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

(71) Applicant: **SAMSUNG DISPLAY CO., LTD.,**
Yongin, Gyeonggi-Do (KR)

(72) Inventors: **Sanghyun Han**, Yongin (KR);
Kwanghyun Kim, Jinju (KR); **Sooyon**
Kim, Yongin (KR); **Haejin Kim**, Jinju
(KR); **Youngkook Kim**, Yongin (KR);
Seokhwan Hwang, Yongin (KR);
Jongwoo Kim, Yongin (KR)

(73) Assignee: **Samsung Display Co., Ltd.**, Yongin-si
(KR)

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This patent is subject to a terminal dis-
claimer.

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549/440; 257/40
See application file for complete search history.

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Primary Examiner — Jennifer A Chriss

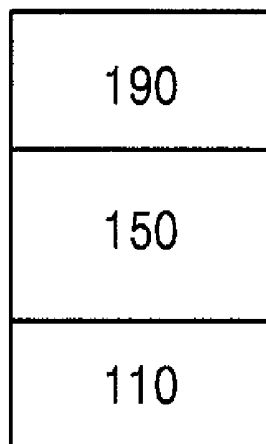
Assistant Examiner — Sean M DeGuire

(74) *Attorney, Agent, or Firm* — Lewis Roca Rothgerber
Christie LLP

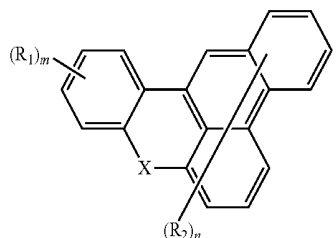
(57) **ABSTRACT**

An organic light-emitting device includes a first electrode; a
second electrode facing the first electrode; and an organic
(Continued)

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layer between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes a compound of Formula 1:



Formula 1

wherein R_1 , R_2 , X, m, and n in Formula 1 are as defined in the specification.

21 Claims, 1 Drawing Sheet

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(52) U.S. Cl.

CPC **C07D 405/04** (2013.01); **C07D 407/04** (2013.01); **C07D 409/04** (2013.01); **C07F 7/0814** (2013.01); **C07F 7/0816** (2013.01); **C09K 11/025** (2013.01); **C09K 11/06** (2013.01); **H01L 51/0052** (2013.01); **H01L 51/0054** (2013.01); **H01L 51/0058** (2013.01); **H01L 51/0067** (2013.01); **H01L 51/0072** (2013.01); **H01L 51/0073** (2013.01); **H01L**

51/0094 (2013.01); **H05B 33/20** (2013.01); **H01L 51/5016** (2013.01); **H01L 51/5056** (2013.01); **H01L 51/5072** (2013.01)

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COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE COMPRISING THE COMPOUND

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2014-0195955, filed on Dec. 31, 2014, in the Korean Intellectual Property Office, the entire content of which is incorporated herein by reference.

BACKGROUND

1. Field

One or more aspects of embodiments of the present disclosure relate to compounds and organic light-emitting devices including the same.

2. Description of the Related Art

Organic light-emitting devices (OLEDs), which are self-emitting devices, have wide viewing angles, excellent contrast, quick response, high brightness, excellent driving voltage characteristics, and can provide multicolored images.

An OLED has a structure including a substrate, and an anode, a hole transport layer (HTL), an emission layer (EML), an electron transport layer (ETL), and a cathode sequentially stacked on the substrate. The HTL, the EML, and the ETL are organic thin films formed of organic compounds.

An operating principle of an OLED having the structure as described above is as follows.

When a voltage is applied between the anode and the cathode, holes injected from the anode move to the EML via the HTL, and electrons injected from the cathode move to the EML via the ETL. The holes and electrons recombine in the EML to generate excitons. When the excitons drop from an excited state to a ground state, light is emitted.

There is an ongoing demand for a material having improved electrical stability, high charge-transport and/or emission capability, and a high enough glass transition temperature to prevent or substantially reduce crystallization, as compared to the existing unimolecular materials.

SUMMARY

One or more aspects of embodiments of the present disclosure are directed to a compound having improved electric characteristics, improved charge transporting and light-emitting capabilities, and a high glass transition temperature capable of preventing or substantially reducing crystallization. The compound can be available as an electron transporting material.

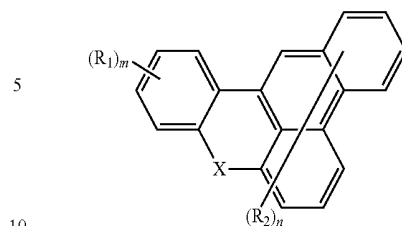
One or more aspects of embodiments of the present disclosure are directed to an organic light-emitting device including the compound, the organic light-emitting device having improved efficiency, low driving voltage, improved luminance, and improved lifetime.

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.

According to one or more embodiments of the present disclosure, there is provided a compound represented by Formula 1:

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Formula 1



In Formula 1,

R_1 and R_2 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_3)(Q_4)(Q_5), and —B(Q_6)(Q_7);

X is O, S, Se, Te, or Po; and

m and n are each independently an integer selected from 1 to 8, and

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

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

a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60}

heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{Si}(\text{Q}_{13})(\text{Q}_{14})(\text{Q}_{15})$, and $-\text{B}(\text{Q}_{16})(\text{Q}_{17})$,

a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_{21})(\text{Q}_{22})$, $-\text{Si}(\text{Q}_{23})(\text{Q}_{24})(\text{Q}_{25})$, and $-\text{B}(\text{Q}_{26})(\text{Q}_{27})$, and $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$, and $-\text{B}(\text{Q}_{36})(\text{Q}_{37})$;

Q_3 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} are each independently selected from 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, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group; and

when m and/or n is 2 or more, the R_1 s and/or R_2 s may respectively be the same as or different from each other.

According to one or more embodiments of the present disclosure, an organic light-emitting device includes: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes the compound of Formula 1.

According to one or more embodiments of the present disclosure, a flat panel display device includes the above-described organic light-emitting device, wherein the first electrode of the organic light-emitting device is electrically connected to a source electrode or a drain electrode of a thin-film transistor.

BRIEF DESCRIPTION OF THE DRAWING

These and/or other aspects will become apparent and more readily appreciated from the following description of

the embodiments, taken in conjunction with the accompanying drawing, which is a schematic cross-sectional view illustrating a structure of an organic light-emitting device according to one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

Reference will now be made to embodiments, examples of which are illustrated in the accompanying drawing, 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 drawing, 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" and "at least one selected from", when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. Further, the use of "may" when describing embodiments of the present invention refers to "one or more embodiments of the present invention."

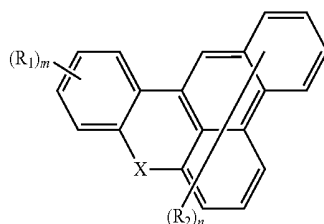
In addition, as used herein, the terms "use," "using," and "used" may be considered synonymous with the terms "utilize," "utilizing," and "utilized," respectively. Also, the term "exemplary" is intended to refer to an example or illustration.

As used herein, the term "substantially," "about," and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art.

Also, any numerical range recited herein is intended to include all subranges of the same numerical precision subsumed within the recited range. For example, a range of "1.0 to 10.0" is intended to include all subranges between (and including) the recited minimum value of 1.0 and the recited maximum value of 10.0, that is, having a minimum value equal to or greater than 1.0 and a maximum value equal to or less than 10.0, such as, for example, 2.4 to 7.6. Any maximum numerical limitation recited herein is intended to include all lower numerical limitations subsumed therein and any minimum numerical limitation recited in this specification is intended to include all higher numerical limitations subsumed therein. Accordingly, Applicant reserves the right to amend this specification, including the claims, to expressly recite any sub-range subsumed within the ranges expressly recited herein. All such ranges are intended to be inherently described in this specification such that amending to expressly recite any such subranges would comply with the requirements of 35 U.S.C. § 112, first paragraph, and 35 U.S.C. § 132(a).

According to one or more embodiments of the present disclosure, there is provided a compound represented by Formula 1:

Formula 1



In Formula 1,

R₁ and R₂ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₃)(Q₄)(Q₅), and —B(Q₆)(Q₇);

X is O, S, Se, Te, or Po; and

m and n are each independently an integer selected from 1 to 8, and

at least one substituent of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

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

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

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

a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇);

where Q₃ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group; and

when m and/or n is 2 or more, the R₁s and/or R₂s may respectively be the same as or different from each other.

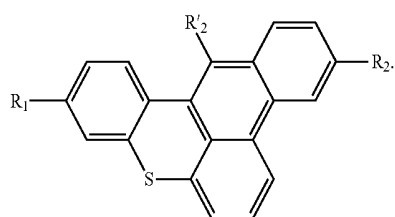
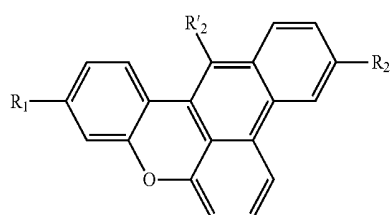
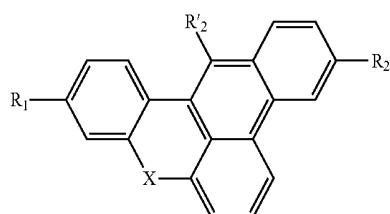
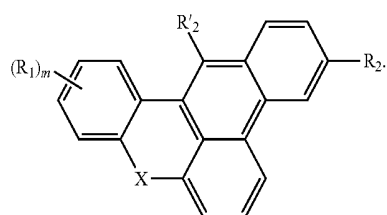
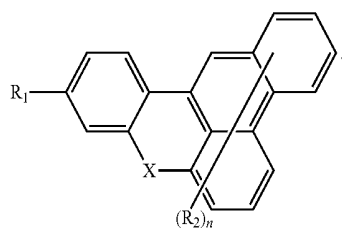
In a comparative organic light-emitting device, when a blue light-emitting compound having a diphenylanthracene structure with an aryl group substituted at a terminal thereof is included, the resulting organic light-emitting device fails to provide satisfactory light-emission efficiency and luminance.

Similarly, when an organic light-emitting device includes a pyrene-based compound, it is not able to implement a deep blue color due to poor color purity in blue light, and thus the resulting organic light-emitting device fails to implement a full natural-color display.

One or more embodiments of the present disclosure include a novel compound, and an organic light-emitting device that includes an organic layer including the novel compound. According to one or more embodiments, the novel compound is a material having improved electric characteristics, improved charge transporting and light-emitting capabilities, and a high glass transition temperature capable of preventing or substantially reducing crystallization. The novel compound is also suitable for use (or utilization) in fluorescent and/or phosphorescent devices of any colors, including but not limited to red, green, blue, and white. According to one or more embodiments, an organic light-emitting device including the novel compound may achieve deep blue light emission. As such, an organic light-emitting device including the novel compound may have improved efficiency, low driving voltage, improved luminance, and improved lifetime.

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In some embodiments, the compound of Formula 1 may be represented by any one of Formulae 2 to 6:



In Formulae 3 to 6, R'_2 may be the same as defined above in conjunction with R_1 and R_2 .

The substituents in Formulae 1 to 6 now will be described in greater detail.

In some embodiments, in Formulae 1 to 4, X may be O or S.

In some embodiments, in Formulae 1 to 6, R_1 may be a substituted or unsubstituted C_6 - C_{60} aryl group, or a substituted or unsubstituted C_2 - C_{60} heteroaryl group.

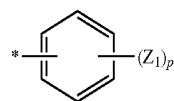
In some embodiments, in Formulae 1 to 6, R_2 may be a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

In some embodiments, in Formulae 3 to 6, R'_2 may be hydrogen, deuterium, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, or a substituted or unsubstituted C_2 - C_{60} heteroaryl group.

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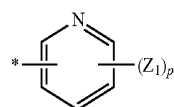
In some embodiments, in Formulae 1 to 6, R_1 may be a group represented by any one of Formulae 2a to 2f:

Formula 2 5



2a

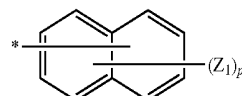
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2b

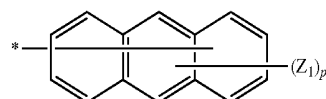
Formula 3

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2c

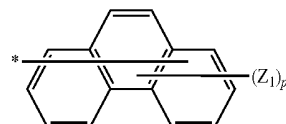
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2d

Formula 4

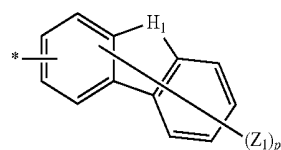
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2e

Formula 5

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2f

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In Formulae 2a to 2f,

Z_1 may be hydrogen, deuterium, a substituted or unsubstituted C_1 to C_{20} alkyl group, a substituted or unsubstituted C_6 to C_{20} aryl group, a substituted or unsubstituted C_2 to C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, a halogen group, a cyano group, a nitro group, a hydroxyl group or a carboxyl group;

H_1 may be $—O—$, or $—CR_{51}R_{52}—$;

may be an integer of 1 to 10;

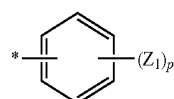
when p is 2 or more, Z_1 s may be the same as or different from each other;

R_{51} and R_{52} may be each independently a substituted or unsubstituted C_1 to C_{20} alkyl group, a substituted or unsubstituted C_6 to C_{20} aryl group, or a substituted or unsubstituted C_2 to C_{20} heteroaryl group; and

* indicates a binding site.

