



US 20190051832A1

(19) **United States**

(12) **Patent Application Publication**  
**KIM et al.**

(10) **Pub. No.: US 2019/0051832 A1**

(43) **Pub. Date: Feb. 14, 2019**

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

(71) Applicants: **Samsung Electronics Co., Ltd.**, Suwon-si (KR); **Samsung SDI Co., Ltd.**, Yongin-si (KR)

(72) Inventors: **Jongsoo KIM**, Seoul (KR); **Wonjoon SON**, Yongin-si (KR); **Daun JEONG**, Anyang-si (KR); **Sunghan KIM**, Seongnam-si (KR); **Joonghyuk KIM**, Seoul (KR); **Youngmok SON**, Hwaseong-si (KR); **Myungsun SIM**, Suwon-si (KR); **Namheon LEE**, Suwon-si (KR); **Sooghang IHN**, Hwaseong-si (KR)

(21) Appl. No.: **16/059,503**

(22) Filed: **Aug. 9, 2018**

(30) **Foreign Application Priority Data**

Aug. 9, 2017 (KR) ..... 10-2017-0101342

**Publication Classification**

(51) **Int. Cl.**  
*H01L 51/00* (2006.01)  
*H01L 51/52* (2006.01)  
*H01L 51/50* (2006.01)  
(52) **U.S. Cl.**  
CPC ..... *H01L 51/0052* (2013.01); *H01L 51/5212* (2013.01); *H01L 51/5056* (2013.01); *H01L 51/0079* (2013.01); *H01L 51/5221* (2013.01)

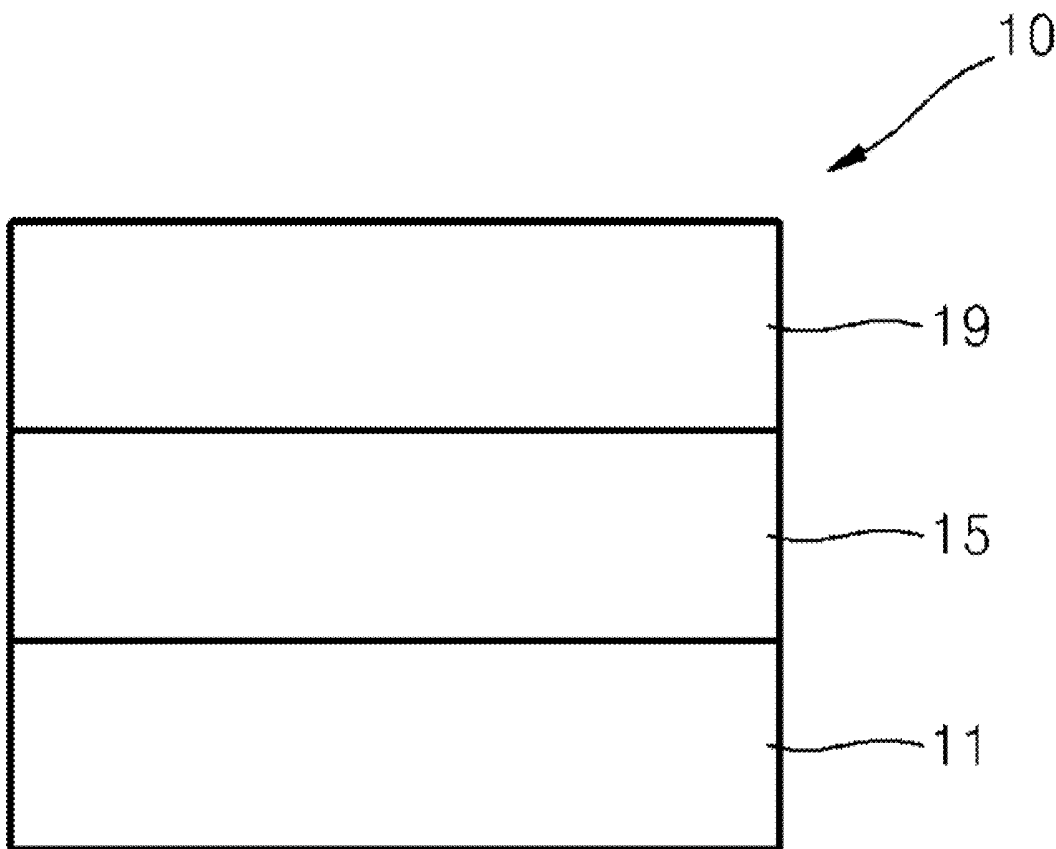
(57) **ABSTRACT**

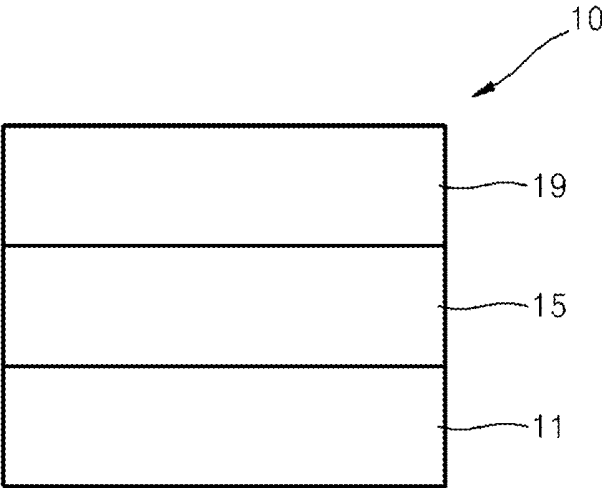
An organometallic compound represented by Formula 1, wherein the organometallic compound has a horizontal orientation ratio of a transition dipole moment in a range of about 85 percent to about 100 percent:

$M(L_1)_n$

Formula 1

wherein, in Formula 1, M is selected from a first-row transition metal of the Periodic Table of Elements, a second-row transition metal of the Periodic Table of Elements, and a third-row transition metal of the Periodic Table of Elements, n is 2 or 3,  $L_1$  is a bidentate organic ligand bound to M, wherein  $L_1$  does not comprise a fluoro group ( $-F$ ), and wherein  $L_1$  groups in the number of n are identical to each other.





**ORGANOMETALLIC COMPOUND AND  
ORGANIC LIGHT-EMITTING DEVICE THE  
SAME**

CROSS-REFERENCE TO RELATED  
APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2017-0101342, filed on Aug. 9, 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] The present disclosure relates 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, as compared with conventional devices, have wide viewing angles, high contrast ratios, short response times, and excellent brightness, driving voltage, and response speed characteristics, and that produce full-color images.

[0004] Typical OLEDs include 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 to thereby generate 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] Provided are a novel organometallic compound satisfying a specific parameter 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] According to an aspect of an embodiment, an organometallic compound is represented by Formula 1 and has a horizontal orientation ratio of a transition dipole moment in a range of about 85 percent to about 100 percent:



[0009] wherein, in Formula 1,

[0010] M is selected from a first-row transition metal of the Periodic Table of Elements, a second-row transition metal of the Periodic Table of Elements, and a third-row transition metal of the Periodic Table of Elements,

[0011] n is 2 or 3,

[0012]  $L_1$  is a bidentate organic ligand bound to M,

[0013] wherein  $L_1$  does not contain a fluoro group (—F), and

[0014] wherein  $L_1$  groups in the number of n are identical to each other.

[0015] According to an aspect of another embodiment, an organic light-emitting device includes:

[0016] a first electrode;

[0017] a second electrode; and

[0018] an organic layer disposed between the first electrode and the second electrode,

[0019] wherein the organic layer includes an emission layer and at least one organometallic compound described above.

[0020] In the organic layer, the organometallic compound may serve as a dopant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] 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:

[0022] the FIGURE is a schematic cross-sectional view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] 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.

**[0028]** 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.

**[0029]** 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.

**[0030]** “About” or “approximately” as used herein is inclusive of the stated value and means within an acceptable range of deviation for the particular value as determined by one of ordinary skill in the art, considering the measurement in question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement system). For example, “about” can mean within one or more standard deviations, or within  $\pm 30\%$ ,  $20\%$ ,  $10\%$ ,  $5\%$  of the stated value.

**[0031]** In an embodiment, an organometallic compound may be represented by Formula 1, and may have a horizontal orientation ratio of a transition dipole moment in a range of about 85 percent (%) to about 100%:



**[0032]** In Formula 1, M may be selected from a first-row transition metal of the Periodic Table of Elements, a second-row transition metal of the Periodic Table of Elements, and a third-row transition metal of the Periodic Table of Elements, n may be 2 or 3,  $L_1$  may be a bidentate organic ligand bound to M, wherein  $L_1$  may not be containing a fluoro group ( $-F$ ), and wherein  $L_1$  groups in the number of n may be identical to each other.

**[0033]** For example, a horizontal orientation ratio of a transition dipole moment of the organometallic compound may be, for example, in a range of about 85 percent (%) to about 100%, about 86% to about 100%, about 87% to about 100%, about 88% to about 100%, about 89% to about 100%, about 90% to about 100%, about 91% to about 100%, about 92% to about 100%, about 93% to about 100%, about 94% to about 100%, about 95% to about 100%, about 96% to about 100%, about 97% to about 100%, about 98% to about 100%, or about 99% to about 100%, or about 100%, but embodiments are not limited thereto.

**[0034]** In some embodiments, a horizontal orientation ratio of a transition dipole moment of the organometallic

compound may be in a range of about 85% to about 95%, for example, about 87% to about 92%, but embodiments are not limited thereto.

**[0035]** The term “horizontal orientation ratio of a transition dipole moment”, as used herein, refers to, in a film including the organometallic compound, a ratio of the organometallic compound having a transition dipole moment which is horizontal with respect to the plane of the film, relative to the total organometallic compound included in the film.

**[0036]** The horizontal orientation ratio of a transition dipole moment may be measured by using an angle-dependent photoluminescence (PL) measuring device. The description of the angle-dependent PL measuring device may be, for example, the same as that of the angle-dependent PL measuring device described in KR Patent Application No. 2013-0150834 incorporated herein by reference.

**[0037]** Since the organometallic compound has a high horizontal orientation ratio of a transition dipole moment as such, namely, a greatly oriented transition dipole moment (i.e., a large optical orientation in a horizontal direction), when the film includes the organometallic compound, it may be possible for the organometallic compound to emit a large electric field in a vertical direction with respect to the film. Since light emitted by this mechanism may pass to the outside with high efficiency (i.e., efficiency of light emitted from the organometallic compound passing to the outside in a device (e.g., an organic light-emitting device) including a film (e.g., an emission layer described herein) including the organometallic compound), an electronic device, e.g., an organic light-emitting device, employing the organometallic compound, may have excellent luminous efficiency.

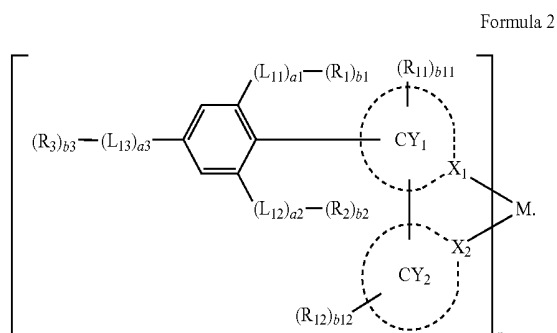
**[0038]** Furthermore, the organometallic compound may be represented by Formula 1, and in Formula 1,  $L_1$  groups in the number of n may be identical to each other. That is, the organometallic compound may have a structure of a homoleptic complex as well as a large optical orientation in a horizontal direction as described above. Accordingly, unlike a heteroleptic complex produced by a complicated synthetic process with a low synthetic yield, which may cause an increase in the production cost of an electronic device (e.g., an organic light-emitting device), the organometallic compound may be produced by a simple synthetic process with a high synthetic yield. Thus, the organometallic compound may contribute to a decrease in the cost of production of various electronic devices.

**[0039]** In addition, since  $L_1$  in Formula 1 is a bidentate organic ligand which may be bound to M and not contain a fluoro group ( $-F$ ), the organometallic compound may not include a fluoro group. A fluoro group may be separated from a ligand upon device storage and/or operation, which may cause the lifespan of a device to deteriorate; however, since the organometallic compound may not include a fluoro group as such, an electronic device, e.g., an organic light-emitting device, including the organometallic compound, may have a long lifespan.

**[0040]** M in Formula 1 may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), thulium (Tm), rhodium (Rh), ruthenium (Ru), rhenium (Re), beryllium (Be), magnesium (Mg), aluminum (Al), calcium (Ca), manganese (Mn), cobalt (Co), copper (Cu), zinc (Zn), gallium (Ga), germanium (Ge), palladium (Pd), silver (Ag), and gold (Au).

**[0041]** In an embodiment, in Formula 1, M may be iridium or osmium, and n may be 3; or M may be platinum or palladium, and n may be 2.

**[0042]** In one or more embodiments, the organometallic compound may be represented by Formula 2:



**[0043]** In Formula 2, M may be selected from a first-row transition metal of the Periodic Table of Elements, a second-row transition metal of the Periodic Table of Elements, and a third-row transition metal of the Periodic Table of Elements, and n may be 2 or 3. M and n may each be the same as those described herein.

**[0044]** In Formula 2, X<sub>1</sub> and X<sub>2</sub> may each independently be C or N.

**[0045]** In some embodiments, X<sub>1</sub> may be N, and X<sub>2</sub> may be C, but embodiments are not limited thereto.

**[0046]** In Formula 1, X<sub>1</sub> may be bound to M via a covalent bond, and X<sub>2</sub> may be bound to M via a coordinate bond; or X<sub>1</sub> may be bound to M via a coordinate bond, and X<sub>2</sub> may be bound to M via a covalent bond.

**[0047]** In some embodiments, X<sub>1</sub> may be bound to M via a coordinate bond, and X<sub>2</sub> may be bound to M via a covalent bond, but embodiments are not limited thereto.

**[0048]** In Formula 2, CY<sub>1</sub> and CY<sub>2</sub> may each independently be selected from a C<sub>5</sub>-C<sub>30</sub> carbocyclic group and a C<sub>1</sub>-C<sub>30</sub> heterocyclic group.

**[0049]** In some embodiments, CY<sub>1</sub> and CY<sub>2</sub> may each independently be selected from i) a 5-membered ring, ii) a 6-membered ring, iii) a condensed ring in which two or more 6-membered rings may be condensed, and iv) a condensed ring in which at least one 6-membered ring and at least one 5-membered ring may be condensed,

**[0050]** the 5-membered ring may be selected from a cyclopentadiene group, a furan group, a thiophene group, a pyrrole group, a silole group, an oxazole group, an isoxazole group, an oxadiazole group, an isoxadiazole group, an oxatriazole group, a thiazole group, an isothiazole group, a thiadiazole group, an isothiadiazole group, a thiatriazole group, a pyrazole group, an imidazole group, a triazole group, a tetrazole group, an azasilole group, a diazasilole group, and a triazasilole group, and

**[0051]** the 6-membered ring may be selected from a cyclohexane group, a cyclohexene group, a benzene group, a pyridine group, a pyrimidine group, a pyrazine group, and a pyridazine group, but embodiments are not limited thereto.

**[0052]** In some embodiments, CY<sub>1</sub> and CY<sub>2</sub> may each independently be selected from a benzene group, a naphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a cyclopentadiene group, a 1,2,3,4-tetrahydronaphthalene

group, a furan group, a thiophene group, a silole group, an indene group, a fluorene group, an indole group, a carbazole group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, a dibenzosilole group, an azafluorene group, an azacarbazole group, an azadibenzofuran group, an azadibenzothiophene group, an azadibenzosilole 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 triazole 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 benzoxazole group, a benzothiazole group, a benzoxadiazole group, a benzothiadiazole group, a 5,6,7,8-tetrahydroisoquinoline group, a 5,6,7,8-tetrahydroquinoline group, a cyclopentenopyridine group, a pyrrolopyridine group, a furopyridine group, and a thienopyridine group.

**[0053]** In Formula 1, L<sub>11</sub> to L<sub>13</sub> may each independently be selected from a substituted or unsubstituted C<sub>5</sub>-C<sub>30</sub> carbocyclic group and a substituted or unsubstituted C<sub>1</sub>-C<sub>30</sub> heterocyclic group.

**[0054]** In some embodiments, L<sub>11</sub> to L<sub>13</sub> may each independently be selected from:

**[0055]** a cyclopentadiene group, a cyclohexane group, a cyclohexene group, a benzene group, a naphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a furan group, a thiophene group, a silole group, an indene group, a fluorene group, an indole group, a carbazole group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, a dibenzosilole group, an azafluorene group, an azacarbazole group, an azadibenzofuran group, an azadibenzothiophene group, an azadibenzosilole 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 triazole 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 benzoxazole group, a benzothiazole group, a benzoxadiazole group, and a benzothiadiazole group, each unsubstituted or substituted with at least one selected from deuterium, -F, -CD<sub>3</sub>, -CD<sub>2</sub>H, -CDH<sub>2</sub>, -CF<sub>3</sub>, -CF<sub>2</sub>H, -CFH<sub>2</sub>, a cyano group, a nitro group, a C<sub>1</sub>-C<sub>10</sub> alkyl group, a C<sub>1</sub>-C<sub>10</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl 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 benzofurananyl group, and a dibenzothiophenyl group, but embodiments are not limited thereto.

**[0056]** In Formula 2, a<sub>1</sub>, a<sub>2</sub>, and a<sub>3</sub> respectively indicate the number of L<sub>11</sub> groups, L<sub>12</sub> groups, and L<sub>13</sub> groups, and may each independently be an integer from 0 to 5 (e.g., an integer selected from 0, 1, and 2).

**[0057]** When a<sub>1</sub> is 0, \*-(L<sub>11</sub>)<sub>a1</sub>-\* may be a single bond; when a<sub>1</sub> is two or greater, at least two L<sub>11</sub> groups may be identical to or different from each other; when a<sub>2</sub> is 0,

\*-(L<sub>12</sub>)<sub>a2</sub>-\* may be a single bond; when a<sub>2</sub> is two or greater, at least two L<sub>12</sub> groups may be identical to or different from each other; when a<sub>3</sub> is 0, \*(L<sub>13</sub>)<sub>a3</sub>-\* may be a single bond; and when a<sub>3</sub> is two or greater, at least two L<sub>13</sub> groups may be identical to or different from each other.

**[0058]** In Formula 2, a sum of a<sub>1</sub>, a<sub>2</sub>, and a<sub>3</sub> may be 1 or greater. That is, Formula 2 may essentially include at least one selected from L<sub>11</sub> to L<sub>13</sub>, i.e., cyclic groups as described herein.

**[0059]** In some embodiments, in Formula 2, a sum of a<sub>1</sub>, a<sub>2</sub>, and a<sub>3</sub> may be 1, 2, 3, or 4.

**[0060]** In an embodiment, in Formula 2,

**[0061]** i) a<sub>1</sub> and a<sub>2</sub> may each independently be 1 or 2, and a<sub>3</sub> may be 0;

**[0062]** ii) a<sub>1</sub> and a<sub>2</sub> may each be 0, and a<sub>3</sub> may be 1, 2, or 3; or

**[0063]** iii) a<sub>1</sub> to a<sub>2</sub> may each be 1, but embodiments are not limited thereto.

**[0064]** In Formula 2, R<sub>1</sub> to R<sub>3</sub> may each independently be selected from hydrogen, deuterium, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), —B(Q<sub>6</sub>)(Q<sub>7</sub>), and —P(=O)(Q<sub>8</sub>)(Q<sub>9</sub>).

**[0065]** In Formula 2, b<sub>1</sub>, b<sub>2</sub>, and b<sub>3</sub> respectively indicate the number of R<sub>1</sub> groups, R<sub>2</sub> groups, and R<sub>3</sub> groups, and may each independently be an integer from 0 to 5 (e.g., an integer selected from 0, 1, 2, and 3). When b<sub>1</sub> is two or greater, at least two R<sub>1</sub> groups may be identical to or different from each other; when b<sub>2</sub> is two or greater, at least two R<sub>2</sub> groups may be identical to or different from each other; and when b<sub>3</sub> is two or greater, at least two R<sub>3</sub> groups may be identical to or different from each other.

**[0066]** In Formula 2, R<sub>11</sub> and R<sub>12</sub> may each independently be selected from:

**[0067]** hydrogen, deuterium, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group; and a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group.

**[0068]** That is, in Formula 2, R<sub>11</sub> and R<sub>12</sub> may not include a cyclic group.

**[0069]** In Formula 2, b<sub>11</sub> and b<sub>12</sub> respectively indicate the number of R<sub>11</sub> groups and R<sub>12</sub> groups, and may each independently be an integer from 0 to 10 (e.g., an integer selected from 0, 1, 2, and 3). When b<sub>11</sub> is two or greater, at least two R<sub>11</sub> groups may be identical to or different from each other, and when b<sub>12</sub> is two or greater, at least two R<sub>12</sub> groups may be identical to or different from each other.

**[0070]** In some embodiments, in Formula 2, R<sub>1</sub> to R<sub>3</sub>, R<sub>11</sub>, and R<sub>12</sub> may each independently be selected from:

**[0071]** hydrogen, deuterium, a cyano group, a C<sub>1</sub>-C<sub>10</sub> alkyl group, and a C<sub>1</sub>-C<sub>10</sub> alkoxy group; and

**[0072]** a C<sub>1</sub>-C<sub>10</sub> alkyl group and a C<sub>1</sub>-C<sub>10</sub> alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a C<sub>1</sub>-C<sub>10</sub> alkyl group, and a C<sub>1</sub>-C<sub>10</sub> alkoxy group.

**[0073]** In some embodiments, in Formula 2, R<sub>1</sub> to R<sub>3</sub>, R<sub>11</sub>, and R<sub>12</sub> may each independently be selected from:

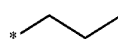
**[0074]** hydrogen, deuterium, and a cyano group; and

**[0075]** a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl 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 isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an isodecyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, and a pentoxy group, each unsubstituted or substituted with at least one selected from deuterium and a cyano group.

**[0076]** In some embodiments, in Formula 2, R<sub>1</sub> to R<sub>3</sub>, R<sub>11</sub>, and R<sub>12</sub> may each independently be selected from hydrogen, deuterium, a cyano group, —CH<sub>3</sub>, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, —CH<sub>2</sub>CD<sub>2</sub>H, —CH<sub>2</sub>CDH<sub>2</sub>, —CHDCH<sub>3</sub>, —CHDCD<sub>2</sub>H, —CHDCH<sub>2</sub>, —CHDCD<sub>3</sub>, —CD<sub>2</sub>CD<sub>3</sub>, —CD<sub>2</sub>CH<sub>3</sub>, —CD<sub>2</sub>CD<sub>2</sub>H, —CD<sub>2</sub>CDH<sub>2</sub>, groups represented by Formulae 9-1 to 9-24, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, and a pentoxy group, but embodiments are not limited thereto:



Formula 9-1



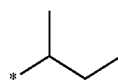
Formula 9-2



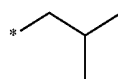
Formula 9-3



Formula 9-4

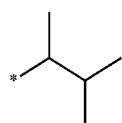


Formula 9-5

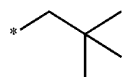


Formula 9-6

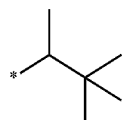
-continued



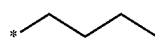
Formula 9-7



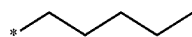
Formula 9-8



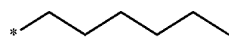
Formula 9-9



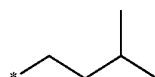
Formula 9-10



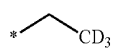
Formula 9-11



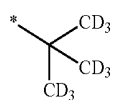
Formula 9-12



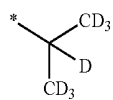
Formula 9-13



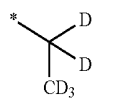
Formula 9-14



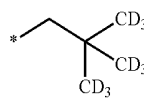
Formula 9-15



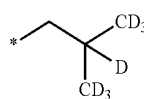
Formula 9-16



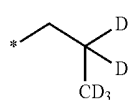
Formula 9-17



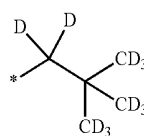
Formula 9-18



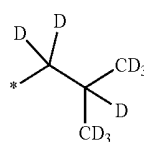
Formula 9-19



Formula 9-20

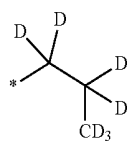


Formula 9-21

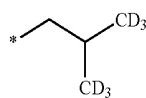


Formula 9-22

-continued



Formula 9-23



Formula 9-24

[0077] wherein, in Formulae 9-1 to 9-24, \* indicates a binding site to an adjacent atom.

