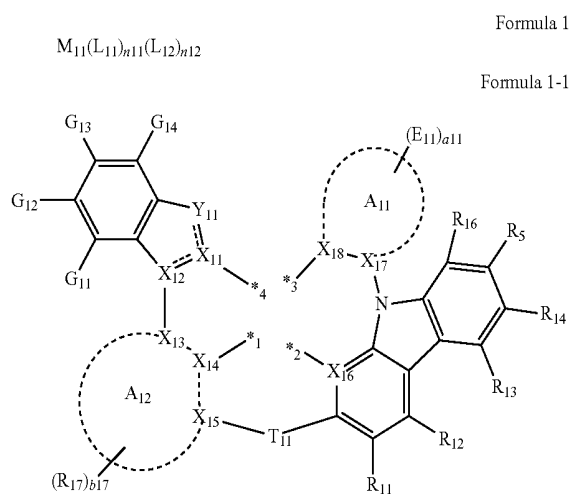
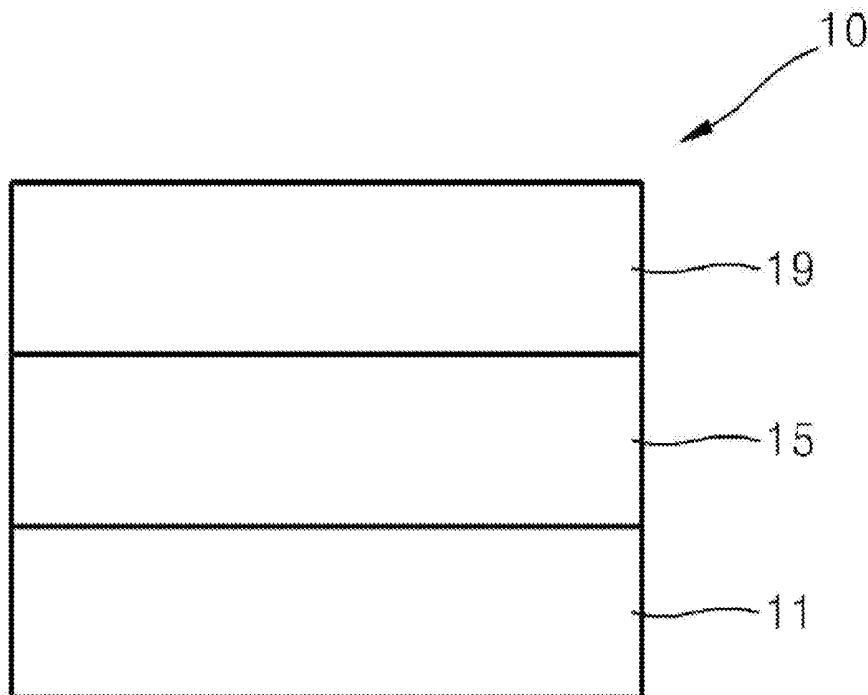


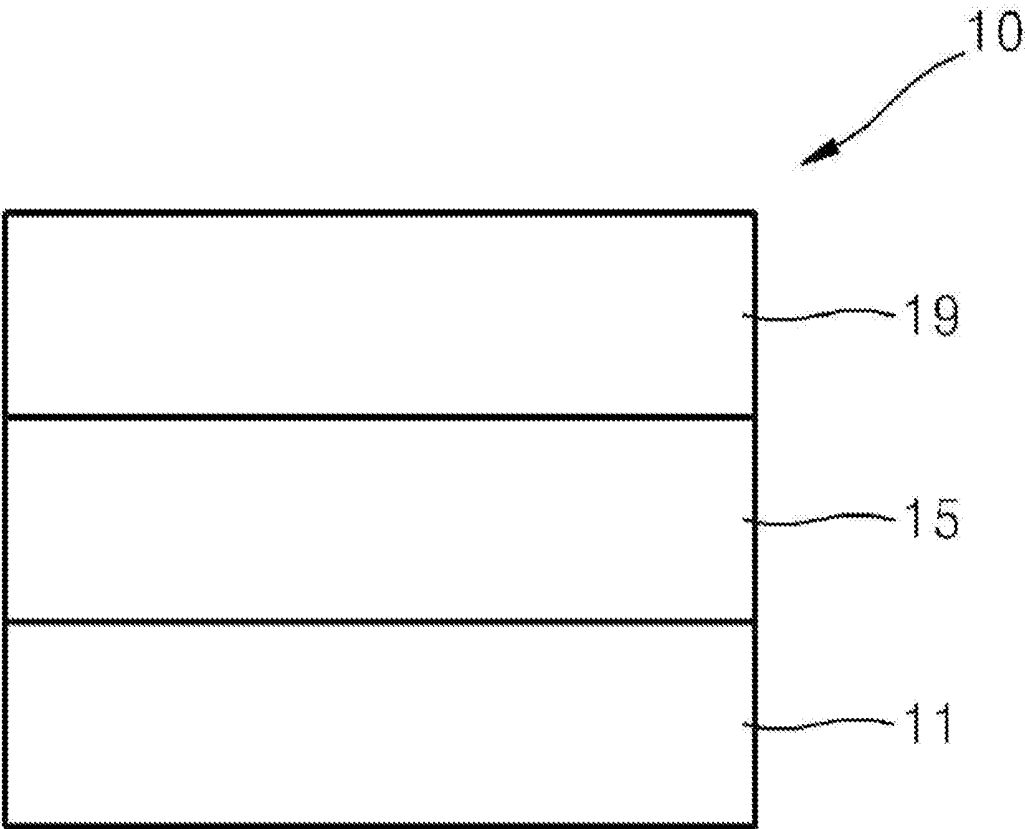


US 20200203635A1

(19) **United States**(12) **Patent Application Publication**
KIM et al.(10) **Pub. No.: US 2020/0203635 A1**(43) **Pub. Date: Jun. 25, 2020**(54) **ORGANOMETALLIC COMPOUND,
ORGANIC LIGHT-EMITTING DEVICE
INCLUDING THE ORGANOMETALLIC
COMPOUND, AND DIAGNOSTIC
COMPOSITION INCLUDING THE
ORGANOMETALLIC COMPOUND**(52) **U.S. Cl.**
CPC **H01L 51/0087** (2013.01); **C07F 15/0086**
(2013.01); **C09K 11/06** (2013.01); **H01L**
51/5012 (2013.01); **C09K 2211/1029**
(2013.01); **C09K 2211/1044** (2013.01); **C09K**
2211/185 (2013.01)(71) Applicants: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR); **SAMSUNG SDI CO.,**
LTD., Yongin-si (KR)(72) Inventors: **Sangmo KIM**, Hwaseong-si (KR);
Hyejin BAE, Suwon-si (KR); **Wook**
KIM, Suwon-si (KR); **Juhyun Kim**,
Suwon-si (KR); **Minsik MIN**, Suwon-si
(KR); **Sangho PARK**, Anyang-si (KR);
Jhunmo SON, Yongin-si (KR);
Yongsik Jung, Seoul (KR); **Won-joon**
SON, Yongin-si (KR); **Hasup LEE**,
Seoul (KR)(21) Appl. No.: **16/718,353**(22) Filed: **Dec. 18, 2019**(30) **Foreign Application Priority Data**Dec. 19, 2018 (KR) 10-2018-0165470
Nov. 18, 2019 (KR) 10-2019-0148082**Publication Classification**(51) **Int. Cl.**
H01L 51/00 (2006.01)
C07F 15/00 (2006.01)
C09K 11/06 (2006.01)(57) **ABSTRACT**

Provided are an organometallic compound, an organic light-emitting device including the organometallic compound, and a diagnostic composition including the organometallic compound. The organometallic compound is represented by Formula 1:

 L_{11} is a ligand represented by Formula 1-1 and L_{12} is a monodentate ligand or a bidentate ligand. The designations M_{11} , $n11$, $n12$, X_{11} - X_{18} , Y_{11} , A_{11} , A_{12} , T_{11} , E_{11} , G_{11} to G_{14} , all, and $b17$ are described in the specification.



**ORGANOMETALLIC COMPOUND,
ORGANIC LIGHT-EMITTING DEVICE
INCLUDING THE ORGANOMETALLIC
COMPOUND, AND DIAGNOSTIC
COMPOSITION INCLUDING THE
ORGANOMETALLIC COMPOUND**

**CROSS-REFERENCE TO RELATED
APPLICATION**

[0001] This application claims the priority to and benefit of Korean Patent Application No. 10-2018-0165470, filed on Dec. 19, 2018, and Korean Patent Application No. 10-2019-0148082, filed on Nov. 18, 2019, in the Korean Intellectual Property Office, and all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

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

2. Description of the Related Art

[0003] Organic light-emitting devices are self-emission devices, which have better characteristics in terms of a viewing angle, a response time, a brightness, a driving voltage, and a response speed, and produce full-color images.

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

[0005] Meanwhile, luminescent compounds may be used to monitor, sense, or detect a variety of biological materials including cells and proteins. An example of the luminescent compounds includes a phosphorescent luminescent compound.

SUMMARY

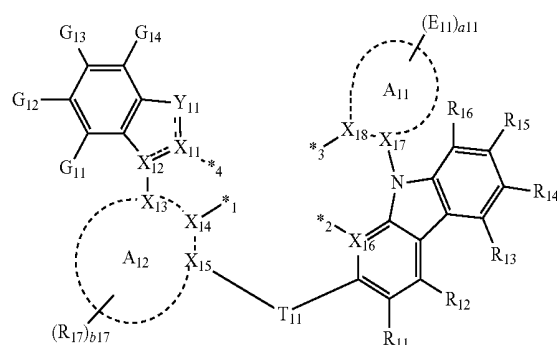
[0006] Aspects of the present disclosure provide a novel organometallic compound, an organic light-emitting device including the organometallic compound, and a diagnostic composition including the organometallic compound.

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

[0008] An aspect of the present disclosure provides an organometallic compound represented by Formula 1:



Formula 1-1



[0009] In Formulae 1 and 1-1,

[0010] M_{11} may be a first-row transition metal, a second-row transition metal, or a third-row transition metal, of the Periodic Table of Elements,

[0011] *1 to *4 each indicate a binding site to M_{11} ,

[0012] L_{11} may be a ligand represented by Formula 1-1,

[0013] L_{12} may be a monodentate ligand or a bidentate ligand,

[0014] $n11$ may be 1,

[0015] $n12$ may be 0, 1, or 2,

[0016] X_{11} and X_{13} to X_{17} may each independently be C,

[0017] X_{12} and X_{18} may each independently be N,

[0018] X_{11} and X_{12} , X_{13} and X_{14} , X_{14} and X_{15} , and X_{17} and X_{18} may each independently be linked via a chemical bond,

[0019] Y_{11} may be N(R_{18}), O, or S,

[0020] A_{11} may be a N-containing C_1 - C_{60} heterocyclic group,

[0021] A_{12} may be a C_5 - C_{60} carbocyclic group, or a C_1 - C_{60} heterocyclic group,

[0022] T_{11} may be C(R_{19})(R_{20}), Si(R_{19})(R_{20}), O, S, or N(R_{19}),

[0023] E_{11} may be a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0024] G_{11} to G_{14} may each independently be hydrogen, deuterium, —F, —Cl, —Br, or —I,

[0025] R_{18} may be a group represented by $*-C(Q_{101})(Q_{102})(Q_{103})$,

[0026] R_{11} to R_{17} and Q_{101} to Q_{103} may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, —SF₅, a hydroxyl group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_1)(Q_2)(Q_3), —B(Q_1)(Q_2), —N(Q_1)(Q_2), —P(Q_1)(Q_2), —C(=O)(Q_1), —S(=O)(Q_1), —S(=O)₂(Q_1), —P(=O)(Q_1)(Q_2), or —P(=S)(Q_1)(Q_2),

[0027] at least one Q_{101} to Q_{103} may be a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0028] R_{19} and R_{20} may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, —SF₅, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or

unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_1)(Q_2)(Q_3), —B(Q_1)(Q_2), —N(Q_1)(Q_2), —P(Q_1)(Q_2), —C(=O)(Q_1), —S(=O)(Q_1), —S(=O)₂(Q_1), —P(=O)(Q_1)(Q_2), or —P(=S)(Q_1)(Q_2),

[0029] two neighboring groups among R_{11} to R_{20} may optionally be linked to form a substituted or unsubstituted C_5 - C_{30} carbocyclic group or a substituted or unsubstituted C_1 - C_{30} heterocyclic group, a11 and b17 may each independently be 1, 2, 3, 4, 5, 6, 7, or 8, and

[0030] Q_1 to Q_3 may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_7 - C_{60} alkylaryl group, a C_7 - C_{60} arylalkyl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a C_2 - C_{60} alkylheteroaryl group, a C_2 - C_{60} heteroarylalkyl group, a C_1 - C_{60} heteroaryloxy group, a C_1 - C_{60} heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a C_1 - C_{60} alkyl group substituted with at least one deuterium, —F, a cyano group, a C_1 - C_{60} alkyl group, a C_6 - C_{60} aryl group, or any combination thereof, or a C_6 - C_{60} aryl group substituted with at least one deuterium, —F, a cyano group, a C_1 - C_{60} alkyl group, a C_6 - C_{60} aryl group, or any combination thereof, or

[0031] * indicates a binding site to a neighboring atom.

[0032] Another aspect of the present disclosure provides an organic light-emitting device including: a first electrode; a second electrode; an organic layer between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes the organometallic compound described above.

[0033] The organometallic compound in the emission layer may act as a dopant.

[0034] Another aspect of the present disclosure provides a diagnostic composition including the organometallic compound described above.

BRIEF DESCRIPTION OF THE DRAWING

[0035] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with FIGURE which is a schematic view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0036] 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.

[0037] It will be understood that when an element is referred to as being “on” another element, it can be directly on 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.

[0038] 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 herein.

[0039] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used herein, “a,” “an,” “the,” and “at least one” do not denote a limitation of quantity, and are intended to cover both the singular and plural, unless the context clearly indicates otherwise. For example, “an element” has the same meaning as “at least one element,” unless the context clearly indicates otherwise.

[0040] “Or” means “and/or.” As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. 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 integers thereof.

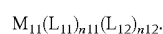
[0041] Furthermore, relative terms, such as “lower” or “bottom” and “upper” or “top,” may be used herein to describe one element’s relationship to another element as illustrated in the FIGURES. It will be understood that relative terms are intended to encompass different orientations of the device in addition to the orientation depicted in the FIGURES. For example, if the device in one of the FIGURES is turned over, elements described as being on the “lower” side of other elements would then be oriented on “upper” sides of the other elements. The exemplary term “lower,” can therefore, encompass both an orientation of “lower” and “upper,” depending on the particular orientation of the FIGURE. Similarly, if the device in one of the FIGURES is turned over, elements described as “below” or “beneath” other elements would then be oriented “above” the other elements. The exemplary terms “below” or “beneath” can, therefore, encompass both an orientation of above and below.

[0042] “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% or 5% of the stated value.

[0043] 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 disclosure 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.

[0044] 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.

[0045] An organometallic compound according to an embodiment is represented by Formula 1:



Formula 1

[0046] In Formula 1, M_{11} may be a first-row transition metal, a second-row transition metal, or a third-row transition metal, of the Periodic Table of Elements.

[0047] For example, in Formula 1, M_{11} may be platinum (Pt), palladium (Pd), copper (Cu), silver (Ag), gold (Au), rhodium (Rh), iridium (Ir), ruthenium (Ru), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), or thulium (Tm), but embodiments of the present disclosure are not limited thereto.

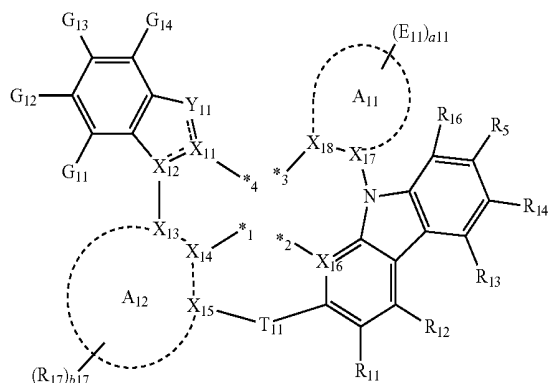
[0048] In one or more embodiments, in Formula 1, M_{11} may be Pt, Pd, Cu, Ag, Au, Rh, Ir, Ru, and Os, but embodiments of the present disclosure are not limited thereto.

[0049] In one or more embodiments, in Formula 1, M_{11} may be Pt and Pd, but embodiments of the present disclosure are not limited thereto.

[0050] In one or more embodiments, in Formula 1, M_{11} may be Pt, but embodiments of the present disclosure are not limited thereto.

[0051] In Formula 1, L_{11} may be a ligand represented by Formula 1-1:

Formula 1-1



[0052] In Formula 1-1, *1 to *4 each indicate a binding site to M_{11} .

[0053] In Formula 1-1, X_{11} and X_{13} to X_{17} may each independently be C, and X_{12} and X_{18} may each independently be N.

[0054] In Formula 1-1, X_{11} and X_{12} , X_{13} and X_{14} , X_{14} and X_{18} , and X_{17} and X_{18} may each independently be linked via a chemical bond.

[0055] In Formulae 1 and 1-1, a ring including M_{11} , X_{11} , X_{12} , X_{13} , and X_{14} may be a 5-membered ring.

[0056] In Formulae 1 and 1-1, a ring including M_{11} , X_{14} , X_{15} , T_{11} , and X_{16} may be a 6-membered ring.

[0057] In Formulae 1 and 1-1, a ring including M_{11} , X_{18} , X_{17} , N, and X_{16} may be a 6-membered ring.

[0058] In Formula 1-1, Y_{11} may be N(R_{18}), O, or S, and R_{18} may be the same as described below.

[0059] For example, in Formula 1-1, Y_{11} may be N(R_{18}), but embodiments of the present disclosure are not limited thereto.

[0060] In Formula 1-1, A_{11} may be an N-containing C_1 - C_{60} heterocyclic group.

[0061] For example, in Formula 1-1, A_{11} may be: a first ring; a condensed ring in which two or more first rings are condensed with each other; or a condensed ring in which one or more first rings are condensed with one or more second rings, respectively,

[0062] the first ring may be a pyrrole group, a pyrrolidine group, an imidazolidine group, a dihydropyrrole group, a dihydroimidazole group, an oxazole group, an isoxazole group, an oxadiazole group, an oxatriazole group, a thiazole group, an isothiazole group, a thiadiazole group, a thiatriazole group, a pyrazole group, an imidazole group, a triazole group, a tetrazole group, a pyridine group, a piperidine group, a tetrahydropyridine group, a dihydropyridine group, a pyrimidine group, a hexahydropyrimidine group, a tetrahydropyrimidine group, a dihydropyrimidine group, a pyrazine group, a piperazine group, a tetrahydropyrazine group, a dihydropyrazine group, a pyridazine group, a tetrahydropyridazine group, a dihydropyridazine group, or a triazine group, or

[0063] the second ring may be a cyclopentane group, a cyclopentene group, a cyclopentadiene group, a furan group, a thiophene group, a silole group, a cyclohexane group, a cyclohexene group, a cyclohexadiene group, a benzene

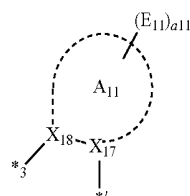
group, an adamantane group, a norbornane group, or a norbornene group, but embodiments of the present disclosure are not limited thereto.

[0064] In one or more embodiments, A_{11} in Formula 1-1 may be an indole group, a carbazole group, an indenopyridine group, an indolopyridine group, a benzofuopyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuopyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a pyridine group, a piperidine group, a tetrahydropyridine group, a dihydropyridine group, a pyrimidine group, a hexahydropyrimidine group, a tetrahydropyrimidine group, a dihydropyrimidine group, a pyrazine group, a piperazine group, a tetrahydropyrazine group, a dihydropyrazine group, a pyridazine group, a tetrahydropyridazine group, a dihydropyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a cinnoline group, a phthalazine group, a phenanthroline group, a pyrrole group, a pyrazole group, an imidazole group, a dihydroimidazole group, a triazole group, a dihydrotriazole group, an oxazole group, an isoxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a dihydrobenzimidazole group, an imidazopyridine group, a dihydroimidazopyridine group, an imidazopyrimidine group, a dihydroimidazopyrimidine group, an imidazopyrazine group, a dihydroimidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzoxadiazole group, a benzothiadiazole group, a tetrahydroisoquinoline group, a tetrahydroquinoline group, a tetrahydropthalazine group, or a tetrahydrocinnoline group, but embodiments of the present disclosure are not limited thereto.

[0065] In one or more embodiments, A_{11} in Formula 1-1 may be an indenopyridine group, an indolopyridine group, a benzofuopyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuopyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a cinnoline group, a phthalazine group, a phenanthroline group, an imidazopyridine group, an imidazopyrimidine group, or an imidazopyrazine group, but embodiments of the present disclosure are not limited thereto.

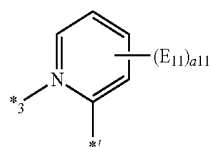
[0066] In one or more embodiments, A_{11} in Formula 1-1 may be a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, or a quinazoline group, but embodiments of the present disclosure are not limited thereto.

[0067] In one or more embodiments, a moiety represented by

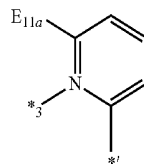


in Formula 1-1 may be Formulae 2-1 to 2-5, but embodiments of the present disclosure are not limited thereto:

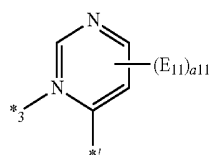
in Formula 101 may be Formulae 2-11 to 2-31, but embodiments of the present disclosure are not limited thereto:



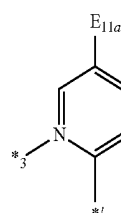
2-1



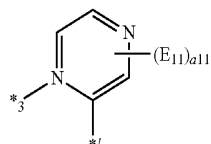
2-11



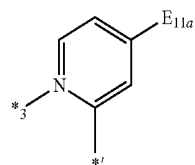
2-2



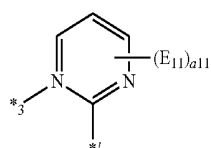
2-12



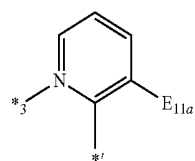
2-3



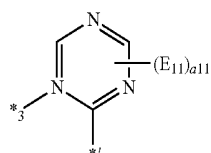
2-13



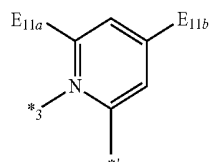
2-4



2-14



2-5



2-15

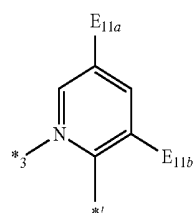
[0068] In Formulae 2-1 to 2-5,

[0069] *3 indicates a binding site to M_{11} ,

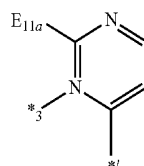
[0070] *1 indicates a binding site to a neighboring atom, and

[0071] E_{11} and a_{11} may each independently be the same as defined in connection with Formula 1-1.

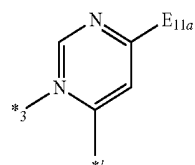
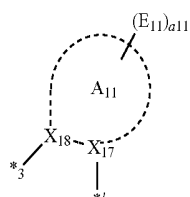
[0072] In one or more embodiment, a moiety represented by



2-16

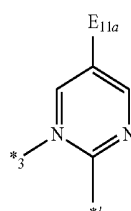
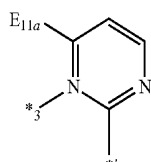
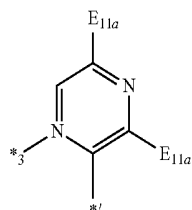
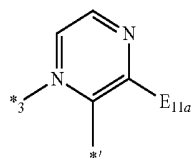
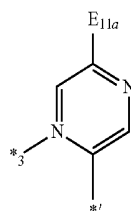
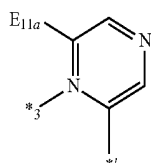
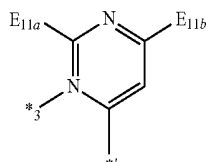
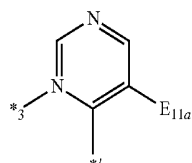


2-17

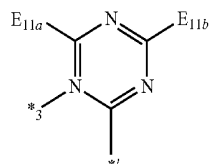
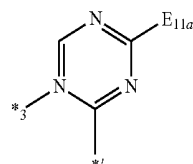
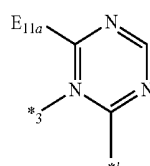
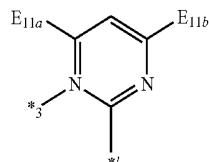
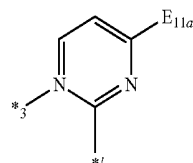


2-18

-continued



-continued

**[0073]** In Formulae 2-11 to 2-31,**[0074]** *3 indicates a binding site to M_{11} ,**[0075]** *1 indicates a binding site to a neighboring atom, and**[0076]** E_{11a} and E_{11b} may each independently be the same as defined in connection with E_{11} in Formula 1-1.**[0077]** In Formula 1-1, A_{12} may be a C_5 - C_{60} carbocyclic group, or a C_1 - C_{60} heterocyclic group.**[0078]** For example, in Formula 1-1, A_{12} may be: a first ring; a second ring; a condensed ring in which two or more first rings are condensed with each other; a condensed ring in which one or more first rings are condensed with one or more second rings, respectively; or a condensed ring in which two or more second rings are condensed with each other,**[0079]** the first ring may be a pyrrole group, a pyrrolidine group, an imidazolidine group, a dihydropyrrole group, a dihydroimidazole group, an oxazole group, an isoxazole group, an oxadiazole group, an oxatriazole group, a thiazole group, an isothiazole group, a thiadiazole group, a thiatriazole group, a pyrazole group, an imidazole group, a triazole group, a tetrazole group, a pyridine group, a piperidine group, a tetrahydropyridine group, a dihydropyridine group, a pyrimidine group, a hexahydropyrimidine group, a tetrahydropyrimidine group, a dihydropyrimidine group, a pyrazine group, a piperazine group, a tetrahydropyrazine group,

a dihydropyrazine group, a pyridazine group, a tetrahydropyridazine group, a dihydropyridazine group, or a triazine group, and

[0080] the second ring may be a cyclopentane group, a cyclopentene group, a cyclopentadiene group, a furan group, a thiophene group, a silole group, a cyclohexane group, a cyclohexene group, a cyclohexadiene group, a benzene group, an adamantane group, a norbornane group, or a norbornene group, but embodiments of the present disclosure are not limited thereto.

[0081] In one or more embodiments, A_{12} in Formula 1-1 may be a benzene group, a naphthalene group, a tetrahydronaphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a cyclopentadiene group, a furan group, a thiophene group, a silole group, an indene group, a fluorene group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, a dibenzosilole group, an indole group, a carbazole group, an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a pyridine group, a piperidine group, a tetrahydropyridine group, a dihydropyridine group, a pyrimidine group, a hexahydropyrimidine group, a tetrahydropyrimidine group, a dihydropyrimidine group, a pyrazine group, a piperazine group, a tetrahydropyrazine group, a dihydropyrazine group, a pyridazine group, a tetrahydropyridazine group, a dihydropyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a cinnoline group, a phthalazine group, a phenanthroline group, a pyrrole group, a pyrazole group, an imidazole group, a dihydroimidazole group, a triazole group, a dihydrotriazole group, an oxazole group, an isoxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a dihydrobenzimidazole group, an imidazopyridine group, a dihydroimidazopyridine group, an imidazopyrimidine group, a dihydroimidazopyrimidine group, an imidazopyrazine group, a dihydroimidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzoxadiazole group, a benzothiadiazole group, a tetrahydroisoquinoline group, a tetrahydroquinoline group, a tetrahydrophthalazine group, or a tetrahydrocinnoline group, but embodiments of the present disclosure are not limited thereto.

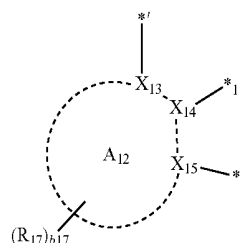
[0082] In one or more embodiments, A_{12} in Formula 1-1 may be a benzene group, a naphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a furan group, a thiophene group, a silole group, an indene group, a fluorene group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, a dibenzosilole group, an indole group, a carbazole group, an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a cinnoline group, a phthalazine group, a phenanthroline group, a pyrrole group, a pyrazole group, an imidazole group, a dihydroimidazole group, a triazole group, a dihydrotriazole group, an oxazole group, an isoxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a dihydrobenzimidazole group, an imidazopyridine group, a dihydroimidazopyridine group, an imidazopyrimidine group, a dihydroimidazopyrimidine group, an imidazopyrazine group, a dihydroimidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzoxadiazole group, a benzothiadiazole group, a tetrahydroisoquinoline group, a tetrahydroquinoline group, a tetrahydrophthalazine group, or a tetrahydrocinnoline group, but embodiments of the present disclosure are not limited thereto.

nazoline group, a cinnoline group, a phthalazine group, a phenanthroline group, a pyrrole group, a pyrazole group, an imidazole group, a triazole group, an oxazole group, an isoxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, an imidazopyridine group, an imidazopyrimidine group, an imidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzoxadiazole group, or a benzothiadiazole group, but embodiments of the present disclosure are not limited thereto.

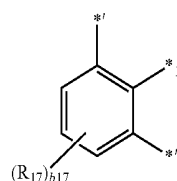
[0083] In one or more embodiments, A_{12} in Formula 1-1 may be a benzene group, a naphthalene group, an indene group, a fluorene group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, a dibenzosilole group, an indole group, a carbazole group, an indenopyridine group, an indolopyridine group, a benzofuropyridine group, a benzothienopyridine group, a benzosilolopyridine group, an indenopyrimidine group, an indolopyrimidine group, a benzofuropyrimidine group, a benzothienopyrimidine group, a benzosilolopyrimidine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a benzopyrazole group, a benzimidazole group, an imidazopyridine group, an imidazopyrimidine group, an imidazopyrazine group, a benzoxazole group, a benzothiazole group, a benzoxadiazole group, or a benzothiadiazole group, but embodiments of the present disclosure are not limited thereto.

[0084] In one or more embodiments, A_{12} in Formula 1-1 may be a benzene group, a naphthalene group, an indene group, a fluorene group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, or a dibenzosilole group, but embodiments of the present disclosure are not limited thereto.

[0085] In one or more embodiments, a moiety represented by



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



3-1

[0086] In Formula 3-1,

[0087] *1 indicates a binding site to M_{11} ,

[0088] *' and *'' each indicate a binding site to a neighboring atom, and

[0089] R_{17} and b_{17} may each independently be the same as defined in connection with Formula 1-1.

[0090] In Formula 1-1, T_{11} may be $C(R_{19})(R_{20})$, $Si(R_{19})(R_{20})$, O, S, or $N(R_{19})$, wherein R_{19} and R_{20} will be described below.

[0091] In Formula 1-1, E_{11} may be a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0092] For example, E_{11} in Formula 1-1 may be:

[0093] a C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group;

[0094] a C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group, each substituted with at least one deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{10} alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

[0095] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophe-

nyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group; or

[0096] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, but embodiments of the present disclosure are not limited thereto.

[0097] In one or more embodiments, E_{11} in Formula 1-1 may be:

[0098] 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 2-methylbutyl group, a sec-pentyl group,

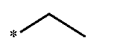
a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an isodecyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group;

[0099] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an isodecyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a cyano group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

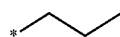
[0100] a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyridazinyl group, or a triazinyl group;

[0101] a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyridazinyl group, or a triazinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a cyano group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, or any combination thereof, but embodiments of the present disclosure are not limited thereto.

[0102] In one or more embodiments, E₁₁ in Formula 1-1 may be —CH₃, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, groups represented by Formulae 9-1 to 9-27, groups represented by Formulae 9-1 to 9-27 of which at least one hydrogen is substituted with deuterium, or groups represented by Formulae 10-1 to 10-56, 10-220, and 10-221, but embodiments of the present disclosure are not limited thereto:



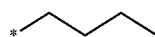
9-1



9-2

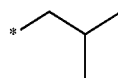


9-3

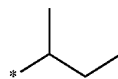


9-4

-continued



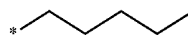
9-5



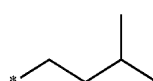
9-6



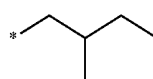
9-7



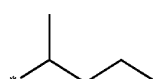
9-8



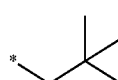
9-9



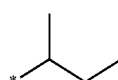
9-10



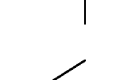
9-11



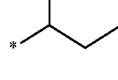
9-12



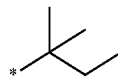
9-13



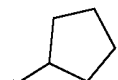
9-14



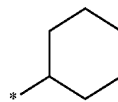
9-15



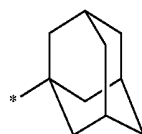
9-16



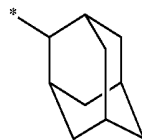
9-17

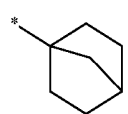
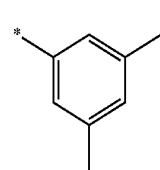
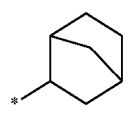
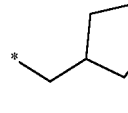
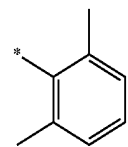
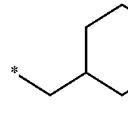
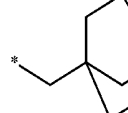
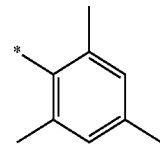
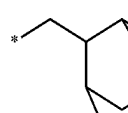
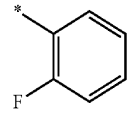
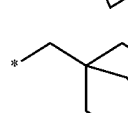
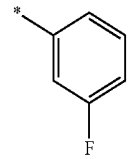
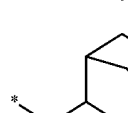
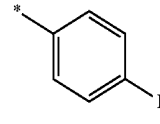
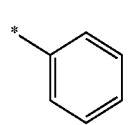
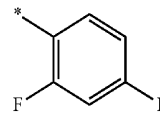
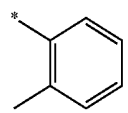
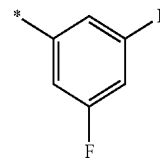
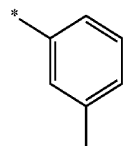
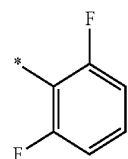
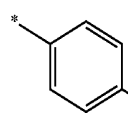
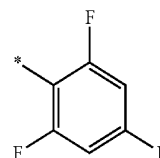
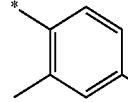


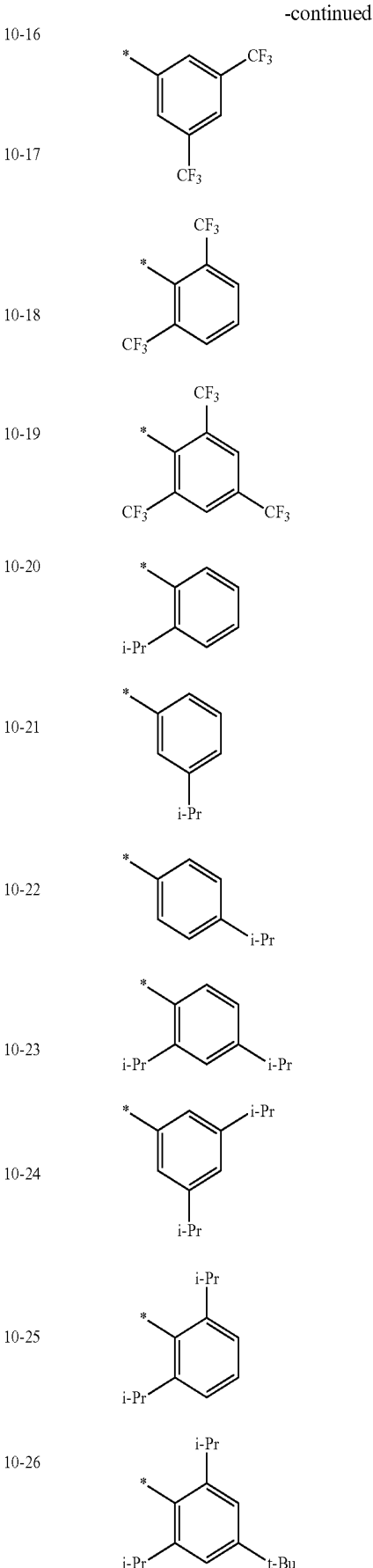
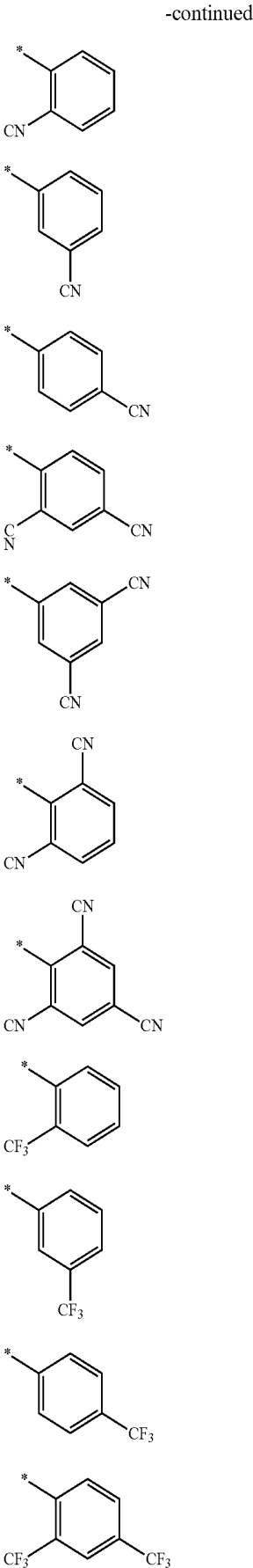
9-18



9-19



-continued		-continued	
	9-20		10-6
	9-21		
	9-22		10-7
	9-23		
	9-24		10-8
	9-25		10-9
	9-26		10-10
	9-27		10-11
	10-1		10-12
	10-2		10-13
	10-3		10-14
	10-4		10-15
	10-5		



10-27

10-28

10-29

10-30

10-31

10-32

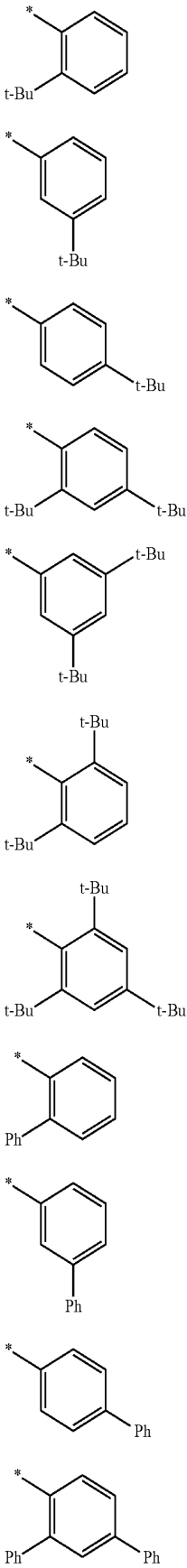
10-33

10-34

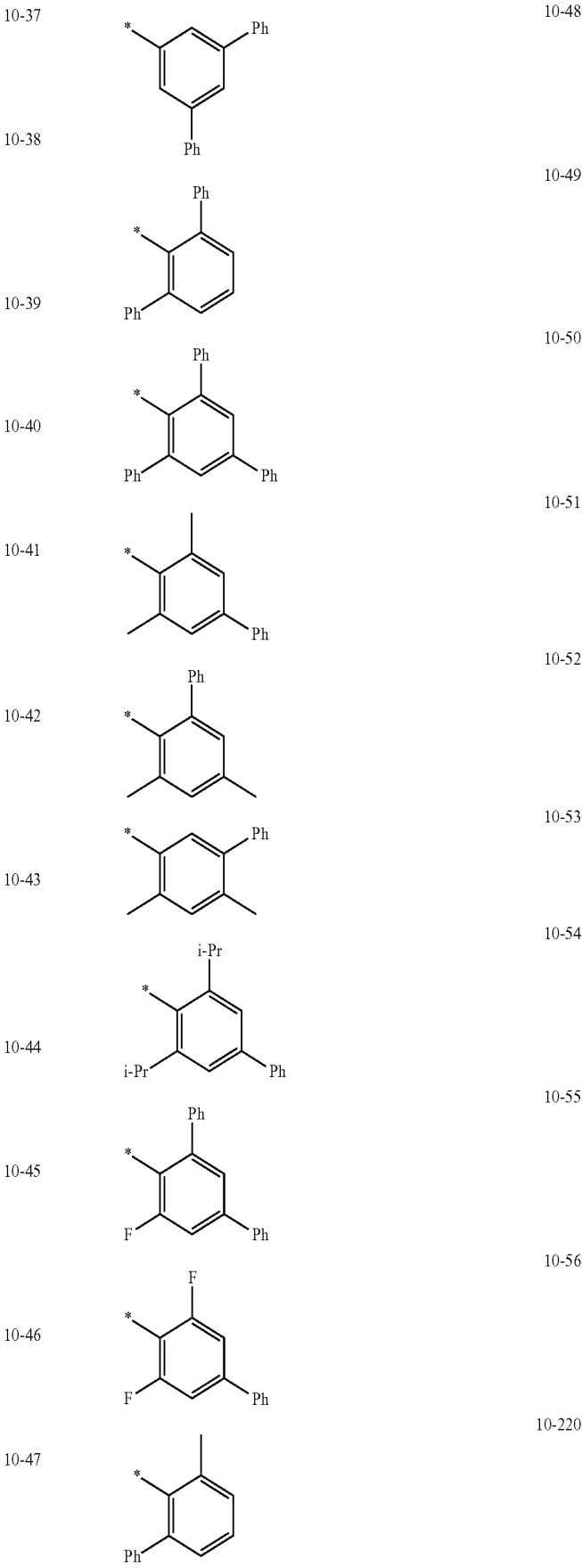
10-35

10-36

-continued

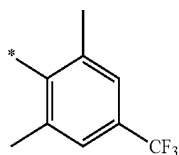


-continued



-continued

10-221



[0103] In Formulae 9-1 to 9-27, 10-1 to 10-56, 10-220, and 10-221,

[0104] * indicates a binding site to a neighboring atom,

[0105] i-Pr indicates an isopropyl group,

[0106] t-Bu indicates a tert-butyl group, and

[0107] Ph indicates a phenyl group.

[0108] In Formula 1-1, G_{11} to G_{14} may each independently be hydrogen, deuterium, —F, —Cl, —Br, or —I, but embodiments of the present disclosure are not limited thereto.

[0109] For example, G_{11} to G_{14} in Formula 1-1 may each independently be hydrogen or deuterium, but embodiments of the present disclosure are not limited thereto.

[0110] In Formula 1-1, R_{18} may be a group represented by $*-C(Q_{101})(Q_{102})(Q_{103})$.

[0111] Q_{101} to Q_{103} may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, —SF₅, a hydroxyl group, a nitro group, an amidino group, a hydrazine group, a hydrazone group, a substituted or unsubstituted C_1 -C₆₀ alkyl group, a substituted or unsubstituted C_2 -C₆₀ alkenyl group, a substituted or unsubstituted C_2 -C₆₀ alkynyl group, a substituted or unsubstituted C_1 -C₆₀ alkoxy group, a substituted or unsubstituted C_3 -C₁₀ cycloalkyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkyl group, a substituted or unsubstituted C_3 -C₁₀ cycloalkenyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C_6 -C₆₀ aryl group, a substituted or unsubstituted C_7 -C₆₀ alkylaryl group, a substituted or unsubstituted C_7 -C₆₀ arylalkyl group, a substituted or unsubstituted C_6 -C₆₀ aryloxy group, a substituted or unsubstituted C_6 -C₆₀ arylthio group, a substituted or unsubstituted C_1 -C₆₀ heteroaryl group, a substituted or unsubstituted C_2 -C₆₀ alkylheteroaryl group, a substituted or unsubstituted C_2 -C₆₀ heteroarylalkyl group, a substituted or unsubstituted C_1 -C₆₀ heteroaryloxy group, a substituted or unsubstituted C_1 -C₆₀ heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_1)(Q_2)(Q_3), —B(Q_1)(Q_2), —N(Q_1)(Q_2), —P(Q_1)(Q_2), —C(=O)(Q_1), —S(=O)(Q_1), —S(=O)₂(Q_1), —P(=O)(Q_1)(Q_2), or —P(=S)(Q_1)(Q_2),

[0112] at least one Q_{101} to Q_{103} may be a substituted or unsubstituted C_3 -C₁₀ cycloalkyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkyl group, a substituted or unsubstituted C_3 -C₁₀ cycloalkenyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C_6 -C₆₀ aryl group, a substituted or unsubstituted C_7 -C₆₀ alkylaryl group, a substituted or unsubstituted C_7 -C₆₀ arylalkyl group, a substituted or unsubstituted C_6 -C₆₀ aryloxy group, a substituted or unsubstituted C_6 -C₆₀ arylthio group, a substituted or unsubstituted C_1 -C₆₀ heteroaryl group, a substituted or unsubstituted C_2 -C₆₀ alkylheteroaryl group, a substituted or unsubstituted C_2 -C₆₀ heteroarylalkyl group, a substituted or unsubstituted C_1 -C₆₀ heteroaryloxy group, a substituted or unsubstituted C_1 -C₆₀ heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0113] Q_1 to Q_3 may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazine group, a hydrazone group, a C_1 -C₆₀ alkyl group, a C_2 -C₆₀ alkenyl group, a C_2 -C₆₀ alkynyl group, a C_1 -C₆₀ alkoxy group, a C_3 -C₁₀ cycloalkyl group, a C_1 -C₁₀ heterocycloalkyl group, a C_3 -C₁₀ cycloalkenyl group, a C_1 -C₁₀ heterocycloalkenyl group, a C_6 -C₆₀ aryl group, a C_7 -C₆₀ alkylaryl group, a C_7 -C₆₀ arylalkyl group, a C_6 -C₆₀ aryloxy group, a C_6 -C₆₀ arylthio group, a C_1 -C₆₀ heteroaryl group, a C_2 -C₆₀ alkylheteroaryl group, a C_2 -C₆₀ heteroarylalkyl group, a C_1 -C₆₀ heteroaryloxy group, a C_1 -C₆₀ heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a C_1 -C₆₀ alkyl group substituted with at least one deuterium, —F, a cyano group, a C_1 -C₆₀ alkyl group, a C_6 -C₆₀ aryl group, or any combination thereof, or a C_6 -C₆₀ aryl group substituted with at least one deuterium, —F, a cyano group, a C_1 -C₆₀ alkyl group, a C_6 -C₆₀ aryl group, or any combination thereof, and

[0114] * indicates a binding site to a neighboring atom.

