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(19) **United States**(12) **Patent Application Publication**
KIM et al.(10) **Pub. No.: US 2015/0318490 A1**(43) **Pub. Date: Nov. 5, 2015**(54) **CONDENSED CYCLIC COMPOUND AND
ORGANIC LIGHT-EMITTING DEVICE
COMPRISING THE SAME***C07D 471/14* (2006.01)*C07D 221/18* (2006.01)*C07D 471/04* (2006.01)(71) Applicants: **SAMSUNG DISPLAY CO., LTD.**,
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Suwon-city (KR)(52) **U.S. CL.**CPC *H01L 51/0072* (2013.01); *C07D 221/18*
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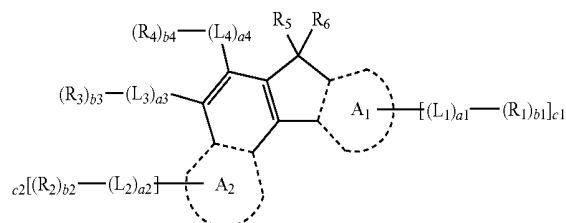
ABSTRACTA condensed cyclic compound represented by Formula 1 and
an organic light-emitting device including the condensed
cyclic compound are provided;(21) Appl. No.: **14/701,088**(22) Filed: **Apr. 30, 2015**

<Formula 1>

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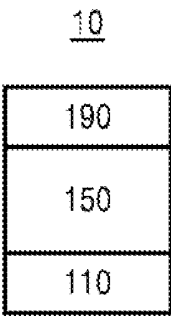
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190

150

110

FIG. 1



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

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Korean Patent Application No. 10-2014-0053610, filed on May 2, 2014, and Korean Patent Application No. 10-2015-0061881, filed on Apr. 30, 2015, in the Korean Intellectual Property Office, and entitled: "Condensed Cyclic Compound and Organic Light-Emitting Device Comprising the Same," are incorporated by reference herein in their entirety.

BACKGROUND

[0002] 1. Field

[0003] Embodiments relate to a condensed cyclic compound and an organic light-emitting device including the same.

[0004] 2. Description of the Related Art

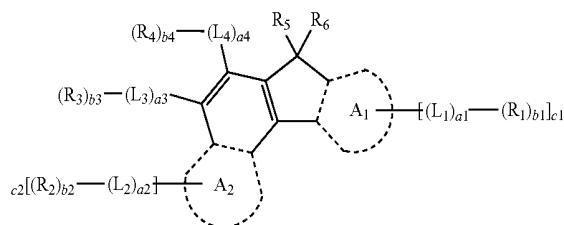
[0005] Organic light-emitting devices (OLEDs) are self-emitting devices that have advantages such as wide viewing angles, excellent contrast, quick response, high brightness, excellent driving voltage characteristics, and can provide multicolored images.

[0006] An organic light-emitting device may have a structure in which a first electrode, a hole transport region, an emission layer, an electron transport region, and a second electrode are sequentially disposed on a substrate in this order. Holes injected from the first electrode move to the emission layer via the hole transport region, while electrons injected from the second electrode move to the emission layer via the electron transport region. Carriers such as the holes and electrons recombine in the emission layer to generate excitons. When the excitons drop from an excited state to a ground state, light is emitted.

SUMMARY

[0007] Embodiments are directed to a condensed cyclic compound represented by Formula 1:

<Formula 1>



[0008] wherein, in Formula 1,

[0009] A₁ ring is a C₂-C₂₀ heterocyclic group including at least one N as a ring member atom, and A₂ ring is a C₆-C₂₀ cyclic group, or a C₂-C₂₀ heterocyclic group including at least one N as a ring member atom, wherein A₂ ring is not a benzene when A₁ ring is a pyridine,

[0010] L₁ to L₄ are each independently selected from a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene

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

[0011] a₁ to a₄ are each independently selected from 0, 1, 2, and 3,

[0012] R₁ to R₆ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁)(Q₂), —Si(Q₃)(Q₄)(Q₅), and —B(Q₆)(Q₇),

[0013] b₁ to b₄ are each independently an integer selected from 0 to 3,

[0014] c₁ and c₂ are each independently an integer selected from 0 to 10, and

[0015] at least one of substituents of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₁-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₁-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted a divalent non-aromatic condensed polycyclic group, the substituted a divalent non-aromatic condensed heteropolycyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

[0016] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and C₁-C₆₀ alkoxy group;

[0017] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino

group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇);

[0018] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0019] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇); and

[0020] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), or —B(Q₃₆)(Q₃₇);

[0021] wherein Q₁ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇ and Q₃₁ to Q₃₇ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0022] Embodiments are also directed to an organic light-emitting device comprising a first electrode; a second electrode disposed opposite to the first electrode; and an organic layer disposed between the first electrode and the second electrode and comprising an emission layer, wherein the organic layer comprises at least one of the condensed cyclic compounds of claim 1 above.

BRIEF DESCRIPTION OF THE DRAWING

[0023] Features will become apparent to those of skill in the art by describing in detail exemplary embodiments with reference to the attached drawing in which:

[0024] FIG. 1 illustrates a schematic view of a structure of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

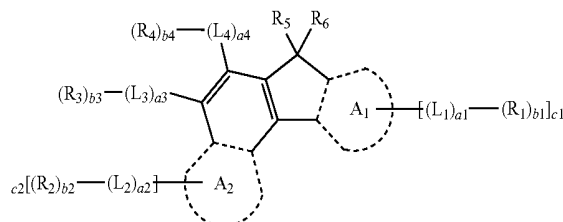
[0025] Example embodiments will now be described more fully hereinafter with reference to the accompanying drawings; however, they may be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey exemplary implementations to those skilled in the art.

[0026] In the drawing figure, the dimensions of layers and regions may be exaggerated for clarity of illustration. Like reference numerals refer to like elements throughout.

[0027] 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.

[0028] According to an embodiment, there is provided a condensed cyclic compound represented by Formula 1.

<Formula 1>



[0029] wherein, in Formula 1, A₁ ring is a C₂-C₂₀ heterocyclic group including at least one N as a ring member atom, and A₂ ring is a C₆-C₂₀ cyclic group, or a C₂-C₂₀ heterocyclic group including at least one N as a ring member atom, wherein A₂ ring is not a benzene when A₁ ring is a pyridine.

[0030] In Formula 1, A₁ ring may be a ring condensed to an adjacent 5-membered ring while sharing carbon with the same, and A₂ ring may be a ring condensed to a 6-membered ring while sharing carbon with the same.

[0031] For example, in Formula 1, A₁ ring may be a pyridine, and A₂ ring may be a naphthalene, a pyridine, a pyrimidine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline or a phenanthroline. In some embodiments, A₁ ring may be a pyrimidine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, or a phenanthroline, and A₂ ring may be a benzene, a naphthalene, a pyridine, a pyrimidine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, or a phenanthroline.

[0032] For example, in Formula 1, A₁ ring may be a pyridine, and A₂ ring may be a naphthalene or a pyridine. In some embodiments, A₁ ring may be a quinoline, a benzoquinoline, or a phenanthroline, and A₂ ring may be a benzene, a naphthalene, a pyridine, or a quinoline. However, embodiments are not limited thereto.

[0033] In Formula 1, L_1 to L_4 are each independently selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted 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.

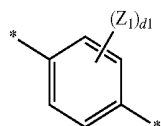
[0034] For example, in Formula 1, L_1 to L_4 may be each independently selected from

[0035] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, a ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, a oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and an imidazopyrimidinylene group; and

[0036] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a phenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, a ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, a oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a puri-

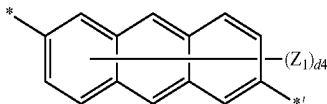
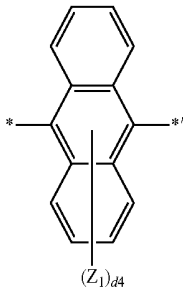
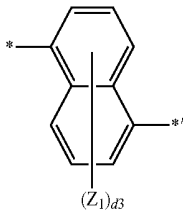
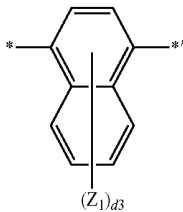
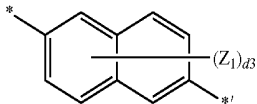
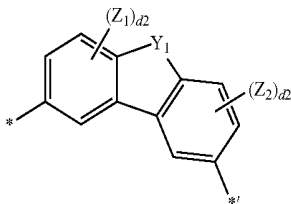
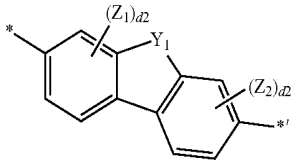
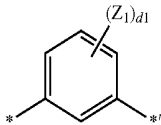
nylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and an imidazopyrimidinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, an a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentalenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

[0037] In some embodiments, in Formula 1, L_1 to L_4 may each independently be selected from groups represented by Formulae 3-1 to 3-33, but are not limited thereto:



Formula 3-1

-continued



Formula 3-2

Formula 3-3

Formula 3-4

Formula 3-5

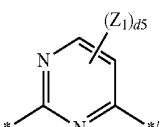
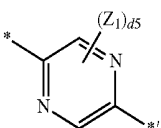
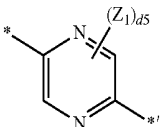
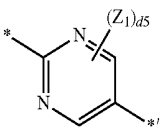
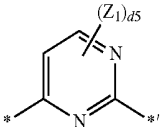
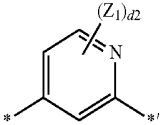
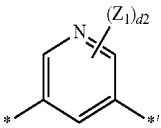
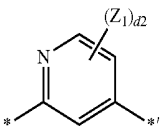
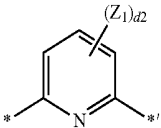
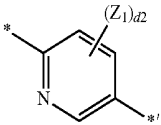
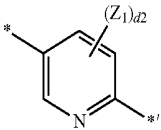
Formula 3-6

Formula 3-7

Formula 3-8

Formula 3-9

-continued



Formula 3-10

Formula 3-11

Formula 3-12

Formula 3-13

Formula 3-14

Formula 3-15

Formula 3-16

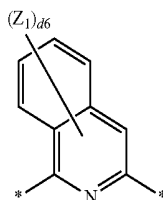
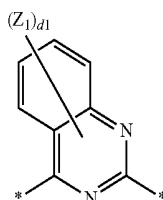
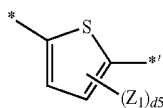
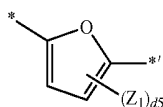
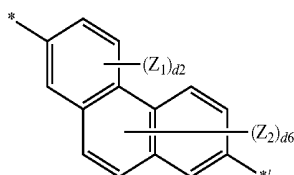
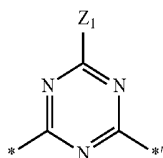
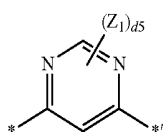
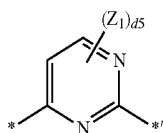
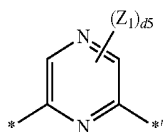
Formula 3-17

Formula 3-18

Formula 3-19

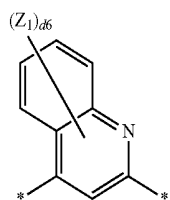
Formula 3-20

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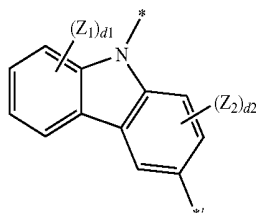


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Formula 3-21

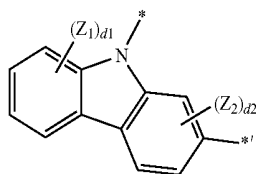


Formula 3-22

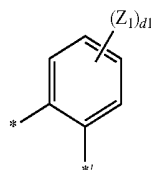


Formula 3-23

Formula 3-24



Formula 3-25



Formula 3-26

Formula 3-27

Formula 3-28

Formula 3-29

Formula 3-30

Formula 3-31

Formula 3-32

Formula 3-33

[0038] In Formulae 3-1 to 3-33,

[0039] Y_1 may be O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$,

[0040] Z_1 to Z_7 may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

[0041] d_1 may be an integer selected from 1 to 4,

[0042] d_2 may be an integer selected from 1 to 3,

[0043] d_3 may be an integer selected from 1 to 6,

[0044] d_4 may be an integer selected from 1 to 8,

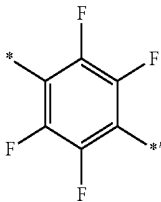
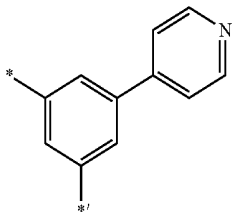
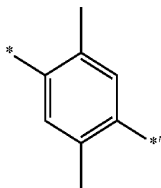
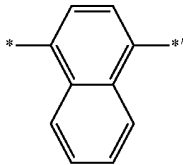
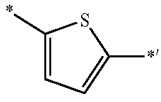
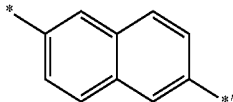
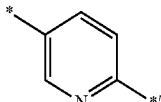
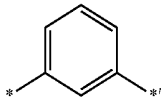
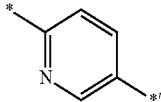
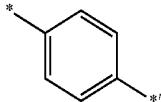
[0045] d_5 may be 1 or 2,

[0046] d_6 may be an integer selected from 1 to 5, and

[0047] * and *' may be binding sites with adjacent atoms.

[0048] In some other embodiments, in Formula 1, L_1 to L_4 may each independently be selected from groups represented by one of Formulae 4-1 to 4-24, but are not limited thereto:

-continued



Formula 4-1

Formula 4-2

Formula 4-3

Formula 4-4

Formula 4-5

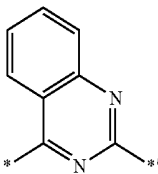
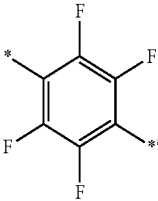
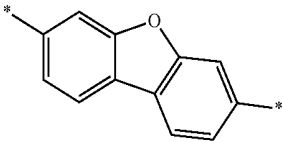
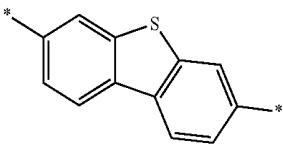
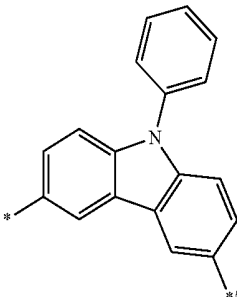
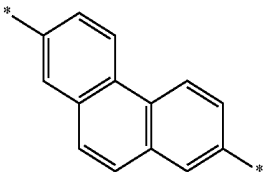
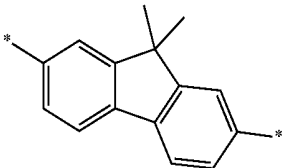
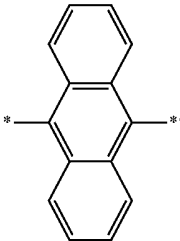
Formula 4-6

Formula 4-7

Formula 4-8

Formula 4-9

Formula 4-10



Formula 4-11

Formula 4-12

Formula 4-13

Formula 4-14

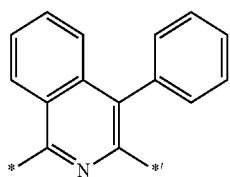
Formula 4-15

Formula 4-16

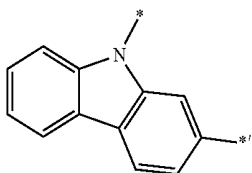
Formula 4-17

Formula 4-18

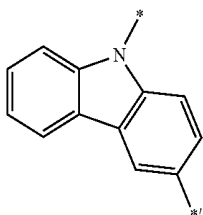
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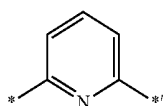
Formula 4-19



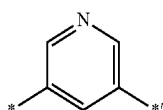
Formula 4-20



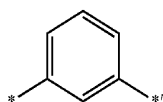
Formula 4-21



Formula 4-22



Formula 4-23



Formula 4-24

[0049] In Formulae 4-1 and 4-24, * and *' are binding sites with adjacent groups.

[0050] In Formula 1, a_1 , which indicates the number of L_1 s, may be an integer selected from 0 to 3. For example, a_1 in Formula 1 may be 0 or 1, but is not limited thereto. When a_1 is 0, $*(L_1)_{a_1}-*'$ is a single bond. When a_1 is 2 or more, two or more L_1 s may be identical or differ. In Formula 1, a_2 , a_3 , and a_4 may be understood based on the description of a_1 and the structure of Formula 1.

[0051] In Formula 1, a_1 to a_4 may each independently be 0 or 1.

[0052] In Formula 1, R_1 to R_6 may each independently be selected from a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryl-

loxy 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, $-N(Q_1)(Q_2)$, $-Si(Q_3)(Q_4)(Q_5)$, and $-B(Q_6)(Q_7)$.

[0053] In some embodiments, in Formula 1, R_1 to R_4 may each independently be selected from a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{20} alkyl group, a substituted or unsubstituted C_1 - C_{20} alkoxy group, a substituted or unsubstituted C_6 - C_{20} aryl group, a substituted or unsubstituted C_1 - C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and $-Si(Q_3)(Q_4)(Q_5)$. In Formula 1, R_5 and R_6 may each independently be selected from 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_6 - C_{20} aryl group, a substituted or unsubstituted C_1 - C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, but are not limited thereto.

[0054] For example, in Formula 1, R_1 to R_4 may each independently be

[0055] a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

[0056] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0057] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

[0058] $Si(Q_3)(Q_4)(Q_5)$, wherein Q_3 to Q_5 may each independently be selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, and a naphthyl group. However, embodiments are not limited thereto.

[0059] In some other embodiments, in Formula 1, R_1 to R_4 may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

[0060] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

[0061] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group,

a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group. However, embodiments are not limited thereto.

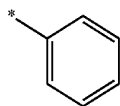
[0062] In some embodiments, in Formula 1, R_5 and R_6 may each independently be selected from

[0063] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group;

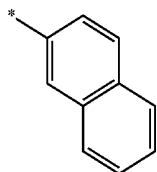
[0064] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, and a chrysenyl group; and

[0065] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, and a chrysenyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, and a chrysenyl group. However, embodiments are not limited thereto.

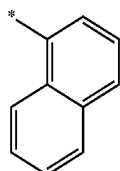
[0066] For example, in Formula 1, R_1 to R_4 may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, and groups represented by Formulae 6-1 to 6-62; and R_5 and R_6 may each independently be selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, and groups represented by Formulae 6-1 to 6-62. However, embodiments are not limited thereto.



Formula 6-1

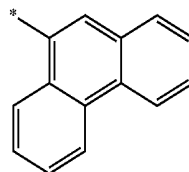


Formula 6-2

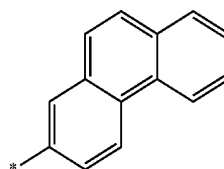


Formula 6-3

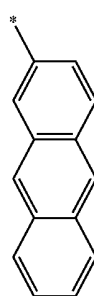
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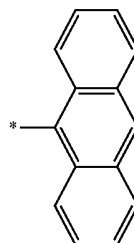
Formula 6-4



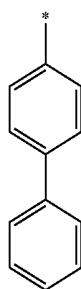
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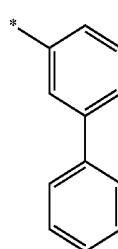
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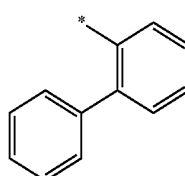
Formula 6-7



Formula 6-8

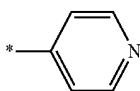
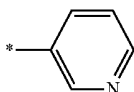
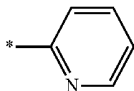
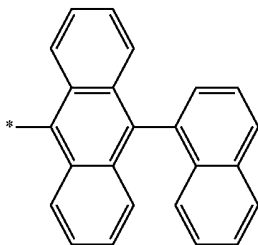
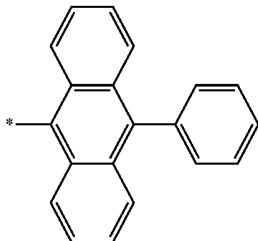
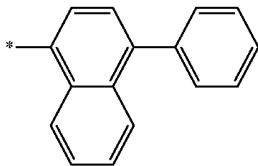
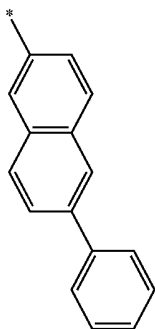
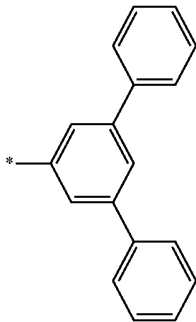


Formula 6-9

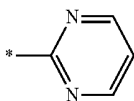
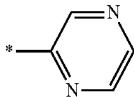
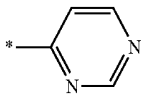


Formula 6-10

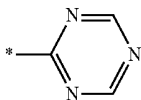
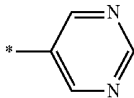
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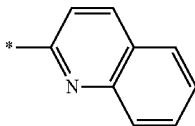
Formula 6-11



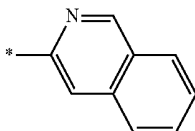
Formula 6-12



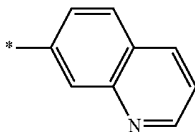
Formula 6-13



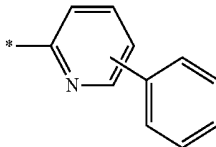
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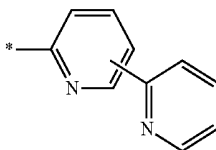
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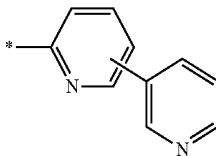
Formula 6-16



Formula 6-17



Formula 6-18



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Formula 6-19

Formula 6-20

Formula 6-21

Formula 6-22

Formula 6-23

Formula 6-24

Formula 6-25

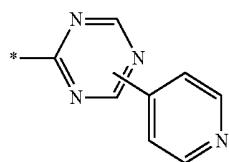
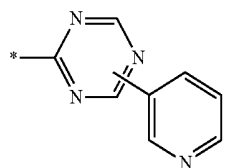
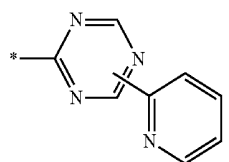
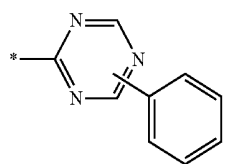
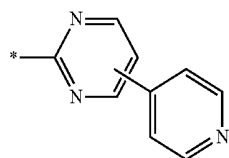
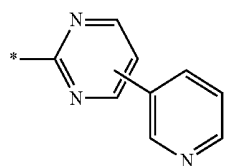
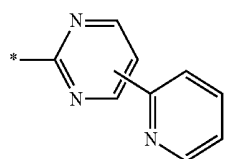
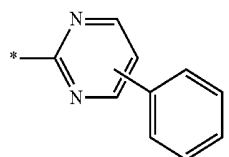
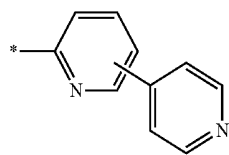
Formula 6-26

Formula 6-27

Formula 6-28

Formula 6-29

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Formula 6-30

Formula 6-31

Formula 6-32

Formula 6-33

Formula 6-34

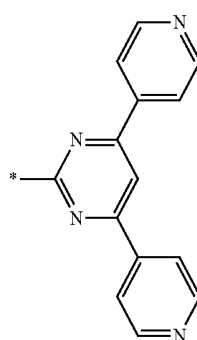
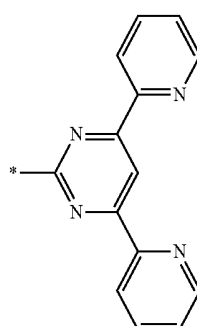
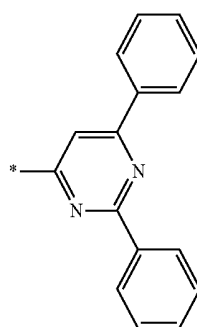
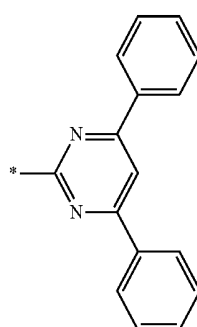
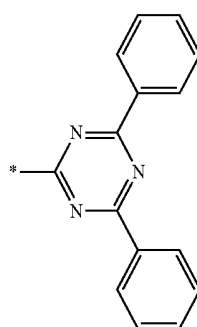
Formula 6-35

Formula 6-36

Formula 6-37

Formula 6-38

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Formula 6-39

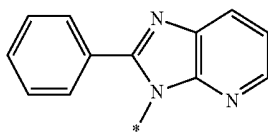
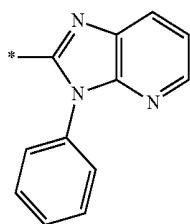
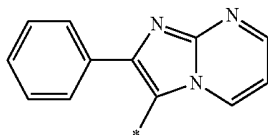
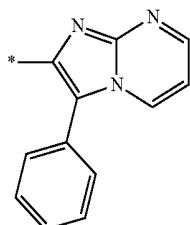
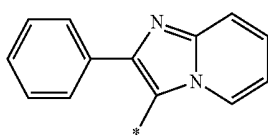
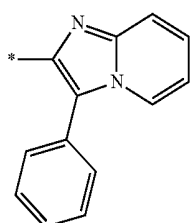
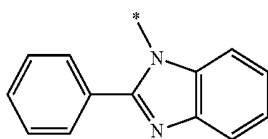
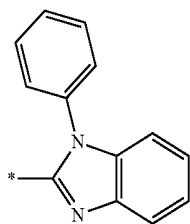
Formula 6-40

Formula 6-41

Formula 6-42

Formula 6-43

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Formula 6-44

Formula 6-45

Formula 6-46

Formula 6-47

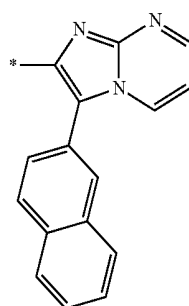
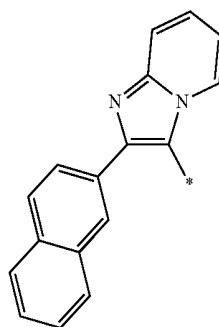
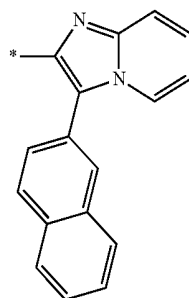
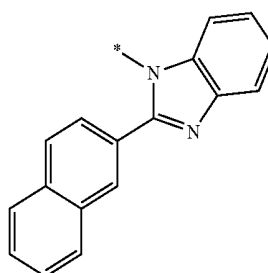
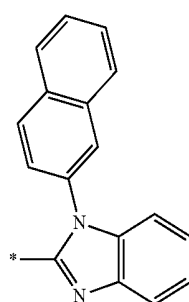
Formula 6-48

Formula 6-49

Formula 6-51

Formula 6-52

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Formula 6-53

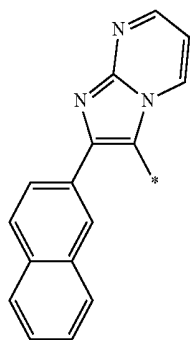
Formula 6-54

Formula 6-55

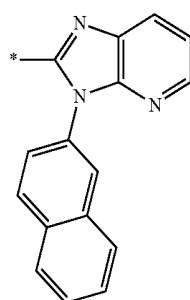
Formula 6-56

Formula 6-57

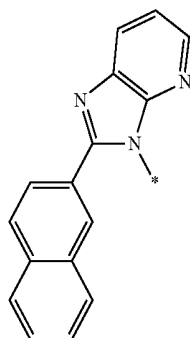
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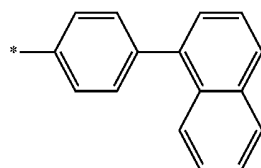
Formula 6-58



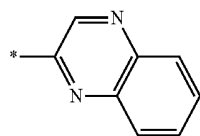
Formula 6-59



Formula 6-60



Formula 6-61



Formula 6-62

[0067] In Formulae 6-1 and 6-62, * is a binding site with an adjacent group.

[0068] In Formula 1, b_1 , which indicates the number of R_1 s, may be an integer selected from 0 to 3. In some embodiments, b_1 may be 1 or 2. Two or more R_1 s may be identical or differ. In Formula 1, b_2 , b_3 , and b_4 may be understood based on the description of b_1 and the structure of Formula 1.

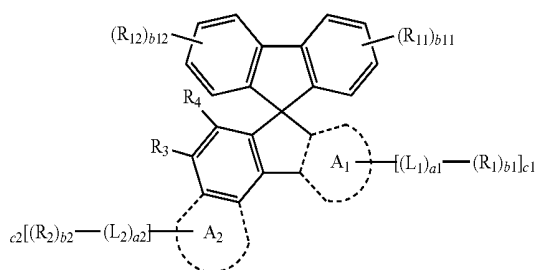
[0069] In Formula 1, c_1 , which indicates the number of $^*-(L_1)_{a1}-(R_1)_{b1}$ s, may be an integer selected from 1 to 4. In some embodiments, c_1 may be 1, 2 or 3. When c_1 is 2 or more, two or more $^*-(L_1)_{a1}-(R_1)_{b1}$ s may be identical or differ. In

Formula 1, c_2 may be understood based on the description of c_1 and the structure of Formula 1.

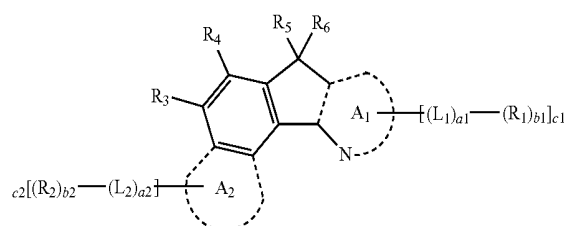
[0070] In some embodiments, in Formula 1, R_5 and R_6 may each independently be selected from a substituted or unsubstituted C_6 - C_{20} aryl group, a substituted or unsubstituted C_1 - C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and R_5 and R_6 may be linked to each other via a single bond or a substituted or unsubstituted C_1 - C_5 alkylene group, for example, to form a structure as in Formula 1A.

[0071] In some embodiments, the condensed cyclic compound of Formula 1 may be represented by Formula 1A or 1B.

<Formula 1A>



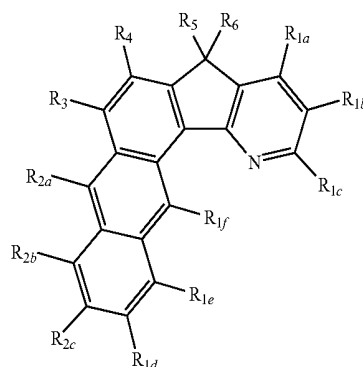
<Formula 1B>



[0072] In Formulae 1A and 1B, A_1 ring, A_2 ring, L_1 , L_2 , a_1 , a_2 , R_1 to R_6 , b_1 , b_2 , c_1 , and c_2 may be defined the same as those described herein; R_{11} and R_{12} may be each independently defined the same as R_1 described herein; and b_{11} and b_{12} may each independently be an integer selected from 1 to 4.

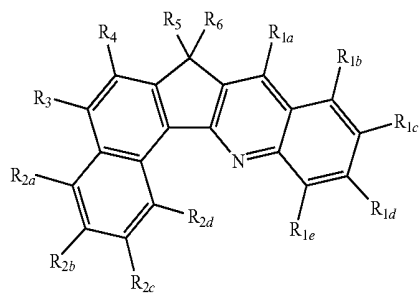
[0073] In some embodiments, the condensed cyclic compound of Formula 1 may be represented by one of Formulae 1(1) to 1(13) and Formulae 1A(1) to 1A(13). However, embodiments are not limited thereto.