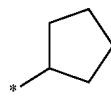
[0078] In some embodiments, in Formula 1,  $*(L_{11})_{a1}-(R_1)_{b1}$ ,  $*(L_{12})_{a2}-(R_2)_{b2}$ , and  $*(L_{13})_{a3}-(R_3)_{b3}$  may each independently be selected from:

[0079] hydrogen, deuterium, a cyano group, a  $C_1$ - $C_{10}$  alkyl group, and a  $C_1$ - $C_{10}$  alkoxy group;

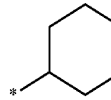
[0080] a  $C_1$ - $C_{10}$  alkyl group and a  $C_1$ - $C_{10}$  alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a  $C_1$ - $C_{10}$  alkyl group, and a  $C_1$ - $C_{10}$  alkoxy group; and

[0081] groups represented by Formulae 10-1 to 10-154, and

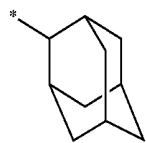
[0082] at least one selected from  $*(L_{11})_{a1}-(R_1)_{b1}$ ,  $*(L_{12})_{a2}-(R_2)_{b2}$ , and  $*(L_{13})_{a3}-(R_3)_{b3}$  may independently be selected from groups represented by Formulae 10-1 to 10-4, 10-9, 10-10 and 10-13 to 10-154:



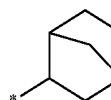
Formula 10-1



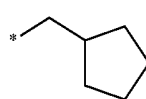
Formula 10-2



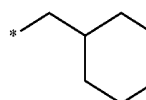
Formula 10-3



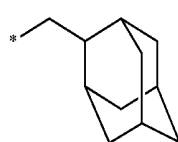
Formula 10-4



Formula 10-5

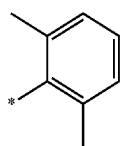
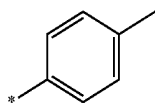
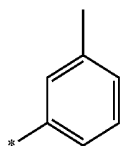
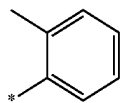
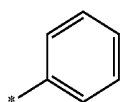
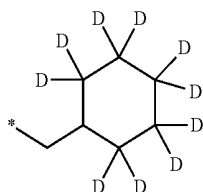
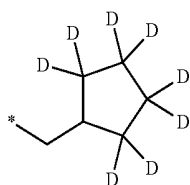
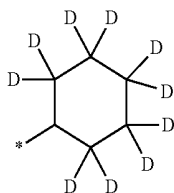
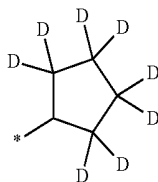
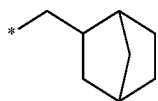


Formula 10-6

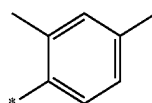


Formula 10-7

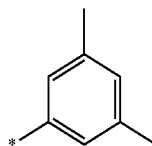
-continued



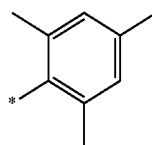
Formula 10-8



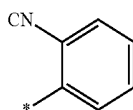
Formula 10-9



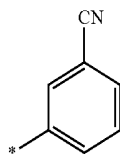
Formula 10-10



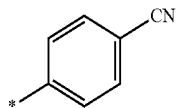
Formula 10-11



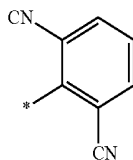
Formula 10-12



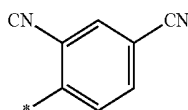
Formula 10-13



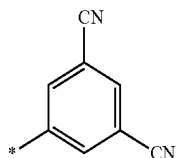
Formula 10-14



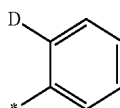
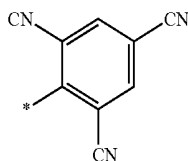
Formula 10-15



Formula 10-16



Formula 10-17



-continued

Formula 10-18

Formula 10-19

Formula 10-20

Formula 10-21

Formula 10-22

Formula 10-23

Formula 10-24

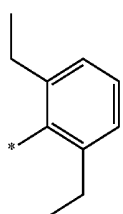
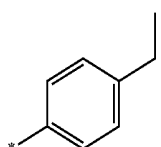
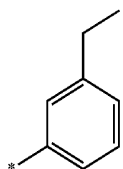
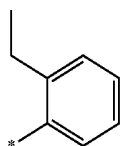
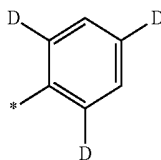
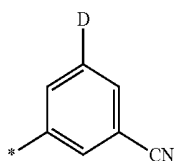
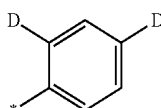
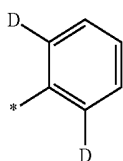
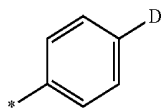
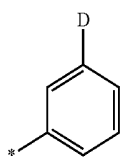
Formula 10-25

Formula 10-26

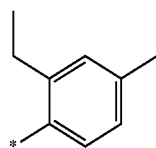
Formula 10-27

Formula 10-28

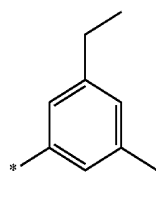
-continued



Formula 10-29

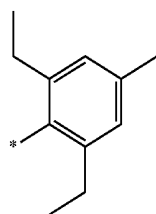


Formula 10-30

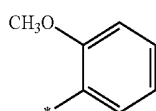


Formula 10-31

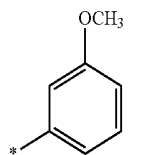
Formula 10-32



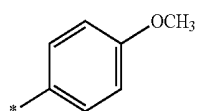
Formula 10-33



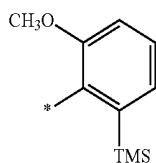
Formula 10-34



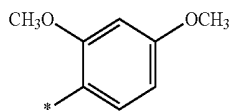
Formula 10-35



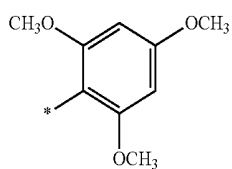
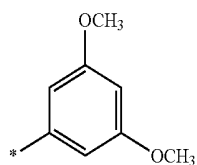
Formula 10-36



Formula 10-37



Formula 10-38



Formula 10-39

Formula 10-40

Formula 10-41

Formula 10-42

Formula 10-43

Formula 10-44

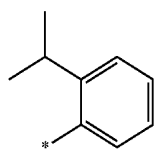
Formula 10-45

Formula 10-46

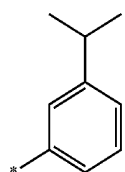
Formula 10-47

Formula 10-48

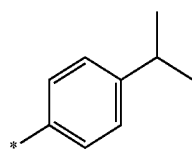
-continued



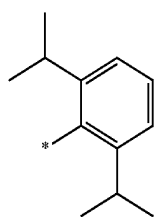
Formula 10-49



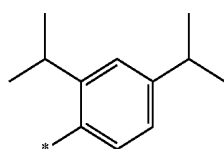
Formula 10-50



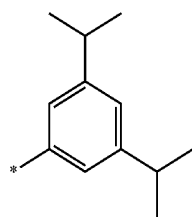
Formula 10-51



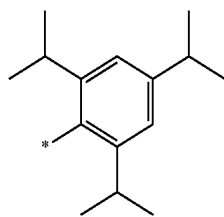
Formula 10-52



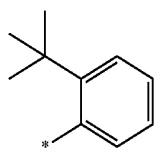
Formula 10-53



Formula 10-54

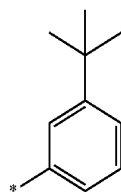


Formula 10-55

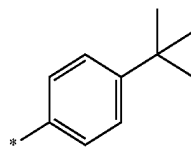


Formula 10-56

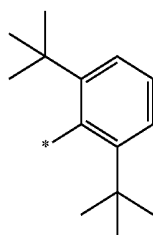
-continued



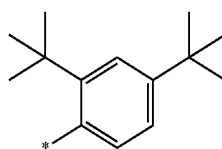
Formula 10-57



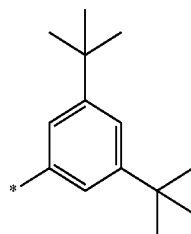
Formula 10-58



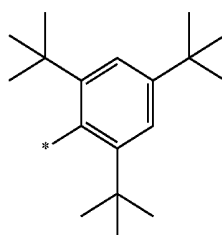
Formula 10-59



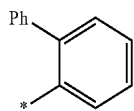
Formula 10-60



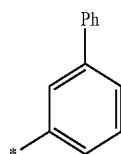
Formula 10-61



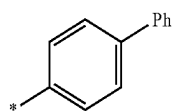
Formula 10-62



Formula 10-63

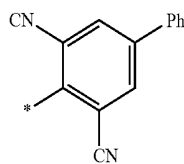
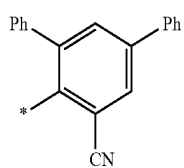
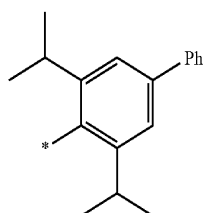
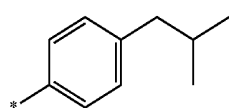
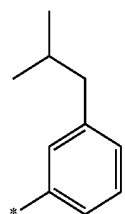
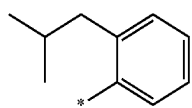
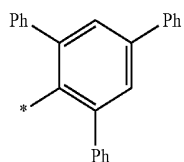
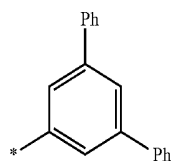
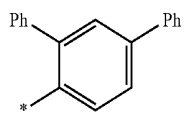
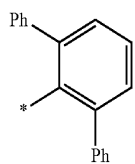


Formula 10-64



Formula 10-65

-continued

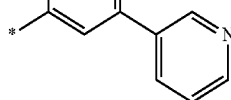


-continued

Formula 10-66



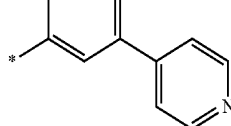
Formula 10-67



Formula 10-68



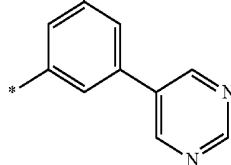
Formula 10-69



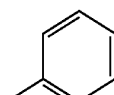
Formula 10-70



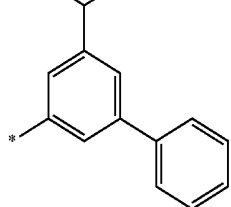
Formula 10-71



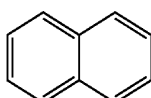
Formula 10-72



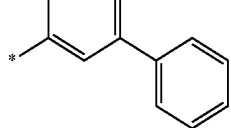
Formula 10-73



Formula 10-74



Formula 10-75



Formula 10-76

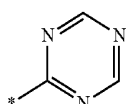
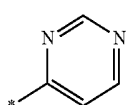
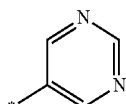
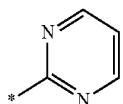
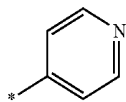
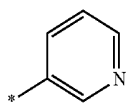
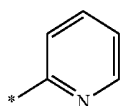
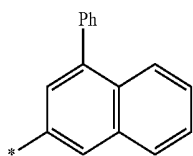
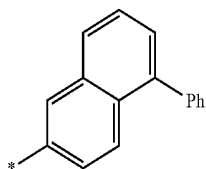
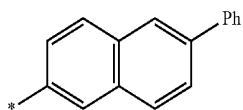
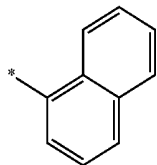
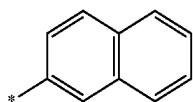
Formula 10-77

Formula 10-78

Formula 10-79

Formula 10-80

-continued



Formula 10-81

Formula 10-82

Formula 10-83

Formula 10-84

Formula 10-85

Formula 10-86

Formula 10-87

Formula 10-88

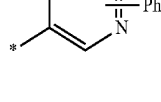
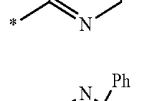
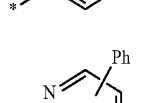
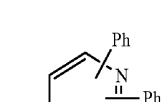
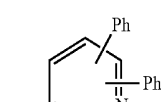
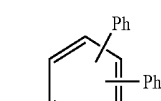
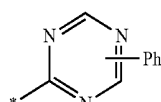
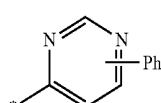
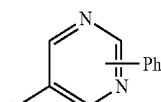
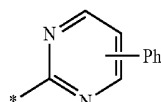
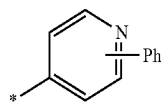
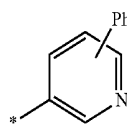
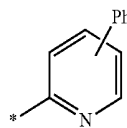
Formula 10-89

Formula 10-90

Formula 10-91

Formula 10-92

-continued



Formula 10-93

Formula 10-94

Formula 10-95

Formula 10-96

Formula 10-97

Formula 10-98

Formula 10-99

Formula 10-100

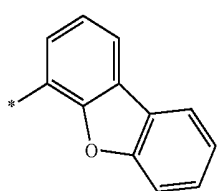
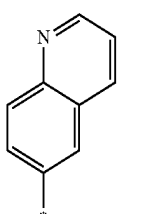
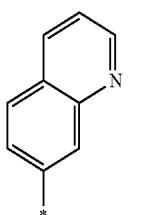
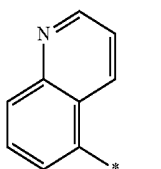
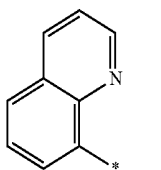
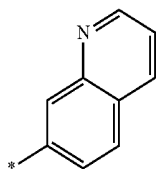
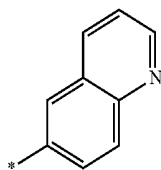
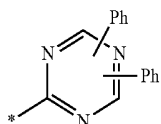
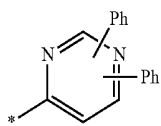
Formula 10-101

Formula 10-102

Formula 10-103

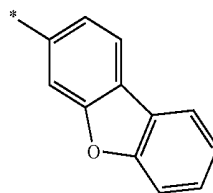
Formula 10-104

-continued



-continued

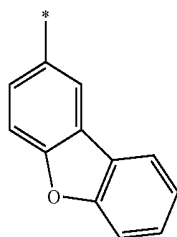
Formula 10-105



Formula 10-114

Formula 10-106

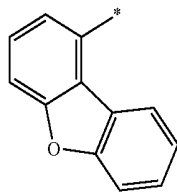
Formula 10-107



Formula 10-115

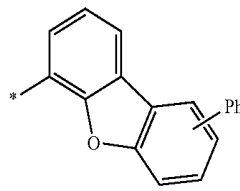
Formula 10-108

Formula 10-109



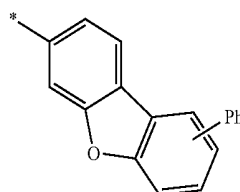
Formula 10-116

Formula 10-110



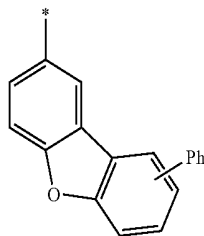
Formula 10-117

Formula 10-111



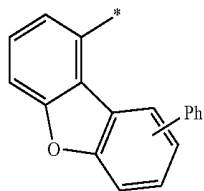
Formula 10-118

Formula 10-112



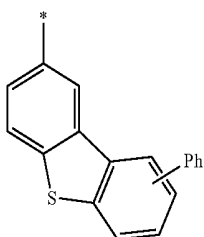
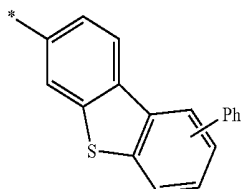
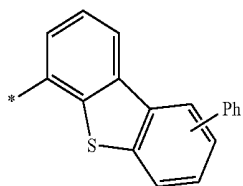
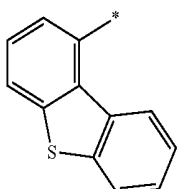
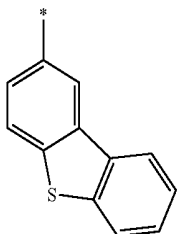
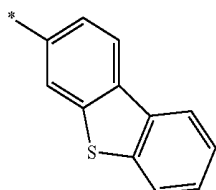
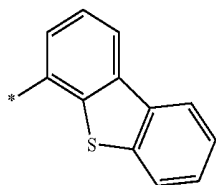
Formula 10-119

Formula 10-113



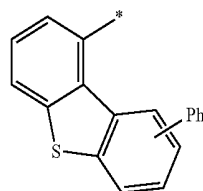
Formula 10-120

-continued

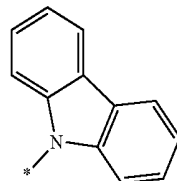


-continued

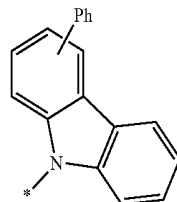
Formula 10-121



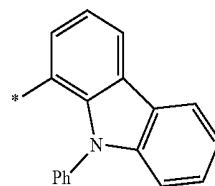
Formula 10-122



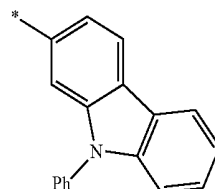
Formula 10-123



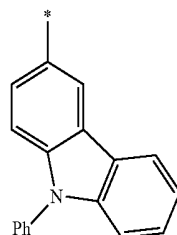
Formula 10-124



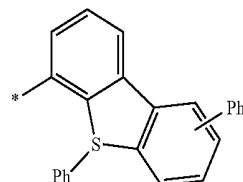
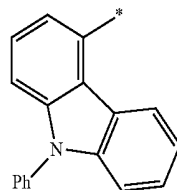
Formula 10-125



Formula 10-126



Formula 10-127



Formula 10-128

Formula 10-129

Formula 10-130

Formula 10-131

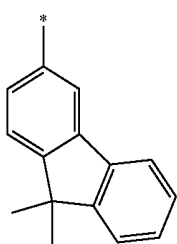
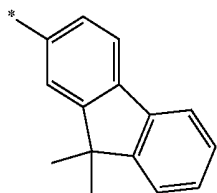
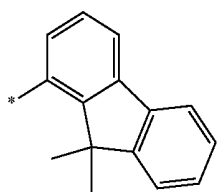
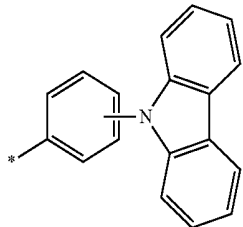
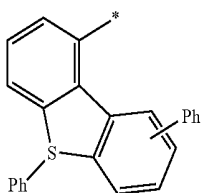
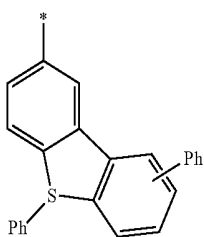
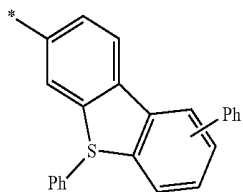
Formula 10-132

Formula 10-133

Formula 10-134

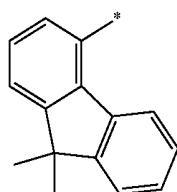
Formula 10-135

-continued

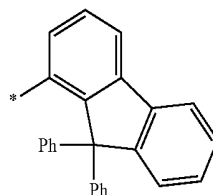


-continued

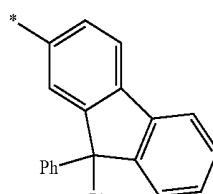
Formula 10-136



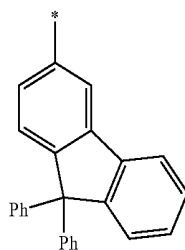
Formula 10-137



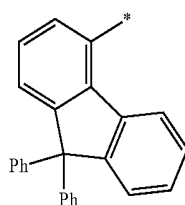
Formula 10-138



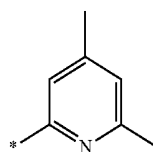
Formula 10-139



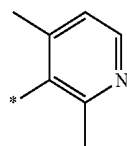
Formula 10-140



Formula 10-141



Formula 10-142



Formula 10-143

Formula 10-144

Formula 10-145

Formula 10-146

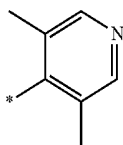
Formula 10-147

Formula 10-148

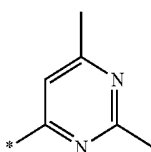
Formula 10-149

Formula 10-150

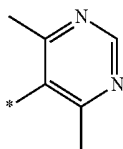
-continued



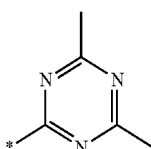
Formula 10-151



Formula 10-152



Formula 10-153

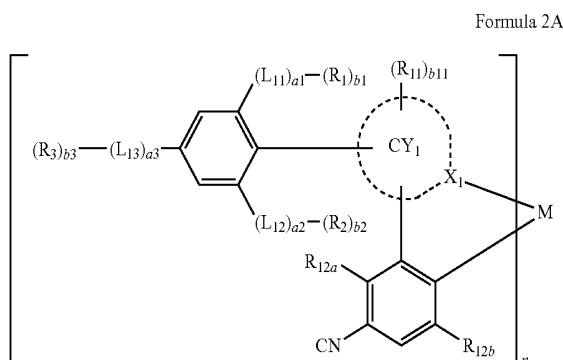


Formula 10-154

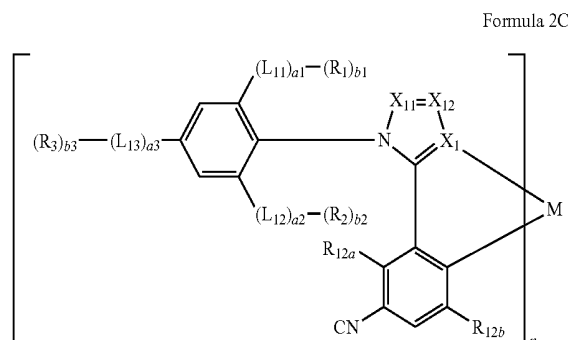
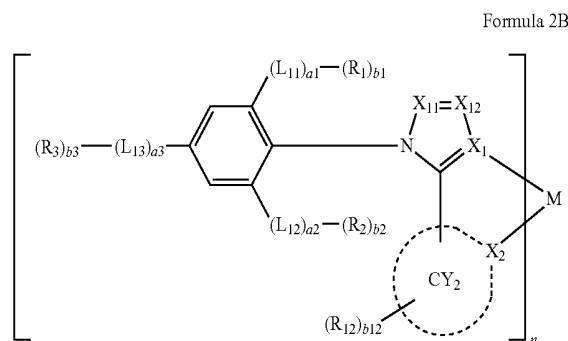
[0083] wherein, in Formulae 10-1 to 10-154, Ph represents a phenyl group, and \* indicates a binding site to an adjacent atom.

[0084] The organometallic compound represented by Formula 2 may not include a fluoro group (—F). Accordingly, an electronic device, e.g., an organic light-emitting device, including the organometallic compound represented by Formula 2 may have long lifespan.

[0085] The organometallic compound represented by Formula 1 or Formula 2 may be represented by one of Formulae 2A to 2C:



-continued



[0086] wherein, in Formulae 2A to 2C,

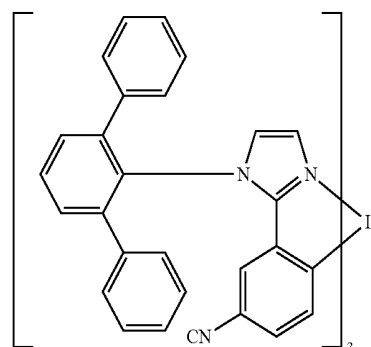
[0087] M, n, X<sub>1</sub>, X<sub>2</sub>, CY<sub>1</sub>, CY<sub>2</sub>, L<sub>11</sub> to L<sub>13</sub>, a<sub>1</sub> to a<sub>3</sub>, R<sub>1</sub> to R<sub>3</sub>, b<sub>1</sub> to b<sub>3</sub>, R<sub>11</sub>, R<sub>12</sub>, b<sub>11</sub>, and b<sub>12</sub> may be the same as those described herein,

[0088] X<sub>11</sub> may be N or C(R<sub>11a</sub>), X<sub>12</sub> may be N or C(R<sub>11b</sub>),

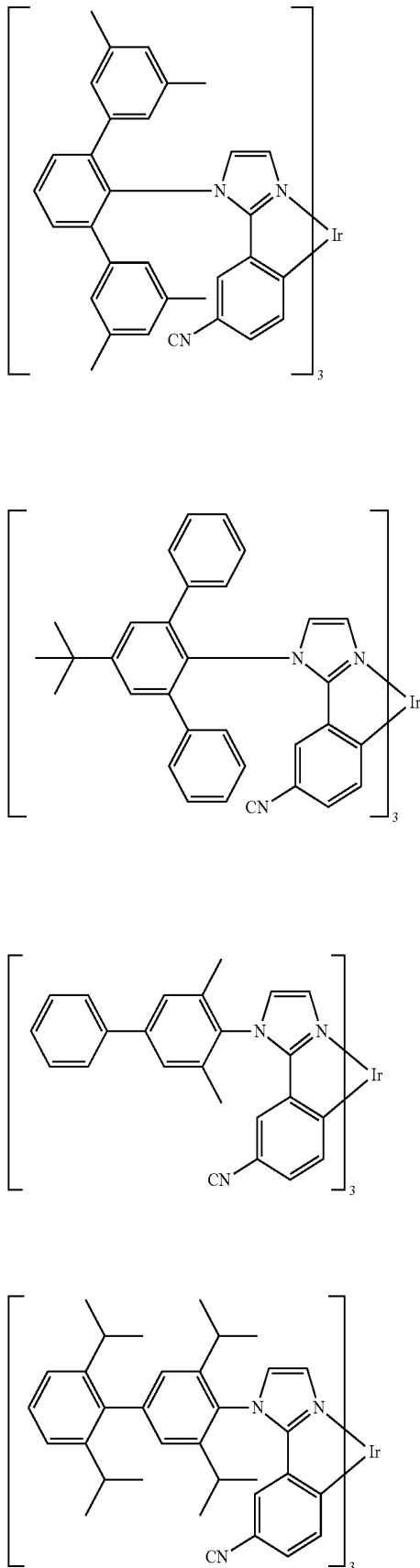
[0089] R<sub>11a</sub> and R<sub>11b</sub> may each be the same as R<sub>11</sub> described herein, and

[0090] R<sub>12a</sub> and R<sub>11b</sub> may each be the same as R<sub>12</sub> described herein.

