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

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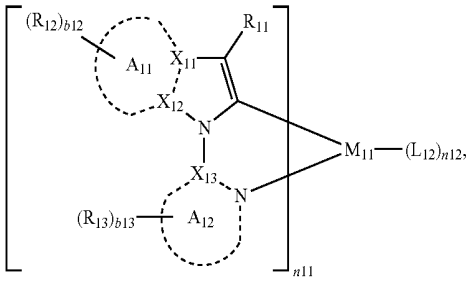
(52) **U.S. Cl.**

CPC ***H01L 51/0085*** (2013.01); *H01L 51/5016* (2013.01); ***C07F 15/0033*** (2013.01)

(57) **ABSTRACT**

An organometallic compound represented by Formula 1:

Formula 1



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

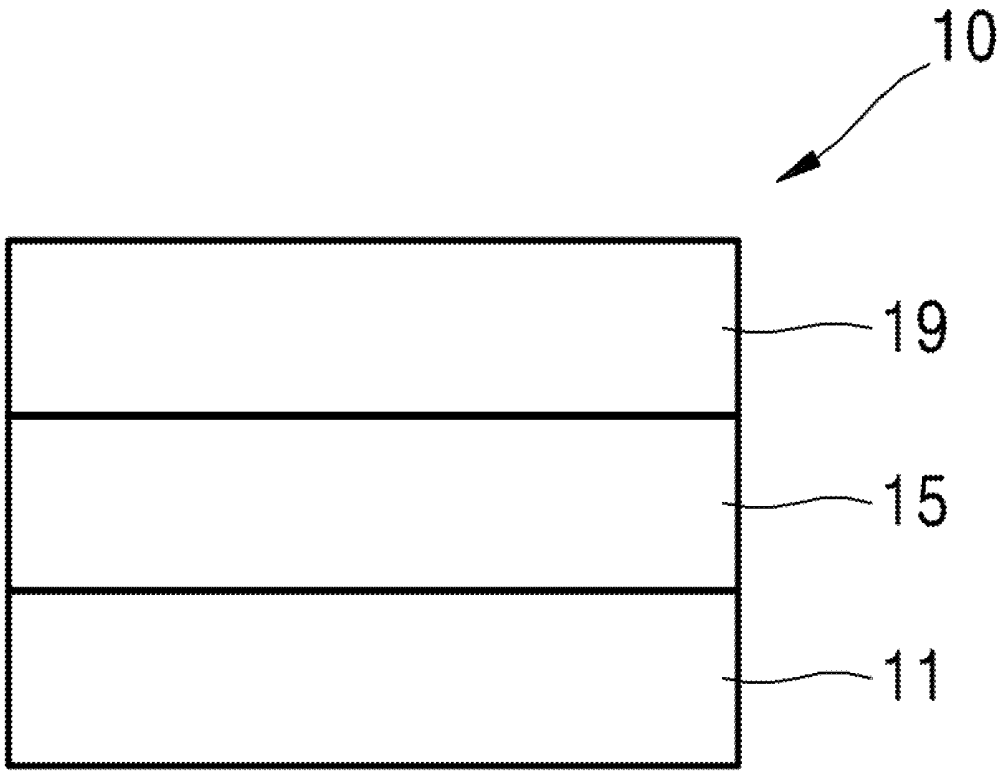


FIG. 1

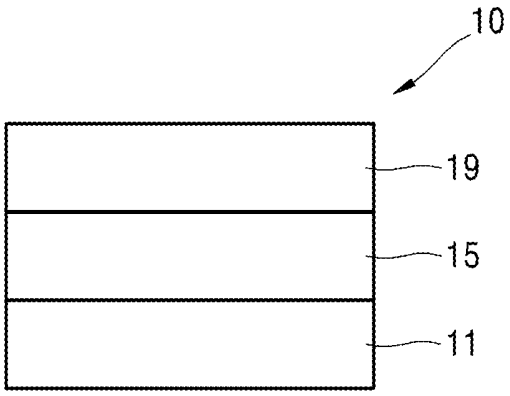
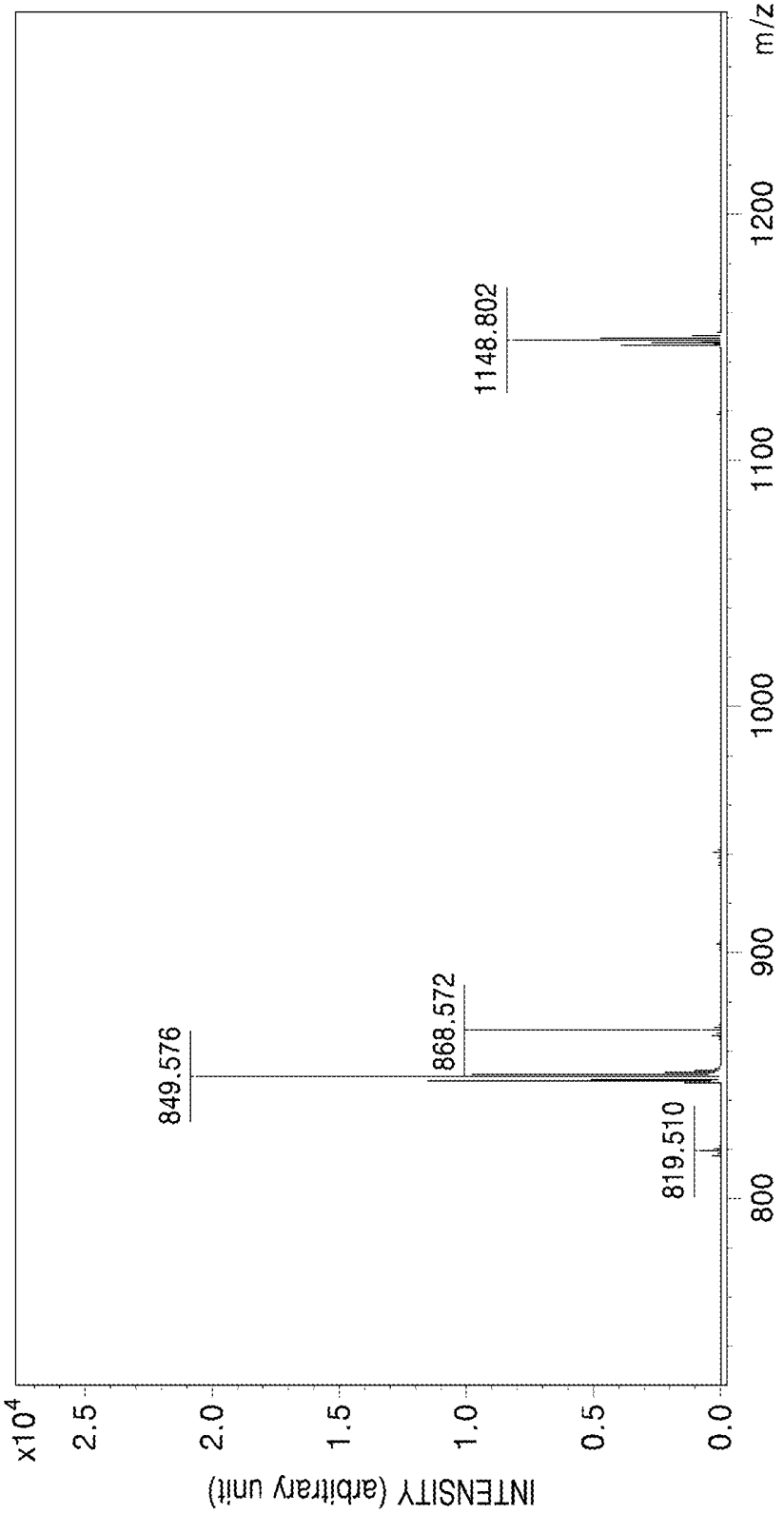


FIG. 2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1.5
1.0
0.5
0.0
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1000
1100
1200
m/z
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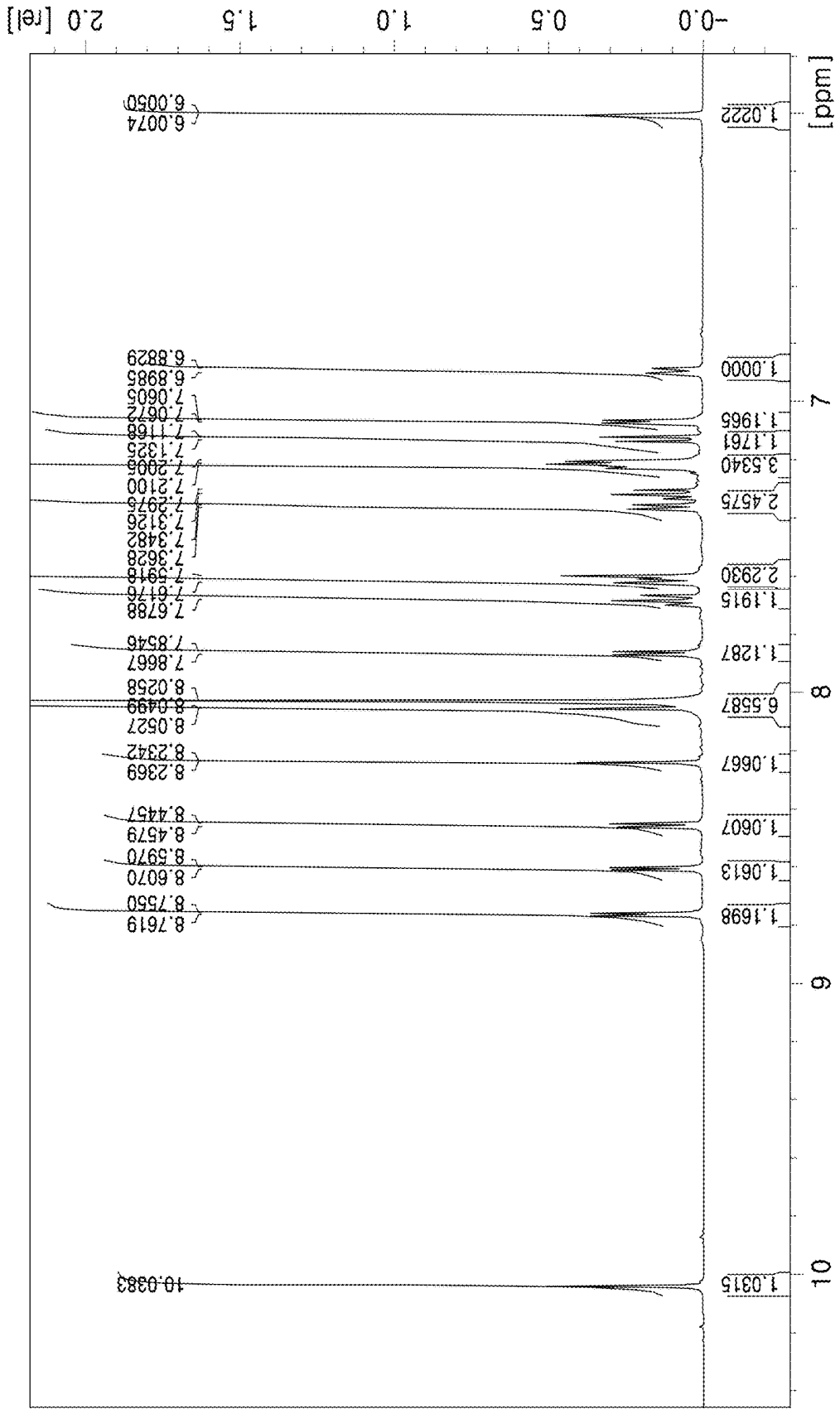
868.572
819.510
1148.802

FIG. 3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7.3628
7.5918
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7.8667
8.0258
8.0499
8.0527
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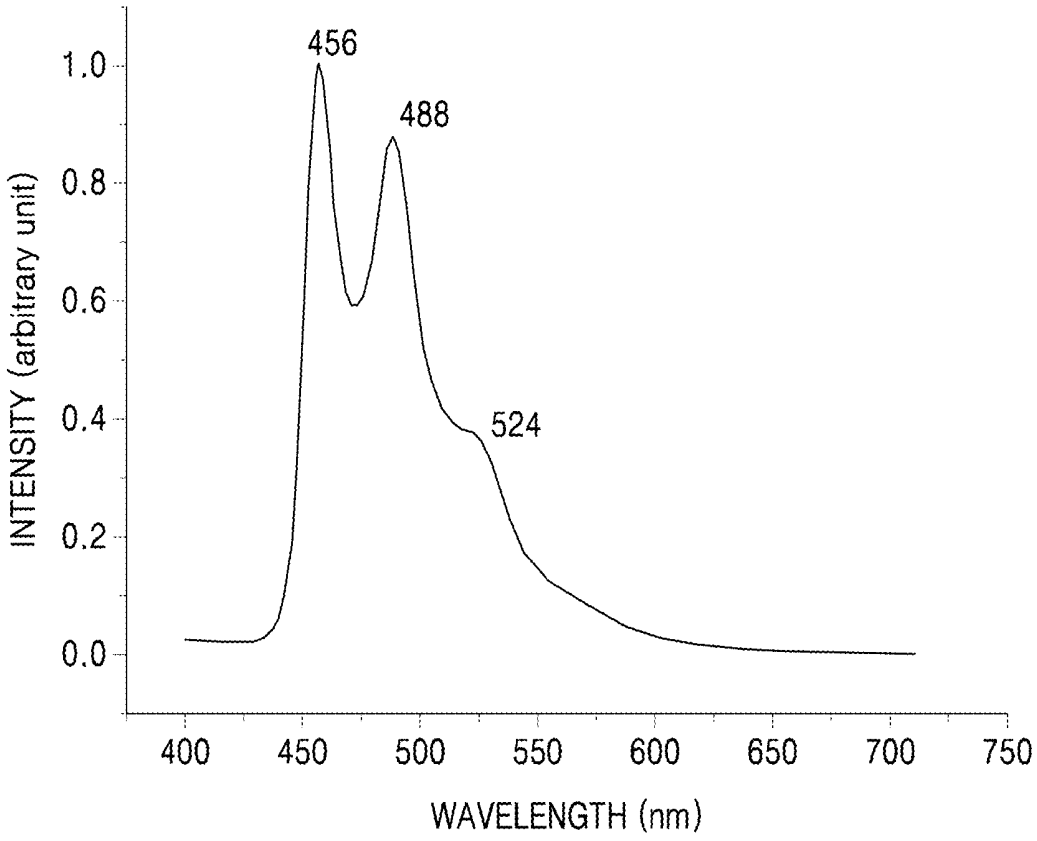
1.0315

FIG. 4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524
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0.8
0.6
0.4
0.2
0.0
INTENSITY (arbitrary unit)
400
450
500
550
600
650
700
750
WAVELENGTH (nm)

ORGANOMETALLIC COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2017-0111043, filed on Aug. 31, 2017, in the Korean Intellectual Property Office, and all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

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

2. Description of the Related Art

[0003] Organic light-emitting devices (OLEDs) are self-emission devices that produce full-color images, and that also have wide viewing angles, high contrast ratios, short response times, and excellent characteristics in terms of brightness, driving voltage, and response speed, compared to devices in the art.

[0004] In an example, an organic light-emitting device includes an anode, a cathode, and an organic layer disposed between the anode and the cathode, wherein the organic layer includes an emission layer. A hole transport region may be disposed between the anode and the emission layer, and an electron transport region may be disposed between the emission layer and the cathode. Holes provided from the anode may move toward the emission layer through the hole transport region, and electrons provided from the cathode may move toward the emission layer through the electron transport region. The holes and the electrons recombine in the emission layer to produce excitons. These excitons transit from an excited state to a ground state, thereby generating light.

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

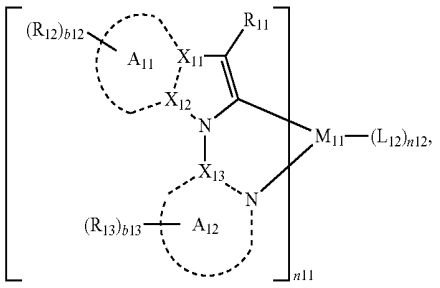
SUMMARY

[0006] Aspects of the present disclosure provide a novel organometallic compound and an organic light-emitting device including the same.

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

[0008] An aspect provides an organometallic compound represented by Formula 1:

Formula 1



[0009] in Formula 1,

[0010] M_{11} is selected from first-row transition metals, second-row transition metals, third-row transition metals, first-row post-transition metals, second-row post-transition metals, and third-row post-transition metals,

[0011] A_{11} and A_{12} are each independently a nitrogen atom-containing C_1-C_{30} heterocyclic group,

[0012] X_{11} and X_{12} are each independently selected from C and N,

[0013] X_{13} is C,

[0014] R_{11} to R_{13} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, —SF_5, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$,

[0015] R_{11} to R_{13} are optionally linked to form a ring,

[0016] two, three, or four of a plurality of R_{11} to R_{13} that are adjacent to each other are optionally linked to form a quadridentate, hexadentate, or octadentate ligand,

[0017] b12 and b13 are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,

[0018] n11 is selected from 1, 2, 3, and 4,

[0019] n12 is selected from 0, 1, 2, and 3,

[0020] L_{12} is selected from a bidentate ligand, and

[0021] Q_1 to Q_9 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro 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_1-C_{60} alkyl group substituted with at least one selected

from deuterium, a C_1-C_{60} alkyl group, and a C_6-C_{60} aryl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, and a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0022] Another aspect provides an organic light-emitting device including:

[0023] a first electrode;

[0024] a second electrode; and

[0025] an organic layer disposed between the first electrode and the second electrode,

[0026] wherein the organic layer includes an emission layer, and

[0027] wherein the organic layer includes the organometallic compound. The organometallic compounds may act as a dopant in the emission layer.

BRIEF DESCRIPTION OF THE DRAWING

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

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

[0030] FIG. **2** is a graph of intensity (arbitrary unit, a. u.) versus mass-to-charge ratio (m/z) that shows data resulted from matrix-assisted laser desorption/ionization (MALDI) with respect to Compound 8;

[0031] FIG. **3** is a graph of intensity versus chemical shift (part per million, ppm) that shows data resulted from ^{1}H-NMR with respect to Compound 8; and

[0032] FIG. **4** is a graph of intensity (arbitrary unit, a. u.) versus wavelength (nanometers, nm) that shows photoluminescence (PL) spectrum data of Compound 8.

DETAILED DESCRIPTION

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

[0034] It will be understood that when an element is referred to as being "on" another element, it can be directly in contact with the other element or intervening elements may be present therebetween. In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.

[0035] It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers, and/or sections, these elements, components, regions, layers, and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer, or section from another element, component, region, layer, or section. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the present embodiments.

[0036] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0037] The term "or" means "and/or." It will be further understood that the terms "comprises" and/or "comprising," or "includes" and/or "including" when used in this specification, specify the presence of stated features, regions, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components, and/or groups thereof.

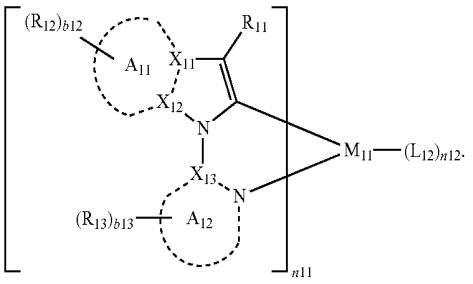
[0038] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this general inventive concept belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0039] Exemplary embodiments are described herein with reference to cross section illustrations that are schematic illustrations of idealized embodiments. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments described herein should not be construed as limited to the particular shapes of regions as illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. For example, a region illustrated or described as flat may, typically, have rough and/or nonlinear features. Moreover, sharp angles that are illustrated may be rounded. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the precise shape of a region and are not intended to limit the scope of the present claims.

[0040] "About" or "approximately" as used herein is inclusive of the stated value and means within an acceptable range of deviation for the particular value as determined by one of ordinary skill in the art, considering the measurement in question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement system). For example, "about" can mean within one or more standard deviations, or within ±30%, 20%, 10%, 5% of the stated value.

[0041] In an embodiment, an organometallic compound represented by Formula 1 is provided:

Formula 1



[0042] In Formula 1, M_{11} may be selected from first-row transition metals, second-row transition metals, third-row transition metals, first-row post-transition metals, second-row post-transition metals, and third-row post-transition metals.

[0043] For example, in Formula 1, M_{11} may be selected from platinum (Pt), palladium (Pd), copper (Cu), silver (Ag), gold (Au), rhodium (Rh), iridium (Ir), ruthenium (Ru), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), rhenium (Re), europium (Eu), terbium (Tb), thulium (Tm), and lead (Pb), but embodiments of the present disclosure are not limited thereto.

[0044] In one or more embodiments, in Formula 1, M_{11} may be selected from Pt, Pd, Ir, Ru, Os, Re, and Pb, but embodiments of the present disclosure are not limited thereto.

[0045] In one or more embodiments, in Formula 1, M_{11} may be selected from Ir, Os, and Pt, but embodiments of the present disclosure are not limited thereto.

[0046] In one or more embodiments, in Formula 1, M_{11} may be Ir, but embodiments of the present disclosure are not limited thereto.

[0047] In Formula 1, A_{11} and A_{12} may each independently be selected from a nitrogen atom-containing C_1-C_{30} heterocyclic group.

[0048] For example, in Formula 1, A_{11} and A_{12} may each independently be selected from an indole group, a carbazole group, an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a dihydropyridine group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a phenanthroline group, a pyrrole group, a pyrazole group, an imidazole group, a 2,3-dihydroimidazole group, a triazole group, a 2,3-dihydrotriazole group, an oxazole group, an isoxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a 2,3-dihydrobenzimidazole group, an imidazopyridine group, a 2,3-dihydroimidazopyridine group, an imidazopyrimidine group, a 2,3-dihydroimidazopyrimidine group, an imidazopyrazine group, a 2,3-dihydroimidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzooxadiazole group, a benzothiadiazole group, a 5,6,7,8-tetrahydroisoquinoline group, and a 5,6,7,8-tetrahydroquinoline group, but embodiments of the present disclosure are not limited thereto.

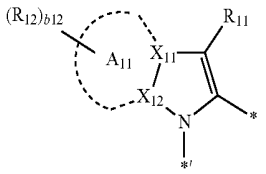
[0049] In one or more embodiments, in Formula 1, A_{11} and A_{12} may each independently be selected from an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolo-pyrimidine group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a phenanthroline group, an imidazopyridine group, an imidazopyrimidine group, and an imidazopyrazine group, but embodiments of the present disclosure are not limited thereto.

[0050] In one or more embodiments, in Formula 1, A_{11} and A_{12} may each independently be selected from a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, and a phenanthroline group, but embodiments of the present disclosure are not limited thereto.

[0051] In Formula 1, X_{11} and X_{12} may each independently be selected from C and N.

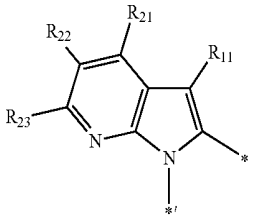
[0052] For example, in Formula 1, X_{11} and X_{12} may each independently C, but embodiments of the present disclosure are not limited thereto.

[0053] In one or more embodiments, in Formula 1, a partial structure represented by



(wherein * and *' each indicate a binding site to a neighboring atom) may be represented by one of Formulae 2-1 to 2-12, but embodiments of the present disclosure are not limited thereto:

2-1



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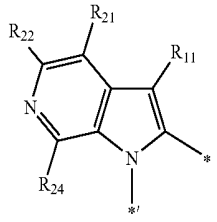

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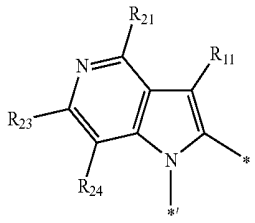
2-3



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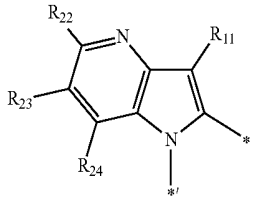

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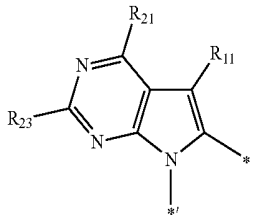
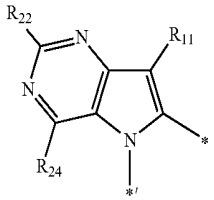


2-6



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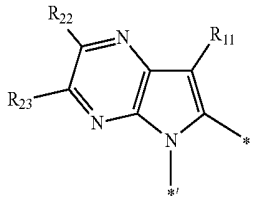

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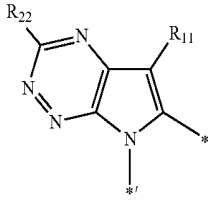

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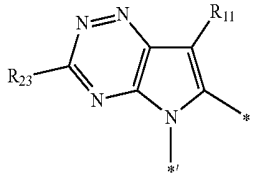

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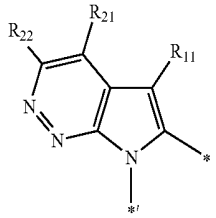
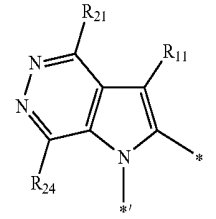
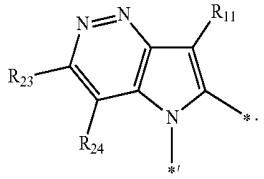
2-10



2-11



2-12



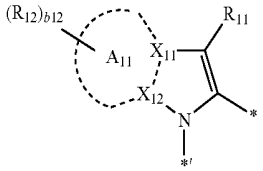
[0054] In Formulae 2-1 to 2-12,

[0055] R_{11} is the same as described in connection with Formula 1,

[0056] R_{21} to R_{24} may each independently be the same as described in connection with R_{12} in Formula 1, and

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

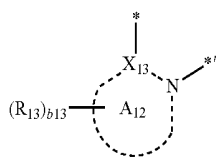
[0058] In various embodiments, in Formula 1, a partial structure represented by



(wherein * and *' each indicate a binding site to a neighboring atom) may be represented by one of Formulae 2-1 to 2-4, but embodiments of the present disclosure are not limited thereto.

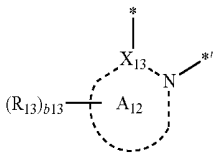
[0059] In Formula 1, X_{13} may be C.

[0060] In one or more embodiments, in, Formula 1, a moiety represented by



may be represented by one of Formulae 3-1 to 3-5, but embodiments of the present disclosure are not limited thereto.

[0061] In one or more embodiments, in Formula 1, a moiety represented by



may be represented by Formula 3-1, but embodiments of the present disclosure are not limited thereto.

[0062] In Formula 1, R_{11} to R_{13} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, —SF_5, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$,

[0063] R_{11} to R_{13} may optionally be linked to form a ring.

[0064] Q_1 to Q_9 may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a 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_1-C_{60} alkyl group substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, and a C_6-C_{60} aryl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, and 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.

[0065] For example, in Formula 1, R_{11} to R_{13} may each independently be selected from:

[0066] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF_5, C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

[0067] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0068] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0069] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$; and

[0070] —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$, and

[0071] Q_1 to Q_9 and Q_{33} to Q_{35} may each independently be selected from:

[0072] —CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2,

[0073] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0074] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C_1-C_{10} alkyl group, and a phenyl group, but embodiments of the present disclosure are not limited thereto.

[0075] In one or more embodiments, in Formula 1, R_{11} to R_{13} may each independently be selected from:

[0076] hydrogen, deuterium, —F, a cyano group, a nitro group, —SF_5, a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an iso-decyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a dibenzosilolyl group;

[0077] a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an iso-decyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a dibenzosilolyl group, each substituted with at least one selected from deuterium, —F, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a cyano group, a nitro group, a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$; and

[0078] —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$, and

[0079] Q_1 to Q_9 and Q_{33} to Q_{35} may each independently be selected from:

[0080] —CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2;

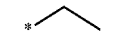
[0081] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl

group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0082] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C_1-C_{10} alkyl group, and a phenyl group, but embodiments of the present disclosure are not limited thereto.

[0083] In one or more embodiments, in Formula 1, R_{11} to R_{13} may each independently be selected from hydrogen, deuterium, —F, a cyano group, a nitro group, —SF_5, —CH_3, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, groups represented by Formulae 9-1 to 9-21, groups represented by Formulae 10-1 to 10-253, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$, but embodiments of the present disclosure are not limited thereto:

9-1



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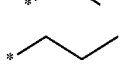

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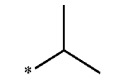

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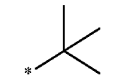

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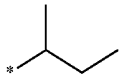

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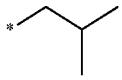

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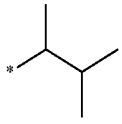

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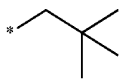

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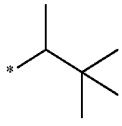

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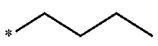

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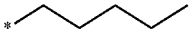

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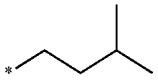

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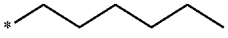

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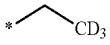

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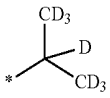

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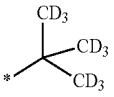

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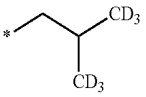

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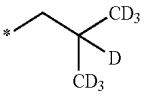

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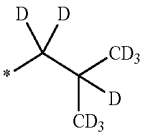

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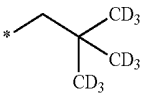
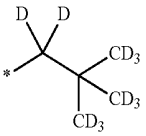


9-21



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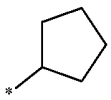

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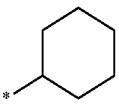

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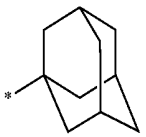

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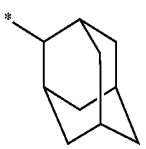

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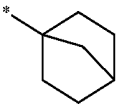

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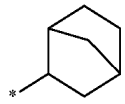

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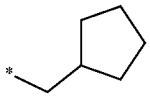

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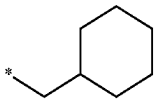

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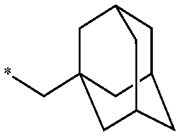

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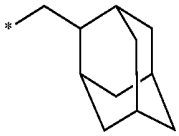

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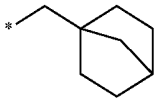

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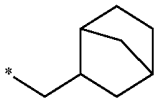

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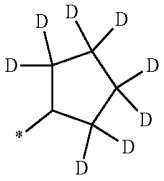

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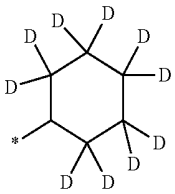

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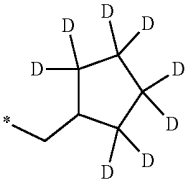

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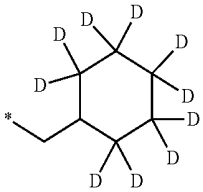

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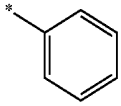

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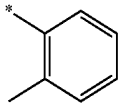

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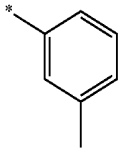

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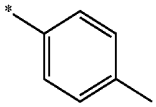

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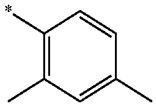

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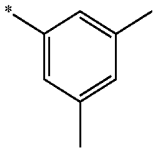

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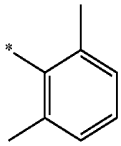

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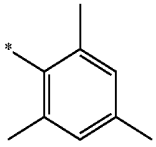

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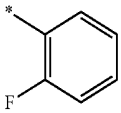

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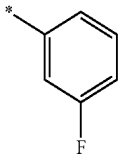

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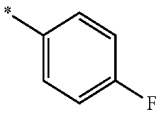

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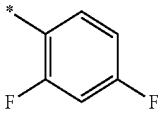

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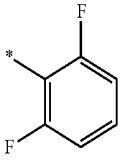

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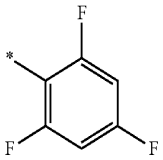

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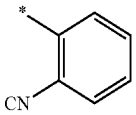

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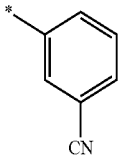

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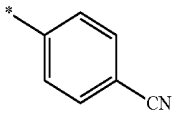

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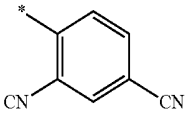

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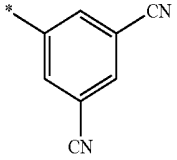

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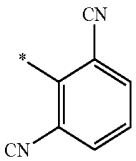

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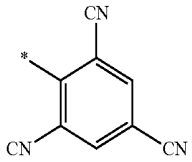

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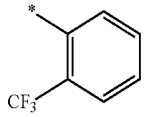

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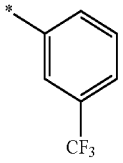

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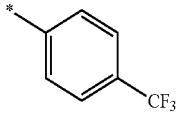

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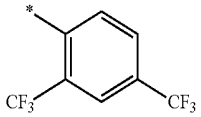

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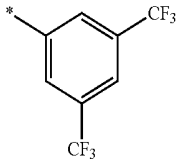

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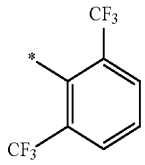

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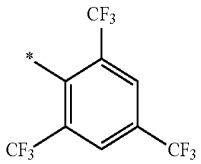

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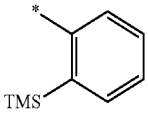

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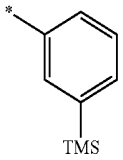

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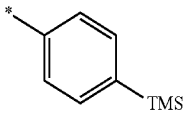

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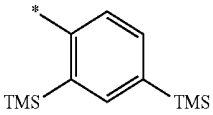

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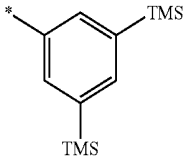

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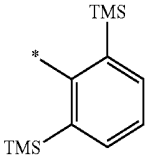

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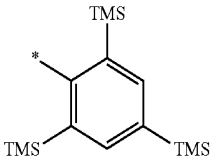

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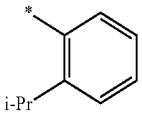

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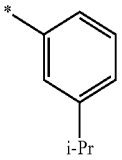

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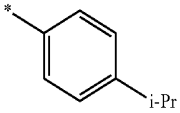

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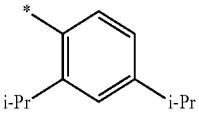

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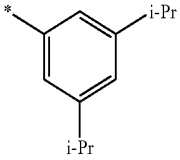

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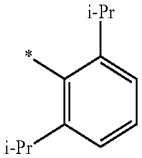

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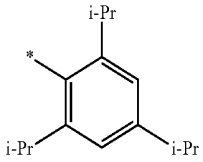

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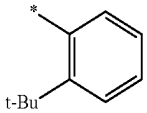

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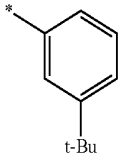

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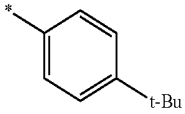

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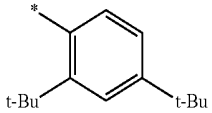

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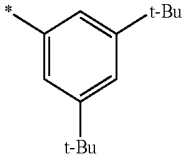

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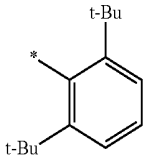

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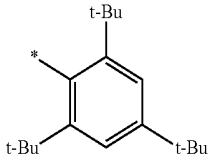

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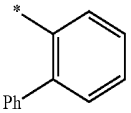

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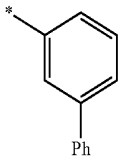

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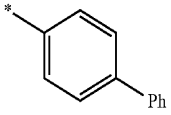

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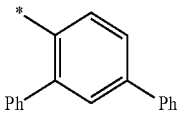

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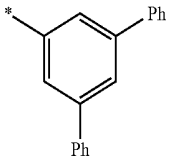

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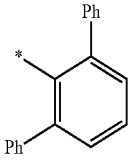