[0115] For example, in Formula 1-1, R_{18} may be a group represented by $*-C(Q_{101})(Q_{102})(Q_{103})$, wherein i) Q_{101} , Q_{102} , and Q_{103} may be different from each other, ii) Q_{101} and Q_{102} may be different from each other, and Q_{102} and Q_{103} may be identical to each other, or iii) Q_{101} to Q_{103} may be identical to each other.

[0116] In detail, in Formula 1-1, Q_{101} and Q_{102} may be different from each other, and Q_{102} and Q_{103} may be identical to each other.

[0117] In one or more embodiments, in Formula 1-1, R_{18} may be a group represented by $*-C(Q_{101})(Q_{102})(Q_{103})$.

[0118] wherein i) at least one Q_{101} to Q_{103} may be a substituted or unsubstituted C_3 -C₁₀ cycloalkyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkyl group, a substituted or unsubstituted C_3 -C₁₀ cycloalkenyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C_6 -C₆₀ aryl group, a substituted or unsubstituted C_7 -C₆₀ alkylaryl group, a substituted or unsubstituted C_7 -C₆₀ arylalkyl group, a substituted or unsubstituted C_6 -C₆₀ aryloxy group, a substituted or unsubstituted C_6 -C₆₀ arylthio group, a substituted or unsubstituted C_1 -C₆₀ heteroaryl group, a substituted or unsubstituted C_2 -C₆₀ alkylheteroaryl group, a substituted or unsubstituted C_2 -C₆₀ heteroarylalkyl group, a substituted or unsubstituted C_1 -C₆₀ heteroaryloxy group, a substituted or unsubstituted C_1 -C₆₀ heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0119] ii) two substituents Q_{101} to Q_{103} may each be a substituted or unsubstituted C_3 -C₁₀ cycloalkyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkyl group, a substituted or unsubstituted C_3 -C₁₀ cycloalkenyl group, a substituted or unsubstituted C_1 -C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C_6 -C₆₀ aryl group, a substituted or unsubstituted C_7 -C₆₀ alkylaryl group, a substituted or unsubstituted C_7 -C₆₀ arylalkyl group, a substituted or unsubstituted C_6 -C₆₀ aryloxy group, a substituted or unsubstituted C_6 -C₆₀ arylthio group, a substituted or unsub-

stituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroarylloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, or

[0120] iii) all substituents Q_{101} to Q_{103} may each be a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroarylloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0121] In one or more embodiments, in Formula 1-1, R_{18} may be a group represented by $*-C(Q_{101})(Q_{102})(Q_{103})$, wherein at least one Q_{101} to Q_{103} may be a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroarylloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0122] For example, in Formula 1-1, R_{18} may be a group represented by $*-C(Q_{101})(Q_{102})(Q_{103})$.

[0123] Q_{101} to Q_{103} may each independently be:

[0124] hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, $-SF_5$, C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group;

[0125] a C_1 - C_{20} alkyl group or a C_1 - C_{20} alkoxy group, each substituted with at least one deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, a hydroxyl group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a C_1 - C_{10} alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkyl-

phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

[0126] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group; or

[0127] $-Si(Q_1)(Q_2)(Q_3)$, $-B(Q_1)(Q_2)$, or $-N(Q_1)(Q_2)$,

[0128] at least one Q_{101} to Q_{103} may be:

[0129] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group; and

[0130] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group,

[0133] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-3-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or a combination thereof.

[0136] a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl

[1037] a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a quinoxaliny group, a quinazolinyl group, a cinnoliny group, a carbazolyl group, a phenanthroliny group, a benzimidazolyl group, a benzofuranly group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranly group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl 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 indazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a quinoxaliny group, a quinazolinyl group, a cinnoliny group, a carbazolyl group, a phenanthroliny group, a benzimidazolyl group, a benzofuranly group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a

triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{11})(\text{Q}_{12})(\text{Q}_{13})$, $-\text{B}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, or any combination thereof, and

[0138] the remaining two substituents may each independently be:

[0139] hydrogen, deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, $-\text{SF}_5$, a $\text{C}_1\text{-C}_{20}$ alkyl group, or a $\text{C}_1\text{-C}_{20}$ alkoxy group; or

[0140] a $\text{C}_1\text{-C}_{20}$ alkyl group, or a $\text{C}_1\text{-C}_{20}$ alkoxy group, each substituted with at least one deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, $-\text{CD}_3$, $-\text{CD}_2\text{H}$, $-\text{CDH}_2$, $-\text{CF}_3$, $-\text{CF}_2\text{H}$, $-\text{CFH}_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{10}$ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a $\text{C}_1\text{-C}_{20}$ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof; or

[0141] ii) two substituents Q_{101} to Q_{103} may each independently be:

[0142] a phenyl group, a biphenyl group, a $\text{C}_1\text{-C}_{20}$ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a carbazolyl group, a phenanthroliny group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{11})(\text{Q}_{12})(\text{Q}_{13})$, $-\text{B}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, or any combination thereof, and

[0143] a phenyl group, a biphenyl group, a $\text{C}_1\text{-C}_{20}$ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a carbazolyl group, a phenanthroliny group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an

isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, $-\text{CD}_3$, $-\text{CD}_2\text{H}$, $-\text{CDH}_2$, $-\text{CF}_3$, $-\text{CF}_2\text{H}$, $-\text{CFH}_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{20}$ alkyl group, a $\text{C}_1\text{-C}_{20}$ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a $\text{C}_1\text{-C}_{20}$ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a carbazolyl group, a phenanthroliny group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{11})(\text{Q}_{12})(\text{Q}_{13})$, $-\text{B}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, or any combination thereof, and

[0144] the remaining one substituent may be:

[0145] hydrogen, deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, $-\text{SF}_5$, a $\text{C}_1\text{-C}_{20}$ alkyl group, or a $\text{C}_1\text{-C}_{20}$ alkoxy group; and

[0146] a $\text{C}_1\text{-C}_{20}$ alkyl group and a $\text{C}_1\text{-C}_{20}$ alkoxy group, each substituted with at least one deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, $-\text{CD}_3$, $-\text{CD}_2\text{H}$, $-\text{CDH}_2$, $-\text{CF}_3$, $-\text{CF}_2\text{H}$, $-\text{CFH}_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{10}$ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a $\text{C}_1\text{-C}_{20}$ alkylphenyl group, a naphthyl group, a pyridinyl group, or a pyrimidinyl group, and

[0147] Q_{11} to Q_{13} may each independently be:

[0148] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, or a naphthyl group; or

[0149] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, and a naphthyl group, each substituted with at least one deuterium, a phenyl group, or a combination thereof.

[0150] In one or more embodiments, in Formula 1-1, R₁₈ may be a substituted or unsubstituted benzyl group, but embodiments of the present disclosure are not limited thereto.

[0151] In Formula 1-1, R₁₁ to R₁₇ may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, —SF₅, a hydroxyl group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₇-C₆₀ alkylaryl group, a substituted or unsubstituted C₇-C₆₀ arylalkyl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted C₂-C₆₀ alkylheteroaryl group, a substituted or unsubstituted C₂-C₆₀ heteroarylalkyl group, a substituted or unsubstituted C₁-C₆₀ heteroaryloxy group, a substituted or unsubstituted C₁-C₆₀ heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —N(Q₁)(Q₂), —P(Q₁)(Q₂), —C(=O)(Q₁), —S(=O)(Q₁), —S(=O)₂(Q₁), —P(=O)(Q₁)(Q₂), or —P(=S)(Q₁)(Q₂).

[0152] R₁₉ and R₂₀ may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, —SF₅, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₇-C₆₀ alkylaryl group, a substituted or unsubstituted C₇-C₆₀ arylalkyl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted C₂-C₆₀ alkylheteroaryl group, a substituted or unsubstituted C₂-C₆₀ heteroarylalkyl group, a substituted or unsubstituted C₁-C₆₀ heteroaryloxy group, a substituted or unsubstituted C₁-C₆₀ heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —N(Q₁)(Q₂), —P(Q₁)(Q₂), —C(=O)(Q₁), —S(=O)(Q₁), —S(=O)₂(Q₁), —P(=O)(Q₁)(Q₂), or —P(=S)(Q₁)(Q₂).

unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —N(Q₁)(Q₂), —P(Q₁)(Q₂), —C(=O)(Q₁), —S(=O)(Q₁), —S(=O)₂(Q₁), —P(=O)(Q₁)(Q₂), or —P(=S)(Q₁)(Q₂).

[0153] two neighboring rings among R₁₁ to R₂₀ may optionally be linked to form a substituted or unsubstituted C₅-C₃₀ carbocyclic group or a substituted or unsubstituted C₁-C₃₀ heterocyclic group, and

[0154] Q₁ to Q₃ may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₇-C₆₀ alkylaryl group, a C₇-C₆₀ arylalkyl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a C₂-C₆₀ alkylheteroaryl group, a C₂-C₆₀ heteroarylalkyl group, a C₁-C₆₀ heteroaryloxy group, a C₁-C₆₀ heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a C₁-C₆₀ alkyl group substituted with at least one deuterium, —F, a cyano group, a C₁-C₆₀ alkyl group, a C₆-C₆₀ aryl group, or any combination thereof, or a C₆-C₆₀ aryl group substituted with at least one deuterium, —F, a cyano group, a C₁-C₆₀ alkyl group, a C₆-C₆₀ aryl group, or any combination thereof.

[0155] For example, R₁₁ to R₁₇ in Formula 1-1 may each independently be:

[0156] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazono 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, —SF₅, a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group;

[0157] a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazono group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

[0158] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group,

[0159] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a

benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{11})(\text{Q}_{12})(\text{Q}_{13})$, $-\text{B}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, or any combination thereof; or

[0160] $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, $-\text{B}(\text{Q}_1)(\text{Q}_2)$, or $-\text{N}(\text{Q}_1)(\text{Q}_2)$,

[0161] R_{19} and R_{20} may each independently be:

[0162] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF₅, a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group;

[0163] a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

[1064] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a $C_{1-C_{20}}$ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[10165] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a

purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —B(Q₁₁)(Q₁₂), —N(Q₁₁)(Q₁₂), or any combination thereof; or

[0166] —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), or —N(Q₁)(Q₂), and

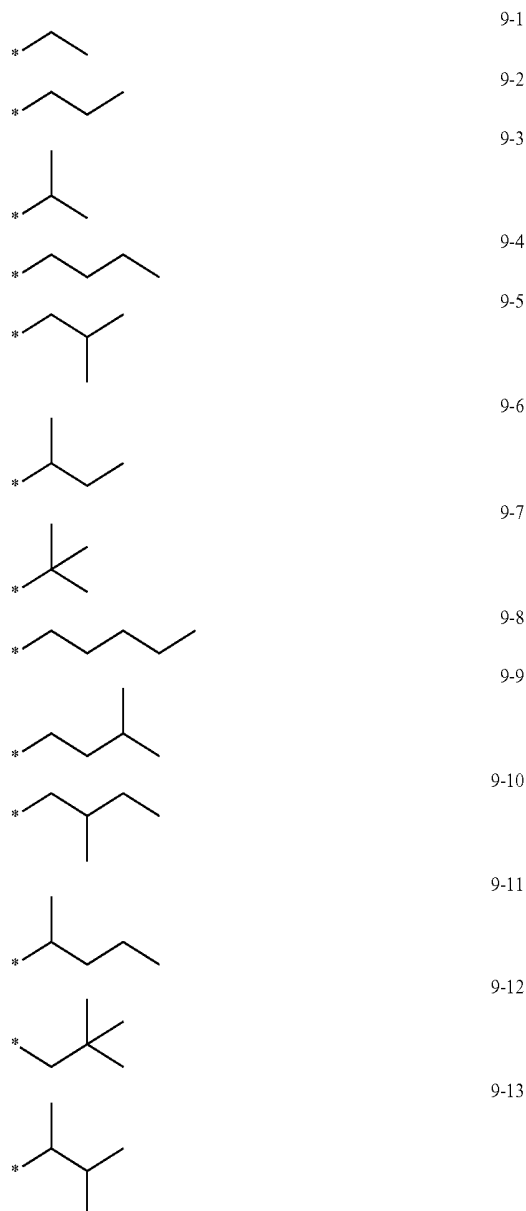
[0167] Q₁ to Q₃ and Q₁₁ to Q₁₃ may each independently be:

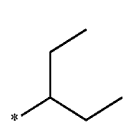
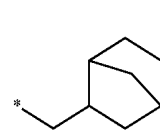
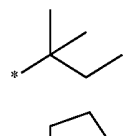
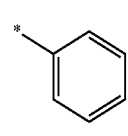
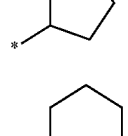
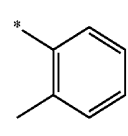
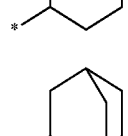
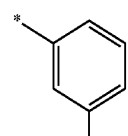
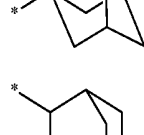
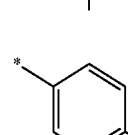
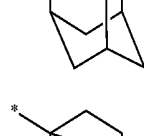
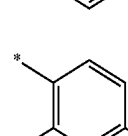
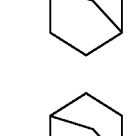
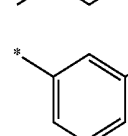
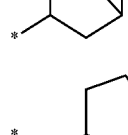
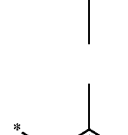
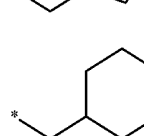
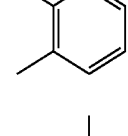
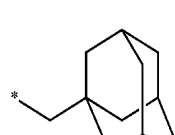
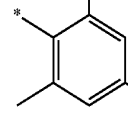
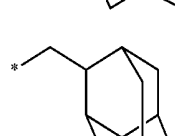
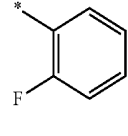
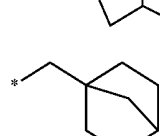
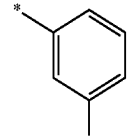
[0168] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, or a naphthyl group; or

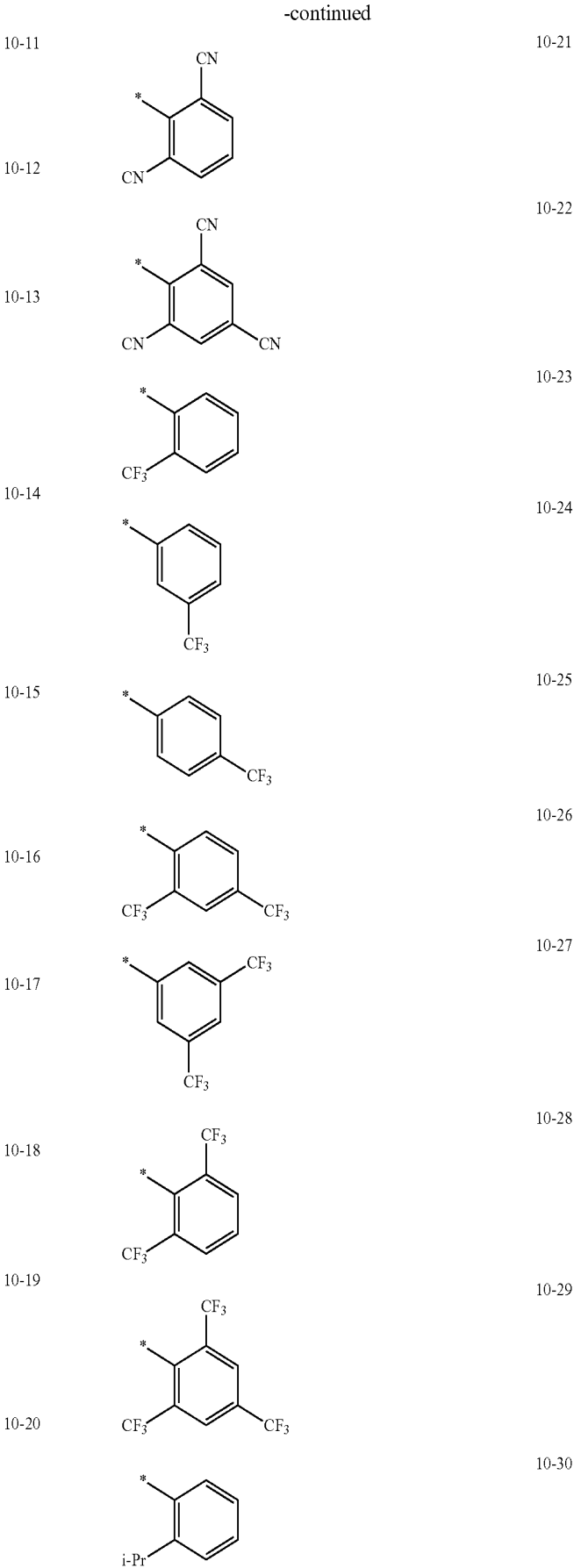
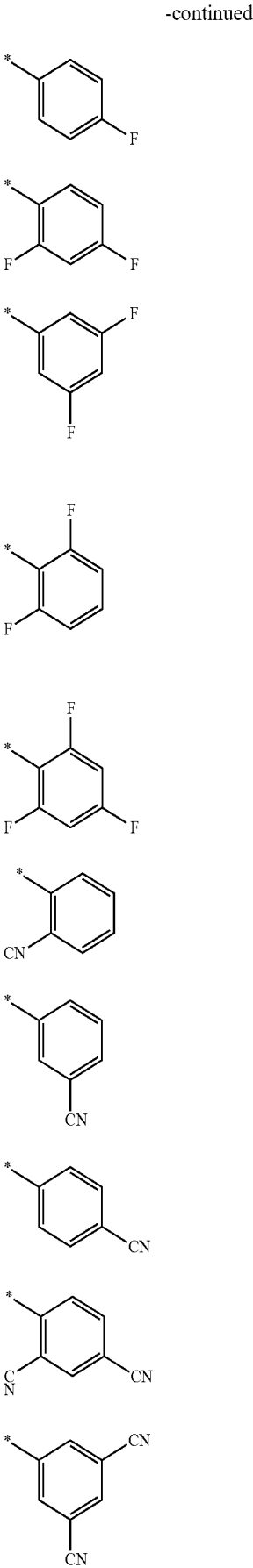
[0169] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or any combination thereof, but embodiments of the present disclosure are not limited thereto.

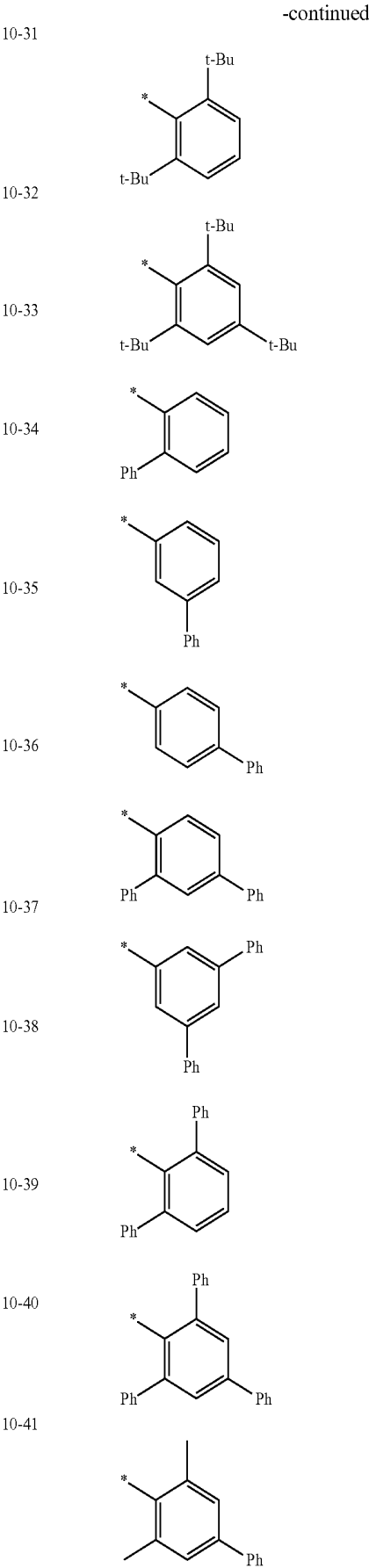
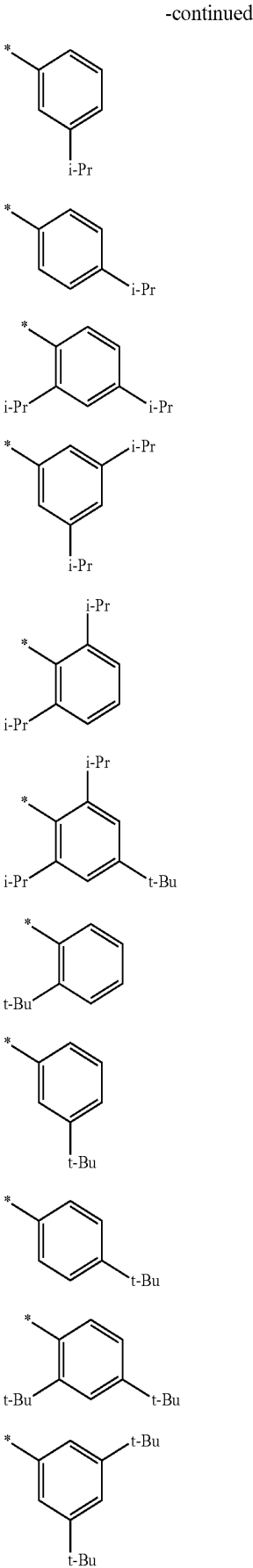
[0170] In one or more embodiments, R₁₁ to R₁₇ in Formula 1-1 may each independently be hydrogen, deuterium, —F, a nitro group, —SF₅, —CH₃, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, groups represented by Formulae 9-1 to 9-27, groups represented by Formulae 9-1 to 9-27 of which at least one hydrogen is substituted with deuterium, groups represented by Formulae 10-1 to 10-227, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), or —N(Q₁)(Q₂),

[0171] R₁₉ and R₂₀ may each independently be hydrogen, deuterium, —F, a cyano group, a nitro group, —SF₅, —CH₃, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, represented by Formulae 9-1 to 9-27, groups represented by Formulae 9-1 to 9-27 of which at least one hydrogen is substituted with deuterium, groups represented by Formulae 10-1 to 10-227, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), or —N(Q₁)(Q₂), but embodiments of the present disclosure are not limited thereto:

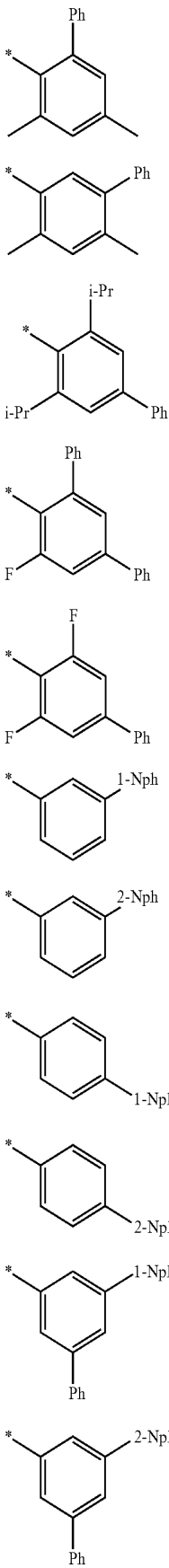


-continued		-continued	
	9-14		9-27
	9-15		10-1
	9-16		10-2
	9-17		10-3
	9-18		10-4
	9-19		10-5
	9-20		10-6
	9-21		10-7
	9-22		10-8
	9-23		10-9
	9-24		10-10
	9-25		
	9-26		

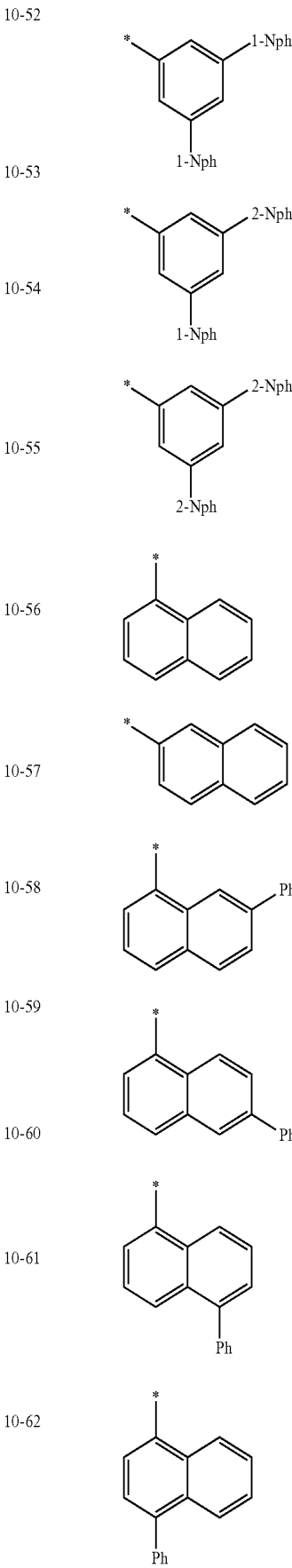




-continued



-continued



10-63

10-64

10-65

10-66

10-67

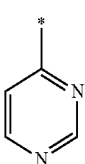
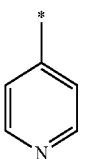
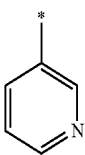
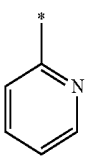
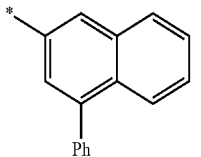
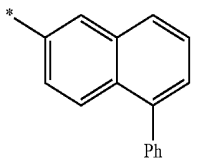
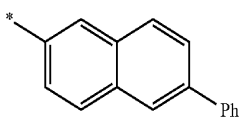
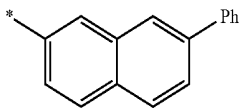
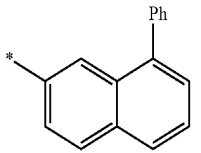
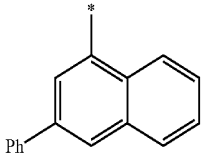
10-68

10-69

10-70

10-71

-continued



10-72

10-73

10-74

10-75

10-76

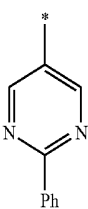
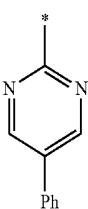
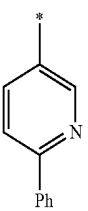
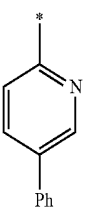
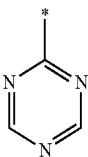
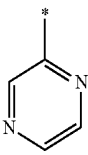
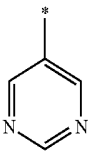
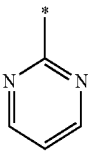
10-77

10-78

10-79

10-80

10-81



-continued

10-82

10-83

10-84

10-85

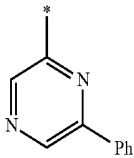
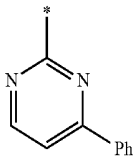
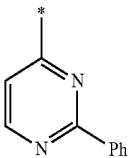
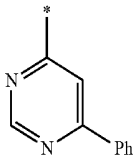
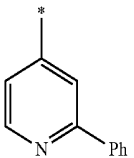
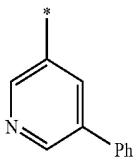
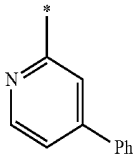
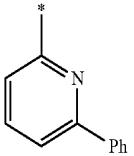
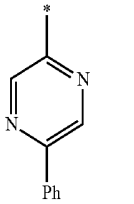
10-86

10-87

10-88

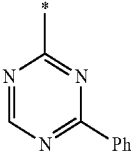
10-89

-continued



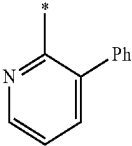
-continued

10-90



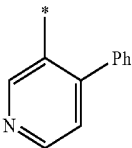
10-99

10-91



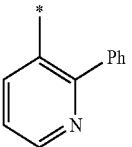
10-100

10-92



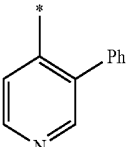
10-101

10-93



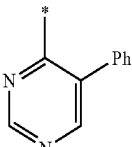
10-102

10-94



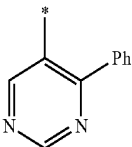
10-103

10-95



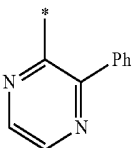
10-104

10-96



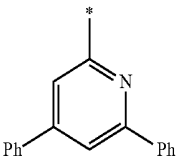
10-105

10-97



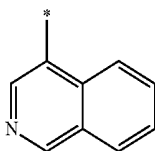
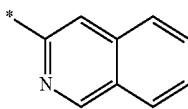
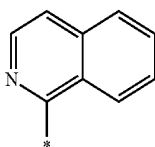
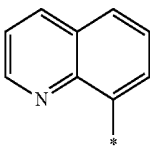
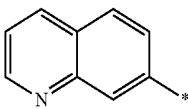
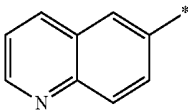
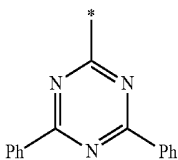
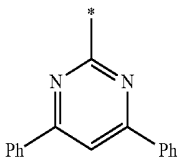
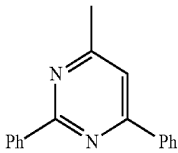
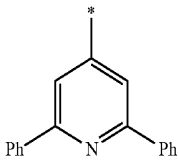
10-106

10-98

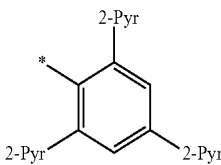
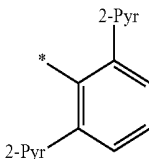
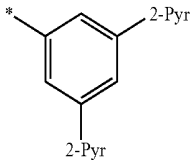
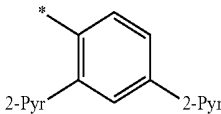
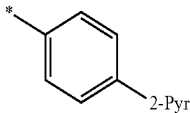
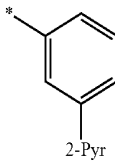
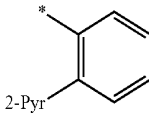
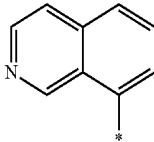
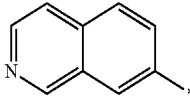
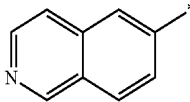
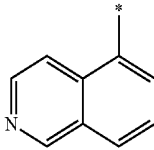


10-107

-continued



-continued



10-108

10-109

10-110

10-111

10-112

10-113

10-114

10-115

10-116

10-117

10-118

10-119

10-120

10-121

10-122

10-123

10-124

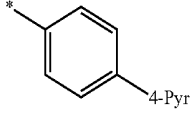
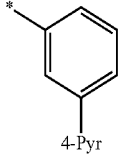
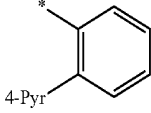
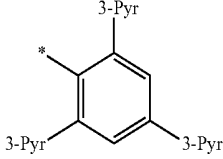
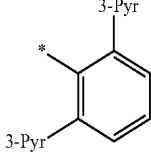
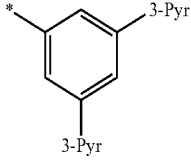
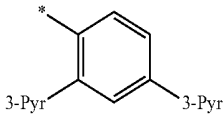
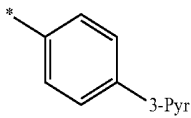
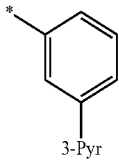
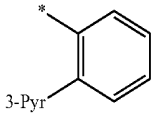
10-125

10-126

10-127

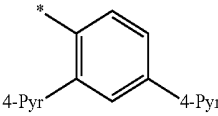
10-128

-continued

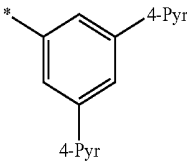


-continued

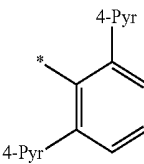
10-129



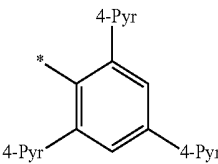
10-130



10-131

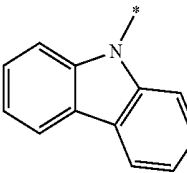


10-132

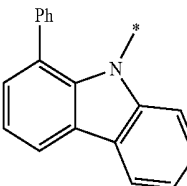


10-133

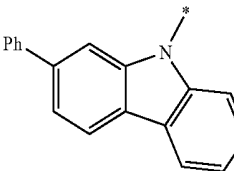
10-134



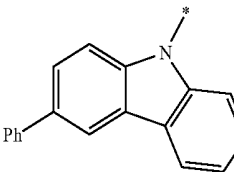
10-135



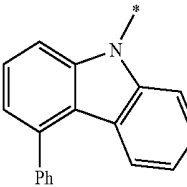
10-136



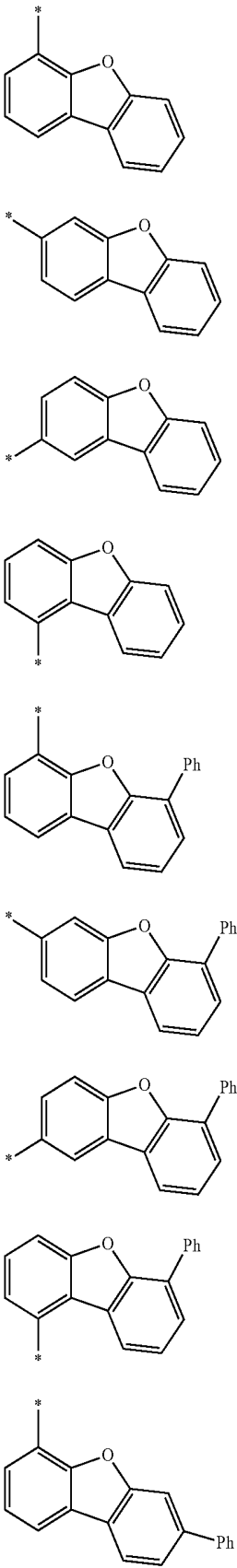
10-137



10-138

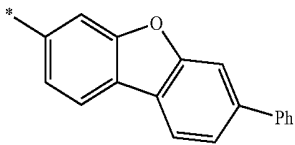


-continued



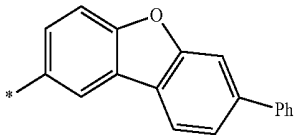
-continued

10-148



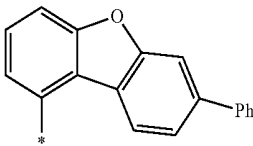
10-157

10-149



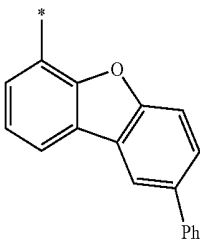
10-158

10-150



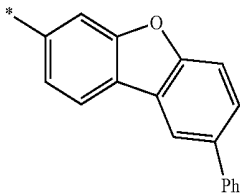
10-159

10-151



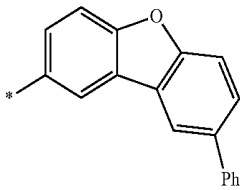
10-160

10-152



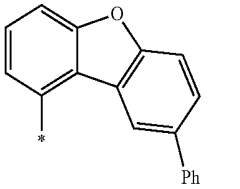
10-161

10-153



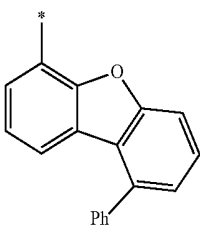
10-162

10-154



10-163

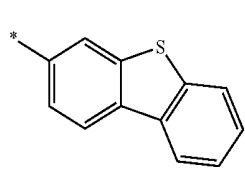
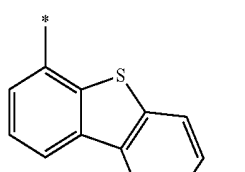
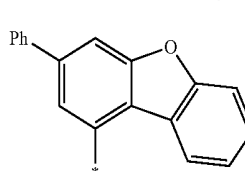
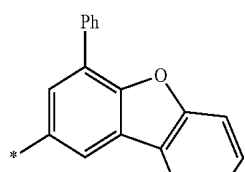
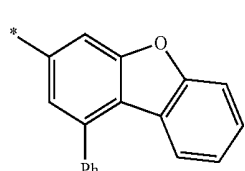
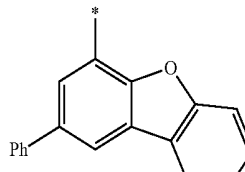
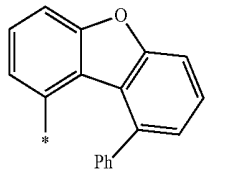
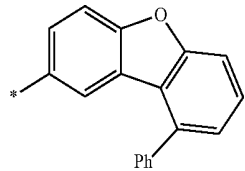
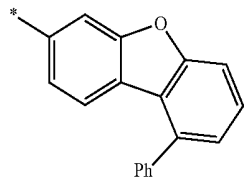
10-155



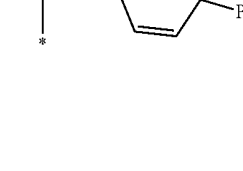
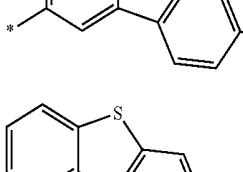
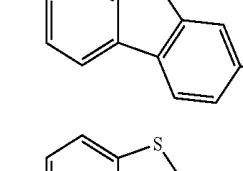
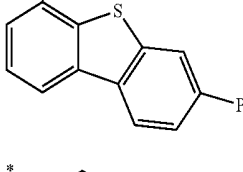
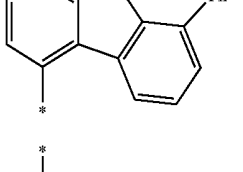
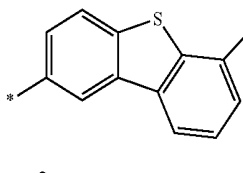
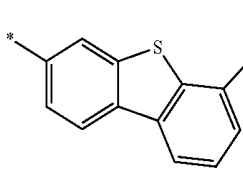
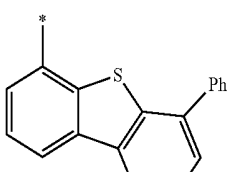
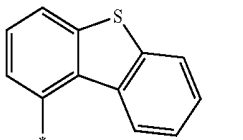
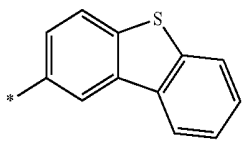
10-164

10-156

-continued



-continued



10-174

10-175

10-176

10-177

10-178

10-179

10-180

10-181

10-182

10-183

10-165

10-166

10-167

10-168

10-169

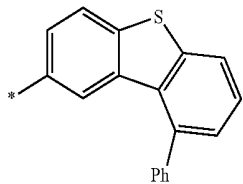
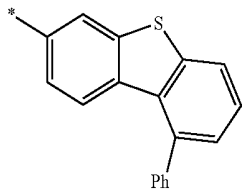
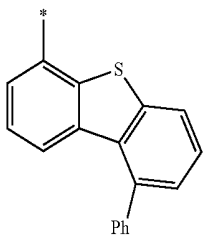
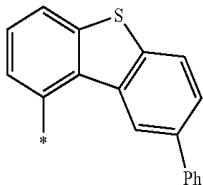
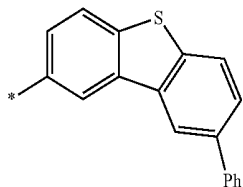
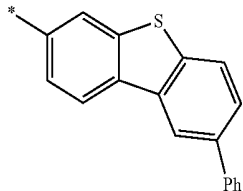
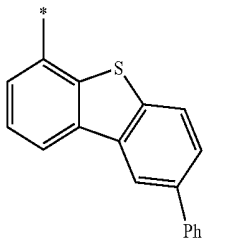
10-170

10-171

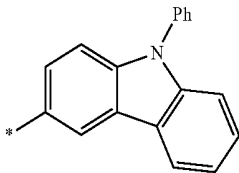
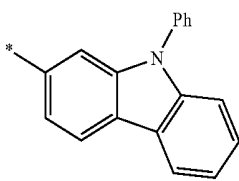
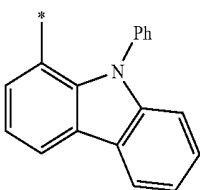
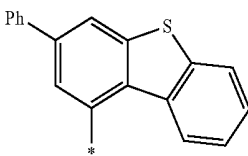
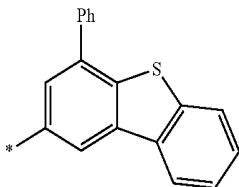
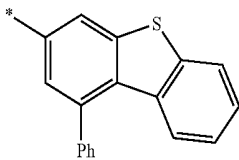
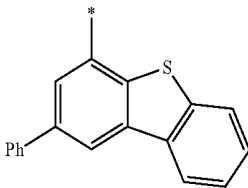
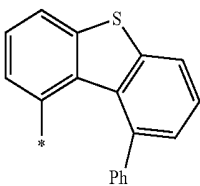
10-172

10-173

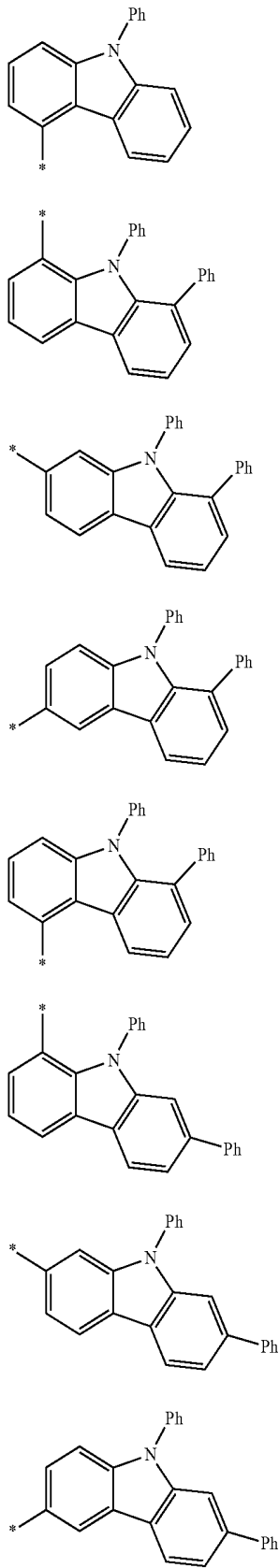
-continued



-continued

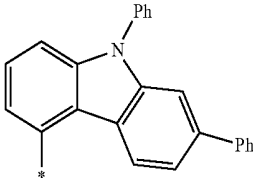


-continued



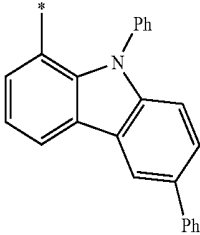
-continued

10-199



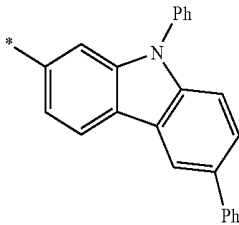
10-207

10-200



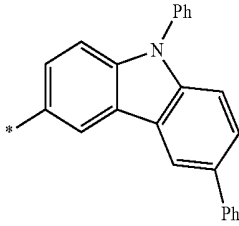
10-208

10-201



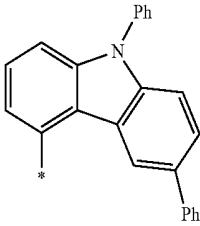
10-209

10-202



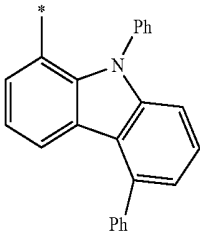
10-210

10-203



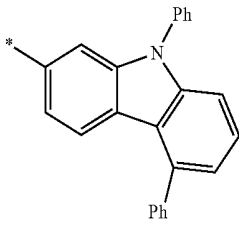
10-211

10-204



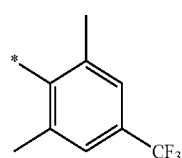
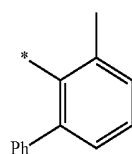
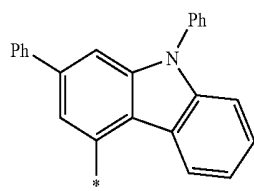
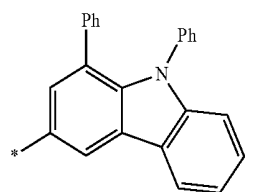
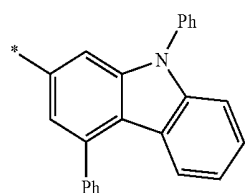
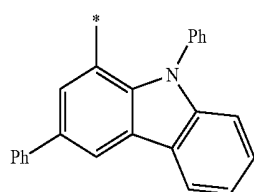
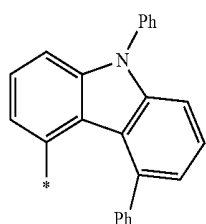
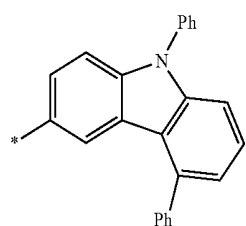
10-212

10-205



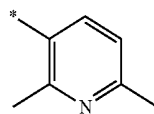
10-213

-continued

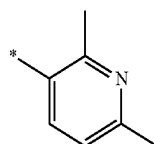


-continued

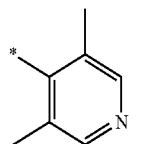
10-214



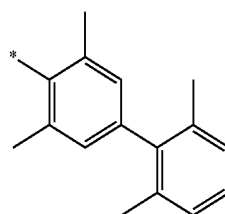
10-215



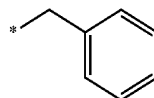
10-216



10-217



10-218



10-219

10-220

10-221

10-222

10-223

10-224

10-225

10-226

10-227

- [0172] * indicates a binding site to a neighboring atom,
 [0173] i-Pr indicates an isopropyl group,
 [0174] t-Bu indicates a tert-butyl group,
 [0175] Ph indicates a phenyl group,
 [0176] 1-Nph indicates a 1-naphthyl group and 2-Nph indicates a 2-naphthyl group,
 [0177] 2-Pyr indicates a 2-pyridyl group, 3-Pyr indicates a 3-pyridyl group, and 4-Pyr indicates a 4-pyridyl group, and
 [0178] Q₁ to Q₃ may each independently be:
 [0179] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, or a naphthyl group; or
 [0180] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a naphthyl group, each substituted with at least one deuterium, a phenyl group, or any combination thereof.
 [0181] In one or more embodiments, in Formula 1-1, R₁₉ and R₂₀ may be linked via the first linking group to form a

substituted or unsubstituted C₅-C₃₀ carbocyclic group or a substituted or unsubstituted C₁-C₃₀ heterocyclic group,

[0182] the first linking group may be a single bond, *—O—*, *—S—*, *—[C(R₁₀₁)(R₁₀₂)]_{k11}—*, *—C(R₁₀₁)=*, *—C(R₁₀₁)—*, *—C(R₁₀₁)=C(R₁₀₂)—*, *—C(=O)—*, *—C(=S)—*, *—C≡C—*, *—N(R₁₀₁)—*, *—P(R₁₀₁)—*, *—[Si(R₁₀₁)(R₁₀₂)]_{k11}—*, or *—P(R₁₀₁)(R₁₀₂)—*,

[0183] R₁₀₁ and R₁₀₂ may each independently be the same as defined in connection with R₁₁,

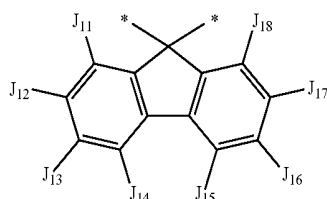
[0184] k11 may be 1, 2, 3, or 4,

[0185] * and *' each indicate a binding site to a neighboring atom, but embodiments of the present disclosure are not limited thereto.