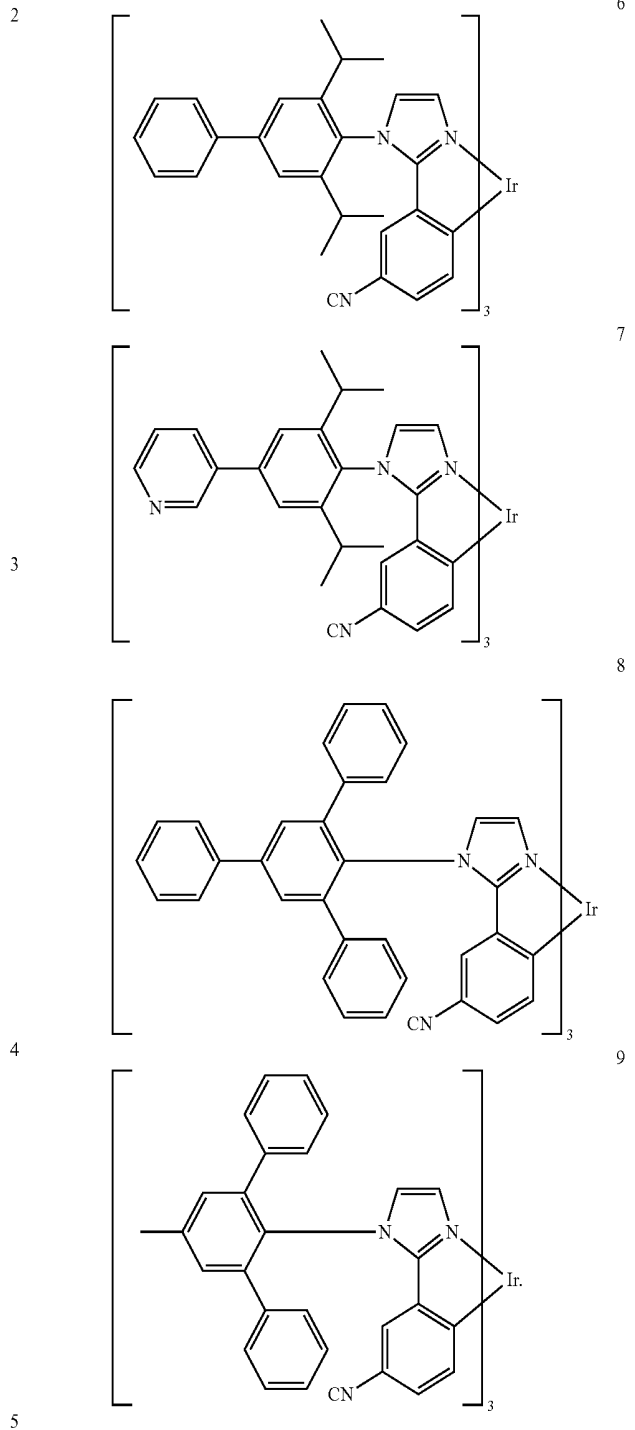
[0091] In some embodiments, the organometallic compound may be selected from Compounds 1 to 9, but embodiments are not limited thereto:



-continued



-continued



[0092] The organometallic compound may emit light of a wide range of wavelengths.

[0093] In some embodiments, the organometallic compound may emit red light, green light, or blue light.

[0094] In an embodiment, a peak emission wavelength of the organometallic compound may be in a range of about 440 nanometers (nm) to about 470 nm (for example, about 440 nm to about 467 nm). When the peak emission wavelength of the organometallic compound is in a range of about 440 nm to about 470 nm, the organic light-emitting device may provide a deep blue emission color.



structure, or a first hole transport layer/second hole transport layer/electron blocking layer structure, wherein layers of each structure are sequentially stacked on the first electrode **11** in each stated order.

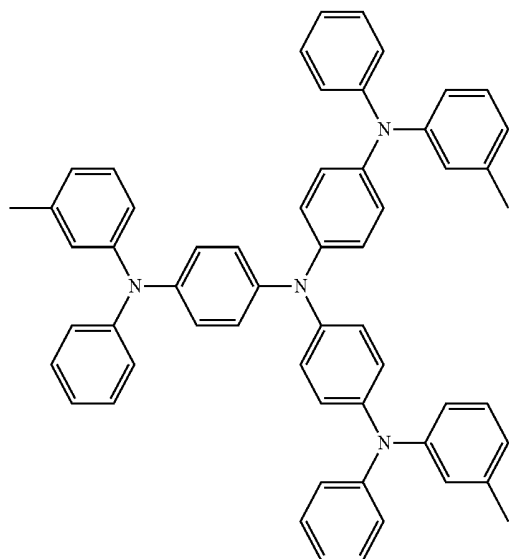
**[0115]** When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **11** by using one or more suitable methods, such as vacuum deposition, spin coating, casting, and Langmuir-Blodgett (LB) deposition.

**[0116]** When a hole injection layer is formed by vacuum-deposition, for example, the vacuum deposition may be performed at a temperature in a range of about 100° C. to about 500° C., at a vacuum degree in a range of about 10<sup>-8</sup> torr to about 10<sup>-3</sup> torr, and at a rate in a range of about 0.01 Angstroms per second (Å/sec) to about 100 Å/sec, though the conditions may vary depending on a compound used as a hole injection material and a structure and thermal properties of a desired hole injection layer, but embodiments are not limited thereto.

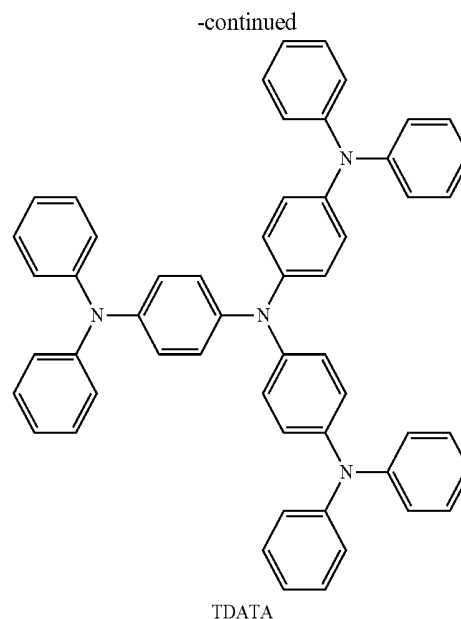
**[0117]** When a hole injection layer is formed by spin coating, the spin coating may be performed at a rate in a range of about 2,000 revolutions per minute (rpm) to about 5,000 rpm and at a temperature in a range of about 80° C. to 200° C. to facilitate removal of a solvent after the spin coating, though the conditions may vary depending on a compound used as a hole injection material and a structure and thermal properties of a desired hole injection layer, but embodiments are not limited thereto.

**[0118]** The conditions for forming a hole transport layer and an electron blocking layer may be inferred from the conditions for forming the hole injection layer.

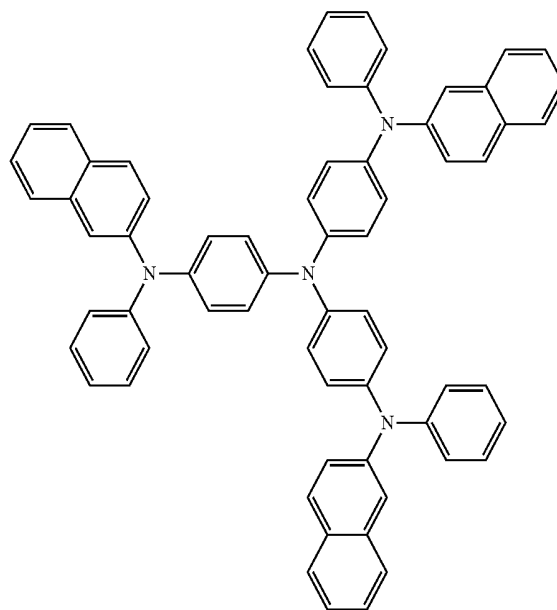
**[0119]** The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, p-NPB, TPD, spiro-TPD, spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrene 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:



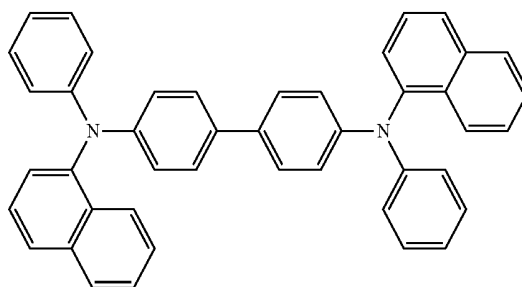
m-MTDATA



TDATA

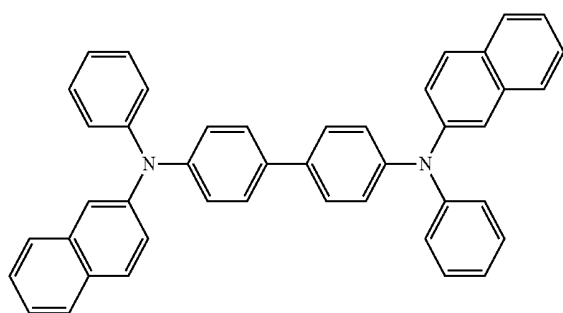
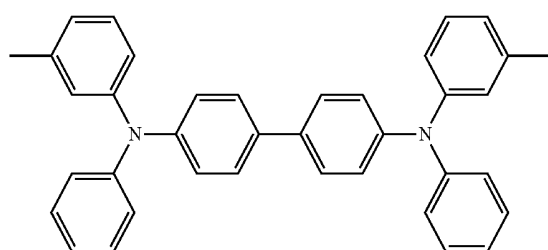


2-TNATA

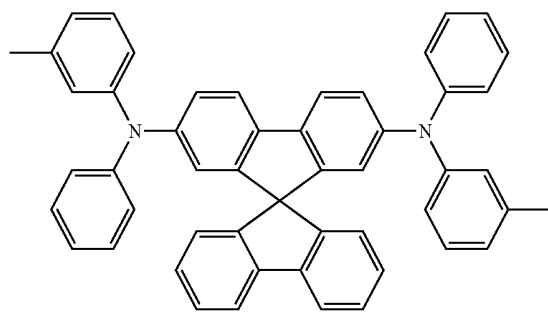


NPB

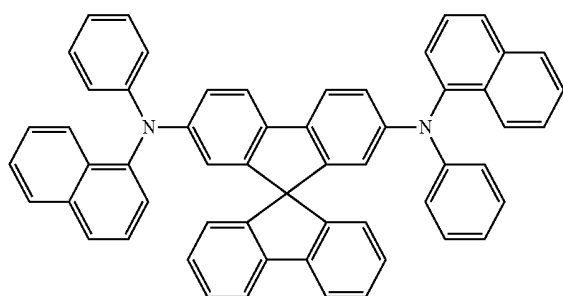
-continued

 $\beta$ -NPB

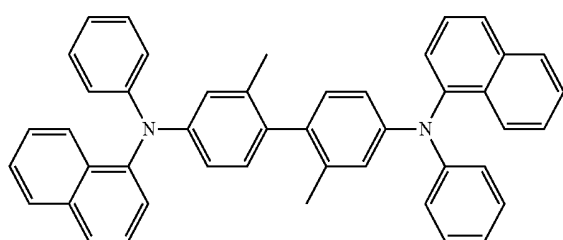
TPD



Spiro-TPD

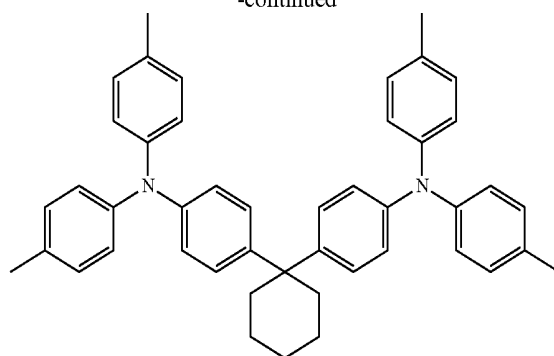


Spiro-NPB

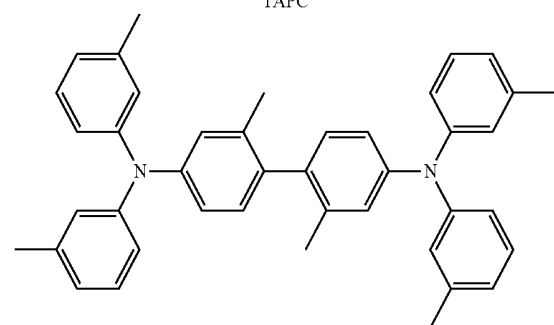


methylated NPB

-continued

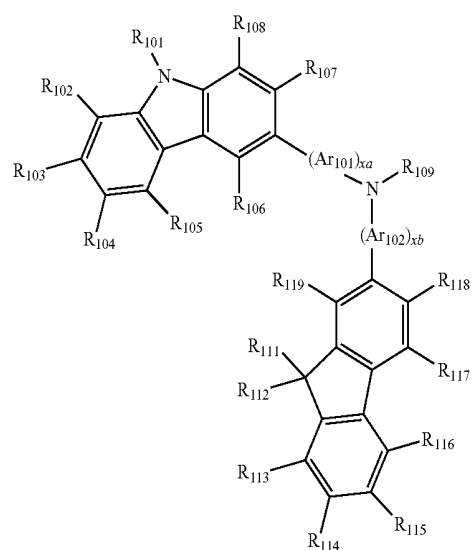


TAPC

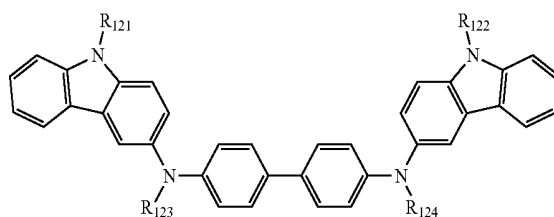


HMTPD

Formula 201



Formula 202



[0120] wherein, in Formula 201, Ar<sub>101</sub> and Ar<sub>102</sub> may each independently be selected from:

[0121] 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 chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, and a pentacenylene group; and

[0122] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene 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 chrysenylene group, a naphthacenylenylene 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0123] In Formula 201, xa and xb may each independently be an integer from 0 to 5. In some embodiments, xa and xb may each independently be an integer selected from 0, 1, and 2. In some embodiments, xa may be 1, and xb may be 0, but embodiments are not limited thereto.

[0124] In Formulae 201 and 202, R<sub>101</sub> to R<sub>108</sub>, R<sub>111</sub> to R<sub>119</sub>, and R<sub>121</sub> to R<sub>124</sub> may each independently be selected from:

[0125] 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<sub>1</sub>-C<sub>10</sub> alkyl group (e.g., a methyl group, an ethyl group, a propyl group, a butyl group, pentyl group, or a hexyl group), and a C<sub>1</sub>-C<sub>10</sub> alkoxy group (e.g., a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group);

[0126] a C<sub>1</sub>-C<sub>10</sub> alkyl group and a C<sub>1</sub>-C<sub>10</sub> 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;

[0127] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group; and

[0128] 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<sub>1</sub>-C<sub>10</sub> alkyl group, and a C<sub>1</sub>-C<sub>10</sub> alkoxy group, but embodiments are not limited thereto.

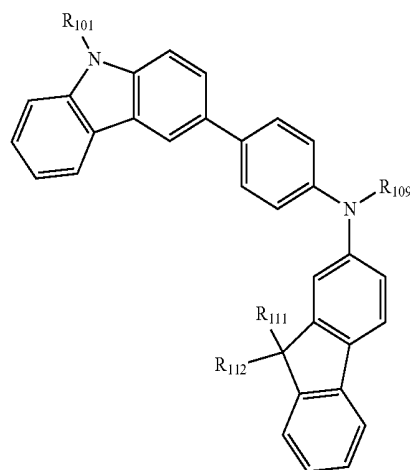
[0129] In Formula 201, R<sub>109</sub> may be selected from:

[0130] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group; and

[0131] 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<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group and a pyridinyl group.

[0132] In some embodiments, the compound represented by Formula 201 may be represented by Formula 201A, but embodiments are not limited thereto:

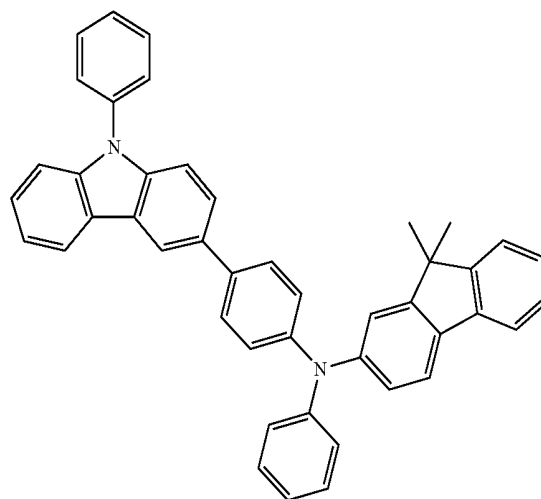
Formula 201A



[0133] R<sub>101</sub>, R<sub>111</sub>, R<sub>112</sub>, and R<sub>109</sub> in Formula 201A may be the same as those described above.

[0134] In some embodiments, the compounds represented by Formulae 201 and 202 may include Compounds HT1 to HT20, but embodiments are not limited thereto:

HT1

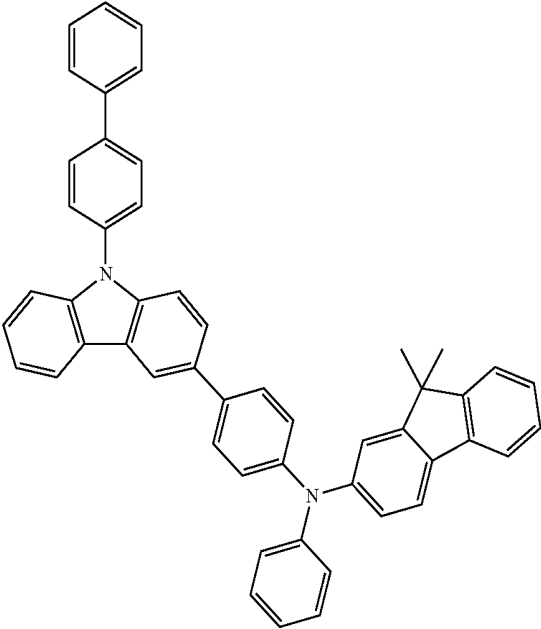
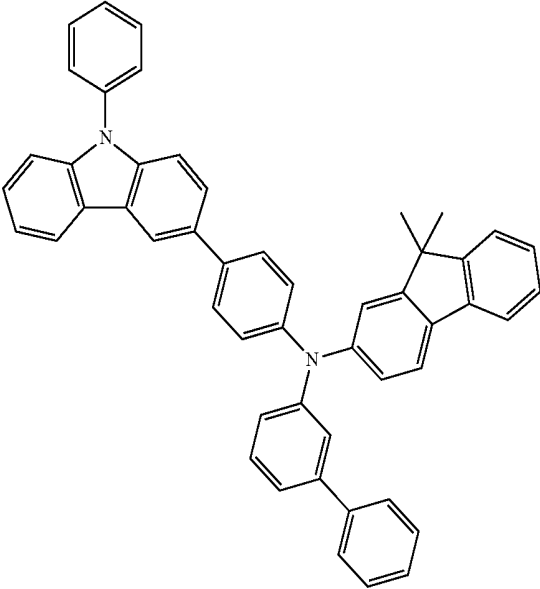


-continued

-continued

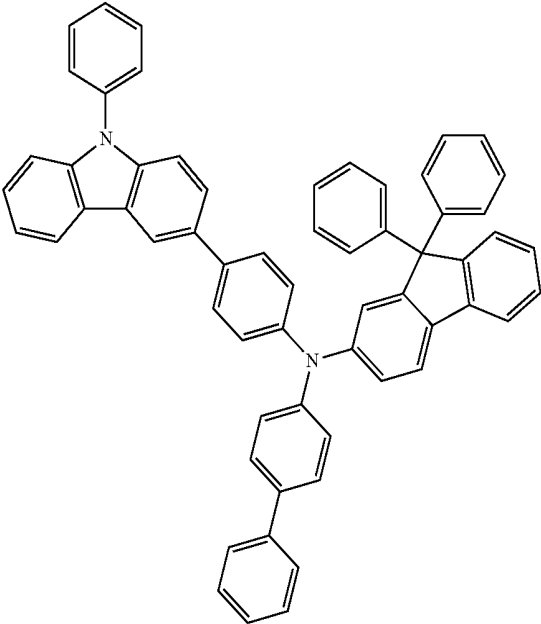
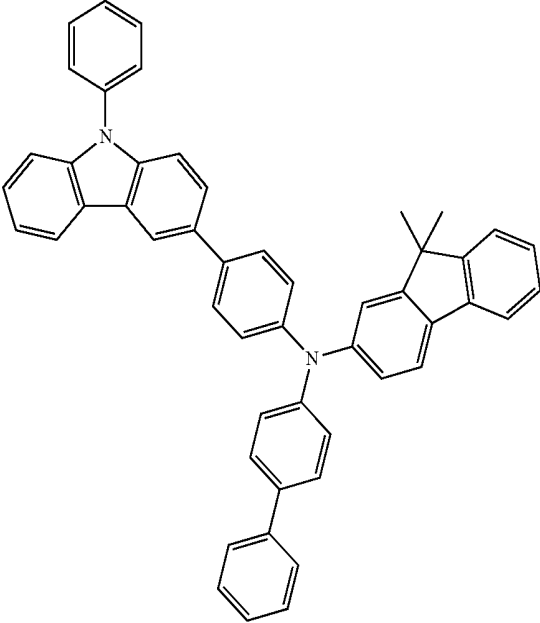
HT2

HT4



HT3

HT5

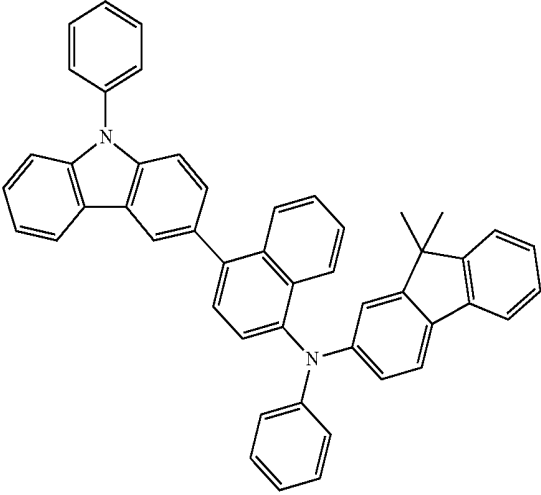
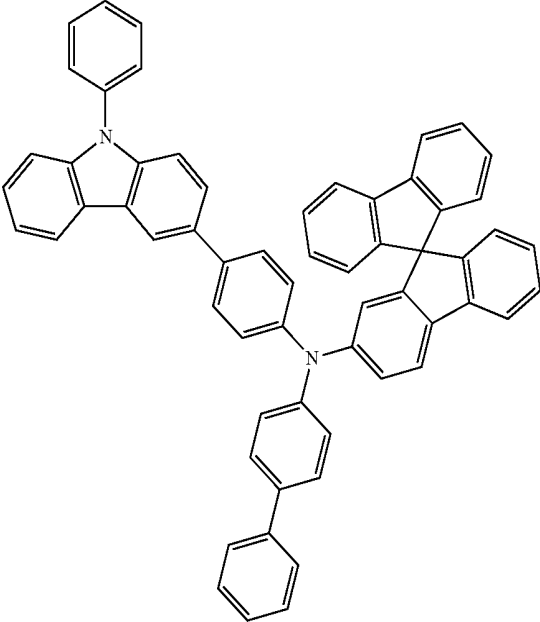