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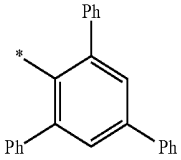

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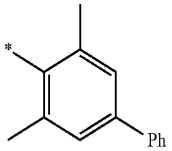

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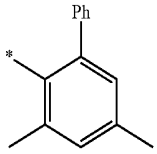

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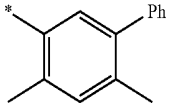

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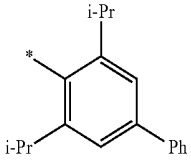

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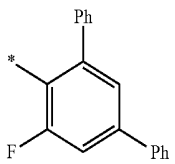

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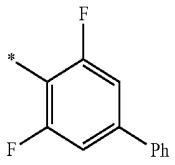

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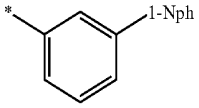

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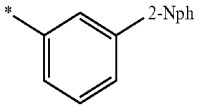

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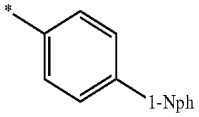

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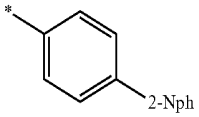

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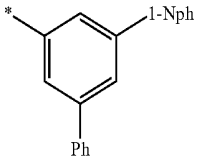

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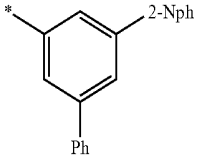

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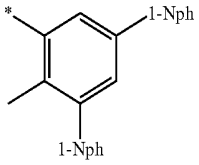

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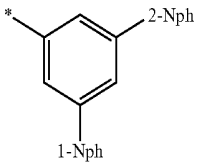

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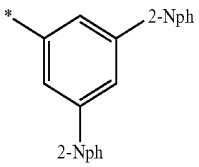

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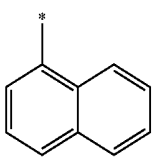

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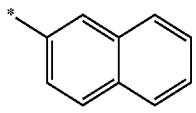

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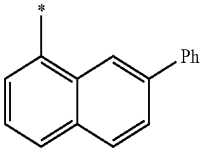

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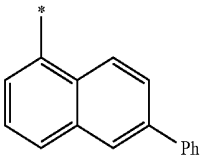

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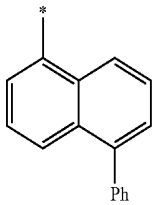

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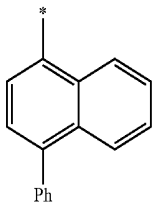

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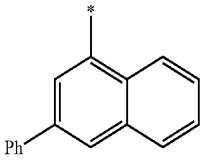

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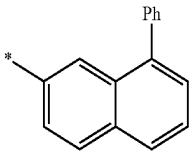

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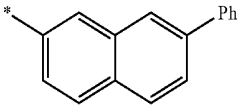

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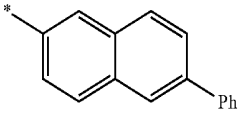

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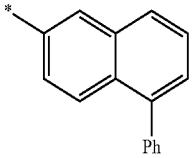

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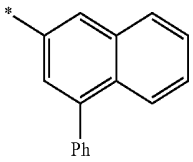

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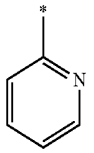

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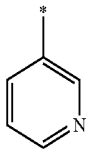

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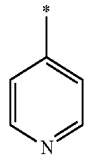

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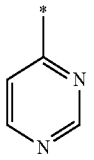

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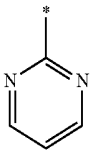

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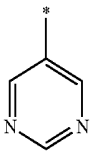

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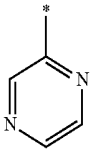

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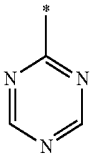

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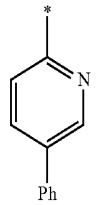

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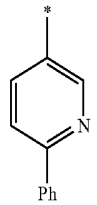

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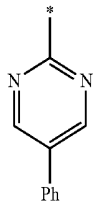

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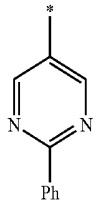

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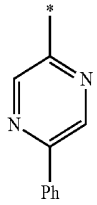

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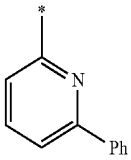

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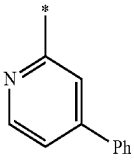

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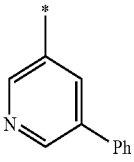

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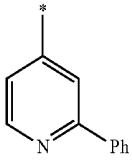

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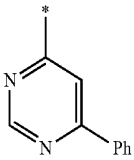

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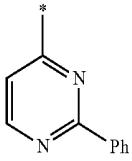

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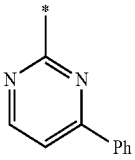

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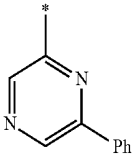

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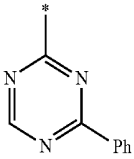

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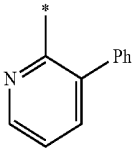

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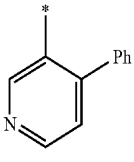

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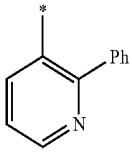

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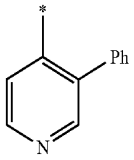

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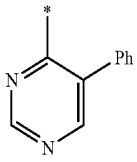

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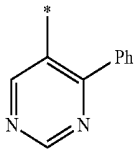

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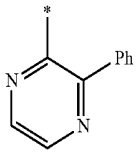

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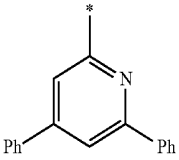

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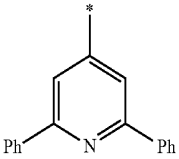

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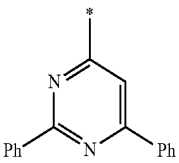

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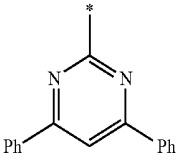

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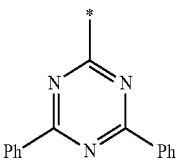

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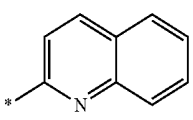

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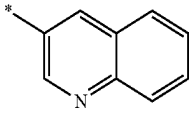

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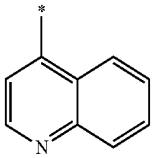

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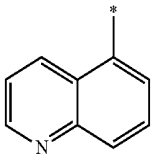

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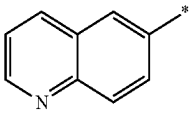

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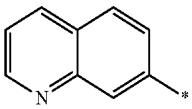

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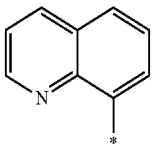

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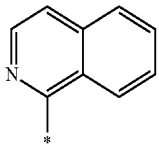

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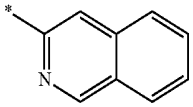

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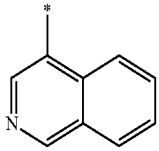

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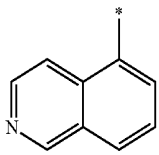

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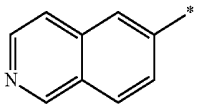

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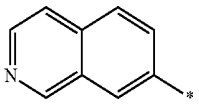

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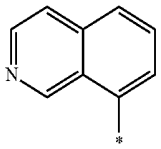

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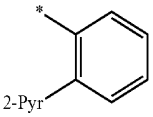

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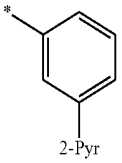

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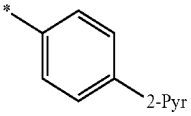

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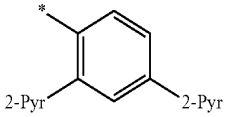

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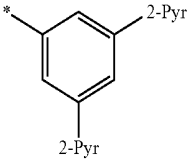

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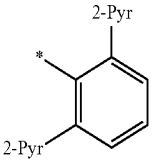

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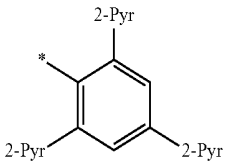

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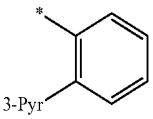

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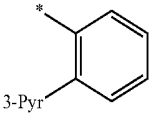

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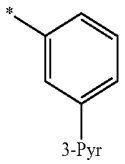

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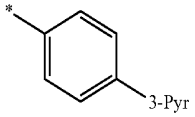

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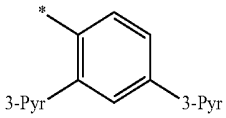

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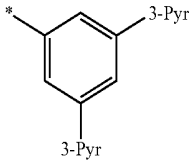

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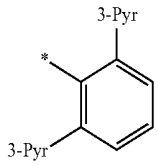

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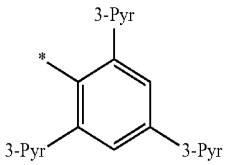

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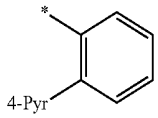

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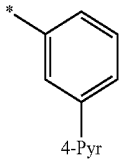

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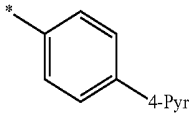

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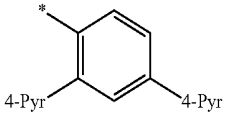

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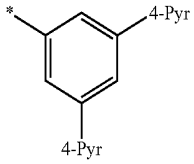

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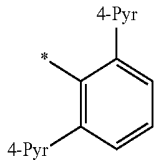

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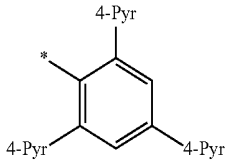

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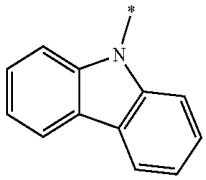

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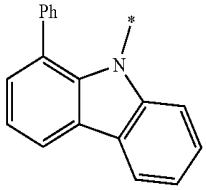

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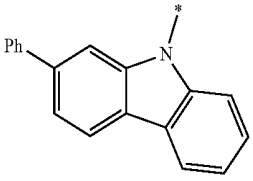

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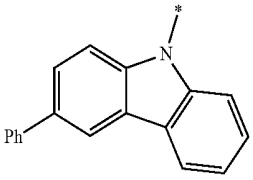

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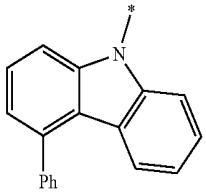

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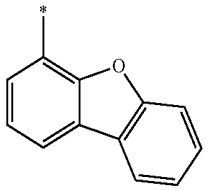

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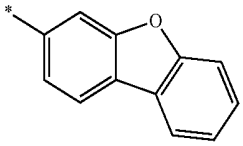

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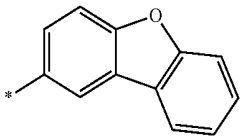

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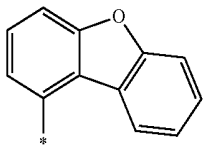

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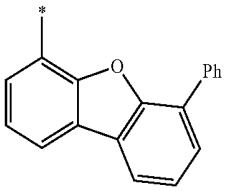

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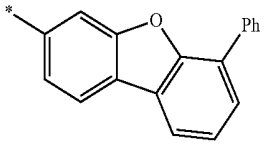

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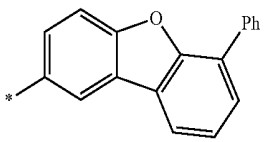

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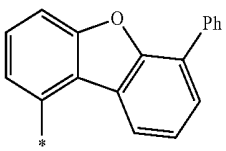

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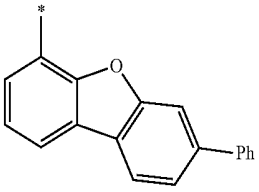

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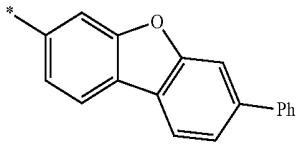

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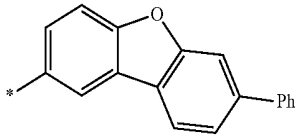

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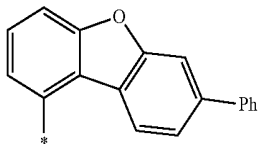

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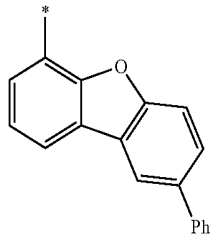

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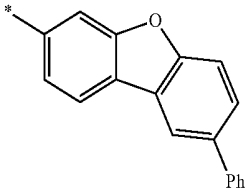

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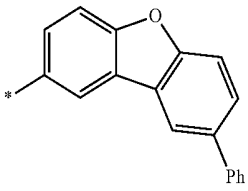

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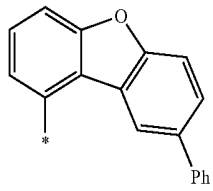

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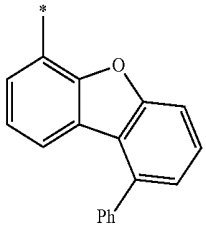

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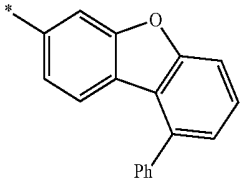

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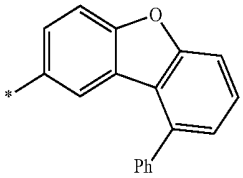

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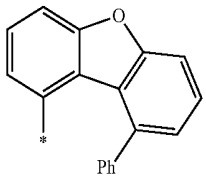

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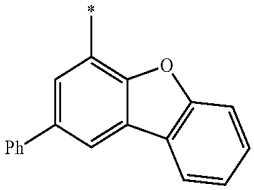

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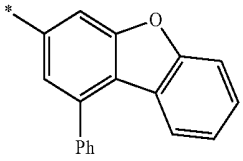

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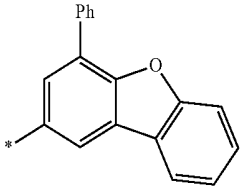

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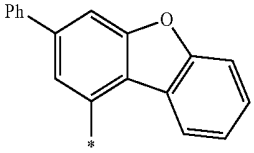

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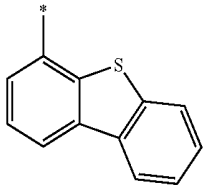

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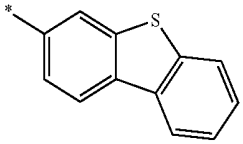

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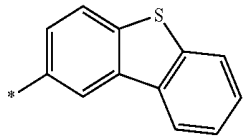

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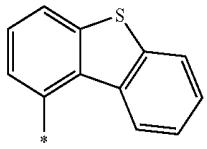

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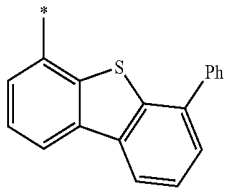

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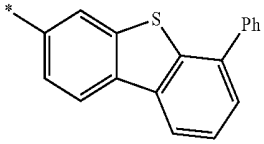

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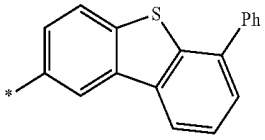

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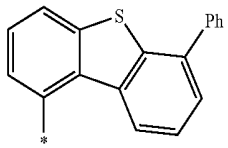

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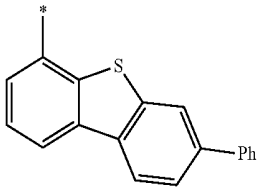

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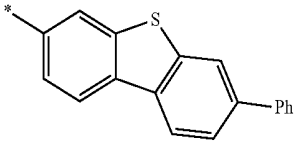

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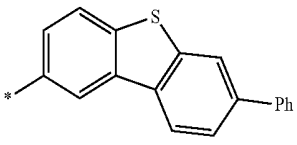

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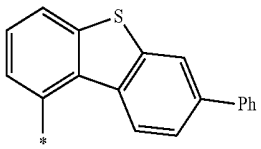

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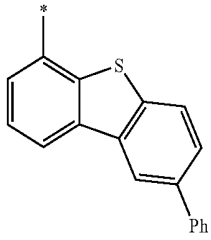

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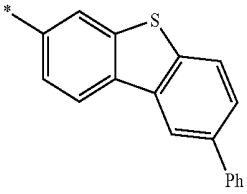

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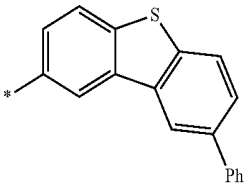

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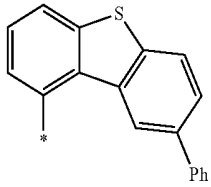

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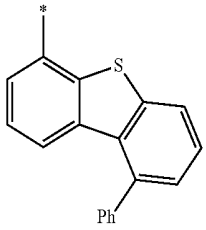

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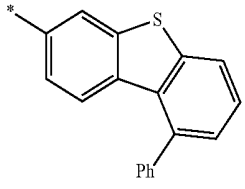

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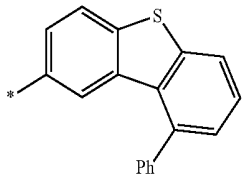

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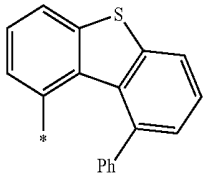

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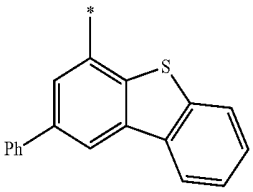

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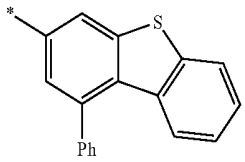

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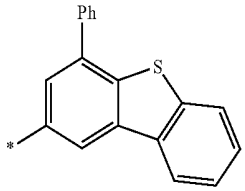

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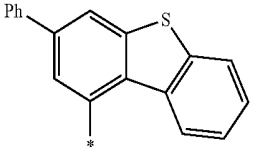

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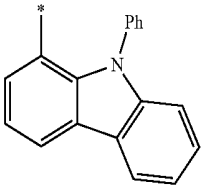

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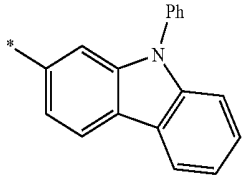

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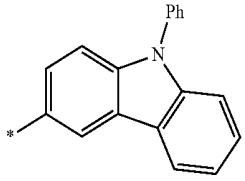

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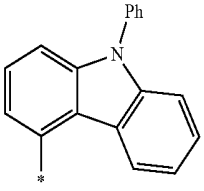

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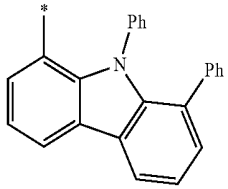

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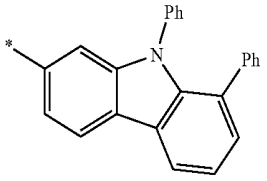

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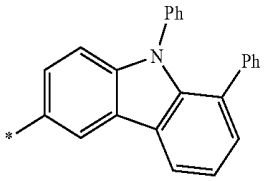

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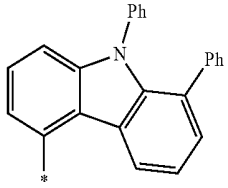

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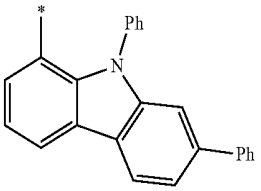

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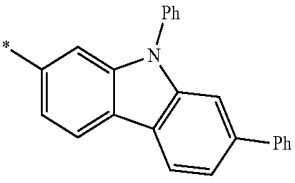

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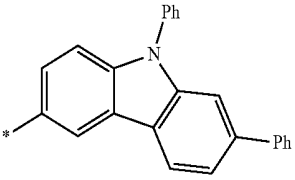

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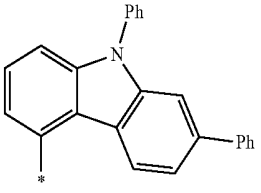

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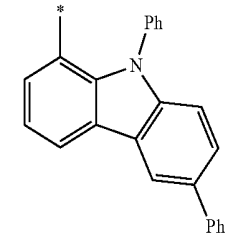

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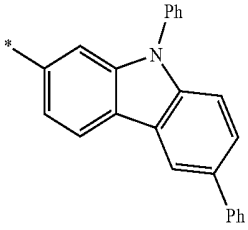

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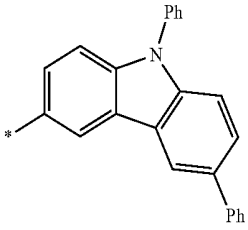

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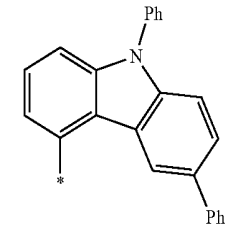

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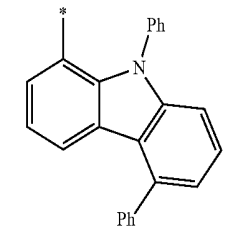

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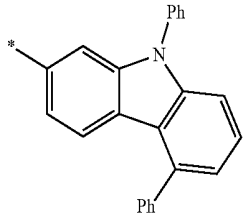

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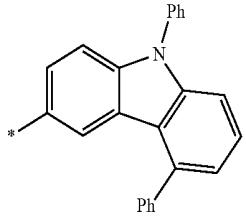

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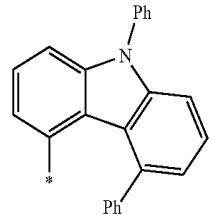

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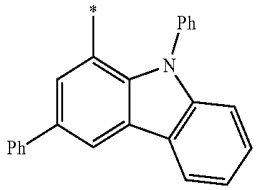

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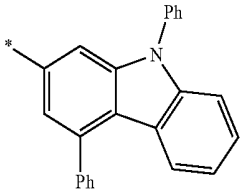

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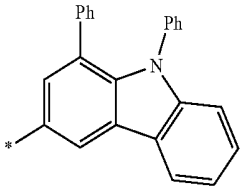

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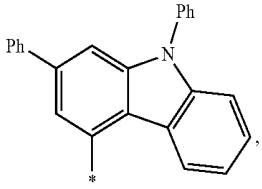


wherein Q_1 to Q_9 are each independently:

—CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2;

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

[0084] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C_1-C_{10} alkyl group, and a phenyl group.

[0085] In Formulae 9-1 to 9-21 and 10-1 to 10-253:

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

[0087] i-Pr indicates an iso-propyl group, t-Bu indicates a tert-butyl group, and Ph indicates a phenyl group,

[0088] 1-Nph indicates a 1-naphthyl group and 2-Nph indicates a 2-naphthyl group,

[0089] 2-Pyr indicates a 2-pyridyl group, 3-Pyr indicates a 3-pyridyl group, and 4-Pyr indicates a 4-pyridyl group, and

[0090] TMS indicates a trimethylsilyl group.

[0091] In one or more embodiments, in Formula 1, R_{11} to R_{13} may each independently be selected from hydrogen, deuterium, —F, a cyano group, a nitro group, —SF_5, —CH_3, —CF_3, groups represented by Formulae 9-1 to 9-13, and groups represented by Formulae 10-17 to 10-79, but embodiments of the present disclosure are not limited thereto.

[0092] In Formula 1, two, three, or four of a plurality of R_{11} to R_{13} that are adjacent to each other may be optionally linked to form a quadridentate, hexadentate, or octadentate ligand.

[0093] For example, in Formula 1, two groups R_{11} that are adjacent to each other may be optionally linked to form a quadridentate ligand, but embodiments of the present disclosure are not limited thereto.

[0094] In one or more embodiments, in Formula 1, two groups R_{12} that are adjacent to each other may be optionally linked to form a quadridentate ligand, but embodiments of the present disclosure are not limited thereto.

[0095] In one or more embodiments, in Formula 1, two groups R_{13} that are adjacent to each other may be optionally linked to form a quadridentate ligand, but embodiments of the present disclosure are not limited thereto.

[0096] For example, in Formula 1, three groups R_{11} that are adjacent to each other may be optionally linked to form a hexadentate ligand, but embodiments of the present disclosure are not limited thereto optionally.

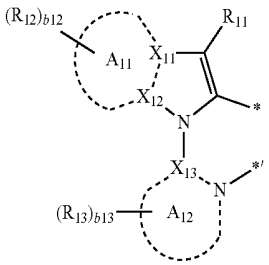
[0097] In one or more embodiments, in Formula 1, three groups R_{12} that are adjacent to each other may be optionally linked to form a hexadentate ligand, but embodiments of the present disclosure are not limited thereto.

[0098] In one or more embodiments, in Formula 1, three groups R_{13} that are adjacent to each other may be optionally linked to form a hexadentate ligand, but embodiments of the present disclosure are not limited thereto.

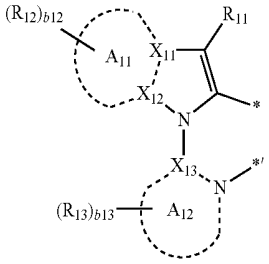
[0099] In Formula 1, b12 indicates the number of R_{12}, and may be selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. When b12 is two or more, a plurality of the R_{12} may be identical to or different from each other.

[0100] In Formula 1, b13 indicates the number of R_{13}, and may be selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. When b13 is two or more, a plurality of the R_{13} may be identical to or different from each other.

[0101] In Formula 1, n11 may be a ligand represented by



(wherein * and *' each indicate a binding site to M_{11} in Formula 1), and may be selected from 1, 2, 3, and 4. When n11 is two or more, a ligand represented by



in Formula 1 may be identical to or different from each other.

[0102] For example, in Formula 1, n11 may be selected from 1, 2, and 3, but embodiments of the present disclosure are not limited thereto.

[0103] In Formula 1, n12 indicates the number of L_{12}, and may be selected from 0, 1, 2, and 3. When n12 is two or more, a plurality of the L_{12} in Formula 1 may be identical to or different from each other.

[0104] For example, in Formula 1, n12 may be selected from 0, 1, and 2, but embodiments of the present disclosure are not limited thereto.

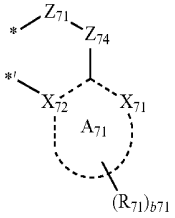
[0105] In one or more embodiments, in Formula 1, M_{11} may be Ir, n11 may be selected from 1, 2, and 3, and n12 may be selected from 0, 1, and 2, but embodiments of the present disclosure are not limited thereto.

[0106] In Formula 1, L_{12} may be selected from a bidentate ligand.

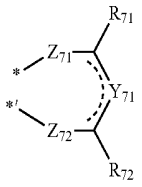
[0107] For example, in Formula, L_{12} may be a bidentate ligand, and may be selected from oxalate, acetylacetonate, picolinic acid, 1,2-bis(diphenylphosphino)ethane, 1,1-bis(diphenylphosphino)methane, glycinate, and ethylenediamine, but embodiments of the present disclosure are not limited thereto.

[0108] In one or more embodiments, in Formula 1, L_{12} may be a ligand represented by one of Formulae 7-1 to 7-7, but embodiments of the present disclosure are not limited thereto:

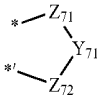
7-1



7-2



7-3



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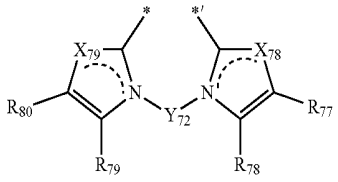
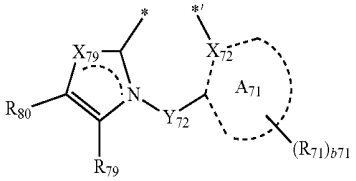
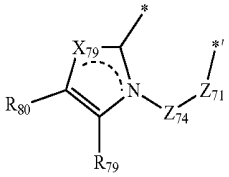
7-4



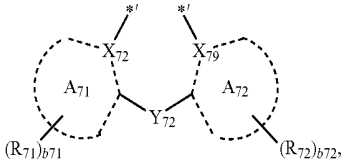
7-5



7-6



7-7



[0109] wherein in Formulae 7-1 to 7-7,

[0110] A_{71} and A_{72} may each independently be selected from a C_5-C_{20} carbocyclic group and a C_1-C_{20} heterocyclic group,

[0111] X_{71} and X_{72} may each independently be selected from C and N,

[0112] X_{78} may be O, S, or N(Q_{78}),

[0113] X_{29} may be O, S, or N(Q_{79}),

[0114] Y_{71} and Y_{72} may each independently be selected from a single bond, a double bond, a substituted or unsubstituted C_1-C_5 alkylene group, a substituted or unsubstituted C_2-C_5 alkenylene group, and a substituted or unsubstituted C_6-C_{10} arylene group,

[0115] Z_{71} and Z_{72} may each independently be selected from N, O, N(R_{75}), P(R_{75})(R_{76}), and As(R_{75})(R_{76}),

[0116] Z_{74} may be selected from CO and CH_2,

[0117] R_{71}, R_{72}, R_{75} to R_{80}, and Q_{73} to Q_{79} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0118] R_{71} and R_{72} may optionally be linked to form a ring,

[0119] R_{77} and R_{78} may optionally be linked to form a ring,

[0120] R_{78} and R_{79} may optionally be linked to form a ring,

[0121] R_{79} and R_{80} may optionally be linked to form a ring,

[0122] b71 and b72 may each independently be selected from 1, 2, 3, 4, 5, and 6, and

[0123] * and *' each independently a binding site to a neighboring atom.

[0124] For example, in Formula 7-1, A_{71} and A_{72} may each independently be selected from a benzene group, a naphthalene group, an imidazole group, a benzimidazole group, a pyridine group, a pyrimidine group, a triazine group, a quinoline group, and an isoquinoline group, but embodiments of the present disclosure are not limited thereto.

[0125] For example, in Formula 7-1, X_{72} and X_{79} may each independently be N, but embodiments of the present disclosure are not limited thereto.

[0126] For example, in Formula 7-4, X_{78} may be N(Q_{78}), and X_{79} may be N(Q_{79}), but embodiments of the present disclosure are not limited thereto.

[0127] For example, in Formulae 7-2 to 7-5, and 7-7, Y_{71} and Y_{72} may each independently be selected from a substituted or unsubstituted methylene group and a substituted or unsubstituted phenylene group, but embodiments of the present disclosure are not limited thereto.

[0128] For example, in Formulae 7-1 and 7-2, Z_{71} and Z_{72} may each independently be O, but embodiments of the present disclosure are not limited thereto.

[0129] For example, in Formulae 7-1 to 7-7, R_{71} R_{72}, R_{75} to R_{80}, and Q_{73} to Q_{79} may each independently be selected from:

[0130] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

[0131] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group,

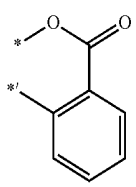
[0132] a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinno-

linyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group; and

[0133] a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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, and an imidazopyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CF_3$, $—CF_2H$, $—CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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, and an imidazopyridinyl group, but embodiments of the present disclosure are not limited thereto.

