



US 20180301640A9

(19) **United States**
(12) **Patent Application Publication**
RAI et al.

(10) **Pub. No.: US 2018/0301640 A9**
(48) **Pub. Date: Oct. 18, 2018**
CORRECTED PUBLICATION

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

(30) **Foreign Application Priority Data**

Jun. 23, 2014 (KR) 10-2014-0076634

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Publication Classification

(51) **Int. Cl.**
H01L 51/00 (2006.01)
C07F 15/00 (2006.01)
C09K 11/06 (2006.01)
C09K 11/02 (2006.01)

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(52) **U.S. Cl.**
CPC **H01L 51/0085** (2013.01); **C07F 15/0033**
(2013.01); **C09K 11/06** (2013.01); **C09K**
11/025 (2013.01); **H01L 51/5012** (2013.01);
C09K 2211/1059 (2013.01); **C09K 2211/1007**
(2013.01); **C09K 2211/1044** (2013.01); **C09K**
2211/185 (2013.01)

(21) Appl. No.: **14/747,051**

(22) Filed: **Jun. 23, 2015**

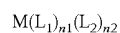
Prior Publication Data

(15) Correction of US 2016/0380214 A1 Dec. 29, 2016
See (30) Foreign Application Priority Data.

(65) US 2016/0380214 A1 Dec. 29, 2016

(57) **ABSTRACT**

An organometallic compound represented by Formula 1:



Formula 1

wherein in Formula 1, M, L_1 , L_2 , n_1 , and n_2 are the same
as described in the specification.

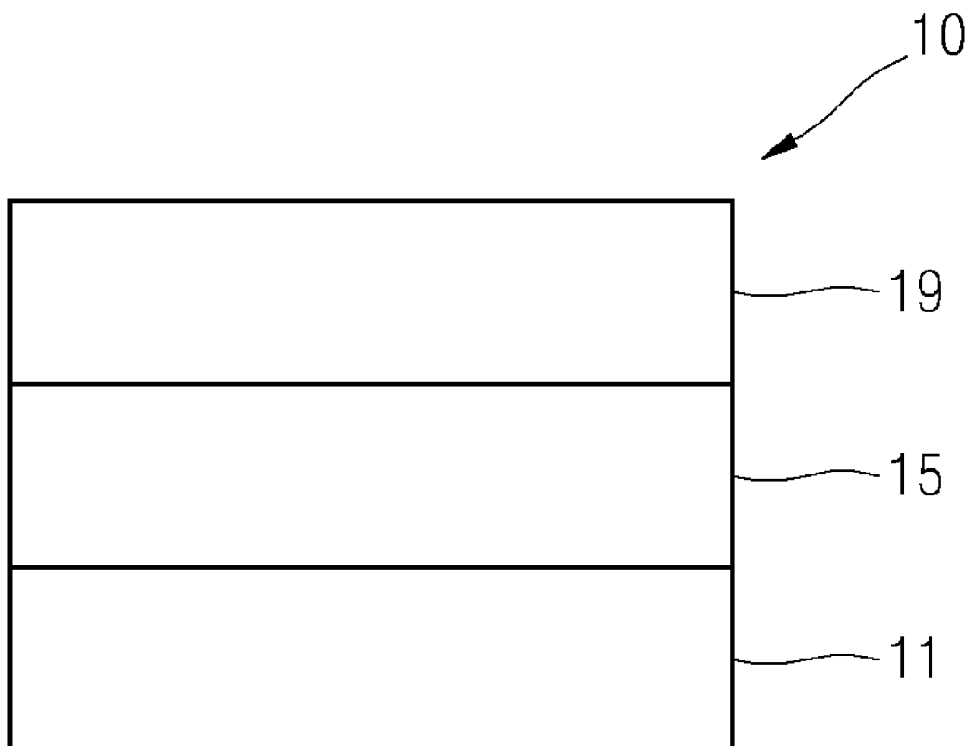


FIG. 1

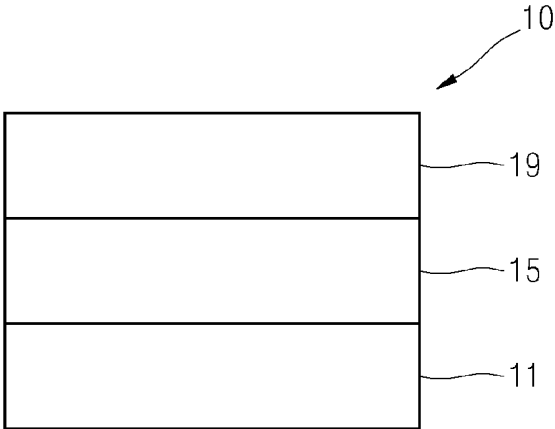


FIG. 2

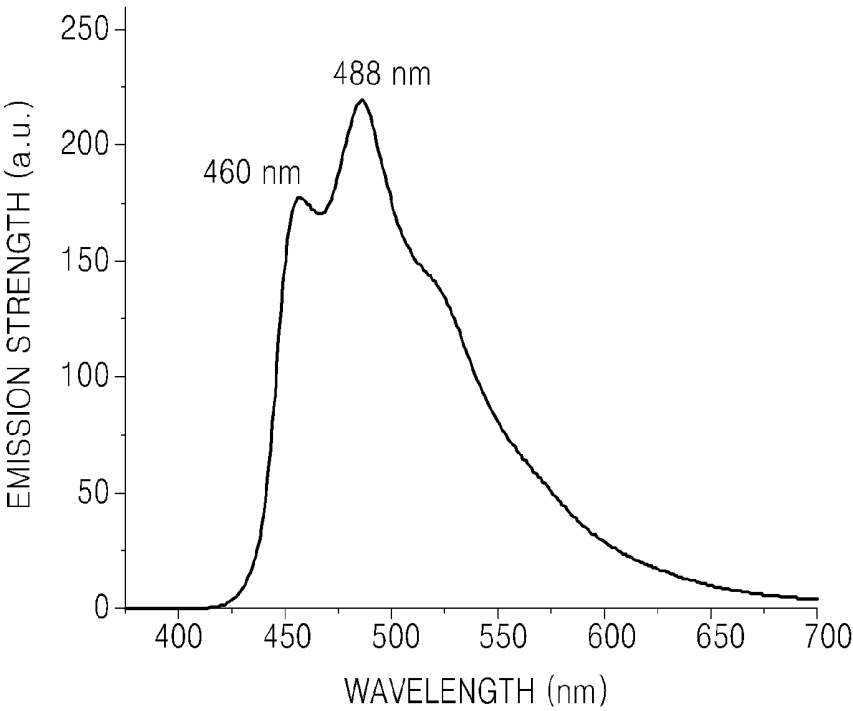


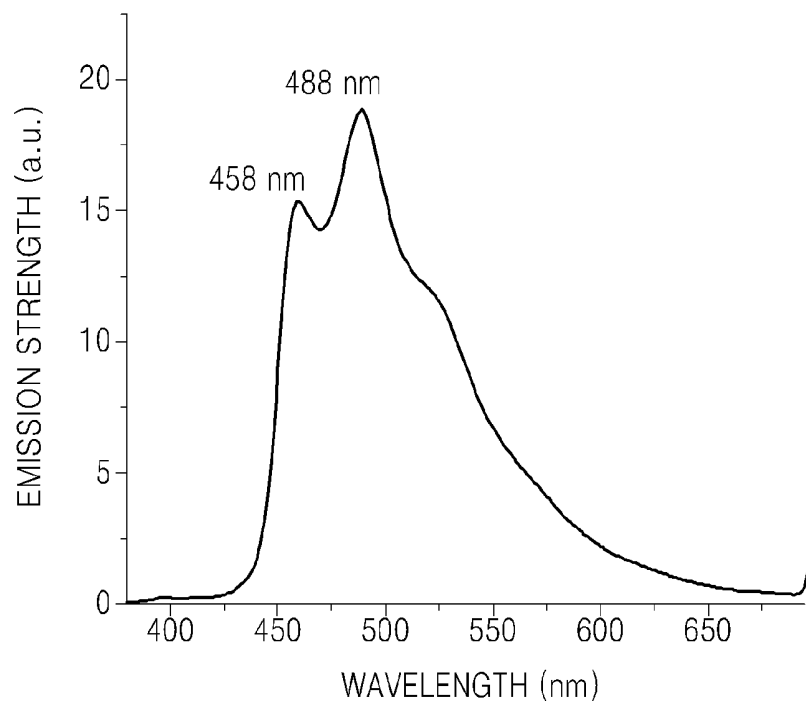
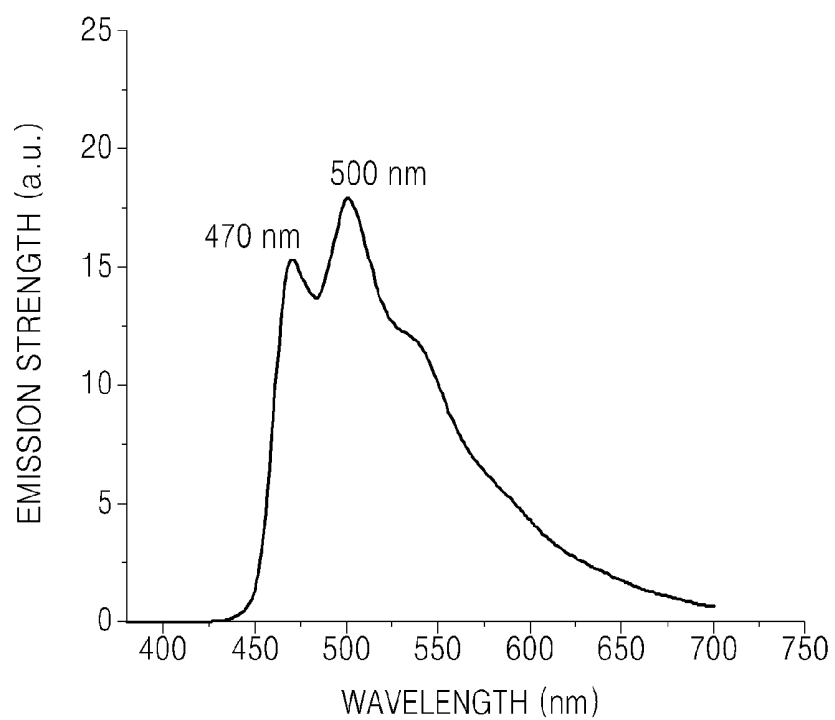
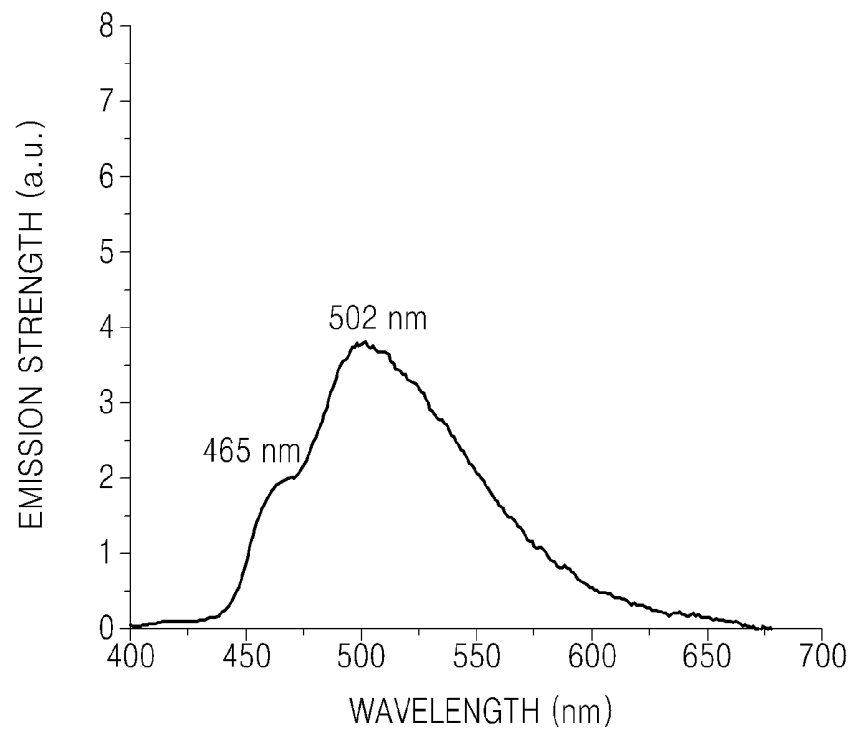
FIG. 3**FIG. 4**

FIG. 5



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

**CROSS-REFERENCE TO RELATED
APPLICATION**

[0001] This application claims the benefit of Korean Patent Application No. 10-2014-0076634, filed on Jun. 23, 2014, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates to organometallic compounds and organic light-emitting devices including the same.

[0004] 2. Description of the Related Art

[0005] Organic light-emitting devices are self-emission devices that have wide viewing angles, high contrast ratios, and short response times. In addition, OLEDs exhibit excellent brightness, driving voltage, and response speed characteristics, and produce multicolored images.

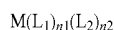
[0006] In an example, an organic light-emitting device includes an anode, a cathode, and an organic layer that is disposed between the anode and the cathode, wherein the organic layer includes an emission layer. A hole transport region may be disposed between the anode and the emission layer, and an 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 electrons are recombined in the emission layer to produce excitons. These excitons change from an excited state to a ground state, thereby generating light.

SUMMARY

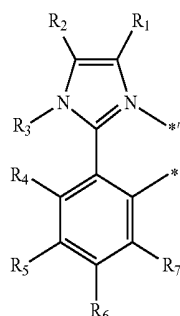
[0007] Provided are novel organometallic compounds and organic light-emitting devices including the same.

[0008] 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.

[0009] According to an aspect of the present disclosure, an organometallic compound represented by Formula 1 is provided:



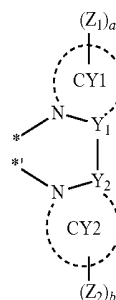
Formula 1



Formula 2

-continued

Formula 3



[0010] wherein in Formulae 1 to 3,

[0011] M is Ir, Pt, Os, Ti, Zr, Hf, Eu, Tb, or Tm;

[0012] L₁ is selected from ligands represented by Formula 2;

[0013] L₂ is selected from ligands represented by Formula 3;

[0014] n₁ and n₂ are each independently 1 or 2, provided that a sum of n₁ and n₂ are 2 or 3;

[0015] when n₁ is 2, two groups L₁ are identical to or different from each other, and when n₂ is 2, two groups L₂ are identical to or different from each other;

[0016] R₁ to R₇, Z₁, and Z₂ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁)(Q₂), —Si(Q₃)(Q₄)(Q₅), and —B(Q₆)(Q₇);

[0017] at least one of R₁ to R₇ is a C₁-C₄ alkoxy group substituted with at least one —F;

[0018] a and b are each independently selected from an integer of 1 to 4;

[0019] CY₁ and CY₂ are each independently a C₁-C₆₀ heterocyclic group including at least one nitrogen as a ring-forming atom;

[0020] Y₁ and Y₂ are each independently C or N;

[0021] N and Y₁ are linked with each other by a single bond or a double bond, and N and Y₂ are linked with each other by a single bond or a double bond;

[0022] * and * indicate a binding site to M;

[0023] at least one of substituents of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted

C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

[0024] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;

[0025] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇);

[0026] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0027] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇); and

[0028] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

[0029] wherein Q₁ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group

or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0030] According to another aspect of the present disclosure, an organic light-emitting device includes:

[0031] a first electrode;

[0032] a second electrode; and

[0033] an organic layer disposed between the first electrode and the second electrode,

[0034] wherein the organic layer includes an emission layer and at least one organometallic compound of Formula 1.

[0035] The organometallic compound may be included in the emission layer, and in this regard, may function as a dopant in the emission layer. The emission layer may further include a host.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] 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:

[0037] FIG. 1 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment;

[0038] FIG. 2 is a graph of emission strength (arbitrary units, a. u.) versus wavelength (nanometers, nm) showing a photoluminescent (PL) spectrum with respect to Compound 10;

[0039] FIG. 3 is a graph of emission strength (arbitrary units, a. u.) versus wavelength (nanometers, nm) showing a PL spectrum with respect to Compound 33;

[0040] FIG. 4 is a graph of emission strength (arbitrary units, a. u.) versus wavelength (nanometers, nm) showing a PL spectrum with respect to Compound 34; and

[0041] FIG. 5 is a graph of emission strength (arbitrary units, a. u.) versus wavelength (nanometers, nm) showing a PL spectrum with respect to Compound 35.

DETAILED DESCRIPTION

[0042] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. Expressions such as “at least one of,” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] 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.

[0047] Spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the exemplary term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0048] 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.

[0049] 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 invention 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.

[0050] 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.

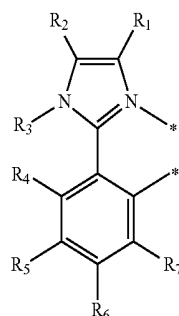
[0051] An organometallic compound may be represented by Formula 1 below:



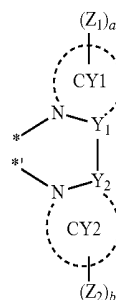
[0052] In Formula 1, M may be iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), or thulium (Tm).

[0053] For example, in Formula 1, M may be Ir or Pt, but is not limited thereto.

[0054] In Formula 1, L_1 may be selected from ligands represented by Formula 2 below, and L_2 may be selected from ligands represented by Formula 3 below. Formulae 2 and 3 may be understood by referring to the descriptions provided herein.



Formula 2



Formula 3

[0055] In Formula 1, $n1$ and $n2$ may be each independently 1 or 2, provided that a sum of $n1$ and $n2$ may be 2 or 3.

[0056] For example, $n1$ may be 2 and $n2$ may be 1, but they are not limited thereto.

[0057] When $n1$ is 2, two groups L_1 may be identical to or different from each other, and when $n2$ is 2, two groups L_2 may be identical to or different from each other.

[0058] The organometallic compound of Formula 1 may be a “neutral” compound. That is, the organometallic compound of Formula 1 may not be a salt form consisting of a pair of a cation and an anion. Thus, a layer including the

organometallic compound of Formula 1 may be formed by using a deposition method. For example, a layer including the organometallic compound of Formula 1 may be formed under controlled conditions of a temperature in a range of about 100° C. to about 500° C., a vacuum pressure in a range of about 10⁻⁸ torr to about 10⁻³ torr, and a deposition rate in a range of about 0.01 Angstroms per second (Å/sec) to about 100 Å/sec. In this regard, a method of manufacturing a device that includes the organometallic compound of Formula 1 may be performed in an improved manner.

[0059] In Formulae 2 and 3, R₁ to R₇, Z₁, and Z₂ may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁)(Q₂), —Si(Q₃)(Q₄)(Q₅), and —B(Q₆)(Q₇). Here, at least one of R₁ to R₇ may be a C₁-C₄ alkoxy group substituted with at least one —F.

[0060] For example, R₁ to R₇, Z₁, and Z₂ may be each independently selected from

[0061] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;

[0062] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0063] a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl group, a carbazolyl group, a phenanthrolyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothio-phenyl group, an isobenzothiazolyl group, a benzoxazolyl

group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, an imida-zopyridinyl group, and an imidazopyrimidinyl group;

[0064] a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl group, a carbazolyl group, a phenanthrolyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothio-phenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, an imida-zopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl group, a carbazolyl group, a phenanthrolyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothio-phenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, an imida-zopyridinyl group, an imidazopyrimidinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅); and

[0065] —Si(Q₃)(Q₄)(Q₅).

[0066] wherein Q₃ to Q₅ and Q₃₃ to Q₃₅ may be each independently selected from a hydrogen, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolyl group, and an isoquinolyl group.

[0067] According to an embodiment, R₁ to R₇, Z₁, and Z₂ may be each independently selected from

[0068] a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;

[0069] a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$; and

[0070] $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$.

[0071] wherein Q_3 to Q_5 and Q_{33} to Q_{35} may be each independently selected from a hydrogen, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group.

[0072] In Formula 2, R_2 may be a hydrogen; R_1 may be a hydrogen; both of R_1 and R_2 may be a hydrogen; or none of R_1 to R_3 may be a hydrogen, but are not limited thereto.

[0073] In Formula 2, at least one of R_1 to R_7 may be selected from $-\text{OCH}_2\text{F}$, $-\text{OCHF}_2$, $-\text{OCF}_3$, $-\text{OC}_2\text{H}_4\text{F}$, $\text{OC}_2\text{H}_3\text{F}_2$, $-\text{OC}_2\text{H}_2\text{F}_3$, $-\text{OC}_2\text{HF}_4$, OC_2F_5 , $-\text{OC}_3\text{H}_6\text{F}$, $-\text{OC}_3\text{H}_5\text{F}_2$, $-\text{OC}_3\text{H}_4\text{F}_3$, $-\text{OC}_3\text{H}_3\text{F}_4$, $-\text{OC}_3\text{H}_2\text{F}_5$, $-\text{OC}_3\text{HF}_6$, $-\text{OC}_3\text{F}_7$, $-\text{OC}_4\text{H}_8\text{F}$, $-\text{OC}_4\text{H}_7\text{F}_2$, $-\text{OC}_4\text{H}_6\text{F}_3$, $-\text{OC}_4\text{H}_5\text{F}_4$, $-\text{OC}_4\text{H}_4\text{F}_5$, $-\text{OC}_4\text{H}_3\text{F}_6$, $-\text{OC}_4\text{H}_2\text{F}_7$, $-\text{OC}_4\text{HF}_8$, and $-\text{OC}_4\text{F}_9$.

[0074] For example, in Formula 2, at least one of R_1 to R_7 may be $-\text{OCH}_2\text{F}$, $-\text{OCHF}_2$, or $-\text{OCF}_3$, and for example, at least one of R_1 to R_7 may be $-\text{OCF}_3$, but is not limited thereto.

[0075] According to another embodiment, in Formula 2, at least one of R_4 to R_7 may be selected from $-\text{OCH}_2\text{F}$, $-\text{OCHF}_2$, $-\text{OCF}_3$, $-\text{OC}_2\text{H}_4\text{F}$, $\text{OC}_2\text{H}_3\text{F}_2$, $-\text{OC}_2\text{H}_2\text{F}_3$, $-\text{OC}_2\text{HF}_4$, OC_2F_5 , $-\text{OC}_3\text{H}_6\text{F}$, $-\text{OC}_3\text{H}_5\text{F}_2$, $-\text{OC}_3\text{H}_4\text{F}_3$, $-\text{OC}_3\text{H}_3\text{F}_4$, $-\text{OC}_3\text{H}_2\text{F}_5$, $-\text{OC}_3\text{HF}_6$, $-\text{OC}_3\text{F}_7$, $-\text{OC}_4\text{H}_8\text{F}$, $-\text{OC}_4\text{H}_7\text{F}_2$, $-\text{OC}_4\text{H}_6\text{F}_3$, $-\text{OC}_4\text{H}_5\text{F}_4$, $-\text{OC}_4\text{H}_4\text{F}_5$, $-\text{OC}_4\text{H}_3\text{F}_6$, $-\text{OC}_4\text{H}_2\text{F}_7$, $-\text{OC}_4\text{HF}_8$, and $-\text{OC}_4\text{F}_9$.

[0076] According to another embodiment, in Formula 2, R_6 may be a C_1 - C_4 alkoxy group substituted with at least one $-\text{F}$; R_5 may be a C_1 - C_4 alkoxy group substituted with at least one $-\text{F}$; R_4 may be a C_1 - C_4 alkoxy group substituted with at least one $-\text{F}$; and R_4 and R_6 may be each independently a C_1 - C_4 alkoxy group substituted with at least one $-\text{F}$, but are not limited thereto.

[0077] In Formula 3, a and b may be each independently selected from an integer of 1 to 4. In Formula 3, a indicates the number of groups Z_1 , and for example, a may be 1 or 2. When a is 2 or greater, two or more groups Z_1 may be

identical to or different from each other. In Formula 3, b indicates the number of groups Z_2 , and for example, b may be 1 or 2. When b is 2 or greater, two or more groups Z_2 may be identical to or different from each other.

[0078] In Formula 3, CY_1 and CY_2 may be each independently a C_1 - C_{60} heterocyclic group including at least one nitrogen as a ring-forming atom.

[0079] In Formula 3, Y_1 and Y_2 may be each independently C or N. For example, Y_1 and Y_2 may be C.

[0080] In Formula 3, N and Y_1 may be linked with each other by a single bond or a double bond, and N and Y_2 may be linked with each other by a single bond or a double bond.

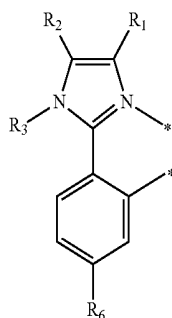
[0081] In Formulae 2 and 3, * and *' may indicate a binding site to the above-described M.