Formula 1(1)

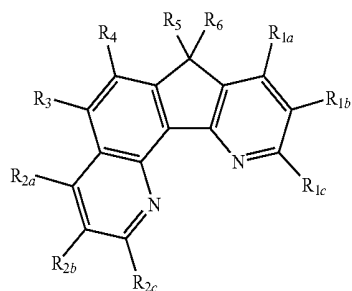


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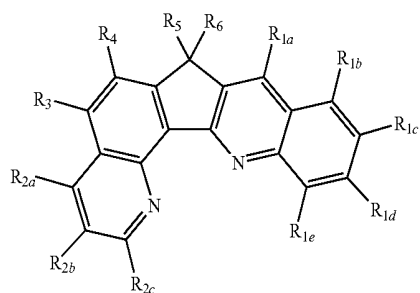
Formula 1(2)



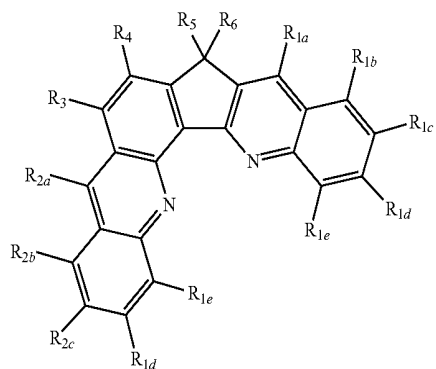
Formula 1(3)



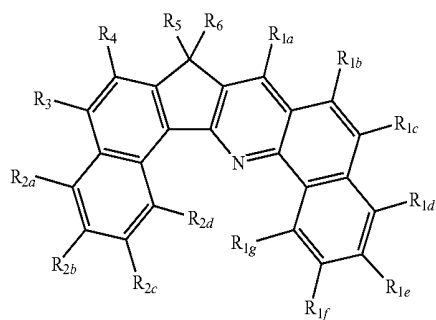
Formula 1(4)



Formula 1(5)

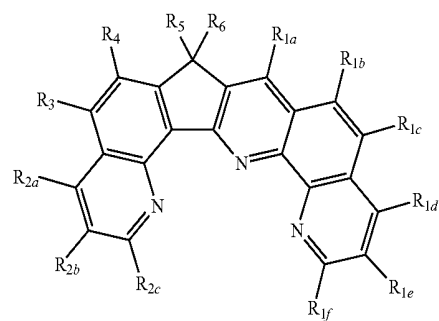


Formula 1(6)

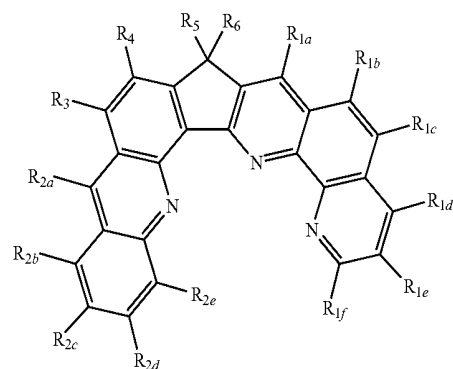


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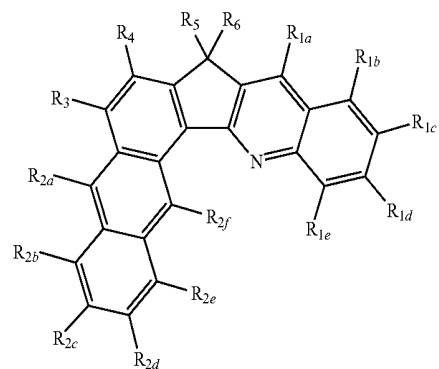
Formula 1(7)



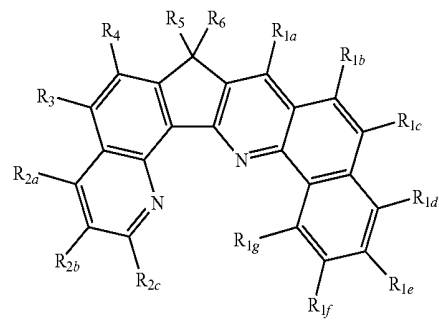
Formula 1(8)



Formula 1(9)

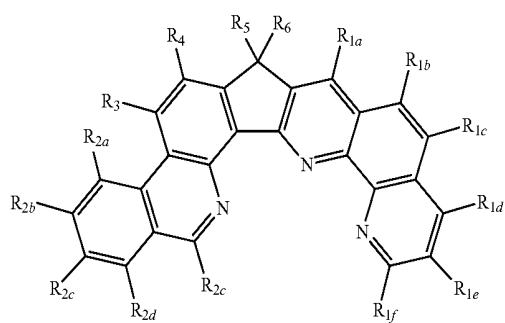


Formula 1(10)

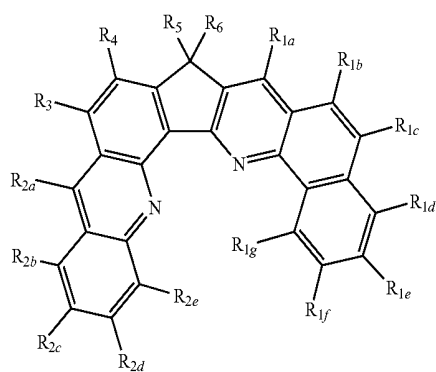


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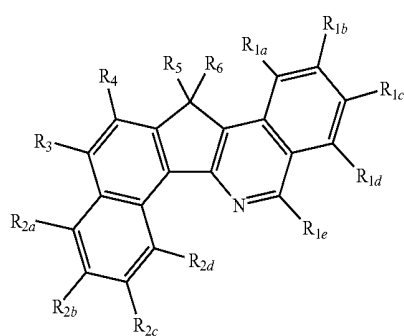
Formula 1(11)



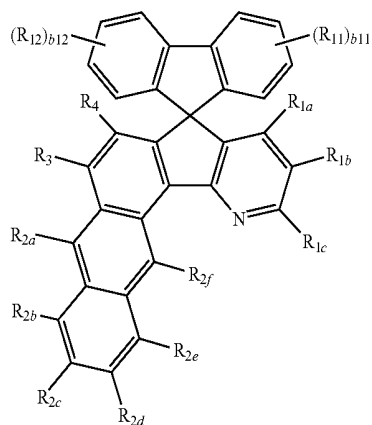
Formula 1(12)



Formula 1(13)

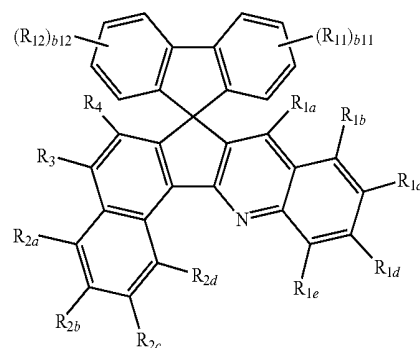


Formula 1A(1)

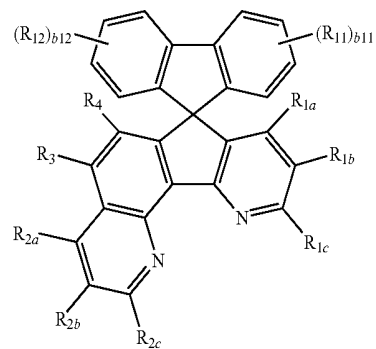


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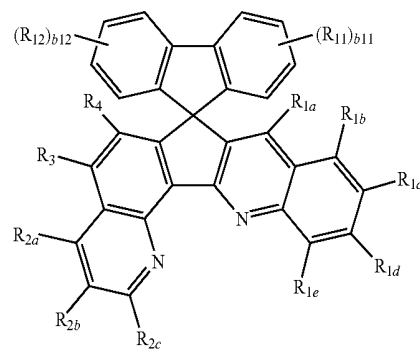
Formula 1A(2)



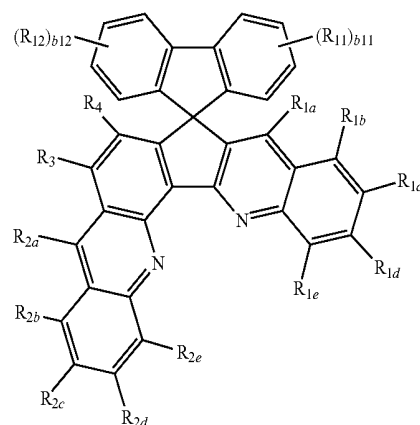
Formula 1A(3)



Formula 1A(4)

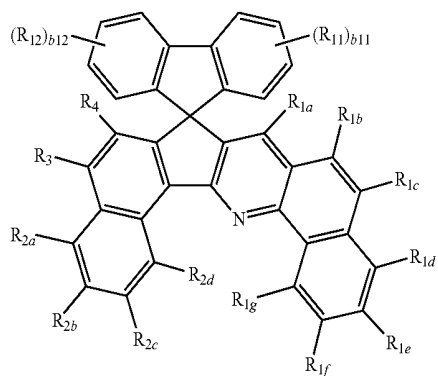


Formula 1A(5)



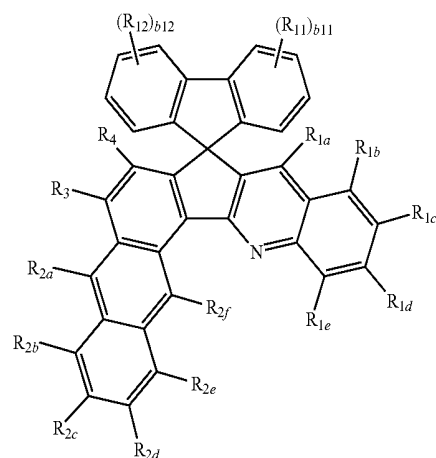
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Formula 1A(6)

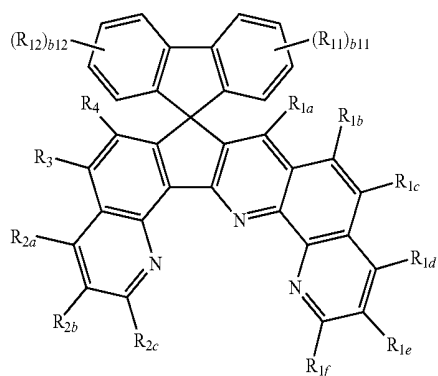


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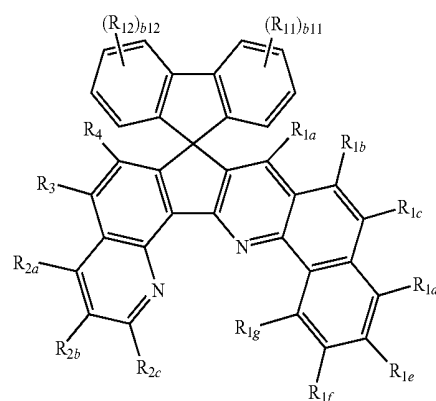
Formula 1A(9)



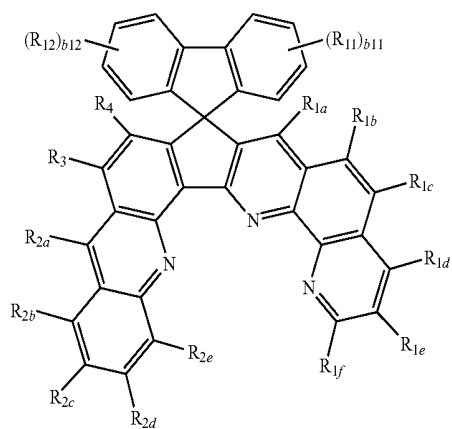
Formula 1A(7)



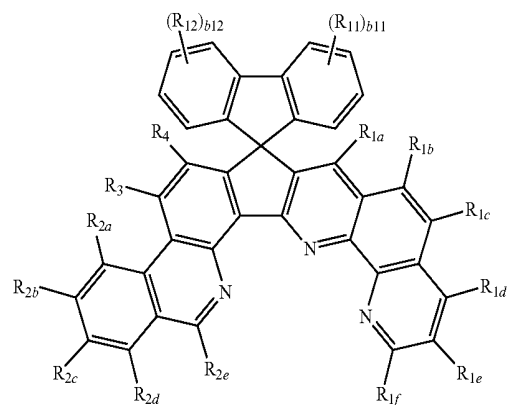
Formula 1A(10)



Formula 1A(8)

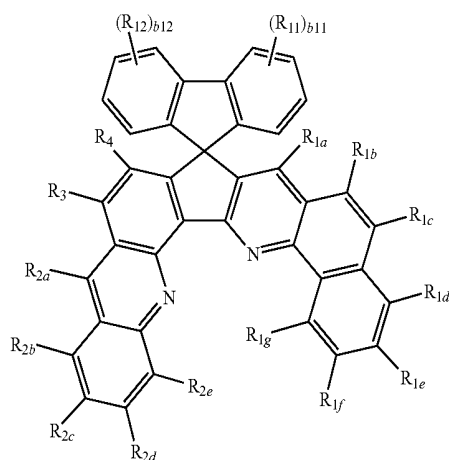


Formula 1A(11)

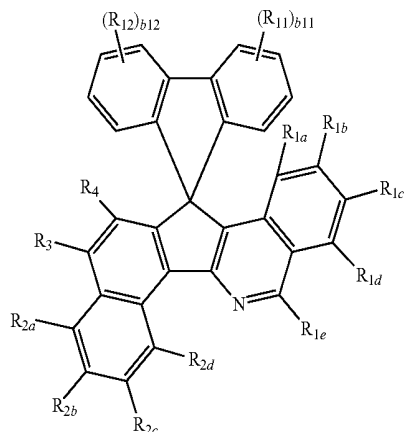


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Formula 1A(12)



Formula 1A(13)



[0074] In Formulae 1(1) to 1(13) and Formula 1A(1) to 1A(13), R₃ and R₄ may be defined the same as those described herein, R_{1a} to R_{1g}, R₁₁, and R₁₂ may each independently be defined the same as R₁ described herein, and R_{2a} to R_{2f} may each independently be defined the same as R₂ described herein.

[0075] For example, in Formulae 1A(1) to 1A(13) of Formulae 1(1) to 1(13), R_{1a} to R_{1g}, R_{2a} to R_{2f}, R₁₁, and R₁₂ may each independently be selected from

[0076] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;

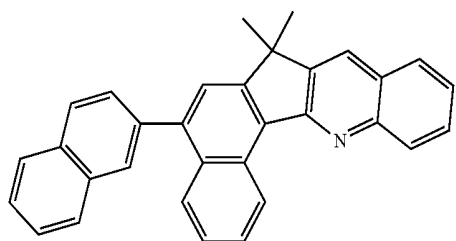
[0077] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group and an imidazopyrimidinyl group; and

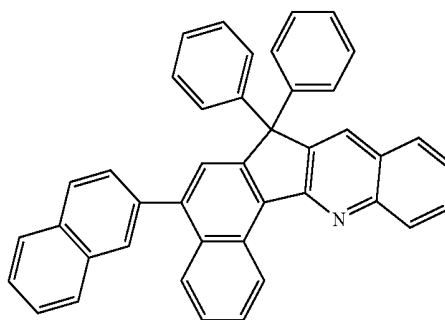
[0078] a phenyl group, a naphthyl group, a fluorenyl group, a Spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium, —F, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

[0079] In some embodiments, in Formulae 1A(1) to 1A(13) of Formulae 1(1) to 1(13), R_{1a} to R_{1g}, R_{2a} to R_{2f}, R₁₁, and R₁₂ may each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, and groups represented by Formulae 6-1 to 6-62. However, embodiments are not limited thereto.

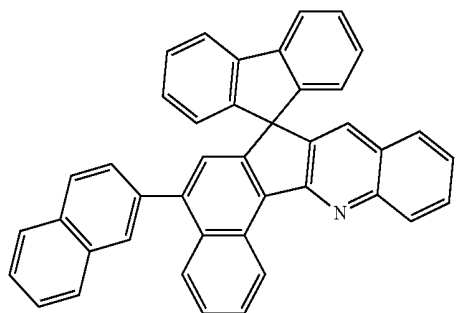
[0080] In some embodiments, the condensed cyclic compound represented by Formula 1 may be one of Compounds 1 to 67.



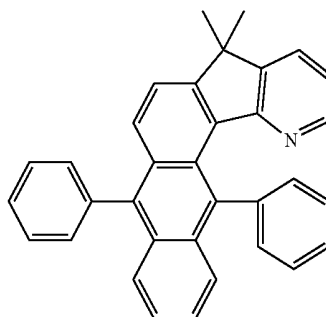
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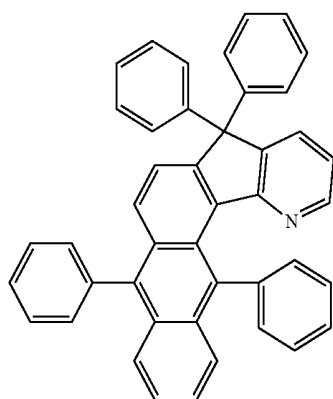
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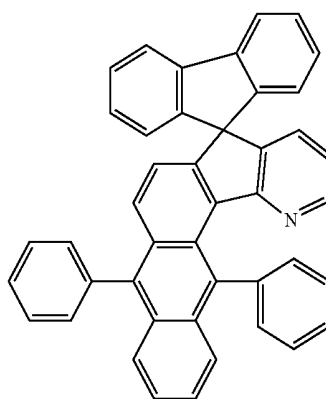
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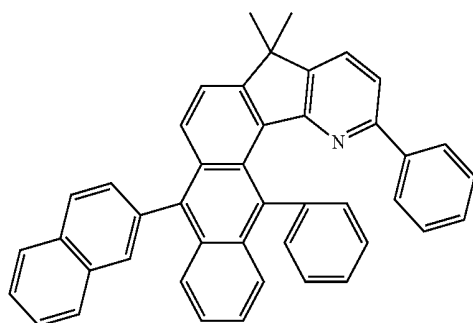
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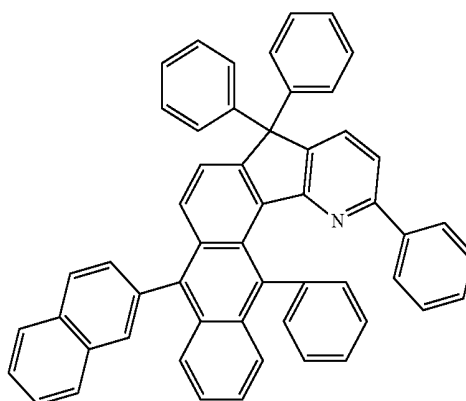
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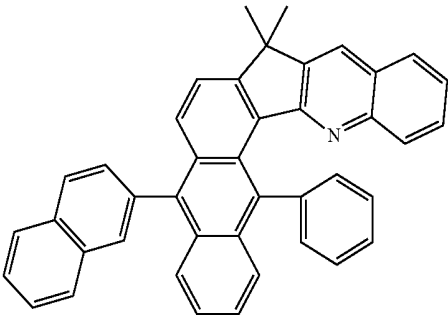
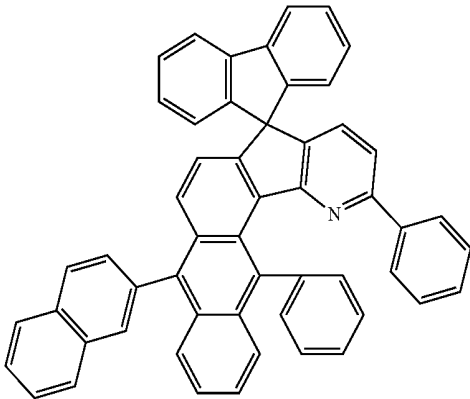


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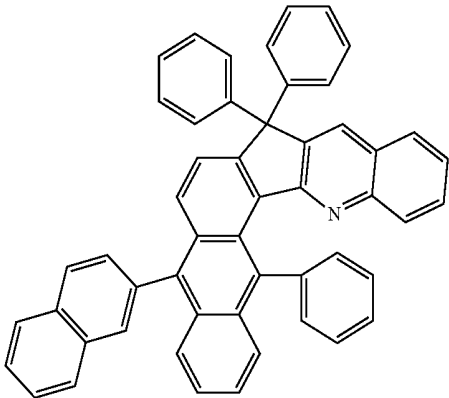
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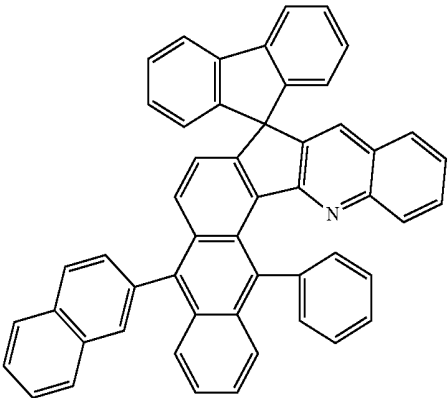


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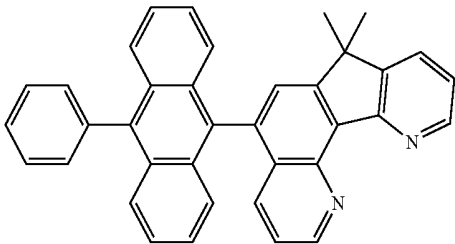
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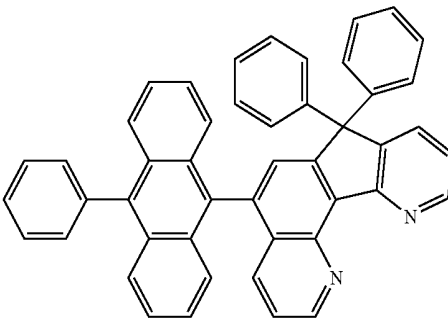
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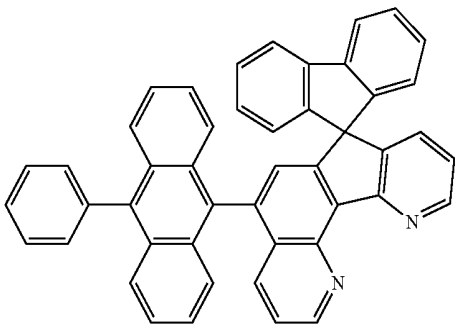
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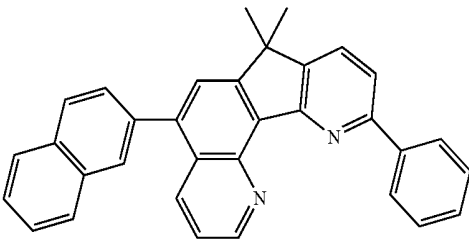
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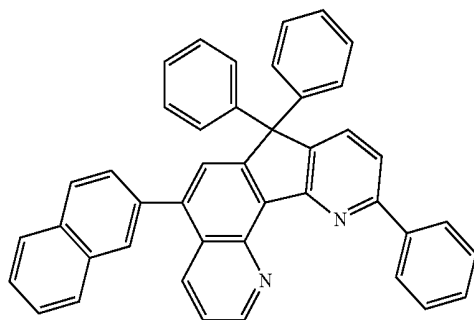
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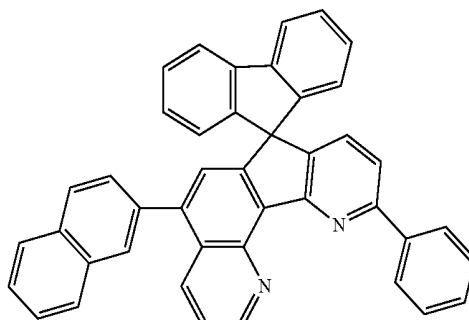


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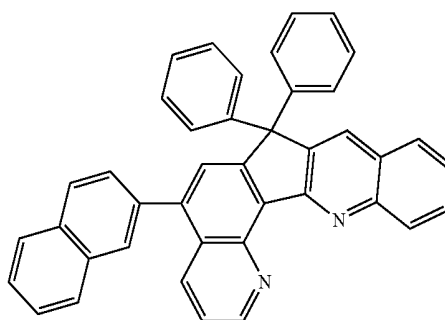
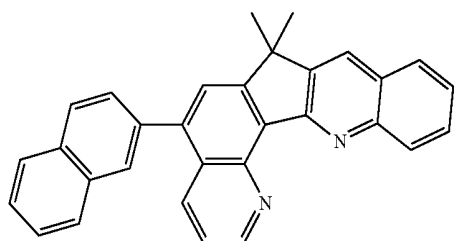
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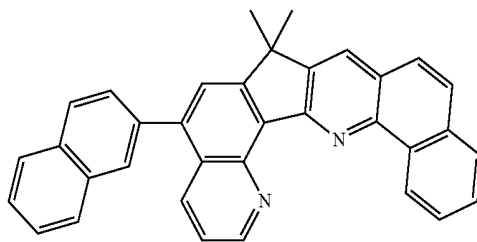
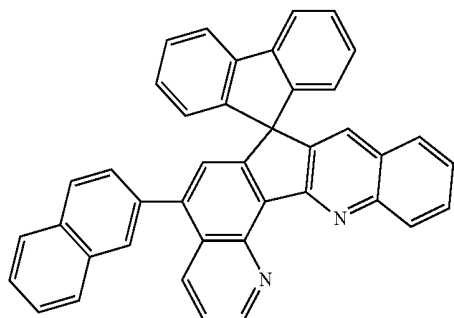
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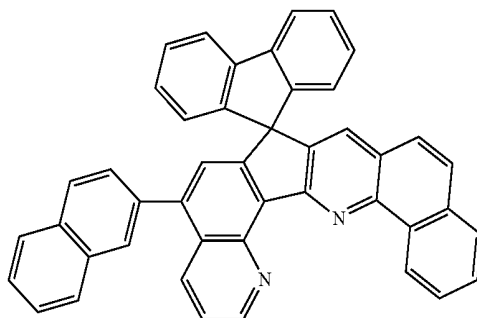
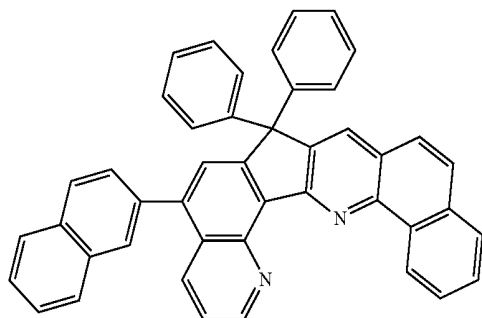
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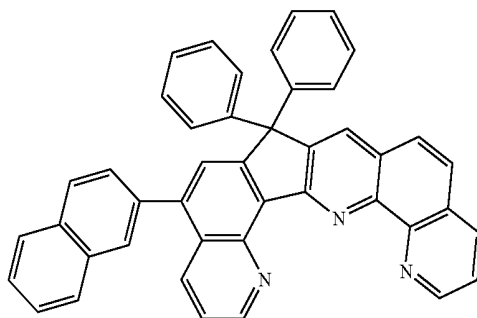
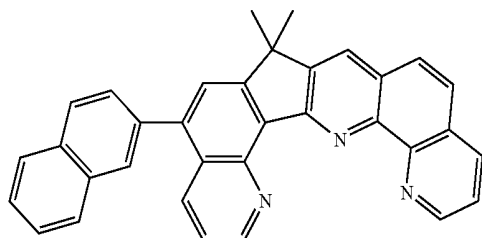
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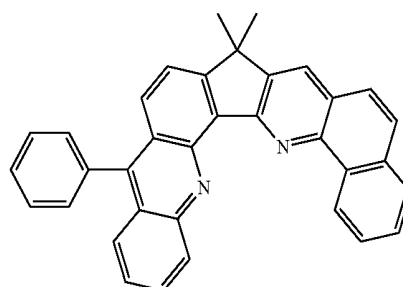
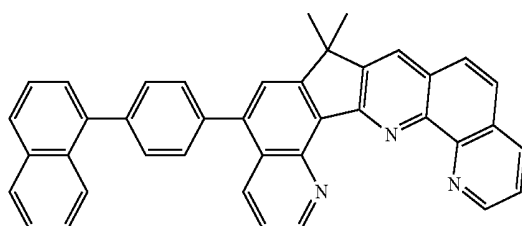
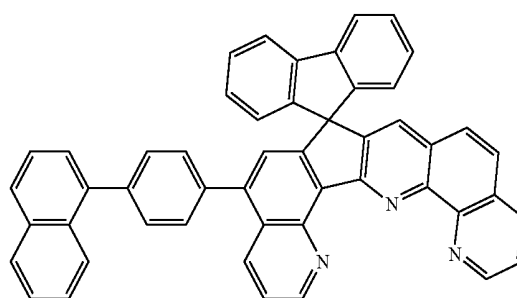
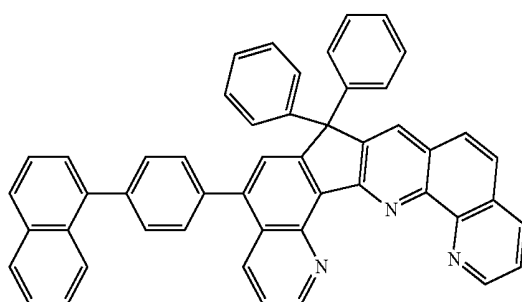
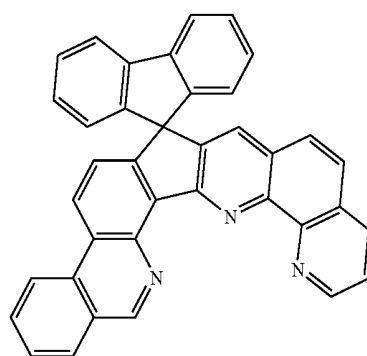
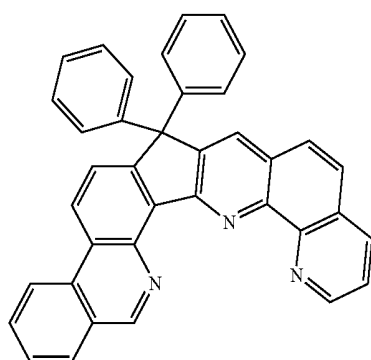
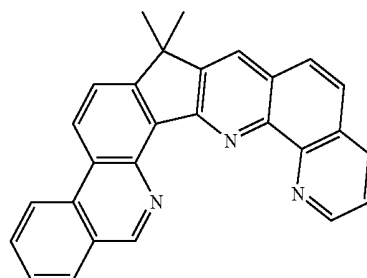
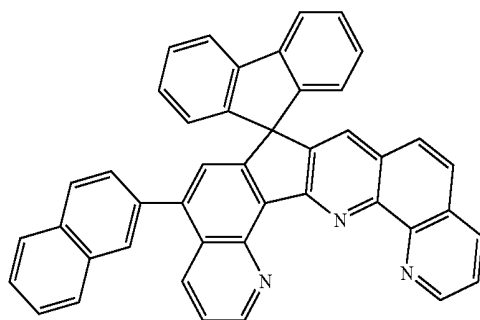


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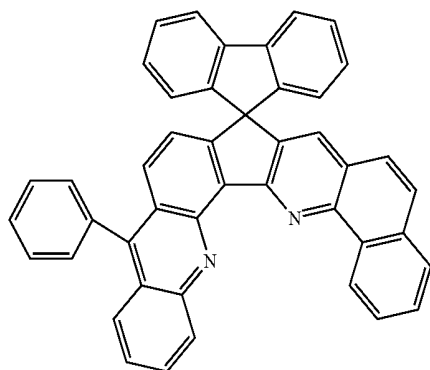


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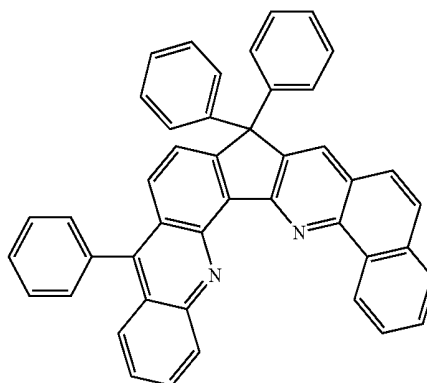


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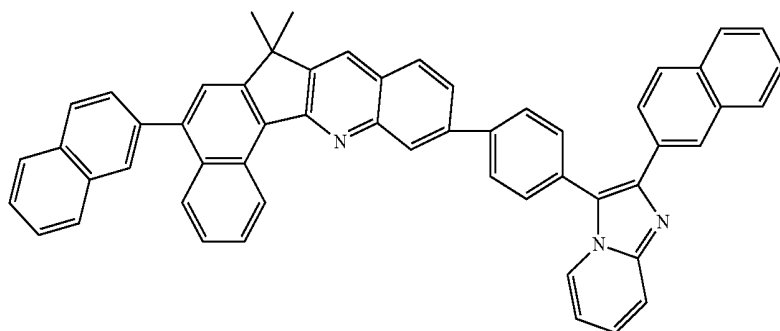
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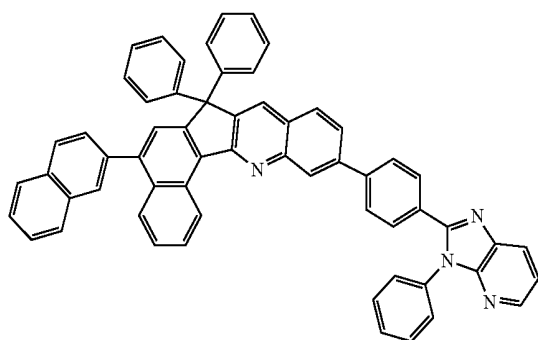
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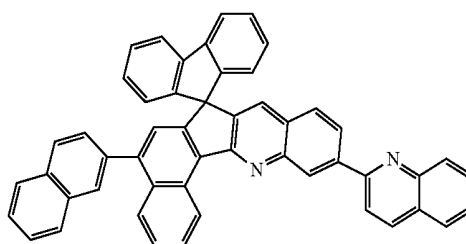
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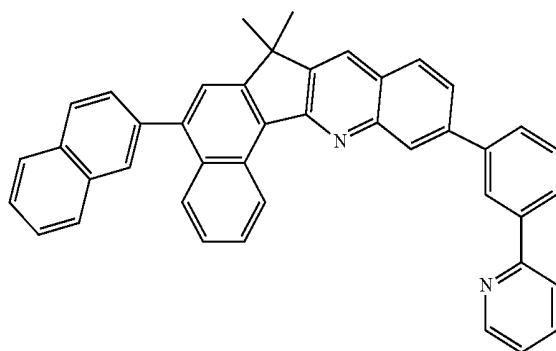
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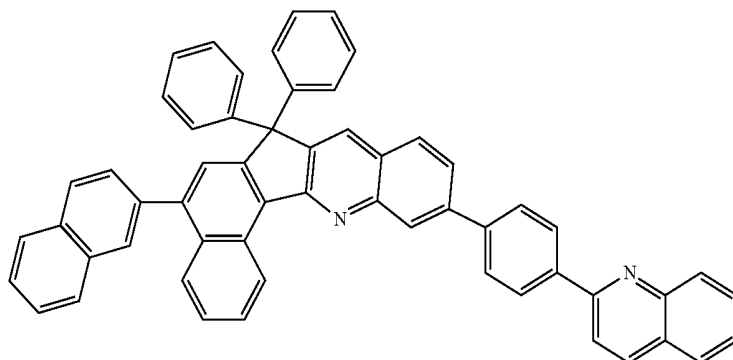


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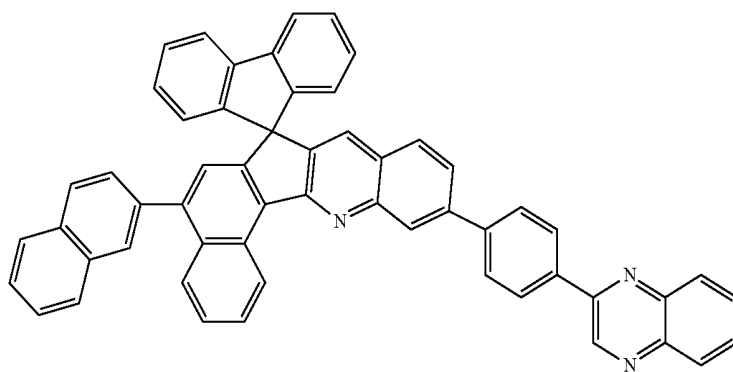


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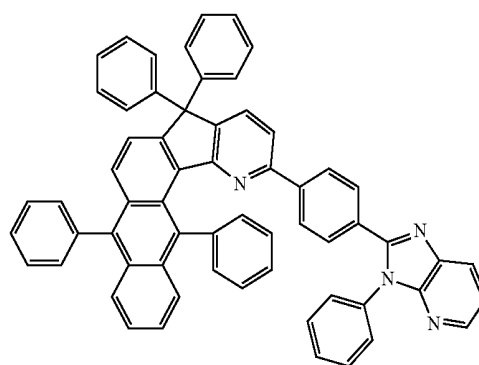
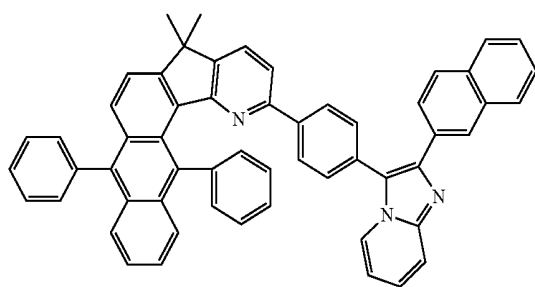


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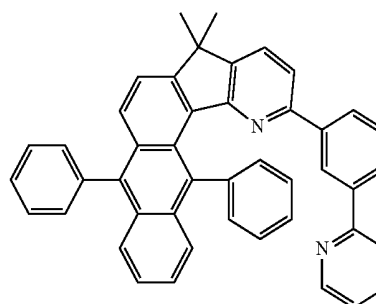
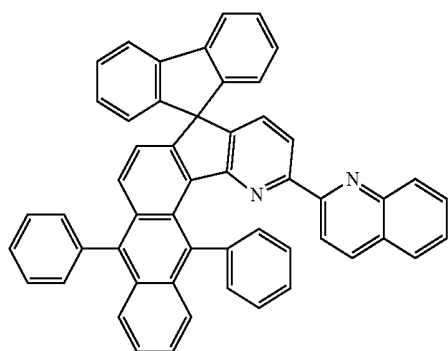
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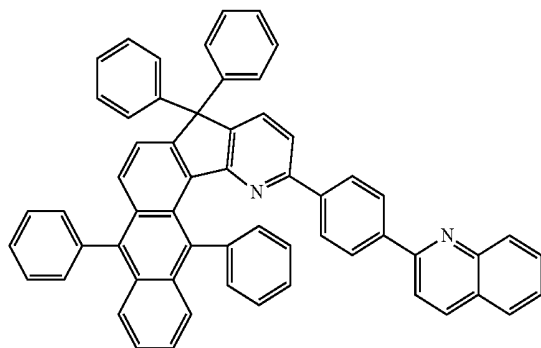
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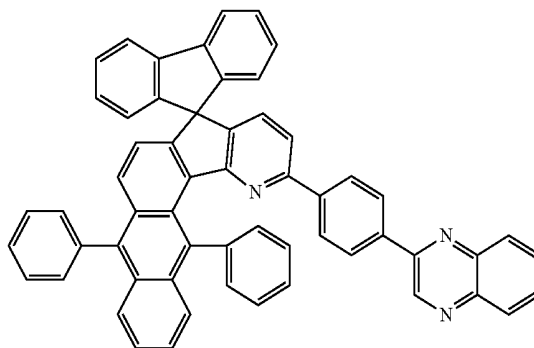


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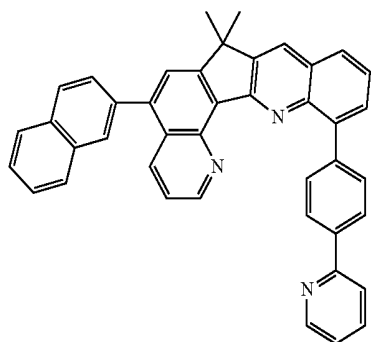
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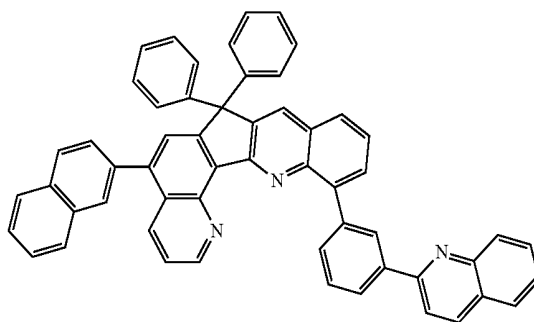
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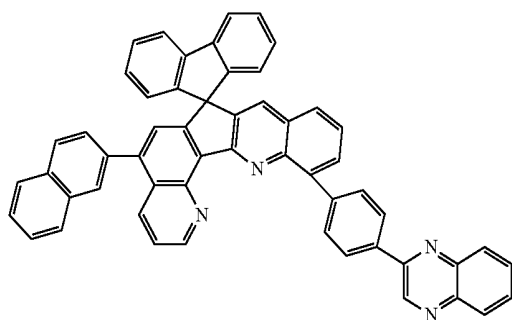
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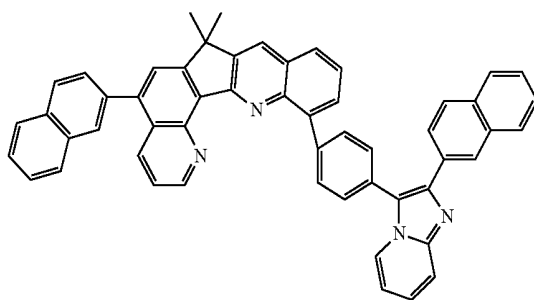
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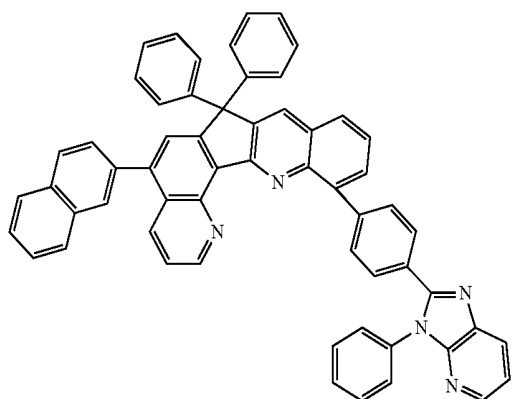
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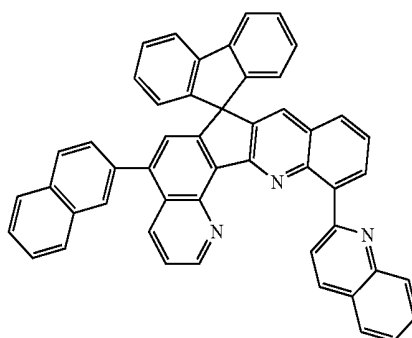
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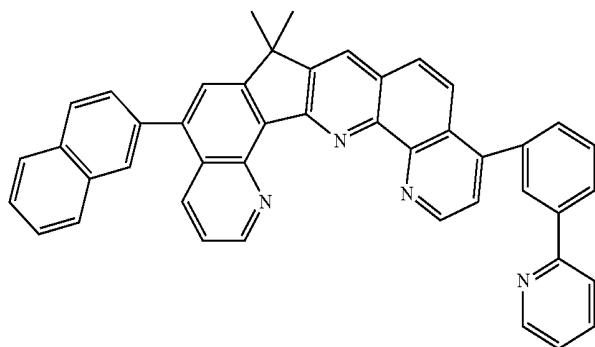