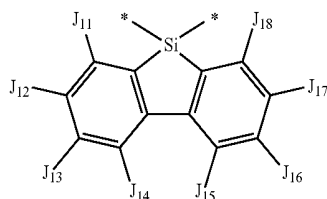
[0186] In one or more embodiments, a moiety represented by



in Formula 1-1 may be *—O—*, *—S—*, *—N(R₁₉)—*, *—C(R₁₉)(R₂₀)—*, *—Si(R₁₉)(R₂₀)—*, or Formulae 4-1 and 4-2, but embodiments of the present disclosure are not limited thereto:



4-1



4-2

[0187] In Formulae 4-1 and 4-2,

[0188] J₁₁ to J₁₈ may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a

pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolynyl group, an isoquinolynyl group, a benzoquinolynyl group, a quinoxalynyl group, a quinazolinyl group, a cinnolynyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —B(Q₁₁)(Q₁₂), or —N(Q₁₁)(Q₁₂),

[0189] Q₁₁ to Q₁₃ may each independently be:

[0190] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, or a naphthyl group; or

[0191] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or any combination thereof, and

[0192] * and *' each indicate a binding site to a neighboring atom.

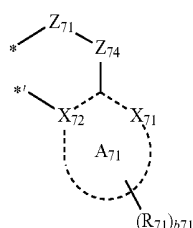
[0193] In one or more embodiments, E₁₁ and R₁₆ may not be linked to each other.

[0194] In Formula 1-1, a11 and b17 may each independently be 1, 2, 3, 4, 5, 6, 7, or 8.

[0195] In Formulae 1 and 1-1, two bonds a bond between X₁₁ and M₁₁, a bond between X₁₄ and M₁₁, a bond between X₁₆ and M₁₁, and a bond between X₁₈ and M₁₁ may each be a coordinate bond while the other two bonds may each be a covalent bond. Accordingly, the organometallic compound represented by Formula 1 may be neutral (in particular, having no (+) or (−) charge).

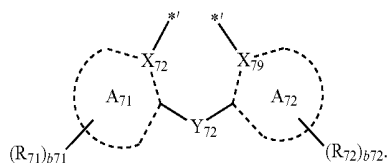
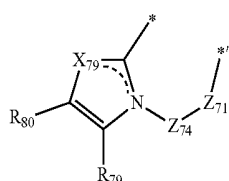
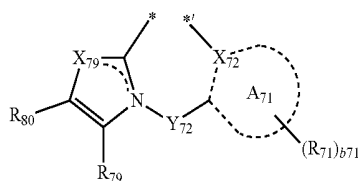
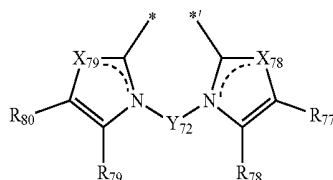
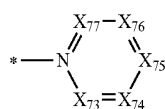
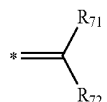
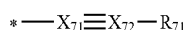
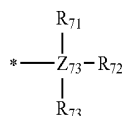
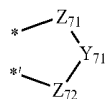
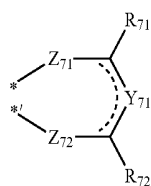
[0196] In Formula 1, L₁₂ may be a monodentate ligand or a bidentate ligand.

[0197] For example, L₁₂ in Formula 1 may be a ligand represented by one Formulae 7-1 to 7-11, but embodiments of the present disclosure are not limited thereto:



7-1

-continued



[0198] In Formulae 7-1 to 7-11,

[0199] A_{71} and A_{72} may each independently be a C_5 - C_{20} carbocyclic group, or a C_1 - C_{20} heterocyclic group,

[0200] X_{71} and X_{72} may each independently be C or N,

7-2 [0201] X_{73} may be N or C(Q_{73}), X_{74} may be N or C(Q_{74}), X_{75} may be N or C(Q_{75}), X_{76} may be N or C(Q_{76}), and X_{77} may be N or C(Q_{77}),

7-3 [0202] X_{78} may be O, S, or N(Q_{78}), and X_{79} may be O, S, or N(Q_{79}),

7-4 [0203] Y_{71} and Y_{72} may each independently be a single bond, a double bond, a substituted or unsubstituted C_1 - C_{05} alkylene group, a substituted or unsubstituted C_2 - C_5 alkenylene group, or a substituted or unsubstituted C_6 - C_{10} arylene group,

7-5 [0204] Z_{71} and Z_{72} may each independently be N, O, N(R_{74}), P(R_{75})(R_{76}), or As(R_{75})(R_{76}),

7-6 [0205] Z_{73} may be P or As,

7-7 [0206] Z_{74} may be C(=O) or CH_2 ,

7-8 [0207] R_{71} to R_{80} and Q_{73} to Q_{79} may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

7-9 [0208] R_{71} and R_{72} may optionally be linked to form a ring,

7-10 [0209] R_{77} and R_{78} may optionally be linked to form a ring,

7-11 [0210] R_{78} and R_{79} may optionally be linked to form a ring,

7-12 [0211] R_{79} and R_{80} may optionally be linked to form a ring,

7-13 [0212] b_{71} and b_{72} may each independently be 1, 2, or 3, and

7-14 [0213] * and *' each indicate a binding site to a neighboring atom.

7-15 [0214] For example, A_{71} and A_{72} in Formulae 7-1, 7-9, and 7-11 may each independently be a benzene group, a naphthalene group, an imidazole group, a benzimidazole group, a pyridine group, a pyrimidine group, a triazine group, a quinoline group, or an isoquinoline group, but embodiments of the present disclosure are not limited thereto.

7-16 [0215] For example, in Formulae 7-1, 7-9, and 7-11, X_{72} and X_{79} may each independently be N, but embodiments of the present disclosure are not limited thereto.

7-17 [0216] For example, in Formula 7-7, X_{73} may be C(Q_{73}), X_{74} may be C(Q_{74}), X_{75} may be C(Q_{75}), X_{76} may be C(Q_{76}), and X_{77} may be C(Q_{77}), but embodiments of the present disclosure are not limited thereto.

7-18 [0217] For example, in Formula 7-8, X_{78} may be N(Q_{78}) and X_{79} may be N(Q_{79}), but embodiments of the present disclosure are not limited thereto.

[0218] For example, in Formulae 7-2, 7-3, and 7-8, Y_{71} and Y_{72} may each independently be a substituted or unsubstituted methylene group, or a substituted or unsubstituted phenylene group, but embodiments of the present disclosure are not limited thereto.

[0219] For example, in Formulae 7-1 and 7-2, Z_{71} and Z_{72} may each independently be O, but embodiments of the present disclosure are not limited thereto.

[0220] For example, in Formula 7-4, Z_{73} may be P, but embodiments of the present disclosure are not limited thereto.

[0221] For example, in Formulae 7-1 to 7-11, R_{71} to R_{80} and Q_{73} to Q_{79} may each independently be:

[0222] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF₅, a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group;

[0223] a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

[0224] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, or any combination thereof;

[0225] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group,

an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —B(Q₁₁)(Q₁₂), —N(Q₁₁)(Q₁₂), or any combination thereof; or

[0226] —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), or —N(Q₁)(Q₂), or

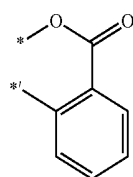
[0227] Q₁ to Q₃ and Q₁₁ to Q₁₃ may each independently be:

[0228] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, or a naphthyl group; or

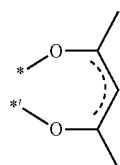
[0229] a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an

isopentyl group, a 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or any combination thereof, but embodiments of the present disclosure are not limited thereto.

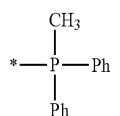
[0230] In Formula 1, L_{12} may be a ligand represented by one Formulae 5-1 to 5-116 and 8-1 to 8-23, but embodiments of the present disclosure are not limited thereto:



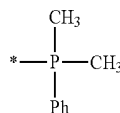
8-1



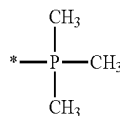
8-2



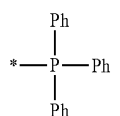
8-3



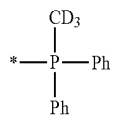
8-4



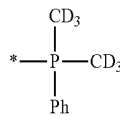
8-5



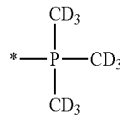
8-6



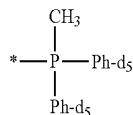
8-7



8-8

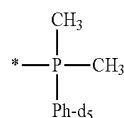


8-9

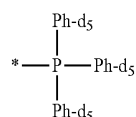


8-10

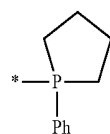
-continued



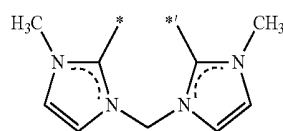
8-11



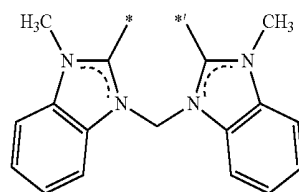
8-12



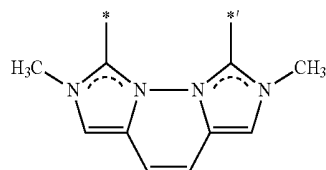
8-13



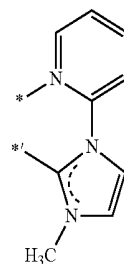
8-14



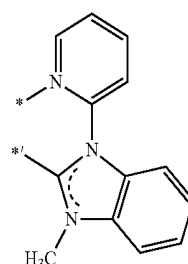
8-15



8-16

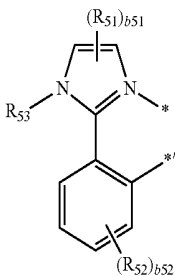
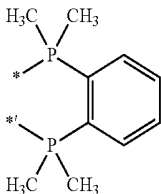
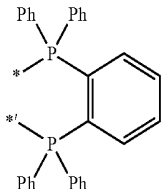
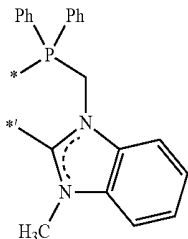
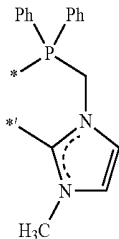
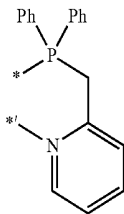


8-17

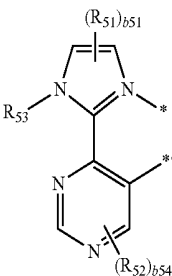
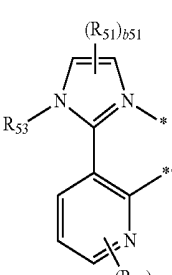
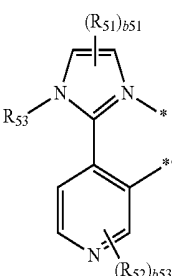
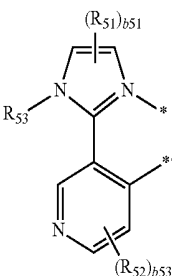
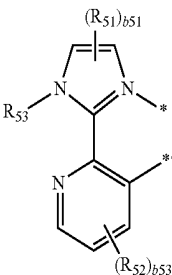


8-18

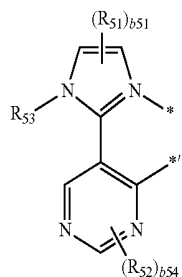
-continued



-continued

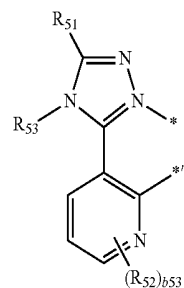


-continued

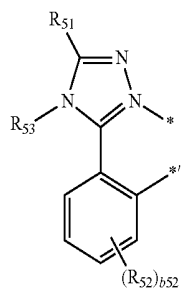


5-7

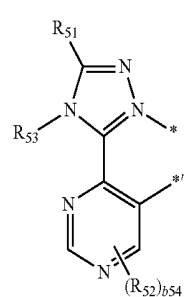
-continued



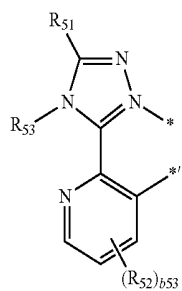
5-12



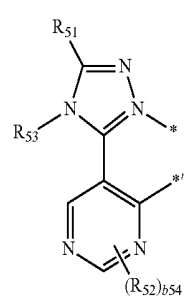
5-8



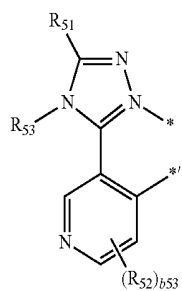
5-13



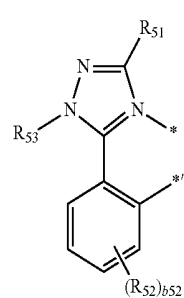
5-9



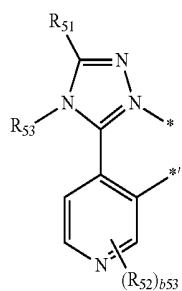
5-14



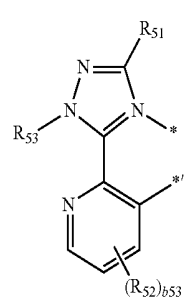
5-10



5-15

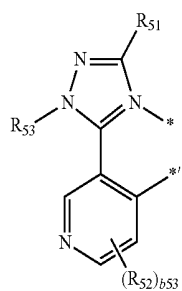


5-11



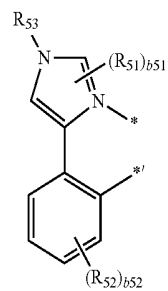
5-16

-continued

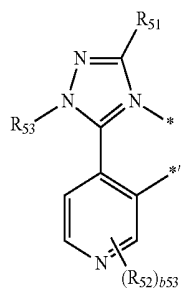


5-17

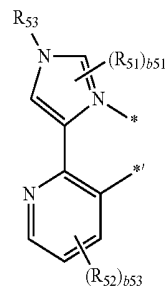
-continued



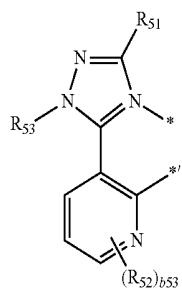
5-22



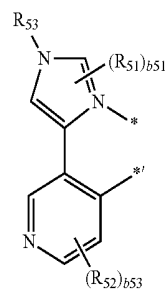
5-18



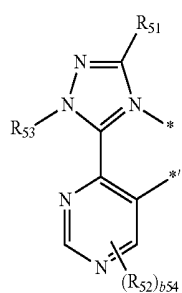
5-23



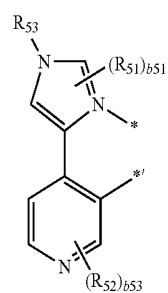
5-19



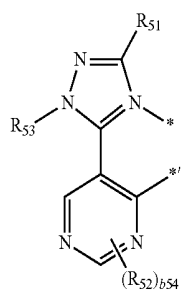
5-24



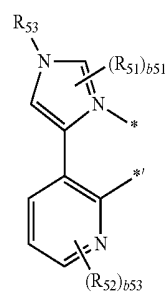
5-20



5-25

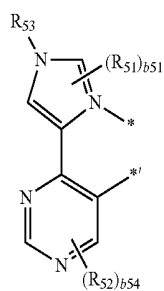


5-21



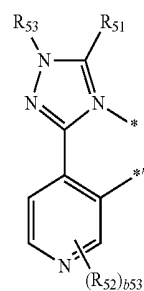
5-26

-continued

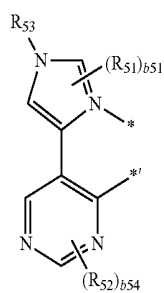


5-27

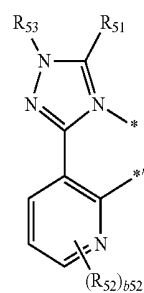
-continued



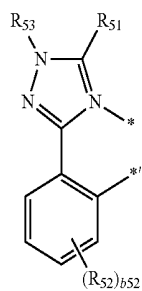
5-32



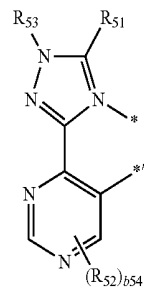
5-28



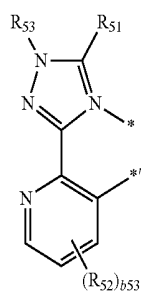
5-33



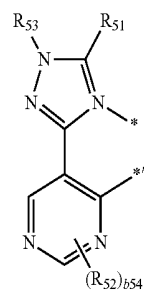
5-29



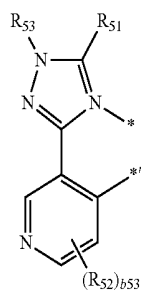
5-34



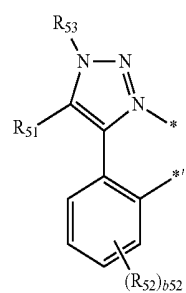
5-30



5-35

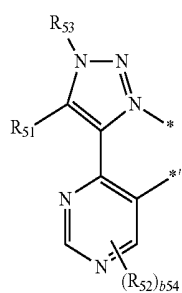
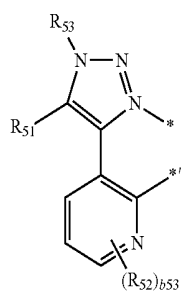
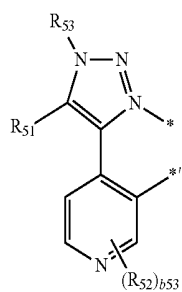
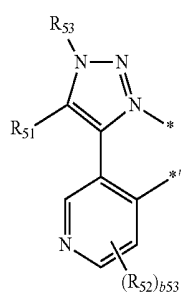
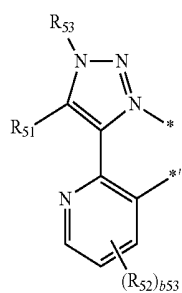


5-31

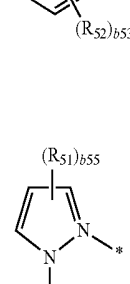
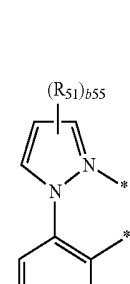
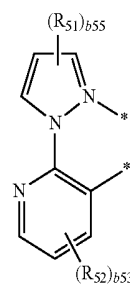
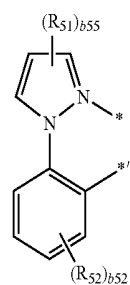
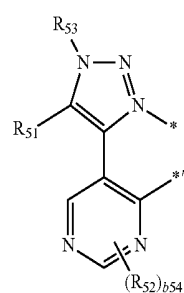


5-36

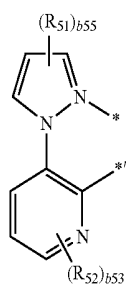
-continued



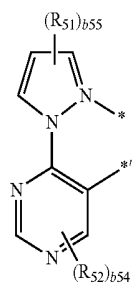
-continued



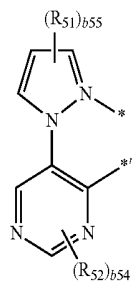
-continued



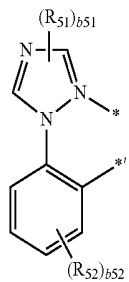
5-47



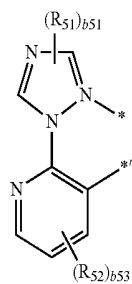
5-48



5-49

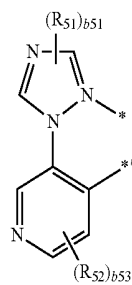


5-50

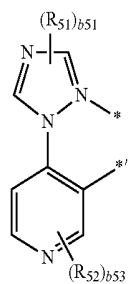


5-51

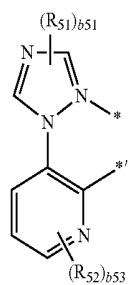
-continued



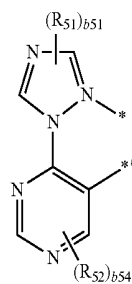
5-52



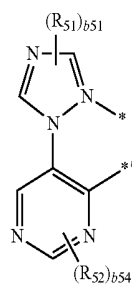
5-53



5-54

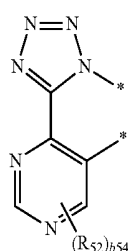
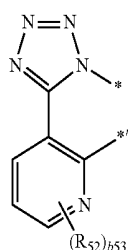
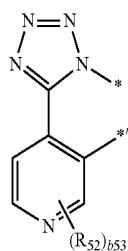
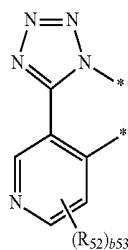
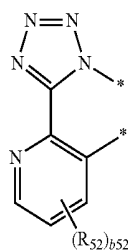
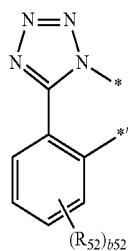


5-55



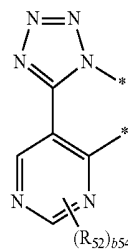
5-56

-continued



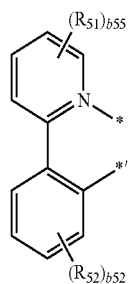
-continued

5-57



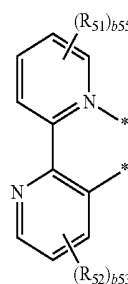
5-63

5-58



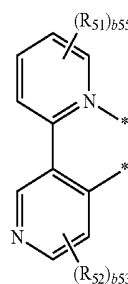
5-64

5-59



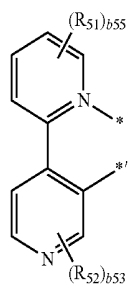
5-65

5-60



5-66

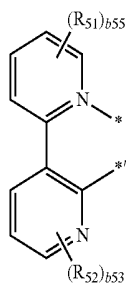
5-61



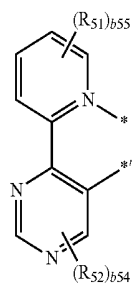
5-67

5-62

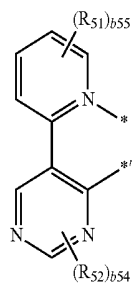
-continued



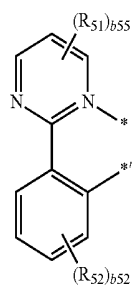
5-68



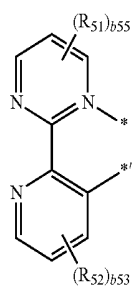
5-69



5-70

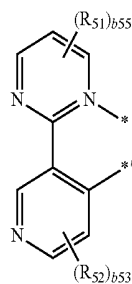


5-71

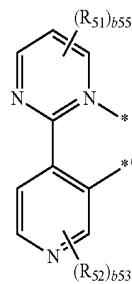


5-72

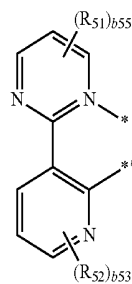
-continued



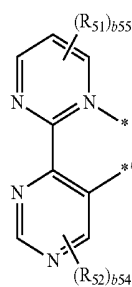
5-73



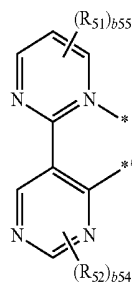
5-74



5-75

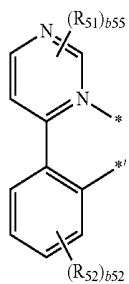


5-76

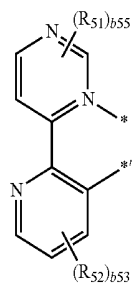


5-77

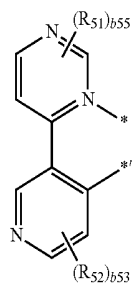
-continued



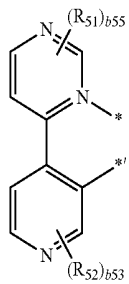
5-78



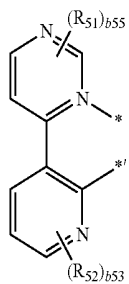
5-79



5-80

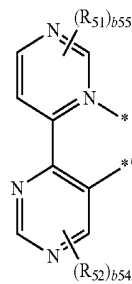


5-81

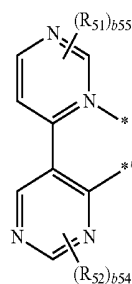


5-82

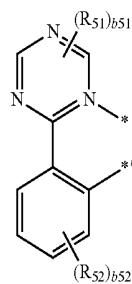
-continued



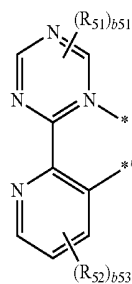
5-83



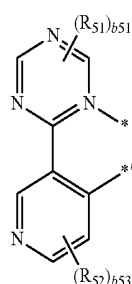
5-84



5-85

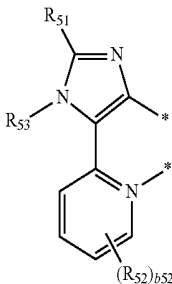
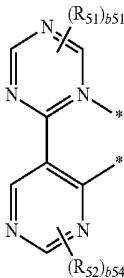
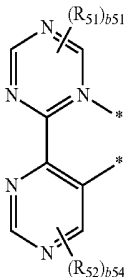
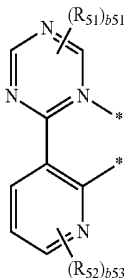
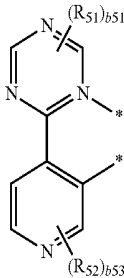


5-86

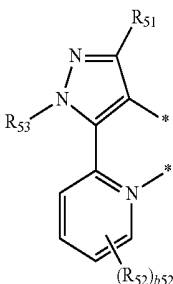
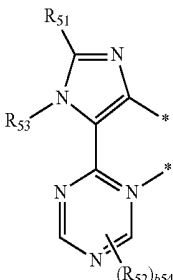
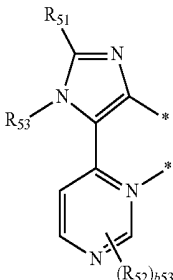
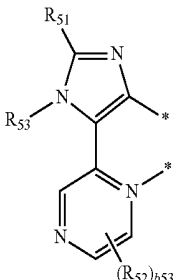
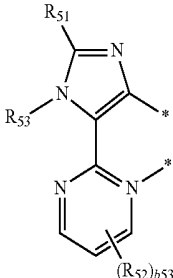


5-87

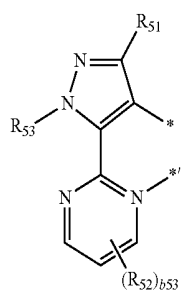
-continued



-continued



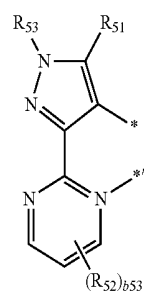
-continued



5-98

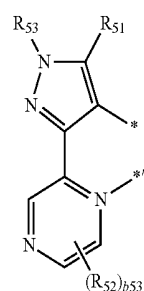
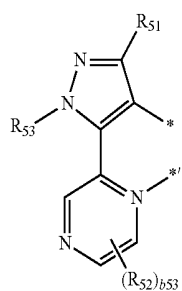
-continued

5-103



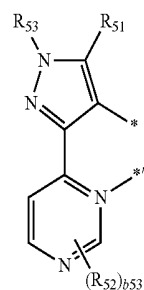
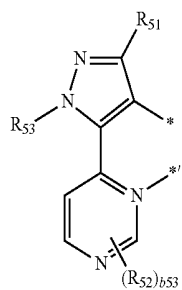
5-99

5-104



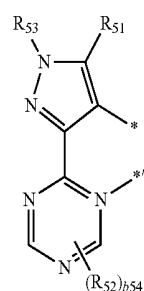
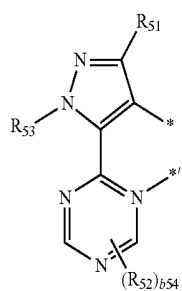
5-100

5-105



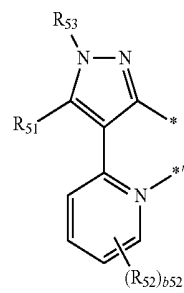
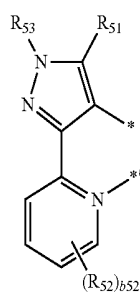
5-101

5-106

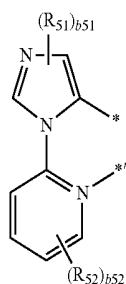
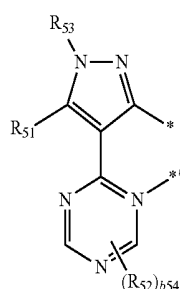
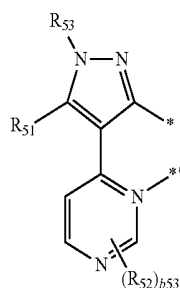
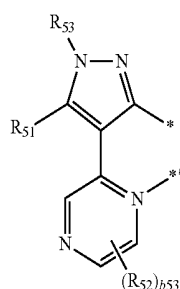
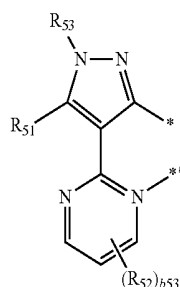


5-102

5-107

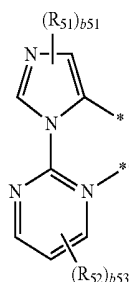


-continued



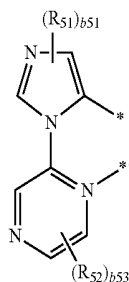
-continued

5-108



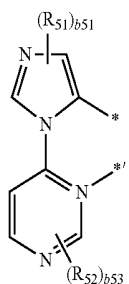
5-113

5-109



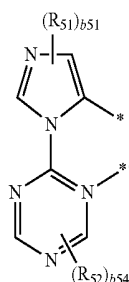
5-114

5-110



5-115

5-111



5-116

5-112

[0231] In Formulae 5-1 to 5-116 and 8-1 to 8-23,

[0232] R_{51} to R_{53} may each independently be:

[0233] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF₅, a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group;

[0234] a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norborne-

nyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

[0235] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group;

[0236] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl

group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —B(Q₁₁)(Q₁₂), —N(Q₁₁)(Q₁₂), or any combination thereof; or

[0237] —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), or —N(Q₁)(Q₂), and

[0238] Q₁ to Q₃ and Q₁₁ to Q₁₃ may each independently be:

[0239] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, or a naphthyl group; or

[0240] 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or a combination thereof,

[0241] and b54 may each independently be 1 or 2,

[0242] b53 and b55 may each independently be 1, 2, or 3,

[0243] b52 may be 1, 2, 3, or 4,

[0244] Ph indicates a phenyl group,

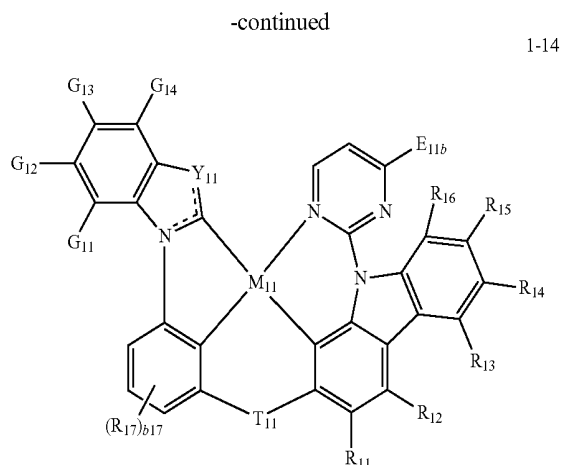
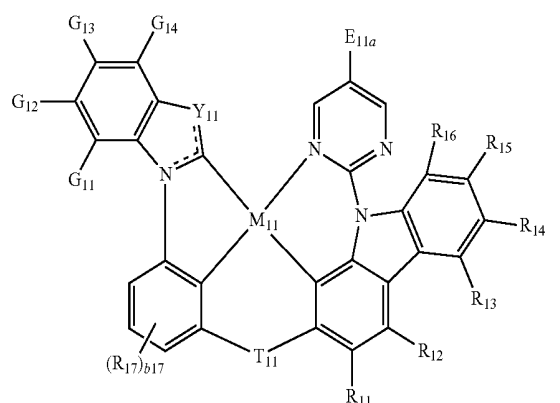
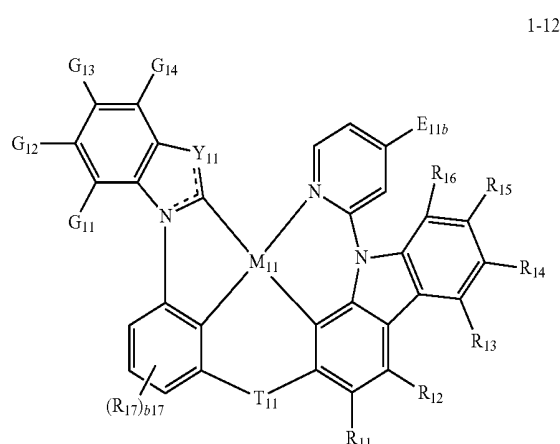
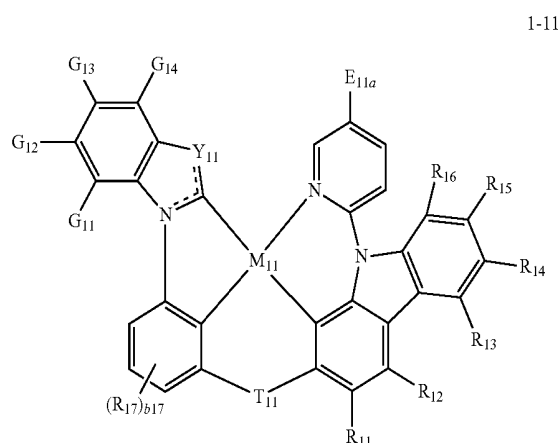
[0245] Ph-d5 indicates a phenyl group in which all hydrogen atoms are substituted with deuterium, and

[0246] * and *^{*} each indicate a binding site to a neighboring atom.

[0247] In Formula 1, n11 may be 1, and n12 may be 0, 1, or 2.

[0248] In one or more embodiments, in Formula 1, M₁₁ may be Pt, n11 may be 1, and n12 may be 0, but embodiments of the present disclosure are not limited thereto.

[0249] In one or more embodiments, the organometallic compound may be represented by Formulae 1-11 to 1-14, but embodiments of the present disclosure are not limited thereto:



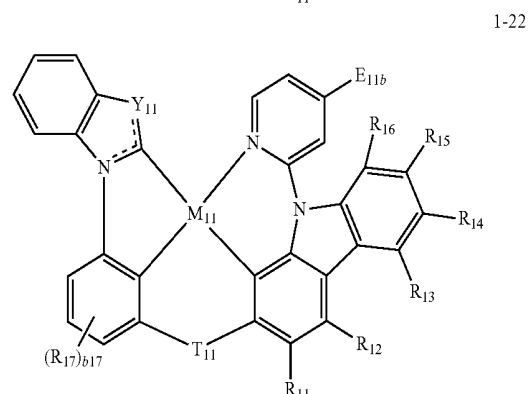
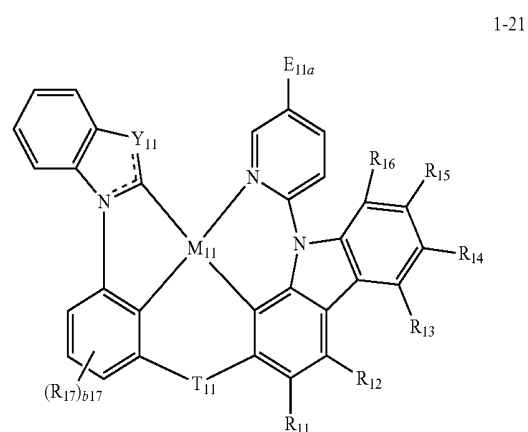
[0250] In Formulae 1-11 to 1-14,

[0251] M_{11} may be the same as defined in connection with Formula 1,

[0252] Y_{11} , T_{11} , G_{11} to G_{14} , R_{11} to R_{17} , and b_{17} may each independently be the same as defined in connection with Formula 1-1, and

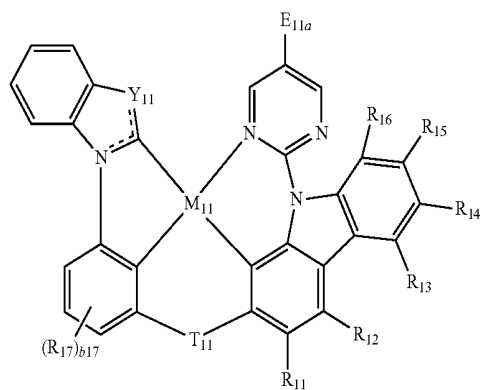
[0253] E_{11a} and E_{11b} may each independently be the same as defined in connection with E_{11} in Formula 1-1.

[0254] In one or more embodiments, the organometallic compound may be represented by Formulae 1-21 to 1-24, but embodiments of the present disclosure are not limited thereto:

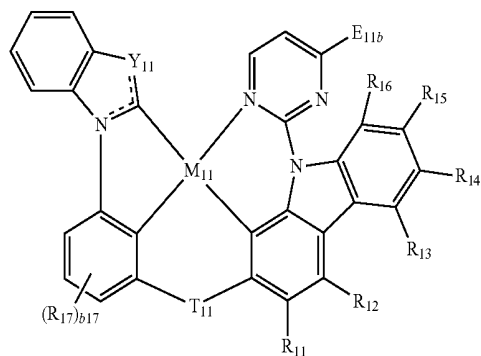


-continued

1-23



1-24



[0255] In Formulae 1-21 to 1-24,

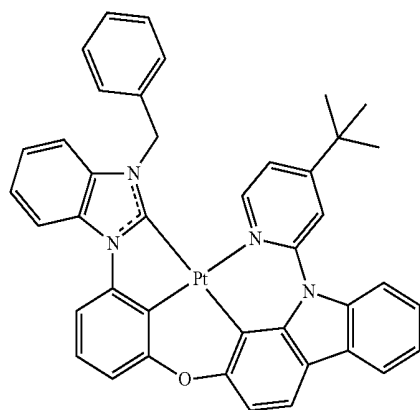
[0256] M_{11} may be the same as defined in connection with Formula 1,

[0257] Y_{11} , T_{11} , R_{11} to R_{17} , and b_{17} may each independently be the same as defined in connection with Formula 1-1, and

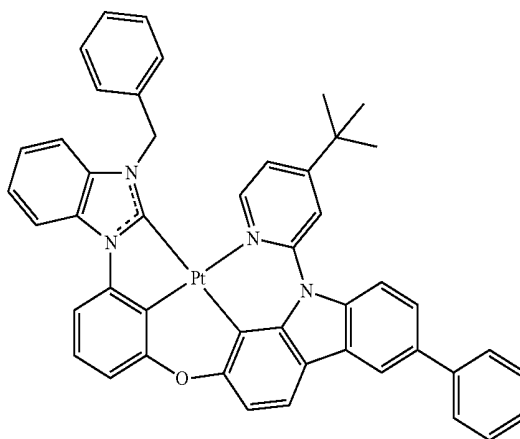
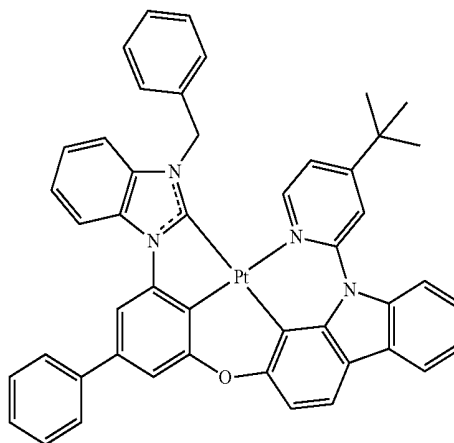
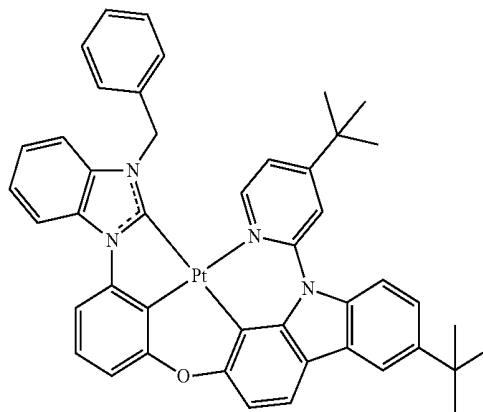
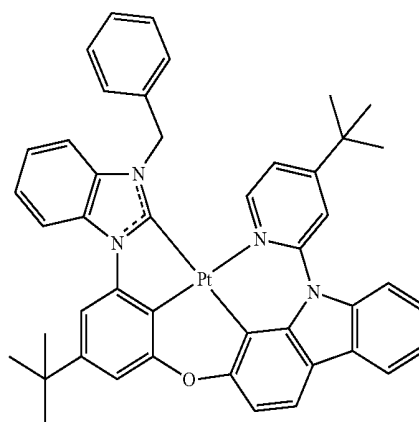
[0258] E_{11a} and E_{11b} may each independently be the same as defined in connection with E_{11} in Formula 1-1.

