, and 7-bromo-9,9-diphenyl-9H-fluorene-2-carbonitrile was used instead of 2-(4-([1,1'-biphenyl]-4-yl)naphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

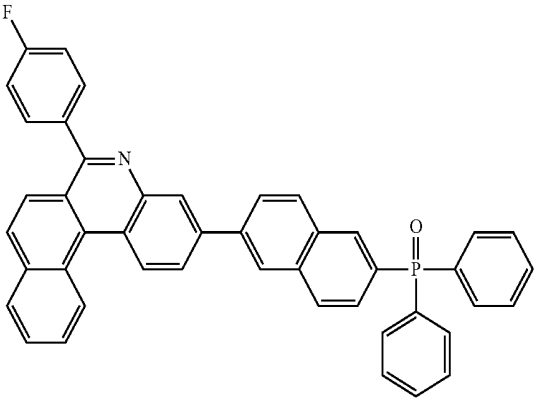
[0437] $C_{49}H_{29}FN_2$ cal. 664.23, found 664.22.

Synthesis Example 9: Synthesis of Compound 105

[0438]



I-12



105

[0439] 4.22 g (yield: 65%) of Compound 99 was obtained in substantially the same manner as in Synthesis of Compound 92, except that Intermediate I-12 was used instead of Intermediate I-13, and (6-bromonaphthalen-2-yl)diphenylphosphine oxide was used instead of 2-(4-([1,1'-biphenyl]-4-yl)naphthalen-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane. The obtained compound was identified by MS/FAB and ^{1}H NMR.

[0440] $C_{45}H_{29}FNOP$ cal. 649.20, found 649.21.

[0441] ^{1}H NMR and MS/FAB of Compounds synthesized in the above-described manner are shown in Table 1. Synthesis methods of compounds other than Compounds shown in Table 1 may also be easily recognized by those of ordinary skill in the art by referring to the synthesis mechanisms and source materials described above.

TABLE 1

Compound	^{1}H NMR ($CDCl_3$, 400 MHz) δ	MS/FAB found	MS/FAB calc.
3	δ = 8.78-8.75 (m, 1H), 8.46-8.44 (m, 1H), 8.27-8.24 (m, 1H), 8.13-8.11 (m, 1H), 8.05-8.00 (m, 2H), 7.87-7.82 (m, 4H), 7.78-7.77 (m, 1H), 7.76-7.75 (m, 1H), 7.73-7.65 (m, 8H), 7.62-7.58 (m, 2H), 7.53-7.49 (m, 2H), 7.42-7.38 (m, 2H), 7.23-7.12 (m, 4H)	627.25	627.24
15	δ = 8.77-8.75 (m, 1H), 8.46-8.44 (m, 1H), 8.27-8.23 (m, 2H), 8.05-8.00 (m, 3H), 7.89-7.80 (m, 3H), 7.75-7.65 (m, 5H), 7.59-7.56 (m, 1H), 7.51-7.38 (m, 3H), 7.26-7.15 (m, 4H), 2.19 (s, 6H)	616.22	616.23
29	δ = 8.83-8.81 (m, 4H), 8.77-8.75 (m, 1H), 8.71-8.65 (m, 4H), 8.52 (dd, 1H), 8.27-8.25 (m, 1H),	680.23	680.24

TABLE 1-continued

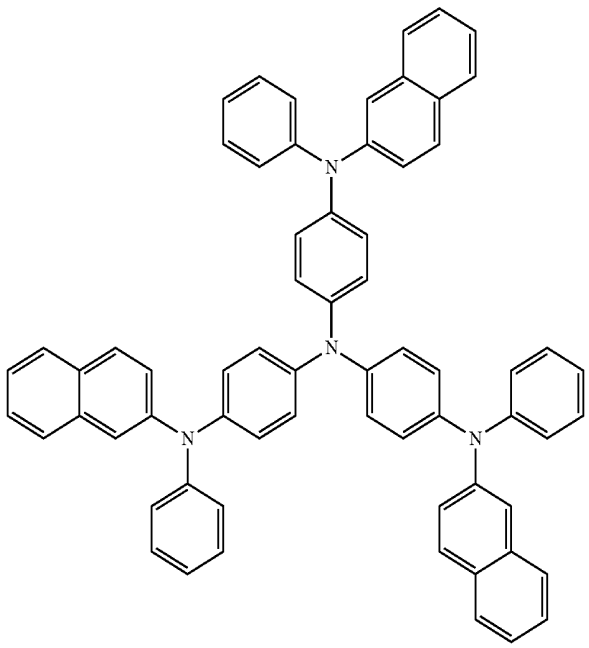
Compound	^{1}H NMR ($CDCl_3$, 400 MHz) δ	MS/FAB found	MS/FAB calc.
	8.15-8.13 (m, 2H), 8.05-8.01 (m, 2H), 7.86-7.82 (m, 1H), 7.75-7.70 (m, 2H), 7.63-7.59 (m, 4H), 7.48-7.39 (m, 3H), 7.23-7.12 (m, 4H)		
38	δ = 8.77-8.75 (m, 1H), 8.45-8.43 (m, 1H), 8.27-8.25 (m, 1H), 8.13-8.11 (m, 1H), 8.06-7.99 (m, 2H), 7.89-7.83 (m, 4H), 7.78-7.64 (m, 6H), 7.56-7.53 (m, 2H), 7.23-7.13 (m, 3H), 6.78-6.75 (m, 4H), 2.19 (s, 18H)	723.36	723.35
50	δ = 8.87-8.83 (m, 1H), 8.77-8.75 (m, 1H), 8.61-8.58 (m, 2H), 8.42 (d, 1H), 8.26 (dd, 1H), 7.96-7.67 (m, 14H), 7.52-7.43 (m, 3H), 7.23-7.17 (m, 2H)	552.20	552.20
72	δ = 8.81-8.76 (m, 5H), 8.61-8.59 (m, 1H), 8.53-8.40 (m, 3H), 8.26 (dd, 1H), 8.11-8.07 (m, 2H), 7.96-7.91 (m, 2H), 7.86-7.71 (m, 3H), 7.63-7.59 (m, 4H), 7.52-7.38 (m, 4H), 7.23-7.17 (m, 2H)	630.21	630.22
92	δ = 8.58-8.56 (m, 1H), 8.40-8.38 (m, 1H), 8.34-8.32 (m, 1H), 8.23-8.21 (m, 1H), 7.99-7.85 (m, 6H), 7.77-7.70 (m, 8H), 7.65-7.58 (m, 4H), 7.52-7.38 (m, 6H), 7.23-7.17 (m, 2H), 7.02-6.96 (m, 2H)	677.26	677.25
99	δ = 8.59-8.57 (m, 1H), 8.40-8.32 (m, 2H), 8.15-8.13 (m, 1H), 7.97-7.92 (m, 4H), 7.86-7.83 (m, 2H), 7.70 (d, 1H), 7.56 (dd, 1H), 7.49-7.41 (m, 3H), 7.39-7.28 (m, 6H), 7.2-7.15 (m, 2H), 7.16-7.06 (m, 6H)	664.22	664.23
105	δ = 8.56-8.53 (m, 1H), 8.40-8.32 (m, 3H), 8.16-8.11 (m, 4H), 7.98-7.88 (m, 6H), 7.75-7.72 (m, 1H), 7.68-7.62 (m, 4H), 7.52-7.39 (m, 8H), 7.23-7.17 (m, 2H)	649.21	649.20

[0442] Synthesis methods of compounds other than Compounds synthesized according to Synthesis Examples 1 to 9 may also be easily recognized by those of ordinary skill in the art by referring to the synthesis mechanisms and source materials described above.

Example 1

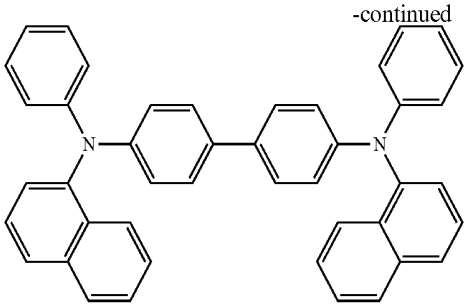
[0443] As an anode, a Corning 15 Ω/cm^2 (1,200 Å) ITO glass substrate was cut to a size of 50 mm×50 mm×0.7 mm, sonicated with isopropyl alcohol and pure water each for 5 minutes, and then cleaned by exposure to ultraviolet rays and ozone for 30 minutes. Then, the ITO glass substrate was provided to a vacuum deposition apparatus.

[0444] 2-TNATA, which is a material available in the art, was vacuum-deposited on the substrate to form a hole injection layer having a thickness of 600 Å, and 4,4'-bis[N-(1-naphthyl)-N-phenylamino]biphenyl (NPB), which is a material available in the art as a hole transport compound, was vacuum-deposited on the hole injection layer to form a hole transport layer having a thickness of 300 Å.

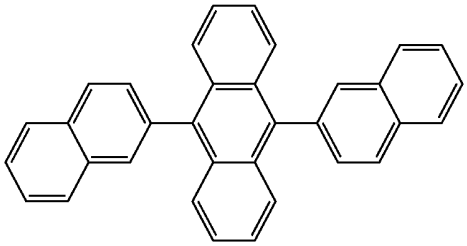


2-TNATA

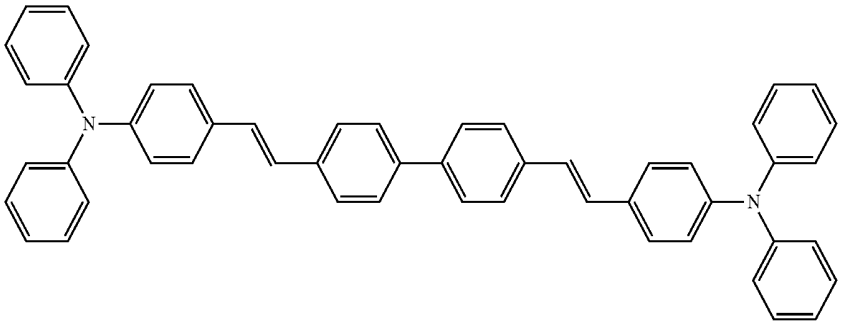
-continued



NPB



ADN



DPAVBi

[0445] 9,10-di-naphthalene-2-yl-anthracene (ADN), which is a compound available in the art as a blue phosphorescent host, and 4,4'-bis[2-(4-(N,N-diphenylamino) phenyl)vinyl]biphenyl (DPAVBi), which is a compound available in the art as a blue phosphorescent dopant, were co-deposited on the hole transport layer at a weight ratio of 98:2 to form an emission layer having a thickness of 300 Å.

[0446] Then, Compound 3 according to an embodiment was deposited on the emission layer to form an electron transport layer having a thickness of 300 Å, LiF, which is an alkali metal halide, was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and Al was vacuum-deposited on the electron injection layer to form a LiF/Al electrode (cathode electrode) having a thickness of 3,000 Å, thereby completing the manufacture of an organic light-emitting device.

Examples 2 to 9 and Comparative Examples 1 and 2

[0447] Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that Compounds shown in Table 2 were used instead of Compound 3 in forming an electron transport layer.

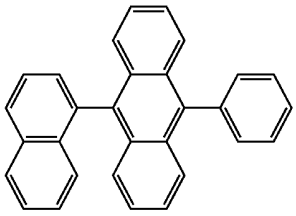
[0448] The driving voltage at a current density of 50 mA/cm^2, luminance, efficiency (cd/A), and half lifespan of the organic light-emitting devices manufactured according to Examples 1 to 9 and Comparative Examples 1 and 2 were measured, and results thereof are shown in Table 2.

TABLE 2

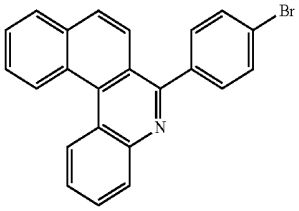
	Material	Driving voltage (V)	Current density (mA/cm^2)	Luminance (cd/m^2)	Efficiency (cd/A)	Emission color	Half lifespan (hr @100 mA/cm^2)
Example 1	Compound 3	3.35	50	3,550	7.10	Blue	700 hr
Example 2	Compound 15	3.25	50	3,790	7.58	Blue	705 hr
Example 3	Compound 29	3.28	50	3,805	7.61	Blue	717 hr

TABLE 2-continued

	Material	Driving voltage (V)	Current density (mA/cm^2)	Luminance (cd/m^2)	Efficiency (cd/A)	Emission color	Half lifespan (hr @100 mA/cm^2)
Example 4	Compound 38	3.20	50	3,810	7.62	Blue	753 hr
Example 5	Compound 50	3.21	50	3,830	7.66	Blue	723 hr
Example 6	Compound 72	3.20	50	3,825	7.65	Blue	735 hr
Example 7	Compound 92	3.36	50	3,760	7.52	Blue	727 hr
Example 8	Compound 99	3.32	50	3,700	7.40	Blue	712 hr
Example 9	Compound 105	3.65	50	3,650	7.30	Blue	810 hr
Comparative Example 1	Compound 200	4.28	50	3,250	6.50	Blue	485 hr
Comparative Example 2	Compound 5i	6.23	50	2,100	4.20	Blue	76 hr



200



5i

[0449] Referring to Table 2, when the compound according to an embodiment is used as an electron transport material, a driving voltage is lowered by 1 V or more, as compared with Compound 200. Also, I-V-L characteristics having significantly improved efficiency are exhibited, and excellent lifespan improvement effects are exhibited.

