



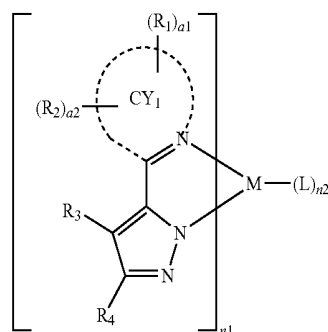
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(19) **United States**(12) **Patent Application Publication**
CHOI et al.(10) **Pub. No.: US 2015/0325807 A1**(43) **Pub. Date: Nov. 12, 2015**(54) **ORGANOMETALLIC COMPOUND AND
ORGANIC LIGHT-EMITTING DEVICE
INCLUDING THE SAME**(52) **U.S. CL.**CPC *H01L 51/5028* (2013.01); *C07F 15/0026*
(2013.01); *C07F 15/0053* (2013.01); *H01L*
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ABSTRACT(72) Inventors: **Whail CHOI**, Seoul (KR); **Yoonhyun**
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An organometallic compound represented by Formula 1:

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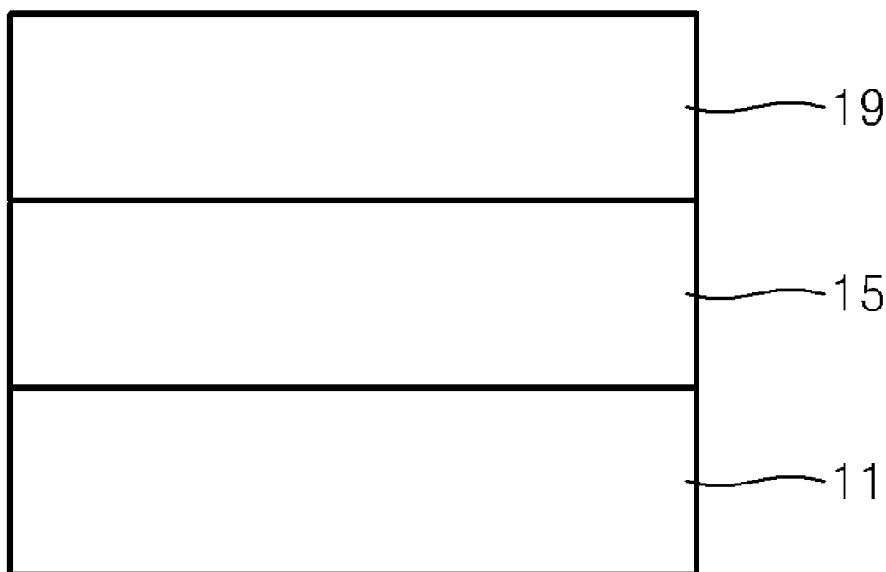
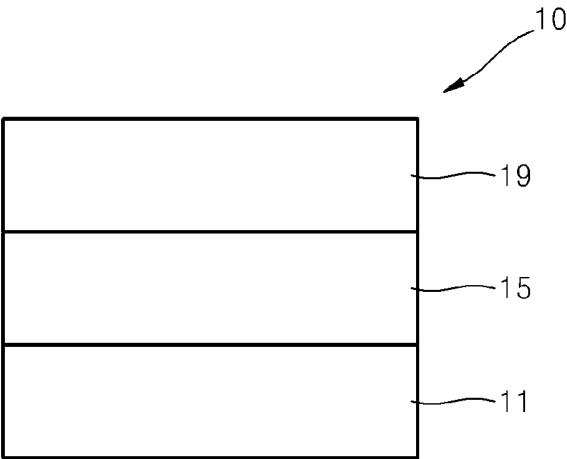
Publication Classification(51) **Int. Cl.***H01L 51/50* (2006.01)*H01L 51/00* (2006.01)*C07F 15/00* (2006.01)wherein in Formula 1, CY1, M, L, R₁, R₂, R₃, R₄, a₁, a₂,
n₁, and n₂ are described in the specification.

FIG. 1



ORGANOMETALLIC COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Korean Patent Application No. 10-2014-0056571, filed on May 12, 2014, in the Korean Intellectual Property Office, and all the benefits accruing therefrom under 35 U.S.C. §119, the content of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] One or more embodiments relate to an organometallic compound and an organic light-emitting device including the same.

[0004] 2. Description of the Related Art

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

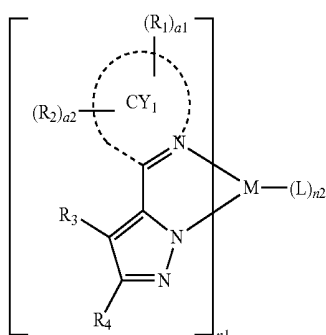
[0006] A typical organic light-emitting device includes an anode, a cathode, and an organic layer that is disposed between the anode and the cathode and includes an emission layer. A hole transport region may be disposed between the anode and the emission layer, and an electron transport region may be 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. Carriers, such as 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.

[0007] Various types of organic light emitting devices are known. However, there still remains a need in OLEDs having low driving voltage, high efficiency, high brightness, and long lifespan.

SUMMARY

[0008] One or more embodiments relate to a novel organometallic compound and an organic light-emitting device including the same.

[0009] An aspect provides an organometallic compound represented by Formula 1:



Formula 1

[0010] wherein in Formula 1,

[0011] M is Os or Ru;

[0012] CY₁ is selected from at least one N-containing 6-membered ring, at least one N-containing 6-membered ring to which at least one 5-membered ring is condensed, and at least one N-containing 6-membered ring to which at least one 6-membered ring is condensed;

[0013] R₁ is a substituted or unsubstituted linear or branched C₄-C₃₀ alkyl group;

[0014] R₂ to R₄ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-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 C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-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 —C(=O)(Q₆), wherein any of R₂ to R₄ are optionally linked to an adjacent ligand via a single bond or a divalent linking group, and R₃ and R₄ may be optionally linked to each other to form a substituted or unsubstituted C₄-C₂₀ carbocyclic ring or a substituted or unsubstituted C₂-C₂₀ heterocyclic ring;

[0015] a1 and a2 are each independently an integer selected from 1 to 5;

[0016] L is a monovalent organic ligand, a divalent organic ligand, or a trivalent organic ligand;

[0017] n1 is an integer of 1 to 3;

[0018] n2 is an integer of 0 to 4;

[0019] 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 C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, the substituted monovalent non-aromatic condensed heteropolycyclic group, the substituted C₄-C₂₀ carbocyclic ring, and the substituted C₂-C₂₀ heterocyclic ring are selected from

[0020] 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;

[0021] 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 selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-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);

[0022] a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0023] a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from 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 C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-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

[0024] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

[0025] wherein Q₁ to Q₆, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from a hydrogen, 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 C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0026] Another aspect provides an organic light-emitting device including:

[0027] a first electrode;

[0028] a second electrode; and

[0029] an organic layer disposed between the first electrode and the second electrode,

[0030] wherein includes an emission layer, and includes at least one of the organometallic compound represented by Formula 1.

[0031] The organometallic compound may be included in the emission layer, the organometallic compound included in the emission layer may act as a dopant, and the emission layer may further include a host.

[0032] The organometallic compound according to embodiments has excellent electric characteristics and thermal stability. Accordingly, an organic light-emitting device including the organometallic compound may have a low driving voltage, high efficiency, high brightness, and a long lifespan.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] 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:

[0034] FIG. 1 is a schematic view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

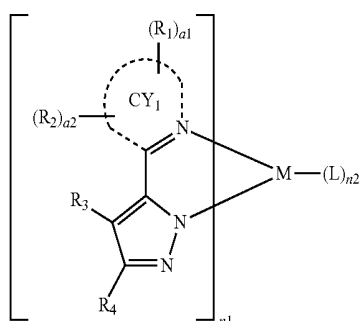
[0040] Spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially 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.

[0041] “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.

[0042] 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.

[0043] 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.

[0044] An organometallic compound according to an embodiment is represented by Formula 1 below:



Formula 1

[0045] M in Formula 1 may be osmium (Os) or ruthenium (Ru); and

[0046] CY₁ in Formula 1 may be selected from at least one N-containing 6-membered ring, at least one N-containing 6-membered ring to which at least one 5-membered ring is condensed, and at least one N-containing 6-membered ring to which at least one 6-membered ring is condensed.

[0047] CY₁ ring in Formula 1 may be selected from a pyridine, a pyrazine, a pyrimidine, a pyridazine, a purine, an isoquinoline, a quinoline, a phthalazine, a 1,8-naphthyridine, a quinoxaline, a quinazoline, a cinnoline, a phenanthridine, a 1,7-phenanthroline, and a pyrrolopyrimidine, but is not limited thereto.

[0048] For example, CY₁ may be selected from a pyridine, a pyridazine, and a pyrrolopyrimidine, but is not limited thereto.

[0049] In Formula 1, R₁ is a substituent at CY₁, which is necessarily present. R₁ may be a substituted or unsubstituted linear or branched C₄-C₃₀ alkyl group. The number of carbons in R₁ may be 4 or more. For example, R₁ may be a substituted or unsubstituted linear or branched C₄-C₁₀ alkyl group.

[0050] According to an embodiment, R₁ may be selected from

[0051] 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, and a tert-decanyl group; and

[0052] 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, and a tert-decanyl group, each substituted with at least one selected from deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group, but is not limited thereto.

[0053] a₁ indicates the number of groups R₁, and may be an integer of 1 to 5. For example, b₁ may be 1 or 2. In some embodiments, a₁ may be 1, but is not limited thereto. When a₁ is 2 or more, groups R₁ may be identical or different.

[0054] R₂ to R₄ in Formula 1 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 C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted

C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-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 —C(=O)(Q₆), wherein any of R₂ to R₄ may be optionally linked to an adjacent ligand via a single bond or a divalent linking group.

[0055] For example, R₂ to R₄ in Formula 1 may be each independently selected from

[0056] 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;

[0057] a C₁-C₂₀ alkyl group and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0058] 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 benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group; and

[0059] 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 benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group, each substituted with at least one selected from a deuterium, —F,

—Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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 benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group.

[0060] In some embodiments, R₂ to R₄ in Formula 1 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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

[0062] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group, but they are not limited thereto.

[0063] In some embodiments, R₃ and R₄ in Formula 1 may be each independently selected from

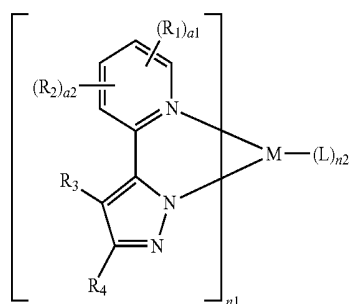
[0064] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₃ alkyl group, and a C₁-C₃ alkoxy group; and

[0065] a C₁-C₃ alkyl group and a C₁-C₃ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, but they are not limited thereto.

[0066] In some embodiments, R₃ and R₄ in Formula 1 may be linked to each other to form a substituted or unsubstituted C₄-C₂₀ carbocyclic ring or a substituted or unsubstituted C₂-C₂₀ heterocyclic ring.

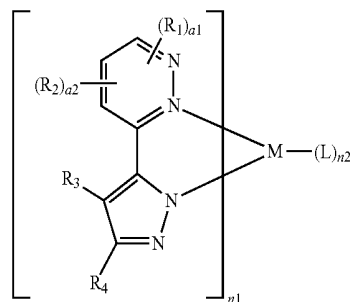
[0067] For example, R₃ and R₄ in Formula 1 may be linked to each other to form a ring selected from a substituted or unsubstituted cyclopropane, a substituted or unsubstituted cyclobutane, a substituted or unsubstituted cyclopentane, a substituted or unsubstituted cyclohexane, a substituted or unsubstituted cycloheptane, a substituted or unsubstituted cyclooctane, a substituted or unsubstituted cyclopentene, a substituted or unsubstituted cyclopentadiene, a substituted or unsubstituted cyclohexadiene, a substituted or unsubstituted cycloheptadiene, a substituted or unsubstituted bicyclo-heptane, a substituted or unsubstituted bicyclo-octane, a substituted or unsubstituted benzene, a substituted or unsubstituted pentalene, a substituted or unsubstituted indene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted azulene, a substituted or unsubstituted heptalene, a substituted or unsubstituted indacene, a substituted or unsubstituted acenaphthylene, a substituted or unsubstituted spiro-fluorene, a substituted or unsubstituted phenalene, a substituted or unsubstituted phenanthrene, a substituted or unsubstituted anthracene, a substituted or unsubstituted fluoranthene, a substituted or unsubstituted triphenylene, a substituted or unsubstituted pyrene, and a substituted or unsubstituted chrysene. Examples of substituents at the ring may be understood by referring to examples of substituents of the substituted C₄-C₂₀ carbocyclic ring.

[0068] According to an embodiment, the organometallic compound represented by Formula 1 may be represented by one of Formulae 1A to 1H below:

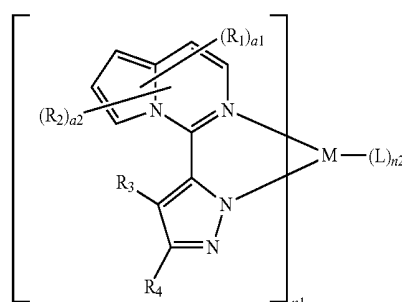


Formula 1A

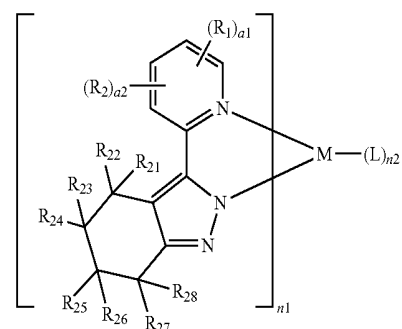
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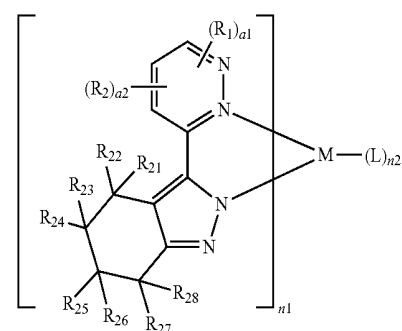
Formula 1B



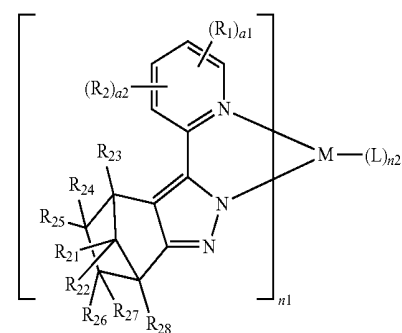
Formula 1C



Formula 1D

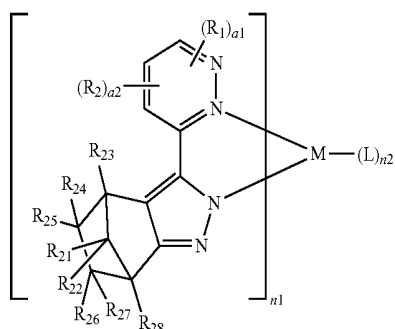


Formula 1E

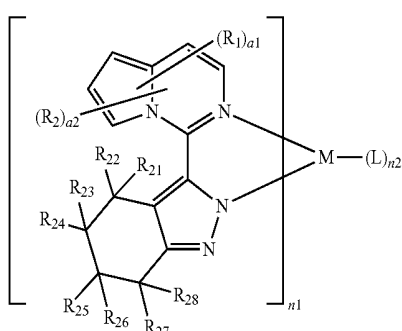


Formula 1F

-continued



Formula 1G



Formula 1H

[0069] R_1 to R_4 , a_1 , a_2 , M , n_1 , n_2 , and L in Formulae 1A to 1H have been already described above, and R_{21} to R_{28} may be understood by referring to the description presented above in connection with R_2 .

[0070] For example, in Formulae 1A to 1H,

[0071] R_1 may be selected from

[0072] 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, and a tert-decanyl group; and

[0073] 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, and a tert-decanyl group, each substituted with at least one selected from deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

[0074] R_2 to R_4 , and R_{21} to R_{28} are each independently selected from

[0075] 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-

butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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

[0076] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

[0077] a_1 and a_2 may be each independently 1 or 2, but are not limited thereto.

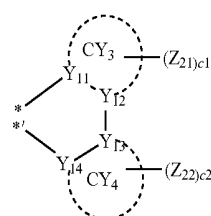
[0078] In some embodiments, R_3 , R_4 , and R_{21} to R_{28} in Formulae 1A to 1H are each independently selected from

[0079] 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_3 alkyl group, and a C_1 - C_3 alkoxy group; and

[0080] a C_1 - C_3 alkyl group and a C_1 - C_3 alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof.

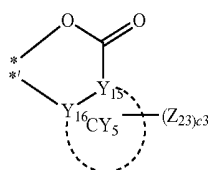
[0081] L in Formula 1 may be a monovalent organic ligand, a divalent organic ligand, or a trivalent organic ligand.

[0082] For example, L in Formula 1 may be selected from a ligand represented by Formula 2A below to a ligand represented by Formula 2G below, but is not limited thereto:

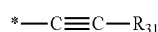


Formula 2A

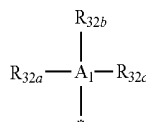
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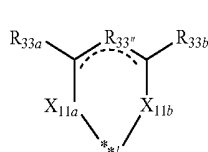
Formula 2B



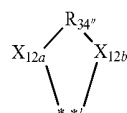
Formula 2C



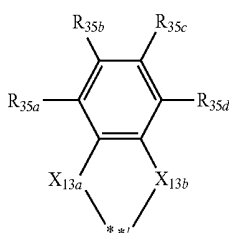
Formula 2D



Formula 2E



Formula 2F



Formula 2G

wherein in Formulae 2A to 2G,

[0083] Y₁₁ to Y₁₆ are each independently carbon (C) or nitrogen (N);

[0084] CY₃ to CY₅ are each independently selected from a C₅-C₆₀ carbocyclic group and a C₂-C₆₀ heterocyclic group;

[0085] c1 to c3 are each independently an integer of 1 to 5;

[0086] A₁ may be P or As;

[0087] X_{11a}, X_{11b}, X_{12a}, X_{12b}, X_{13a}, and X_{13b} may be each independently selected from N, O, N(R₃₄), P(R₃₅)(R₃₆), and As(R₃₇)(R₃₈), provided that each of X_{12a}, X_{12b}, X_{13a}, and X_{13b} is neither N nor O;

[0088] R_{33a} and R_{34a} may be each independently selected from a single bond, a double bond, a substituted or unsubstituted C₁-C₅ alkylene group, a substituted or unsubstituted C₂-C₅ alkenylene group, and a substituted or unsubstituted C₆-C₁₀ arylene group;

[0089] Z₂₁ to Z₂₃, R₃₁, R_{32a}, R_{32b}, R_{32c}, R_{33a}, R_{33b}, R₃₄ to R₃₈, R_{35a}, R_{35b}, R_{35c}, and R_{35d} 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 C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted

C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and

[0090] * and *' each indicates a binding site to M in Formula 1.

[0091] In Formulae 3-1 to 3-2,

[0092] CY₃ to CY₅ may be each independently selected from a benzene, a naphthalene, a fluorene, a spiro-fluorene, an indene, a pyrrole, a thiophene, a furan, a imidazole, a pyrazole, a thiazole, an isothiazole, an oxazole, an isooxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, a quinoline, an isoquinoline, a benzoquinoline, a quinoxaline, a quinazoline, a carbazole, a benzoimidazole, a benzofuran, a benzothiophene, an isobenzothiophene, a benzooxazole, an isobenzooxazole, a triazole, a tetrazole, an oxadiazole, a triazine, a dibenzofuran, and a dibenzothiophene.

[0093] Z₂₁ to Z₂₃ may be each independently selected from **[0094]** 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;

[0095] a C₁-C₂₀ alkyl group and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

[0096] 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 isobenzothiiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group; and

[0097] 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 iso-

quinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazoyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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 carbazoyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group.

[0098] c1 to c3 may be each independently 1 or 2.

[0099] In some embodiments, L in Formula 1 may be selected from a ligand represented by Formula 3-1 and a ligand represented by Formula 3-2, and in Formulae 3-1 and 3-2,

[0100] CY₃ may be selected from a pyridine, a triazole, an imidazole, and a pyrazole, and CY₄ may be selected from a benzene and a pyridine, and CY₅ may be a benzene;

[0101] Z₂₁ to Z₂₃ may be each independently selected from

[0102] a hydrogen, —F, a cyano group, a nitro group, a methyl group, an ethyl group, n-a propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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

[0103] a methyl group, an ethyl group, n-a propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl

group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from —F, a cyano group, and a nitro group.

[0104] c1 to c3 may be each independently 1 or 2.

[0105] Z₂₁ to Z₂₃, R₃₁, R_{32a}, R_{32b}, R_{32c}, R_{33a}, R_{33b}, R₃₄ to R₃₈, R_{35a}, R_{35b}, R_{35c}, and R_{35d} in Formulae 2A to 2G may be each independently selected from

[0106] 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;

[0107] a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl group;

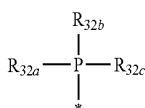
[0108] a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, 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 carbazoyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group; and

[0109] 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 carbazoyl group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro

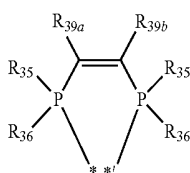
group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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 benzofuran group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuran group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group.

[0110] L in Formula 1 may be selected from a ligand represented by Formula 2C, a ligand represented by Formula 2D, a ligand represented by Formula 2F, and a ligand represented by Formula 2G.

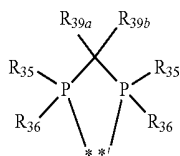
[0111] L in Formula 1 may be selected from a ligand represented by Formula 2D-1, a ligand represented by Formula 2F-1, a ligand represented by Formula 2F-2, and a ligand represented by Formula 2G-1:



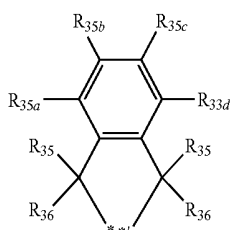
Formula 2D-1



Formula 2F-1



Formula 2F-2



Formula 2G-1

[0112] In Formulae 2D-1, 2F-1, 2F-2, and 2G-1,

[0113] R_{32a}, R_{32b}, R_{32c}, R₃₅, R₃₆, R_{35a}, R_{35b}, R_{35c}, R_{35d}, R_{39a}, and R_{39b} may be each independently selected from

[0114] 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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

[0115] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group.