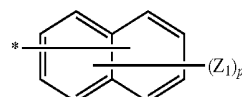
In some embodiments, in Formulae 1 to 6, R_2 may be a group represented by any one of Formulae 3a to 3g:

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3a

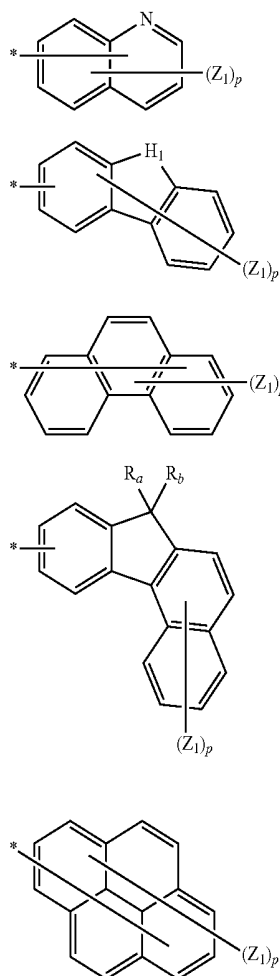
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3b

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-continued



In Formulae 3a to 3g,

Z_1 may be hydrogen, deuterium, a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted C2 to C20 heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, a halogen group, a cyano group, a nitro group, a hydroxyl group, or a carboxyl group;

H_1 may be $-O-$, $-S-$, $-CR_{51}R_{52}-$, or $-SiR_{61}R_{62}-$;

may be an integer of 1 to 9;

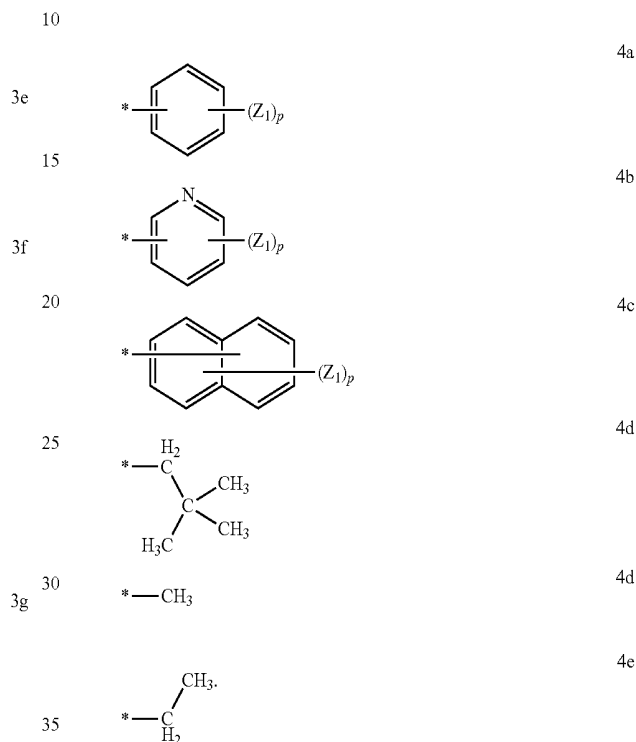
when p is 2 or more, Z_1 s may be the same as or different from each other;

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R_{51} , R_{52} , R_{61} , R_{62} , R_a , and R_b may be each independently a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted C2 to C20 heteroaryl group; and

* indicates a binding site.

In some embodiments, in Formulae 3 to 6, R'_2 may be hydrogen, deuterium, or a group represented by any one of Formulae 4a to 4e:



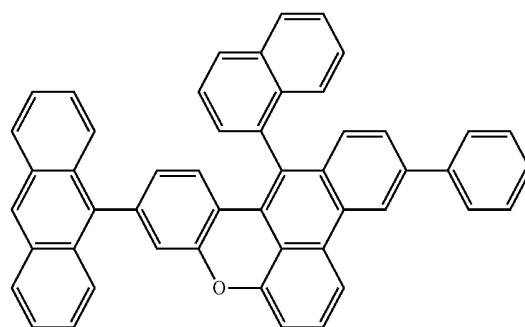
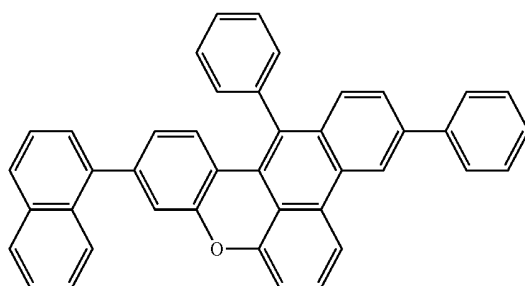
In Formulae 4a to 4e, Z_1 may be hydrogen, deuterium, a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted C2 to C20 heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, a halogen group, a cyano group, a nitro group, a hydroxyl group, or a carboxyl group;

may be an integer of 1 to 7; and

when p is 2 or more, Z_1 s may be the same as or different from each other; and

* indicates a binding site.

In some embodiments, the compound of Formula 1 may be one of Compounds 1 to 40, but is not limited thereto.



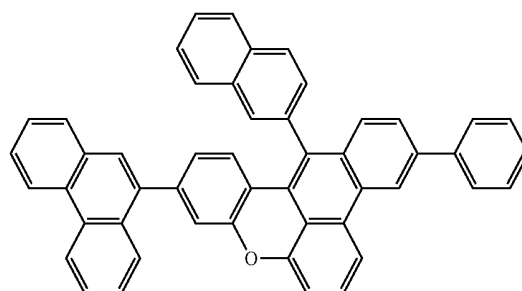
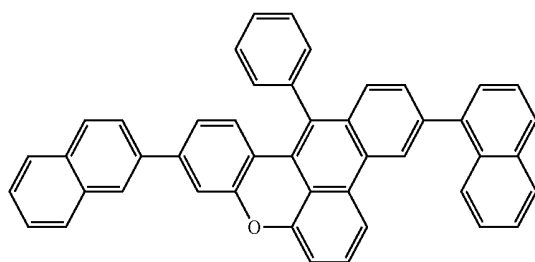
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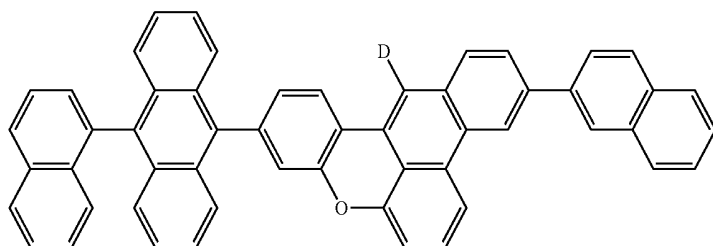
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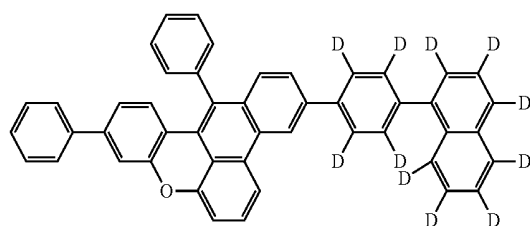
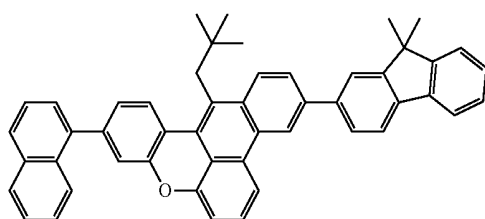


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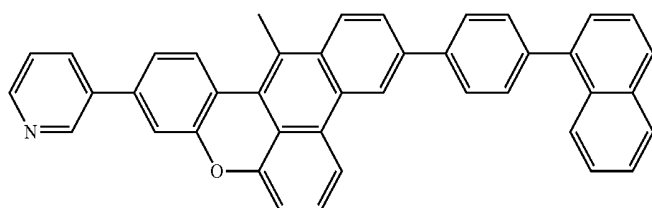


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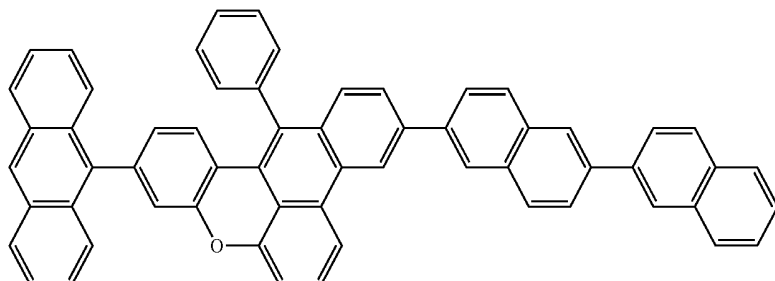
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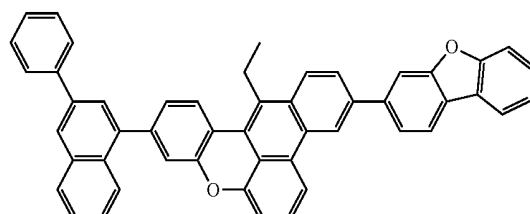
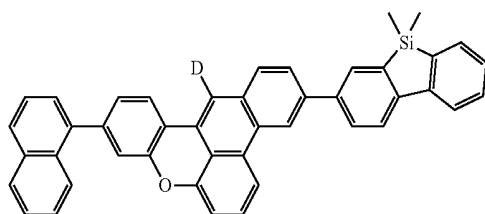


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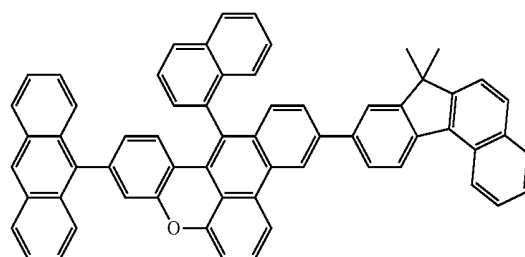
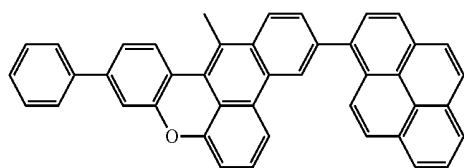
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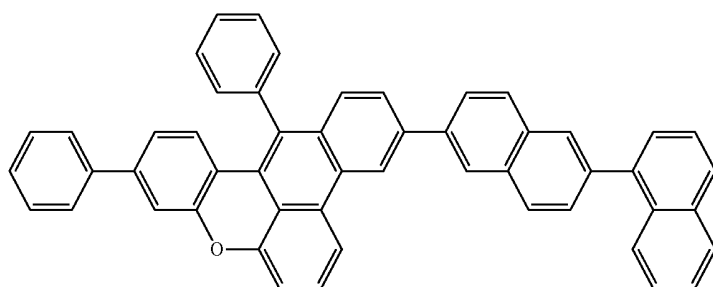
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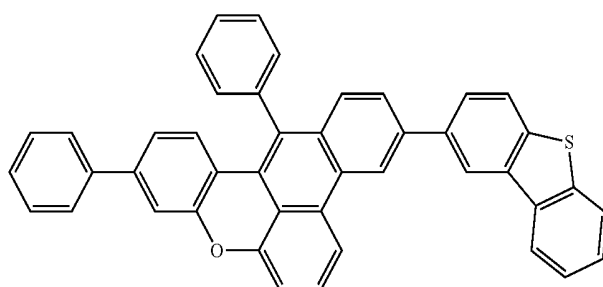
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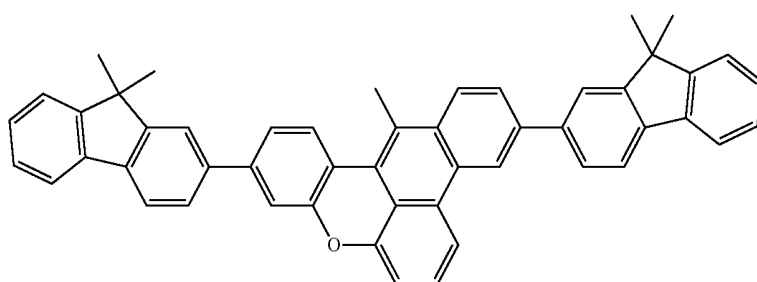
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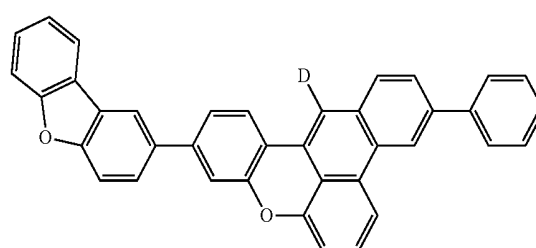
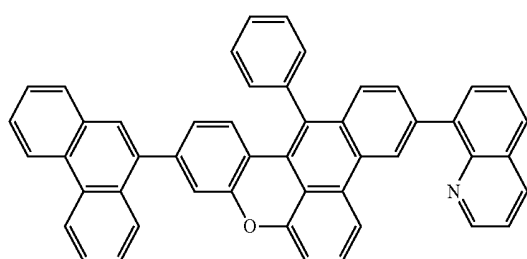