[0134] In one or more embodiments, in Formula 1, L_{12} may be a ligand represented by one of Formulae 5-1 to 5-116 and 8-1 to 8-32, but embodiments of the present disclosure are not limited thereto:

8-1



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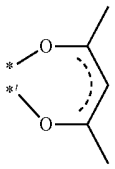

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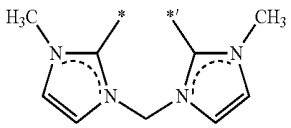

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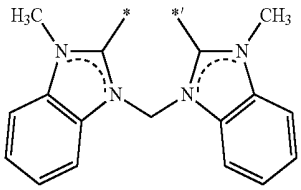

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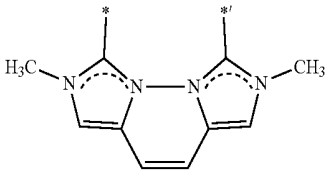

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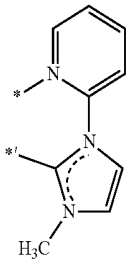

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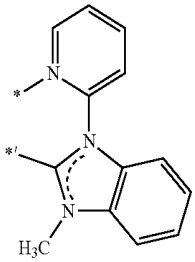

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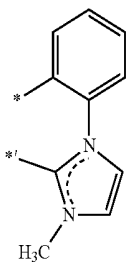

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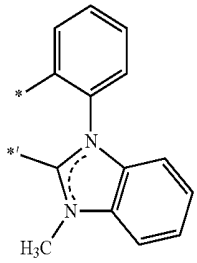
8-9



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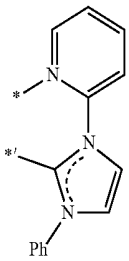

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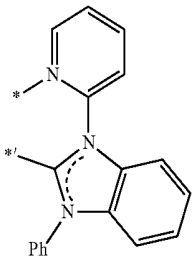

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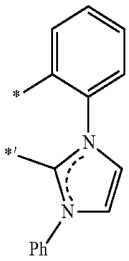

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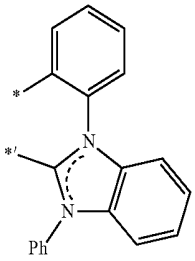

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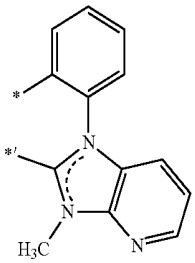

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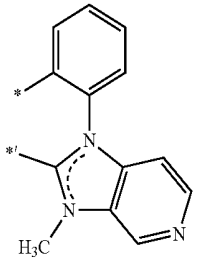

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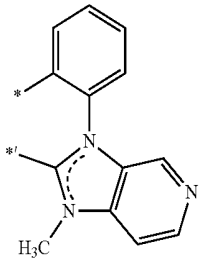

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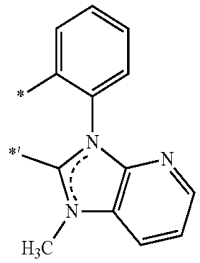

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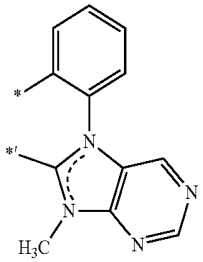

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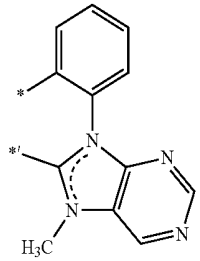

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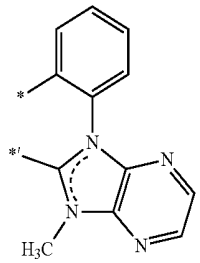

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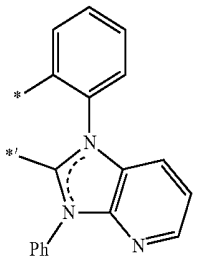

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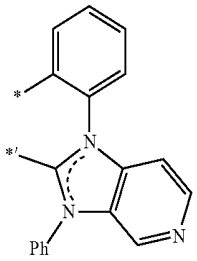

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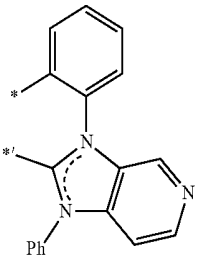

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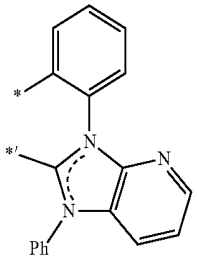

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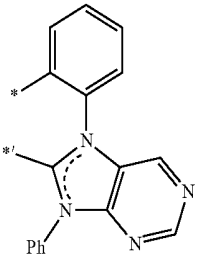

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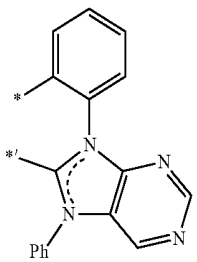

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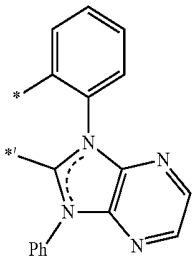

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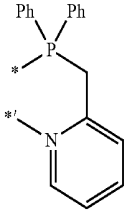

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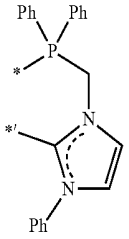

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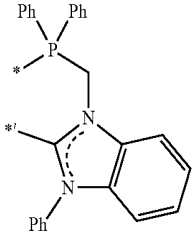

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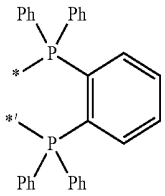

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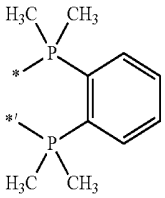

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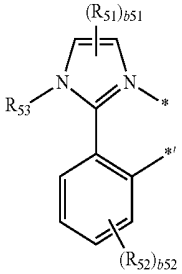

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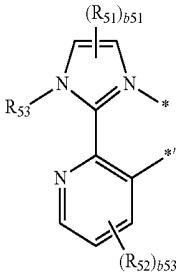

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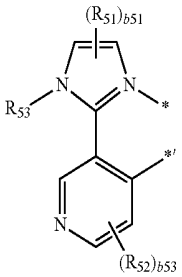

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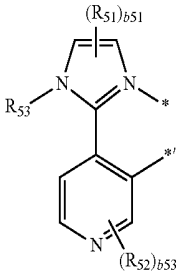

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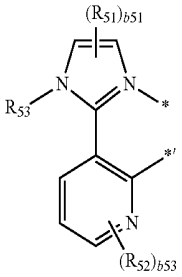

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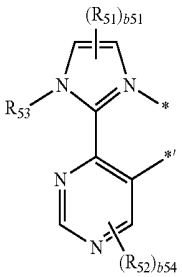

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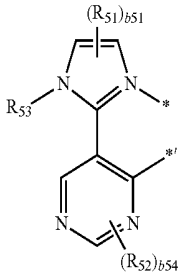

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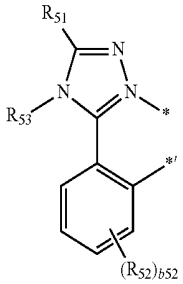

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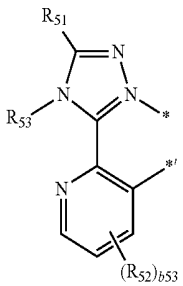

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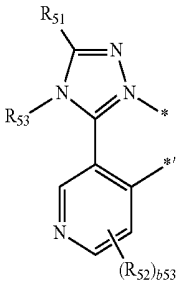

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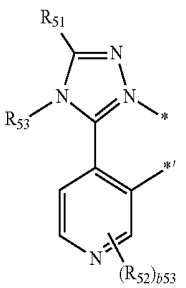

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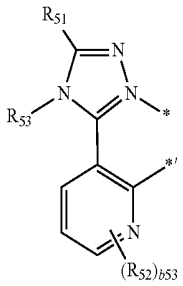

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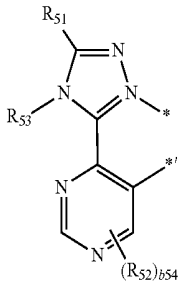

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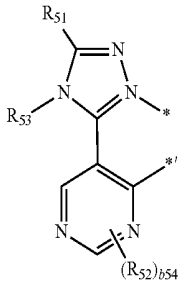

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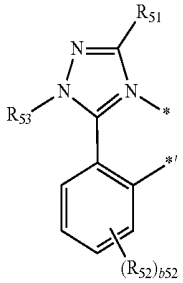

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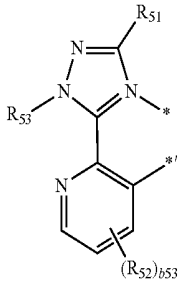

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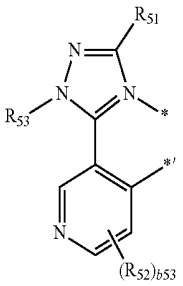

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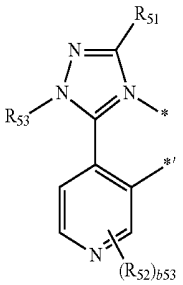

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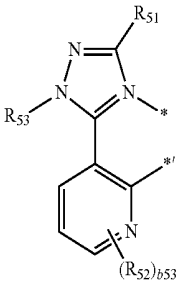

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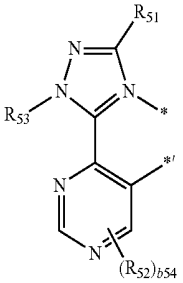

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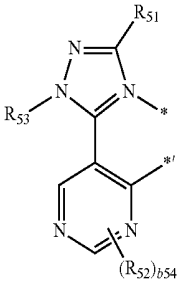

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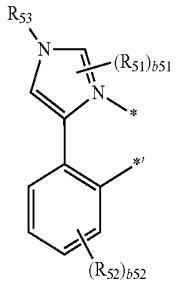

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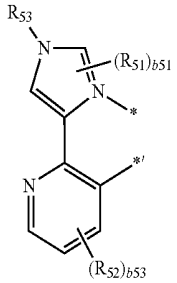

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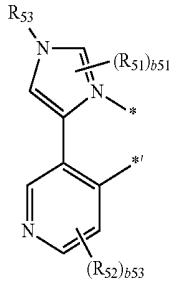

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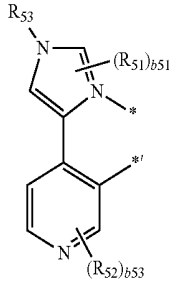

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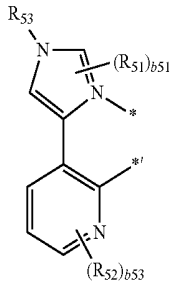

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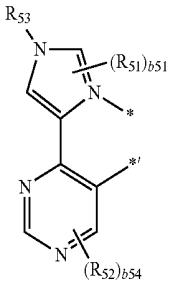

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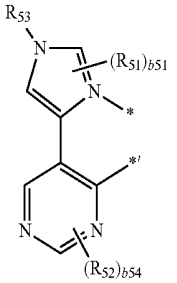

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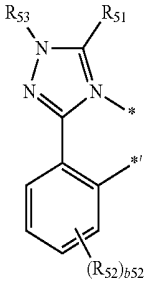

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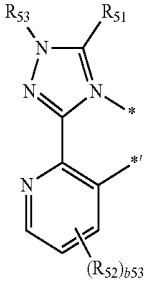

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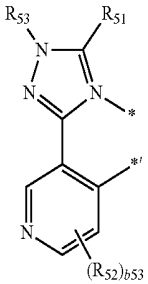

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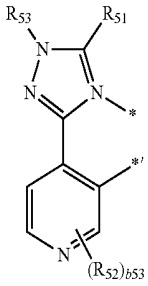

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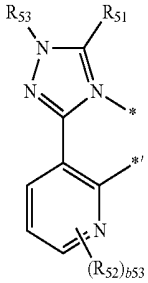

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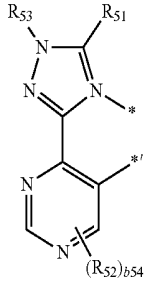

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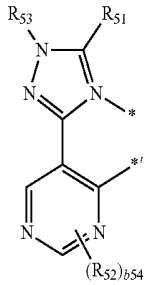

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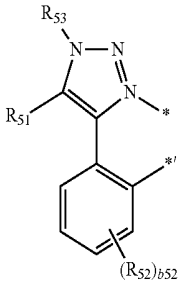

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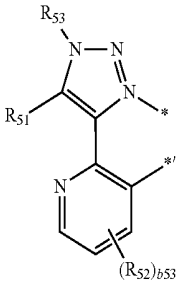

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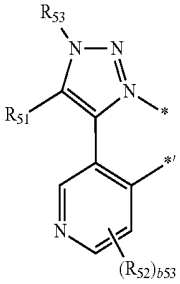

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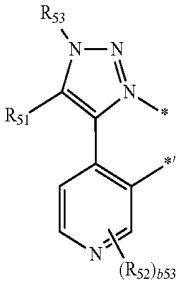

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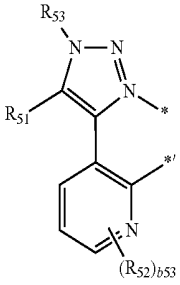

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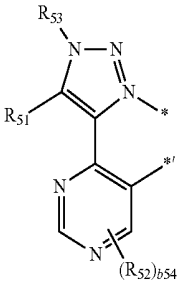

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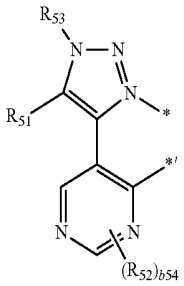

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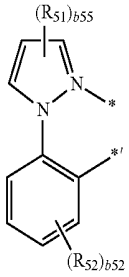

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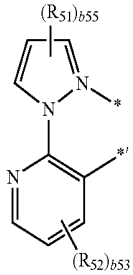

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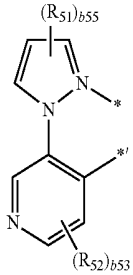

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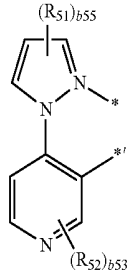

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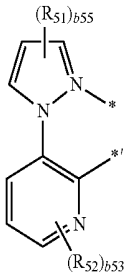

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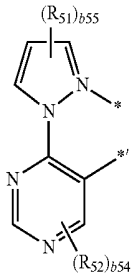

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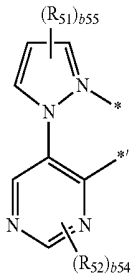

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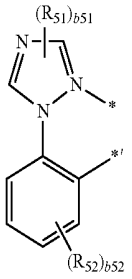

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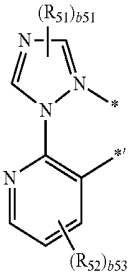

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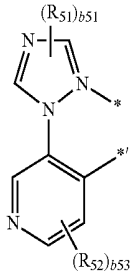

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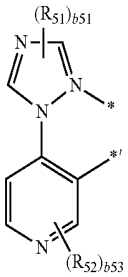

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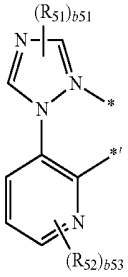

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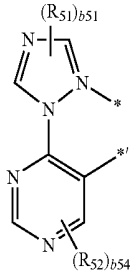

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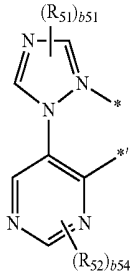

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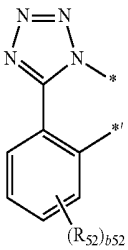

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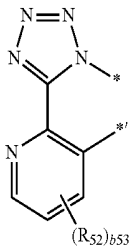

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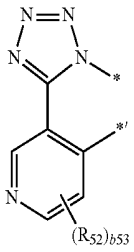

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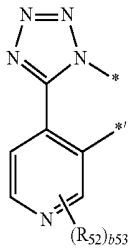

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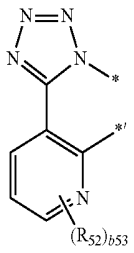

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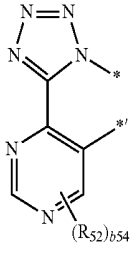

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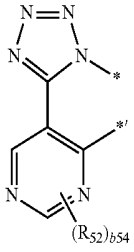

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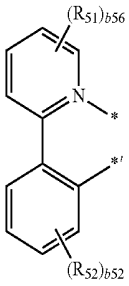

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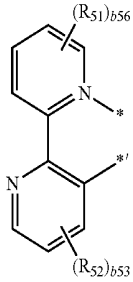

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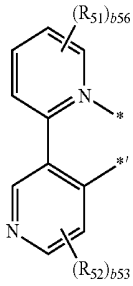

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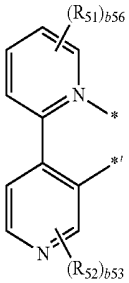

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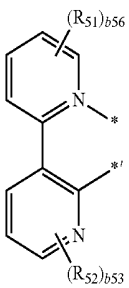

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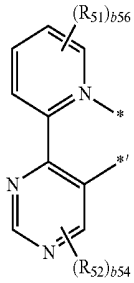

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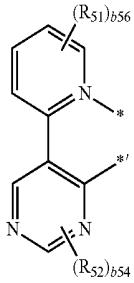

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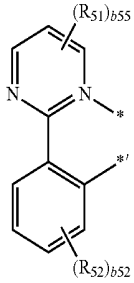

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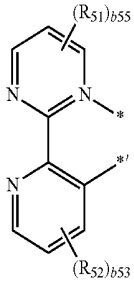

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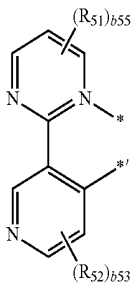

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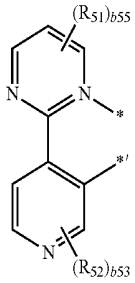

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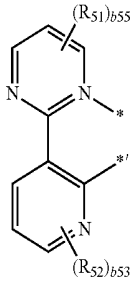

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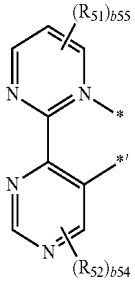

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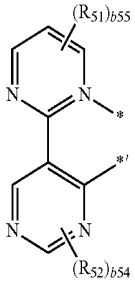

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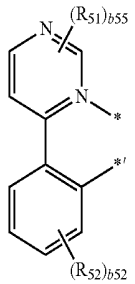

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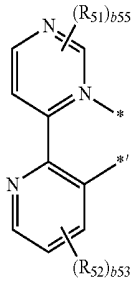

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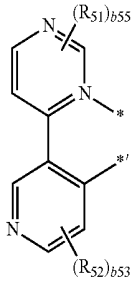

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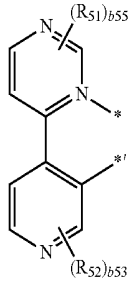

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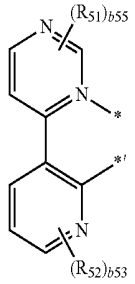

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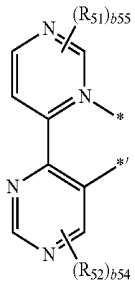

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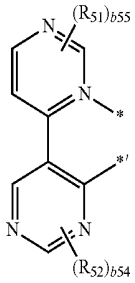

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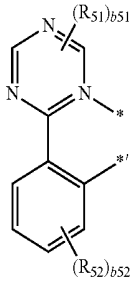

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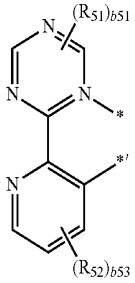

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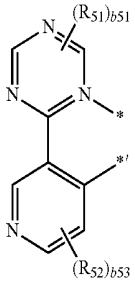

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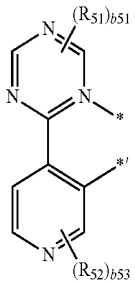

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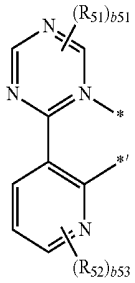

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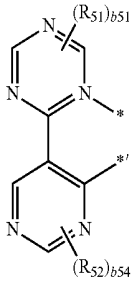

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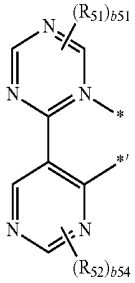

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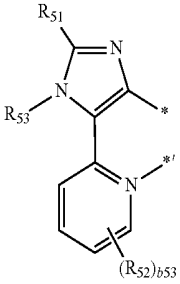

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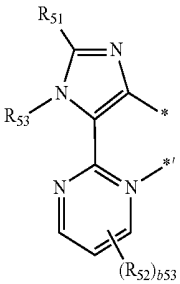

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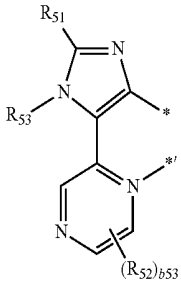

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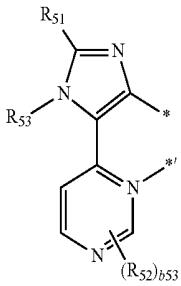

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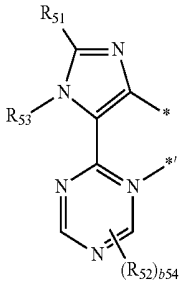

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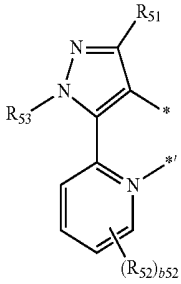

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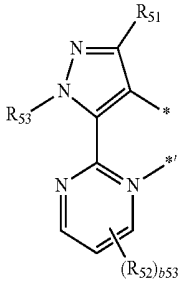

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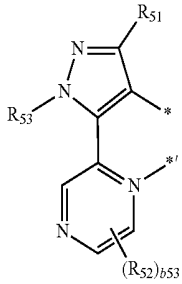

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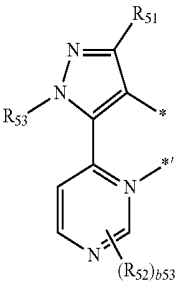

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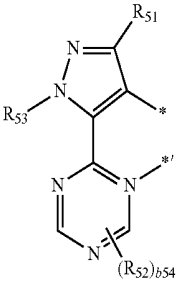

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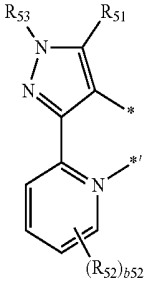

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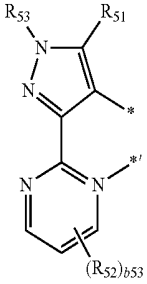

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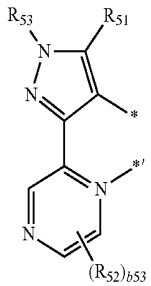

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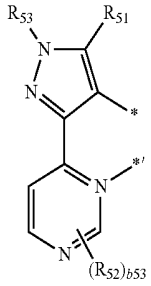

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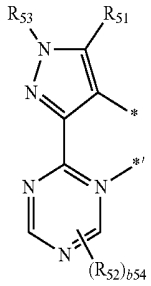

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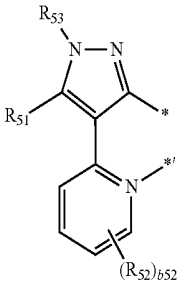

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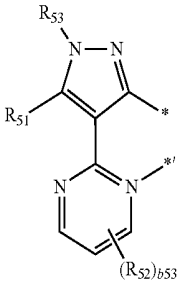

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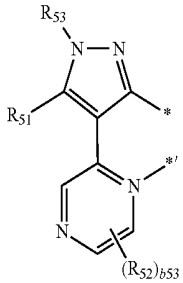

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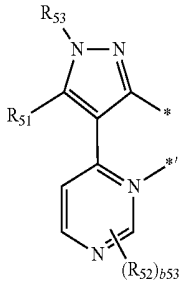

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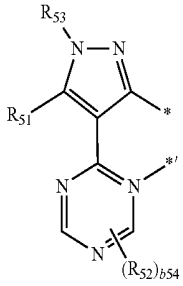

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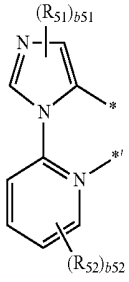

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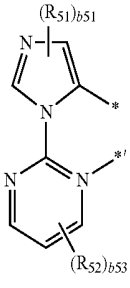

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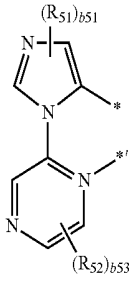

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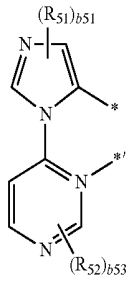

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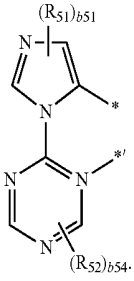


[0135] In Formulae 5-1 to 5-116 and 8-1 to 8-32,

[0136] R_{51} to R_{53} may each independently be selected from hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an iso-decanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

[0137] a methyl group, an ethyl group, a propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an iso-decanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from —F, a cyano group, and a nitro group,

[0138] b51 and b54 may each independently be selected from 1 and 2,

[0139] b53 and b55 may each independently be selected from 1, 2, and 3,

[0140] b52 may be selected from 1, 2, 3, and 4,

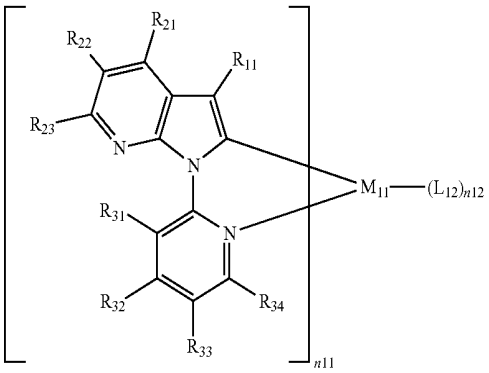
[0141] Ph indicates a phenyl group,

[0142] Ph-d5 indicates a phenyl group of which all hydrogen atoms are substituted with deuterium, and

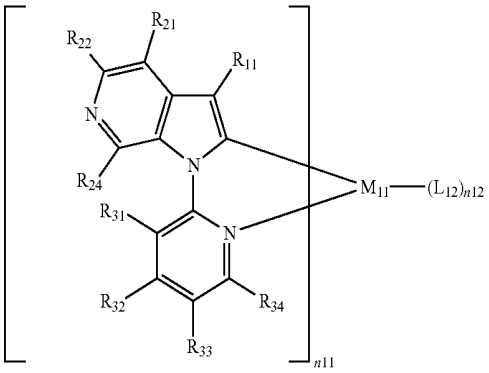
[0143] * and *' each indicate a binding site to a neighboring atom.

[0144] In one or more embodiments, the organometallic compound of Formula 1 may be represented by one of Formulae 1-1 to 1-4, but embodiments of the present disclosure are not limited thereto:

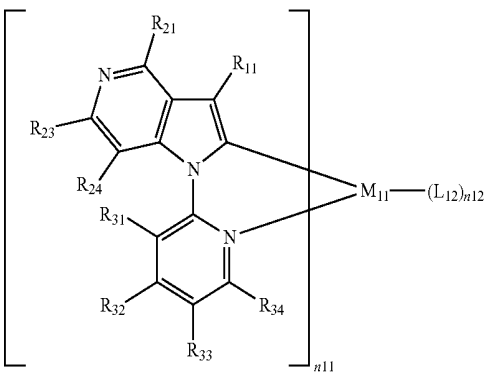
1-1



1-2



1-3



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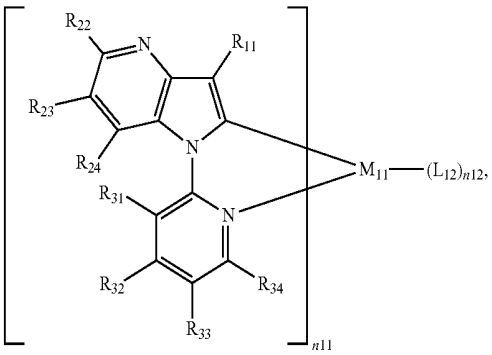
1-4



wherein, in Formulae 1-1 to 1-4,

[0145] M_{11}, R_{11}, n11, n12, and L_{12} are each independently the same as described in Formula 1,

[0146] R_{21} to R_{24} are each independently the same as described in connection with R_{12} in Formula 1, and

[0147] R_{31} to R_{34} are each independently the same as described in connection with R_{13} in Formula 1.

[0148] For example, in Formulae 1-1 to 1-4, R_{11}, R_{21} to R_{24}, and R_{31} to R_{34} may each independently be selected from:

[0149] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF_5, C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

[0150] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0151] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0152] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$; and

[0153] —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$, and

[0154] Q_1 to Q_9 and Q_{33} to Q_{35} may each independently be selected from:

[0155] —CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2;

[0156] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0157] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C_1-C_{10} alkyl group, and a phenyl group, but embodiments of the present disclosure are not limited thereto.

[0158] In one or more embodiments, in Formulae 1-1 to 1-4, R_{11}, R_{21} to R_{24}, and R_{31} to R_{34} may each independently be selected from:

[0159] hydrogen, deuterium, —F, a cyano group, a nitro group, —SF_5, a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an iso-decyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a dibenzosilolyl group;

[0160] a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an iso-decyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a dibenzosilolyl group, each substituted with at least one selected from deuterium, —F, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a cyano group, a nitro group, a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$; and

[0161] —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$, and

[0162] Q_1 to Q_9 and Q_{33} to Q_{35} may each independently be selected from:

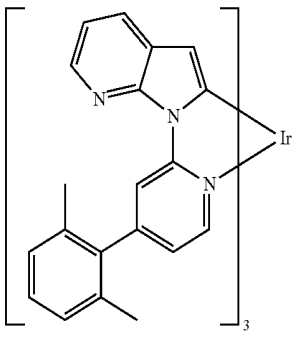
[0163] —CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2;

[0164] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group; and

[0165] an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, a phenyl group, and a naphthyl group, each substituted with at least one selected from deuterium, a C_1-C_{10} alkyl group, and a phenyl group, but embodiments of the present disclosure are not limited thereto.

[0166] In one or more embodiments, the organometallic compound of Formula 1 may be selected from Compounds 1 to 8, but embodiments of the present disclosure are not limited thereto:

1



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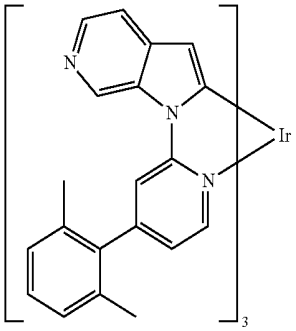

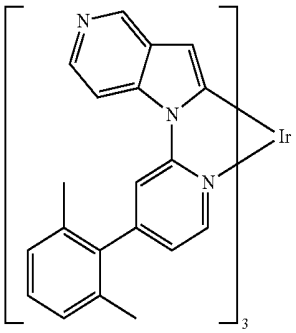

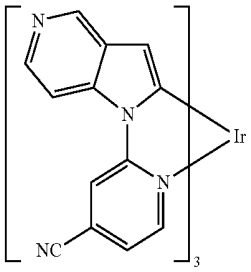

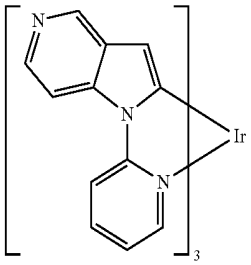

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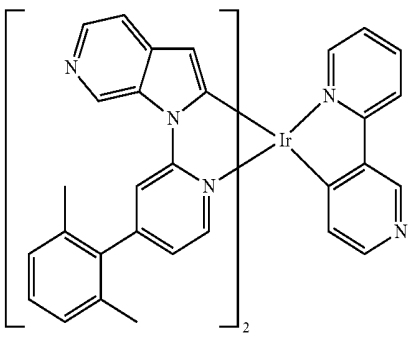

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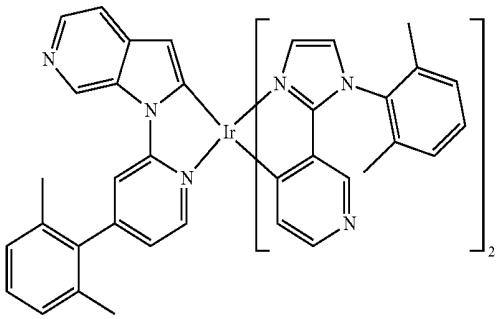

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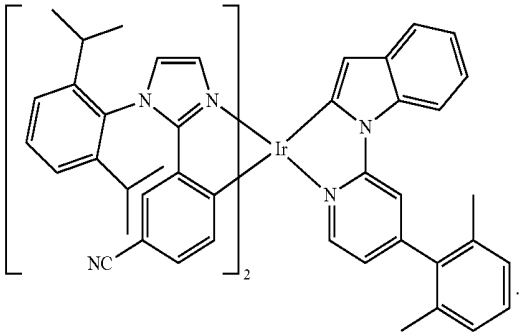

4

[0167] The organometallic compound of Formula 1 may have a maximum emission wavelength (measured value) in a range of about 440 nanometers (nm) or more to about less than 500 nm, for example, in a range of about 440 nm to about 495 nm. While not wishing to be bound by theory, it is understood that when the maximum emission wavelength of the organometallic compound of Formula 1 is within a range of about 440 nm to about 495 nm, dark blue light may be emitted from an organic light-emitting device including the organometallic compound of Formula 1.

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[0168] The organometallic compound of Formula 1 always includes a nitrogen atom-containing C_1-C_{30} heterocyclic group represented by A_{11}, and accordingly, may have a shallow lowest unoccupied molecular orbital (LUMO) energy level. In this regard, the organometallic compound of Formula 1 may have the broader band gap resulting in the higher triplet energy level. Thus, dark blue emission light may be emitted from an organic light-emitting device including the organometallic compound of Formula 1.

[0169] The organometallic compound of Formula 1 may have a triplet energy level suitable for blue light and relatively short fluorescence lifetime. Therefore, the organometallic compound of Formula 1 may serve as a blue dopant with a high absolute quantum yield.

[0170] Synthesis methods of the organometallic compound of Formula 1 may be recognizable by one of ordinary skill in the art by referring to Synthesis Examples provided below.

[0171] The organometallic compound of Formula 1 may be suitable for use in an organic layer of an organic light-emitting device, for example, for use as a dopant in an emission layer of the organic layer. Thus, another aspect of the present description provides an organic light-emitting device that includes: a first electrode; a second electrode; and an organic layer that is disposed between the first electrode and the second electrode, wherein the organic

layer includes an emission layer, and wherein the organic layer further includes at least one organometallic compound represented by Formula 1.

[0172] The organic light-emitting device may have, due to the inclusion of an organic layer including the organometallic compound represented by Formula 1, a low driving voltage, high efficiency, high power, high quantum efficiency, a long lifespan, a low roll-off ratio, and excellent color purity.

[0173] The organometallic compound of Formula 1 may be used between a pair of electrodes of an organic light-emitting device. For example, the organometallic compound represented by Formula 1 may be included in the emission layer. In this regard, the organometallic compound may act as a dopant, and the emission layer may further include a host (that is, an amount of the organometallic compound represented by Formula 1 is smaller than an amount of the host). In this regard, the dopant may emit blue light.

[0174] The expression "(an organic layer) includes at least one organometallic compound" as used herein may include an embodiment in which "(an organic layer) includes identical compounds represented by Formula 1" and an embodiment in which "(an organic layer) includes two or more different organometallic compounds represented by Formula 1."

[0175] For example, the organic layer may include, as the organometallic compound, only Compound 1. In this regard, Compound 1 may be included in an emission layer of the organic light-emitting device. In one or more embodiments, the organic layer may include, as the organometallic compound, Compound 1 and Compound 2. In this regard, Compound 1 and Compound 2 may be included in an identical layer (for example, Compound 1 and Compound 2 may be included in an emission layer).

[0176] The first electrode may be an anode, which is a hole injection electrode, and the second electrode may be a cathode, which is an electron injection electrode; or the first electrode may be a cathode, which is an electron injection electrode, and the second electrode may be an anode, which is a hole injection electrode.

[0177] In one or more embodiments, in the organic light-emitting device, the first electrode is an anode, and the second electrode is a cathode, and the organic layer further includes a hole transport region disposed between the first electrode and the emission layer and an electron transport region disposed between the emission layer and the second electrode, wherein the hole transport region includes at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer, and wherein the electron transport region includes at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

[0178] The term "organic layer" as used herein refers to a single layer and/or a plurality of layers disposed between the first electrode and the second electrode of the organic light-emitting device. The "organic layer" may include, in addition to an organic compound, an organometallic compound including metal.

[0179] FIG. **1** is a schematic view of an organic light-emitting device **10** according to an embodiment. Hereinafter, the structure of an organic light-emitting device according to an embodiment and a method of manufacturing an organic light-emitting device according to an embodiment will be described in connection with FIG. **1**. The organic light-emitting device **10** includes a first electrode **11**, an organic layer **15**, and a second electrode **19**, which are sequentially stacked.

[0180] A substrate may be additionally disposed under the first electrode **11** or above the second electrode **19**. For use as the substrate, any substrate that is used in general organic light-emitting devices may be used, and the substrate may be a glass substrate or a transparent plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0181] In one or more embodiments, the first electrode **11** may be formed by depositing or sputtering a material for forming the first electrodel **1** on the substrate. The first electrode **11** may be an anode. The material for forming the first electrode **11** may be selected from materials with a high work function to facilitate hole injection. The first electrode **11** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. The material for forming the first electrode **11** may be indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), or zinc oxide (ZnO). In one or more embodiments, the material for forming the first electrode **11** may be metal, such as magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag).

[0182] The first electrode **11** may have a single-layered structure or a multi-layered structure including two or more layers. For example, the first electrode **11** may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode **110** is not limited thereto.

[0183] The organic layer **15** is disposed on the first electrode **11**.

[0184] The organic layer **15** may include a hole transport region, an emission layer, and an electron transport region.

[0185] The hole transport region may be disposed between the first electrode **11** and the emission layer.

[0186] The hole transport region may include at least one selected from a hole injection layer, a hole transport layer, an electron blocking layer, and a buffer layer.

[0187] The hole transport region may include only either a hole injection layer or a hole transport layer. In one or more embodiments, the hole transport region may have a hole injection layer/hole transport layer structure or a hole injection layer/hole transport layer/electron blocking layer structure, which are sequentially stacked in this stated order from the first electrode **11**.

[0188] When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **11** by using one or more suitable methods, for example, vacuum deposition, spin coating, casting, and/or Langmuir-Blodgett (LB) deposition.

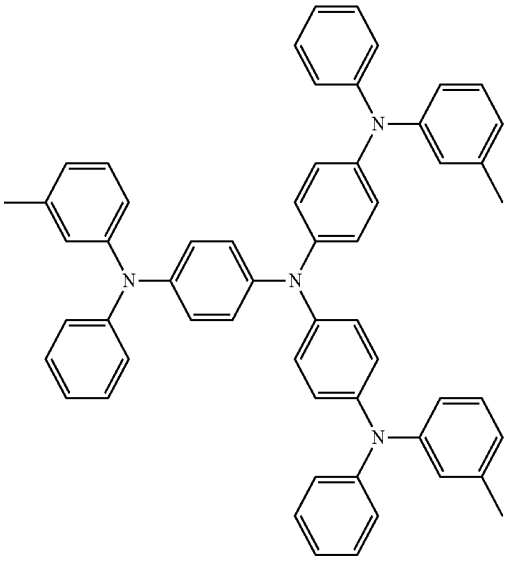
[0189] When a hole injection layer is formed by vacuum deposition, the deposition conditions may vary according to a material that is used to form the hole injection layer, and the structure and thermal characteristics of the hole injection

layer. For example, the deposition conditions may include a deposition temperature in a range of about 100° C. to about 500° C., a vacuum pressure in a range of about 10^{-8} torr to about 10-3 torr, and a deposition rate in a range of about 0 Angstroms per second (Å/sec) to about 100 Å/sec. However, the deposition conditions are not limited thereto.

[0190] When the hole injection layer is formed using spin coating, coating conditions may vary according to the material used to form the hole injection layer, and the structure and thermal properties of the hole injection layer. For example, a coating speed may be in a range of about 2,000 revolutions per minute (rpm) to about 5,000 rpm, and a temperature at which a heat treatment is performed to remove a solvent after coating may be in a range of about 80° C. to about 200° C. However, the coating conditions are not limited thereto.

[0191] Conditions for forming a hole transport layer and an electron blocking layer may be understood by referring to conditions for forming the hole injection layer.