[0082] For example, in Formula 3, CY_1 and CY_2 may be each independently selected from a pyrrole, an imidazole, a pyrazole, a thiazole, an isothiazole, an oxazole, an isooxazole, a triazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, a benzimidazole, a benzoxazole, an isobenzoxazole, a triazole, a tetrazole, an oxadiazole, a triazine, a benzofuropyridine, and a benzothienopyridine.

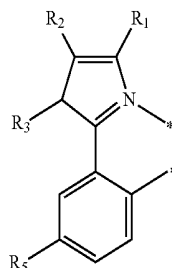
[0083] According to another embodiment, in Formula 3, CY_1 may be a triazole, an imidazole, or a pyrazole, and CY_2 may be a pyridine, a pyrimidine, a triazine, a benzofuropyridine, or a benzothienopyridine.

[0084] According to another embodiment, in Formula 1, L_1 may be selected from ligands represented by Formula 2-1 to 2-4 below:

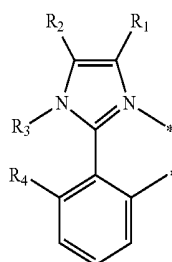
Formula 2-1



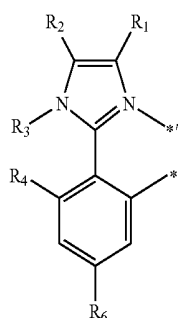
Formula 2-2



Formula 2-3



-continued



Formula 2-4

[0085] In Formulae 2-1 to 2-4, R_1 to R_6 , and * and *' may be understood by referring to the descriptions provided herein. In Formulae 2-1 to 2-4, R_1 to R_6 may be each independently a C_1 - C_4 alkoxy group substituted with at least one —F.

[0086] For example, in Formulae 2-1 to 2-4,

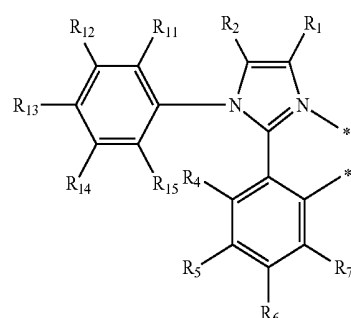
[0087] R_1 to R_3 may be each independently selected from

[0088] a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

[0089] a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q_{33})(Q_{34})(Q_{35}); and

[0090] at least one of R_4 to R_6 may be each independently a C_1 - C_4 alkoxy group substituted with at least one —F (e.g., —OCF₃).

[0091] According to another embodiment, in Formula 1, L_1 may be selected from ligands represented by Formula 2(1) below:



Formula 2(1)

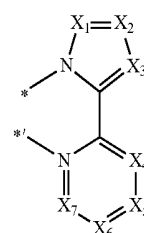
[0092] In Formula 2(1), R_1 , R_2 , R_4 to R_7 , and * and *' may be understood by referring to the descriptions provided herein, and R_{11} to R_{15} may be understood by referring to the description presented in connection with R_1 .

[0093] For example, in Formula 2(1), R_1 , R_2 , R_4 to R_7 , and R_{11} to R_{15} may be each independently selected from

[0094] a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

[0095] a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q_{33})(Q_{34})(Q_{35}), and at least one of R_4 to R_7 may be each independently a C_1 - C_4 alkoxy group substituted with at least one —F (e.g., —OCF₃).

[0096] According to another embodiment, in Formula 1, L_2 may be selected from ligands represented by Formula 3(1) below:



Formula 3(1)

[0097] In Formula 3(1),

[0098] X_1 may be N or C(Z_{11}); X_2 may be N or C(Z_{12}); X_3 may be N or C(Z_{13}); X_4 may be N or C(Z_{14}); X_5 may be N or C(Z_{15}); X_6 may be N or C(Z_{16}); and X_7 may be N or C(Z_{17}).

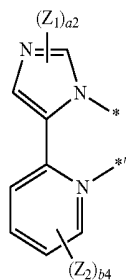
[0099] wherein Z_{11} to Z_{13} may be understood by referring to the description presented in connection with Z_1 , and Z_{14} to Z_{17} may be understood by referring to the description presented in connection with Z_2 .

[0100] For example, in Formula 3(1), Z_{11} to Z_{17} may be each independently selected from

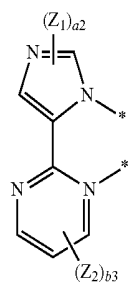
[0101] a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

[0102] a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q_{33})(Q_{34})(Q_{35}), but are not limited thereto.

[0103] According to another embodiment, in Formula 1, L_2 may be selected from ligands represented by Formulae 3-1 to 3-30 below, but is not limited thereto:

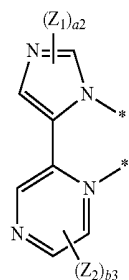


Formula 3-1

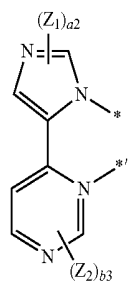


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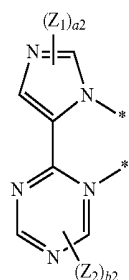
Formula 3-2



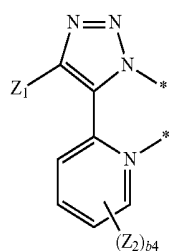
Formula 3-3



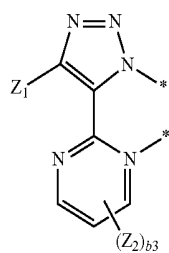
Formula 3-4



Formula 3-5

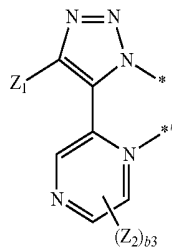


Formula 3-6

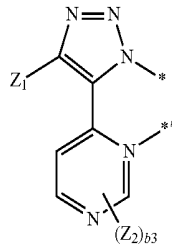


Formula 3-7

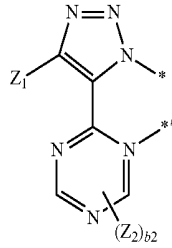
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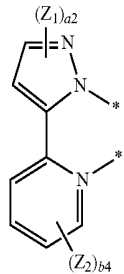
Formula 3-8



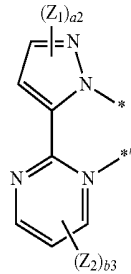
Formula 3-9



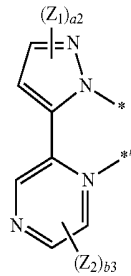
Formula 3-10



Formula 3-11

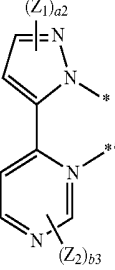


Formula 3-12

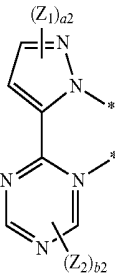


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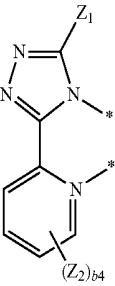
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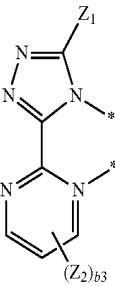
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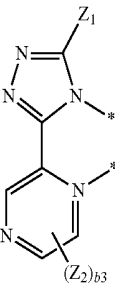
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Formula 3-16

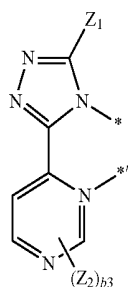


Formula 3-17



Formula 3-18

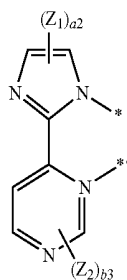
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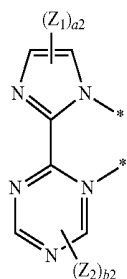
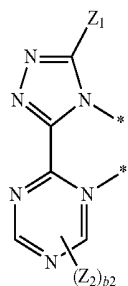
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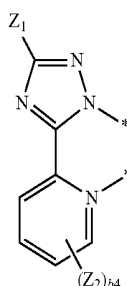
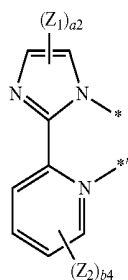
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Formula 3-25



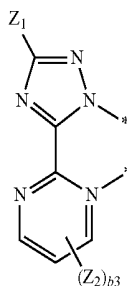
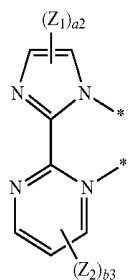
Formula 3-21

Formula 3-26



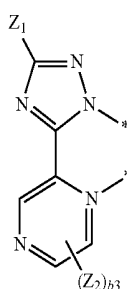
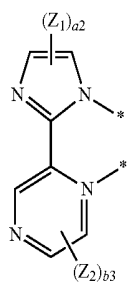
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Formula 3-27

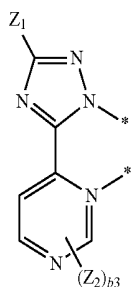


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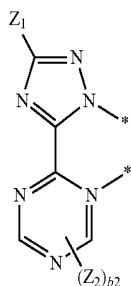
Formula 3-28



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Formula 3-29



Formula 3-30

[0104] In Formulae 3-1 to 3-30, Z_1 and Z_2 may be each independently selected from

[0105] a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

[0106] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one of a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;

[0107] a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;

[0108] a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and $-Si(Q_{33})(Q_{34})(Q_{35})$; and

[0109] $-Si(Q_3)(Q_4)(Q_5)$,

[0110] wherein Q_3 to Q_5 and Q_{33} to Q_{35} may be each independently selected from a hydrogen, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group; and

[0111] wherein

[0112] b_4 may be 1, 2, 3, or 4,

[0113] b_3 may be 1, 2, or 3,

[0114] a_2 and b_2 may be each independently 1 or 2; and

[0115] * and *' may indicate a binding site to the above-described M in Formula 1.

[0116] For example, in Formulae 3-1 to 3-30, Z_1 and Z_2 may be each independently selected from

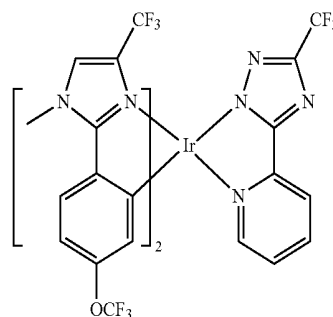
[0117] a hydrogen, $-F$, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;

[0118] a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of $-F$, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and $-Si(Q_{33})(Q_{34})(Q_{35})$; and

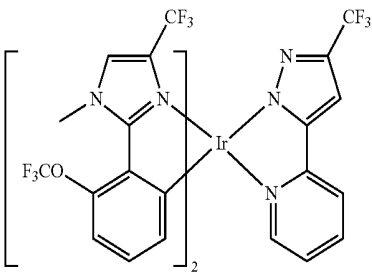
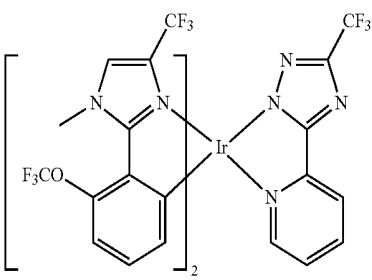
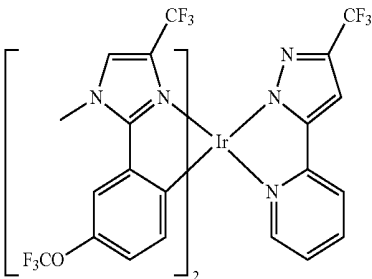
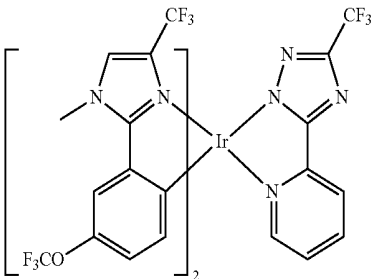
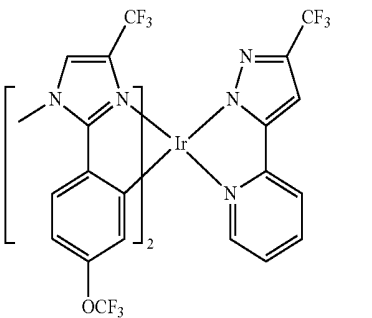
[0119] $-Si(Q_3)(Q_4)(Q_5)$,

[0120] wherein Q_3 to Q_5 and Q_{33} to Q_{35} may be each independently selected from a hydrogen, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group.

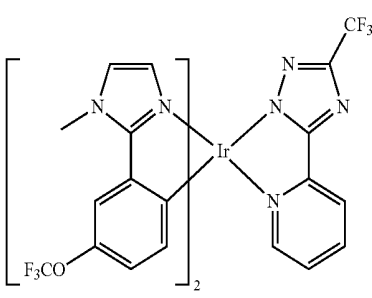
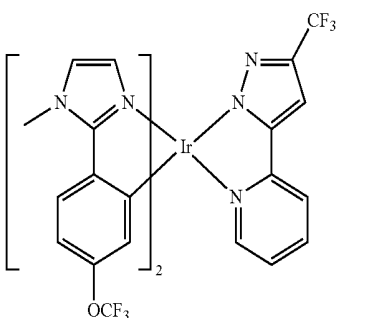
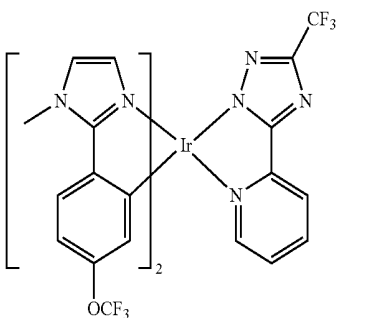
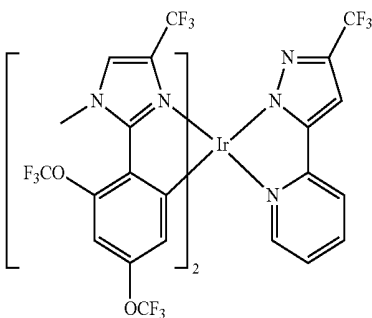
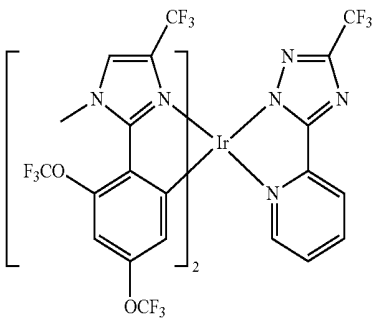
[0121] The organometallic compound of Formula 1 may be any one of Compounds 1 to 35 below:



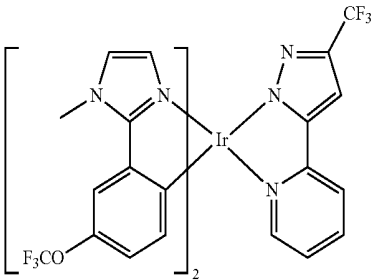
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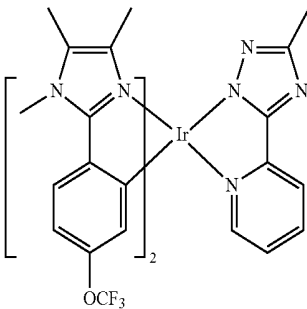


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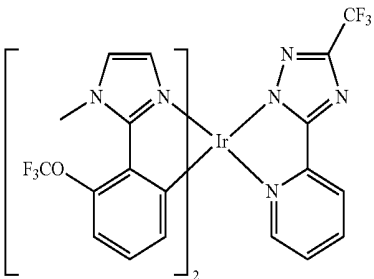
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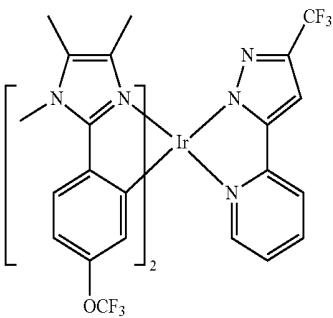


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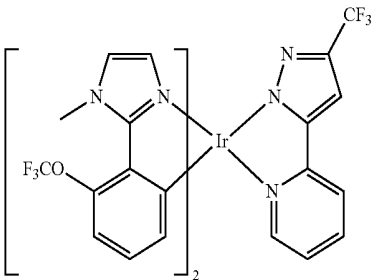
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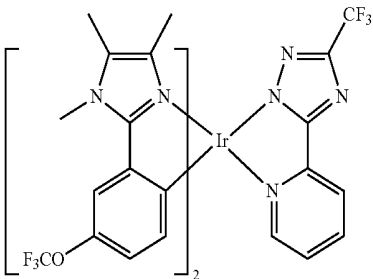
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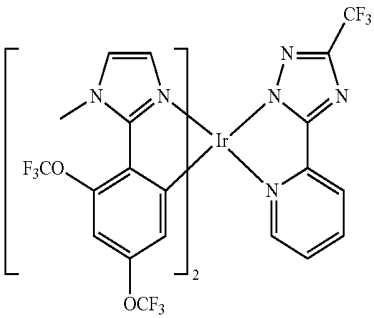
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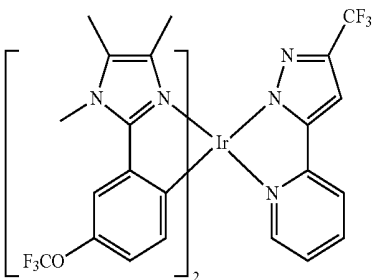
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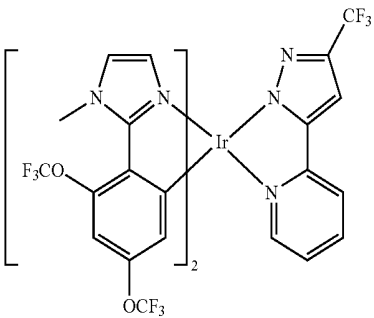
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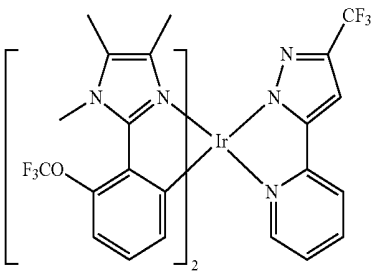
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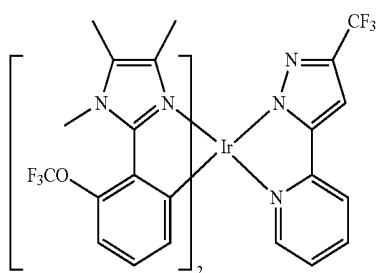
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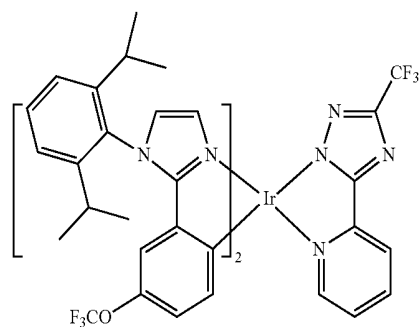


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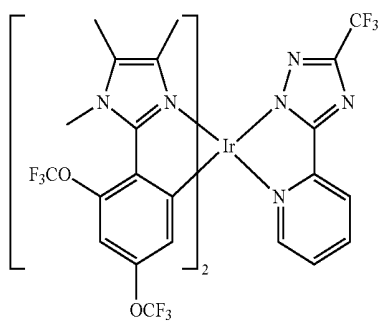


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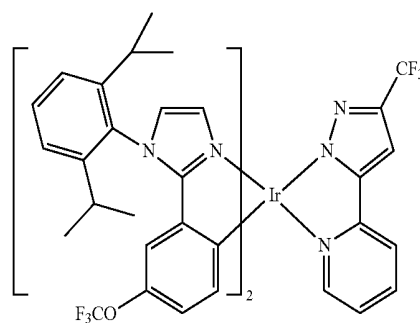
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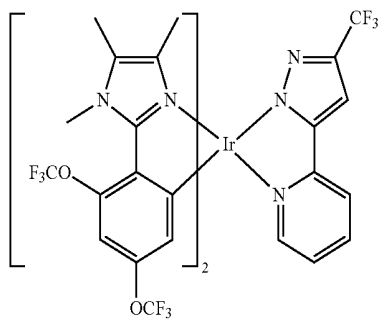
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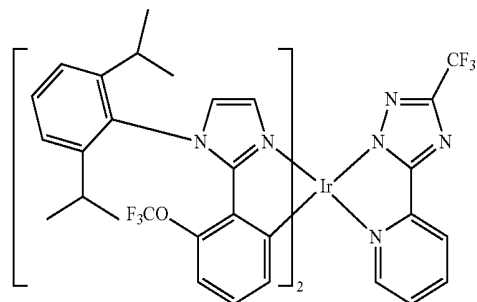
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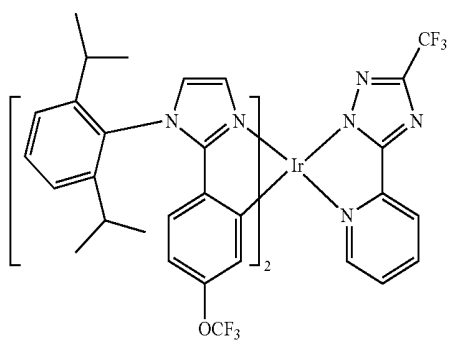
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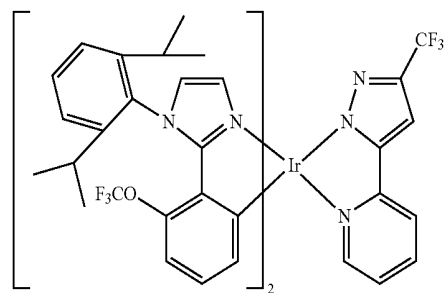
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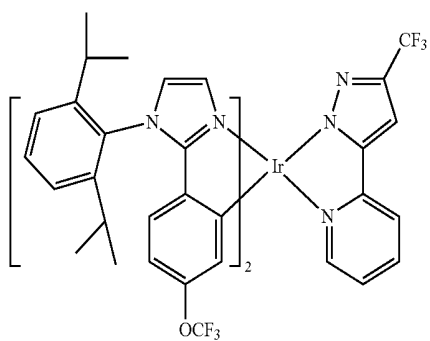
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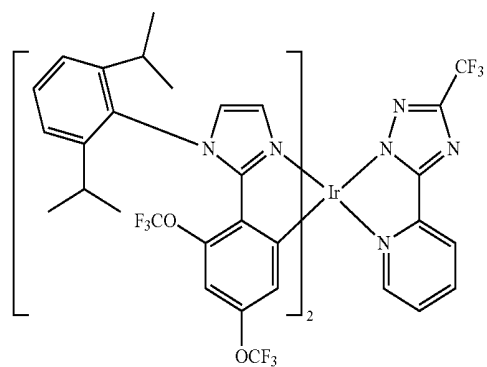
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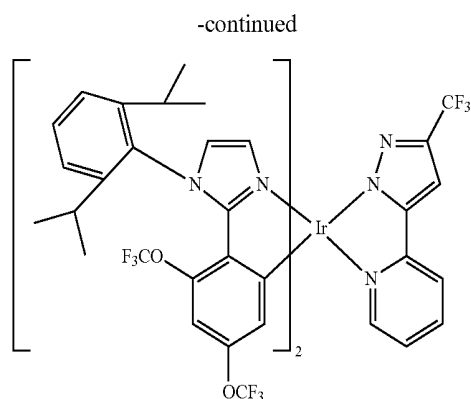
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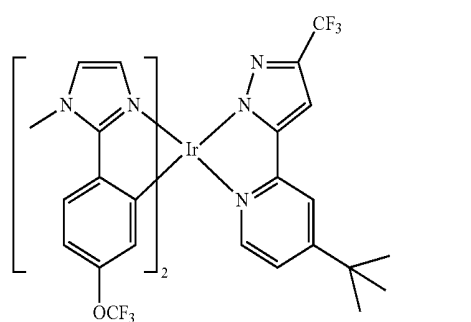
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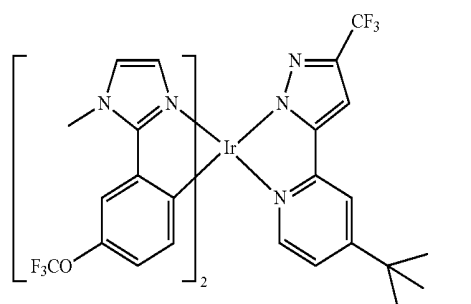
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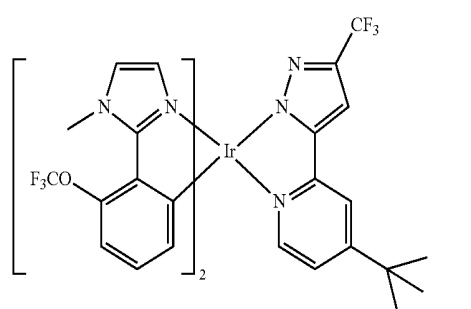
32



33



34



35

[0122] In the organometallic compound of Formula 1, L_1 may be the ligand of Formula 2, wherein at least one of R_1 to R_7 in Formula 2 may be a C_1 - C_4 alkoxy group substituted with at least one $-F$. In this regard, the organometallic compound of Formula 1 may contribute to emission of blue light having excellent color coordination.