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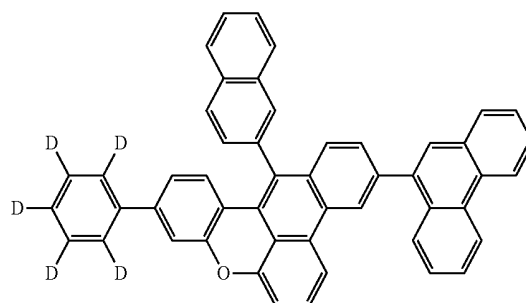
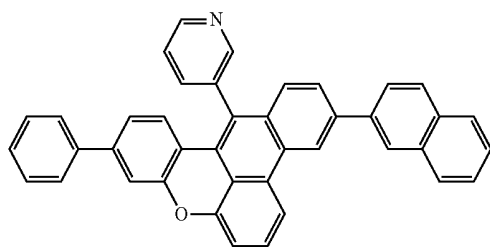
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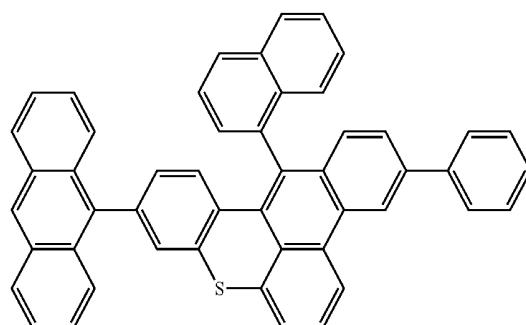
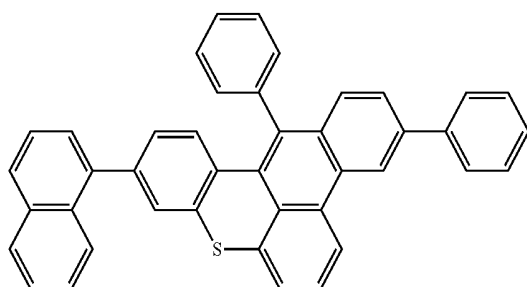
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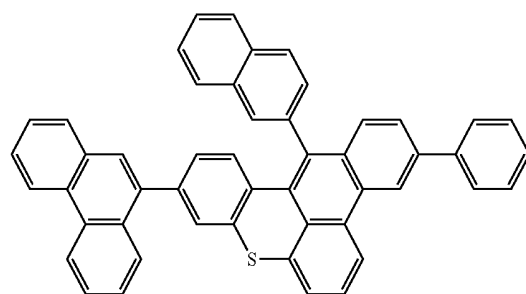
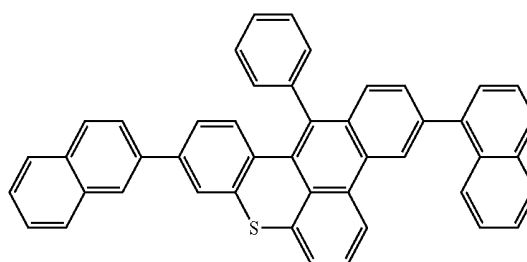
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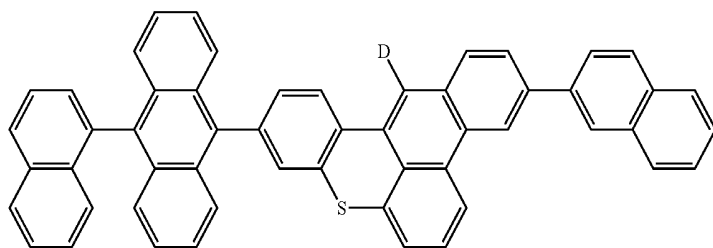


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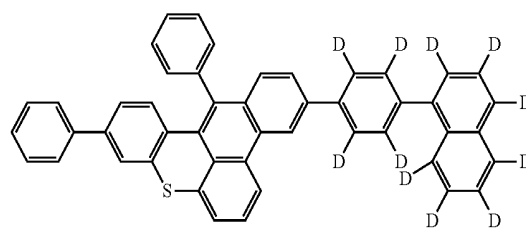
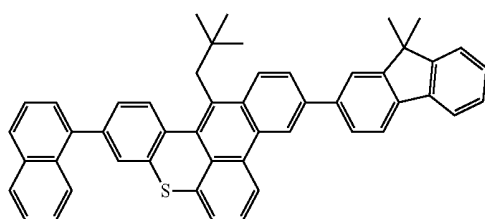


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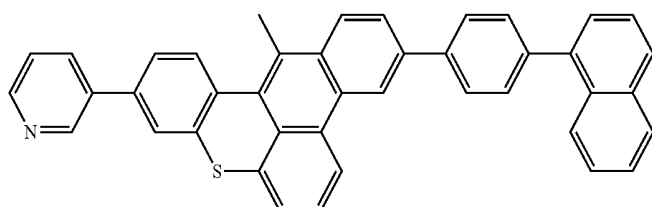


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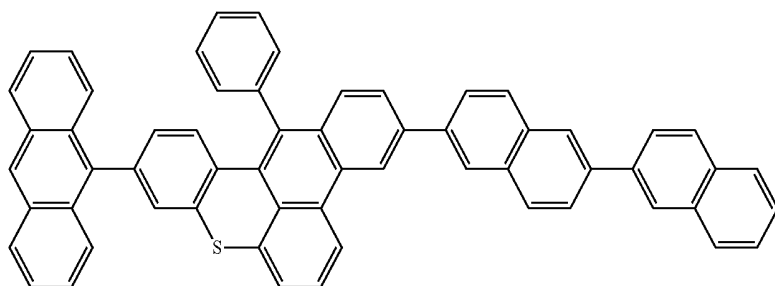


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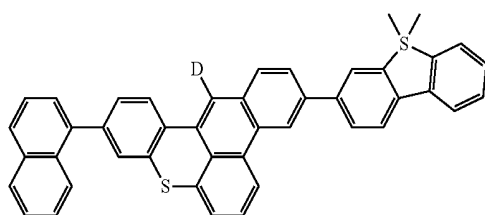
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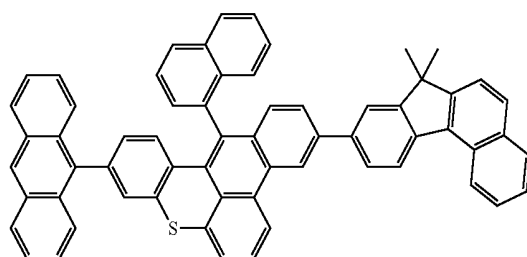
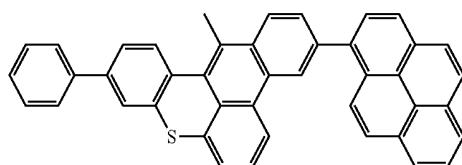
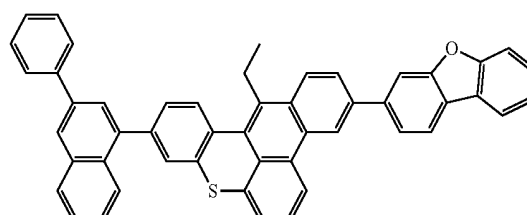
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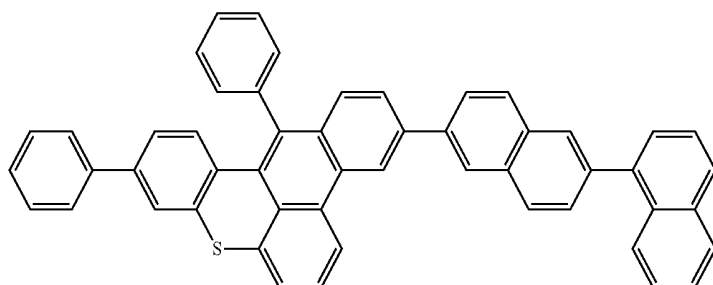


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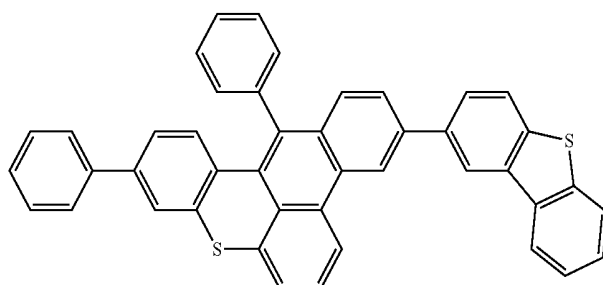
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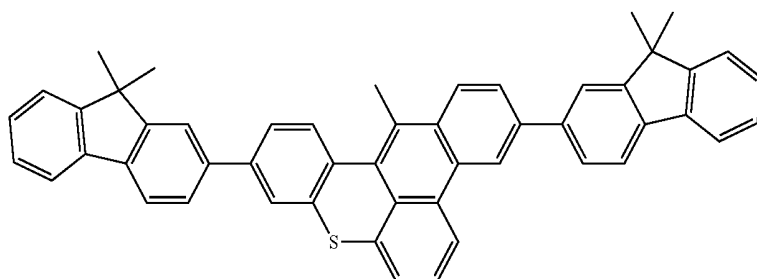
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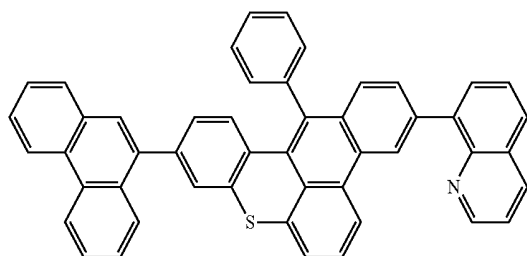
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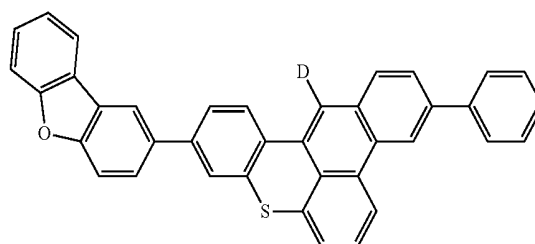
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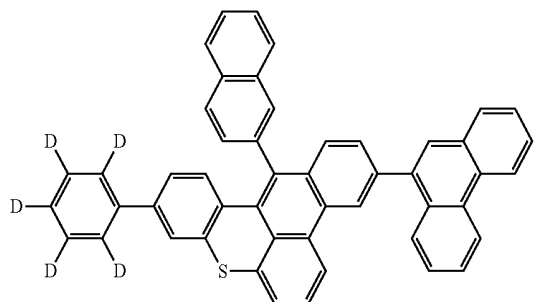
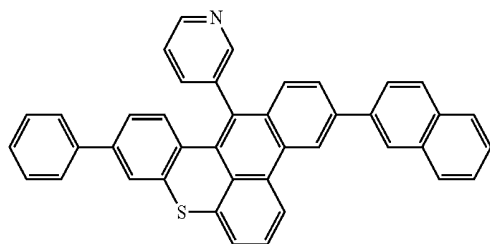
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According to one or more embodiments of the present disclosure, an organic light-emitting device includes: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer and the compound of Formula 1.

In some embodiments, in the organic light-emitting device, the first electrode may be an anode, the second electrode may be a cathode, and the organic layer may include i) a hole transport region between the first electrode and the emission layer, the hole transport region including at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer, and ii) an electron transport region between the emission layer and the second electrode, the electron transport region including at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

In some embodiments, the emission layer of the organic light-emitting device may include a compound of Formula 1 according to any of the above-described embodiments. In this regard, the compound of Formula 1 may be used as a host. For example, the compound of Formula 1 may be used as a blue host, for example, as a blue phosphorescent host. However, embodiments of the present disclosure are not limited thereto.

In some embodiments, the electron transport region of the organic light-emitting device may include the compound of Formula 1. For example, the compound of Formula 1 may be used in the electron transport layer. However, embodiments of the present disclosure are not limited thereto.

As used herein, the term “organic layer” refers to a single layer and/or a plurality of layers disposed between the first and second electrodes of the organic light-emitting device. The materials included in the organic layer are not limited to organic materials.

Hereinafter, a structure of an organic light-emitting device according to one or more embodiments of the present disclosure and a method of manufacturing the same will be described with reference to the drawing.

The drawing is a schematic cross-sectional view of an organic light-emitting device **10** according to some embodiments. Referring to the drawing, the organic light-emitting device **10** includes a first electrode **110**, an organic layer **150**, and a second electrode **190**.

A substrate may be positioned under the first electrode **110** or on the second electrode **190** in the drawing. The substrate may be a glass or transparent plastic substrate with good mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and/or water resistance.

For example, the first electrode **110** may be formed by depositing or sputtering a first electrode-forming material on the substrate. When the first electrode **110** is an anode, a material having a high work function may be used (utilized) as the first electrode-forming material so as to facilitate hole injection. The first electrode **110** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. Transparent and conductive materials such as ITO, IZO, SnO₂, and/or ZnO may be used to form the first electrode. When the first electrode **110** as a semi-transmissive electrode or a reflective electrode, the first electrode-forming material may include at least one material selected from magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag).

The first electrode **110** may have a single-layer structure or a multi-layer structure including a plurality of layers. For example, the first electrode **110** may have a three-layered structure of ITO/Ag/ITO, but is not limited thereto.

The organic layer **150** may be positioned on the first electrode **110**. The organic layer **150** may include an emission layer (EML).

The organic layer **150** may further include a hole transport region between the first electrode and the EML, and an electron transport region between the EML and the second electrode.

For example, the hole transport region may include at least one selected from a hole injection layer (HIL), a hole transport layer (HTL), a buffer layer, and an electron block-

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ing layer (EBL). The electron transport layer may include at least one selected from a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL). However, embodiments of the present disclosure are not limited thereto.

The hole transport region may have a single-layered structure including a single material, a single-layered structure including a plurality of materials, or a multi-layered structure including a plurality of layers including different materials.

In some embodiments, the hole transport region may have a single-layered structure including a plurality of materials, or a multi-layered structure of HIL/HTL, HIL/HTL/buffer layer, HIL/buffer layer, HTL/buffer layer, or HIL/HTL/EBL, wherein the layers forming a multi-layered structure are sequentially disposed on the first electrode **110** in the order stated above. However, embodiments of the present disclosure are not limited thereto.

When the hole transport region includes a HIL, the HIL may be formed on the first electrode **110** by using (utilizing) one or more suitable methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), and/or the like.