-continued

-continued

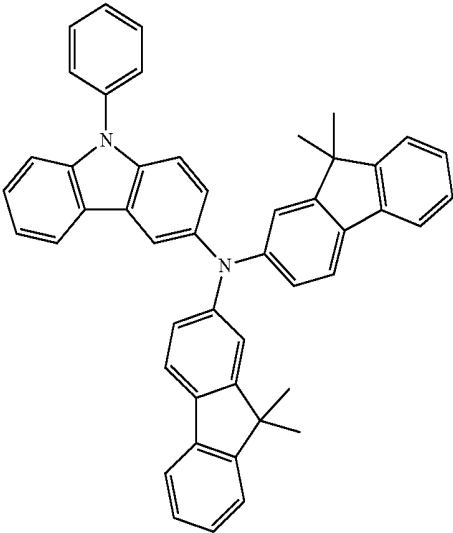
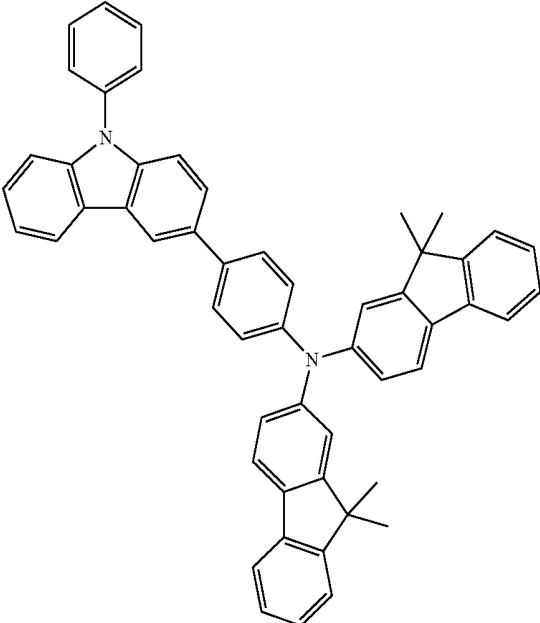
HT6

HT8



HT9

HT7

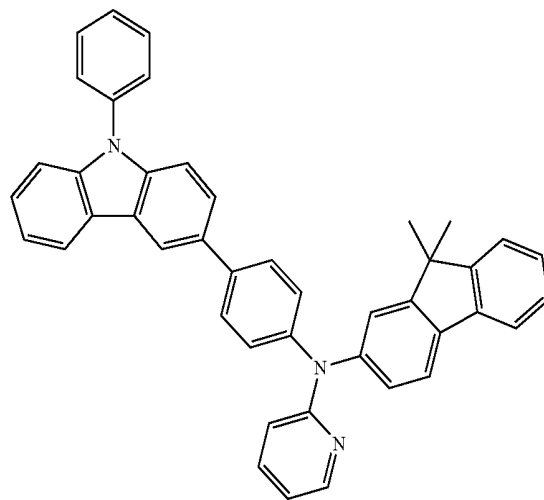
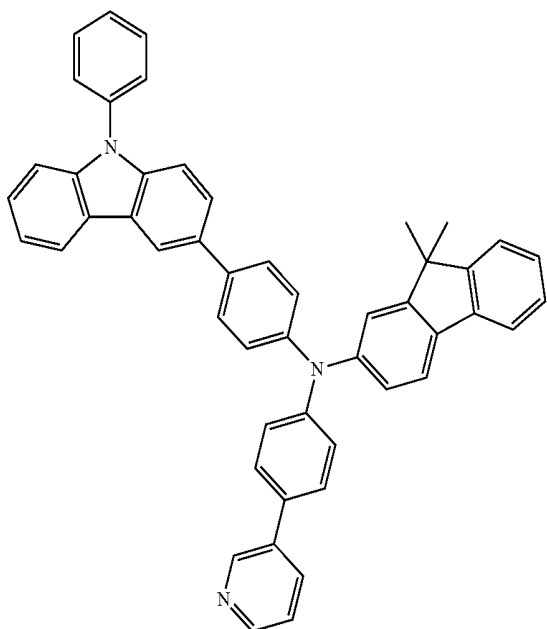


-continued

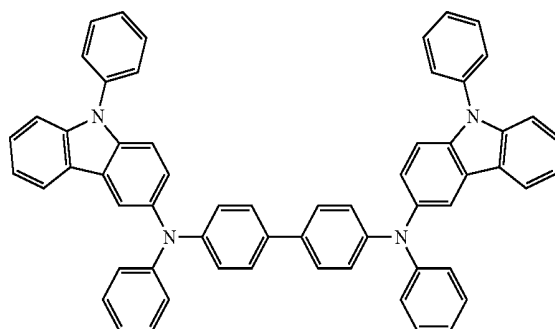
-continued

HT12

HT10

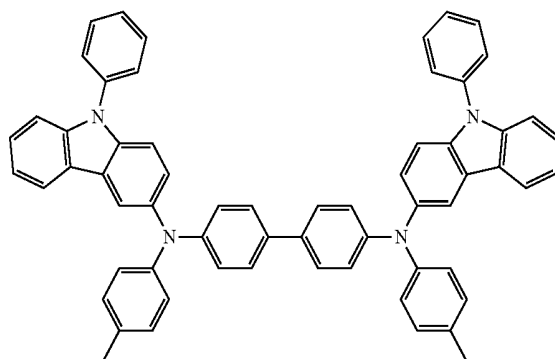
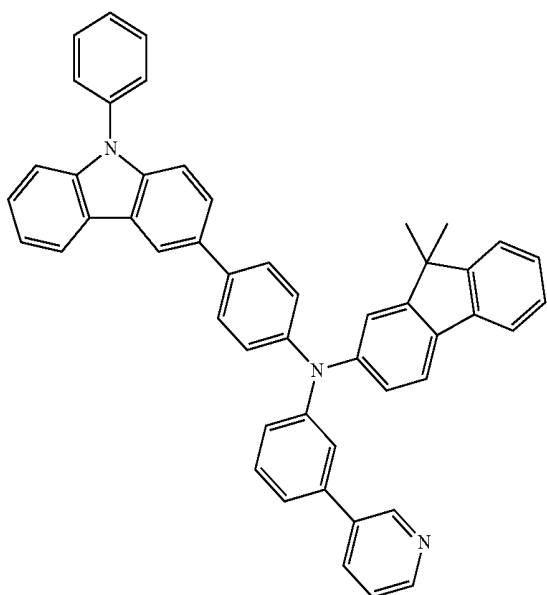


HT13

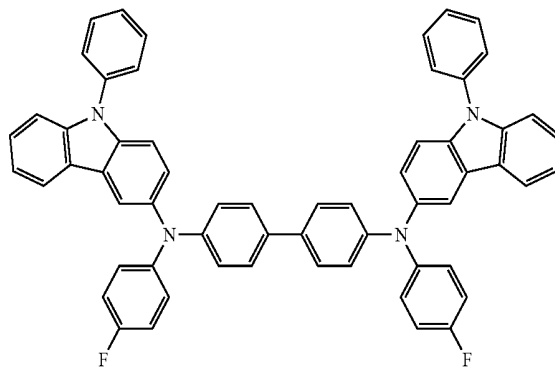


HT14

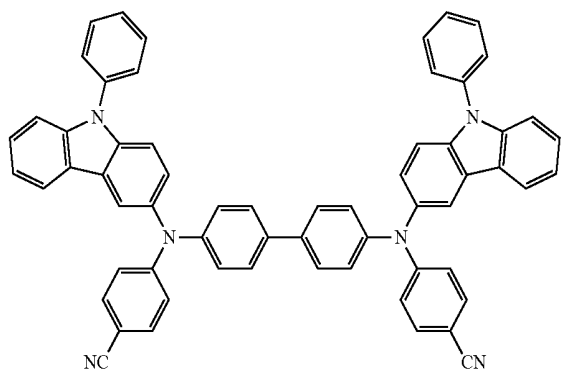
HT11



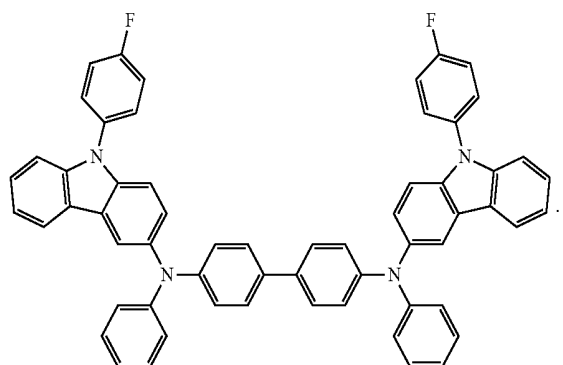
HT15



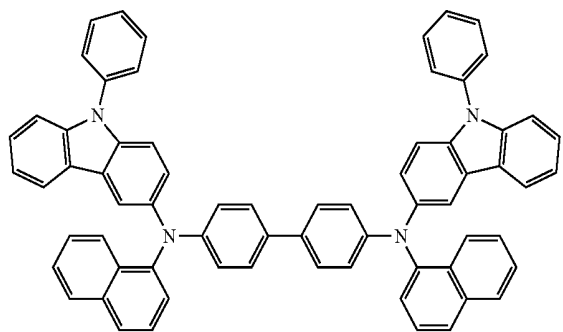
-continued



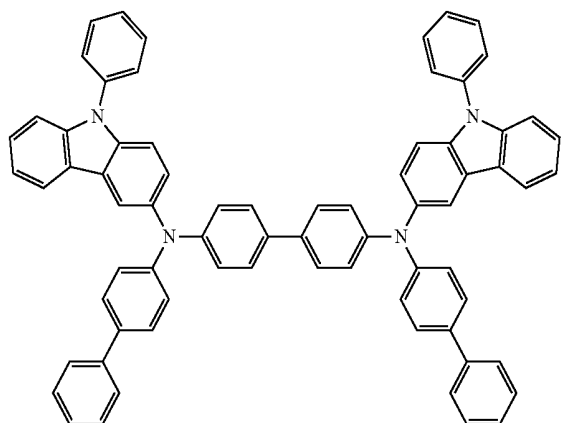
-continued



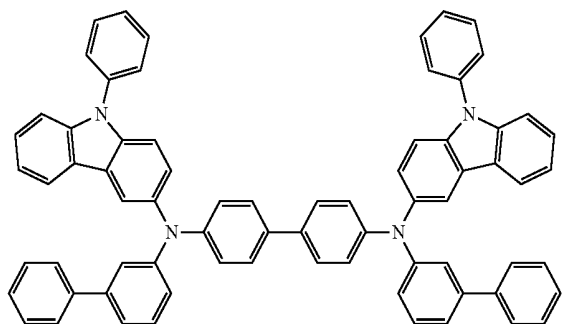
HT17



HT18



HT19

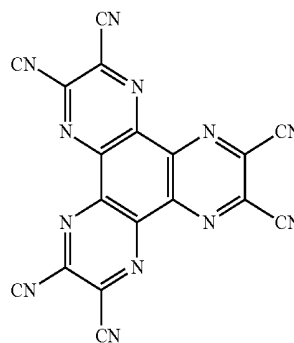


**[0135]** The thickness of the hole transport region may be in a range of about 100 Angstroms (Å) to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region includes a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å, 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 any of these ranges, excellent hole transport characteristics may be obtained without a substantial increase in driving voltage.

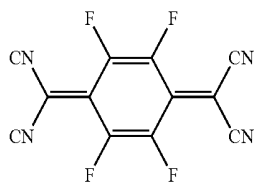
**[0136]** The hole transport region may include a charge generating material as well as the aforementioned materials, to improve conductive properties of the hole transport region. The charge generating material may be substantially homogeneously or non-homogeneously dispersed in the hole transport region.

**[0137]** The charge generating material may include, for example, a p-dopant. The p-dopant may include one of a quinone derivative, a metal oxide, and a compound containing a cyano group, but embodiments are not limited thereto. For example, non-limiting examples of the p-dopant include a quinone derivative, such as tetracyanoquinodimethane (TCNQ) or 2,3,5,6-tetrafluoro-7,7,8,8-tetracyano-1,4-benzoquinodimethane (F4-TCNQ); a metal oxide, such as a tungsten oxide or a molybdenum oxide; and a compound containing a cyano group, such as Compound HT-D1 or Compound HT-D2, but embodiments are not limited thereto:

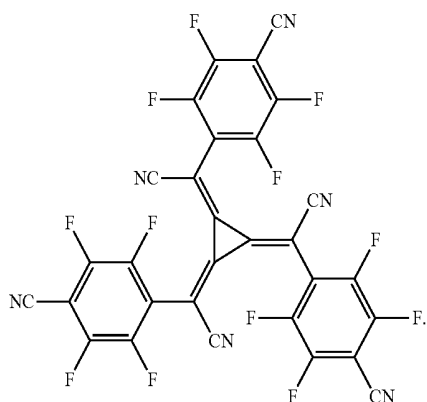
HT-D1



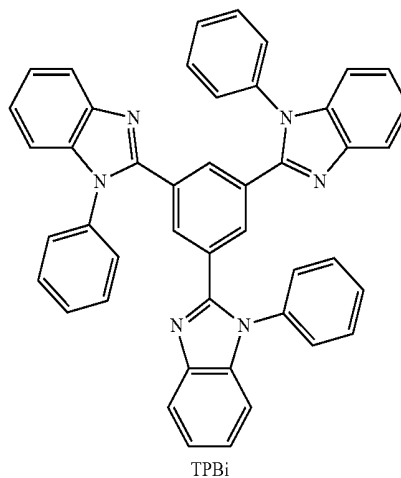
-continued



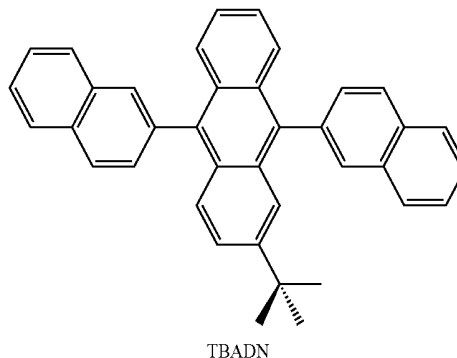
F4-TCNQ



HT-D2



TPBi



TBADN

[0138] The hole transport region may further include a buffer layer.

[0139] The buffer layer may compensate for an optical resonance distance depending on a wavelength of light emitted from the emission layer to improve the efficiency of an organic light-emitting device.

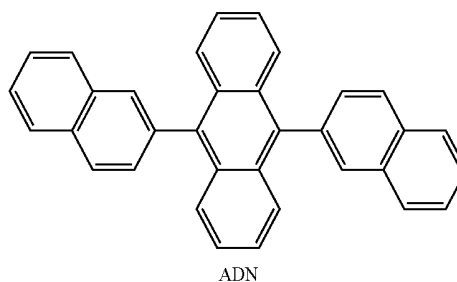
[0140] An emission layer may be formed on the hole transport region by using one or more suitable methods, such as vacuum deposition, spin coating, casting, or LB deposition. When the emission layer is formed by vacuum deposition or spin coating, vacuum deposition and coating conditions for forming the emission layer may be generally similar to the those conditions for forming a hole injection layer, though the conditions may vary depending on a compound that is used.

[0141] When the hole transport region includes an electron blocking layer, a material for forming the electron blocking layer may be selected from the materials for forming a hole transport region and host materials described herein, but embodiments are not limited thereto. In some embodiments, when the hole transport region includes an electron blocking layer, mCP described herein may be used for forming the electron blocking layer.

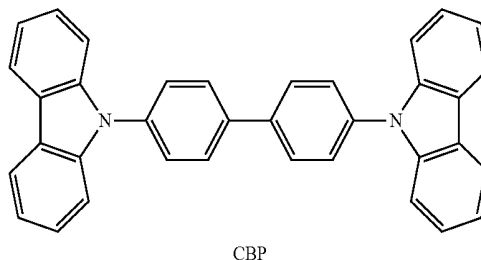
[0142] The emission layer may include a host and a dopant, and the dopant may include the organometallic compound represented by Formula 1.

[0143] Any suitable host material may be used as a host. The host may be composed of one kind of compound or a composition of two different kinds of compounds.

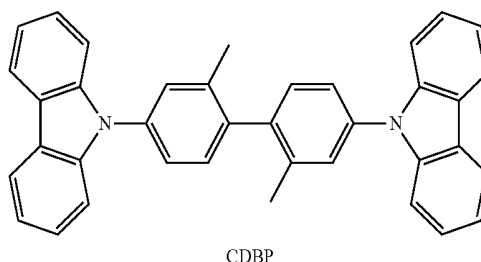
[0144] The host may include, for example, at least one selected from TPBi, TBADN, ADN (also known as "DNA"), CBP, CDBP, TCP, mCP, and Compounds H50 and H51:



ADN

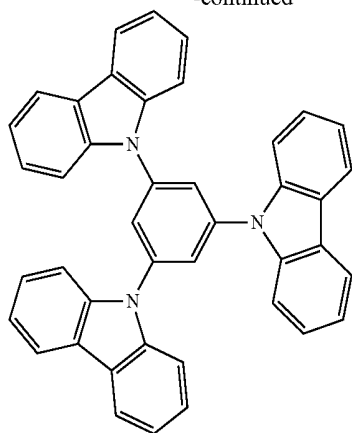


CBP

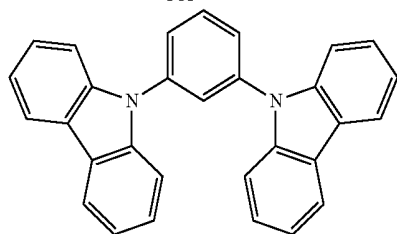


CDBP

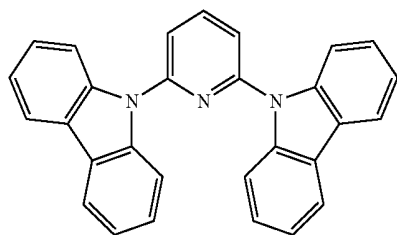
-continued



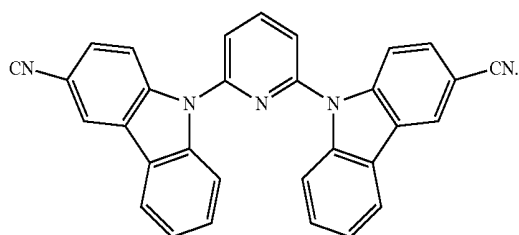
TCP



mCP



H50



H51

[0145] In some embodiments, the host may include at least one of compounds including at least one selected from a carbazole group, a fluorene group, a spirobifluorene group, a dibenzofuran group, a dibenzothiophene group, a dibenzosilole group, an indenocarbazole group, an indolocarbazole group, a benzofurocarbazole group, a benzothienocarbazole group, an acridine group, a dihydroacridine group, a triindolobenzene group, an azadibenzofuran group, an azadibenzothiophene group, an azacarbazole group, an azafluorene group, an azadibenzosilole 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 phenanthroline group, a phenazine group, a cinnoline group, a cyano group, a phosphine oxide group, and a sulfoxide group.

[0146] The host may be a composition including two different kinds of compounds selected from among the foregoing compounds.

[0147] For example, the host may include a hole transport host (a host not including an electron transport moiety) and an electron transport host (a host including an electron transport moiety).

[0148] When the organic light-emitting device 10 is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and a blue emission layer. In some embodiments, the emission layer may have a structure in which the red emission layer, the green emission layer, and/or the blue emission layer are layered to emit white light. In some embodiments, the structure of the emission layer may vary.

[0149] When the emission layer includes the host and the dopant, an amount of the dopant may be selected from a range of about 0.01 parts to about 15 parts by weight based on about 100 parts by weight of the host, but embodiments are not limited thereto.

[0150] The thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, and in some embodiments, about 200 Å to about 600 Å. While not wishing to be bound by theory, it is understood that when the thickness of the emission layer is within any of these ranges, improved luminous characteristics may be obtained without a substantial increase in driving voltage.

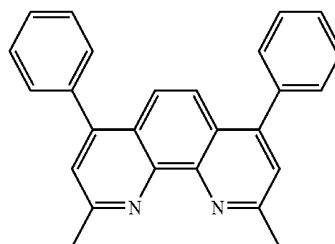
[0151] Next, an electron transport region may be formed on the emission layer.

[0152] The electron transport region may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer, but embodiments not limited thereto.

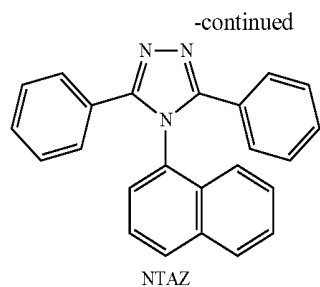
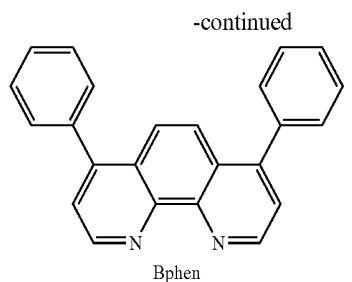
[0153] In some embodiments, the electron transport region may have a hole blocking layer/an electron transport layer/an electron injection layer structure or an electron transport layer/an electron injection layer structure, but embodiments are not limited thereto. The electron transport layer may have a single-layered structure or a multi-layered structure including two or more different materials.

[0154] The conditions for forming a hole blocking layer, an electron transport layer, and an electron injection layer may be inferred based on the conditions for forming the hole injection layer.

[0155] When the electron transport region includes a hole blocking layer, the hole blocking layer may include, for example, at least one selected from BCP, Bphen, and BALq, but embodiments are not limited thereto:



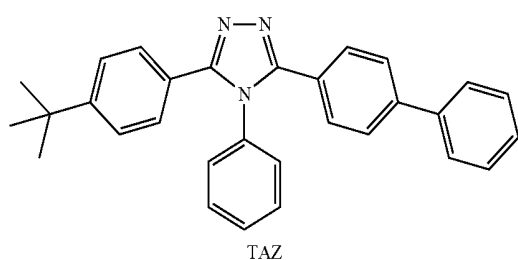
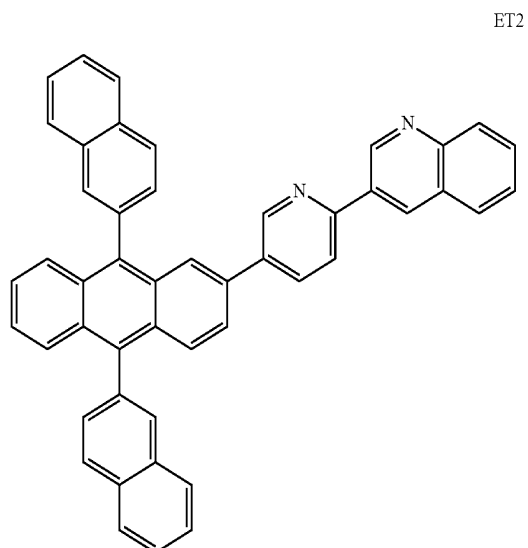
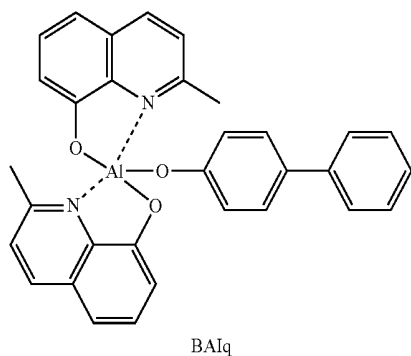
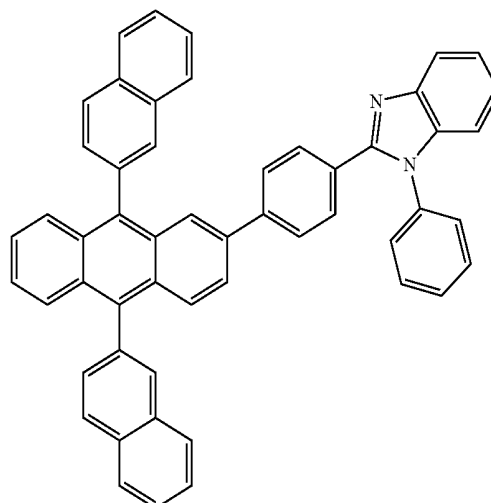
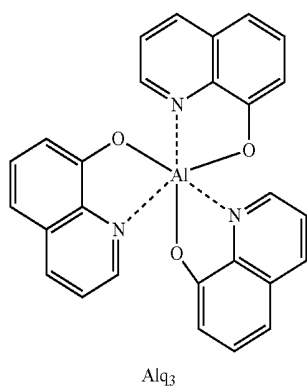
BCP



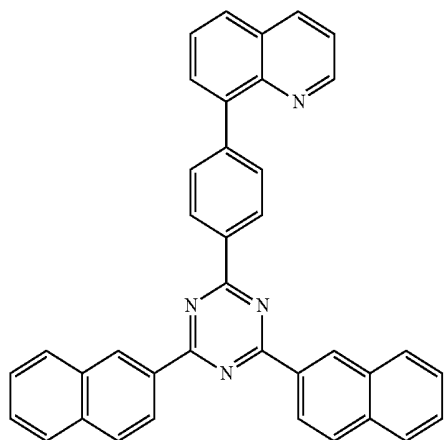
**[0156]** The thickness of the hole blocking layer may be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. While not wishing to be bound by theory, it is understood that when the thickness of the hole blocking layer is within these ranges, excellent hole blocking characteristics may be obtained without a substantial increase in driving voltage.