[0192] The hole transport region may include at least one selected from, for example, m-MTDATA, TDATA, 2-TNATA, NPB, R-NPB, TPD, spiro-TPD, spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrene sulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly (4-styrene sulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202:



m-MTDATA

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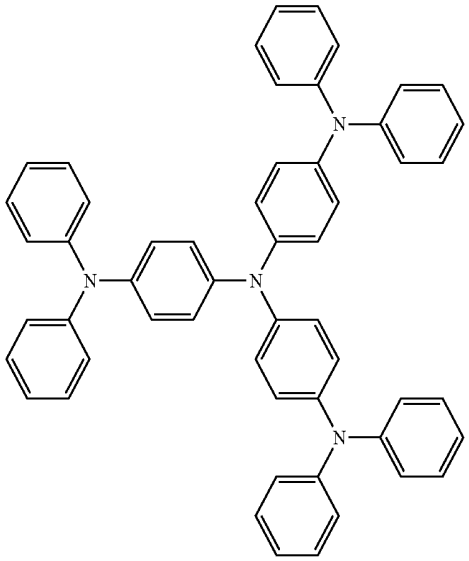
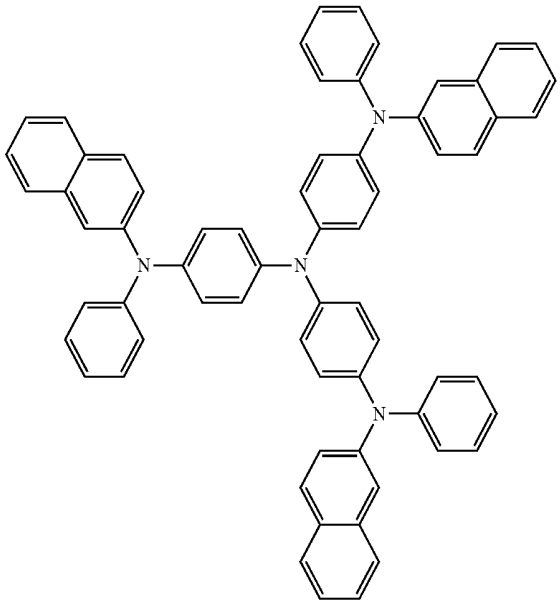
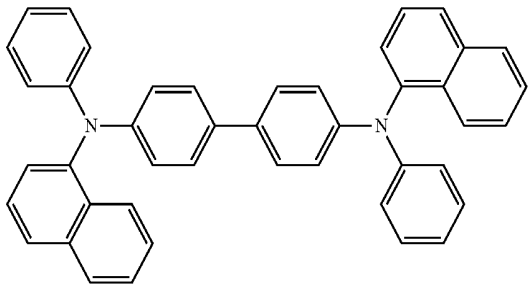


TDATA



2-TNATA



NPB

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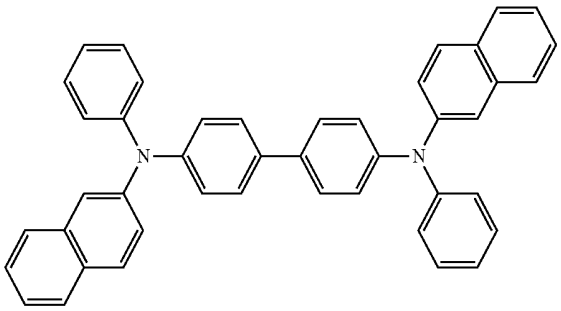
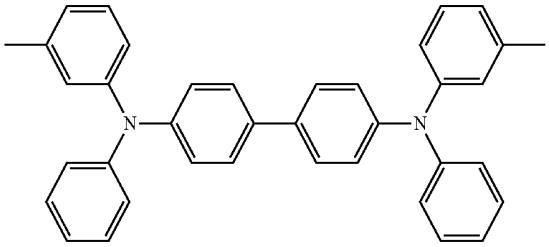
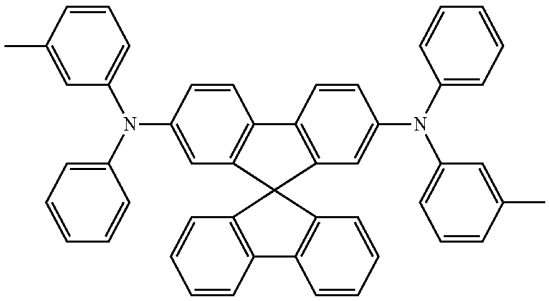


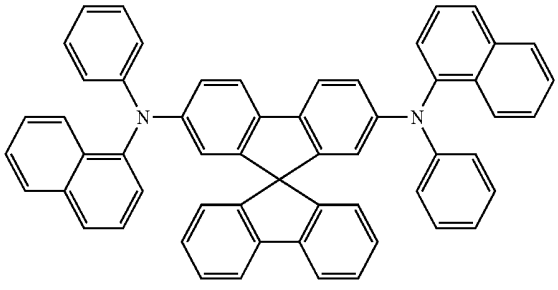
β-NPB



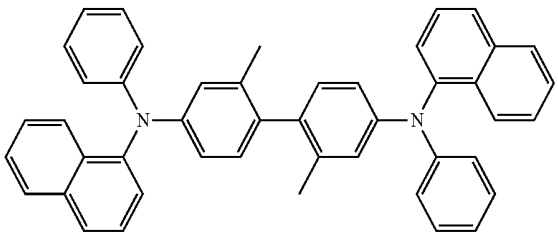
TPD



Spiro-TPD



Spiro-NPD



methylated NPB

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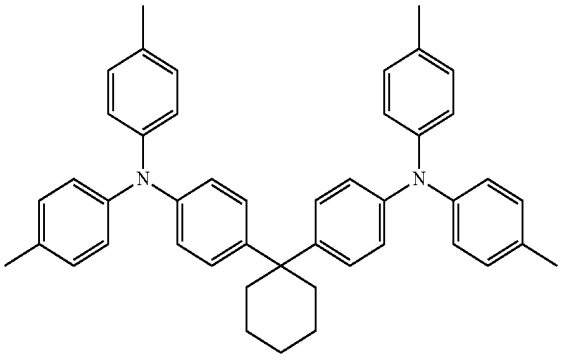
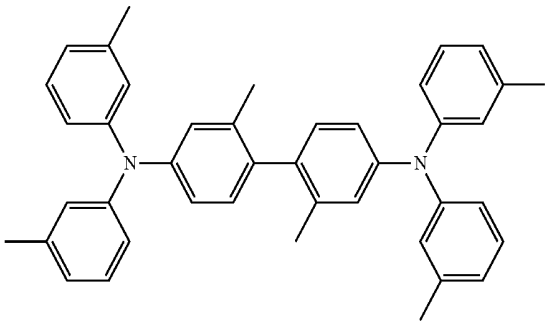
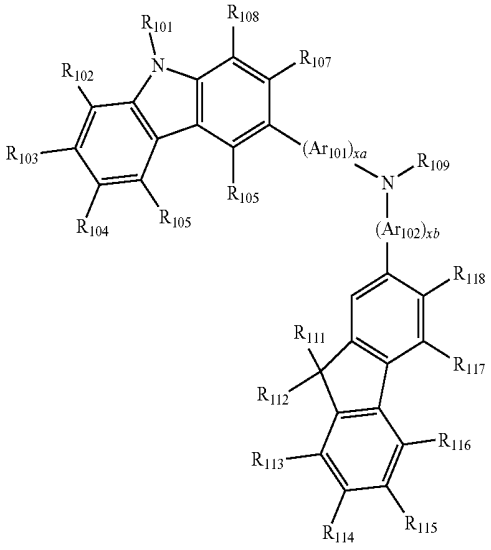


TAPC

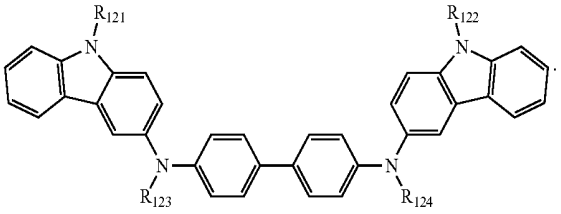


HMTPD

Formula 201



Formula 202



[0193] In Formula 201, Ar_{101} and Ar_{102} may each independently be selected from:

[0194] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluore-

nylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group; and

[0195] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a 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_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkyl 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.

[0196] In Formula 201, xa and xb may each independently be an integer from 0 to 5, or may be 0, 1, or 2. For example, xa may be 1 and xb may be 0, but xa and xb are not limited thereto.

[0197] In Formulae 201 and 202, R_{101} to R_{108}, R_{111} to R_{119}, and R_{121} to R_{124} may each independently be selected from:

[0198] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group (for example, a methyl group, an ethyl group, a propyl group, a butyl group, pentyl group, or a hexyl group), and C_1-C_{10} alkoxy group (for example, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group);

[0199] a C_1-C_{10} alkyl group and a C_1-C_{10} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0200] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group; and

[0201] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, and a C_1-C_{10} alkoxy group, but embodiments of the present disclosure are not limited thereto.

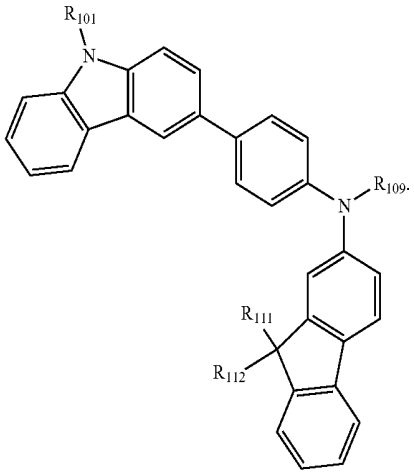
[0202] In Formula 201, R_{109} may be selected from:

[0203] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group; and

[0204] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group.

[0205] In one or more embodiments, the compound of Formula 201 may be represented by Formula 201A below, but embodiments of the present disclosure are not limited thereto:

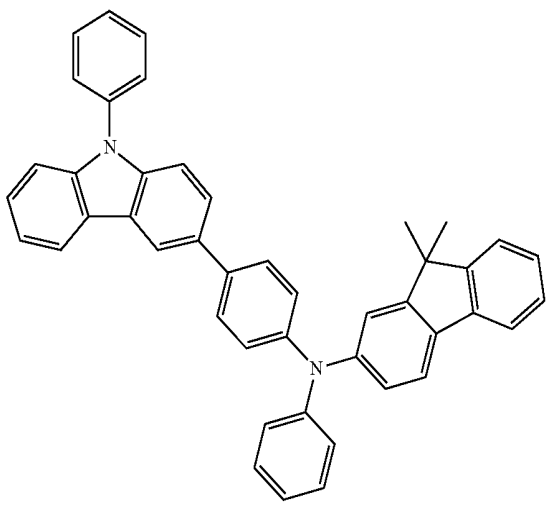
Formula 201A



[0206] In Formula 201A, R_{101}, R_{111}, R_{112}, and R_{109} are the same as described above.

[0207] For example, the compound of Formula 201 and the compound of Formula 202 may include Compounds HT1 to HT20, but are not limited thereto:

HT1



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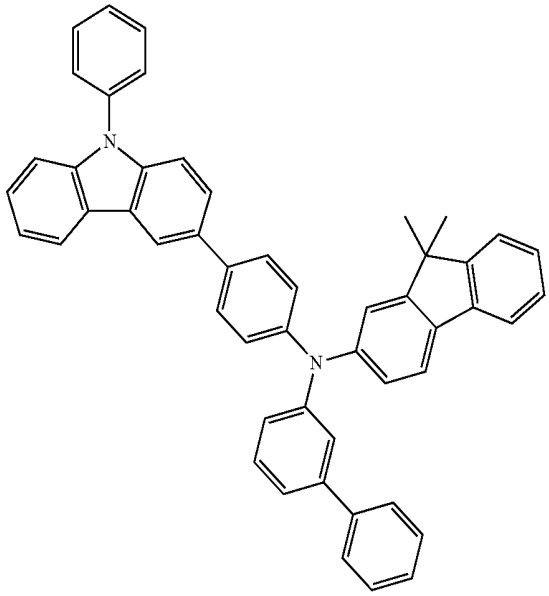
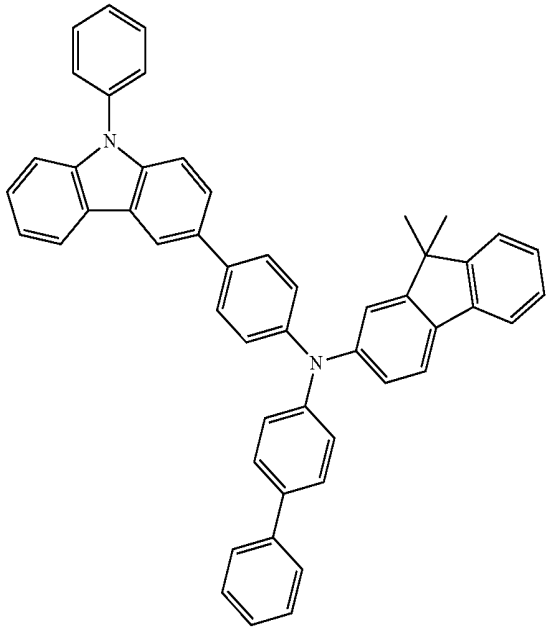
HT2



HT3



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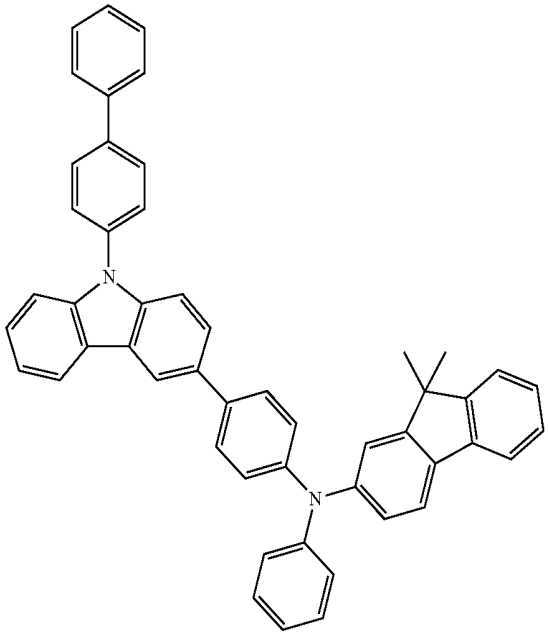
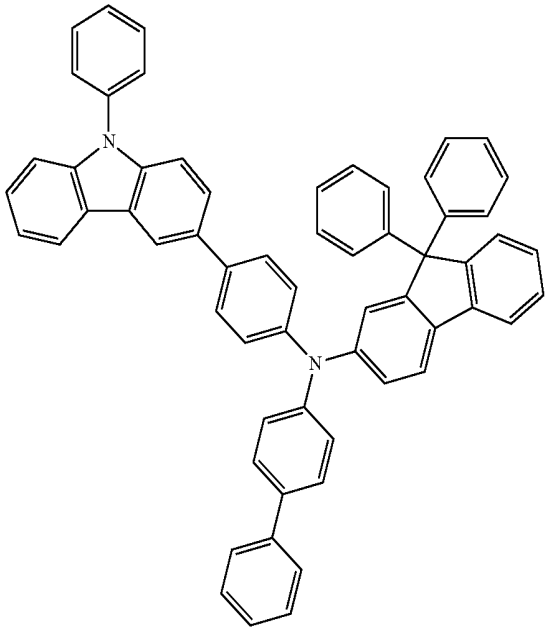
HT4



HT5



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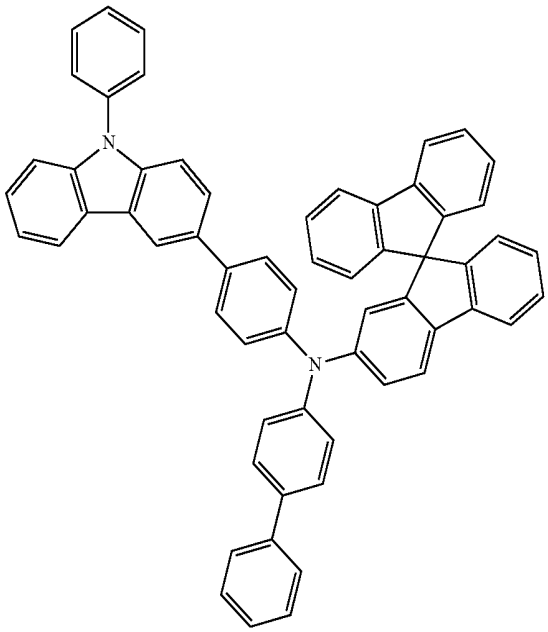
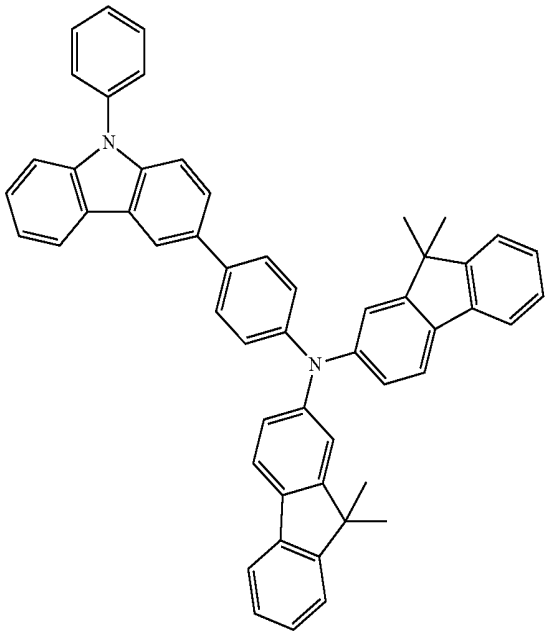
HT6



HT7



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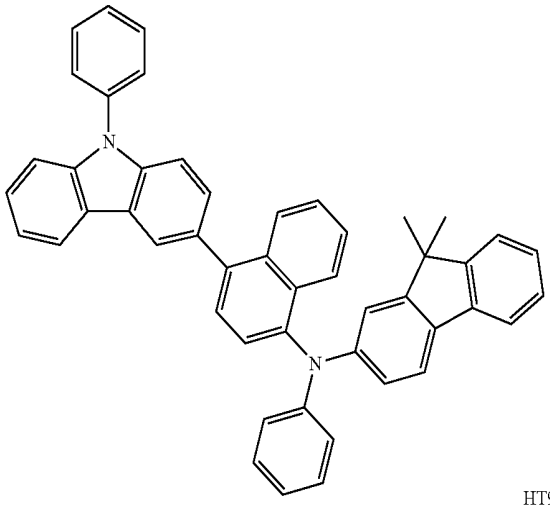
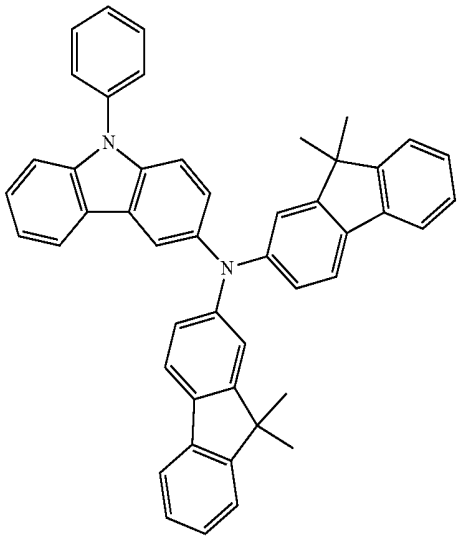
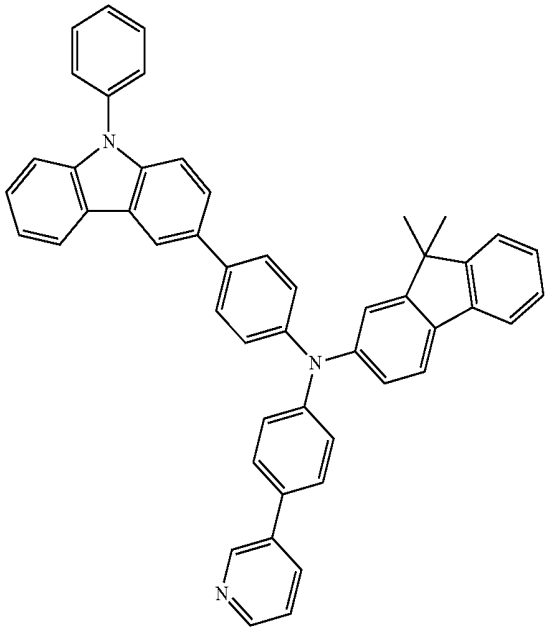
HT8



HT9



HT10



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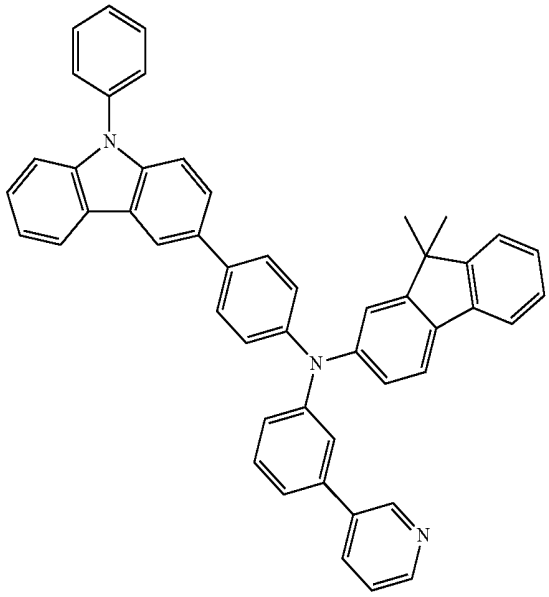
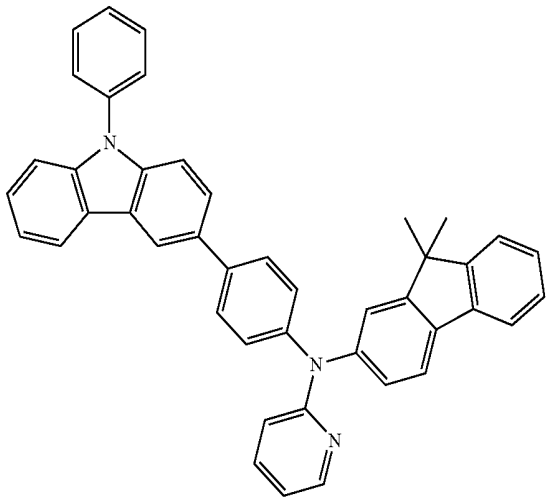
HT11



HT12



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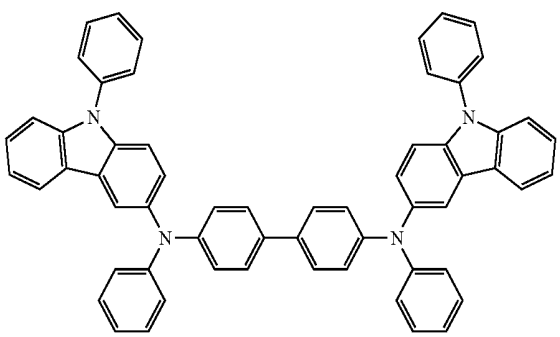

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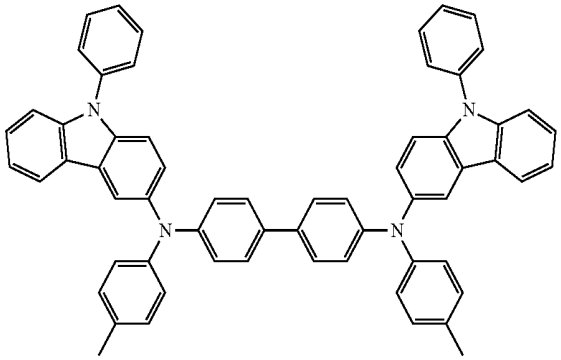
HT14



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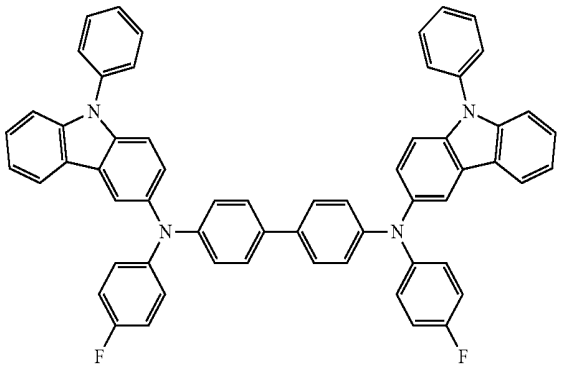

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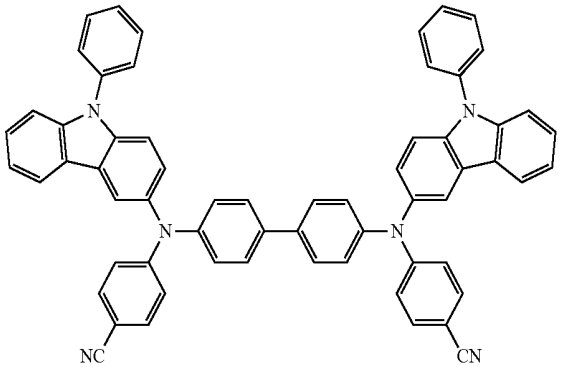

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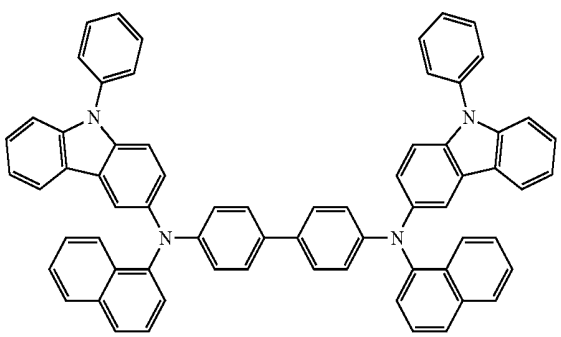

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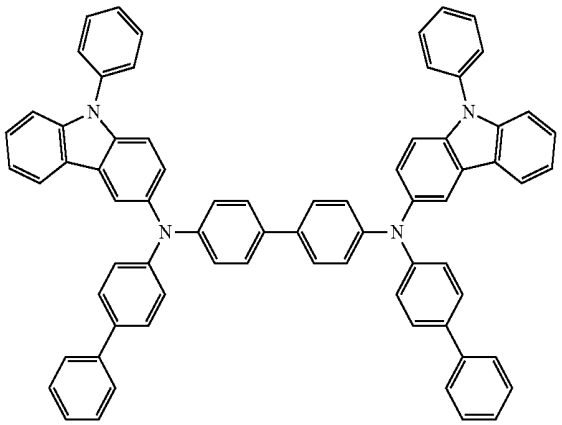
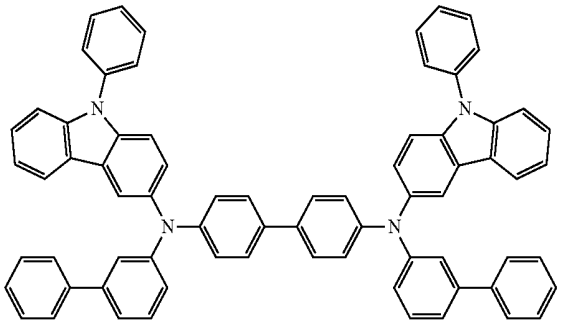


HT19



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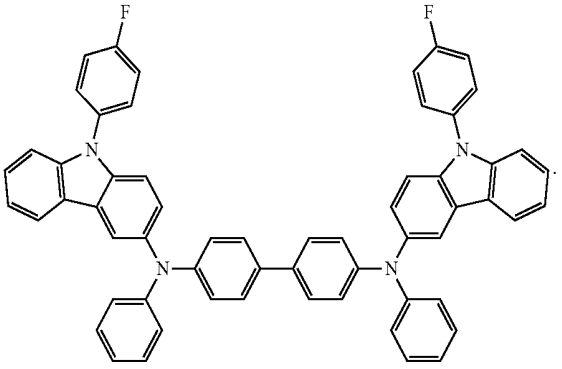
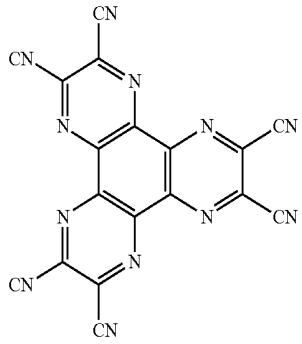


[0208] A thickness of the hole transport region may be in a range of about 100 Angstroms (Å) to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region includes both a hole injection layer and a hole transport layer, a thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å, and a thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, for example about 100 Å to about 1,500 Å. While not wishing to be bound by theory, it is understood that when the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

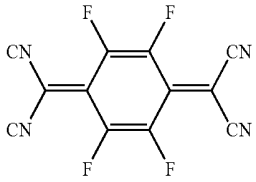
[0209] The hole transport region may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0210] The charge-generation material may be, for example, a p-dopant. The p-dopant may be one selected from a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto. Non-limiting examples of the p-dopant are a quinone derivative, such as tetracyanoquinonedimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4-TCNQ); a metal oxide, such as a tungsten oxide or a molybdenum oxide; and a cyano group-containing compound, such as Compound HT-D1 or Compound HT-D2, but are not limited thereto:

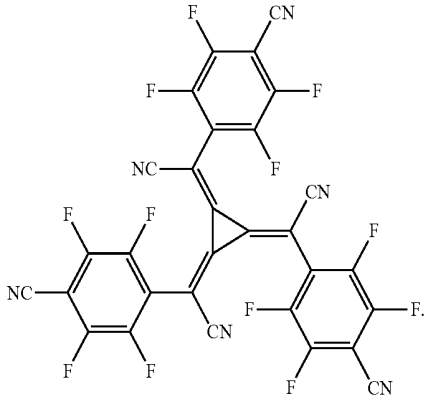
HT-D1



F4-TCNQ



HT-D2



[0211] The hole transport region may include a buffer layer.

[0212] Also, the buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, and thus, efficiency of a formed organic light-emitting device may be improved.

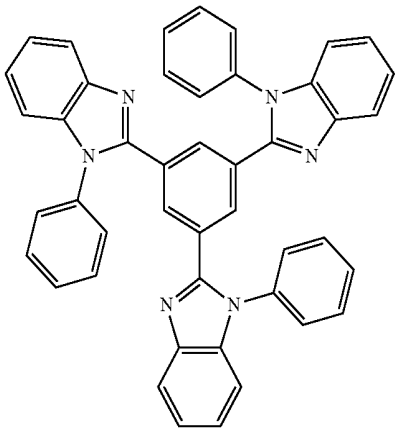
[0213] Then, an emission layer may be formed on the hole transport region by vacuum deposition, spin coating, casting, LB deposition, or the like. When the emission layer is formed by vacuum deposition or spin coating, the deposition or coating conditions may be similar to those applied in forming the hole injection layer although the deposition or

coating conditions may vary according to a compound that is used to form the emission layer.

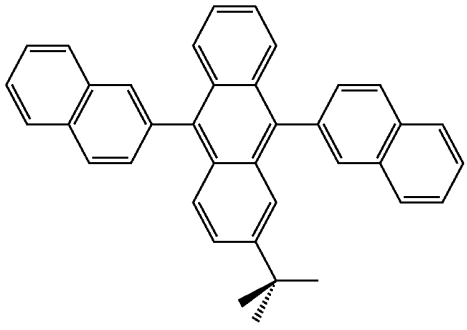
[0214] Meanwhile, when the hole transport region includes an electron blocking layer, a material for the electron blocking layer may be selected from materials for the hole transport region described above and materials for a host to be explained later. However, the material for the electron blocking layer is not limited thereto. For example, when the hole transport region includes an electron blocking layer, a material for the electron blocking layer may be mCP, which will be explained later.

[0215] The emission layer may include a host and a dopant, and the dopant may include the organometallic compound represented by Formula 1.

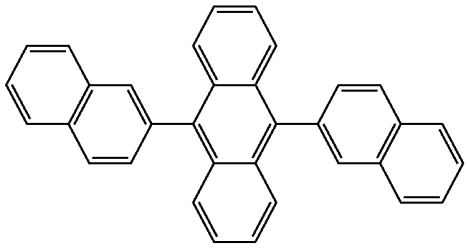
[0216] The host may include at least one selected from TPBi, TBADN, ADN (also referred to as "DNA"), CBP, CDBP, TCP, mCP, Compound H50, and Compound H51:



TPBi



TBADN



ADN

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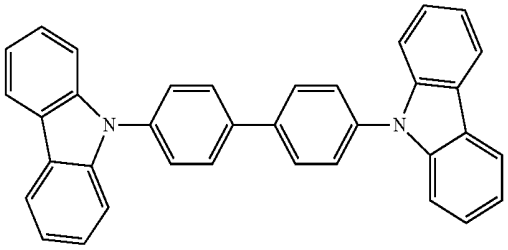
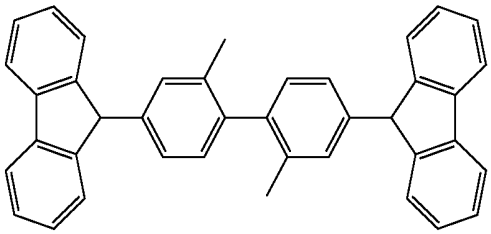
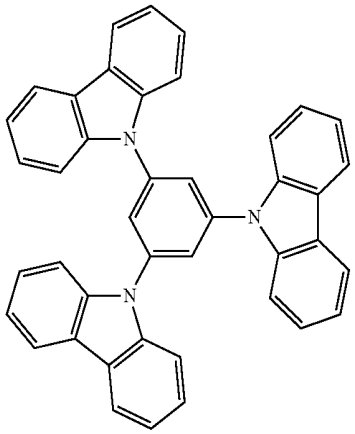


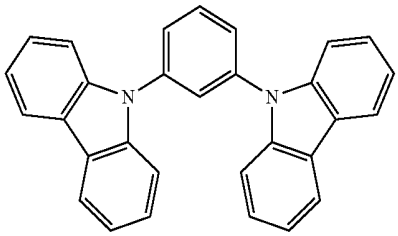
CBP



CDBP

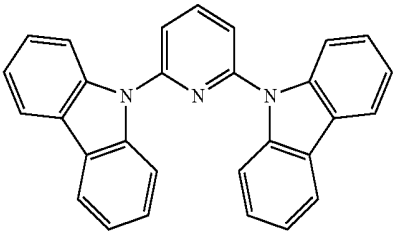


TCP



mCP

Compound H50



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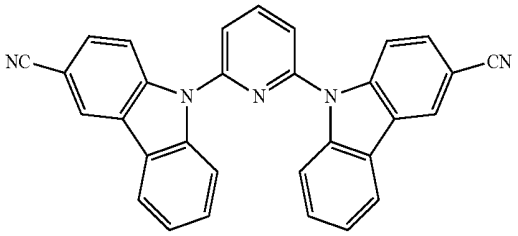
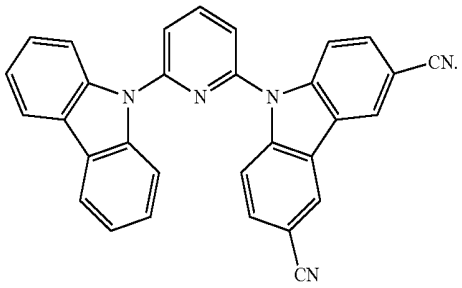
Compound H51

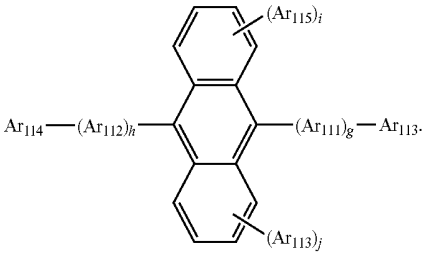


H52



[0217] In one or more embodiments, the host may further include a compound represented by Formula 301:

Formula 301



[0218] In Formula 301, Ar_{111} and Ar_{112} may each independently be selected from:

[0219] a phenylene group, a naphthylene group, a phenanthrenylene group, and a pyrenylene group; and

[0220] a phenylene group, a naphthylene group, a phenanthrenylene group, and a pyrenylene group, each substituted with at least one selected from a phenyl group, a naphthyl group, and an anthracenyl group.