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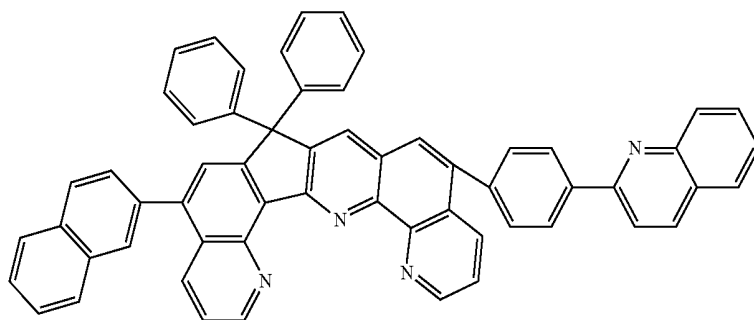


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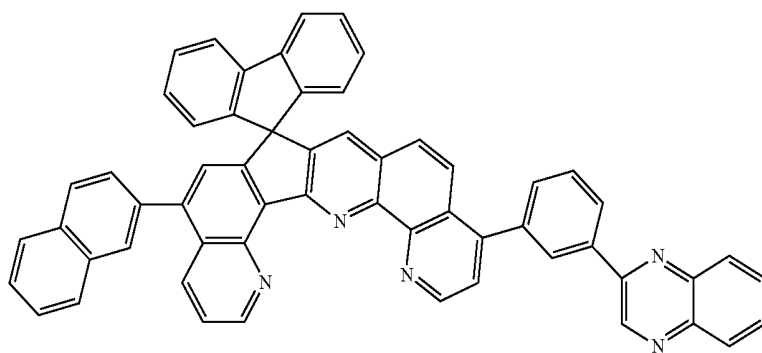
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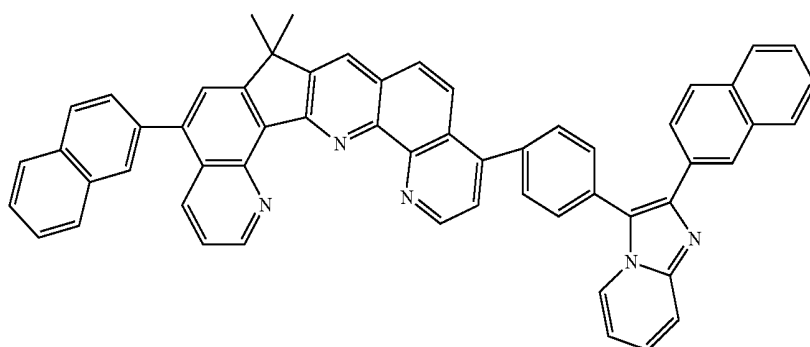
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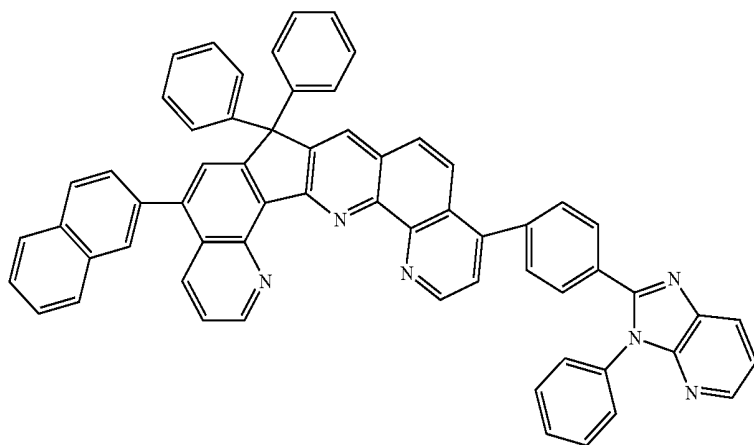


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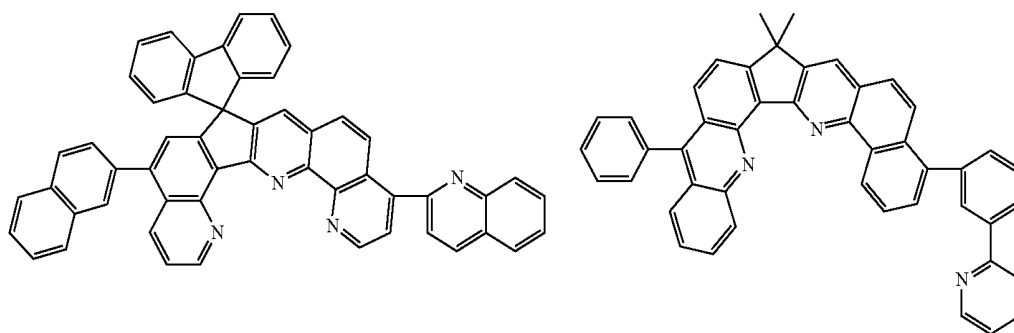
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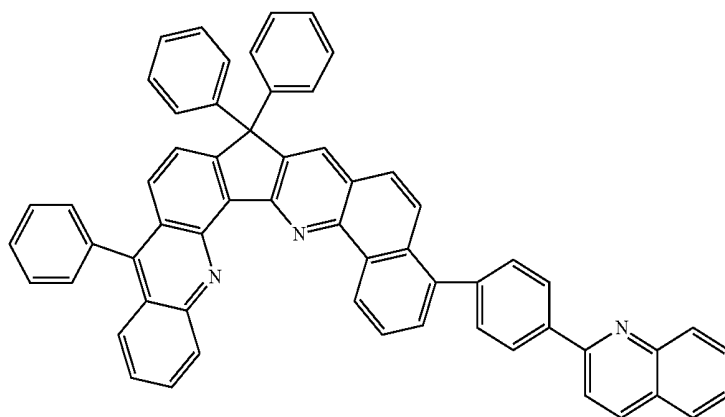


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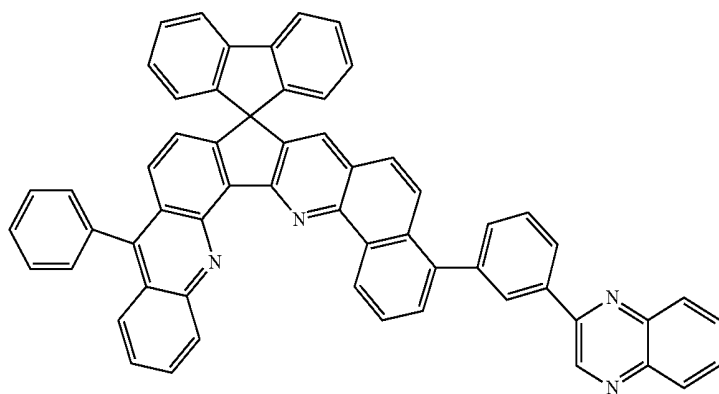
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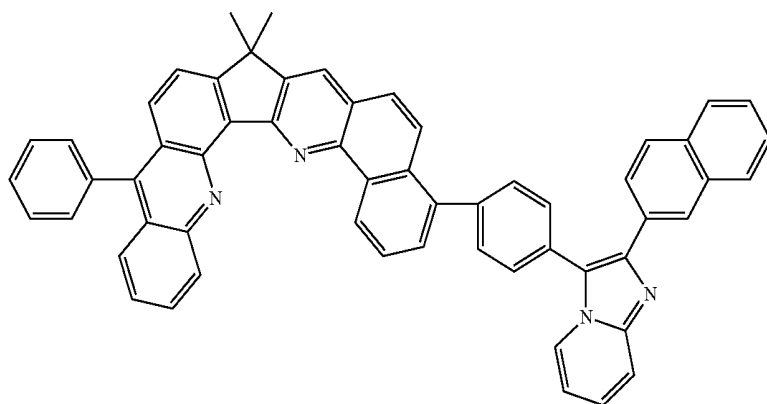


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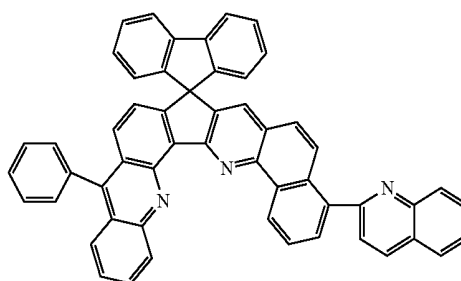
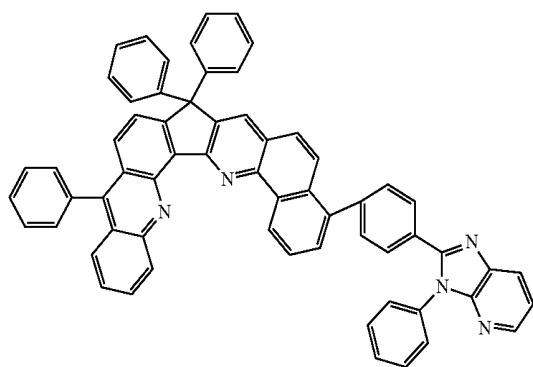
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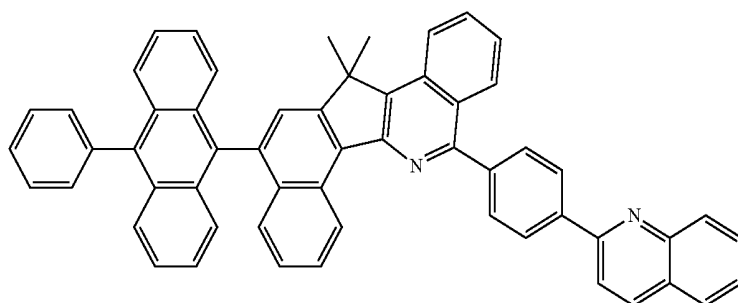


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[0081] The condensed cyclic compound of Formula 1 may be synthesized using a general organic synthesis method. Methods of synthesizing the condensed cyclic compound of Formula 1 may be understood by based on the examples that will be described below.

[0082] At least one of the condensed cyclic compounds of Formula 1 may be used between a pair of electrodes of an organic light-emitting device. For example, the at least one of the condensed cyclic compounds of Formula 1 may be in an electron transport region, for example, in an electron transport layer.

[0083] According to another embodiment, an organic light-emitting device includes a first electrode, a second electrode disposed opposite to the first electrode, and an organic layer disposed between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes at least one of the condensed cyclic compounds of Formula 1 described above.

[0084] As used herein, “[the organic layer (for example)] including at least one condensed cyclic compound means “[the organic layer] including one of the condensed cyclic compounds of Formula 1, or at least two different condensed cyclic compounds of Formula 1.”

[0085] In some embodiments, the organic layer may include only Compound 1 as the condensed cyclic compound. In this regard, Compound 1 may be present in the emission layer of the organic light-emitting device. In some embodiments, the organic layer may include Compounds 1 and 2 as the condensed cyclic compounds. In this regard, Compounds 1 and 2 may be present both in the same layer (for example, in the electron transport layer) or may be present in different layers (for example, in the emission layer and the electron transport layer, respectively).

[0086] The organic layer may include i) a hole transport region disposed between the first electrode (anode) and the emission layer and including at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer; and ii) an electron transport region disposed between the emission layer and the second electrode (cathode) and including at least one of a hole blocking layer, an electron transport layer, and an electron injection layer. The electron transport region may include at least one of the condensed cyclic compounds of Formula 1. For example, the electron transport region may include the electron transport layer, wherein the electron transport layer may include the at least one of the condensed cyclic compounds of Formula 1.

[0087] As used herein, the term “organic layer” refers to a single layer and/or a plurality of layers disposed between the first and second electrodes of the organic light-emitting device. A material in the “organic layer” is not limited to an organic material.

[0088] Hereinafter, a structure of an organic light-emitting device according to an embodiment and a method of manufacturing the same will now be described with reference to FIG. 1.

[0089] FIG. 1 is a schematic sectional view of an organic light-emitting device 10 according to an embodiment. Referring to FIG. 1, the organic light-emitting device 10 includes a first electrode 110, an organic layer 150, and a second electrode 190.

[0090] A substrate (not shown) may be disposed under the first electrode 110 or on the second electrode 190 in FIG. 1. The substrate may be a glass or transparent plastic substrate with good mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0091] For example, the first electrode 110 may be formed by depositing or sputtering a first electrode-forming material on the substrate 11. When the first electrode 110 is an anode, a material having a high work function may be used as the first electrode-forming material to facilitate hole injection. The first electrode 110 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. Transparent and conductive materials such as ITO, IZO, SnO_2 , and ZnO may be used to form the first electrode. The first electrode 110 as a semi-transmissive electrode or a reflective electrode may be formed of at least one material selected from magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag).

[0092] The first electrode 110 may have a single-layer structure or a multi-layer structure including a plurality of layers. For example, the first electrode 110 may have a three-layered structure of ITO/Ag/ITO, but is not limited thereto.

[0093] The organic layer 150 may be disposed on the first electrode 110. The organic layer 150 may include an emission layer (EML).

[0094] The organic layer 150 may include a hole transport region disposed between the first electrode and the EML, and an electron transport region between the EML and the second electrode.

[0095] For example, the hole transport region may include at least one of a hole injection layer (HIL), a hole transport layer (HTL), a buffer layer, and an electron blocking layer (EBL). For example, the electron transport layer may include at least one of a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL). However, embodiments are not limited thereto.

[0096] The hole transport region may have a single-layered structure including a single material, a single-layered structure including a plurality of materials, or a multi-layered structure including a plurality of layers including different materials.

[0097] In some embodiments, the electron transport region may have a single-layered structure including a plurality of materials, or a multi-layered structure of HIL/HTL, HIL/HTL/buffer layer, HIL/buffer layer, HTL/buffer layer, or HIL/HTL/EBL, wherein these layers forming a multi-layered structure are sequentially disposed on the first electrode 110 in the order stated above. However, embodiments are not limited thereto.

[0098] When the hole transport region includes a HIL, the HIL may be formed on the first electrode 110 by using any of

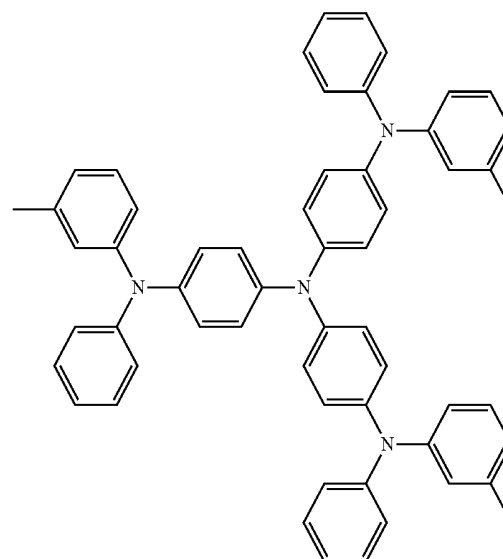
a variety of methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like.

[0099] When the HIL is formed using vacuum deposition, the deposition conditions may vary depending on the material that is used to form the HIL and the structure of the HIL. For example, the deposition conditions may be selected from the following conditions: a deposition temperature of about 100°C . to about 500°C ., a degree of vacuum of about 10^{-8} to about 10^{-3} torr, and a deposition rate of about 0.01 to about 100 Å/sec.

[0100] When the HIL is formed using spin coating, the coating conditions may vary depending on the material that is used to form the HIL and the structure of the HIL. For example, the coating conditions may be selected from the following conditions: a coating rate of about 2,000 rpm to about 5,000 rpm and a heat treatment temperature of about 800°C . to about 200°C .

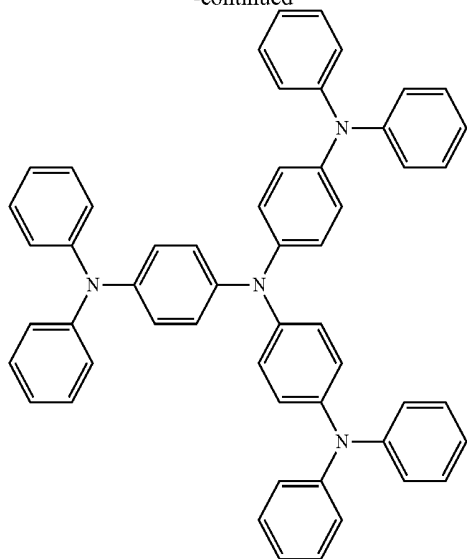
[0101] When the hole transport region includes a HTL, the HTL may be formed on the first electrode 110 or the HIL by using any of a variety of methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the HTL is formed using vacuum deposition or spin coating, the conditions for deposition and coating may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in detail.

[0102] In some embodiments, the hole transport region may include at least one of m-MTDATA, TDATA, 2-TNATA, NPB, (3-NPB, TPD, Spiro-TPD, Spiro-NPB, α -NPB, TAPC, HMTDP, 4,4',4''-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, and a compound represented by Formula 202 below.



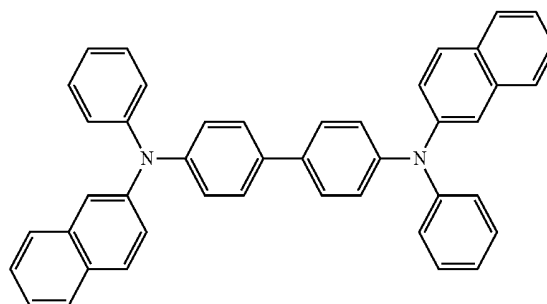
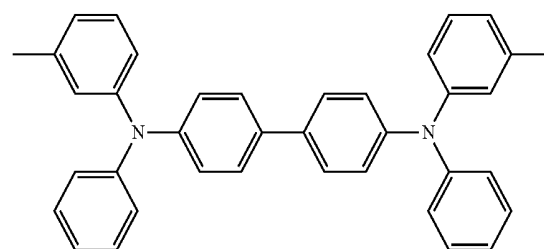
m-MTDATA

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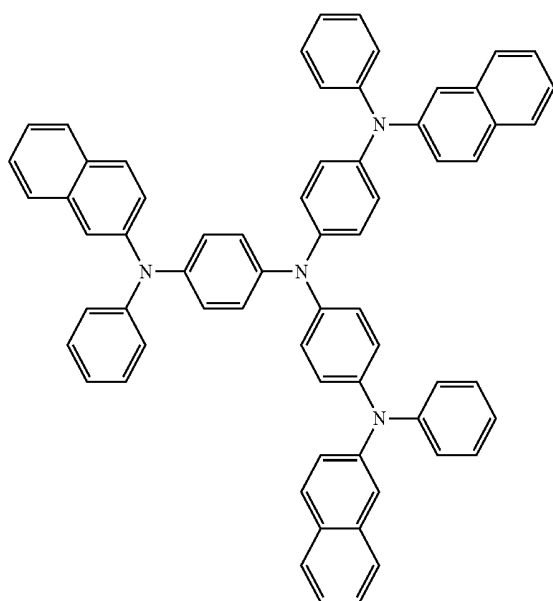


TDATA

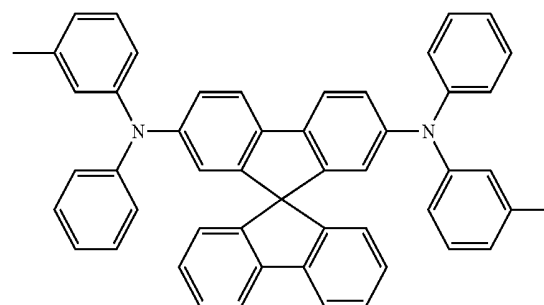
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 β -NPB

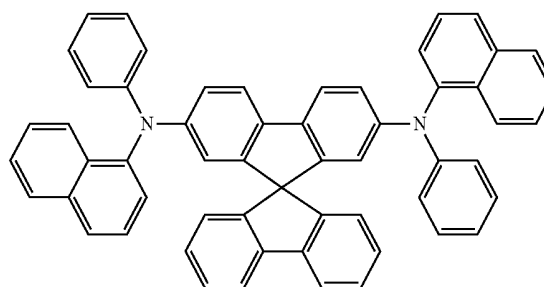
TPD



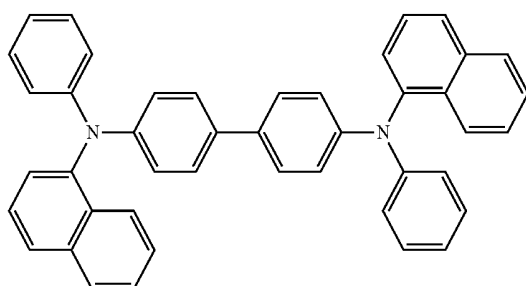
2-TNATA



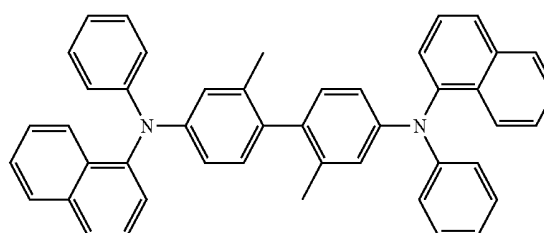
Spiro-TPD



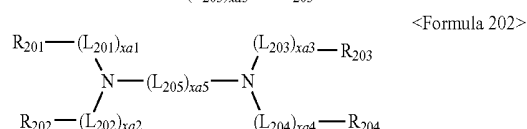
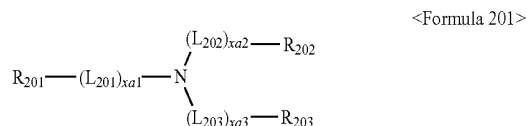
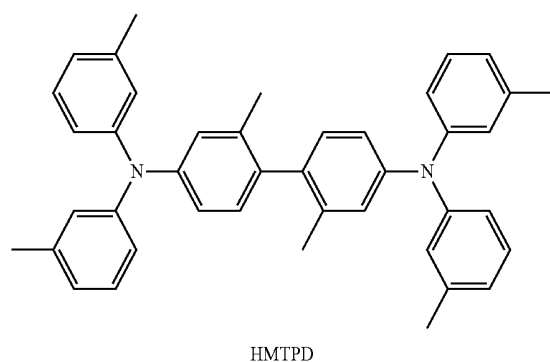
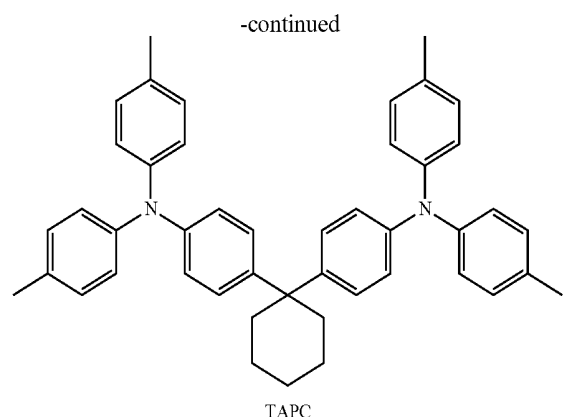
Spiro-NPB



NPB



methylated NPB



[0103] In Formulae 201 and 202,

[0104] L_{201} to L_{205} may each independently be defined as described above in conjunction with

[0105] L_1 in Formula 1;

[0106] $\text{xa}1$ to $\text{xa}4$ are each independently selected from 0, 1, 2, and 3;

[0107] $\text{xa}5$ may be selected from 1, 2, 3, 4, and 5;

[0108] R_{201} to R_{204} 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.

[0109] For example, in Formulae 201 and 202,

[0110] L_{201} to L_{205} may each independently be selected from

[0111] a phenylene group, a naphthylene group, a fluorenylene group, a Spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthraceny-

lene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthraceny-
lene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyraziny-
lene group, a pyrimidinylene group, a pyridazinylene group, a quinoliny-
lene group, an isoquinolinylene group, a quinoxaliny-
lene group, a quinazolinylene group, a carbazoly-
lene group, and a triazinylene; and

[0112] a phenylene group, a naphthylene group, a fluorenylene group, a Spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthraceny-
lene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyraziny-
lene group, a pyrimidinylene group, a pyridazinylene group, a quinoliny-
lene group, an isoquinolinylene group, a quinoxaliny-
lene group, a quinazolinylene group, a carbazoly-
lene group, and a triazinylene group, each substituted with at least one selected from a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a Spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny-
lene group, a carbazoly-
lene group, and a triazinyl group,

[0113] $\text{xa}1$ to $\text{xa}4$ may each independently be 0, 1, or 2;

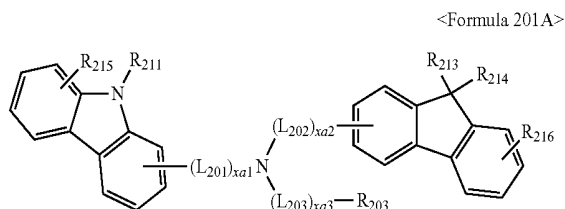
[0114] $\text{xa}5$ may be 1, 2, or 3;

[0115] R_{201} to R_{204} may each independently be selected from

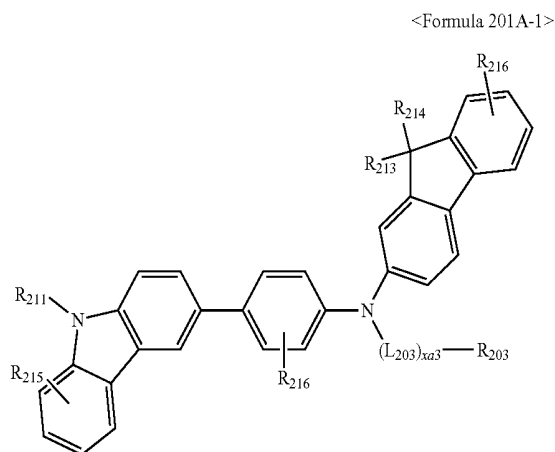
[0116] a phenyl group, a naphthyl group, a fluorenyl group, a Spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny-
lene group, a carbazoly-
lene group, and a triazi-
nyl group; and

[0117] a phenyl group, a naphthyl group, a fluorenyl group, a Spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny-
lene group, a carbazoly-
lene group, and a triazi-
nyl group, each substituted with at least one of a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, an azulenyl group, a fluorenyl group, a Spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny-
lene group, a carbazoly-
lene group, and a triazinyl group. However, embodiments are not limited thereto.

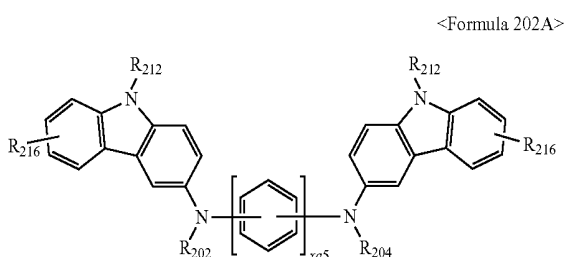
[0118] The compound of Formula 201 may be represented by Formula 201A:



[0119] For example, the compound of Formula 201 may be represented by Formula 201A-1, but is not limited thereto:



[0120] The compound of Formula 202 may be represented by Formula 202A, but is not limited thereto:



[0121] In Formulae 201A, 201A-1, and 202A,

[0122] L_{201} to L_{203} , $xa1$ to $xa3$, $xa5$, and R_{202} to R_{204} may be defined as described in conjunction with Formula 201;

[0123] R_{211} and R_{212} may be defined as described in conjunction with R_{203} in Formula 201;

[0124] R_{213} to R_{216} may each independently be selected from a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a

C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic hetero-condensed polycyclic group.

[0125] In some other embodiments, in Formulae 201A, 201A-1, and 202A,

[0126] L_{201} to L_{203} may each independently be selected from

[0127] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolinylenylene group, and a triazinylene group; and

[0128] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolinylenylene group, and a triazinylene group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny group, a carbazolyl group, and a triazinyl group,

[0129] $xa1$ to $xa3$ may each independently be 0 or 1,

[0130] R_{202} to R_{204} , R_{211} , and R_{212} may each independently be selected from

[0131] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny group, a carbazolyl group, and a triazinyl group; and

[0132] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazoliny group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a

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

[0133] R_{213} and R_{214} may each independently be selected from

[0134] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group;

[0135] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

[0136] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0137] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

[0138] R_{215} and R_{216} may each independently be selected from

[0139] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

[0140] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group

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

[0141] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, and a triazinyl group; and

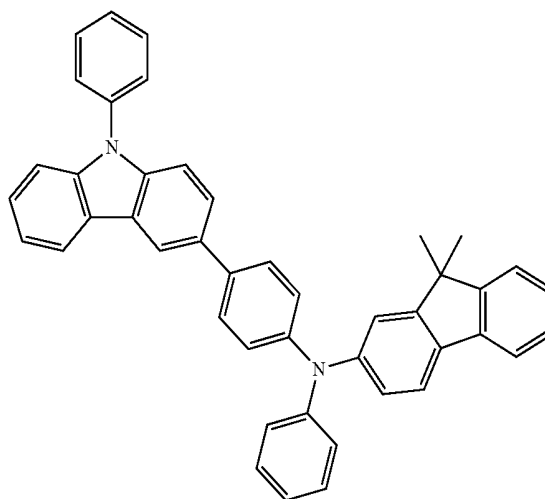
[0142] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

[0143] x_5 may be 1 or 2.

[0144] In Formulae 201A and 201A-1, R_{213} and R_{214} may be linked to each other to form a saturated or unsaturated ring.

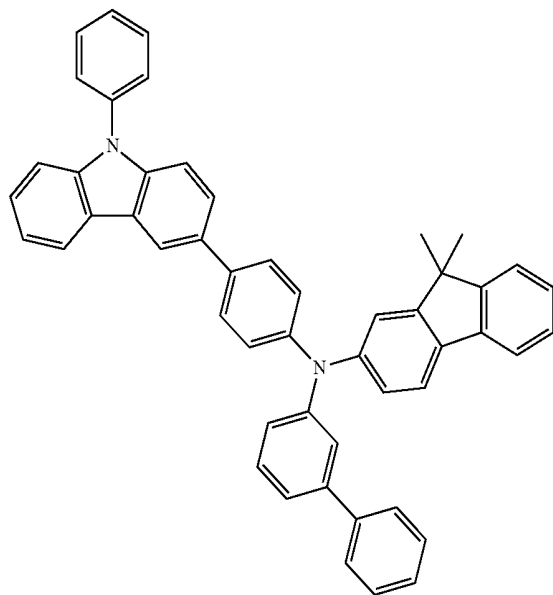
[0145] The compound represented by Formula 201, and the compound represented by Formula 202 may be compounds HT1 to HT20 illustrated below, but are not limited thereto.

HT1



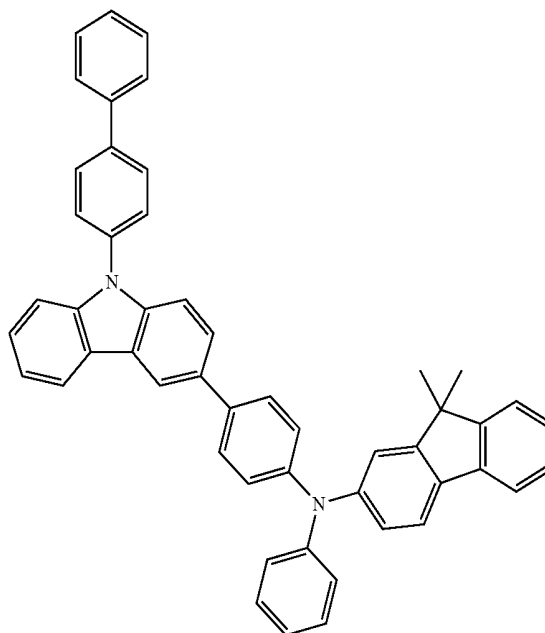
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HT2

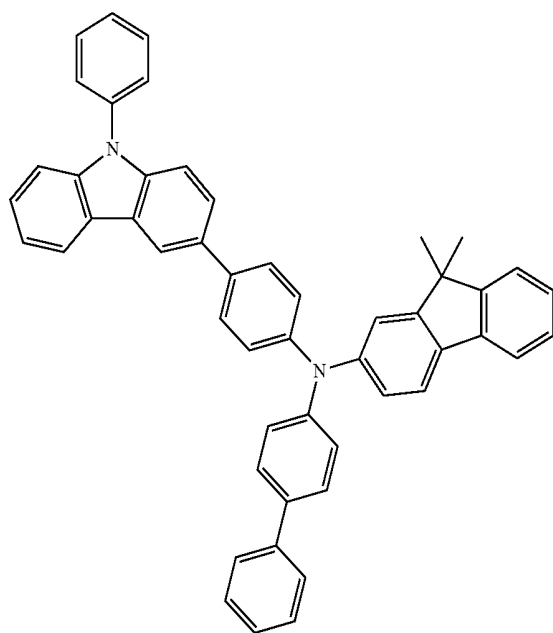


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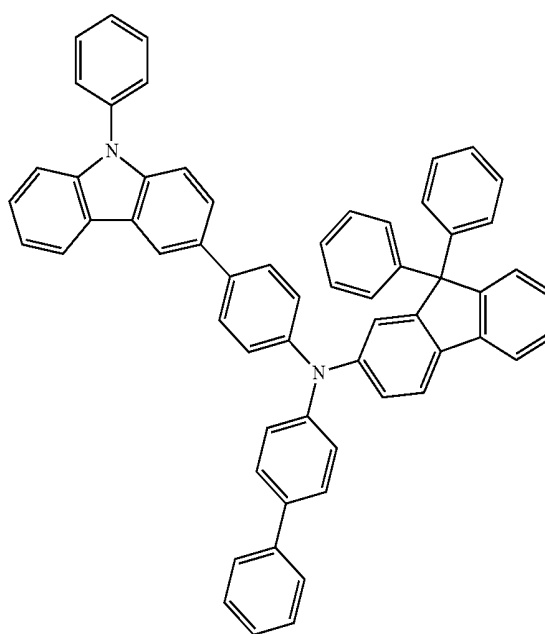
HT4



HT3

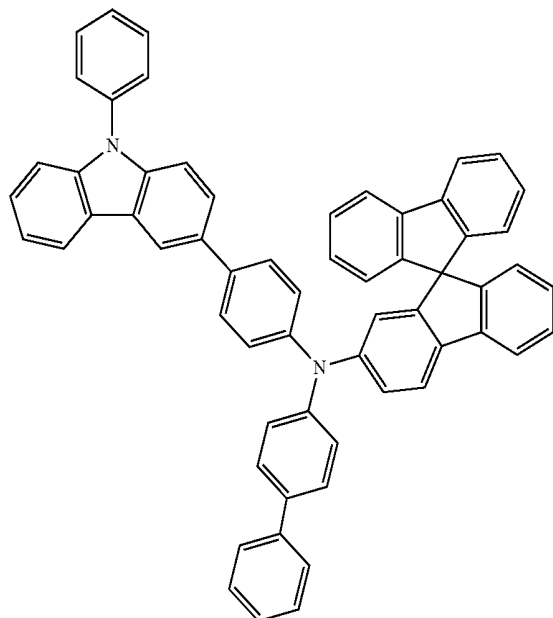


HT5



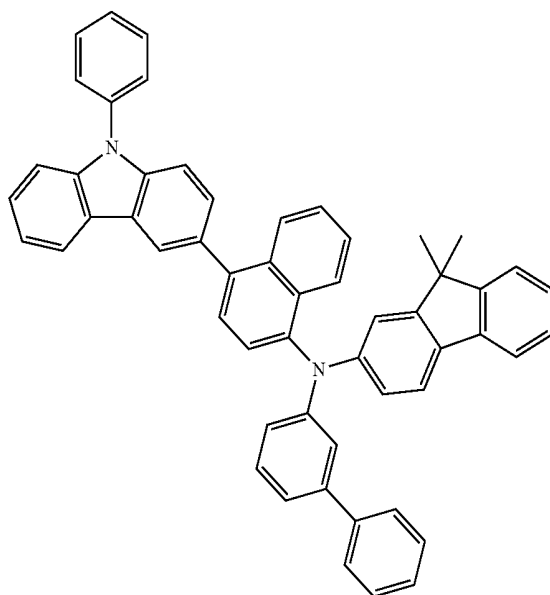
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HT6