[0450] For example, when the compound according to an embodiment is used as the electron transport material, excellent effects are exhibited in terms of the driving voltage, luminance, efficiency, and lifespan.

[0451] The organic light-emitting device may have a low driving voltage, high efficiency, and a long lifespan.

[0452] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0453] It will be understood that, although the terms "first," "second," "third," etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section described below could be termed a second element, component, region, layer or section, without departing from the spirit and scope of the present disclosure.

[0454] Spatially relative terms, such as "beneath," "below," "lower," "under," "above," "upper," and the like, may be used herein for ease of explanation to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or in operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" or "under" other elements or features would then be oriented "above" the other elements or features. Thus, the example terms "below" and "under" can encompass both an orientation of above and below. The device may be otherwise oriented (e.g., rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein should be interpreted accordingly.

[0455] It will be understood that when an element or layer is referred to as being "on," "connected to," or "coupled to" another element or layer, it can be directly on, connected to, or coupled to the other element or layer, or one or more intervening elements or layers may be present. In addition, it will also be understood that when an element or layer is referred to as being "between" two elements or layers, it can

be the only element or layer between the two elements or layers, or one or more intervening elements or layers may also be present.

[0456] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a" and "an" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and "including," when used in this specification, specify the presence of the stated features, integers, acts, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, acts, operations, elements, components, and/or groups thereof.

[0457] As used herein, the terms "substantially," "about," and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art. Further, the use of "may" when describing embodiments of the present disclosure refers to "one or more embodiments of the present disclosure." As used herein, the terms "use," "using," and "used" may be considered synonymous with the terms "utilize," "utilizing," and "utilized," respectively. Also, the term "exemplary" is intended to refer to an example or illustration.

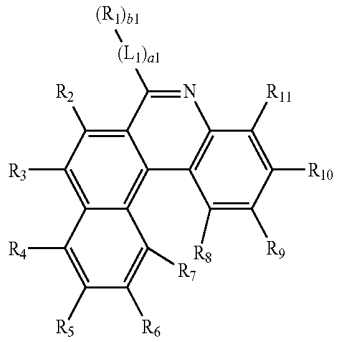
[0458] Also, any numerical range recited herein is intended to include all sub-ranges of the same numerical precision subsumed within the recited range. For example, a range of "1.0 to 10.0" is intended to include all subranges between (and including) the recited minimum value of 1.0 and the recited maximum value of 10.0, that is, having a minimum value equal to or greater than 1.0 and a maximum value equal to or less than 10.0, such as, for example, 2.4 to 7.6. Any maximum numerical limitation recited herein is intended to include all lower numerical limitations subsumed therein, and any minimum numerical limitation recited in this specification is intended to include all higher numerical limitations subsumed therein. Accordingly, Applicant reserves the right to amend this specification, including the claims, to expressly recite any sub-range subsumed within the ranges expressly recited herein.

[0459] While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope as defined by the following claims, and equivalents thereof.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1:

Formula 1



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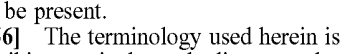
Formula 2



wherein, in Formulae 1 and 2,

L_1 and L_{11} are each independently a substituted or unsubstituted C_3-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

a1 and a11 are each independently 0, 1, 2, 3, 4, or 5,

when a1 is zero, *-$(L_1)_{a1}$-*' is a single bond, and when a11 is zero, *-$(L_{11})_{a11}$-*' is a single bond,

when a1 is two or more, two or more L_1(s) are identical to or different from each other, and when a11 is two or more, two or more L_{21}(s) are identical to or different from each other,

R_1 is selected from —F, a fluorine-containing C_3-C_{60} carbocyclic group, and a fluorine-containing C_1-C_{60} heterocyclic group,

b1 is 1, 2, 3, 4, or 5,

R_2 to R_{11} are each independently selected from a group represented by Formula 2, hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$,

R_2 and R_3 are not linked to form a ring,

Ar_{11} is selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_1)(Q_2)(Q_3)$, —$N(Q_1)(Q_2)$, —$B(Q_1)(Q_2)$, —$C(=O)(Q_1)$, —$S(=O)_2(Q_1)$, and —$P(=O)(Q_1)(Q_2)$,

c11 is 1, 2, 3, or 4,

at least one substituent of the substituted C_3-C_{60} carbocyclic group, the substituted C_1-C_{60} heterocyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_2-C_{60} alkenyl group, the substituted C_2-C_{60} alkynyl group, the substituted C_1-C_{60} alkoxy group, the substi-

tuted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} aryl group, the substituted C_6-C_{60} aryloxy group, the substituted C_6-C_{60} arylthio group, the substituted C_1-C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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;

a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_{ii})(Q_{12})(Q_{13})$, —$N(Q_{11})(Q_{12})$, —$B(Q_{11})(Q_{12})$, —$C(=O)(Q_{11})$, —$S(=O)_2(Q_{11})$, and —$P(=O)(Q_{11})(Q_{12})$;

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

a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$Si(Q_{21})(Q_{22})(Q_{23})$, —$N(Q_{21})(Q_{22})$, —$B(Q_{21})(Q_{22})$, —$C(=O)(Q_{21})$, —$S(=O)_2(Q_{21})$, and —$P(=O)(Q_{21})(Q_{22})$; and

—$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, —$B(Q_{31})(Q_{32})$, —$C(=O)(Q_{31})$, —$S(=O)_2(Q_{31})$, and —$P(=O)(Q_{31})(Q_{32})$, and

Q_1 to Q_3, Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

2. The condensed cyclic compound of claim **1**, wherein:

at least one of R_2 to R_{11} in Formula 1 is represented by Formula 2.

3. The condensed cyclic compound of claim **1**, wherein:

L_1 and L_{11} are each independently selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a dibenzosilole group, a carbazole group, a quinoline group, an isoquinoline group, a benzocarbazole group, a dibenzocarbazole group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group; and

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a dibenzosilole group, a carbazole group, a quinoline group, an isoquinoline group, a benzocarbazole group, a dibenzocarbazole group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, 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 biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluo-

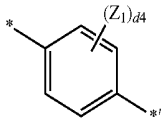
renyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a carbazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, —$Si(Q_{31})(Q_{32})(Q_{33})$, —$N(Q_{31})(Q_{32})$, and —$B(Q_{31})(Q_{32})$, and

Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a phenyl group substituted with a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

4. The condensed cyclic compound of claim **1**, wherein:

L_1 and L_{11} are each independently selected from groups represented by Formulae 3-1 to 3-33:

3-1



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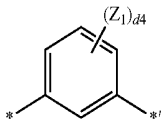

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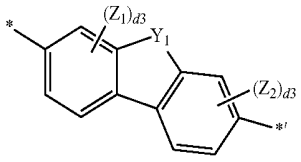

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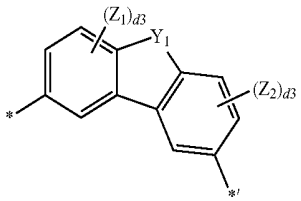

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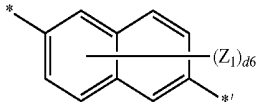

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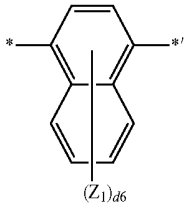

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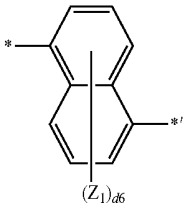

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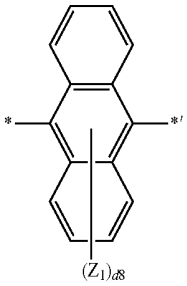

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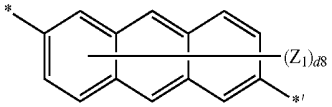

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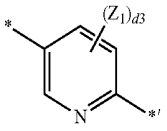

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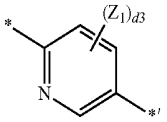

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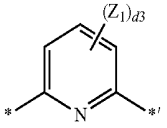

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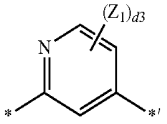

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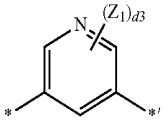

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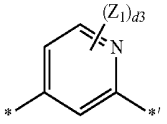

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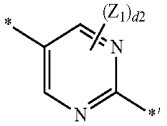

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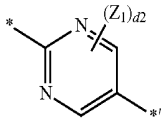
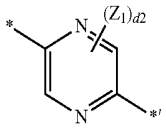
3-17



3-18



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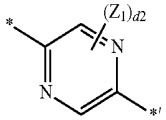

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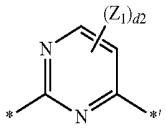

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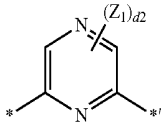

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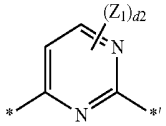

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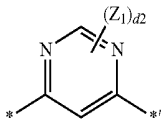

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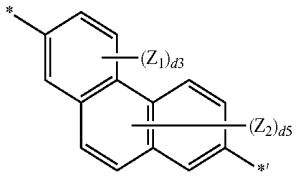

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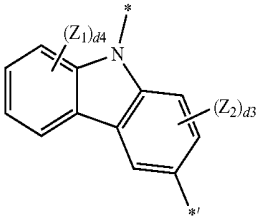

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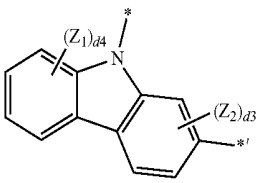

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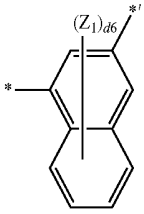

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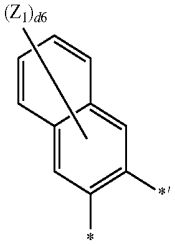

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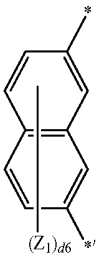

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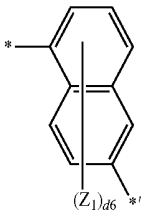

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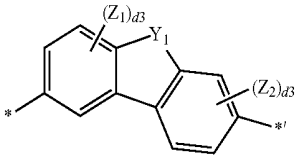

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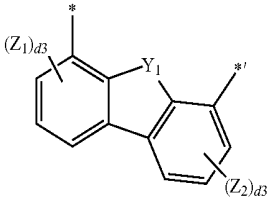

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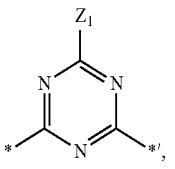


wherein, in Formulae 3-1 to 3-33,

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:

hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, 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 biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl 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, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and —Si(Q_{31})(Q_{32})(Q_{33}); and

a phenyl group substituted with a fluoro group (—F),

Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group,

d2 is an integer from 0 to 2,

d3 is an integer from 0 to 3,

d4 is an integer from 0 to 4,

d6 is an integer from 0 to 6,

d8 is an integer from 0 to 8, and

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

5. The condensed cyclic compound of claim **1**, wherein:

Ar_{11} is selected from:

a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

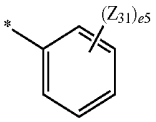
a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, —Si(Q_{31})(Q_{32})(Q_{33}), —B(Q_{31})(Q_{32}), and —P(=O)(Q_{31})(Q_{32}); and —Si(Q_1)(Q_2)(Q_3), —B(Q_1)(Q_2), and —P(=O)(Q_1)(Q_2), and

Q_1 to Q_3 and Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a phenyl group substituted with a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

6. The condensed cyclic compound of claim **1**, wherein:

Ar_{11} is selected from —B(Q_1)(Q_2), —P(=O)(Q_1)(Q_2), and groups represented by Formulae 5-1 to 5-35:

5-1



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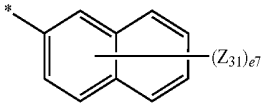

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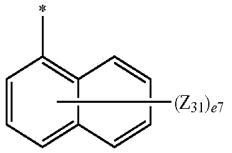

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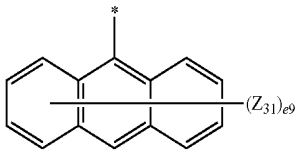

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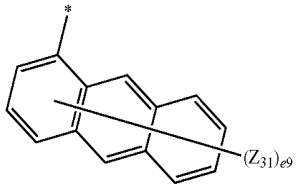

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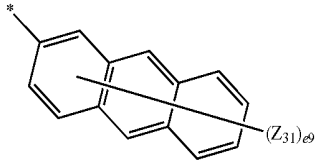

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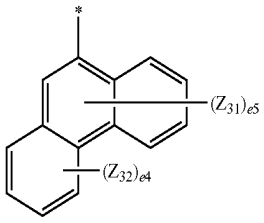

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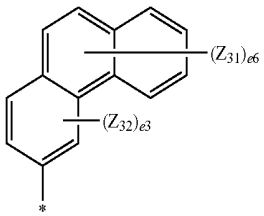

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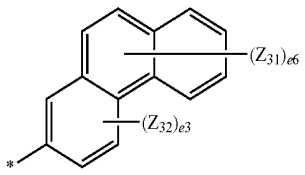