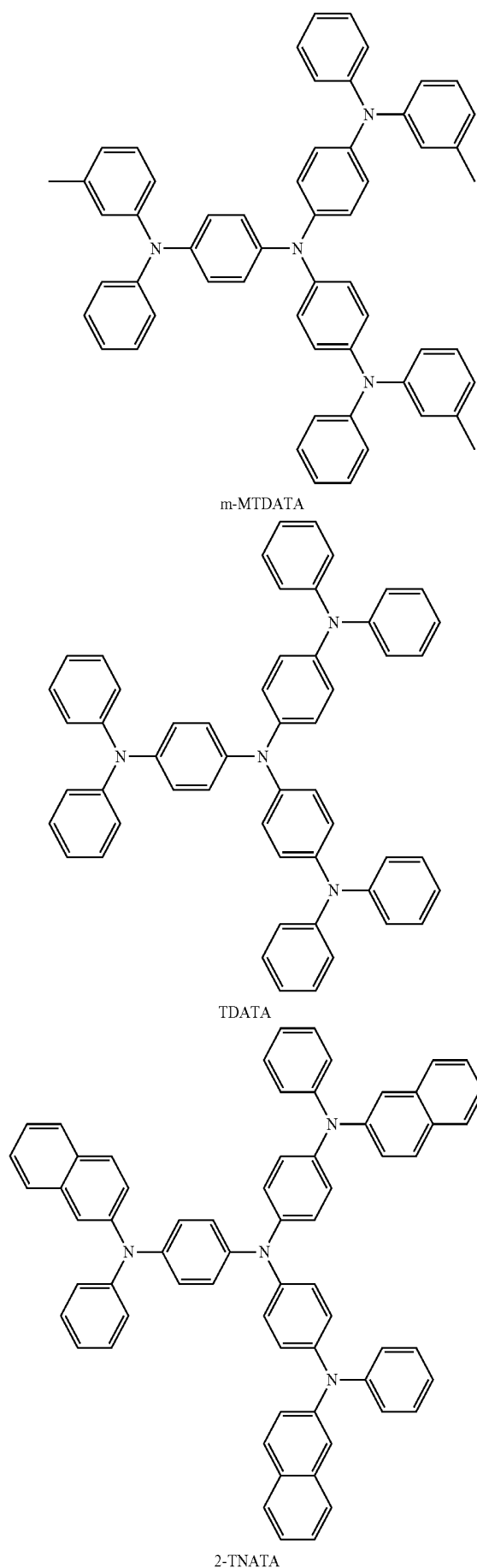
When the HIL is formed using vacuum deposition, the deposition conditions may vary depending on the material that is used to form the HIL and the structure of the HIL. For example, the deposition conditions may include a deposition temperature of about 100° C. to about 500° C., a degree of vacuum of about 10⁻⁸ to about 10⁻³ torr, and a deposition rate of about 0.01 to 100 Å/sec.

When the HIL is formed using spin coating, the coating conditions may vary depending on the material that is used to form the HIL and the structure of the HIL. For example, the coating conditions may include a coating rate of about 2,000 rpm to about 5,000 rpm and a heat treatment temperature of about 80° C. to about 200° C.

When the hole transport region includes a HTL, the HTL may be formed on the first electrode **110** or the HIL by using (utilizing) one or more suitable methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), and/or the like. When the HTL is formed using vacuum deposition and/or spin coating, the conditions for deposition and coating may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

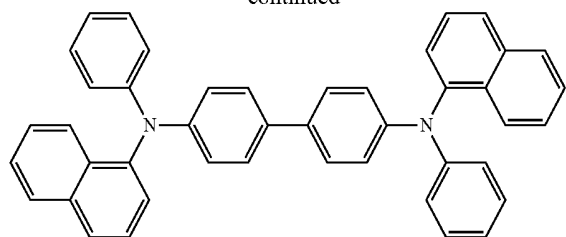
In some embodiments, the hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, β -NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate)(PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202.

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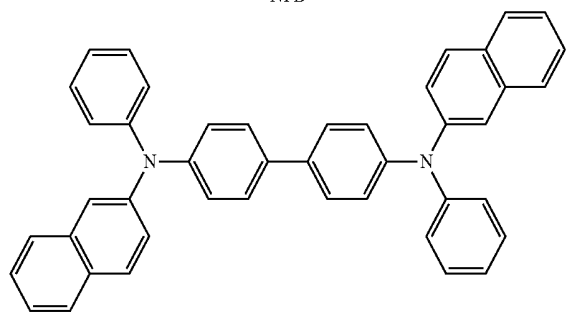
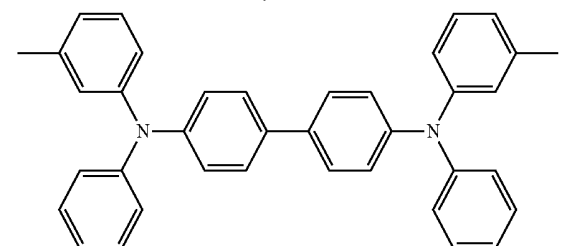


23

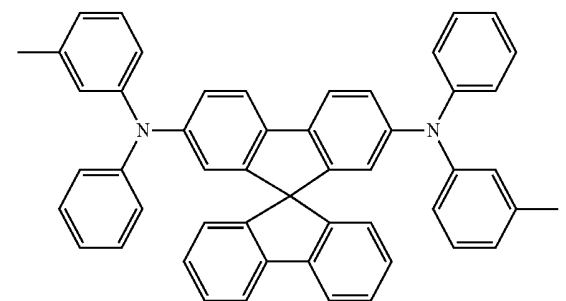
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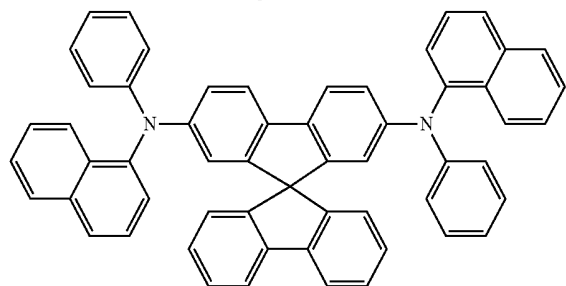
NPB

 β -NPB

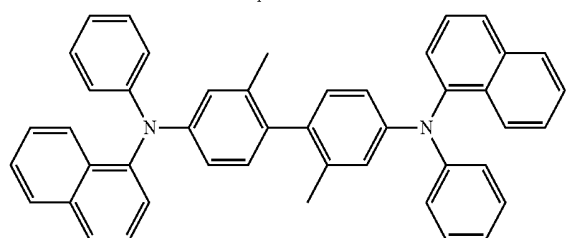
TPD



Spiro-TPD



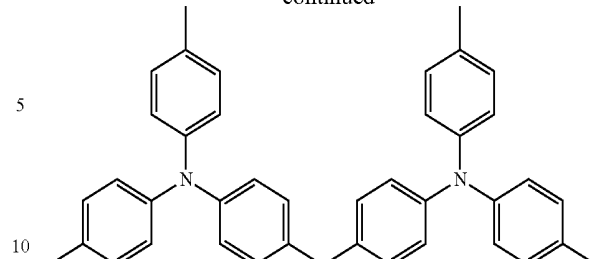
Spiro-NPB



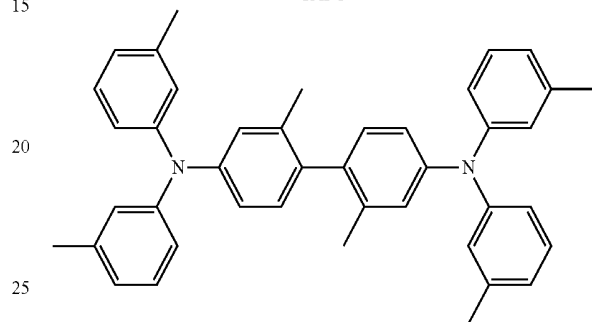
methylated NPB

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-continued

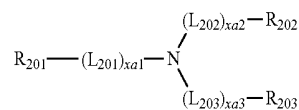


TAPC

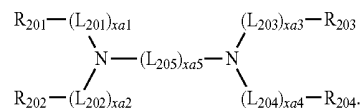


HMTDP

Formula 201



Formula 202



In Formulae 201 and 202,

L_{201} to L_{205} may be each independently selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_2 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

$\text{xa}1$ to $\text{xa}4$ may be each independently selected from 0, 1, 2, and 3;

$\text{xa}5$ may be selected from 1, 2, 3, 4, and 5; and

R_{201} to R_{204} may be each independently selected from a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent nonaromatic condensed polycyclic group, and a substituted or unsubstituted monovalent nonaromatic condensed heteropolycyclic group.

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For example, in Formulae 201 and 202,

L_{201} to L_{205} may be each independently selected from:

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysénylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolylene group, and a triazinylenylene group, and

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysénylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolylene group, and a triazinylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalynyl group, a quinazolynyl group, a carbazolyl group, and a triazinyl group;

$xa1$ to $xa4$ may be each independently 0, 1, or 2;

$xa5$ may be 1, 2, or 3;

R_{201} to R_{204} may be each independently selected from:

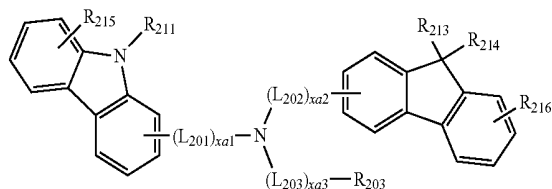
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalynyl group, a quinazolynyl group, a carbazolyl group, and a triazinyl group, and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalynyl group, a quinazolynyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalynyl group, a quinazolynyl group, a carbazolyl group, and a triazinyl group, but are not limited thereto.

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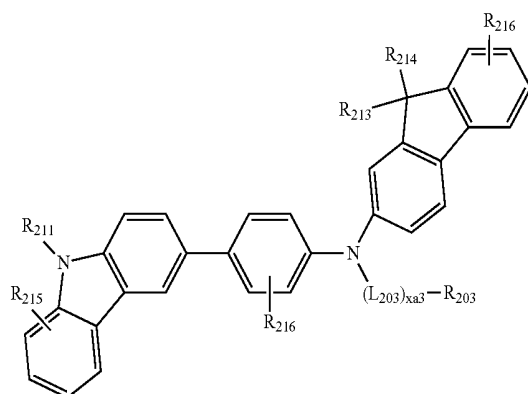
The compound of Formula 201 may be a compound represented by Formula 201A:

Formula 201A



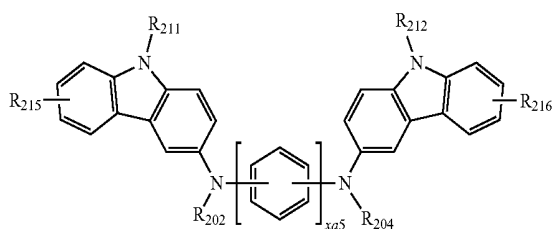
For example, the compound of Formula 201 may be a compound represented by Formula 201A-1, but is not limited thereto.

Formula 201A-1



The compound of Formula 202 may be a compound represented by Formula 202A, but is not limited thereto.

Formula 202A



In Formulae 201A, 201A-1, and 202A,

L_{201} to L_{203} , $xa1$ to $xa3$, $xa5$, and R_{202} to R_{204} may be the same as those described herein;

R_{211} may be defined as described herein in conjunction with R_{203} ; and

R_{213} to R_{216} may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl 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_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group,

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group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

R₂₁₃ and R₂₁₄ may be each independently selected from:
a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group,

a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each

substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro

group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group.

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a

carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

R₂₁₅ and R₂₁₆ may be each independently selected from:
hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl

group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, and a C₁-C₂₀ alkoxy group,

a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group,

a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from deuterium, —F,

—Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a

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pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

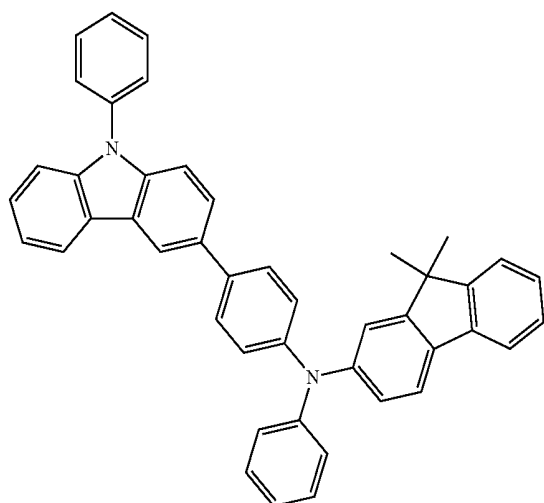
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

xa5 may be 1 or 2.

In Formulae 201A and 201A-1, R₂₁₃ and R₂₁₄ may be linked to each other to form a saturated or unsaturated ring.

The compound of Formula 201 and the compound of Formula 202 may each independently be selected from Compounds HT1 to HT20, but are not limited thereto.