[0221] In Formula 301, Ar_{113} to Ar_{116} may each independently be selected from:

[0222] a C_1-C_{10} alkyl group, a phenyl group, a naphthyl group, a phenanthrenyl group, and a pyrenyl group; and

[0223] a phenyl group, a naphthyl group, a phenanthrenyl group, and a pyrenyl group, each substituted with at least one selected from a phenyl group, a naphthyl group, and an anthracenyl group.

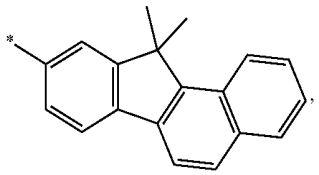
[0224] In Formula 301, g, h, i, and j may each independently be an integer from 0 to 4, and may be, for example, 0, 1, or 2.

[0225] In Formula 301, Ar_{113} to Ar_{116} may each independently be selected from:

[0226] a C_1-C_{10} alkyl group substituted with at least one selected from a phenyl group, a naphthyl group, and an anthracenyl group;

[0227] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl, a phenanthrenyl group, and a fluorenyl group;

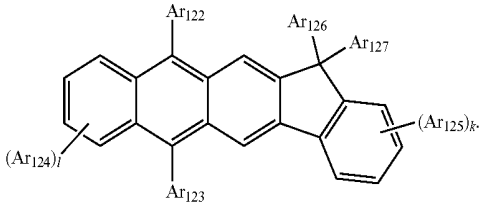
[0228] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{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 phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group; and



but embodiments of the present disclosure are not limited thereto.

[0229] In one or more embodiments, the host may include a compound represented by Formula 302 below:

[0230] Formula 302



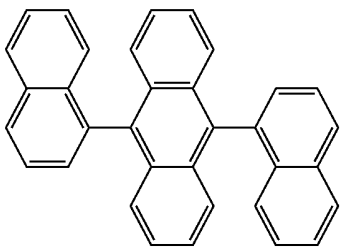
[0231] In Formula 302, Ar_{122} to Ar_{125} are the same as described in connection with Ar_{113} in Formula 301.

[0232] In Formula 302, Ar_{126} and Ar_{127} may each independently be a C_1-C_{10} alkyl group (for example, a methyl group, an ethyl group, or a propyl group).

[0233] In Formula 302, k and I may each independently be an integer from 0 to 4. For example, k and I may be 0, 1, or 2.

[0234] The compound of Formula 301 and the compound of Formula 302 may include Compounds H1 to H42, but are not limited thereto.

H1



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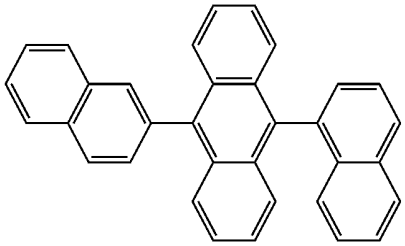
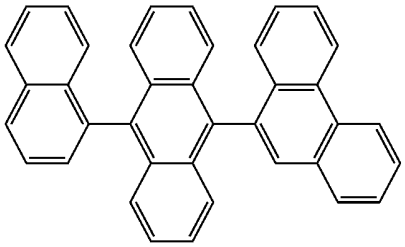
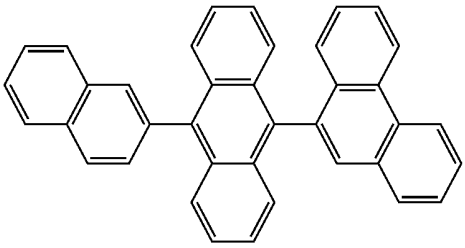
H2



H3



H4



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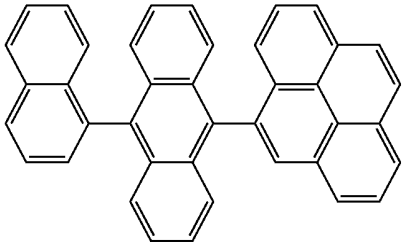
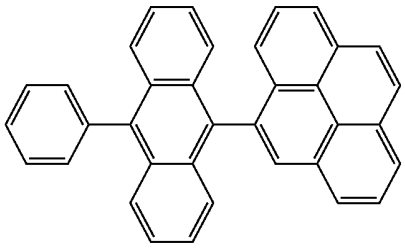


H6



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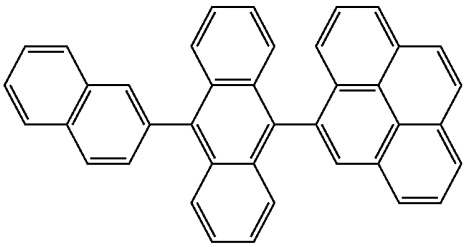

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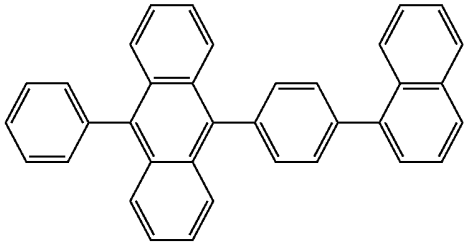
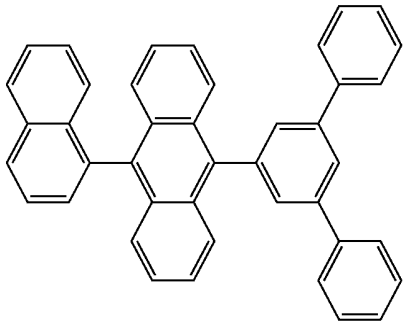
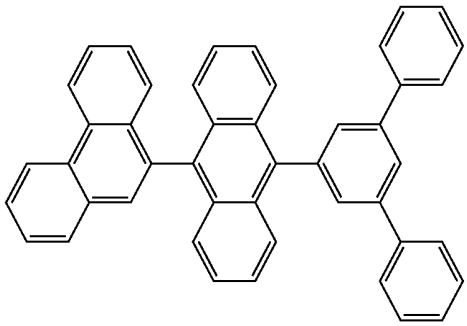
H8



H9



H10



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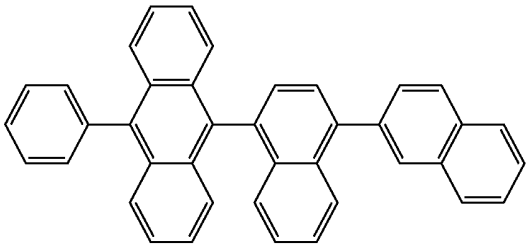

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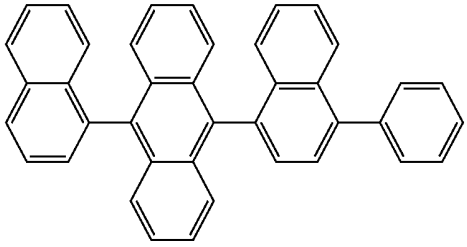

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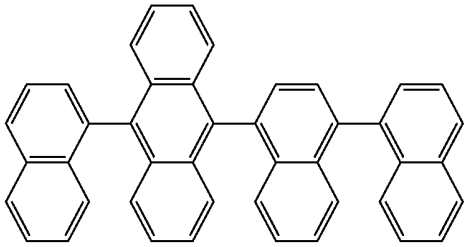
H13



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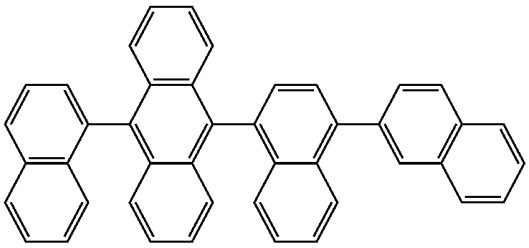
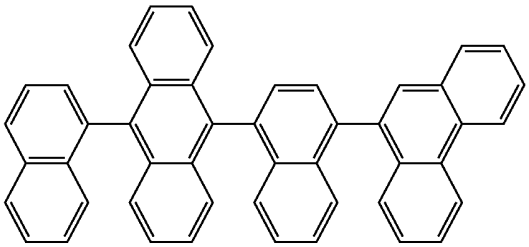


H15



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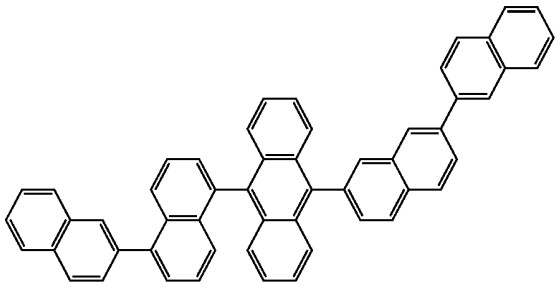
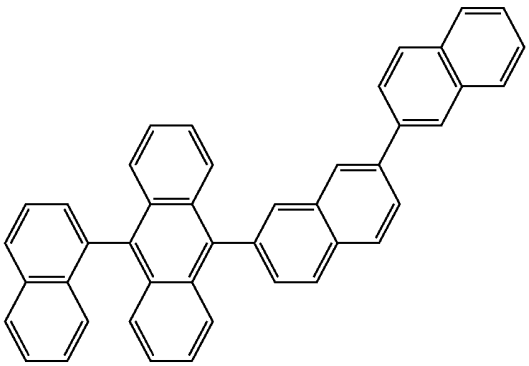


H17



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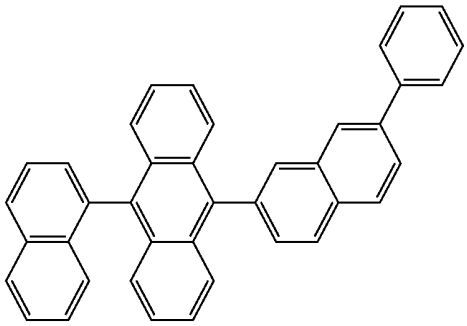
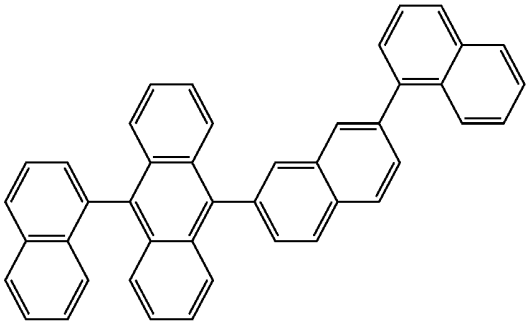
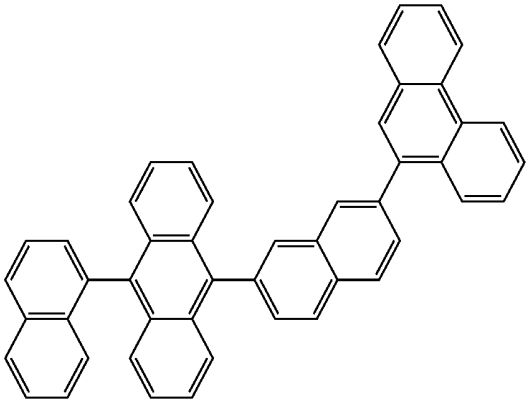
H18



H19



H20



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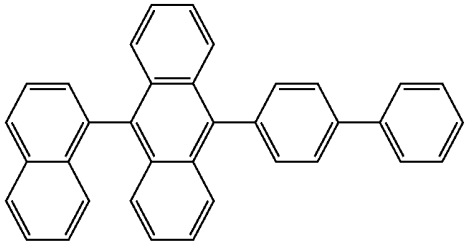
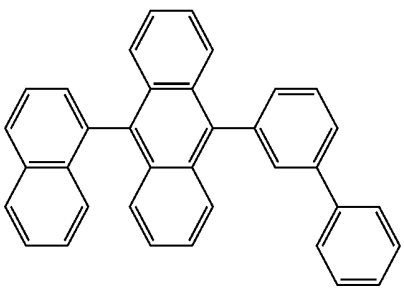


H22



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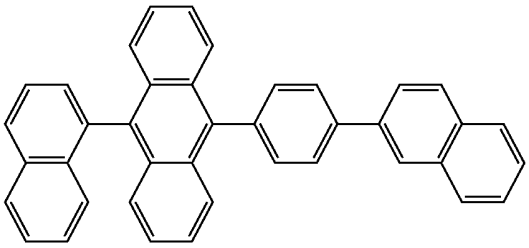
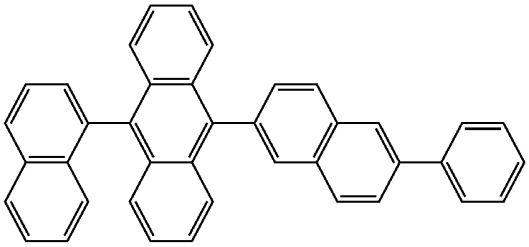
H23



H24



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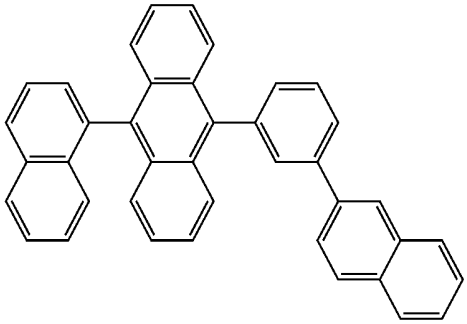

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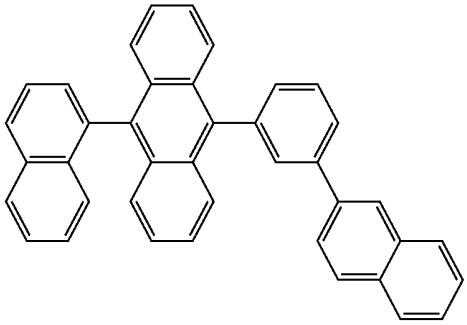

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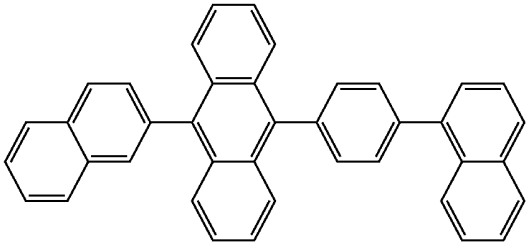

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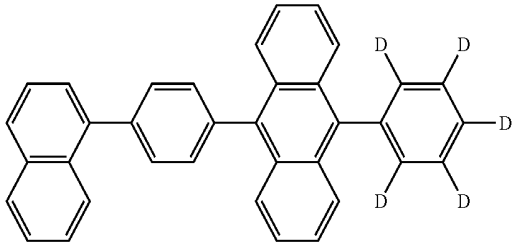

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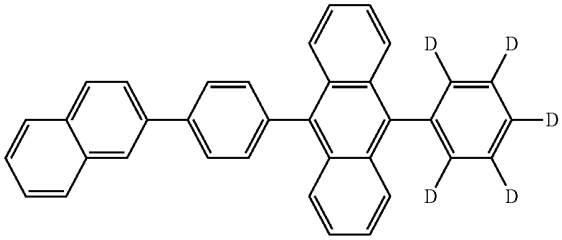

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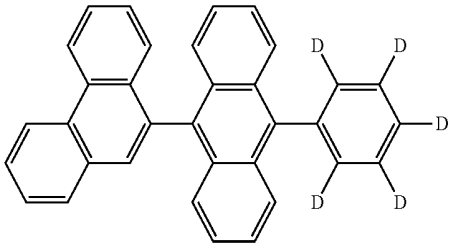

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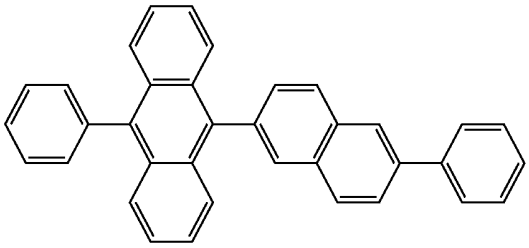

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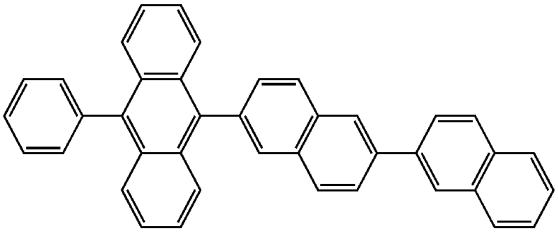

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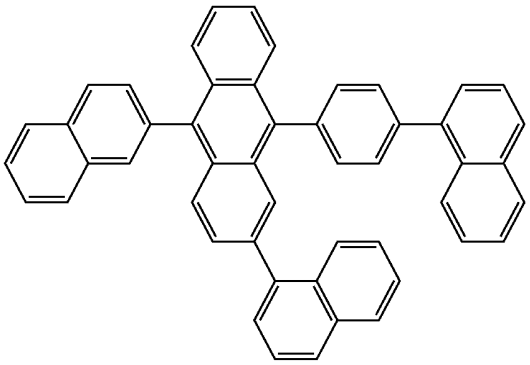

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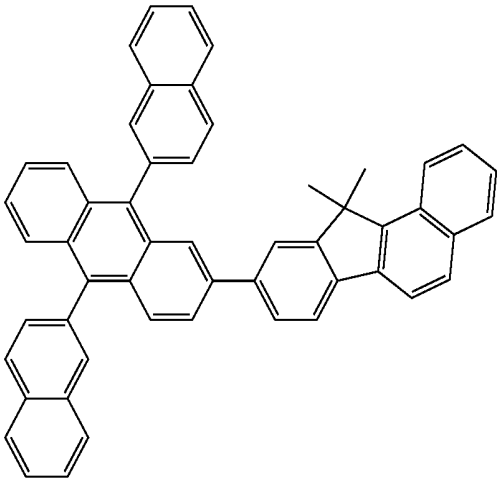

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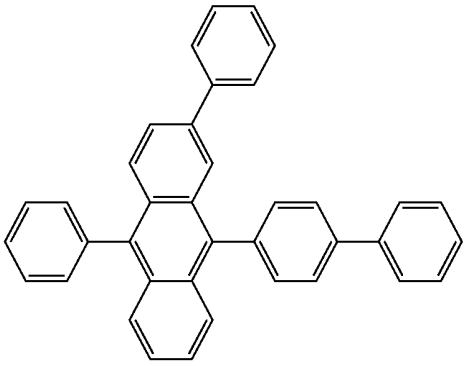

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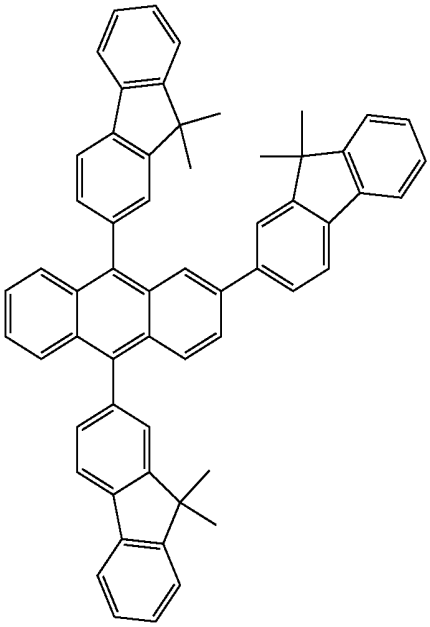

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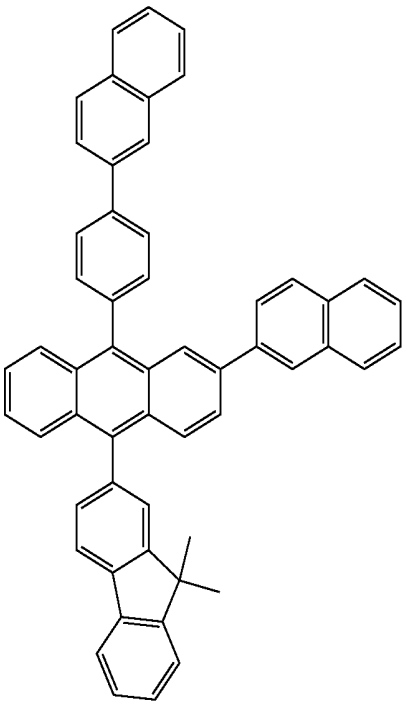

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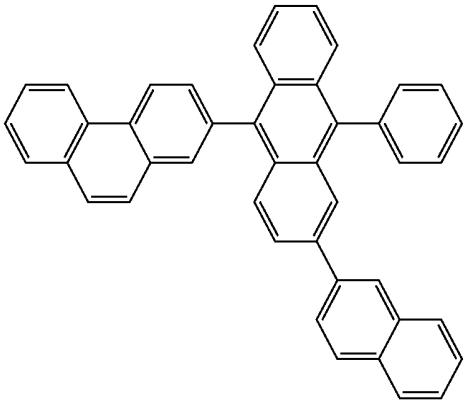

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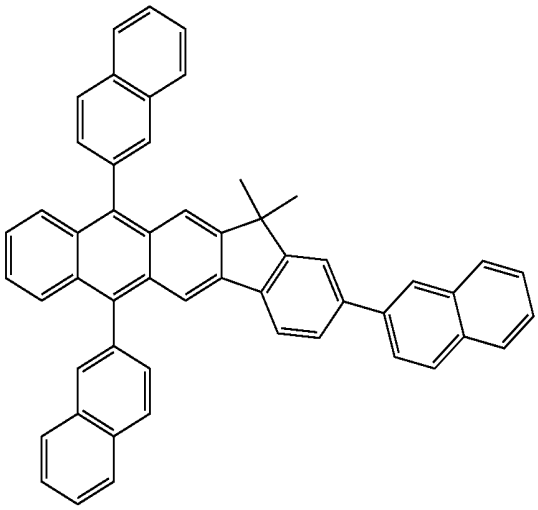

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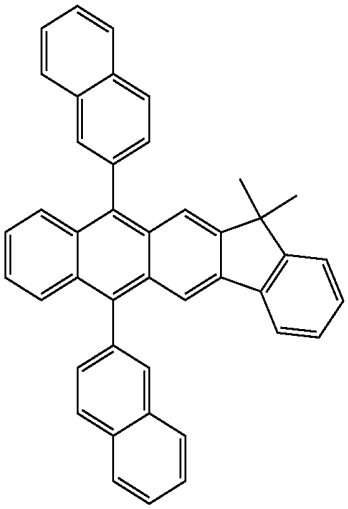

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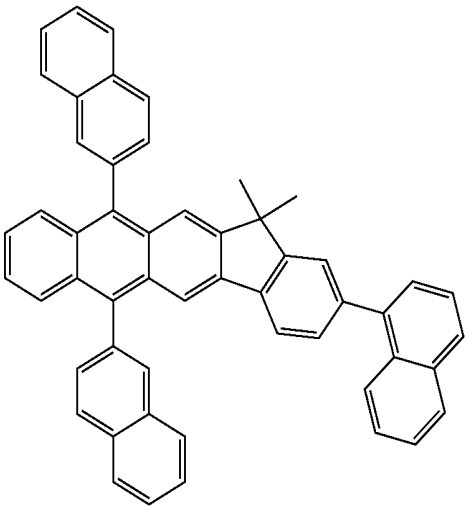

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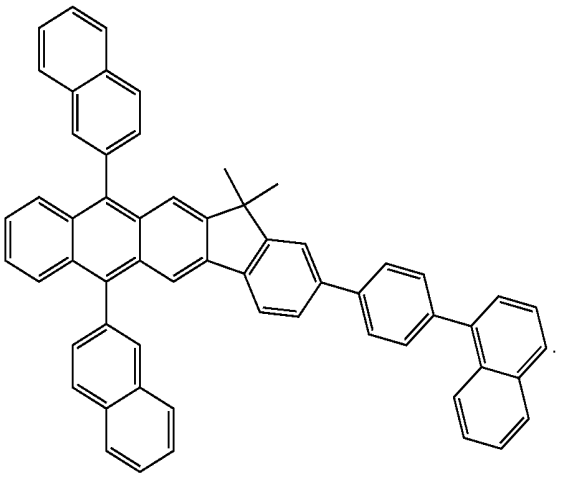
H42



[0235] When the organic light-emitting device is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and a blue emission layer. In one or more embodiments, due to a stacked structure including a red emission layer, a green emission layer, and/or a blue emission layer, the emission layer may emit white light.

[0236] When the emission layer includes a host and a dopant, an amount of the dopant may be in a range of about 0.01 part to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

[0237] The dopant may include at least one organometallic compound of Formula 1.

[0238] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

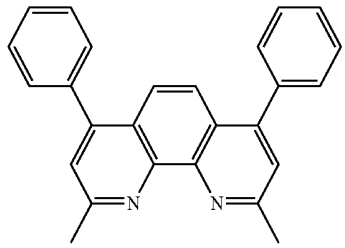
[0239] Then, an electron transport region may be disposed on the emission layer.

[0240] The electron transport region may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

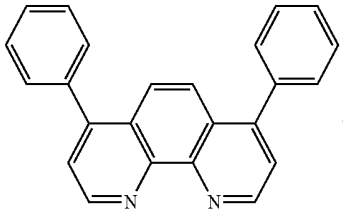
[0241] For example, the electron transport region may have a hole blocking layer/electron transport layer/electron injection layer structure or an electron transport layer/electron injection layer structure, but the structure of the electron transport region is not limited thereto. The electron transport layer may have a single-layered structure or a multi-layered structure including two or more different materials.

[0242] Conditions for forming the hole blocking layer, the electron transport layer, and the electron injection layer which constitute the electron transport region may be understood by referring to the conditions for forming the hole injection layer.

[0243] When the electron transport region includes a hole blocking layer, the hole blocking layer may include, for example, at least one of BCP, Bphen, and BAlq but embodiments of the present disclosure are not limited thereto:



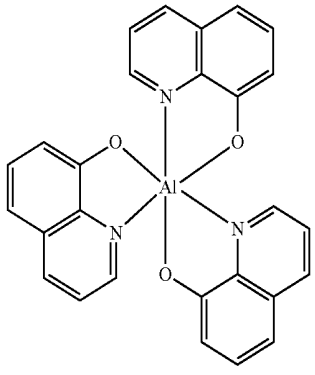
BCP



Bphen

[0244] A thickness of the hole blocking layer may be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. While not wishing to be bound by theory, it is understood that when the thickness of the hole blocking layer is within these ranges, the hole blocking layer may have excellent hole blocking characteristics without a substantial increase in driving voltage.

[0245] The electron transport layer may further include at least one selected from BCP, Bphen, Alq_3, BAlq, TAZ, and NTAZ:



Alq_3

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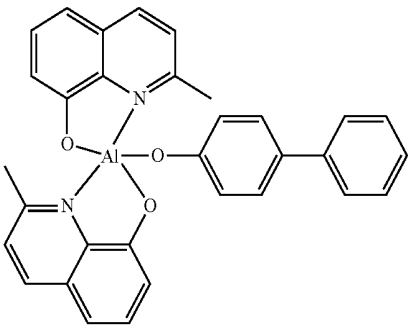
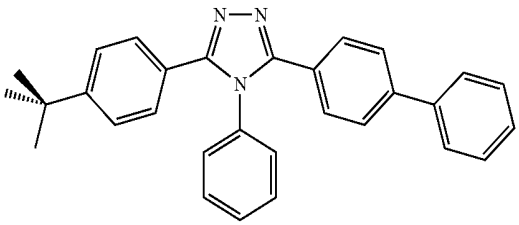
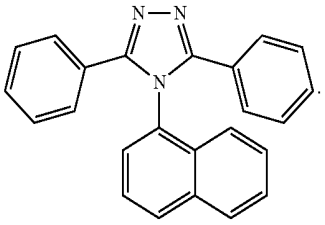


BAlq



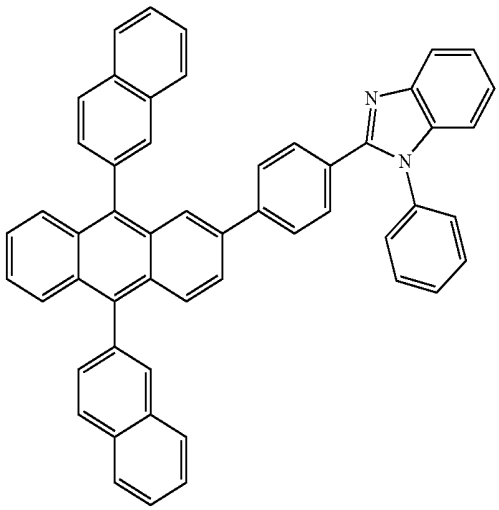
TAZ



NTAZ

[0246] In one or more embodiments, the electron transport layer may include at least one of ET1 and ET25, but are not limited thereto:

ET1



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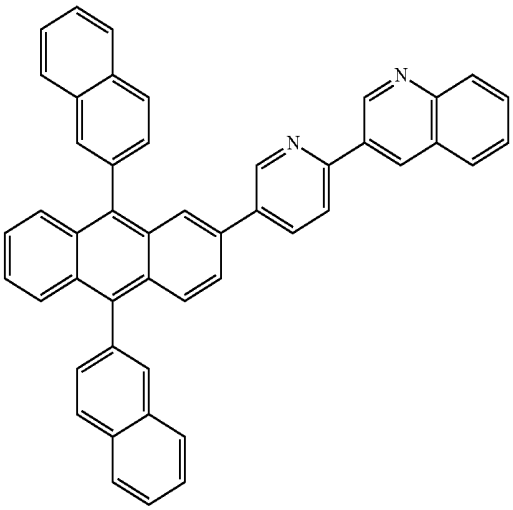
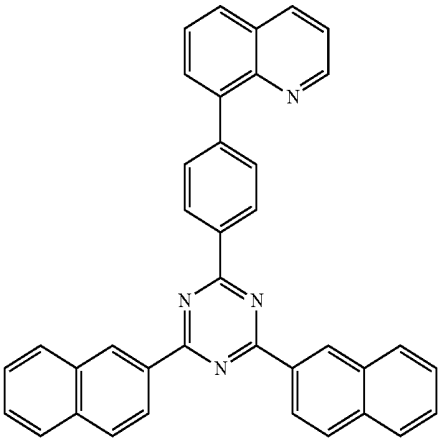
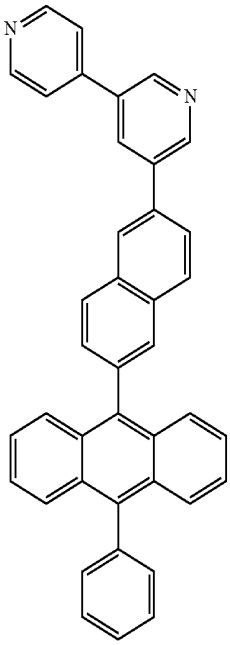
ET2



ET3



ET4



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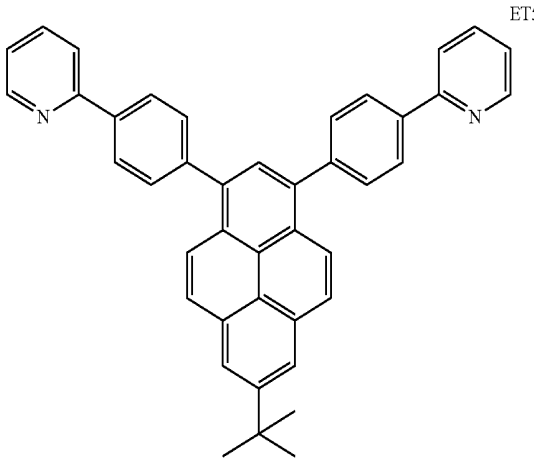
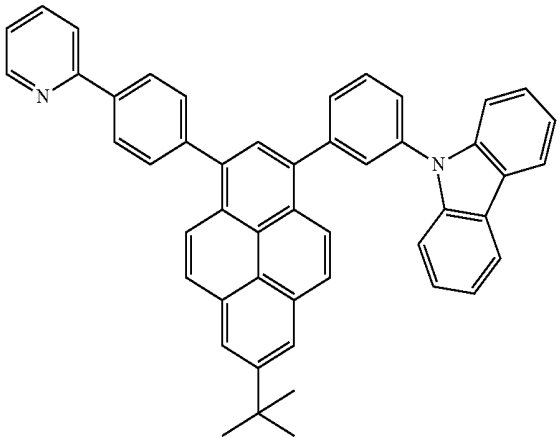
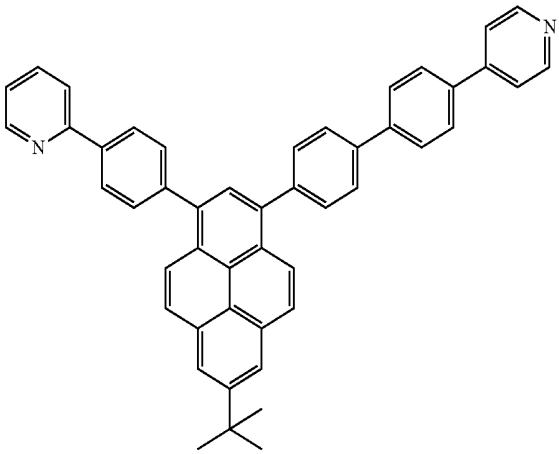
ET5



ET6



ET7



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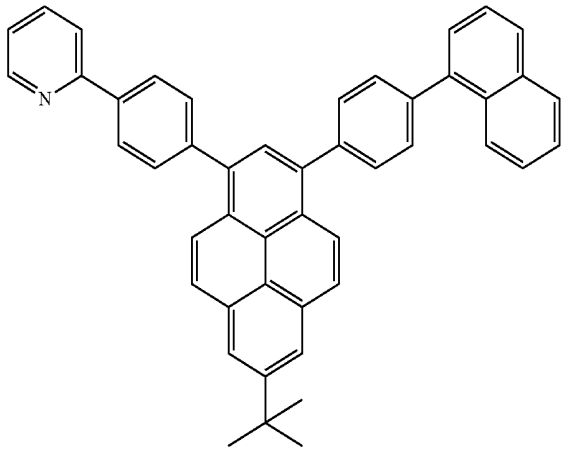
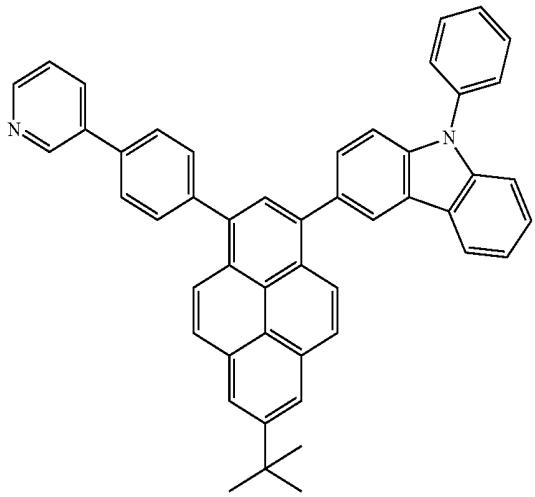
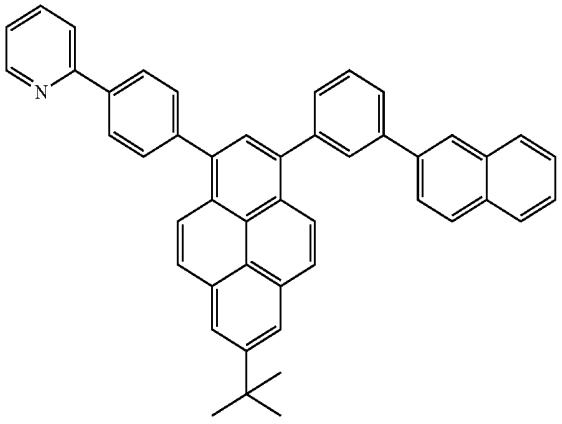
ET8



ET9



ET10



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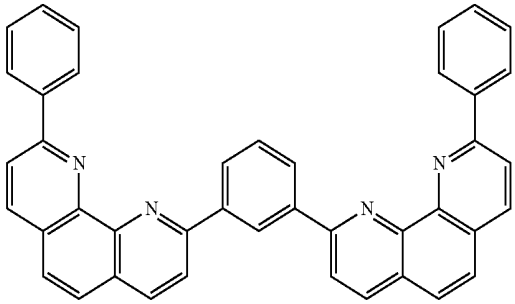