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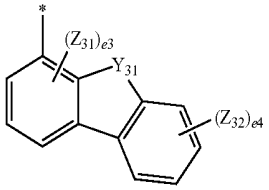

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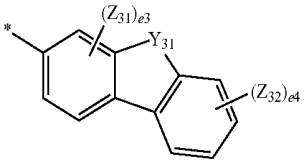

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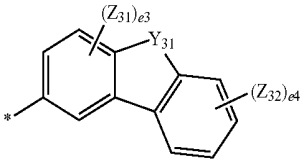

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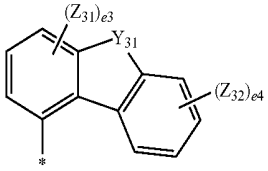

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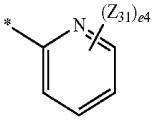

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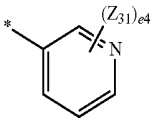

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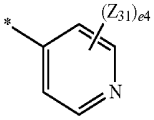

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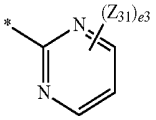

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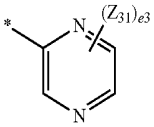

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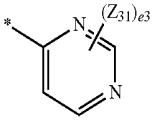

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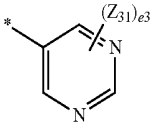

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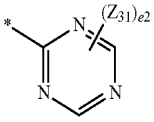

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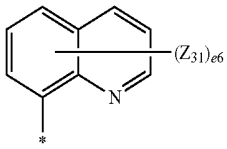

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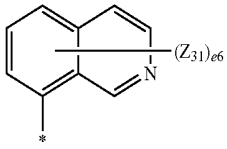

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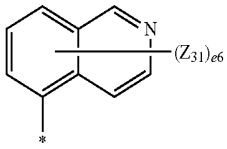

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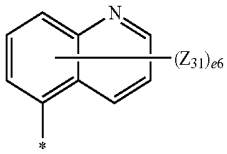

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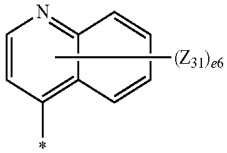

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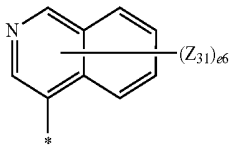

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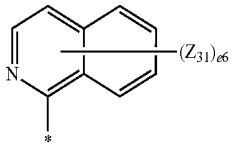

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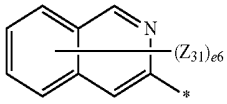

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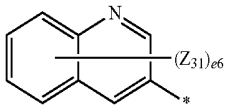

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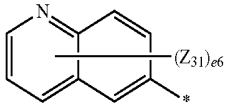

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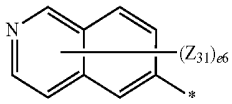

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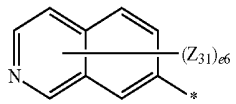

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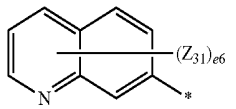

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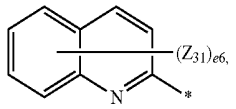


wherein, in Formulae 5-1 to 5-35,

Y_{31} is O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$,

Z_{31} to Z_{37} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, 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 biphenyl group, a terphenyl 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 benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a pyridinyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a carbazolyl group, and $—Si(Q_{31})(Q_{32})(Q_{33})$,

Q_1, Q_2, and Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a phenyl group substituted with a C_1-C_{20} alkyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

e2 is an integer from 0 to 2,

e3 is an integer from 0 to 3,

e4 is an integer from 0 to 4,

e5 is an integer from 0 to 5,

e6 is an integer from 0 to 6,

e7 is an integer from 0 to 7,

e9 is an integer from 0 to 9, and

* indicates a binding site to a neighboring atom.

7. The condensed cyclic compound of claim **1**, wherein:

R_1 is selected from —F, a C_3-C_{10} cycloalkyl group substituted with —F, a C_1-C_{10} heterocycloalkyl group substituted with —F, a C_3-C_{10} cycloalkenyl group substituted with —F, a C_1-C_{10} heterocycloalkenyl group substituted with —F, a C_6-C_{60} aryl group substituted with —F, a C_6-C_{60} aryloxy group substituted with —F, a C_6-C_{60} arylthio group substituted with —F, a C_1-C_{60} heteroaryl group substituted with —F, a monovalent non-aromatic condensed polycyclic group substituted with —F, and a monovalent non-aromatic condensed heteropolycyclic group substituted with —F.

8. The condensed cyclic compound of claim **1**, wherein:

R_1 is selected from —F and a C_6-C_{60} aryl group substituted with —F.

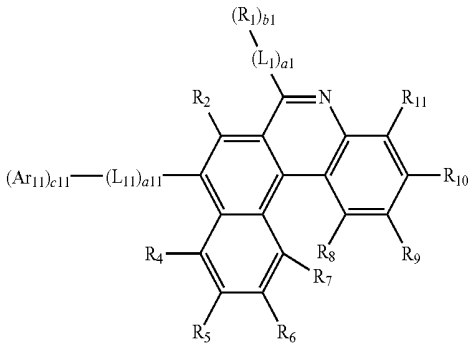
9. The condensed cyclic compound of claim **1**, wherein:

at least one of R_3, R_4, and R_{10} in Formula 1 is represented by Formula 2.

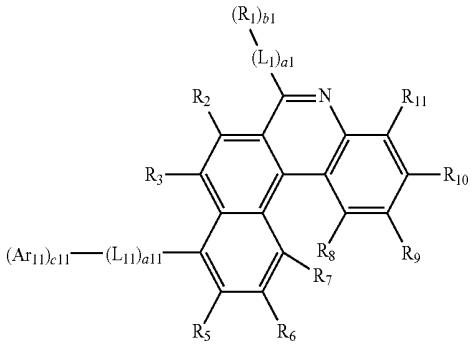
10. The condensed cyclic compound of claim **1**, wherein:

the condensed cyclic compound is represented by one of Formulae 1-1 to 1-3:

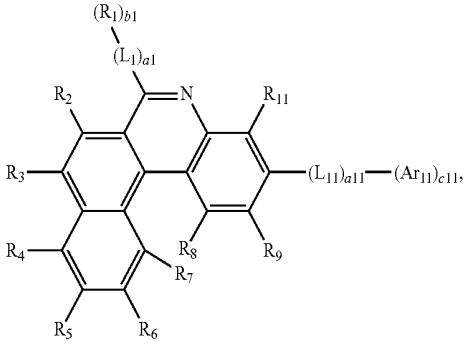
Formula 1-1



Formula 1-2



Formula 1-3



wherein R_1 to R_{11}, b1, L_1, L_{11}, a1, a11, Ar_{11}, and c11 in Formulae 1-1 to 1-3 are the same as described in claim **1**.

11. The condensed cyclic compound of claim **1**, wherein:

in Formula 1,

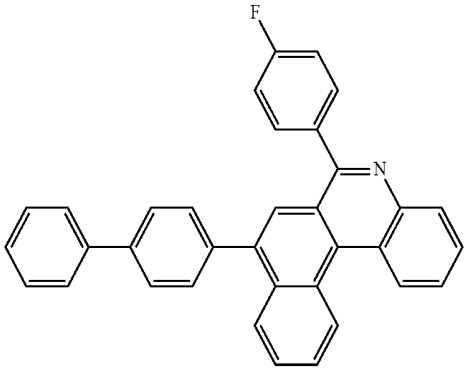
(i) R_3 is a group represented by Formula 2, and R_2 and R_4 to R_{11} are each hydrogen;

(ii) R_4 is a group represented by Formula 2, and R_2, R_3, and R_5 to R_{11} are each hydrogen; or

(iii) R_{10} is a group represented by Formula 2, and R_2 to R_9 and R_{11} are each hydrogen.

12. The condensed cyclic compound of claim **1**, wherein: the condensed cyclic compound is one of Compounds 1 to 106:

1



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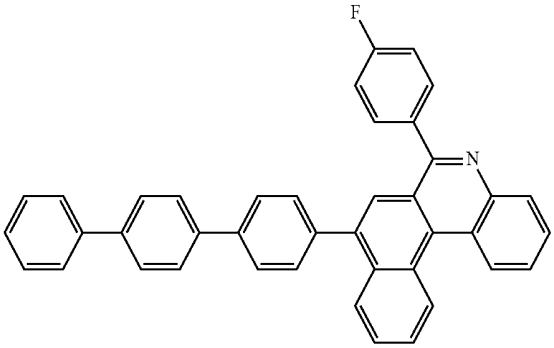

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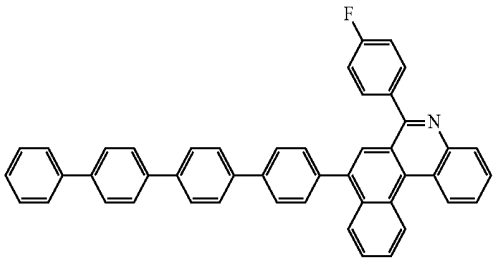

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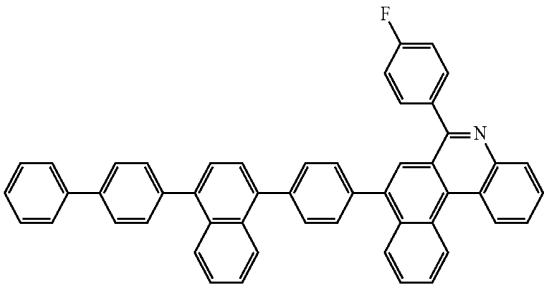

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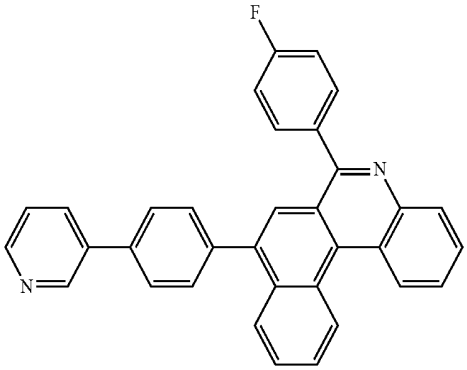

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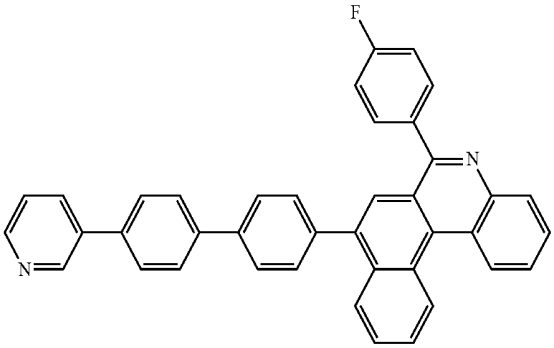

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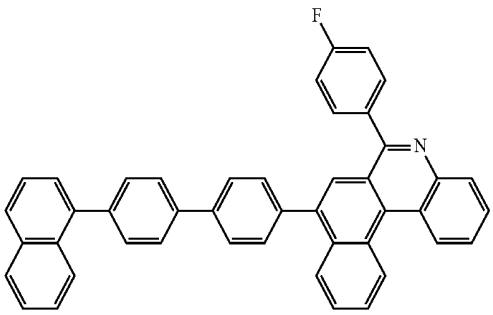

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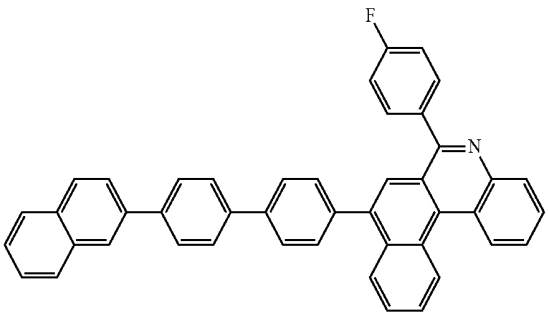

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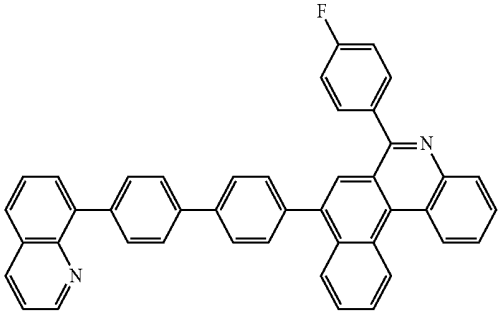

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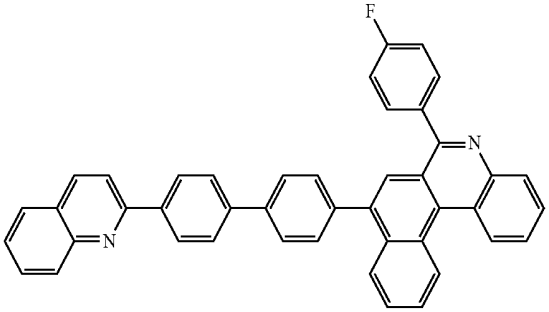