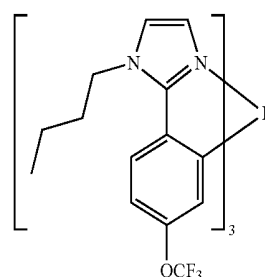
[0123] In addition, the organometallic compound of Formula 1 may include L_2 selected from the ligands of Formula 3, which is different from L_1 that is selected from the ligands of Formula 2. In this regard, the organometallic compound of Formula 1 including L_2 may facilitate a compound synthesis and have high efficiency in an emission region of blue light. In addition, the organometallic compound of

Formula 1 including L_2 may have a highest occupied molecular orbital (HOMO) energy level, a lowest unoccupied molecular orbital (LUMO) energy level, and a triplet (T_1) energy level that are suitable enough for use as a material for forming an organic layer included in an organic light-emitting device.

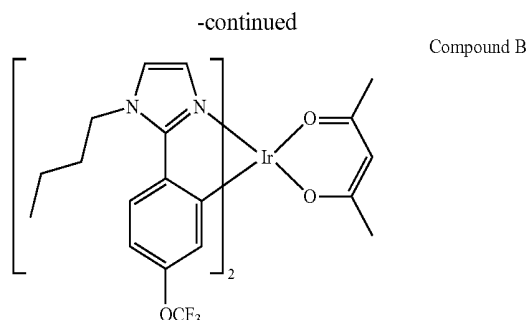
[0124] For example, regarding Compounds 1 to 32 and Compounds A and B, HOMO, LUMO, and triplet (T_1) energy levels are calculated with density functional theory (DFT) using the Gaussian program (having optimized structures at the B3LYP/6-31G(d,p) levels), and results of the calculation are shown in Table 1 below.

TABLE 1

Compound No.	HOMO (eV)	LUMO (eV)	T_1 (eV)
1	-5.58	-1.51	2.93
2	-5.56	-1.59	2.88
3	-5.53	-1.58	2.81
4	-5.85	-1.81	2.89
5	-5.29	-1.42	2.67
6	-5.34	-1.50	2.65
7	-5.25	-1.49	2.65
8	-5.62	-1.76	2.88
9	-5.41	-1.31	2.95
10	-5.42	-1.40	2.89
11	-5.41	-1.39	2.88
12	-5.70	-1.65	2.92
13	-5.39	-1.56	2.86
14	-5.40	-1.62	2.82
15	-5.35	-1.61	2.79
16	-5.26	-1.29	2.74
17	-5.28	-1.34	2.74
18	-5.29	-1.27	2.79
19	-4.89	-1.00	2.77
20	-5.18	-1.30	2.91
21	-5.14	-1.32	2.84
22	-5.43	-1.46	2.89
23	-5.50	-1.80	2.70
24	-5.58	-1.51	2.93
25	-5.56	-1.59	2.88
26	-5.53	-1.58	2.88
27	-5.85	-1.81	2.89
28	-5.29	-1.42	2.67
29	-5.34	-1.50	2.65
30	-5.25	-1.49	2.65
31	-5.62	-1.58	2.88
32	-5.41	-1.31	2.95
A	-5.00	-2.31	2.68
B	-5.18	-2.34	2.62



Compound A



[0125] Referring to Table 1 above, it is confirmed that Compounds 1 to 32 have higher LUMO levels (i.e., smaller LUMO absolute values) than those of Compounds A and B, and that is, the organometallic compound of Formula 1 including any one of Compounds 1 to 32 has HOMO, LUMO, and T_1 energy levels that are suitable for use as a material for forming an organic layer included in an organic light-emitting device, wherein the material may be used as a dopant in an emission layer.

[0126] In this regard, the organometallic compound of Formula 1 may have electrical characteristics that are suitable for use as a material for an organic light-emitting device, and accordingly, the organic light-emitting device including the organometallic compound of Formula 1 may have excellent efficiency, brightness, and lifespan characteristics.

[0127] For example, the organometallic compound of Formula 1 may be configured to emit light having an emission wavelength peak in a range of about 435 nanometers (nm) to about 500 nm, an x color coordinate in a range of about 0.14 to about 0.26 (e.g., a range of about 0.19 to about 0.25), and a y color coordinate in a range of about 0.30 to about 0.47 (e.g., a range of about 0.31 to about 0.45).

[0128] A method of synthesizing the organometallic compound of Formula 1 may be understood by one of ordinary skill in the art based on Synthesis Examples described below.

[0129] Thus, the organometallic compound of Formula 1 may be suitable for forming an organic layer included in an organic light-emitting device, and for example, may be used as a dopant in an emission layer included in the organic layer.

[0130] According to another aspect, an organic light-emitting device may include:

[0131] a first electrode;

[0132] a second electrode; and

[0133] an organic layer that is disposed between the first electrode and the second electrode,

[0134] wherein the organic layer includes an emission layer and at least one organometallic compound of Formula 1.

[0135] The organic light-emitting device may include an organic layer including the organometallic compound of Formula 1 as described above. Accordingly, the organic light-emitting device may have low driving voltage, high efficiency, high brightness, and long lifespan characteristics. In addition, the organic light-emitting device including the organometallic compound of Formula 1 may be configured to emit light having an emission wavelength peak in a range of about 435 nm to about 500 nm, an x color coordinate in a range of about 0.14 to about 0.26 (e.g., a range of about

0.19 to about 0.25), and a y color coordinate in a range of about 0.30 to about 0.47 (e.g., a range of about 0.31 to about 0.45).

[0136] The organometallic compound of Formula 1 may be used between a pair of electrodes of the organic light-emitting device. For example, the organometallic compound of Formula 1 may be included in the emission layer. Here, the organometallic compound of Formula 1 may function as a dopant, and the emission layer may further include a host (that is, an amount of the organometallic compound of Formula 1 is less than that of the host).

[0137] The expression “(an organic layer) includes at least one organometallic compound” used herein includes an embodiment in which “(an organic layer) may include at least one organometallic compound of Formula 1 or an embodiment in which (an organic layer) includes two or more different organometallic compounds of Formula 1”.

[0138] For example, the organic layer may include only Compound 1 as the organometallic compound. Here, Compound 1 may be present in the emission layer included in the organic light-emitting device. Alternatively, the organic layer may include Compounds 1 and 2 as the organometallic compound. Here, Compounds 1 and 2 may be present on the same layer (for example, both of Compounds 1 and 2 may be present on the emission layer).

[0139] The first electrode may be an anode, which is a hole injection electrode, and the second electrode may be a cathode, which is an electron injection electrode. Alternatively, the first electrode may be a cathode, which is an electron injection electrode, and the second electrode may be an anode, which is a hole injection electrode.

[0140] For example,

[0141] the first electrode may be an anode,

[0142] the second electrode may be a cathode, and

[0143] the organic layer may include:

[0144] i) a hole transport region that is disposed between the first electrode and the emission layer,

[0145] wherein the hole transport region includes at least one of a hole injection layer (HIL), a hole transport layer (HTL), and an electron blocking layer (EBL); and

[0146] ii) an electron transport region that is disposed between the emission layer and the second electrode,

[0147] wherein the electron transport region includes at least one of a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL).

[0148] The term “organic layer” used herein refers to a single layer and/or a plurality of layers disposed between the first electrode and the second electrode of an organic light-emitting device. The “organic layer” may include, in addition to an organic compound, an organometallic complex including metal.

[0149] FIG. 1 is a schematic cross-sectional view of an organic light-emitting device 10 according to an embodiment. Hereinafter, the structure of the organic light-emitting device 10 according to an embodiment and a method of manufacturing the organic light-emitting device 10 according to an embodiment will be described in connection with FIG. 1. The organic light-emitting device 10 has a stacked structure of a first electrode 11, an organic layer 15, and a second electrode 19 that are sequentially stacked in the stated order.

[0150] A substrate may be additionally disposed under the first electrode **11** or on top of the second electrode **19**. For use as the substrate, any substrate that is used in a typical organic light-emitting device may be used. The substrate may be a glass substrate or a transparent plastic substrate, each of which has excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water-proofness.

[0151] The first electrode **11** may be formed by, for example, depositing or sputtering a material for forming the first electrode **11** on top of the substrate. When the first electrode **11** is an anode, the material for forming the first electrode **11** may be selected from materials having a high work function to facilitate hole injection. The first electrode **11** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. The material for forming the first electrode **11** may be, for example, indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO₂), or zinc oxide (ZnO). Alternatively, the material for forming the first electrode **11** may be metal, such as magnesium (Mg), aluminum (Al), aluminum-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), or magnesium-silver (Mg-Ag).

[0152] The first electrode **11** may have a single-layer structure or a multi-layer structure consisting of two or more different layers. For example, the first electrode **11** may have a triple-layered structure of ITO/Ag/ITO, but the structure of the first electrode **11** is not limited thereto.

[0153] The organic layer **15** may be disposed on top of the first electrode **11**.

[0154] The organic layer **15** may include a hole transport region; an emission layer; and an electron transport region.

[0155] The hole transport region may be disposed between the first electrode **11** and the emission layer.

[0156] The hole transport region may include at least one of an HIL, an HTL, and EBL, and a buffer layer.

[0157] The hole transport region may only include an HIL, or only include an HTL. Alternatively, the hole transport region may have a structure of HIL/HTL or a structure of HIL/HTL/EBL, each of which layers are sequentially stacked in the stated order from the first electrode **11**.

[0158] When the hole transport region includes an HIL, the HIL may be formed on top of the first electrode **11** by using various methods, such as vacuum deposition, spin coating, casting, and a Langmuir-Blodgett (LB) method.

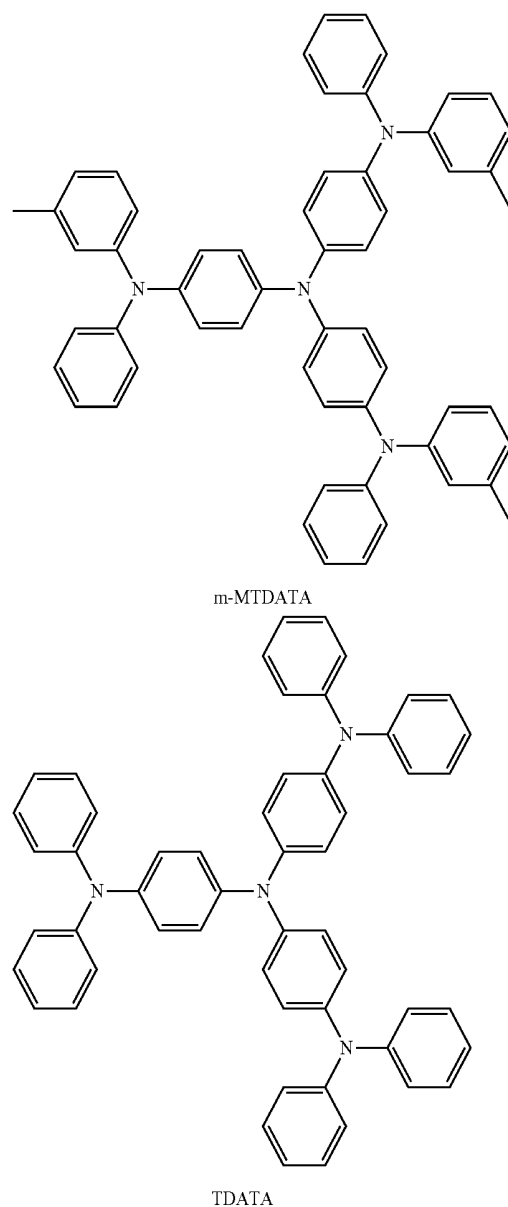
[0159] When an HIL is formed by vacuum deposition, the deposition conditions may vary according to a compound that is used to form the HIL, and the structure and thermal characteristics of the HIL. For example, the deposition conditions may include a deposition temperature in a range of about 100° C. to about 500° C., a vacuum pressure in a range of about 10⁻⁸ torr to about 10⁻³ torr, and a deposition rate in a range of about 0.01 Å/sec to about 100 Å/sec, but are not limited thereto.

[0160] When an HIL is formed by spin coating, the coating conditions may vary according to a compound that is used to form the HIL, and the structure and thermal characteristics of the HIL. For example, the coating conditions may include a coating speed in a range of about 2,000 revolutions

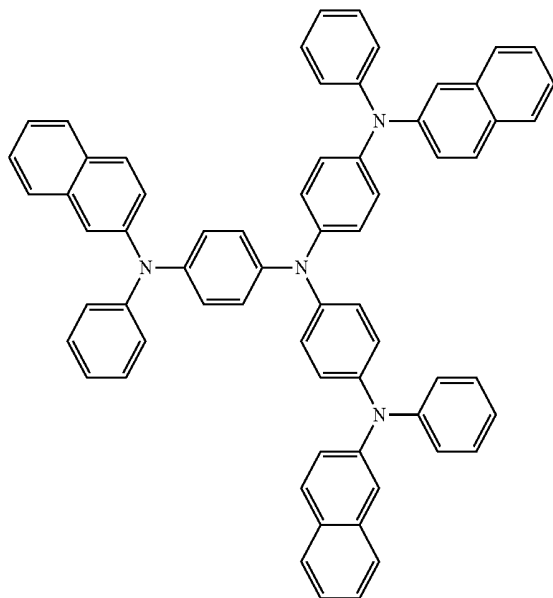
per minute (rpm) to about 5,000 rpm, and a temperature at which a heat treatment is performed to remove a solvent after coating may be in a range of about 80° C. to about 200° C. However, the coating conditions are not limited thereto.

[0161] Conditions for forming a HTL and an EBL may be understood by referring to conditions for forming the HIL.

[0162] The hole transport region may include m-MT-DATA, TDATA, 2-TNATA, NPB, β-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-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), or one of a compound represented by Formula 201 below, and a compound represented by Formula 202 below:

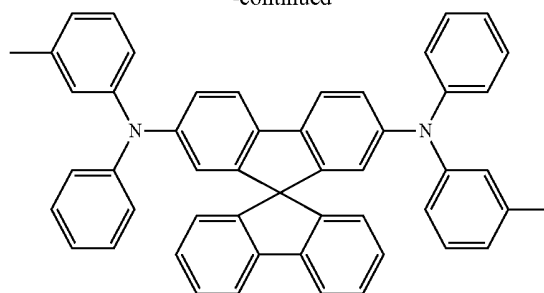


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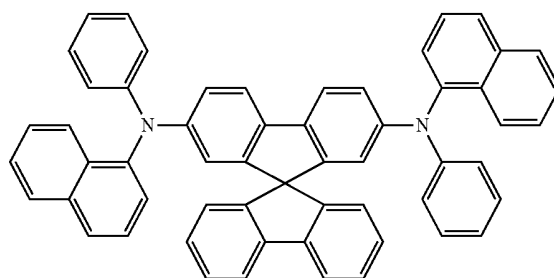


2-TNATA

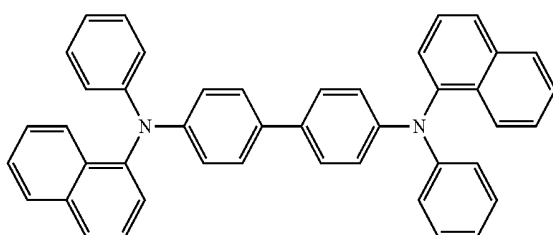
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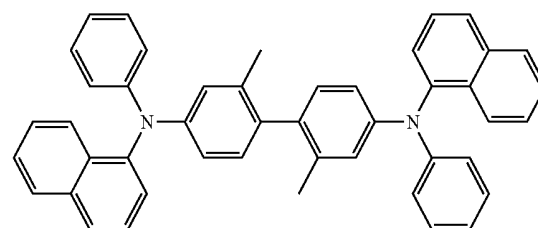
Spiro-TPD



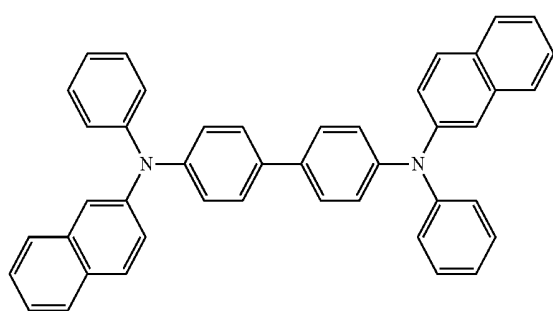
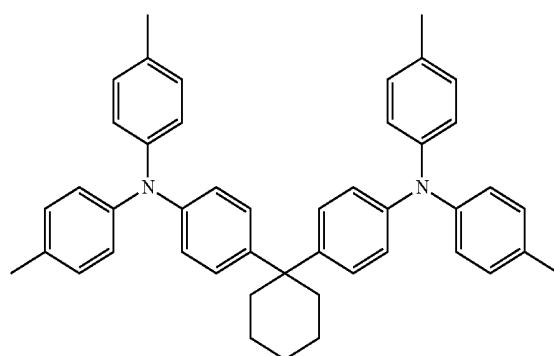
Spiro-NPB



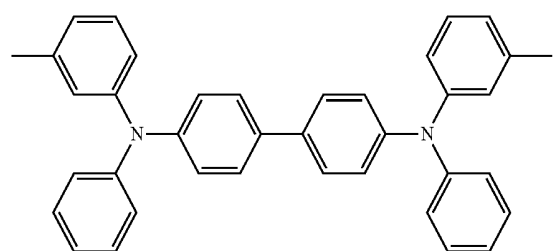
NPB



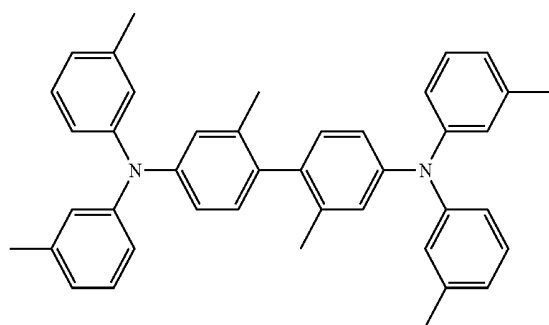
methylated NPB

 β -NPB

TAPC



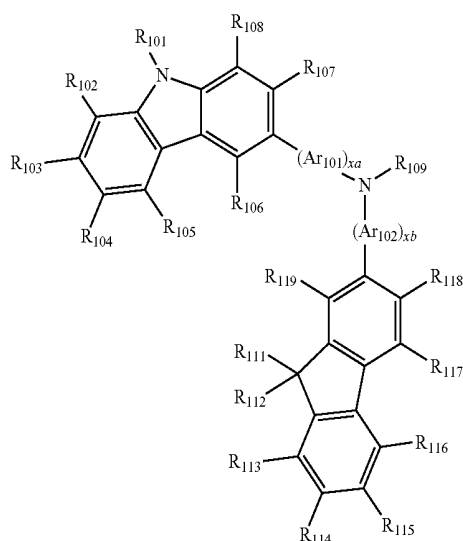
TPD



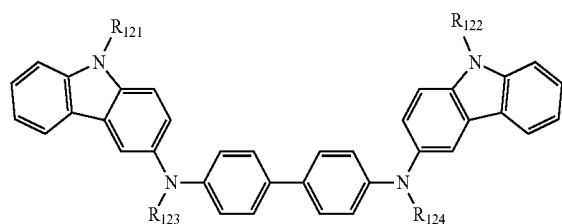
HMTPD

-continued

Formula 201



Formula 202



[0163] In Formula 201, Ar₁₀₁ and Ar₁₀₂ may be each independently selected from

[0164] 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 naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group; and

[0165] 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 naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0166] In Formula 201, xa and xb may be each independently an integer of 0 to 5, or may be 0, 1 or 2. For example, in Formula 201, xa may be 1 and xb may be 0, but are not limited thereto.

[0167] In Formulae 201 and 202, R₁₀₁ to R₁₀₈, R₁₁₁ to R₁₁₉, and R₁₂₁ to R₁₂₄ may be each independently selected from

[0168] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group (e.g., a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, and a hexyl group), and a C₁-C₁₀ alkoxy group (e.g., a methoxy group, an ethoxy group, a propoxy group, a butoxy group, and a pentoxy group);

[0169] a C₁-C₁₀ alkyl group and a C₁-C₁₀ alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0170] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group; and

[0171] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, and a C₁-C₁₀ alkoxy group, but they are not limited thereto.

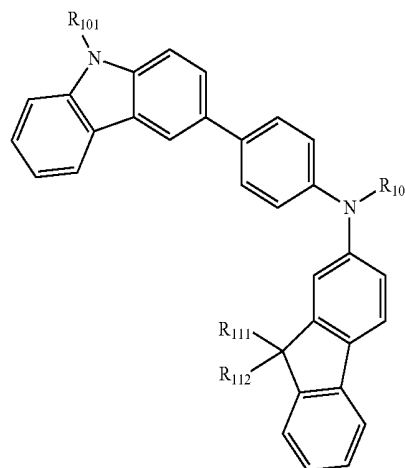
[0172] In Formula 201, R₁₀₉ may be selected from

[0173] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group; and

[0174] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group.

[0175] According to an embodiment, the compound of Formula 201 may be represented by Formula 201A below, but is not limited thereto:

Formula 201A

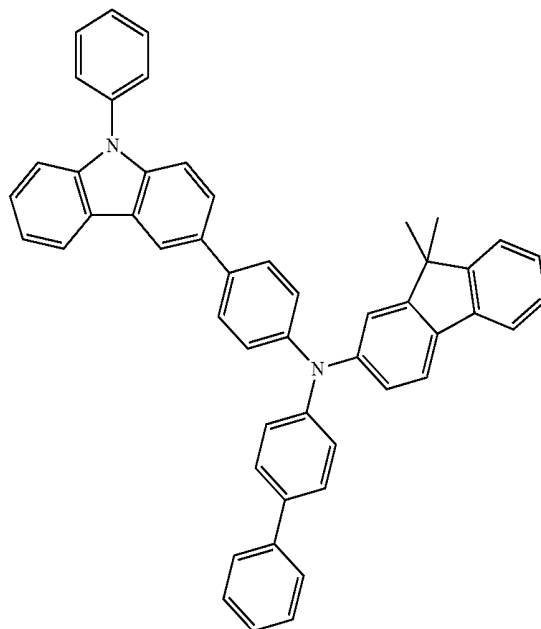
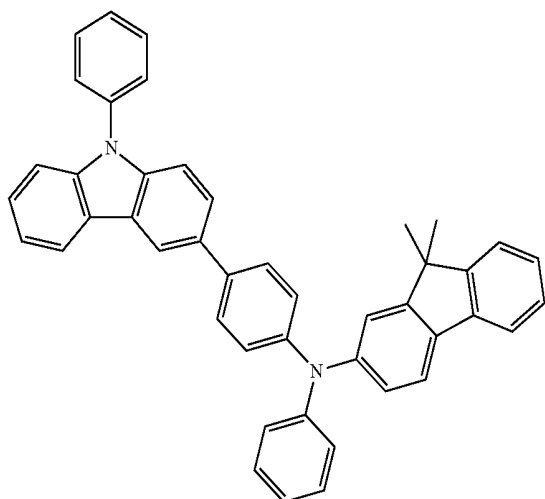


[0176] In Formula 201A, R_{101} , R_{111} , R_{112} , and R_{109} may be understood by referring to the description provided herein.