[0259] In one or more embodiments, the organometallic compound may be compounds of Group I, but embodiments of the present disclosure are not limited thereto:

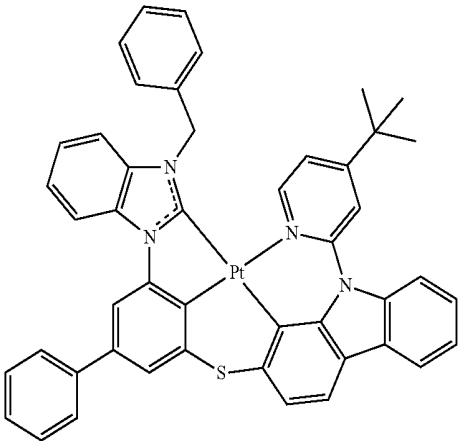
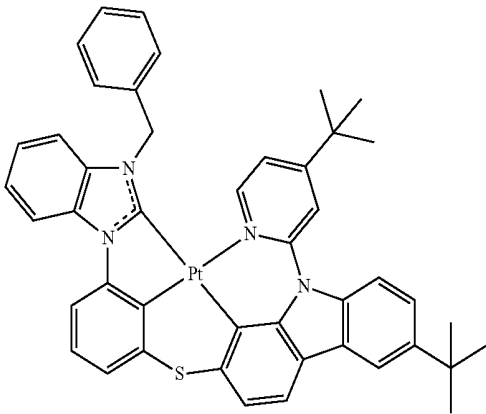
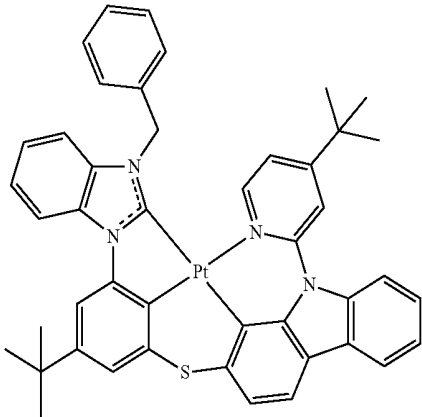
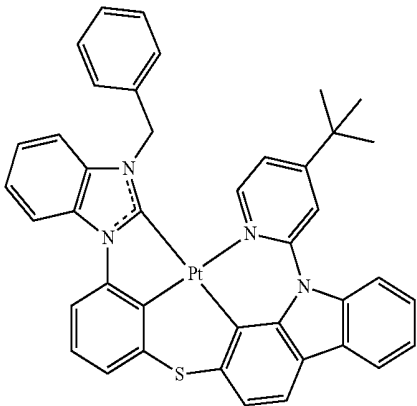
Group I



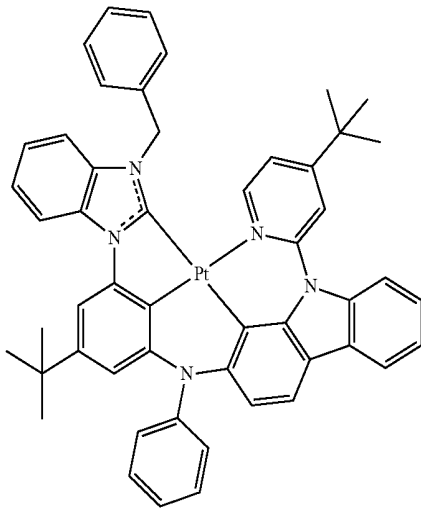
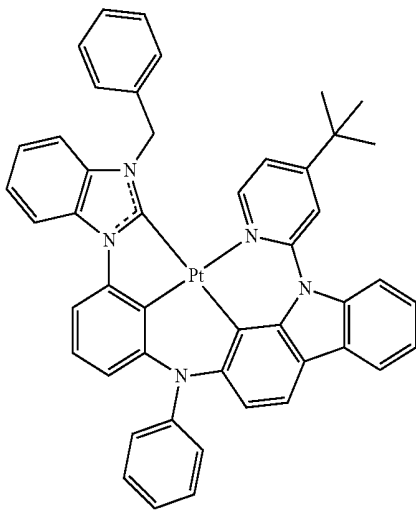
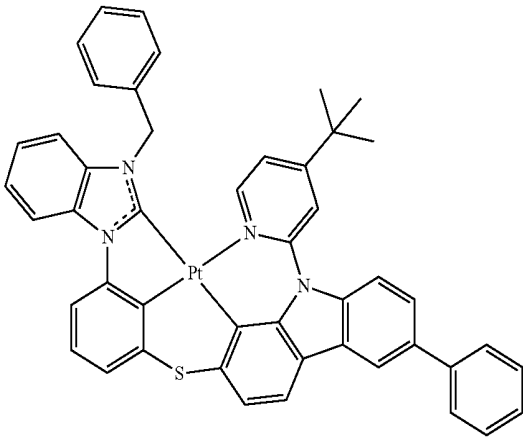
-continued



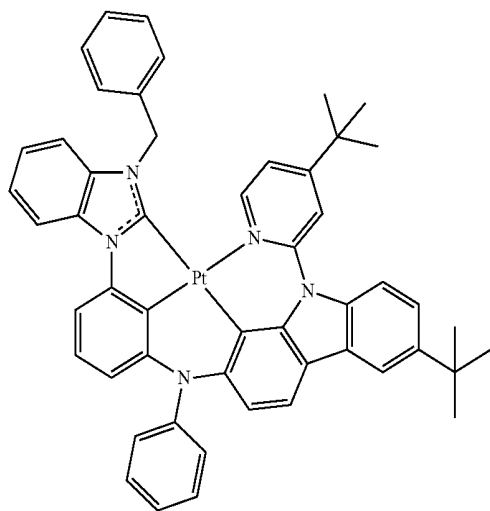
-continued



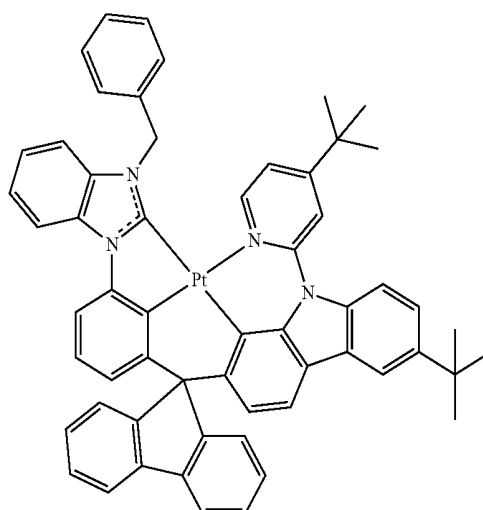
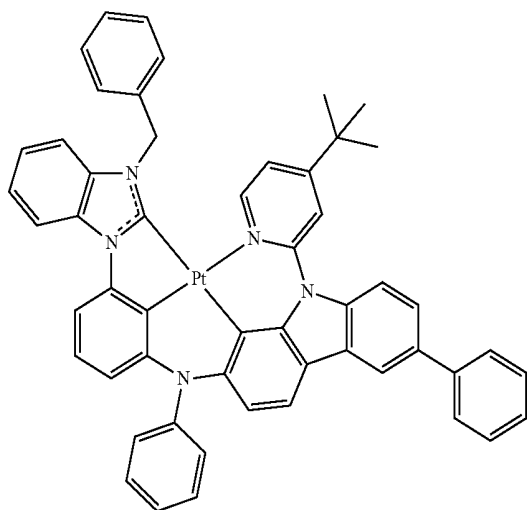
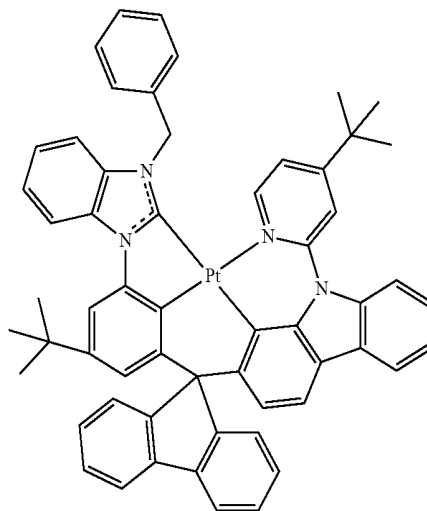
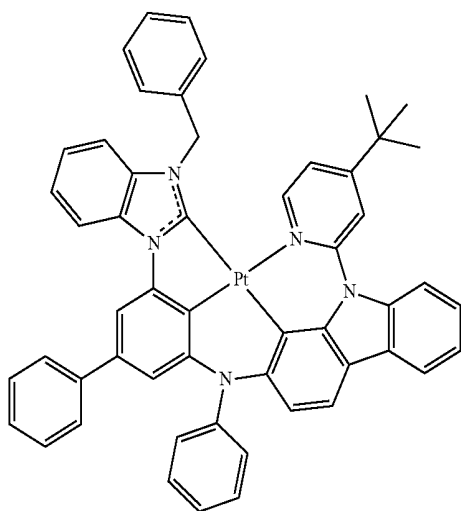
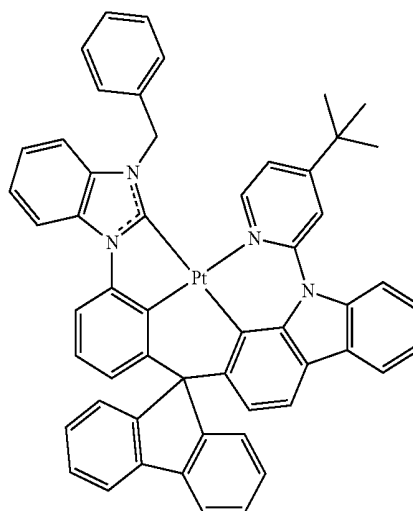
-continued



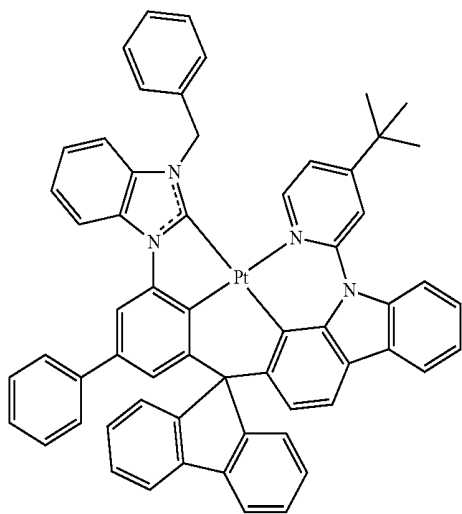
-continued



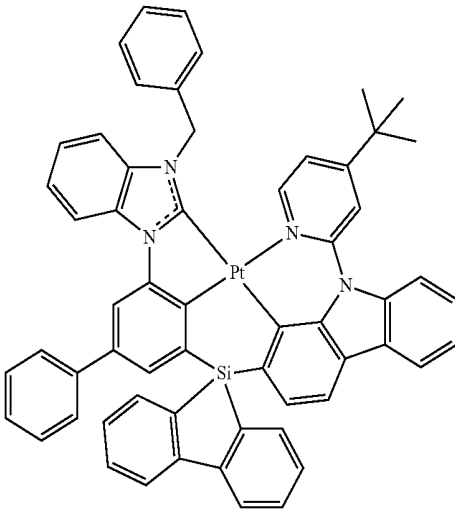
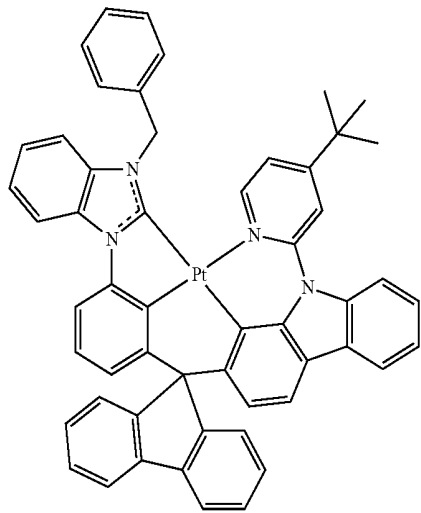
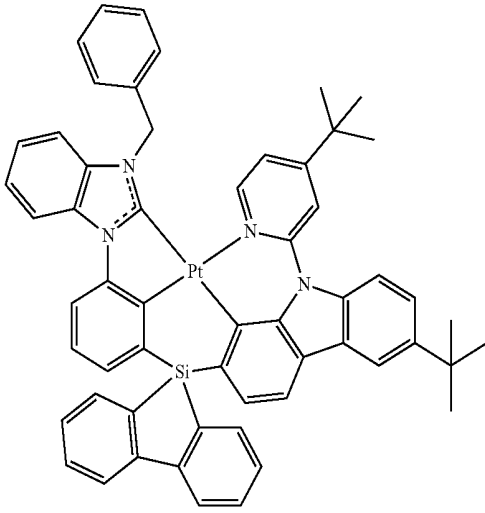
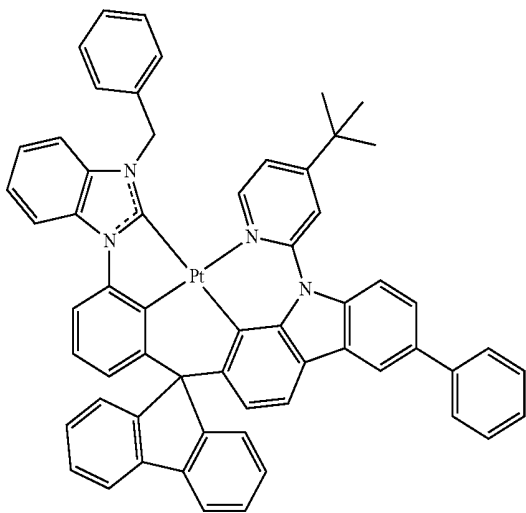
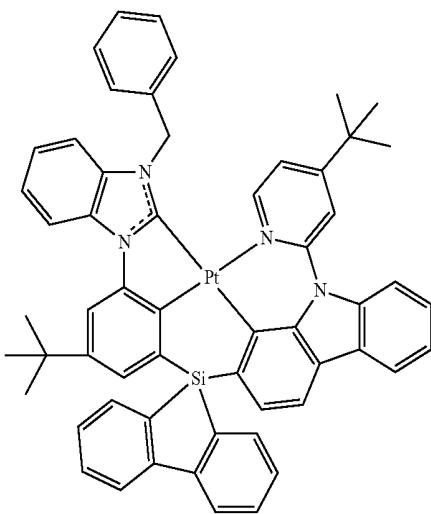
-continued



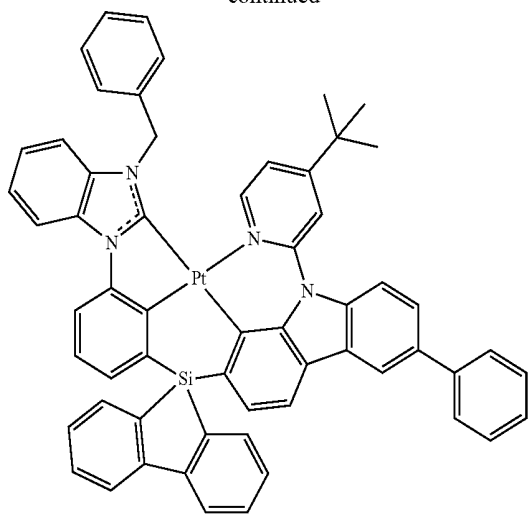
-continued



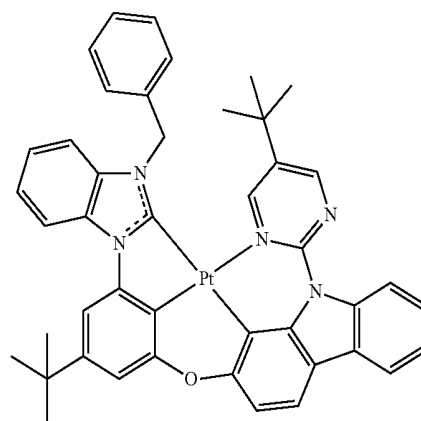
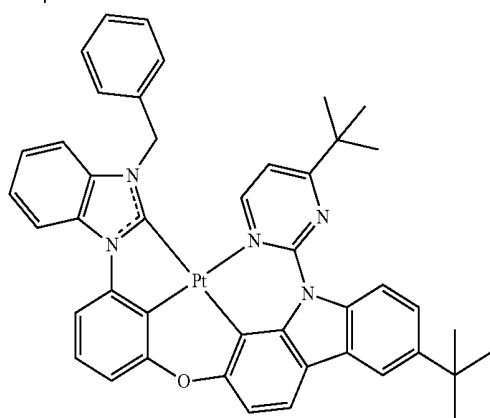
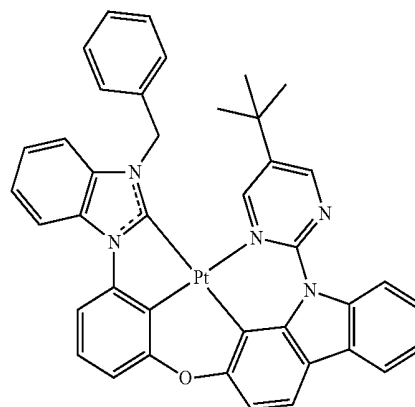
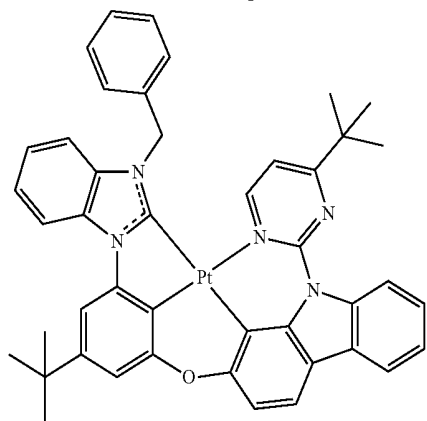
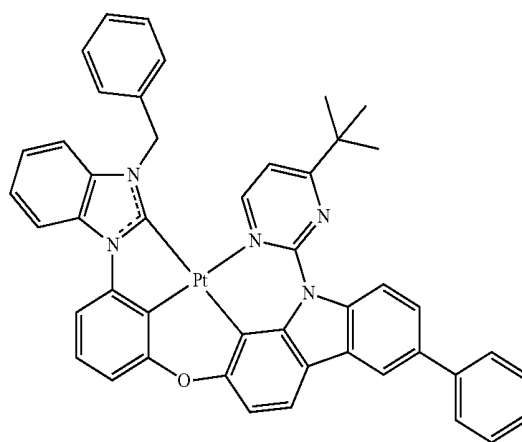
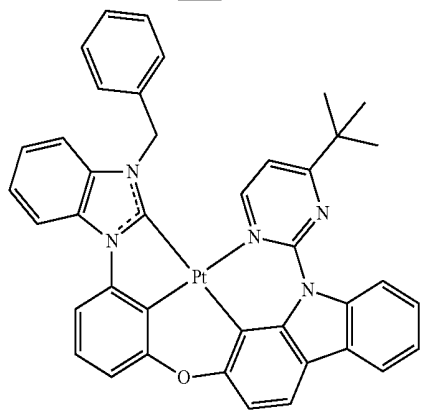
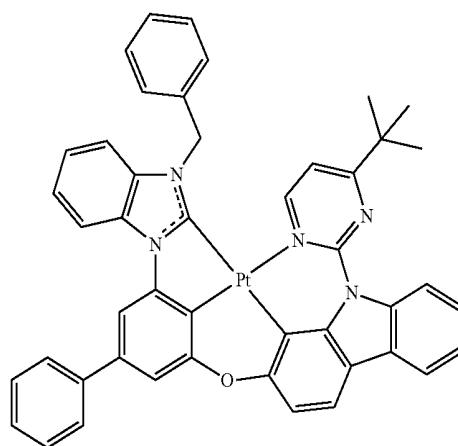
-continued



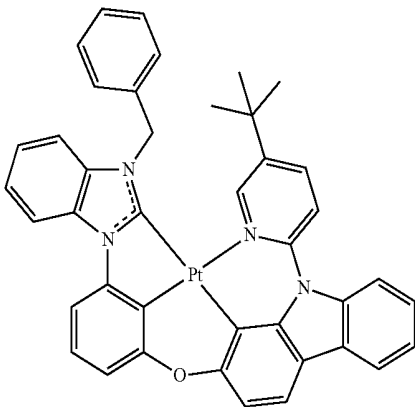
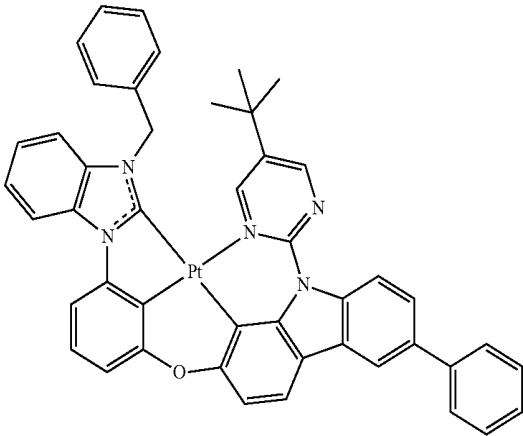
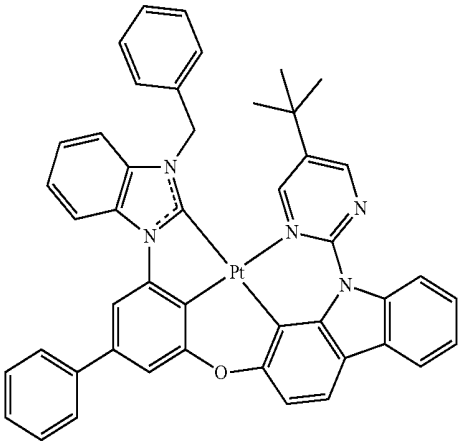
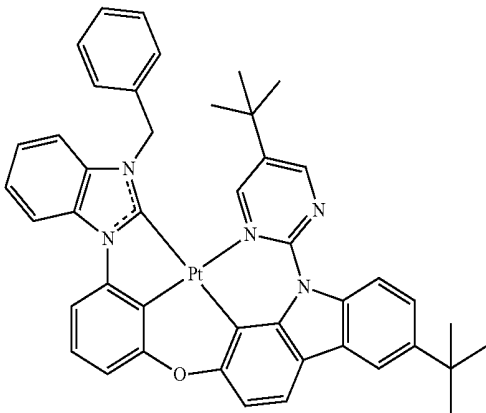
-continued



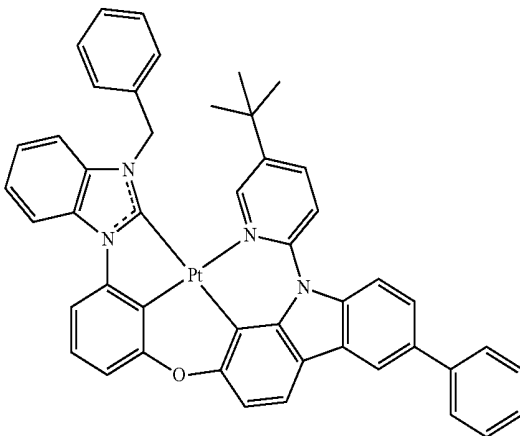
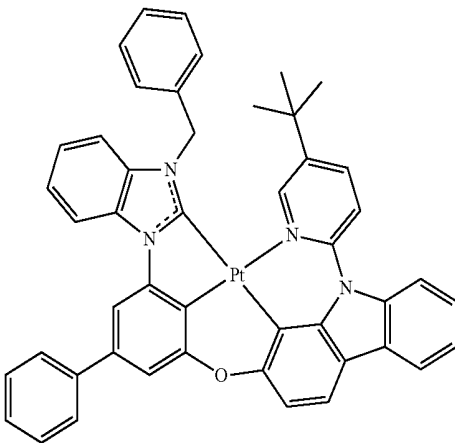
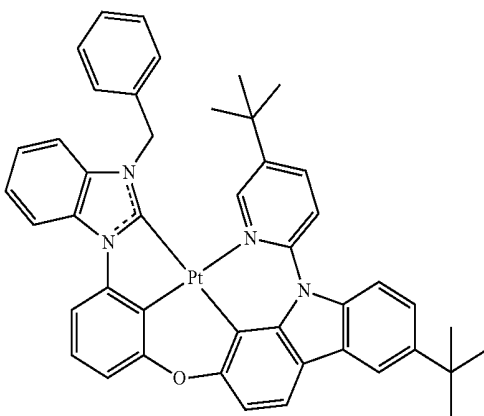
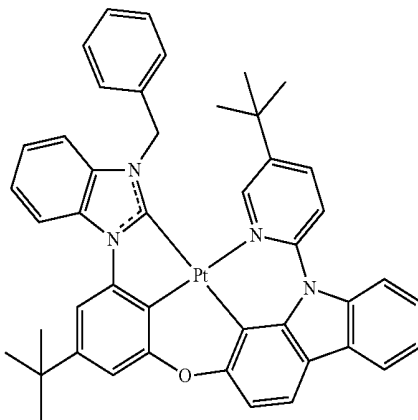
-continued



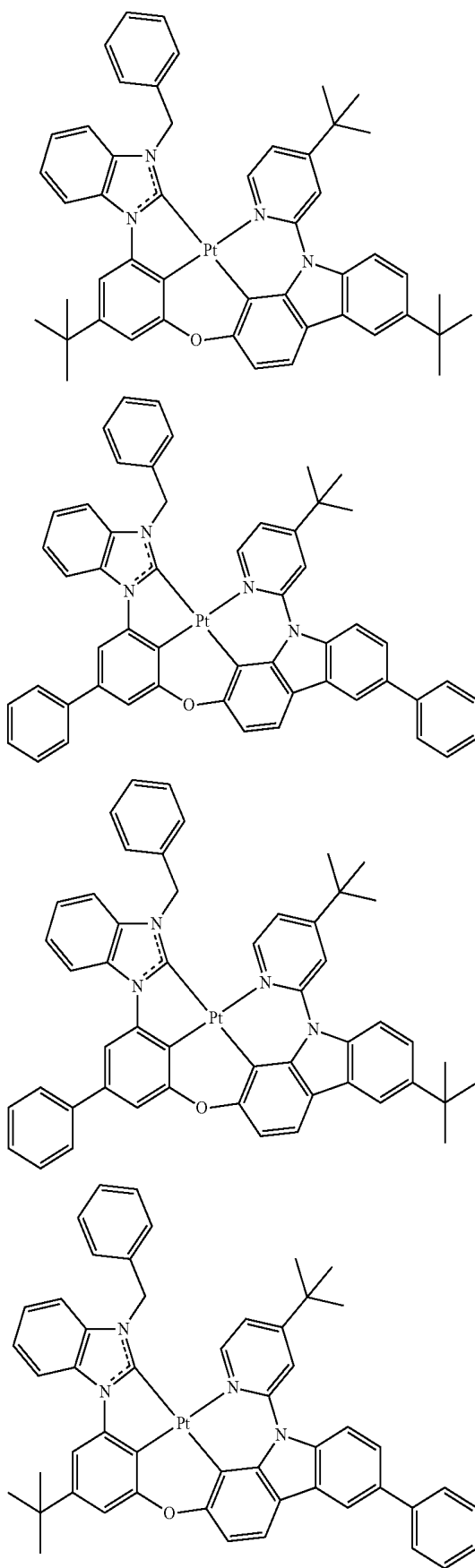
-continued



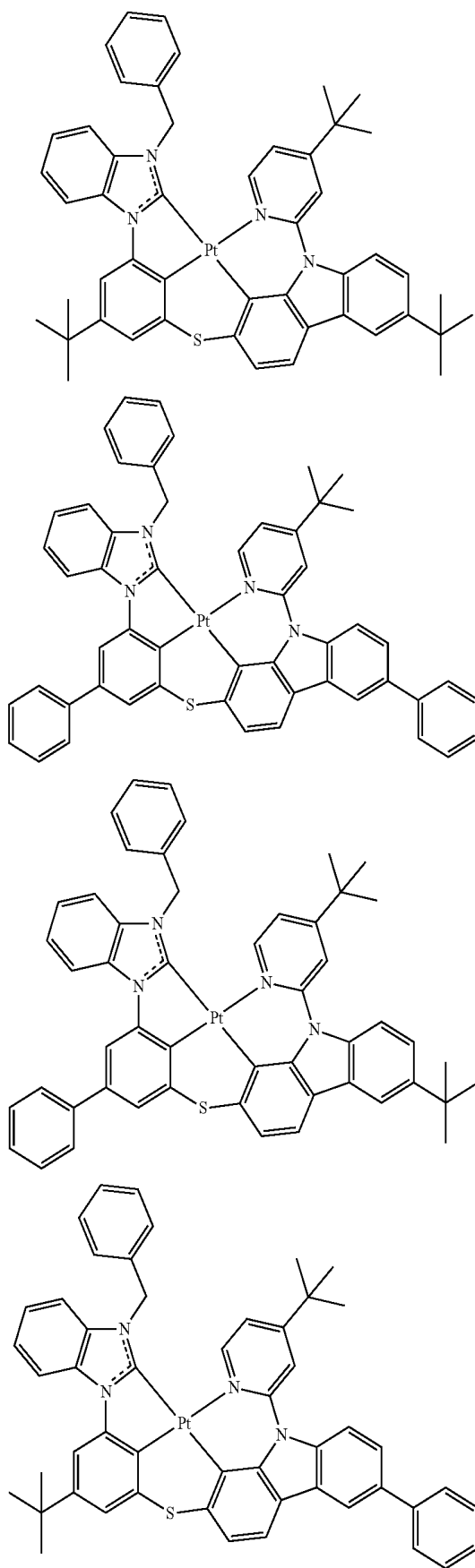
-continued



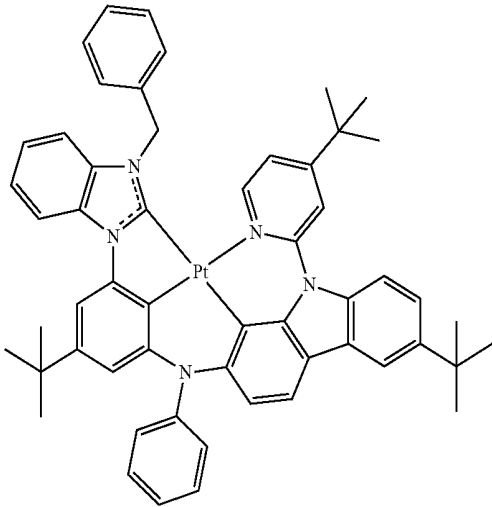
-continued



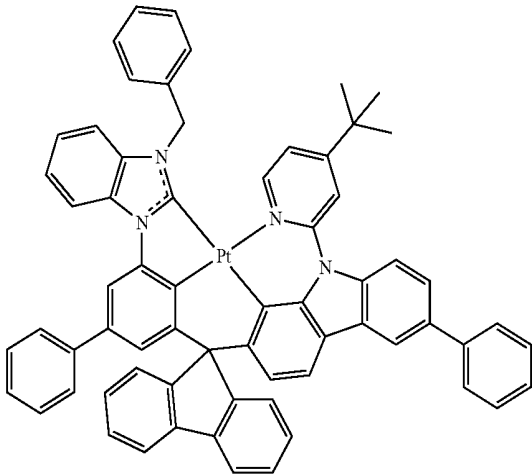
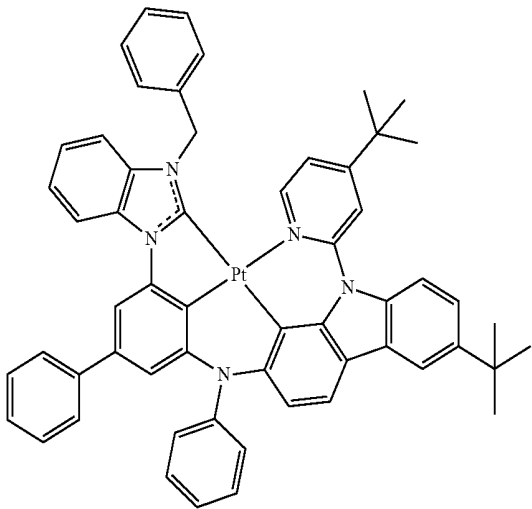
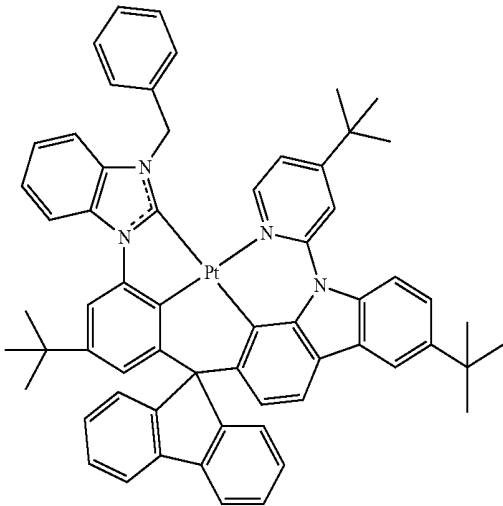
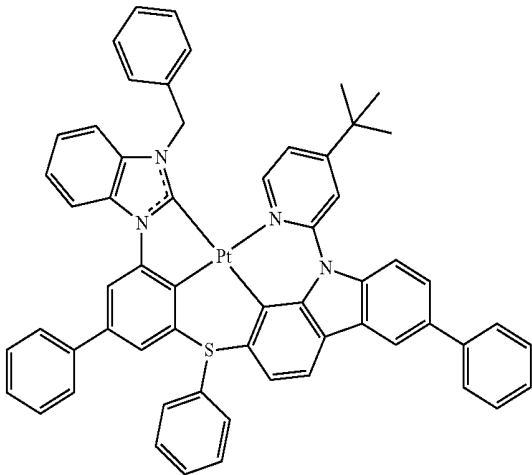
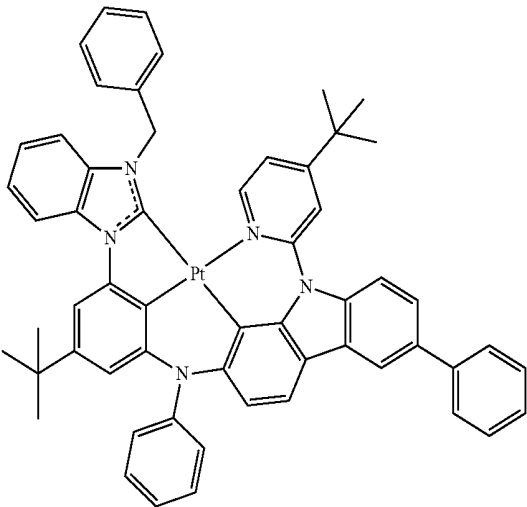
-continued



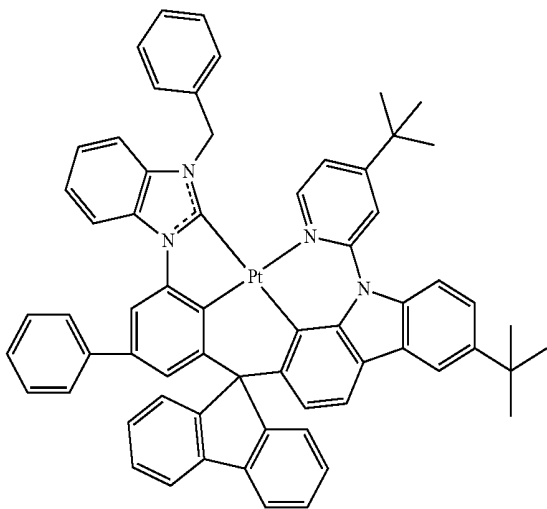
-continued



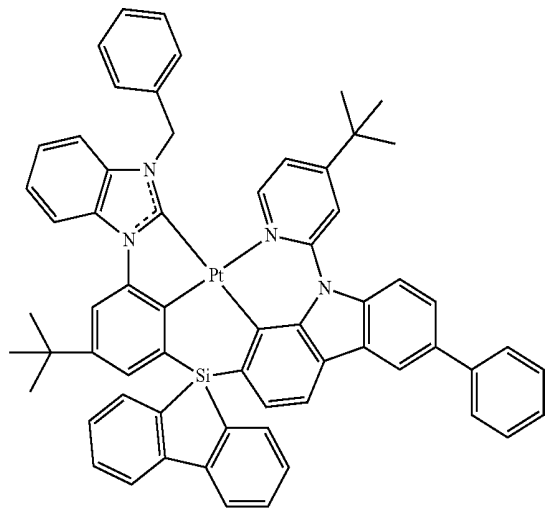
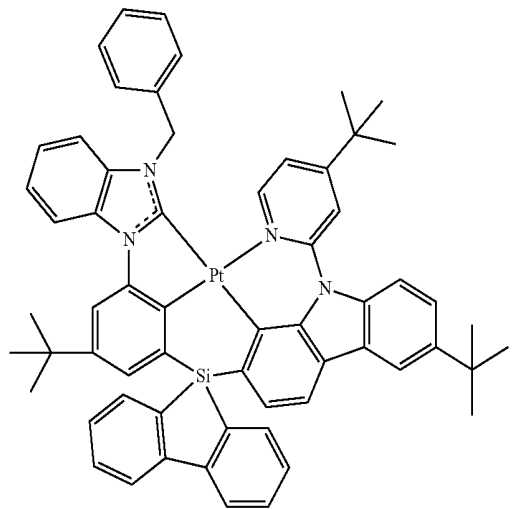
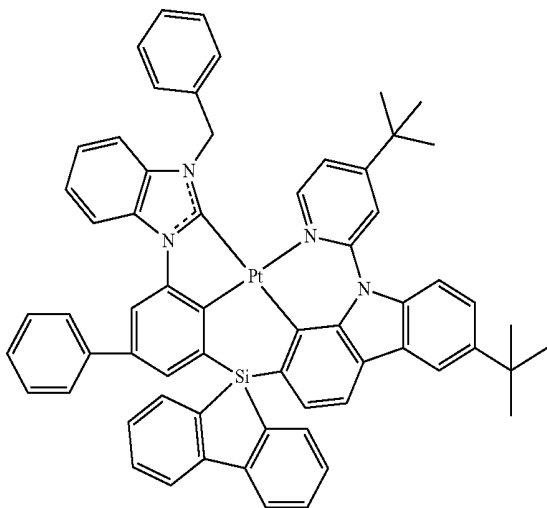
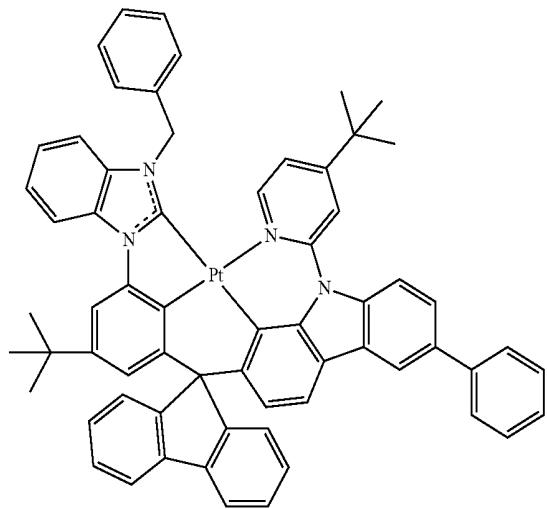
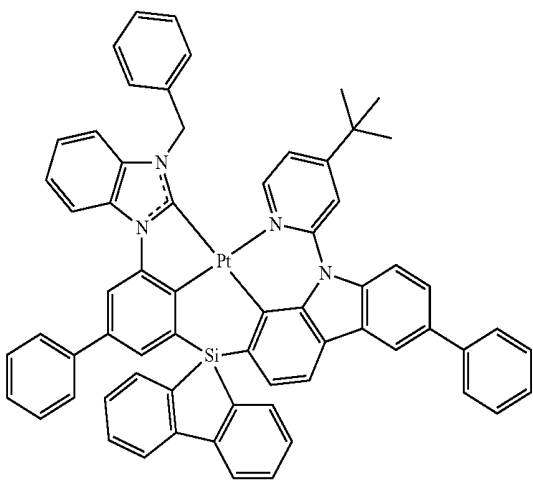
-continued



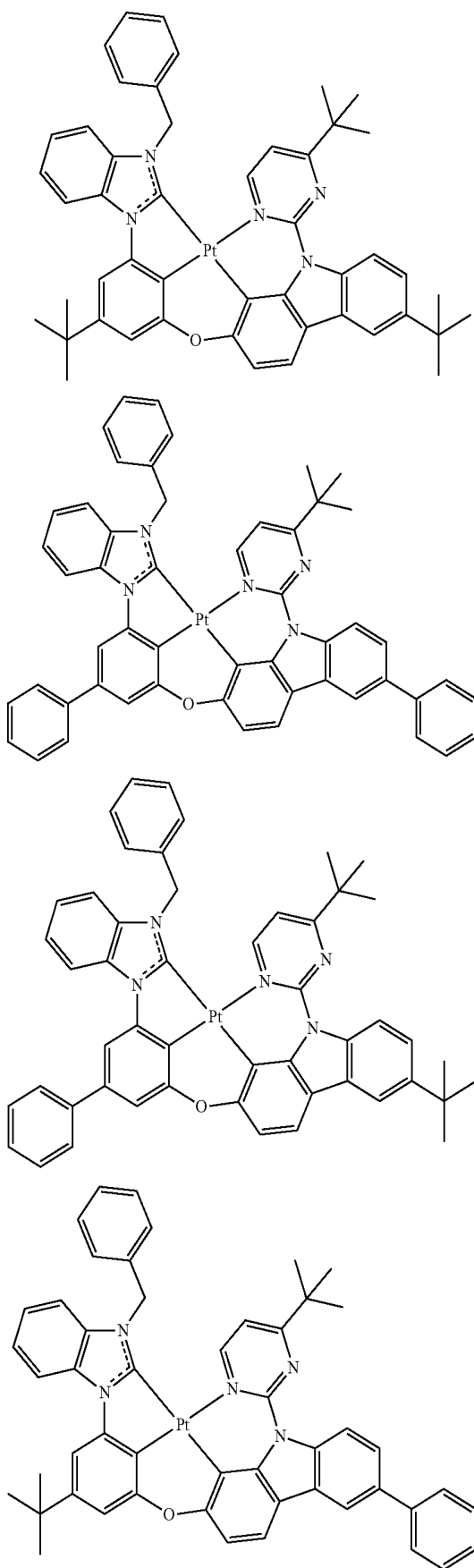
-continued



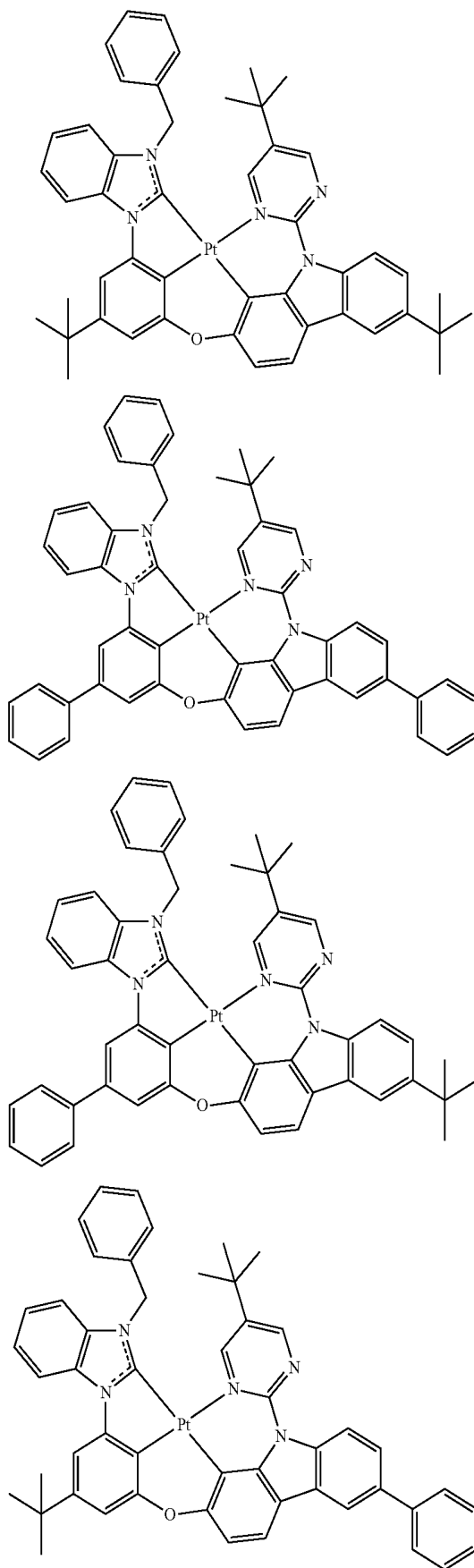
-continued



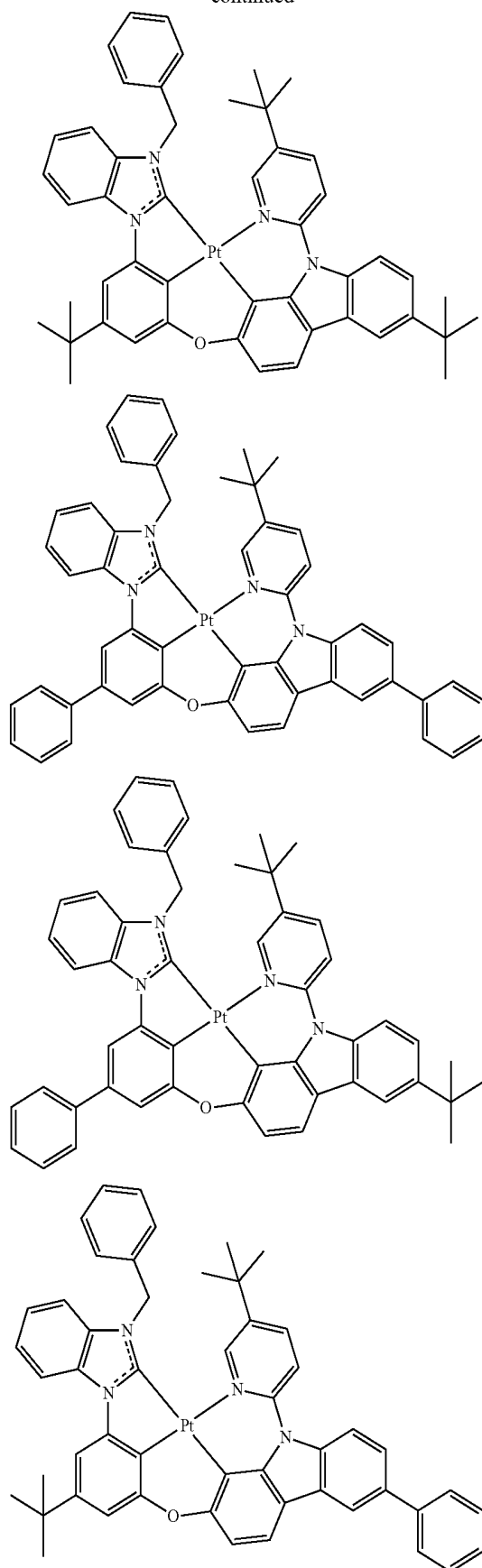
-continued



-continued



-continued



[0260] The organometallic compound represented by Formula 1 may have a maximum emission wavelength (experimental value) of about 420 nm or more and about less than 520 nm, for example, in a range of about 450 nm to about 475 nm. In particular, when the maximum emission wavelength is in a range of about 455 nm to about 465 nm, an organic light-emitting device emitting deep blue color light may be provided.

[0261] In the organometallic compound represented by Formula 1, both the benzocarbene- A_{12} part and the A_{11} -carbazole part may participate in light emission. Specifically, the benzocarbene- A_{12} part participates in light emission as highest occupied natural transition orbital (HONTO), and the A_{11} -carbazole part participates in light emission as lowest unoccupied natural transition orbital (LUNTO). Therefore, a luminescent spectrum having high color purity may be provided.