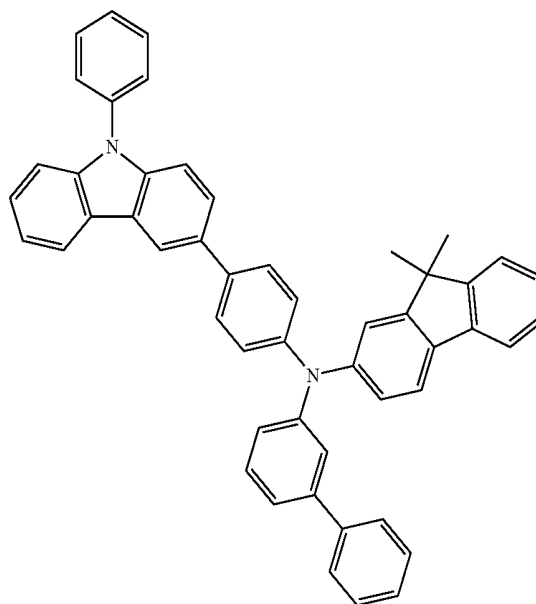
HT1

65

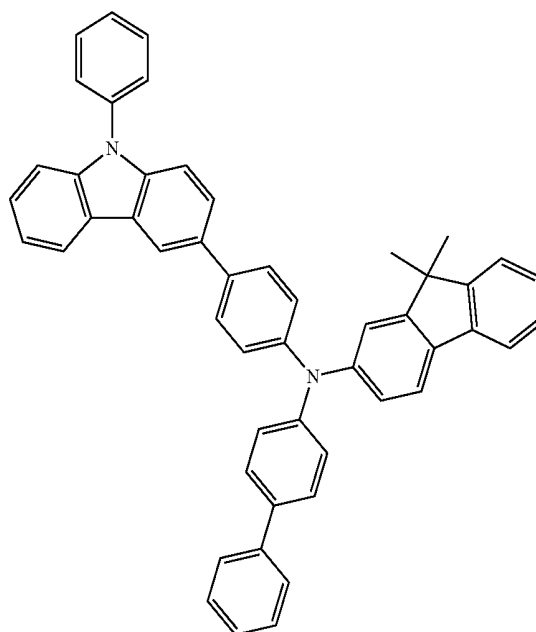
30

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HT2



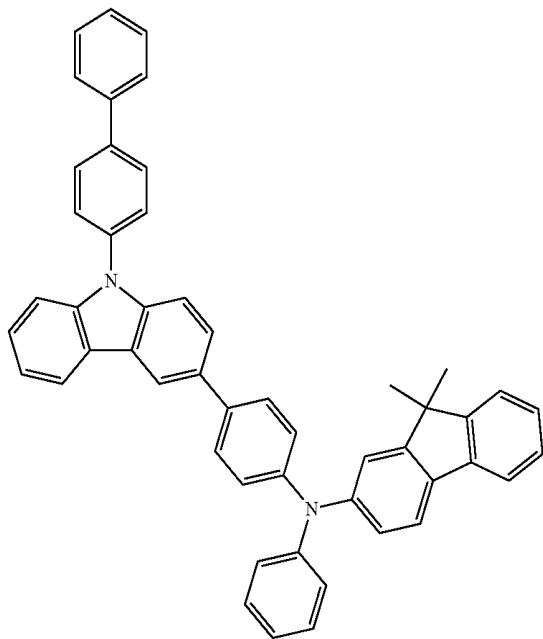
HT3



31

-continued

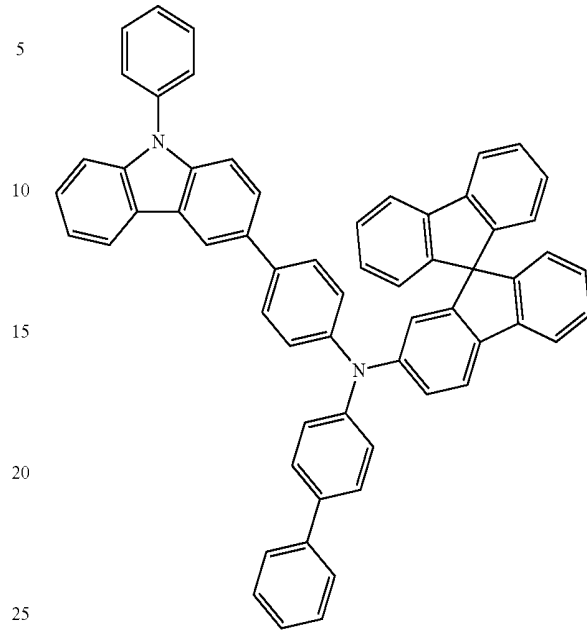
HT4



32

-continued

HT6



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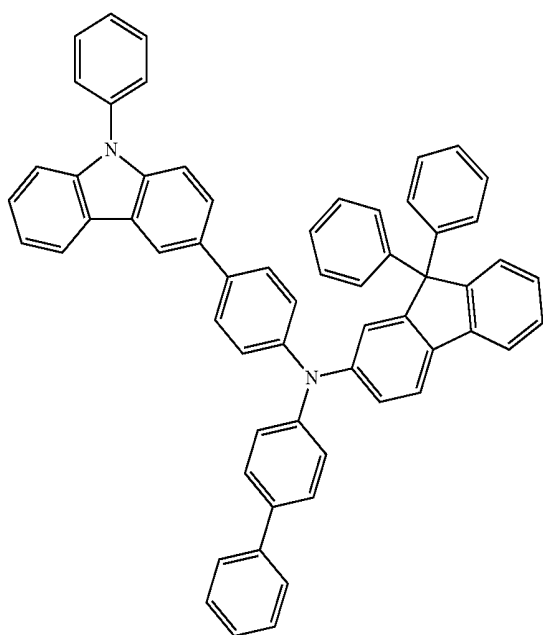
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HT5



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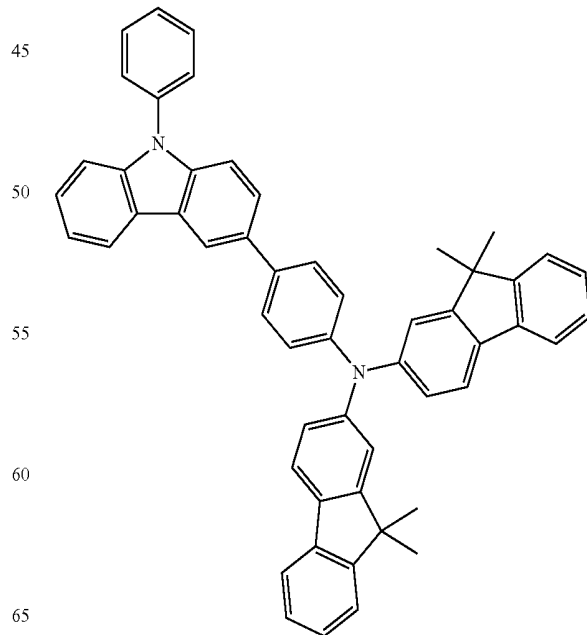
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60

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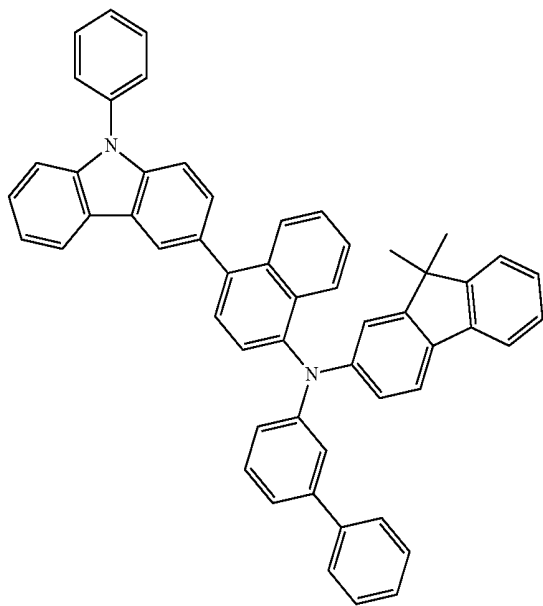
HT7



33

-continued

HT8



34

-continued

HT10

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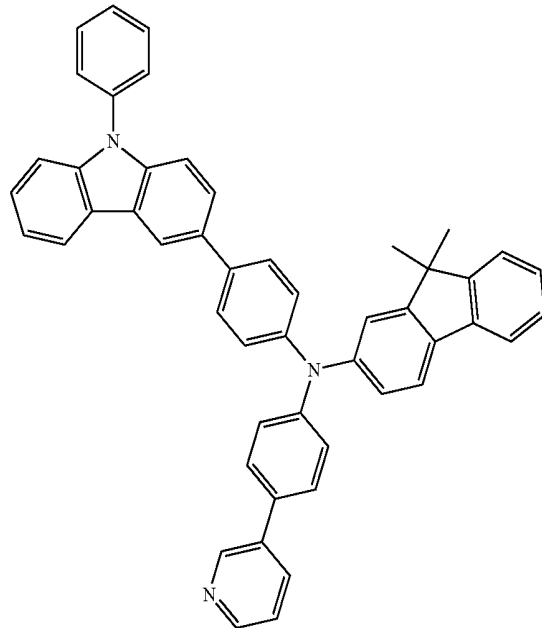
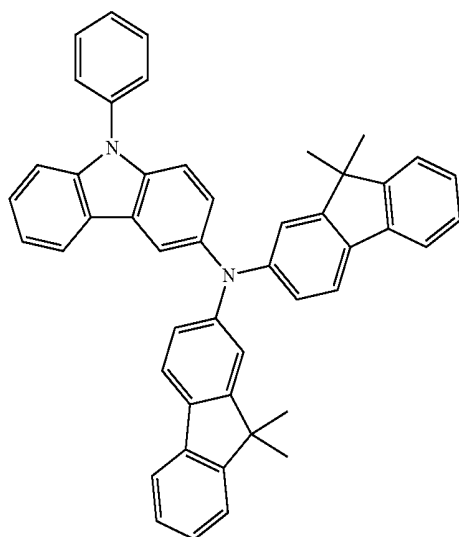
HT9

50

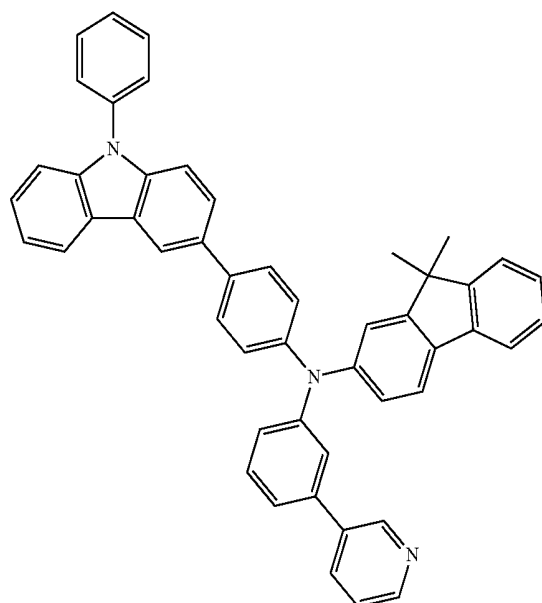
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60

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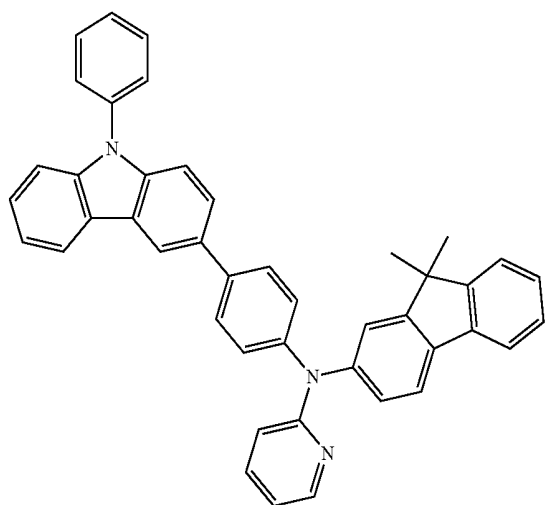


HT11



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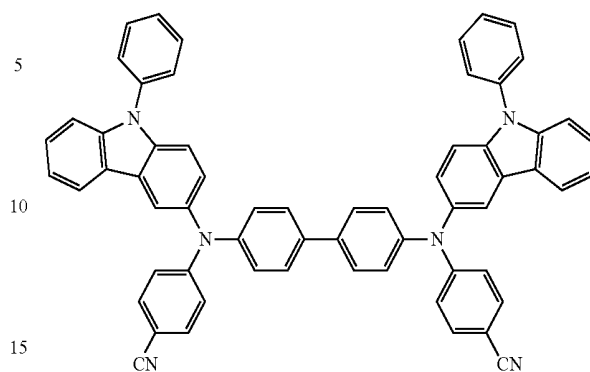
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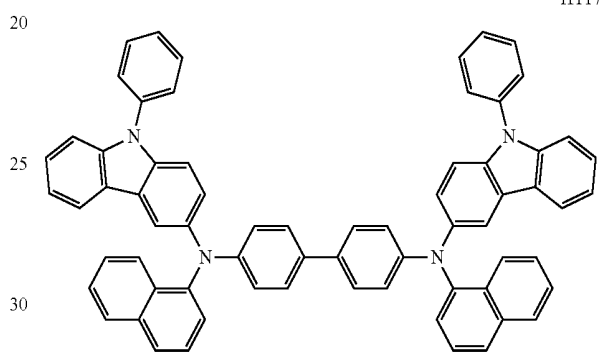
HT12

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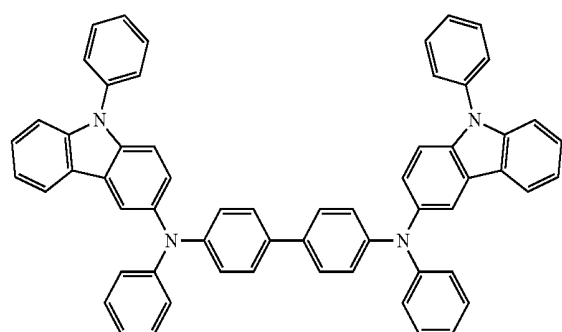
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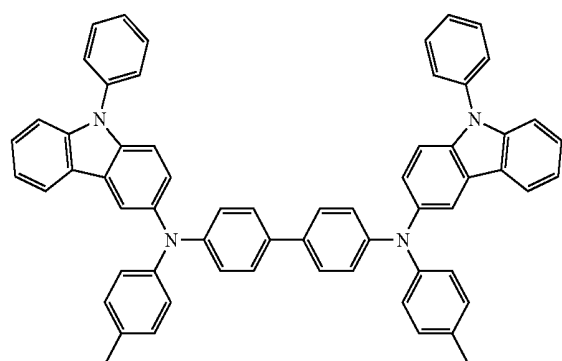
HT16