[0116] n₂ indicates the number of groups L, and may be an integer selected from 0 to 4. When n₂ is 2 or more, groups L may be identical or different.

[0117] In Formula 1, n₁ may be 2 and n₂ may be 1 or 2, but is not limited thereto.

[0118] In some embodiments, the organometallic compound represented by Formula 1 is represented by one of Formulae 1A to 1H above, and in Formulae 1A to 1H,

[0119] R₁ may be selected from

[0120] 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, and a tert-decanyl group; and

[0121] 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, and a tert-decanyl group, each substituted with at least one

selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

[0122] R_2 may be selected from

[0123] 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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

[0124] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

[0125] R_3 , R_4 , and R_{21} to R_{28} are each independently selected from

[0126] 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_3 alkyl group, and a C_1 - C_3 alkoxy group; and

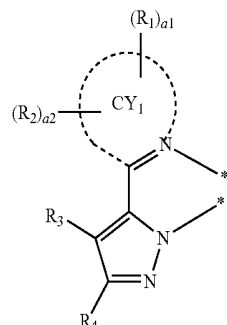
[0127] a C_1 - C_3 alkyl group and a C_1 - C_3 alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0128] a_1 and a_2 are each independently 1 or 2;

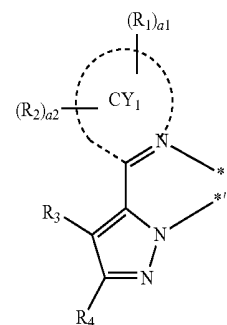
[0129] L may be selected from a ligand represented by Formula 2D-1, a ligand represented by Formula 2F-1, a ligand represented by Formula 2F-2, and a ligand represented by Formula 2G-1.

[0130] n_1 may be 2 and n_2 may be 1 or 2.

[0131] n_1 in Formula 1 indicates the number of a ligand represented by

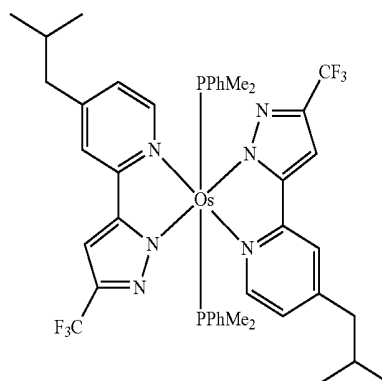
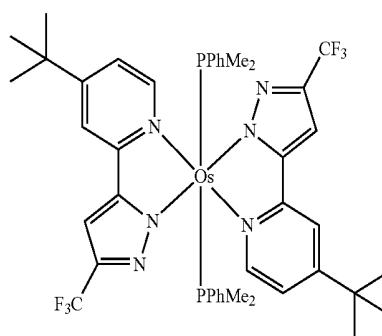


and may be selected from 1, 2, and 3. When n_1 is 2 or more, groups

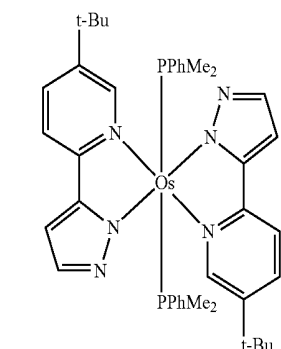


may be identical or different.

[0132] The organometallic compound may be one of Compounds 1 to 15 below, but is not limited thereto:

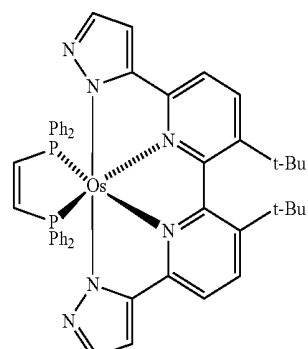


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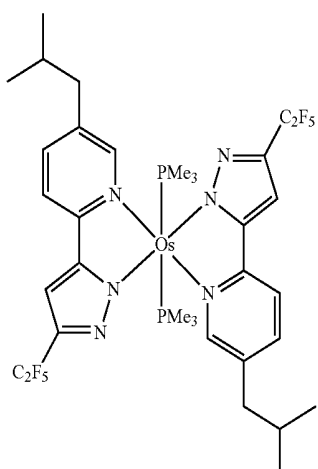


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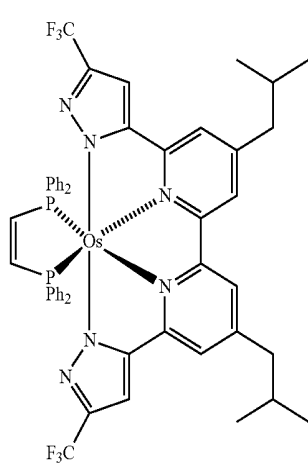
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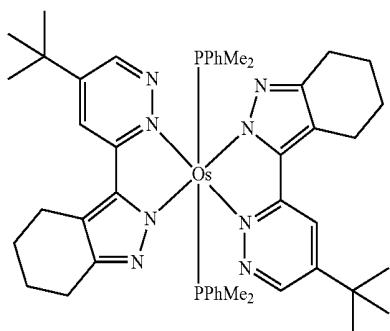
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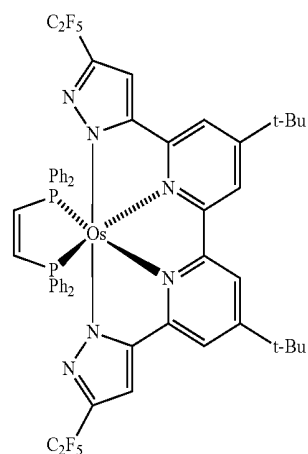
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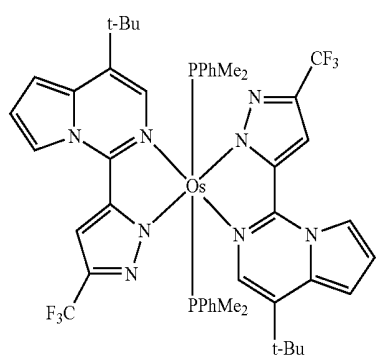
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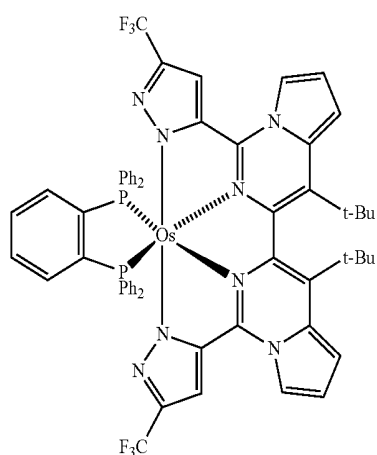
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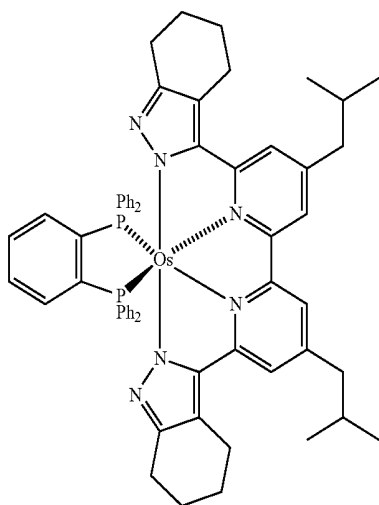
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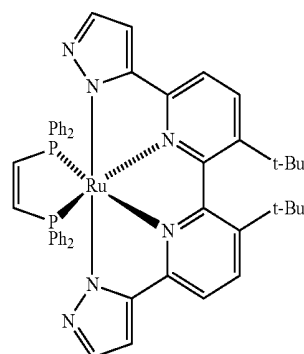
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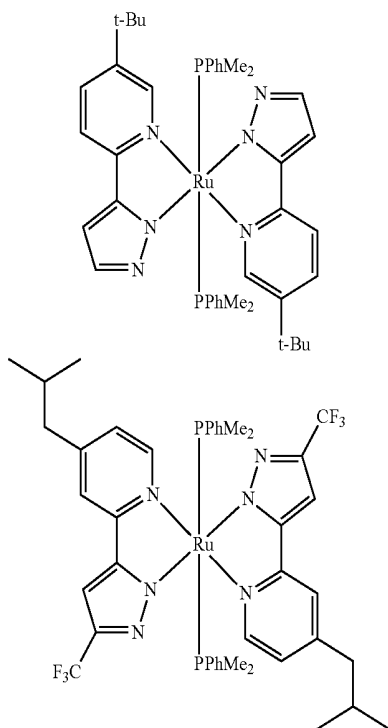
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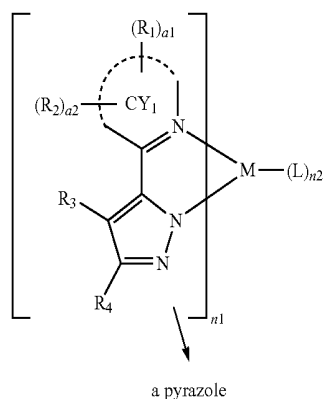
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[0133] The ligands of the organometallic compound represented by Formula 1 includes a pyrazole ring as a 5-membered ring as shown in Formula 1' below. The pyrazole ring has strong N—H basicity (for example, pKa of pyrazole is about 19.8), and thus, the bond between N of the pyrazole ring and M of Formula 1' may be strengthened. Thus, the organometallic compound represented by Formula 1 may have excellent electrostability.

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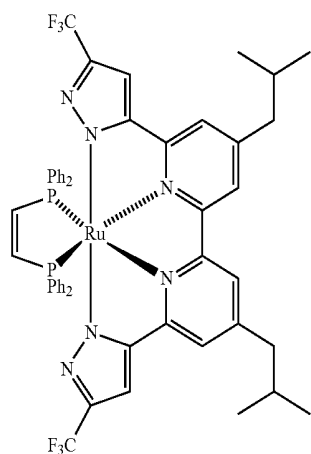


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Formula 1'

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[0134] In the organometallic compound represented by Formula 1, CY₁ is necessarily substituted with R₁, which is an alkyl group having four or more carbon atoms (a₁, which indicates the number of groups R₁, is not 0). Accordingly, intermolecular aggregation between organometallic compound molecules may be minimized or substantially prevented. Accordingly, an organic light-emitting device including the organometallic compound represented by Formula 1 may have high luminescence efficiency.

[0135] In some embodiments, when the organometallic compound is represented by one of Formulae 1A to 1H, R₃, R₄, and R₂₁ to R₂₈ in Formulae 1A to 1H are each independently a substituent other than carbon, for example, a hydrogen, an alkyl or alkoxy group having three or less carbon atoms, and L in Formulae 1A to 1H is a phosphine-based ligand such as a ligand represented by Formula 2D-1, a ligand represented by 2F-1, a ligand represented by 2F-2, and a ligand represented by 2G-1. When R₃, R₄, and R₂₁ to R₂₈ are each a substituent other than carbon, for example a hydrogen, an alkyl or alkoxy group having three or less carbon atoms as described above, a bond between M and L that is selected

from phosphine-based ligands is stabilized, and thus, quantum efficiency may be improved.

[0136] Synthesis methods of the organometallic compound represented by Formula 1 may be apparent to one of ordinary skill in the art by referring to Synthesis Examples provided below.

[0137] The organometallic compound represented by Formula 1 is suitable for use in an organic layer of an organic light-emitting device, for example, for use as a dopant in an emission layer of the organic layer. Thus, another aspect provides an organic light-emitting device that includes:

[0138] a first electrode;

[0139] a second electrode; and

[0140] an organic layer that is disposed between the first electrode and the second electrode,

[0141] wherein the organic layer includes an emission layer and at least one of the organometallic compound represented by Formula 1.

[0142] The organic light-emitting device may have, due to the inclusion of an organic layer including the organometallic compound represented by Formula 1, low driving voltage, high efficiency, high brightness, and long lifespan.

[0143] The organometallic compound of Formula 1 may be used between a pair of electrodes of an organic light-emitting device. For example, the organometallic compound represented by Formula 1 may be included in the emission layer. In this regard, the organometallic compound may act as a dopant, and the emission layer may further include a host, wherein an amount of the organometallic compound represented by Formula 1 is smaller than an amount of the host.

[0144] The expression “(an organic layer) includes at least one organometallic compounds” used herein may include a case in which “(an organic layer) includes identical organometallic compounds of Formula 1 and a case in which (an organic layer) includes two or more different organometallic compounds of Formula 1.

[0145] For example, the organic layer may include, as the organometallic compound, only Compound 1. In this case, Compound 1 may exist in an emission layer of the organic light-emitting device. In some embodiments, the organic layer may include, as the organometallic compound, Compound 1 and Compound 2. In this case, Compound 1 and Compound 2 may exist in an identical layer (for example, Compound 1 and Compound 2 all may exist in an emission layer).

[0146] The first electrode may be an anode, which is a hole injection electrode, and the second electrode may be a cathode, which is an electron injection electrode, or the first electrode may be a cathode, which is an electron injection electrode, or the second electrode may be an anode, which is a hole injection electrode.

[0147] For example, the first electrode is an anode, and the second electrode is a cathode, and the organic layer includes:

[0148] i) a hole transport region that is disposed between the first electrode and the emission layer, wherein the hole transport region includes at least one of a hole injection layer, a hole transport layer, and an electron blocking layer, and

[0149] ii) an electron transport region that is disposed between the emission layer and the second electrode, wherein the electron transport region includes at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

[0150] 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.

[0151] FIG. 1 is a schematic view of an organic light-emitting device 10 according to an embodiment. Hereinafter, the structure of an organic light-emitting device according to an embodiment and a method of manufacturing an organic light-emitting device according to an embodiment will be described in connection with FIG. 1. The organic light-emitting device 10 includes a first electrode 11, an organic layer 15, and a second electrode 19, which are sequentially stacked.

[0152] In FIG. 1, a substrate may be additionally disposed under the first electrode 11 or above the second electrode 19. For use as the substrate, any substrate that is used in general organic light-emitting devices may be used. The substrate may be a glass substrate or transparent plastic substrate, each with excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and waterproofness.

[0153] The first electrode 11 may be formed by depositing or sputtering a material for forming the first electrode on the substrate. The first electrode 11 may be an anode. The material for the first electrode 11 may be selected from materials with a high work function to ensure that holes are easily provided. The first electrode 11 may be a reflective electrode or a transmissive electrode. The material for the first electrode 11 may be an indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), or zinc oxide (ZnO). In some embodiments, the material for 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).

[0154] The first electrode 11 may have a single-layer structure or a multi-layer structure including two or more layers. For example, the first electrode 11 may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode 11 is not limited thereto.

[0155] An organic layer 15 is disposed on the first electrode 11.

[0156] The organic layer 15 may include a hole transport region, an emission layer, and an electron transport region.

[0157] The hole transport region may be disposed between the first electrode 11 and the emission layer.

[0158] The hole transport region may include at least one of a hole injection layer, a hole transport layer, an electron blocking layer, and a buffer layer.

[0159] The hole transport region may include only either a hole injection layer or a hole transport layer. According to another embodiment, the hole transport region may have a structure of hole injection layer/hole transport layer or hole injection layer/hole transport layer/electron blocking layer, which are sequentially stacked in this stated order from the first electrode 11.

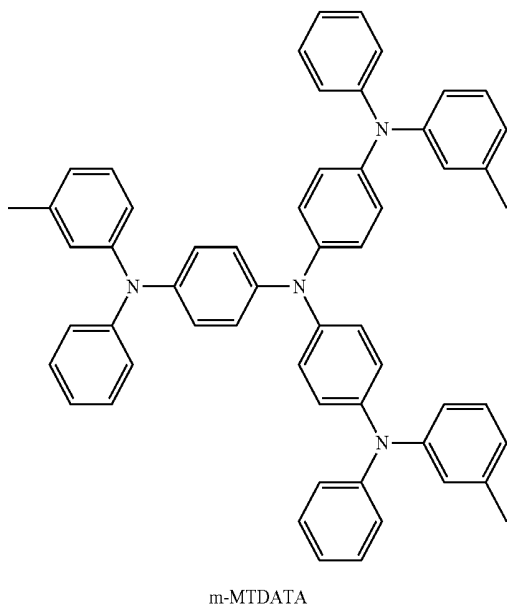
[0160] When the hole transport region includes a hole injection layer (HIL), the hole injection layer may be formed on the first electrode 11 by using any one of various methods, for example, vacuum deposition, spin coating, casting, or Langmuir-Blodgett (LB) deposition.

[0161] When a hole injection layer is formed by vacuum deposition, the deposition conditions may vary according to a material that is used to form the hole injection layer, and the structure and thermal characteristics of the hole injection layer. For example, the deposition conditions may include a deposition temperature of about 100 to about 500° C., a vacuum pressure of about 10^{-8} to about 10^{-3} torr, and a deposition rate of about 0.01 to about 100 Angstroms per second (Å/sec). However, the deposition conditions are not limited thereto.

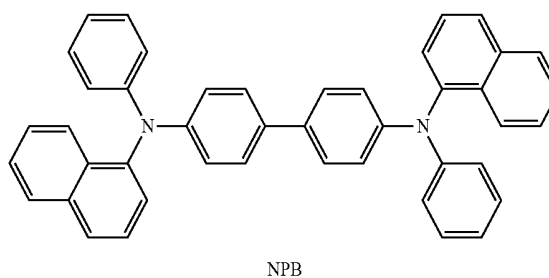
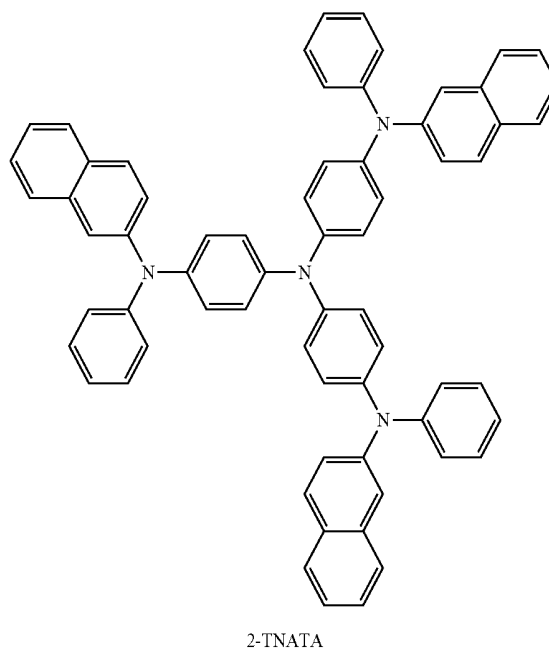
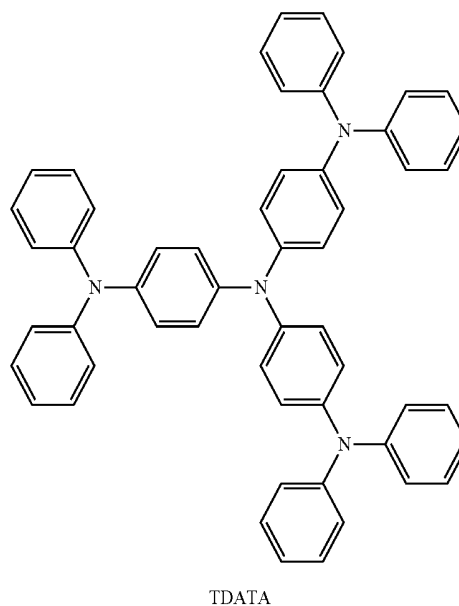
[0162] When the hole injection layer is formed using spin coating, coating conditions may vary according to the material used to form the hole injection layer, and the structure and thermal properties of the hole injection layer. For example, a coating speed may be from about 2,000 revolutions per minute (rpm) to about 5,000 rpm, and a temperature at which a heat treatment is performed to remove a solvent after coating may be from about 80° C. to about 200° C. However, the coating conditions are not limited thereto.

[0163] Conditions for a hole transport layer and an electron blocking layer may be understood by referring to conditions for forming the hole injection layer.