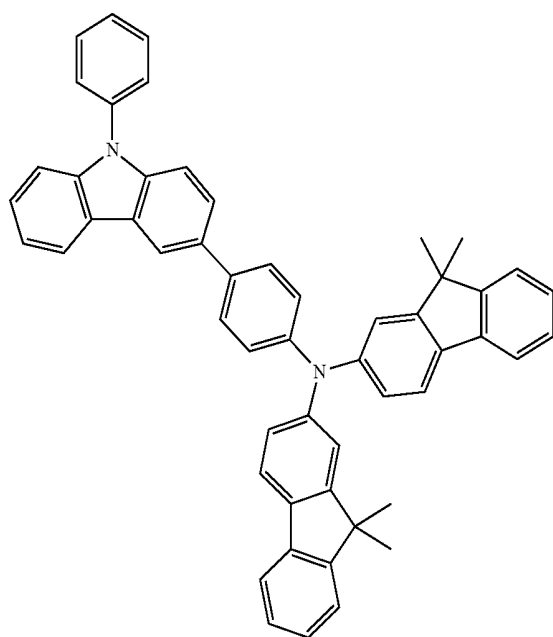


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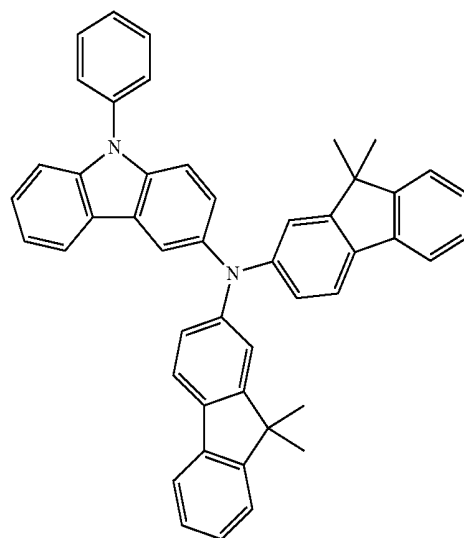
HT8



HT7

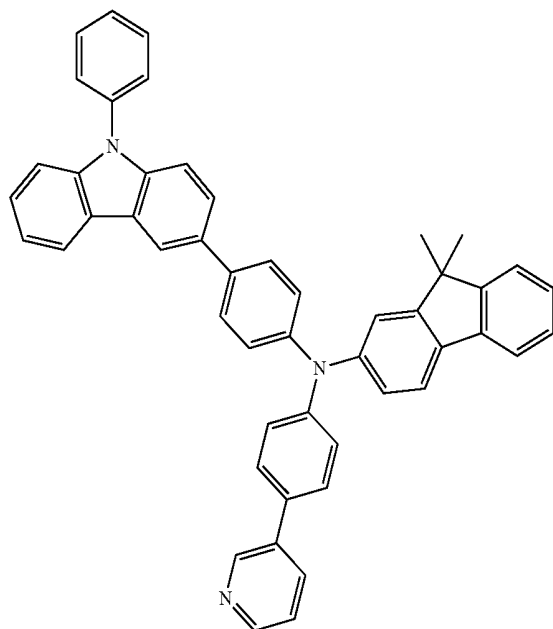


HT9



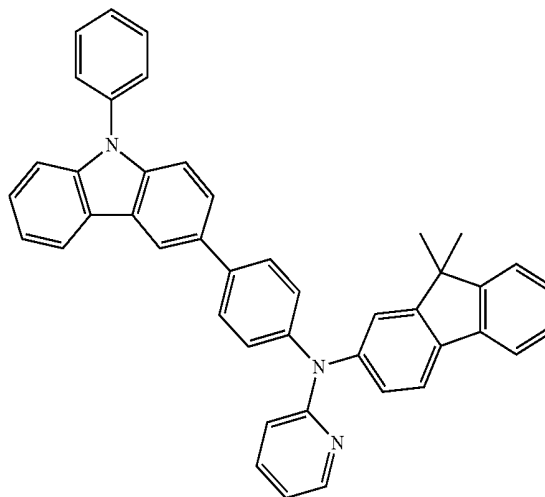
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HT10

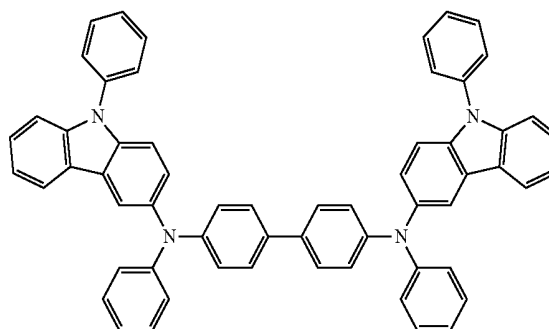


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HT12

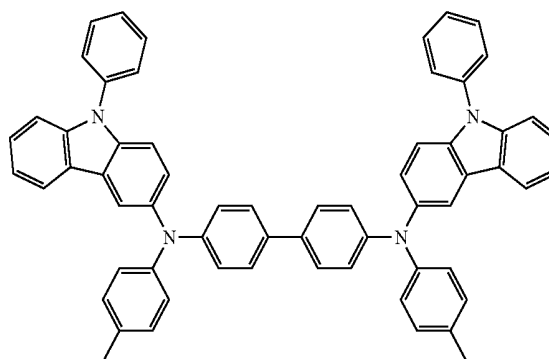
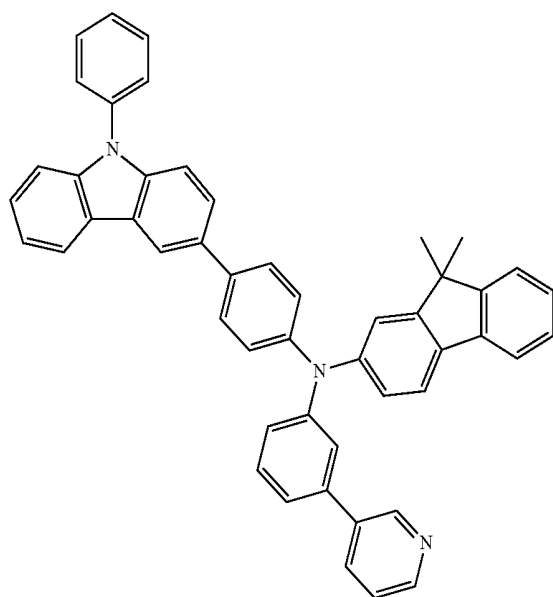


HT13

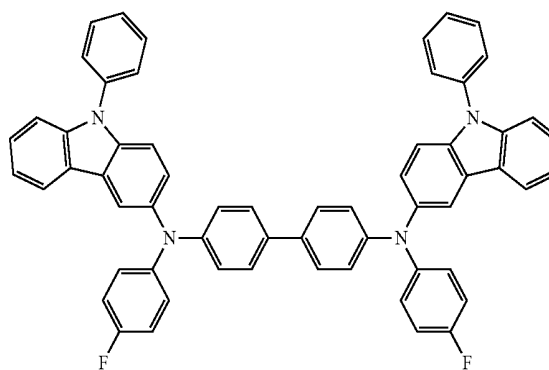


HT14

HT11

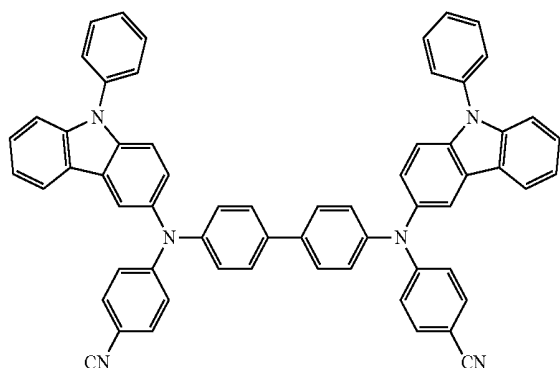


HT15



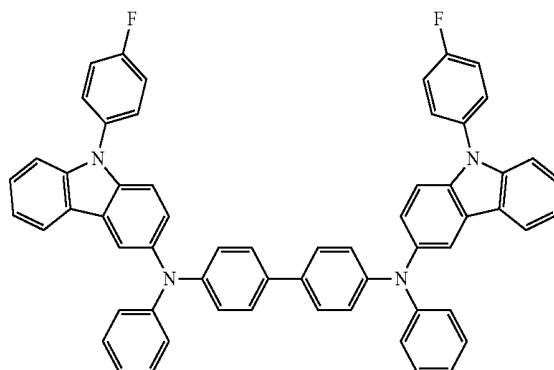
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HT16

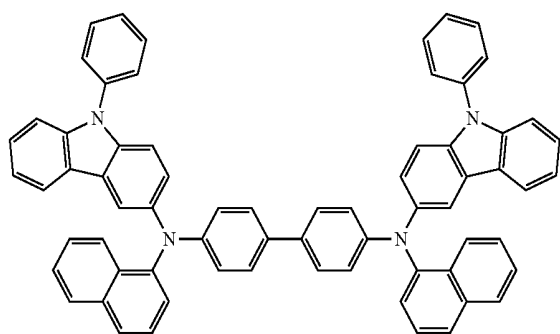


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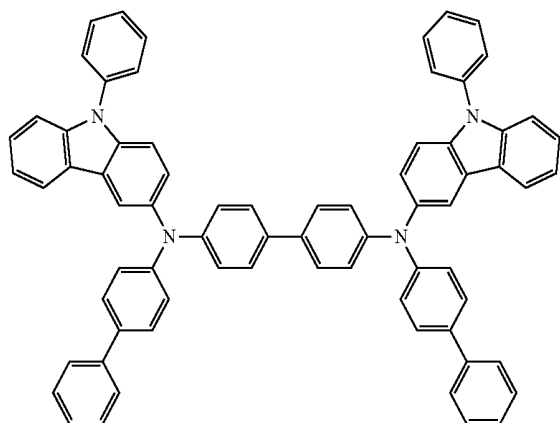
HT20



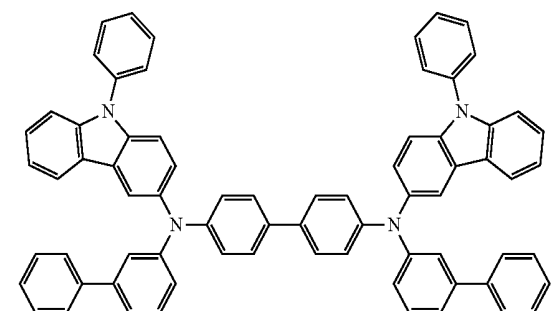
HT17



HT18



HT19

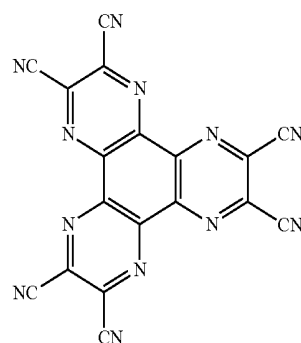


[0146] The thickness of the hole transport region may be from about 100 Å to about 10000 Å, and in some embodiments, from about 100 Å to about 1000 Å. When the hole transport region includes a HIL and a HTL, a thickness of the HIL may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 1,000 Å, and a thickness of the HTL may be from about 50 Å to about 2,000 Å, and in some embodiments, from about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the HIL, and the HTL are within these ranges, satisfactory hole transport characteristics may be obtained without a substantial increase in driving voltage.

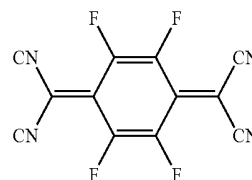
[0147] The hole transport region may further include a charge-generating material to improve conductivity, in addition to the materials as described above. The charge-generating material may be homogeneously or inhomogeneously dispersed in the hole transport region.

[0148] The charge-generating material may be, for example, a p-dopant. The p-dopant may be one of quinine derivatives, metal oxides, and compounds with a cyano group, but is not limited thereto. Non-limiting examples of the p-dopant are quinone derivatives such as tetracyanoquinodimethane (TCNQ), 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinodimethane (F4-TCNQ), and the like; metal oxides such as tungsten oxide, molybdenum oxide, and the like; and Compound HT-D1.

<Compound HT-D1>



<F4-TCNQ>



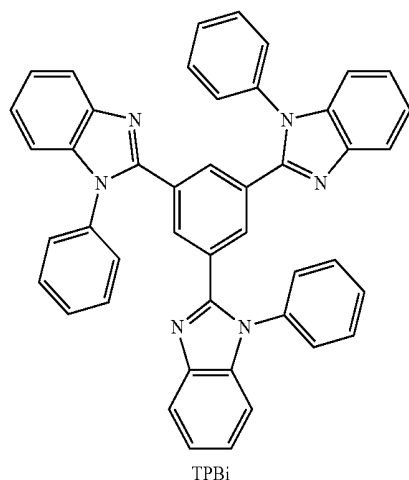
[0149] The hole transport region may further include at least one of a buffer layer and an EBL, in addition to the HIL and HTL described above. The buffer layer may compensate for an optical resonance distance of light according to a wavelength of the light emitted from the EML, and thus may improve light-emission efficiency. A material in the buffer layer may be any material used in the hole transport region. The EBL may block migration of electrons from the electron transport region into the EML.

[0150] The EML may be formed on the first electrode 110 or the hole transport region by using any of a variety of methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the EML is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the EML may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in detail.

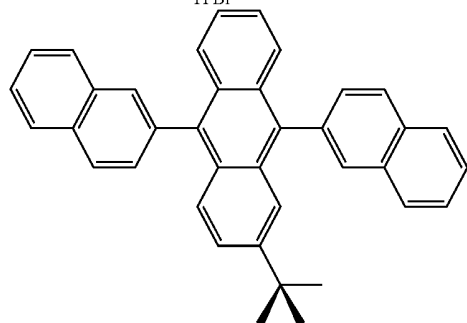
[0151] When the organic light-emitting device 10 is a full color organic light-emitting device, the EML may be patterned into a red emission layer, a green emission layer, and a blue emission layer to correspond to individual subpixels, respectively. In some embodiments, the EML may have a structure in which a red emission layer, a green emission layer and a blue emission layer are stacked upon one another, or a structure including a mixture of a red light-emitting material, a green light-emitting material, and a blue light-emitting material, and thus may emit white light.

[0152] The EML may include a host and a dopant.

[0153] The host may include at least one of TPBi, TBADN, AND (also referred to as "DNA"), CBP, CDBP, and TCP.

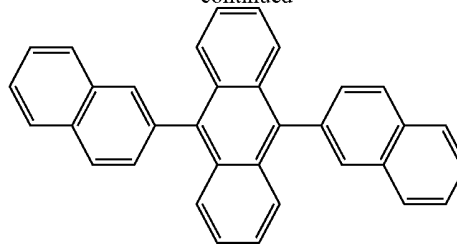


TPBi

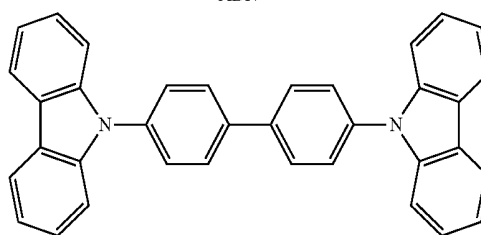


TBADN

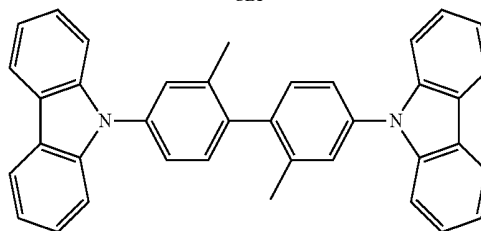
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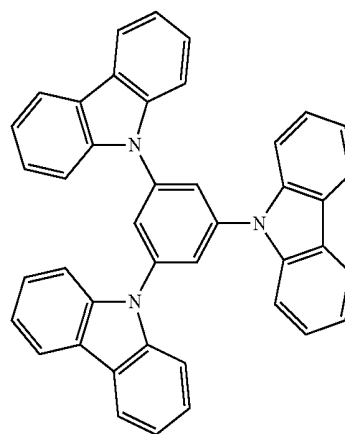
ADN



CBP

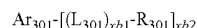


CDBP



TCP

[0154] For example, the host may include a compounds represented by Formula 301.



<Formula 301>

[0155] In Formula 301,

[0156] Ar_{301} may be selected from

[0157] a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene; and

[0158] a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with

at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q₃₀₁)(Q₃₀₂)(Q₃₀₃), wherein Q₃₀₁ to Q₃₀₃ may each independently be selected from a hydrogen, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₆-C₆₀ aryl group, and a C₁-C₆₀ heteroaryl group;

[0159] L₃₀₁ may be defined the same as L₂₀₁ described herein,

[0160] R₃₀₁ may be selected from

[0161] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group;

[0162] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

[0163] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazole group, or a triazinyl group; and

[0164] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group; and

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

[0165] xb1 may be selected from 0, 1, 2, and 3, and

[0166] xb2 may be selected from 1, 2, 3, and 4.

[0167] For example, in Formula 301,

[0168] L₃₀₁ may be selected from

[0169] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, or a chrysenylene group; and

[0170] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, and a chrysenylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group,

[0171] R₃₀₁ may be selected from

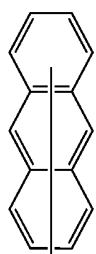
[0172] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group;

[0173] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group;

[0174] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group; and

[0175] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group. However, embodiments are not limited thereto.

[0176] For example, the host may include a compound represented by Formula 301A.



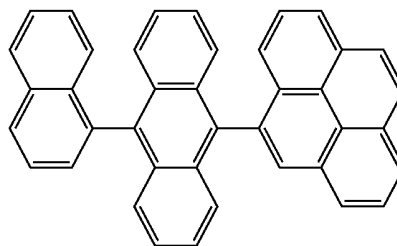
$[(L_{301})_{xb1}-R_{301}]_{kb2}$

<Formula 301A>

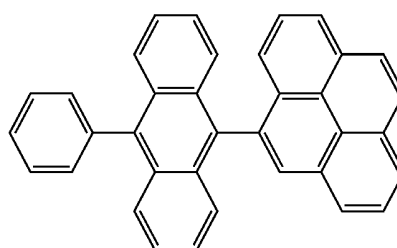
[0177] Substituents R_{301} , L_{301} , $Xb1$, and $xb2$ in Formula 301A may be defined the same as those described herein.

[0178] The compound of Formula 301 may include at least one of compounds H1 to H42, but is not limited thereto.

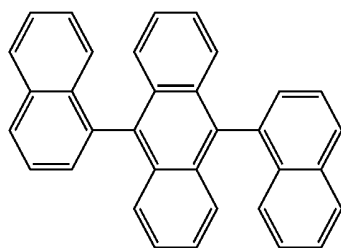
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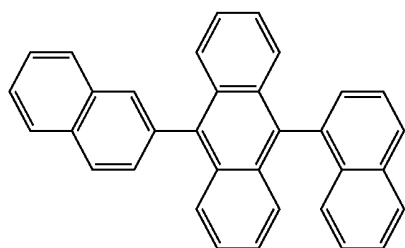
H5



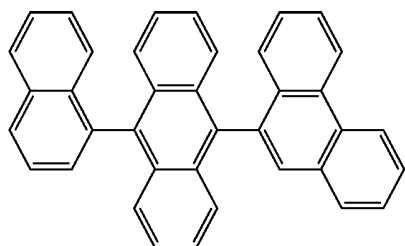
H6



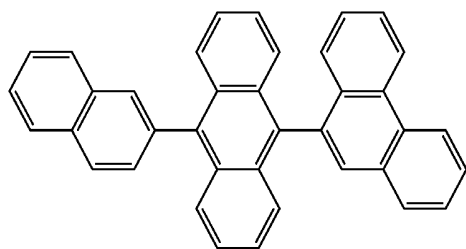
H1



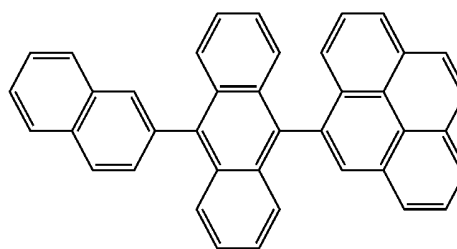
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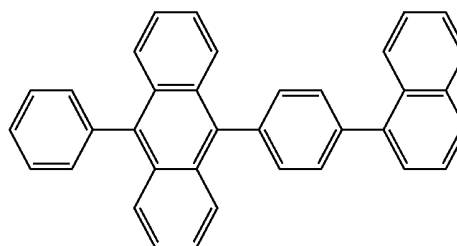
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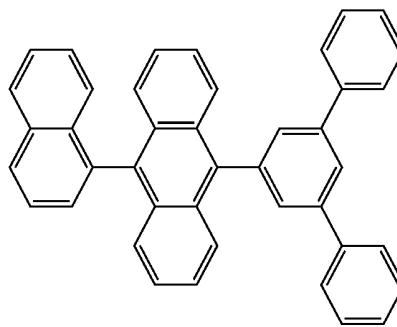
H4



H7

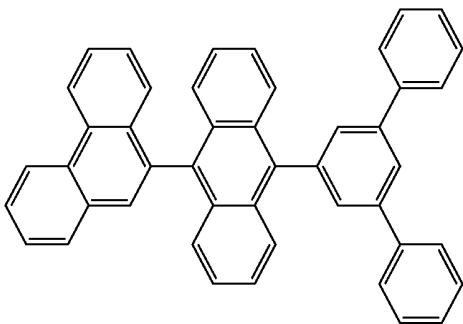


H8



H9

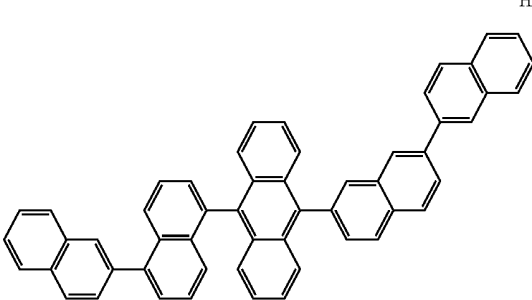
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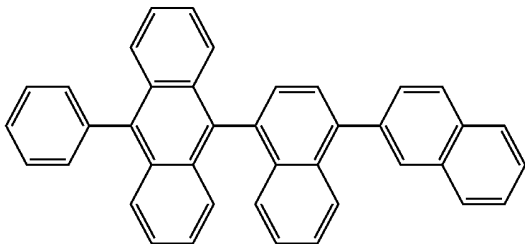
H10

H11

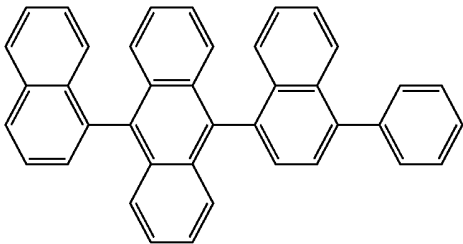
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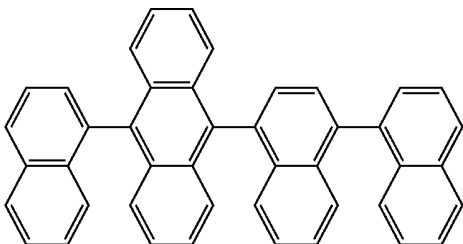
H16



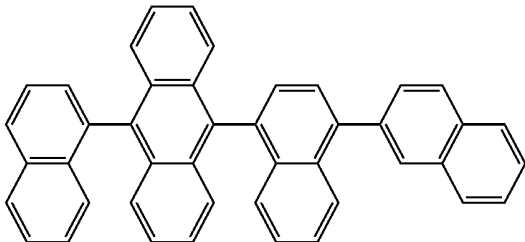
H12



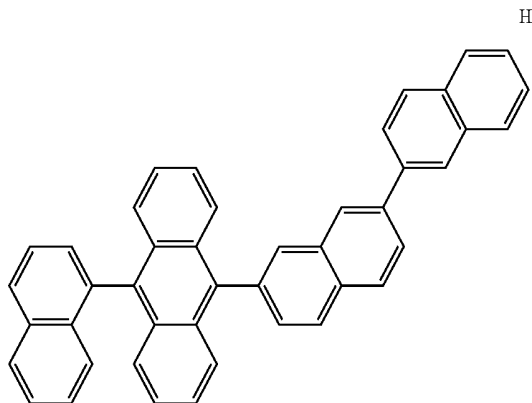
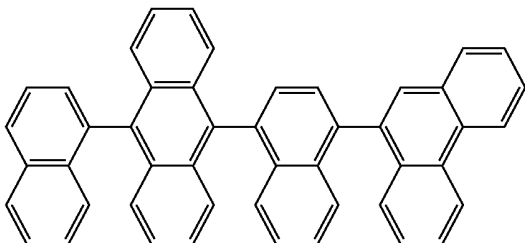
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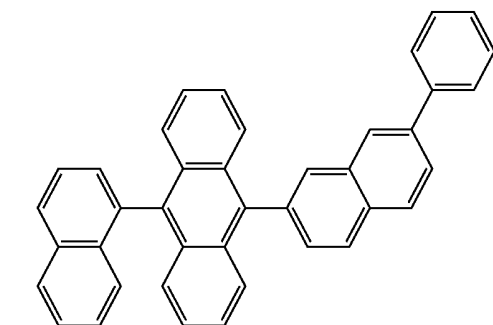
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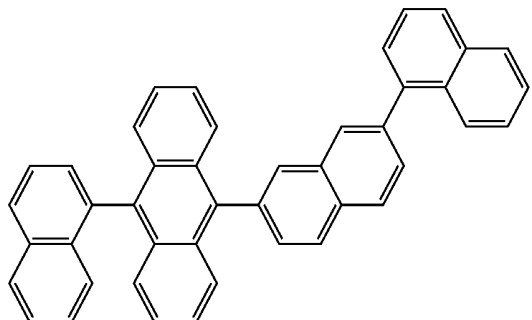
H15



H17



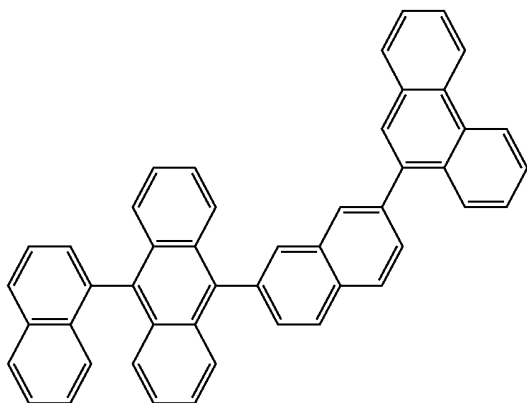
H18



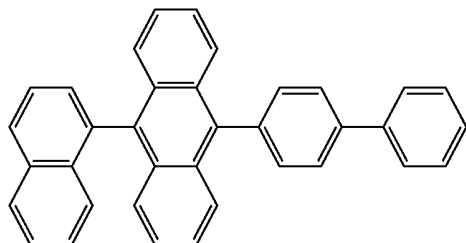
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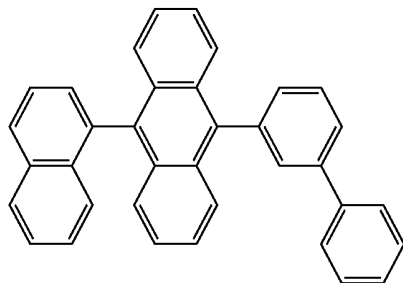
H20



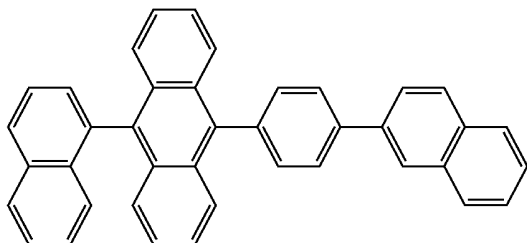
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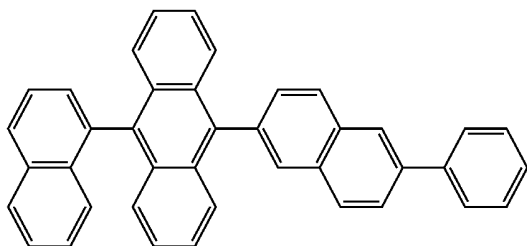
H22



H23

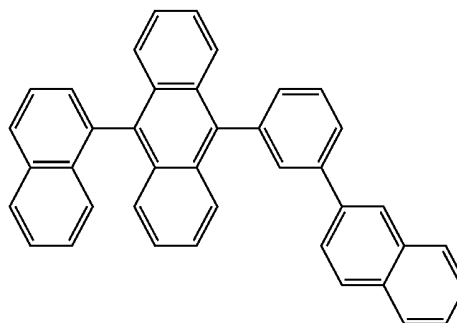


H24

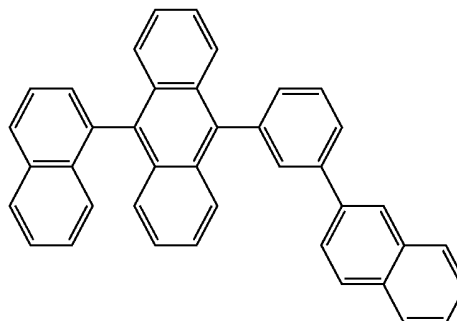


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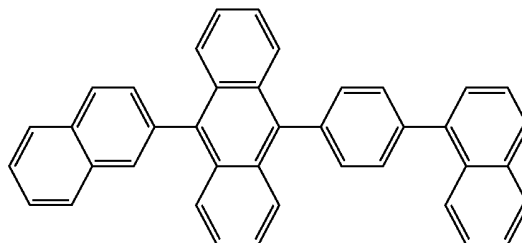
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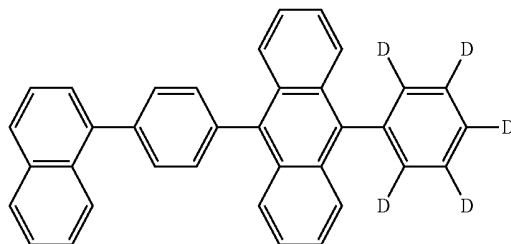
H26



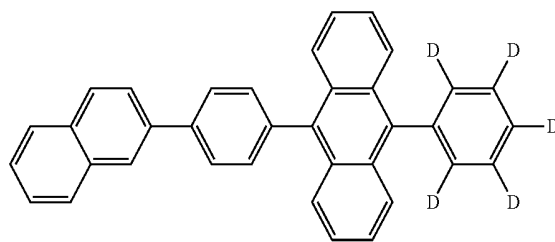
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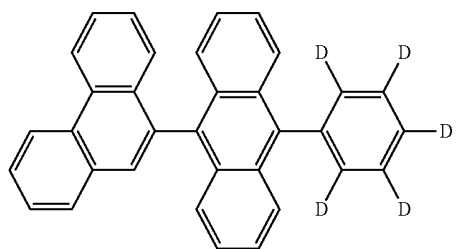
H28



H29

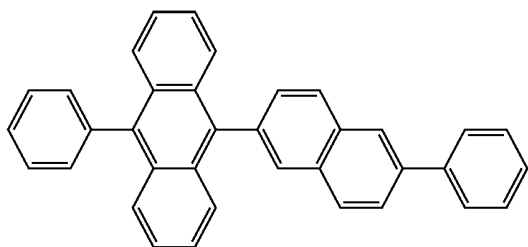


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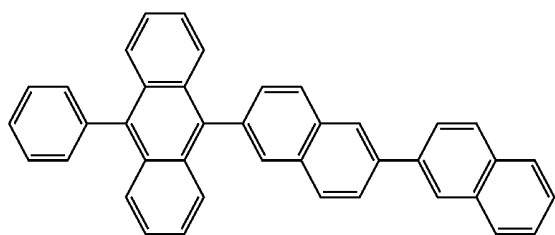


H30

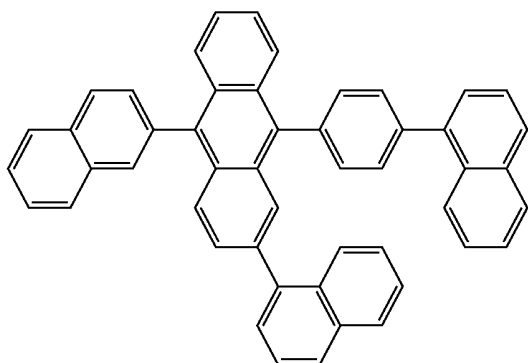
H31



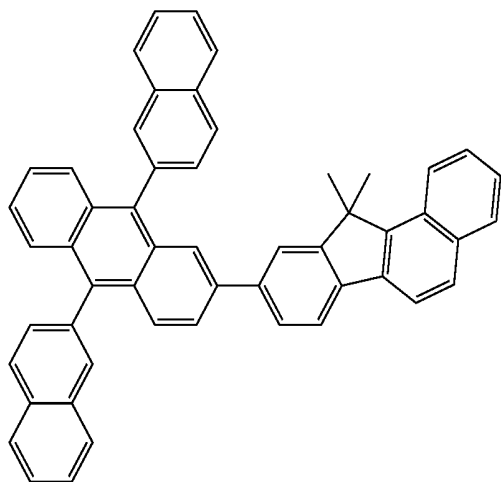
H32



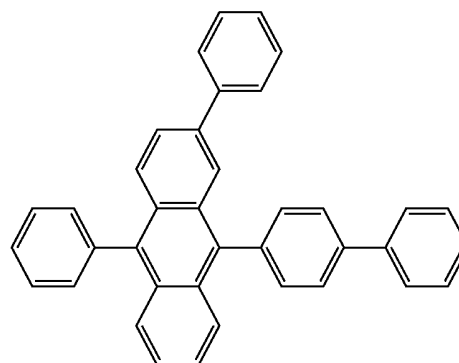
H33



H34

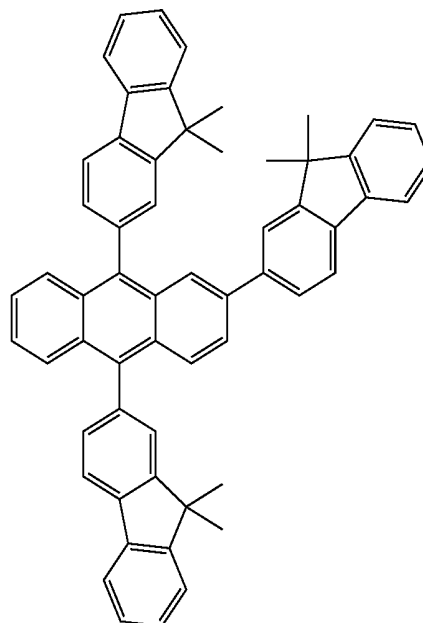


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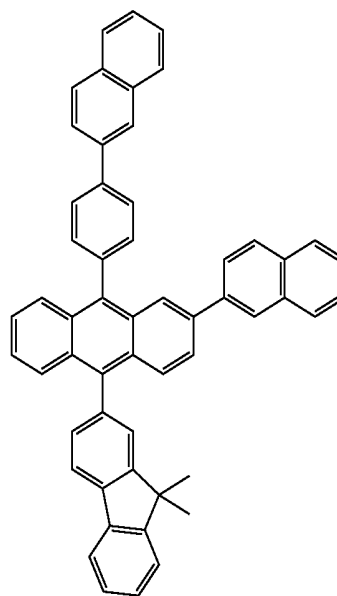


H35

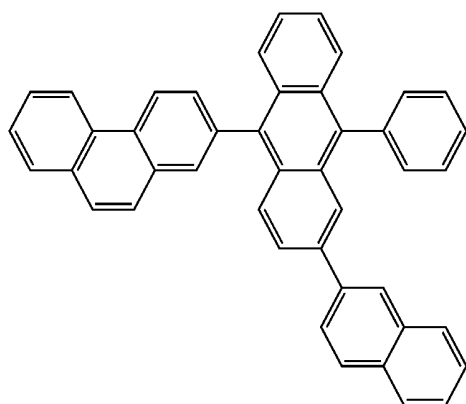
H36



H37

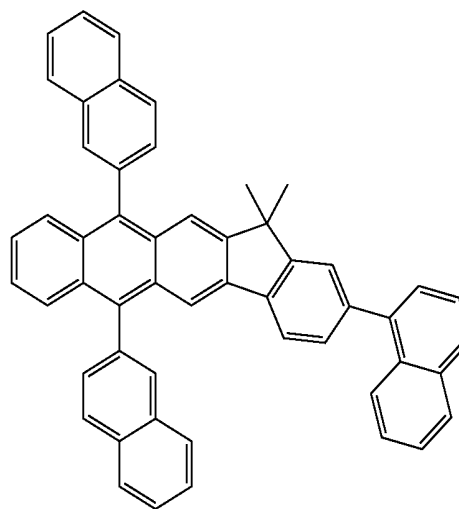


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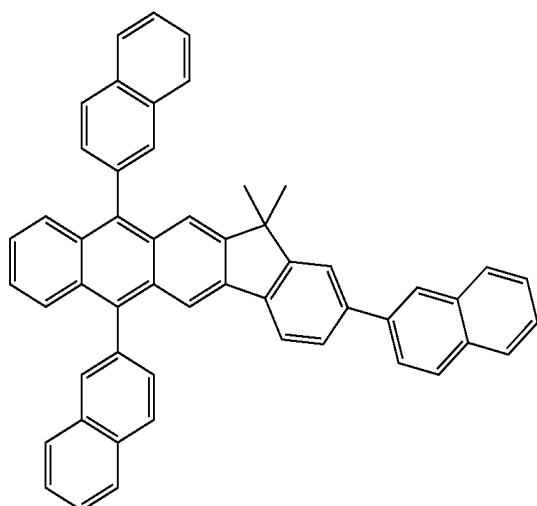
H38

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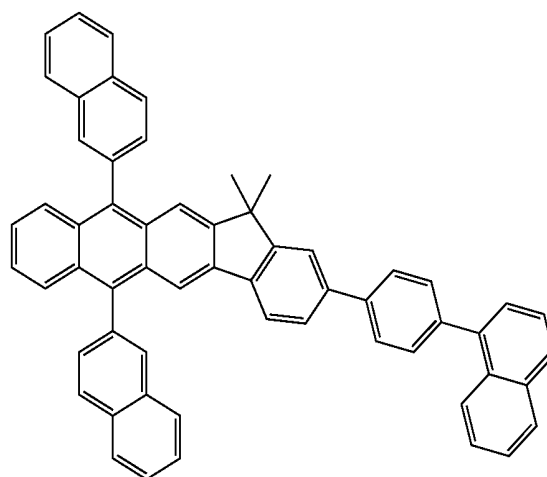


H41

H39

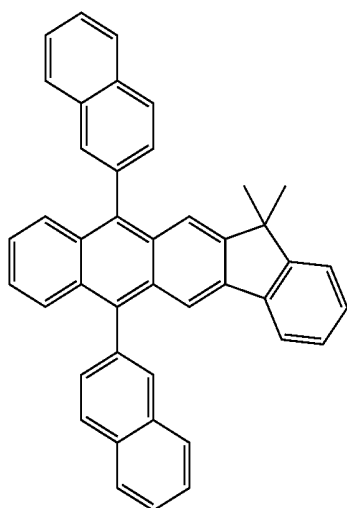


H42

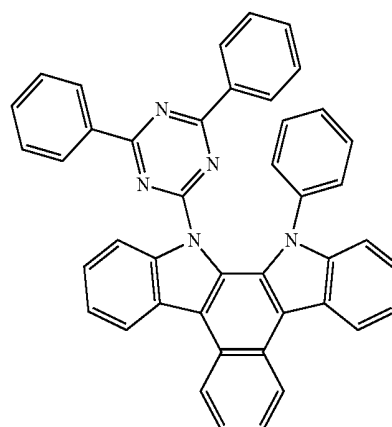


[0179] For example, the host may include at least one of compounds H43 to H49. However, embodiments are not limited thereto.