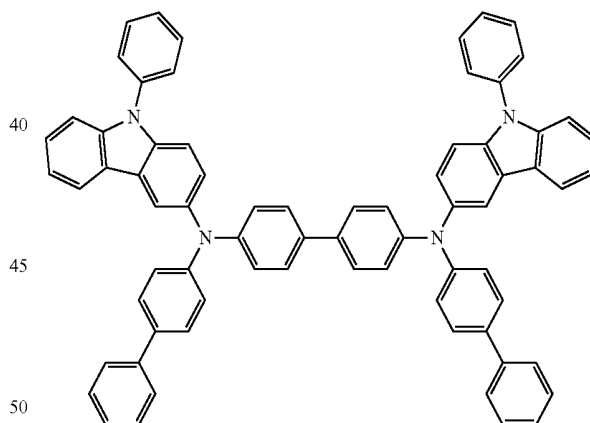
HT17



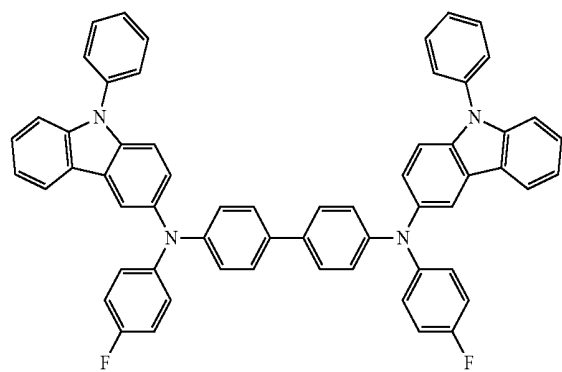
HT13



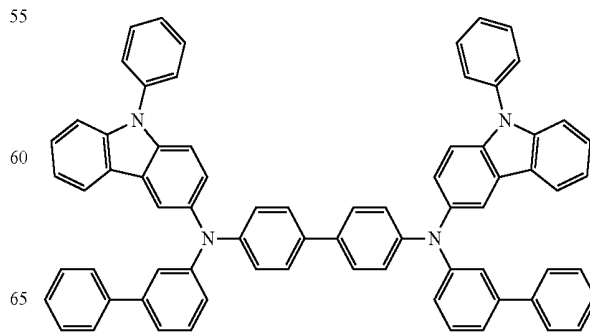
HT14



HT18



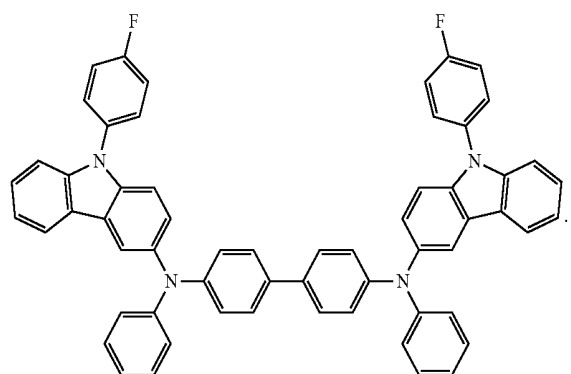
HT15



HT19

37

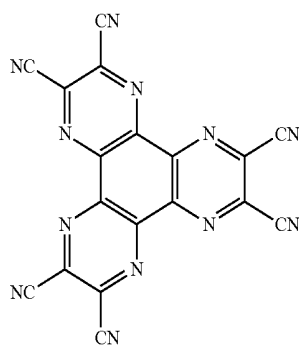
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A thickness of the hole transport region may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 1,000 Å. When the hole transport region includes a HIL and a HTL, a thickness of the HIL may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 9,950 Å, or from about 100 Å to about 1,000 Å, and a thickness of the HTL may be from about 50 Å to about 2,000 Å, and in some embodiments, from about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the HIL, and the HTL are within any of these ranges, satisfactory hole transport characteristics may be obtained without a substantial increase in driving voltage.

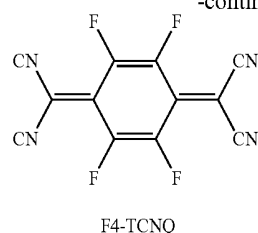
The hole transport region may further include a charge-generating material to improve conductivity, in addition to the materials described above. The charge-generating material may be homogeneously or inhomogeneously dispersed in the hole transport region.

The charge-generating material may be, for example, a p-dopant. The p-dopant may be selected from quinone derivatives, metal oxides, and cyano group-containing compounds, but is not limited thereto. Non-limiting examples of the p-dopant include quinone derivatives such as tetracyanoquinonodimethane (TCNQ), 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonodimethane (F4-TCNQ), and/or the like; metal oxides such as tungsten oxide, molybdenum oxide, and/or the like; and Compound HT-D1.



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The hole transport region may further include at least one of a buffer layer and an EBL, in addition to the HIL and HTL described above. The buffer layer may compensate for an optical resonance distance of light according to a wavelength of the light emitted from the EML, and thus may improve light-emission efficiency. A material in the buffer layer may be any suitable material used in the hole transport region. The EBL may block migration of electrons from the electron transport region into EML.

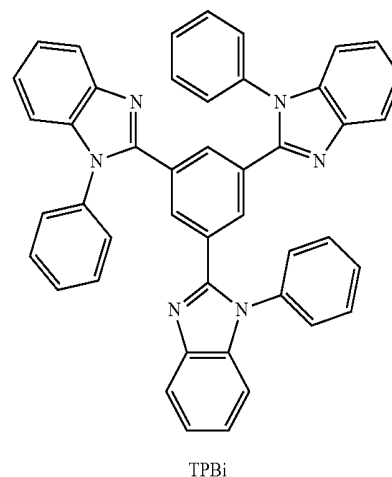
The EML may be formed on the first electrode **110** or the hole transport region by using one or more suitable methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), and/or the like. When the EML is formed using vacuum deposition and/or spin coating, the deposition and coating conditions for forming the EML may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

When the organic light-emitting device **10** is a full color organic light-emitting device, the EML may be patterned into a red emission layer, a green emission layer, and a blue emission layer to correspond to individual subpixels, respectively. In some embodiments, the EML may have a structure in which a red emission layer, a green emission layer and a blue emission layer are stacked upon one another, or a structure including a mixture of a red light-emitting material, a green light-emitting material, and a blue light-emitting material, without separation of layers for the different color emission, to emit white light.

The EML may include a host and a dopant.

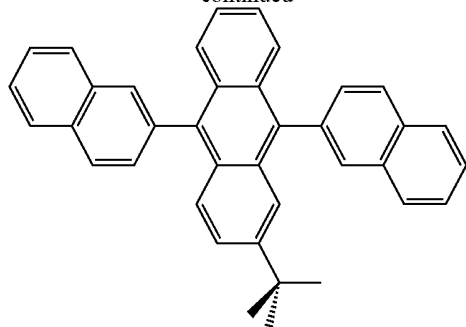
The EML may include the compound of Formula 1 according to any of the above-described embodiments as a host. The EML may further include a known and/or suitable host, in addition to the compound of Formula 1.

In some embodiments, the host may include at least one selected from TPBi, TBADN, AND (also referred to herein as "DNA" or "ADN"), CBP, CDBP, and TCP.

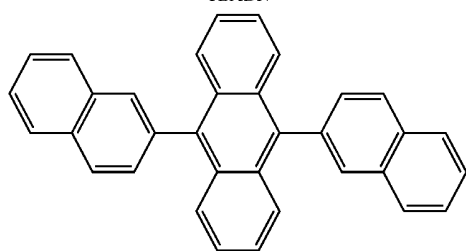


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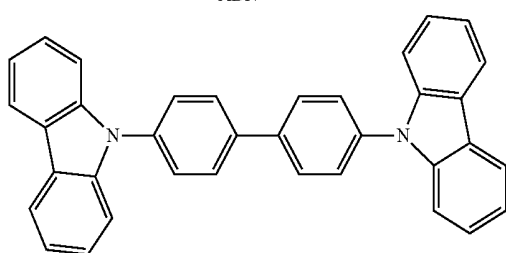
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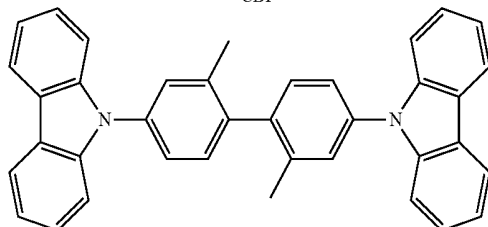
TBADN



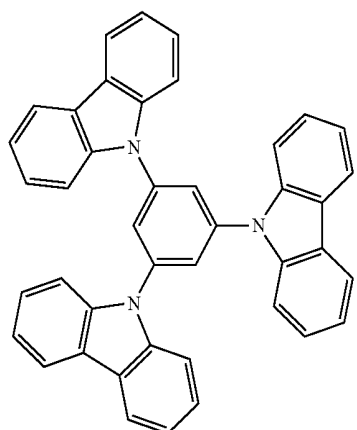
ADN



CBP

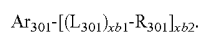


CDBP



TCP

In some embodiments, the host may include a compound represented by Formula 301.



Formula 301

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In Formula 301,

 Ar_{301} may be selected from:

- a naphthalene group, a heptalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, and an indenoanthracene group, and
- a naphthalene group, a heptalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, and an indenoanthracene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q_{301})(Q_{302})(Q_{303}) (where Q_{301} to Q_{303} are each independently selected from hydrogen, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, and a $\text{C}_2\text{-C}_{60}$ heteroaryl group);

L_{301} may be defined as described herein in conjunction with L_{201} ;

 R_{301} may be selected from:

- a $\text{C}_1\text{-C}_{20}$ alkyl group and a $\text{C}_1\text{-C}_{20}$ alkoxy group,
- 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 selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,
- a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and
- a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one

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selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

xb1 may be selected from 0, 1, 2, and 3;

xb2 may be selected from 1, 2, 3, and 4.

For example, in Formula 301,

L₃₀₁ may be selected from:

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, and a chrysenylene group, and

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, and a chrysenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group; and

R₃₀₁ may be selected from:

a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group,

a C₁-C₂₀ alkyl group and a C₁-C₂₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group,

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group, and

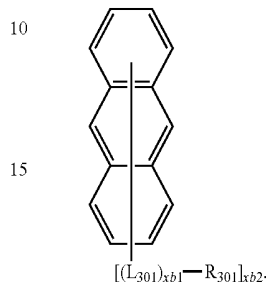
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl

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group, a pyrenyl group, and a chrysenyl group. However, embodiments of the present disclosure are not limited thereto.

In some embodiments, the host may include a compound represented by Formula 301A.

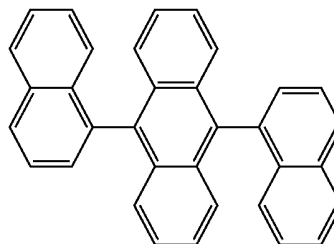
Formula 301A



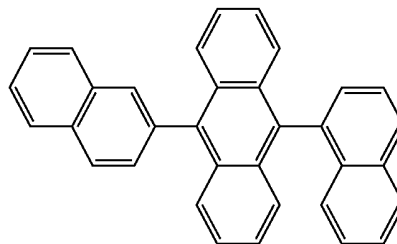
In Formula 301A, substituents may be defined as they are described herein.

The compound of Formula 301 may include at least one selected from Compounds H1 to H42, but is not limited thereto.

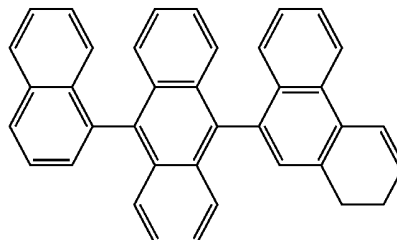
H1



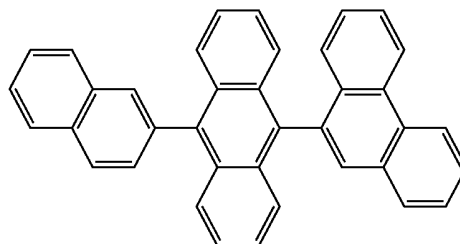
H2



H3

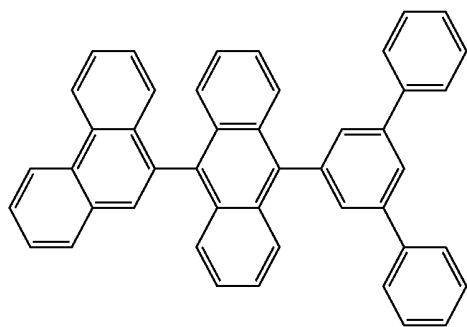
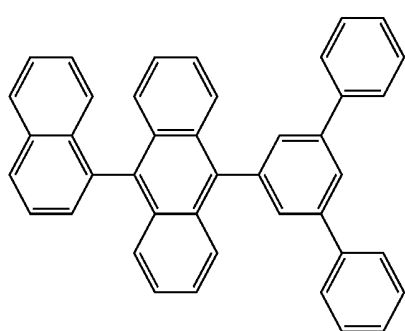
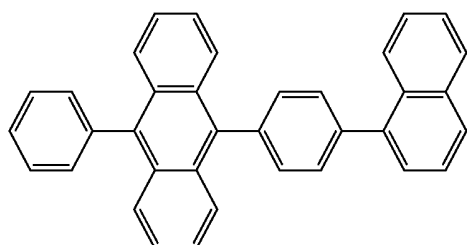
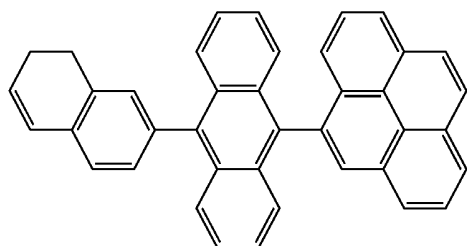
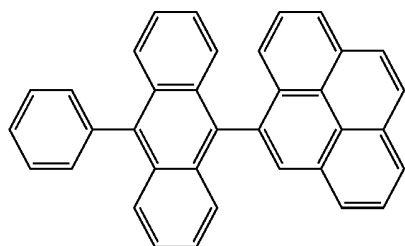
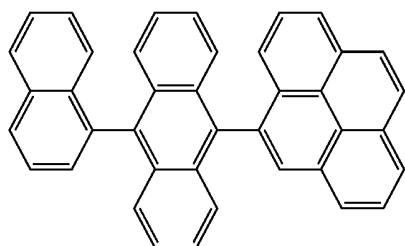