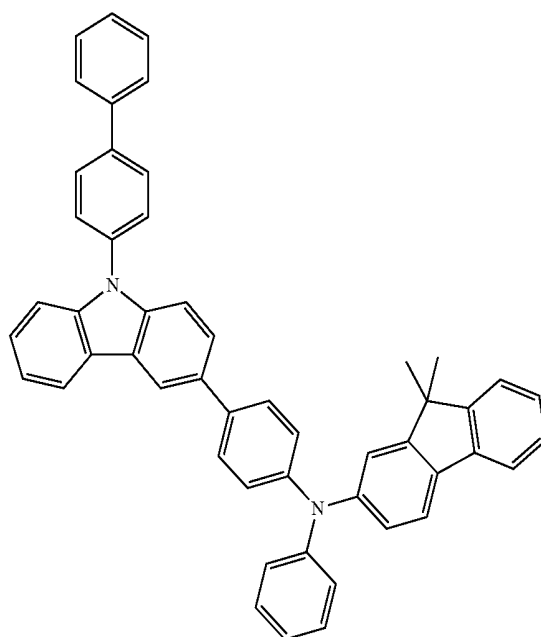
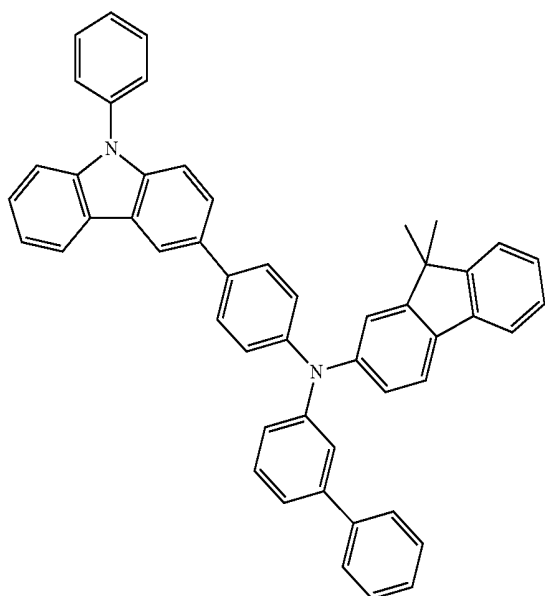
[0177] For example, the compound of Formula 201 and the compound of Formula 202 may include Compounds HT1 to HT20 below, but are not limited thereto:

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HT3

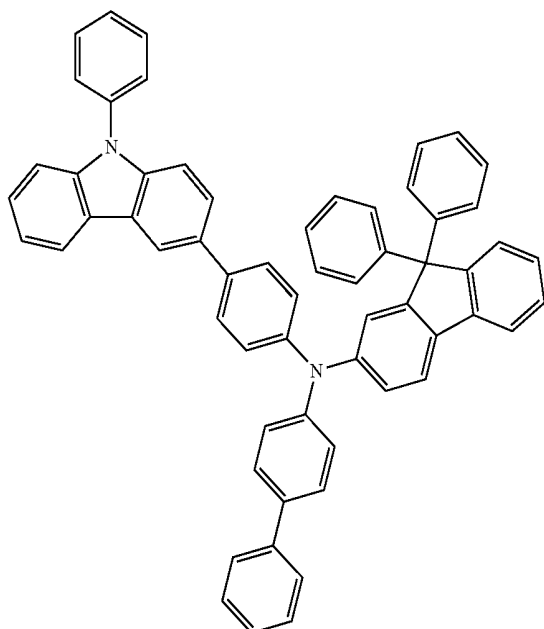


HT4



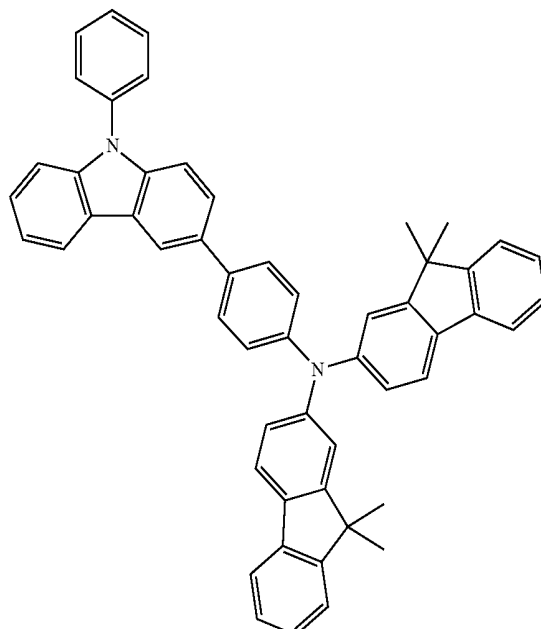
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HT5

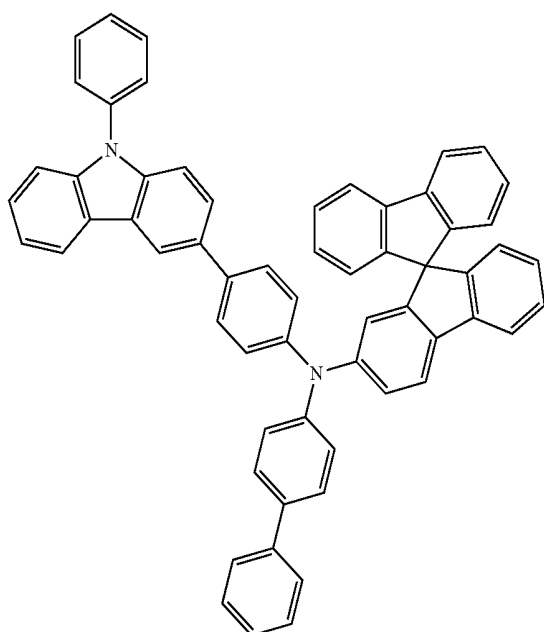


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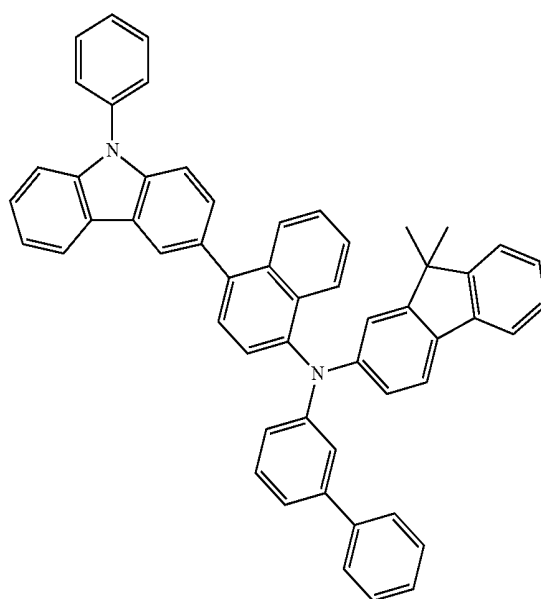
HT7



HT6

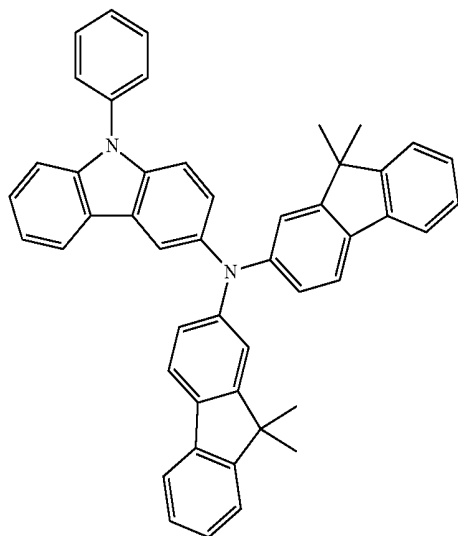


HT8



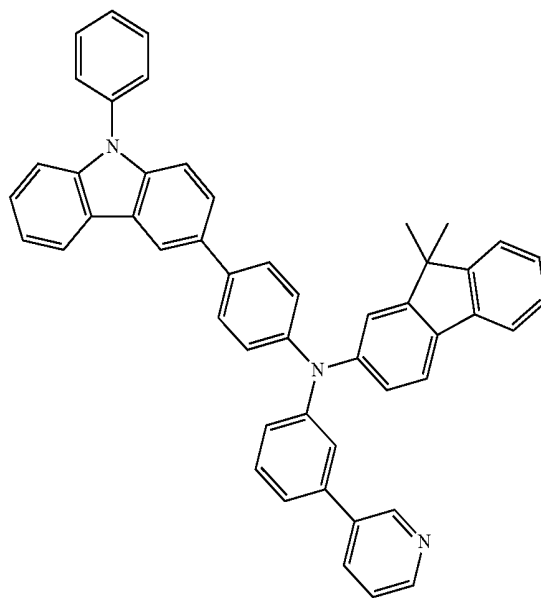
-continued

HT9



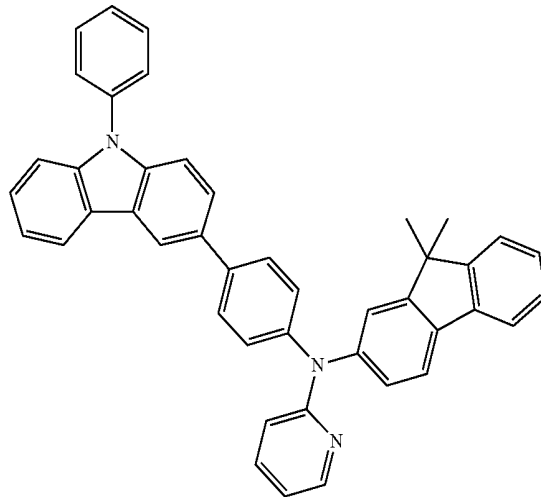
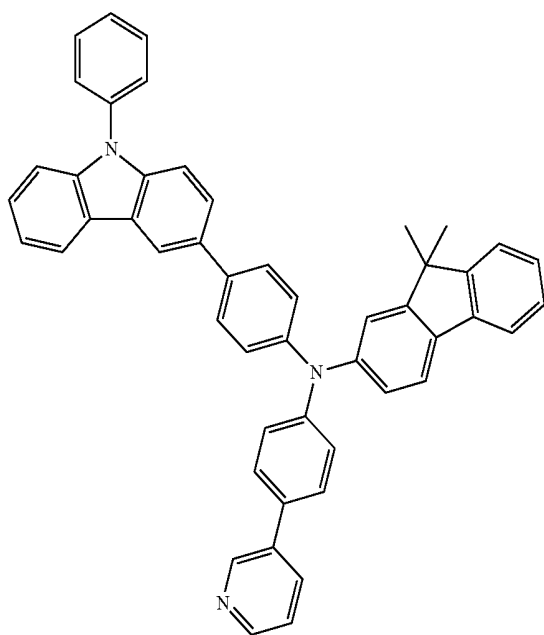
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HT11

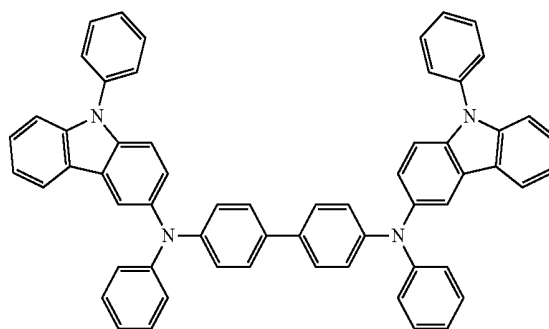


HT12

HT10

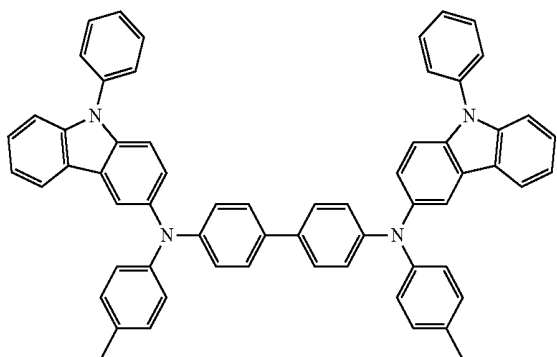


HT13

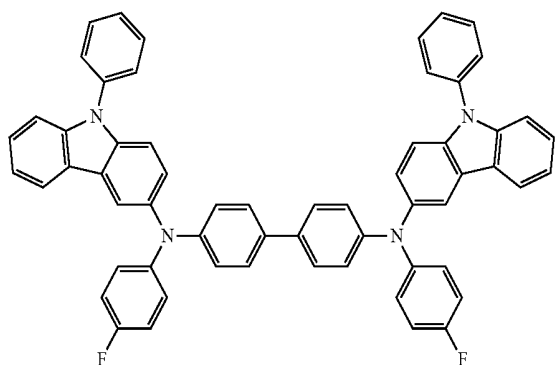


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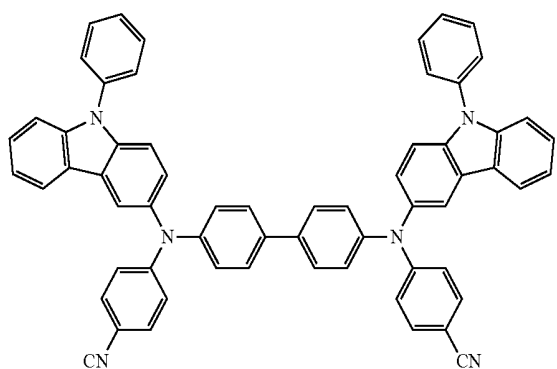
HT14



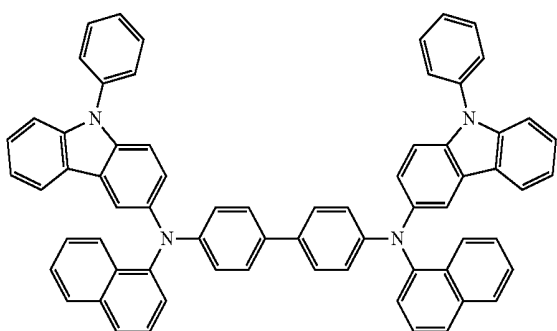
HT15



HT16

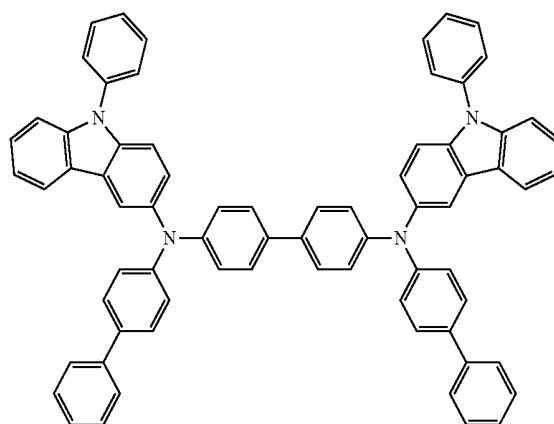


HT17

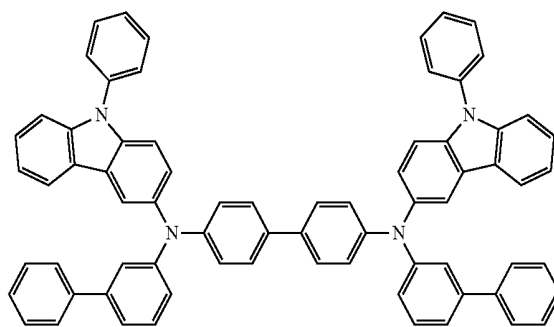


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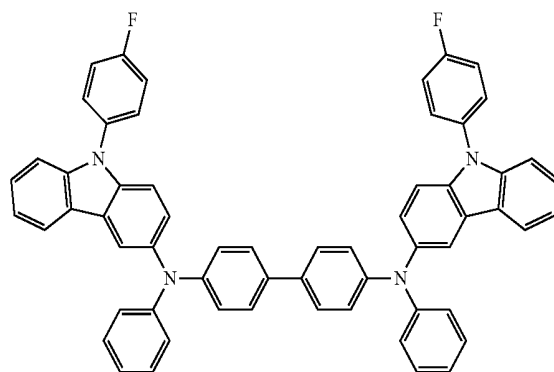
HT18



HT19



HT20

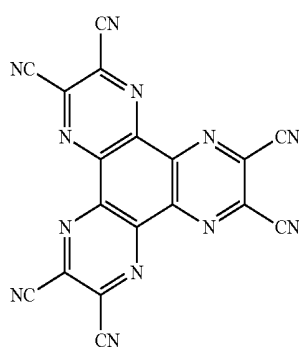


[0178] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å, for example, a range of about 100 Å to about 1,000 Å. When the hole transport region includes both an HIL and an HTL, a thickness of the HIL may be in a range of about 100 Å to about 10,000 Å, for example, a range of about 100 Å to about 1,000 Å, and a thickness of the HTL may be in a range of about 50 Å to about 2,000 Å, for example, a range of about 100 Å to about 1,500 Å. While not wishing to be bound by a theory, it is believed that when the thicknesses of the hole transport region, the HIL, and the HTL are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

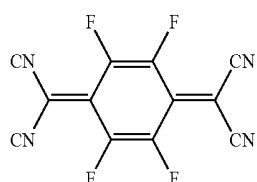
[0179] The hole transport region may further include, in addition to these materials, a charge-generation material for

the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0180] The charge-generation material may be, for example, a p-dopant. The p-dopant may be one of a quinone derivative, a metal oxide, and a cyano group-containing compound, but is not limited thereto. For example, non-limiting examples of the p-dopant are a quinone derivative, such as tetracyanoquinonedimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4-TCNQ); a metal oxide, such as a tungsten oxide or a molybdenum oxide; and a cyano group-containing compound, such as Compound HT-D1 below, but are not limited thereto.



Compound HT-D1



F4-TCNQ

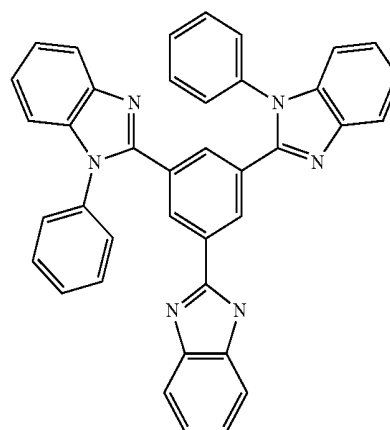
[0181] The hole transport region may further include a buffer layer.

[0182] The buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, and thus, light-emission efficiency of a formed organic light-emitting device may be improved.

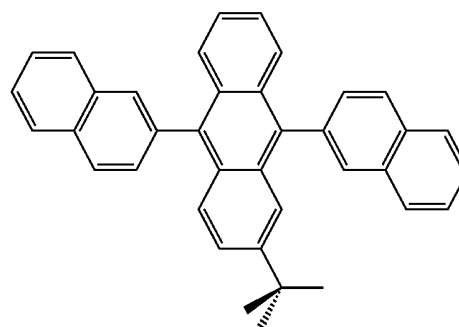
[0183] The EML may be formed on top of the hole transport region by using various methods, such as vacuum deposition, spin coating, casting, and an LB method. When the EML is formed by vacuum deposition and spin coating, the deposition and spin coating conditions may vary according to a compound that is used to form the EML, but in general, the deposition and spin coating conditions may be determined by referring to those applied to form the HIL.

[0184] The emission layer may include a host and a dopant, and the dopant may include the organometallic compound of Formula 1.

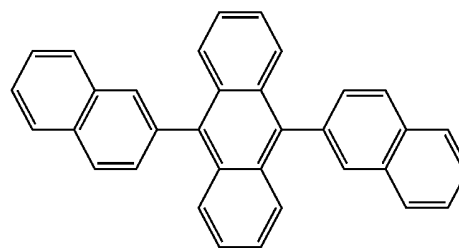
[0185] The host may include at least one of TPBi, TBADN, ADN (also referred to as "DNA"), CBP, CDBP, and TCP below:



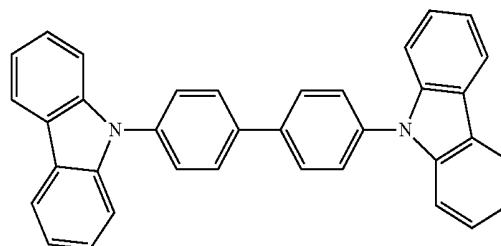
TPBi



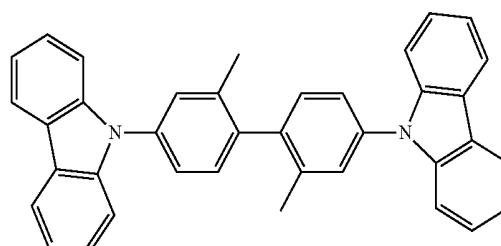
TBADN



ADN

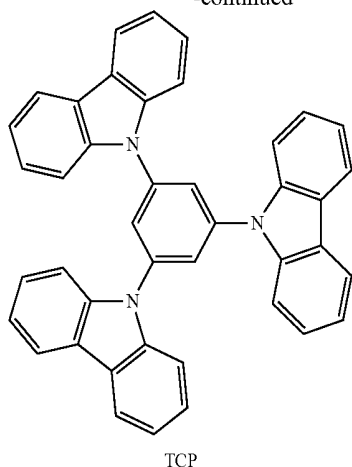


CBP



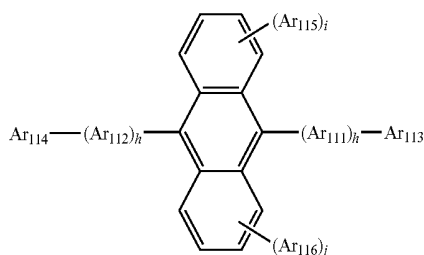
CDBP

-continued



[0186] Alternatively, the host may further include a compound represented by Formula 301 below:

Formula 301



[0187] In Formula 301, Ar_{111} and Ar_{112} may be each independently selected from

[0188] a phenylene group, a naphthylene group, a phenanthrenylene group, and a pyrenylene group; and

[0189] a phenylene group, a naphthylene group, a phenanthrenylene group, and a pyrenylene group, each substituted with at least one of a phenyl group, a naphthyl group, and an anthracenyl group.

[0190] In Formula 301, Ar_{113} to Ar_{116} may be each independently selected from

[0191] a C_1 - C_{10} alkyl group, a phenyl group, a naphthyl group, a phenanthrenyl group, and a pyrenyl group; and

[0192] a phenyl group, a naphthyl group, a phenanthrenyl group, and a pyrenyl group, each substituted with at least one of a phenyl group, a naphthyl group, and an anthracenyl group.

[0193] In Formula 301, g, h, i, and j may be each independently an integer of 0 to 4, and for example, may be 0, 1, or 2.

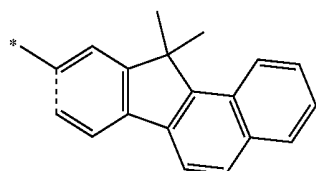
[0194] In Formula 301, Ar_{113} to Ar_{116} may be each independently selected from

[0195] a C_1 - C_{10} alkyl group substituted with at least one of a phenyl group, a naphthyl group, and an anthracenyl group;

[0196] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group;

[0197] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano

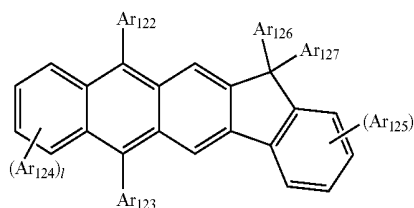
group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group; and



but are not limited thereto.

[0198] Alternatively, the host may include a compound represented by Formula 302 below:

Formula 302



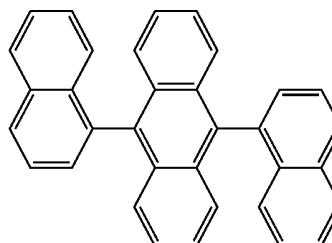
[0199] In Formula 302, Ar_{122} to Ar_{125} may be understood by referring to the description provided in connection with Ar_{113} in Formula 301.

[0200] In Formula 302, Ar_{126} and Ar_{127} may be each independently a C_1 - C_{10} alkyl group (e.g., a methyl group, an ethyl group, or a propyl group).

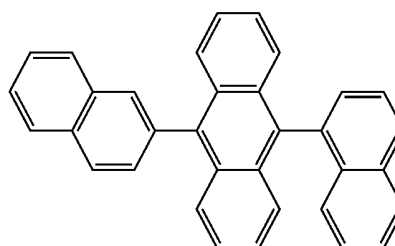
[0201] In Formula 302, k and l may be each independently an integer of 0 to 4. For example, in Formula 302, k and l may be each independently 0, 1, or 2.