[0262] In the organometallic compound represented by Formula 1, since E_{11} is selected as an alkyl group or the like, the electron distribution of LUNTO is changed, and it is possible to provide an organometallic compound having improved light emission characteristics, for example, the change in the maximum emission wavelength and/or the width change in the emission wavelength. Therefore, the organometallic compound represented by Formula 1 may have high color purity and may have improved conversion efficiency when applied to the resonant device.

[0263] In the organometallic compound represented by Formula 1. Due to steric hindrance or electron effect of E_{11} , E_{11} is selected as an alkyl group, and thus, color coordinates (in particular, y value in CIE color coordinates) are constantly maintained and the FWHM is constantly maintained, regardless of the concentration of the organometallic compound. Therefore, it is possible to provide an organic light-emitting device emitting deep blue light, regardless of the concentration of the organometallic compound.

[0264] Since the organometallic compound represented by Formula 1 includes benzocarbene, the organometallic compound may emit deep blue light having a predetermined wavelength. Since the organometallic compound including carbene instead of benzocarbene emits blue light having a shorter wavelength, luminescent efficiency in a desired wavelength range may be significantly lowered. That is, the organic light-emitting device including the organometallic compound represented by Formula 1 may have improved luminescent efficiency in a predetermined wavelength range.

[0265] In the organometallic compound represented by Formula 1, G_{11} to G_{14} may not be fluorescent light emitters. Therefore, it is possible to prevent an increase in the change in emission wavelength according to MADF fluorescence expression (that is, a reduction in color purity according to an increase in FWHM) and/or a reduction in conversion efficiency of the resonant device.

[0266] In the organometallic compound represented by Formula 1, R_{18} may be represented by $^*C(Q_{101})(Q_{102})(Q_{103})$, and in this regard, electrons in luminophore may be controlled, thereby improving the efficiency of the organic light-emitting device including the organometallic compound represented by Formula 1.

[0267] For example, HOMO, LUMO, and Ti energy levels of some of Compounds were evaluated by using a B3LYP density functional theory of Gaussian program (Pt was structurally optimized at a level of LanL2DZ basis set, and

another atom was structurally optimized at a level of B3LYP, 6-31G(d,p)), and results thereof are shown in Table 1.

TABLE 1

Compound No.	HOMO (eV)	LUMO (eV)	T1 (eV)
Compound 6	-4.68	-1.27	2.67
Compound X1	-4.75	-1.43	2.60
Compound X2	-4.58	-1.20	2.69
Compound X3	-4.75	-1.52	2.58
Compound X4	-4.66	-1.23	2.61
Compound X5	-4.44	-1.40	2.35
Compound X6	-4.69	-1.32	2.65
Compound X7	-4.67	-1.24	2.63
Compound X8	-4.68	-1.31	2.67

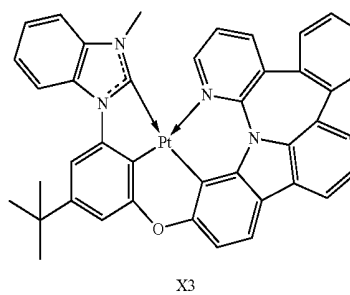
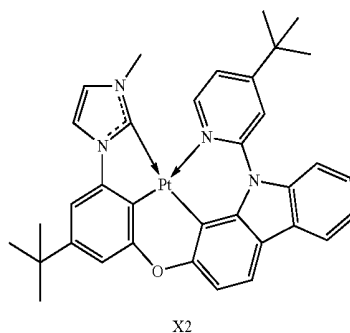
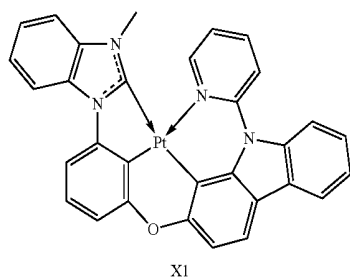
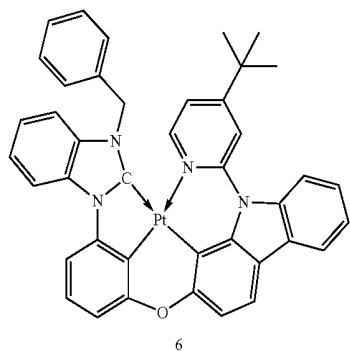
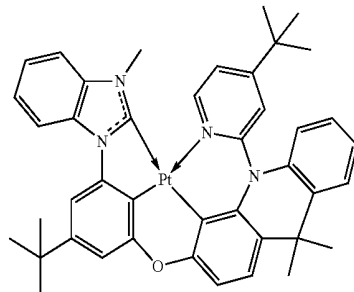
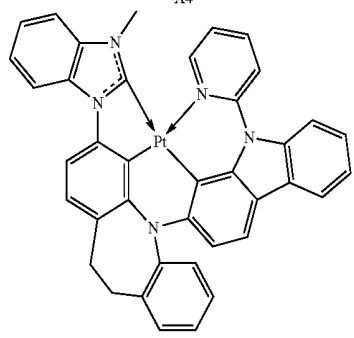
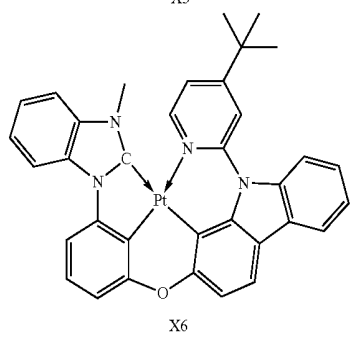
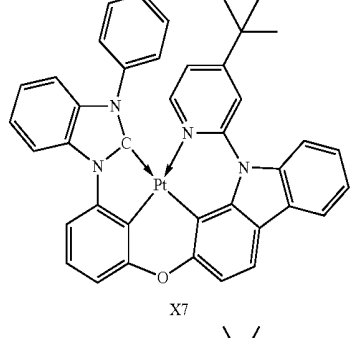
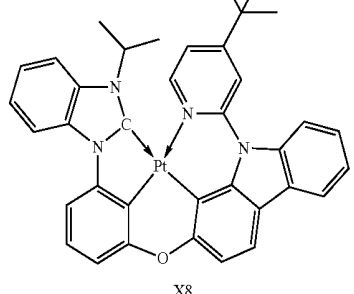


TABLE 1-continued

Compound No.	HOMO (eV)	LUMO (eV)	T1 (eV)
			
			
			
			
			

[0268] From Table 1, it is confirmed that Compounds represented by Formula 1 are suitable for deep blue light emission. On the other hand, Compound X2 is not suitable for deep blue light emission since Compound X2 has high T1, and Compounds X4, X5, and X6 are not suitable for deep blue light emission since Compounds X4, X5, and X6 have low T1.

[0269] Synthesis methods of the organometallic compound represented by Formula 1 may be understood by one of ordinary skill in the art by referring to Synthesis Examples provided below.

[0270] 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: a first electrode; a second electrode; and an organic layer that is located between the first electrode and the second electrode and includes an emission layer; and the organic layer includes at least one organometallic compound represented by Formula 1.

[0271] The organic light-emitting device may have, due to the inclusion of an organic layer including the organometallic compound represented by Formula 1, a low driving voltage, high efficiency, high power, high quantum efficiency, a long lifespan, a low roll-off ratio, and excellent color purity.

[0272] The organometallic compound of Formula 1 may be used between a pair of electrodes of an organic light-emitting device. For example, the organometallic compound represented by Formula 1 may be included in the emission layer. In this regard, the organometallic compound may act as a dopant, and the emission layer may further include a host (that is, an amount of the organometallic compound represented by Formula 1 is smaller than an amount of the host). In this regard, the dopant may emit blue light.

[0273] The expression “(an organic layer) includes at least one organometallic compound” used herein may include a case in which “(an organic layer) includes identical compounds represented by Formula 1” and a case in which “(an organic layer) includes two or more different organometallic compounds represented by Formula 1.”

[0274] For example, the organic layer may include, as the organometallic compound, only Compound 1. In this regard, Compound 1 may exist in an emission layer of the organic light-emitting device. In one or more embodiments, the organic layer may include, as the organometallic compound, Compound 1 and Compound 2. In this regard, Compound 1 and Compound 2 may exist in an identical layer (for example, Compound 1 and Compound 2 all may exist in an emission layer).

[0275] The first electrode may be an anode, which is a hole injection electrode, and the second electrode may be a cathode, which is an electron injection electrode; or the first electrode may be a cathode, which is an electron injection electrode, and the second electrode may be an anode, which is a hole injection electrode.

[0276] In one or more embodiments, in the organic light-emitting device, the first electrode is an anode, and the second electrode is a cathode, and the organic layer further includes a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode, and the hole transport region includes at least one a hole injection

layer, a hole transport layer, and an electron blocking layer, and the electron transport region includes at least one a hole blocking layer, an electron transport layer, and an electron injection layer.

[0277] The term “organic layer” as used herein refers to a single layer and/or a plurality of layers between the first electrode and the second electrode of the organic light-emitting device. The “organic layer” may include, in addition to an organic compound, an organometallic compound including metal.

[0278] FIGURE 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 the FIGURE. The organic light-emitting device 10 includes a first electrode 11, an organic layer 15, and a second electrode 19, which are sequentially stacked.

[0279] A substrate may be additionally disposed under the first electrode 11 or above the second electrode 19. For use as the substrate, any substrate that is used in general organic light-emitting devices may be used, and the substrate may be a glass substrate or a transparent plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0280] In one or more embodiments, the first electrode 11 may be formed by depositing or sputtering a material for forming the first electrode 11 on the substrate. The first electrode 11 may be an anode. The material for forming the first electrode 11 may be a material with a high work function to facilitate hole injection. The first electrode 11 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. The material for forming the first electrode 11 may be indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO₂), or zinc oxide (ZnO). In one or more embodiments, the material for forming the first electrode 11 may be metal, such as magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag).

[0281] The first electrode 11 may have a single-layered structure or a multi-layered structure including two or more layers. For example, the first electrode 11 may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode 11 is not limited thereto.

[0282] The organic layer 15 is disposed on the first electrode 11.

[0283] The organic layer 15 may include a hole transport region, an emission layer, and an electron transport region.

[0284] The hole transport region may be disposed between the first electrode 11 and the emission layer.

[0285] The hole transport region may include at least one a hole injection layer, a hole transport layer, an electron blocking layer, a buffer layer, or any combination thereof.

[0286] The hole transport region may include only either a hole injection layer or a hole transport layer. In one or more embodiments, the hole transport region may have a hole injection layer/hole transport layer structure or a hole injection layer/hole transport layer/electron blocking layer structure, which are sequentially stacked in this stated order from the first electrode 11.

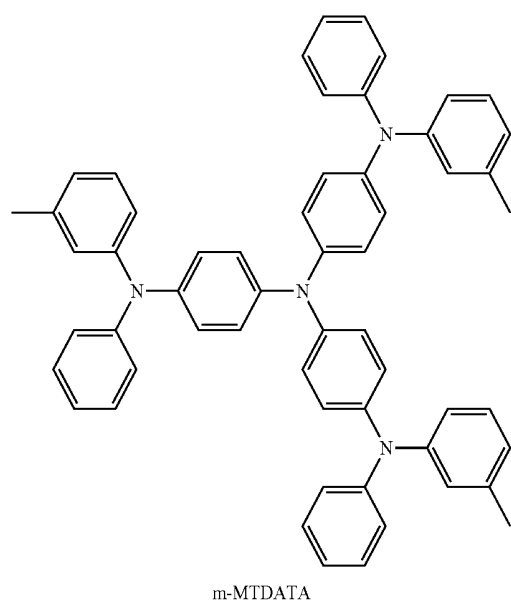
[0287] When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **11** by using one or more suitable methods, for example, vacuum deposition, spin coating, casting, and/or Langmuir-Blodgett (LB) deposition.

[0288] 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° C. to about 500° C., a vacuum pressure of about 10⁻⁸ torr to about 10⁻³ torr, and a deposition rate of about 0.01 Å/sec to about 100 Å/sec. However, the deposition conditions are not limited thereto.

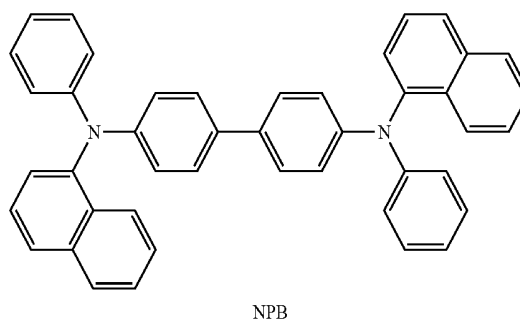
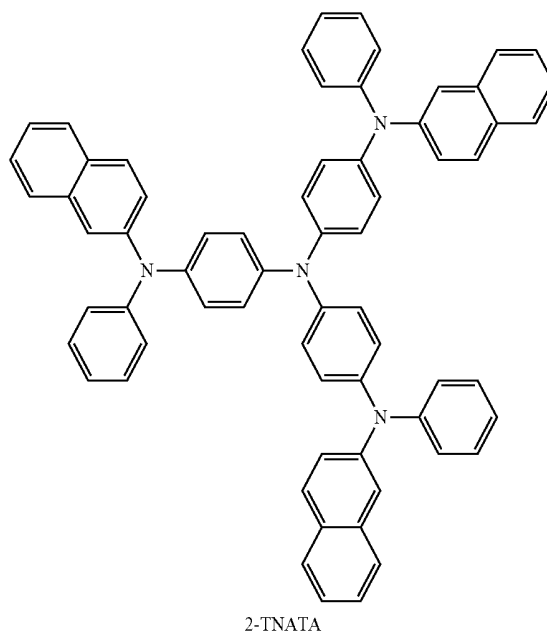
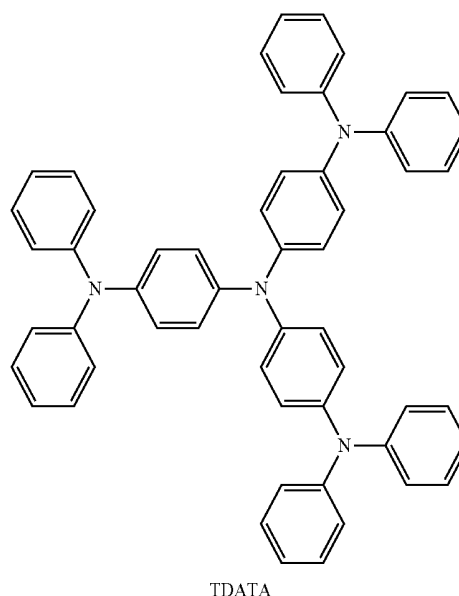
[0289] When the hole injection layer is formed using spin coating, coating conditions may vary according to the material used to form the hole injection layer, and the structure and thermal properties of the hole injection layer. For example, a coating speed may be from about 2,000 rpm to about 5,000 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.

[0290] Conditions for forming a hole transport layer and an electron blocking layer may be understood by referring to conditions for forming the hole injection layer.

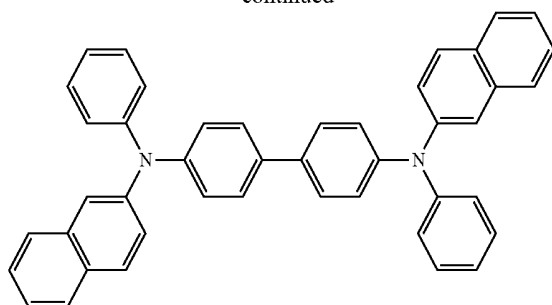
[0291] The hole transport region may include at least one m-MTDATA, TDATA, 2-TNATA, NPB, β -NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTDP, 4,4',4''-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, a compound represented by Formula 202, or any combination thereof, below:



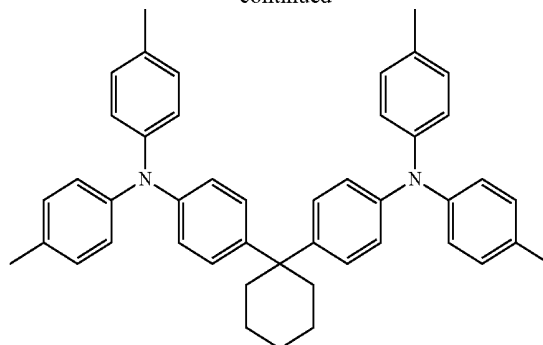
-continued



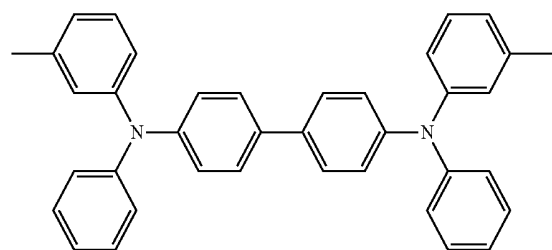
-continued

 β -NPB

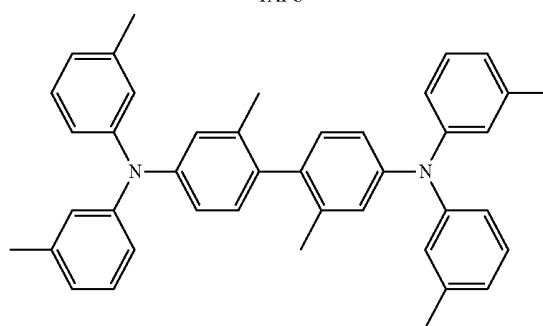
-continued



TAPC

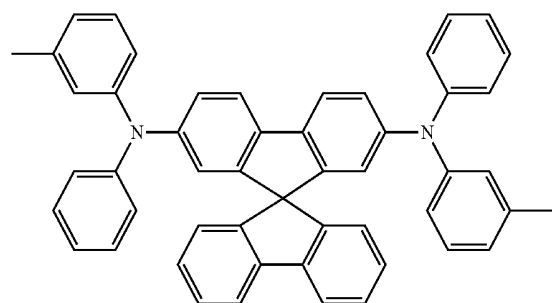


TPD

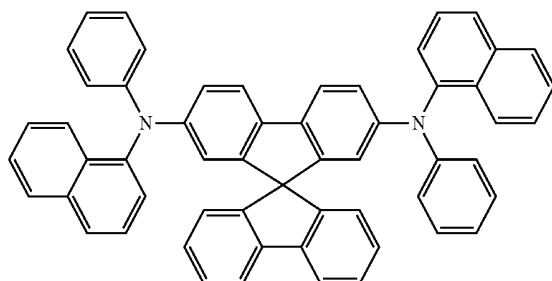


HMTDP

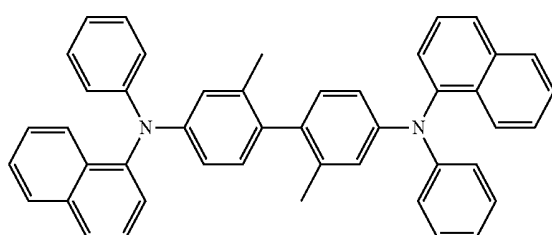
Formula 201



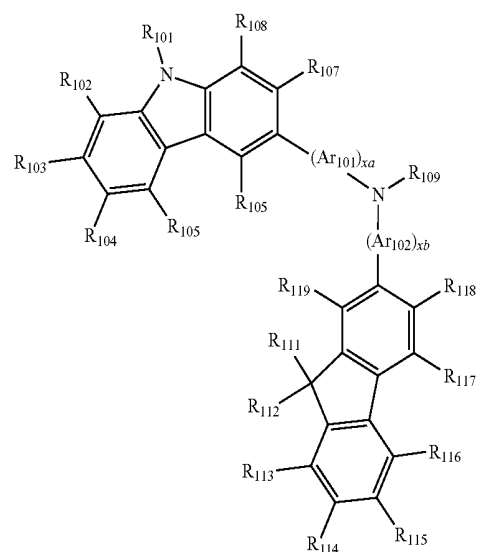
Spiro-TPD



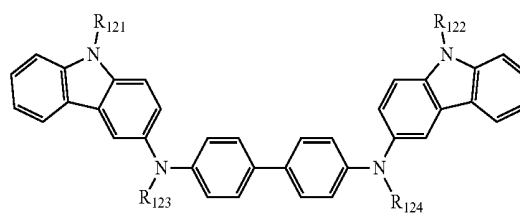
Spiro-NPB



methylated NPB



Formula 202



[0292] In Formula 201, Ar₁₀₁ and Ar₁₀₂ may each independently be:

[0293] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene

group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, or a pentacenylene group; or

[0294] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an acenaphthylenylene group, a fluorenylenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, or a monovalent non-aromatic condensed heteropolycyclic group.

[0295] In Formula 201, xa and xb may each independently be an integer from 0 to 5, or may be 0, 1, or 2. For example, xa may be 1, and xb may be 0, but embodiments of the present disclosure are not limited thereto.

[0296] In Formulae 201 and 202, R_{101} to R_{108} , R_{111} to R_{119} , and R_{121} to R_{124} may each independently be:

[0297] hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{10} alkyl group (for example, a methyl group, an ethyl group, a propyl group, a butyl group, pentyl group, a hexyl group, or the like), or a C_1 - C_{10} alkoxy group (for example, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, or the like);

[0298] a C_1 - C_{10} alkyl group, or a C_1 - C_{10} alkoxy group, each substituted with at least one 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, or any combination thereof;

[0299] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, or a pyrenyl group; or

[0300] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one 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, or a C_1 - C_{10} alkoxy group, but embodiments of the present disclosure are not limited thereto.

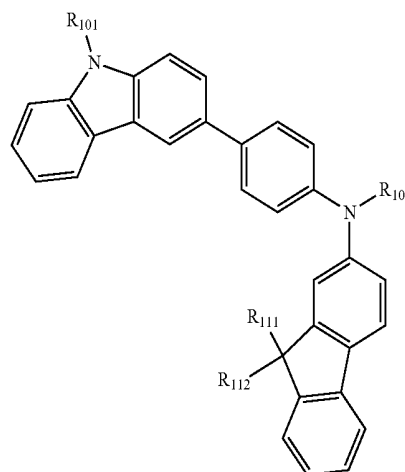
[0301] In Formula 201, R_{109} may be:

[0302] a phenyl group, a naphthyl group, an anthracenyl group, or a pyridinyl group; and

[0303] a phenyl group, a naphthyl group, an anthracenyl group, or a pyridinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyridinyl group, or any combination thereof.

[0304] In one or more embodiments, the compound represented by Formula 201 may be represented by Formula 201A, but embodiments of the present disclosure are not limited thereto:

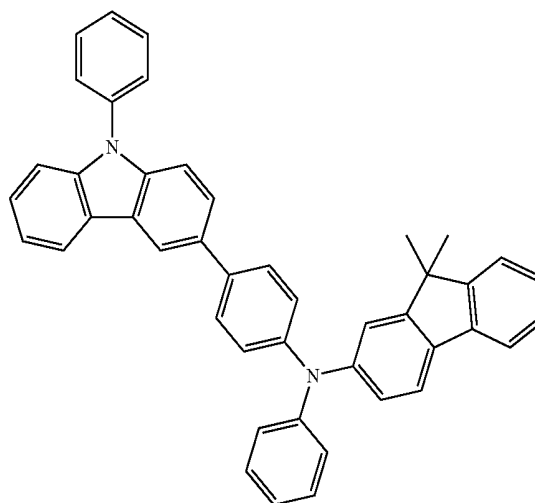
Formula 201A



[0305] Detailed descriptions about R_{101} , R_{111} , R_{112} , and R_{109} in Formula 201A are already described above.

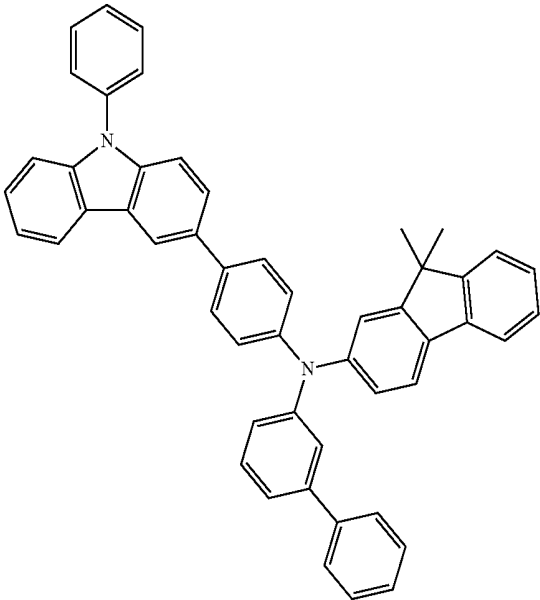
[0306] For example, the compound represented by Formula 201, and the compound represented by Formula 202 may include compounds HT1 to HT20 illustrated below, but are not limited thereto:

HT1



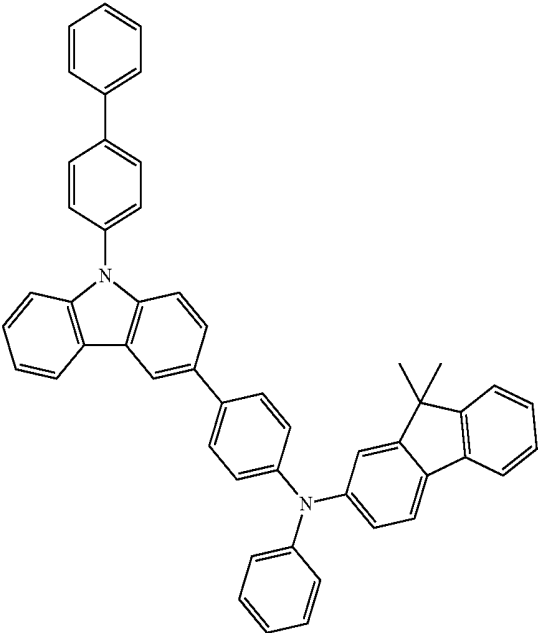
-continued

HT2

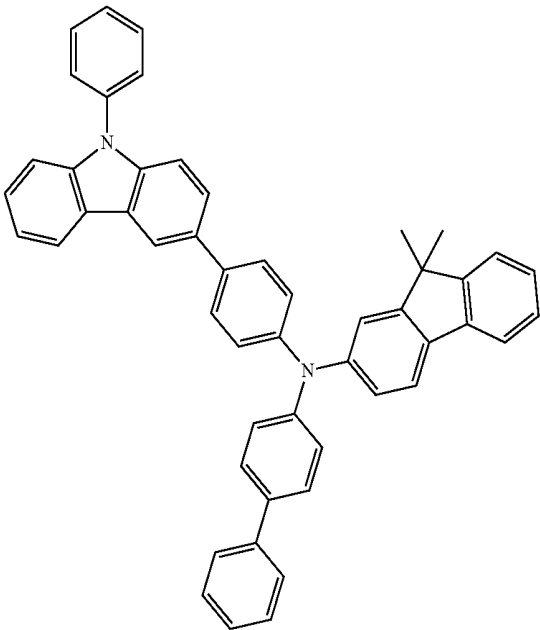


-continued

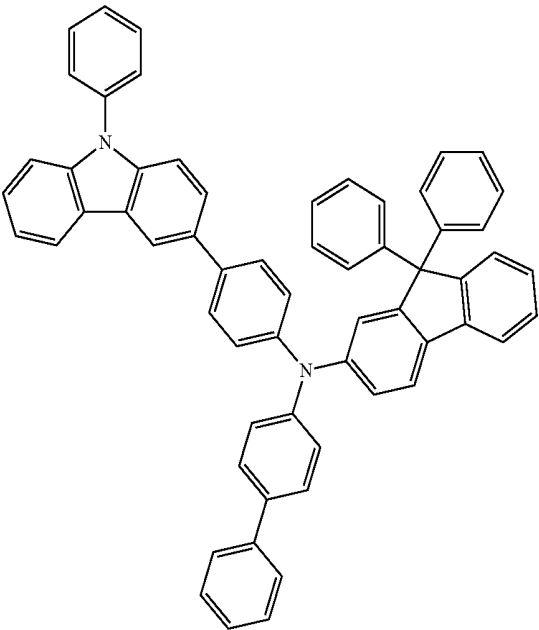
HT4



HT3

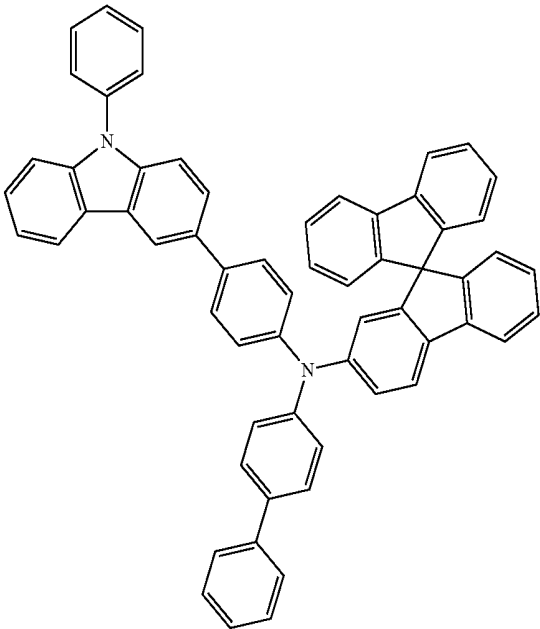


HT5



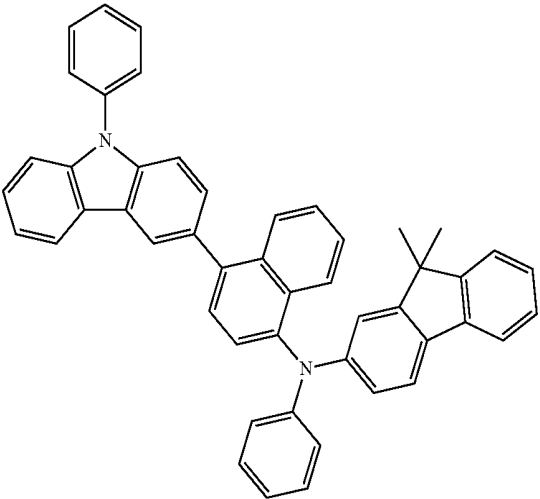
-continued

HT6

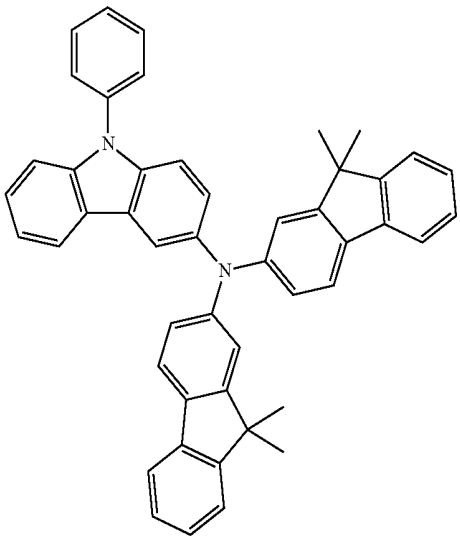


-continued

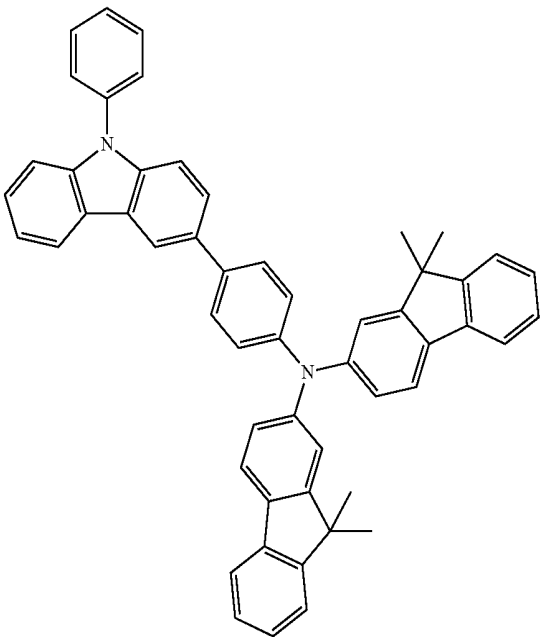
HT8



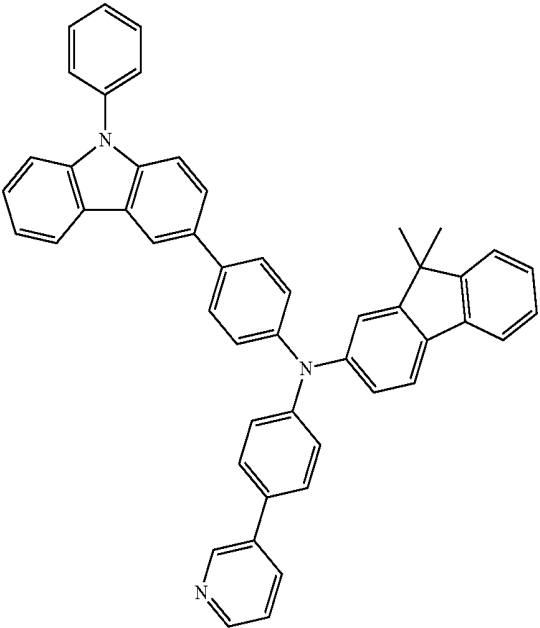
HT9



HT7

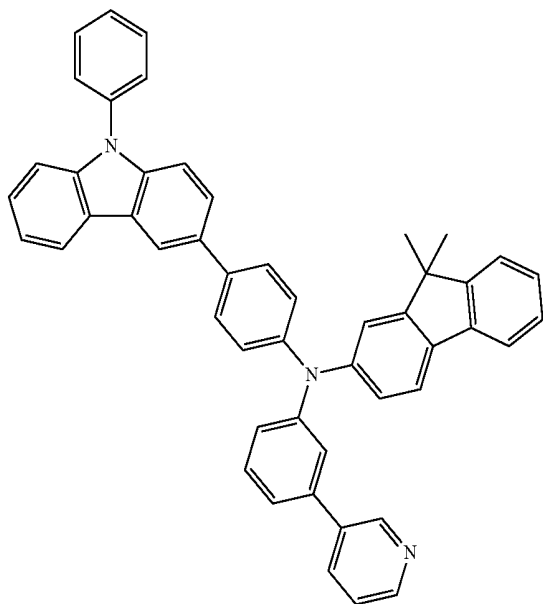


HT10

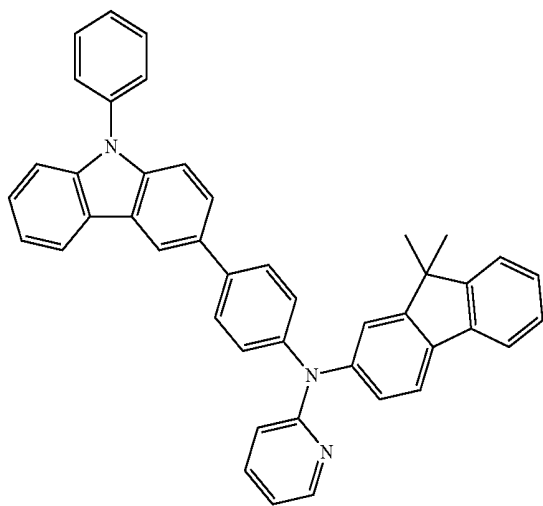


-continued

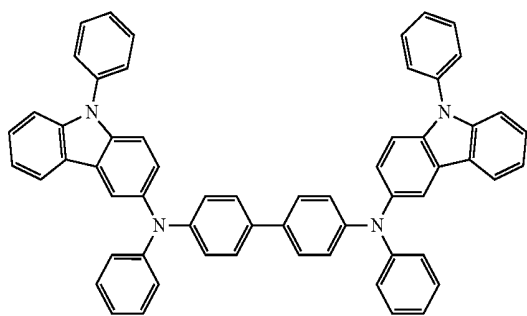
HT11



HT12

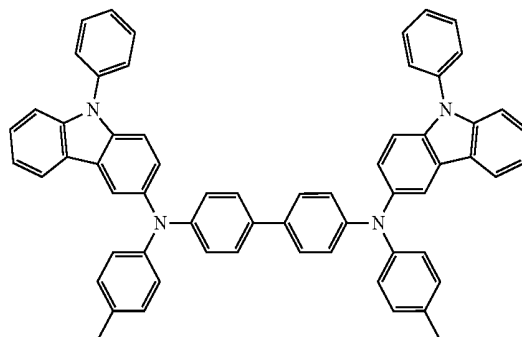


HT13

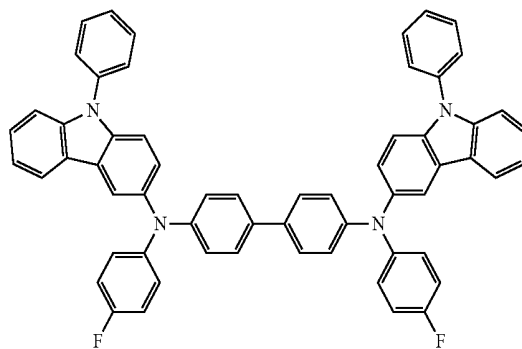


-continued

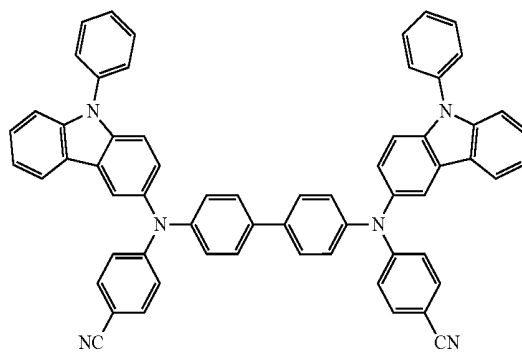
HT14



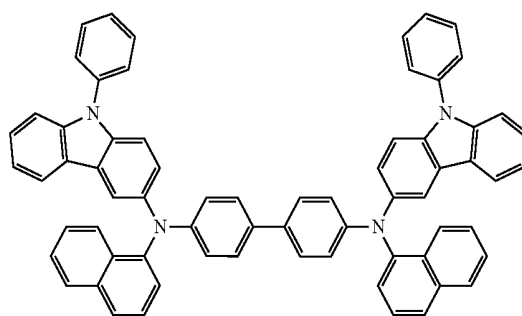
HT15



HT16

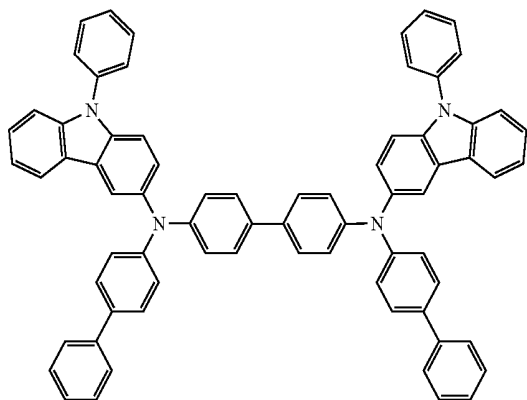


HT17

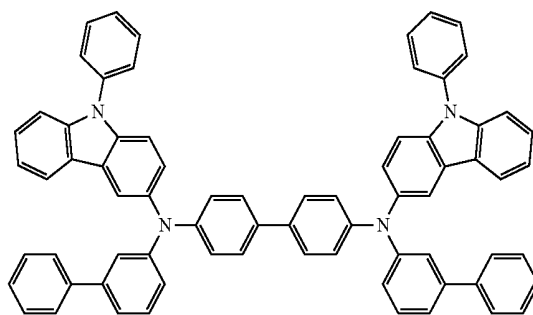


-continued

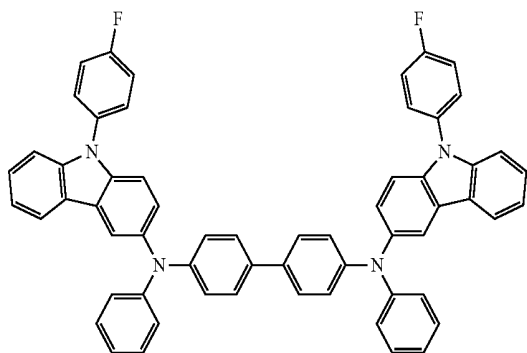
HT18



HT19



HT20

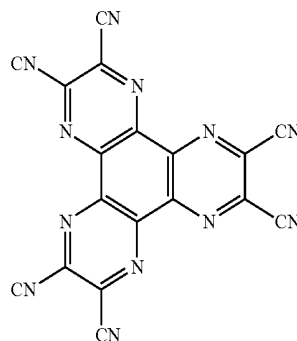


[0307] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region includes both a hole injection layer and a hole transport layer, a thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å, and a thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, for example about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

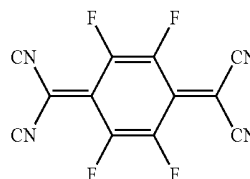
[0308] The hole transport region may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0309] The charge-generation material may be, for example, a p-dopant. The p-dopant may be one a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto. Non-limiting examples of the p-dopant are a quinone derivative, such as 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 or Compound HT-D2 below, but are not limited thereto:

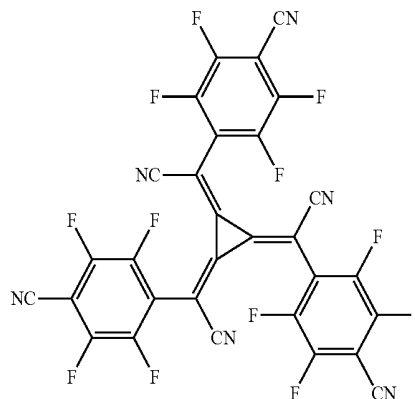
HT-D1



F4-TCNQ



HT-D2



[0310] The hole transport region may include a buffer layer.

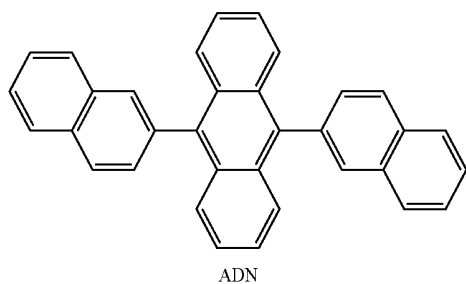
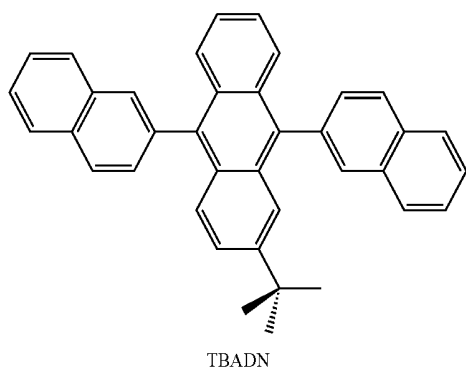
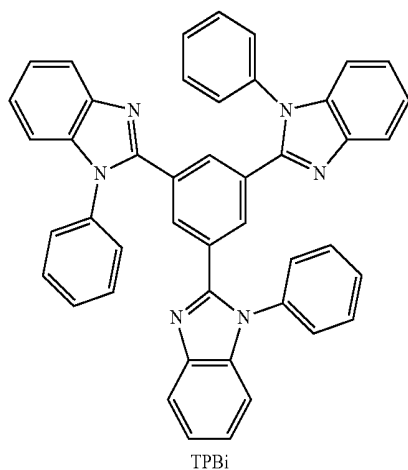
[0311] Also, the buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, and thus, efficiency of a formed organic light-emitting device may be improved.

[0312] Then, an emission layer may be formed on the hole transport region by vacuum deposition, spin coating, casting, LB deposition, or the like. When the emission layer is formed by vacuum deposition or spin coating, the deposition or coating conditions may be similar to those applied in forming the hole injection layer although the deposition or coating conditions may vary according to a compound that is used to form the emission layer.

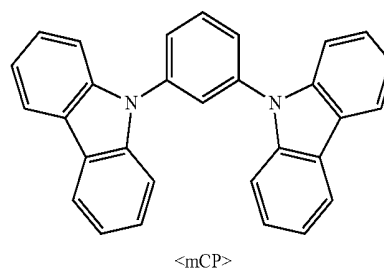
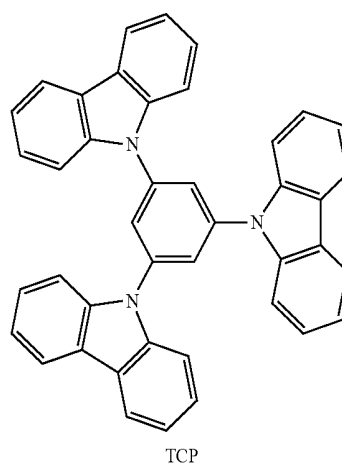
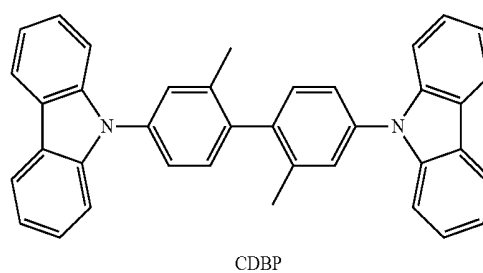
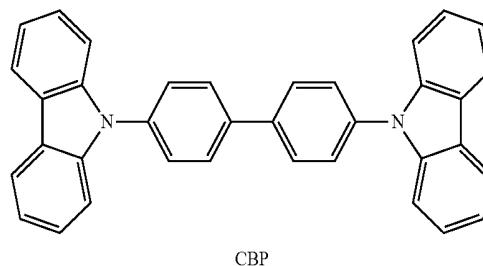
[0313] Meanwhile, when the hole transport region includes an electron blocking layer, a material for the electron blocking layer may be a material for the hole transport region described above or a material for a host to be explained later. However, the material for the electron blocking layer is not limited thereto. For example, when the hole transport region includes an electron blocking layer, a material for the electron blocking layer may be mCP, which will be explained later.

[0314] The emission layer may include a host and a dopant, and the dopant may include the organometallic compound represented by Formula 1.