**[0157]** The electron transport layer may further include at least one selected from BCP, BPhen, Alq<sub>3</sub>, BAIq, TAZ, and NTAZ:

**[0158]** Alternatively, the electron transport layer may include at least one selected from Compounds ET1 to ET19, but embodiments are not limited thereto:



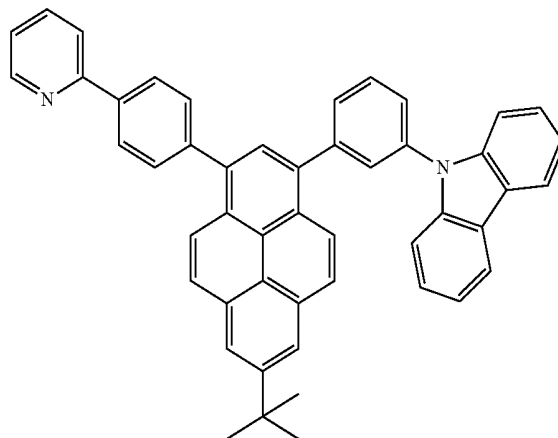
-continued



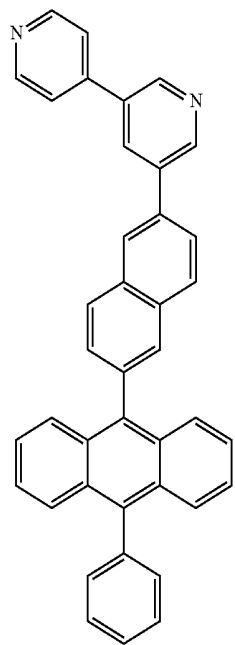
ET3

-continued

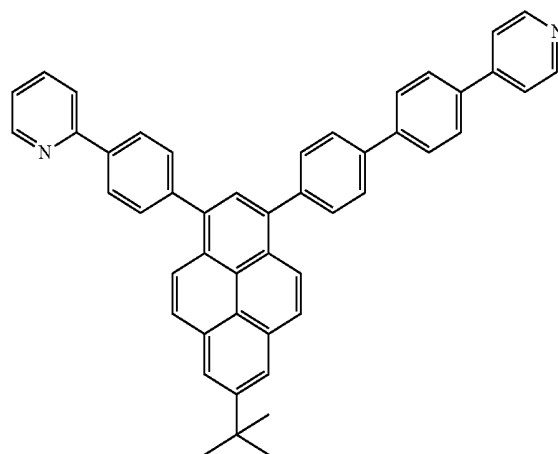
ET6



ET4

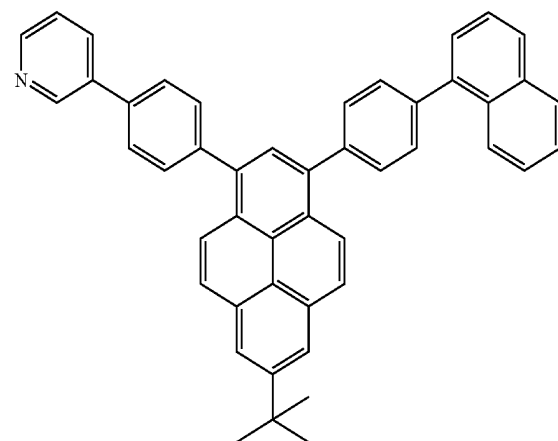
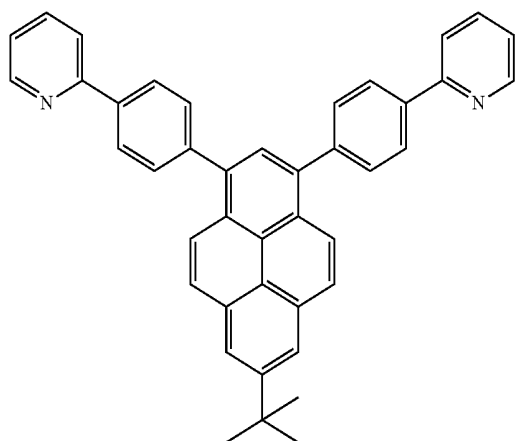


ET7



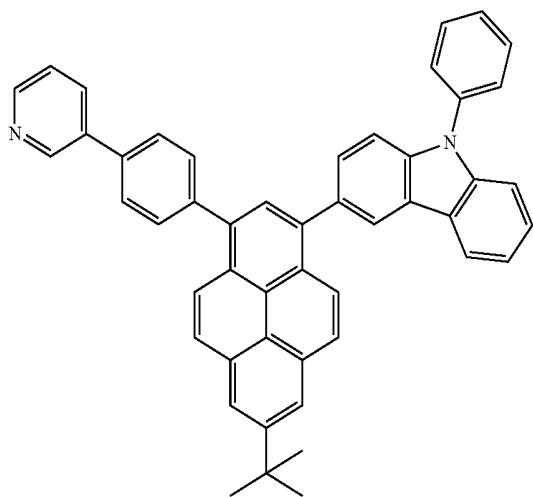
ET5

ET8

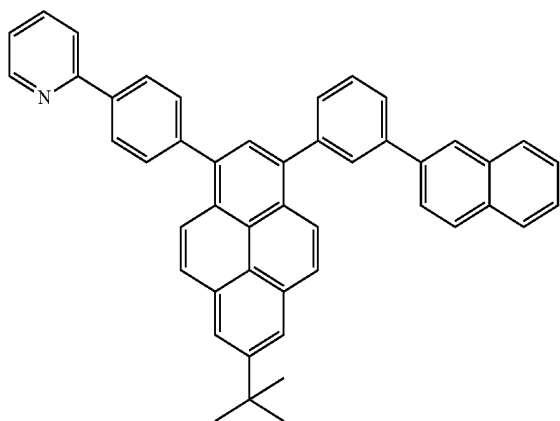


-continued

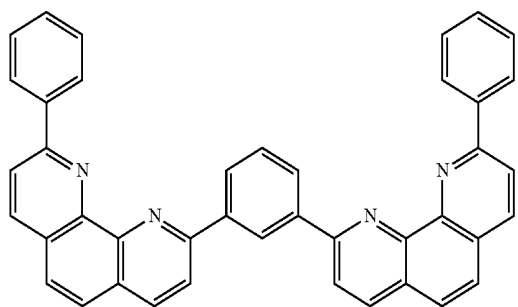
ET9



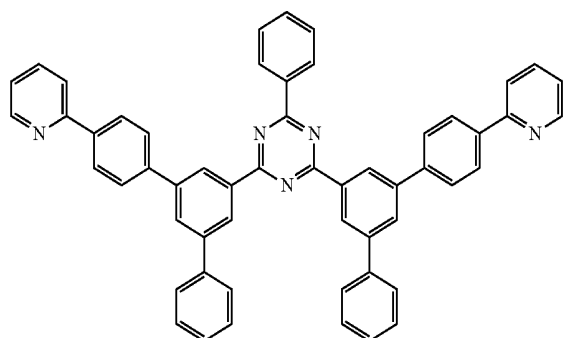
ET10



ET11

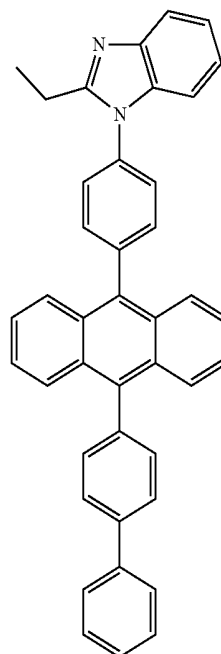


ET12

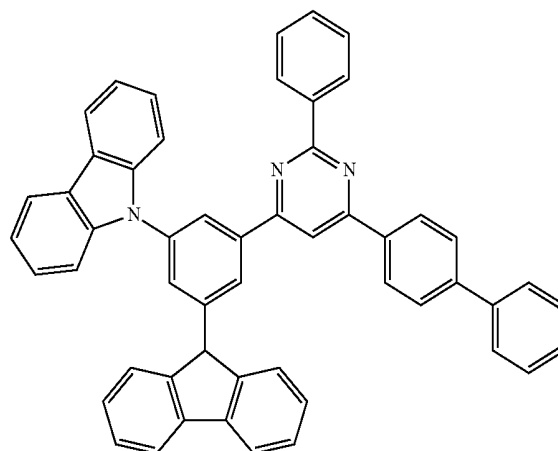


-continued

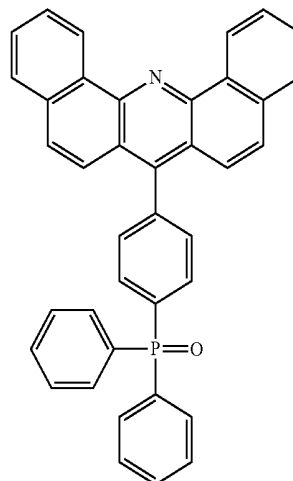
ET13



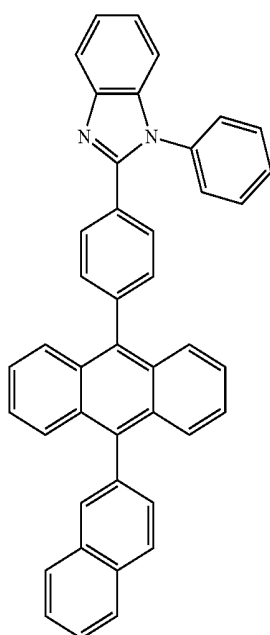
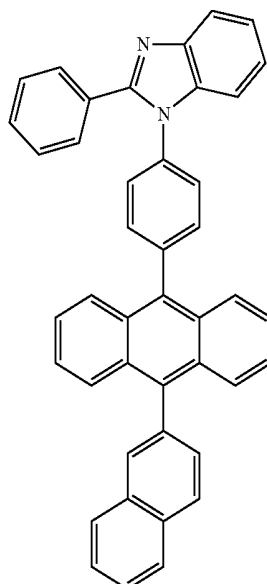
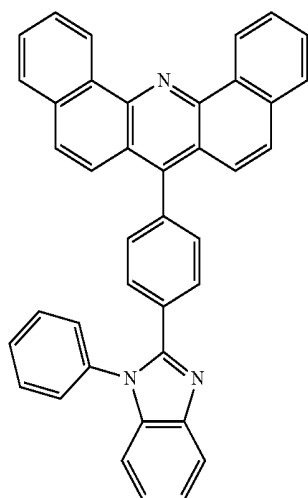
ET14



ET15



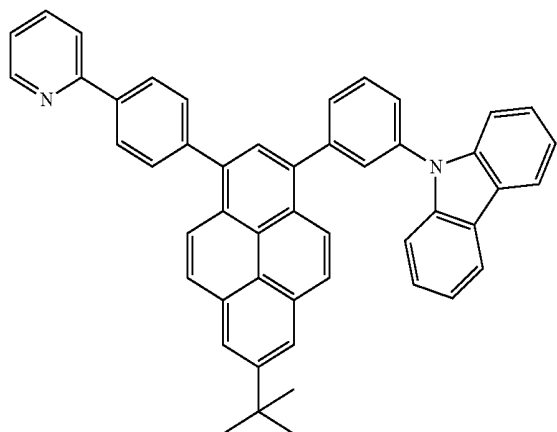
-continued



-continued

ET16

ET19



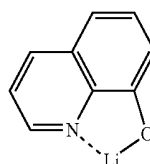
ET17

**[0159]** The thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, and in some embodiments, 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 any of these ranges, excellent electron transport characteristics may be obtained without a substantial increase in driving voltage.

**[0160]** The electron transport layer may further include a material containing metal, in addition to the materials described above.

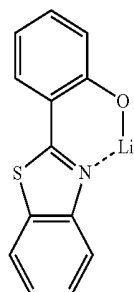
**[0161]** The material containing metal may include a lithium (Li) complex. The Li complex may include, e.g., Compound ET-D1 (lithium 8-hydroxyquinolate, LiQ) or Compound ET-D2:

ET-D1



ET18

ET-D2



**[0162]** The electron transport region may include an electron injection layer that facilitates electron injection from the second electrode 19.

**[0163]** The electron injection layer may include at least one selected from LiF, NaCl, CsF, Li<sub>2</sub>O, and BaO.

**[0164]** The thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, and in some embodiments, 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 any of

these ranges, excellent electron injection characteristics may be obtained without a substantial increase in driving voltage.

**[0165]** The second electrode **19** may be formed on the organic layer **15**. The second electrode **19** may be a cathode. A material for forming the second electrode **19** may be a material with a relatively low work function, such as a metal, an alloy, an electrically conductive compound, and a mixture thereof. Examples of the material for forming the second electrode **19** may include lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, ITO or IZO may be used to form a transmissive second electrode **19** to manufacture a top emission light-emitting device. In some embodiments, the material for forming the second electrode **19** may vary.

**[0166]** Hereinbefore the organic light-emitting device **10** has been described with reference to the FIGURE, but embodiments are not limited thereto.

**[0167]** The term “C<sub>1</sub>-C<sub>60</sub> alkyl group” as used herein refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms. 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<sub>1</sub>-C<sub>60</sub> alkylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>1</sub>-C<sub>60</sub> alkyl group.

**[0168]** The term “C<sub>1</sub>-C<sub>60</sub> alkoxy group” as used herein refers to a monovalent group represented by —OA<sub>101</sub> (wherein A<sub>101</sub> is a C<sub>1</sub>-C<sub>60</sub> alkyl group). Examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group.

**[0169]** The term “C<sub>2</sub>-C<sub>60</sub> alkenyl group” as used herein refers to a group formed by placing at least one carbon-carbon double bond in the middle or at the terminus of the C<sub>2</sub>-C<sub>60</sub> alkyl group. Examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term “C<sub>2</sub>-C<sub>60</sub> alkenylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>2</sub>-C<sub>60</sub> alkenyl group.

**[0170]** The term “C<sub>2</sub>-C<sub>60</sub> alkynyl group” as used herein refers to a group formed by placing at least one carbon-carbon triple bond in the middle or at the terminus of the C<sub>2</sub>-C<sub>60</sub> alkyl group. Examples thereof include an ethynyl group and a propynyl group. The term “C<sub>2</sub>-C<sub>60</sub> alkynylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>2</sub>-C<sub>60</sub> alkynyl group.

**[0171]** The term “C<sub>3</sub>-C<sub>10</sub> cycloalkyl group” as used herein refers to a monovalent monocyclic saturated hydrocarbon group including 3 to 10 carbon atoms. Examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term “C<sub>3</sub>-C<sub>10</sub> cycloalkylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkyl group.

**[0172]** The term “C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group” as used herein refers to a monovalent saturated monocyclic group including at least one heteroatom selected from N, O, P, Si, and S as a ring-forming atom and 1 to 10 carbon atoms. Examples thereof include a tetrahydrofuranlyl group and a tetrahydrothiophenyl group. The term “C<sub>1</sub>-C<sub>10</sub> heterocycloalkylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group.

**[0173]** The term “C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group” as used herein refers to a monovalent monocyclic group including 3 to 10 carbon atoms and at least one carbon-carbon double bond in its ring, wherein the molecular structure as a whole is non-aromatic. Examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term “C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group.

**[0174]** The term “C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group” as used herein refers to a monovalent monocyclic group including 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 double bond in its ring. Examples of the C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group include a 2,3-dihydrofuranlyl group and a 2,3-dihydrothiophenyl group. The term “C<sub>1</sub>-C<sub>10</sub> heterocycloalkenylene group” as used herein refers to a divalent group having substantially the same structure as the C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group.

**[0175]** The term “C<sub>6</sub>-C<sub>60</sub> aryl group” as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. The term “C<sub>6</sub>-C<sub>60</sub> arylene group” as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Examples of the C<sub>6</sub>-C<sub>60</sub> 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<sub>6</sub>-C<sub>60</sub> aryl group and a C<sub>6</sub>-C<sub>60</sub> arylene group each include at least two rings, the at least two rings may be fused.

**[0176]** The term “C<sub>1</sub>-C<sub>60</sub> heteroaryl group” as used herein refers to a monovalent group having a heterocyclic aromatic system having 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<sub>1</sub>-C<sub>60</sub> heteroarylene group” as used herein refers to a divalent group having a heterocyclic aromatic system having at least one heteroatom selected from N, O, P, Si and S as a ring-forming atom and 1 to 60 carbon atoms. Examples of the C<sub>1</sub>-C<sub>60</sub> 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<sub>1</sub>-C<sub>60</sub> heteroaryl group and the C<sub>1</sub>-C<sub>60</sub> heteroarylene group each include at least two rings, the at least two rings may be fused.

**[0177]** The term “C<sub>6</sub>-C<sub>60</sub> aryloxy group” as used herein indicates —OA<sub>102</sub> (wherein A<sub>102</sub> is a C<sub>6</sub>-C<sub>60</sub> aryl group). The term “C<sub>6</sub>-C<sub>60</sub> arylthio group” as used herein indicates —SA<sub>103</sub> (wherein A<sub>103</sub> is a C<sub>6</sub>-C<sub>60</sub> aryl group).

**[0178]** The term “monovalent non-aromatic condensed polycyclic group” as used herein refers to a monovalent group that has two or more condensed rings and only carbon atoms (e.g., the number of carbon atoms may be in a range of 8 to 60) as ring-forming atoms, wherein the molecular structure as a whole is non-aromatic. 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 substantially the same structure as the monovalent non-aromatic condensed polycyclic group.

**[0179]** The term “monovalent non-aromatic condensed heteropolycyclic group” as used herein refers to a monovalent group that has two or more condensed rings, and a heteroatom selected from N, O, P, Si, and S and carbon atoms (e.g., the number of carbon atoms may be in a range of 1 to 60) as ring-forming atoms, wherein the molecular

structure as a whole is non-aromatic. 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 substantially the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

**[0180]** The term “C<sub>5</sub>-C<sub>30</sub> carbocyclic group” as used herein refers to a saturated or unsaturated cyclic group including 5 to 30 carbon atoms only as ring-forming atoms. The C<sub>5</sub>-C<sub>30</sub> carbocyclic group may be a monocyclic group or a polycyclic group. Depending on formula structure, the C<sub>5</sub>-C<sub>30</sub> carbocyclic group may be monovalent, divalent, trivalent, quadrivalent, pentavalent, or hexavalent.

**[0181]** The term “C<sub>1</sub>-C<sub>30</sub> heterocyclic group” as used herein refers to saturated or unsaturated cyclic group including 1 to 30 carbon atoms and at least one heteroatom selected from N, O, P, Si, and S as ring-forming atoms. The C<sub>1</sub>-C<sub>30</sub> heterocyclic group may be a monocyclic group or a polycyclic group. Depending on formula structure, the C<sub>5</sub>-C<sub>30</sub> heterocyclic group may be monovalent, divalent, trivalent, quadrivalent, pentavalent, or hexavalent.

**[0182]** In the present specification, at least one substituent of the substituted C<sub>5</sub>-C<sub>30</sub> carbocyclic group, substituted C<sub>1</sub>-C<sub>30</sub> heterocyclic group, substituted C<sub>1</sub>-C<sub>60</sub> alkyl group, substituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, substituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, substituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, substituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, substituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, substituted C<sub>6</sub>-C<sub>60</sub> aryl group, substituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, substituted C<sub>6</sub>-C<sub>60</sub> arylthio group, substituted C<sub>7</sub>-C<sub>60</sub> arylalkyl group, substituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, substituted C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, substituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, substituted C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, substituted monovalent non-aromatic condensed polycyclic group, and substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

**[0183]** deuterium, —F, —Cl, —Br, —I, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, —CF<sub>3</sub>, —CF<sub>2</sub>H, —CFH<sub>2</sub>, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group;

**[0184]** a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, —CF<sub>3</sub>, —CF<sub>2</sub>H, —CFH<sub>2</sub>, 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<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub>

heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>11</sub>)(Q<sub>12</sub>), —Si(Q<sub>13</sub>)(Q<sub>14</sub>)(Q<sub>15</sub>), —B(Q<sub>16</sub>)(Q<sub>17</sub>), and —P(=O)(Q<sub>18</sub>)(Q<sub>19</sub>);

**[0185]** a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

**[0186]** a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl 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<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, —CF<sub>3</sub>, —CF<sub>2</sub>H, —CFH<sub>2</sub>, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>21</sub>)(Q<sub>22</sub>), —Si(Q<sub>23</sub>)(Q<sub>24</sub>)(Q<sub>25</sub>), —B(Q<sub>26</sub>)(Q<sub>27</sub>), and —P(=O)(Q<sub>28</sub>)(Q<sub>29</sub>); and

**[0187]** —N(Q<sub>31</sub>)(Q<sub>32</sub>), —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), —B(Q<sub>36</sub>)(Q<sub>37</sub>), and —P(=O)(Q<sub>38</sub>)(Q<sub>39</sub>),

**[0188]** wherein Q<sub>1</sub> to Q<sub>9</sub>, Q<sub>11</sub> to Q<sub>19</sub>, Q<sub>21</sub> to Q<sub>29</sub>, and Q<sub>31</sub> to Q<sub>39</sub> 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryl group substituted with at least one selected from a C<sub>1</sub>-C<sub>60</sub> alkyl group and a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl

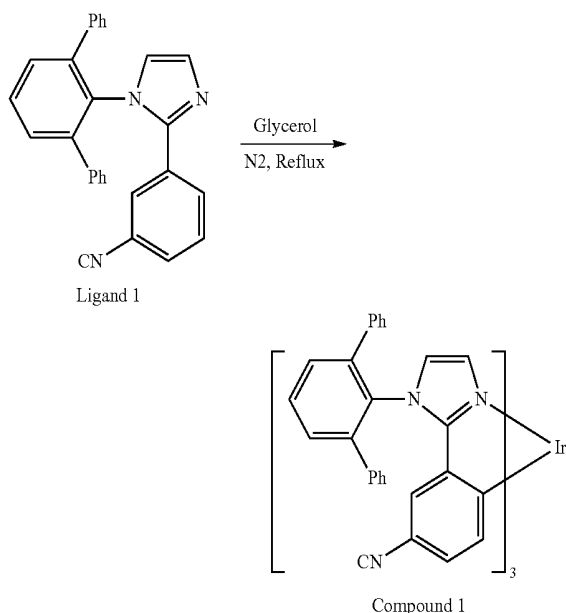
group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0189] Hereinafter, a compound and an organic light-emitting device according to an embodiment will be described in detail with reference to Synthesis Examples and Examples, however, the present disclosure is not limited thereto. The wording "B was used instead of A" used in describing Synthesis Examples means that an amount of B used was identical to an amount of A used in terms of molar equivalents.

### EXAMPLES

#### Synthesis Example 1: Synthesis of Compound 1

[0190]

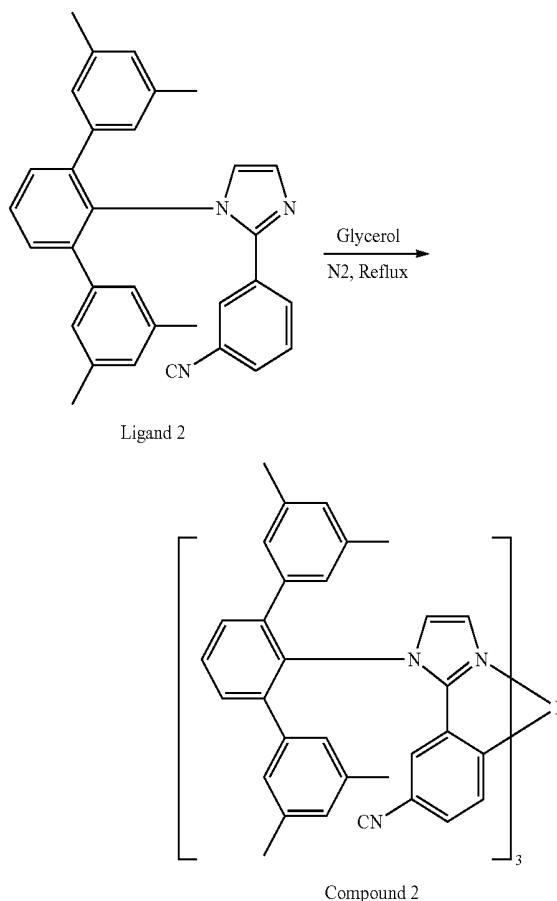


[0191] 3.29 millimoles (mmol) of  $\text{Ir}(\text{acac})_3$ , 16.47 mmol of Ligand 1, and glycerol were added to a reaction vessel. Next, the mixture was refluxed for 12 hours under nitrogen atmosphere. Once the reaction was complete, the mixture was cooled to room temperature. Dichloromethane and distilled water were added thereto, and the organic layer was separated. The obtained organic layer was washed with distilled water two times and dried with magnesium sulfate ( $\text{MgSO}_4$ ) to remove moisture therefrom. The resultant mixture was filtered and evaporated to remove the organic solvent. The obtained crude product was purified through silica gel column chromatography (using dichloromethane and n-hexane as an eluent) to obtain 0.51 mmol of Compound 1. The structure and purity (greater than 99%) of Compound 1 were identified by using nuclear magnetic resonance (NMR), high-performance liquid chromatography (HPLC), and liquid chromatography-mass spectrometry (LCMS).