H4



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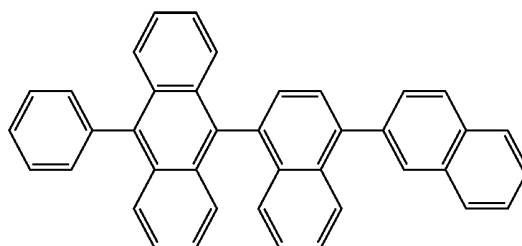
**44**

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H5

H11

5

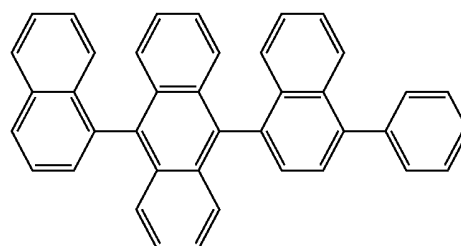


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H6

15

H12

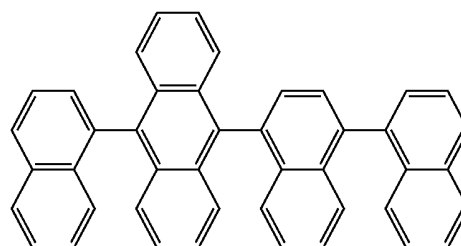


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H7

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H13

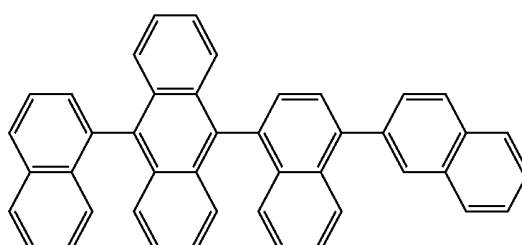


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H8

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H14

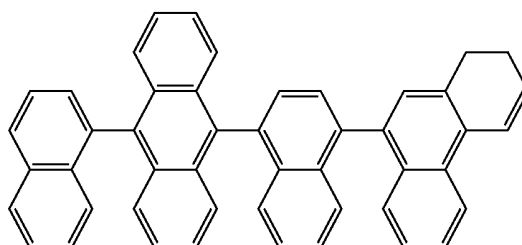


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H9

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H15

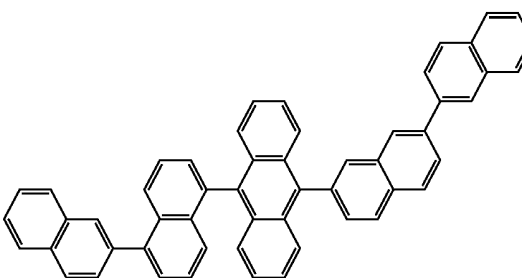


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H10

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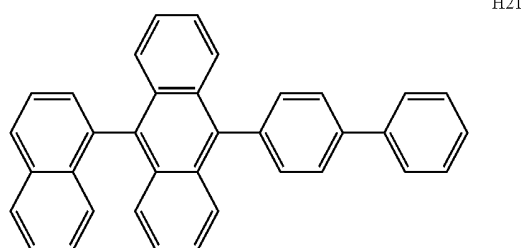
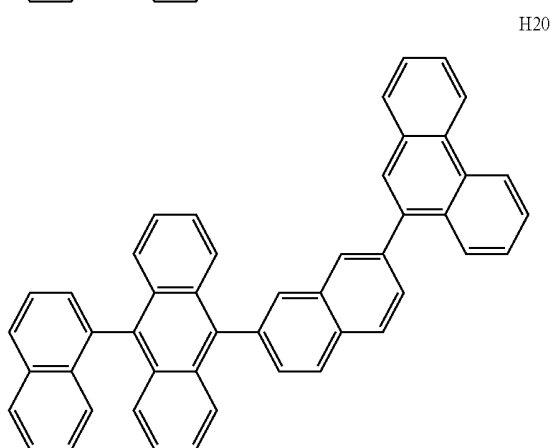
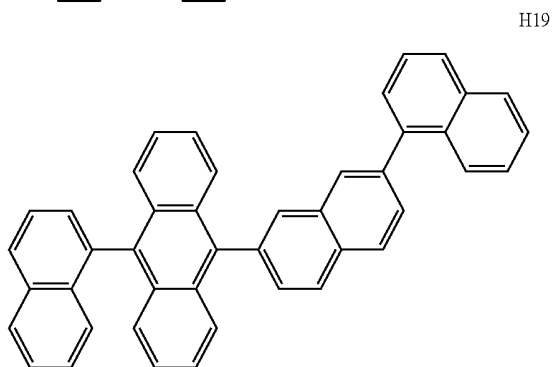
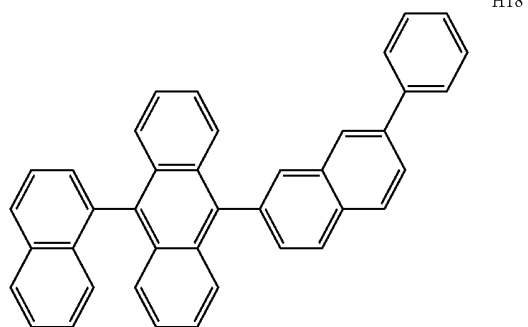
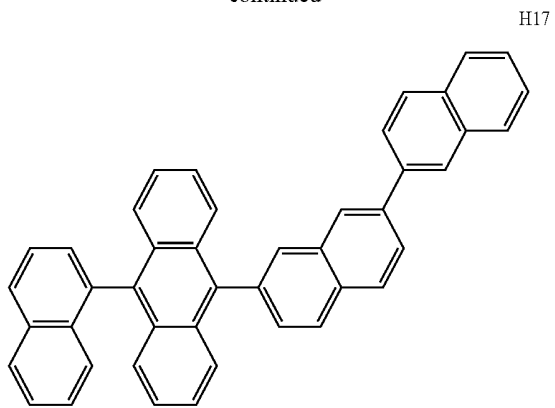
H16



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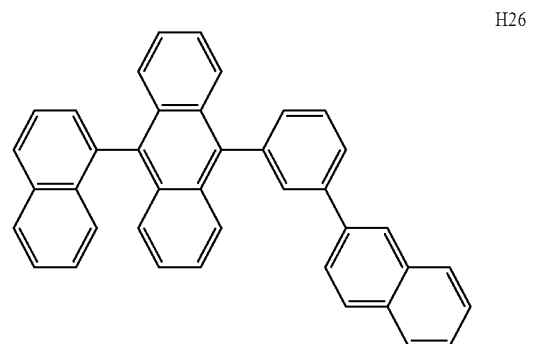
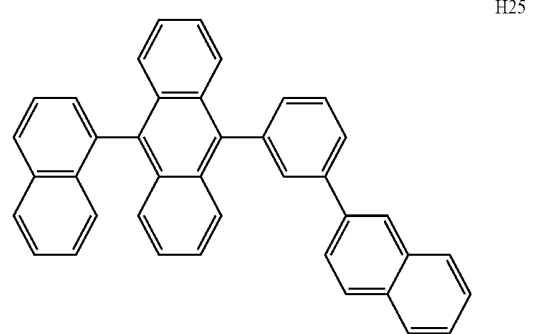
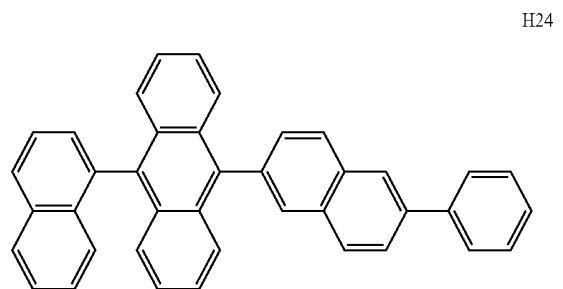
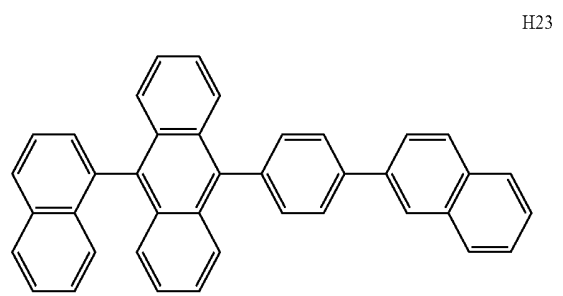
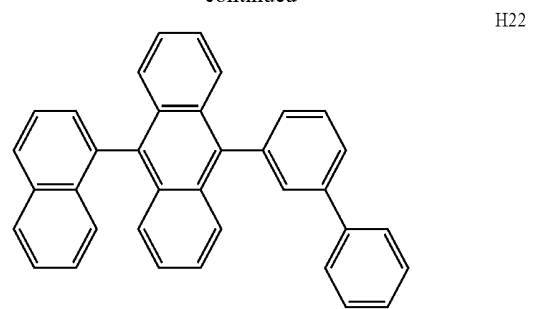
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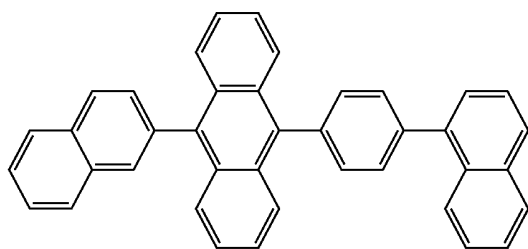
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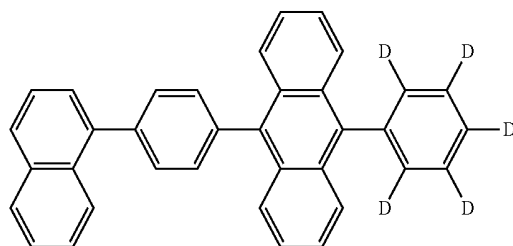
H27



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H28

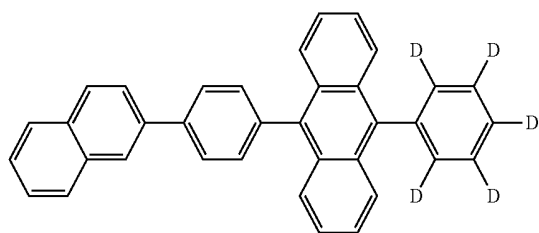


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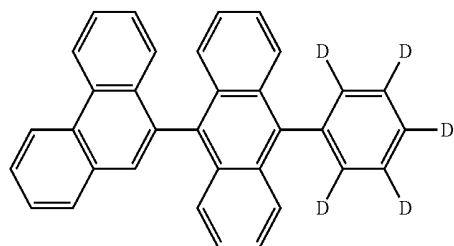
H29



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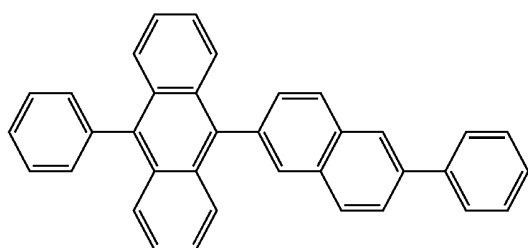
H30



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H31



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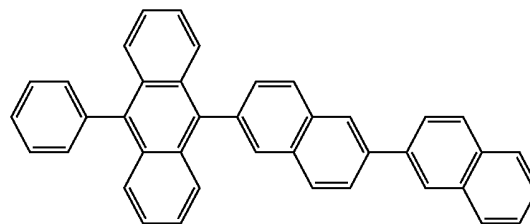
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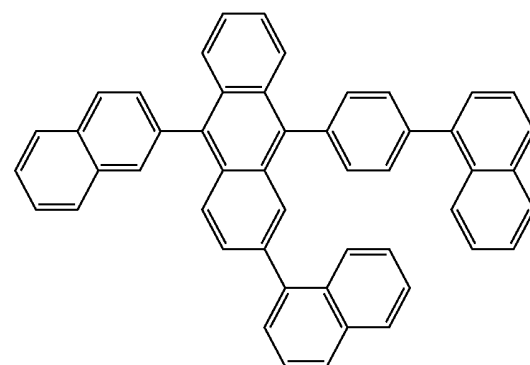
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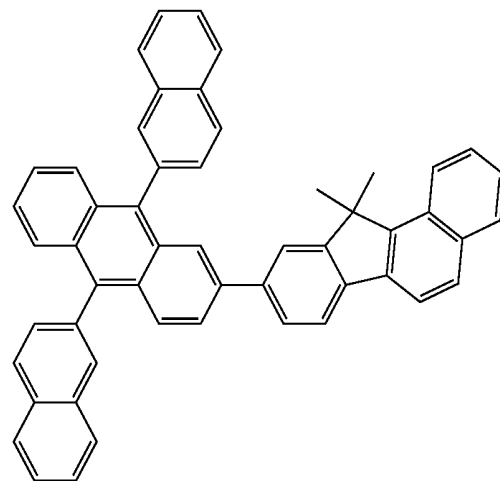
H32