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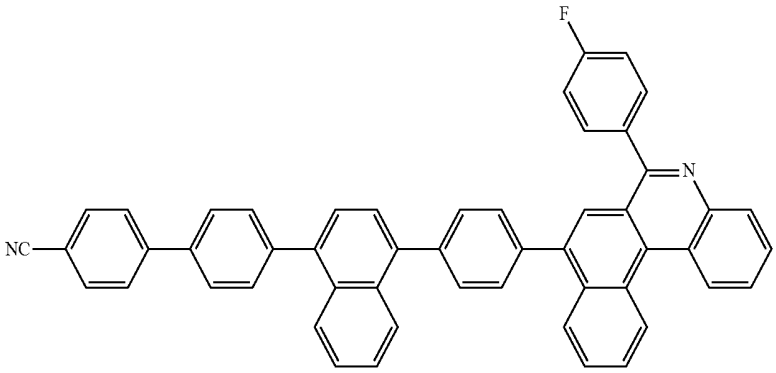

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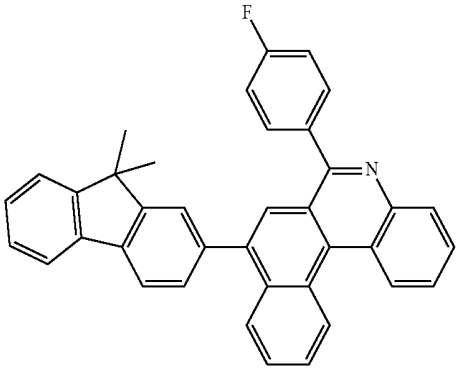

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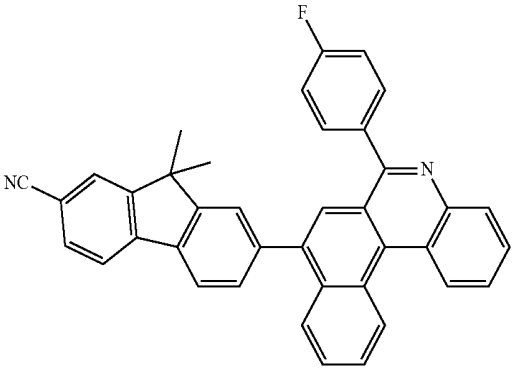

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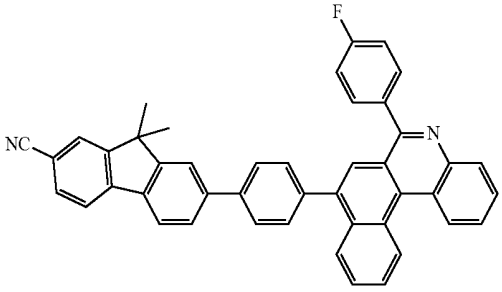

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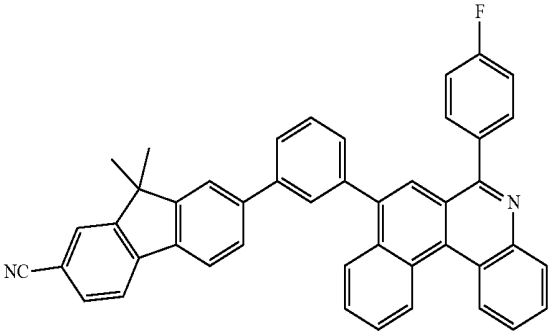

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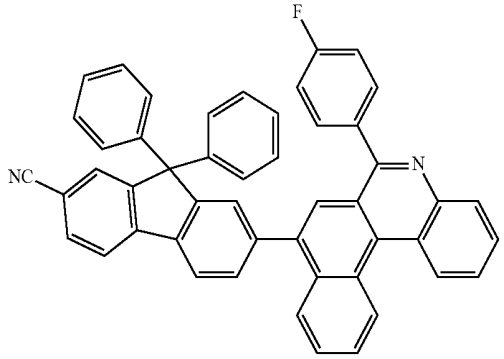

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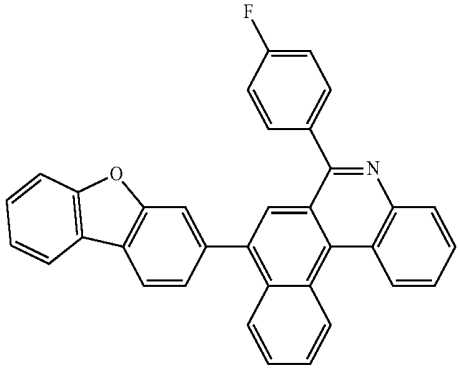

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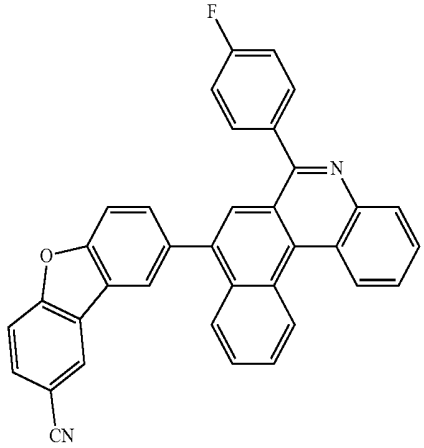

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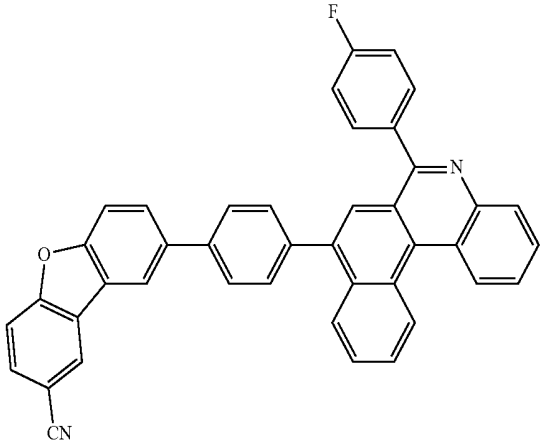

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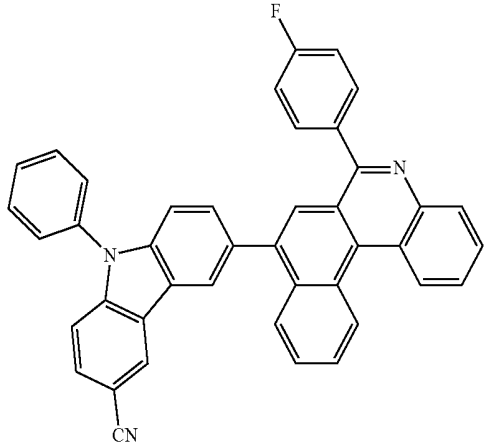

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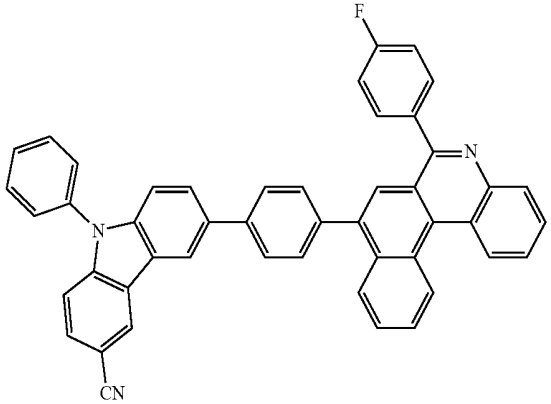

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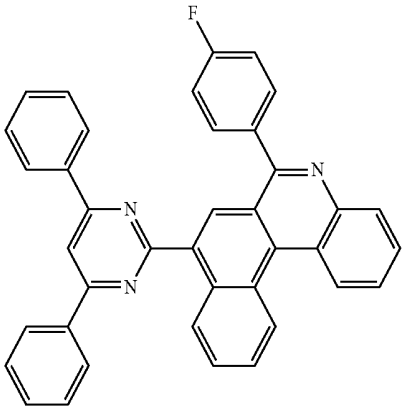

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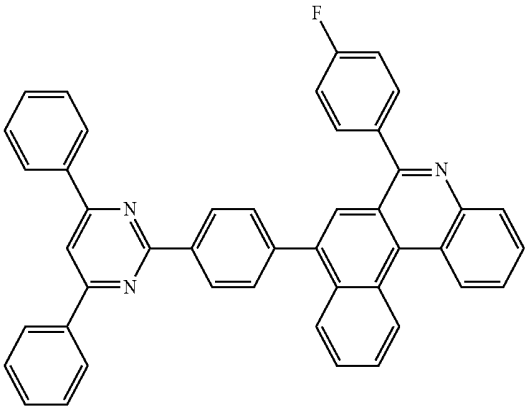

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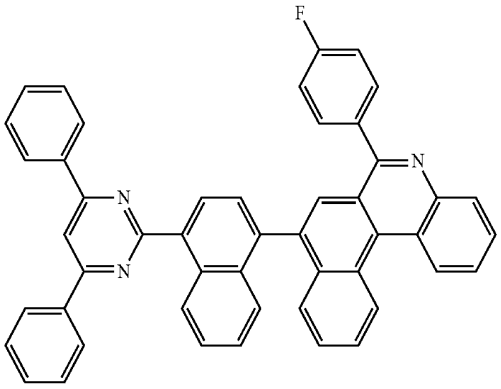

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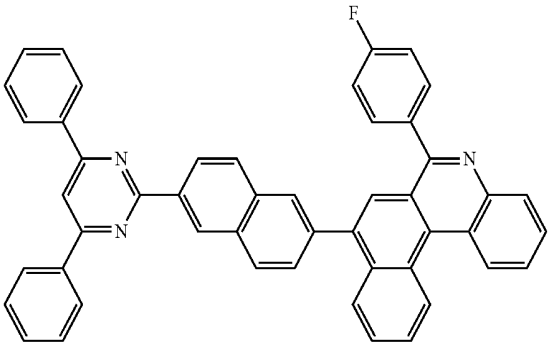

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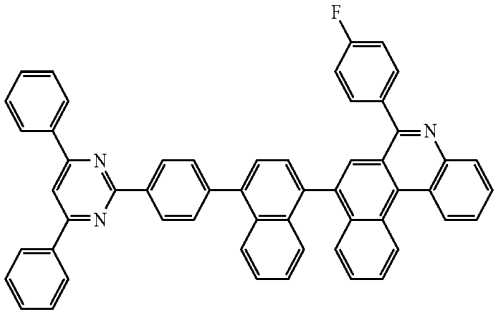

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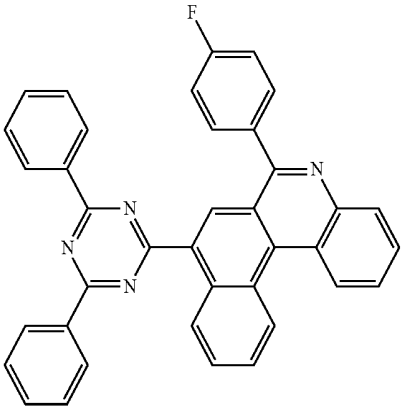

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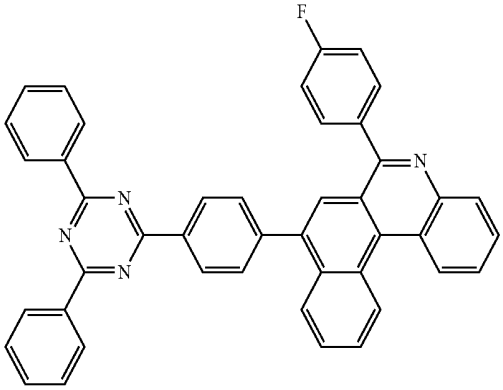

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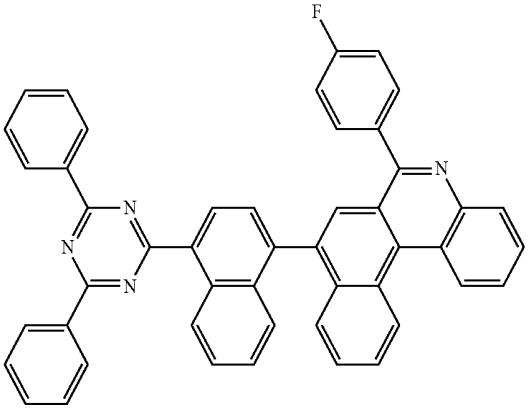

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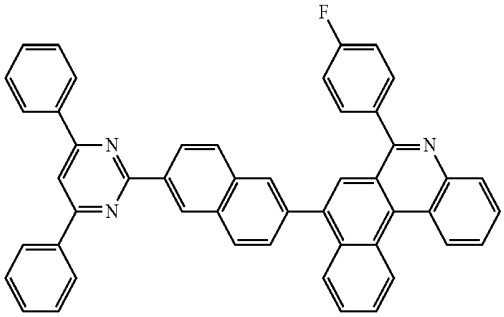

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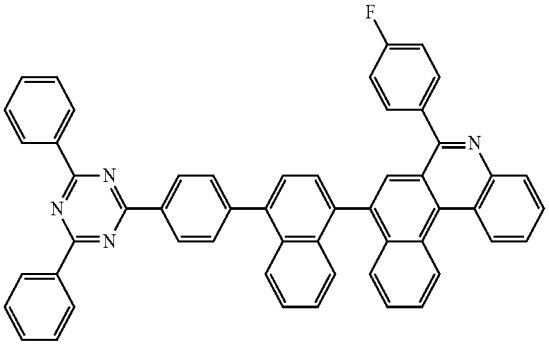