[0192]  $^1\text{H-NMR}$  (300 MHz,  $\text{CD}_2\text{Cl}_2$ )  $\delta$  7.8 (1H, t), 7.7-7.55 (2H, m), 7.1-6.7 (10.5H, m), 6.6 (1H, s), 6.55-6.4 (2H, m)

#### Synthesis Example 2: Synthesis of Compound 2

[0193]

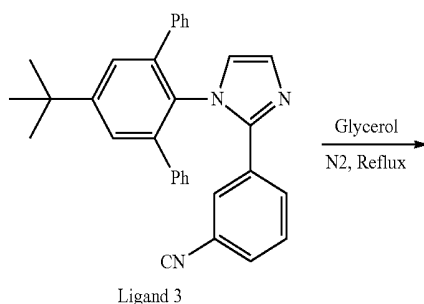


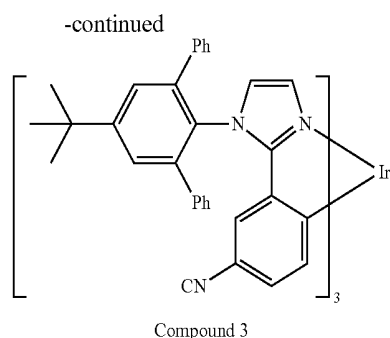
[0194] 0.3 grams (g) of Compound 2 (having a purity of 99.83%) was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 2 was used instead of Ligand 1.

[0195] LC-MS (calculated value: 1,381.14 grams per mole (g/mol), measured value:  $M^{+1}=1,382$  g/mol)

#### Synthesis Example 3: Synthesis of Compound 3

[0196]



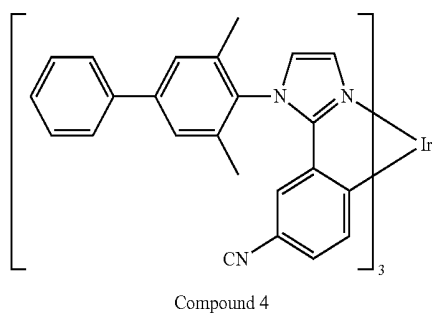
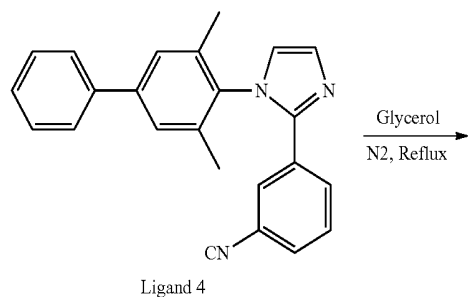


[0197] 0.51 mmol of Compound 3 was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 3 was used instead of Ligand 1. The structure and purity (greater than 99%) of Compound 3 were identified by using NMR, HPLC, and LCMS.

[0198]  $^1\text{H-NMR}$  (300 MHz,  $\text{CD}_2\text{Cl}_2$ )  $\delta$  7.65 (1H, s), 7.56 (1H, s), 7.2-7.0 (3H, m), 6.9-6.6 (8H, m), 5.4 (1H, s), 1.47 (9H, s)

#### Synthesis Example 4: Synthesis of Compound 4

[0199]

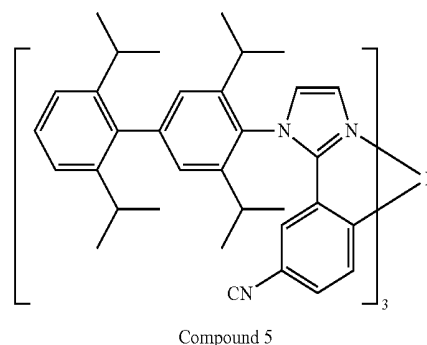
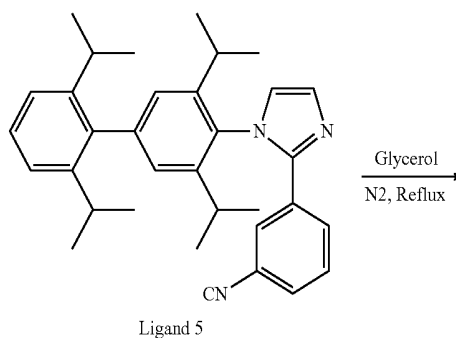


[0200] 0.3 g of Compound 4 (having a purity of 99.03%) was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 4 was used instead of Ligand 1.

[0201] LC-MS (calculated value: 1,237.41 g/mol, measured value:  $M^{+1}=1,238$  g/mol)

#### Synthesis Example 5: Synthesis of Compound 5

[0202]

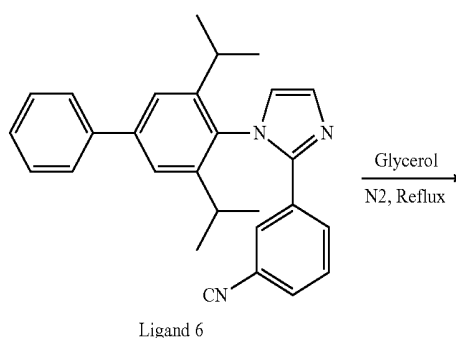


[0203] 0.37 g of Compound 5 (having a purity of 98.3%) was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 5 was used instead of Ligand 1.

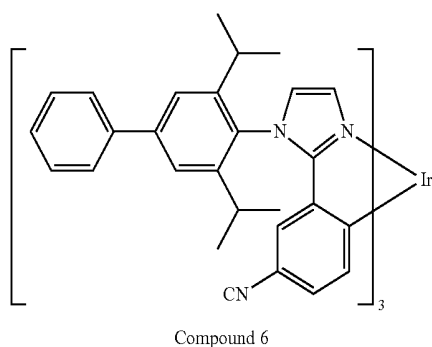
[0204] LC-MS (calculated value: 1,657.88 g/mol, measured value:  $M^{+1}=1,658$  g/mol)

#### Synthesis Example 6: Synthesis of Compound 6

[0205]



-continued

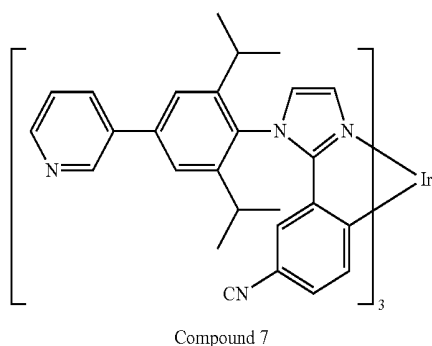
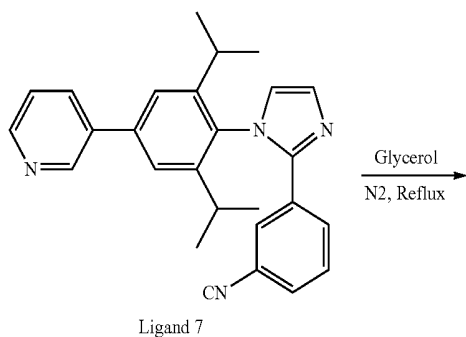


[0206] 0.23 g of Compound 6 (having a purity of 99.2%) was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 6 was used instead of Ligand 1.

[0207] LC-MS (calculated value: 1,405.60 g/mol, measured value:  $M^{+1}=1,406$  g/mol)

#### Synthesis Example 7: Synthesis of Compound 7

[0208]

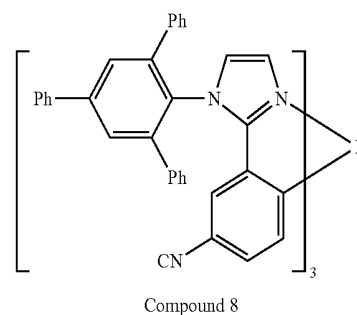
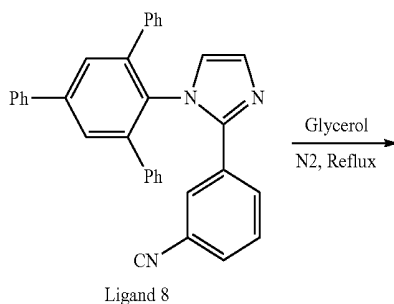


[0209] 0.17 g of Compound 7 (having a purity of 99.7%) was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 7 was used instead of Ligand 1.

[0210] LC-MS (calculated value: 1,408.59 g/mol, measured value:  $M^{+1}=1,409$  g/mol)

#### Synthesis Example 8: Synthesis of Compound 8

[0211]

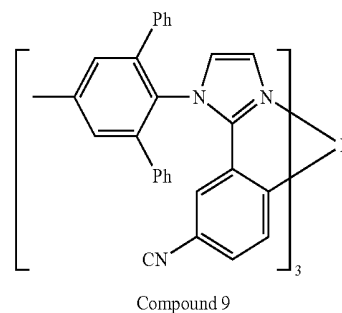
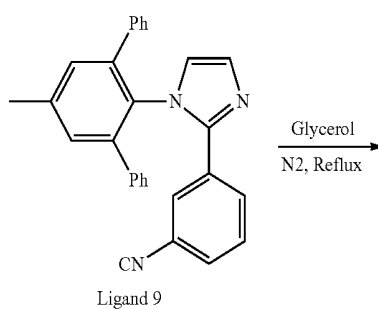


[0212] 0.48 mmol of Compound 8 was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 8 was used instead of Ligand 1. The structure and purity (greater than 99%) of Compound 8 were identified by using NMR, HPLC, and LCMS.

[0213]  $^1\text{H-NMR}$  (300 MHz,  $\text{CD}_2\text{Cl}_2$ )  $\delta$  7.8 (1H, s), 7.7 (2H, d), 7.6-7.5 (2H, m), 7.5-7.4 (1H, m), 7.1-7.0 (3H, t), 7.0-6.9 (5H, m), 6.9-6.8 (4H, m), 6.55 (1H, s), 6.5-6.4 (1H, m), 5.5 (1H, s)

#### Synthesis Example 9: Synthesis of Compound 9

[0214]



[0215] 0.50 mmol of Compound 9 was obtained in substantially the same manner as in Synthesis Example 1, except that Ligand 9 was used instead of Ligand 1. The structure and purity (greater than 99%) of Compound 9 were identified by using NMR, HPLC, and LCMS.

[0216]  $^1\text{H-NMR}$  (300 MHz,  $\text{CD}_2\text{Cl}_2$ )  $\delta$  7.50 (1H, s), 7.45 (1H, s), 7.15-6.88 (3H, m), 6.86-6.84 (3H, m), 6.82-6.72 (5H, m), 6.68 (1H, s), 6.46-6.42 (2H, m), 5.46 (1H, s), 2.59 (3H, s)

#### Evaluation Example 1: Evaluation of Horizontal Orientation Ratio

[0217] In a vacuum deposition device, mCP and Compound 1 were co-deposited at a weight ratio of 92:8 (Compound 1 being 8 percent by weight, wt %) onto a fused silica substrate layer (having a thickness of 1 millimeter (mm)) at a vacuum degree of  $1 \times 10^{-7}$  torr, thereby preparing Sample 1 having a thickness of 30 nanometers (nm). The structure was then sealed by using glass and glue under a nitrogen atmosphere. Substantially the same process was performed using each of Compounds 2 to 9, A to D, and F to thereby prepare Samples 2 to 9, A to D, and F, respectively.

[0218] Here, an angle-dependent PL measuring device having a structure as shown in FIG. 3 of Korean Patent Application No. 2013-0150834 was prepared. The detailed specification of the device is as follows:

[0219] Excited light wavelength: 325 nanometers (nm)

[0220] Excited light source: He—Cd laser available from Melles Griot

[0221] Excited light irradiator: Optical fiber having a diameter of 1 mm available from Thorlabs

[0222] Semicylindrical prism: Fused silica having a diameter of 100 mm and a length of 30 mm

[0223] Emitted light detector: Photomultiplier tube available from Acton

[0224] Polarizer mounted on the emission light detector: Linear polarizer available from Thorlabs

[0225] Recorder: Spectrasense available from Acton

[0226] Excited light incidence angle:  $\theta\text{P}=45^\circ$ ,  $\theta\text{H}=0^\circ$

[0227] Distance from sample to the emitted light detector (or, a radius of moving route of the emitted light detector): 900 mm

[0228] Afterwards, Samples 1 to 9, A to D, and F were fixed on a semicylindrical lens, and irradiated with a 325 nm laser so as to cause light emission from each Sample. Emitted light passed through a polarization film, and then, in order to measure a p-polarized light emission intensity of 530 nm light within a range of 0 to 90 degrees, the semicylindrical lens, on which the sample was fixed, was rotated by 1 degree with respect to an axis of the semicylindrical lens by using a charge-coupled device (CCD).

[0229] The p-polarized light emission intensity (a first p-polarized light emission intensity) in a case where each compound is vertically aligned and the p-polarized light emission intensity (a second p-polarized light emission intensity) in a case where each compound is horizontally aligned were respectively calculated within a range of 0 to 90 degrees. The first p-polarized light emission intensity and the second p-polarized light emission intensity were respectively multiplied by a weight value such that the obtained total p-polarized light emission intensity was identical to the measured p-polarized light emission intensity, thereby obtaining a weight value. Then, the horizontal orientation ratio of each of Compounds 1 to 9, A to D, and F was

measured. The results thereof are shown in Table 1. Here, the angle-dependent light emission spectrum was analyzed by using a classical dipole model in which emission from excitons is regarded as dissipated power from an oscillating dipole.

TABLE 1

Sample No.	Co-deposition material	Horizontal orientation ratio (%)
1	mCP:Compound 1 (8 wt %)	87
2	mCP:Compound 2 (8 wt %)	88
3	mCP:Compound 3 (8 wt %)	90
4	mCP:Compound 4 (8 wt %)	92
5	mCP:Compound 5 (8 wt %)	90
6	mCP:Compound 6 (8 wt %)	90
7	mCP:Compound 7 (8 wt %)	91
8	mCP:Compound 8 (8 wt %)	91
9	mCP:Compound 9 (8 wt %)	91
A	mCP:Compound A (8 wt %)	82
B	mCP:Compound B (8 wt %)	82
C	mCP:Compound C (8 wt %)	83
D	mCP:Compound D (8 wt %)	83
F	mCP:Compound F (8 wt %)	84

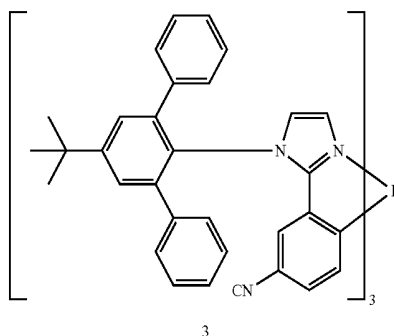
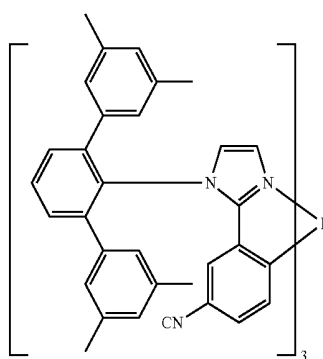
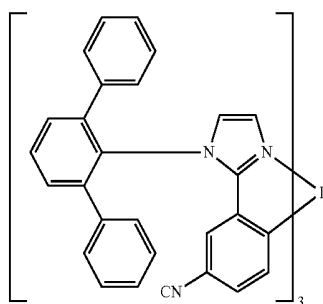


TABLE 1-continued

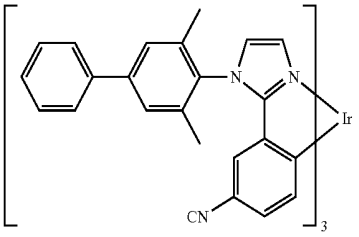
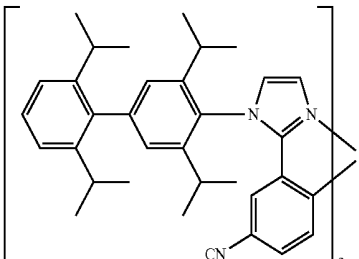
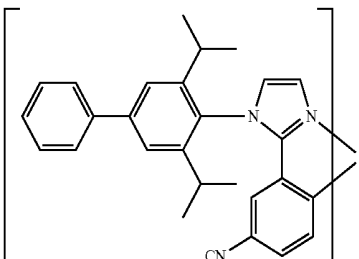
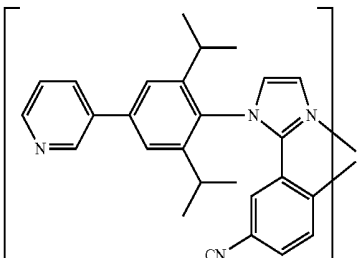
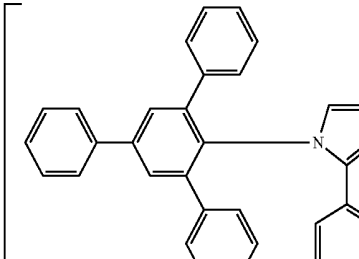
Sample No.	Co-deposition material	Horizontal orientation ratio (%)
4		
5		
6		
7		
8		

TABLE 1-continued

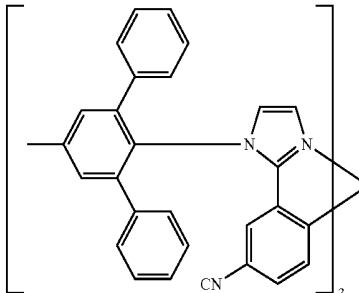
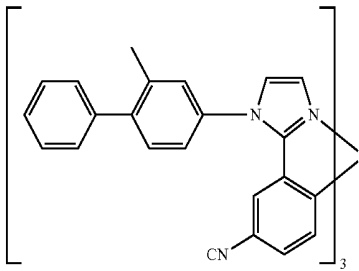
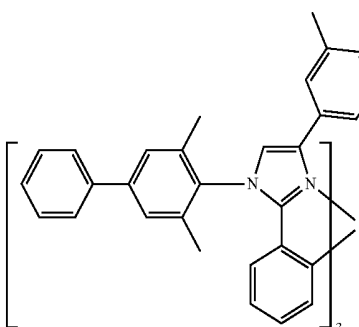
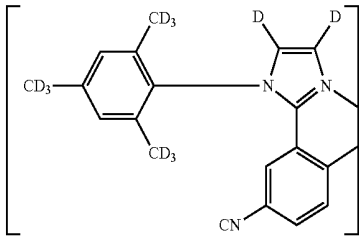
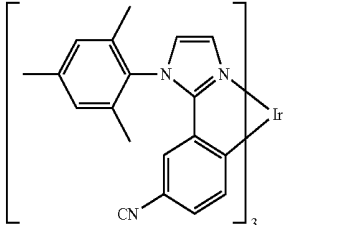
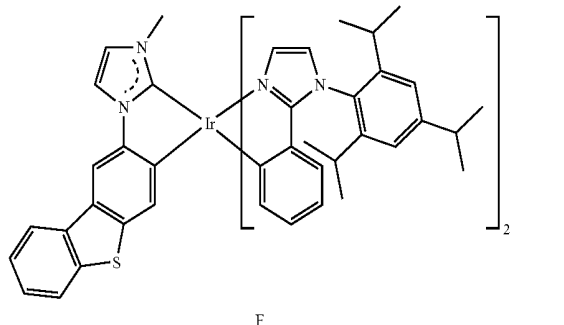
Sample No.	Co-deposition material	Horizontal orientation ratio (%)
9		
A		
B		
C		
D		

TABLE 1-continued

Sample No.	Co-deposition material	Horizontal orientation ratio (%)
		

[0230] As it may be seen in Table 1, Compounds 1 to 9 were found to have excellent horizontal orientation ratios, i.e., optical orientation in a horizontal direction, as compared with Compounds A to D and F.

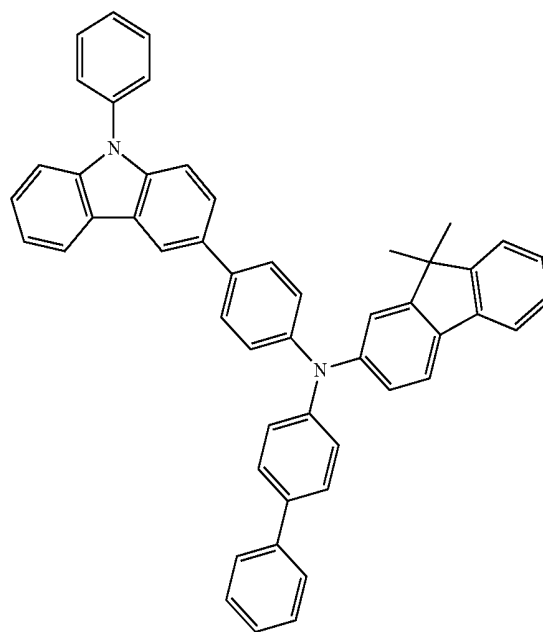
#### Example 1

[0231] A glass substrate having 1,500 Å thickness of indium tin oxide (ITO) electrode (first electrode, anode) deposited thereon was washed with distilled water in the presence of ultrasound waves. Once the washing with distilled water was complete, ultrasound wave washing was performed on the substrate by using iso-propyl alcohol, acetone, and methanol in this stated order. Subsequently, the substrate was dried, transferred to a plasma washer, washed for 5 minutes using oxygen plasma, and mounted in a vacuum deposition device.

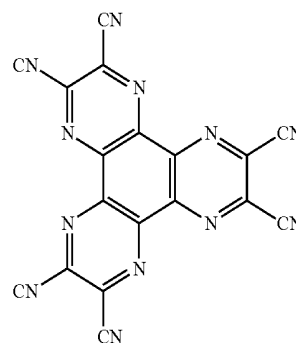
[0232] Compound HT3 was vacuum-deposited on the ITO electrode of the glass substrate to form a first hole injection layer having a thickness of about 3,500 Å, Compound HT-D1 was vacuum-deposited on the first hole injection layer to form a second hole injection layer having a thickness of about 300 Å, and TAPC was vacuum-deposited on the second hole injection layer to form an electron blocking layer having a thickness of about 100 Å, thereby forming a hole transport region.

[0233] mCP (as a host) and Compound 1 (as a dopant, 7 wt %) were co-deposited on the hole transport region to form an emission layer having a thickness of about 300 Å.

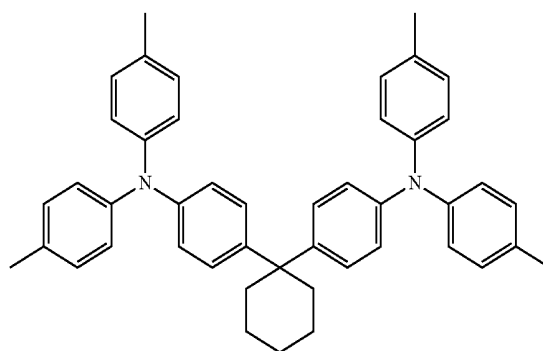
[0234] Compound ET3 was vacuum-deposited on the emission layer to form an electron transport layer having a thickness of about 250 Å, ET-D1 (Liq) was deposited on the electron transport layer to form an electron injection layer having a thickness of about 5 Å, and an Al second electrode (a cathode) was formed on the electron injection layer to have a thickness of about 1,000 Å, thereby completing the manufacture of an organic light-emitting device.



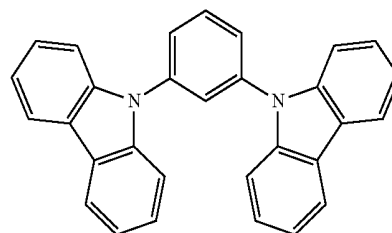
HT3



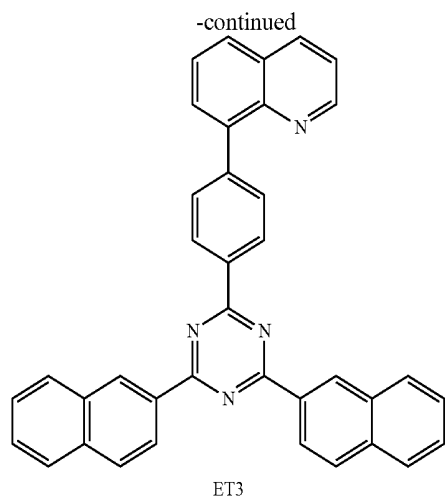
HT-D1



TAPC



mCP



Examples 2 to 9 and Comparative Examples A to F

**[0235]** Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that the compounds shown in Table 2 were used instead of Compound 1 as a dopant in the formation of an emission layer.

#### Evaluation Example 2: Evaluation of Characteristics of Organic Light-Emitting Device

**[0236]** Emission color and maximum external quantum emission efficiency of the organic light-emitting devices manufactured in Examples 1 to 9 and Comparative Examples A to F were measured. The measurement method is as follows. The results thereof are shown in Table 2.

**[0237]** (1) Emission Color

**[0238]** EL spectra of the manufactured organic light-emitting devices at a luminance of about 500 candelas per square meter ( $\text{cd}/\text{m}^2$ ) were measured by using a luminance meter (Minolta Cs-1000A).

**[0239]** (2) Measurement of Maximum External Quantum Efficiency

**[0240]** The maximum external quantum emission efficiency was measured, based on the EL spectra measured in above item (1).