[0202] The compound of Formula 301 and the compound of Formula 302 may include Compounds H1 to H42 below, but are not limited thereto:

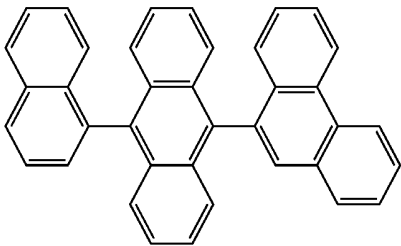
H1



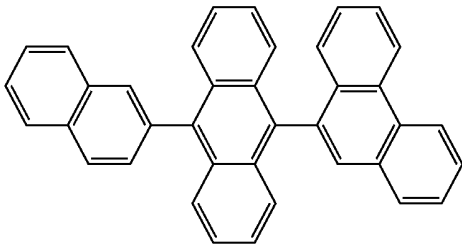
H2



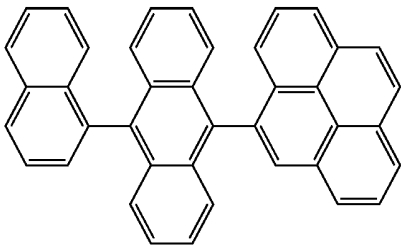
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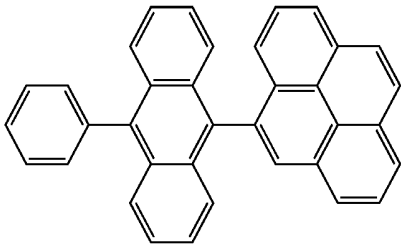
H3



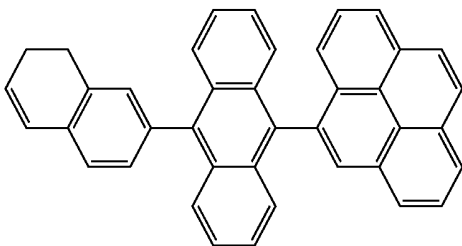
H4



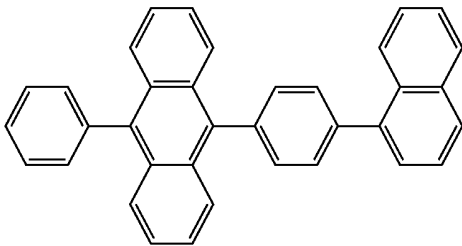
H5



H6

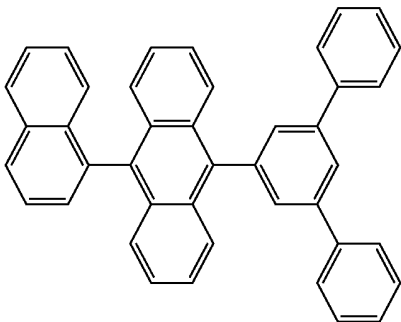


H7

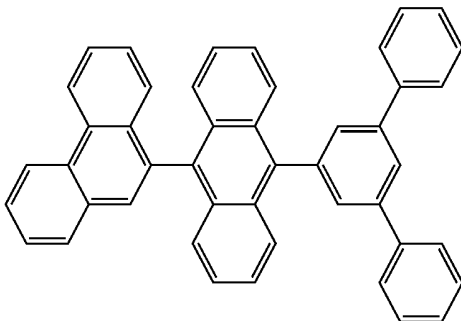


H8

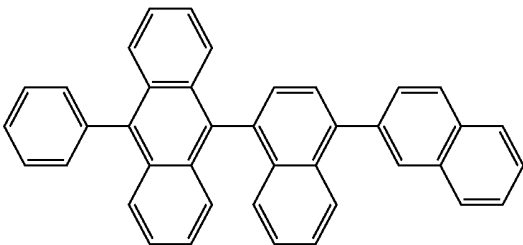
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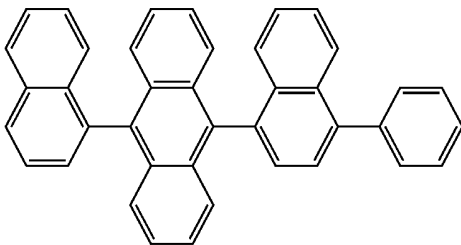
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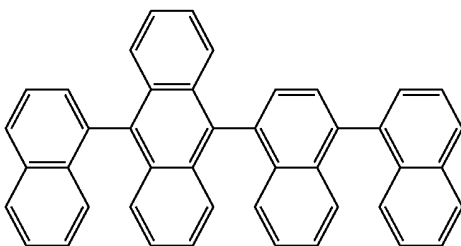
H10



H11



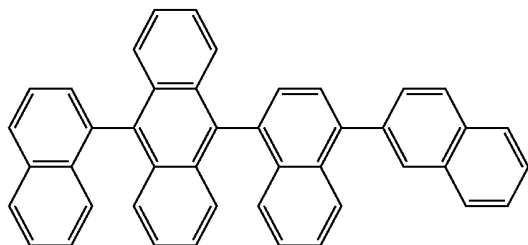
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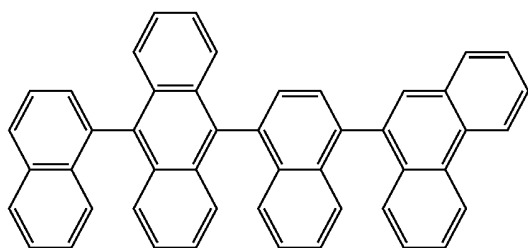
H13

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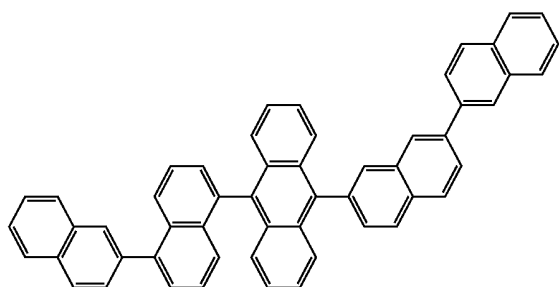
H14



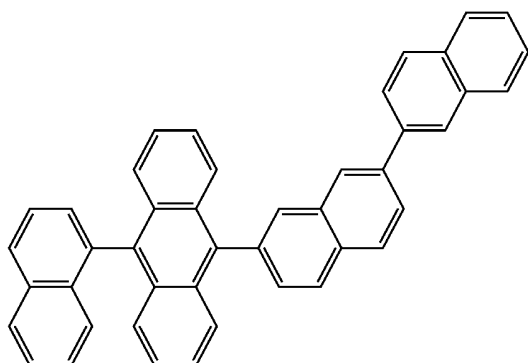
H15



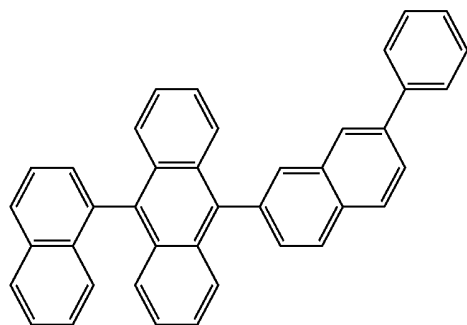
H16



H17

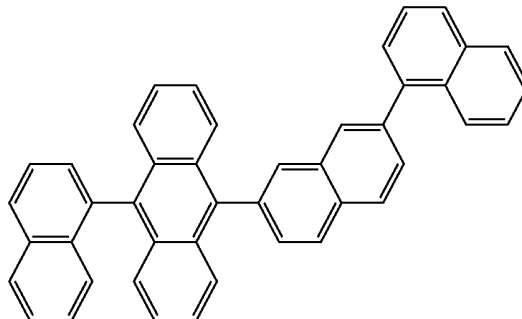


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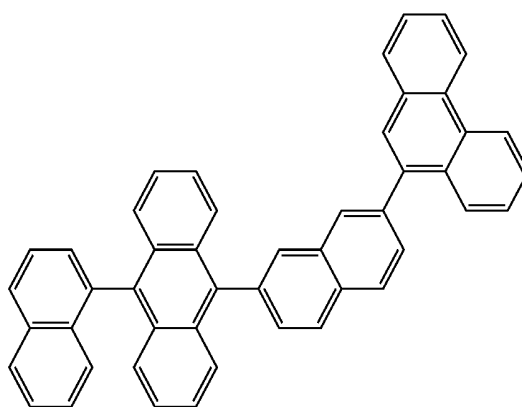


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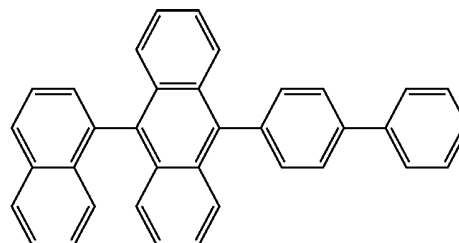
H19



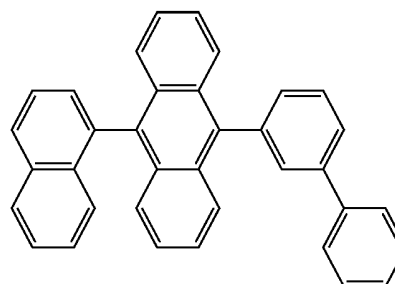
H20



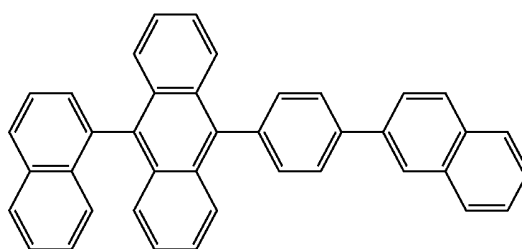
H21



H22

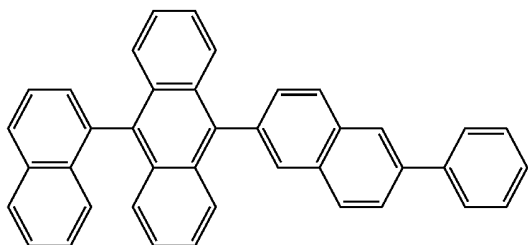


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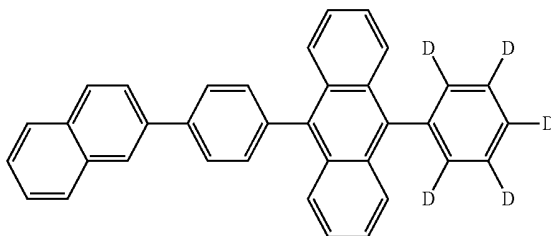
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H24

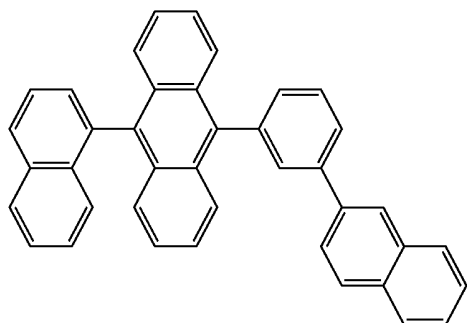


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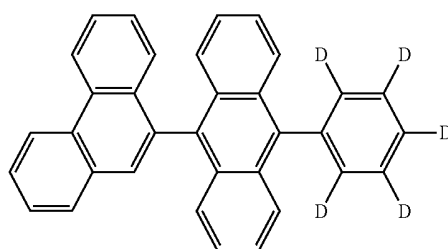
H29



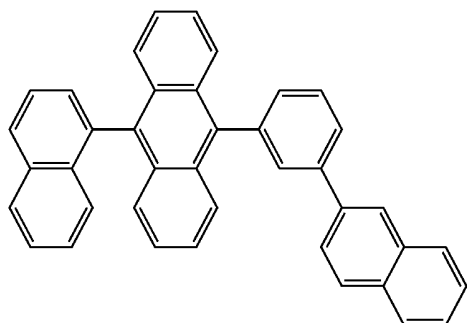
H25



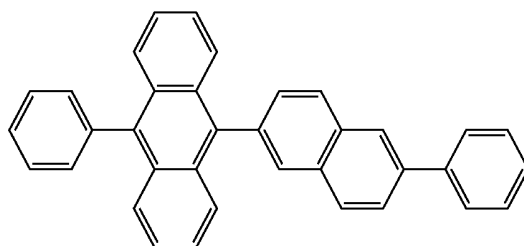
H30



H26

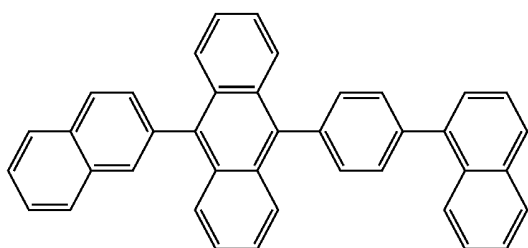


H31

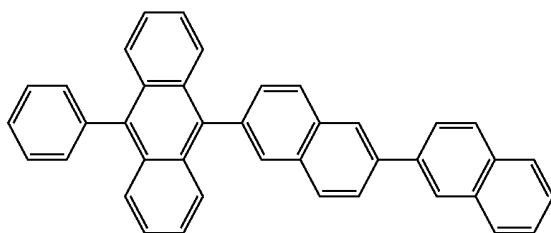


H32

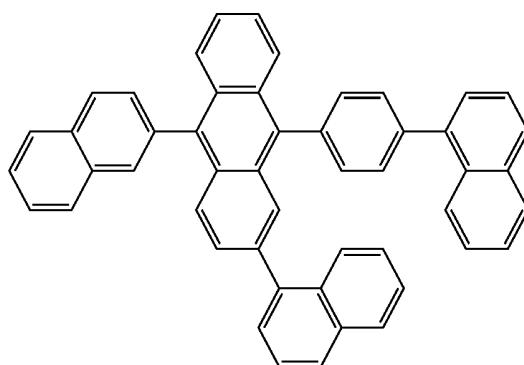
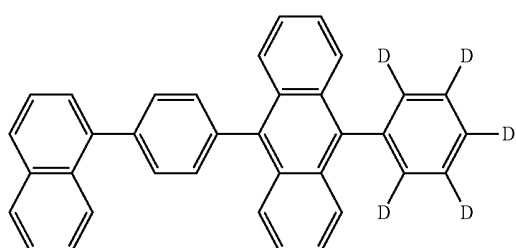
H27



H33

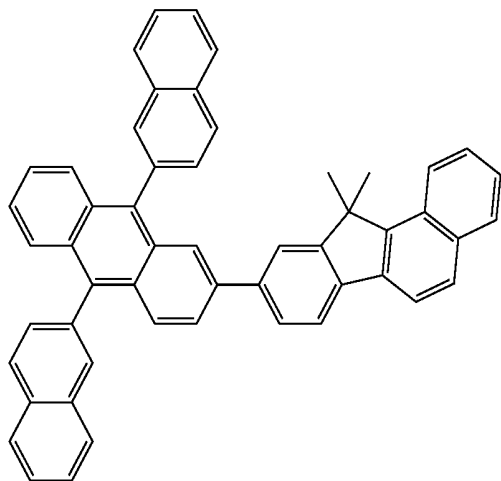


H28



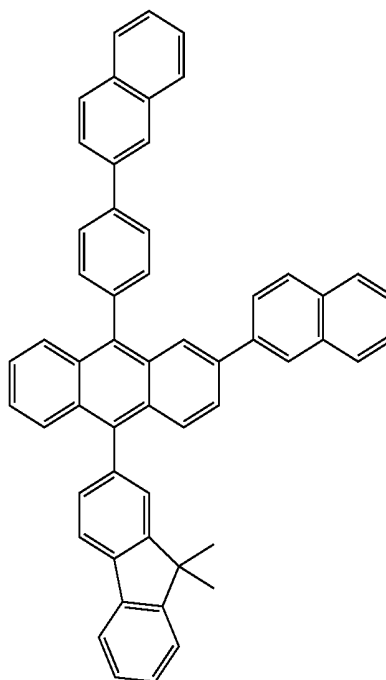
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H34

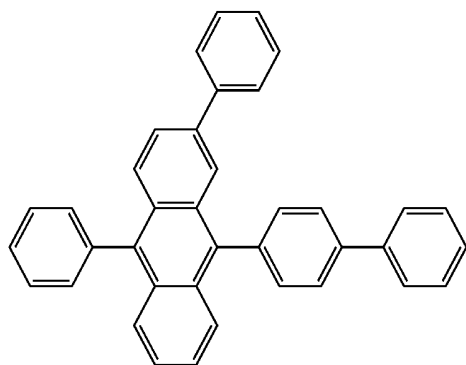


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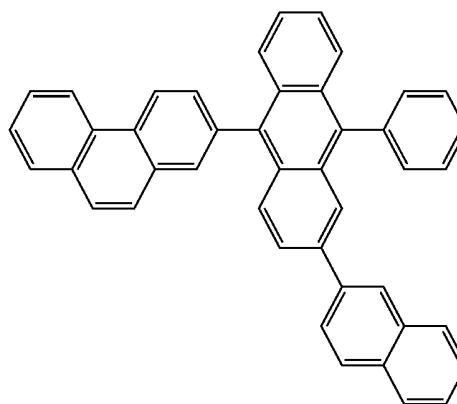
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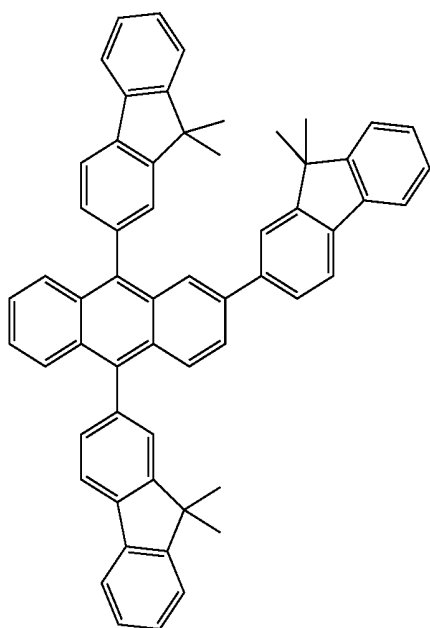
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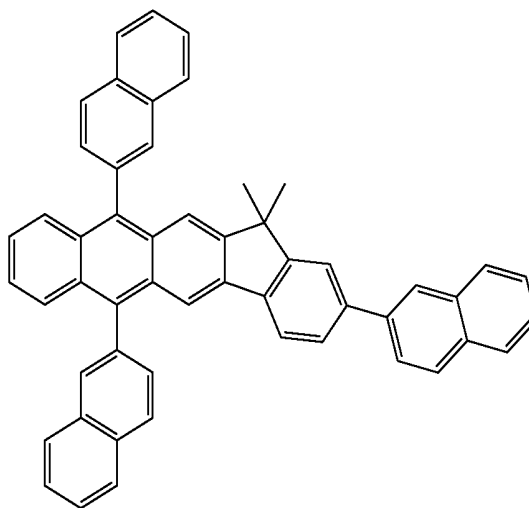
H38



H36

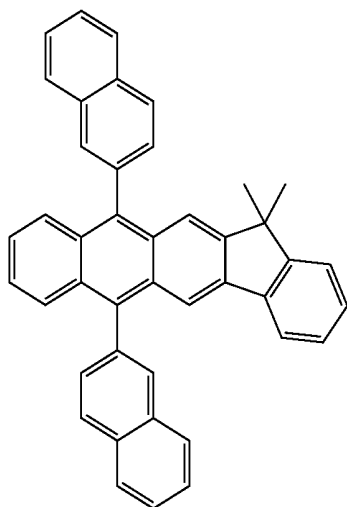


H39

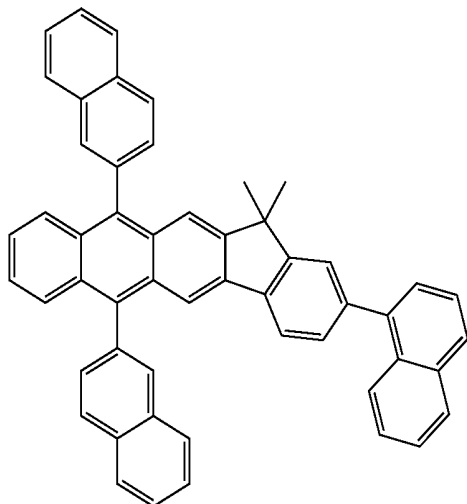


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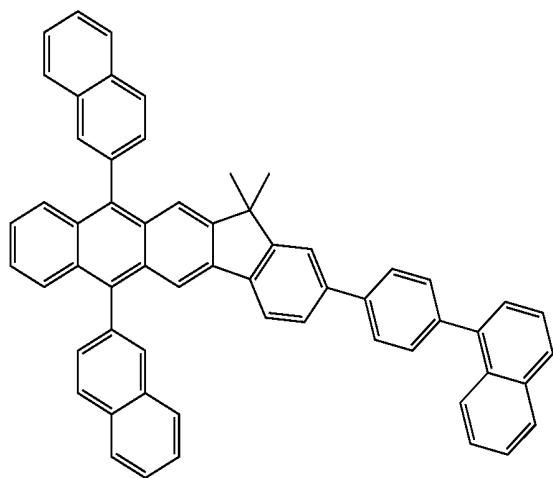
H40



H41



H42



[0203] When the organic light-emitting device 10 is a full-color organic light-emitting device, the EML may be patterned into a red EML, a green EML, and a blue EML. In some embodiments, due to a stacked structure of a red EML, a green EML, and/or a blue EML, the EML may emit white light.

[0204] When the EML includes a host and a dopant, an amount of the dopant may be in a range of about 0.01 to

about 15 parts by weight based on 100 parts by weight of the host, but is not limited thereto.

[0205] A thickness of the EML may be in a range of about 100 Angstroms (Å) to about 1,000 Å, for example, a range of about 200 Å to about 600 Å. While not wishing to be bound by a theory, it is believed that when the thickness of the EML is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

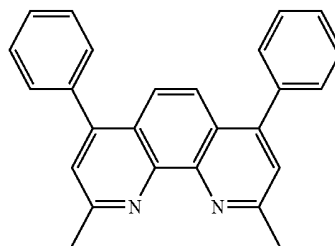
[0206] Then, an electron transport region may be disposed on top of the EML.

[0207] The electron transport region may include at least one of a HBL, an ETL, and an EIL.

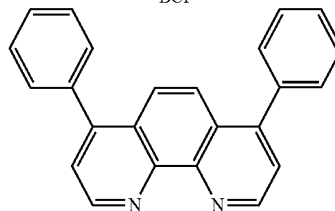
[0208] For example, the electron transport region may have a structure of HBL/ETL/EIL or a structure of ETL/EIL, but the structure is not limited thereto. The ETL may have a single-layer structure or a multi-layer structure consisting of two or more different layers.

[0209] Conditions for forming a HBL, an ETL, and an EIL in the electron transport region may be understood by referring to those applied to form the HIL.

[0210] When the electron transport region includes an HBL, the HBL may include, for example, at least one of BCP and Bphen below, but is not limited thereto:



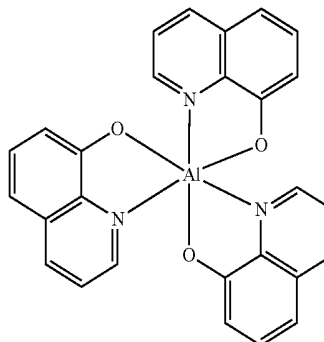
BCP



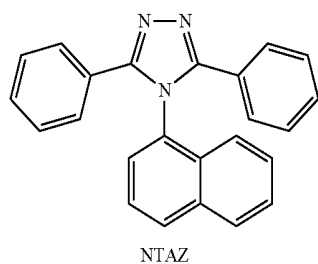
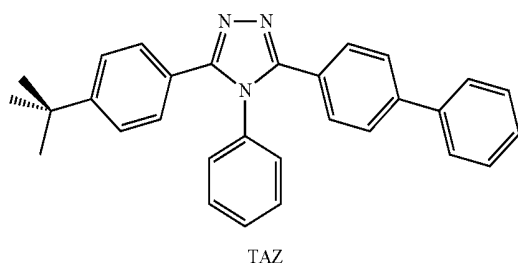
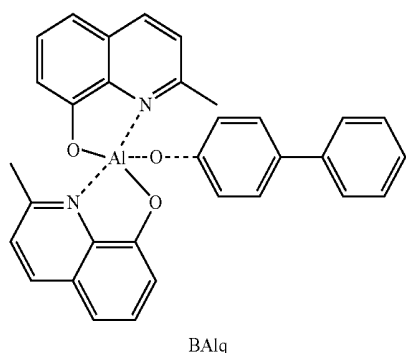
Bphen

[0211] A thickness of the HBL may be in a range of about 20 Å to about 1,000 Å, for example, a range of about 30 Å to about 300 Å. While not wishing to be bound by a theory, it is believed that when the thickness of the HBL is within this range, excellent hole blocking characteristics may be obtained without a substantial increase in driving voltage.

[0212] The ETL may further include at least one of BCP, Bphen (shown above), Alq₃, Balq, TAZ, and NTAZ below:

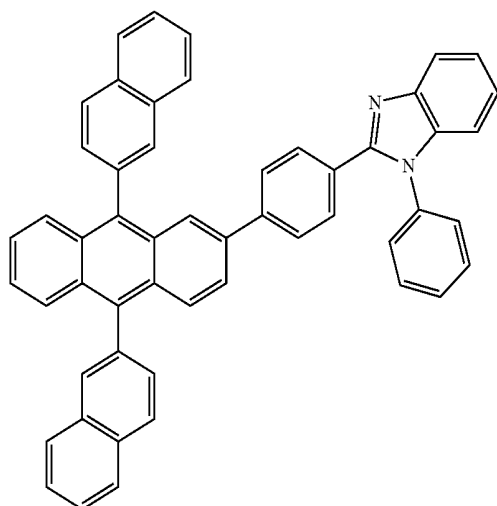
Alq₃

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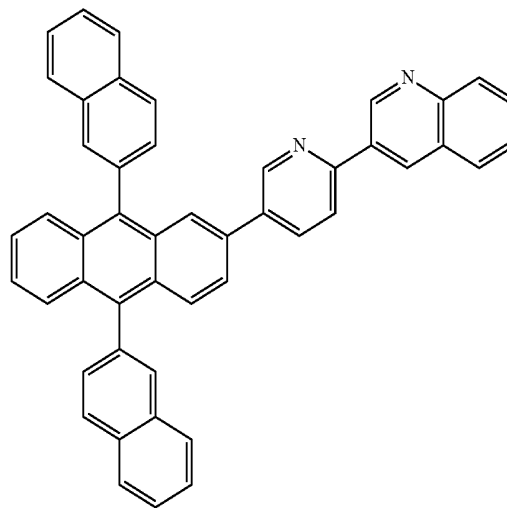
[0213] Alternatively, the ETL may include at least one of Compounds ET1 and ET2 below, but is not limited thereto:

ET1



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ET2

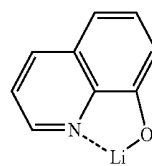


[0214] A thickness of the ETL may be in a range of about 100 Å to about 1,000 Å, for example, a range of about 150 Å to about 500 Å. While not wishing to be bound by a theory, it is believed that when the thickness of the ETL is within this range, satisfactory electron transporting characteristics may be obtained without a substantial increase in driving voltage.