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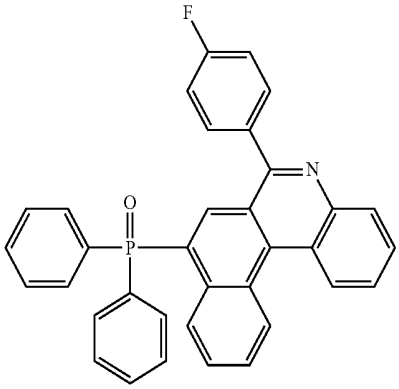

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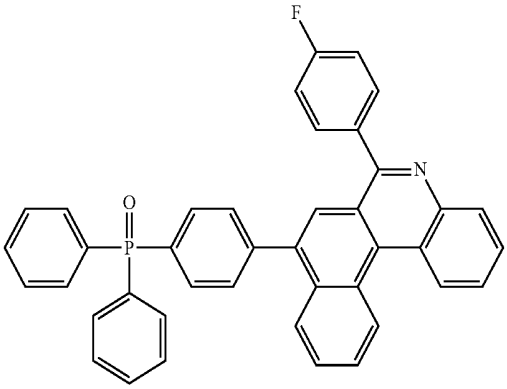

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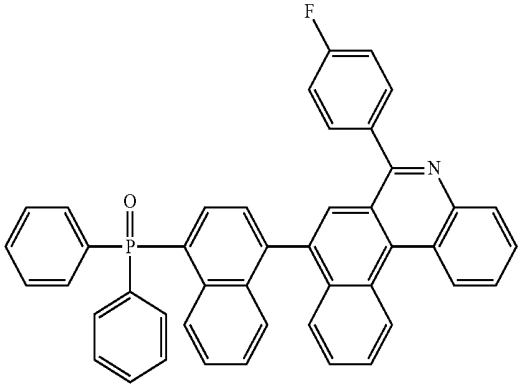

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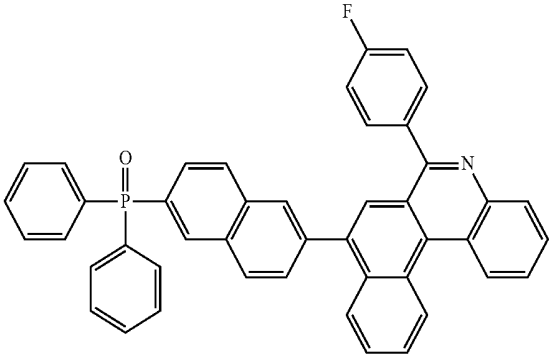

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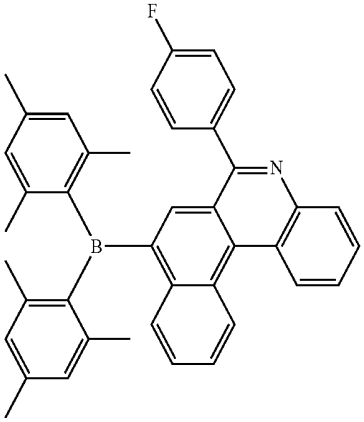

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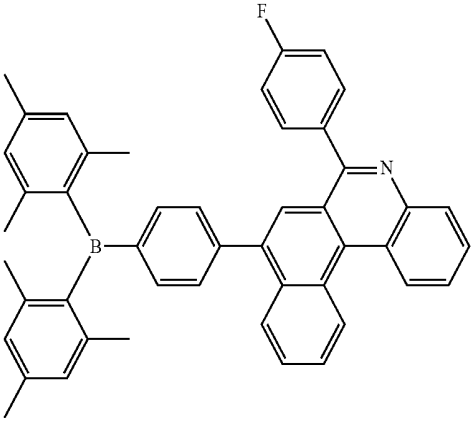

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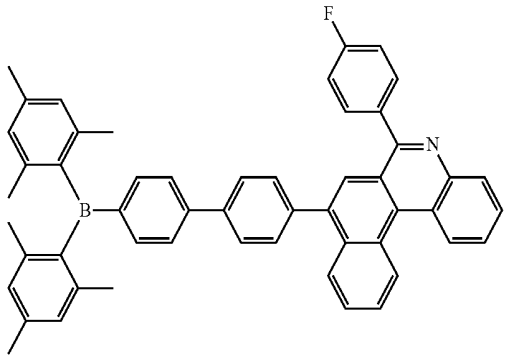

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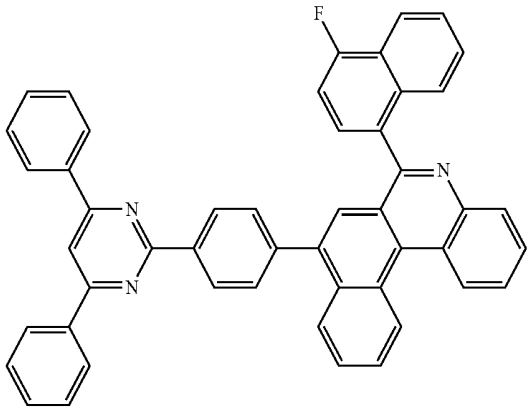

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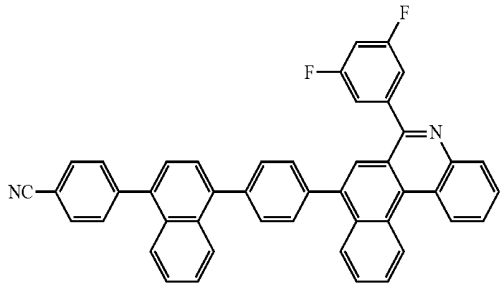

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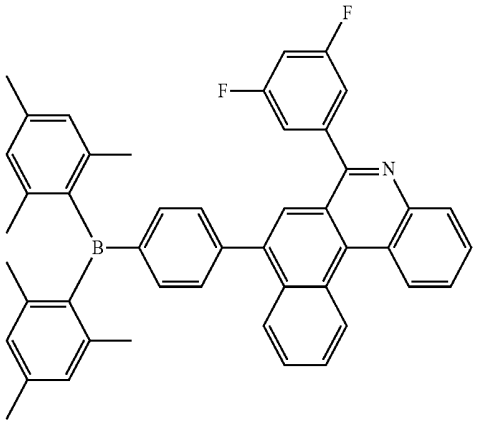

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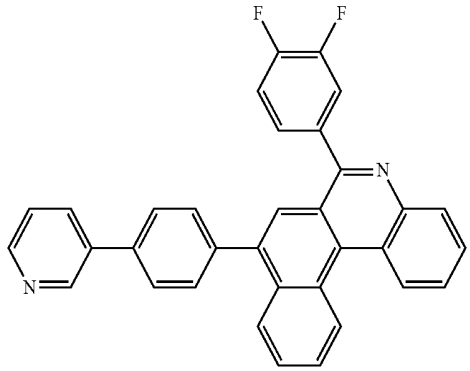

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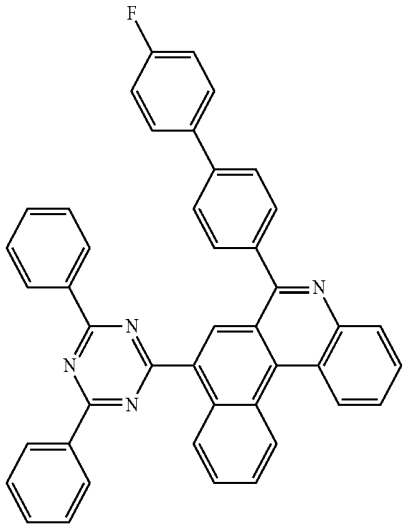

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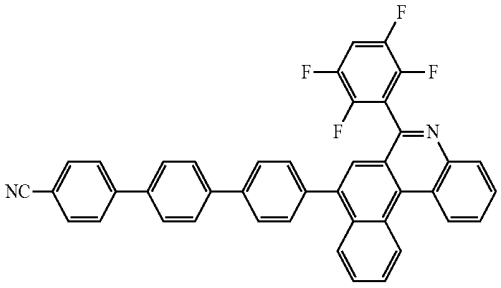

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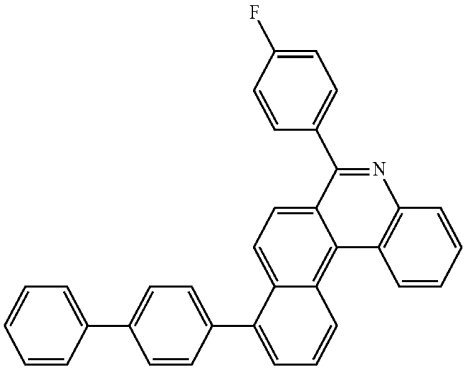

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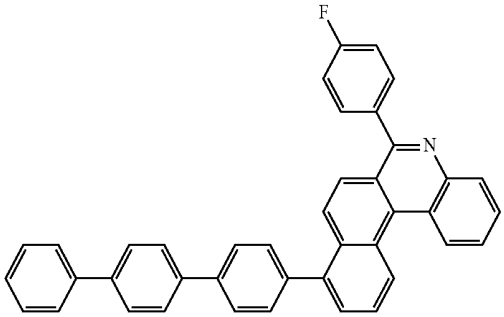

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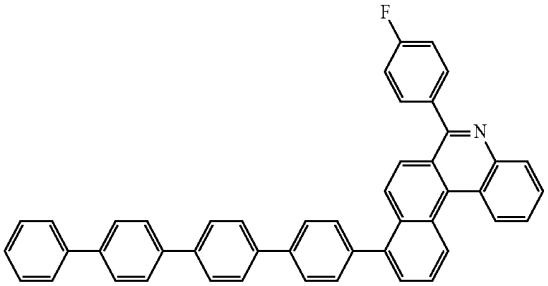

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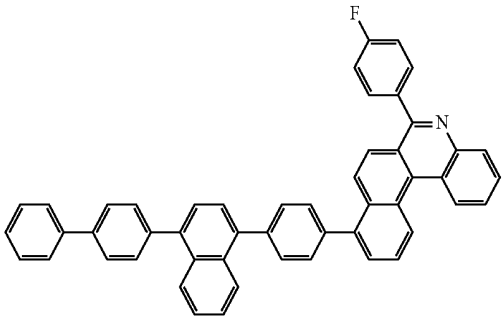

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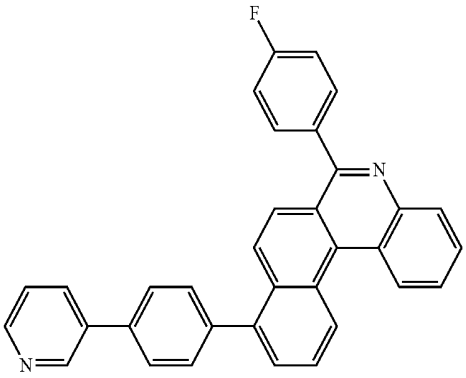

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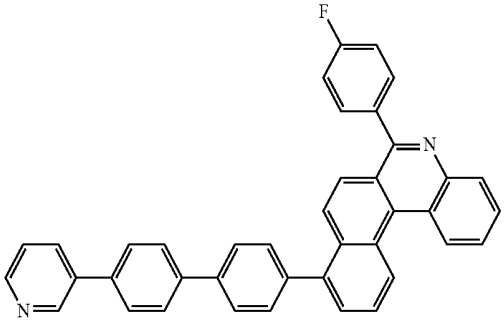

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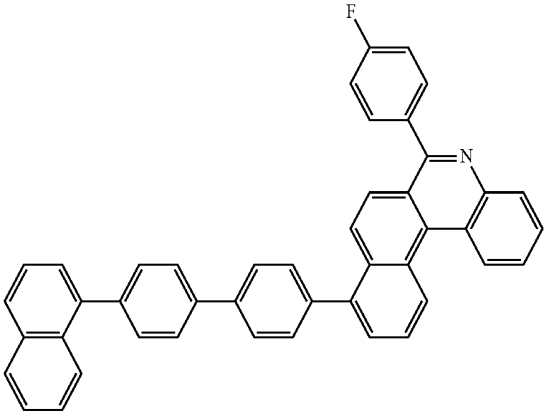

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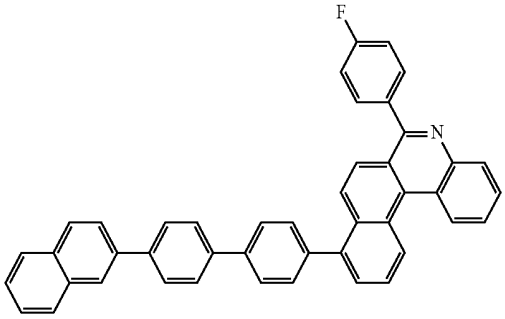