TABLE 2

	Emission layer Host	Dopant	Color	Maximum external quantum emission efficiency (%)
Example 1	mCP	1	Blue	24
Example 2	mCP	2	Blue	24
Example 3	mCP	3	Blue	26
Example 4	mCP	4	Blue	26
Example 5	mCP	5	Blue	28
Example 6	mCP	6	Blue	26
Example 7	mCP	7	Blue	26
Example 8	mCP	8	Blue	26
Example 9	mCP	9	Blue	24
Comparative Example A	mCP	A	Blue	21
Comparative Example B	mCP	B	Blue	20

TABLE 2-continued

	Emission layer Host	Dopant	Color	Maximum external quantum emission efficiency (%)
Comparative Example C	mCP	C	Blue	22
Comparative Example D	mCP	D	Blue	21
Comparative Example E	mCP	E	Blue	22
Comparative Example F	mCP	F	Blue	21

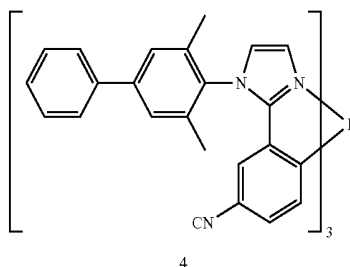
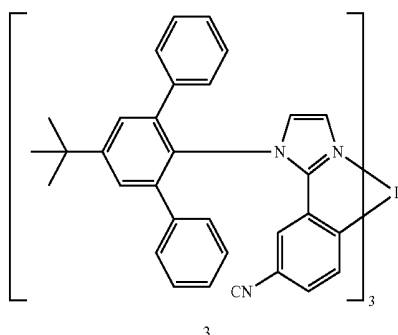
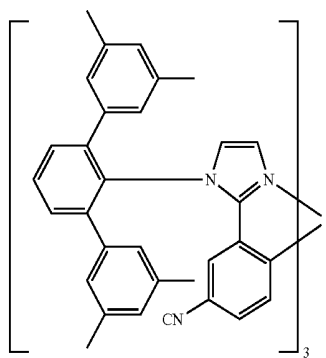
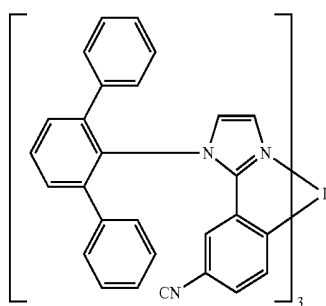


TABLE 2-continued

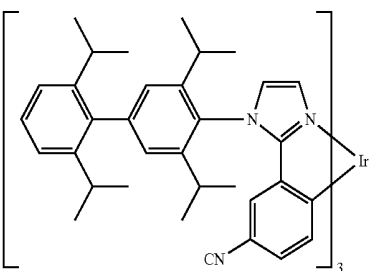
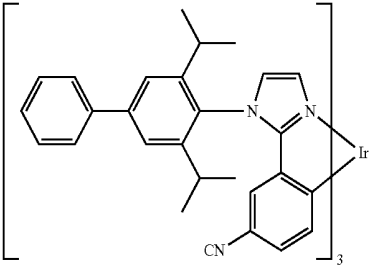
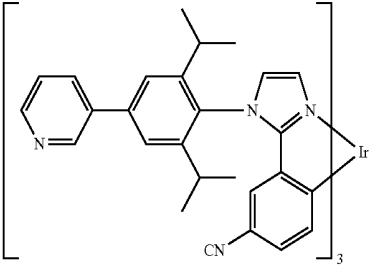
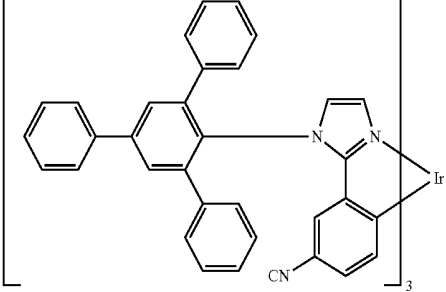
Emission layer Host	Dopant	Color	Maximum external quantum emission efficiency (%)
			
5			
			
6			
			
7			
			
8			

TABLE 2-continued

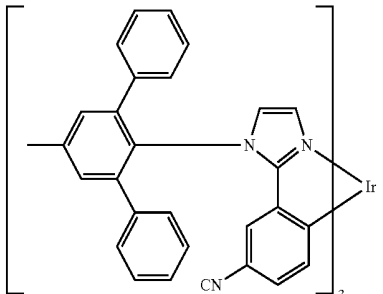
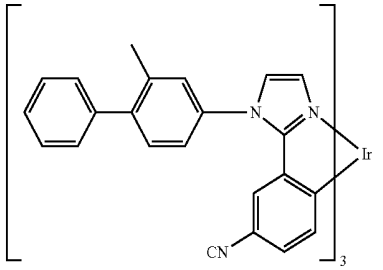
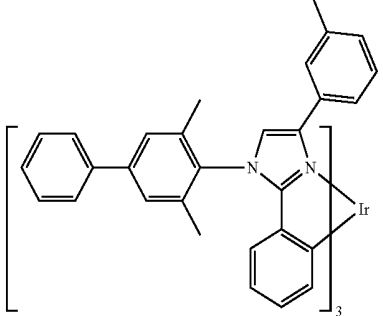
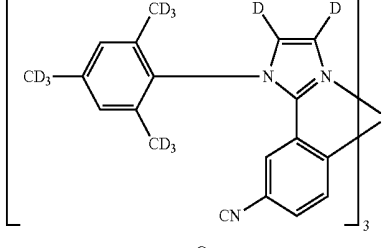
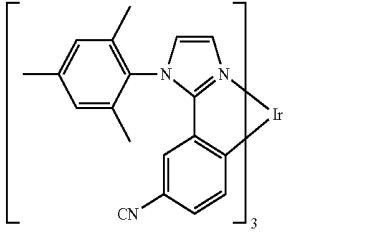
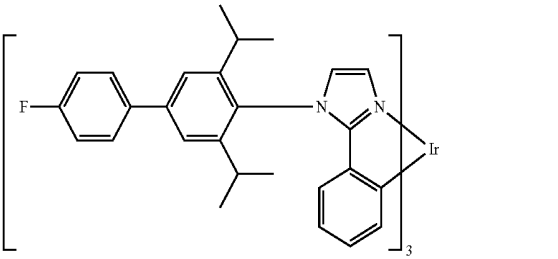
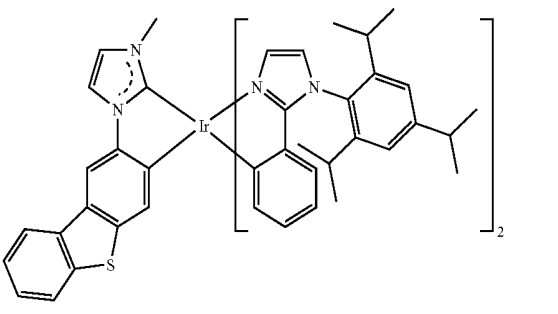
Emission layer Host	Dopant	Color	Maximum external quantum emission efficiency (%)
			
9			
			
A			
			
B			
			
C			
			
D			

TABLE 2-continued

Emission layer Host	Dopant	Color	Maximum external quantum emission efficiency (%)
			
			

[0241] Referring to the results of Table 2, it was found that the organic light-emitting devices of Examples 1 to 9 emit blue light, and have improved maximum external quantum emission efficiency, as compared with the organic light-emitting devices manufactured in Comparative Examples A to F.

[0242] As apparent from the foregoing description, since the organometallic compound is a homoleptic complex having an anisotropic structure with an excellent optical orientation, the organometallic compound, which may be easily synthesized, may have excellent electrical characteristics and optical properties as well. Accordingly, an organic light-emitting device including the organometallic compound may have excellent driving voltage, current density, efficiency, electric power, color purity, and/or lifespan characteristics, with a relatively low production cost.

[0243] 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.

[0244] 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, wherein the organometallic compound has a horizontal orientation ratio of a transition dipole moment in a range of about 85 percent to about 100 percent:



Formula 1

wherein, in Formula 1,

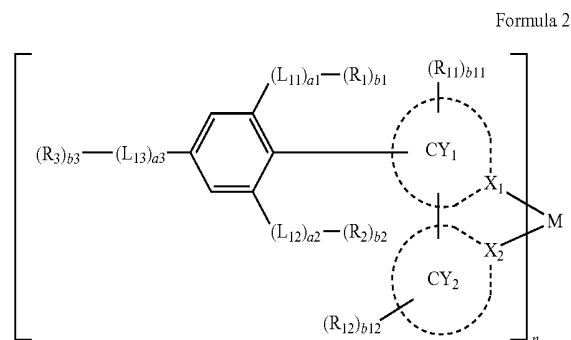
M is selected from a first-row transition metal of the Periodic Table of Elements, a second-row transition metal of the Periodic Table of Elements, and a third-row transition metal of the Periodic Table of Elements, n is 2 or 3,

$L_1$  is a bidentate organic ligand bound to M, wherein  $L_1$  does not comprise a fluoro group (—F), and wherein  $L_1$  groups in the number of n are identical to each other.

2. The organometallic compound of claim 1, wherein the horizontal orientation ratio of a transition dipole moment is in a range of about 92 percent to about 100 percent.

3. The organometallic compound of claim 1, wherein M is iridium or osmium, and n is 3; or M is platinum or palladium, and n is 2.

4. The organometallic compound of claim 1, represented by Formula 2:



wherein, in Formula 2,

M is selected from a first-row transition metal of the Periodic Table of Elements, a second-row transition metal of the Periodic Table of Elements, and a third-row transition metal of the Periodic Table of Elements, n is 2 or 3,

$X_1$  and  $X_2$  are each independently C or N,

$X_1$  is bound to M via a covalent bond, and  $X_2$  is bound to M via a coordinate bond; or  $X_1$  is bound to M via a coordinate bond, and  $X_2$  is bound to M via a covalent bond,

$CY_1$  and  $CY_2$  are each independently selected from a  $C_5$ - $C_{30}$  carbocyclic group and a  $C_1$ - $C_{30}$  heterocyclic group,

$L_{11}$  to  $L_{13}$  are each independently selected from a substituted or unsubstituted  $C_5$ - $C_{30}$  carbocyclic group and a substituted or unsubstituted  $C_1$ - $C_{30}$  heterocyclic group,  $a_1$  to  $a_3$  are each independently an integer from 0 to 5, when  $a_1$  is 0,  $*(L_{11})_{a_1}-*$  is a single bond; when  $a_1$  is two or greater, at least two  $L_{11}$  groups are identical to or different from each other; when  $a_2$  is 0,  $*(L_{12})_{a_2}-*$  is a single bond; when  $a_2$  is two or greater, at least two  $L_{12}$  groups are identical to or different from each other; when  $a_3$  is 0,  $*(L_{13})_{a_3}-*$  is a single bond; when  $a_3$  is two or greater, at least two  $L_{13}$  groups are identical to or different from each other,

a sum of  $a_1$ ,  $a_2$ , and  $a_3$  is 1 or greater,

$R_1$  to  $R_3$  are each independently selected from hydrogen, deuterium, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), —B(Q<sub>6</sub>)(Q<sub>7</sub>), and —P(=O)(Q<sub>8</sub>)(Q<sub>9</sub>),
- b1 to b3 are each independently an integer from 0 to 5, R<sub>11</sub> and R<sub>12</sub> are each independently selected from hydrogen, deuterium, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group; and
- a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group,
- b11 and b12 are each independently an integer from 0 to 10,
- the organometallic compound represented by Formula 2 does not comprise a fluoro group (—F), and
- at least one substituent of the substituted C<sub>1</sub>-C<sub>60</sub> alkyl group, substituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, substituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, substituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, substituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, substituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, substituted C<sub>6</sub>-C<sub>60</sub> aryl group, substituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, substituted C<sub>6</sub>-C<sub>60</sub> arylthio group, substituted C<sub>7</sub>-C<sub>60</sub> arylalkyl group, substituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, substituted C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, substituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, substituted C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, substituted monovalent non-aromatic condensed polycyclic group, and substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:
- deuterium, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group;
- a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one selected from deuterium, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, 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<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>11</sub>)(Q<sub>12</sub>), —Si(Q<sub>13</sub>)(Q<sub>14</sub>)(Q<sub>15</sub>), —B(Q<sub>16</sub>)(Q<sub>17</sub>), and —P(=O)(Q<sub>18</sub>)(Q<sub>19</sub>);
- a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;
- a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl 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, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>21</sub>)(Q<sub>22</sub>), —Si(Q<sub>23</sub>)(Q<sub>24</sub>)(Q<sub>25</sub>), —B(Q<sub>26</sub>)(Q<sub>27</sub>), and —P(=O)(Q<sub>28</sub>)(Q<sub>29</sub>); and
- N(Q<sub>31</sub>)(Q<sub>32</sub>), —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), —B(Q<sub>36</sub>)(Q<sub>37</sub>), and —P(=O)(Q<sub>38</sub>)(Q<sub>39</sub>),
- wherein Q<sub>1</sub> to Q<sub>9</sub>, Q<sub>11</sub> to Q<sub>19</sub>, Q<sub>21</sub> to Q<sub>29</sub>, and Q<sub>31</sub> to Q<sub>39</sub> are each independently selected from hydrogen, deuterium, 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<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryl group substituted with at least one selected from a C<sub>1</sub>-C<sub>60</sub> alkyl group and a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>7</sub>-C<sub>60</sub> arylalkyl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

5. The organometallic compound of claim 4, wherein X<sub>1</sub> is N, and X<sub>2</sub> is C.

6. The organometallic compound of claim 4, wherein X<sub>1</sub> is bound to M via a coordinate bond, and X<sub>2</sub> is bound to M via a covalent bond.

7. The organometallic compound of claim 4, wherein CY<sub>1</sub> and CY<sub>2</sub> are each independently selected from i) a 5-membered ring, ii) a 6-membered ring, iii) a condensed ring in which two or more 6-membered rings are condensed, and iv) a condensed ring in which at least one 6-membered ring and at least one 5-membered ring are condensed,

the 5-membered ring is selected from a cyclopentadiene group, a furan group, a thiophene group, a pyrrole group, a silole group, an oxazole group, an isoxazole group, an oxadiazole group, an isoxadiazole group, an oxatriazole group, a thiazole group, an isothiazole group, a thiadiazole group, an isothiadiazo group, a thiatriazole group, a pyrazole group, an imidazole group, a triazole group, a tetrazole group, an azasilole group, a diazasilole group, and a triazasilole group, and the 6-membered ring is selected from a cyclohexane group, a cyclohexene group, a benzene group, a pyridine group, a pyrimidine group, a pyrazine group, and a pyridazine group.

8. The organometallic compound of claim 4, wherein L<sub>11</sub> to L<sub>13</sub> are each independently selected from

a cyclopentadiene group, a cyclohexane group, a cyclohexene group, a benzene group, a naphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a furan group, a thiophene group, a silole group, an indene group, a fluorene group, an indole group, a carbazole group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, a dibenzosilole group, an azafluorene group, an azacarbazole group, an azadibenzofuran group, an azadibenzothiophene group, an azadibenzosilole 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 triazole 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 benzoxazole group, a benzothiazole group, a benzoxadiazole group, and a benzothiadiazo group, each unsubstituted or substituted with at least one selected from deuterium, —F, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, —CF<sub>3</sub>, —CF<sub>2</sub>H, —CFH<sub>2</sub>, a cyano group, a nitro group, a C<sub>1</sub>-C<sub>10</sub> alkyl group, a C<sub>1</sub>-C<sub>10</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl

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 dibenzofuran group, and a dibenzothiophenyl group.

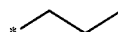
9. The organometallic compound of claim 4, wherein i) a1 and a2 are each independently 1 or 2, and a3 is 0; ii) a1 and a2 are each 0, and a3 is 1, 2, or 3; or iii) a1 to a3 are each 1.

10. The organometallic compound of claim 4, wherein R<sub>1</sub> to R<sub>3</sub>, R<sub>11</sub>, and R<sub>12</sub> are each independently selected from hydrogen, deuterium, a cyano group, a C<sub>1</sub>-C<sub>10</sub> alkyl group, and a C<sub>1</sub>-C<sub>10</sub> alkoxy group; and a C<sub>1</sub>-C<sub>10</sub> alkyl group and a C<sub>1</sub>-C<sub>10</sub> alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a C<sub>1</sub>-C<sub>10</sub> alkyl group, and a C<sub>1</sub>-C<sub>10</sub> alkoxy group.

11. The organometallic compound of claim 4, wherein R<sub>1</sub> to R<sub>3</sub>, R<sub>11</sub>, and R<sub>12</sub> are each independently selected from hydrogen, deuterium, a cyano group, —CH<sub>3</sub>, —CD<sub>3</sub>, —CD<sub>2</sub>H, —CDH<sub>2</sub>, —CH<sub>2</sub>CD<sub>2</sub>H, —CH<sub>2</sub>CDH<sub>2</sub>, —CHDCH<sub>3</sub>, —CHDCH<sub>2</sub>H, —CHDCHD<sub>2</sub>H, —CHDCHD<sub>3</sub>, —CD<sub>2</sub>CD<sub>3</sub>, —CD<sub>2</sub>CH<sub>3</sub>, —CD<sub>2</sub>CD<sub>2</sub>H, —CD<sub>2</sub>CDH<sub>2</sub>, groups represented by Formulae 9-1 to 9-24, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, and a pentoxy group:



Formula 9-1



Formula 9-2



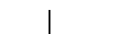
Formula 9-3



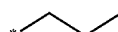
Formula 9-4



Formula 9-5



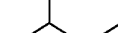
Formula 9-6



Formula 9-7



Formula 9-8



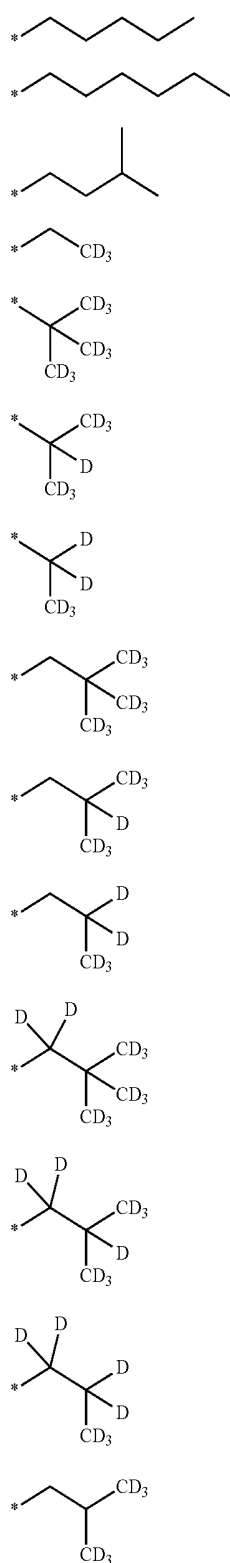
Formula 9-9



Formula 9-10



-continued



wherein, in Formulae 9-1 to 9-24, \* indicates a binding site to an adjacent atom.

12. The organometallic compound of claim 4, wherein, in Formula 2,  $*(L_{11})_{a1}-(R_1)_{b1}$ ,  $*(L_{12})_{a2}-(R_2)_{b2}$ , and  $*(L_{13})_{a3}-(R_3)_{b3}$  are each independently selected from:

Formula 9-11

Formula 9-12

Formula 9-13

Formula 9-14

Formula 9-15

Formula 9-16

Formula 9-17

Formula 9-18

Formula 9-19

Formula 9-20

Formula 9-21

Formula 9-22

Formula 9-23

Formula 9-24

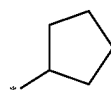
hydrogen, deuterium, a cyano group, a  $C_1$ - $C_{10}$  alkyl group, and a  $C_1$ - $C_{10}$  alkoxy group;

a  $C_1$ - $C_{10}$  alkyl group and a  $C_1$ - $C_{10}$  alkoxy group, each substituted with at least one selected from deuterium, a cyano group, a  $C_1$ - $C_{10}$  alkyl group, and a  $C_1$ - $C_{10}$  alkoxy group; and

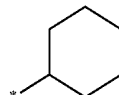
groups represented by Formulae 10-1 to 10-154, wherein

at least one selected from  $*(L_{11})_{a1}-(R_1)_{b1}$ ,  $*(L_{12})_{a2}-(R_2)_{b2}$ , and  $*(L_{13})_{a3}-(R_3)_{b3}$  is independently selected from groups represented by Formulae 10-1 to 10-4, 10-9, 10-10 and 10-13 to 10-154:

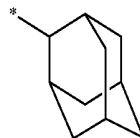
Formula 10-1



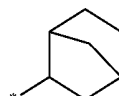
Formula 10-2



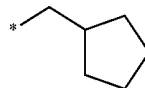
Formula 10-3



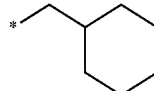
Formula 10-4



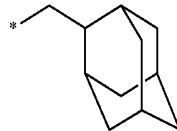
Formula 10-5



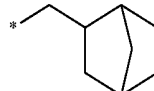
Formula 10-6



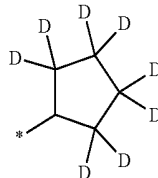
Formula 10-7



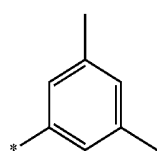
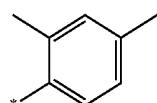
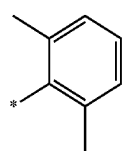
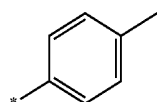
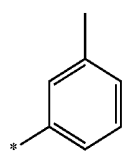
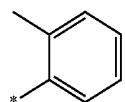
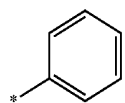
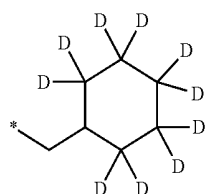
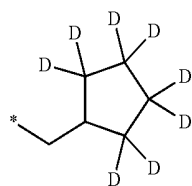
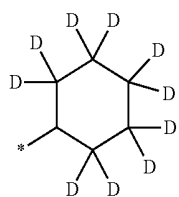
Formula 10-8



Formula 10-9

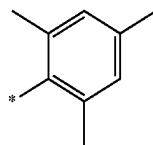


-continued

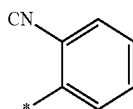


-continued

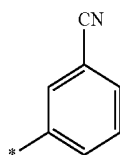
Formula 10-10



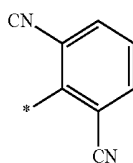
Formula 10-11



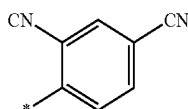
Formula 10-12



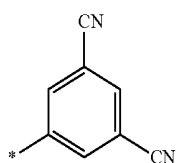
Formula 10-13



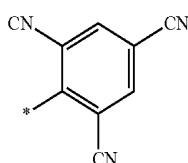
Formula 10-14



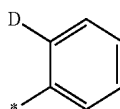
Formula 10-15



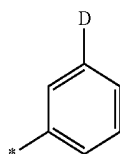
Formula 10-16



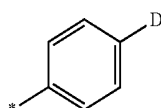
Formula 10-17



Formula 10-18



Formula 10-19



Formula 10-20

Formula 10-21

Formula 10-22

Formula 10-23

Formula 10-24

Formula 10-25

Formula 10-26

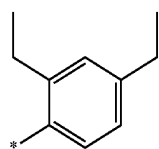
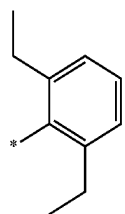
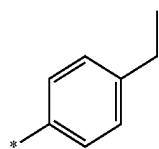
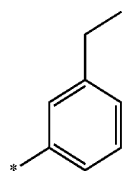
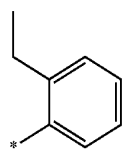
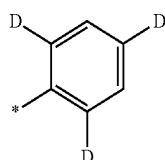
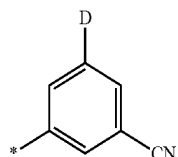
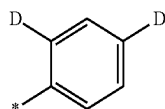
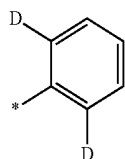
Formula 10-27

Formula 10-28

Formula 10-29

Formula 10-30

-continued



Formula 10-31

Formula 10-32

Formula 10-33

Formula 10-34

Formula 10-35

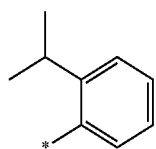
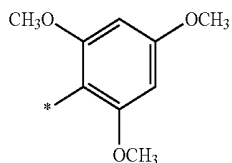
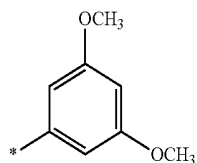
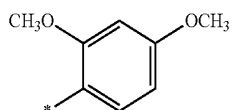
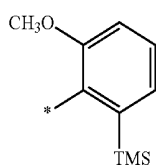
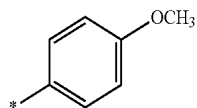
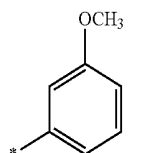
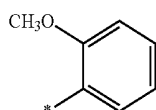
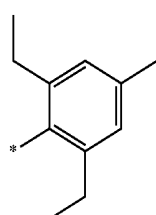
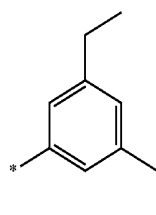
Formula 10-36