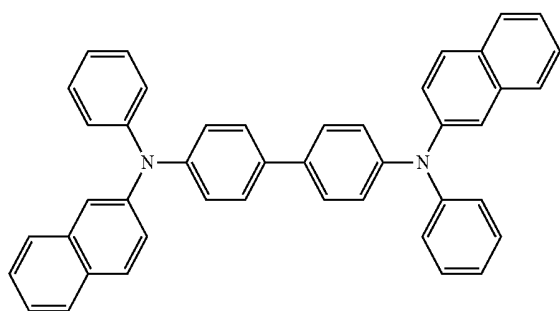
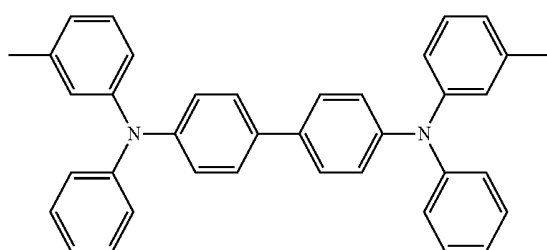
[0164] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, β -NPB, TPD, Spiro-TPD, Spiro-NPB, α -NPB, TAPC, HMTPD, 4,4',4''-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), (polyaniline)/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, and a compound represented by Formula 202 below:



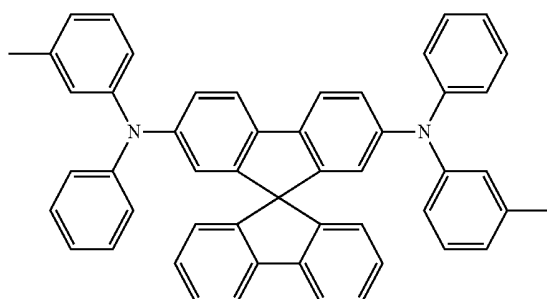
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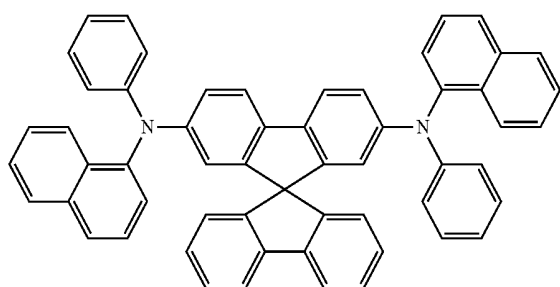
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 β -NPB

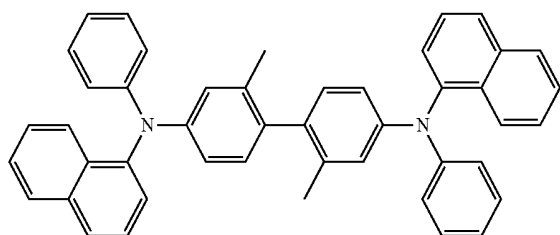
TPD



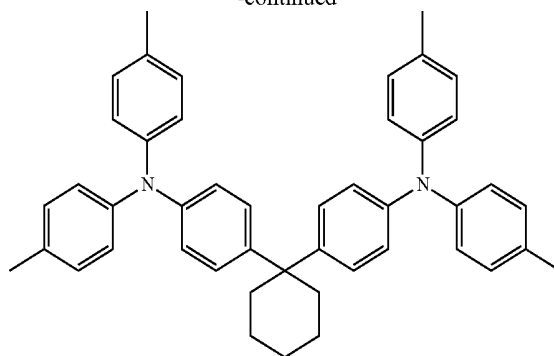
Spiro-TPD



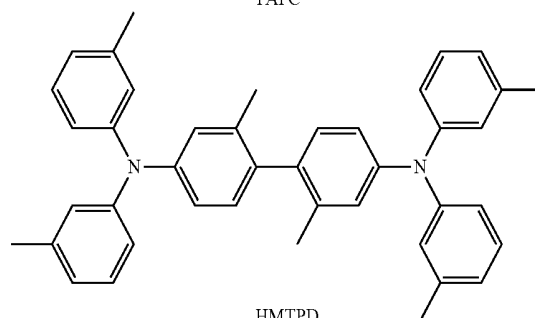
Spiro-NPB

 α -NPB

-continued

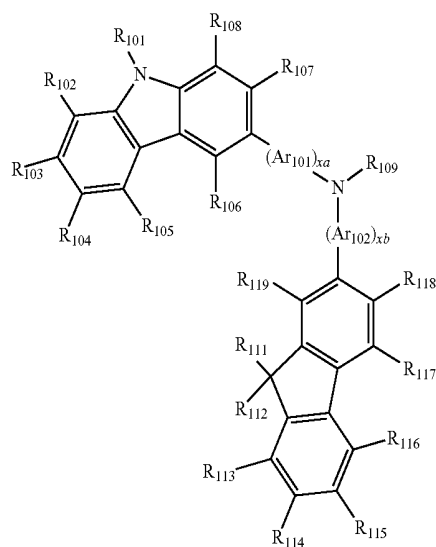


TAPC

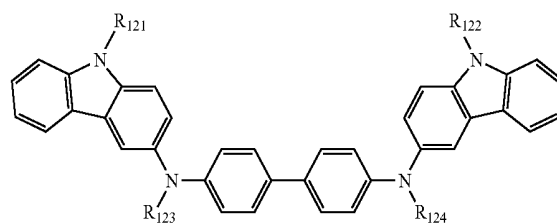


HMTPD

Formula 201



Formula 202



[0165] Ar_{101} and Ar_{102} in Formula 201 may be each independently selected from

[0166] a phenylene group, a pentalenylene group, an indenylene group, a naphthylenylene group, an azulenylenylene group, a heptalenylene group, an acenaphthylenylene group, a fluorenylenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a

triphenylenylene group, a pyrenylene group, a chrysénylene group, a naphthacénylene group, a picenylene group, a perylenylene group, and a pentacénylene group; and

[0167] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulénylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracénylene group, a fluoranthénylene group, a triphenylenylene group, a pyrenylene group, a chrysénylene group, a naphthacénylene group, a picenylene group, a perylenylene group, and a pentacénylene 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_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkyl group, a C_2 - 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_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0168] x_a and x_b in Formula 201 may be each independently an integer of 0 to 5, or 0, 1 or 2. For example, x_a may be 1 and x_b may be 0, but x_a and x_b are not limited thereto.

[0169] R_{101} to R_{108} , R_{111} to R_{119} , and R_{121} to R_{124} in Formulae 201 and 202 may be each independently selected from

[0170] 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_{10} alkyl group (for example, a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, and so on), and a C_1 - C_{10} alkoxy group (for example, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, and so on);

[0171] a C_1 - C_{10} alkyl group and a C_1 - C_{10} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0172] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group; and

[0173] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{10} alkyl group and a C_1 - C_{10} alkoxy group, but they are not limited thereto.

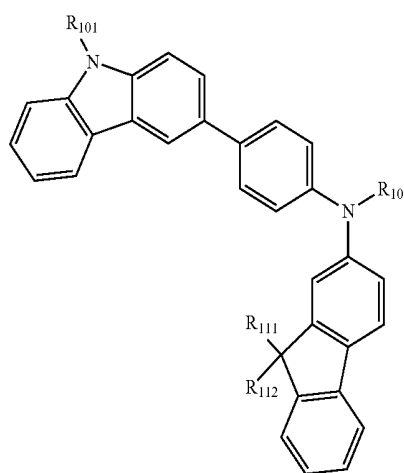
[0174] R_{109} in Formula 201 may be selected from

[0175] a phenyl group, a naphthyl group, an anthracenyl group, a biphenyl group, and a pyridinyl group; and

[0176] a phenyl group, a naphthyl group, an anthracenyl group, a biphenyl group, and a pyridinyl group, each substi-

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

[0177] According to an embodiment, the compound represented by Formula 201 may be represented by Formula 201A below, but is not limited thereto.

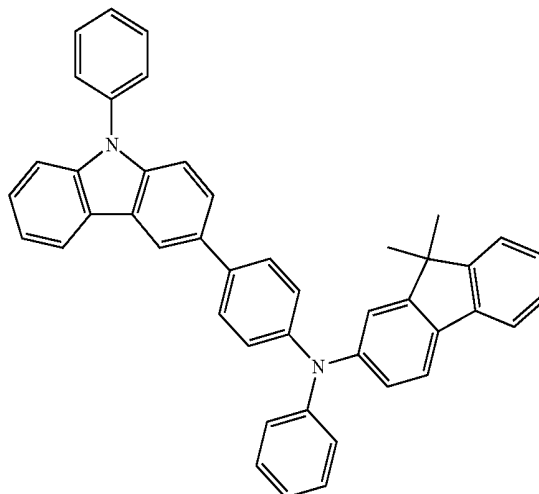


Formula 201A

[0178] R_{101} , R_{111} , R_{112} , and R_{109} in Formula 201A may be understood by referring to the description provided herein.

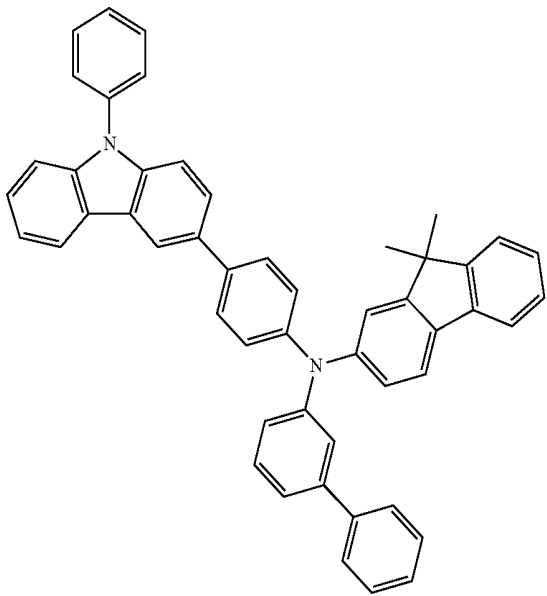
[0179] For example, the compound represented by Formula 201, and the compound represented by Formula 202 may include compounds HT1 to HT20 illustrated below, but are not limited thereto.

HT1



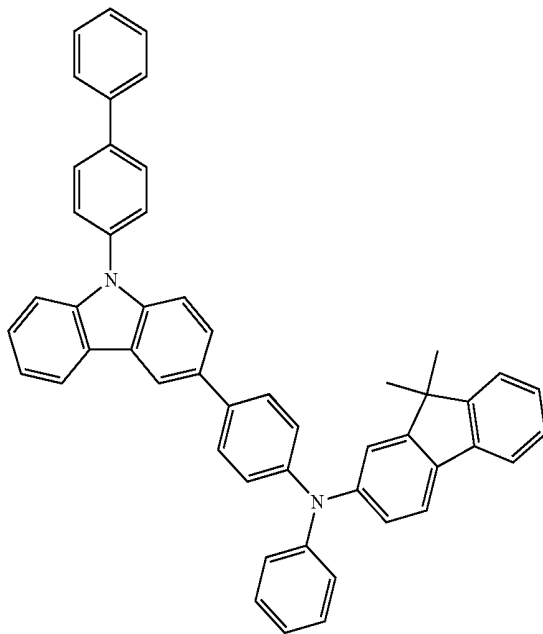
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HT2

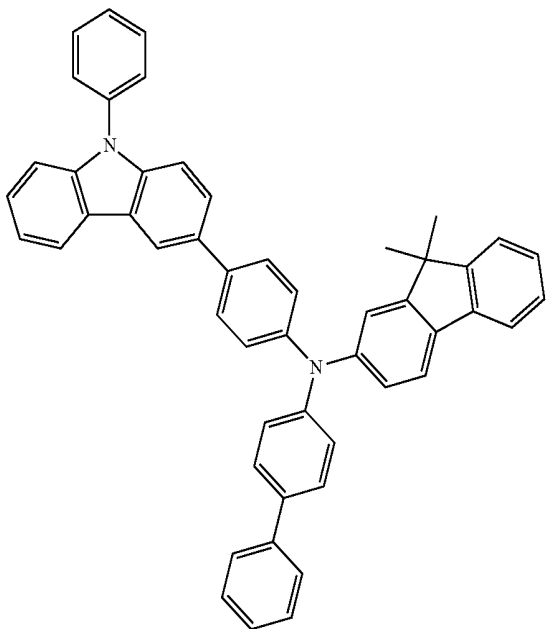


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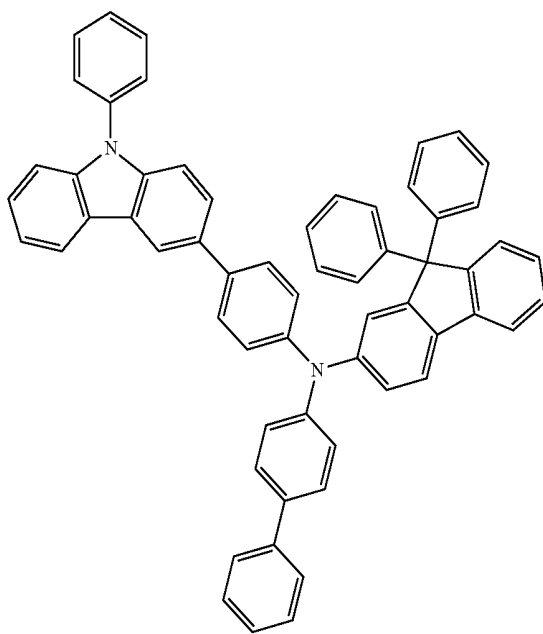
HT4



HT3

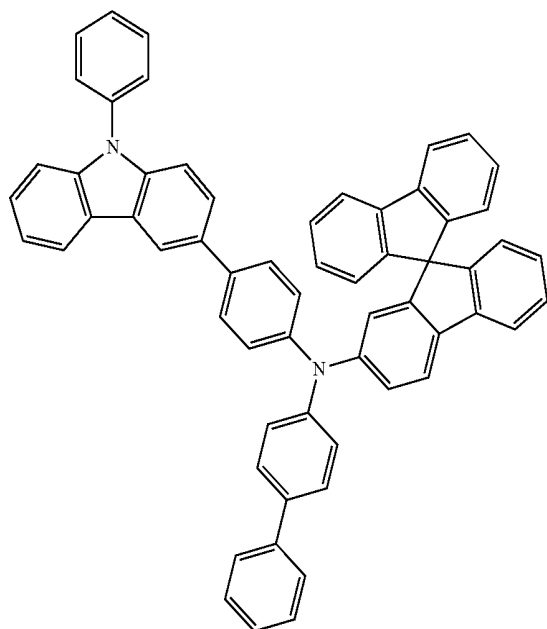


HT5



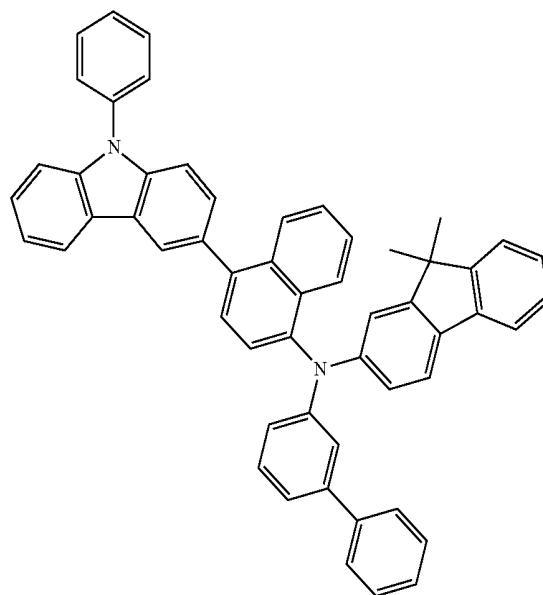
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HT6



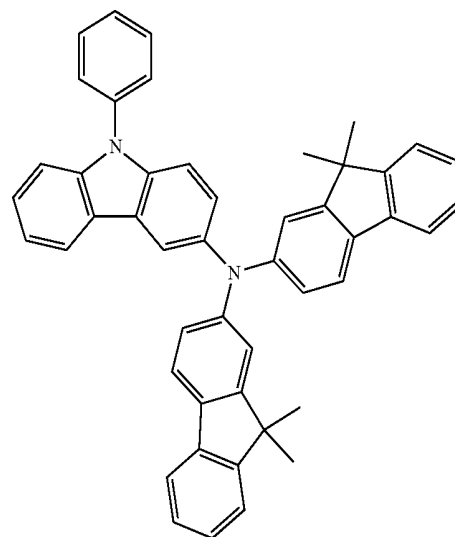
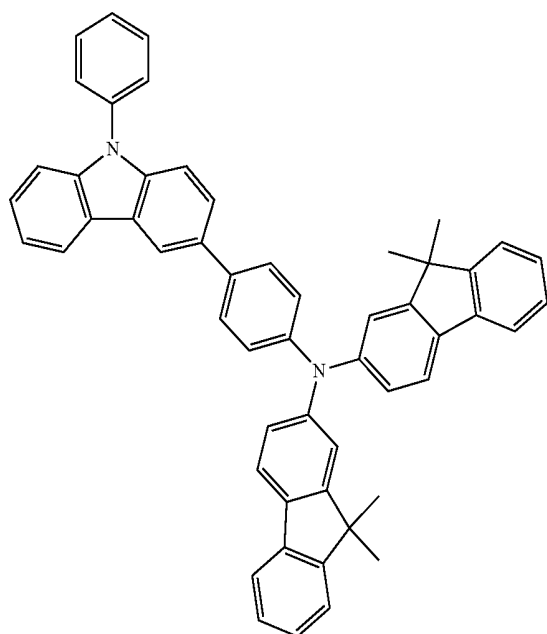
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HT8



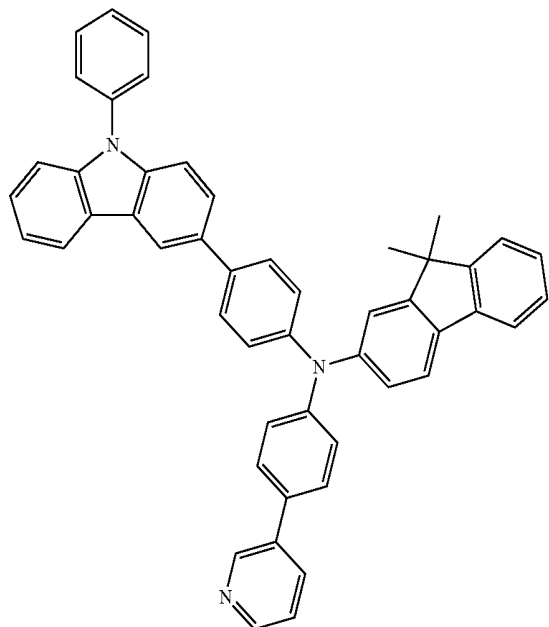
HT9

HT7



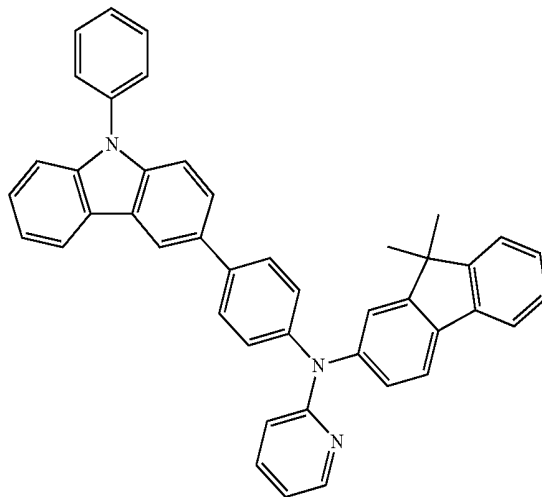
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HT10

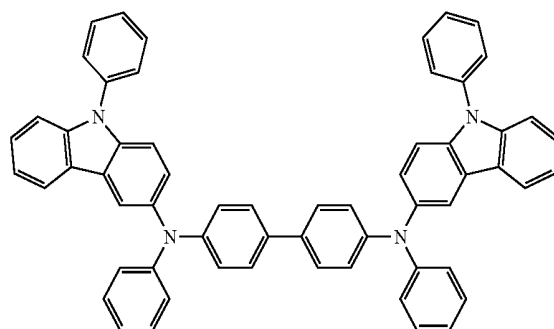


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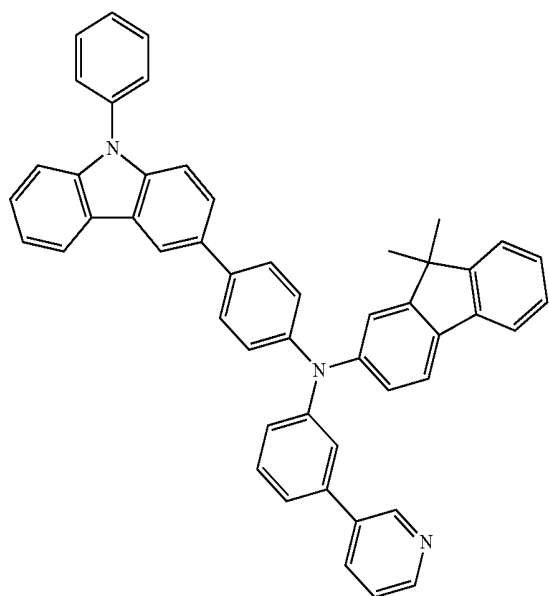
HT12



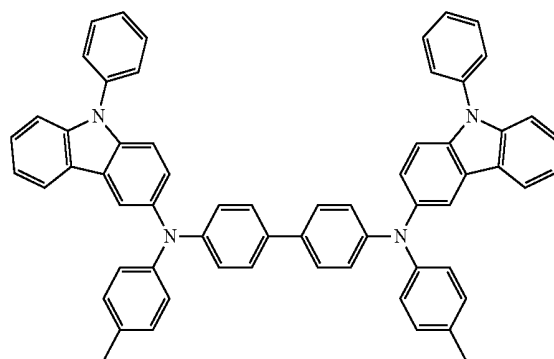
HT13



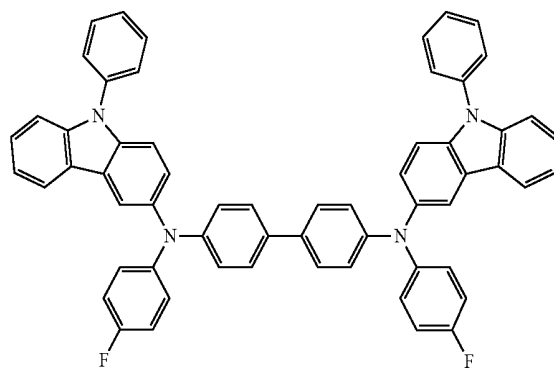
HT11



HT14

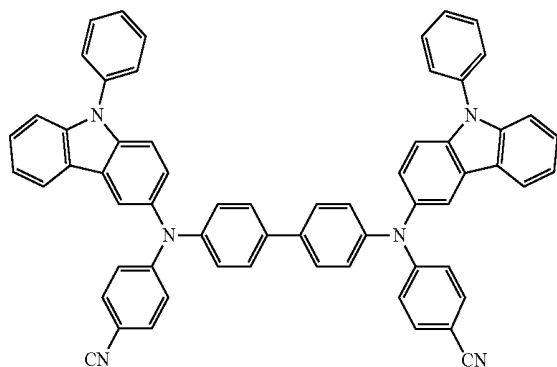


HT15



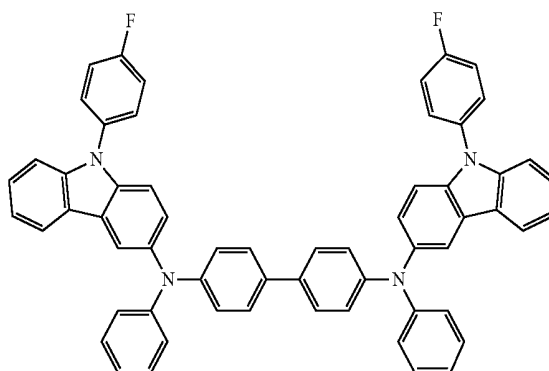
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HT16