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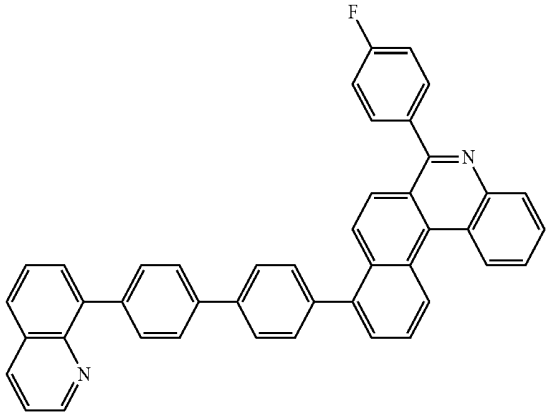

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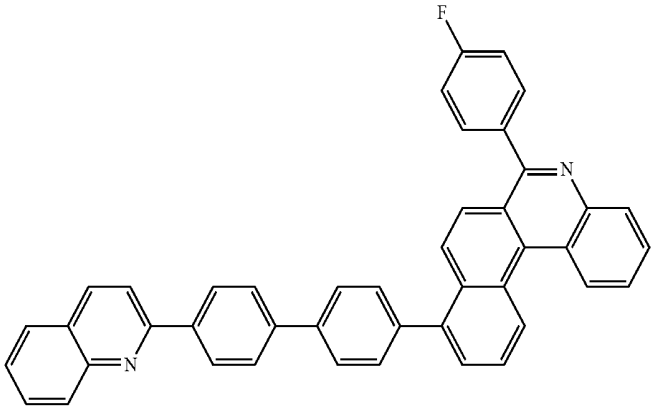

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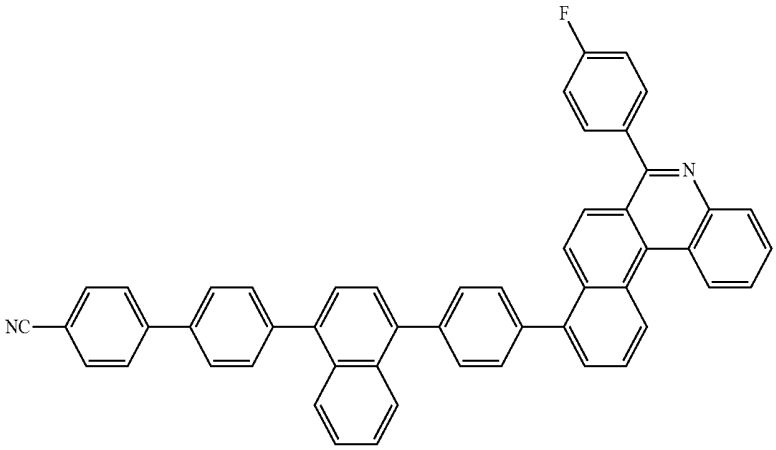

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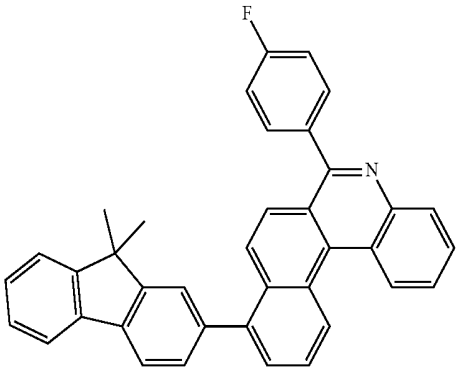

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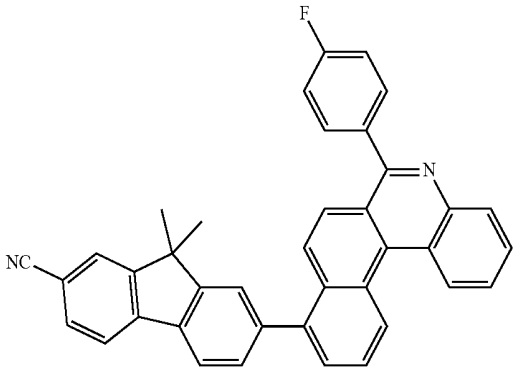

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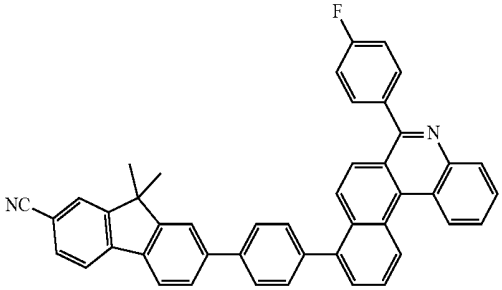

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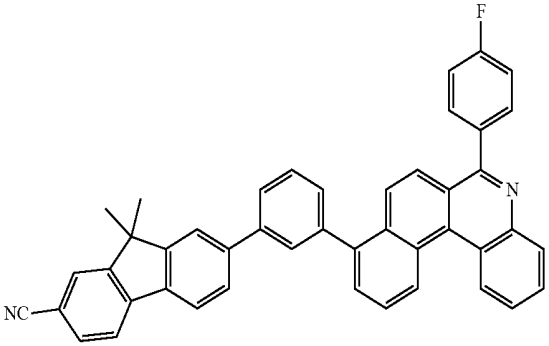

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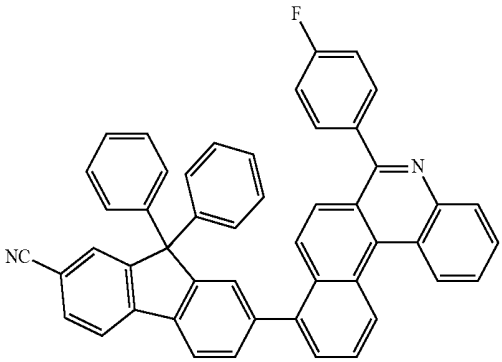

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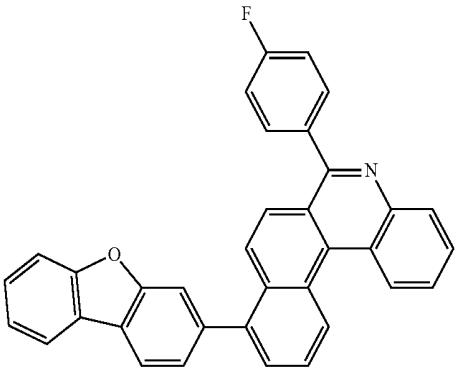

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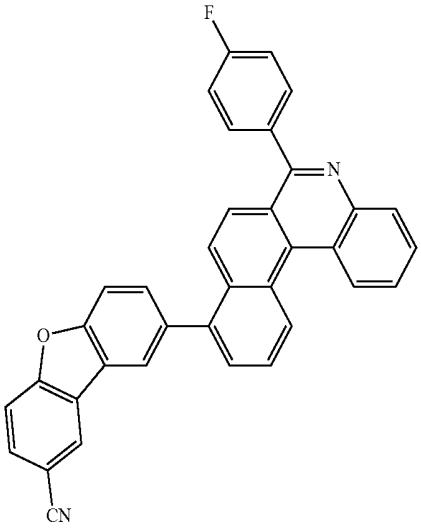

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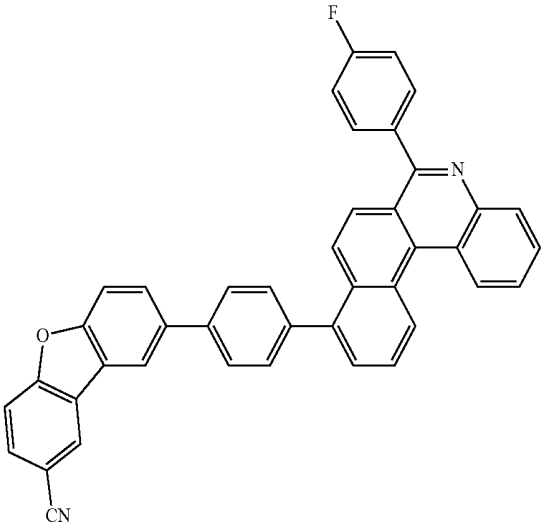

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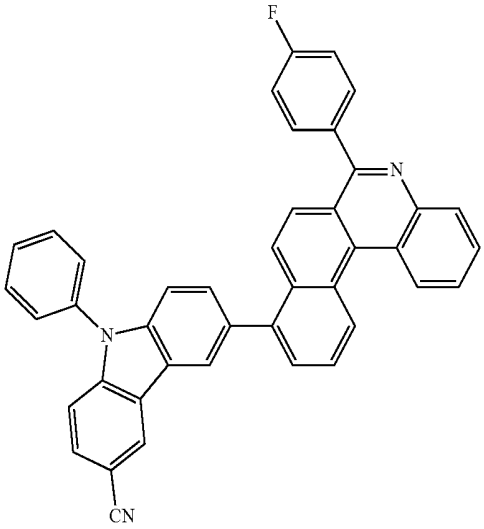

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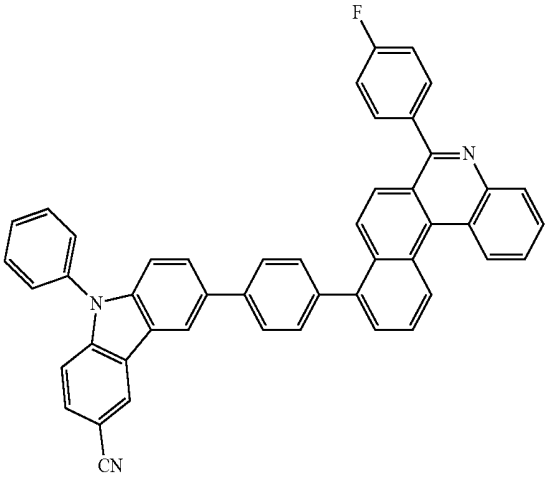

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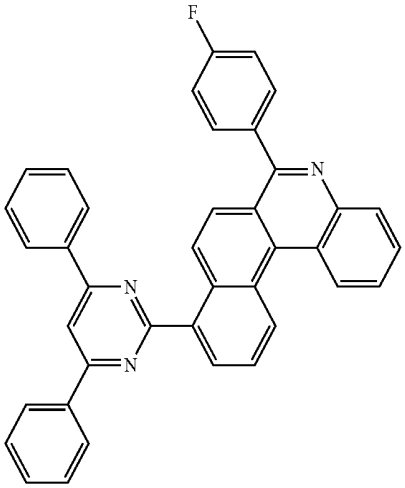

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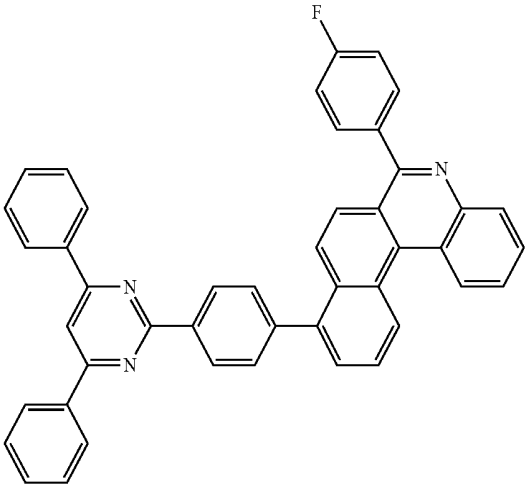

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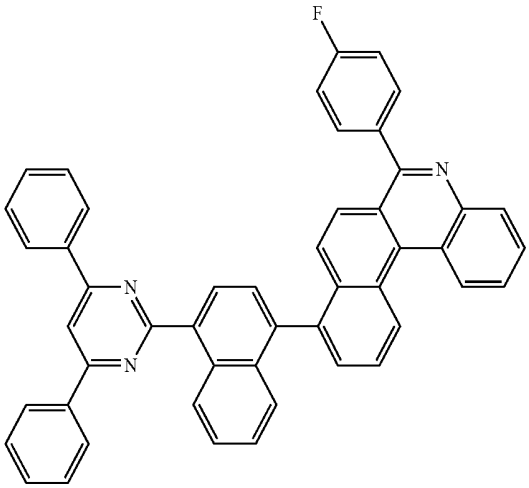

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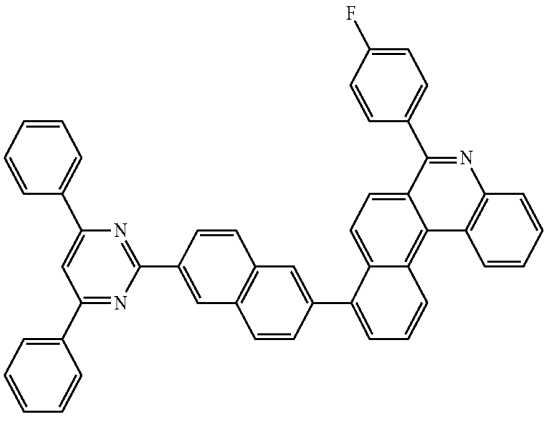

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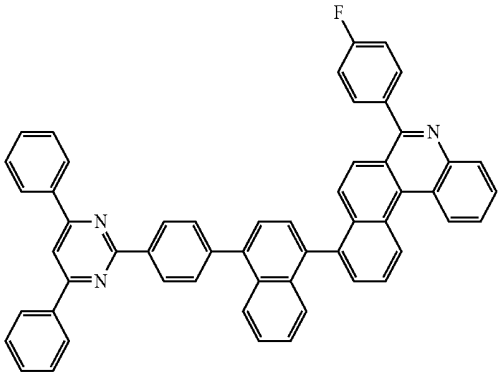