Formula 10-37

Formula 10-38

Formula 10-39

-continued



Formula 10-40

Formula 10-41

Formula 10-42

Formula 10-43

Formula 10-44

Formula 10-45

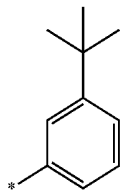
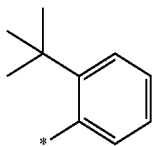
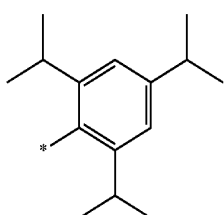
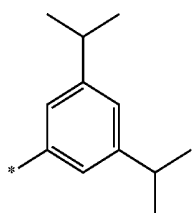
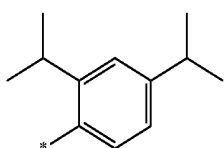
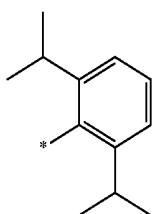
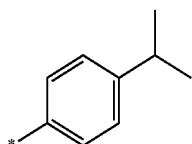
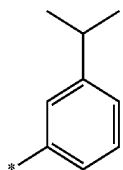
Formula 10-46

Formula 10-47

Formula 10-48

Formula 10-49

-continued



Formula 10-50

Formula 10-51

Formula 10-52

Formula 10-53

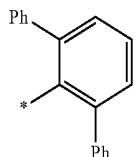
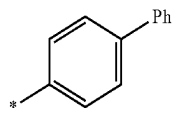
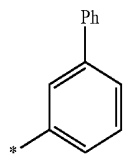
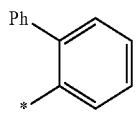
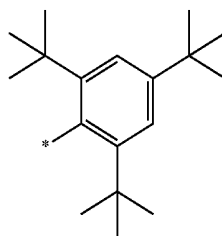
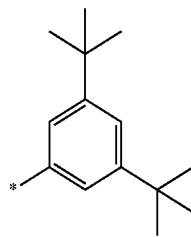
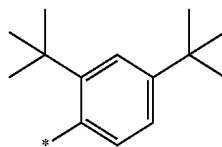
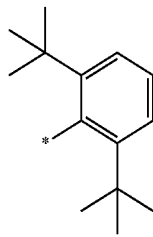
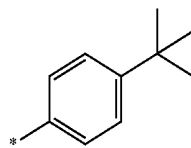
Formula 10-54

Formula 10-55

Formula 10-56

Formula 10-57

-continued



Formula 10-58

Formula 10-59

Formula 10-60

Formula 10-61

Formula 10-62

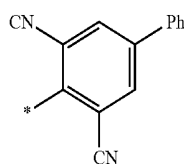
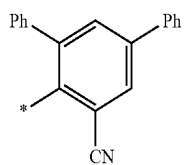
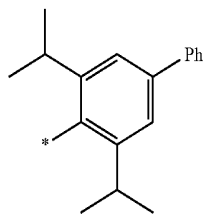
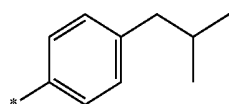
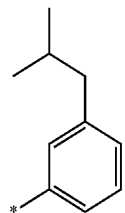
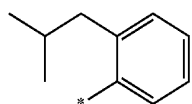
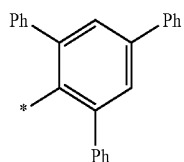
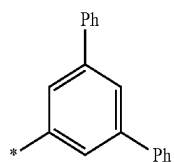
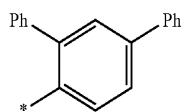
Formula 10-63

Formula 10-64

Formula 10-65

Formula 10-66

-continued



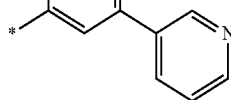
-continued

Formula 10-67



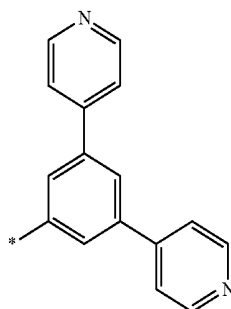
Formula 10-76

Formula 10-68



Formula 10-77

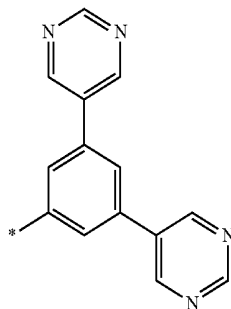
Formula 10-69



Formula 10-78

Formula 10-70

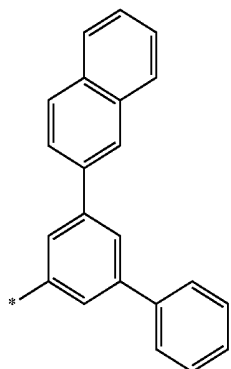
Formula 10-71



Formula 10-79

Formula 10-72

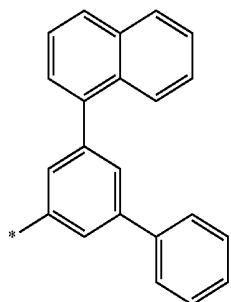
Formula 10-73



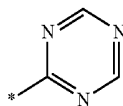
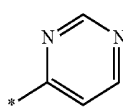
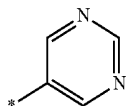
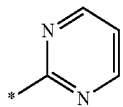
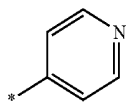
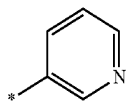
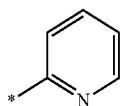
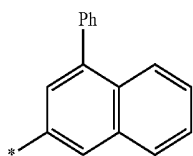
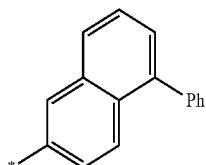
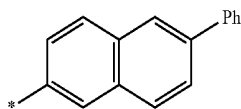
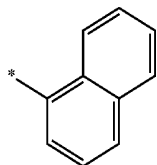
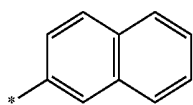
Formula 10-80

Formula 10-74

Formula 10-75



-continued



Formula 10-81

Formula 10-82

Formula 10-83

Formula 10-84

Formula 10-85

Formula 10-86

Formula 10-87

Formula 10-88

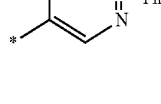
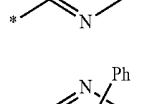
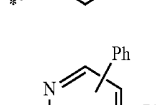
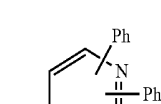
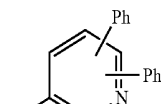
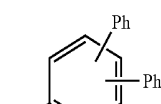
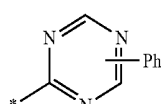
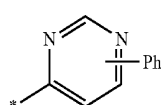
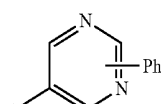
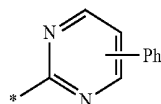
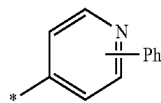
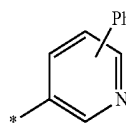
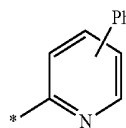
Formula 10-89

Formula 10-90

Formula 10-91

Formula 10-92

-continued



Formula 10-93

Formula 10-94

Formula 10-95

Formula 10-96

Formula 10-97

Formula 10-98

Formula 10-99

Formula 10-100

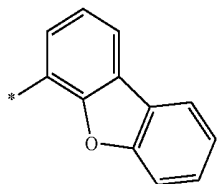
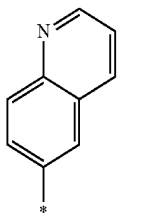
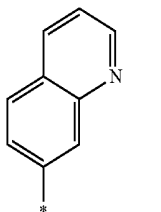
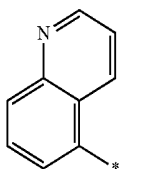
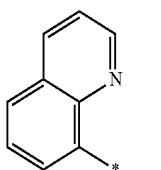
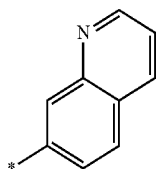
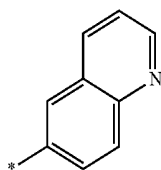
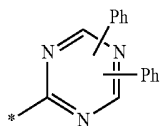
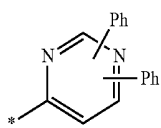
Formula 10-101

Formula 10-102

Formula 10-103

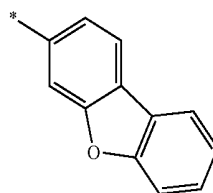
Formula 10-104

-continued



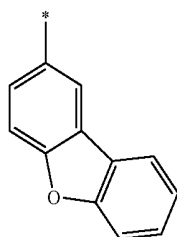
-continued

Formula 10-105



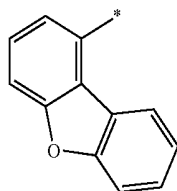
Formula 10-106

Formula 10-107

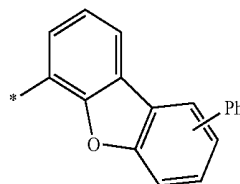


Formula 10-108

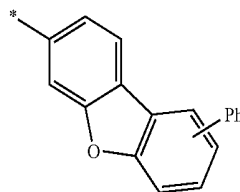
Formula 10-109



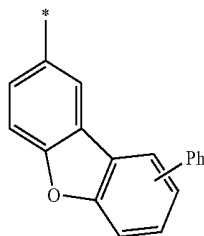
Formula 10-110



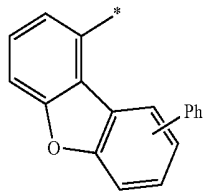
Formula 10-111



Formula 10-112



Formula 10-113



Formula 10-114

Formula 10-115

Formula 10-116

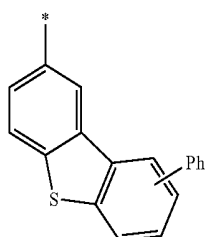
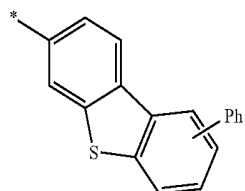
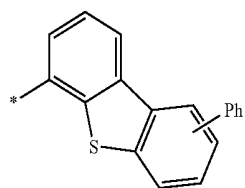
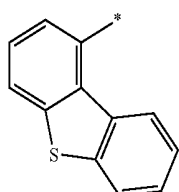
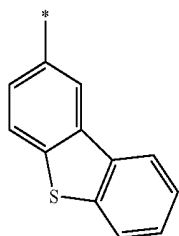
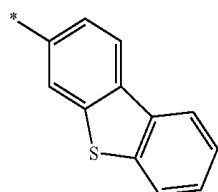
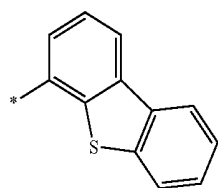
Formula 10-117

Formula 10-118

Formula 10-119

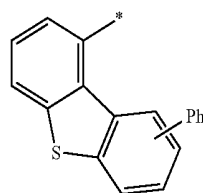
Formula 10-120

-continued

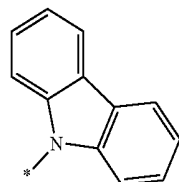


-continued

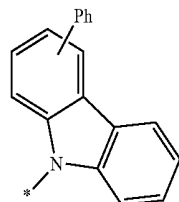
Formula 10-121



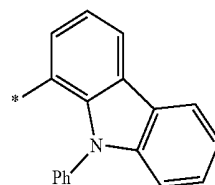
Formula 10-122



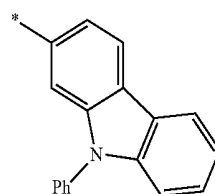
Formula 10-123



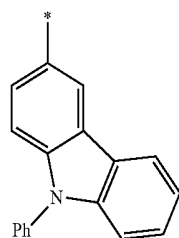
Formula 10-124



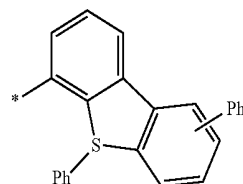
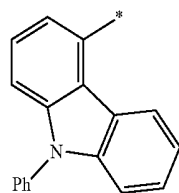
Formula 10-125



Formula 10-126



Formula 10-127



Formula 10-128

Formula 10-129

Formula 10-130

Formula 10-131

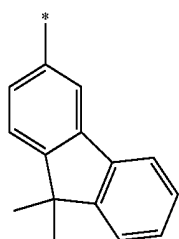
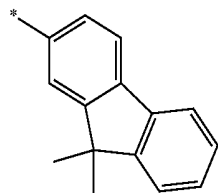
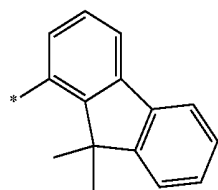
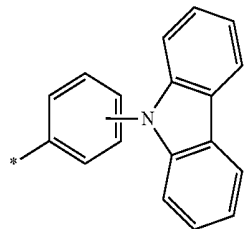
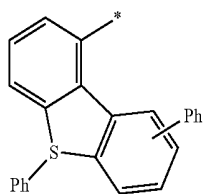
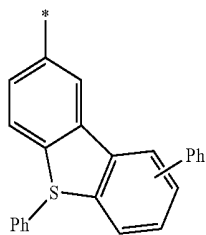
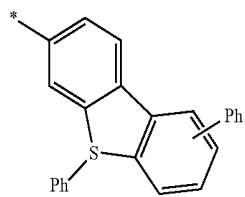
Formula 10-132

Formula 10-133

Formula 10-134

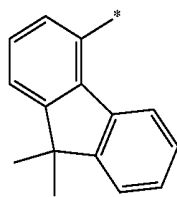
Formula 10-135

-continued

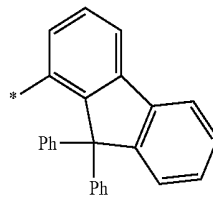


-continued

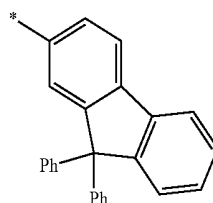
Formula 10-136



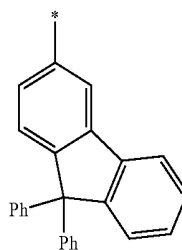
Formula 10-137



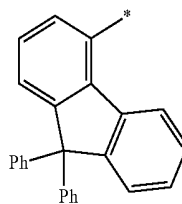
Formula 10-138



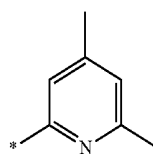
Formula 10-139



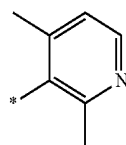
Formula 10-140



Formula 10-141



Formula 10-142



Formula 10-143

Formula 10-144

Formula 10-145

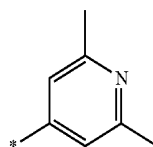
Formula 10-146

Formula 10-147

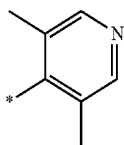
Formula 10-148

Formula 10-149

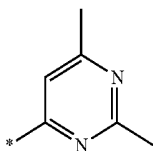
Formula 10-150



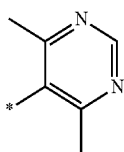
-continued



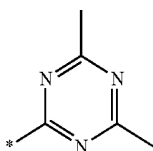
Formula 10-151



Formula 10-152



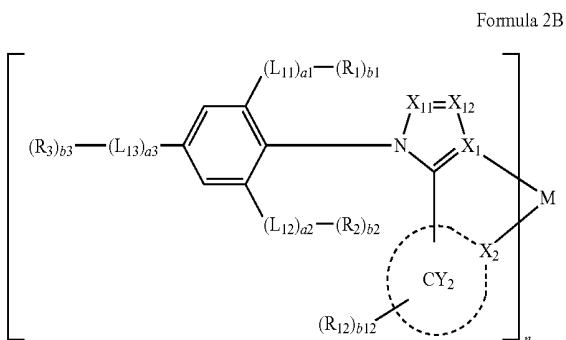
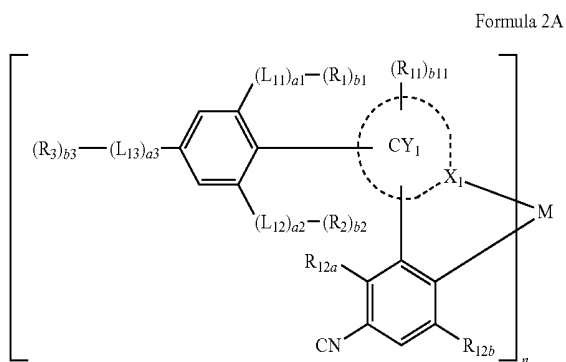
Formula 10-153



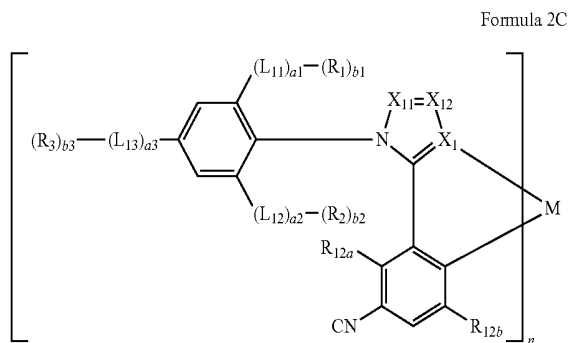
Formula 10-154

wherein, in Formulae 10-1 to 10-154, Ph represents a phenyl group, and \* indicates a binding site to an adjacent atom.

13. The organometallic compound of claim 4, represented by one of Formulae 2A to 2C:



-continued



wherein, in Formulae 2 A to 2C,

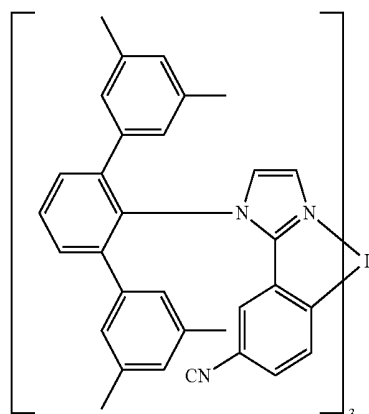
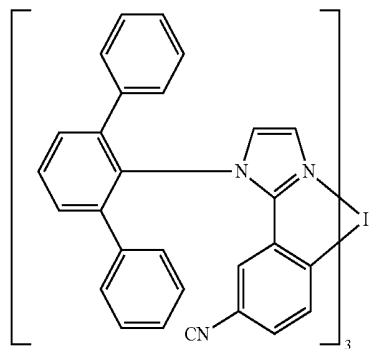
M, n, X<sub>1</sub>, X<sub>2</sub>, CY<sub>1</sub>, CY<sub>2</sub>, L<sub>11</sub> to L<sub>13</sub>, a<sub>1</sub> to a<sub>3</sub>, R<sub>1</sub> to R<sub>3</sub>, b<sub>1</sub> to b<sub>3</sub>, R<sub>11</sub>, R<sub>12</sub>, b<sub>11</sub>, and b<sub>12</sub> are the same as those defined in claim 4.

X<sub>11</sub> is N or C(R<sub>11a</sub>), X<sub>12</sub> is N or C(R<sub>11b</sub>),

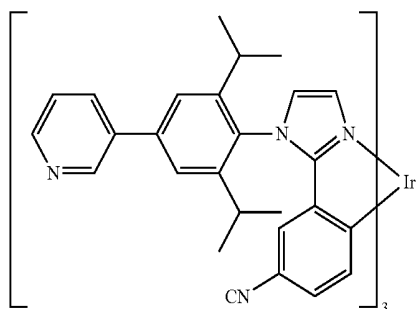
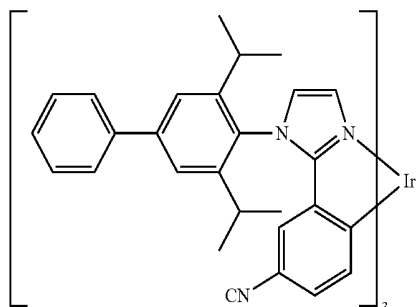
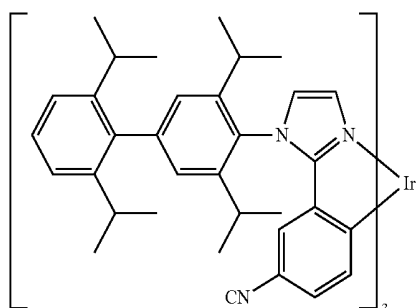
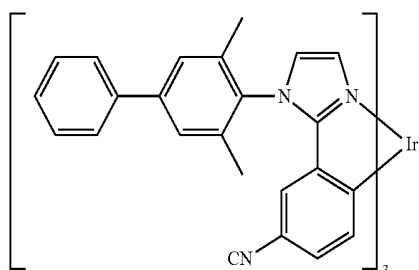
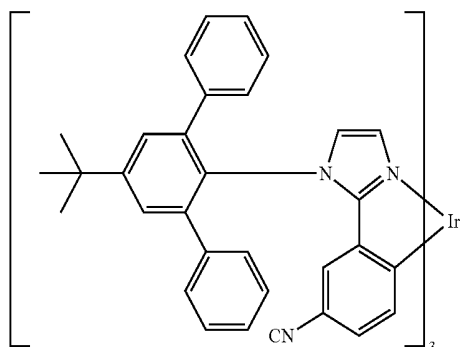
R<sub>11a</sub> and R<sub>11b</sub> are each the same as R<sub>11</sub> as defined in claim 4, and

R<sub>12a</sub> and R<sub>12b</sub> are each the same as R<sub>12</sub> as defined in claim 4.

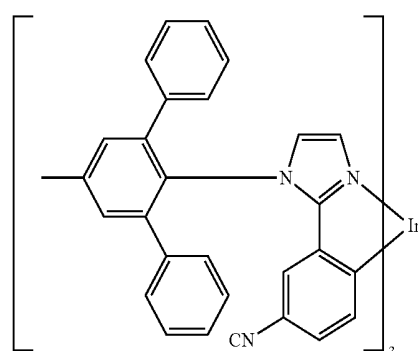
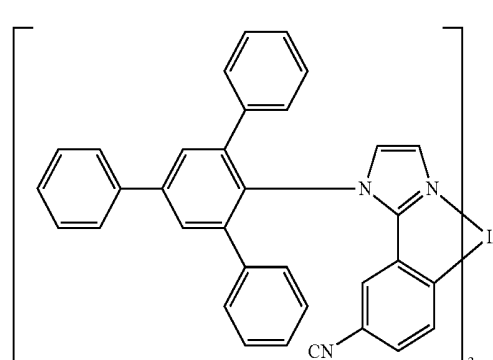
14. The organometallic compound of claim 1, selected from Compounds 1 to 9:



-continued



-continued



**15.** An organic light-emitting device comprising:

a first electrode;

a second electrode; and

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

wherein the organic layer comprises an emission layer and at least one organometallic compound of claim 1.

**16.** The organic light-emitting device of claim 15, wherein the emission layer comprises the organometallic compound.

**17.** The organic light-emitting device of claim 16, wherein a horizontal orientation ratio of a transition dipole moment of the organometallic compound with respect to a plane of the emission layer is in a range of about 85 percent to about 100 percent.

**18.** The organic light-emitting device of claim 16, wherein the emission layer further comprises a host.

**19.** The organic light-emitting device of claim 18, wherein the host comprises at least one of compounds comprising at least one selected from a carbazole group, a fluorene group, a spirobifluorene group, a dibenzofuran group, a dibenzothiophene group, a dibenzosilole group, an indenocarbazole group, an indolocarbazole group, a benzofurocarbazole group, a benzothienocarbazole group, an acridine group, a dihydroacridine group, a triindolobenzene group, an azadibenzothiophene group, an azacarbazole group, an azafluorene group, an azadibenzosilole 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 phenazine group, a cinnoline group, a cyano group, a phosphine oxide group, and a sulfoxide group.

**20.** The organic light-emitting device of claim **18**, wherein the host comprises a hole transport host and an electron transport host.

\* \* \* \* \*

专利名称(译)	有机金属化合物和有机发光器件相同		
公开(公告)号	<a href="#">US20190051832A1</a>	公开(公告)日	2019-02-14
申请号	US16/059503	申请日	2018-08-09
[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.		
[标]发明人	KIM JONGSOO SON WONJOON JEONG DAUN KIM SUNGHAN KIM JOONGHYUK SON YOUNGMOK SIM MYUNGSUN LEE NAMHEON IHN SOOGHANG		
发明人	KIM, JONGSOO SON, WONJOON JEONG, DAUN KIM, SUNGHAN KIM, JOONGHYUK SON, YOUNGMOK SIM, MYUNGSUN LEE, NAMHEON IHN, SOOGHANG		
IPC分类号	H01L51/00 H01L51/52 H01L51/50		
CPC分类号	H01L51/0052 H01L51/5212 H01L51/5221 H01L51/0079 H01L51/5056 C07F15/0033 H01L51/0085 H01L51/5016		
优先权	1020170101342 2017-08-09 KR		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

#### 摘要(译)

由式1表示的有机金属化合物，其中有机金属化合物的过渡偶极矩的水平取向比在约85%至约100%的范围内： $M(L_1)_n$   
 20032003公式1 其中，在式1中，M选自元素周期表的第一行过渡金属，周期表的第二行过渡金属。元素和元素周期表的第三行过渡金属，n为2或3，L<sub>1</sub>是与M结合的二齿有机配体，其中L<sub>1</sub>不包含氟基团(-F)，并且其中n个数目的L<sub>1</sub>基团彼此相同。