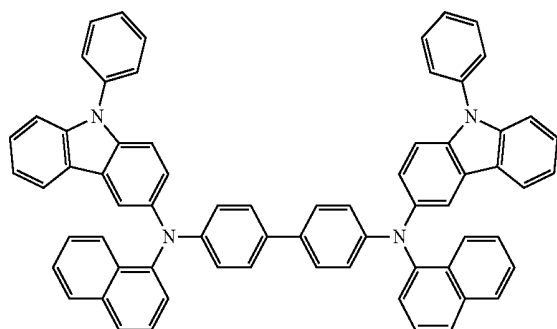


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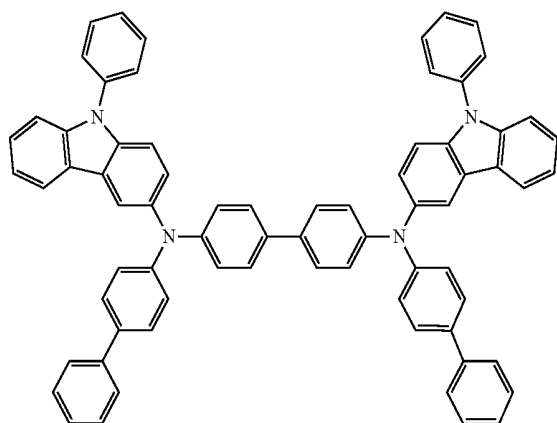
HT20



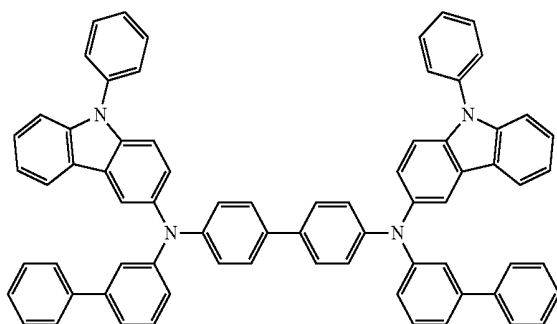
HT17



HT18



HT19

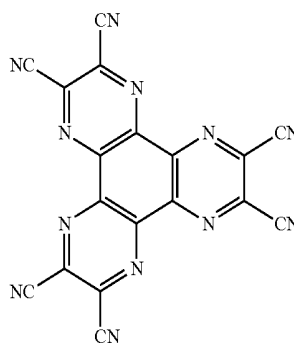


[0180] A thickness of the hole transport region **130** may be in a range of about 100 Angstrom (Å) to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region **130** includes both a hole injection layer and a hole transport layer, a thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å, and a thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, for example about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region **130**, the hole injection layer, and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

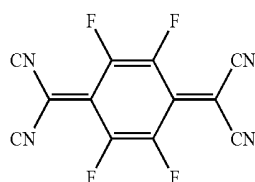
[0181] The hole transport region **130** may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0182] 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. Non-limiting examples of the p-dopant are a quinone derivative, such as tetracyanoquinonodimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonodimethane (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



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F4-TCNQ

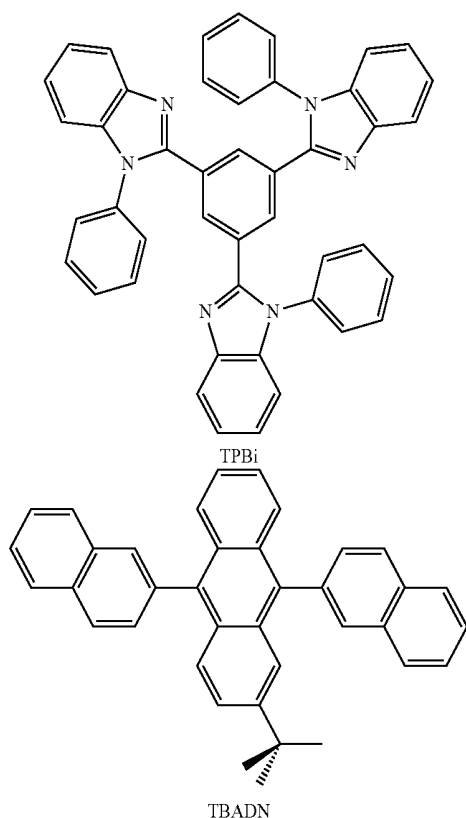
[0183] The hole transport region may include a buffer layer.

[0184] Also, the buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, and thus, efficiency of a formed organic light-emitting device may be improved.

[0185] Then, an emission layer (EML) may be formed on the hole transport region by vacuum deposition, spin coating, casting, LB deposition, or the like. When the emission layer is formed by vacuum deposition or spin coating, the deposition or coating conditions may be similar to those applied to form the hole injection layer although the deposition or coating conditions may vary according to the material that is used to form the emission layer.

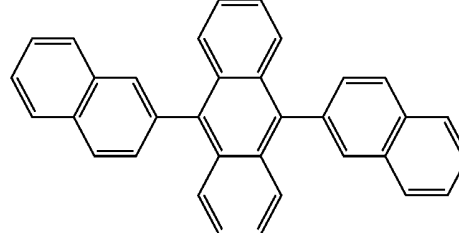
[0186] The emission layer may include a host and a dopant, and the dopant may include the organometallic compound represented by Formula 1.

[0187] The host may include at least one selected from TPBi, TBADN, ADN (also referred to as "DNA"), CBP, CDBP, and TCP.

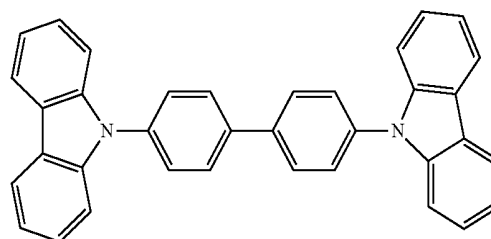


TBADN

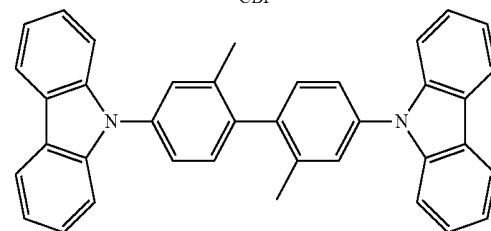
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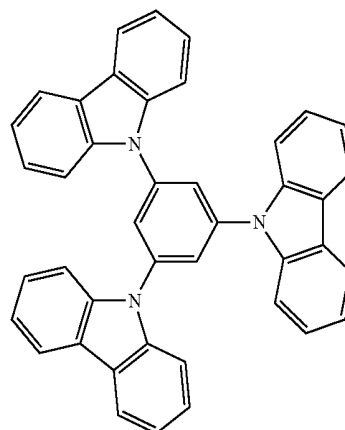
ADN



CBP

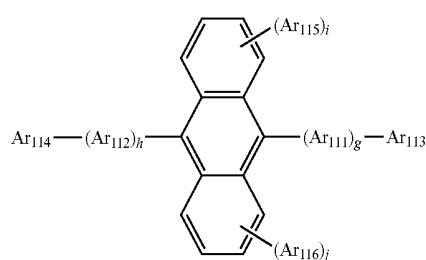


CDBP



TCP

[0188] According to another embodiment, the host may further include a compound represented by Formula 301 below.



Formula 301

[0189] Ar_{111} and Ar_{112} in Formula 301 may be each independently selected from

[0190] a phenylene group, a naphthylene group, a phenanthrenylene group, and a pyrenylene group; and

[0191] a phenylene group, a naphthylene group, a phenanthrenylene group, a fluorenylene group, and a pyrenylene group, each substituted with at least one selected from a phenyl group, a naphthyl group, and an anthracenyl group.

[0192] Ar_{113} to Ar_{116} in Formula 301 may be each independently selected from

[0193] a C_1 - C_{10} alkyl group, a phenyl group, a naphthyl group, a phenanthrenyl group and a pyrenyl group; and

[0194] a phenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one selected from a phenyl group, a naphthyl group, and an anthracenyl group.

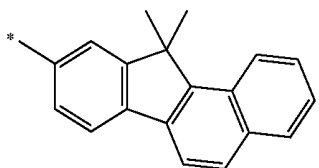
[0195] g, h, i, and j in Formula 301 may be each independently an integer of 0 to 4, for example, an integer of 0, 1, or 2.

[0196] Ar_{113} and Ar_{116} in Formula 301 may be each independently selected from

[0197] a C_1 - C_{10} alkyl group substituted with at least one selected from a phenyl group, a naphthyl group, and an anthracenyl group;

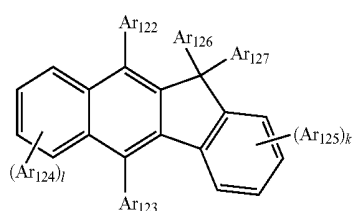
[0198] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group;

[0199] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group, each substituted with at least one selected from 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 they are not limited thereto.

[0200] In some embodiments, the host may include a compound represented by Formula 302 below.



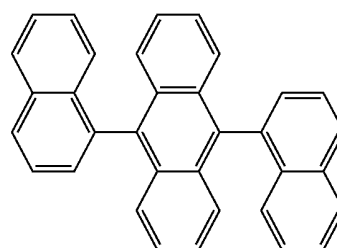
Formula 302

[0201] Ar_{122} to Ar_{125} in Formula 302 are the same as described in detail in connection with Ar_{113} in Formula 301.

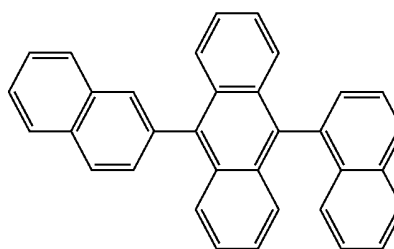
[0202] Ar_{126} and Ar_{127} in Formula 302 may be each independently a C_1 - C_{10} alkyl group (for example, a methyl group, an ethyl group, or a propyl group).

[0203] k and l in Formula 302 may be each independently an integer of 0 to 4. For example, k and l may be 0, 1, or 2.

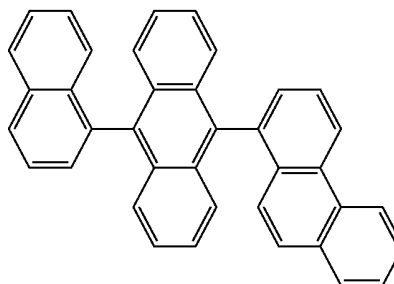
[0204] The compound represented by Formula 301 and the compound represented by Formula 302 may include Compounds H1 to H42 illustrated below, but are not limited thereto.



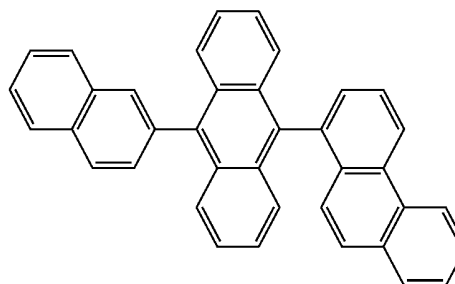
H1



H2

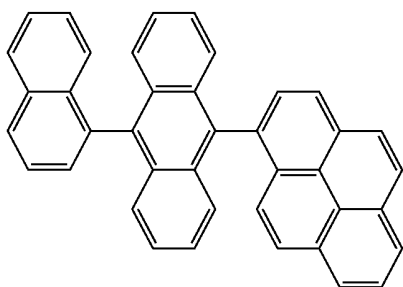


H3



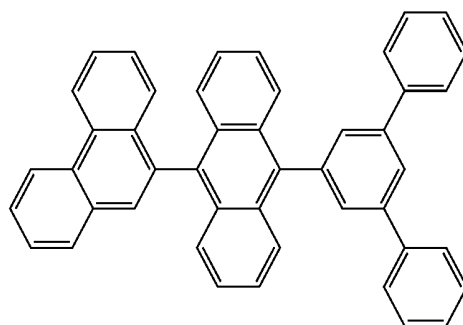
H4

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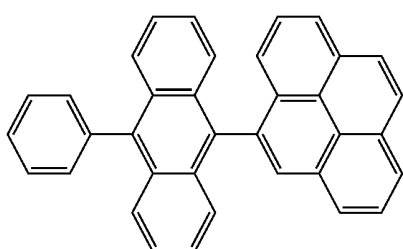


H5

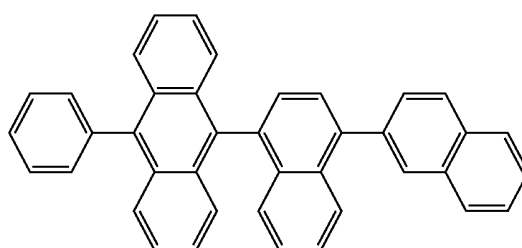
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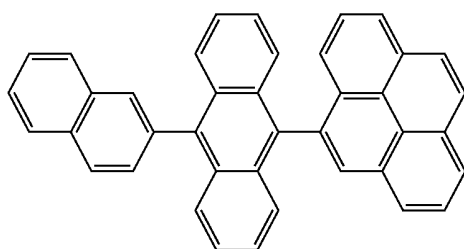
H10



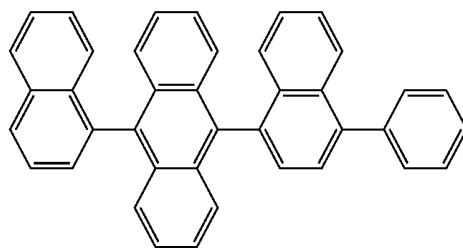
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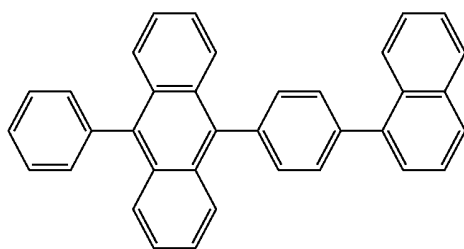
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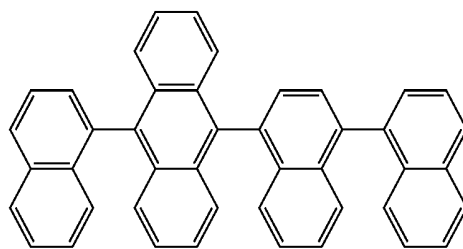
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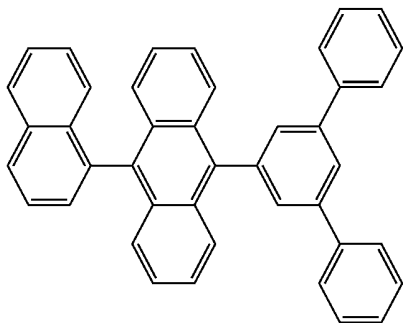
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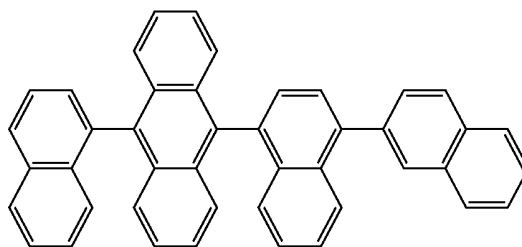
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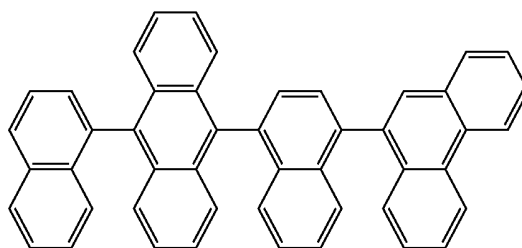
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H9

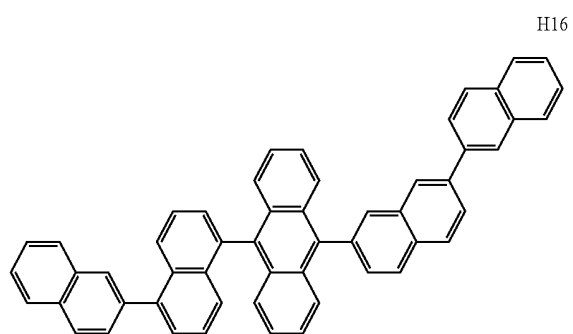


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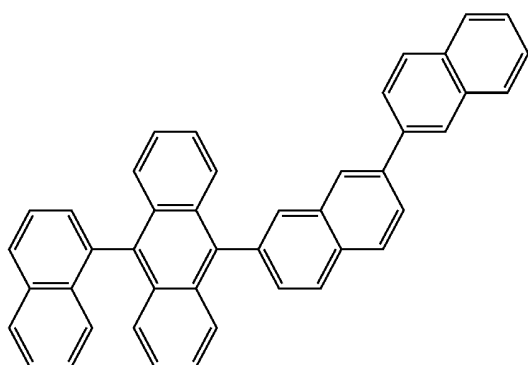


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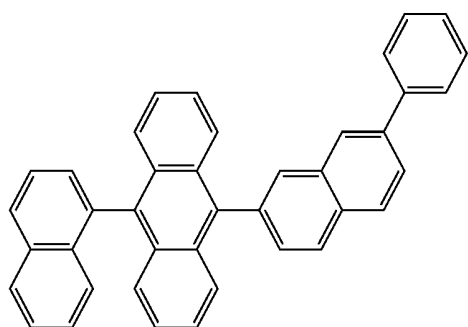
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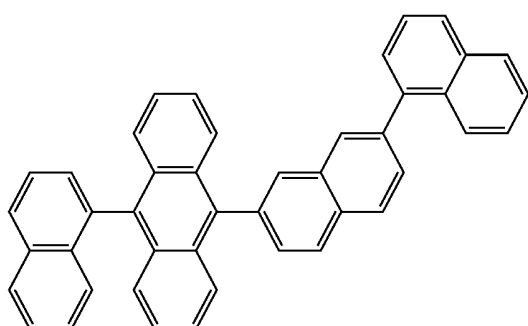
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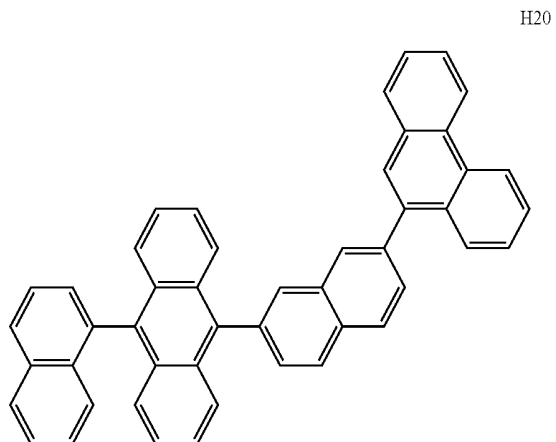
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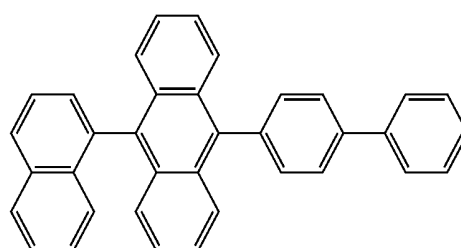
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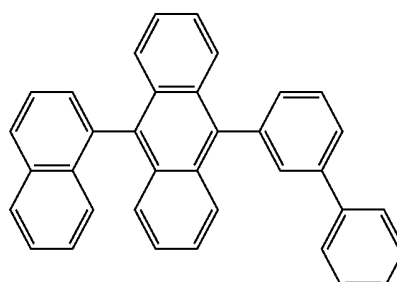
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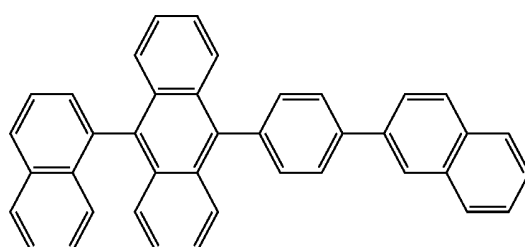
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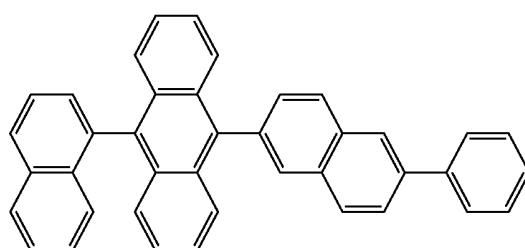
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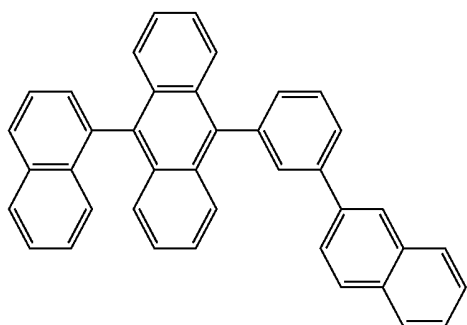
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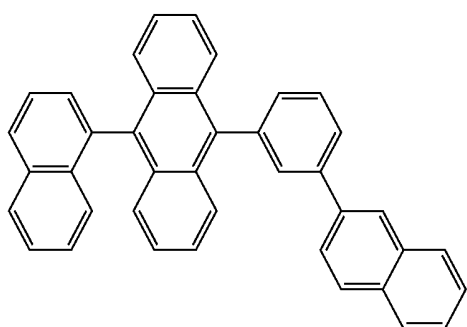
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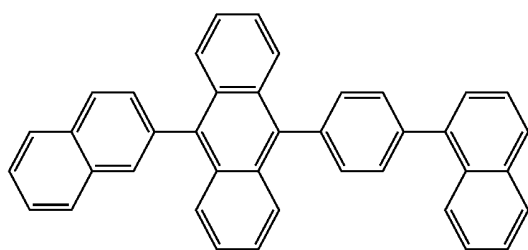
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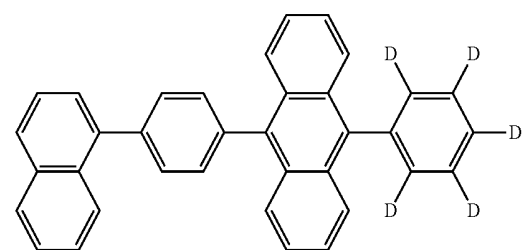
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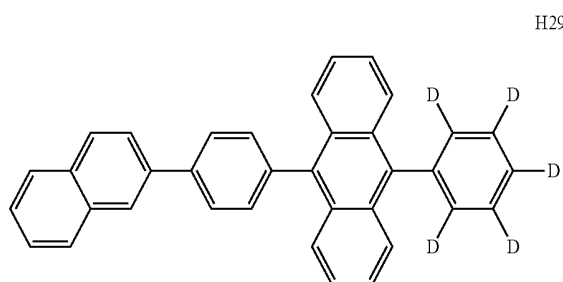
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H27