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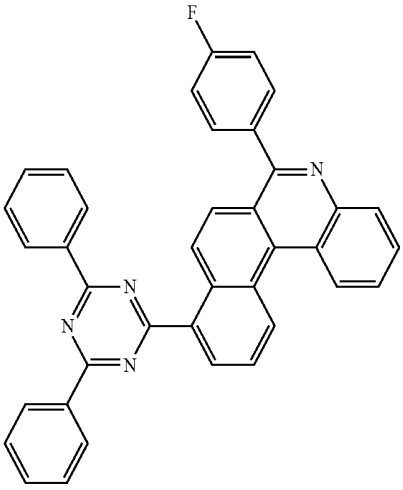

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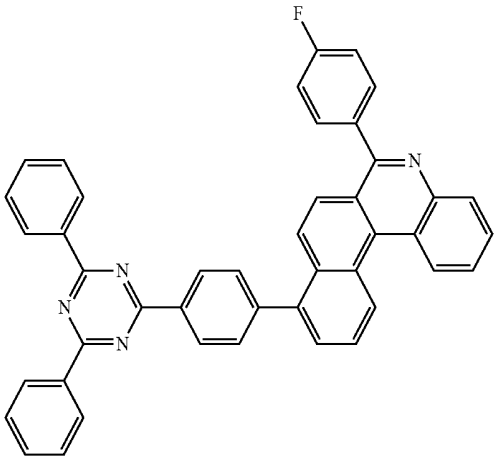

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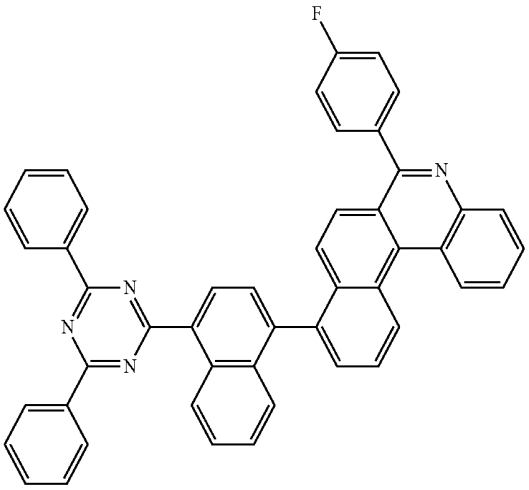

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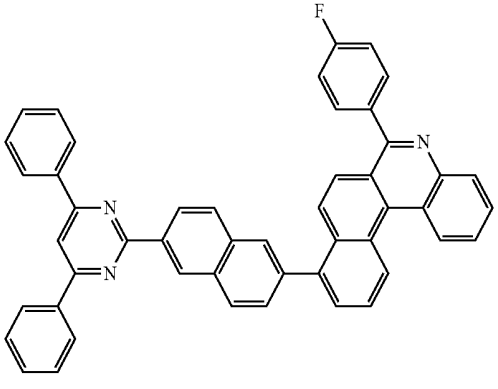

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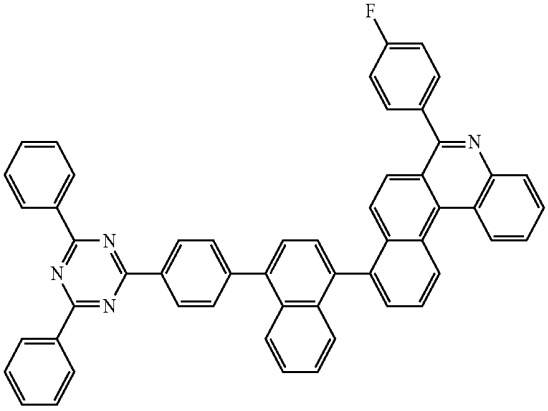

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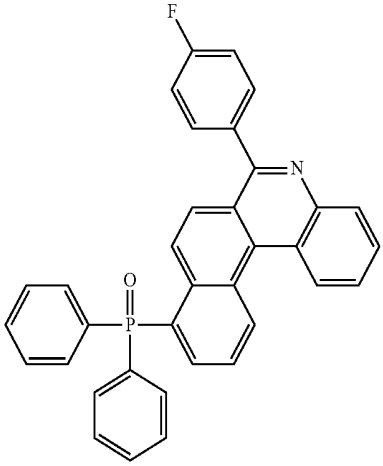

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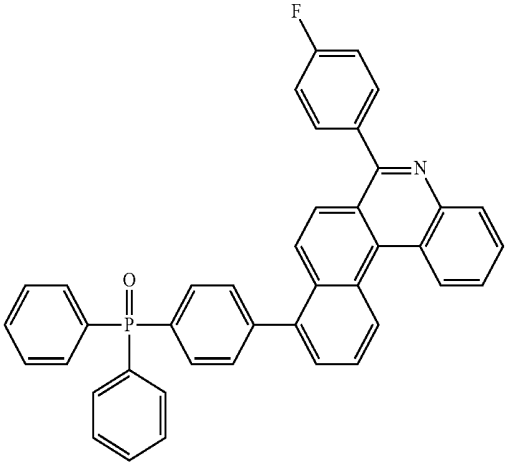

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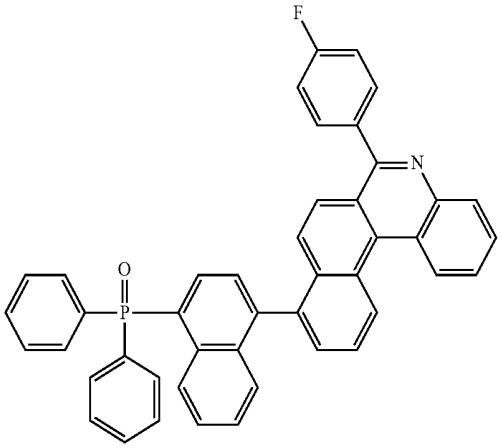

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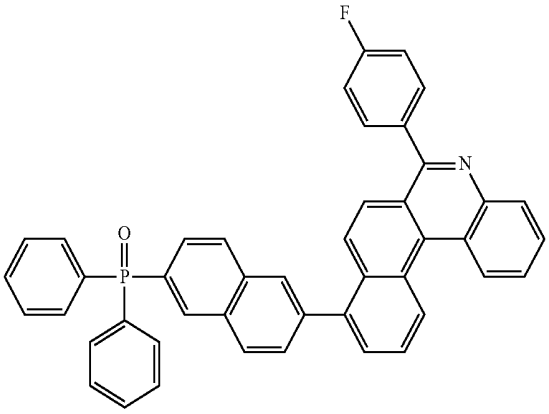

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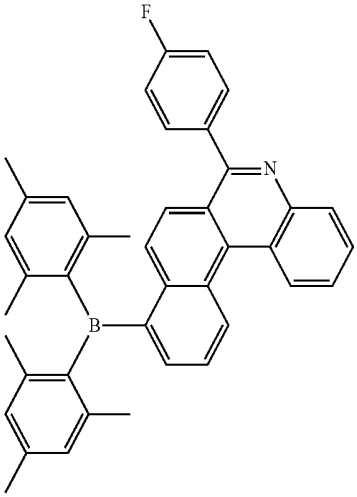

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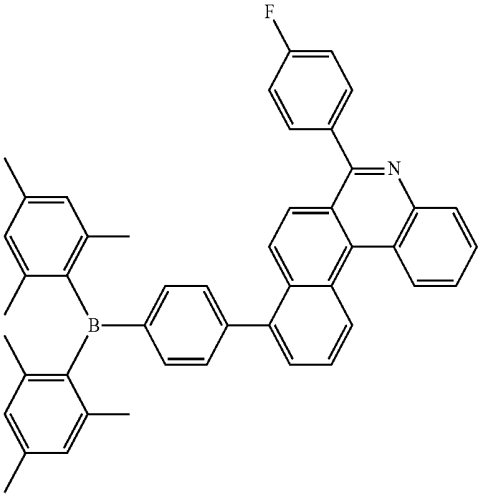

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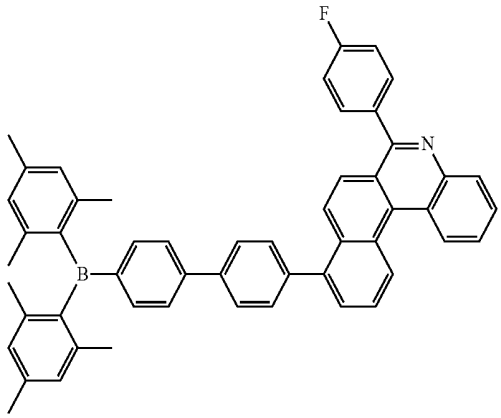

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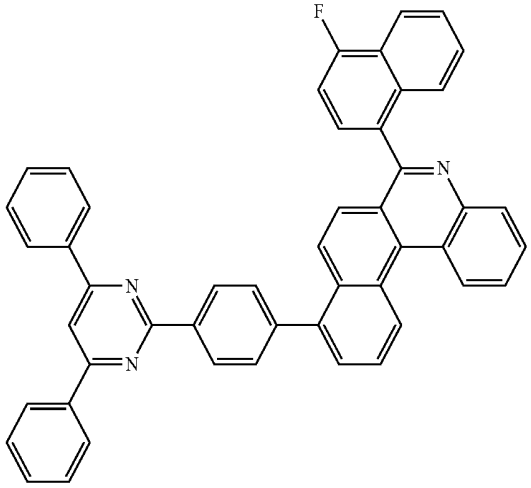

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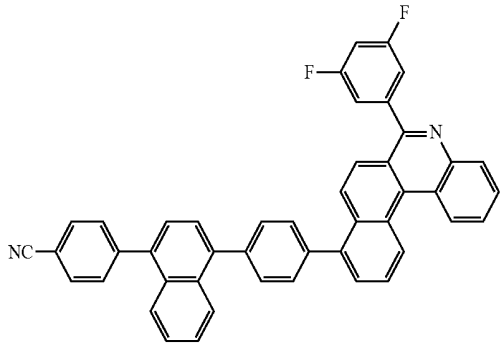

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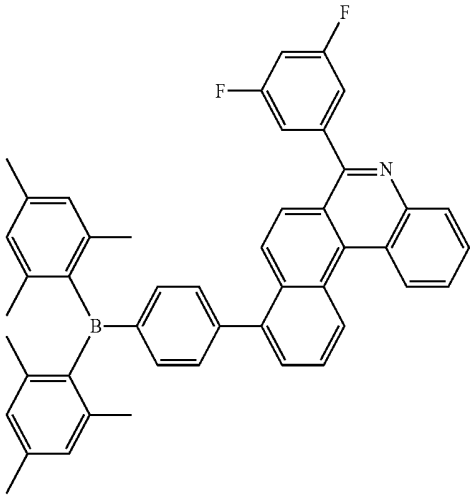

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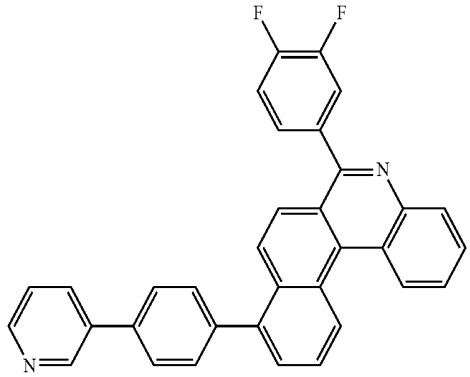

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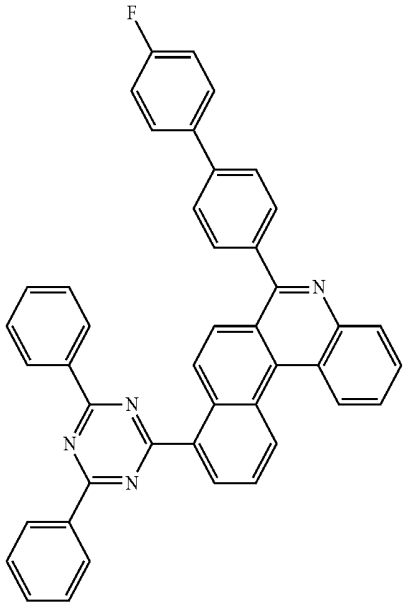

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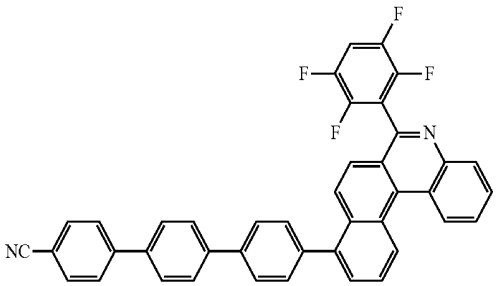

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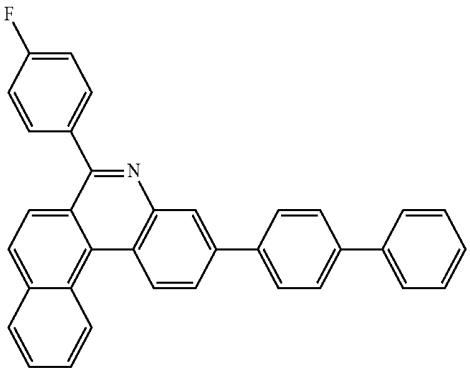