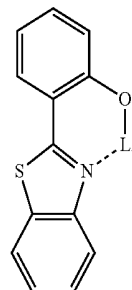
[0215] The ETL may further include, in addition to these materials, a metal-containing material.

[0216] The metal-containing material may be a lithium (Li) complex. The Li complex may include, for example, Compound ET-D1 (e.g., lithium quinolate (LiQ)) or Compound ET-D2 below:

ET-D1



ET-D2



[0217] In addition, the electron transport region may include an EIL that facilitates electron injection from the second electrode 19.

[0218] The EIL may include at least one selected from LiF, NaCl, CsF, Li₂O, and BaO.

[0219] A thickness of the EIL may be in a range of about 1 Å to about 100 Å, for example, a range of about 3 Å to about 90 Å. While not wishing to be bound by a theory, it

is believed that when the thickness of the EIL is within this range, satisfactory electron injecting characteristics may be obtained without a substantial increase in driving voltage.

[0220] The second electrode **19** may be disposed on top of the organic layer **15**, and the second electrode **19** may be a cathode. A material for forming the second electrode **19** may be metal, an alloy, an electrically conductive compound, or a combination thereof, which has a relatively low work function. Detailed examples of the material for forming the second electrode **19** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), and magnesium-silver (Mg-Ag). Alternatively, to manufacture a top emission type light-emitting device, a transmissive electrode formed of ITO or IZO may be used as the second electrode **19**.

[0221] Hereinbefore, the organic light-emitting device **10** has been described with reference to FIG. 1, but is not limited thereto.

[0222] A C_1 - C_{60} alkyl group as used herein refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms. Detailed examples thereof are a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. A C_1 - C_{60} alkylene group as used herein refers to a divalent group having the same structure as the C_1 - C_{60} alkyl group.

[0223] A C_1 - C_{60} alkoxy group as used herein refers to a monovalent group represented by $-OA_{101}$ (wherein A_{101} is the C_1 - C_{60} alkyl group). Detailed examples thereof are a methoxy group, an ethoxy group, and an isopropoxy group.

[0224] A C_2 - C_{60} alkenyl group as used herein refers to a hydrocarbon group formed by introducing at least one carbon-carbon double bond in the middle or at the terminal of the C_2 - C_{60} alkyl group. Detailed examples thereof are an ethenyl group, a propenyl group, and a butenyl group. A C_2 - C_{60} alkenylene group as used herein refers to a divalent group having the same structure as the C_2 - C_{60} alkenyl group.

[0225] A C_2 - C_{60} alkynyl group as used herein refers to a hydrocarbon group formed by introducing at least one carbon-carbon triple bond in the middle or at the terminal of the C_2 - C_{60} alkyl group. Detailed examples thereof are an ethynyl group and a propynyl group. A C_2 - C_{60} alkynylene group as used herein refers to a divalent group having the same structure as the C_2 - C_{60} alkynyl group.

[0226] A C_3 - C_{10} cycloalkyl group as used herein refers to a saturated monovalent hydrocarbon monocyclic group having 3 to 10 carbon atoms. Detailed examples thereof are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C_3 - C_{10} cycloalkylene group as used herein refers to a divalent group having the same structure as the C_3 - C_{10} cycloalkyl group.

[0227] A C_1 - C_{10} heterocycloalkyl group as used herein refers to a monovalent monocyclic group having at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 2 to 10 carbon atoms. Detailed examples thereof are a tetrahydrofuranyl group and a tetrahydrothiophenyl group. A C_1 - C_{10} heterocycloalkylene group as used herein refers to a divalent group having the same structure as the C_1 - C_{10} heterocycloalkyl group.

[0228] A C_3 - C_{10} cycloalkenyl group as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one double bond in the ring thereof, and which is not aromatic. Detailed examples thereof are a

cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C_3 - C_{10} cycloalkenylene group as used herein refers to a divalent group having the same structure as the C_3 - C_{10} cycloalkenyl group.

[0229] A C_1 - C_{10} heterocycloalkenyl group as used herein refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom, 1 to 10 carbon atoms and at least one double bond in its ring. Detailed examples of the C_1 - C_{10} heterocycloalkenyl group are a 2,3-dihydrofuranyl group and a 2,3-dihydrothiophenyl group. A C_1 - C_{10} heterocycloalkenylene group as used herein refers to a divalent group having the same structure of the C_1 - C_{10} heterocycloalkenyl group.

[0230] A C_6 - C_{60} aryl group as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and a C_6 - C_{60} arylene group as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Detailed examples of the C_6 - C_{60} aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6 - C_{60} aryl group and the C_6 - C_{60} arylene group each include two or more rings, the rings may be fused to each other.

[0231] A C_1 - C_{60} heteroaryl group as used herein refers to a monovalent group having a carbon cyclic aromatic system that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 1 to 60 carbon atoms. A C_1 - C_{60} heteroarylene group as used herein refers to a divalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 1 to 60 carbon atoms. Detailed examples of the C_1 - C_{60} heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1 - C_{60} heteroaryl group and the C_1 - C_{60} heteroarylene group each include two or more rings, the rings may be fused to each other.

[0232] A C_6 - C_{60} aryloxy group as used herein refers to a monovalent group represented by $-OA_{102}$ (wherein A_{102} is the C_6 - C_{60} aryl group), and a C_6 - C_{60} arylthio group as used herein refers to a monovalent group represented by $-SA_{103}$ (wherein A_{103} is the C_6 - C_{60} aryl group).

[0233] A monovalent non-aromatic condensed polycyclic group as used herein refers to a monovalent group (for example, having 8 to 60 carbon atoms) that has two or more rings condensed to each other, only carbon atoms as a ring-forming atom, and which is non-aromatic in the entire molecular structure. A detailed example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0234] A monovalent non-aromatic condensed heteropolycyclic group as used herein refers to a monovalent group (for example, having 1 to 60 carbon atoms) that has two or more rings condensed to each other, a heteroatom selected from N, O, P, and S, other than carbon atoms, as a ring-forming atoms, and which is non-aromatic in the entire molecular structure. A detailed example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazoyl group. A divalent non-aromatic condensed heteropolycyclic group as used herein refers to a divalent group

having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0235] At least one of substituents of the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0236] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and C_1 - C_{60} alkoxy group;

[0237] a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q_{11})(Q_{12}), —Si(Q_{13})(Q_{14})(Q_{15}), and —B(Q_{16})(Q_{17});

[0238] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0239] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q_{21})(Q_{22}), —Si(Q_{23})(Q_{24})(Q_{25}), and —B(Q_{26})(Q_{27}); and

[0240] —N(Q_{31})(Q_{32}), —Si(Q_{33})(Q_{34})(Q_{35}), and —B(Q_{36})(Q_{37}),

[0241] wherein Q_1 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0242] For example, at least one of substituents of the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0243] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group;

[0244] a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-

nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{Si}(\text{Q}_{13})(\text{Q}_{14})(\text{Q}_{15})$, and $-\text{B}(\text{Q}_{16})(\text{Q}_{17})$;

[0245] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0246] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imida-

zopyrimidinyl group, each substituted with at least one of a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{N}(\text{Q}_{21})(\text{Q}_{22})$, $-\text{Si}(\text{Q}_{23})(\text{Q}_{24})(\text{Q}_{25})$, and $-\text{B}(\text{Q}_{26})(\text{Q}_{27})$; and

[0247] $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$, and $-\text{B}(\text{Q}_{36})(\text{Q}_{37})$;

[0248] wherein Q_1 to Q_7 , Q_i to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} may be each independently selected from a hydrogen, a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a

quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

[0249] Hereinafter, a compound and an organic light-emitting device according to embodiments are described in

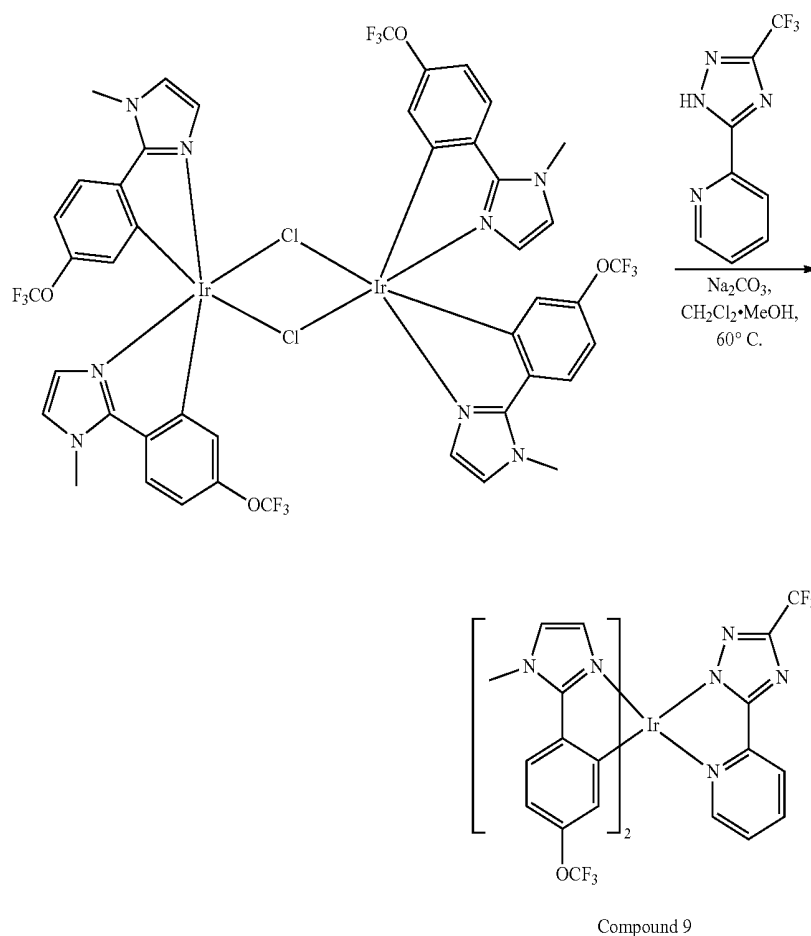
detail with reference to Synthesis Examples and Examples. However, the organic light-emitting device is not limited thereto. The wording “‘B’ was used instead of ‘A’” used in describing Synthesis Examples means that a molar equivalent of ‘A’ was identical to a molar equivalent of ‘B’.

EXAMPLE

Synthesis Example 1

Synthesis of Compound 9

[0250]

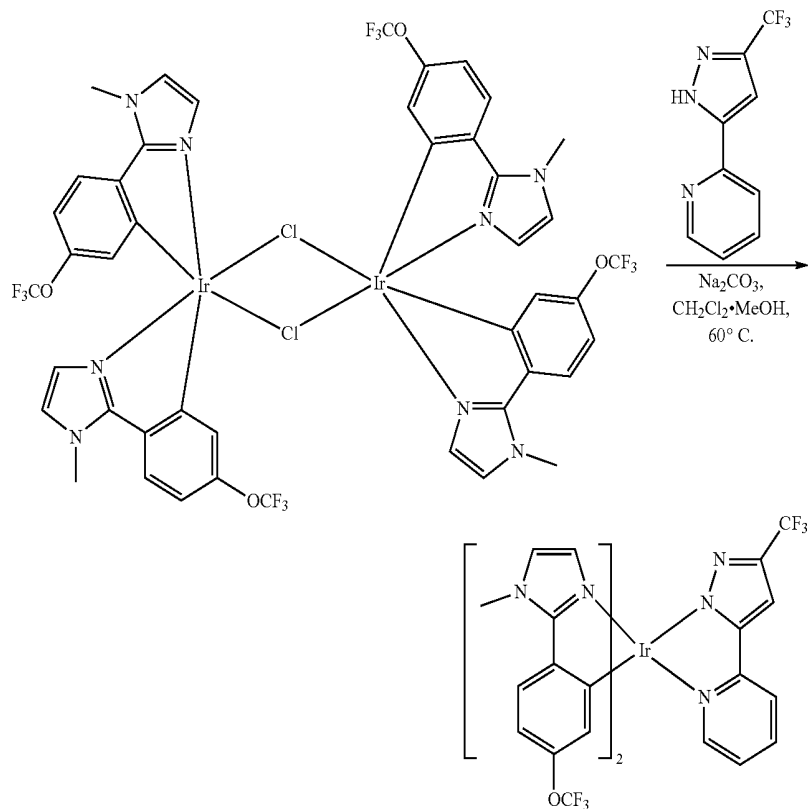


[0251] 1.420 grams (gm) (1 millimoles (mmol)) of 2-(4'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer $[\{(phenyl-imidazole)_2Ir(-Cl)_2\}]_2$ in a mixture of 450 milliliters (mL) of CH_2Cl_2 and 15 mL of MeOH was degassed for an hour. 0.473 milligrams (mg) (2.2 mmol) of CF_3 -pyridyltriazole and 1.0 gm (10 mmol) of sodium carbonate were added thereto, and the mixed solution was refluxed for 14 hours. The resultant obtained therefrom was cooled to room temperature, and an organic phase was washed with 30 to 50 mL of water and dried with $MgSO_4$ to obtain a crude product. The crude product was then purified by column chromatography to provide Compound 9 (yield: 72%).

[0252] NMR: 1H NMR (300 MHz, CD_2Cl_2 , room temperature (rt)): δ 7.63-7.81 (m, 4 H), 7.49-7.53 (m, 2 H), 6.94-6.98 (m, 2 H), 6.79-6.85 (m, 2 H), 6.15-6.28, (m, 4 H), 4.04 (s, 3 H), 4.02 (s, 3 H).

Synthesis Example 2
Synthesis of Compound 10

[0253]



Compound 10

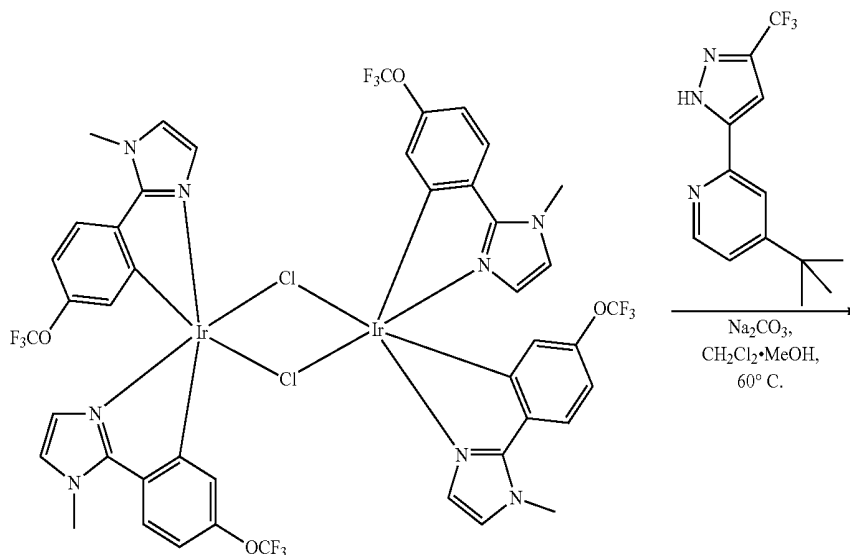
[0254] Compound 10 (yield: 76%) was synthesized in the same manner as in Synthesis Example 1, except that 0.468 mg (2.2 mmol) of CF₃-pyridylpyrazole was used instead of CF₃-pyridyltriazole.

[0255] ¹H NMR (300 MHz, CD₂Cl₂, rt): δ 7.63-7.81 (m, 4 H), 7.49-7.53 (m, 2 H), 6.94-6.98 (m, 2 H), 6.79-6.85 (m, 3 H), 6.15-6.28, (m, 4 H), 4.04 (s, 3 H), 4.02 (s, 3 H).

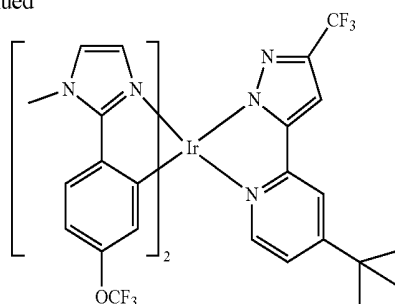
Synthesis Example 3

Synthesis of Compound 33

[0256]



-continued



Compound 33

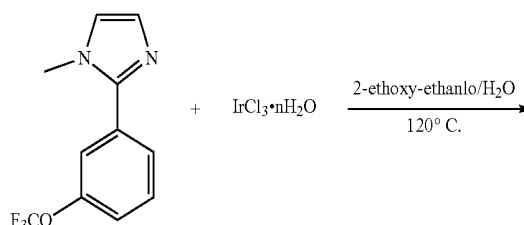
[0257] Compound 33 (yield: 78%) was synthesized in the same manner as in Synthesis Example 1, except that 0.592 mg (2.2 mmol) of tert-butyl-CF₃-pyridylpyrazole was used instead of CF₃-pyridyltriazole.

[0258] ¹H NMR (300 MHz, CD₂Cl₂, rt): δ 7.51-7.79 (m, 4 H), 6.82-6.97 (m, 6 H), 6.16-6.22 (m, 4 H), 4.05 (s, 6 H), 1.35 (s, 9 H).

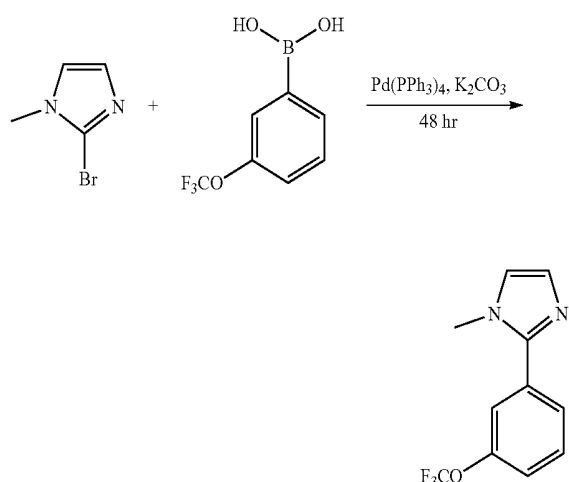
Synthesis Example 4

Synthesis of Compound 11

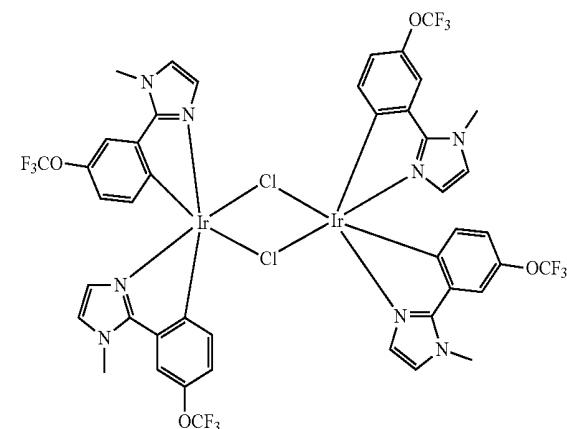
[0261] Synthesis of 2-(3'-trifluoromethoxyphenyl)methyl-imidazole-Ir-dimer



[0259] Synthesis of 2-(3'-trifluoromethoxyphenyl)methyl-imidazole

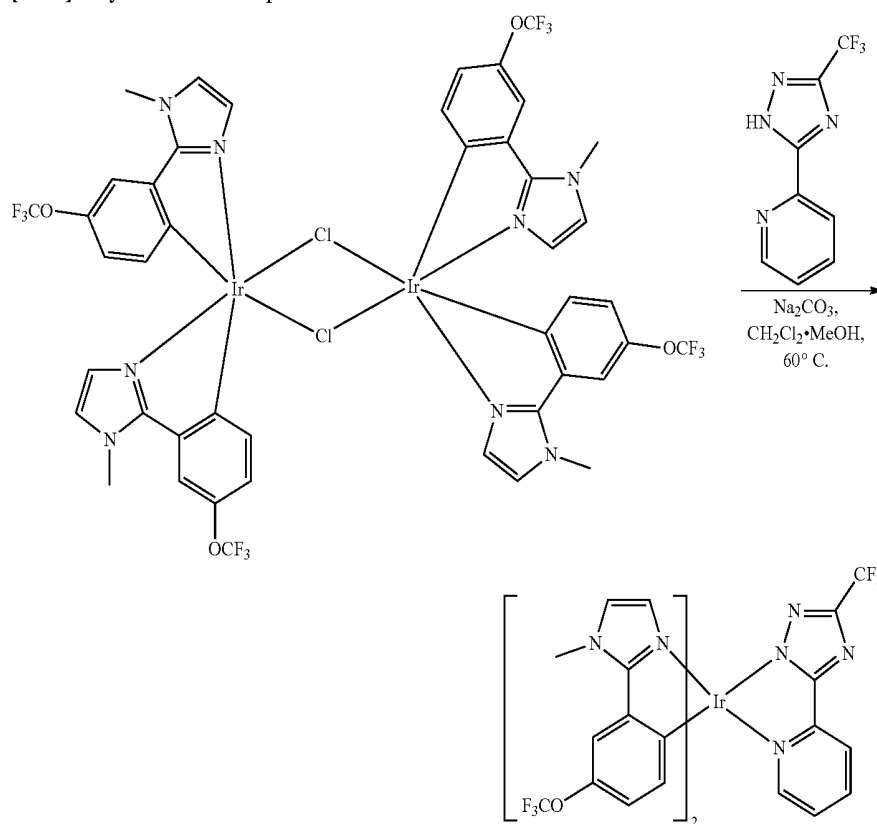


[0260] 0.800 g (4.9 mmol) of 2-bromo-1-methylimidazole, 1.38 g (5.8 mmol) of 3-(trifluoromethoxy)phenylboronic acid, 1.84 g (13.3 mmol) of K₂CO₃ were mixed with THF/water (30 mL/10 mL) at room temperature. 59 mg (0.051 mmol) of Pd(PPh₃)₄ was added thereto, and the mixed solution was stirred at a temperature of 85° C. for 48 hours to obtain a bright yellow solution. The bright yellow solution was then purified by silica chromatography (2×20 g, by sequentially using hexane/CH₂Cl₂/ether (1/1/1) and diethyl-ether) to provide 2-(3'-trifluoromethoxyphenyl)methylimidazole.



[0262] Under argon atmosphere and in the absence of light, 258 mg (0.739 mmol) of

[0263] IrCl₃·H₂O was mixed with 2-ethoxyethanol/water (at a volume ratio of 3/1, i.e., 10.5 mL/3.5 mL) at a temperature of 60° C. to obtain a purple solution. An excessive amount (400 mg, 1.65 mmol) of 2-(3'-trifluoromethoxyphenyl)methylimidazole was added to the obtained purple solution, and the mixed solution was then stirred overnight at a temperature of 120° C. The resultant obtained therefrom was cooled to room temperature, and 3 mL of water was slowly added thereto to form a precipitate. The precipitate was filtered and washed sequentially with ethanol/water (1/1), water, ethanol/water (1/1) again, and hexane in the stated order to provide 2-(3'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer (yield: 70%).

[0264] Synthesis of Compound 11

Compound 11

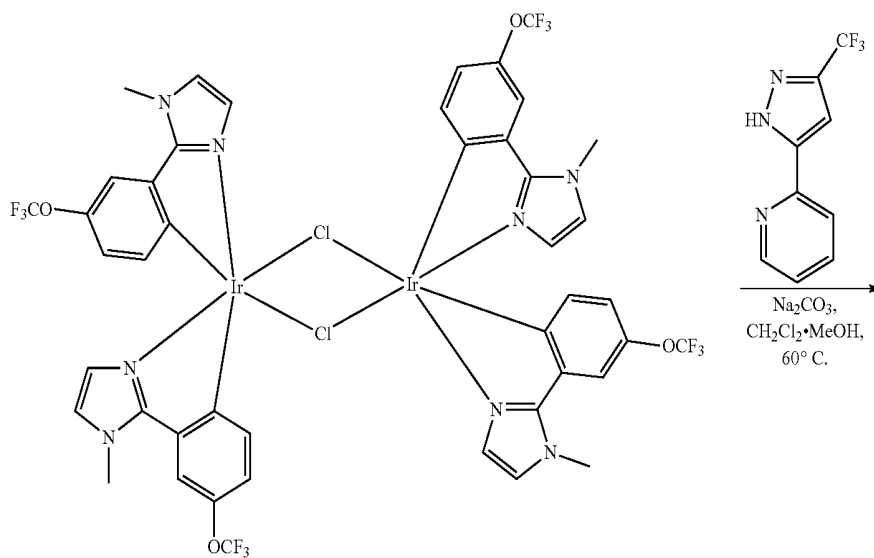
[0265] Compound 11 (yield: 65%) was synthesized in the same manner as in synthesis of Compound 9 (Synthesis Example 1), except that 1.420 gm (1 mmol) of 2-(3'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer was used instead of 2-(4'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer.