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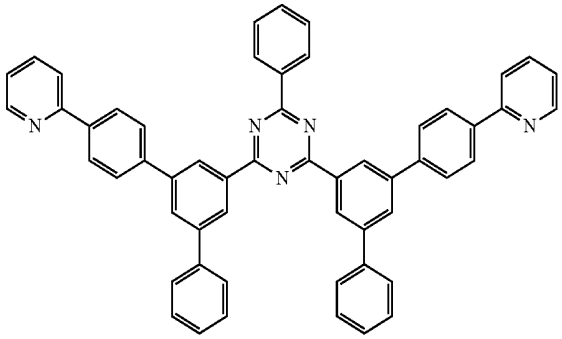

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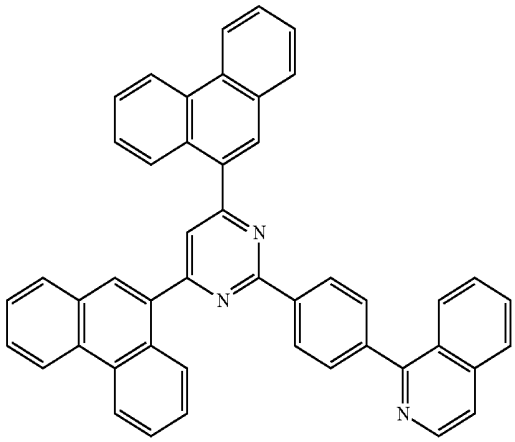
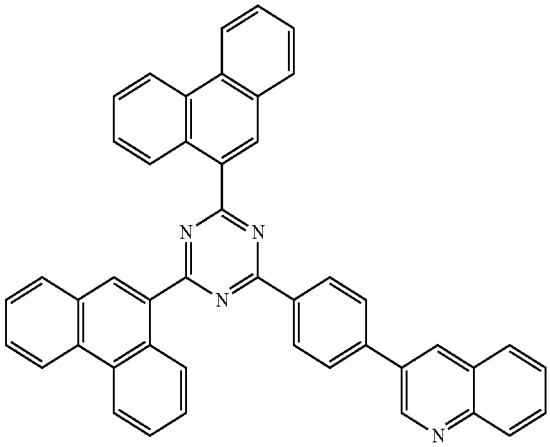


ET14



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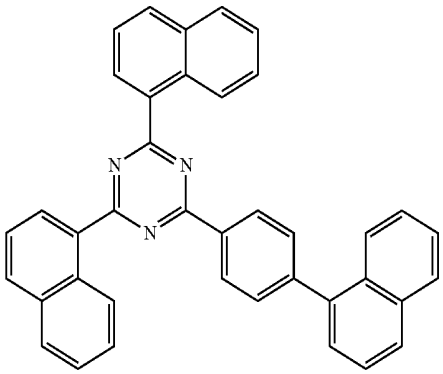
ET15



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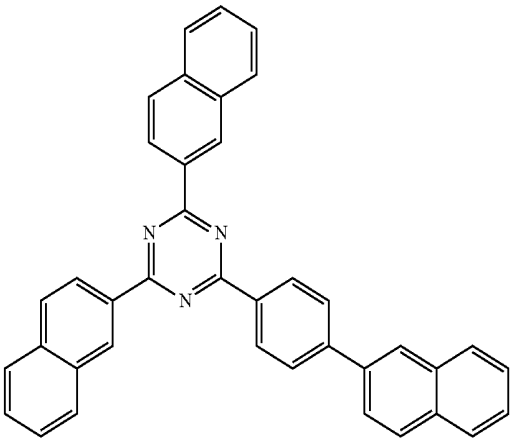
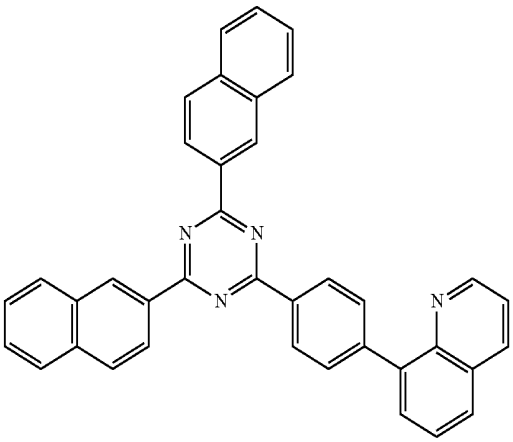


ET17



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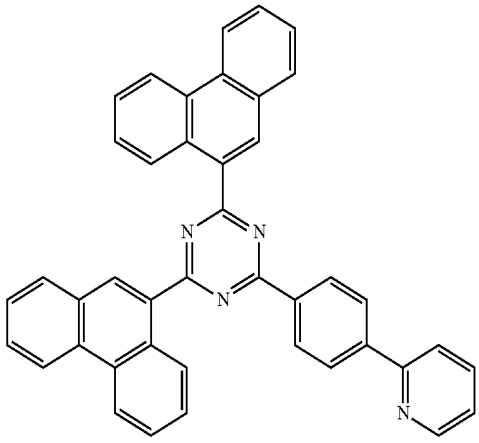

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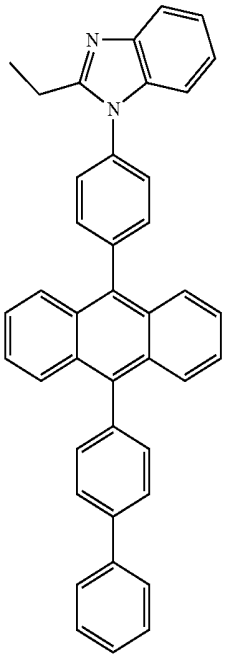
ET19



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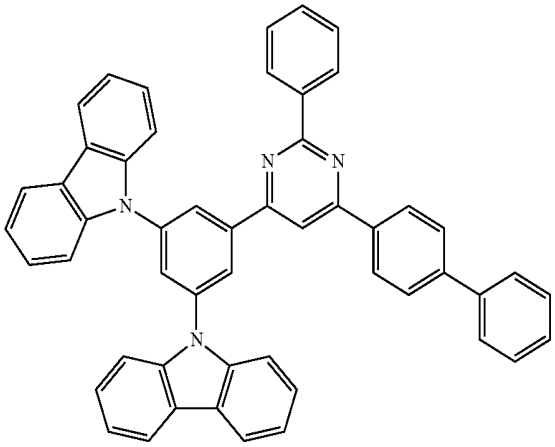

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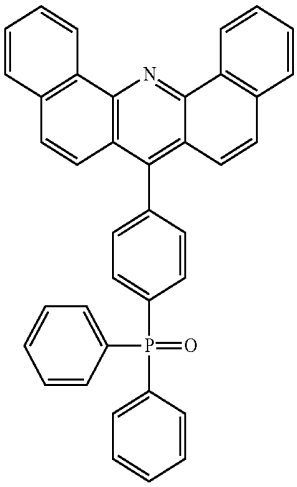

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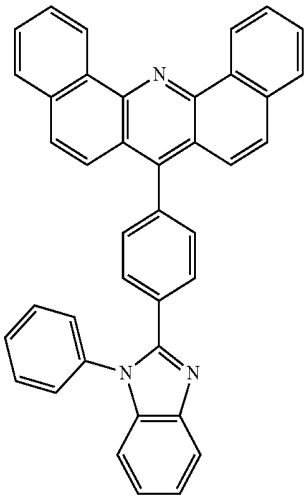
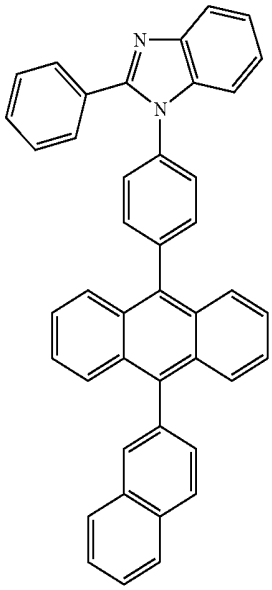
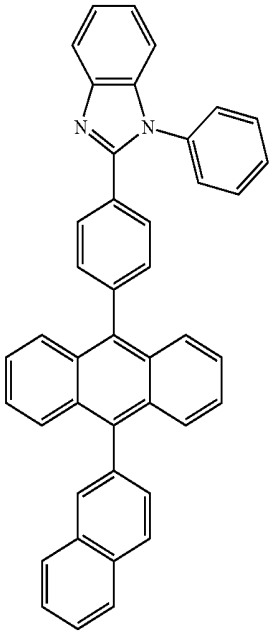
ET22



ET23



ET24



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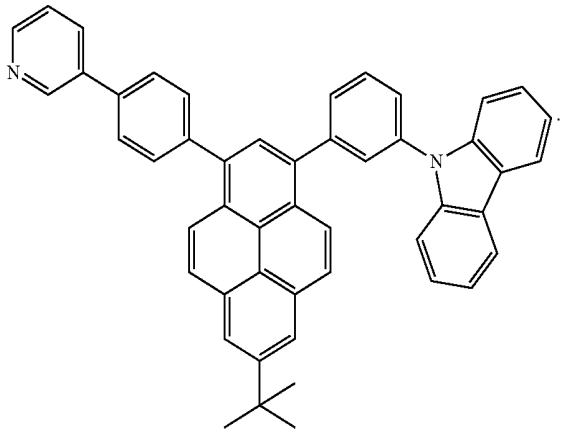
ET25

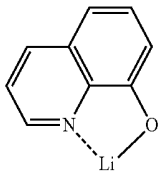


[0247] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. While not wishing to be bound by theory, it is understood that when the thickness of the electron transport layer is within the range described above, the electron transport layer may have satisfactory electron transport characteristics without a substantial increase in driving voltage.

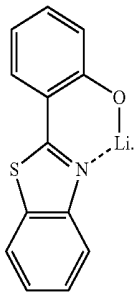
[0248] Also, the electron transport layer may further include, in addition to the materials described above, a metal-containing material.

[0249] The metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium 8-hydroxyquinolate, LiQ) or ET-D2:

ET-D1



ET-D2



[0250] The electron transport region may include an electron injection layer that promotes flow of electrons from the second electrode **19** thereinto.

[0251] The electron injection layer may include at least one selected from LiF, NaCl, CsF, Li_2O, and BaO.

[0252] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. While not wishing to be bound by theory, it is understood that when the thickness of the electron

injection layer is within the range described above, the electron injection layer may have satisfactory electron injection characteristics without a substantial increase in driving voltage.

[0253] The second electrode **19** is disposed on the organic layer **15**. The second electrode **19** may be a cathode. A material for forming the second electrode **19** may be metal, an alloy, an electrically conductive compound, or a combination thereof, which have a relatively low work function. For example, lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag) may be formed as the material for forming the second electrode **19**. To manufacture a top-emission type light-emitting device, a transmissive electrode formed using ITO or IZO may be used as the second electrode **19**.

[0254] Hereinbefore, the organic light-emitting device has been described with reference to FIG. **1**, but embodiments of the present disclosure are not limited thereto.

[0255] The term "first-row transition metals" as used herein refers to d-block elements from Period 4 of the Periodic Table of Elements, and examples thereof are scandium (Sc), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), and zinc (Zn).

[0256] The term "second-row transition metals" as used refers to d-block elements from Period 5 of the Periodic Table of Elements, and examples thereof are yttrium (Y), zirconium (Zr), niobium (Nb), molybdenum (Mo), technetium (Tc), ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), and cadmium (Cd).

[0257] The term "third-row transition metals" as used herein refers to d-block and f-block elements of Period 6 of the Periodic Table of Elements, and examples thereof are lanthanum (La), samarium (Sm), europium (Eu), terbium (Tb), thulium (Tm), ytterbium (Yb), lutetium (Lu), hafnium (Hf), tantalum (Ta), tungsten (W), rhenium (Re), osmium (Os), iridium (Ir), platinum (Pr), gold (Au), and mercury (Hg).

[0258] The term "first-row post-transition metals" as used herein refers to elements that belong to Period 4 of the Periodic Table of Elements but are not transition metals, typical elements, and metalloid elements, and an example thereof is gallium (Ga).

[0259] The term "second-row post-transition metals" as used herein refers to elements that belong to Period 5 of the Periodic Table of Elements but are not transition metals, typical elements, and metalloid elements, and examples thereof are indium (In) and tin (Sn).

[0260] The term "third-row post-transition metals" as used herein refers elements that belong to Period 6 of the Periodic Table of Elements but are not transition metals, typical elements, and metalloid elements, and examples thereof are thallium (TI), lead (Pb), and bismuth (Bi).

[0261] The term "C_1-C_{60} alkyl group" as used herein refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms, and examples thereof include a methyl group, an ethyl group, a propyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. The term "C_1-C_{60} alkylene group" as used herein refers to a divalent group having the same structure as the C_1-C_{60} alkyl group.

[0262] The term "C_1-C_{60} alkoxy group" as used herein refers to a monovalent group represented by —OA_{101} (wherein A_{101} is the C_1-C_{60} alkyl group), and examples thereof include a methoxy group, an ethoxy group, and an iso-propyloxy group.

[0263] The term "C_2-C_{60} alkenyl group" as used herein refers to a hydrocarbon group formed by including at least one carbon-carbon double bond in the middle or at the terminus of the C_2-C_{60} alkyl group, and examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term "C_2-C_{60} alkenylene group" as used herein refers to a divalent group having the same structure as the C_2-C_{60} alkenyl group.

[0264] The term "C_{60}-C_{60} alkynyl group" as used herein refers to a hydrocarbon group formed by including at least one carbon-carbon triple bond in the middle or at the terminus of the C_2-C_{60} alkyl group, and examples thereof include an ethynyl group, and a propynyl group. The term "C_2-C_{60} alkynylene group" as used herein refers to a divalent group having the same structure as the C_2-C_{60} alkynyl group.

[0265] The term "C_3-C_{10} cycloalkyl group" as used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and non-limiting examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term "C_3-C_{10} cycloalkylene group" as used herein refers to a divalent group having the same structure as the C_3-C_{10} cycloalkyl group.

[0266] The term "C_1-C_{10} heterocycloalkyl group" as used herein refers to a monovalent saturated monocyclic group having at least one heteroatom selected from N, O, P, Si and S as a ring-forming atom and 1 to 10 carbon atoms, and non-limiting examples thereof include a tetrahydrofuranyl group, and a tetrahydrothiophenyl group. The term "C_1-C_{10} heterocycloalkylene group" as used herein refers to a divalent group having the same structure as the C_1-C_{10} heterocycloalkyl group.

[0267] The term "C_3-C_{10} cycloalkenyl group" as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity, and non-limiting examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term "C_3-C_{10} cycloalkenylene group" as used herein refers to a divalent group having the same structure as the C_3-C_{10} cycloalkenyl group.

[0268] The term "C_1-C_{10} heterocycloalkenyl group" as used herein refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom, 1 to 10 carbon atoms, and at least one carbon-carbon double bond in its ring. Examples of the C_1-C_{10} heterocycloalkenyl group are a 2,3-dihydrofuranyl group, and a 2,3-dihydrothiophenyl group. The term "C_1-C_{10} heterocycloalkenylene group" as used herein refers to a divalent group having the same structure as the C_1-C_{10} heterocycloalkenyl group.

[0269] The term "C_6-C_{60} aryl group" as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and the term "C_6-C_{60} arylene group" as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Non-limiting examples of the C_6-C_{60} aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a

phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6-C_{60} aryl group and the C_6-C_{60} arylene group each include two or more rings, the rings may be fused to each other.

[0270] The term "C_1-C_{60} heteroaryl group" as used herein refers to a monovalent group having a heterocyclic aromatic system that has at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom, and 1 to 60 carbon atoms. The term C_1-C_{60} heteroarylene group" as used herein refers to a divalent group having a heterocyclic aromatic system that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom, and 1 to 60 carbon atoms. Non-limiting examples of the C_1-C_{60} heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1-C_{60} heteroaryl group and the C_1-C_{60} heteroarylene group each include two or more rings, the rings may be fused to each other.

[0271] The term "C_6-C_{60} aryloxy group" as used herein indicates —OA_{102} (wherein A_{102} is the C_6-C_{60} aryl group), and a C_6-C_{60} arylthio group used herein indicates —SA_{103} (wherein A_{103} is the C_6-C_{60} aryl group).

[0272] The term "monovalent non-aromatic condensed polycyclic group" as used herein refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed to each other, only carbon atoms as ring-forming atoms, and no aromaticity in its entire molecular structure. Examples of the monovalent non-aromatic condensed polycyclic group include a fluorenyl group. The term "divalent non-aromatic condensed polycyclic group," as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0273] The term "monovalent non-aromatic condensed heteropolycyclic group" as used herein refers to a monovalent group (for example, having 2 to 60 carbon atoms) having two or more rings condensed to each other, a heteroatom selected from N, O, P, Si, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure. Non-limiting examples of the monovalent non-aromatic condensed heteropolycyclic group include a carbazolyl group. The term "divalent non-aromatic condensed heteropolycyclic group" as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0274] The term "C_5-C_{30} carbocyclic group" as used herein refers to a saturated or unsaturated cyclic group having, as a ring-forming atom, 5 to 30 carbon atoms only. The term "C_5-C_{30} carbocyclic group" as used herein refers to a monocyclic group or a polycyclic group, and, according to its chemical structure, a monovalent, divalent, trivalent, tetravalent, pentavalent, or hexavalent group.

[0275] The term "C_1-C_{30} heterocyclic group" as used herein refers to a saturated or unsaturated cyclic group having, as a ring-forming atom, at least one heteroatom selected from N, O, Si, P, and S other than 1 to 30 carbon atoms. The term "C_1-C_{30} heterocyclic group" as used herein refers to a monocyclic group or a polycyclic group, and, according to its chemical structure, a monovalent, divalent, trivalent, tetravalent, pentavalent, or hexavalent group.

[0276] The term "nitrogen atom-containing C_1-C_{30} heterocyclic group" as used herein refers to a saturated or unsaturated cyclic group having at least on N as a ring-forming atom and 1 to 30 carbon atoms. The term "nitrogen atom-containing C_1-C_{30} heterocyclic group" as used herein refers to a monocyclic group or a polycyclic group, and, according to its chemical structure, a monovalent, divalent, trivalent, tetravalent, pentavalent, or hexavalent group.

[0277] At least one substituent of the substituted C_5-C_{30} carbocyclic group, the substituted C_1-C_{30} heterocyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_2-C_{60} alkenyl group, the substituted C_2-C_{60} alkynyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the 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, substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0278] deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group; a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-$C_{10}o$ 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, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, —$B(Q_{16})(Q_{17})$, and —$P(=O)(Q_{18})(Q_{19})$;

[0279] 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;

[0280] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group,

a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, —$B(Q_{26})(Q_{27})$, and —$P(=O)(Q_{28})(Q_{29})$; and

[0281] —$N(Q_{31})(Q_{32})$, —$Si(Q_{33})(Q_{34})(Q_{35})$, —$B(Q_{36})(Q_{37})$, and —$P(=O)(Q_{38})(Q_{39})$,

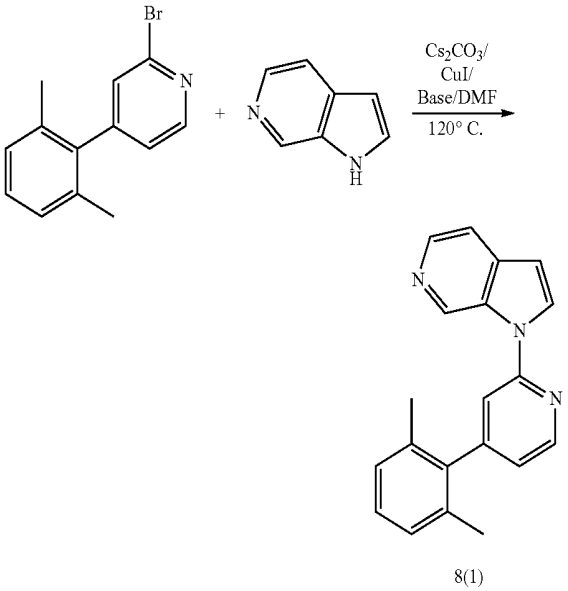
[0282] wherein Q_1 to Q_9, Q_{11} to Q_{19}, Q_{21} to Q_{29}, and Q_{31} to Q_{39} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with at least one selected from a C_1-C_{60} alkyl group, and 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.

[0283] Hereinafter, a compound and an organic light-emitting device according to embodiments are described in detail with reference to Synthesis Example and Examples. However, the organic light-emitting device is not limited thereto. The wording "'B' was used instead of 'A'" used in describing Synthesis Examples means that a molar equivalent of 'A' was identical to a molar equivalent of 'B'.

EXAMPLES

Synthesis Example 1: Synthesis of Compound 8

[0284] (1) Synthesis of Intermediate 8(1)



8(1)

[0285] 2.24 grams (g) (0.0085 moles, mol) of 2-bromo-4-(2,6-dimethylphenyl)pyridine, 1 g (0.0085 mol) of 6-azeindole, 0.33 g (0.0017 mol) of copper iodide, 1.11 g (0.0034 mol) of cesium carbonate, and 0.51 g (0.0051 mol) of 1,2-diaminobenzene were added to 20 milliliters (ml) of dimethyl sulfoxide, and the mixed solution was heated at a temperature of 120° C. for 12 hours in a nitrogen atmosphere. After the termination of the reaction, the reaction mixture was cooled, and then, diluted with chloromethane and water. The organic layer obtained therefrom was dried by using $MgSO_4$, and concentrated. The resultant crude compound was purified by column chromatography (dichloromethane::ethyl acetate=9:1 (volume:volume)) to obtain 1.54 g (yield: 54%) of Intermediate 8(1). The obtained compound was identified by ^{1}H-NMR and LC-MASS.

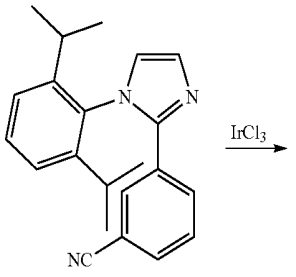
[0286] ^{1}H-NMR, (600 MHz, CD_2Cl_2): δ (ppm) 6.76 (d, 1H, J-7.44 Hz), 7.10 (m, 1H), 7.18 (m, 2H) 7.26 (m, 1H), 7.38 (s, 1H), 7.64 (s, 1H), 7.39 (s, 1H), 8.44 (s, 1H), 8.67 (d, 1H, J=6.66 Hz), 9.84 (s, 1H).

[0287] LC-MASS (MH^+-300.139).

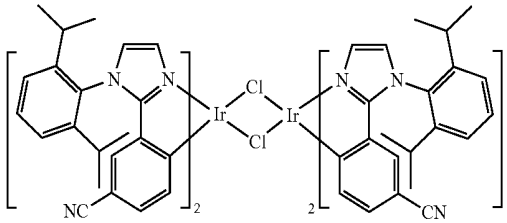
[0288] ^{1}H-NMR, (600 MHz, CD_2Cl_2): δ (ppm) 6.76 (d, 1H, J-7.44 Hz), 7.10 (m, 1H), 7.18 (m, 2H) 7.26 (m, 1H), 7.38 (s, 1H), 7.64 (s, 1H), 7.39 (s, 1H), 8.44 (s, 1H), 8.67 (d, 1H, J=6.66 Hz), 9.84 (s, 1H).

[0289] LC-MASS (MH^+-300.139)

[0290] (2) Synthesis of Intermediate 8(2)



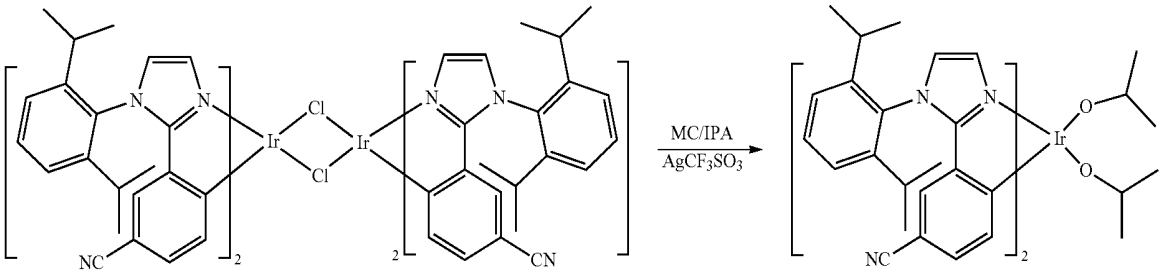
8(1)



8(2)

[0291] 6.58 g (0.02 mol) of Intermediate 8(1), 3 g (0.008 mol) of iridium chloride, and 40 ml of a mixture of ethoxyethanol:water (4:1=volume:volume) were heated at a temperature of 115° C. overnight. After the termination of the reaction, the mixture was cooled at room temperature, and then, diluted with 30 ml of water. The yellow precipitate was filtered therefrom, washed by using water and ethanol, and then, dried under vacuum to obtain Intermediate 8(2). Intermediate 8(2) was used in the next step without further purification.

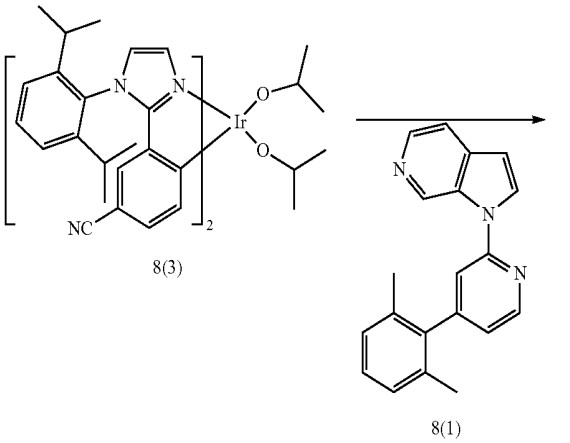
[0292] (3) Synthesis of Intermediate 8(3)



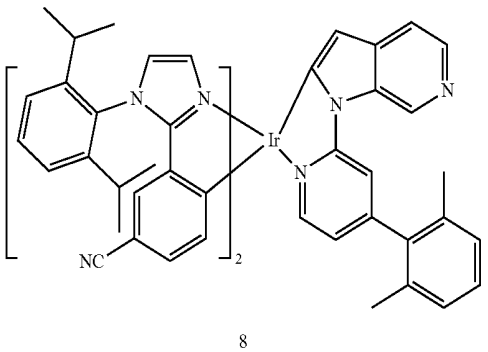
8(2) 8(3)

[0293] 3.54 g (0.001 g) of Intermediate 8(2) and 0.56 g (0.0022 mol) of silver triflate were dissolved in 15 ml of iso-propyl alcohol and 35 ml of dichloromethane. The mixture was stirred for 5 hours, filtered by using Celite, and washed by using dichloromethane. The solvent was evaporated therefrom under vacuum to obtain Intermediate 8(3). Intermediate 8(3) was used in the next step without a further purification process performed thereon.

[0294] (4) Synthesis of Compound 8



8(3) 8(1)



8

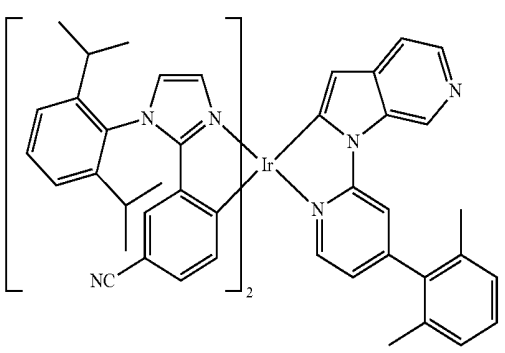
[0295] 1.54 g (0.0051 mol) of Intermediate 8(1) and 3 g (0.0031 mol) of Intermediate 8(3) were dissolved in 15 ml of 1,2-propanediol, and the mixed solution was heated at a temperature of 180° C. overnight. After the completion of the reaction, the reaction mixture was diluted with dichloromethane, and purified by column chromatography (dichloromethane::ethyl acetate=2:1 (volume:volume)) to obtain 0.73 g (yield=21%) of Compound 8. The obtained compound was identified by MALDI and ^{1}H-NMR, and the results are shown in FIGS. **2** and **3**.

[0296] ^{1}H-NMR, (600 MHz, DMF-d7): δ (ppm) 6.00 (s, 1H), 6.88 (d, 1H, J=9.36 Hz), 7.06 (d, 1H, J=4 Hz), 7.12 (d, 1H, J=9.42 Hz), 7.20-7.36, (m, 6H), 7.59 (m, 1H), 7.68 (t, 1H, J=9.45 Hz), 7.85 (d, 1H, J=7.26), 8.02 (m, 6H), 8.23 (s, 1H), 8.45 (d, 1H, J=7.32), 8.60 (d, 1H, J=6 Hz), 8.76 (d, 1H, J=4.14), 10.04 (s, 1H).

Evaluation Example 1: Evaluation of Photoluminescence (PL) Spectrum

[0297] As the PL spectra of Compound 8 and Compound A were evaluated, photoluminescent properties of each compound were also evaluated. In detail, Compound 8 was diluted with CH_2Cl_2 to a concentration of about 10 millimolar (mM), and an ISC PC1 spectrofluorometer equipped with a xenon light source was used to measure a PL spectrum of Compound 8 at room temperature. The same process was repeated on Compound A to measure a PL thereof. A maximum wavelength in the PL spectrum of Compound 8 is summarized in Table 1 and FIG. **4**:

8



-continued

A

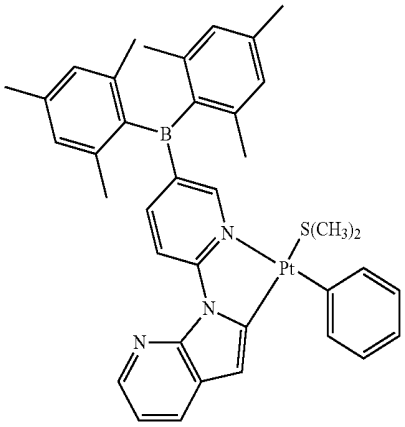


TABLE 1

Compound No.	λ_{max} (nm)
8	456,488
A	535

[0298] Referring to Table 1, it was confirmed that Compound 8 was able to emit blue light.

Evaluation Example 2: Evaluation of PL Quantum Yield of Compound 8

[0299] Samples of Compound 8 and Compound A were measured in PMMA film having 1 weight percent of each compound, respectively, were prepared. Then, PL spectrum of the compounds were measured by using a PL measurement meter (model name: F-7000, available from Hitachi technologies Corporation, Japan) at room temperature. A PL quantum yield of each sample was calculated by calculating a ratio of the number of photons emitted by each sample as photoluminescence to the number of photons absorbed by each sample, and the results thereof are shown in Table 2:

TABLE 2

Compound No.	PLQY/1.05 (%)
8	0.797
A	0.032

[0300] Referring to Table 2, it was confirmed that Compound 8 has a higher PL quantum yield than Compound A.

Evaluation Example 3: Evaluation of Fluorescence Lifetime

[0301] For each of Compound 8 and Compound A, a PMMA film having 1 weight % of each compound, respectively, were prepared. A Quantaurus-Tau fluorescence lifetime spectrometer (C11367 series, available from HAMAMATSU, Japan) was used to measure fluorescence lifetime of the PMMA film, and the results thereof are shown in Table 3:

TABLE 3

Compound No.	Fluorescence lifetime (μs)
8	6.69
A	11.9

[0302] Referring to Table 3, it was confirmed that Compound 8 had a shorter fluorescence lifetime than Compound A.

[0303] As described above, an organometallic compound according to an embodiment may have improved electric characteristics and/or thermal stability, and thus, an organic light-emitting device including the organometallic compound may have improved lifespan, efficiency, and color purity characteristics.

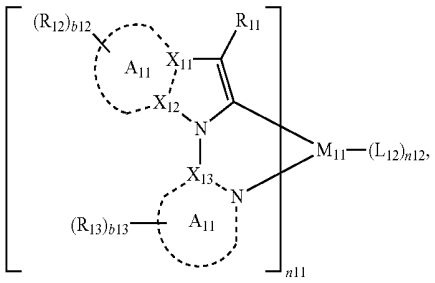
[0304] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0305] While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present description as defined by the following claims.

What is claimed is:

1. An organometallic compound represented by Formula 1:

Formula 1



wherein, in Formula 1,

M_{11} is selected from first-row transition metals, second-row transition metals, third-row transition metals, first-row post-transition metals, second-row post-transition metals, and third-row transition metals,

A_{11} and A_{12} are each independently selected from a nitrogen atom-containing C_1-C_{30} heterocyclic group,

X_{11} and X_{12} are each independently selected from C and N,

X_{13} is C,

R_{11} to R_{13} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, —SF_5, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted

C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$,

R_{11} to R_{13} are optionally linked to form a ring,

two, three, or four of a plurality of R_{11} to R_{13} that are adjacent to each other are optionally linked to form a quadridentate, hexadentate, or octadentate ligand,

b12 and b13 are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,

n11 is selected from 1, 2, 3, and 4,

n12 is selected from 0, 1, 2, and 3,

L_{12} is selected from a bidentate ligand,

Q_1 to Q_9 were each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro 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_1-C_{60} alkyl group substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, and a C_6-C_{60} aryl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with at least one selected from deuterium, a C_1-C_{60} alkyl group, and 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.

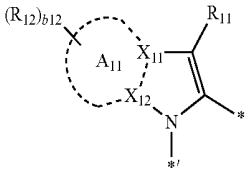
2. The organometallic compound of claim **1**, wherein the M_{11} is selected from platinum (Pt), palladium (Pd), copper (Cu), silver (Ag), gold (Au), rhodium (Rh), iridium (Ir), ruthenium (Ru), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), rhenium (Re), europium (Eu), terbium (Tb), thulium (Tm), and lead (Pb).

3. The organometallic compound of claim **1**, wherein A_{11} and A_{12} are each independently selected from an indole group, a carbazole group, an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indeno pyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a dihydropyridine group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a phenanthroline group, a pyrrole group, a pyrazole group, an imidazole group, a 2,3-dihydroimidazole group, a triazole group, a 2,3-dihydrotriazole group, an oxazole group, an iso-oxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a 2,3-dihydrobenzimidazole group, an imidazopyridine group, a 2,3-dihydroimidazopyridine group, an imidazopyrimidine group, a 2,3-dihydroimidazopyrimidine group, an imidazopyrazine group, a 2,3-dihydroimidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzooxadiazole group, a benzothiadiazole group, a 5,6,7,8-tetrahydroisoquinoline group, and a 5,6,7,8-tetrahydroquinoline group.

4. The organometallic compound of claim **1**, wherein A_{11} and A_{12} are each independently selected from an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indeno pyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a phenanthroline group, an imidazopyridine group, an imidazopyrimidine group, and an imidazopyrazine group.

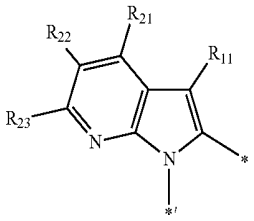
5. The organometallic compound of claim **1**, wherein X_{11} and X_{12} are each independently C.