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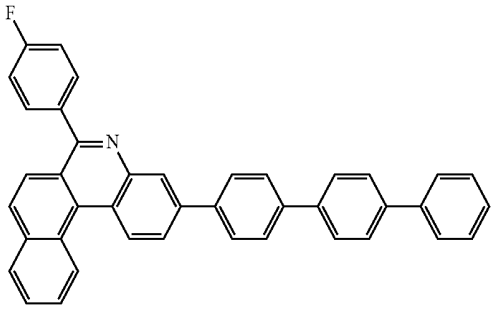

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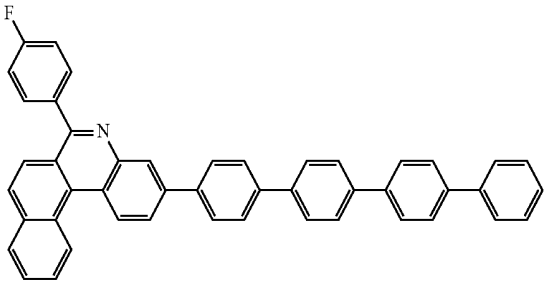

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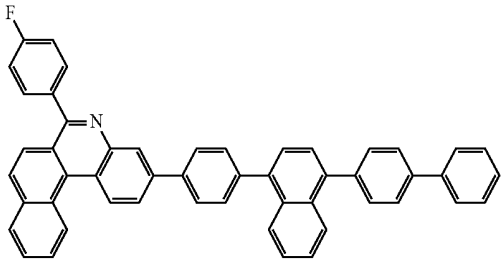

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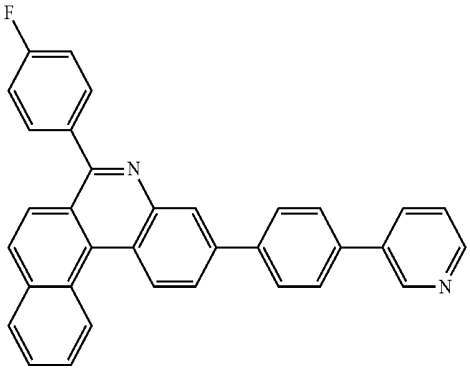

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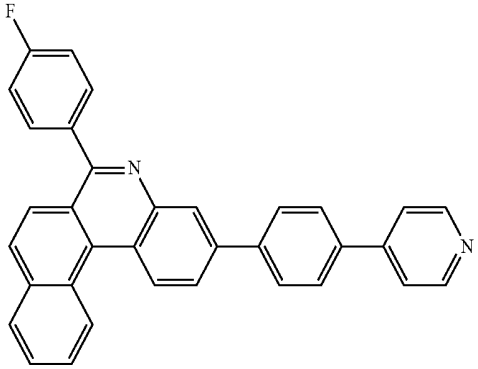

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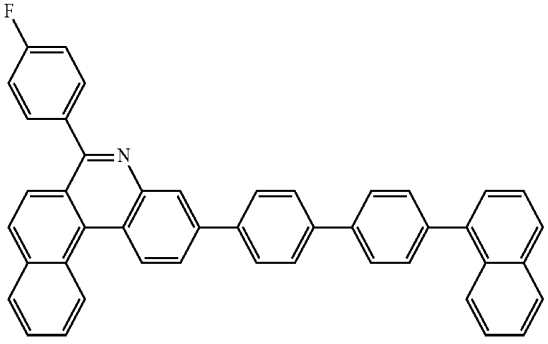

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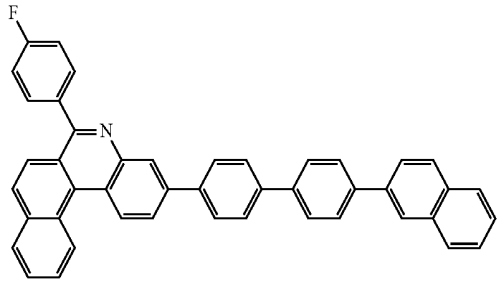

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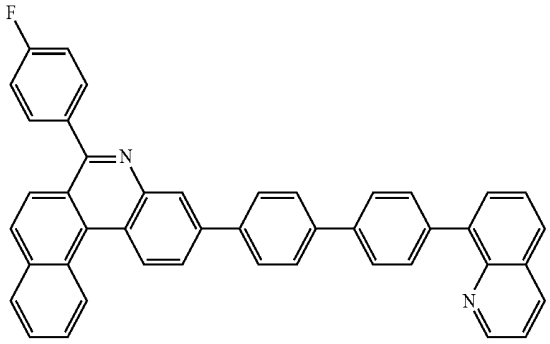

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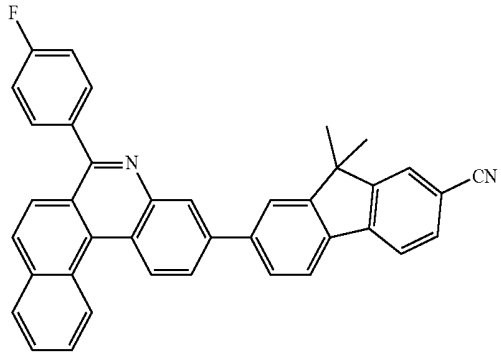

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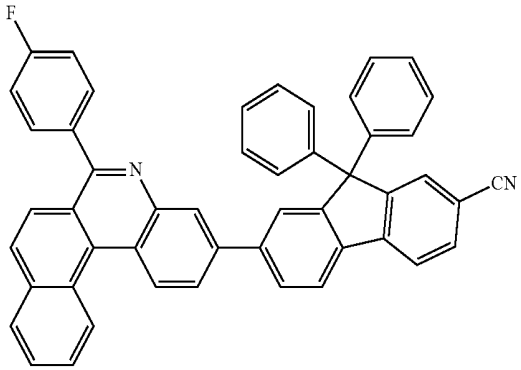

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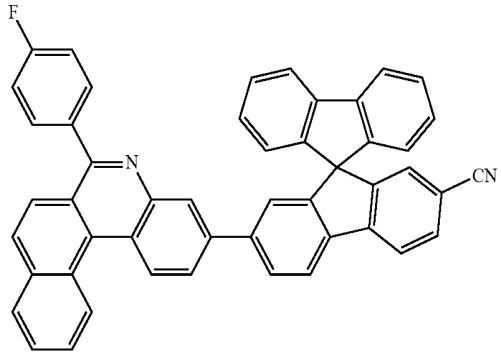

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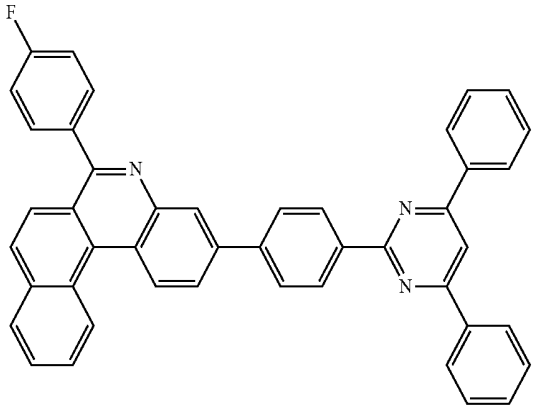

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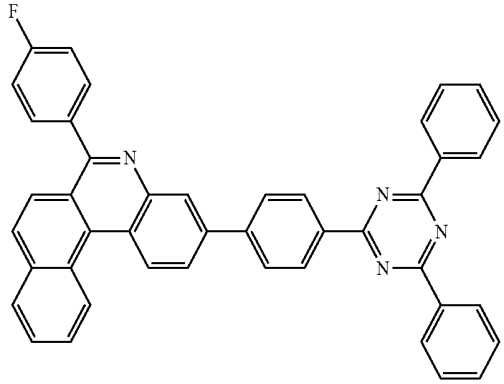

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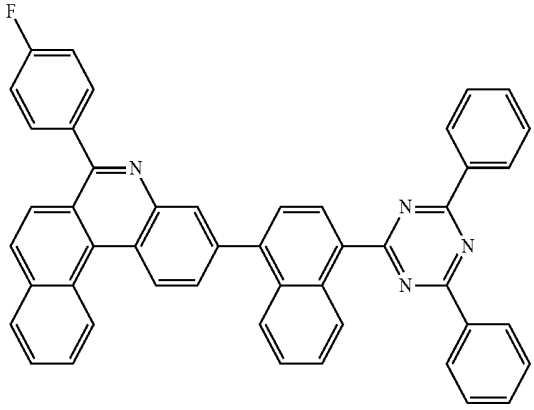

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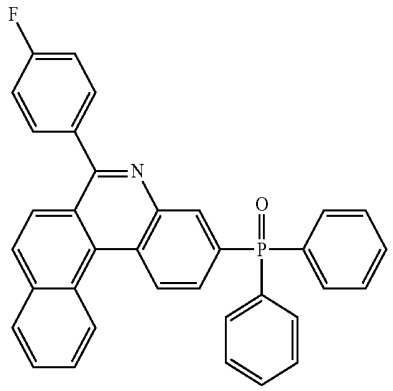

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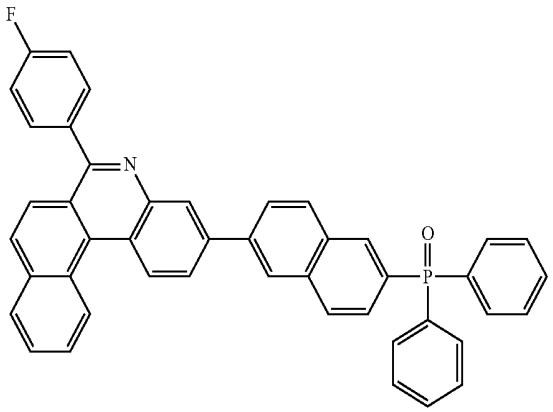

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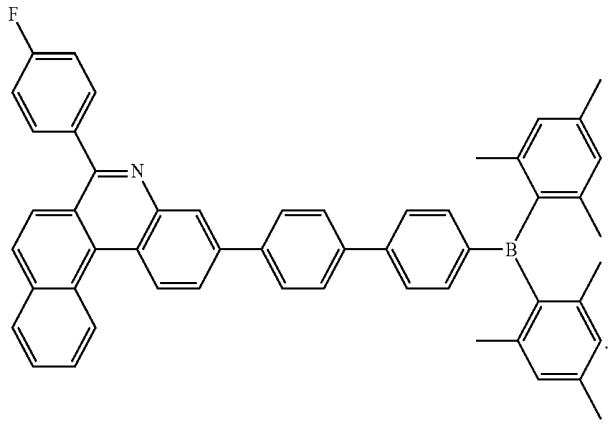

13. An organic light-emitting device comprising:

a first electrode;

a second electrode facing the first electrode; and

an organic layer between the first electrode and the second electrode and comprising an emission layer and at least one of the condensed cyclic compound of claim **1**.

14. The organic light-emitting device of claim **13**, wherein:

the first electrode is an anode,

the second electrode is a cathode, and

the organic layer further comprises i) a hole transport region between the first electrode and the emission layer and comprising a hole injection layer, a hole transport layer, a buffer layer, an electron blocking layer, or any combination thereof and ii) an electron transport region between the emission layer and the second electrode and comprising a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof.

15. The organic light-emitting device of claim **14**, wherein:

the electron transport region comprises the at least one of the condensed cyclic compound.

16. The organic light-emitting device of claim **14**, wherein:

the electron transport region comprises the electron transport layer and the electron injection layer, and

the electron transport layer comprises the at least one of the condensed cyclic compound.

17. The organic light-emitting device of claim **14**, wherein:

the hole transport region further comprises a p-dopant, and

the p-dopant comprises a cyano group-containing compound.

18. The organic light-emitting device of claim **13**, wherein:

the emission layer comprises a pyrene-containing compound, an arylamine-based compound, and a styryl-based compound.

19. The organic light-emitting device of claim **13**, wherein:

the emission layer is a first emission layer for emitting first color light,

the organic light-emitting device further comprises i) at least one second emission layer for emitting second color light or ii) at least one second emission layer for emitting second color light and at least one third emission layer for emitting third color light, between the first electrode and the second electrode,

a maximum emission wavelength of the first color light, a maximum emission wavelength of the second color light, and a maximum emission wavelength of the third color light are identical to or different from each other, and

the first color light and the second color light are emitted in the form of mixed light, or the first color light, the second color light, and the third color light are emitted in the form of mixed light.

20. An electronic apparatus comprising:
a thin film transistor; and
the organic light-emitting device of claim **13**,
wherein the thin film transistor comprises a source electrode, a drain electrode, an active layer, and a gate electrode, and
wherein the first electrode of the organic light-emitting device is electrically coupled to one of the source electrode and the drain electrode of the thin film transistor.

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摘要(译)

本发明提供一种缩合环状化合物和包含该化合物的有机发光装置。有机发光装置包括：第一电极;面向第一电极的第二电极;第一电极和第二电极之间的有机层，包括发光层和至少一种缩合环状化合物。