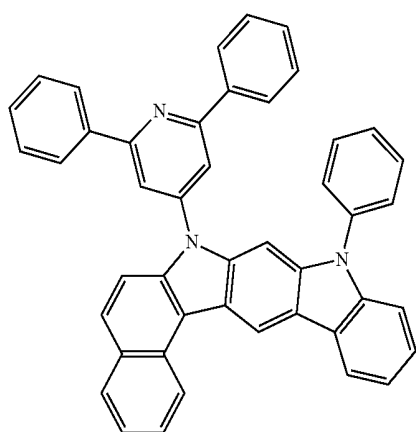
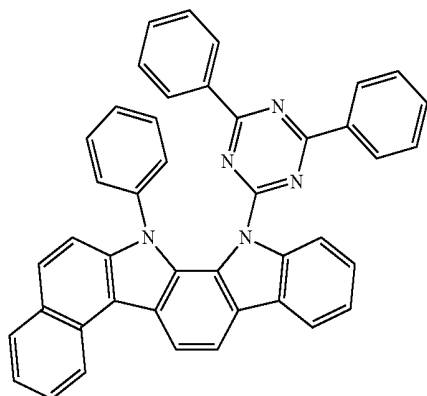
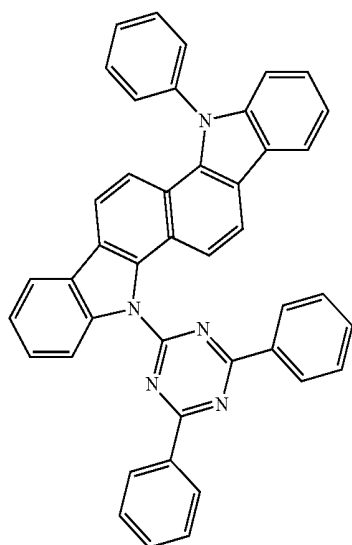
H40



H43

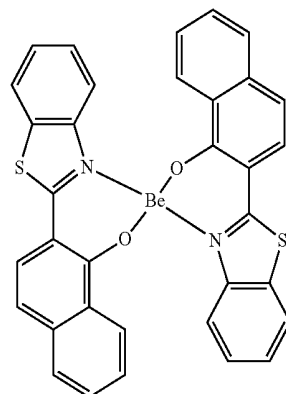
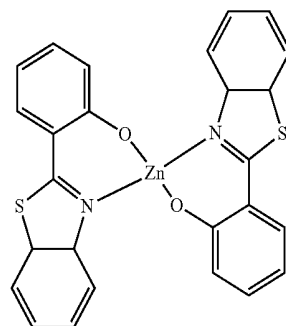
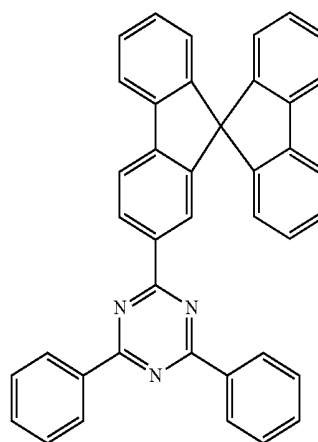


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H44

-continued



H47

H48

H45

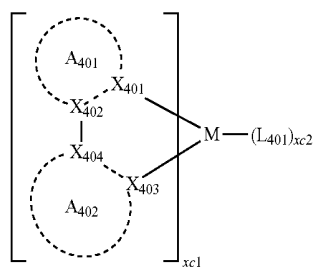
H49

[0180] The dopant may include at least one of a fluorescent dopant and a phosphorescent dopant.

[0181] The phosphorescent dopant may include an organo-metallic complex represented by Formula 401.

H46

<Formula 401>



[0182] In Formula 401,

[0183] M may iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), or thulium (Tm);

[0184] X_{401} to X_{404} may each independently be a nitrogen or a carbon;

[0185] rings A_{401} and A_{402} may each independently be selected from a substituted or unsubstituted benzene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted fluorene, a substituted or unsubstituted spiro-fluorene, a substituted or unsubstituted indene, a substituted or unsubstituted pyrrole, a substituted or unsubstituted thiophene, a substituted or unsubstituted furan, a substituted or unsubstituted imidazole, a substituted or unsubstituted pyrazole, a substituted or unsubstituted thiazole, a substituted or unsubstituted isothiazole, a substituted or unsubstituted oxazole, a substituted or unsubstituted isoxazole, a substituted or unsubstituted pyridine, a substituted or unsubstituted pyrazine, a substituted or unsubstituted pyrimidine, a substituted or unsubstituted pyridazine, a substituted or unsubstituted quinoline, a substituted or unsubstituted isoquinoline, a substituted or unsubstituted benzoquinoline, a substituted or unsubstituted quinoxaline, a substituted or unsubstituted quinazoline, a substituted or unsubstituted carbazole, a substituted or unsubstituted benzoimidazole, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted isobenzothiophene, a substituted or unsubstituted benzoxazole, a substituted or unsubstituted isobenzoxazole, a substituted or unsubstituted triazole, a substituted or unsubstituted oxadiazole, a substituted or unsubstituted triazine, a substituted or unsubstituted dibenzofuran, and a substituted or unsubstituted dibenzothiophene;

[0186] at least one of substituents of the substituted benzene, the substituted naphthalene, the substituted fluorene, the substituted spiro-fluorene, the substituted indene, the substituted pyrrole, the substituted thiophene, the substituted furan, the substituted imidazole, the substituted pyrazole, the substituted thiazole, the substituted isothiazole, the substituted oxazole, the substituted isoxazole, the substituted pyridine, the substituted pyrazine, the substituted pyrimidine, the substituted pyridazine, the substituted quinoline, the substituted isoquinoline, the substituted benzoquinoline, the substituted quinoxaline, the substituted quinazoline, the substituted carbazole, the substituted benzoimidazole, the substituted benzofuran, the substituted benzothiophene, the substituted isobenzothiophene, the substituted benzoxazole, the substituted isobenzoxazole, the substituted triazole, the substituted oxadiazole, the substituted triazine, the substituted dibenzofuran, and the substituted dibenzothiophene may be selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group;

[0187] 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 of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl

group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q_{401})(Q_{402}), —Si(Q_{403})(Q_{404})(Q_{405}), and —B(Q_{406})(Q_{407}),

[0188] 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,

[0189] 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 of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q_{411})(Q_{412}), —Si(Q_{413})(Q_{414})(Q_{415}), and —B(Q_{416})(Q_{417}), and

[0190] —N(Q_{421})(Q_{422}), —Si(Q_{423})(Q_{424})(Q_{425}), and —B(Q_{426})(Q_{427});

[0191] L_{401} may be an organic ligand;

[0192] $xc1$ may be 1, 2, or 3;

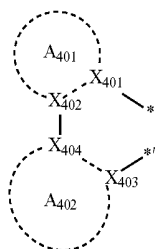
[0193] $xc2$ may be 0, 1, 2, or 3.

[0194] The Q_{401} to Q_{407} , Q_{411} to Q_{417} and Q_{421} to Q_{427} may each independently be selected from a hydrogen, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_6 - C_{60} aryl group, and a C_1 - C_{60} heteroaryl group.

[0195] For example, in Formula 401, L_{401} may be a monovalent, divalent, or trivalent organic ligand. For example, L_{401} in Formula 401 may be selected from a halogen ligand (for example, Cl or F), a diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propanedionate, 2,2,6,6-tetramethyl-3,5-heptanedionate, or hexafluoroacetonate), a carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazolecarboxylate, or benzoate), a carbon monoxide ligand, an isonitrile ligand, a cyano ligand, and a phosphorous ligand (for example, phosphine or phosphite). However, embodiments are not limited thereto.

[0196] When A_{401} in Formula 401 has at least two substituent groups, the at least two substituent groups of A_{401} may be linked to each other to form a saturated or unsaturated ring.

[0197] When A_{402} in Formula 401 has at least two substituent groups, the at least two substituent groups of A_{402} may be linked to each other to form a saturated or unsaturated ring.



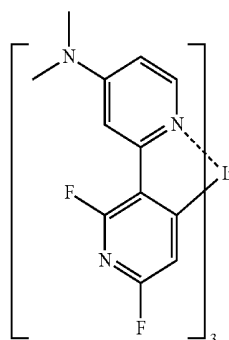
[0198] When xc1 in Formula 401 is 2 or greater, a plurality of ligands

in Formula 401 may be identical to or different from each other. When xc1 in Formula 1 is 2 or greater, A₄₀₁ and A₄₀₂ may be linked to A₄₀₁ and A₄₀₂ of another adjacent ligand, respectively, directly or via a linking group (for example, a C₁-C₅ alkylene group, —N(R')— (where R' is a C₁-C₁₀ alkyl group or a C₆-C₂₀ aryl group), or C(=O)—).

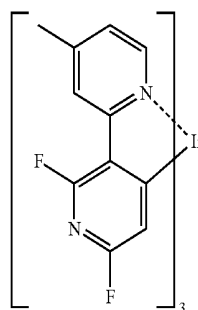
[0199] The phosphorescent dopant may include at least one of Compounds PD1 to PD74, but is not limited thereto.

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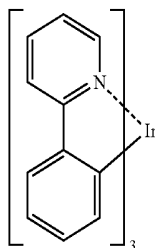
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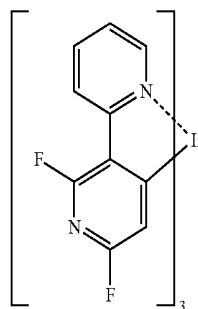
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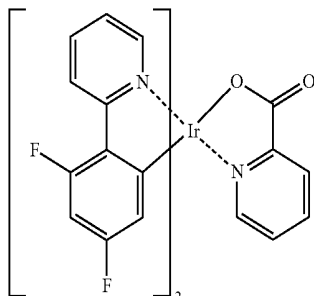
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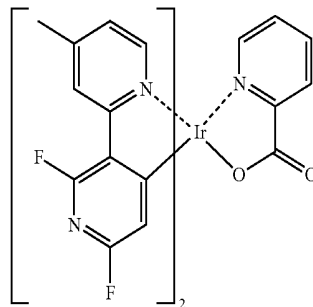
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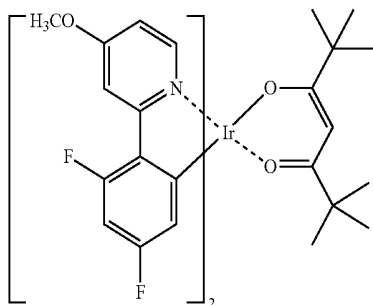
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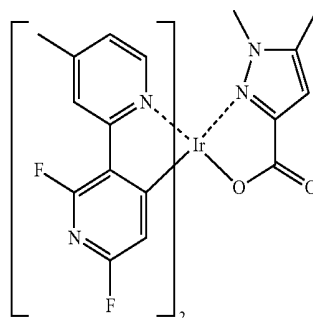
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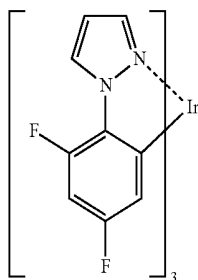
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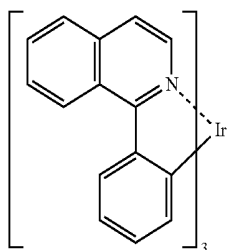
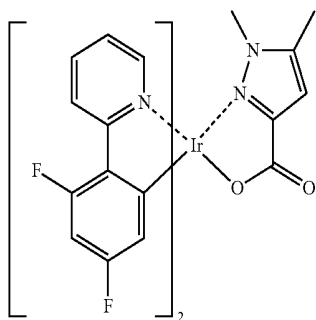
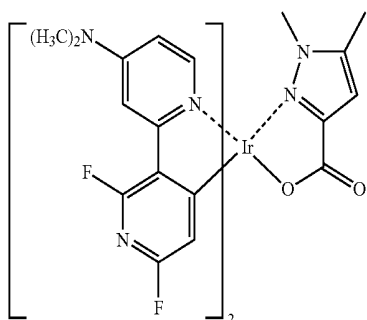
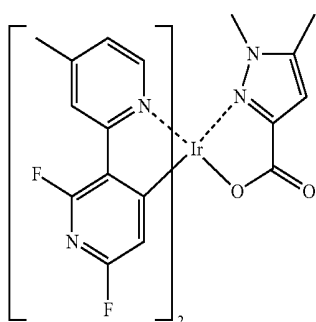
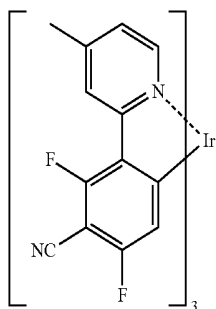
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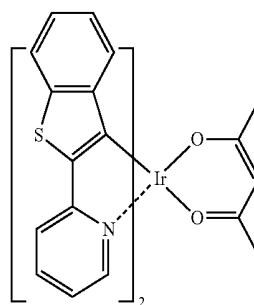


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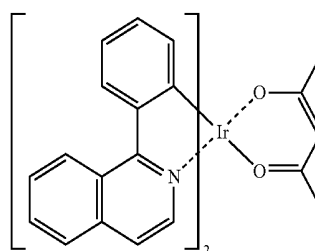
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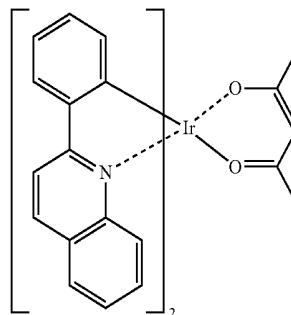
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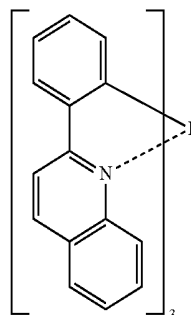
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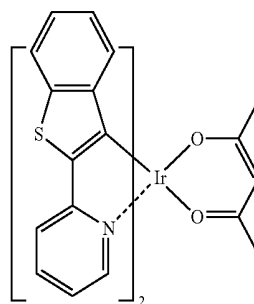
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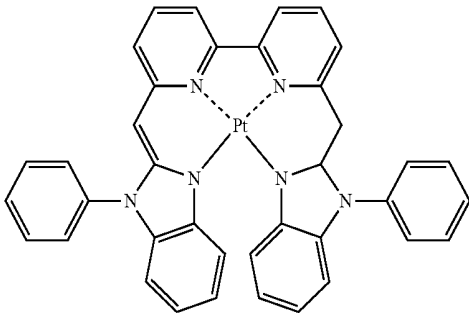
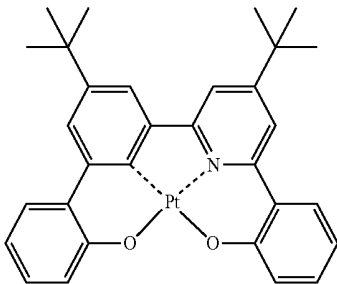
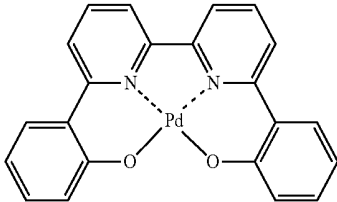
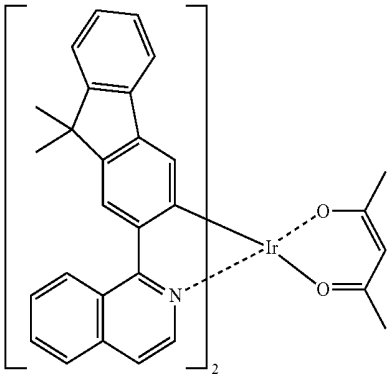
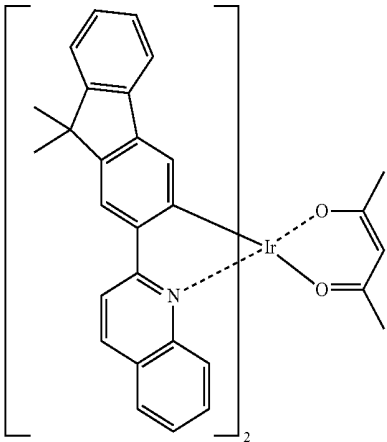
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PD14



PD19

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PD20

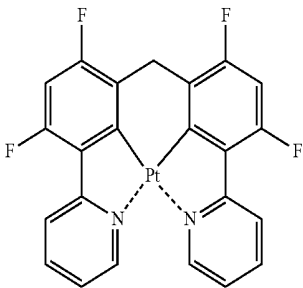
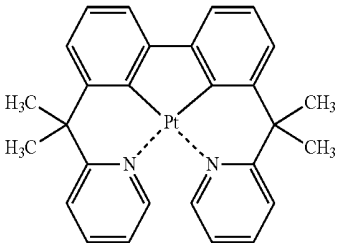
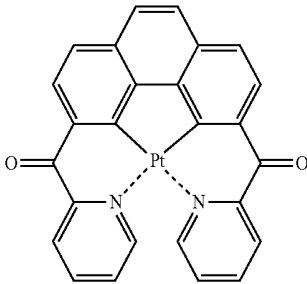
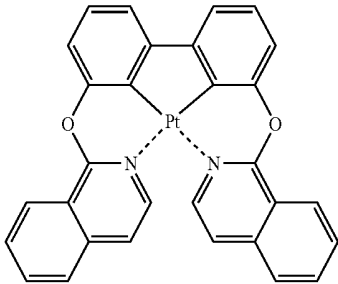
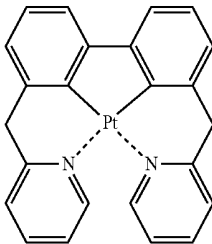
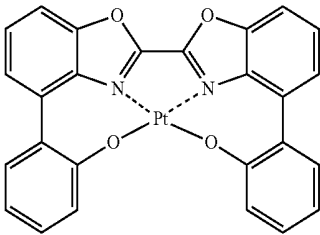
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PD25

PD26

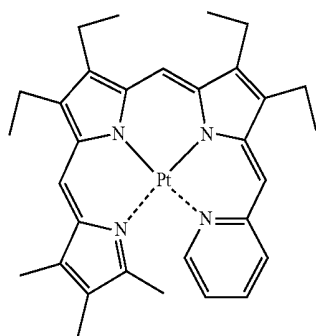
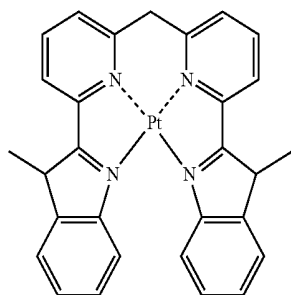
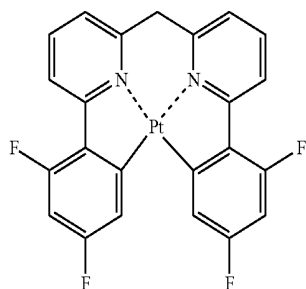
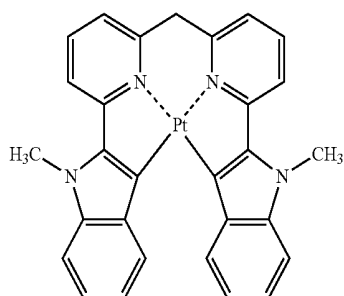
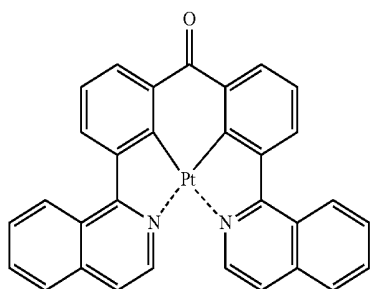
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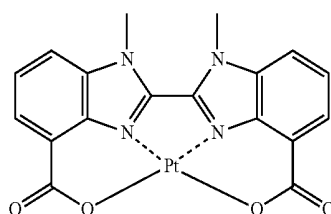
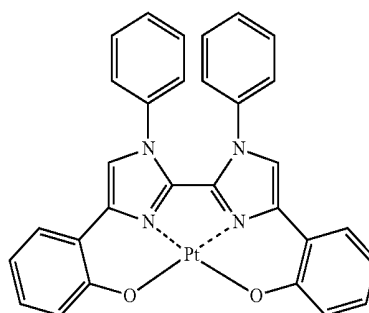
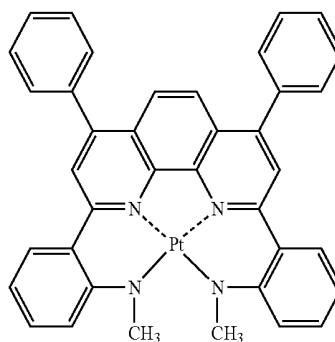
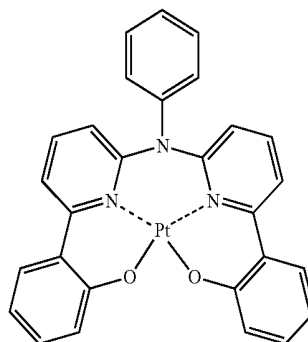
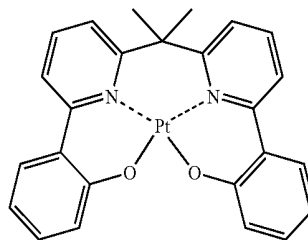
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PD31

PD36

PD32

D37

PD33

D38

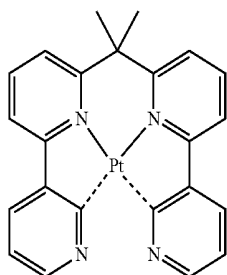
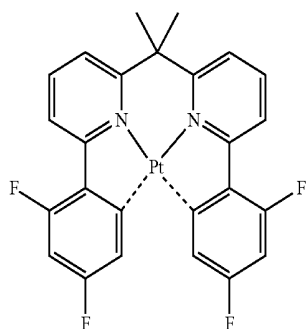
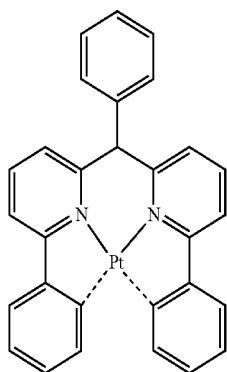
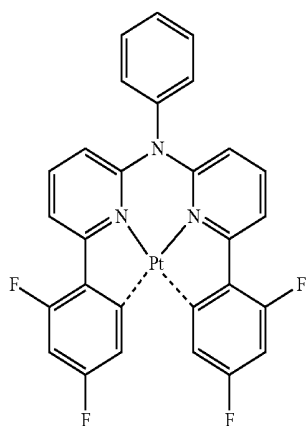
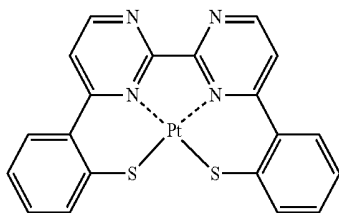
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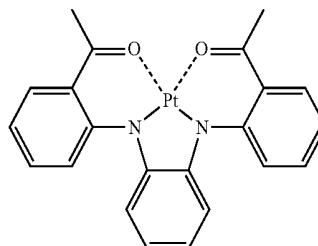
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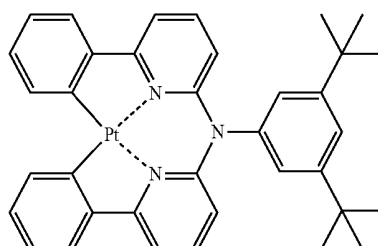
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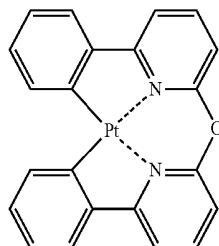
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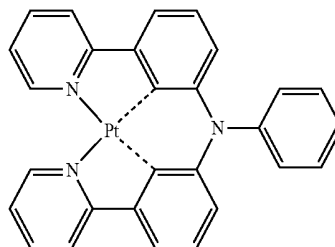
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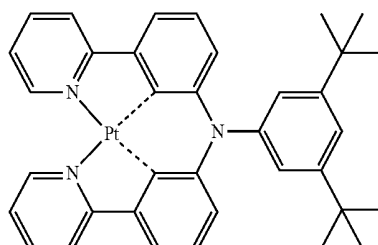
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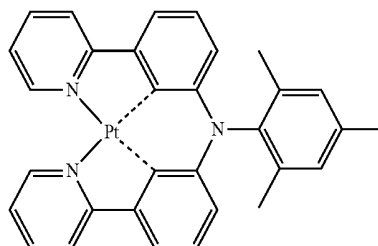
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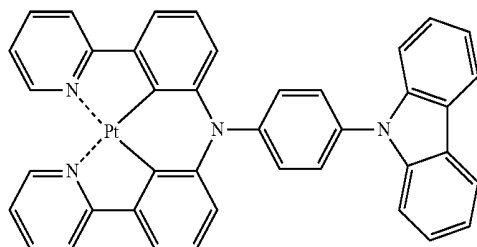
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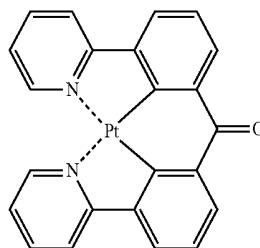
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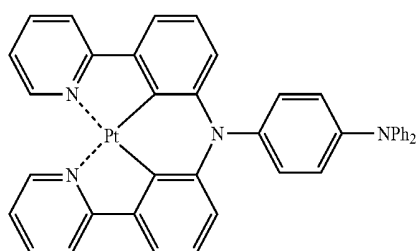


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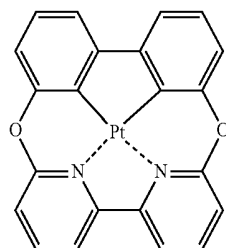
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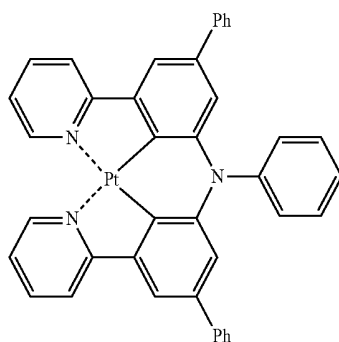
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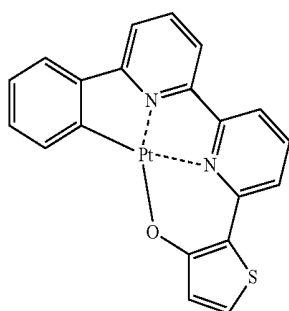
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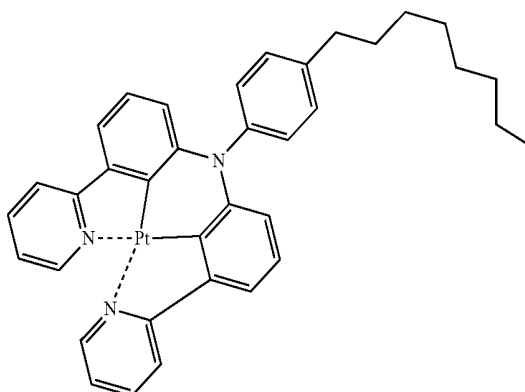
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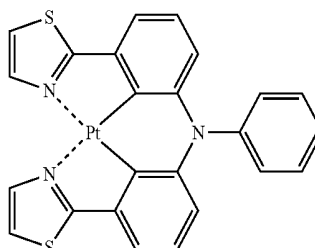
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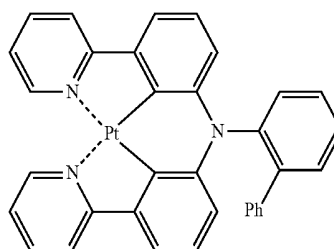
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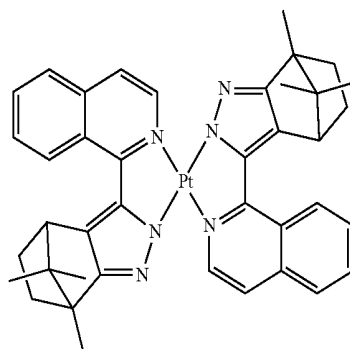
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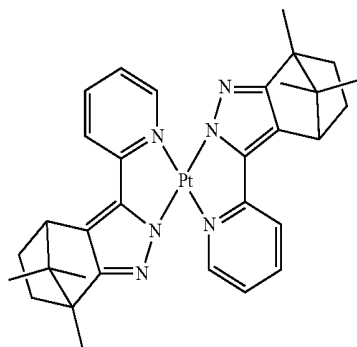
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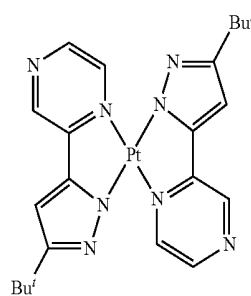


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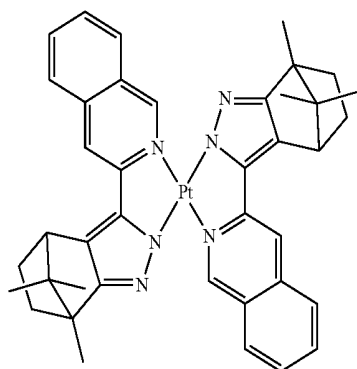


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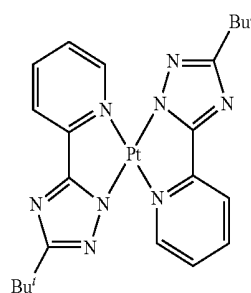
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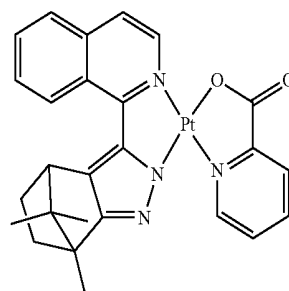
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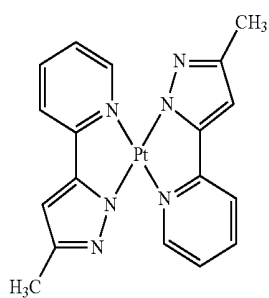
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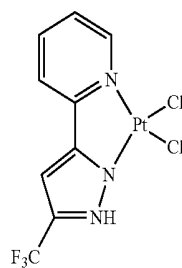
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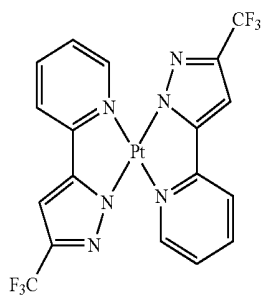
PD68



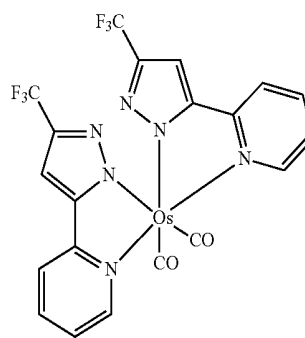
PD64



PD69

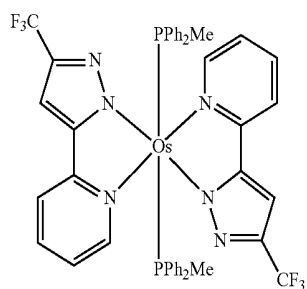


PD65



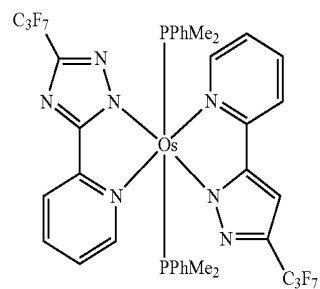
PD70

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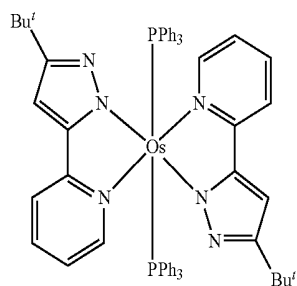


PD71

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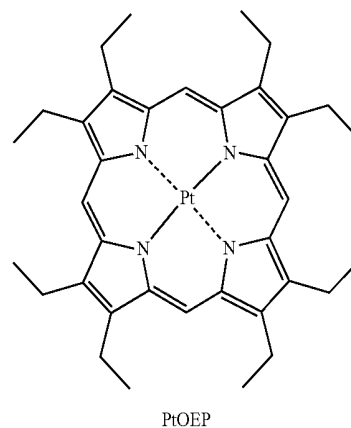


PD74



PD72

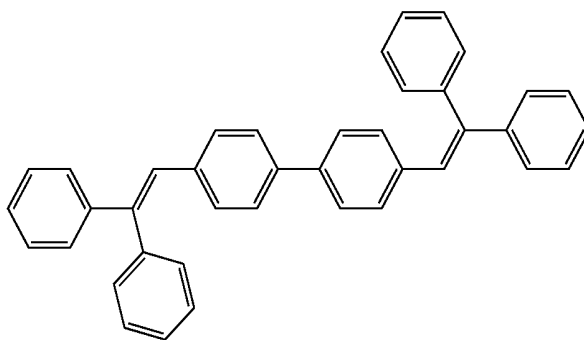
[0200] For example, the phosphorescent dopant may include PtOEP:



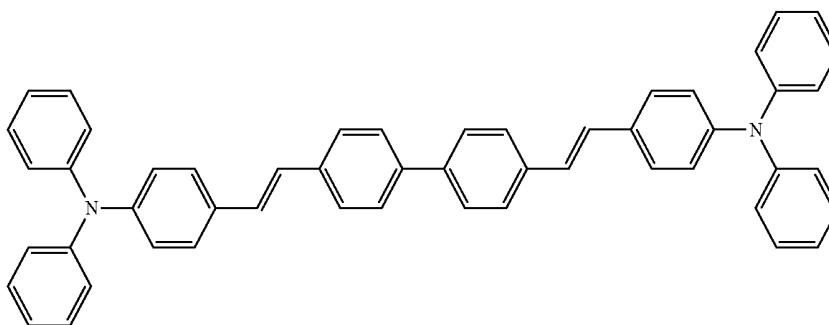
PD73

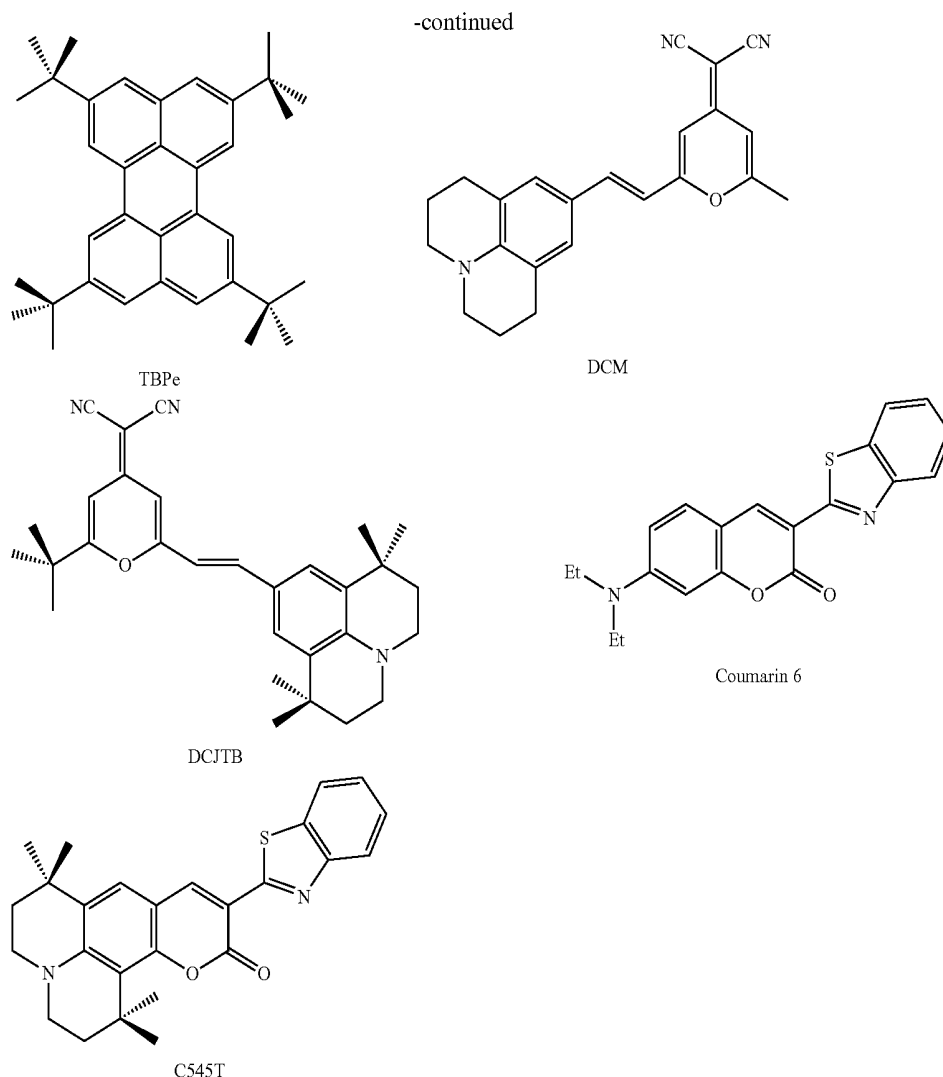
PtOEP

[0201] For example, the fluorescent dopant may further include at least one of DPAVB_i, BDAVB_i, TBPe, DCM, DCJT_B, Coumarin 6, and C545T.