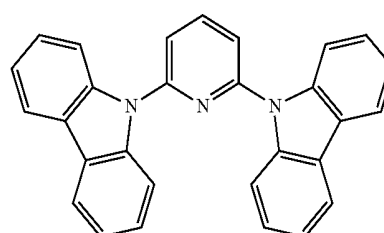
[0315] The host may include at least one of TPBi, TBADN, ADN (also referred to as "DNA"), CBP, CDBP, TCP, mCP, Compound H50, Compound H52, or any combination thereof:



-continued

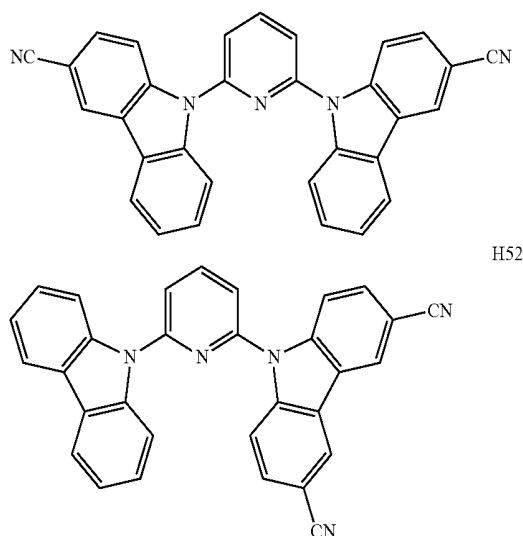


<Compound H50>



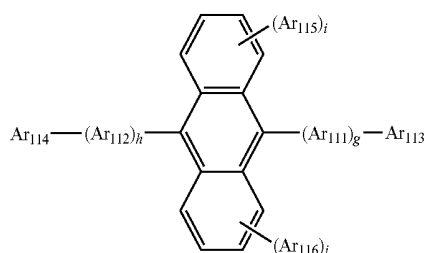
-continued

<Compound H51>



[0316] In one or more embodiments, the host may further include a compound represented by Formula 301:

Formula 301



[0317] Ar_{111} and Ar_{112} in Formula 301 may each independently be:

[0318] a phenylene group, a naphthylene group, a phenanthrenylene group, or a pyrenylene group; or

[0319] a phenylene group, a naphthylene group, a phenanthrenylene group, or a pyrenylene group, each substituted with at least one a phenyl group, a naphthyl group, an anthracenyl group, or any combination thereof.

[0320] In Formula 301, Ar_{113} to Ar_{116} may each independently be:

[0321] a C_1 - C_{10} alkyl group, a phenyl group, a naphthyl group, a phenanthrenyl group, or a pyrenyl group; or

[0322] a phenyl group, a naphthyl group, a phenanthrenyl group, or a pyrenyl group, each substituted with at least one a phenyl group, a naphthyl group, an anthracenyl group, or any combination thereof.

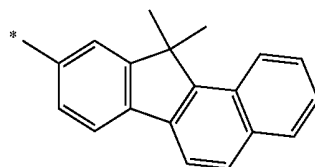
[0323] The designations g, h, i, and j in Formula 301 may each independently be an integer from 0 to 4, and for example, may be 0, 1, or 2.

[0324] Ar_{113} to Ar_{116} in Formula 301 may each independently be:

[0325] a C_1 - C_{10} alkyl group substituted with at least one of a phenyl group, a naphthyl group, or an anthracenyl group;

[0326] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, or a fluorenyl group;

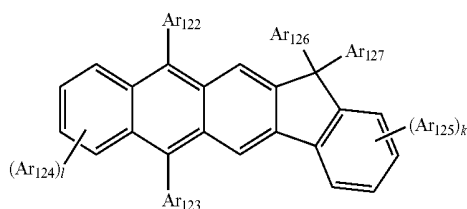
[0327] a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, or a fluorenyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone 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, a fluorenyl group, or any combination thereof; or



but embodiments of the present disclosure are not limited thereto.

[0328] In one or more embodiments, the host may include a compound represented by Formula 302 below:

Formula 302



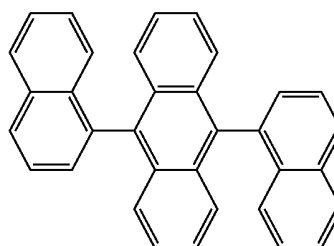
[0329] Ar_{122} to Ar_{125} in Formula 302 are the same as described in detail in connection with Ar_{113} in Formula 301.

[0330] Ar_{126} and Ar_{127} in Formula 302 may each independently be a C_1 - C_{10} alkyl group (for example, a methyl group, an ethyl group, or a propyl group).

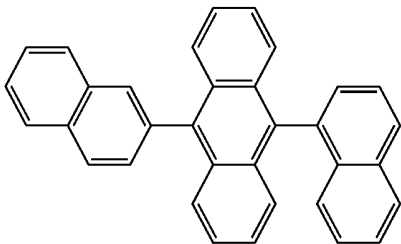
[0331] k and l in Formula 302 may each independently be an integer from 0 to 4. For example, k and l may be 0, 1, or 2.

[0332] 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:

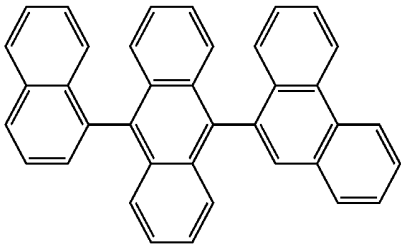
H1



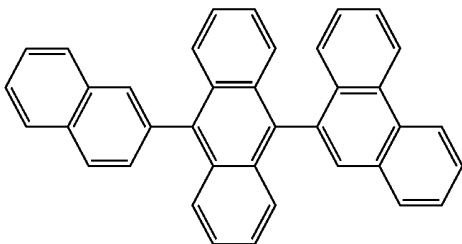
-continued



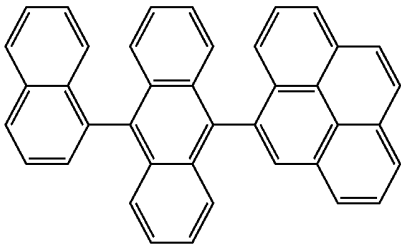
H2



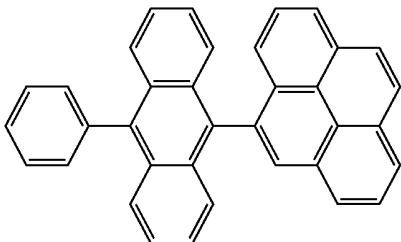
H3



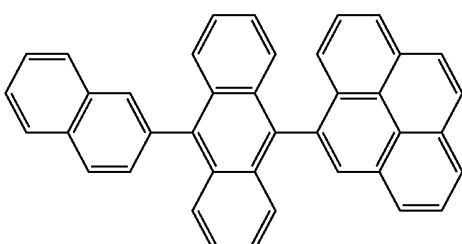
H4



H5

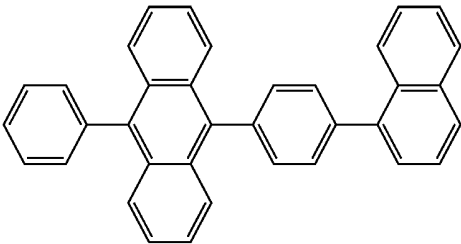


H6

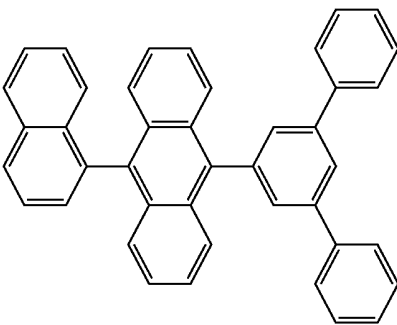


H7

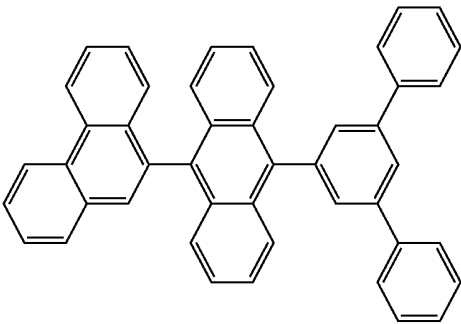
-continued



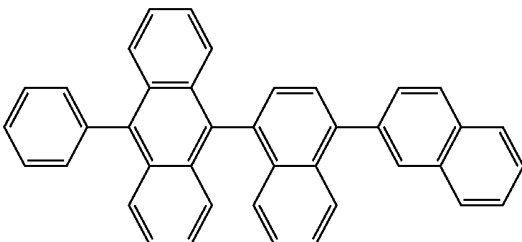
H8



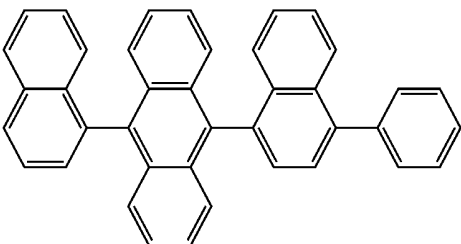
H9



H10

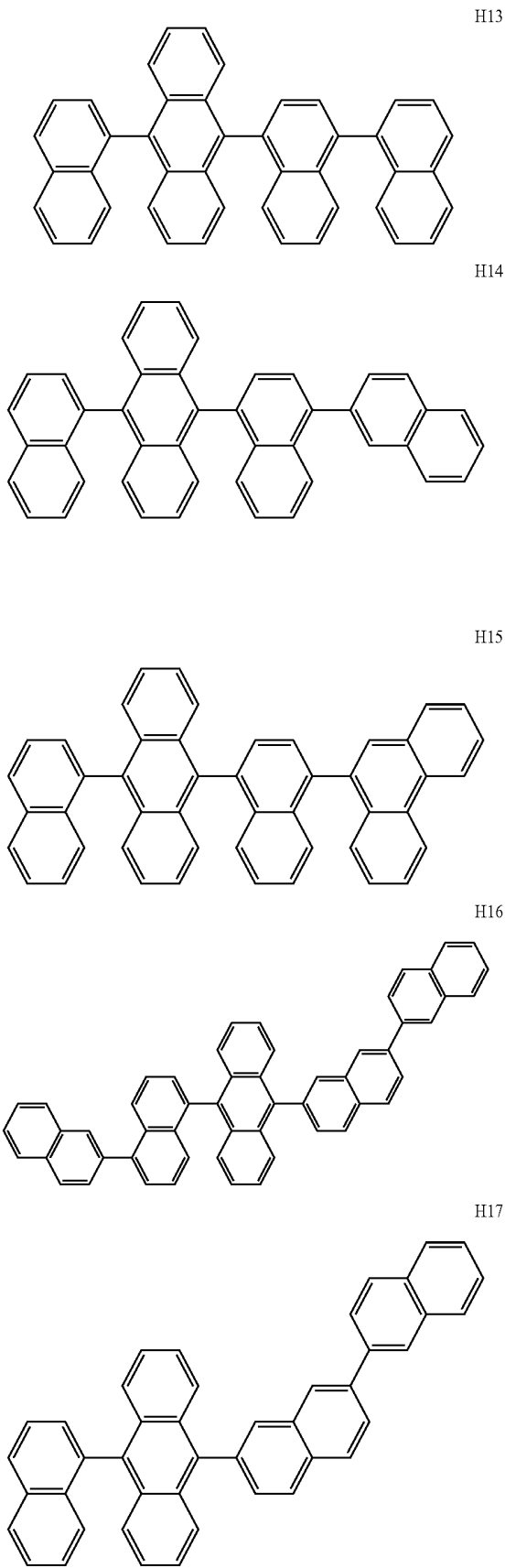


H11

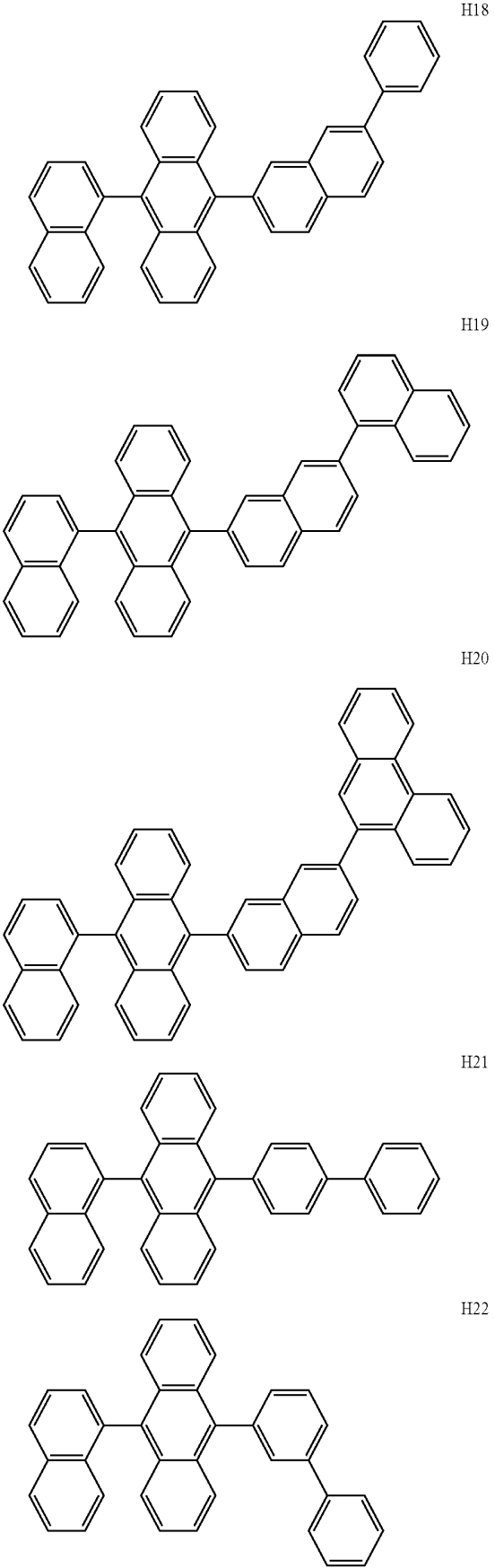


H12

-continued

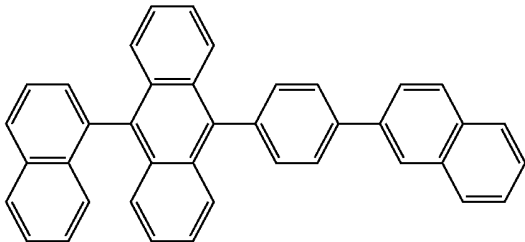


-continued

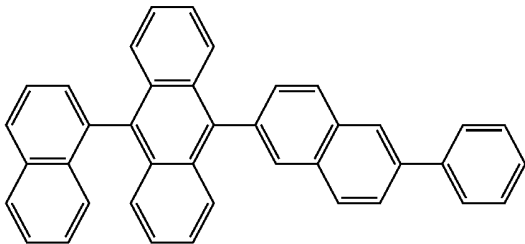


-continued

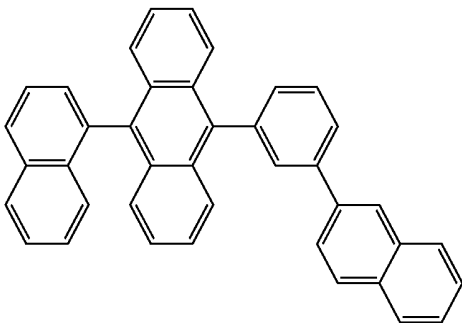
H23



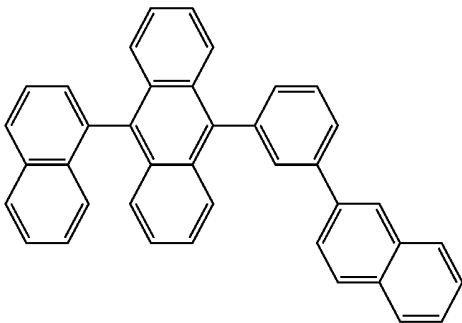
H24



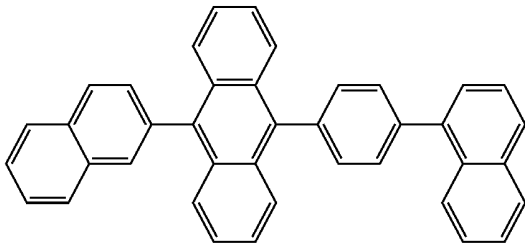
H25



H26

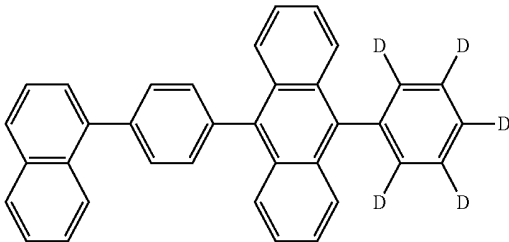


H27

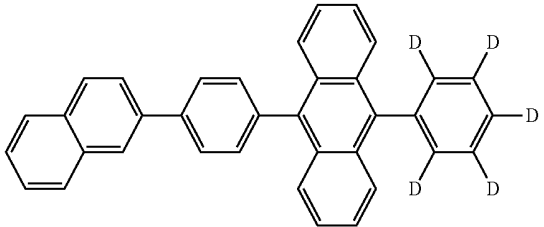


-continued

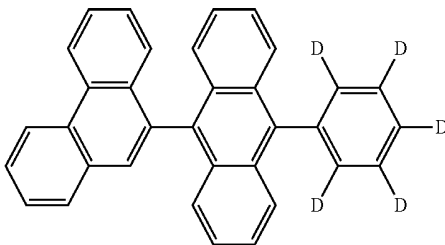
H28



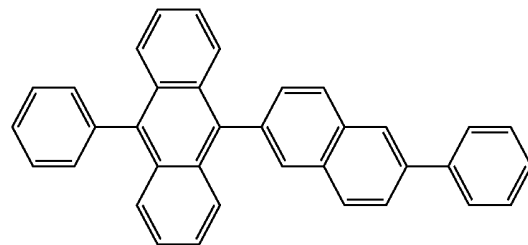
H29



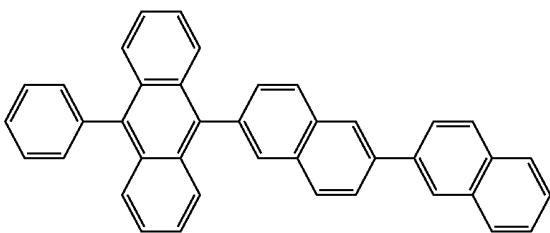
H30



H31

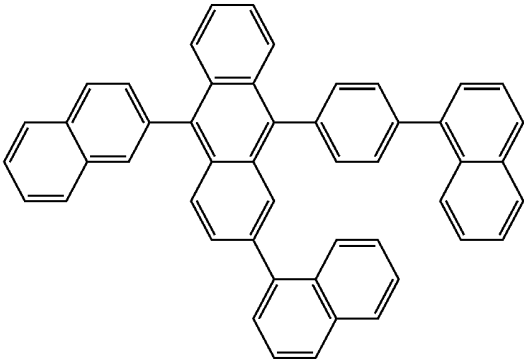


H32



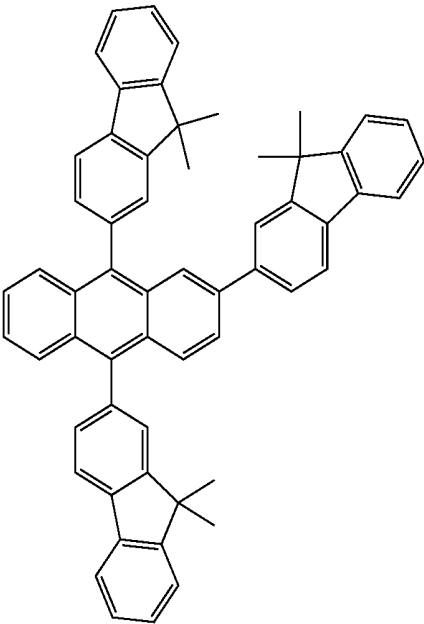
-continued

H33

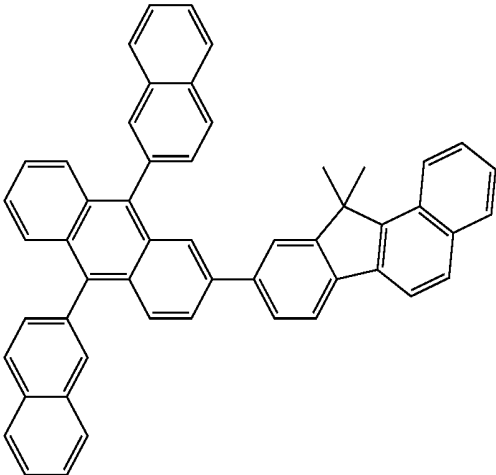


-continued

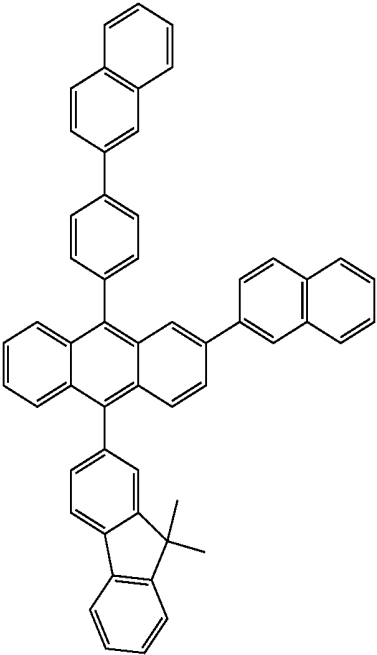
H36



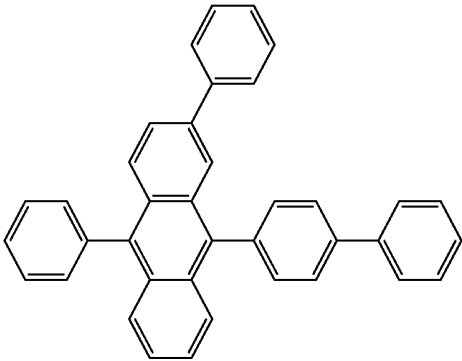
H34



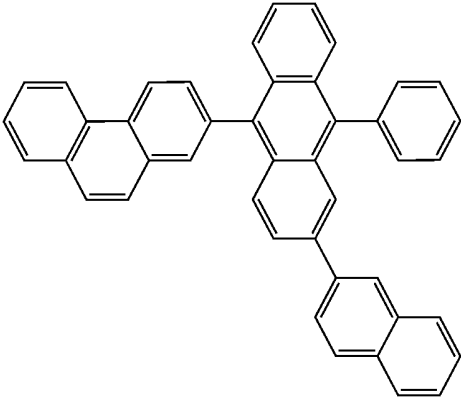
H37



H35

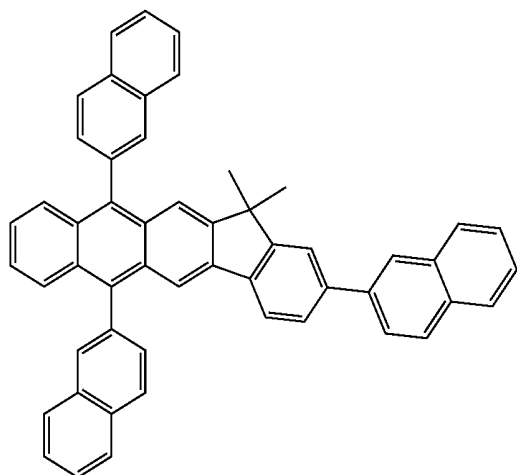


H38



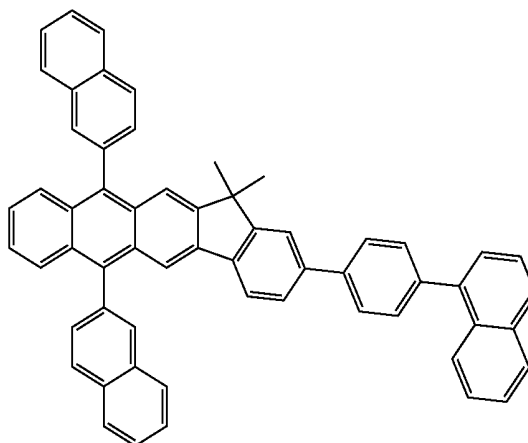
-continued

H39

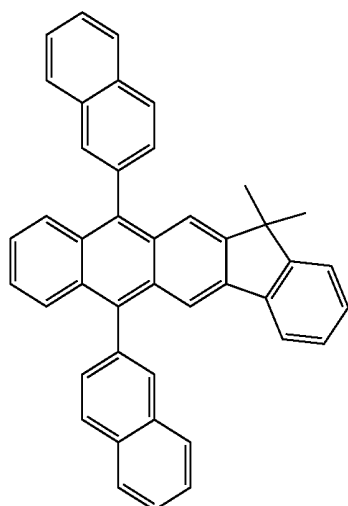


-continued

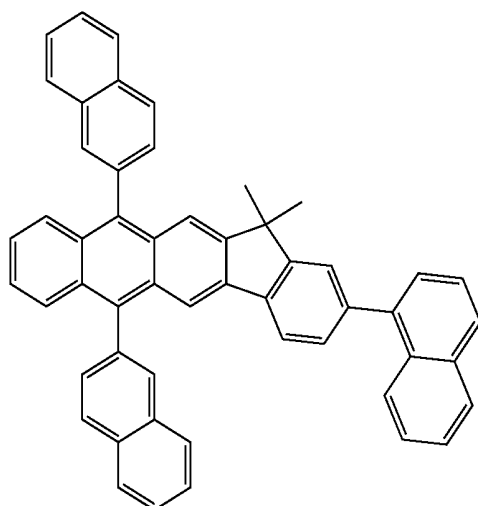
H42



H40



H41



[0333] When the organic light-emitting device is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and a blue emission layer. In one or more embodiments, due to a stacked structure including a red emission layer, a green emission layer, and/or a blue emission layer, the emission layer may emit white light.

[0334] When the emission layer includes a host and a dopant, an amount of the dopant may be in a range of about 0.01 parts by weight to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

[0335] The dopant may include at least one of organometallic compounds represented by Formula 1.

[0336] 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.

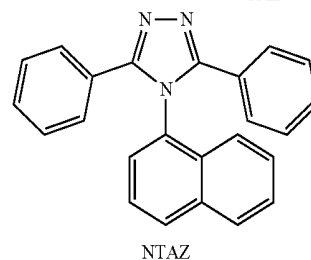
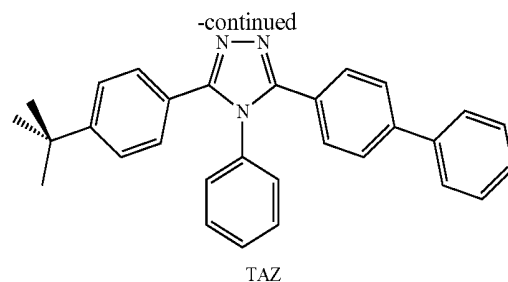
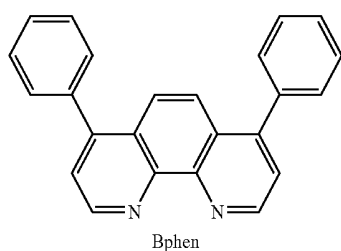
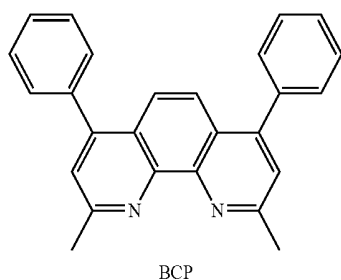
[0337] Then, an electron transport region may be located on the emission layer.

[0338] The electron transport region may include at least one a hole blocking layer, an electron transport layer, and an electron injection layer.

[0339] For example, the electron transport region may have a hole blocking layer/electron transport layer/electron injection layer structure or an electron transport layer/electron injection layer structure, but the structure of the electron transport region is not limited thereto. The electron transport layer may have a single-layered structure or a multi-layered structure including two or more different materials.

[0340] 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.

[0341] When the electron transport region includes a hole blocking layer, the hole blocking layer may include, for example, at least one of BCP, Bphen, BAiq, or any combination thereof, but embodiments of the present disclosure are not limited thereto:

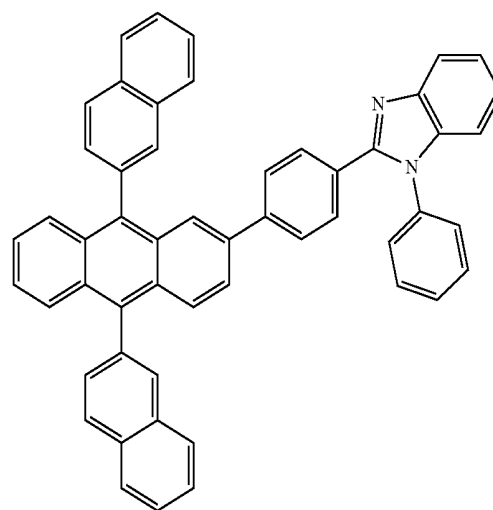


[0344] In one or more embodiments, the electron transport layer may include at least one of ET1 and ET25, but are not limited thereto:

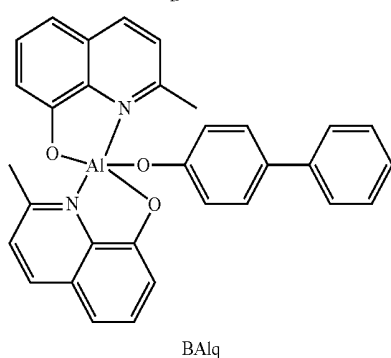
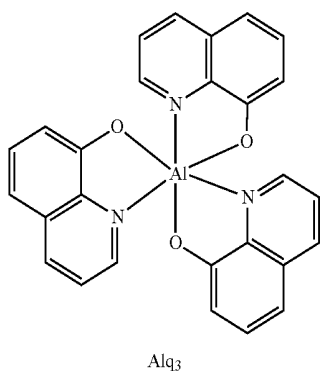
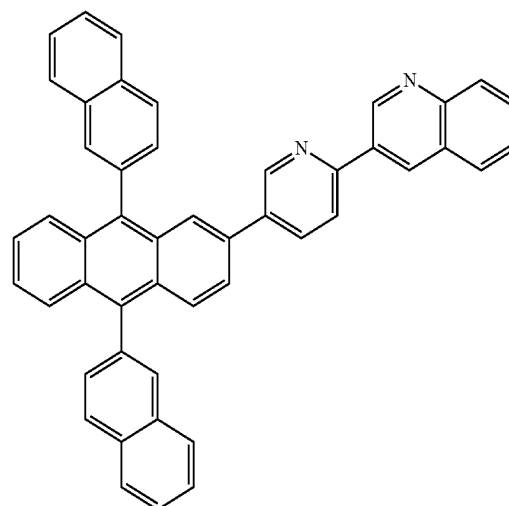
ET1

[0342] 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.

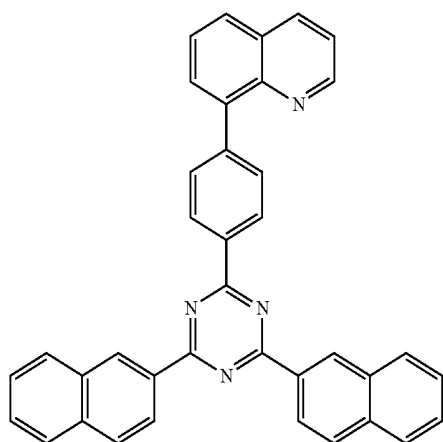
[0343] The electron transport layer may further include at least one BCP, Bphen, Alq₃, BAlq, TAZ, NTAZ, or any combination thereof:



ET2

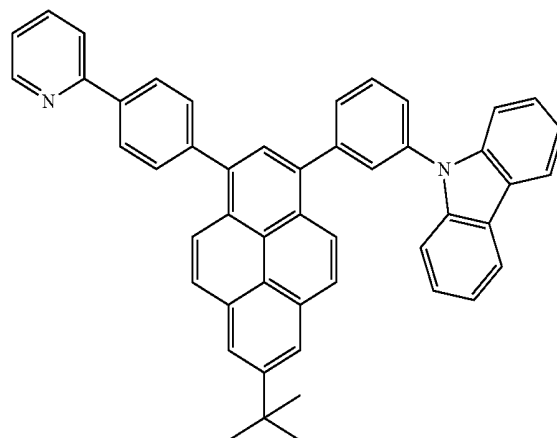


-continued

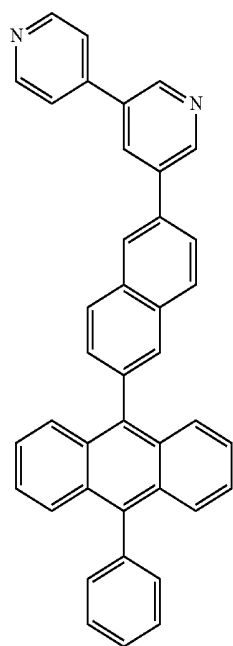


ET3

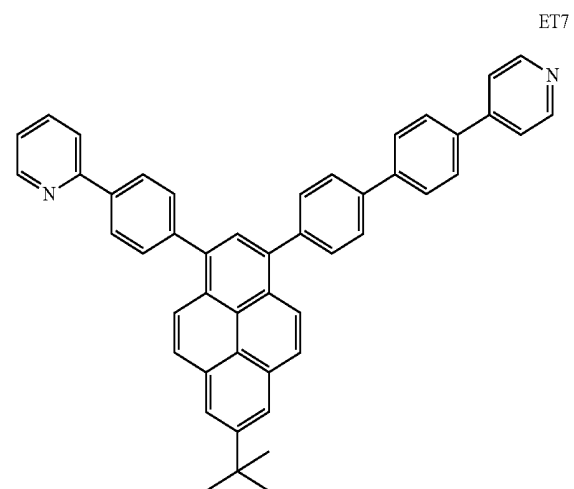
-continued



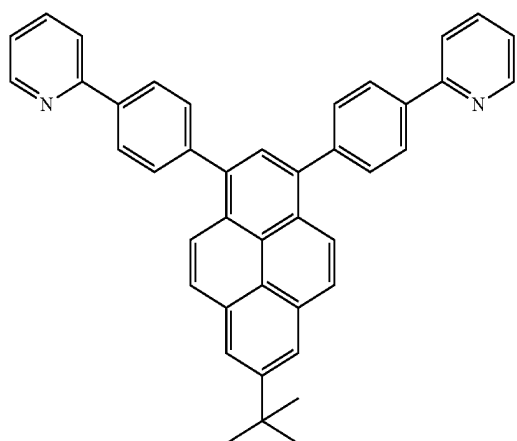
ET6



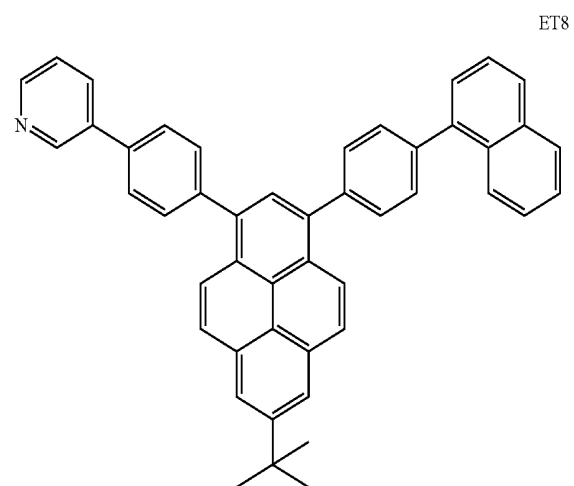
ET4



ET7



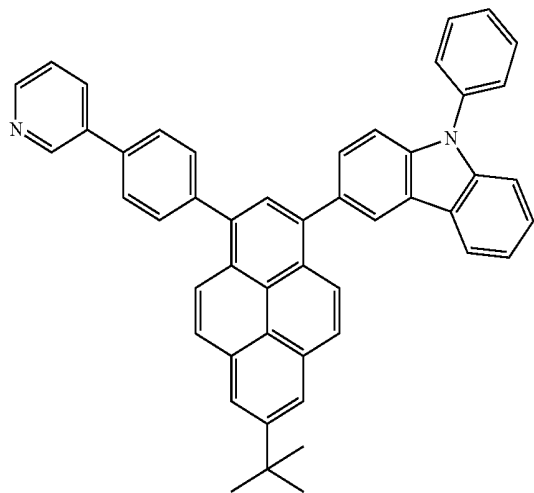
ET5



ET8

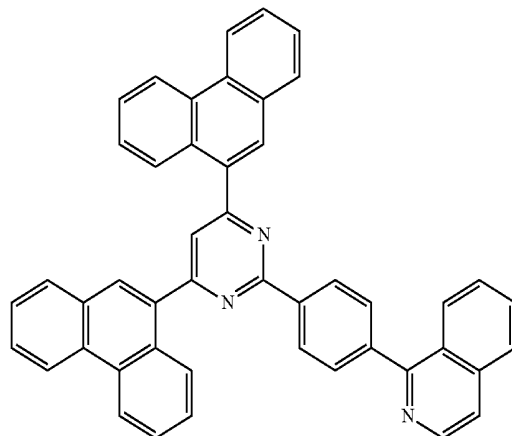
-continued

ET9

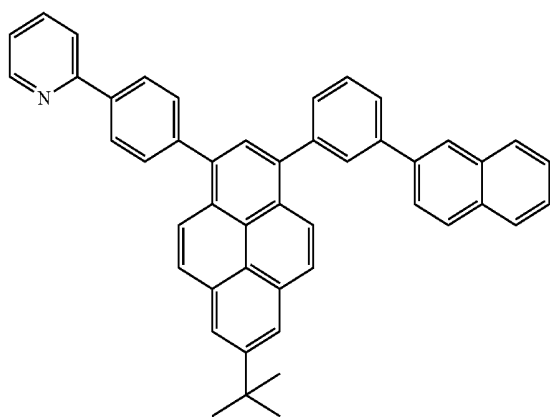


-continued

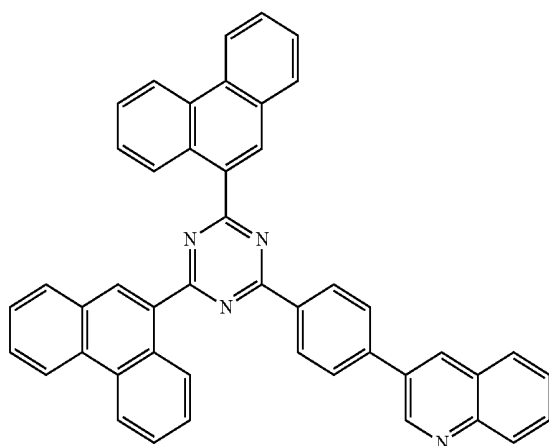
ET13



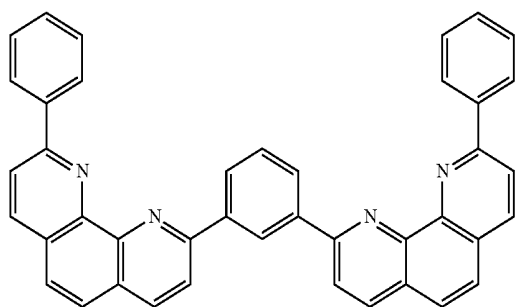
ET10



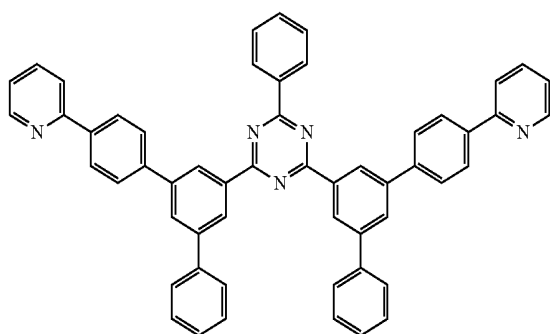
ET14



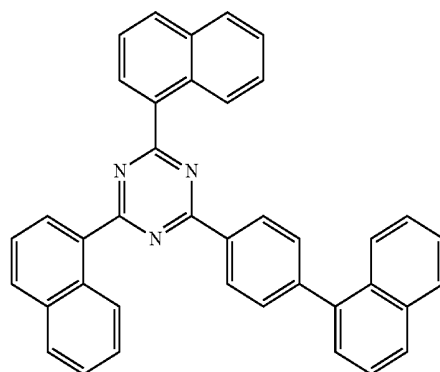
ET11



ET12

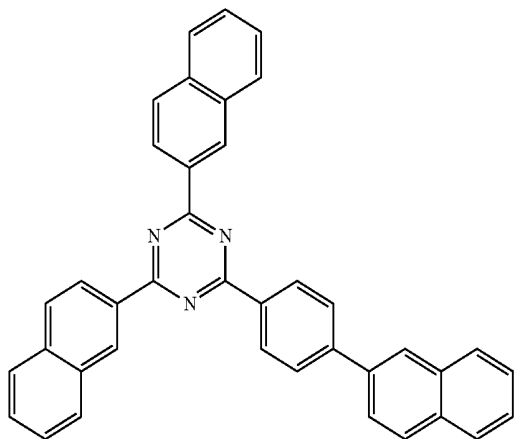


ET15



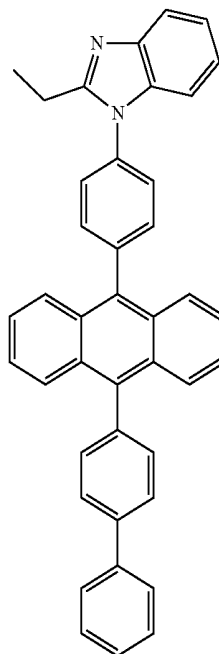
-continued

ET16

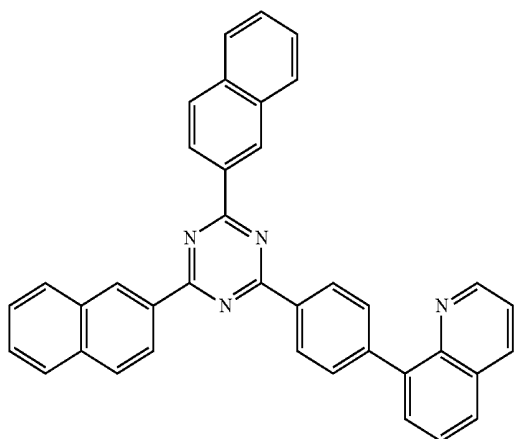


-continued

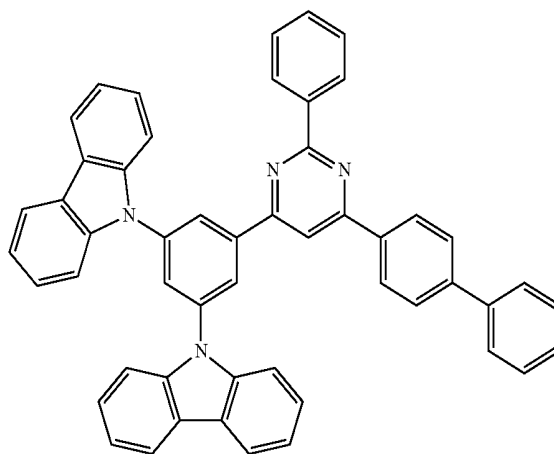
ET19



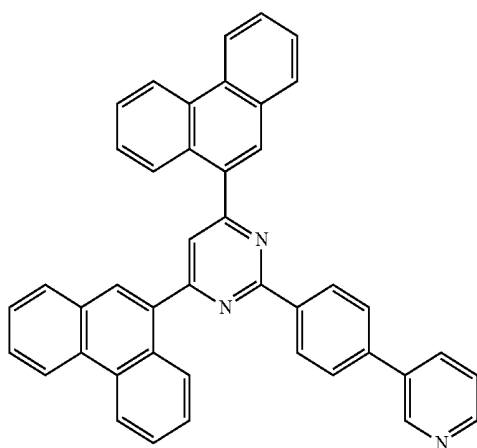
ET17



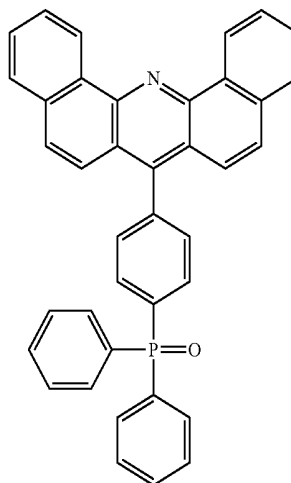
ET20



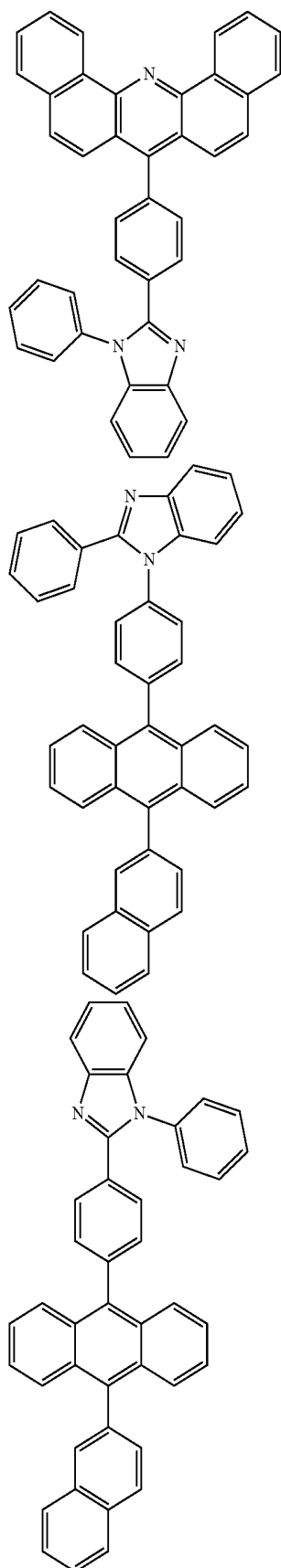
ET18



ET21



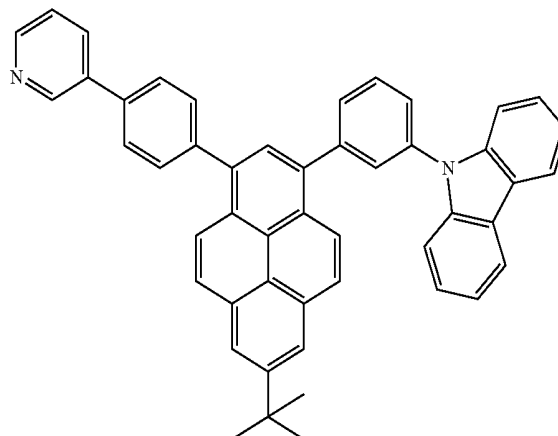
-continued



-continued

ET25

ET22



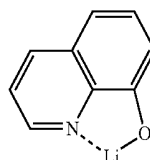
ET23

[0345] A thickness of the electron transport layer may be in an 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.