6. The organometallic compound of claim **1**, wherein a partial structure represented by

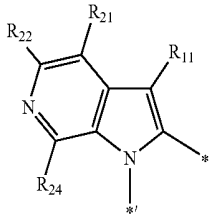


(wherein * and *' each indicate a binding site to a neighboring atom) is represented by one of Formulae 2-1 to 2-12:

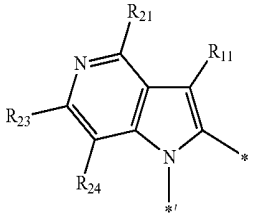
2-1



2-2



2-3



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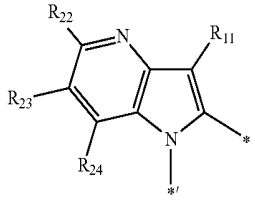
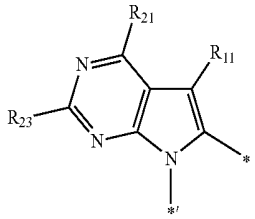
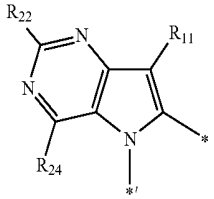
2-4



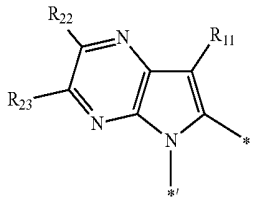
2-5



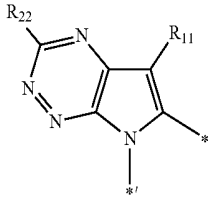
2-6



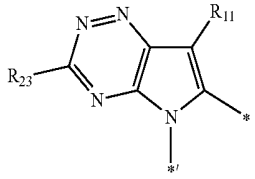
2-7



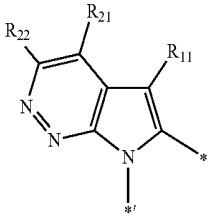
2-8



2-9



2-10



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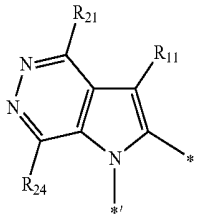
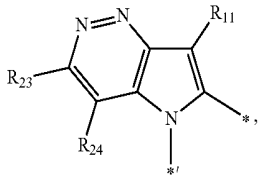
2-11



2-12



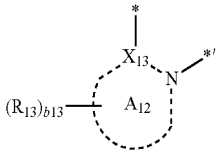
wherein, in Formulae 2-1 to 2-12,

R_{11} is the same as described in Formula 1,

R_{21} to R_{24} are each independently the same as described in connection with R_{12} in Formula 1, and

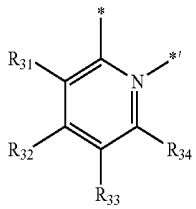
and *' each indicate a binding site to a neighboring atom.

7. The organometallic compound of claim **1**, wherein a moiety represented by

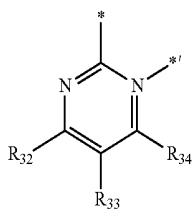


is represented by one of Formulae 3-1 to 3-5:

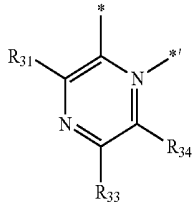
3-1



3-2



3-3



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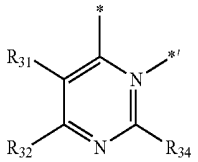
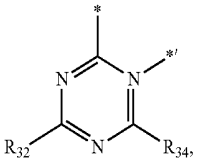
3-4



3-5



wherein, in Formulae 3-1 to 3-5,

R_{31} to R_{34} are each independently the same as described in connection with R_{13} in Formula 1, and

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

8. The organometallic compound of claim **1**, wherein R_{11} to R_{13} are each independently selected from:

hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, $—SF_5$, C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CF_3$, $—CF_2H$, $—CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosililolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosililolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CF_3$, $—CF_2H$, $—CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a

cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$; and

$—N(Q_1)(Q_2)$, $—Si(Q_3)(Q_4)(Q_5)$, $—B(Q_6)(Q_7)$, and $—P(=O)(Q_8)(Q_9)$, and

Q_1 to Q_9 and Q_{33} to Q_{35} are each independently selected from:

$—CH_3$, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CH_2CH_3$, $—CH_2CD_3$, $—CH_2CD_2H$, $—CH_2CDH_2$, $—CHDCH_3$, $—CHDCD_2H$, $—CHDCDH_2$, $—CHDCD_3$, $—CD_2CD_3$, $—CD_2CD_2H$, and $—CD_2CDH_2$;

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

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

9. The organometallic compound of claim **1**, wherein R_{11} to R_{13} are each independently selected from:

hydrogen, deuterium, —F, a cyano group, a nitro group, $—SF_5$, a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an iso-decyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a dibenzosilolyl group;

a methyl group, an ethyl group, an n-propyl group, an iso-propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an iso-decyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, each substituted with at least one selected from deuterium, —F, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CF_3$, $—CF_2H$, $—CFH_2$, a cyano group, a nitro group, a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$; and

$—N(Q_1)(Q_2)$, $—Si(Q_3)(Q_4)(Q_5)$, $—B(Q_6)(Q_7)$, and $—P(=O)(Q_8)(Q_9)$, and

Q_1 to Q_9 and Q_{33} to Q_{35} are each independently selected from:

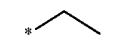
$—CH_3$, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CH_2CH_3$, $—CH_2CD_3$, $—CH_2CD_2H$, $—CH_2CDH_2$, $—CHDCH_3$, $—CHDCD_2H$, $—CHDCDH_2$, $—CHDCD_3$, $—CD_2CD_3$, $—CD_2CD_2H$, and $—CD_2CDH_2$;

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

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

10. The organometallic compound of claim **1**, wherein R_{11} to R_{13} are each independently selected from hydrogen, deuterium, —F, a cyano group, a nitro group, $—SF_5$, $—CH_3$, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CF_3$, $—CF_2H$, $—CFH_2$, groups represented by Formulae 9-1 to 9-21, groups represented by Formulae 10-1 to 10-253, $—N(Q_1)(Q_2)$, $—Si(Q_3)(Q_4)(Q_5)$, $—B(Q_6)(Q_7)$, and $—P(=O)(Q_8)(Q_9)$:

9-1



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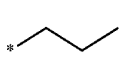

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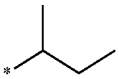

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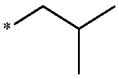

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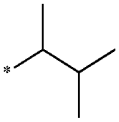

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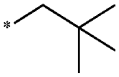

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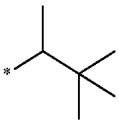

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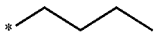

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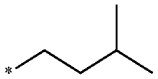
9-12



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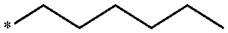

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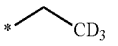

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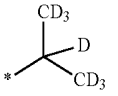

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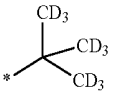

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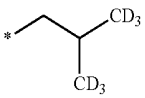

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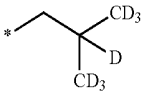

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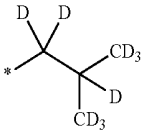

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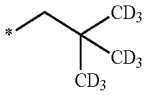

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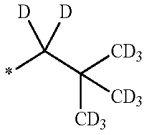

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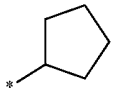

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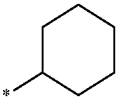

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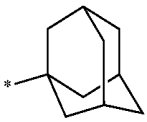

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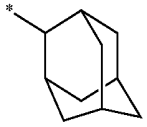

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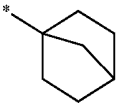

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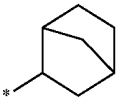

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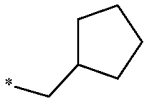

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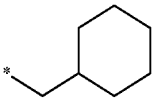

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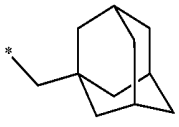

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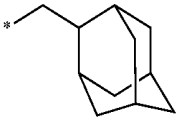

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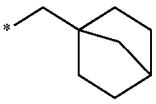

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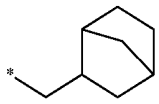

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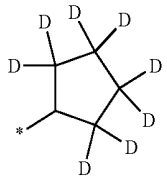

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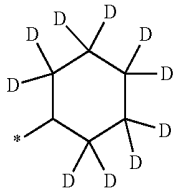

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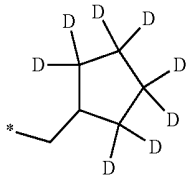

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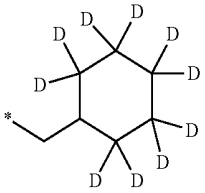

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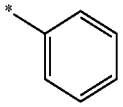

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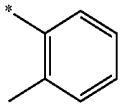

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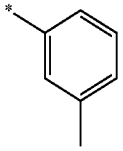

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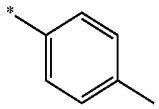

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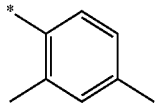

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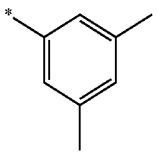

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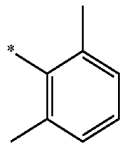

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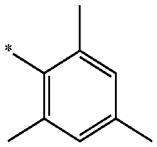

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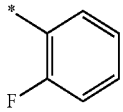

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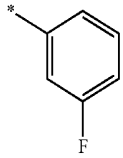

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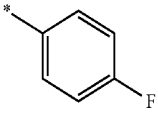

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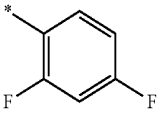

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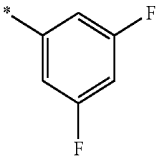

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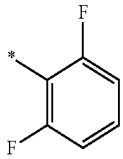

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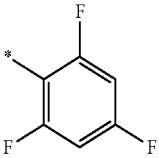

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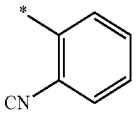

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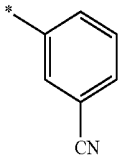

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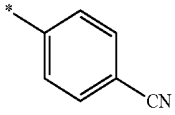

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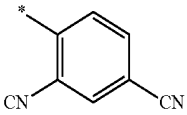

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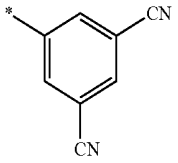

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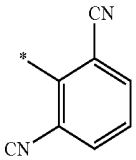

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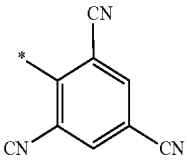

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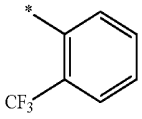

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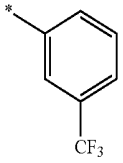

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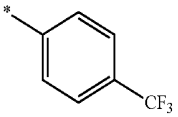

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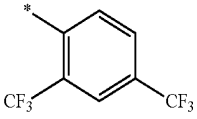

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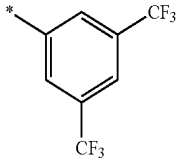

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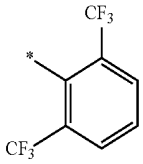

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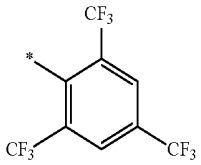

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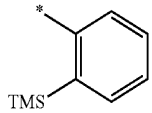

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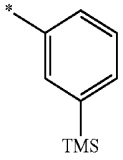

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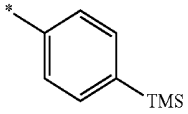

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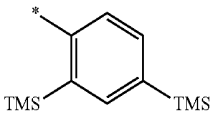

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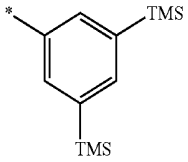

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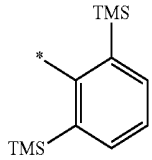

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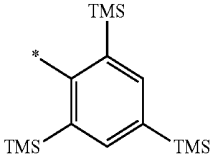

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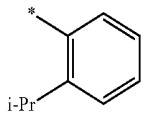

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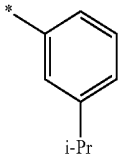

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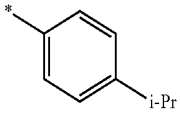

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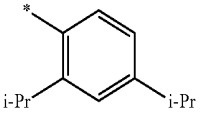

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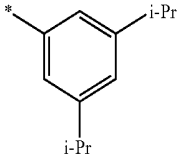

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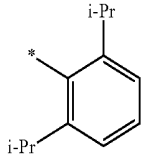

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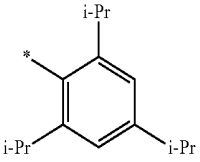

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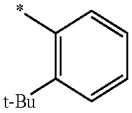

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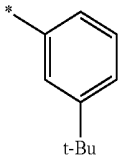

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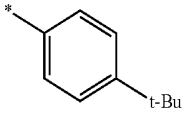

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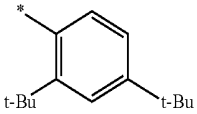

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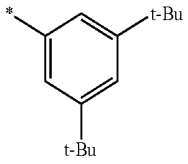

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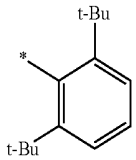

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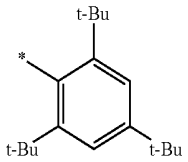

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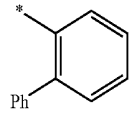

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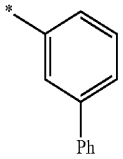

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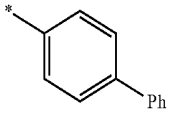

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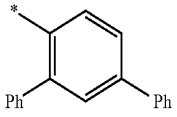

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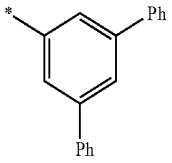

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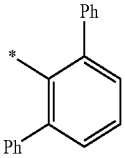

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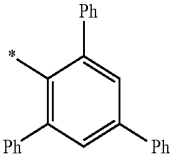

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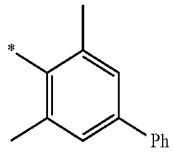

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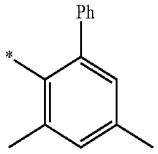

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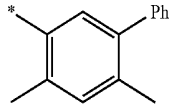

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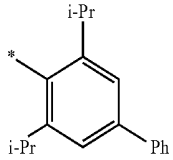

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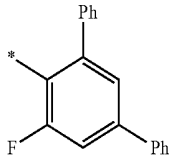

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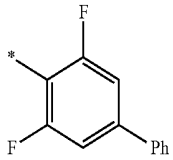

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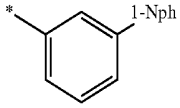

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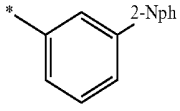

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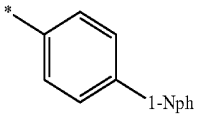

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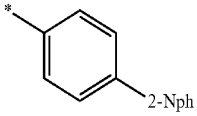

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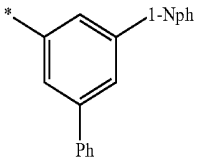

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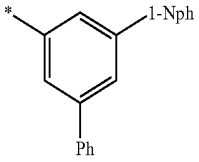

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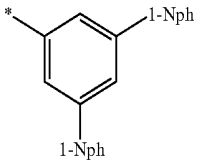

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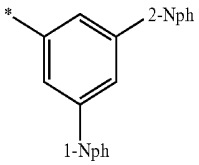

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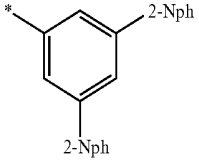

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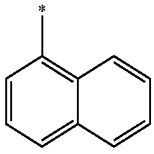

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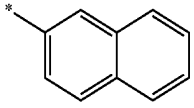

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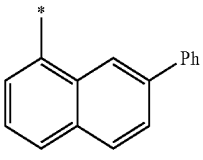

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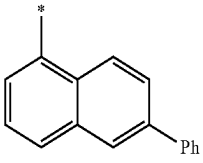

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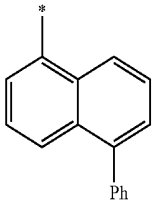

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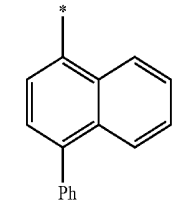

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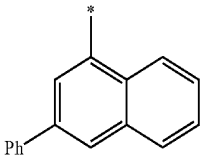

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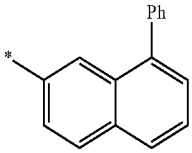

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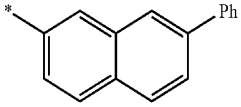

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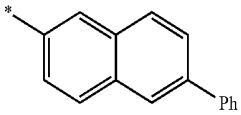

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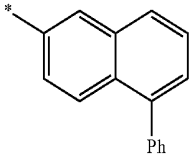

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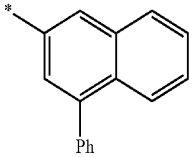

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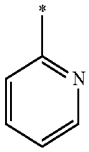

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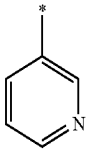

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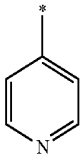

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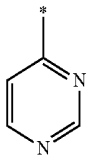

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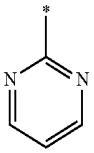

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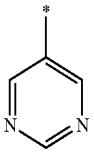

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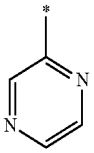

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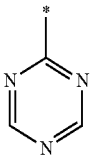

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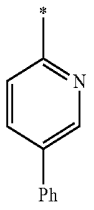

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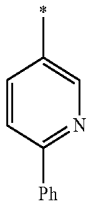

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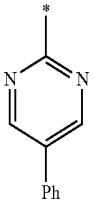

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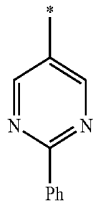

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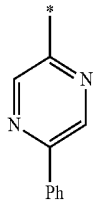

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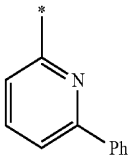

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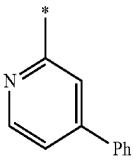

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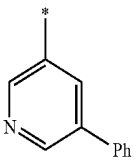

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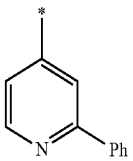

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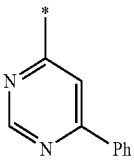

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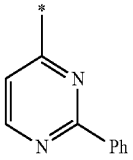

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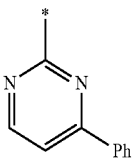

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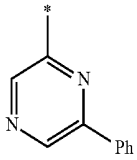

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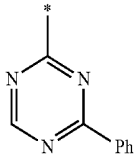

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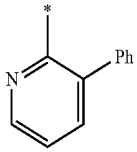

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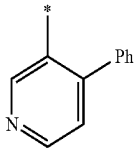

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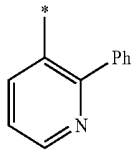

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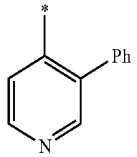

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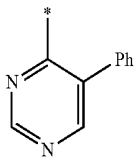

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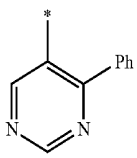

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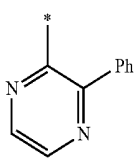

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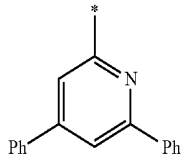

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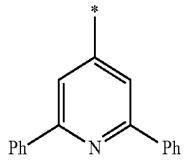

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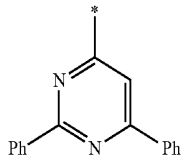

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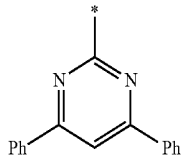

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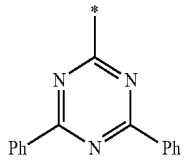

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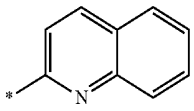

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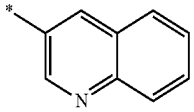

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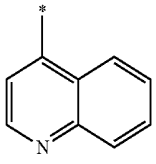

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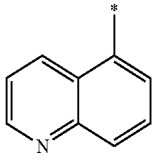

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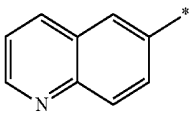

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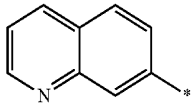

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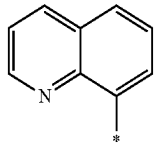

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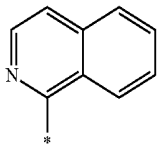

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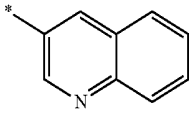

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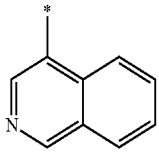

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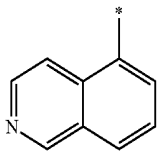

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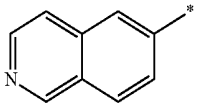

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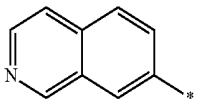

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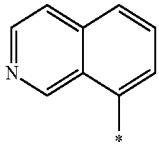

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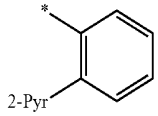

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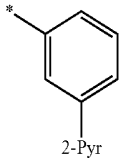

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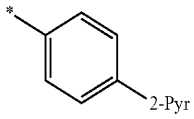

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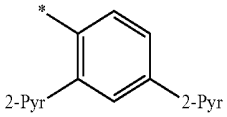

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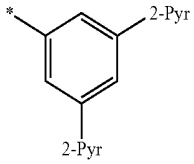

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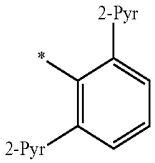

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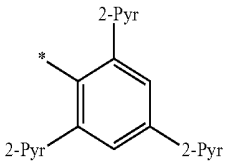

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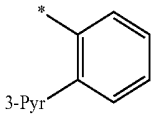

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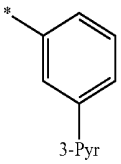

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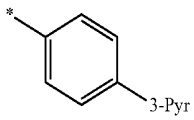

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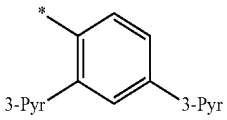

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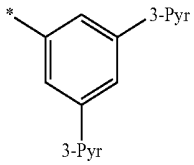

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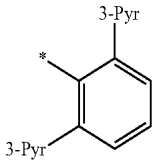

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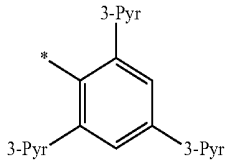

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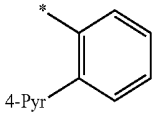

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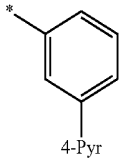

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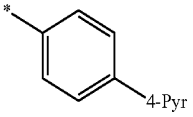

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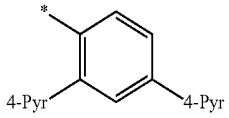

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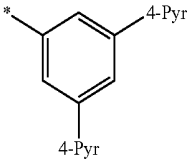

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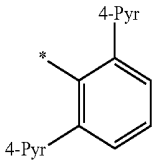

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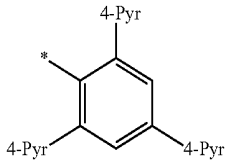

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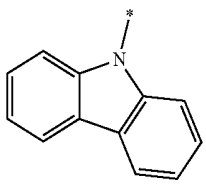

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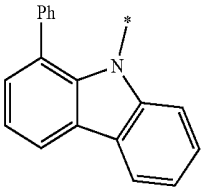

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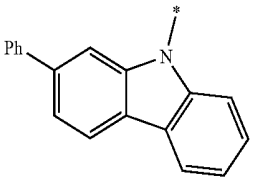

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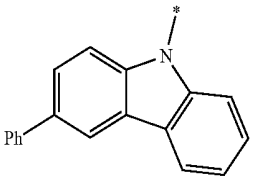

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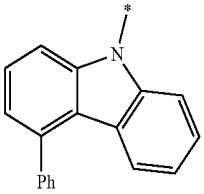

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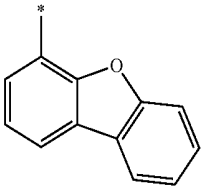

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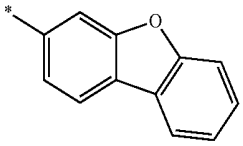

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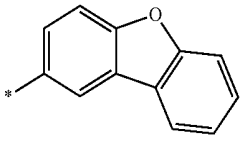

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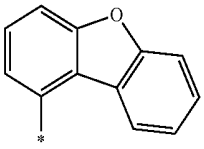

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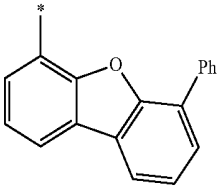

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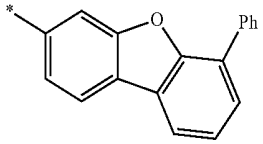

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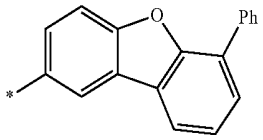

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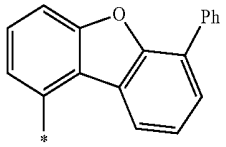

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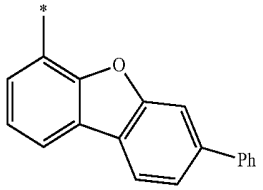

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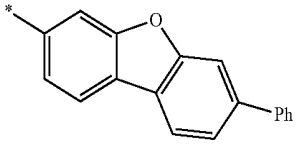

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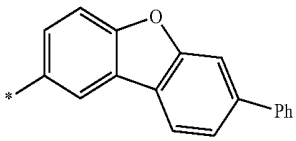

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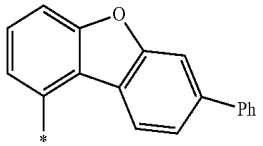

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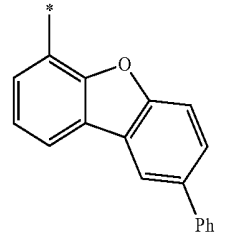

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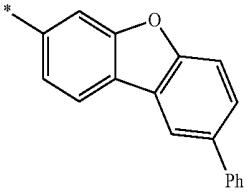

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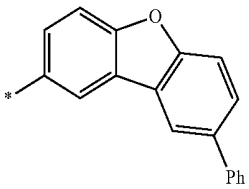

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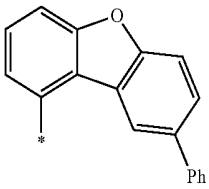

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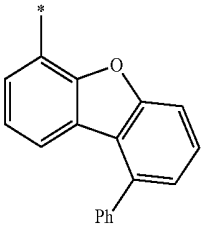

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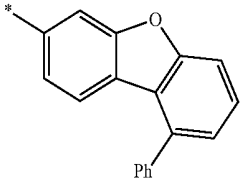

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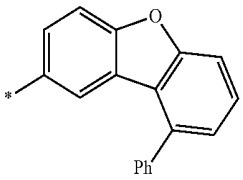

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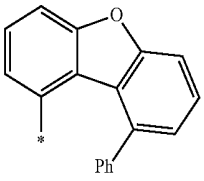

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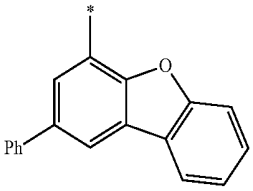

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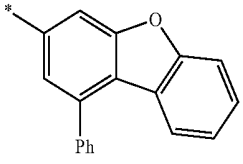

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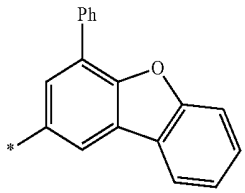

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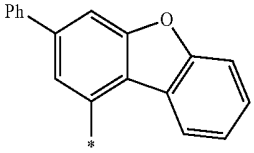

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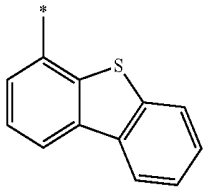

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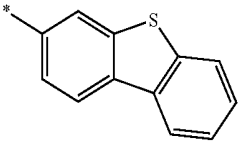

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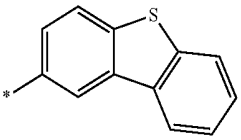

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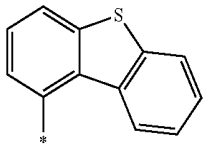

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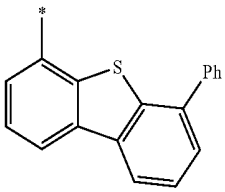

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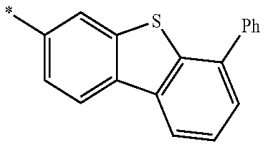

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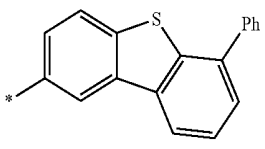

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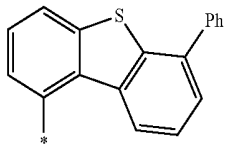

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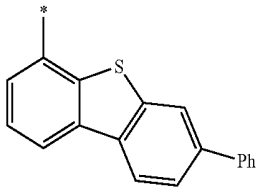

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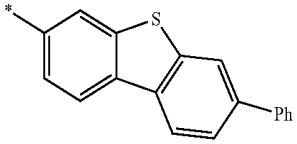

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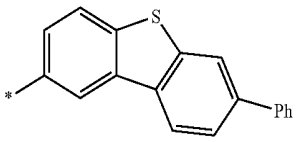

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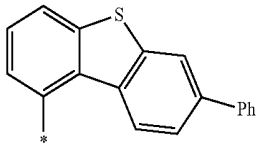

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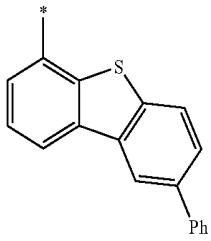
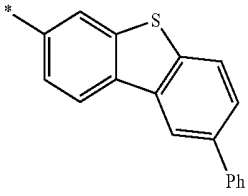
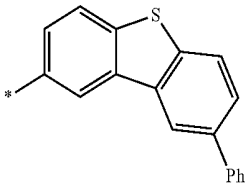


10-212



10-213



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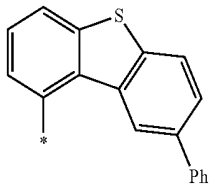
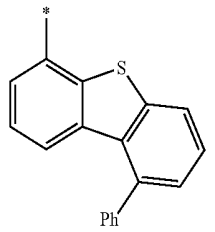
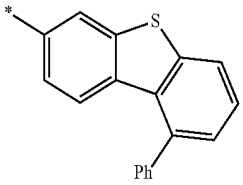
10-214



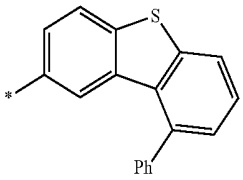
10-215



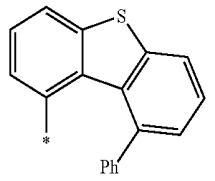
10-216



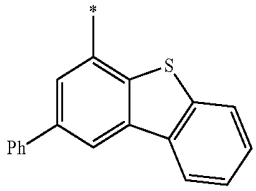
10-217



10-218



10-219



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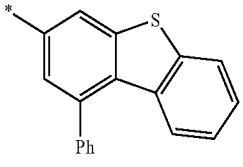
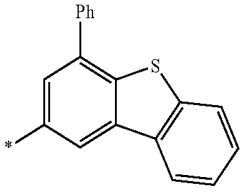


10-221



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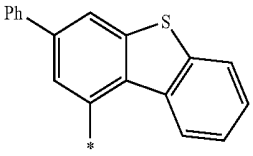
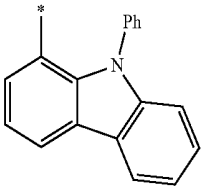
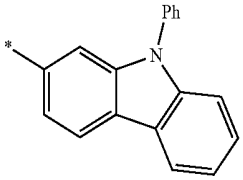
10-222



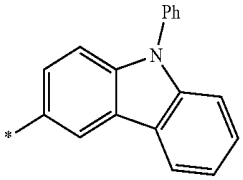
10-223



10-224



10-225



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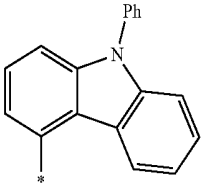
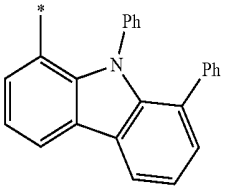
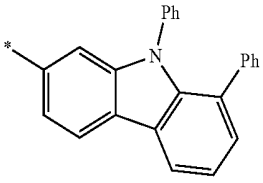


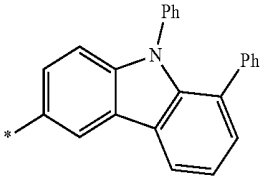
10-227



10-228



10-229



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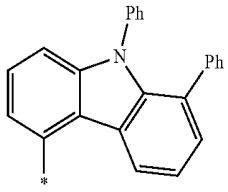
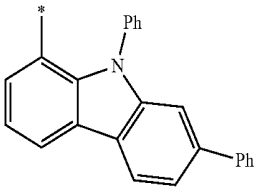
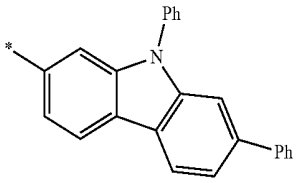
10-230



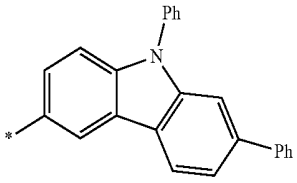
10-231



10-232



10-233



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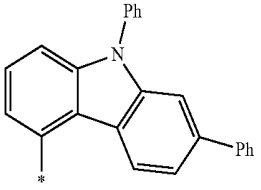

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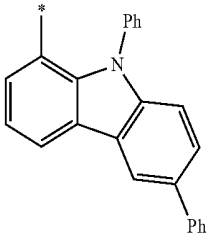
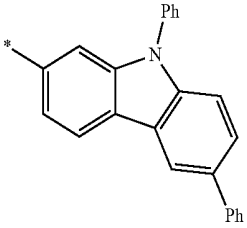


10-236



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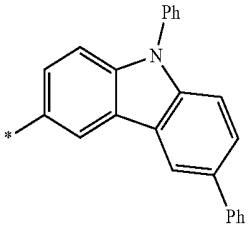
10-237



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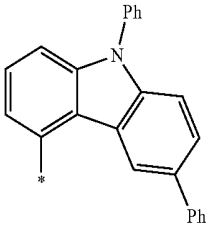
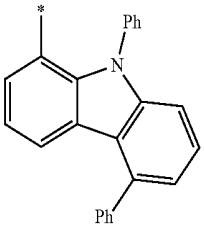
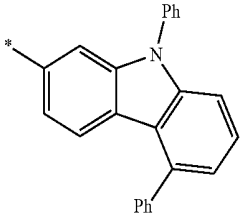


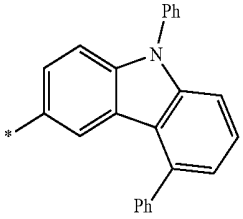
10-239



10-240



10-241



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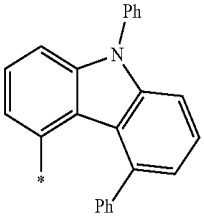
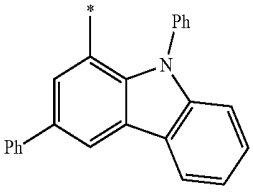


10-243



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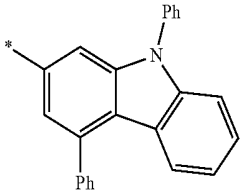
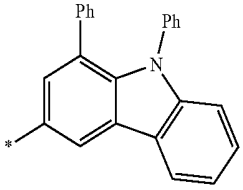
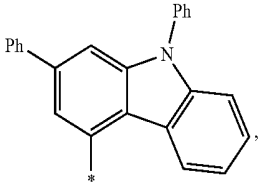
10-244



10-245



10-246



wherein, in Formulae 9-1 to 9-21 and 10-1 to 10-253,

Q_1 to Q_9 are each independently selected from:

—CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2;

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

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

* indicates a binding site to a neighboring atom,

i-Pr indicates an iso-propyl group,

t-Bu indicates t-butyl group,

Ph indicates a phenyl group,

1-Nph indicates a 1-naphthyl group and 2-Nph indicates a 2-naphthyl group,

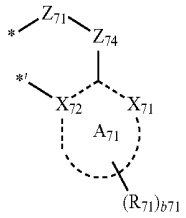
2-Pyr indicates a 2-pyridyl group, 3-Pyr indicates a 3-pyridyl group, and 4-Pyr indicates a 4-pyridyl group, and

TMS indicates a trimethylsilyl group.