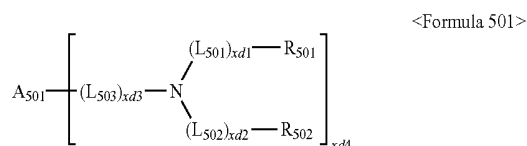


DPVBi

DPAVB_i



[0202] For example, the fluorescent dopant may include a compound represented by Formula 501.



[0203] In Formula 501,

[0204] Ar_{501} may be selected from

[0205] a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene,

[0206] a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with at least one selected from a deuterium, —F, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt

thereof, a C_1 - C_{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, and —Si(Q_{501})(Q_{502})(Q_{503}), wherein Q_{501} to Q_{503} may each independently be selected from a hydrogen, C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_6 - C_{60} aryl group, and a C_1 - C_{60} heteroaryl group;

[0207] L_{501} to L_{503} may be the same as those for L_{201} defined herein;

[0208] R_{501} and R_{502} may each independently be selected from

[0209] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazoyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothio group, and

[0210] a phenyl group, a naphthyl group, a fluorenyl group, spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluo-

renyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothio group, each substituted with at least one selected from a phenyl group, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and a dibenzofuranyl group, and a dibenzothiophenyl group;

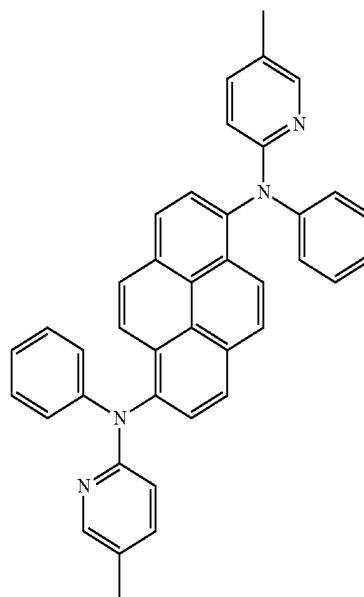
[0211] xd1 to xd3 may each independently be selected from 0, 1, 2, and 3; and

[0212] xb4 may be selected from 1, 2, 3, and 4.

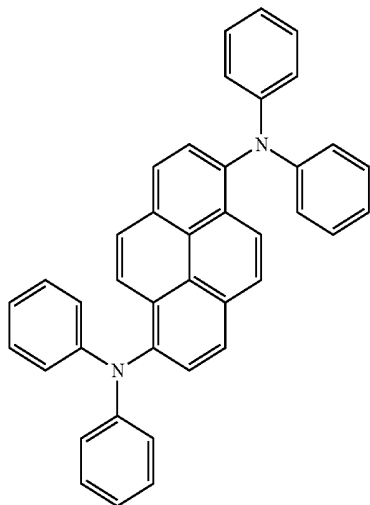
[0213] For example, the fluorescent host may include at least one of Compounds FD1 to FD9.

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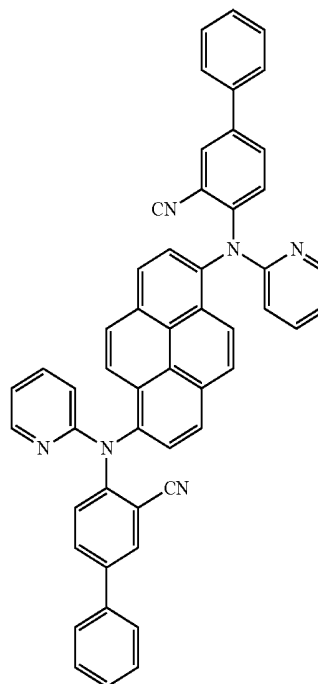
FD3



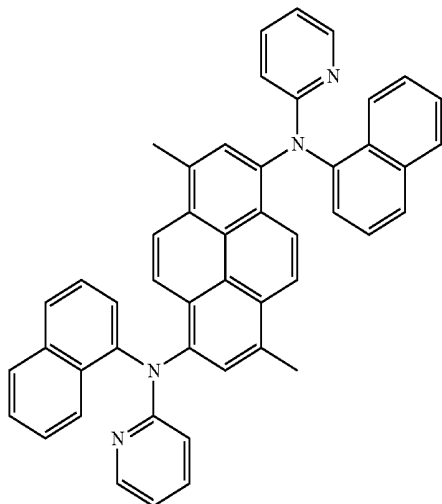
FD1



FD4

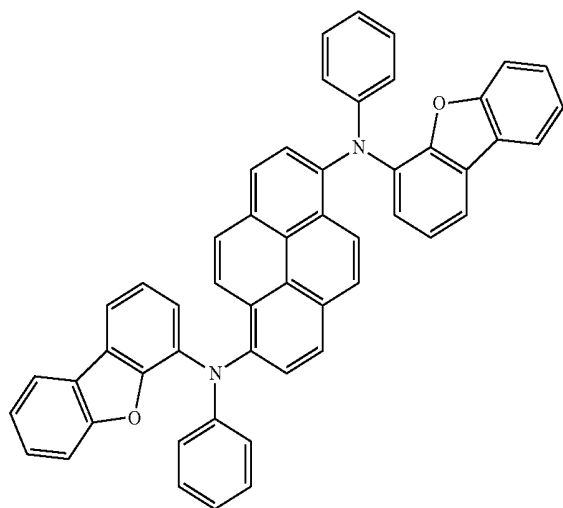


FD2



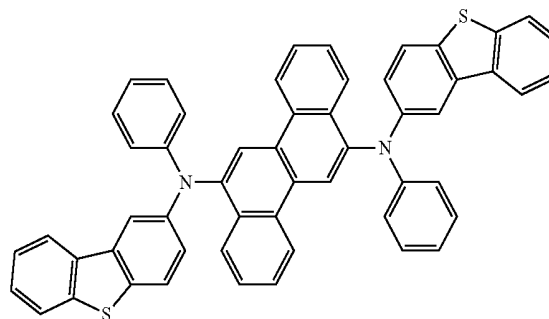
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FD5

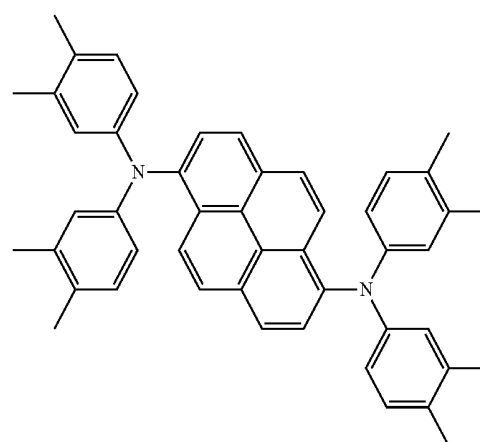


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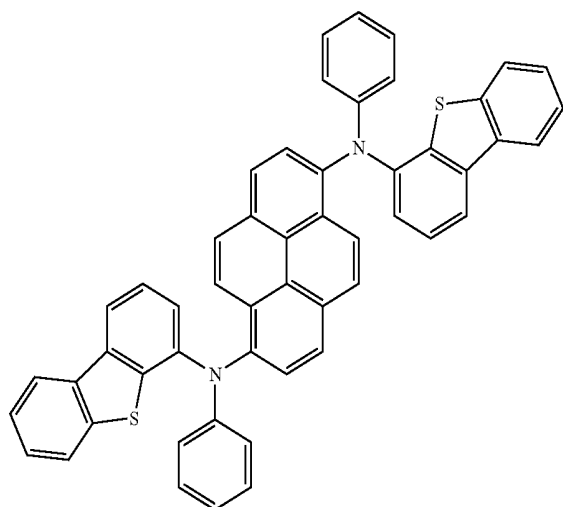
FD8



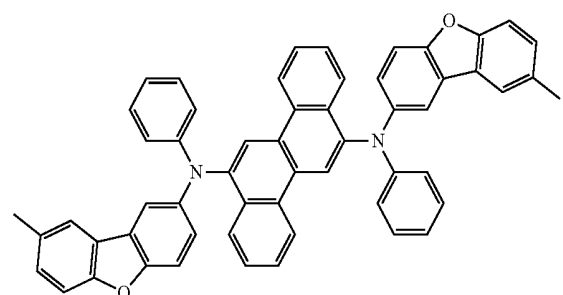
<Compound FD9>



FD6



FD7



[0214] The amount of the dopant in the EML may be from about 0.01 parts to about 15 parts by weight based on 100 parts by weight of the host, but is not limited to this range.

[0215] The thickness of the EML may be about 100 Å to about 1000 Å, and in some embodiments, may be from about 200 Å to about 600 Å. When the thickness of the EML is within these ranges, the EML may have good light emitting ability without a substantial increase in driving voltage.

[0216] Next, the electron transport region may be disposed on the EML.

[0217] The electron transport region may include at least one of a HBL, an ETL, and an EIL. However, embodiments are not limited thereto.

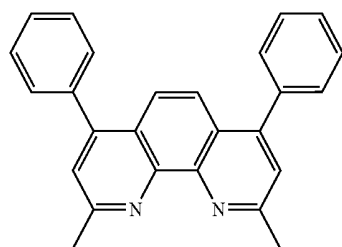
[0218] In some embodiments, the electron transport region may have a structure including an ETL/EIL, or a HBL/ETL/EIL, wherein the layers forming a structure of the electron transport region may be sequentially stacked on the EML in the order stated above. However, embodiments are not limited thereto:

[0219] In some embodiments, the organic layer 150 of the organic light-emitting device 10 may include the electron transport region between the EML and the second electrode 190, and at least one of the condensed cyclic compounds of Formulae 1A and 1B may be in the electron transport region.

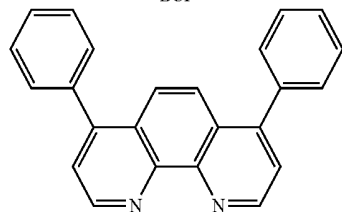
[0220] The electron transport region may include a HBL. When the EML includes a phosphorescent dopant, the HBL may prevent diffusion of triplet excitons or holes into the ETL from the EML.

[0221] When the electron transport region includes a HBL, the HBL may be formed on the EML by using any of a variety of methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the HBL is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the HBL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in detail.

[0222] For example, the HBL may include at least one of BCP below and Bphen below. However, embodiments are not limited thereto.



BCP



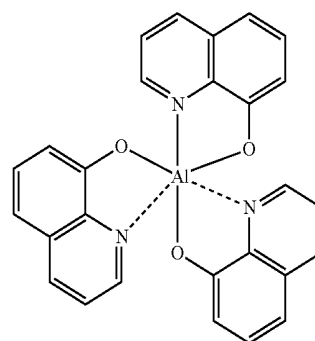
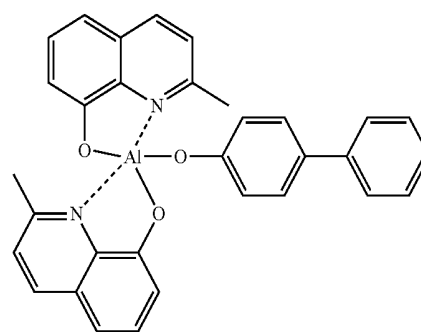
Bphen

[0223] The thickness of the HBL may be from about 20 Å to about 1,000 Å, and in some embodiments, from about 30 Å to about 300 Å. When the thickness of the HBL is within these ranges, the HBL may have improved hole blocking ability without a substantial increase in driving voltage.

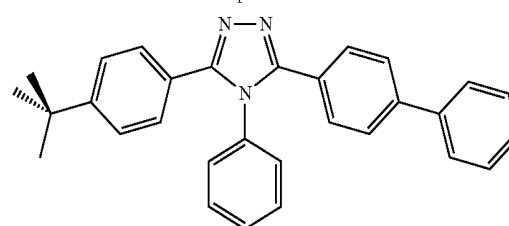
[0224] The electron transport region may include an ETL. The ETL may be formed on the EML or the HBL by using any of a variety of methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the ETL is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the ETL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in detail.

[0225] In some embodiments, the organic layer 150 of the organic light-emitting device may include an electron transport region between the EML and the second electrode 190, wherein the electron transport region may include an ETL, and the ETL may include at least one of the condensed cyclic compounds of Formula 1.

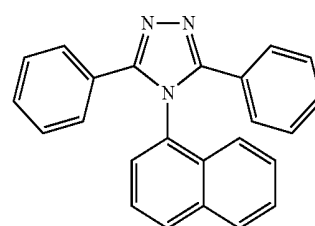
[0226] The ETL may further include at least one of BCP, Bphen, Alq₃, Balq, TAZ, and NTAZ, in addition to at least one of the condensed cyclic compounds of Formula 1.

Alq₃

Balq



TAZ

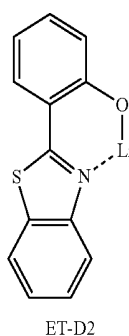
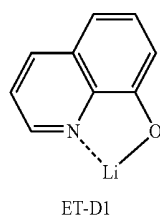


NTAZ

[0227] The thickness of the ETL may be from about 100 Å to about 1,000 Å, and in some embodiments, from about 150 Å to about 500 Å. When the thickness of the ETL is within these ranges, the ETL may have satisfactory electron transporting ability without a substantial increase in driving voltage.

[0228] In some embodiments the ETL may further include a metal-containing material, in addition to the above-described materials.

[0229] The metal-containing material may include a lithium (Li) complex. Non-limiting examples of the Li complex are compound ET-D1 below (lithium quinolate (LiQ)), or compound ET-D2.



[0230] The electron transport region may include an EIL that may facilitate injection of electrons from the second electrode **190**.

[0231] The EIL may be formed on the ETL by using any of a variety of methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the EIL is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the EIL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in detail.

[0232] The EIL may include at least one selected from LiF, NaCl, CsF, Li₂O, BaO, and LiQ.

[0233] A thickness of the EIL may be from about 1 Å to about 100 Å, and in some embodiments, from about 3 Å to about 90 Å. When the thickness of the EIL is within these ranges, the EIL may have satisfactory electron injection ability without a substantial increase in driving voltage.

[0234] The second electrode **190** may be disposed on the organic layer **150**, as described above. The second electrode **190** may be a cathode as an electron injecting electrode. A material for forming the second electrode **190** may be a metal, an alloy, an electrically conductive compound, which have a low-work function, or a mixture thereof. Non-limiting examples of materials for forming the second electrode **190** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, a material for forming the second electrode **190** may be ITO or IZO. The second electrode **190** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

[0235] Although the organic light-emitting device of FIG. 1 is described above, embodiments are not limited thereto.

[0236] As used herein, a C₁-C₆₀ alkyl group refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms. Non-limiting examples of the C₁-C₆₀ alkyl group are 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. A C₁-C₆₀ alkylene group refers to a divalent group having the same structure as the C₁-C₆₀ alkyl.

[0237] As used herein, a C₁-C₆₀ alkoxy group refers to a monovalent group represented by—OA₁₀₁ (where A₁₀₁ is a C₁-C₆₀ alkyl group as described above. Non-limiting examples of the C₁-C₆₀ alkoxy group are a methoxy group, an ethoxy group, and an isopropoxy group.

[0238] As used herein, a C₂-C₆₀ alkenyl group refers to a hydrocarbon group including at least one carbon double bond

in the middle or terminal of the C₂-C₆₀ alkyl group. Non-limiting examples of the C₂-C₆₀ alkenyl group are an ethenyl group, a propenyl group, and a butenyl group. A C₂-C₆₀ alkylene group refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

[0239] As used herein, a C₂-C₆₀ alkynyl group refers to a hydrocarbon group including at least one carbon triple bond in the middle or terminal of the C₂-C₆₀ alkyl group. Non-limiting examples of the C₂-C₆₀ alkynyl group are an ethynyl group and a propynyl group. A C₂-C₆₀ alkynylene group used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkynyl group.

[0240] As used herein, a C₃-C₁₀ cycloalkyl group refers to a monovalent, monocyclic hydrocarbon group having 3 to 10 carbon atoms. Non-limiting examples of the C₃-C₁₀ cycloalkyl group are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C₃-C₁₀ cycloalkylene group refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkyl group.

[0241] As used herein, a C₁-C₁₀ heterocycloalkyl group refers to a monovalent monocyclic group having 1 to 10 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom (ring member atom). Non-limiting examples of the C₁-C₁₀ heterocycloalkyl group are a tetrahydrofuran group and a tetrahydrothiophenyl group. A C₁-C₁₀ heterocycloalkylene group refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkyl group.

[0242] As used herein, a C₃-C₁₀ cycloalkenyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms that includes at least one double bond in the ring but does not have aromaticity. Non-limiting examples of the C₃-C₁₀ cycloalkenyl group are a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C₃-C₁₀ cycloalkenylene group refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkenyl group.

[0243] As used herein, a C₁-C₁₀ heterocycloalkenyl group used herein refers to a monovalent monocyclic group having 1 to 10 carbon atoms that includes at least one double bond in the ring and in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C₁-C₁₀ heterocycloalkenyl group are a 2,3-dihydrofuran group and a 2,3-dihydrothiophenyl group. A C₁-C₁₀ heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkenyl group.

[0244] As used herein, a C₆-C₆₀ aryl group refers to a monovalent, aromatic carbocyclic aromatic group having 6 to 60 carbon atoms, and a C₆-C₆₀ arylene group refers to a divalent, aromatic carbocyclic group having 6 to 60 carbon atoms. Non-limiting examples of the C₆-C₆₀ aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C₆-C₆₀ aryl group and the C₆-C₆₀ arylene group include at least two rings, the rings may be fused to each other.

[0245] As used herein, a C₁-C₆₀ heteroaryl group refers to a monovalent, aromatic carbocyclic aromatic group having 1 to 60 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom, and 1 to 60 carbon atoms. A C₁-C₆₀ heteroarylene group refers to a divalent, aromatic carbocyclic group having 1 to 60 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting

examples of the C_1 - C_{60} heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1 - C_{60} heteroaryl and the C_1 - C_{60} heteroarylene include at least two rings, the rings may be fused to each other.

[0246] As used herein, a C_6 - C_{60} aryloxy group indicates $—OA_{102}$ (where A_{102} is a C_6 - C_{60} aryl group as described above), and a C_6 - C_{60} arylthio group indicates $—SA_{103}$ (where A_{103} is a C_6 - C_{60} aryl group as described above).

[0247] As used herein, a monovalent non-aromatic condensed polycyclic group refers to a monovalent group having at least two rings condensed to each other, in which only carbon atoms (for example, 8 to 60 carbon atoms) are exclusively included as ring-forming atoms and the entire molecule has non-aromaticity. A non-limiting example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0248] As used herein, a monovalent non-aromatic condensed heteropolycyclic group refers to a monovalent group having at least two rings condensed to each other, in which carbon atoms (for example, 1 to 60 carbon atoms) and a hetero atom selected from N, O, P, and S are as ring-forming atoms and the entire molecule has non-aromaticity. A non-limiting example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0249] As used herein, at least one of substituents of 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 cyclic group, the substituted divalent non-aromatic hetero-condensed cyclic 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 hetero-condensed polycyclic group, may be selected from

[0250] a deuterium, $—F$, $—Cl$, $—Br$, $—I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group,

[0251] 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 of a deuterium, $—F$, $—Cl$, $—Br$, $—I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid

group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—B(Q_{16})(Q_{17})$,

[0252] 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,

[0253] 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 of a deuterium, $—F$, $—Cl$, $—Br$, $—I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{21})(Q_{22})$, $—Si(Q_{23})(Q_{24})(Q_{25})$, and $—B(Q_{26})(Q_{27})$, and

[0254] $—N(Q_{31})(Q_{32})$, $—Si(Q_{33})(Q_{34})(Q_{35})$, and $—B(Q_{36})(Q_{37})$,

[0255] wherein Q_1 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} may each independently be selected from a hydrogen, a deuterium, $—F$, $—Cl$, $—Br$, $—I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0256] For example, at least one of substituents of 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_{20} heterocycloalkenylene group, the substituted C_6 - C_{60} heteroarylene 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

C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group,

[0257] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovaenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇),

[0258] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovaenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a

pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group,

[0259] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovaenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovaenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a

ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-N(Q_{21})(Q_{22})$, $-Si(Q_{23})(Q_{24})(Q_{25})$, and $-B(Q_{26})(Q_{27})$, and

[0260] $-N(Q_{31})(Q_{32})$, $-Si(Q_{33})(Q_{34})(Q_{35})$, or $-B(Q_{36})(Q_{37})$,

[0261] wherein Q_1 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} may each independently be selected from a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

[0262] The acronym "Ph" used herein refers to phenyl, the acronym "Me" used herein refers to methyl, the acronym "Et" used herein refers to ethyl, and the acronym "ter-Bu" or "Bu" used herein refers to tert-butyl.

[0263] One or more embodiments, which include condensed cyclic compounds, and organic light-emitting devices including the same, will now be described in detail with

reference to the following examples. However, these examples are only for illustrative purposes and are not intended to limit the scope of the one or more embodiments. In the following synthesis example, the expression that "'B' instead of 'A' was used" means that the amounts of 'B' and 'A' were the same in equivalent amounts.

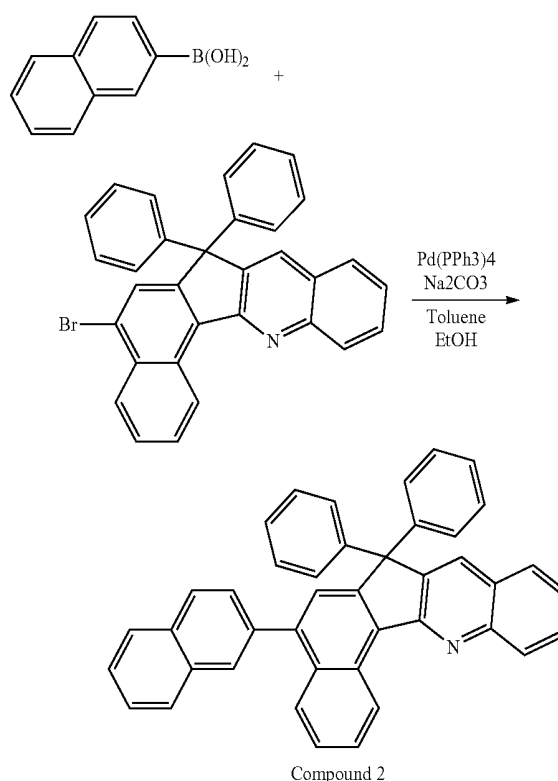
[0264] The following Examples and Comparative Examples are provided in order to highlight characteristics of one or more embodiments, but it will be understood that the Examples and Comparative Examples are not to be construed as limiting the scope of the embodiments, nor are the Comparative Examples to be construed as being outside the scope of the embodiments. Further, it will be understood that the embodiments are not limited to the particular details described in the Examples and Comparative Examples.

Examples

Synthesis Example 3

Synthesis of Compound 2

[0265]



[0266] 0.67 g (1 eq, 1.30 mmol) of 5-bromo-7,7-diphenyl-7H-benzo[6,7]indeno[1,2-b]quinoline, 0.24 g (1.1 eq, 1.43 mmol) of naphthalen-2-ylboronic acid, and 0.06 g (0.04 eq, 0.052 mmol) of Tetrakis(triphenylphosphine)palladium(0) were put into a container, vacuum-dried, and then purged with nitrogen gas. After 13 mL of toluene was added into the reaction vessel to dissolve the reactant compounds, 6.5 mL of ethanol and 6.5 mL (10 eq, 13.0 mmol) of a 2.0M aqueous sodium carbonate solution were added thereto and stirred under reflux at about 80° C. for about 3 hours. After termination of the reaction, the reaction product was washed with distilled water, followed by extraction with ethyl acetate to obtain an organic layer. This organic layer was dried using magnesium sulfate, followed by filtration using a Celite and

column chromatography to obtain 0.760 g of Compound 8 (5-(naphthalen-2-yl)-7,7-diphenyl-7H-benzo[6,7]indeno[1,2-b]quinoline) (Yield: 75%).

[0267] ^1H NMR: 8.52 (2H), 8.02 (6H), 7.73 (3H), 7.59 (6H), 7.33 (6H), 7.11 (4H).

[0268] APCI-MS (m/z): 548[M+]

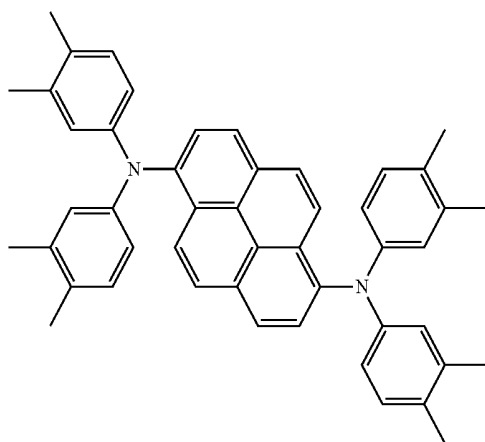
Example 1

[0269] A Corning $15\Omega/\text{cm}^2$ (1200 Å) ITO glass substrate was cut to a size of 50 mm×50 mm×0.7 mm and then sonicated in isopropyl alcohol and pure water each for five minutes, and then cleaned by irradiation of ultraviolet rays for 30 minutes and exposure to ozone. The resulting ITO glass substrate was mounted into a vacuum deposition device.

[0270] After m-MTDATA was vacuum-deposited on the ITO anode of the ITO glass substrate to form an HIL having a thickness of 600 Å, NPB was deposited on the HIL to form a HTL having a thickness of about 300 Å, and then ADN (host) and Compound FD9 (dopant) were co-deposited in a weight ratio of 95:5 on the HTL to form an EML having a thickness of about 200 Å.

[0271] Then, Compound 2 was deposited on the EML to form an ETL having a thickness of about 300 Å, and then LiF was deposited on the ETL to form an EIL having a thickness of about 10 Å. Then, Al was deposited on the EIL to form a cathode having a thickness of about 1000 Å, thereby completing the manufacture of an organic light-emitting device.

<Compound FD9>



Examples 2 to 5 and Comparative Examples 1 and 2

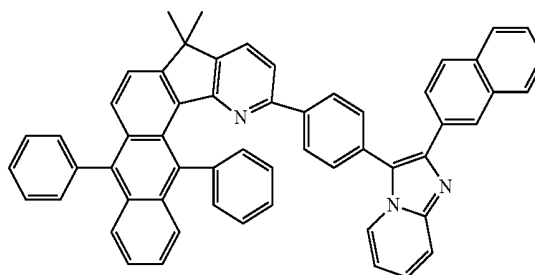
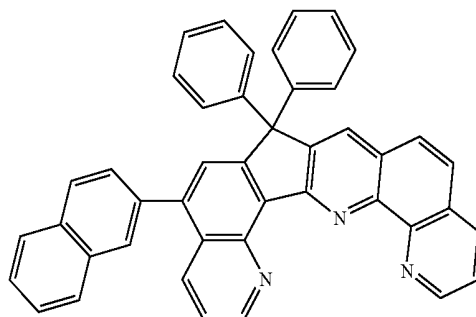
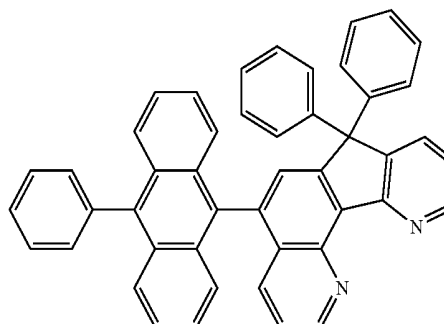
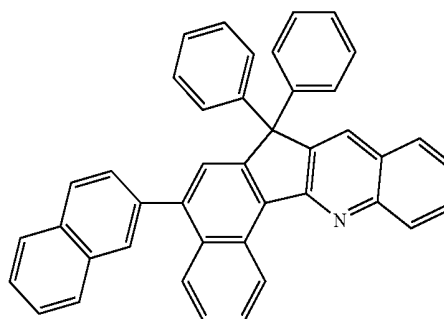
[0272] Organic light-emitting devices were manufactured in the same manner as in Example 1, except that compounds in Table 1, instead of Compound 2, were used to form the ETL.

Evaluation Example 1

[0273] Driving voltages, colors, efficiencies, and lifetimes (T_{95}) of the organic light-emitting devices of Examples 1 to 5 and Comparative Examples 1 and 2 were evaluated using a Keithley Source-Measure Unit (SMU 236) and a PR650 (Spectroscan) Source Measurement Unit. (available from Photo Research, Inc.). The results are shown in Table 1. The lifetime (T_{95}) was measured as the time taken until a measured initial luminance at 1000 nit (assumed as 100%) was reduced to 95% after operation. The efficiencies and lifetimes of the organic light-emitting devices of Examples 1 to 5 and Comparative Example 1 in Table 1 are relative ones with respect to the efficiency and lifetime of the organic light-emitting device of Comparative Example 2.

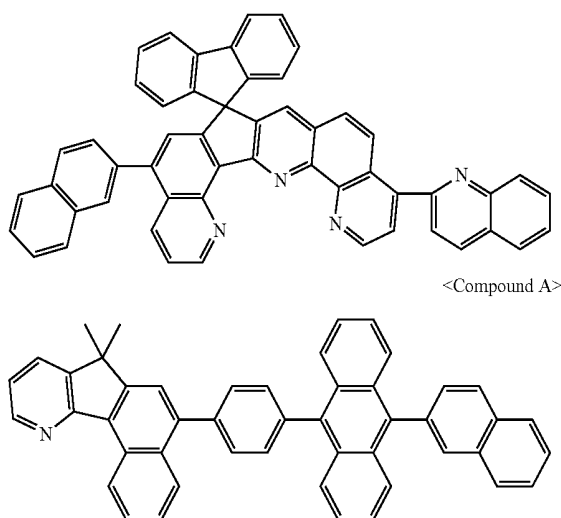
TABLE 1

Example No.	Electron transport layer	Color	Efficiency	Lifetime (T_{95})
Example 1	Compound 2	Blue	1	2.1
Example 2	Compound 14	Blue	1	1.0
Example 3	Compound 26	Blue	1.3	1.7
Example 4	Compound 43	Blue	1.2	1.4
Example 5	Compound 60	Blue	1.35	0.85
Comparative Example 1	Compound A	Blue	0.9	1.1
Comparative Example 2	Alq ₃	Blue	1	1



-continued

60



[0274] Referring to Table 1, the organic light-emitting devices of Examples 1 to 5 were found to have improved efficiency and/or lifetime compared to the organic light-emitting device of Comparative Examples 1 and 2.

[0275] As described above, according to the one or more of the above embodiments, an organic light-emitting device including a condensed cyclic compound of Formula 1 may have a low driving voltage, a high efficiency, a high luminance, and a long lifetime.

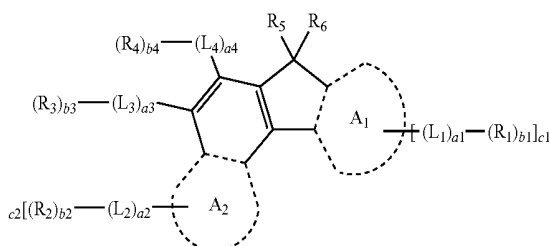
[0276] As described above, embodiments are directed to a condensed cyclic compound and an organic light-emitting device including the same.

[0277] Example embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. In some instances, as would be apparent to one of ordinary skill in the art as of the filing of the present application, features, characteristics, and/or elements described in connection with a particular embodiment may be used singly or in combination with features, characteristics, and/or elements described in connection with other embodiments unless otherwise specifically indicated. Accordingly, it will be understood by those of skill in the art that various changes in form and details may be made without departing from the spirit and scope as set forth in the following claims.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1:

<Formula 1>



wherein, in Formula 1,

A₁ ring is a C₂-C₂₀ heterocyclic group including at least one N as a ring member atom, and A₂ ring is a C₆-C₂₀

cyclic group, or a C₂-C₂₀ heterocyclic group including at least one N as a ring member atom, wherein A₂ ring is not a benzene when A₁ ring is a pyridine,

L₁ to L₄ are each independently selected from a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

a₁ to a₄ are each independently selected from 0, 1, 2, and 3,

R₁ to R₆ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₂₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁)(Q₂), —Si(Q₃)(Q₄)(Q₅), and —B(Q₆)(Q₇),

b₁ to b₄ are each independently an integer selected from 0 to 3,

c₁ and c₂ are each independently an integer selected from 0 to 10, and

at least one of substituents of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₁-C₂₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₁-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted a divalent non-aromatic condensed polycyclic group, the substituted a divalent non-aromatic condensed heteropolycyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

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

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

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

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

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

wherein Q₁ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇ and Q₃₁ to Q₃₇ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalk-

enyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

2. The condensed cyclic compound as claimed in claim 1, wherein:

the A₁ ring is a pyridine, and the A₂ ring is a naphthalene, a pyridine, a pyrimidine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, or a phenanthroline; or

the A₁ ring is a pyrimidine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, or a phenanthroline, and the A₂ ring is a benzene, a naphthalene, a pyridine, a pyrimidine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, or a phenanthroline.

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

the A₁ ring is a pyridine, and the A₂ ring is a naphthalene or a pyridine; or

the A₁ ring is a quinoline, a benzoquinoline, or a phenanthroline, and the A₂ ring is a benzene, a naphthalene, a pyridine, or a quinoline.