[0266] ^1H NMR (300 MHz, CD_2Cl_2 , rt): δ 7.67-7.69 (m, 2 H), 6.31-7.37 (m, 2 H), 6.93-7.00 (m, 2 H), 6.72-6.85 (m,

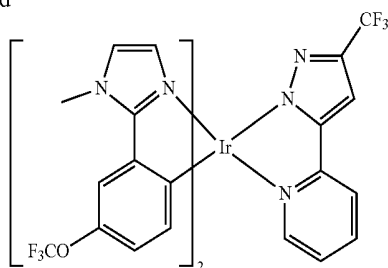
4 H), 6.48-6.52 (m, 2 H), 6.23 (s, 1 H), 6.16 (s, 1 H), 4.07 (s, 3 H), 4.03 (s, 3 H).

Synthesis Example 5

Synthesis of Compound 12

[0267]

-continued



Compound 12

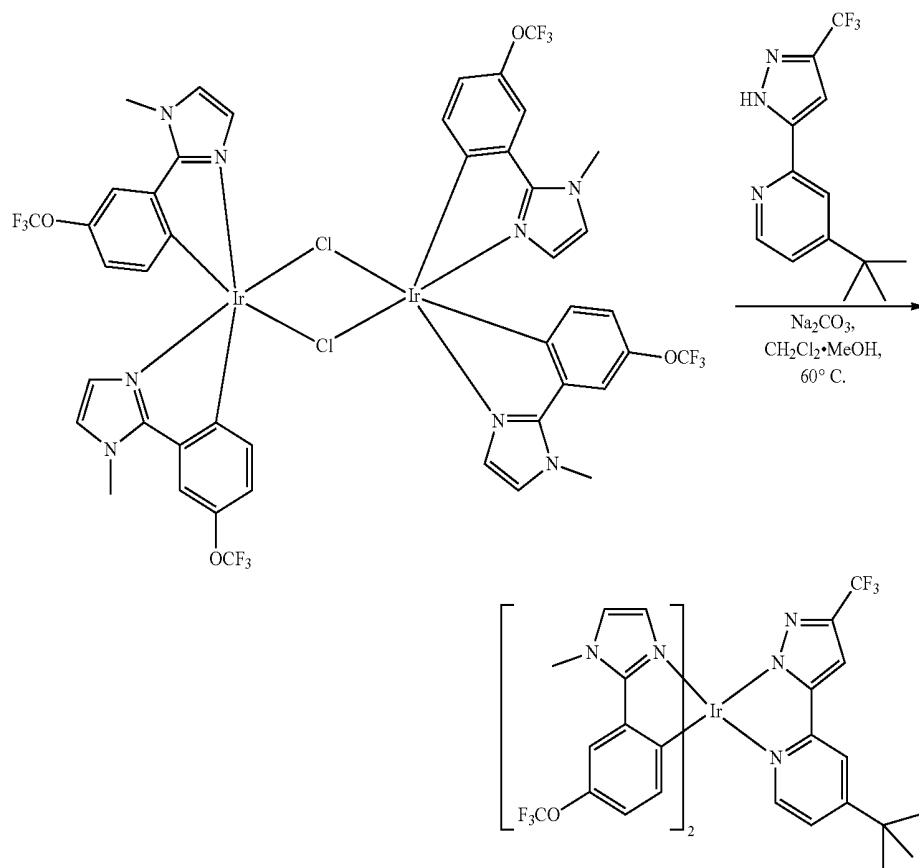
[0268] Compound 12 (yield: 79%) was synthesized in the same manner as in Synthesis Example 4, except that 0.468 mg (2.2 mmol) of CF₃-pyridylpyrazole was used instead of CF₃-pyridyltriazole.

[0269] ¹H NMR (300 MHz, CD₂Cl₂, rt): δ 7.67-7.69 (m, 2 H), 6.31-7.37 (m, 2 H), 6.93-7.00 (m, 2 H), 6.72-6.85 (m,

4 H), 6.48-6.52 (m, 3 H), 6.23 (s, 1 H), 6.16 (s, 1 H), 4.07 (s, 3 H), 4.03 (s, 3 H).

Synthesis Example 6

Synthesis of Compound 34

[0270]

Compound 34

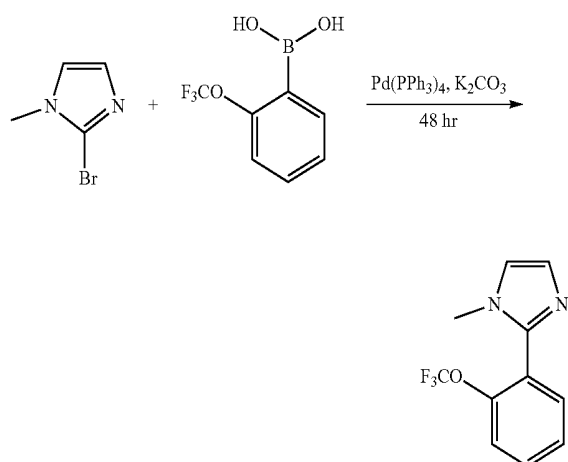
[0271] Compound 34 (yield: 71%) was synthesized in the same manner as in Synthesis Example 4, except that 0.592 mg (2.2 mmol) of tert-butyl-CF₃-pyridylpyrazole was used instead of CF₃-pyridyltriazole.

[0272] ¹H NMR (300 MHz, CD₂Cl₂, rt): δ 7.67-7.69 (m, 2 H), 6.31-7.37 (m, 2 H), 6.93-7.00 (m, 2 H), 6.72-6.85 (m, 4 H), 6.48-6.52 (m, 2 H), 6.23 (s, 1 H), 6.16 (s, 1 H), 4.07 (s, 3 H), 4.03 (s, 3 H), 1.31 (s, 9 H).

Synthesis Example 7

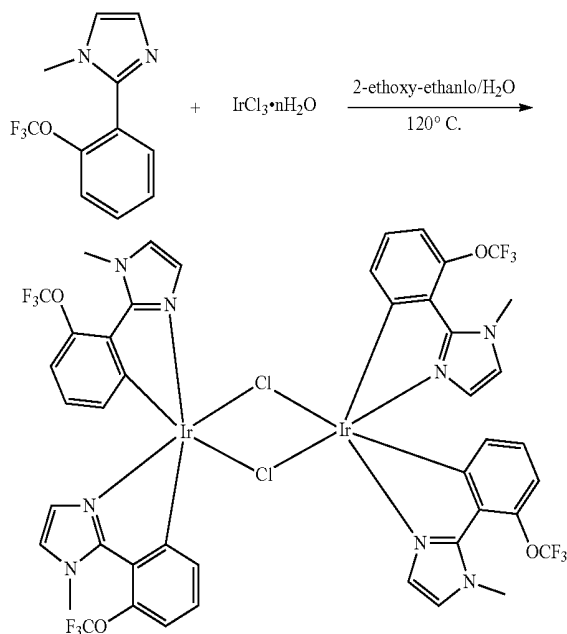
Synthesis of Compound 13

[0273] Synthesis of 2-(2'-trifluoromethoxyphenyl)methylimidazole



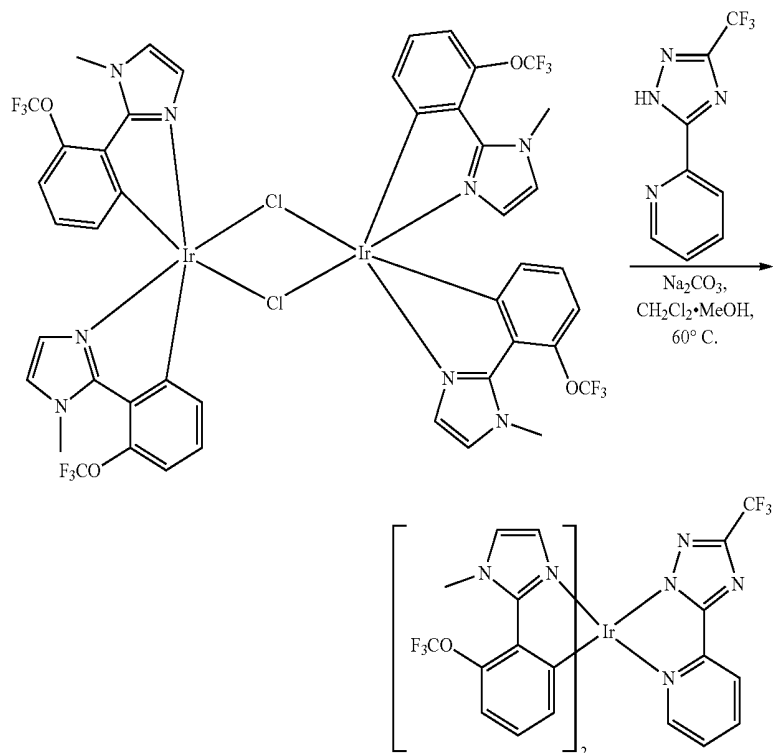
[0274] 2-(2'-trifluoromethoxyphenyl)methylimidazole was synthesized in the same manner as in synthesis of 2-(3'-trifluoromethoxyphenyl)methylimidazole (Synthesis Example 4), except that 2-(trifluoromethoxy)phenyl boronic acid was used instead of 3-(trifluoromethoxy)phenylboronic acid.

[0275] Synthesis of 2-(2'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer



[0276] 2-(2'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer (yield: 54%) was synthesized in the same manner as in synthesis of 2-(3'-trifluoromethoxyphenyl)methylimidazole-Ir-dimer (Synthesis Example 4), except that 2-(2'-trifluoromethoxyphenyl)methylimidazole was used instead of 2-(3'-trifluoromethoxyphenyl)methylimidazole.

[0277] Synthesis of Compound 13



Compound 13

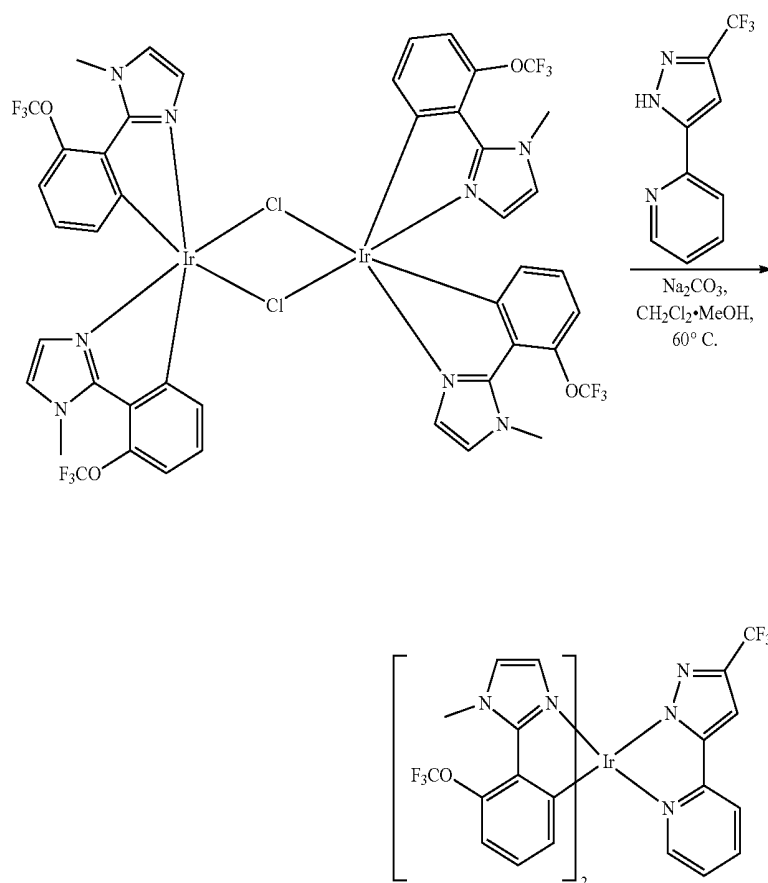
[0278] Compound 13 (yield: 54%) was synthesized in the same manner as in synthesis of Compound 9 (Synthesis Example 1), except that 1.420 gm (1 mmol) 2-(2'-trifluoromethoxyphenyl)methylimidazole-*Ir*-dimer was used instead of 2-(4'-trifluoromethoxyphenyl)methylimidazole-*Ir*-dimer.

[0279] ¹H NMR (300 MHz, CDCl₃, rt): δ 7.58-7.85 (m, 2 H), 7.47-7.54 (m, 2 H), 7.34-7.42 (m, 2 H), 7.16 (m, 4 H), 7.01 (m, 2 H), 6.55 (s, 1 H), 6.05 (s, 1 H), 3.55 (s, 3 H), 4.01 (s, 3 H).

Synthesis Example 8

Synthesis of Compound 14

[0280]



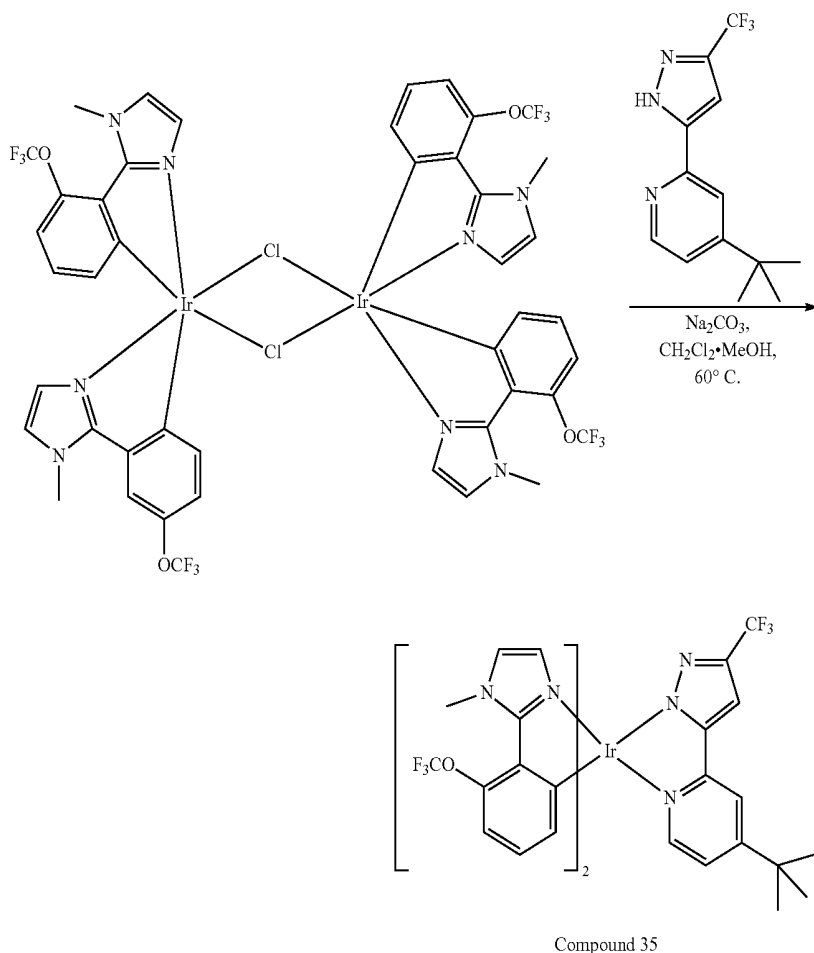
Compound 14

[0281] Compound 14 (yield: 54%) was synthesized in the same manner as in Synthesis Example 7, except that 0.468 gm (2.2 mmol) of CF₃-pyridylpyrazole was used instead of CF₃-pyridyltriazole.

[0282] ¹H NMR (300 MHz, CDCl₃, rt): δ 7.58-7.85 (m, 2 H), 7.47-7.54 (m, 2 H), 7.34-7.42 (m, 2 H), 7.16 (m, 4 H), 7.05 (m, 3 H), 6.55 (s, 1 H), 6.05 (s, 1 H), 3.55 (s, 3 H), 4.01 (s, 3 H).

Synthesis Example 9
Synthesis of Compound 35

[0283]



[0284] Compound 35 (yield: 71%) was synthesized in the same manner as in Synthesis Example 7, except that 0.592 mg (2.2 mmol) of tert-butyl-CF₃-pyridylpyrazole was used instead of CF₃-pyridylpyrazole.

[0285] ¹H NMR (300 MHz, CD₂Cl₂, rt): δ 7.58-7.85 (m, 2 H), 7.47-7.54 (m, 2 H), 7.34-7.42 (m, 2 H), 6.85-7.16 (m, 4 H), 7.01 (s, 1 H), 6.48-6.52 (m, 2 H), 6.16 (s, 1 H), 4.07 (s, 3 H), 4.03 (s, 3 H), 1.31 (s, 9 H).

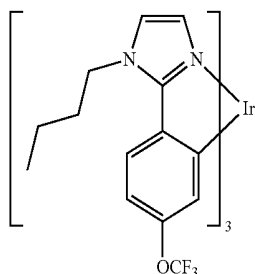
Evaluation Example

[0286] Compound 9 was diluted with toluene to a concentration of 10 millimolar (mM), and an ISC PC1 spectrofluorometer equipped with a Xenon lamp was used with respect to the diluted solution so as to measure photoluminescence (PL) spectrum of Compound 9 in solution. The same experiment procedure was repeated with respect to Compounds 10, 33, 11, 12, 34, 13, 14, and 35, and the results of the measurement, i.e., PL spectra of Compounds 9, 10, 33, 11, 12, 34, 13, 14, and 35, are shown in Table 2 below. In addition, PL spectra of Compounds 10, 33, 34, and 35 are each shown in FIGS. 2 to 5.

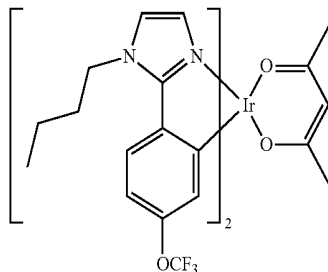
[0287] In addition, a CH₂Cl₂ solution in PMMA was mixed with 8 percent by weight (wt %) of Compound 9, and a mixture obtained therefrom was coated on a quartz substrate by using a spin coater. Then, the coated substrate was heat treated in an oven at a temperature of 80° C., cooled to room temperature so as to obtain a film. PL quantum yields (PLQY) and color coordinations of Compound 9 were evaluated by using the film. Regarding Compound 9, luminescence quantum yields in film and color coordination in film were evaluated according to a Hamamatsu Photonics absolute PL quantum yield measurement system that is equipped with a xenon light source, a monochromator, a photonic multichannel analyzer, and an integrating sphere, and employs a PLQY measurement software (Hamamatsu Photonics, Ltd., Shizuoka, Japan). The same experiment procedure was repeated with respect to Compounds 10, 33, 11, 12, 34, 13, 14, and 35 and Compounds A and B below, and as a result, luminescence quantum yields in film and color coordination in film regarding Compounds 9, 10, 33, 11, 12, 34, 13, 14, and 35 and Compounds A and B were evaluated and their data are shown in Table 2 below.

TABLE 2

Compound No.	Emission peak wavelength (T_{00} , nm)	PLQY (%)	CIE color coordination
9	458	76	(0.19, 0.31)
10	458	72	(0.20, 0.33)
33	458	80	(0.19, 0.31)
11	501	82	(0.19, 0.38)
12	505	80	(0.20, 0.36)
34	500	79	(0.25, 0.43)
13	509	79	(0.22, 0.38)
14	511	76	(0.22, 0.43)
35	502	81	(0.22, 0.45)
A	525	53	(0.173, 0.240)
B	539	0.0079	(0.197, 0.33)



Compound A



Compound B

[0288] From Table 2 and FIGS. 2 to 5, it was confirmed that Compounds 9, 10, 33, 11, 12, 34, 13, 14, and 35 had excellent luminescence quantum yields and color coordinations in comparison with those of Compounds A and B.

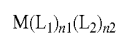
[0289] As described above, according to the one or more of the above embodiments of the present disclosure, an organometallic compound may have excellent electrical characteristics and thermal stability. In this regard, an organic light-emitting device including the organometallic compound may have low driving voltage, high efficiency, high brightness, and long lifespan characteristics.

[0290] It should be understood that the exemplary embodiments described therein 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.

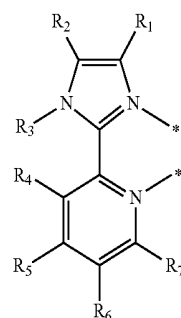
[0291] While one or more embodiments of the present disclosure have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the following claims.

What is claimed is:

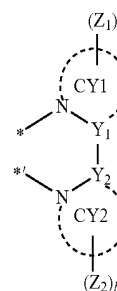
1. An organometallic compound represented by Formula 1:



Formula 1



Formula 2



Formula 3

wherein in Formulae 1 to 3,

M is Ir, Pt, Os, Ti, Zr, Hf, Eu, Tb, or Tm;

L_1 is selected from ligands represented by Formula 2;

L_2 is selected from ligands represented by Formula 3;

n_1 and n_2 are each independently 1 or 2, provided that a sum of n_1 and n_2 is 2 or 3;

when n_1 is 2, two or more groups L_1 are identical to or different from each other, and when n_2 is 2, two or more groups L_2 are identical to or different from each other;

R_1 to R_7 , Z_1 , and Z_2 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubsti-

tuted monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_1)(\text{Q}_2)$, $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$, and $-\text{B}(\text{Q}_6)(\text{Q}_7)$;
 at least one of R_1 to R_7 is a C_1 - C_4 alkoxy group substituted with at least one $-\text{F}$;
 a and b are each independently selected from an integer of 1 to 4;
 CY_1 and CY_2 are each independently a C_1 - C_{60} heterocyclic group having at least one nitrogen as a ring-forming atom;
 Y_1 and Y_2 are each independently C or N;
 N and Y_1 are linked with each other by a single bond or a double bond, and N and Y_2 are linked with each other by a single bond or a double bond;
 * and * indicate a binding site to M in Formula 1;
 at least one of substituents of the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from
 a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group;
 a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted with at least one of a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{Si}(\text{Q}_{13})(\text{Q}_{14})(\text{Q}_{15})$, and $-\text{B}(\text{Q}_{16})(\text{Q}_{17})$;
 a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;
 a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino

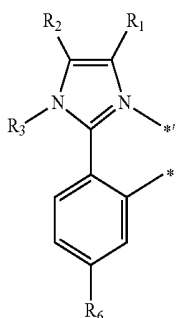
group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_{21})(\text{Q}_{22})$, $-\text{Si}(\text{Q}_{23})(\text{Q}_{24})(\text{Q}_{25})$, and $-\text{B}(\text{Q}_{26})(\text{Q}_{27})$; and $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$ and $-\text{B}(\text{Q}_{36})(\text{Q}_{37})$,
 wherein Q_1 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} are each independently selected from a hydrogen, a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.
 2. The organometallic compound of claim 1, wherein n_1 is 2 and n_2 is 1.
 3. The organometallic compound of claim 1, wherein R_1 to R_7 , Z_1 , and Z_2 are each independently selected from a hydrogen, a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;
 a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one of a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;
 a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a

- benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;
- a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅); and —Si(Q₃)(Q₄)(Q₅),
- wherein Q₃ to Q₅ and Q₃₃ to Q₃₅ are each independently selected from a hydrogen, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅); and
4. The organometallic compound of claim 1, wherein R₁ to R₇, Z₁, and Z₂ are each independently selected from a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;
- a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅); and —Si(Q₃)(Q₄)(Q₅),
- wherein Q₃ to Q₅ and Q₃₃ to Q₃₅ are each independently selected from a hydrogen, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅); and
5. The organometallic compound of claim 1, wherein R₂ is a hydrogen; R₁ is a hydrogen; both R₁ and R₂ are a hydrogen; or neither R₁ nor R₃ are a hydrogen.
6. The organometallic compound of claim 1, wherein at least one of R₁ to R₇ is selected from —OCH₂F, —OCHF₂, —OCF₃, —OC₂H₄F, OC₂H₃F₂, —OC₂H₂F₃, —OC₂HF₄, OC₂F₅, —OC₃H₆F, —OC₃H₅F₂, —OC₃H₄F₃, —OC₃H₃F₄, —OC₃H₂F₅, —OC₃HF₆, —OC₃F₇, —OC₄H₈F, —OC₄H₇F₂, —OC₄H₆F₃, —OC₄H₅F₄, —OC₄H₄F₅, —OC₄H₃F₆, —OC₄H₂F₇, —OC₄HF₈, and —OC₄F₉.
7. The organometallic compound of claim 1, wherein R₆ is a C₁-C₄ alkoxy group substituted with at least one —F; R₅ is a C₁-C₄ alkoxy group substituted with at least one —F; R₄ is a C₁-C₄ alkoxy group substituted with at least one —F; or R₄ and R₆ are each independently a C₁-C₄ alkoxy group substituted with at least one —F.
8. The organometallic compound of claim 1, wherein CY₁ and CY₂ are each independently a pyrrole, an imidazole, a pyrazole, a thiazole, an isothiazole, an oxazole, an isooxazole, a triazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, a quinoline, an isoquinoline, a benzoquinoline, a

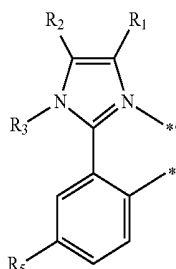
quinoxaline, a quinazoline, a benzoimidazole, a benzoxazole, an isobenzoxazole, a triazole, a tetrazole, an oxadiazole, a triazine, a benzofuopyridine, or a benzothienopyridine.