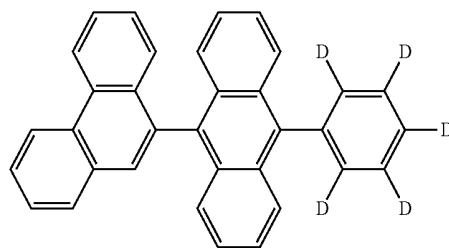


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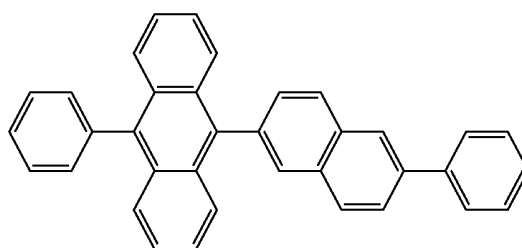


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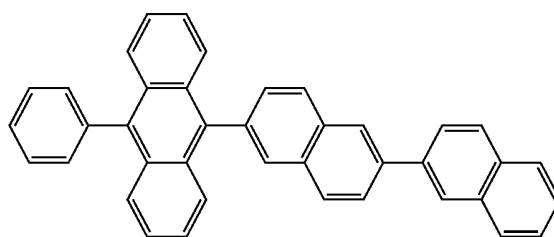
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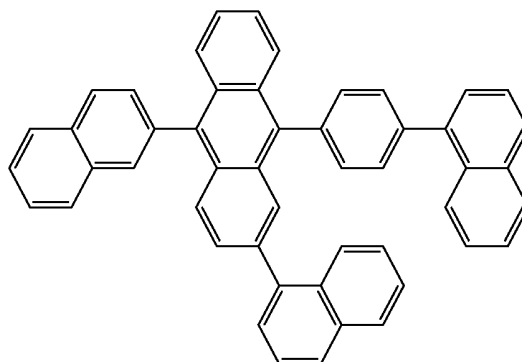
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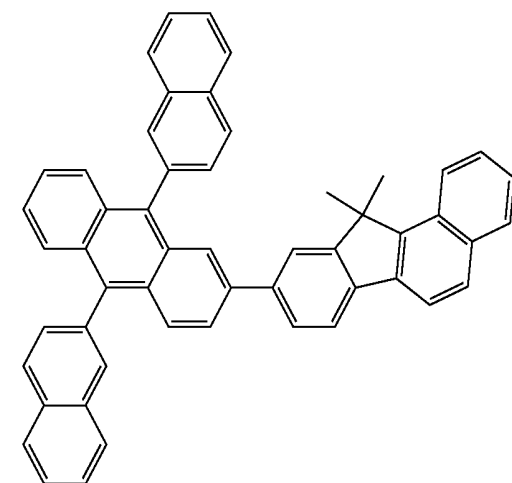
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H32

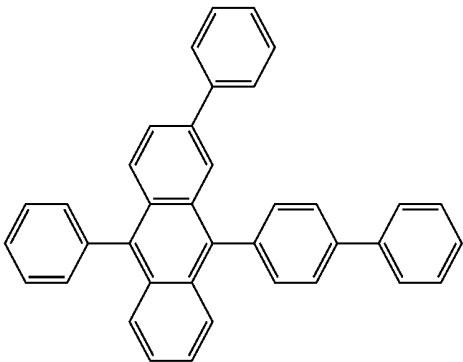


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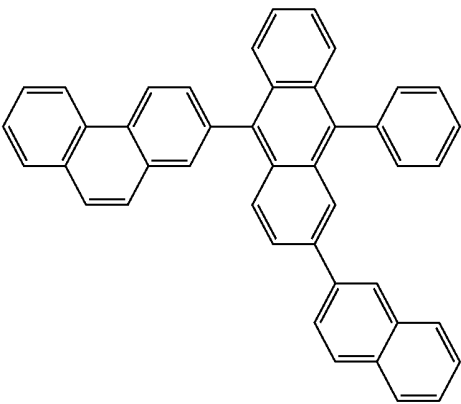
H34

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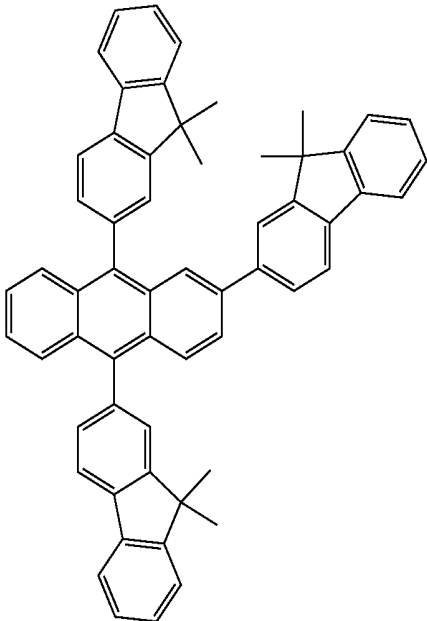
H35

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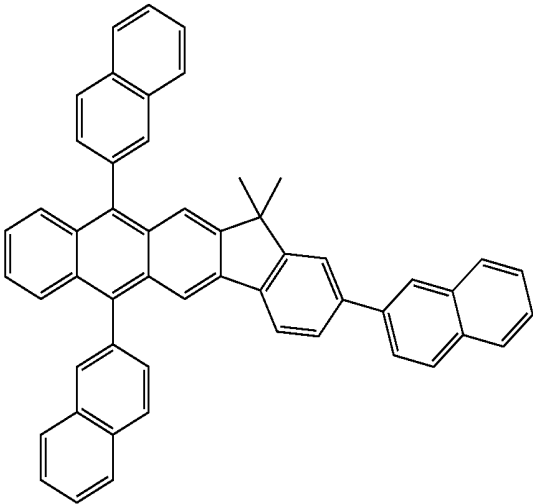


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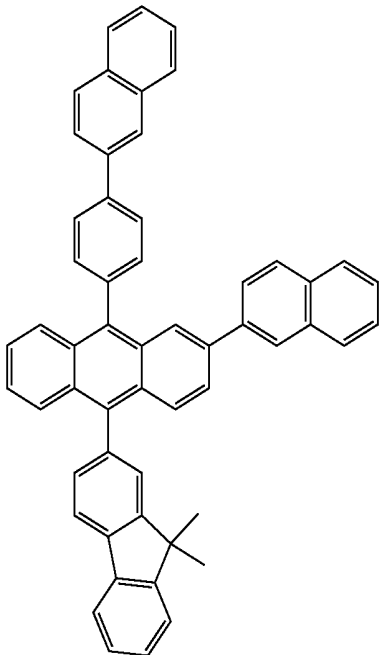
H36



H37



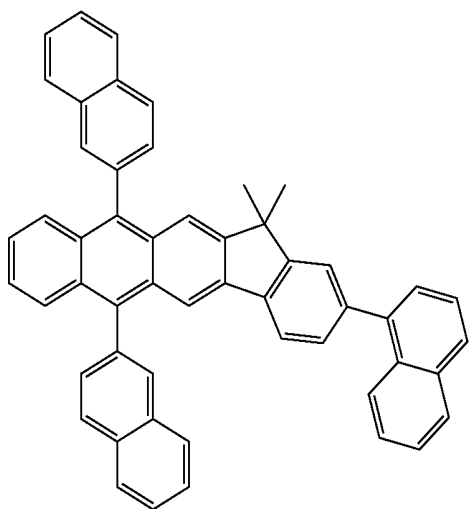
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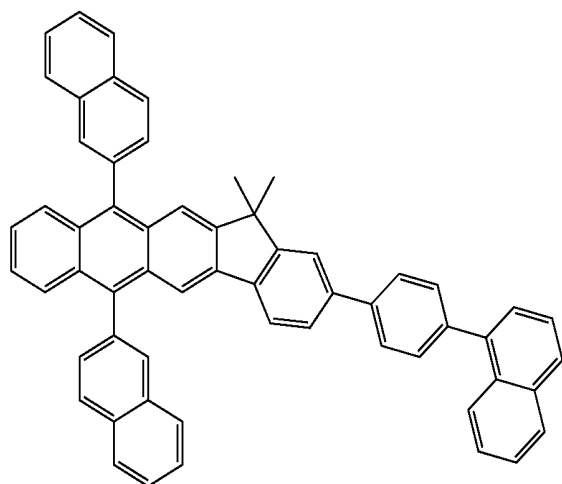
H40

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H41



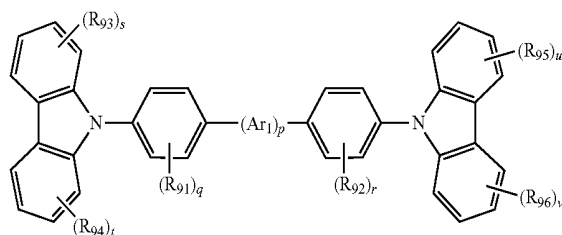
H42



[0205] In some embodiments, the host in the emission layer may include a carbazole compound.

[0206] For example, the carbazole compound may be represented by Formula 10 below:

Formula 10



wherein in Formula 10,

[0207] Ar_1 may be selected from a substituted or unsubstituted C_1 - C_{60} alkylene group, a substituted or unsubstituted C_2 - C_{60} alkenylene group, $-C(=O)-$, $-N(R_{100})-$ (wherein R_{100} is a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted heteropolycyclic group), a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_2 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

wherein p is an integer of 0 to 10, R_{91} to R_{96} 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 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_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - 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_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, wherein two neighboring substituents of R_{91} to R_{96} may be optionally linked to each other to form a substituted or unsubstituted C_5 - C_{20} carbocyclic ring or a substituted or unsubstituted C_2 - C_{20} heterocyclic ring;

[0208] p is an integer of 0 to 10,

[0209] R_{91} to R_{96} 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 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_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - 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_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, wherein two neighboring substituents of R_{91} to R_{96} may be optionally linked to each other to form a substituted or unsubstituted C_5 - C_{20} carbocyclic ring or a substituted or unsubstituted C_2 - C_{20} heterocyclic ring;

[0210] q , r , s , t , u , and v may be each independently an integer of 1 to 4.

[0211] Ar_1 in Formula 10 may be a C_1 - C_5 alkylene group, a C_2 - C_5 alkenylene group, $-C(=O)-$ or $-N(R_{100})-$. Herein, R_{100} may be selected from

[0212] a phenyl group, a naphthyl group, an anthryl group, a fluorenyl group, a carbazolyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group; and

[0213] a phenyl group, a naphthyl group, an anthryl group, a fluorenyl group, a carbazolyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{20} alkyl group, a substituted or unsubstituted C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, an anthryl group, a fluorenyl group, a carbazolyl group, a pyridinyl group, a pyrimidinyl group, and a triazinyl group.

[0214] R_{91} to R_{96} in Formula 10 may be each independently selected from

[0215] a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{20} alkyl group, and a substituted or unsubstituted C_1 - C_{20} alkoxy group; and

[0216] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro

group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof.

[0217] When the organic light-emitting device is a full color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and a blue emission layer. According to another embodiment, due to a stack structure including a red emission layer, a green emission layer, and/or a blue emission layer, the emission layer may emit white light.

[0218] When the emission layer 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.

[0219] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

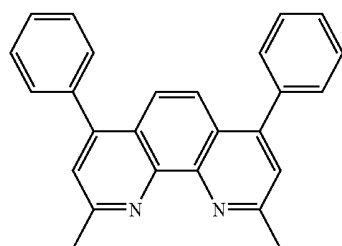
[0220] Then, an electron transport region may be disposed on the emission layer.

[0221] The electron transport region may include at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

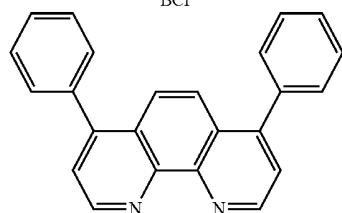
[0222] For example, the electron transport region may have a structure of hole blocking layer/electron transport layer/electron injection layer or a structure of electron transport layer/electron injection layer, but the structure of the electron transport region is not limited thereto. The electron transport layer may have a single-layered structure or a multi-layer structure including two or more different materials.

[0223] Conditions for forming the hole blocking layer, the electron transport layer, and the electron injection layer which constitute the electron transport region may be understood by referring to the conditions for forming the hole injection layer.

[0224] When the electron transport layer includes a hole blocking layer, the hole blocking layer may include, for example, at least one of BCP and Bphen, but may also include other materials.



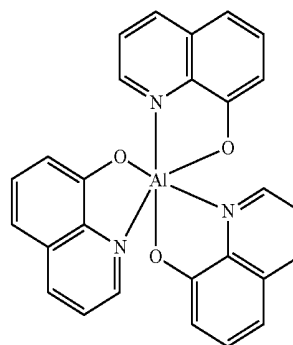
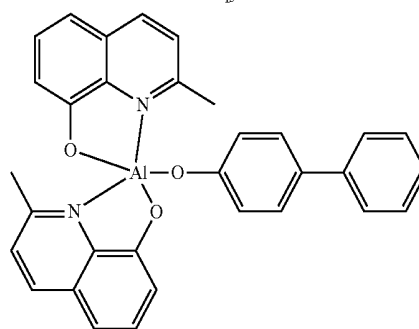
BCP



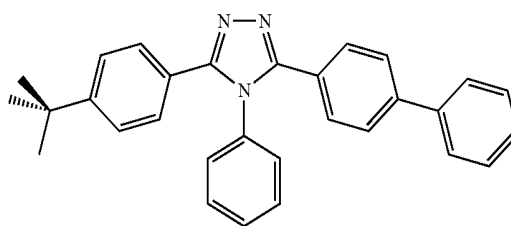
Bphen

[0225] A thickness of the hole blocking layer may be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. When the thickness of the hole blocking layer is within these ranges, the hole blocking layer may have excellent hole blocking characteristics without a substantial increase in driving voltage.

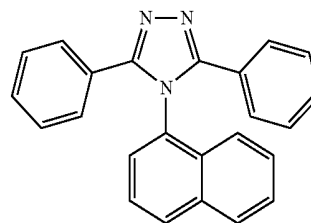
[0226] The electron transport layer may include, at least one selected from BCP, Bphen, Alq₃, Balq, TAZ, and NTAZ.

Alq₃

Balq

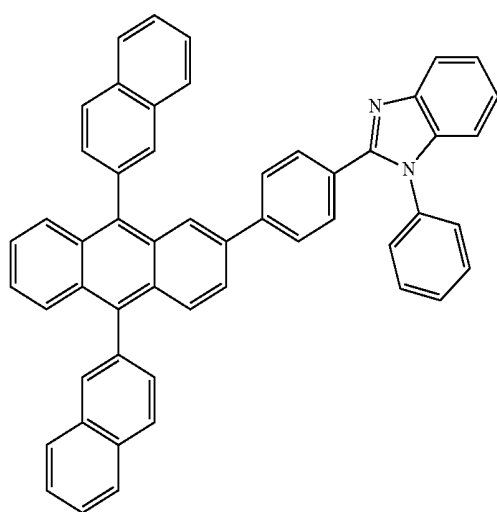


TAZ

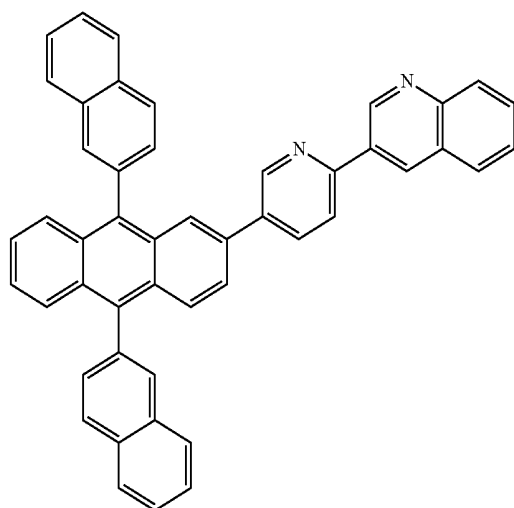


NTAZ

[0227] According to another embodiment, the electron transport layer may include at least one of ET1 and ET2, but are not limited thereto:



ET1

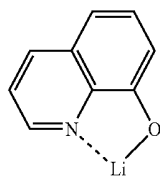


ET2

[0228] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within the range described above, the electron transport layer may have satisfactory electron transport characteristics without a substantial increase in driving voltage.

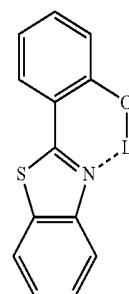
[0229] Also, the electron transport layer may further include, in addition to the materials described above, a metal-containing material.

[0230] The metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2.



ET-D1

-continued



ET-D2

[0231] The electron transport region may include an electron injection layer (EIL) that allows electrons to be easily provided from a second electrode 19.

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

[0233] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. When the thickness of the electron injection layer is within the range described above, the electron injection layer may have satisfactory electron injection characteristics without a substantial increase in driving voltage.

[0234] The second electrode 19 is disposed on the organic layer 15. The second electrode 19 may be a cathode. A material for forming the second electrode 19 may be metal, an alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function. For example, lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag) may be formed as the material for forming the second electrode 19. To manufacture a top emission type light-emitting device, a transmissive electrode formed using ITO or IZO may be used as the second electrode 19.

[0235] Hereinbefore, the organic light-emitting device has been described with reference to FIG. 1, but is not limited thereto.

[0236] A C₁-C₆₀ alkyl group 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 C₁-C₆₀ alkylene group used herein refers to a divalent group having the same structure as the C₁-C₆₀ alkyl group.

[0237] A C₁-C₆₀ alkoxy group used herein refers to a monovalent group represented by —OA₁₀₁ (wherein A₁₀₁ is the C₁-C₆₀ alkyl group). Detailed examples thereof are a methoxy group, an ethoxy group, and an isopropoxy group.

[0238] A C₂-C₆₀ alkenyl group used herein refers to a hydrocarbon group formed by substituting at least one carbon double bond in the middle or at the terminal of the C₂-C₆₀ alkyl group. Detailed examples thereof are an ethenyl group, a propenyl group, and a butenyl group. A C₂-C₆₀ alkenylene group used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

[0239] A C₂-C₆₀ alkynyl group used herein refers to a hydrocarbon group formed by substituting at least one carbon triple bond in the middle or at the terminal of the C₂-C₆₀ alkyl group. Detailed examples thereof are an ethynyl group, and a

propynyl group. A C_2 - C_{60} alkynylene group used herein refers to a divalent group having the same structure as the C_2 - C_{60} alkynyl group.

[0240] A C_3 - C_{10} cycloalkyl group used herein refers to a 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 used herein refers to a divalent group having the same structure as the C_3 - C_{10} cycloalkyl group.

[0241] A C_3 - C_{10} heterocycloalkyl group used herein refers to a monovalent monocyclic group having at least one hetero atom selected from N, O, P, and S as a ring-forming atom and 3 to 10 carbon atoms. Detailed examples thereof are a tetrahydrofuranyl group, and a tetrahydrothiophenyl group. A C_3 - C_{10} heterocycloalkylene group used herein refers to a divalent group having the same structure as the C_3 - C_{10} heterocycloalkyl group.

[0242] A C_3 - C_{10} cycloalkenyl group 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, 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 used herein refers to a divalent group having the same structure as the C_3 - C_{10} cycloalkenyl group.

[0243] A C_3 - C_{10} heterocycloalkenyl group used herein refers to a monovalent monocyclic group that has at least one hetero atom selected from N, O, P, and S as a ring-forming atom, 3 to 10 carbon atoms, and at least one double bond in its ring. Detailed examples of the C_3 - C_{10} heterocycloalkenyl group are a 2,3-dihydrofuranyl group and a 2,3-dihydrothiophenyl group. A C_3 - C_{10} heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C_3 - C_{10} heterocycloalkenyl group.

[0244] A C_6 - C_{60} aryl group used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. A C_6 - C_{60} arylene group 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.

[0245] A C_2 - C_{60} heteroaryl group used herein refers to a monovalent group having a carbocyclic aromatic system that has at least one hetero atom selected from N, O, P, and S as a ring-forming atom, and 2 to 60 carbon atoms. A C_2 - C_{60} heteroarylene group used herein refers to a divalent group having a carbocyclic aromatic system that has at least one hetero atom selected from N, O, P, and S as a ring-forming atom, and 2 to 60 carbon atoms. Examples of the C_2 - 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_2 - C_{60} heteroaryl group and the C_2 - C_{60} heteroarylene group each include two or more rings, the rings may be fused to each other.

[0246] A C_6 - C_{60} aryloxy group used herein indicates $-OA_{102}$ (wherein A_{102} is the C_6 - C_{60} aryl group), and a C_6 - C_{60} arylthio group indicates $-SA_{103}$ (wherein A_{103} is the C_6 - C_{60} aryl group).