[0346] Also, the electron transport layer may further include, in addition to the materials described above, a metal-containing material.

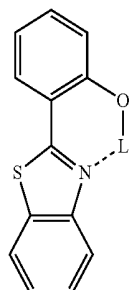
[0347] The metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2:

ET-D1



ET24

ET-D2



[0348] The electron transport region may include an electron injection layer that promotes flow of electrons from the second electrode **19** thereinto.

[0349] The electron injection layer may include at least one LiF, NaCl, CsF, Li₂O, BaO, or any combination thereof.

[0350] 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.

[0351] The second electrode **19** is disposed on the organic layer **15**. The second electrode **19** may be a cathode. A material for forming the second electrode **19** may be metal, an alloy, an electrically conductive compound, or a combination thereof, which have a relatively low work function. For example, lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag) may be formed as the material for forming the second electrode **19**. To manufacture a top-emission type light-emitting device, a transmissive electrode formed using ITO or IZO may be used as the second electrode **19**.

[0352] Hereinbefore, the organic light-emitting device has been described with reference to the FIGURE, but embodiments of the present disclosure are not limited thereto.

[0353] Another aspect of the present disclosure provides a diagnostic composition including at least one organometallic compound represented by Formula 1.

[0354] The organometallic compound represented by Formula 1 provides high luminescence efficiency. Accordingly, a diagnostic composition including the organometallic compound may have high diagnostic efficiency.

[0355] The diagnostic composition may be used in various applications including a diagnosis kit, a diagnosis reagent, a biosensor, and a biomarker.

[0356] The term “t-Bu” or “tBu” as used herein indicates a tert-butyl group.

[0357] The term “first-row transition metal of the Periodic Table of Elements” as used herein refers to a fourth-row element of the Periodic Table of Elements that is included in d-block. Specific examples include scandium (Sc), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), and zinc (Zn).

[0358] The term “second-row transition metal of the Periodic Table of Elements” as used herein refers to a fifth-row element of the Periodic Table of Elements that is included in d-block. Specific examples include yttrium (Y), zirconium (Zr), niobium (Nb), molybdenum (Mo), technetium (Tc), ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), and cadmium (Cd).

[0359] The term “third-row transition metal of the Periodic Table of Elements” as used herein refers to a sixth-row element of the Periodic Table of Elements that is included in d-block and f-block. Specific examples include lanthanum (La), samarium (Sm), europium (Eu), terbium (Tb), thulium (Tm), ytterbium (Yb), lutetium (Lu), hafnium (Hf), tantalum (Ta), tungsten (W), rhenium (Re), osmium (Os), iridium (Ir), platinum (Pr), gold (Au), and mercury (Hg).

[0360] The term “C₁-C₆₀ alkyl group” as used herein refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms, and examples thereof include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an isoamyl group, and a hexyl group. The term “C₁-C₆₀ alkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₆₀ alkyl group.

[0361] The term “C₁-C₆₀ alkoxy group” as used herein refers to a monovalent group represented by —OA₁₀₁ (wherein

A₁₀₁ is the C₁-C₆₀ alkyl group), and examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group.

[0362] The term “C₂-C₆₀ alkenyl group” as used herein refers to a hydrocarbon group formed by substituting at least one carbon-carbon double bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term “C₂-C₆₀ alkenylene group” as used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

[0363] The term “C₂-C₆₀ alkynyl group” as used herein refers to a hydrocarbon group having at least one carbon-carbon triple bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and examples thereof include an ethynyl group, and a propynyl group. The term “C₂-C₆₀ alkynylene group” as used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkynyl group.

[0364] The term “C₃-C₁₀ cycloalkyl group” as used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and non-limiting examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term “C₃-C₁₀ cycloalkylene group” as used herein refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkyl group.

[0365] The term “C₁-C₁₀ heterocycloalkyl group” as used herein refers to a monovalent saturated monocyclic group having at least one N, O, P, Se, B, Ge, Si, S, or any combination thereof, as a ring-forming atom and 1 to 10 carbon atoms, and non-limiting examples thereof include a tetrahydrofuranyl group, and a tetrahydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkyl group.

[0366] The term “C₃-C₁₀ cycloalkenyl group” as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity, and non-limiting examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term “C₃-C₁₀ cycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkenyl group.

[0367] The term “C₁-C₁₀ heterocycloalkenyl group” as used herein refers to a monovalent monocyclic group that has at least one N, O, P, Si, Se, B, Ge, S, or any combination thereof as a ring-forming atom, 1 to 10 carbon atoms, and at least one carbon-carbon double bond in its ring. Examples of the C₁-C₁₀ heterocycloalkenyl group are a 2,3-dihydrofuranyl group, and a 2,3-dihydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkenyl group.

[0368] The term “C₆-C₆₀ aryl group” as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and the term “C₆-C₆₀ arylene group” as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Non-limiting examples of the C₆-C₆₀ aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl

group. When the C₆-C₆₀ aryl group and the C₆-C₆₀ arylene group each include two or more rings, the rings may be fused to each other.

[0369] The term “C₁-C₆₀ heteroaryl group” as used herein refers to a monovalent group having a heterocyclic aromatic system that has at least one N, O, P, Si, Se, B, Ge, S, or any combination thereof as a ring-forming atom, and 1 to 60 carbon atoms. The term “C₁-C₆₀ heteroarylene group” as used herein refers to a divalent group having a heterocyclic aromatic system that has at least one heteroatom N, O, P, Si, Se, B, Ge, S, or any combination thereof as a ring-forming atom, and 1 to 60 carbon atoms. Non-limiting examples of the C₁-C₆₀ heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C₁-C₆₀ heteroaryl group and the C₁-C₆₀ heteroarylene group each include two or more rings, the rings may be fused to each other.

[0370] The term “C₆-C₆₀ aryloxy group” as used herein indicates —OA₁₀₂ (wherein A₁₀₂ is the C₆-C₆₀ aryl group), and a C₆-C₆₀ arylthio group used herein indicates —SA₁₀₃ (wherein A₁₀₃ is the C₆-C₆₀ aryl group).

[0371] The term “C₇-C₆₀ alkylaryl group” as used herein indicates —A₁₀₄A₁₀₅ (wherein A₁₀₄ is the C₆-C₅₉ arylene group, and A₁₀₅ is the C₁-C₅₄ alkyl group), and a C₂-C₆₀ alkylheteroaryl group used herein indicates —A₁₀₆A₁₀₇ (wherein A₁₀₆ is the C₁-C₅₉ heteroarylene group, and A₁₀₇ is the C₁-C₅₉ alkyl group).

[0372] The term “C₇-C₆₀ arylalkyl group” as used herein indicates —A₁₀₈A₁₀₉ (wherein A₁₀₈ is the C₁-C₅₄ alkylene group, and A₁₀₉ is the C₆-C₅₉ aryl group), and a C₂-C₆₀ heteroarylalkyl group used herein indicates —A₁₁₀A₁₁₁ (wherein A₁₁₀ is the C₁-C₅₉ alkylene group, and A₁₁₁ is the C₁-C₅₉ heteroaryl group).

[0373] The term “monovalent non-aromatic condensed polycyclic group” as used herein refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed to each other, only carbon atoms as ring-forming atoms, and no aromaticity in its entire molecular structure. Examples of the monovalent non-aromatic condensed polycyclic group include a fluorenyl group. The term “divalent non-aromatic condensed polycyclic group” as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0374] The term “monovalent non-aromatic condensed heteropolycyclic group” as used herein refers to a monovalent group (for example, having 2 to 60 carbon atoms) having two or more rings condensed to each other, a heteroatom N, O, P, Si, Se, B, Ge, S, or any combination thereof, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure. Non-limiting examples of the monovalent non-aromatic condensed heteropolycyclic group include a carbazolyl group. The term “divalent non-aromatic condensed heteropolycyclic group” as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0375] The term “C₅-C₃₀ carbocyclic group” as used herein refers to a saturated or unsaturated cyclic group having, as a ring-forming atom, 5 to 30 carbon atoms only.

The term “C₅-C₃₀ carbocyclic group” as used herein refers to a monocyclic group or a polycyclic group, and, according to its chemical structure, a monovalent, divalent, trivalent, tetravalent, pentavalent, or hexavalent group.

[0376] The term “C₁-C₃₀ heterocyclic group” as used herein refers to a saturated or unsaturated cyclic group having, as a ring-forming atom, at least one heteroatom N, O, Si, P, and S other than 1 to 30 carbon atoms. The term “C₁-C₃₀ heterocyclic group” as used herein refers to a monocyclic group or a polycyclic group, and, according to its chemical structure, a monovalent, divalent, trivalent, tetravalent, pentavalent, or hexavalent group.

[0377] In the present specification, at least one substituent of the substituted C₅-C₃₀ carbocyclic group, the substituted C₁-C₃₀ heterocyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₇-C₆₀ alkylaryl group, the substituted C₇-C₆₀ arylalkyl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted C₂-C₆₀ alkylheteroaryl group, the substituted C₂-C₆₀ heteroarylalkyl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be:

[0378] deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, 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, or any combination thereof;

[0379] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, or any combination thereof, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₇-C₆₀ alkylaryl group, a C₇-C₆₀ arylalkyl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a C₂-C₆₀ alkylheteroaryl group, a C₂-C₆₀ heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), —B(Q₁₆)(Q₁₇), —P(=O)(Q₁₈)(Q₁₉), or any combination thereof;

[0380] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₇-C₆₀ alkylaryl group, a C₇-C₆₀ arylalkyl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a C₂-C₆₀ alkylheteroaryl group, a C₂-C₆₀ heteroarylalkyl group, a C₁-C₆₀ heteroaryloxy group, a C₁-C₆₀ heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), —B(Q₁₆)(Q₁₇), —P(=O)(Q₁₈)(Q₁₉), or any combination thereof.

clic group, a monovalent non-aromatic condensed heteropolycyclic group, or any combination thereof;

[0381] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₇-C₆₀ alkylaryl group, a C₇-C₆₀ arylalkyl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a C₂-C₆₀ alkylheteroaryl group, a C₂-C₆₀ heteroarylalkyl group, a C₁-C₆₀ heteroaryloxy group, a C₁-C₆₀ heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, or any combination thereof, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₇-C₆₀ alkylaryl group, a C₇-C₆₀ arylalkyl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a C₂-C₆₀ alkylheteroaryl group, a C₂-C₆₀ heteroarylalkyl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), —B(Q₂₆)(Q₂₇), —P(=O)(Q₂₈)(Q₂₉), or any combination thereof; or

[0382] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), —B(Q₃₆)(Q₃₇), —P(=O)(Q₃₈)(Q₃₉), or any combination thereof; and

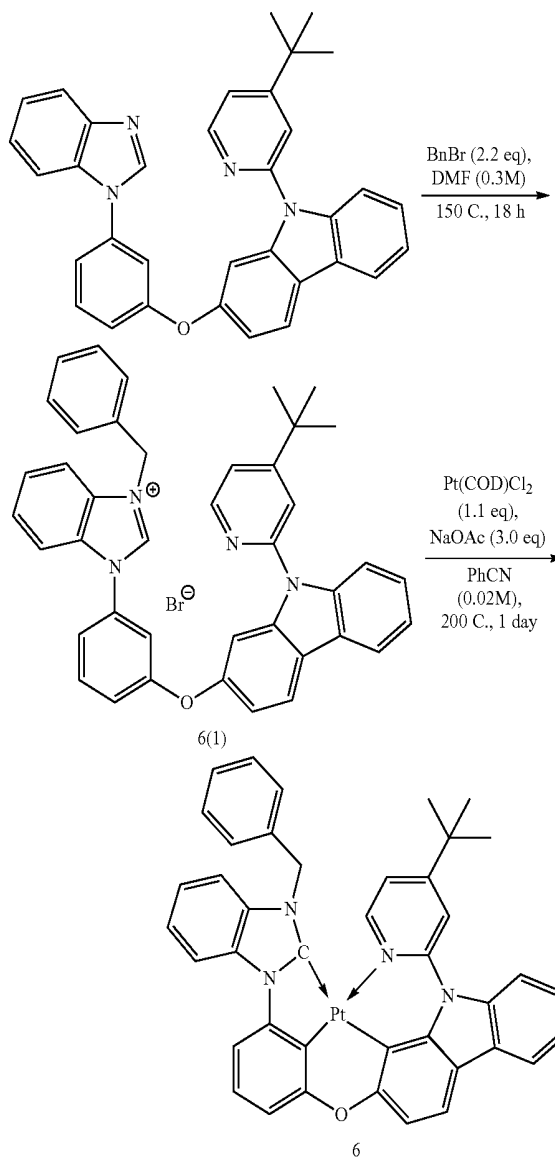
[0383] Q₁ to Q₀, Q₁₁ to Q₁₉, Q₂₁ to Q₂₉, and Q₃₁ to Q₃₉ may each independently be hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryl group substituted with at least one a C₁-C₆₀ alkyl group, and a C₆-C₆₀ aryl group, a C₇-C₆₀ alkylaryl group, a C₇-C₆₀ arylalkyl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a C₂-C₆₀ alkylheteroaryl group, a C₂-C₆₀ heteroarylalkyl group, a C₁-C₆₀ heteroaryloxy group, a C₁-C₆₀ heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, or a monovalent non-aromatic condensed heteropolycyclic group.

[0384] Hereinafter, a compound and an organic light-emitting device according to embodiments are described in detail with reference to Synthesis Example and Examples. However, the organic light-emitting device is not limited thereto. The wording “‘B’ was used instead of ‘A’” used in describing Synthesis Examples means that a molar equivalent of ‘A’ was identical to a molar equivalent of ‘B’.

EXAMPLES

Synthesis Example 1: Synthesis of Compound 6

[0385]



(1) Synthesis of Intermediate 6(1)

[0386] 2-(3-(1H-benzo[d]imidazol-1-yl)phenoxy)-9-(4-(tert-butyl)pyridin-2-yl)-9H-carbazole (1.0 eq) and benzyl bromide (2.2 eq) were added to DMF (0.3 M), and the mixed solution was heated and stirred at a temperature of 150° C. for 18 hours. When the reaction was completed, the solvent was removed therefrom by using a rotavapor, and then, the resulting product was purified by flash column chromatography using acetone and methylene chloride, thereby obtaining Intermediate 6(1).

(2) Synthesis of Compound 6

[0387] 3-benzyl-1-(3-((9-(4-(tert-butyl)pyridin-2-yl)-9H-carbazol-2-yl)oxy)phenyl)-1H-benzo[d]imidazol-3-ium

bromide (1.0 eq), bis(benzonitrile)dichloroplatinum (II) (1.1 eq), and sodium acetate (3.0 eq) were added to benzonitrile (0.02 M), and the mixed solution was heated and stirred at a temperature of 200° C. for 1 day. When the reaction was completed, the reaction solution was cooled to room temperature, and benzonitrile was removed therefrom by using vacuum distillation to obtain a solid. The obtained solid was dissolved by using 100 ml of methylene chloride and removed through a celite filter, and a filtered solution was concentrated and purified by flash column chromatography using methylene chloride and hexane, thereby obtaining Compound 6 (0.80 g) was identified by LC-MS.

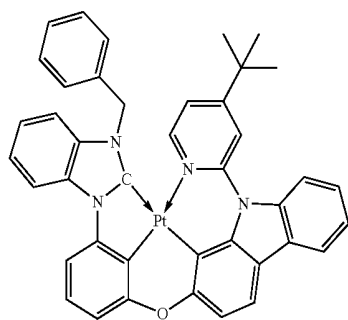
[0388] $C_{41}H_{32}N_4O$ Pt: M+792.2122.

Evaluation Example 1: Evaluation of Maximum Emission Wavelength (PL Max)

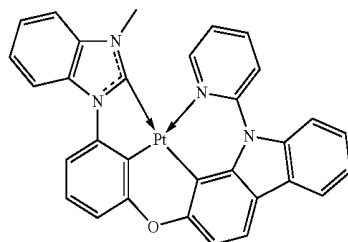
[0389] Compound 6 was diluted in toluene at a concentration of 1 mg/10 ml, and a photoluminescence (PL) spectrum was measured at room temperature by using ISC PC1 Spectrofluorometer equipped with a xenon lamp. The same experiment was repeated with respect to Compounds X1 and X6 to X8. In addition, Compound X2 was diluted in methylene chloride at a concentration of 1 mg/10 ml, and PL spectra were measured at room temperature in the same manner. Results thereof are shown in Table 1.

TABLE 2

Compound No.	PL max (nm)
Compound 6	457
X1	465
X2	446
X6	457
X7	460
X8	456

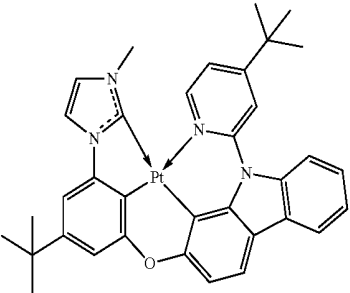
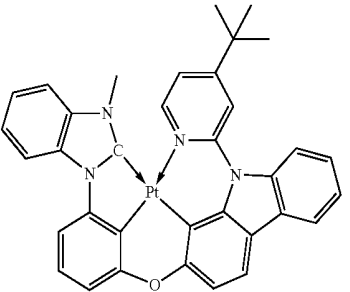
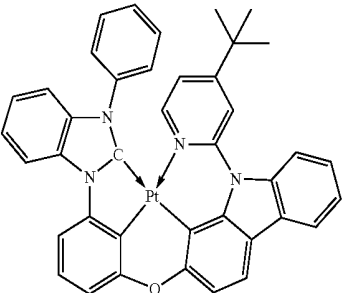
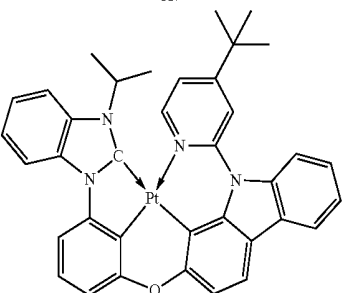


6



X1

TABLE 2-continued

Compound No.	PL max (nm)
	
X2	
	
X6	
	
X7	
	
X8	

[0390] From Table 2, it is confirmed that Compound 6 emits deeper blue color light than Compound X2.

Evaluation Example 2: Evaluation of PLQY

[0391] CBP and Compound 6 were co-deposited at a weight ratio of 90:10 under a vacuum pressure of 10^{-7} torr to form a film having a thickness of 50 nm.

[0392] The PQYL of the film was evaluated with respect to an excitation wavelength of 270 nm by using a Hamamatsu Photonics absolute PL quantum yield measurement system including a xenon light source, a monochromator, a photonic multichannel analyzer, and an integrating sphere

and employing a PLQY measurement software (Hamamatsu Photonics, Ltd, Shizuoka, Japan), and results thereof are shown in Table 3. Here, the results are described as relative values based on the value of Compound 6.

TABLE 3

Compound No.	PLQY (%)
Compound 6	100
Compound X1	82.4
Compound X6	69.1
Compound X7	53.76
Compound X8	50.9

[0393] From Table 3, it was confirmed that Compound 6 has a high PLQY value, as compared with that of Compounds X1 and X6 to X8.

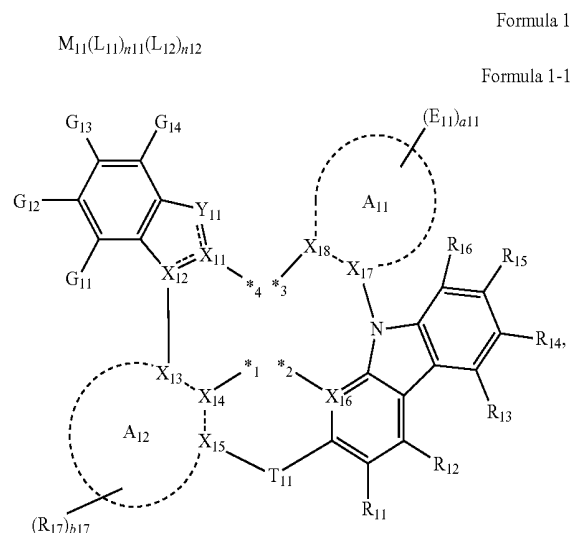
[0394] Since the organometallic compound emits light having a relatively small full width at half maximum (FWHM), has a relatively small change in emission wavelength according to concentration, and has relatively high thermal stability, an organic light-emitting device including the organometallic compound may have improved driving voltage, external quantum efficiency, roll-off ratio, and color purity. In addition, since the organometallic compound has excellent phosphorescence characteristics, a diagnostic composition having high diagnostic efficiency may be provided by using the organometallic compound.

[0395] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0396] 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 as defined by the following claims.

What is claimed is:

1. An organometallic compound represented by Formula 1:



wherein, in Formulae 1 and 1-1,

M_{11} is a first-row transition metal, a second-row transition metal, or a third-row transition metal, of the Periodic Table of Elements,

*1 to *4 each indicate a binding site to M_{11} ,

L_{11} is a ligand represented by Formula 1-1,

L_{12} is a monodentate ligand or a bidentate ligand,

$n11$ is 1,

$n12$ is 0, 1, or 2,

X_{11} and X_{13} to X_{17} are each independently C,

X_{12} and X_{18} are each independently N,

X_{11} and X_{12} , X_{13} and X_{14} , X_{14} and X_{15} , and X_{17} and X_{18} are each independently linked to each other via a chemical bond,

Y_{11} is N(R_{18}), O, or S,

A_{11} is a N-containing C_1 - C_{60} heterocyclic group,

A_{12} is a C_5 - C_{60} carbocyclic group, or a C_1 - C_{60} heterocyclic group,

T_{11} is C(R_{19})(R_{20}), Si(R_{19})(R_{20}), O, S, or N(R_{19}),

E_{11} is a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

G_{11} to G_{14} are each independently hydrogen, deuterium, —F, —Cl, —Br, or —I,

R_{18} is a group represented by $^*C(Q_{101})(Q_{102})(Q_{103})$,

R_{11} to R_{17} and Q_{101} to Q_{103} are each independently hydrogen, deuterium, —F, —Cl, —Br, —I, —SF₅, a hydroxyl group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60}

heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, $-\text{B}(\text{Q}_1)(\text{Q}_2)$, $-\text{N}(\text{Q}_1)(\text{Q}_2)$, $-\text{P}(\text{Q}_1)(\text{Q}_2)$, $-\text{C}(=\text{O})(\text{Q}_1)$, $-\text{S}(=\text{O})(\text{Q}_1)$, $-\text{S}(=\text{O})_2(\text{Q}_1)$, $-\text{P}(=\text{O})(\text{Q}_1)(\text{Q}_2)$, or $-\text{P}(=\text{S})(\text{Q}_1)(\text{Q}_2)$,

at least one Q_{101} to Q_{103} is a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

R_{19} and R_{20} are each independently hydrogen, deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, $-\text{SF}_5$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_7 - C_{60} alkylaryl group, a substituted or unsubstituted C_7 - C_{60} arylalkyl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted C_2 - C_{60} alkylheteroaryl group, a substituted or unsubstituted C_2 - C_{60} heteroarylalkyl group, a substituted or unsubstituted C_1 - C_{60} heteroaryloxy group, a substituted or unsubstituted C_1 - C_{60} heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, $-\text{B}(\text{Q}_1)(\text{Q}_2)$, $-\text{N}(\text{Q}_1)(\text{Q}_2)$, $-\text{P}(\text{Q}_1)(\text{Q}_2)$, $-\text{C}(=\text{O})(\text{Q}_1)$, $-\text{S}(=\text{O})(\text{Q}_1)$, $-\text{S}(=\text{O})_2(\text{Q}_1)$, $-\text{P}(=\text{O})(\text{Q}_1)(\text{Q}_2)$, or $-\text{P}(=\text{S})(\text{Q}_1)(\text{Q}_2)$,

two neighboring groups among R_{11} to R_{20} are optionally linked to each other to form a substituted or unsubstituted C_5 - C_{30} carbocyclic group or a substituted or unsubstituted C_1 - C_{30} heterocyclic group,

a_{11} and b_{17} are each independently 1, 2, 3, 4, 5, 6, 7, or 8, and

Q_1 to Q_3 are each independently hydrogen, deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group,

a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_7 - C_{60} alkylaryl group, a C_7 - C_{60} arylalkyl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a C_2 - C_{60} alkylheteroaryl group, a C_2 - C_{60} heteroarylalkyl group, a C_1 - C_{60} heteroaryloxy group, a C_1 - C_{60} heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a C_1 - C_{60} alkyl group substituted with at least one deuterium, $-\text{F}$, a cyano group, a C_1 - C_{60} alkyl group, a C_6 - C_{60} aryl group, or any combination thereof, or a C_6 - C_{60} aryl group substituted with at least one deuterium, $-\text{F}$, a cyano group, a C_1 - C_{60} alkyl group, a C_6 - C_{60} aryl group, or any combination thereof, and

* indicates a binding site to a neighboring atom.

2. The organometallic compound of claim 1, wherein M_{11} is Pt or Pd.

3. The organometallic compound of claim 1, wherein

A_{11} is: a first ring; a condensed ring in which two or more first rings are condensed with each other; or a condensed ring in which one or more first rings are condensed with one or more second rings,

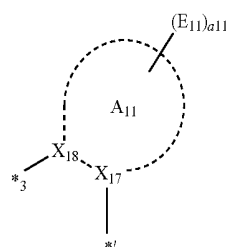
the first ring is a pyrrole group, a pyrrolidine group, an imidazolidine group, a dihydropyrrole group, a dihydroimidazole group, an oxazole group, an isoxazole group, an oxadiazole group, an oxatriazole group, a thiazole group, an isothiazole group, a thiadiazole group, a thiatriazole group, a pyrazole group, an imidazole group, a triazole group, a tetrazole group, a pyridine group, a piperidine group, a tetrahydropyridine group, a dihydropyridine group, a pyrimidine group, a hexahydropyrimidine group, a tetrahydropyrimidine group, a dihydropyrimidine group, a pyrazine group, a piperazine group, a tetrahydropyrazine group, a dihydropyrazine group, a pyridazine group, a tetrahydropyridazine group, a dihydropyridazine group, or a triazine group, and

the second ring is a cyclopentane group, a cyclopentene group, a cyclopentadiene group, a furan group, a thiophene group, a silole group, a cyclohexane group, a cyclohexene group, a cyclohexadiene group, a benzene group, an adamantane group, a norbornane group, or a norbornene group.

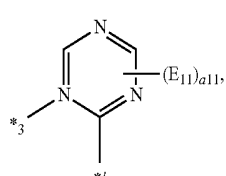
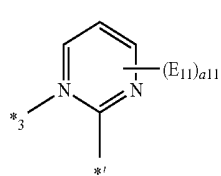
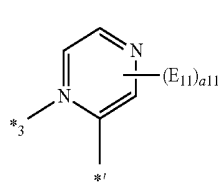
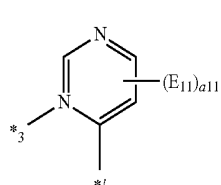
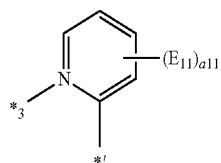
4. The organometallic compound of claim 1, wherein

A_{11} is a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, or a quinazoline group.

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



is Formulae 2-1 to 2-5:



wherein, in Formulae 2-1 to 2-5,

*3 indicates a binding site to M_{11} ,

*1 indicates a binding site to a neighboring atom, and

E_{11} and a_{11} are each independently the same as defined in connection with Formula 1-1 of claim 1.

6. The organometallic compound of claim 1, wherein

A_{12} is: a first ring; a second ring; a condensed ring in which two or more first rings are condensed with each other; a condensed ring in which one or more first rings are condensed with one or more second rings; or two or more second rings are condensed with each other,

the first ring is a pyrrole group, a pyrrolidine group, an imidazolidine group, a dihydropyrrole group, a dihydroimidazole group, an oxazole group, an isoxazole group, an oxadiazole group, an oxatriazole group, a thiazole group, an isothiazole group, a thiadiazole group, a thiatriazole group, a pyrazole group, an imidazole group, a triazole group, a tetrazole group, a pyridine group, a piperidine group, a tetrahydropyridine group, a dihydropyridine group, a pyrimidine group, a hexahydropyrimidine group, a tetrahydropyrimidine group, a dihydropyrimidine group, a pyrazine group, a piperazine group, a tetrahydropyrazine group,

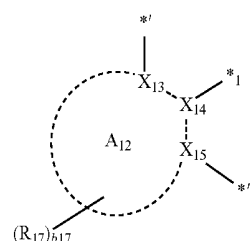
a dihydropyrazine group, a pyridazine group, a tetrahydropyridazine group, a dihydropyridazine group, or a triazine group, and

the second ring is a cyclopentane group, a cyclopentene group, a cyclopentadiene group, a furan group, a thiophene group, a silole group, a cyclohexane group, a cyclohexene group, a cyclohexadiene group, a benzene group, an adamantane group, a norbornane group, or a norbornene group.

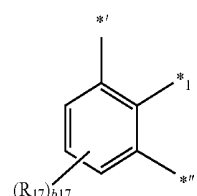
7. The organometallic compound of claim 1, wherein

A_{12} is a benzene group, a naphthalene group, an indene group, a fluorene group, a benzofuran group, a dibenzofuran group, a benzothiophene group, a dibenzothiophene group, a benzosilole group, or a dibenzosilole group.

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



is represented by Formula 3-1:



wherein, in Formula 3-1,

*1 indicates a binding site to M_{11} ,

*1' and *1'' each indicate a binding site to a neighboring atom, and

R_{17} and b_{17} are each independently the same as defined in connection with Formula 1-1 of claim 1.

9. The organometallic compound of claim 1, wherein

E_{11} is:

a C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group;

a C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{10} alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a

- naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;
- a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group; or
- a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohex-

enyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, or any combination thereof.

10. The organometallic compound of claim 1, wherein E₁₁ is:

- 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an isodecyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group;
- 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decyl group, an isodecyl group, a sec-decyl group, a tert-decyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a cyano group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;
- a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyridazinyl group, or a triazinyl group;

a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyridazinyl group, or a triazinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a cyano group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, or any combination thereof.

11. The organometallic compound of claim 1, wherein G₁₁ to G₁₄ are each independently hydrogen or deuterium.

12. The organometallic compound of claim 1, wherein R₁₁ to R₁₇ are each independently:

hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl 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, —SF₅, a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group;

a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyridazinyl group, an indazolyl group, an isoindolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a

norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyridazinyl group, an indazolyl group, an isoindolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyridazinyl group, a pyrimidinyl group, a pyridazinyl group, an indazolyl group, an isoindolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —B(Q₁₁)(Q₁₂), —N(Q₁₁)(Q₁₂), or any combination thereof; or

—Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), or —N(Q₁)(Q₂).

R₁₉ and R₂₀ are each independently:

hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group,

- a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, $-\text{SF}_5$, a C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group;
- a C_1 - C_{20} alkyl group, or a C_1 - C_{20} alkoxy group, each substituted with at least one deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, $-\text{CD}_3$, $-\text{CD}_2\text{H}$, $-\text{CDH}_2$, $-\text{CF}_3$, $-\text{CF}_2\text{H}$, $-\text{CFH}_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{10} alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;
- a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, an isobenzothiazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group;
- a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, an isobenzothiazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group;
- 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, or a naphthyl group; or
- 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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or a combination thereof.

group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, $-\text{CD}_3$, $-\text{CD}_2\text{H}$, $-\text{CDH}_2$, $-\text{CF}_3$, $-\text{CF}_2\text{H}$, $-\text{CFH}_2$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranlyl group, an isobenzothiazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{11})(\text{Q}_{12})(\text{Q}_{13})$, $-\text{B}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, or any combination thereof; or

$-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, $-\text{B}(\text{Q}_1)(\text{Q}_2)$, or $-\text{N}(\text{Q}_1)(\text{Q}_2)$, and

Q_1 to Q_3 and Q_{11} to Q_{13} are each independently:

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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, or a naphthyl group; or

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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or a combination thereof.

13. The organometallic compound of claim 1, wherein Q₁₀₁ to Q₁₀₃ are each independently:

hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, —SF₅, a C₁–C₂₀ alkyl group, or a C₁–C₂₀ alkoxy group;

a C₁-C₂₀ alkyl group, or a C₁-C₂₀ alkoxy group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a C₁-C₁₀ alkyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, or any combination thereof;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group; or

$$-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3), -\text{B}(\text{Q}_1)(\text{Q}_2), \text{ or } -\text{N}(\text{Q}_1)(\text{Q}_2),$$

at least one Q₁₀₁ to Q₁₀₃ is a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a

phenanthrolyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group; or

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, or an imidazopyrimidinyl group, each substituted with at least one deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantyl group, a norbornyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a biphenyl group, a C₁-C₂₀ alkylphenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a dibenzo-

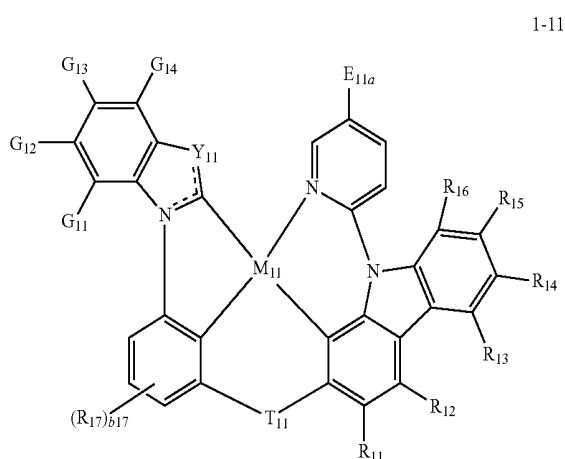
carbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{11})(\text{Q}_{12})(\text{Q}_{13})$, $-\text{B}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, or any combination thereof, and

Q_1 to Q_3 and Q_{11} to Q_{13} are each independently:

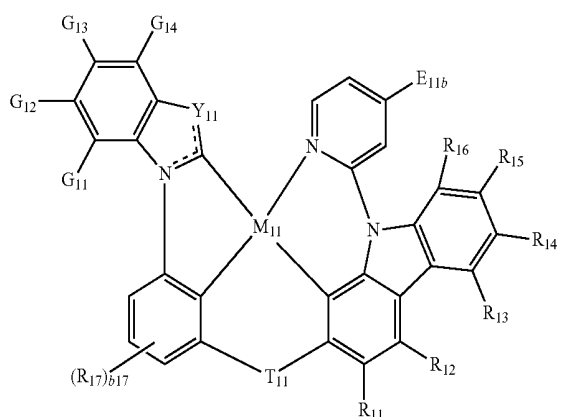
a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, a biphenyl group, a C_1 - C_{20} alkylphenyl group, or a naphthyl group; or

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 2-methylbutyl group, a sec-pentyl group, a tert-pentyl group, a neo-pentyl group, a 3-pentyl group, a 3-methyl-2-butyl group, a phenyl group, or a naphthyl group, each substituted with at least one deuterium, a phenyl group, or a combination thereof.

14. The organometallic compound of claim 1, wherein the organometallic compound is represented by Formulae 1-11 to 1-14:



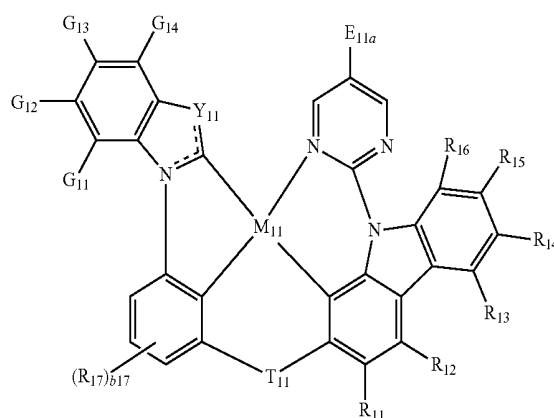
1-11



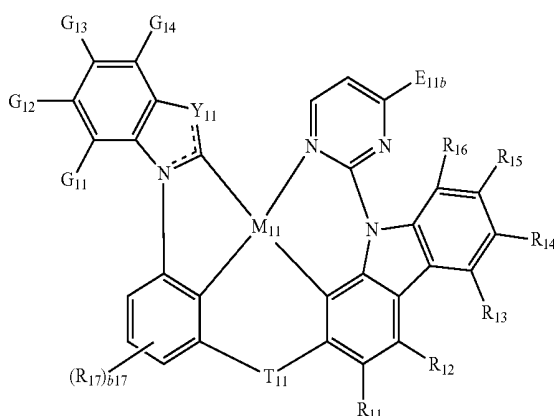
1-12

-continued

1-13



1-14



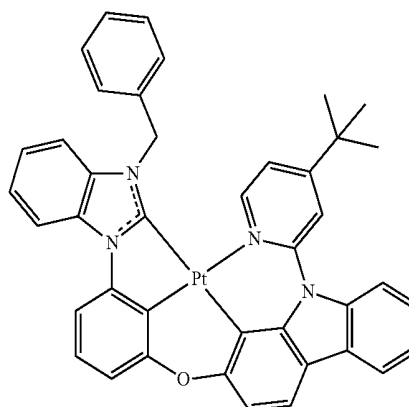
wherein, in Formulae 1-11 to 1-14,

M_{11} is the same as defined in connection with Formula 1 of claim 1,

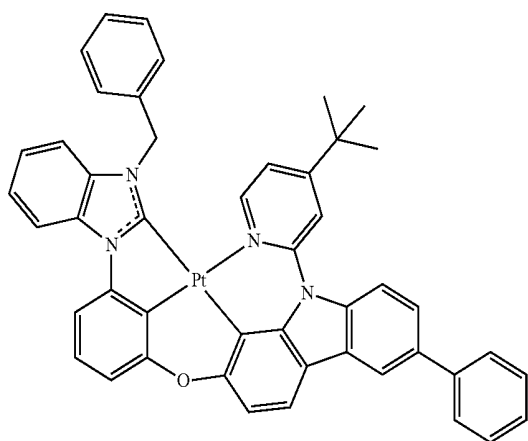
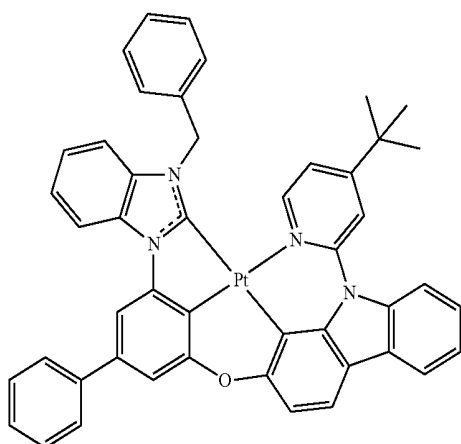
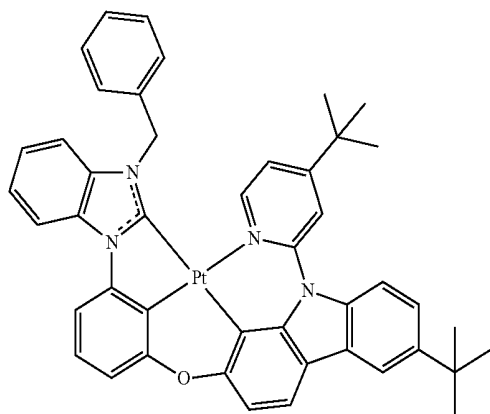
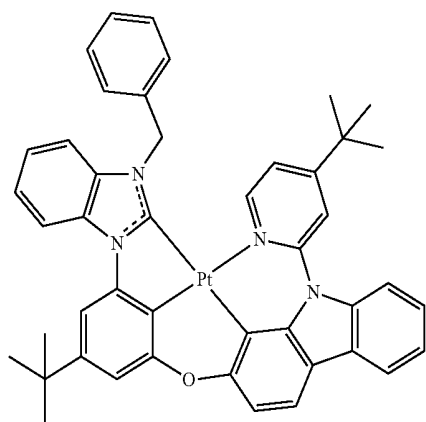
Y_{11} , T_{11} , G_{11} to G_{14} , R_{11} to R_{17} , and $\text{b}17$ are each independently the same as defined in connection with Formula 1-1 of claim 1, and

E_{11a} and E_{11b} are each independently the same as defined in connection with E_{11} in Formula 1-1 of claim 1.