4. The condensed cyclic compound as claimed in claim 1, wherein L₁ to L₄ are each independently selected from

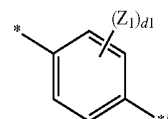
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spirofluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylenylene group, an ovalenylenylene group, a pyrrolylene group, a thiophenylenylene group, a furanylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a carbazolylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzoimidazolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an oxadiazolylenylene group, a triazinylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a thiadiazolylenylene group, an imidazopyridinylenylene group, and an imidazopyrimidinylenylene group; and

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-

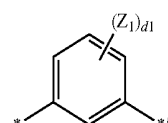
fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylene group, a rubicenylenylene group, a coronenylenylene group, an ovalenylenylene group, a pyrrolylenylene group, a thiophenylenylene group, a furanylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a carbazolylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzoimidazolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an oxadiazolylenylene group, a triazinylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a thiadiazolylenylene group, an imidazopyridinylenylene group, and an imidazopyrimidinylenylene group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolynyl group, an isoquinolynyl group, a benzoquinolynyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalynyl group, a quinazolynyl group, a cinnolynyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl

group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

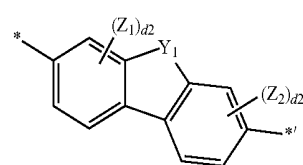
5. The condensed cyclic compound as claimed in claim 1, wherein L₁ to L₄ are each independently selected from groups represented by Formulae 3-1 to 3-33:



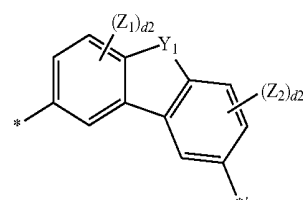
Formula 3-1



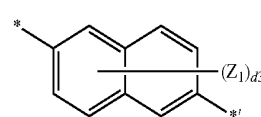
Formula 3-2



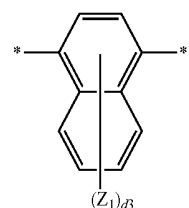
Formula 3-3



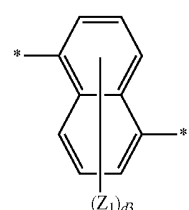
Formula 3-4



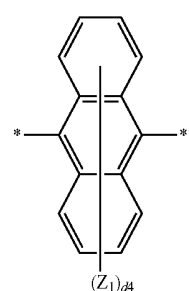
Formula 3-5



Formula 3-6

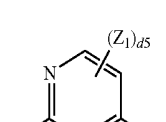
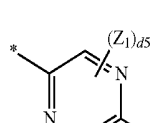
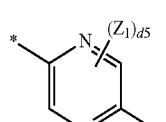
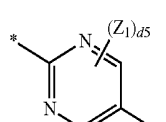
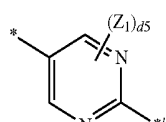
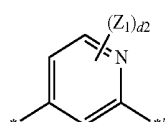
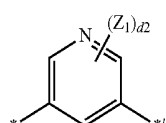
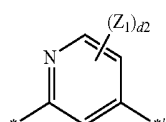
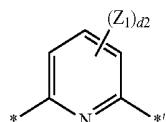
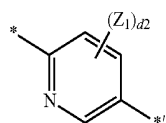
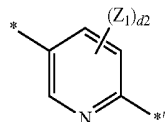
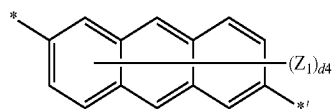


Formula 3-7



Formula 3-8

-continued



Formula 3-9

Formula 3-10

Formula 3-11

Formula 3-12

Formula 3-13

Formula 3-14

Formula 3-15

Formula 3-16

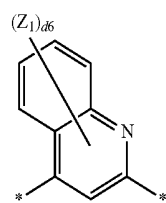
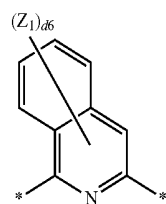
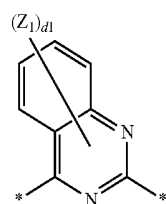
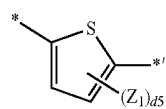
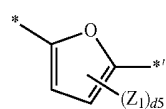
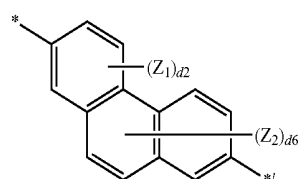
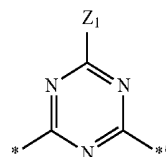
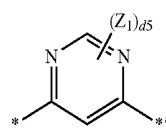
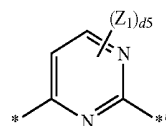
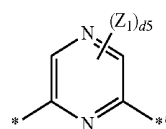
Formula 3-17

Formula 3-18

Formula 3-19

Formula 3-20

-continued



Formula 3-21

Formula 3-22

Formula 3-23

Formula 3-24

Formula 3-25

Formula 3-26

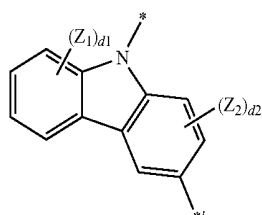
Formula 3-27

Formula 3-28

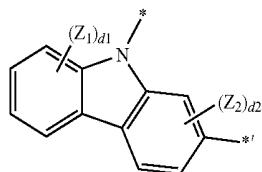
Formula 3-29

Formula 3-30

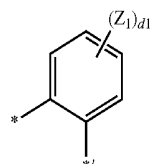
-continued



Formula 3-31



Formula 3-32



Formula 3-33

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

d_1 is an integer selected from 1 to 4,

d_2 is an integer selected from 1 to 3,

d_3 is an integer selected from 1 to 6,

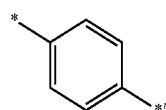
d_4 is an integer selected from 1 to 8,

d_5 is 1 or 2,

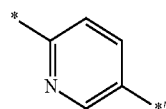
d_6 is an integer selected from 1 to 5 and

* and *1 are binding sites with an adjacent atom.

6. The condensed cyclic compound as claimed in claim 1, wherein L_1 to L_4 are each independently selected from groups represented by Formulae 4-1 to 4-24:

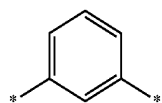


Formula 4-1

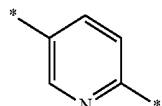


Formula 4-2

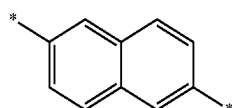
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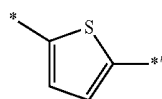
Formula 4-3



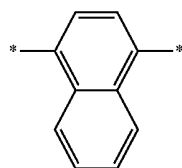
Formula 4-4



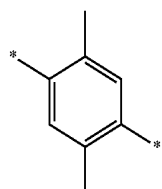
Formula 4-5



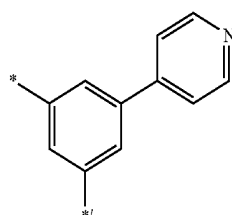
Formula 4-6



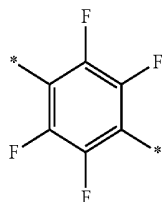
Formula 4-7



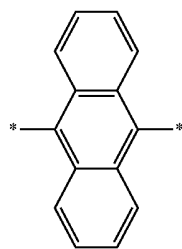
Formula 4-8



Formula 4-9

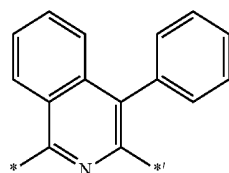
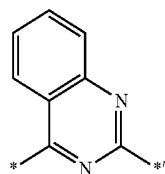
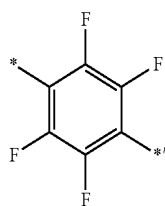
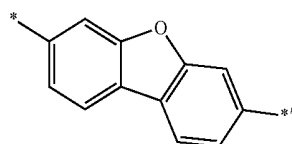
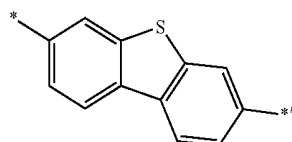
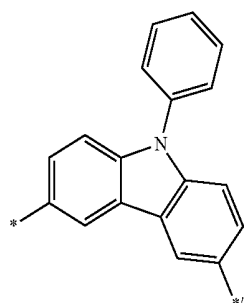
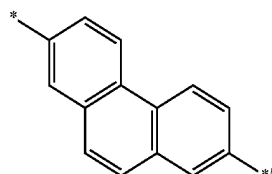
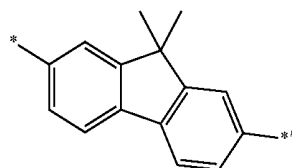


Formula 4-10



Formula 4-11

-continued



Formula 4-12

Formula 4-13

Formula 4-14

Formula 4-15

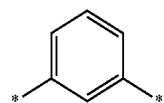
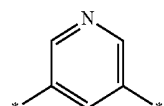
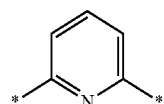
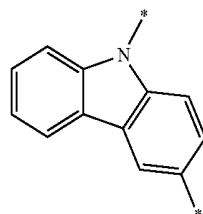
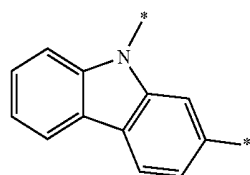
Formula 4-16

Formula 4-17

Formula 4-18

Formula 4-19

-continued



Formula 4-20

Formula 4-21

Formula 4-22

Formula 4-23

Formula 4-24

wherein, in Formulae 4-1 and 4-24, * and *' are binding sites with an adjacent atom.

7. The condensed cyclic compound as claimed in claim 1, wherein a1 to a4 are each independently 0 or 1.

8. The condensed cyclic compound as claimed in claim 1, wherein:

R₁ to R₄ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₂₀ alkyl group, a substituted or unsubstituted C₁-C₂₀ alkoxy group, a substituted or unsubstituted C₆-C₂₀ aryl group, a substituted or unsubstituted C₁-C₂₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q₃)(Q₄)(Q₅), and

R₅ and R₆ are each independently selected from a substituted or unsubstituted C₁-C₂₀ alkyl group, a substituted or unsubstituted C₁-C₂₀ alkoxy group, a substituted or unsubstituted C₆-C₂₀ aryl group, a substituted or unsubstituted C₁-C₂₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

9. The condensed cyclic compound as claimed in claim 1, wherein R₁ to R₄ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a

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

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

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

at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

Si(Q₃)(Q₄)(Q₅), wherein Q₃ to Q₅ are each independently selected from a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, and a naphthyl group.

10. The condensed cyclic compound as claimed in claim 1, wherein R₁ to R₄ are each independently selected from

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

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a ben-

zoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group and an imidazopyrimidinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

11. The condensed cyclic compound as claimed in claim 1, wherein R_5 and R_6 are each independently selected from a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group;

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

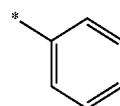
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, and a

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

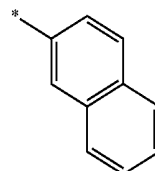
12. The condensed cyclic compound as claimed in claim 1, wherein:

R_1 to R_4 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, and groups represented by Formulae 6-1 to 6-62, and

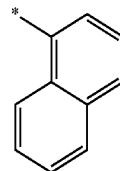
R_5 and R_6 are each independently selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, and groups represented by Formulae 6-1 to 6-62:



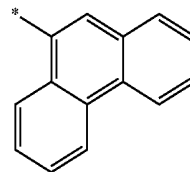
Formula 6-1



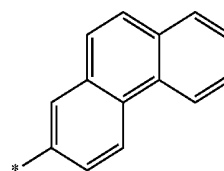
Formula 6-2



Formula 6-3

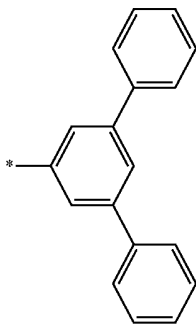
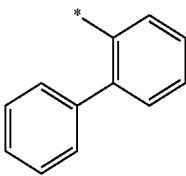
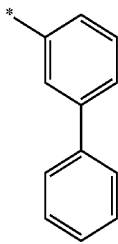
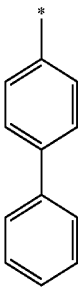
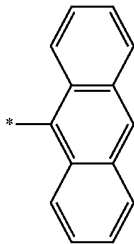
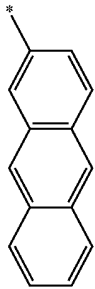


Formula 6-4



Formula 6-5

-continued



Formula 6-6

Formula 6-7

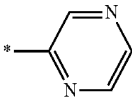
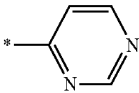
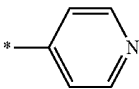
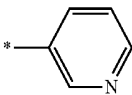
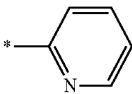
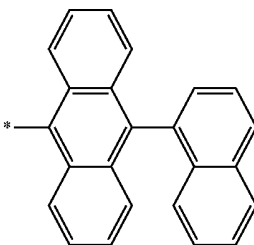
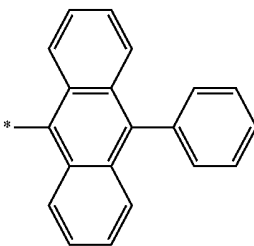
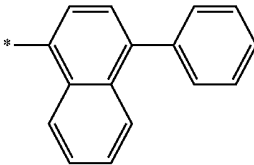
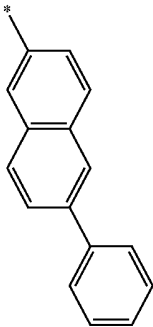
Formula 6-8

Formula 6-9

Formula 6-10

Formula 6-11

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Formula 6-12

Formula 6-13

Formula 6-14

Formula 6-15

Formula 6-16

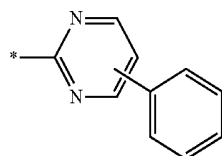
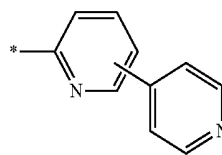
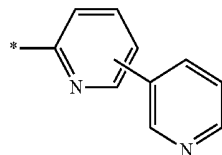
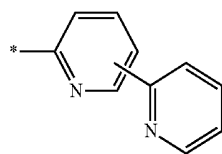
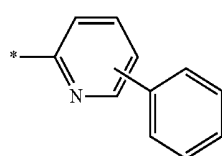
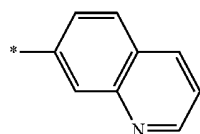
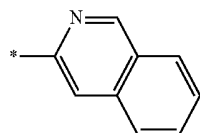
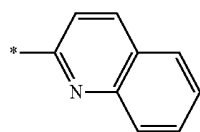
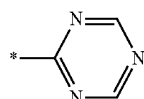
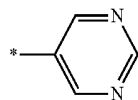
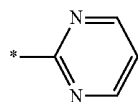
Formula 6-17

Formula 6-18

Formula 6-19

Formula 6-20

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Formula 6-21

Formula 6-22

Formula 6-23

Formula 6-24

Formula 6-25

Formula 6-26

Formula 6-27

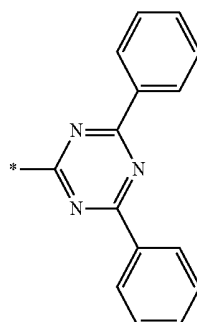
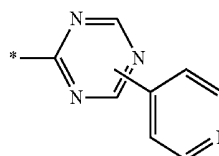
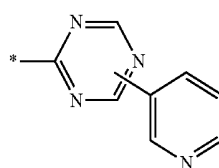
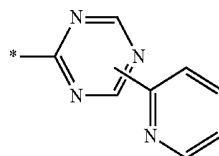
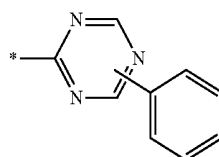
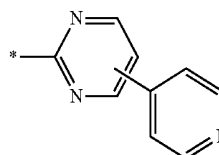
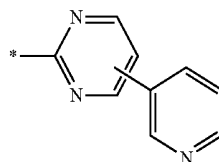
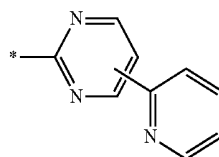
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Formula 6-29

Formula 6-30

Formula 6-31

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Formula 6-32

Formula 6-33

Formula 6-34

Formula 6-35

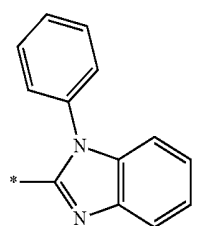
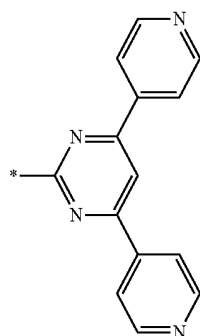
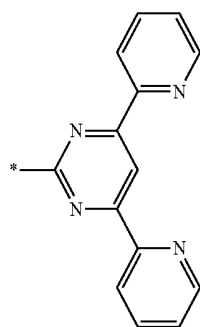
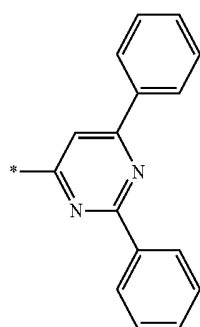
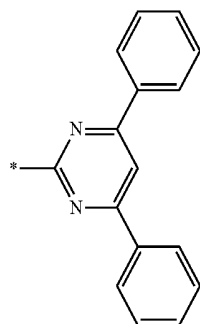
Formula 6-36

Formula 6-37

Formula 6-38

Formula 6-39

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Formula 6-40

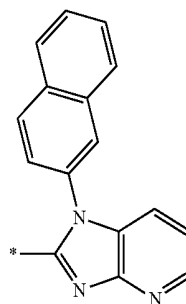
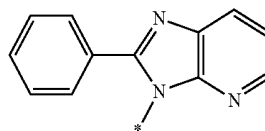
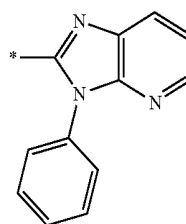
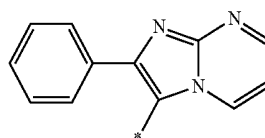
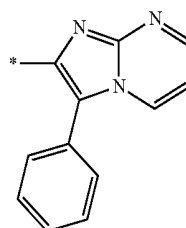
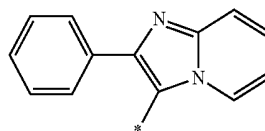
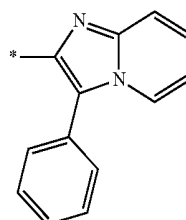
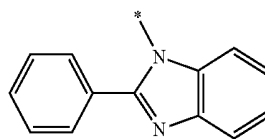
Formula 6-41

Formula 6-42

Formula 6-43

Formula 6-44

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Formula 6-45

Formula 6-46

Formula 6-47

Formula 6-48

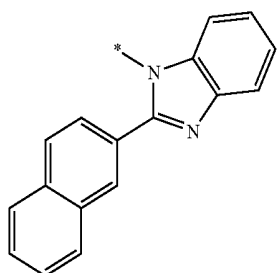
Formula 6-49

Formula 6-51

Formula 6-52

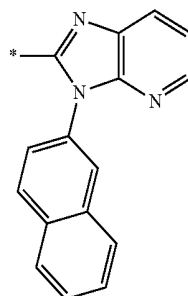
Formula 6-53

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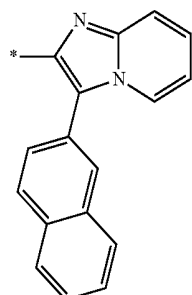


Formula 6-54

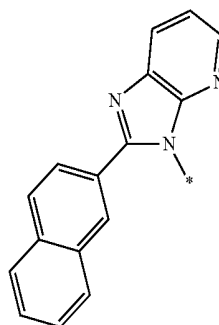
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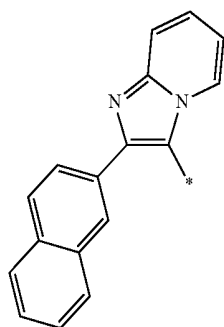
Formula 6-59



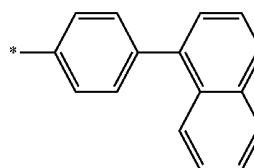
Formula 6-55



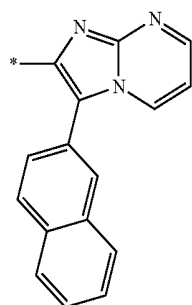
Formula 6-60



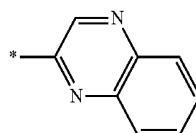
Formula 6-56



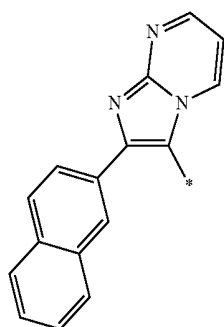
Formula 6-61



Formula 6-57



Formula 6-62



Formula 6-58

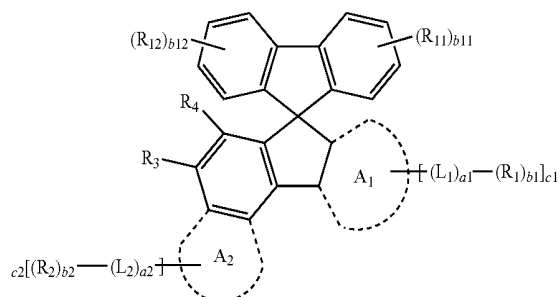
13. The condensed cyclic compound as claimed in claim 1, wherein:

R_5 and R_6 are each independently selected from a substituted or unsubstituted C_6 - C_{20} aryl group, a substituted or unsubstituted C_1 - C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and

R_5 and R_6 are linked to each other via a single bond or a substituted or unsubstituted C_1 - C_5 alkylene group.

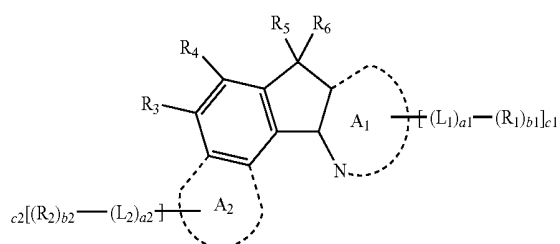
14. The condensed cyclic compound as claimed in claim 1, wherein the condensed cyclic compound of Formula 1 is represented by Formula 1A or 1B:

<Formula 1A>



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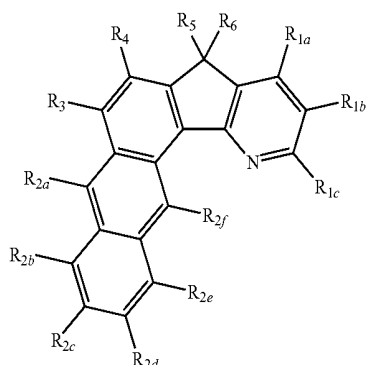
<Formula 1B>



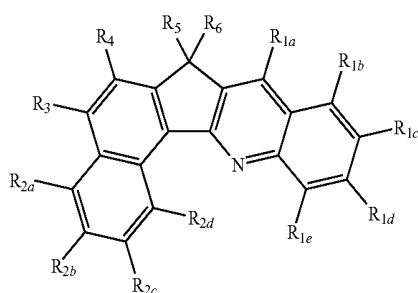
wherein, in Formulae 1A and 1B, A₁ ring, A₂ ring, L₁, L₂, a₁, a₂, R₁ to R₆, b₁, b₂, c₁, and c₂ are defined the same as those in claim 1; R₁₁ and R₁₂ are each independently defined the same as R₁ in claim 1; and b₁₁ and b₁₂ are each independently an integer selected from 1 to 4.

15. The condensed cyclic compound as claimed in claim 1, wherein the condensed cyclic compound of Formula 1 is represented by one of Formulae 1(1) to 1(13) and Formulae 1A(1) to 1A(13):

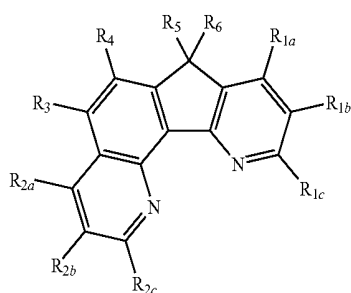
Formula 1(1)



Formula 1(2)

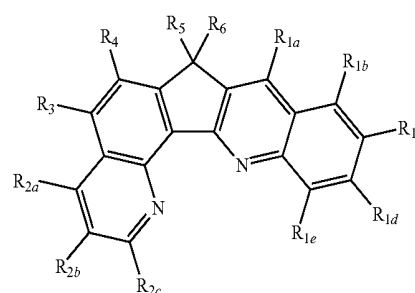


Formula 1(3)

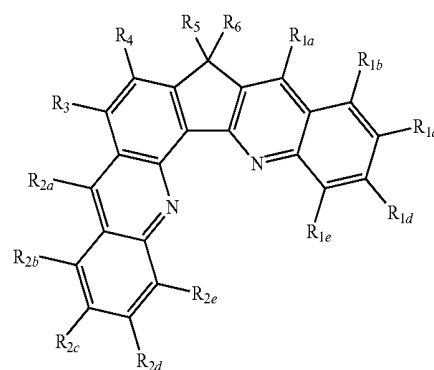


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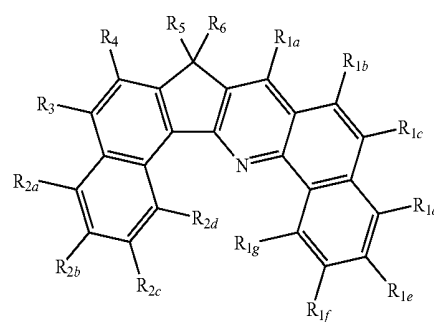
Formula 1(4)



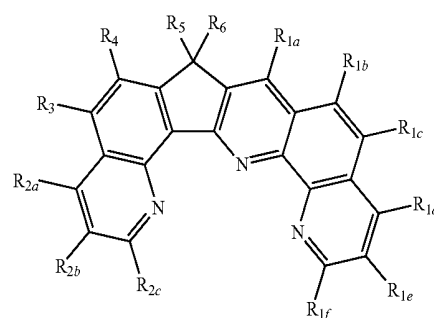
Formula 1(5)



Formula 1(6)

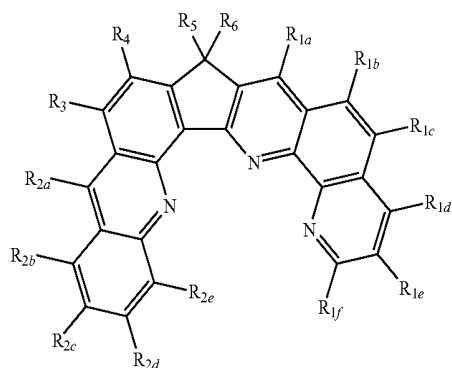


Formula 1(7)



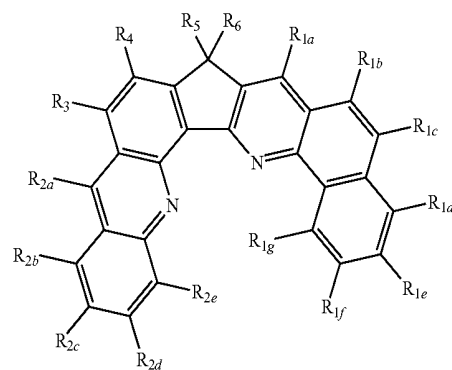
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Formula 1(8)

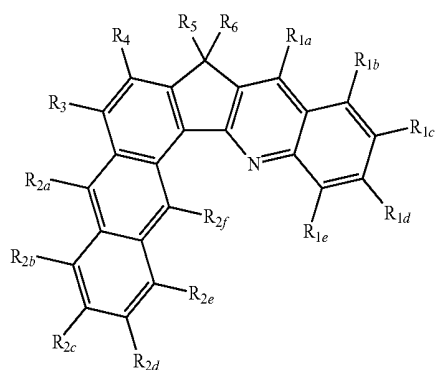


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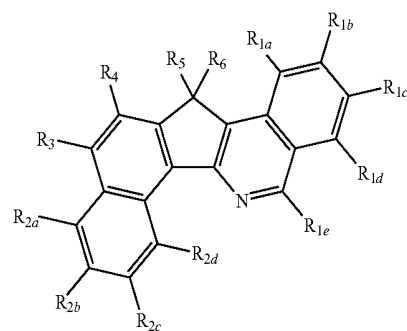
Formula 1(12)



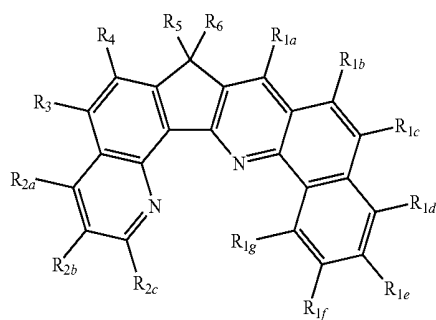
Formula 1(9)



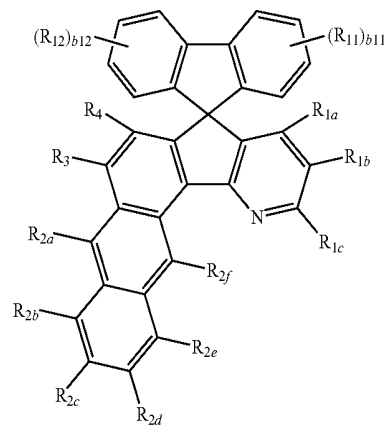
Formula 1(13)



Formula 1(10)

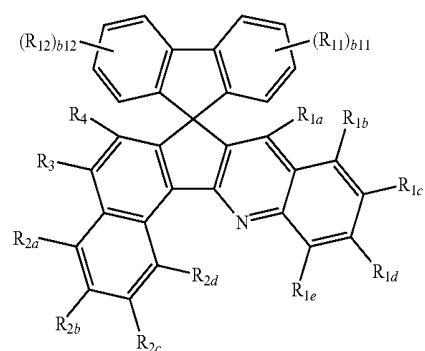
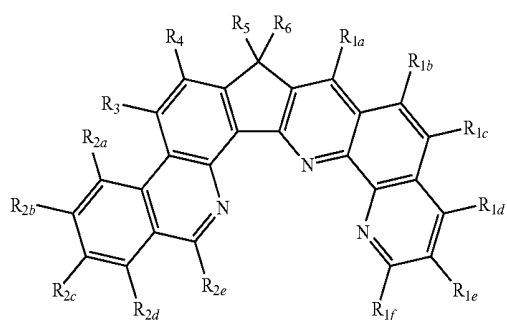


Formula 1A(1)



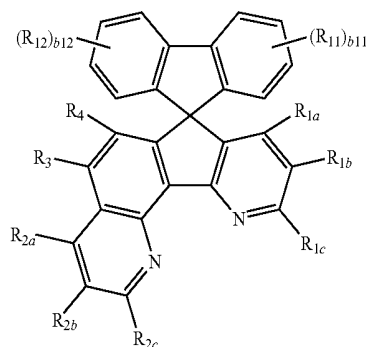
Formula 1A(2)

Formula 1(11)



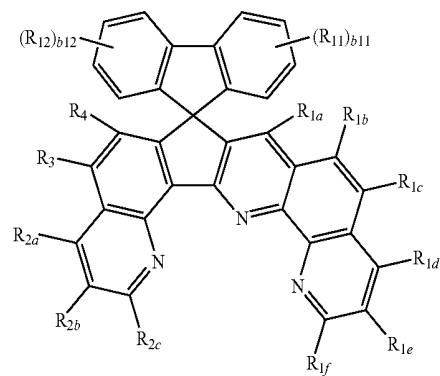
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Formula 1A(3)

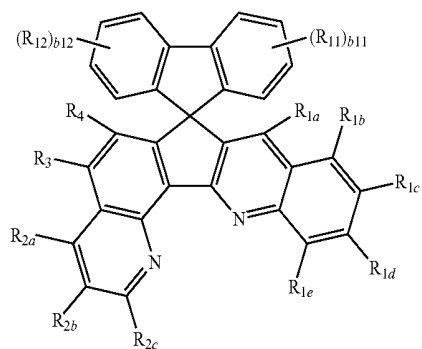


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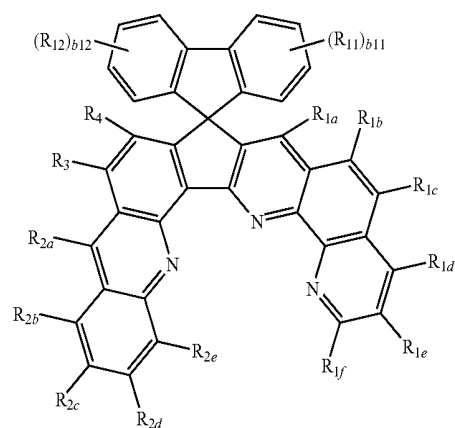
Formula 1A(7)



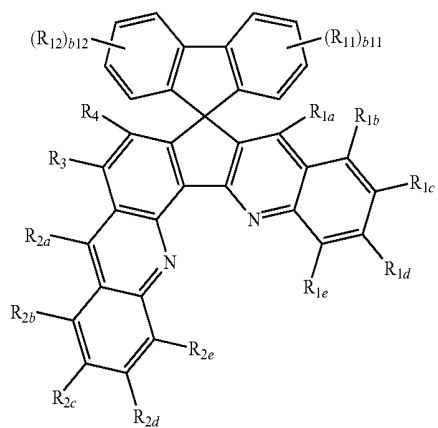
Formula 1A(4)



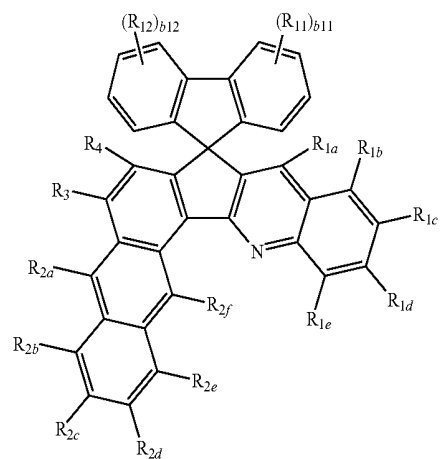
Formula 1A(8)



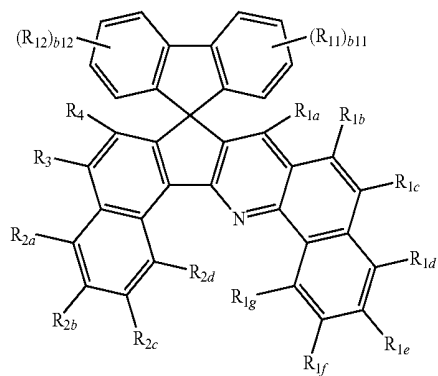
Formula 1A(5)



Formula 1A(9)

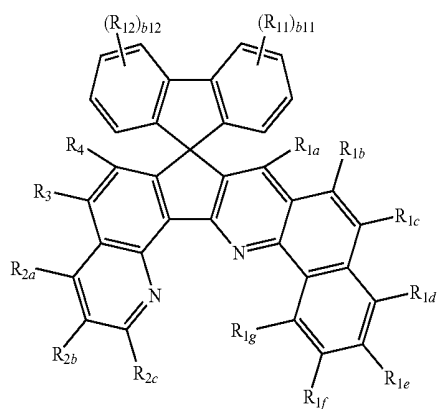


Formula 1A(6)



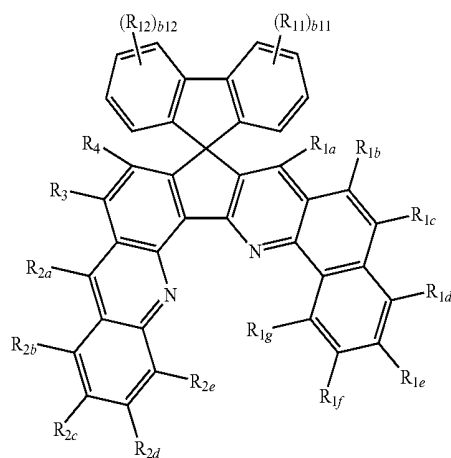
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Formula 1A(10)

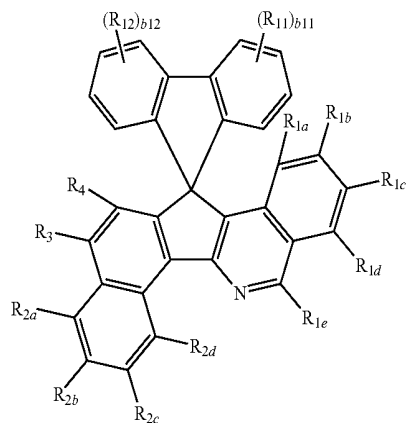


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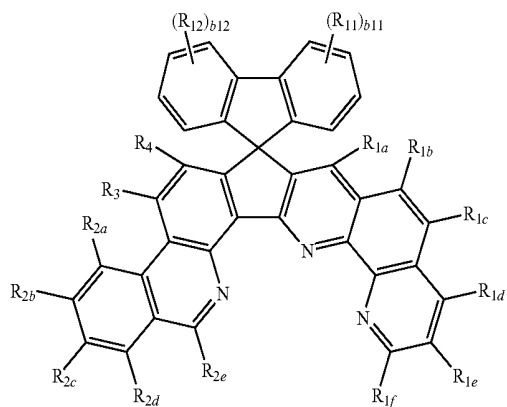
Formula 1A(12)



Formula 1A(13)

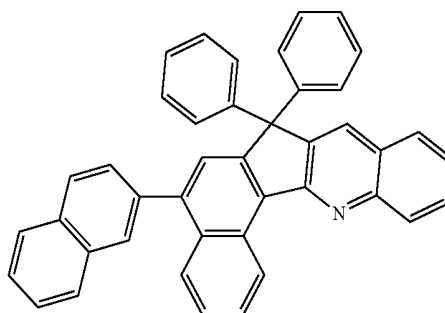
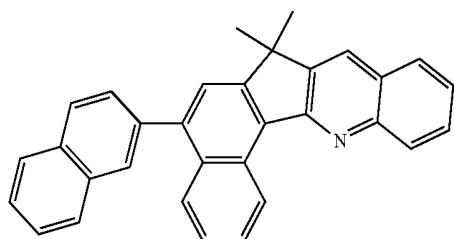


Formula 1A(11)

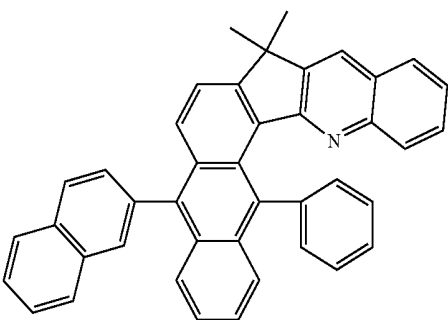
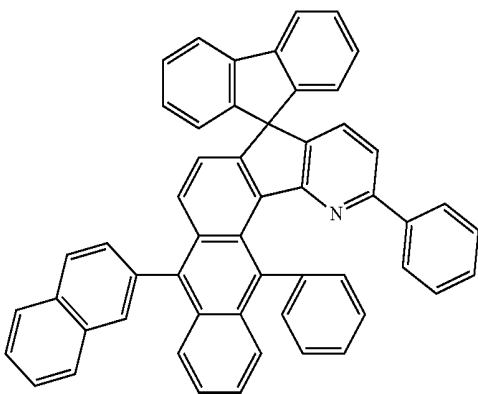
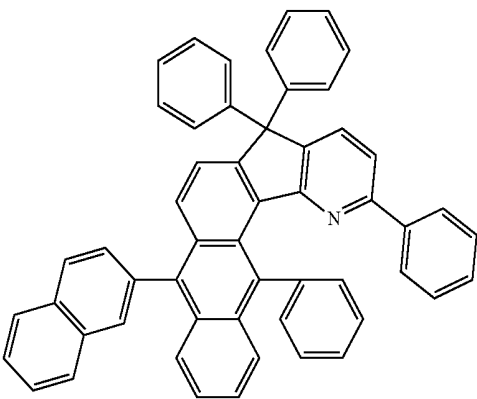
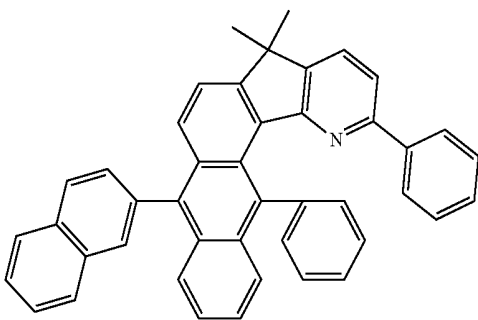
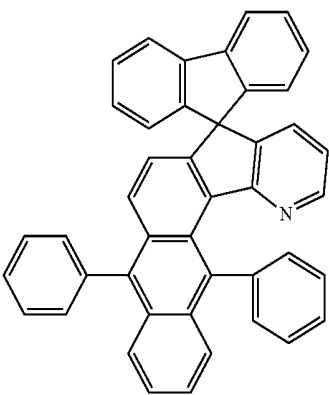
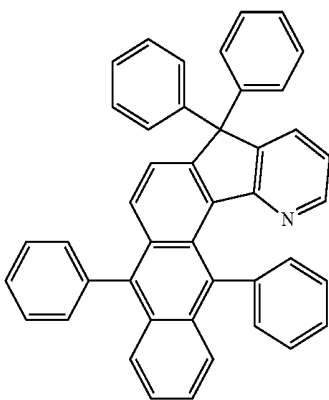
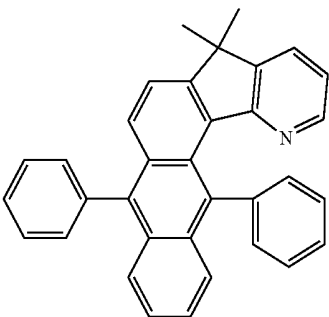
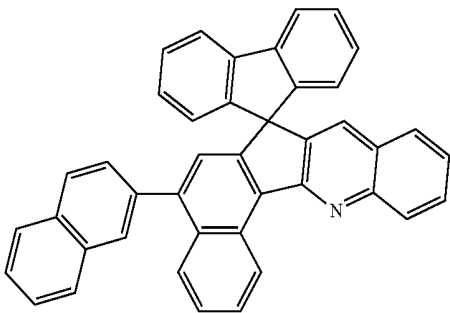


wherein, in Formulae 1(1) to 1(13) and Formula 1A(1) to 1A(13), R₃ and R₄ are defined the same as those in claim 1, R_{1a} to R_{1g}, R₁₁, and R₁₂ are each independently defined the same as R₁ in claim 1, and R_{2a} to R_{2f} are each independently defined the same as R₂ in claim 1.