[0247] A monovalent non-aromatic condensed polycyclic group 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 ring forming atoms, 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 used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0248] A monovalent non-aromatic condensed heteropolycyclic group used herein refers to a monovalent group (for example, having 2 to 60 carbon atoms) that has two or more rings condensed to each other, has a heteroatom selected from N, O, P, and S, other than carbon atoms, as ring forming atoms, and which is non-aromatic in the entire molecular structure. An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0249] 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_3 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_3 - 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_2 - C_{60} heteroaryl group, the substituted a monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

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

[0251] a C_1 - C_{60} alkyl group, a C_3 - C_{60} alkenyl group, a C_3 - C_{60} alkynyl group, or a C_1 - C_{60} alkoxy group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - 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_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-N(Q_{11})(Q_{12})$, $-Si(Q_{13})(Q_{14})(Q_{15})$, and $-B(Q_{16})(Q_{17})$;

[0252] a C_3 - C_{10} cycloalkyl group, a C_3 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_3 - 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_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, or a monovalent non-aromatic condensed heteropolycyclic group;

[0253] a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₃-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, or a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, a n 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 C₃-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₃-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₃-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-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); or

[0254] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), or —B(Q₃₆)(Q₃₇),

[0255] wherein Q₁ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently 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 C₃-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₃-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, or a monovalent non-aromatic condensed heteropolycyclic group.

[0256] In some embodiments, 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 C₃-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₃-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0257] 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;

[0258] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, or a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group

or a salt thereof, a phenyl group, a 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, arubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇);

[0259] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a 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, a n isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group;

[0260] 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 naph-

thacenyl 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 furinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl 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 furinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group.

[0261] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), or —B(Q₃₆)(Q₃₇).

[0262] wherein Q₁ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ may be each independently 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 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 furinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group.

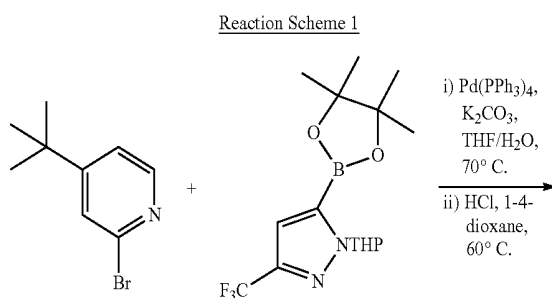
[0263] Hereinafter, a compound and an organic light-emitting device according to embodiments are described in detail with reference to Synthesis Example and Examples. However, the organic light-emitting device is not limited thereto. The wording “B was used instead of A” used in describing Synthesis Examples means that a molar equivalent of A was identical to a molar equivalent of B.

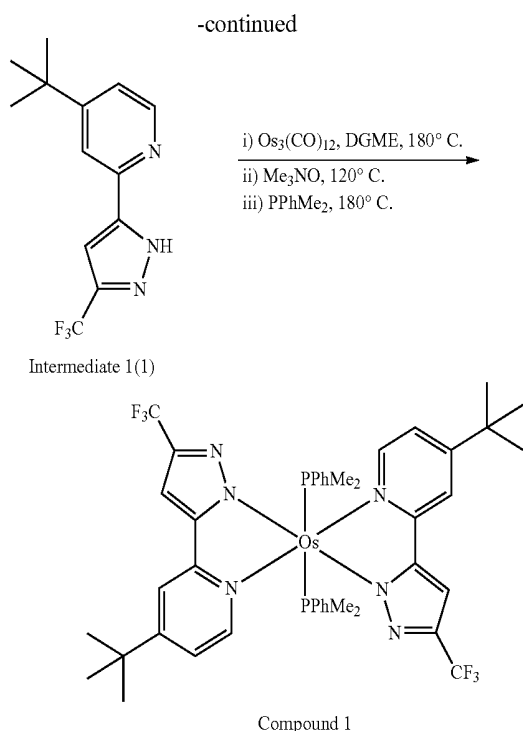
EXAMPLE

Synthesis Example 1

Synthesis of Compound 1

[0264] Compound 1 was synthesized according to Reaction Scheme 1 below:



**[0265]** Synthesis of Intermediate 1(1)

[0266] 2.42 g (11.3 mmol) of 2-bromo-4-tert-butylpyridine, 4.70 g (13.6 mmol) of pyrazole, 0.916 g (0.792 mmol) of tetrakis(triphenylphosphine) palladium, and 2.35 g (17.0 mmol) of potassium carbonate were dissolved in 60 mL of a mixed solution including tetrahydrofuran and distilled water in a ratio of 2:1, and then the result was heated to a temperature of 70° C. When the reaction stopped, 100 mL of ethyl acetate was added thereto, and an extraction process was performed thereon. The obtained organic layer was dried by using sodium sulfate, distilled under reduced pressure, and filtered through a filter cake in which celite, terra alba, and silica gel were mixed. The filtrate was distilled under reduced pressure. A reaction mixture obtained therefrom was dissolved in 40 mL of 1,4-dioxane. 12 mL (24.0 mmol) of 2 N HCl in diethyl ether was slowly added thereto, and the result was heated at a temperature of 60° C. When the reaction stopped, a produced white solid salt was filtered, and the filtrate was neutralized by using a sodium hydrogen carbonate aqueous solution. 100 mL of ethyl acetate was added thereto, and an extraction process was performed thereon. The obtained organic layer was dried by using sodium sulfate, and distilled under reduced pressure to obtain 1.75 g (6.50 mmol, yield 58%) of a target compound. The synthesized compound was identified by LCMS and ¹H NMR.

[0267] ¹H-NMR (CDCl₃) δ 13.2 (br. s, 1H), 8.61 (d, 1H), 7.65 (s, 1H), 7.34 (dd, 1H), 7.00 (s, 1H), 1.37 (s, 9H)

[0268] MS: m/z 270.12 [(M+1)⁺]

Synthesis of Compound 1

[0269] At room temperature, 500 mg (1.86 mmol) of Intermediate 1(1) was dissolved in 15 ml of diethylene glycol monoethyl ether. 272 mg (0.299 mmol) of Os₃(CO)₁₂ was added thereto and the reaction mixture was heated for 12 hours at a temperature of 180° C. When the reaction stopped, the reaction product was cooled to a temperature of 120° C.

157 mg (2.10 mmol) of trimethylamine-N-oxide was added thereto, and the result was stirred for 10 minutes. Thereafter, 336 mg (1.68 mmol) of dimethylphenylphosphine was added thereto, and the result was heated for 14 hours at a temperature of 180° C. When the reaction stopped, the reaction product was cooled to room temperature. 80 ml of distilled water and 80 ml of ethyl acetate were added thereto, and an extraction process was performed thereon. The obtained organic layer was dried by using magnesium sulfate, distilled under reduced pressure, and separation-purified by column chromatography to obtain 280 mg (0.247 mmol, yield 82%) of a target compound. The synthesized compound was identified by LCMS and ¹H NMR.

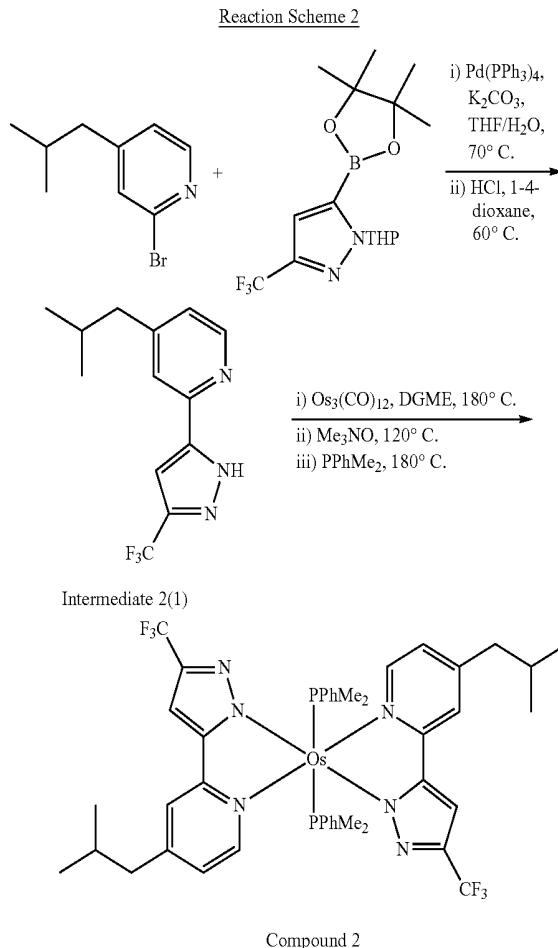
[0270] ¹H-NMR (Acetone-d₆) δ 10.1 (d, 2H), 7.48 (d, 2H), 7.04 (m, 2H), 6.98 (s, 2H), 6.94 (dd, 2H), 6.88 (m, 4H), 6.41 (m, 4H), 1.36 (s, 18H), 0.84 (t, 6H), 0.56 (t, 6H)

[0271] MS: m/z 1004.29 [(M+1)⁺]

Synthesis Example 2

Synthesis of Compound 2

[0272] Compound 2 was synthesized according to Reaction Scheme 2 below:



[0273] Synthesis of Intermediate 2(1)

[0274] Intermediate 2(1) (5.94 mmol, yield of 53%) was synthesized in the same manner as Intermediate 1(1) of Synthesis Example 1, except that 2.42 g (11.3 mmol) of 2-bromo-4-isobutylpyridine was used instead of 2-bromo-4-tert-butylpyridine. The synthesized compound was identified by LCMS and ^1H NMR.

[0275] ^1H -NMR (CDCl_3) δ 12.1 (br. s, 1H), 8.53 (dd, 1H), 7.43 (s, 1H), 7.11 (dd, 1H), 6.95 (s, 1H), 2.55 (d, 2H), 1.96 (m, 1H), 0.96 (s, 3H), 0.95 (s, 3H)

[0276] MS: m/z 270.11 $[(M-1)^+]$

[0277] Synthesis of Compound 2

[0278] 240 mg of Compound 2 (0.212 mmol, yield of 71%) was synthesized in the same manner as Compound 1 of Synthesis Example 1, except that 500 mg (1.86 mmol) of Intermediate 2(1) was used instead of Intermediate 1(1). The synthesized compound was identified by LCMS and ^1H NMR.

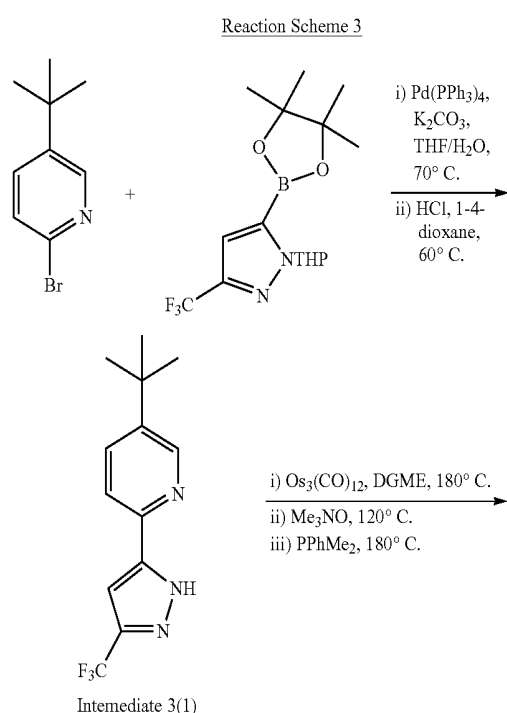
[0279] ^1H -NMR (Acetone- d_6) δ 10.3 (d, 2H), 7.55 (d, 2H), 7.32 (m, 2H), 7.00 (s, 2H), 6.95 (dd, 2H), 6.86 (m, 4H), 6.44 (m, 4H), 2.53 (d, 4H), 1.95 (m, 2H), 0.96 (s, 6H), 0.95 (s, 6H), 0.82 (t, 6H), 0.54 (t, 6H)

[0280] MS: m/z 1004.20 $[(M-1)^+]$

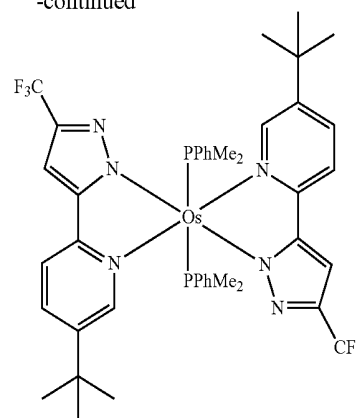
Synthesis Example 3

Synthesis of Compound 3

[0281] Compound 3 was synthesized according to Reaction Scheme 3 below:



-continued



Compound 3

[0282] Synthesis of Intermediate 3(1)

[0283] 1.68 g of Intermediate 3(1) (6.24 mmol, yield of 56%) was synthesized in the same manner as Intermediate 1(1) of Synthesis Example 1, except that 2.42 g (11.3 mmol) of 2-bromo-5-tert-butylpyridine was used instead of 2-bromo-4-tert-butylpyridine. The synthesized compound was identified by LCMS and ^1H NMR.

[0284] ^1H -NMR (CDCl_3) δ 13.0 (br. s, 1H), 8.53 (s, 1H), 7.93 (d, 1H), 7.88 (d, 1H), 6.98 (s, 1H), 1.37 (s, 9H)

[0285] MS: m/z 270.11 $[(M-1)^+]$

[0286] Synthesis of Compound 3

[0287] 190 mg of Compound 3 (0.167 mmol, yield of 56%) was synthesized in the same manner as Compound 1 of Synthesis Example 1, except that 500 mg (1.86 mmol) of Intermediate 3(1) was used instead of Intermediate 1(1) and methyldiphenyl phosphine was used instead of dimethyldiphenyl phosphine. The synthesized compound was identified by LCMS and ^1H NMR.

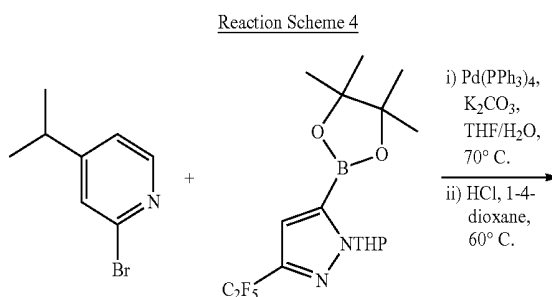
[0288] ^1H -NMR (Acetone- d_6) δ 10.0 (s, 2H), 7.88 (d, 2H), 7.85 (d, 2H), 7.00 (s, 2H), 6.94 (dd, 2H), 6.88 (m, 4H), 6.41 (m, 4H), 1.35 (s, 18H), 0.96 (s, 6H), 0.95 (s, 6H)

[0289] MS: m/z 1004.21 $[(M-1)^+]$

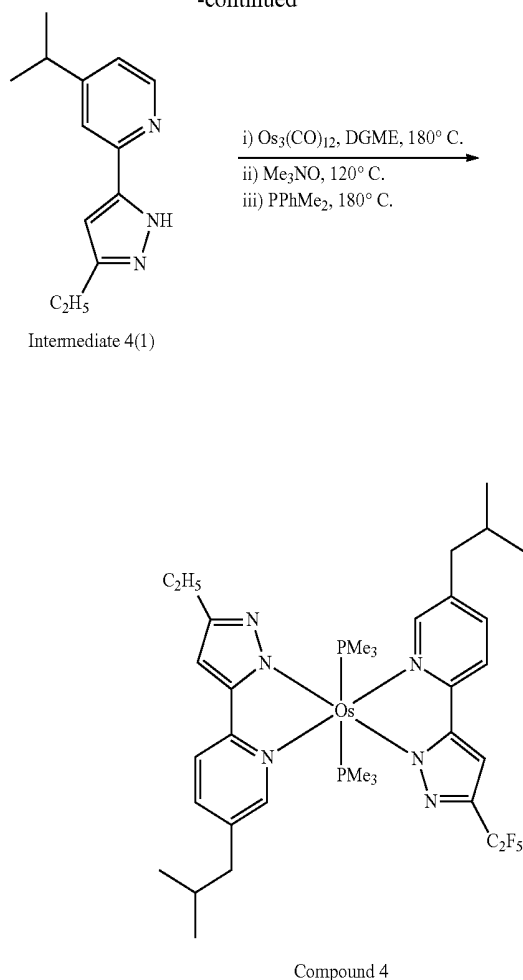
Synthesis Example 4

Synthesis of Compound 4

[0290] Compound 4 was synthesized according to Reaction Scheme 4 below:



-continued

**[0291]** Synthesis of Intermediate 4(1)

[0292] 1.40 g of Intermediate 4(1) (5.20 mmol, yield of 47%) was synthesized in the same manner as Intermediate 1(1) of Synthesis Example 1, except that 2.42 g (11.3 mmol) of 2-bromo-5-isobutylpyridine was used instead of 2-bromo-4-tert-butylpyridine. The target compound was identified by LCMS and ^1H NMR.

[0293] ^1H -NMR (CDCl_3) δ 12.5 (br. s, 1H), 8.59 (s, 1H), 7.88 (m, 2H), 6.95 (s, 1H), 2.51 (d, 2H), 1.87 (m, 1H), 0.94 (s, 3H), 0.92 (s, 3H)

[0294] MS: m/z 319.10 [(M-1) $^+$]

[0295] Synthesis of Compound 4

[0296] 236 mg of Compound 4 (0.215 mmol, yield of 72%) was synthesized in the same manner as Compound 1 of Synthesis Example 1, except that 500 mg (1.86 mmol) of Intermediate 4(1) was used instead of Intermediate 1(1) and trimethylphosphine was used instead of dimethyldiphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0297] ^1H -NMR (Acetone- d_6) δ 10.5 (d, 2H), 7.58 (d, 2H), 7.30 (m, 2H), 7.00 (s, 2H), 6.95 (dd, 2H), 6.86 (m, 4H), 6.44 (m, 4H), 2.57 (d, 4H), 1.90 (m, 2H), 0.96 (s, 18H), 0.85 (t, 6H), 0.56 (t, 6H)

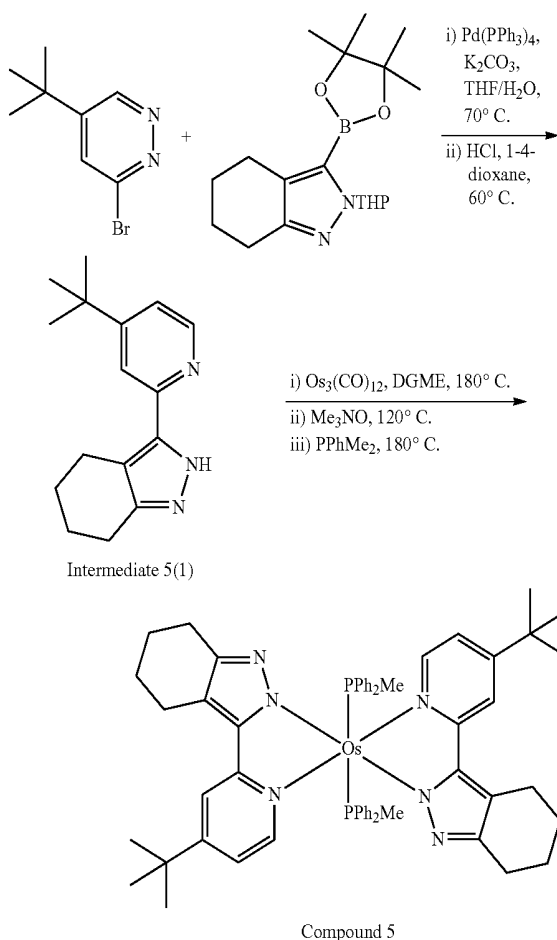
[0298] MS: m/z 980.23 [(M-1) $^+$]

Synthesis Example 5

Synthesis of Compound 5

[0299]

Reaction Scheme 5

**[0300]** Synthesis of Intermediate 5(1)

[0301] 1.23 g of Intermediate 5(1) (4.80 mmol, yield of 41%) was synthesized in the same manner as Intermediate 1(1) of Synthesis Example 1, except that 2.50 g (11.6 mmol) of 3-bromo-5-tert-butylpyridazine was used instead of 2-bromo-4-tert-butylpyridine. The synthesized compound was identified by LCMS and ^1H NMR.

[0302] ^1H -NMR (CDCl_3) δ 12.6 (br. s, 1H), 9.40 (s, 1H), 7.63 (s, 1H), 2.75 (m, 4H), 1.85 (m, 4H), 1.37 (s, 9H)

[0303] MS: m/z 256.15 [(M-1) $^+$]

[0304] Synthesis of Compound 5

[0305] 200 mg of Compound 5 (0.182 mmol, yield of 57%) was synthesized in the same manner as Compound 1 of Synthesis Example 1, except that 500 mg (1.95 mmol) of Intermediate 5(1) was used instead of Intermediate 1(1) and methyldiphenyl phosphine was used instead of dimethyldiphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0306] ^1H -NMR (Acetone- d_6) δ 9.25 (s, 2H), 7.82 (s, 2H), 7.46 (m, 12H), 7.16 (m, 8H), 2.77 (m, 8H), 1.87 (m, 8H), 1.35 (s, 18H), 0.99 (s, 6H)

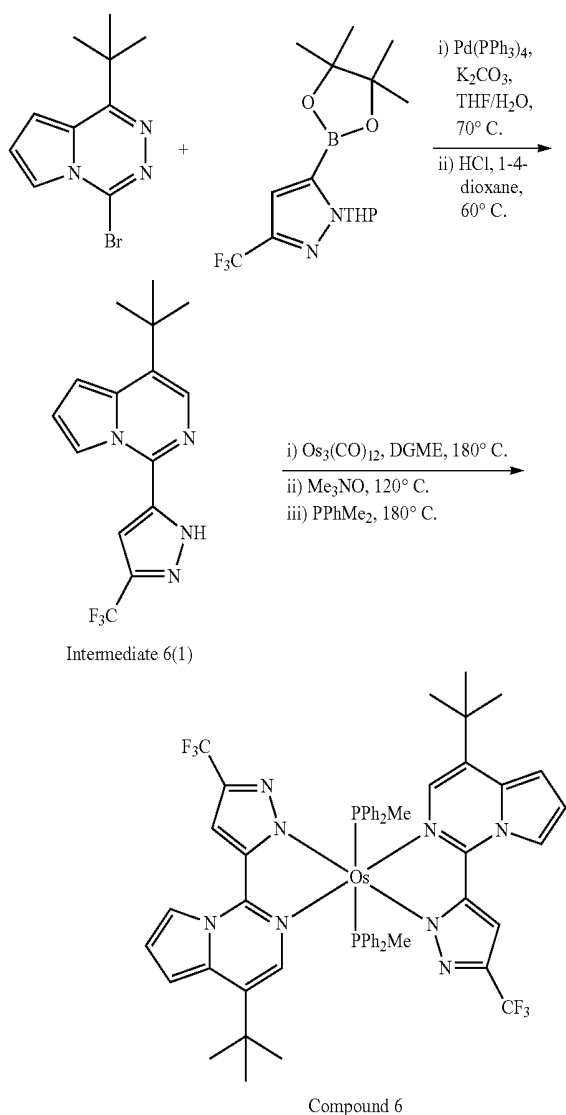
[0307] MS: m/z 1102.44 [(M-1) $^+$]

Synthesis Example 6

Synthesis of Compound 6

[0308]

Reaction Scheme 6



[0309] Synthesis of Intermediate 6(1)

[0310] 1.37 g of Intermediate 6(1) (4.44 mmol, yield of 45%) was synthesized in the same manner as Intermediate 1(1) of Synthesis Example 1, except that 2.50 g (9.88 mmol) of 1-bromo-4-(tert-butyl)pyrrolo[1,2-c]pyrimidine was used instead of 2-bromo-4-tert-butylpyridine. The synthesized compound was identified by LCMS and ^1H NMR.