9. The organometallic compound of claim 1, wherein CY_1 is a triazole, an imidazole, or a pyrazole, and CY_2 is a pyridine, a pyrimidine, a triazine, a benzofuopyridine, or a benzothienopyridine.

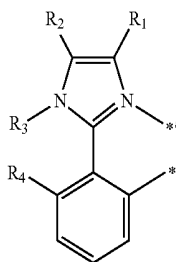
10. The organometallic compound of claim 1, wherein L_1 is selected from ligands represented by Formulae 2-1 to 2-4:



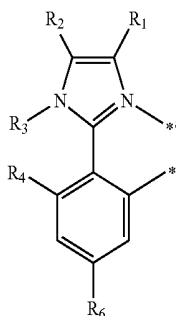
Formula 2-1



Formula 2-2



Formula 2-3



Formula 2-4

wherein in Formulae 2-1 to 2-4,

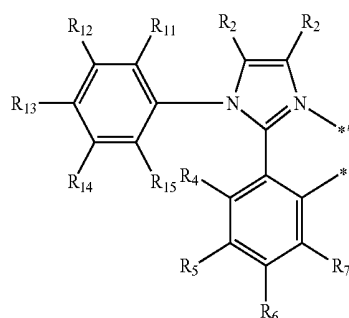
R_1 to R_3 are each independently selected from

a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q_{33})(Q_{34})(Q_{35}); and R_4 to R_6 are each independently a C_1 - C_4 alkoxy group substituted with at least one —F.

11. The organometallic compound of claim 1, wherein L_1 is selected from ligands represented by Formula 2(1):



Formula 2(1)

wherein in Formula 2(1),

R_1 , R_2 , R_4 to R_7 , and R_{11} to R_{15} are each independently selected from

a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy

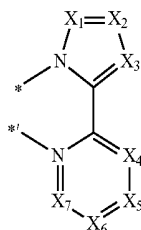
group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅),

wherein at least one of R₄ to R₇ is each independently a C₁-C₄ alkoxy group substituted with at least one —F; and

* and *' indicate a binding site to M.

12. The organometallic compound of claim 1, wherein L₂ is selected from ligands represented by Formula 3(1):



Formula 3(1)

wherein in Formula 3(1),

X₁ is N or C(Z₁₁); X₂ is N or C(Z₁₂); X₃ is N or C(Z₁₃); X₄ is N or C(Z₁₄); X₅ is N or C(Z₁₅); X₆ is N or C(Z₁₆); and X₇ is N or C(Z₁₇); and

Z₁₁ to Z₁₃ are the same as Z₁, and Z₁₄ to Z₁₇ are the same as Z₂.

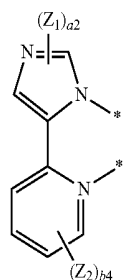
13. The organometallic compound of claim 12, wherein Z₁₁ to Z₁₇ are each independently selected from

a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

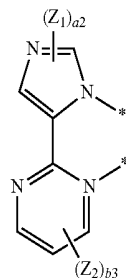
a methyl group, an ethyl group, a propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl

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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅).

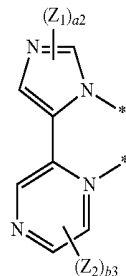
14. The organometallic compound of claim 1, wherein L₂ in Formula 1 is selected from ligands represented by Formulae 3-1 to 3-30:



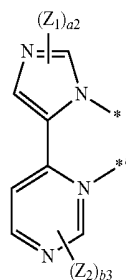
Formula 3-1



Formula 3-2

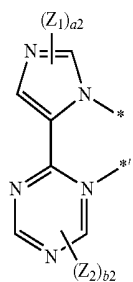


Formula 3-3



Formula 3-4

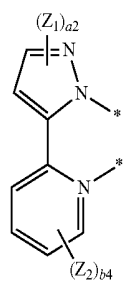
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Formula 3-5

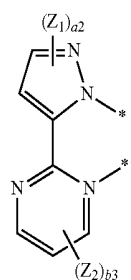
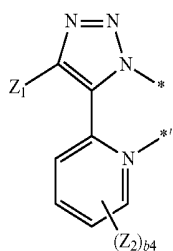
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Formula 3-11



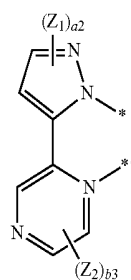
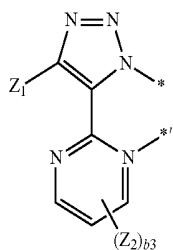
Formula 3-6

Formula 3-12



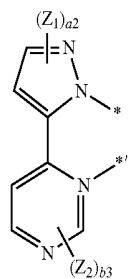
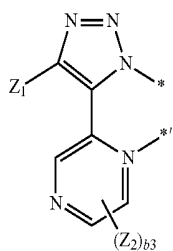
Formula 3-7

Formula 3-13



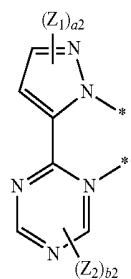
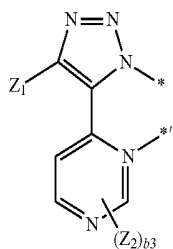
Formula 3-8

Formula 3-14



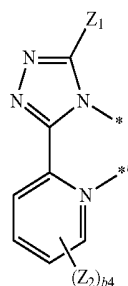
Formula 3-9

Formula 3-15

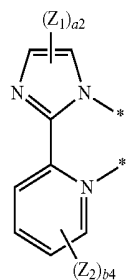


Formula 3-10

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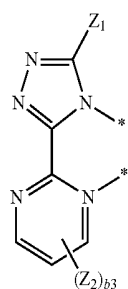


Formula 3-16

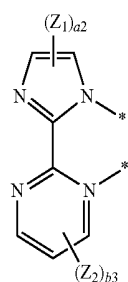


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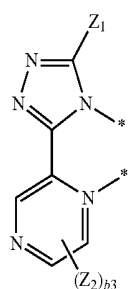
Formula 3-21



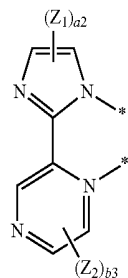
Formula 3-17



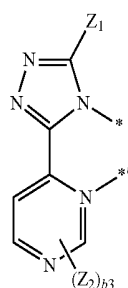
Formula 3-22



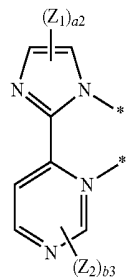
Formula 3-18



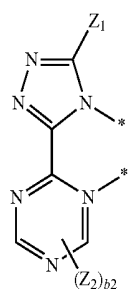
Formula 3-23



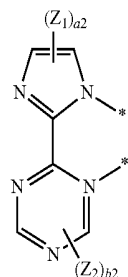
Formula 3-19



Formula 3-24

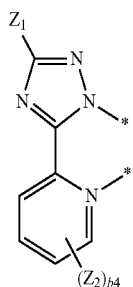


Formula 3-20

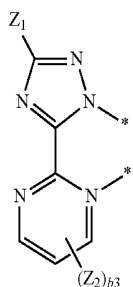


Formula 3-25

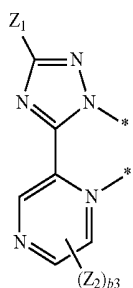
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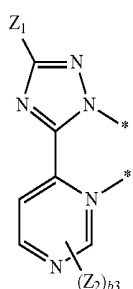
Formula 3-26



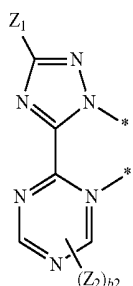
Formula 3-27



Formula 3-28



Formula 3-29



Formula 3-30

wherein in Formulae 3-1 to 3-30,

Z_1 and Z_2 are each independently selected from

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

group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

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

a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;

a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q_{33})(Q_{34})(Q_{35}), and —Si(Q_3)(Q_4)(Q_5);

wherein Q_3 to Q_5 and Q_{33} to Q_{35} are each independently selected from a hydrogen, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group, and

wherein

b4 is 1,2,3, or 4,

b3 is 1,2, or 3,

a2 and b2 are each independently 1 or 2; and

* and *' indicates a binding site to M in Formula 1.

15. The organometallic compound of claim 14, wherein Z_1 and Z_2 are each independently selected from

a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, a propyl 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group;

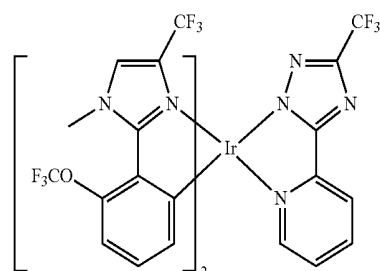
a methyl group, an ethyl group, a propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an 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-decanyl group, an isodecanyl group, a sec-decanyl group, a tert-decanyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one of —F, a cyano group, a nitro group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅); and —Si(Q₃)(Q₄)(Q₅),

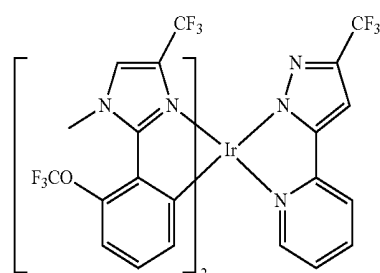
wherein Q₃ to Q₅ and Q₃₃ to Q₃₅ are each independently selected from a hydrogen, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group.

16. The organometallic compound of claim 1, wherein the organometallic compound is one of Compounds 1 to 35:

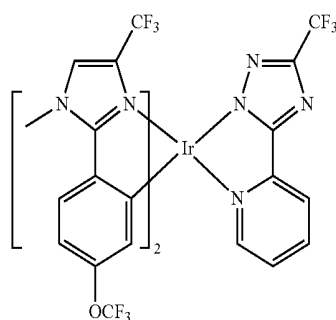
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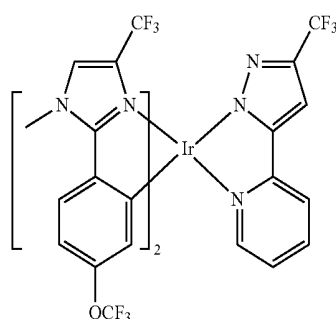
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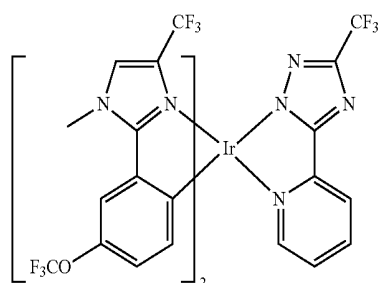
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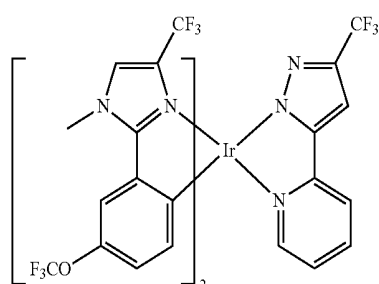
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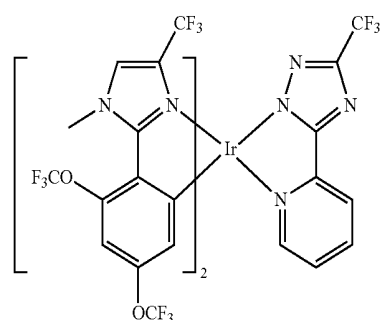
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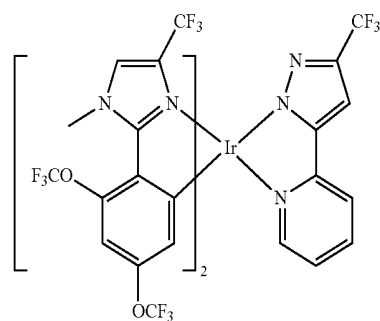
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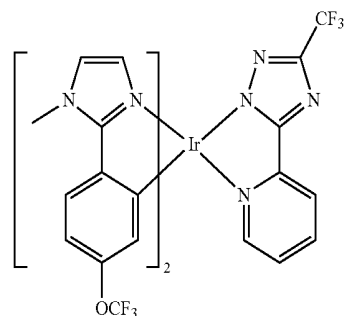
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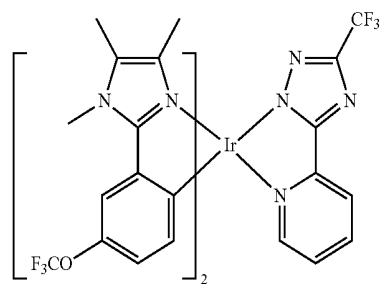
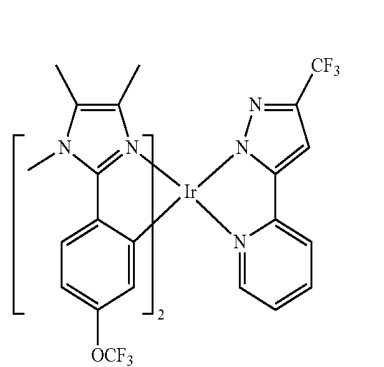
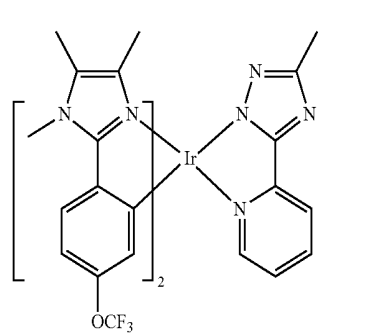
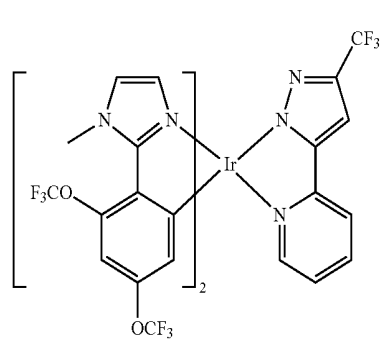
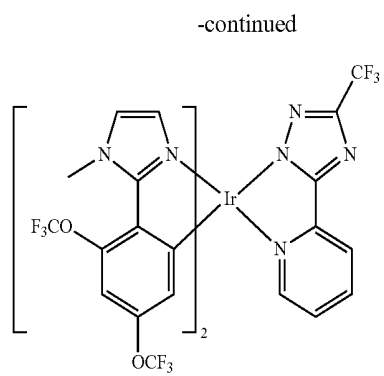


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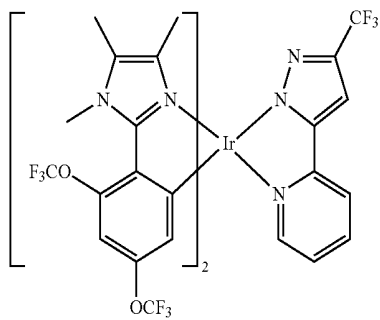
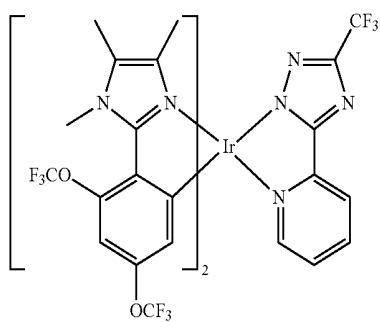
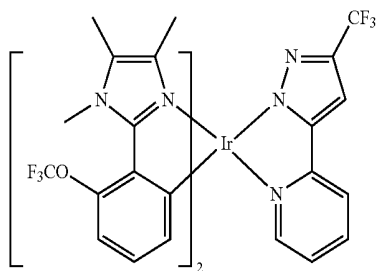
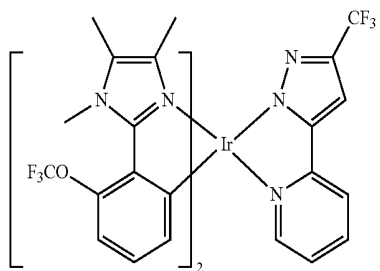
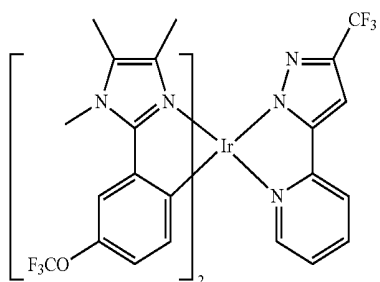


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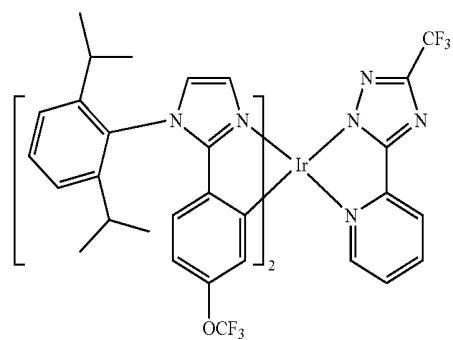


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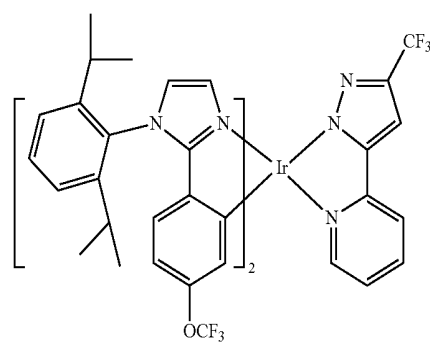
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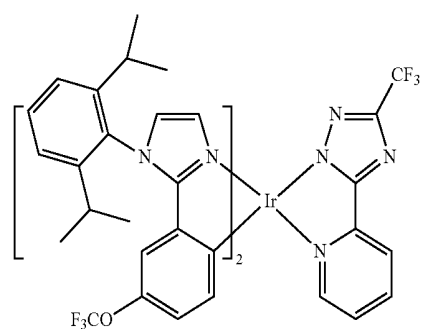
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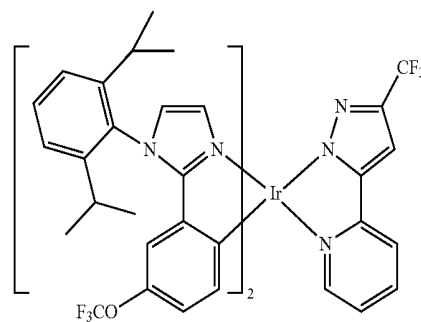
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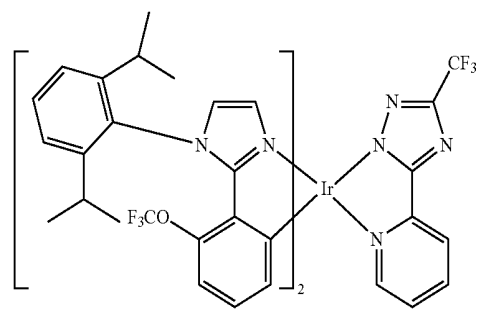
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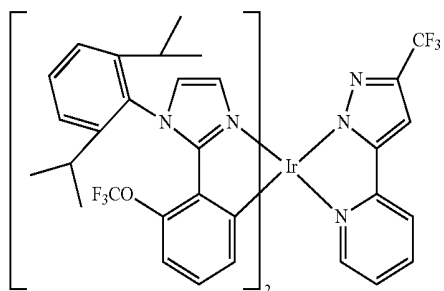
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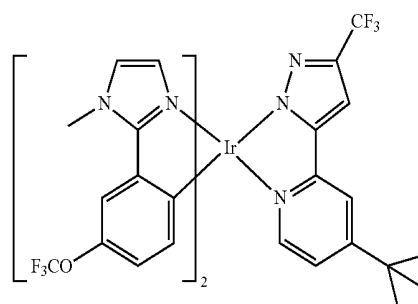
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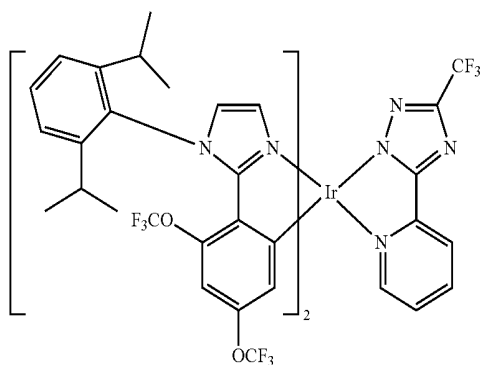


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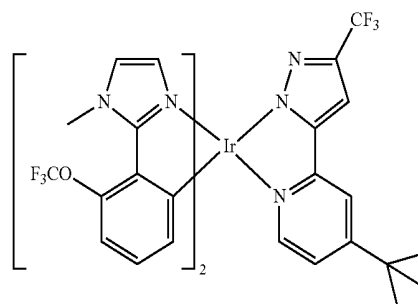
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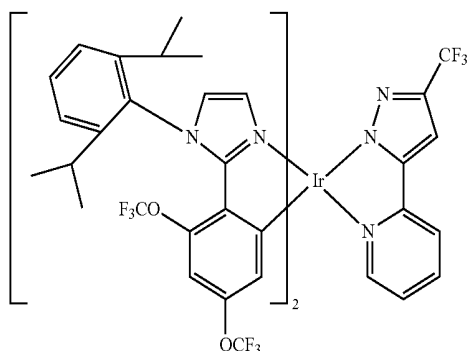
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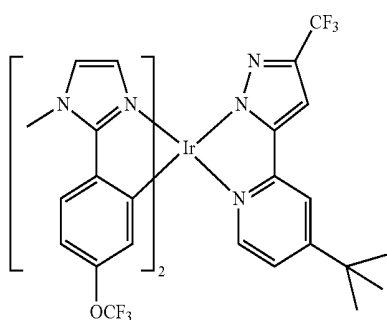
31



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17. 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 the organometallic compound of claim 1.

18. The organic light-emitting device of claim 17, wherein the first electrode is an anode,

the second electrode is a cathode, and

the organic layer comprises:

- i) a hole transport region disposed between the first electrode and the emission layer, wherein the hole transport region comprises at least one of a hole injection layer, a hole transport layer, and an electron blocking layer; and

- ii) an electron transport region that is disposed between the emission layer and the second electrode, wherein the electron transporting region comprises at least one of a hole blocking layer, an electron transport layer, and an electron injection layer.

19. The organic light-emitting device of claim 17,

wherein the emission layer comprises the organometallic compound of claim 1,

wherein the emission layer further comprises a host, and wherein an amount of the organometallic compound in the emission layer is less than an amount of the host.

* * * * *

专利名称(译)	有机金属化合物和包括其的有机发光器件		
公开(公告)号	US20180301640A9	公开(公告)日	2018-10-18
申请号	US14/747051	申请日	2015-06-23
[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	RAI VIRENDRA KUMAR NOH CHANGHO DAS RUPASREE RAGINI LEE KANGMUN KRAVCHUK DMITRY		
发明人	RAI, VIRENDRA KUMAR NOH, CHANGHO DAS, RUPASREE RAGINI LEE, KANGMUN KRAVCHUK, DMITRY		
IPC分类号	H01L51/00 C07F15/00 C09K11/06 C09K11/02		
CPC分类号	H01L51/0085 C07F15/0033 C09K11/06 C09K11/025 H01L51/5012 C09K2211/1059 C09K2211/1007 C09K2211/1044 C09K2211/185 C09K2211/1029 H05B33/14		
优先权	1020140076634 2014-06-23 KR		
其他公开文献	US20160380214A1		
外部链接	Espacenet USPTO		

摘要(译)

由式1表示的有机金属化合物： $M(L_1)_{n1}(L_2)_{n2}$ 式1 其中在式1中，M，L₁，L₂，n₁，n₂与说明书中描述的相同。