16. The condensed cyclic compound as claimed in claim 1, wherein the condensed cyclic compound is one of Compounds 1 to 67:

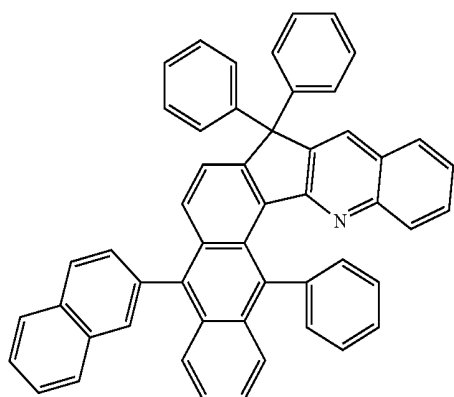


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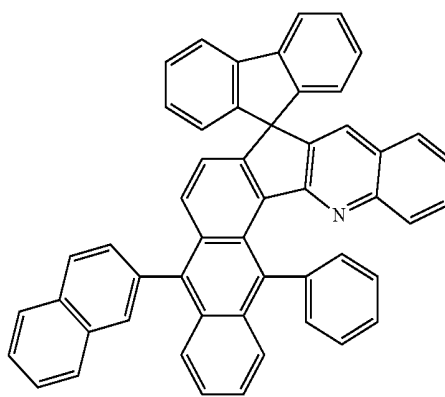


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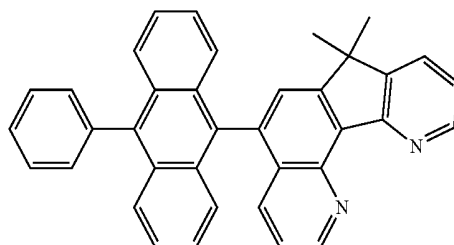
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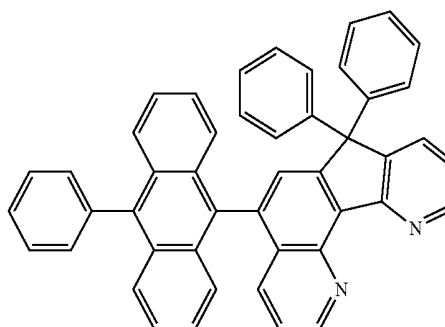
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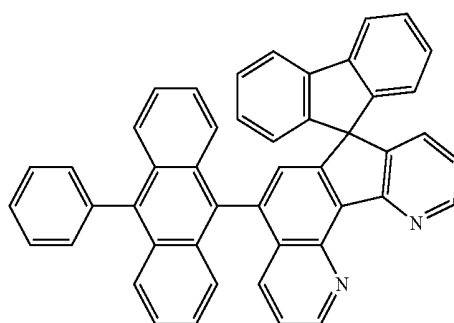
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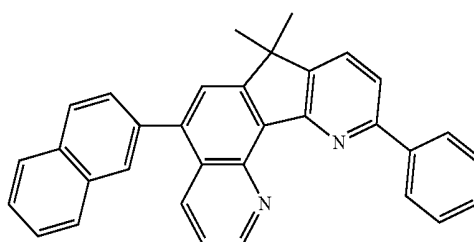
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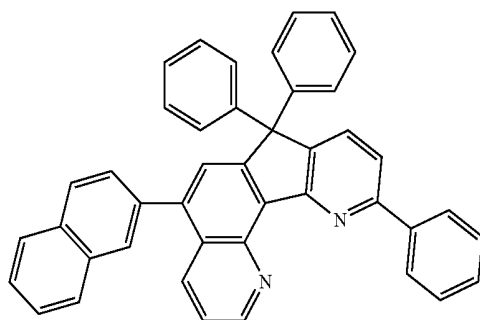
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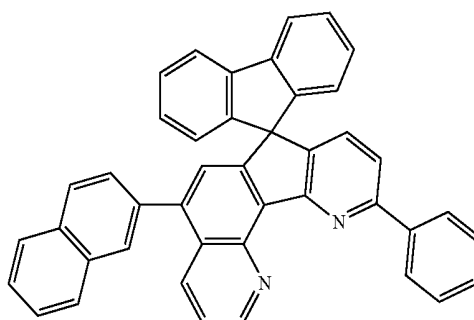
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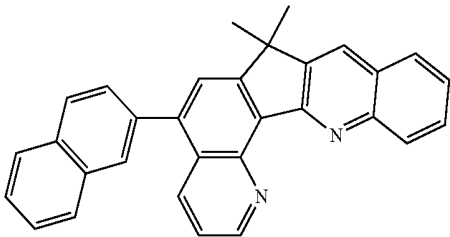
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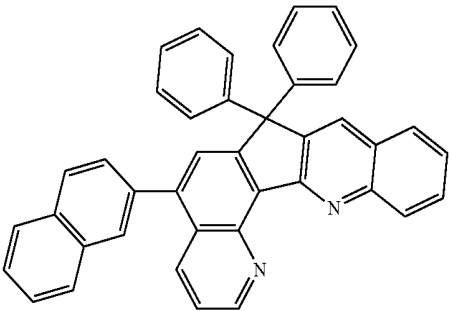
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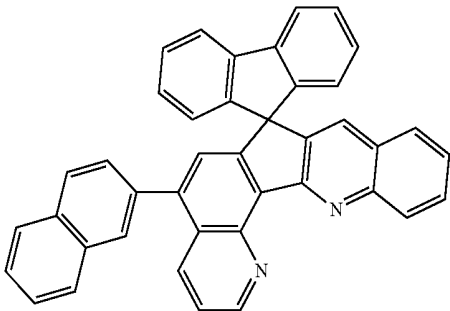
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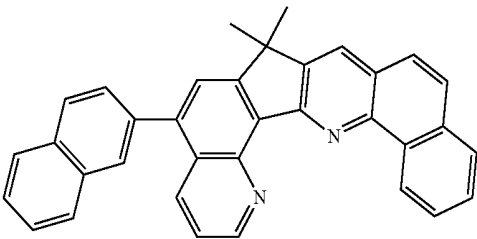
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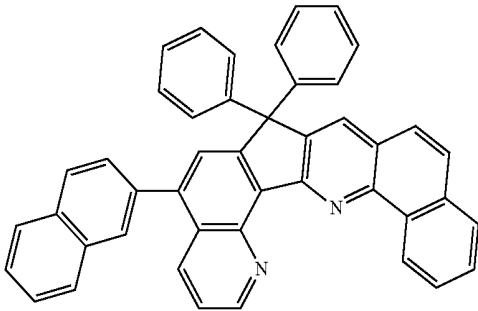
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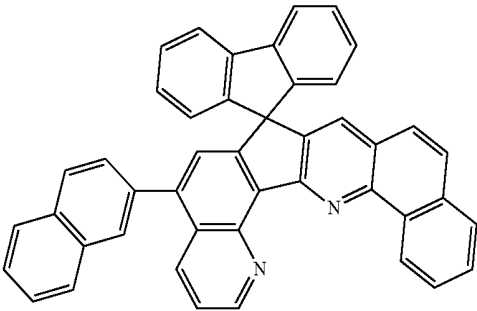
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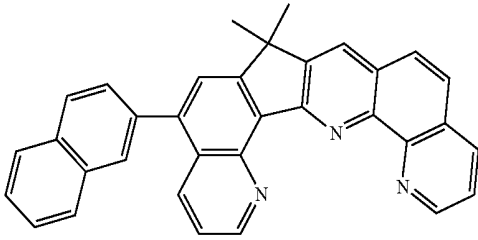
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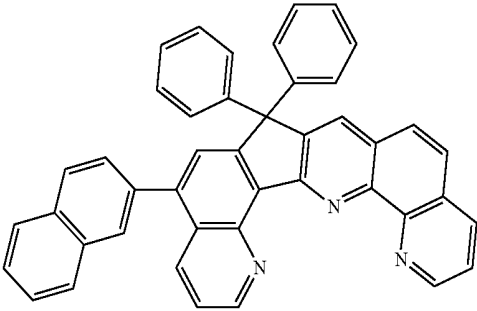
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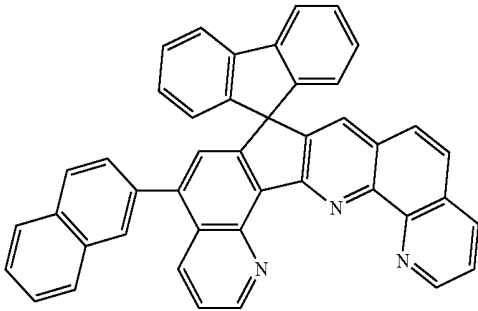
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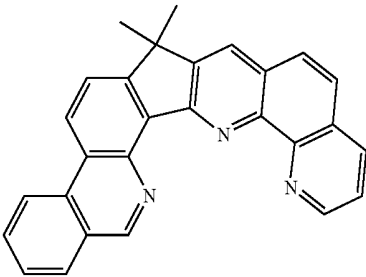
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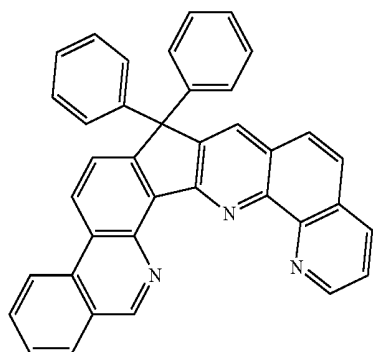
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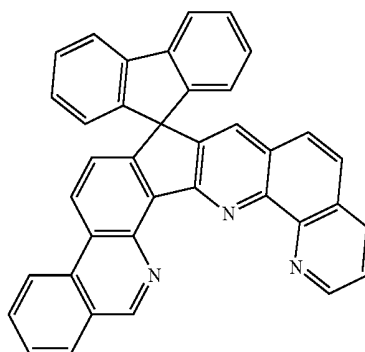
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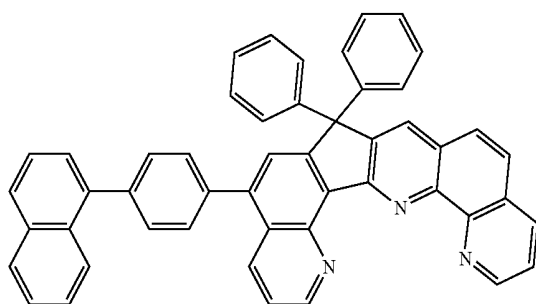
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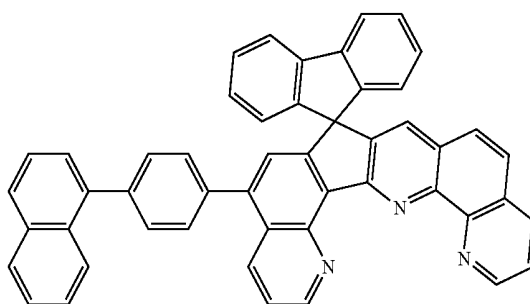
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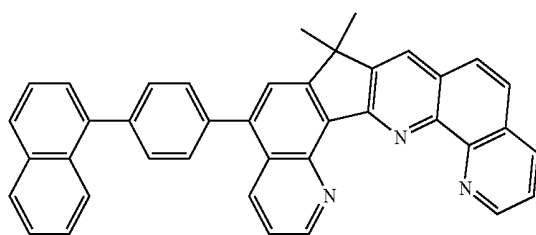
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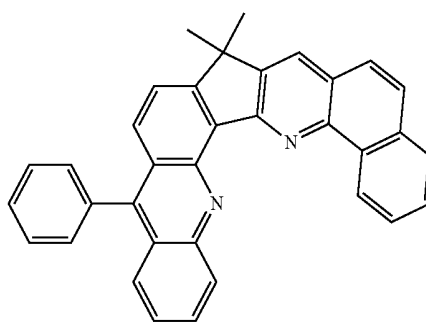
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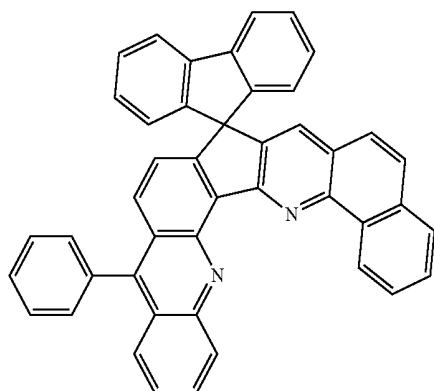
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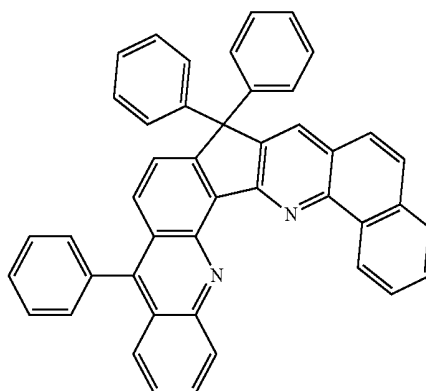
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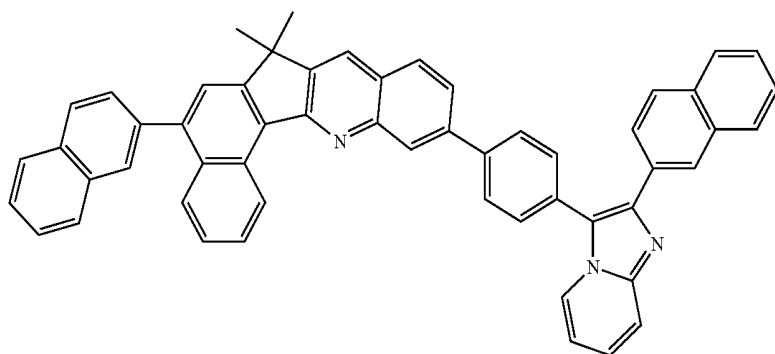


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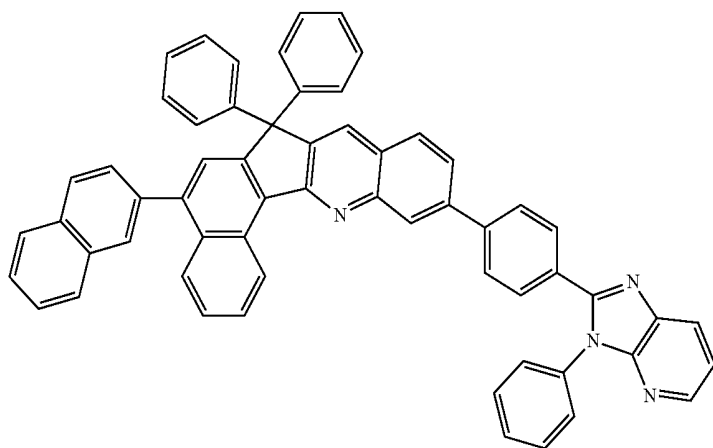


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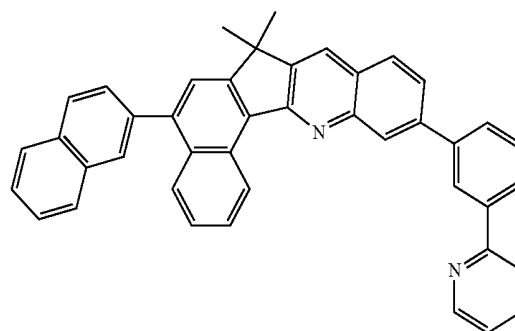
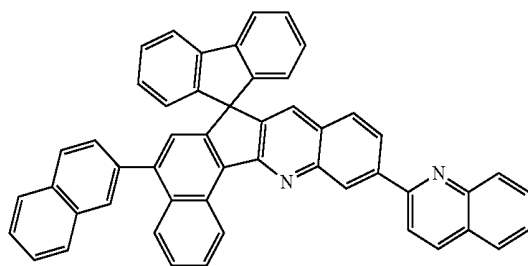


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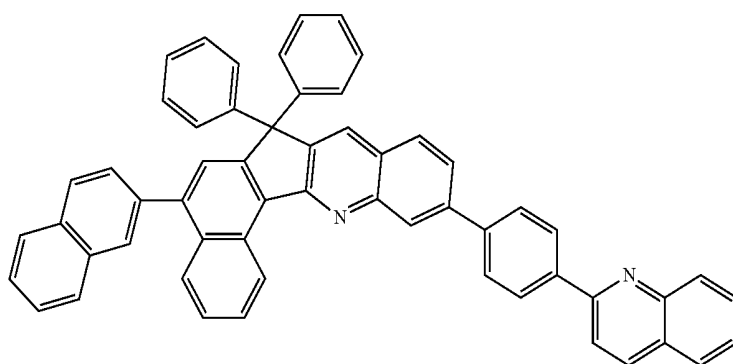


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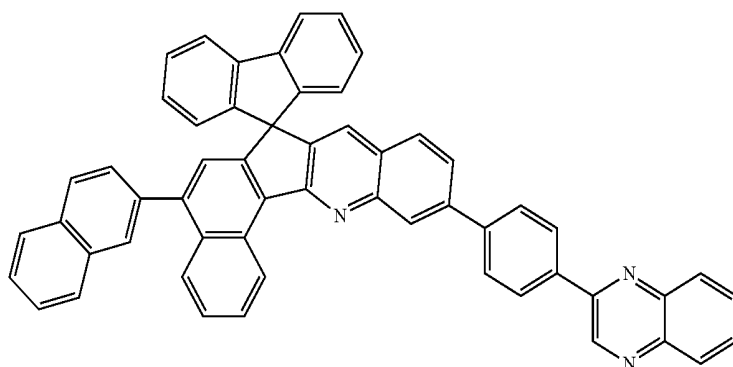


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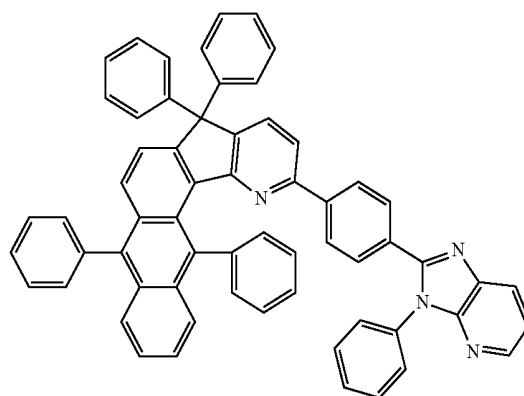
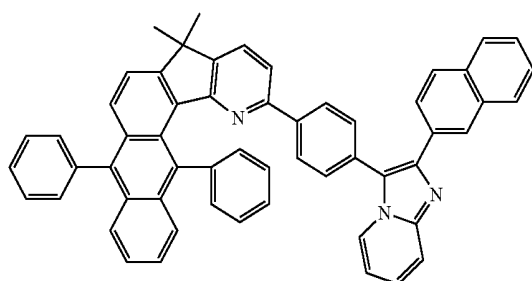
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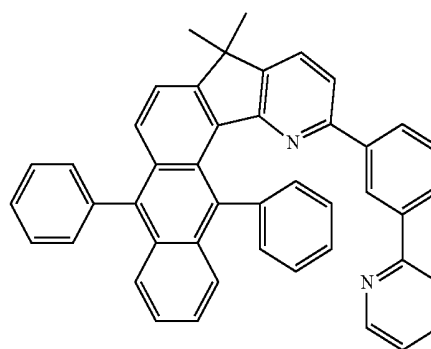
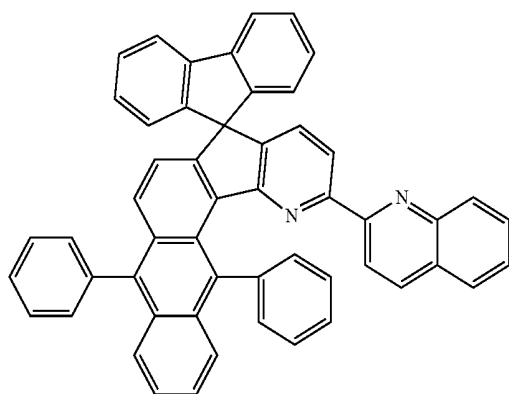
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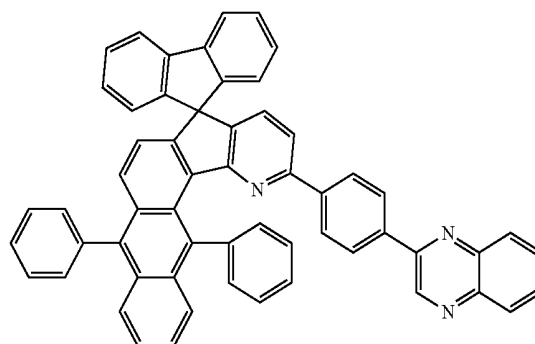
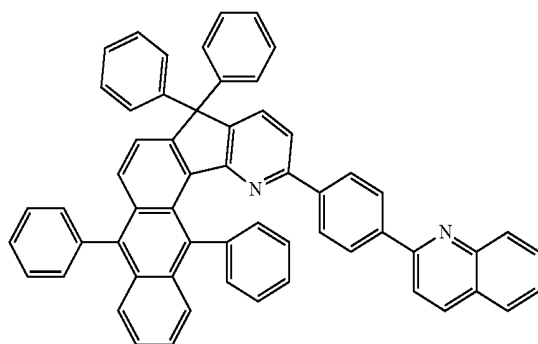
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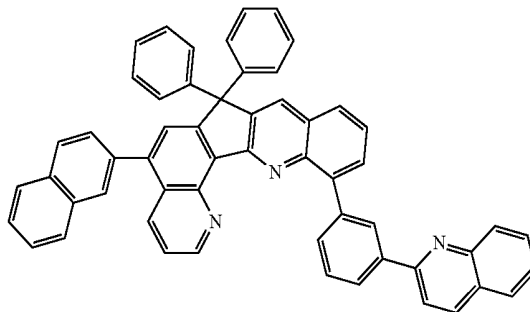
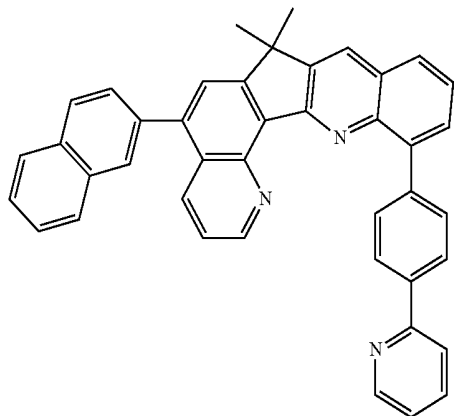
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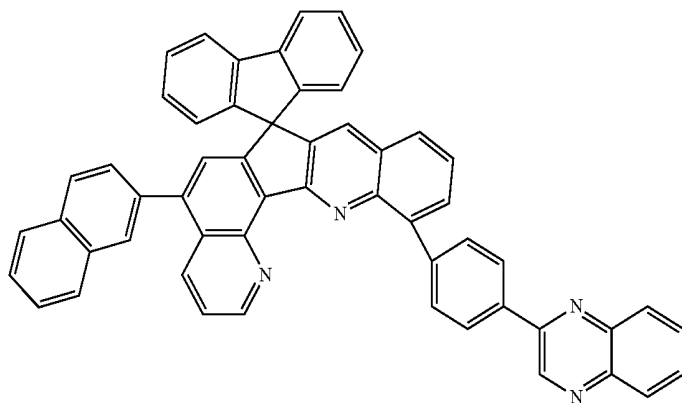
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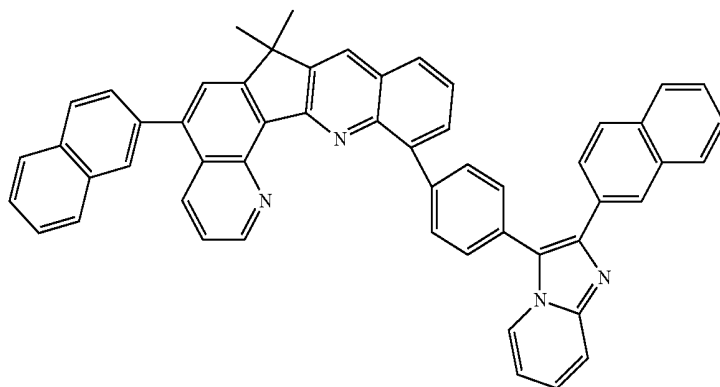
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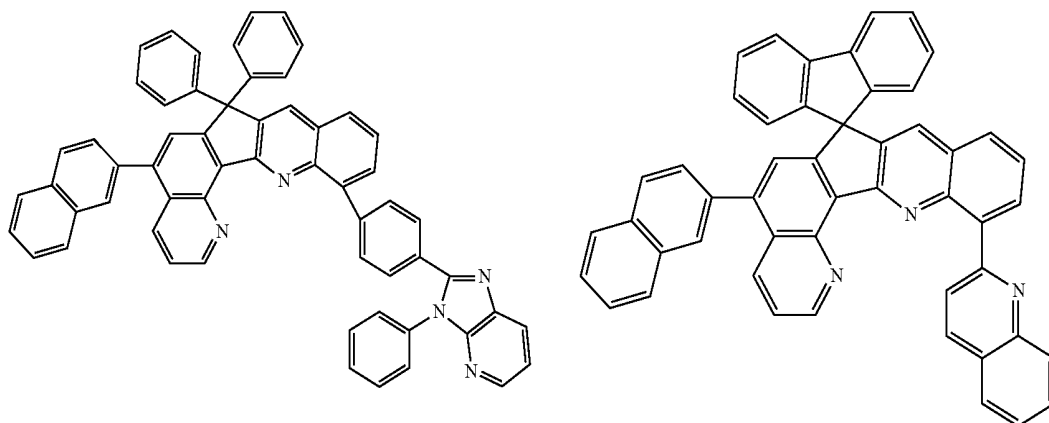
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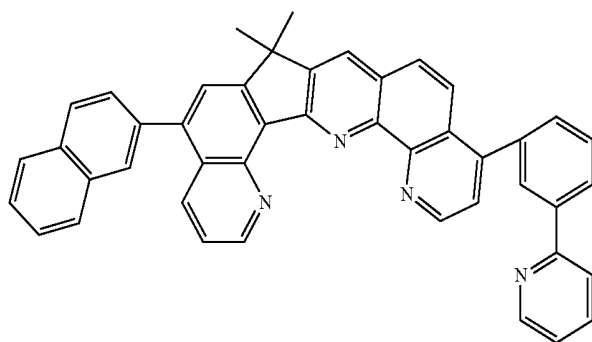
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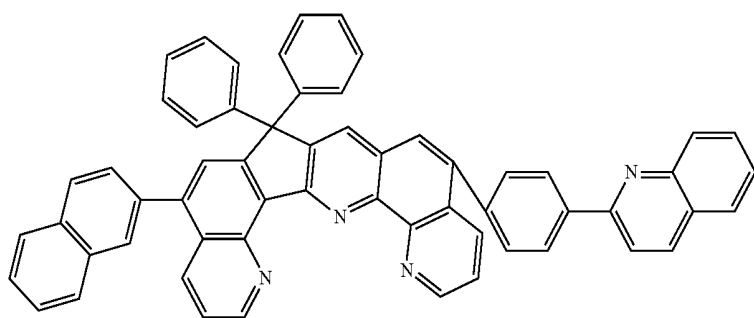
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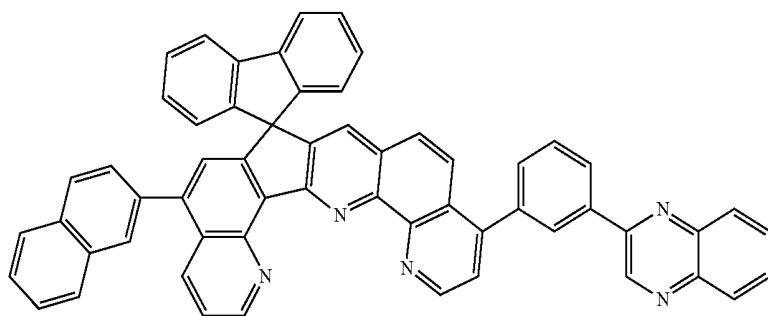
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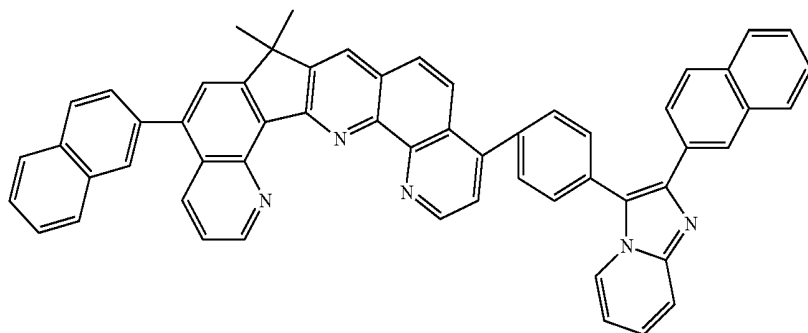


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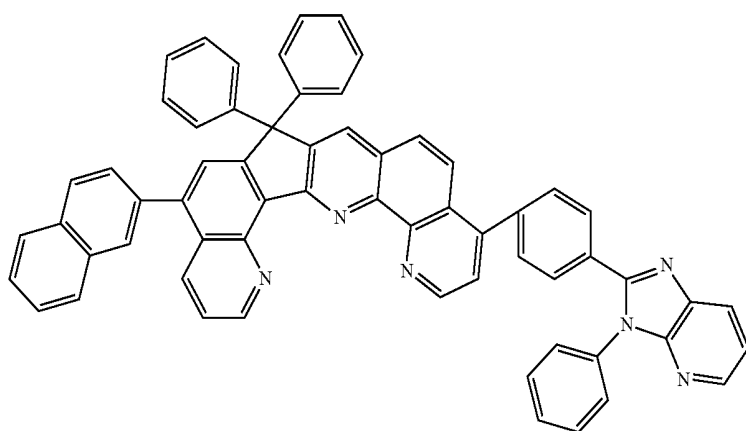


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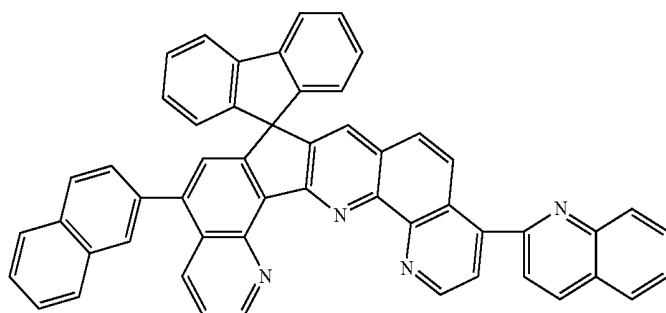
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17. An organic light-emitting device, comprising:
a first electrode;

a second electrode disposed opposite to the first electrode;
and

an organic layer disposed between the first electrode and the second electrode and comprising an emission layer, wherein the organic layer comprises at least one condensed cyclic compound as claimed in claim 1.

18. The organic light-emitting device as claimed in claim 17, wherein:

the first electrode is an anode,

the second electrode is a cathode, and

the organic layer includes:

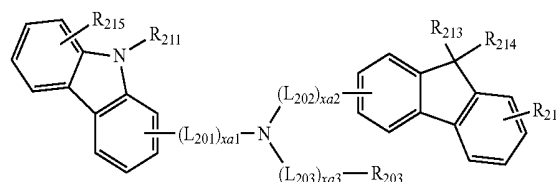
- i) a hole transport region disposed between the first electrode and the emission layer and including at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and
- ii) an electron transport region disposed between the emission layer and the second electrode and including at least

one of a hole blocking layer, an electron transport layer, and an electron injection layer.

19. The organic light-emitting device as claimed in claim 18, wherein the electron transport region includes the at least one condensed cyclic compound.

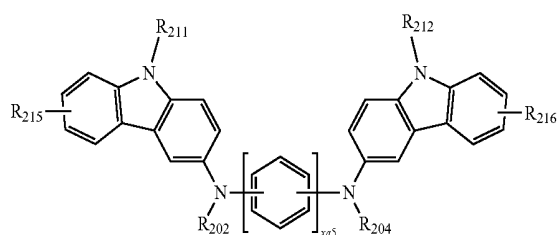
20. The organic light-emitting device as claimed in claim 18, wherein the hole transport region includes at least one of a compound represented by Formula 201 A and a compound represented by Formula 202A:

<Formula 201A>



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<Formula 202A>



wherein, in Formulae 201A and 202A,

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

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolylenylene group, and a triazinylene group; and

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolylenylene group, and a triazinylene group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, and a triazinyl group,

$xa1$ to $xa3$ are each independently 0 or 1;

R_{202} to R_{204} , R_{211} , and R_{212} are each independently selected from

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

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a

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

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

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

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

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

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

quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, and a triazinyl group,

R₂₁₅ and R₂₁₆ are each independently selected from

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

a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, and a triazinyl group;

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

nyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, and a triazinyl group, and

xa5 is 1 or 2.

* * * * *

专利名称(译)	缩合环状化合物和包含其的有机发光器件		
公开(公告)号	US20150318490A1	公开(公告)日	2015-11-05
申请号	US14/701088	申请日	2015-04-30
[标]申请(专利权)人(译)	三星显示有限公司 成均馆大学校产学协力团		
申请(专利权)人(译)	三星DISPLAY CO. , LTD. 研究与业务基础韩国成均馆大学		
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发明人	KIM, MYEONGSUK KIM, SUNGWOOK HWANG, JINSOO YOON, SEUNGSOO		
IPC分类号	H01L51/00 C09K11/06 C07D471/14 C07D221/18 C07D471/04		
CPC分类号	H01L51/0072 C07D221/18 C07D471/04 C07D471/14 H01L51/5056 C09K2211/1029 C09K2211/1011 C09K2211/1007 H01L51/5072 C09K11/06 C09B1/00 C09B5/00 C09B23/148 C09B57/00 C09B57/001 C09B57/008 C09B57/02 C09B57/10 H01L51/0052 H01L51/0054 H01L51/006		
优先权	1020140053610 2014-05-02 KR 1020150061881 2015-04-30 KR		
其他公开文献	US10087145		
外部链接	Espacenet USPTO		

摘要(译)

提供由式1表示的稠环化合物和包含该稠环化合物的有机发光装置;