[0311] ^1H -NMR (CDCl_3) δ 12.6 (br. s, 1H), 9.20 (s, 1H), 7.94 (d, 1H), 7.69 (d, 1H), 7.44 (m, 1H), 6.28 (s, 1H), 1.37 (s, 9H)

[0312] MS: m/z 308.12 [(M-1) $^+$]

[0313] Synthesis of Compound 6

[0314] 131 mg of Compound 6 (0.109 mmol, yield of 42%) was synthesized in the same manner as Compound 1 of Synthesis Example 1, except that 500 mg (1.62 mmol) of Inter-

mediate 6(1) was used instead of Intermediate 1(1) and methyldiphenyl phosphine was used instead of dimethylphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0315] ^1H -NMR (CDCl_3) δ 9.01 (s, 2H), 7.92 (d, 2H), 7.70 (d, 2H), 7.44 (m, 14H), 7.18 (m, 8H), 6.45 (s, 2H), 1.35 (s, 18H), 1.07 (s, 6H)

[0316] MS: m/z 1206.33 [(M-1) $^+$]

Synthesis Example 7

Synthesis of Compound 7

[0317] 70 mg (0.071 mmol, yield of 23%) of Compound 7 was synthesized in the same manner as in Synthesis Example 3, except that in synthesizing Compound 3, 381 mg (0.960 mmol) of cis-1,2-bis(diphenylphosphino)ethylene was used instead of dimethylphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0318] ^1H -NMR (CDCl_3) δ 8.75 (d, 2H), 7.90 (d, 2H), 7.78 (d, 2H), 7.43 (m, 12H), 7.35 (d, 2H), 7.17 (m, 8H), 7.09 (m, 2H), 6.68 (d, 2H), 1.37 (s, 9H), 1.35 (s, 9H)

[0319] MS: m/z 989.33 [(M+1) $^+$]

Synthesis Example 8

Synthesis of Compound 8

[0320] 85 mg (0.076 mmol, yield of 25%) of Compound 8 was synthesized in the same manner as in Synthesis Example 2, except that in synthesizing Compound 2, 381 mg (0.960 mmol) of cis-1,2-bis(diphenylphosphino)ethylene was used instead of dimethylphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0321] ^1H -NMR (CDCl_3) δ 8.67 (d, 2H), 8.00 (s, 2H), 7.58 (d, 2H), 7.43 (m, 12H), 7.15 (m, 8H), 6.98 (m, 2H), 6.86 (s, 2H), 2.55 (d, 4H), 1.93 (m, 2H), 0.84 (t, 6H), 0.56 (t, 6H)

[0322] MS: m/z 1125.25 [(M-1) $^+$]

Synthesis Example 9

Synthesis of Compound 9

[0323] 135 mg (0.121 mmol, yield of 40%) of Compound 9 was synthesized in the same manner as in Synthesis Example 1, except that in synthesizing Compound 1, 657 mg (1.65 mmol) of bis(diphenylphosphanyl)methane was used instead of dimethylphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0324] ^1H -NMR (CDCl_3) δ 8.77 (d, 2H), 8.01 (s, 2H), 7.53 (d, 2H), 7.05 (m, 2H), 6.98 (m, 10H), 6.86 (m, 4H), 6.80 (m, 4H), 6.68 (s, 2H), 2.98 (s, 2H)

[0325] MS: m/z 1114.27 [(M-1) $^+$]

Synthesis Example 10

Synthesis of Compound 10

[0326] 67 mg (0.0535 mmol, yield of 21%) of Compound 10 was synthesized in the same manner as in Synthesis Example 6, except that in synthesizing Compound 6, 361 mg (0.809 mmol) of bis(diphenylphosphanyl)benzene was used instead of dimethylphenylphosphine. The synthesized compound was identified by LCMS and ^1H NMR.

[0327] ^1H -NMR (CDCl_3) δ 8.50 (s, 2H), 7.91 (d, 2H), 7.71 (d, 2H), 7.48 (m, 2H), 7.41 (m, 2H), 7.10 (m, 4H), 7.03 (m, 6H), 6.98 (m, 2H), 6.93 (t, 2H), 6.78 (m, 8H), 6.61 (s, 2H)

[0328] MS: m/z 1253.33 [(M+1) $^+$]

Synthesis Example 11

Synthesis of Compound 11

[0329] 89 mg (0.0775 mmol, yield of 25%) of Compound 11 was synthesized in the same manner as in Synthesis Example 5, except that in synthesizing Compound 5, 435 mg (0.975 mmol) of bis(diphenylphosphanyl)benzene was used instead of dimethylphenylphosphine. The synthesized compound was identified by LCMS and ¹H NMR.

[0330] ¹H-NMR (CDCl₃) δ 9.20 (s, 2H), 7.85 (s, 2H), 7.40 (m, 2H), 7.08 (m, 4H), 7.00 (m, 6H), 6.96 (m, 2H), 6.90 (t, 2H), 6.77 (m, 8H), 2.80 (m, 8H), 2.55 (d, 4H), 1.95 (m, 2H), 1.85 (m, 8H), 0.85 (t, 6H), 0.58 (t, 6H)

[0331] MS: m/z 1149.40 [(M-1)⁺]

Synthesis Example 12

Synthesis of Compound 12

[0332] 141 mg (0.181 mmol, yield of 60%) of Compound 12 was synthesized in the same manner as in Synthesis Example 3, except that in synthesizing Compound 3, 192 mg (0.300 mmol) of trirutheniumdodecacarbonyl was used instead of triosmiumdodecacarbonyl. The synthesized compound was identified by LCMS and ¹H NMR.

[0333] ¹H-NMR (CDCl₃) δ 10.6 (d, 2H), 8.00 (d, 2H), 7.83 (d, 2H), 7.31 (d, 2H), 6.88 (m, 8H), 6.79 (m, 4H), 6.70 (m, 8H), 6.63 (d, 2H), 1.80 (t, 6H), 1.37 (s, 18H)

[0334] MS: m/z 779.27 [(M+1)⁺]

Synthesis Example 13

Synthesis of Compound 13

[0335] 110 mg (0.106 mmol, yield of 35%) of Compound 13 was synthesized in the same manner as in Synthesis Example 2, except that in synthesizing Compound 2, 192 mg (0.300 mmol) of trirutheniumdodecacarbonyl was used instead of triosmiumdodecacarbonyl. The synthesized compound was identified by LCMS and ¹H NMR.

[0336] ¹H-NMR (CDCl₃) δ 10.7 (d, 2H), 7.62 (d, 2H), 7.30 (m, 2H), 7.02 (s, 2H), 6.98 (m, 8H), 6.88 (m, 4H), 6.75 (m, 8H), 2.57 (d, 4H), 1.98 (m, 2H), 1.82 (t, 6H), 0.85 (t, 6H), 0.60 (t, 6H)

[0337] MS: m/z 1039.25 [(M-1)⁺]

Synthesis Example 14

Synthesis of Compound 14

[0338] 156 mg (0.151 mmol, yield of 50%) of Compound 14 was synthesized in the same manner as in Synthesis Example 8, except that in synthesizing Compound 8, 192 mg (0.300 mmol) of trirutheniumdodecacarbonyl was used instead of triosmiumdodecacarbonyl. The synthesized compound was identified by LCMS and ¹H NMR.

[0339] ¹H-NMR (CDCl₃) δ 8.80 (d, 2H), 8.06 (s, 2H), 7.61 (d, 2H), 7.05 (m, 12H), 6.99 (m, 8H), 6.94 (d, 2H), 6.86 (s, 2H), 2.55 (d, 4H), 1.93 (m, 2H), 0.84 (t, 6H), 0.56 (t, 6H)

[0340] MS: m/z 1035.26 [(M-1)⁺]

Synthesis Example 15

Synthesis of Compound 15

[0341] 122 mg (0.137 mmol, yield of 46%) of Compound 15 was synthesized in the same manner as in Synthesis

Example 9, except that in synthesizing Compound 9, 500 mg (1.86 mmol) of Intermediate 3(1) was used instead of Intermediate 1(1) and 192 mg (0.300 mmol) of trirutheniumdodecacarbonyl was used instead of triosmiumdodecacarbonyl. The synthesized compound was identified by LCMS and ¹H NMR.

[0342] ¹H-NMR (CDCl₃) δ 8.89 (d, 2H), 8.04 (s, 2H), 7.52 (d, 2H), 7.41 (d, 2H), 7.05 (m, 2H), 6.98 (m, 10H), 6.89 (m, 4H), 6.80 (m, 4H), 6.68 (d, 2H), 2.98 (s, 2H), 1.35 (s, 18H)

[0343] MS: m/z 887.24 [(M-1)⁺]

Example 1

[0344] An anode was prepared by cutting a glass substrate with ITO/Ag/ITO having a thickness of 70 Å/1,000 Å/70 Å deposited thereon to a size of 50 mm×50 mm×0.7 mm, ultrasonically cleaning the glass substrate by using isopropyl alcohol and pure water for 5 minutes each, and then irradiating UV light for 30 minutes thereto and exposing to ozone to clean. Then, the anode was loaded into a vacuum deposition apparatus.

[0345] 2-TNATA was deposited on the anode to form a hole injection layer having a thickness of 600 Å, and then, 4,4'-bis [N-(1-naphthyl)-N-phenylamino]biphenyl (NPB) was deposited thereon to form a hole transport layer having a thickness of 1,000 Å.

[0346] CBP (host) and Compound 8 (dopant) were co-deposited on the hole transport layer at a weight ratio of 91:9 to form an emission layer having a thickness of 250 Å, and then, BCP was deposited on the emission layer to form a hole blocking layer having a thickness of 50 Å. Then, Alq₃ was deposited on the hole blocking layer to form an electron transport layer having a thickness of 350 Å, and then, LiF was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and MgAg was deposited on the electron injection layer at a weight ratio of 90:10 to form a cathode having a thickness of 120 Å to manufacture an organic light-emitting device (emission of green light).

Example 2

[0347] An organic light-emitting device (emission of green light) was manufactured in the same manner as in Example 1, except that in forming an emission layer, Compound 9 was used instead of Compound 8.

Example 3

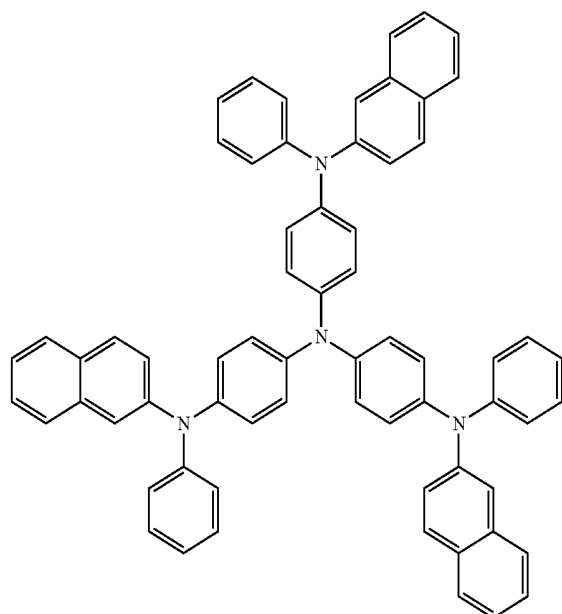
[0348] An organic light-emitting device (emission of red light) was manufactured in the same manner as in Example 1, except that the thickness of the hole transport layer was 1,350 Å, and in forming the emission layer, CBP (host) and Compound 2 (dopant) were co-deposited at a weight ratio of 94:6 to form an emission layer having a thickness of 400 Å.

Comparative Example 1

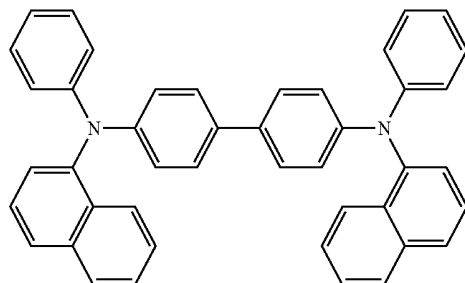
[0349] An organic light-emitting device was manufactured in the same manner as in Example 1, except that in forming an emission layer, Ir(ppy)₃ was used instead of Compound 8.

Comparative Example 2

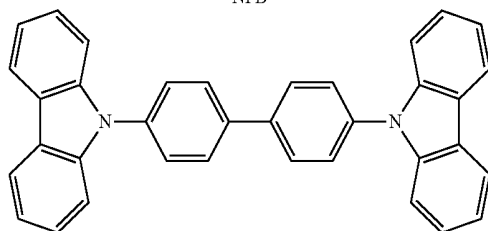
[0350] An organic light-emitting device was manufactured in the same manner as in Example 3, except that in forming an emission layer, PtOEP was used instead of Compound 2.



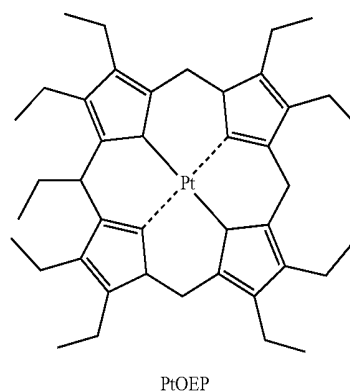
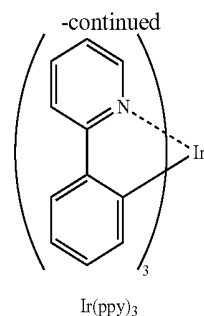
2-TNATA



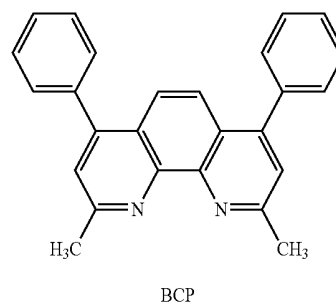
NPB



CBP



PtOEP



BCP

Evaluation Example 1

[0351] Driving voltage, current density, brightness, efficiency, and color purity of the organic light-emitting devices of Examples 1 to 3 and Comparative Examples 1 and 2 were evaluated by using PR650 Spectroscan Source Measurement Unit. (a product of PhotoResearch Company). LT_{97} is a lifespan data when brightness is reduced from 100% (initial brightness) to 97% at the current density of 10 milliamperes per square centimeter (mA/cm^2). Results thereof are shown in Table 1 below.

TABLE 1

	Host	Dopant	Driving Voltage (V)	Current Density (Ma/cm^2)	Brightness (cd/m^2)	Efficiency (cd/A)	Emission color	Color coordinate	LT_{97} (HR)
Example 1	CBP	Compound 8	5.8	10	5,371	53.7	Green	0.25, 0.69	81
Example 2	CBP	Compound 9	5.3	10	6,422	64.2	Green	0.25, 0.71	80
Example 3	CBP	Compound 2	5.5	10	2,540	25.4	Red	0.68, 0.31	110

TABLE 1-continued

	Host	Dopant	Driving Voltage (V)	Current Density (Ma/cm ²)	Brightness (cd/m ²)	Efficiency (cd/A)	Emission color	Color coordinate	LT ₉₇ (HR)
Comparative Example 1	CBP	Ir(ppy) ₃	6.8	10	4,766	47.7	Green	0.25, 0.70	61
Comparative Example 2	CBP	PtOEP	7.3	10	2,212	22.1	Red	0.67, 0.32	89

[0352] From Table 1, it was confirmed that the organic light-emitting devices of Examples 1 and 2 had lower driving voltage, higher brightness, higher efficiency, and better lifespan characteristics than the organic light-emitting device of Comparative Example 1, and the organic light-emitting device of Example 3 had lower driving voltage, higher brightness, higher efficiency, and better lifespan characteristics than the organic light-emitting device of Comparative Example 2.

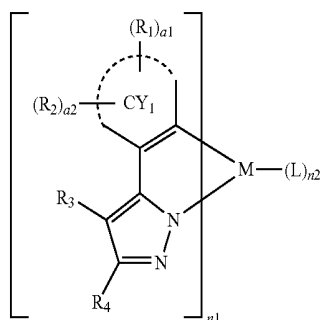
[0353] The organometallic compound according to embodiments has excellent electric characteristics and thermal stability. Accordingly, an organic light-emitting device including the organometallic compound may have a low driving voltage, high efficiency, high brightness, and a long lifespan.

[0354] 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.

[0355] While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the following claims.

What is claimed is:

1. An organometallic compound represented by Formula 1:



Formula 1

wherein in Formula 1,

M is Os or Ru;

CY₁ is selected from at least one N-containing 6-membered ring, at least one N-containing 6-membered ring to which at least one 5-membered ring is condensed, and at least one N-containing 6-membered ring to which at least one 6-membered ring is condensed;

R₁ is a substituted or unsubstituted linear or branched C₄-C₃₀ alkyl group;

R₂ to R₄ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-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 C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-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 —C(=O)(Q₆), wherein any of R₂ to R₄ are optionally linked to an adjacent ligand via a single bond or a divalent linking group, and R₃ and R₄ are optionally linked to each other to form a substituted or unsubstituted C₄-C₂₀ carbocyclic ring or a substituted or unsubstituted C₂-C₂₀ heterocyclic ring;

a1 and a2 are each independently an integer selected from 1 to 5;

L is a monovalent organic ligand, a divalent organic ligand, or a trivalent organic ligand;

n1 is an integer selected from 1 to 3;

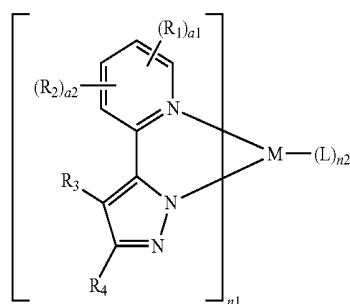
n2 is an integer selected from 0 to 4;

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 C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, the substituted monovalent non-aromatic condensed heteropolycyclic group, the substituted C₄-C₂₀ carbocyclic ring, and the substituted C₂-C₂₀ heterocyclic ring are selected from

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

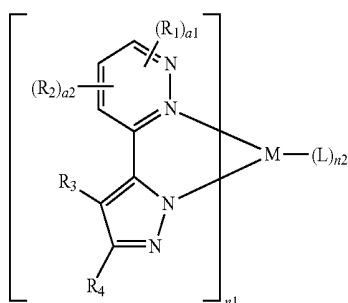
- C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;
- a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇);
- a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;
- a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇); and —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),
- wherein Q₁ to Q₆, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from a hydrogen, 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 C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ 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 CY₁ is selected from a pyridine, a pyrazine, a pyrimidine, a pyridazine, a purine, an isoquinoline, a quinoline, a phthalazine, a 1,8-naphthyridine, a quinoxaline, a quinazoline, a cinnoline, a phenanthridine, a 1,7-phenanthroline, and a pyrrolopyrimidine.
3. The organometallic compound of claim 1, wherein CY₁ is selected from a pyridine, a pyridazine, and a pyrrolopyrimidine.
4. The organometallic compound of claim 1, wherein R₁ is a substituted or unsubstituted linear or branched C₄-C₁₀ alkyl group.
5. The organometallic compound of claim 1, wherein R₁ is selected from 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, and a tert-decanyl group; and 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, and a tert-decanyl group, each substituted with at least one selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group.
6. The organometallic compound of claim 1, wherein R₂ to R₄ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group;
- a C₁-C₂₀ alkyl group and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a pyridinyl group, and a pyrimidinyl 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 carbazoyl

- group, a phenanthrolinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group; and
- 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 benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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 benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and an imidazopyridinyl group.
7. The organometallic compound of claim 1, wherein R_2 to R_4 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group.
8. The organometallic compound of claim 1, wherein R_3 and R_4 are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_3 alkyl group, and a C_1 - C_3 alkoxy group; and
- a C_1 - C_3 alkyl group and a C_1 - C_3 alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, and a phosphoric acid group or a salt thereof.
9. The organometallic compound of claim 1, wherein the organometallic compound is represented by one of Formulae 1A to 1H:



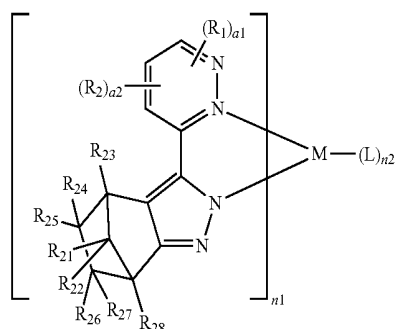
Formula 1A

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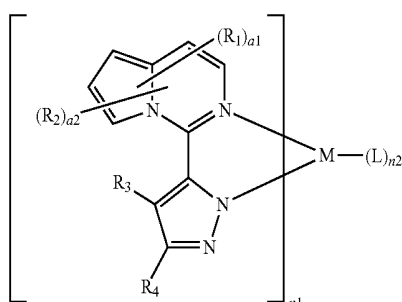


Formula 1B

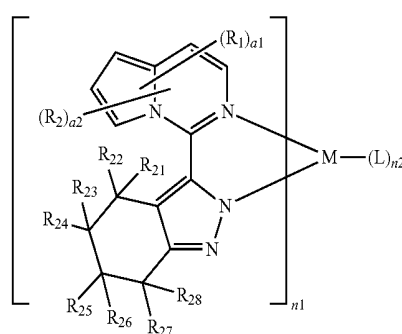
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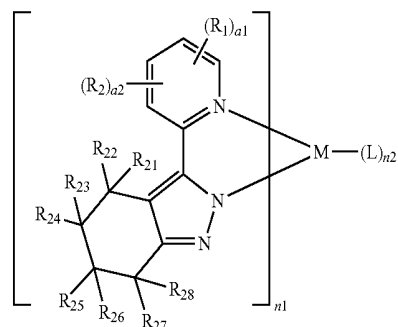
Formula 1G



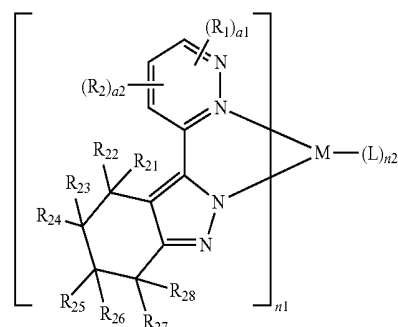
Formula 1C



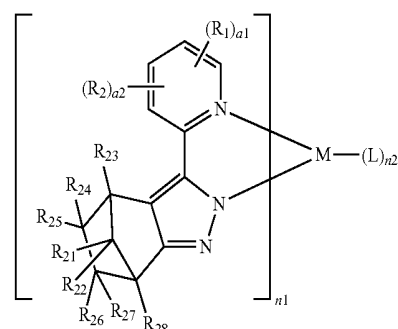
Formula 1H



Formula 1D



Formula 1E



Formula 1F

wherein in Formulae 1A to 1H,

R_1 is selected from

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, and a tert-decanyl group; and

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, and a tert-decanyl group, each substituted with at least one selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

R_2 to R_4 , and R_{21} to R_{28} 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-

pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group; and

a1 and a2 are each independently 1 or 2.