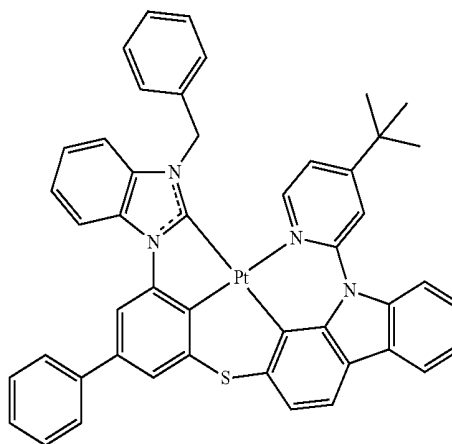
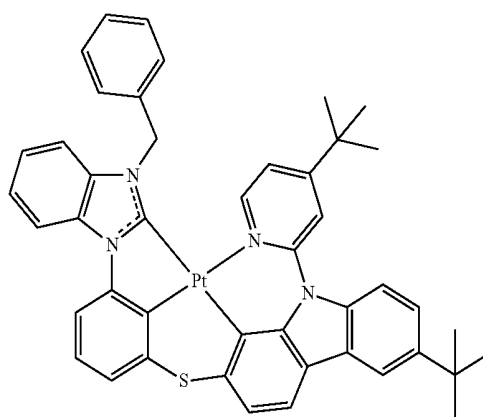
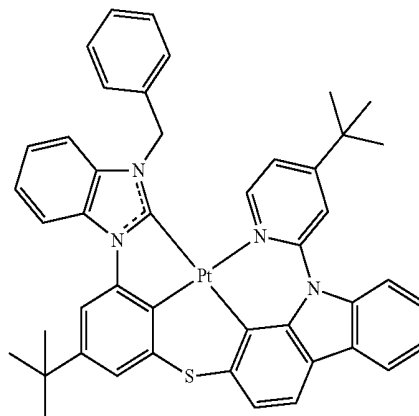
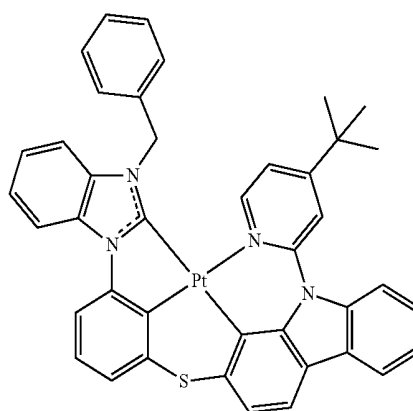
15. The organometallic compound of claim 1, wherein the organometallic compound is a compound of Group I:



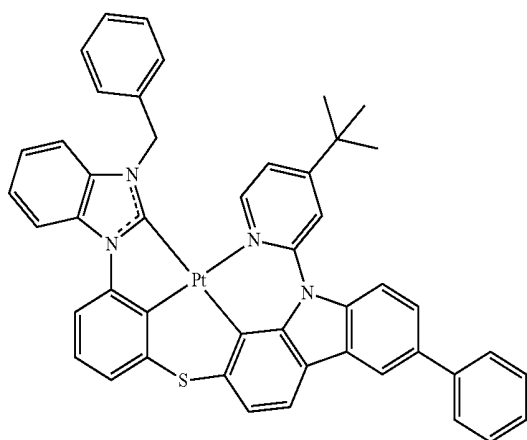
-continued



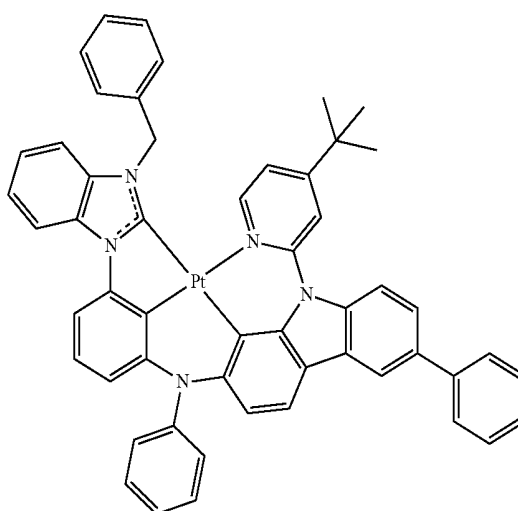
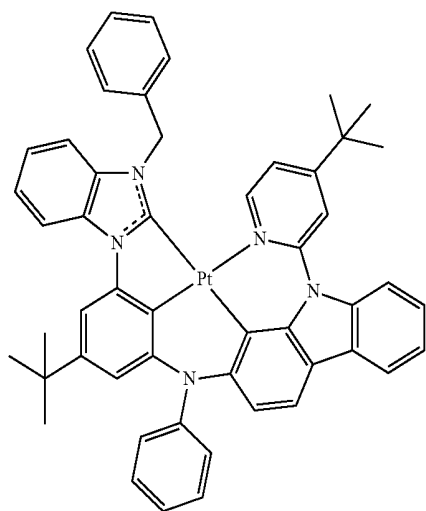
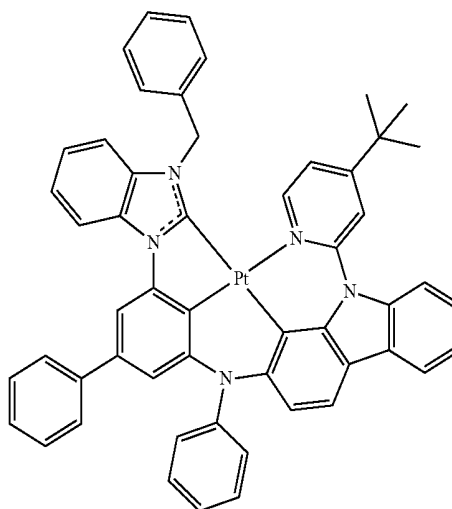
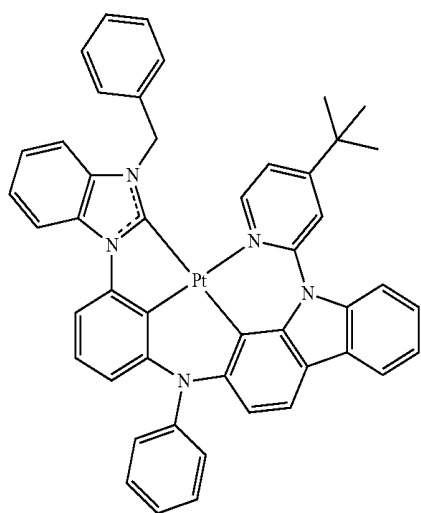
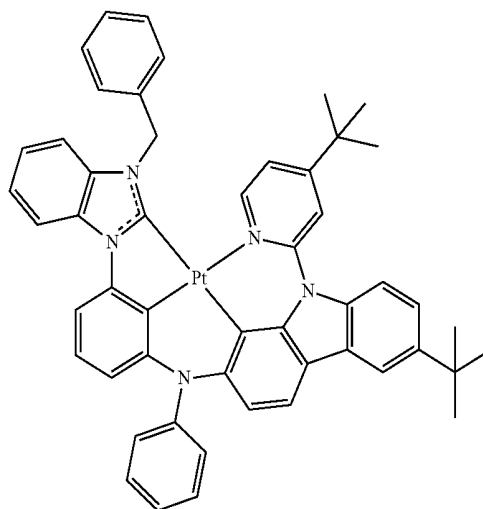
-continued



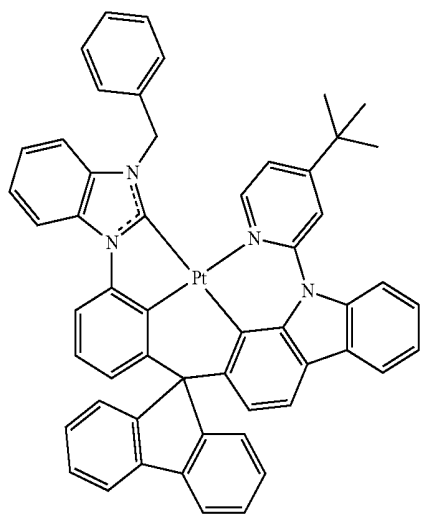
-continued



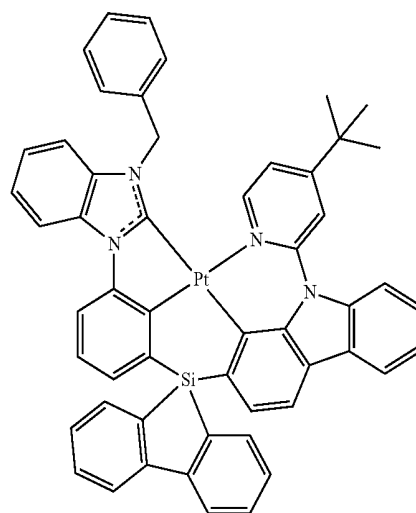
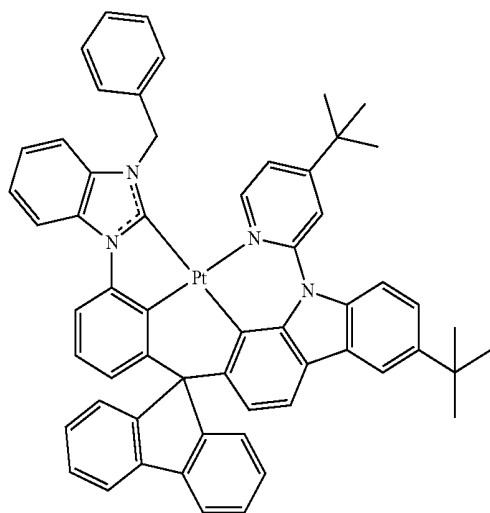
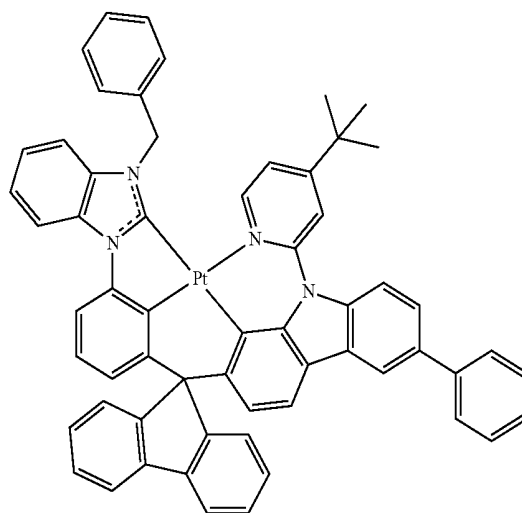
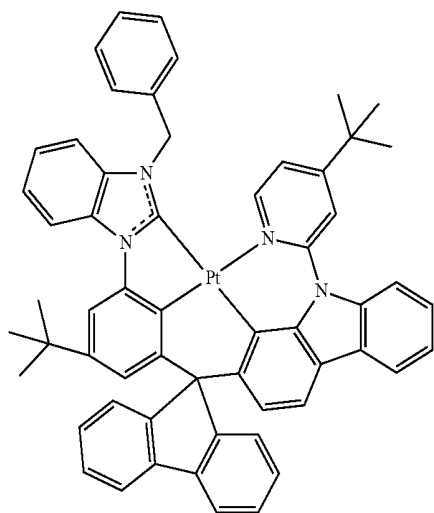
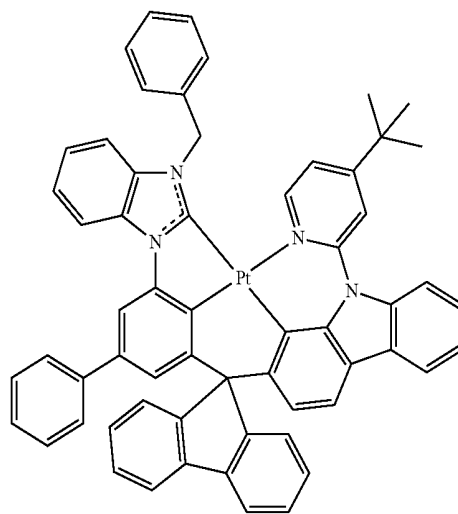
-continued



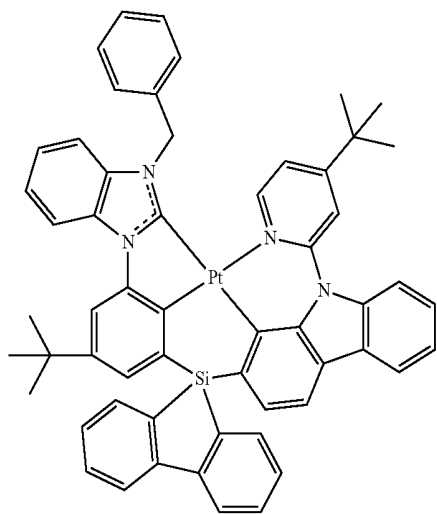
-continued



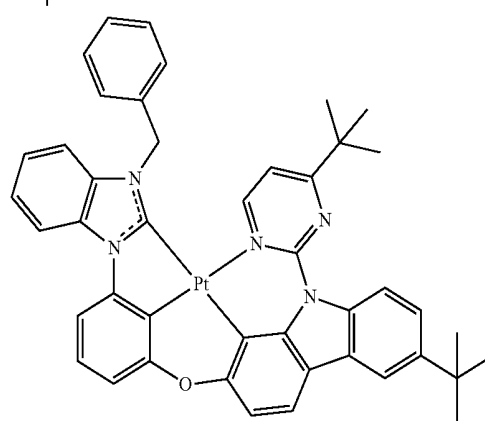
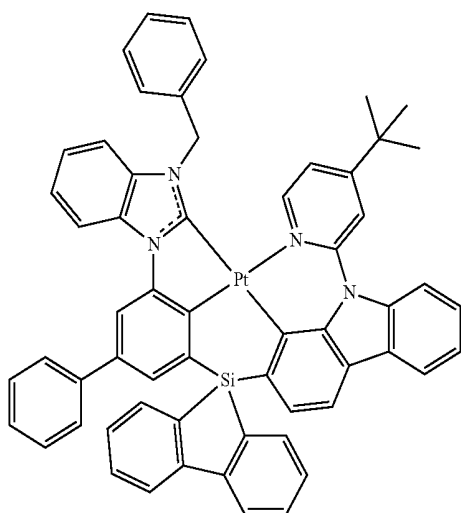
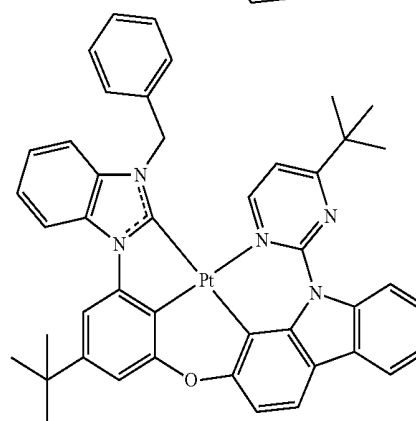
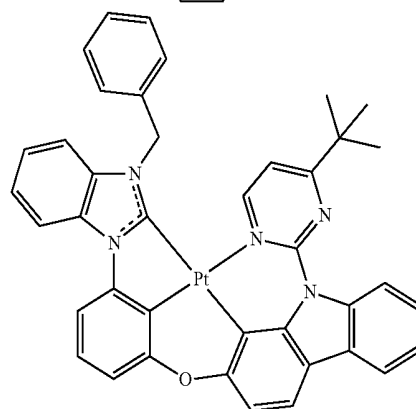
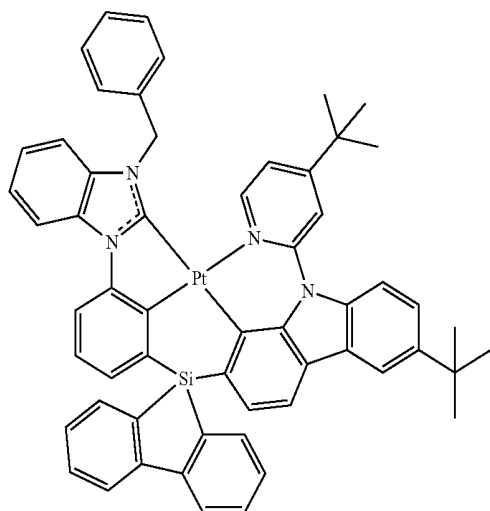
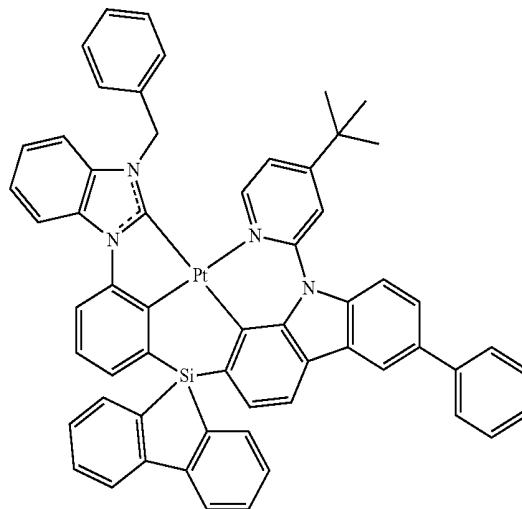
-continued



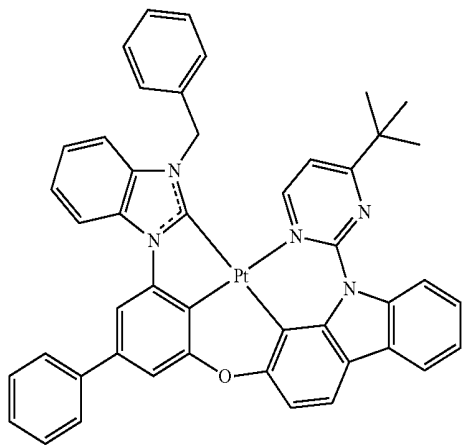
-continued



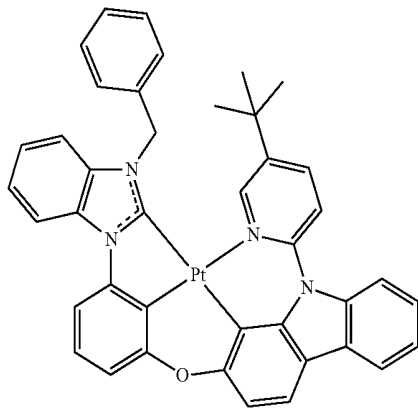
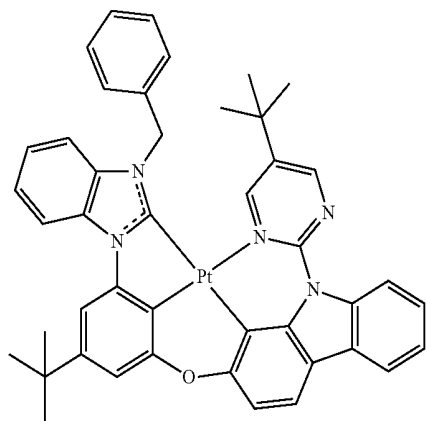
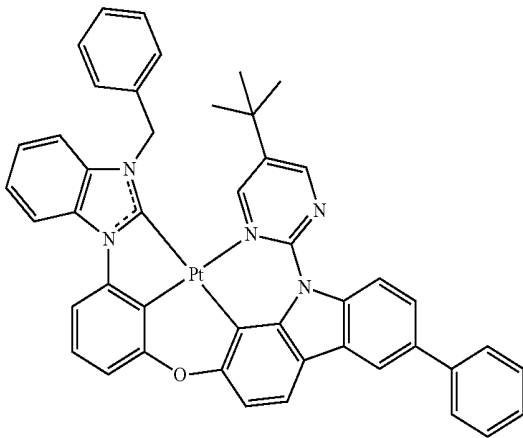
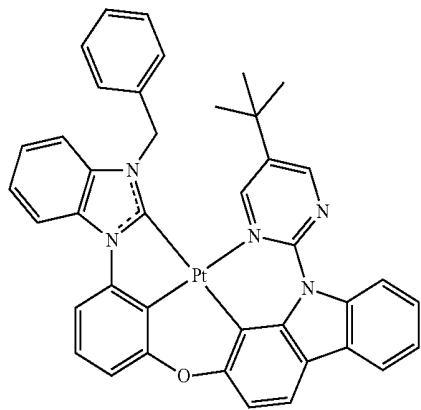
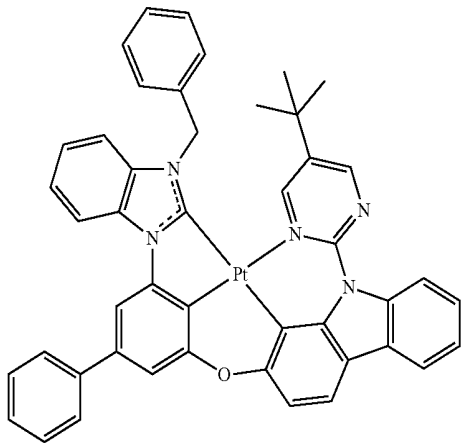
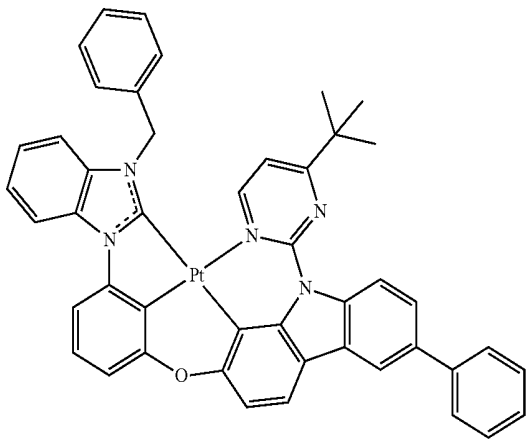
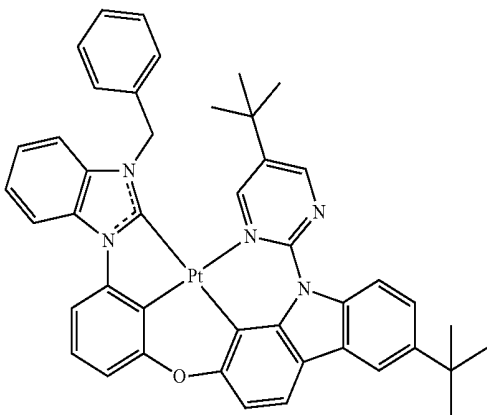
-continued



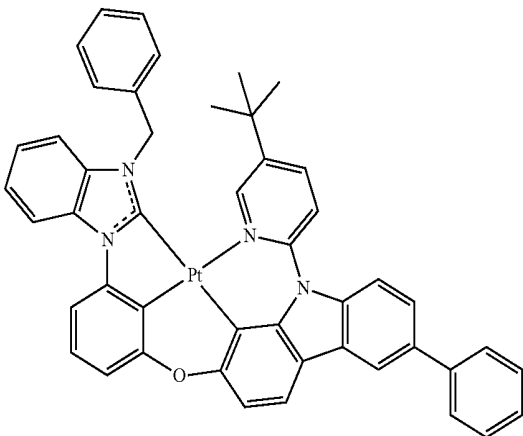
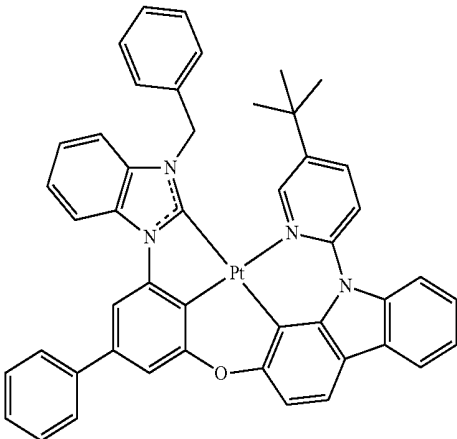
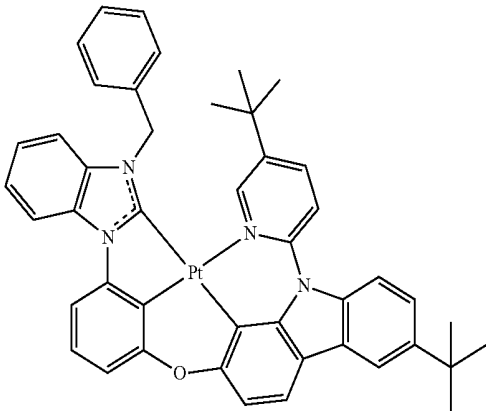
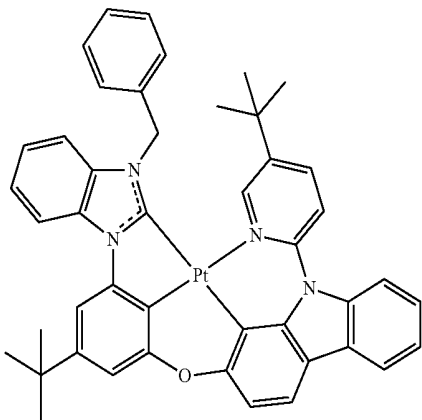
-continued



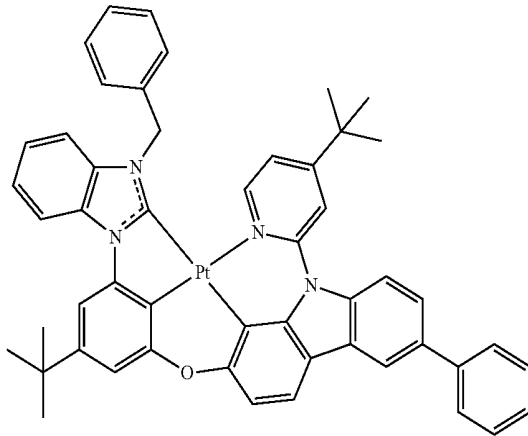
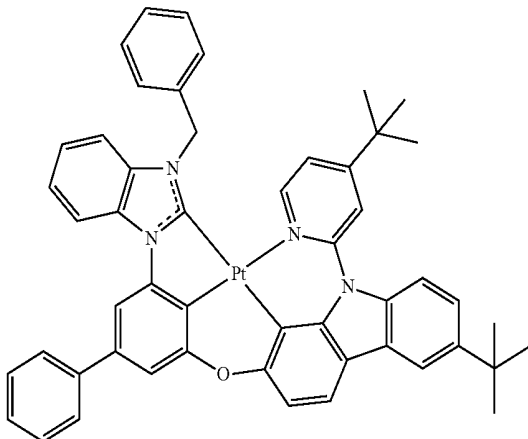
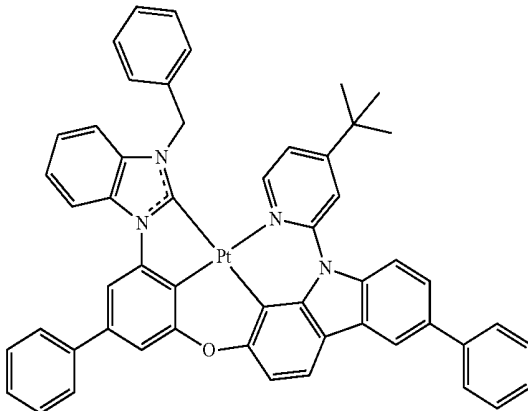
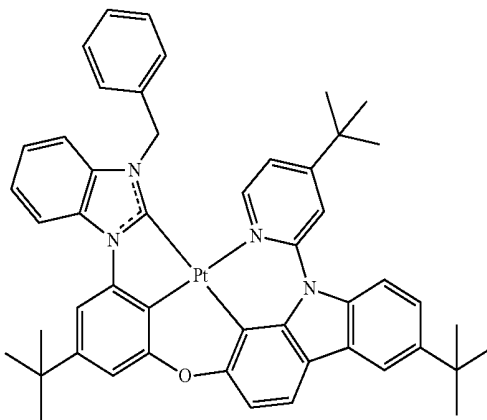
-continued



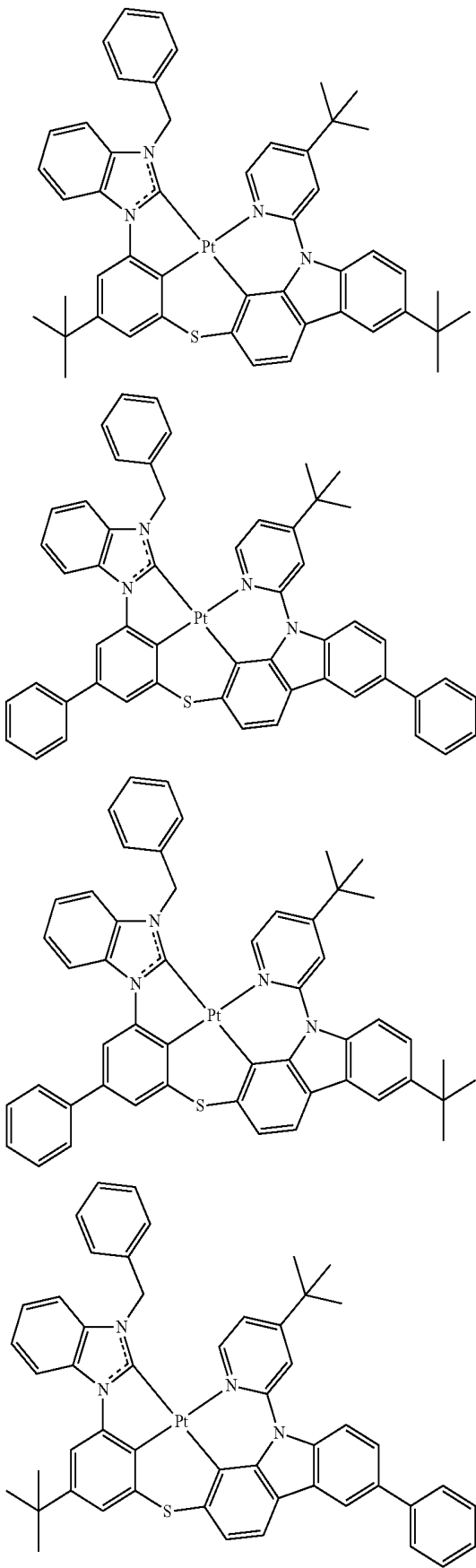
-continued



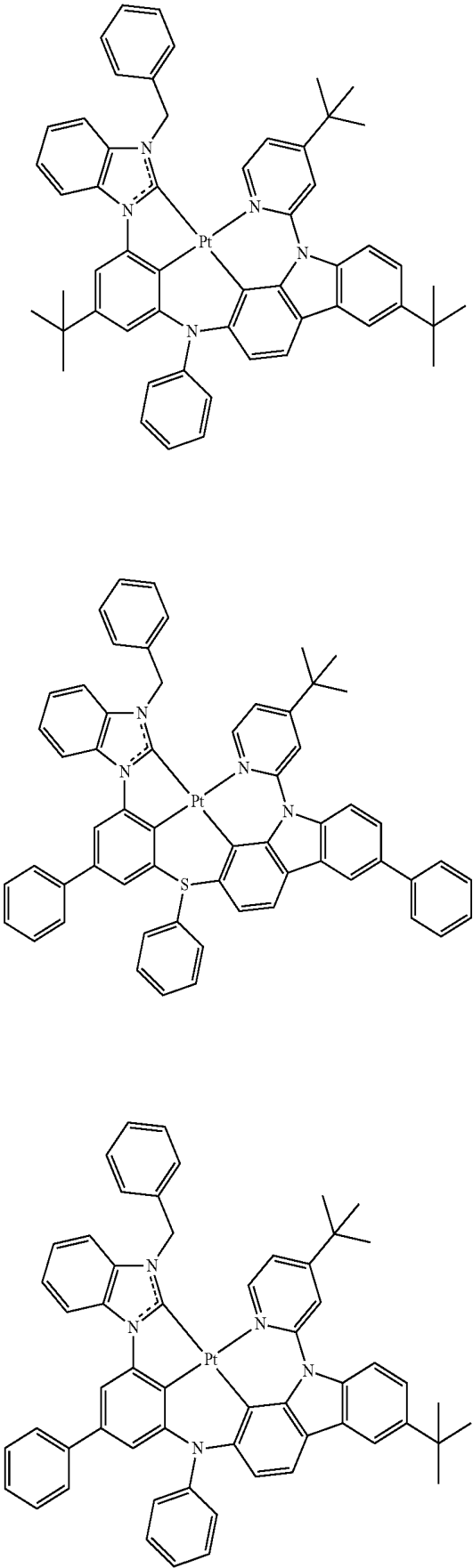
-continued



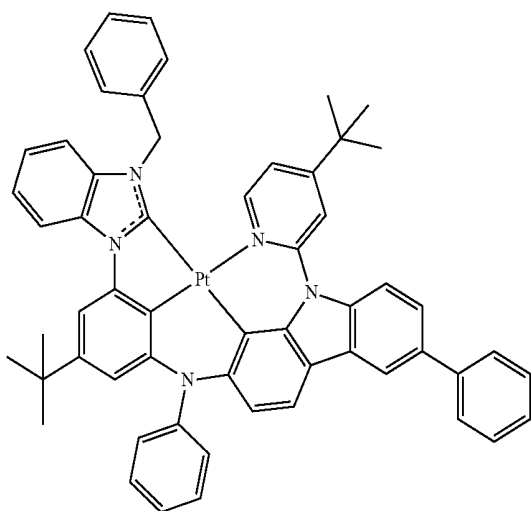
-continued



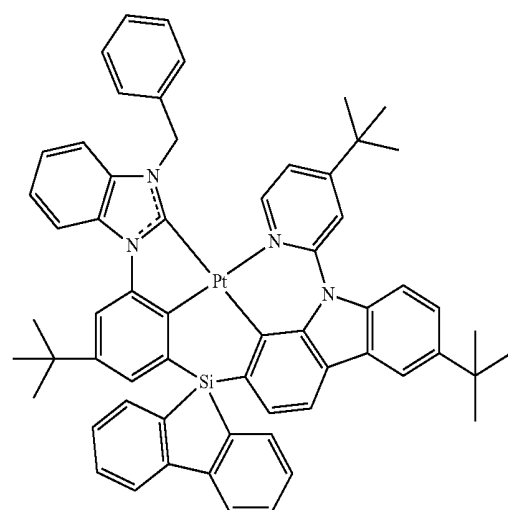
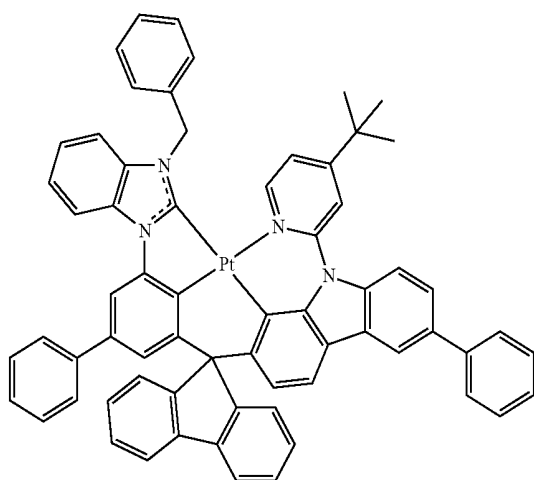
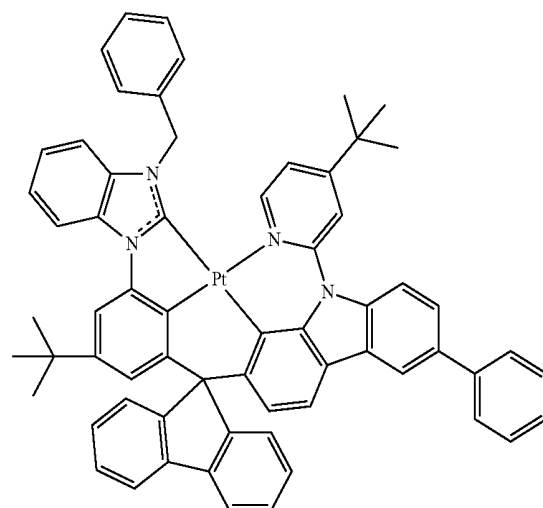
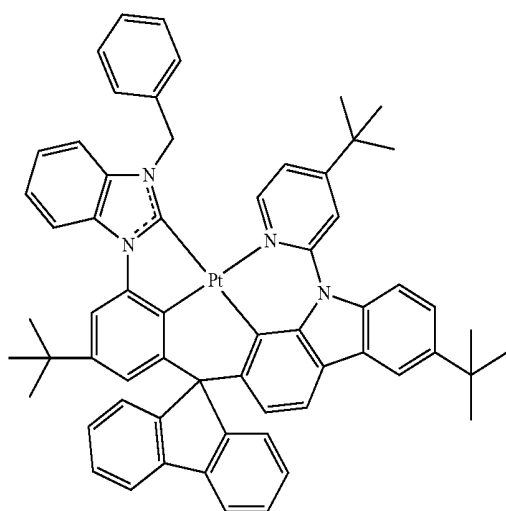
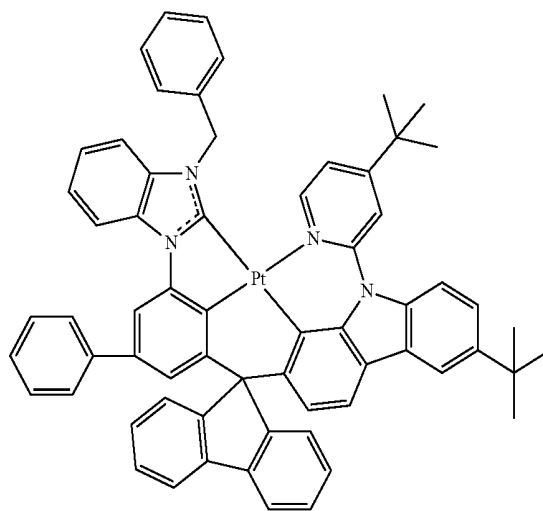
-continued



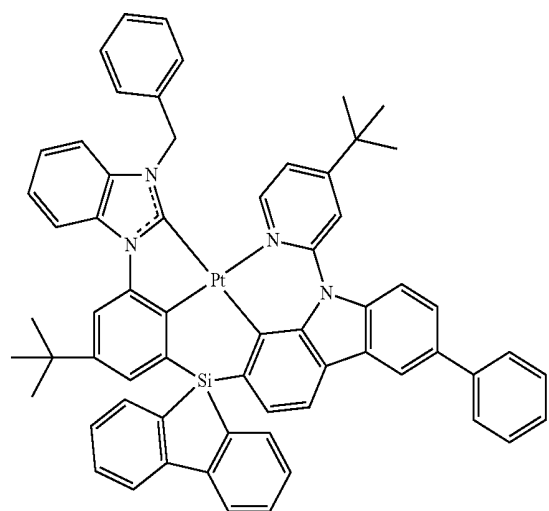
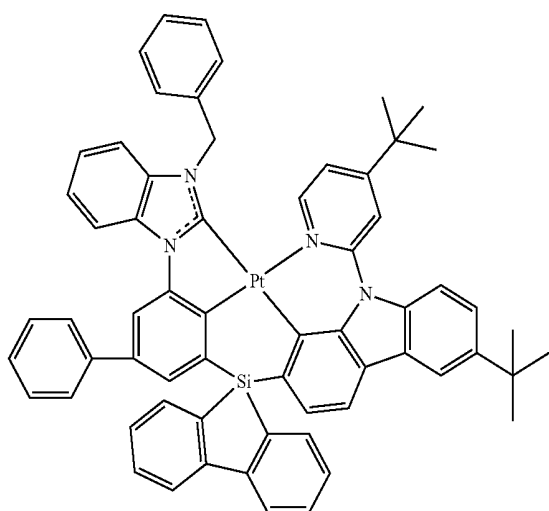
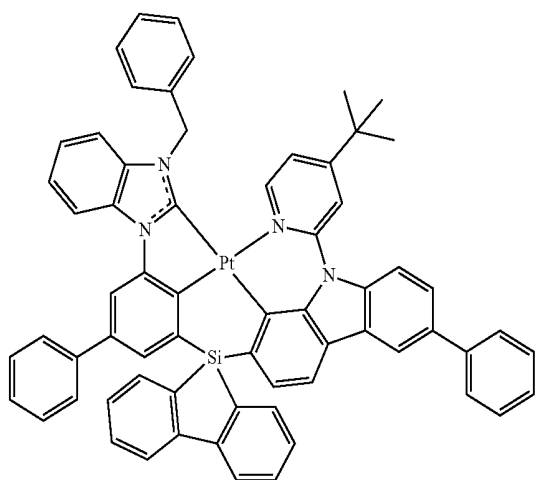
-continued



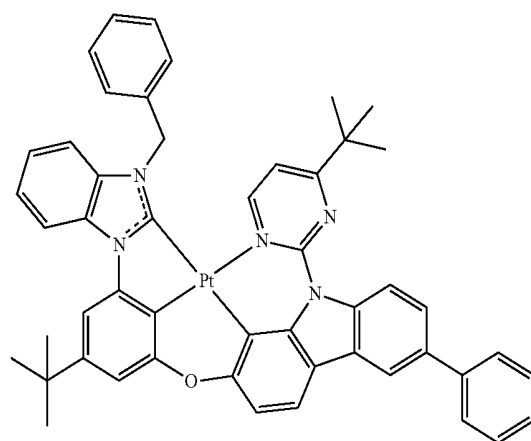
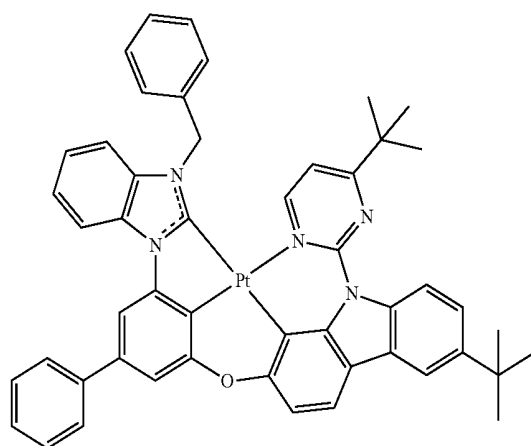
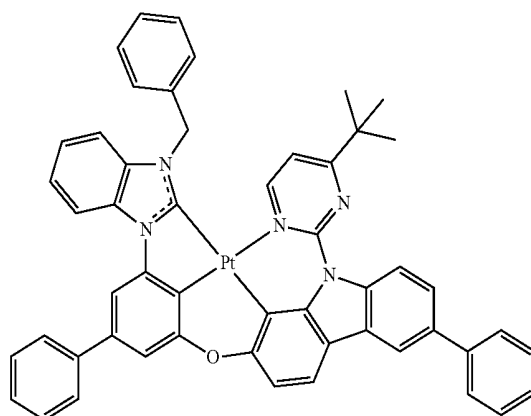
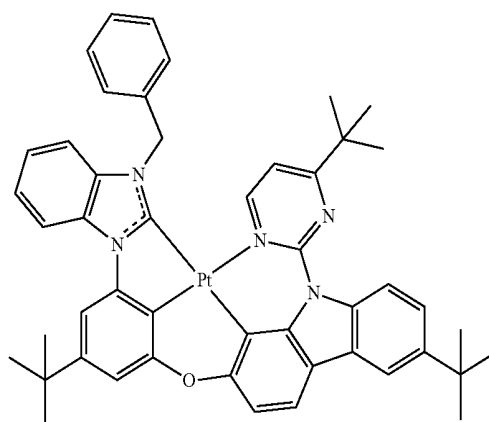
-continued



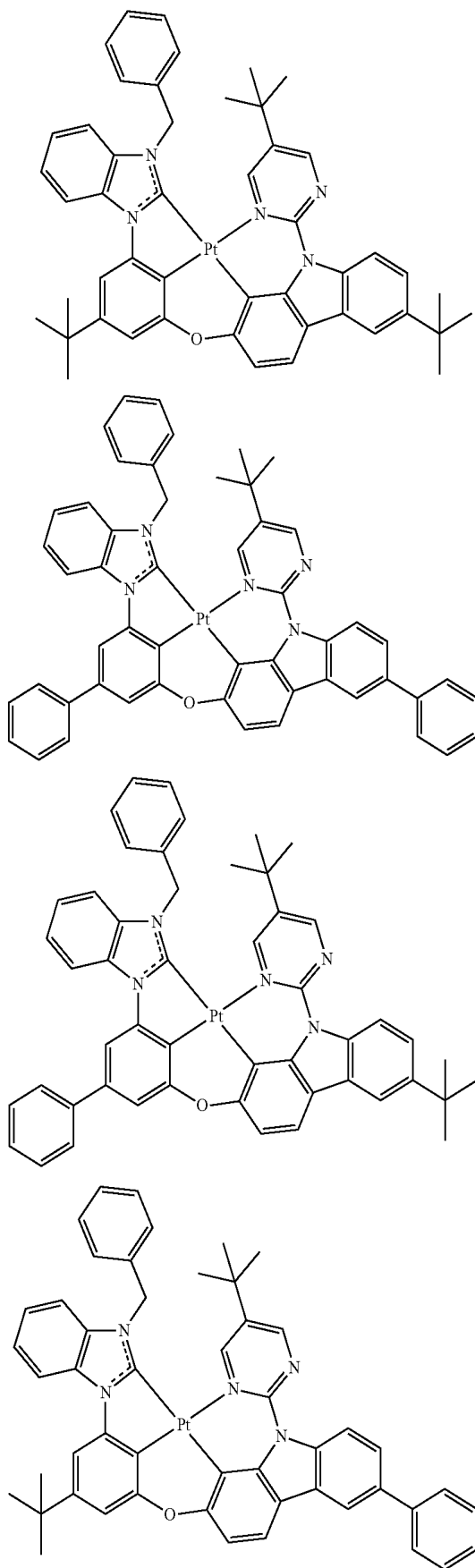
-continued



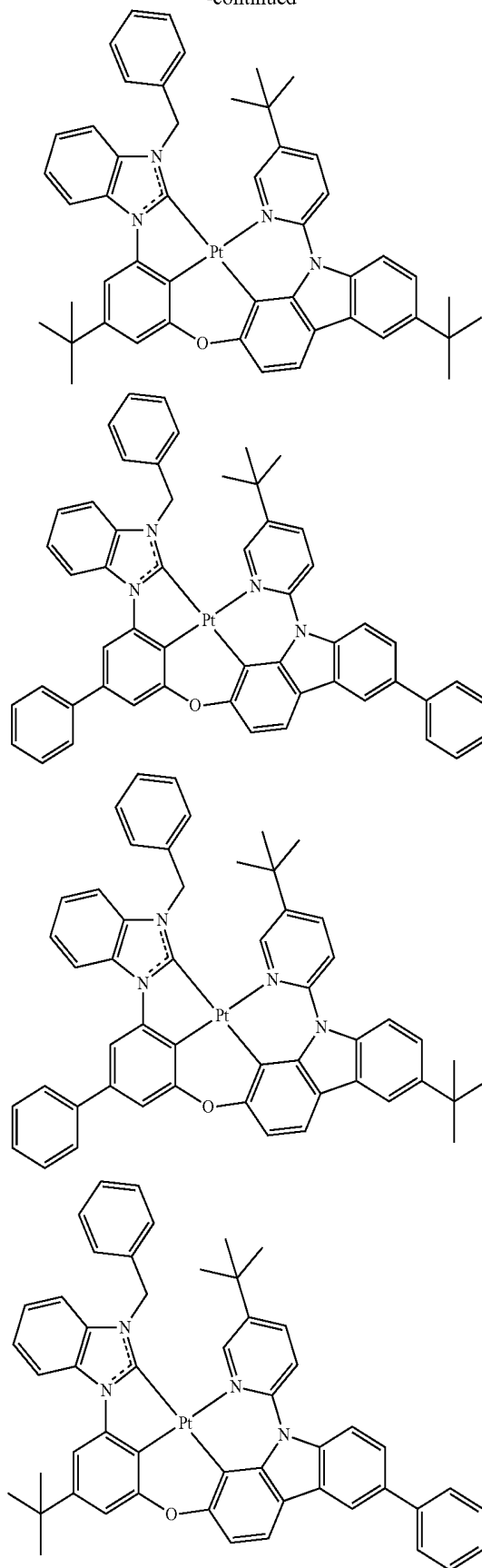
-continued



-continued



-continued



- 16.** An organic light-emitting device comprising:
a first electrode;
a second electrode; and
an organic layer between the first electrode and the second electrode and comprising an emission layer,
wherein the organic layer comprises 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,
the organic layer further comprises a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,
the hole transport region comprises a hole injection layer, a hole transport layer, an electron blocking layer, or any combination thereof, and
the electron transport region comprises a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof.
- 18.** The organic light-emitting device of claim 16, wherein the emission layer comprises the organometallic compound.
- 19.** The organic light-emitting device of claim 18, wherein the emission layer further comprises a host, and an amount of the host is larger than an amount of the organometallic compound.
- 20.** A diagnostic composition comprising at least one organometallic compound of claim 1.

* * * * *

专利名称(译)	有机金属化合物，包括该有机金属化合物的有机发光器件以及包括该有机金属化合物的诊断组合物		
公开(公告)号	US20200203635A1	公开(公告)日	2020-06-25
申请号	US16/718353	申请日	2019-12-18
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD. 三星SDI CO. , LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO. , LTD. 三星SDI CO. , LTD.		
[标]发明人	KIM SANGMO BAE HYEJIN KIM WOOK KIM JUHYUN MIN MINSIK PARK SANGHO SON JHUNMO JUNG YONGSIK SON WON JOON LEE HASUP		
发明人	KIM, SANGMO BAE, HYEJIN KIM, WOOK KIM, JUHYUN MIN, MINSIK PARK, SANGHO SON, JHUNMO JUNG, YONGSIK SON, WON-JOON LEE, HASUP		
IPC分类号	H01L51/00 C07F15/00 C09K11/06		
CPC分类号	H01L51/5096 C09K2211/185 H01L2251/552 C09K2211/1029 H01L51/5012 C07F15/0086 H01L51/0087 C09K2211/1044 H01L51/5092 H01L51/5056 C09K11/06 H01L51/5004 H01L51/5088 H01L51/5072 H01L51/5016		
优先权	1020180165470 2018-12-19 KR 1020190148082 2019-11-18 KR		
外部链接	Espacenet USPTO		

摘要(译)

提供一种有机金属化合物，包括该有机金属化合物的有机发光器件以及包括该有机金属化合物的诊断组合物。有机金属化合物由式1表示：L 11 是由式1-1和L 12 表示的配体。是单齿配体或双齿配体。名称M 11 ，n11，n12，X 11 -X 18 ，Y 11 ，11 ，12 ，T 11 ，E 11 ，G 11 到G 14 ，全部和b17在规范中进行了描述。