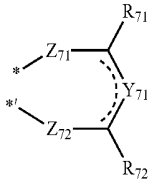
11. The organometallic compound of claim **1**, wherein M_{11} is Ir, n11 is selected from 1, 2, and 3, and n12 is selected from 0, 1, and 2.

12. The organometallic compound of claim **1**, wherein L_{12} is a ligand represented by one of Formulae 7-1 to 7-7:

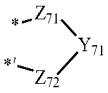
7-1



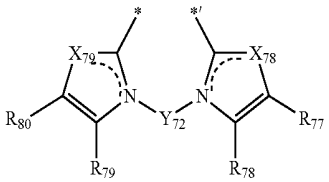
7-2



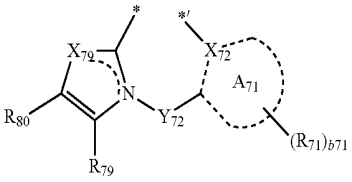
7-3



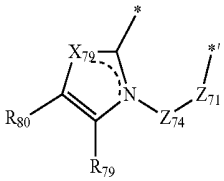
7-4



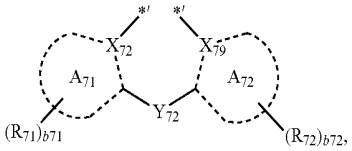
7-5



7-6



7-7



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

A_{71} and A_{72} are each independently selected from a C_5-C_{20}carbocyclic group and a C_1-C_{20} heterocyclic group,

X_{71} and X_{72} are each independently selected from C and N,

X_{78} is O, S, or N(Q_{79}),

X_{29} is O, S, or N(Q_{79}),

Y_{71} and Y_{72} are each independently selected from a single bond, a double bond, a substituted or unsubstituted C_1-C_5 alkylene group, a substituted or unsubstituted C_2-C_5 alkenylene group, and a substituted or unsubstituted C_6-C_{10} arylene group,

Z_{71} and Z_{72} are each independently selected from N, O, N(R_{75}), P(R_{75})(R_{76}), and As(R_{75})(R_{76}),

Z_{74} is selected from CO and CH_2,

R_{71} R_{72}, R_{75} to R_{80}, and Q_{73} to Q_{79} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

R_{71} and R_{72} are optionally linked to form a ring,

R_{77} and R_{78} are optionally linked to form a ring,

R_{78} and R_{79} are optionally linked to form a ring,

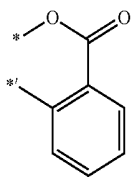
R_{79} and R_{80} are optionally linked to form a ring,

b71 and b72 are each independently selected from 1, 2, 3, 4, 5, and 6, and

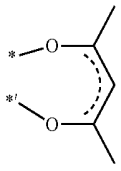
* and *' each indicate a binding site to a neighboring atom.

13. The organometallic compound of claim **1**, wherein L_{12} is a ligand represented by one of Formulae 5-1 to 5-116 and 8-1 to 8-32:

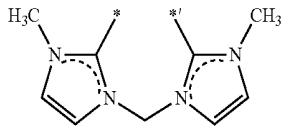
8-1



8-2



8-3



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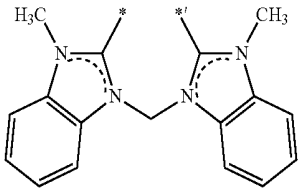
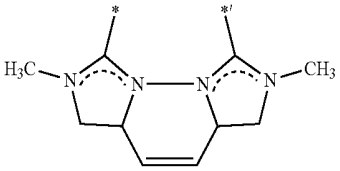
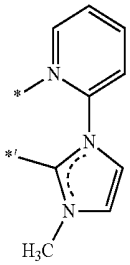
8-4



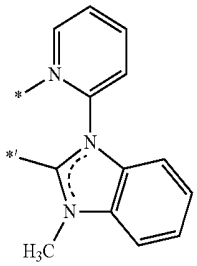
8-5



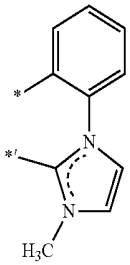
8-6



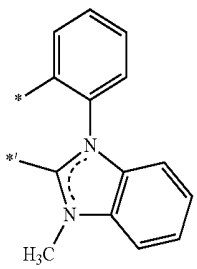
8-7



8-8



8-9



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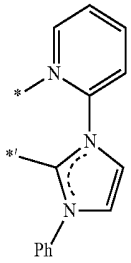

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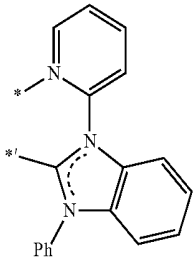

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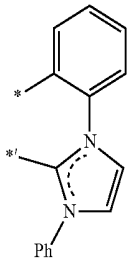

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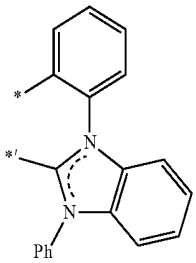

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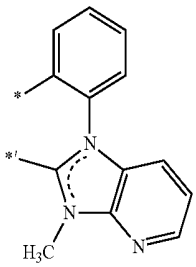

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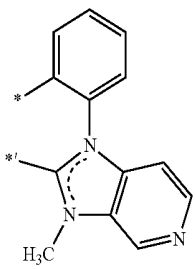

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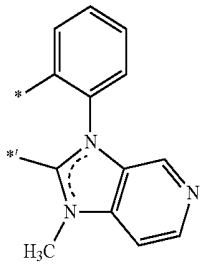

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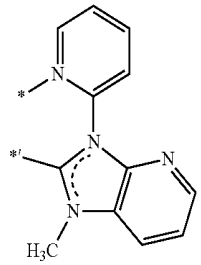

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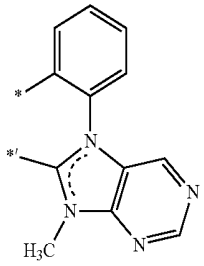

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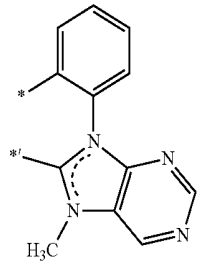

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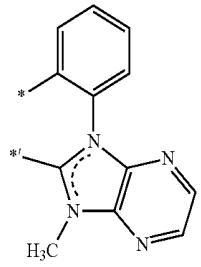

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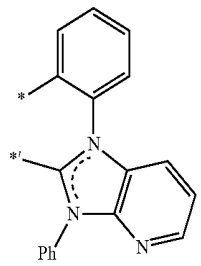

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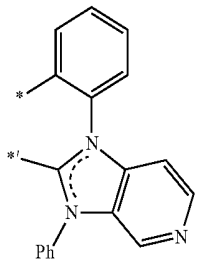

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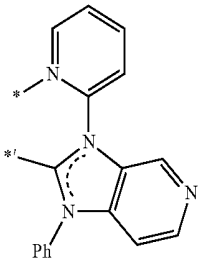

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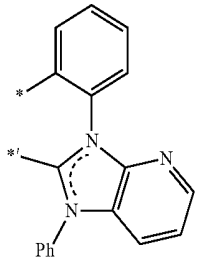

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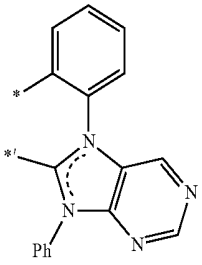

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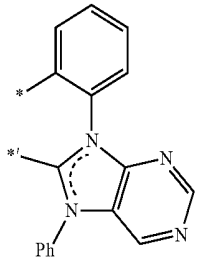

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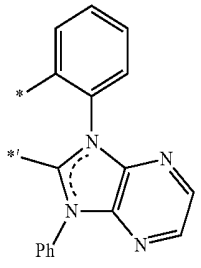

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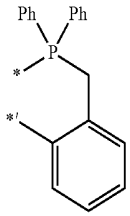

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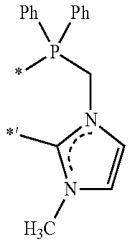

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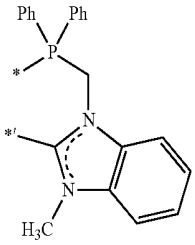

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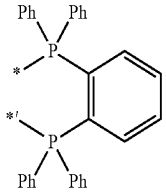

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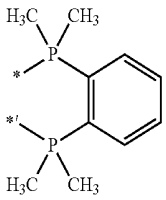

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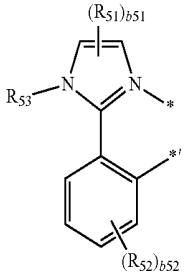

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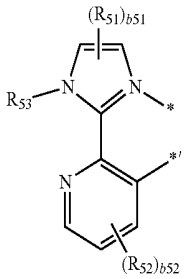

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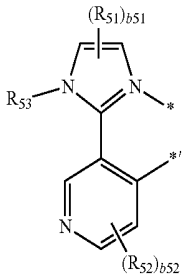

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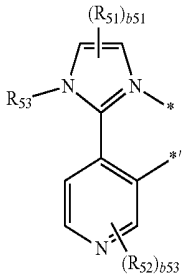

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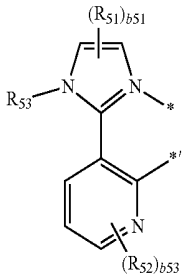

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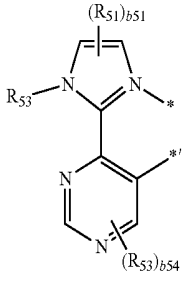

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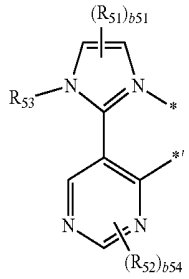

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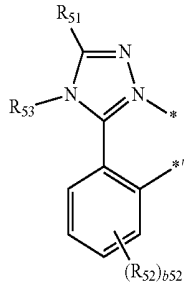

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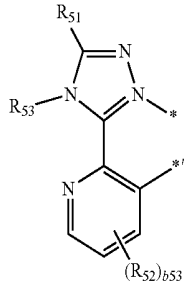

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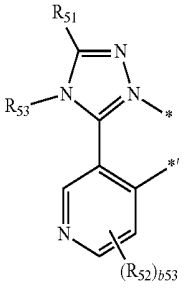

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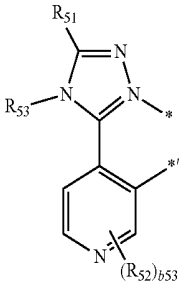

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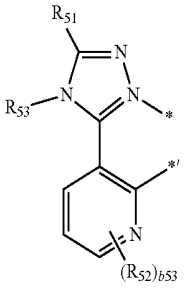

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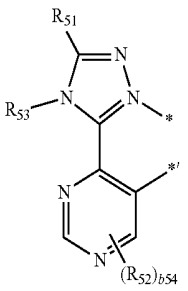

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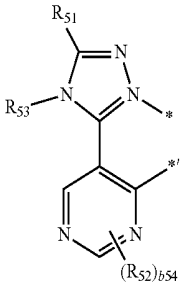

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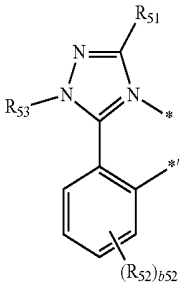

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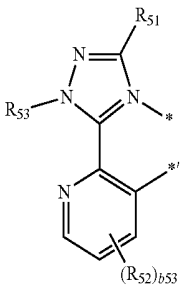

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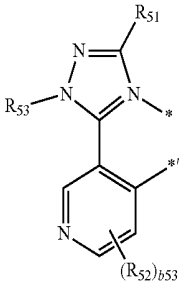

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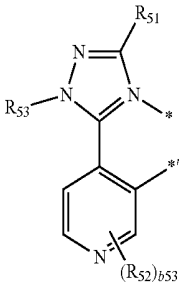

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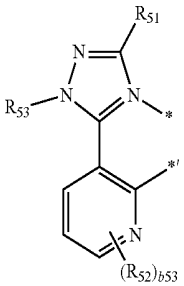

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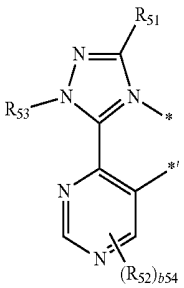

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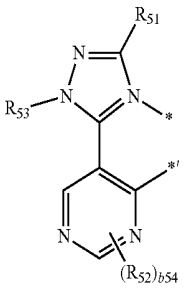

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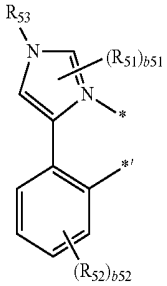

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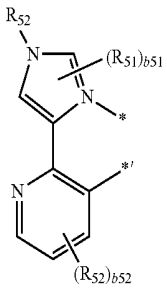

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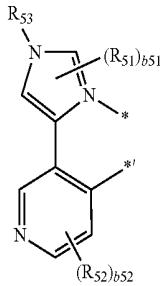

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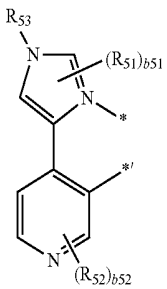

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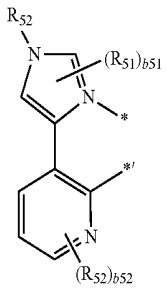

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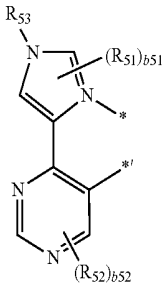

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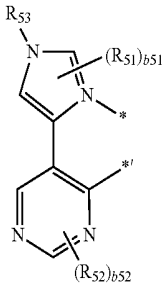

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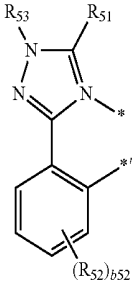

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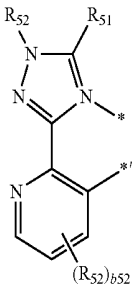

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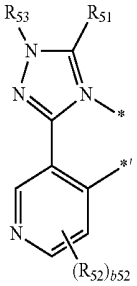

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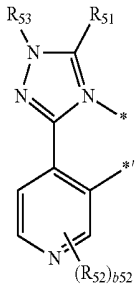

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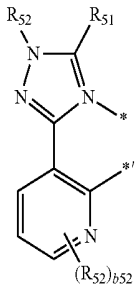

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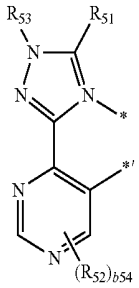

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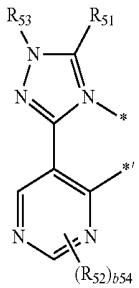

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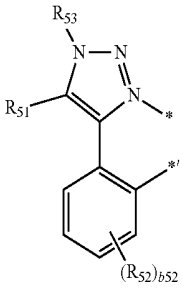

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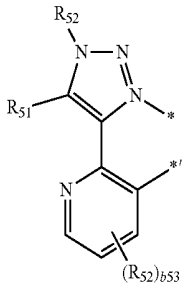

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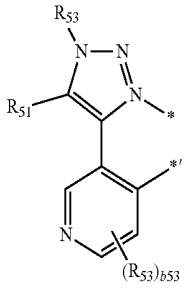

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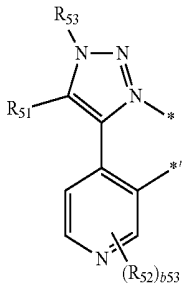

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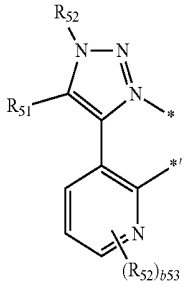

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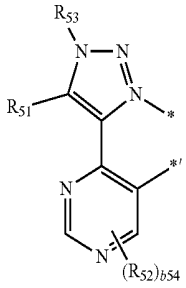

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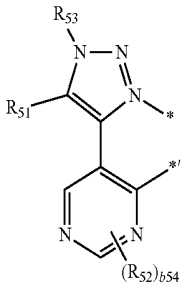

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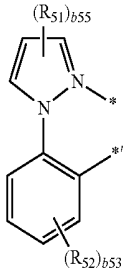

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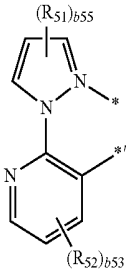

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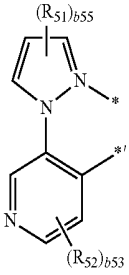

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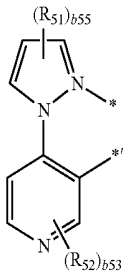

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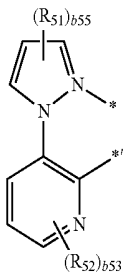

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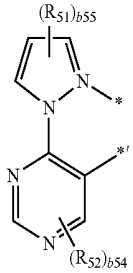

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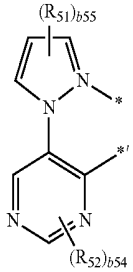

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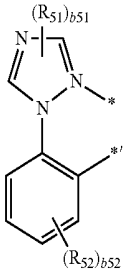

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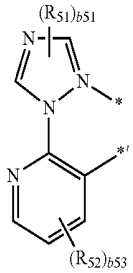

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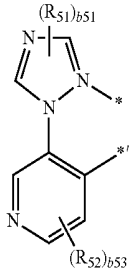

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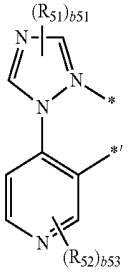

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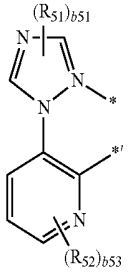

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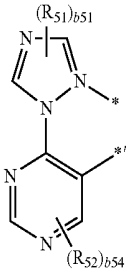

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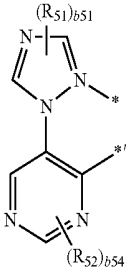

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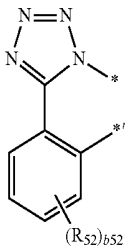

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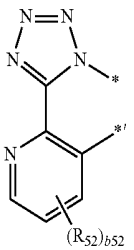

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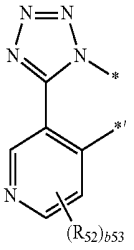

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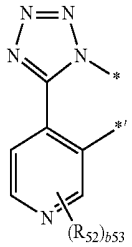

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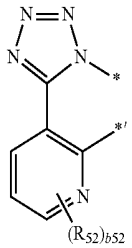

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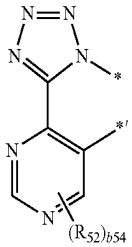

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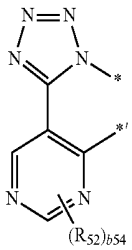

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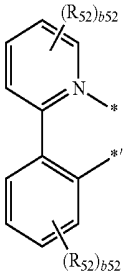

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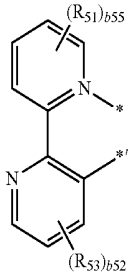

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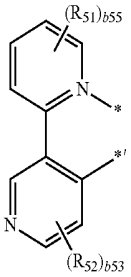

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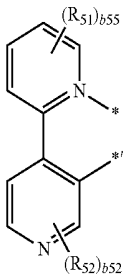

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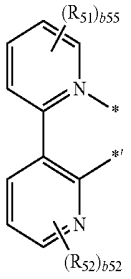

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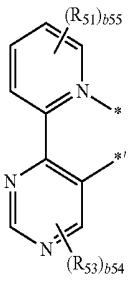

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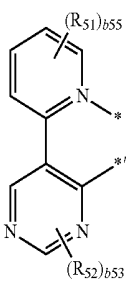

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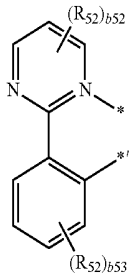

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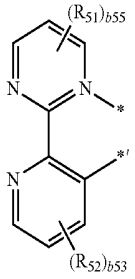

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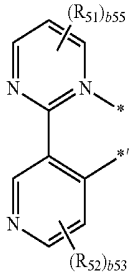

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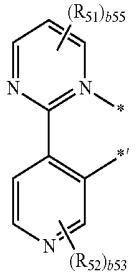

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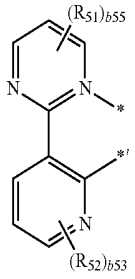

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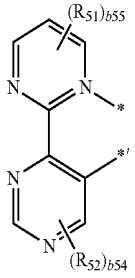

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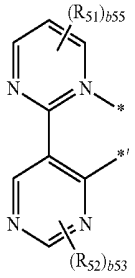

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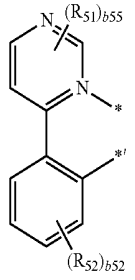

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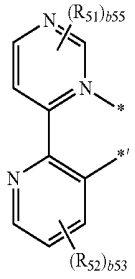

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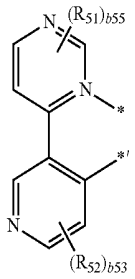

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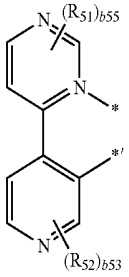

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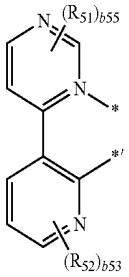

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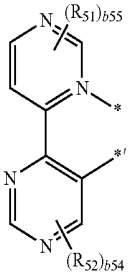

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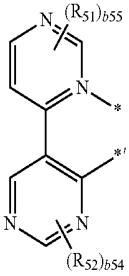

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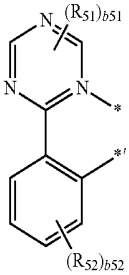

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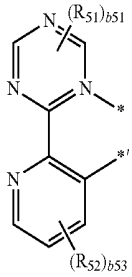

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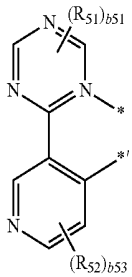

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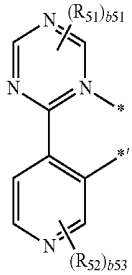

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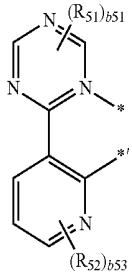

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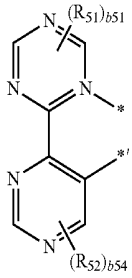

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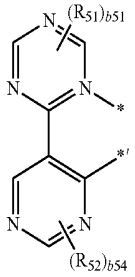

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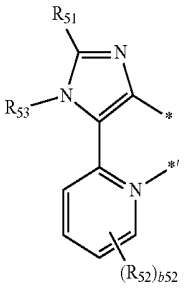

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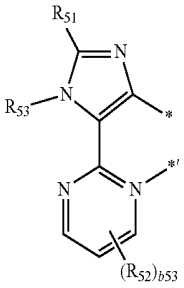

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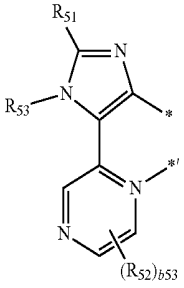

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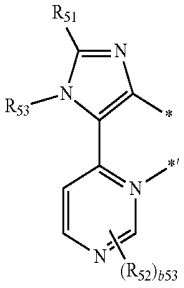

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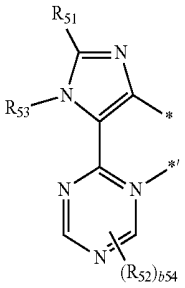

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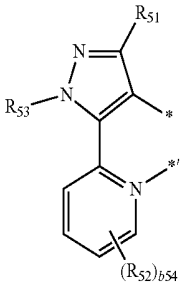

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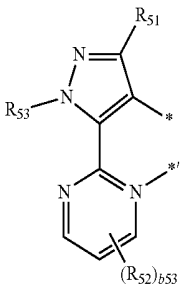

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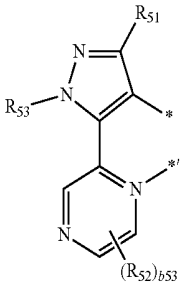

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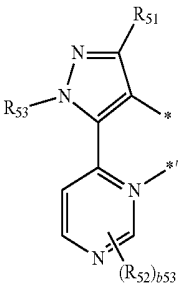

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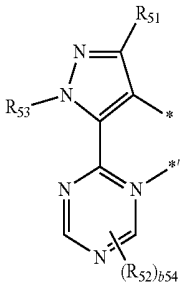

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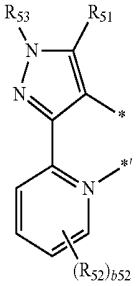

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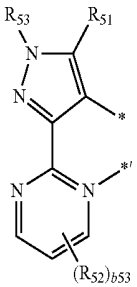

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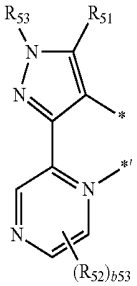

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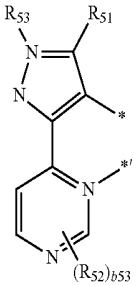

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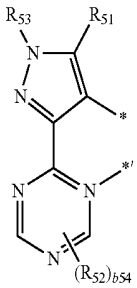

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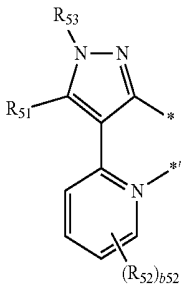

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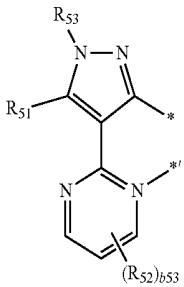

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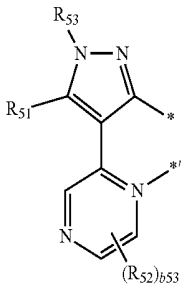

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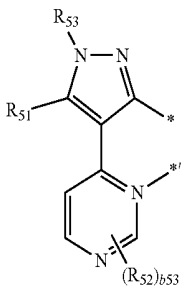

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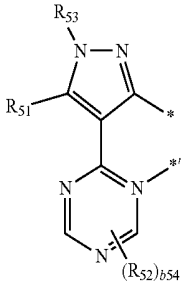

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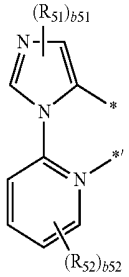

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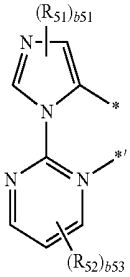

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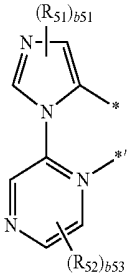

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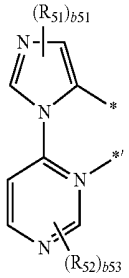

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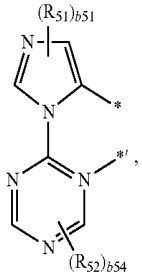


wherein, in Formulae 5-1 to 5-116 and 8-1 to 8-32,

R_{51} to R_{53} are each independently selected from:

hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an iso-decanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

a methyl group, an ethyl group, a propyl group, an n-butyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an iso-pentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an iso-hexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an iso-heptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an iso-octyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an iso-nonyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an iso-decanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from —F, a cyano group, and a nitro group,

b51 and b54 are each independently selected from 1 and 2,

b53 and b55 are each independently selected from 1, 2, and 3,

b52 is selected from 1, 2, 3, and 4,

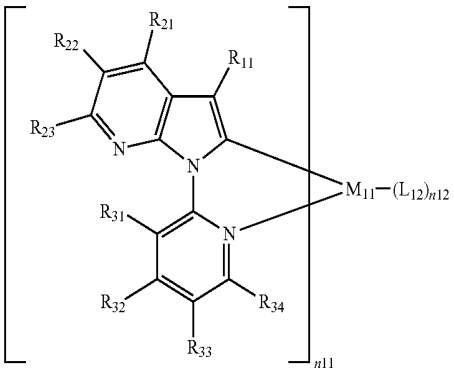
Ph indicates a phenyl group,

Ph-d5 indicates a phenyl group of which all hydrogen atoms are substituted with deuterium, and

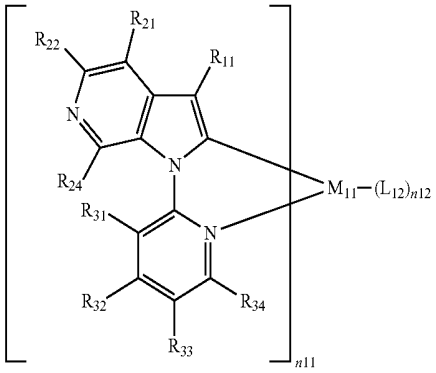
* and *' each indicate a binding site to a neighboring atom.

14. The organometallic compound of claim **1**, wherein the organometallic compound of Formula 1 is represented by one of Formulae 1-1 to 1-4:

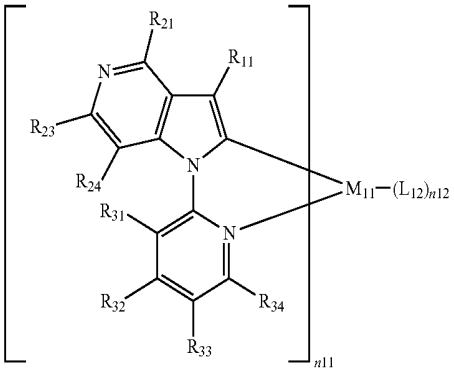
1-1



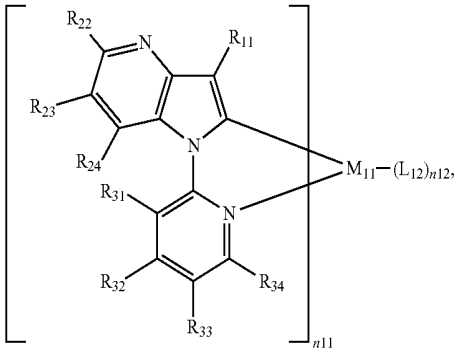
1-2



1-3



1-4



wherein, in Formulae 1-1 to 1-4,

M_{11}, R_{11}, n11, n12, and L_{12} are the same as described in Formula 1,

R_{21} to R_{24} are each independently the same as described in connection with R_{12} in Formula 1, and

R_{31} to R_{34} are each independently the same as described in connection with R_{13} in Formula 1.

15. The organometallic compound of claim **14**, wherein R_{11}, R_{21} to R_{24}, and R_{31} to R_{34} are each independently selected from:

hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, $—SF_5$, C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, $—CD_3$, $—CD_2H$, $—CDH_2$, $—CF_3$, $—CF_2H$, $—CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group), an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl

group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD_3, —CD_2H, —CDH_2, —CF_3, —CF_2H, —CFH_2, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclopentyl group substituted with deuterium, a cyclohexyl group, a cyclohexyl group substituted with deuterium, a cycloheptyl group, a cycloheptyl group substituted with deuterium, a cyclooctyl group, a cyclooctyl group substituted with deuterium, a bicyclo[2.2.1]heptanyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a 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 dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$; and

—$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, —$B(Q_6)(Q_7)$, and —$P(=O)(Q_8)(Q_9)$, and

Q_1 to Q_9 and Q_{33} to Q_{35} are each independently selected from:

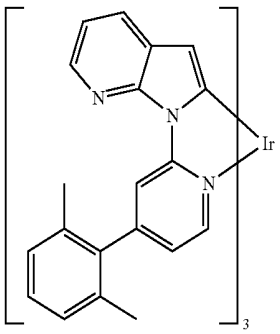
—CH_3, —CD_3, —CD_2H, —CDH_2, —CH_2CH_3, —CH_2CD_3, —CH_2CD_2H, —CH_2CDH_2, —$CHDCH_3$, —$CHDCD_2H$, —$CHDCDH_2$, —$CHDCD_3$, —CD_2CD_3, —CD_2CD_2H, and —CD_2CDH_2;

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

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

16. The organometallic compound of claim **1**, wherein the organometallic compound of Formula 1 is selected from Compounds 1 to 8:

1



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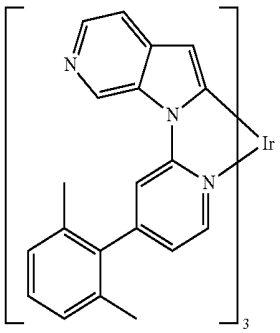

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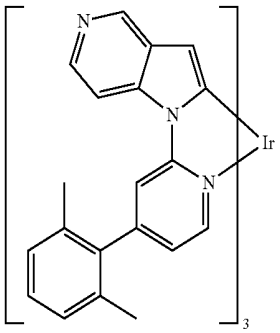

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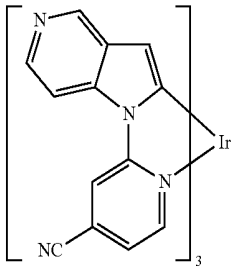

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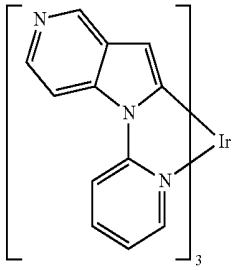

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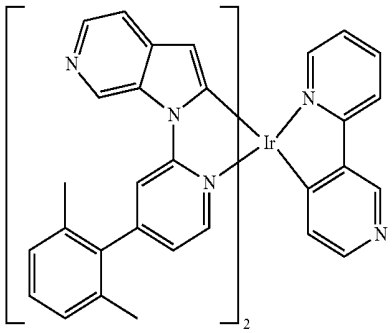

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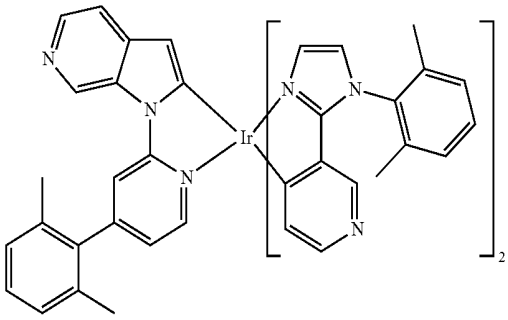

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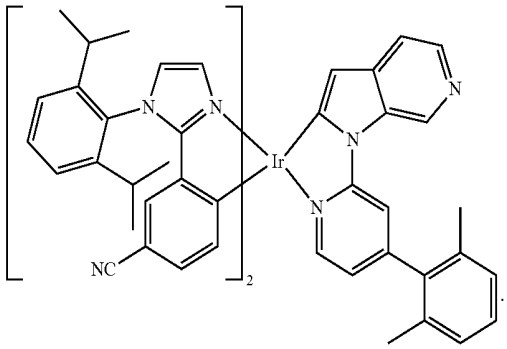
8



17. The organometallic compound of claim **1**, wherein a maximum emission wavelength of the organometallic compound is in a range of about 440 nanometers or more to less than about 500 nanometers.

18. An organic light-emitting device comprising:

a first electrode;

a second electrode; and

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

wherein the organic layer comprises an emission layer, and

wherein the organic layer comprises at least one organometallic compound of claim **1**.

19. The organic light-emitting device of claim **18**, wherein the emission layer comprises the organometallic compound.

20. The organic light-emitting device of claim **19**, wherein the emission layer further comprises a host, wherein an amount of the host is greater than an amount of the organometallic compound.

* * * * *

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申请号	US16/057929	申请日	2018-08-08
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD. 三星SDI CO.，LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD. 三星SDI CO.，LTD.		
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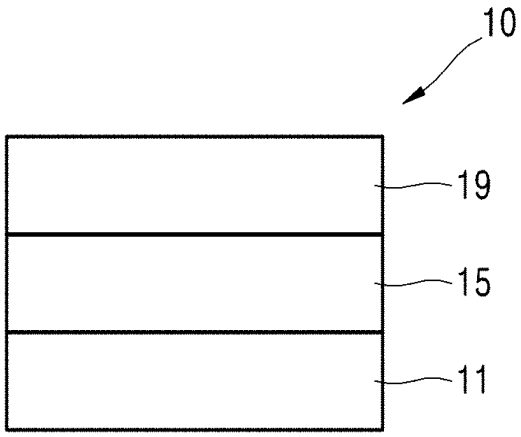
摘要(译)

由式1表示的有机金属化合物： 其中，在公式1中，组和变量与规范中描述的相同。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