10. The organometallic compound of claim 9, wherein

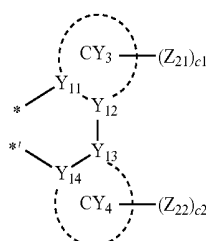
R₃, R₄, and R₂₁ to R₂₈ are each independently selected from

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-C₃ alkyl group, and a C₁-C₃ alkoxy group; and

a C₁-C₃ alkyl group and a C₁-C₃ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof.

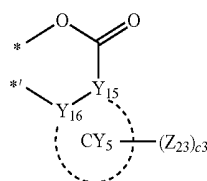
11. The organometallic compound of claim 1, wherein

L in Formula 1 is selected from a ligand represented by Formula 2A to a ligand represented by Formula 2G;

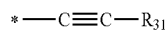


Formula 2A

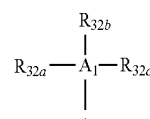
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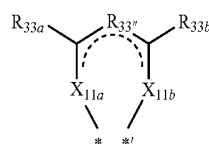
Formula 2B



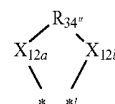
Formula 2C



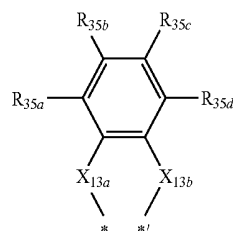
Formula 2D



Formula 2E



Formula 2F



Formula 2G

wherein in Formulae 2A to 2G,

Y₁₁ to Y₁₆ are each independently C or N;

CY₃ to CY₅ are each independently selected from a C₅-C₆₀ carbocyclic group and a C₂-C₆₀ heterocyclic group;

c1 to c3 are each independently an integer of 1 to 5;

A₁ is P or As;

X_{11a}, X_{11b}, X_{12a}, X_{12b}, X_{13a}, and X_{13b} are each independently selected from N, O, N(R₃₄), P(R₃₅)(R₃₆), and As(R₃₇)(R₃₈), provided that each of X_{12a}, X_{12b}, X_{13a}, and X_{13b} is neither N nor O;

R_{33''} and R_{34''} are each independently selected from a single bond, a double bond, a substituted or unsubstituted C₁-C₅ alkylene group, a substituted or unsubstituted C₂-C₅ alkenylene group, and a substituted or unsubstituted C₆-C₁₀ arylene group;

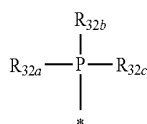
Z₂₁ to Z₂₃, R₃₁, R_{32a}, R_{32b}, R_{32c}, R_{33a}, R_{33b}, R₃₄ to R₃₈, R_{35a}, R_{35b}, R_{35c}, and R_{35d} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone 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 C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and

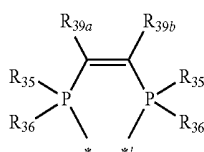
* and *¹ each indicates a binding site to M in Formula 1.

12. The organometallic compound of claim 1, wherein

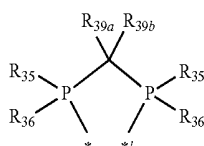
L is selected from a ligand represented by Formula 2D-1, a ligand represented by Formula 2F-1, a ligand represented by Formula 2F-2, and a ligand represented by Formula 2G-1:



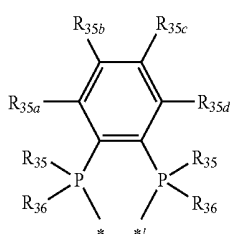
Formula 2D-1



Formula 2F-1



Formula 2F-2



Formula 2G-1

wherein in Formulae 2D-1, 2F-1, 2F-2, and 2G-1,

R_{32a}, R_{32b}, R_{32c}, R₃₅, R₃₆, R_{39a}, R_{35b}, R_{35c}, R_{35d}, R_{39a}, and R_{39b} 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl

group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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

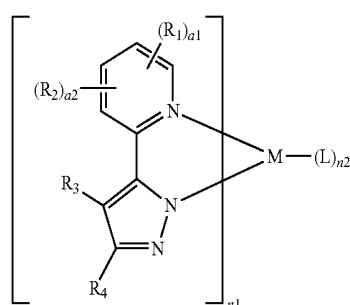
a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group.

13. The organometallic compound of claim 1, wherein

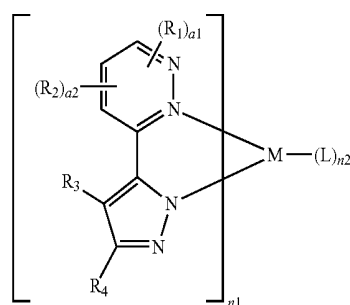
n₁ is 2 and n₂ is 1 or 2.

14. The organometallic compound of claim 1, wherein

the organometallic compound is represented by one of Formulae 1A to 1H:

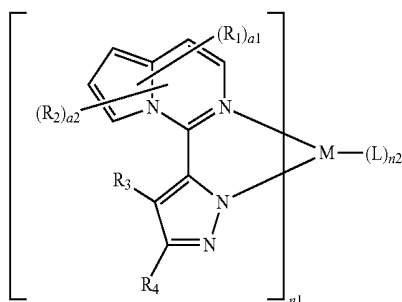


Formula 1A



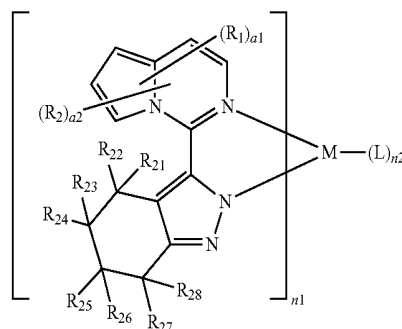
Formula 1B

-continued



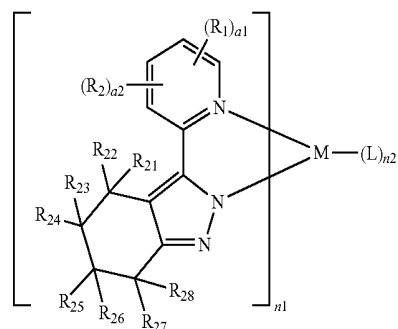
Formula 1C

-continued

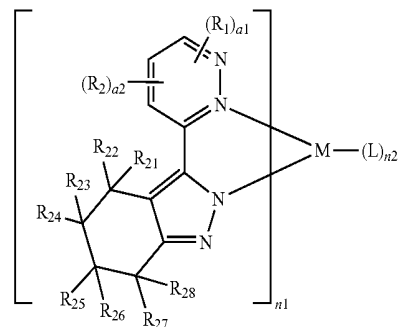


Formula 1H

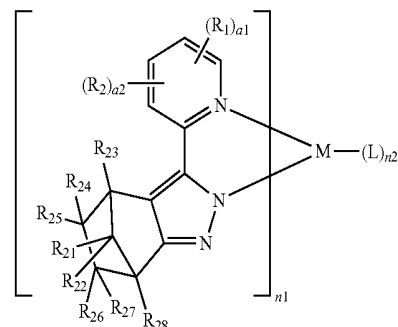
Formula 1D



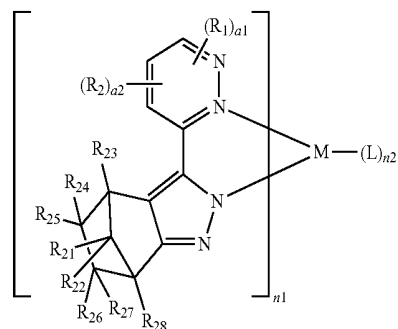
Formula 1E



Formula 1F



Formula 1G



wherein in Formulae 1A to 1H,

R_1 is selected from

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, and a tert-decanyl group; and

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, and a tert-decanyl group, each substituted with at least one selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

R_2 is 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 methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group;

a1 and a2 are each independently 1 or 2;

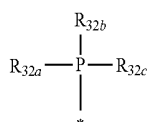
R₃, R₄, and R₂₁ to R₂₈ are each independently selected from

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-C₃ alkyl group, and a C₁-C₃ alkoxy group; and

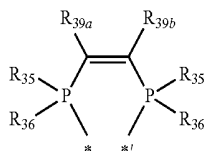
a C₁-C₃ alkyl group and a C₁-C₃ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

n1 is 2, and n2 is 1 or 2;

L is selected from a ligand represented by Formula 2D-1, a ligand represented by Formula 2F-1, a ligand represented by Formula 2F-2, and a ligand represented by Formula 2G-1:

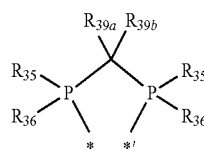


Formula 2D-1

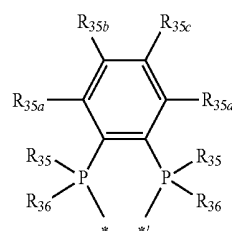


Formula 2F-1

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Formula 2F-2



Formula 2G-1

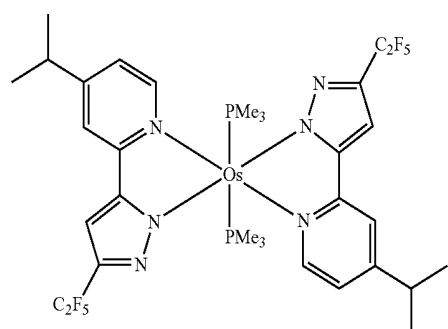
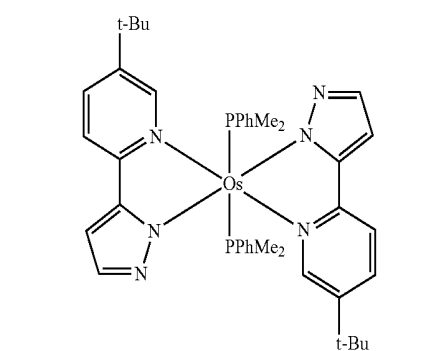
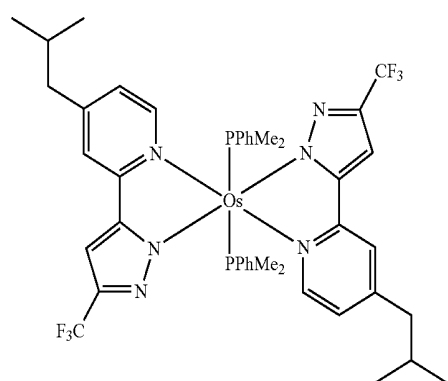
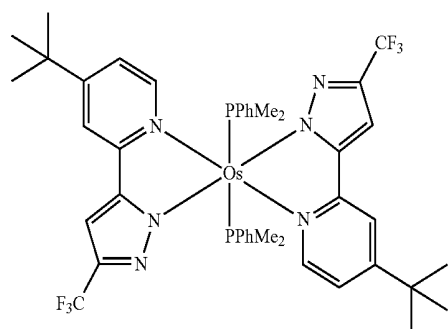
wherein in Formulae 2D-1, 2F-1, 2F-2, and 2G-1,

R_{32a}, R_{32b}, R_{32c}, R₃₅, R₃₆, R_{35a}, R_{35b}, R_{35c}, R_{35d}, R_{39a}, and R_{39b} are each independently selected from

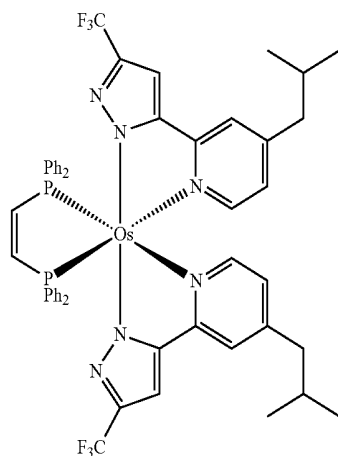
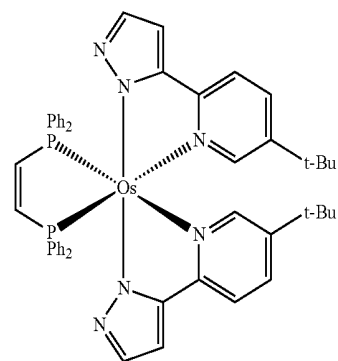
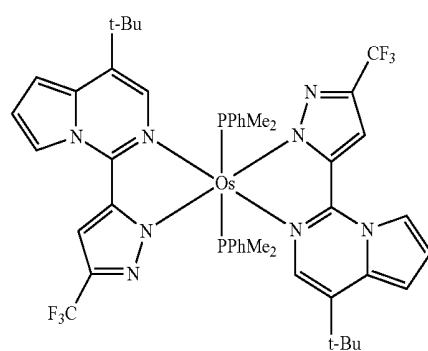
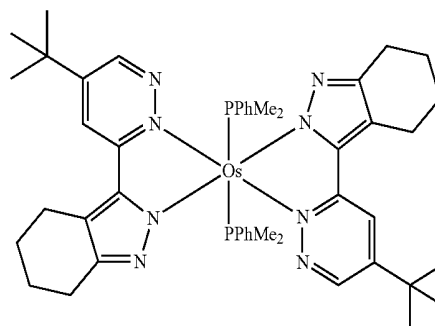
a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-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 selected from a deuterium, —F, a hydroxyl group, a cyano group, a nitro group, and an amino group.

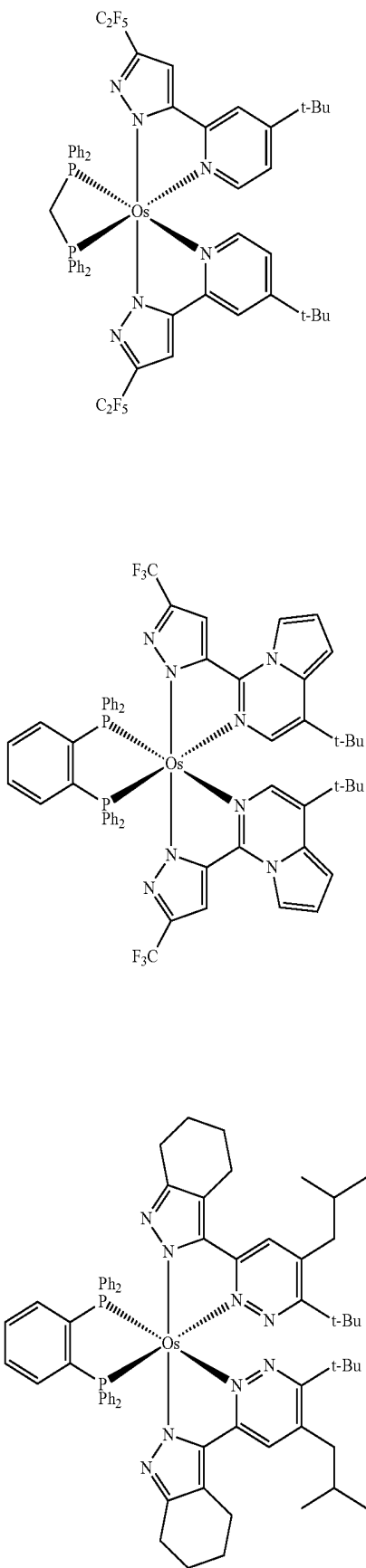
15. The organometallic compound of claim 1, wherein the organometallic compound is one of Compounds 1 to 15:



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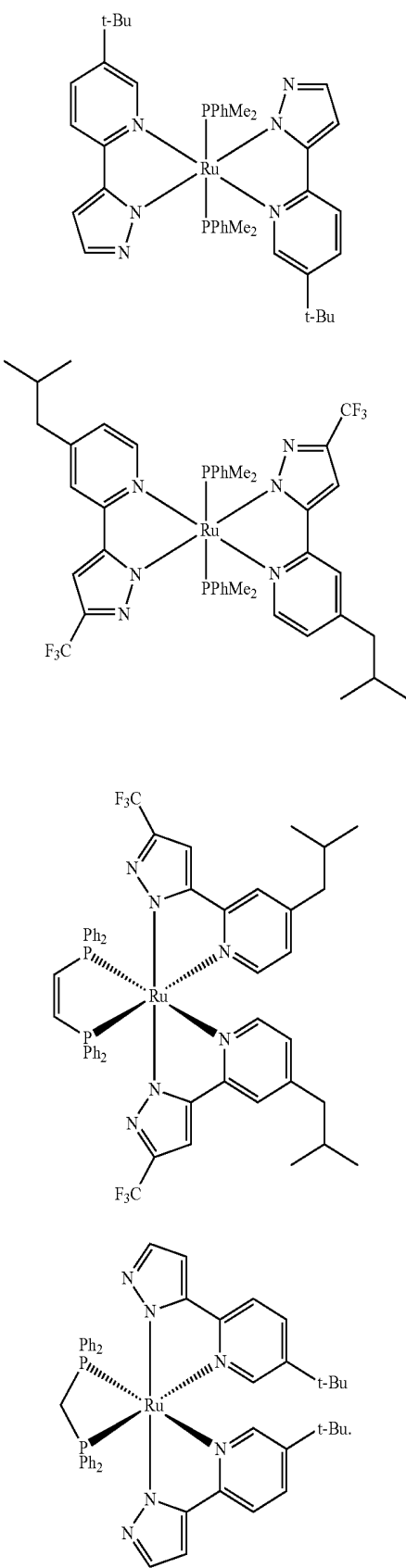


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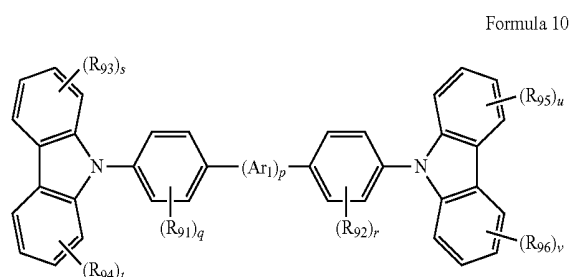
12

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15

- 16.** An organic light-emitting device comprising:
 a first electrode;
 a second electrode; and
 an organic layer disposed between the first electrode and the second electrode,
 wherein the organic layer comprises an emission layer and at least one organometallic compound of claim 1.
- 17.** The organic light-emitting device of claim 16, wherein the first electrode is an anode, the second electrode is a cathode, and the organic layer comprises:
- 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
 - an electron transport region disposed between the emission layer and the second electrode, wherein the electron transport region comprises at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.
- 18.** The organic light-emitting device of claim 16, wherein the emission layer comprises the organometallic compound of claim 1, and further comprises a host, wherein an amount of the organometallic compound of claim 1 is smaller than an amount of the host.
- 19.** The organic light-emitting device of claim 18, wherein the host comprises a carbazole compound.
- 20.** The organic light-emitting device of claim 19, wherein the carbazole compound is represented by Formula 10:



wherein in Formula 10,

Ar₁ is selected from a substituted or unsubstituted C₁-C₆₀ alkenylene group, a substituted or unsubstituted C₂-C₆₀ alkenylene group, —C(=O)—, —N(R₁₀₀)— (wherein R₁₀₀ is a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group), a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₂-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

p is an integer of 0 to 10,

R₉₁ to R₉₆ 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 C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, wherein two neighboring substituents of R₉₁ to R₉₆ are optionally linked to each other to form a substituted or unsubstituted C₅-C₂₀ carbocyclic ring or a substituted or unsubstituted C₂-C₂₀ heterocyclic ring; and q, r, s, t, u, and v are each independently an integer of 1 to 4.

* * * * *

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	US20150325807A1	公开(公告)日	2015-11-12
申请号	US14/602337	申请日	2015-01-22
[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	CHOI WHAIL KWAK YOONHYUN KIM SOYEON PARK BUMWOO LEE SUNYOUNG LEE JIYOUN CHOI JONGWON		
发明人	CHOI, WHAIL KWAK, YOONHYUN KIM, SOYEON PARK, BUMWOO LEE, SUNYOUNG LEE, JIYOUN CHOI, JONGWON		
IPC分类号	H01L51/50 H01L51/00 C07F15/00		
CPC分类号	H01L51/5028 C07F15/0026 H01L51/0086 H01L51/0088 C07F15/0053		
优先权	1020140056571 2014-05-12 KR		
其他公开文献	US10023598		
外部链接	Espacenet USPTO		

摘要(译)

由式1表示的有机金属化合物：其中在公式1中，CY1，M，L，R1，R2，R3，R4，a1，a2，n1，n2在说明书中描述。