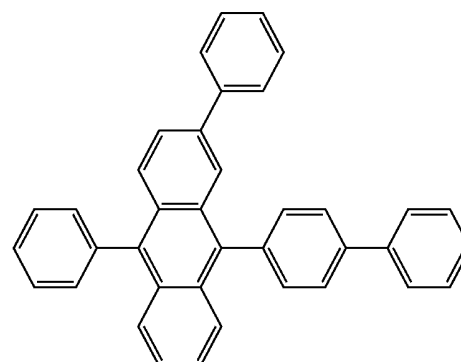
H33



H34

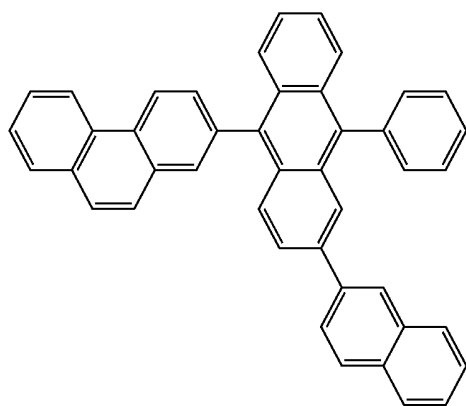
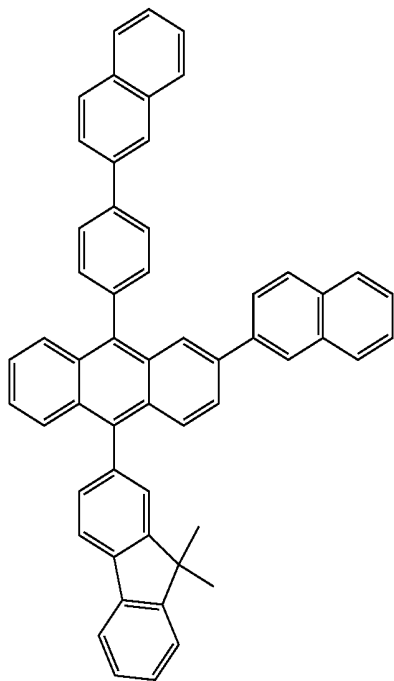
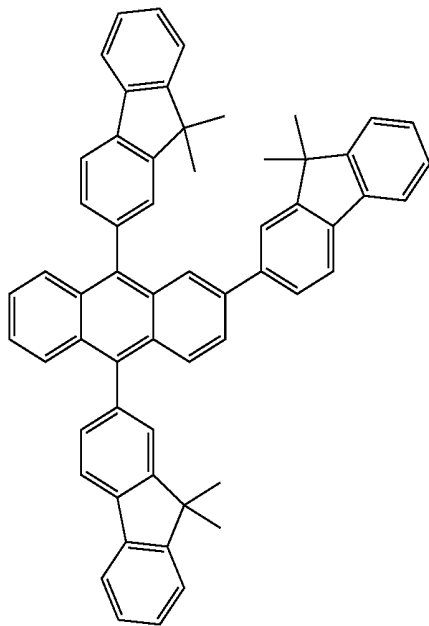


H35



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-continued



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H36

H39

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H37

H40

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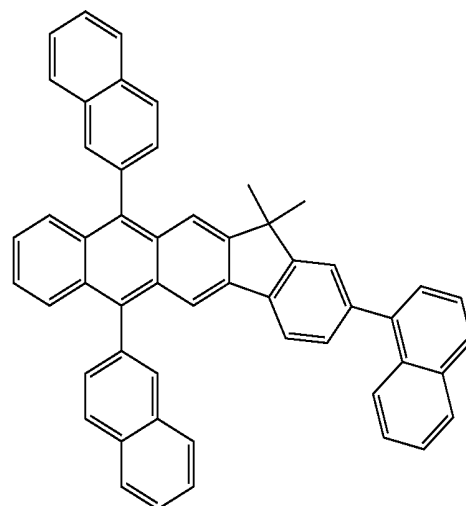
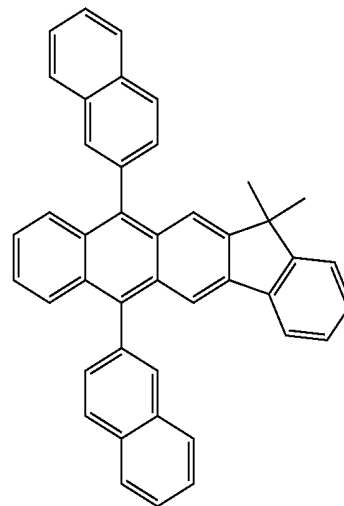
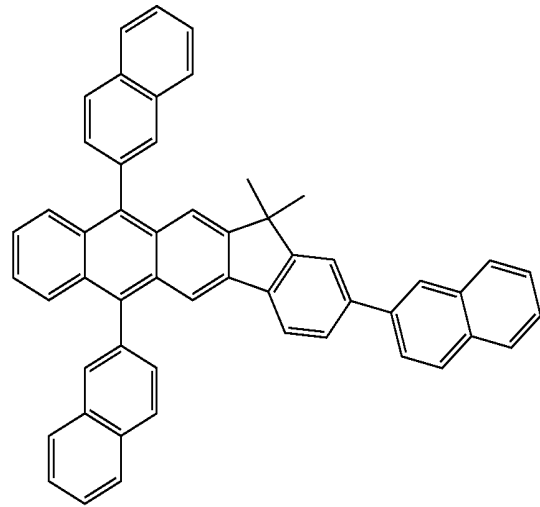
H38

H41

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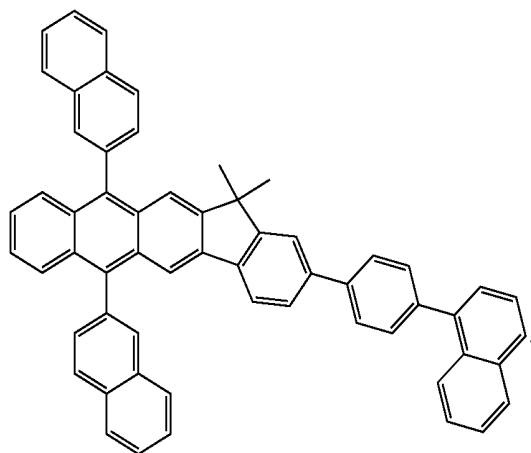
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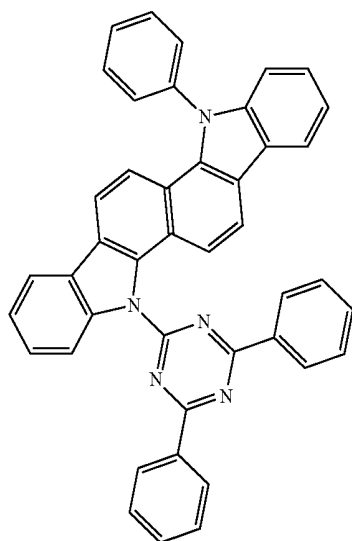
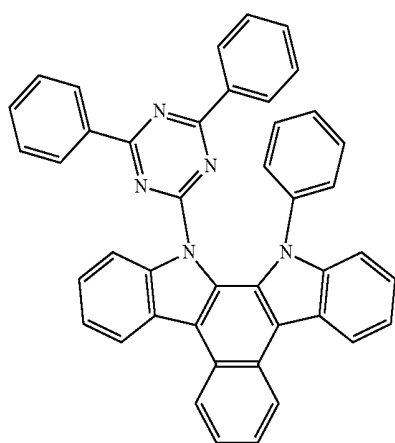


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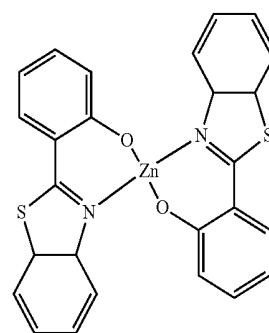
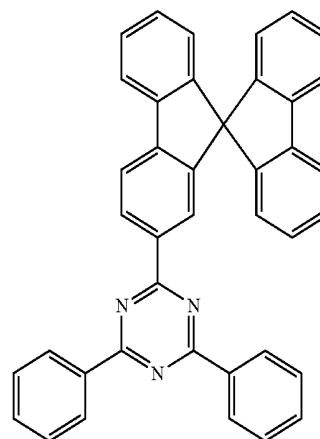
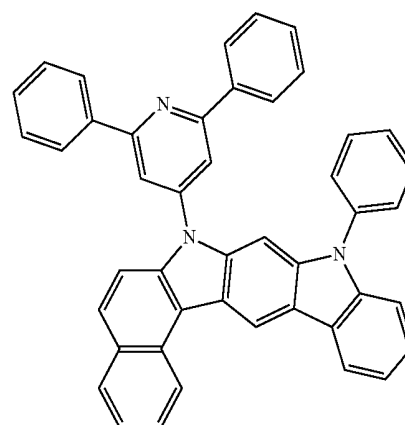
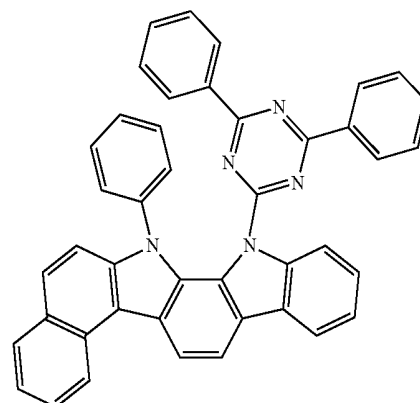
-continued



In some embodiments, the host may include at least one selected from Compounds H43 to H49, but is not limited thereto.

**52**

-continued



H42

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H43

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H44

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H45

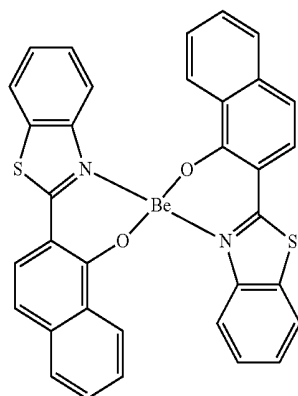
H46

H47

H48

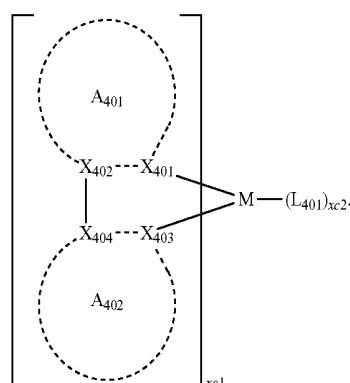
53

-continued



The dopant for the EML may include at least one selected from a fluorescent dopant and a phosphorescent dopant.

The phosphorescent dopant may include an organic metal complex represented by Formula 401.



In Formula 401,

M may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), and thulium (Tm),

X₄₀₁ to X₄₀₄ may be each independently nitrogen or carbon,

A₄₀₁ and A₄₀₂ ring may be each independently selected from a substituted or unsubstituted benzene group, a substituted or unsubstituted naphthalene group, a substituted or unsubstituted fluorene group, a substituted or unsubstituted spiro-fluorene group, a substituted or unsubstituted indene group, a substituted or unsubstituted pyrrole group, a substituted or unsubstituted thiophene group, a substituted or unsubstituted furan group, a substituted or unsubstituted imidazole group, a substituted or unsubstituted pyrazole group, a substituted or unsubstituted thiazole group, a substituted or unsubstituted isothiazole group, a substituted or unsubstituted oxazole group, a substituted or unsubstituted isooxazole group, a substituted or unsubstituted pyridine group, a substituted or unsubstituted pyrazine group, a substituted or unsubstituted pyrimidine group, a substituted or unsubstituted pyridazine group, a substituted or unsubstituted quinoline group, a substituted or unsubstituted isoquinoline group, a substituted or unsubstituted benzoquinoline group, a substituted or unsubstituted quinoxaline group, a substituted or unsubstituted quinazoline group, a substituted or unsubstituted carbazole group, a substituted or

54

H49

unsubstituted benzoimidazole group, a substituted or unsubstituted benzofuran group, a substituted or unsubstituted benzothiophene group, a substituted or unsubstituted isobenzothiophene group, a substituted or unsubstituted benzoxazole group, a substituted or unsubstituted isobenzoxazole group, a substituted or unsubstituted triazole group, a substituted or unsubstituted oxadiazole group, a substituted or unsubstituted triazine group, a substituted or unsubstituted dibenzofuran group, and a substituted or unsubstituted dibenzothiophene group,

at least one substituent of the substituted benzene group, the substituted naphthalene group, the substituted fluorene group, the substituted spiro-fluorene group, the substituted indene group, the substituted pyrrole group, the substituted thiophene group, the substituted furan group, the substituted imidazole group, the substituted pyrazole group, the substituted thiazole group, the substituted isothiazole group, the substituted oxazole group, the substituted isooxazole group, the substituted pyridine group, the substituted pyrazine group, the substituted pyrimidine group, the substituted pyridazine group, the substituted quinoline group, the substituted isoquinoline group, the substituted benzoquinoline group, the substituted quinoxaline group, the substituted quinazoline group, the substituted carbazole group, the substituted benzoimidazole group, the substituted benzofuran group, the substituted benzothiophene group, the substituted isobenzothiophene group, the substituted benzoxazole group, the substituted isobenzoxazole group, the substituted triazole group, the substituted oxadiazole group, the substituted triazine group, the substituted dibenzofuran group, and the substituted dibenzothiophene group may be selected from:

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

a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazine group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₄₀₁)(Q₄₀₂), —Si(Q₄₀₃)(Q₄₀₄)(Q₄₀₅), and —B(Q₄₀₆)(Q₄₀₇);

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

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

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group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl 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_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₄₁₁)(Q₄₁₂), —Si(Q₄₁₃)(Q₄₁₄)(Q₄₁₅), and —B(Q₄₁₆)(Q₄₁₇); and
 —N(Q₄₂₁)(Q₄₂₂), —Si(Q₄₂₃)(Q₄₂₄)(Q₄₂₅), and
 —B(Q₄₂₆)(Q₄₂₇),

L₄₀₁ may be an organic ligand,

xc1 may be 1, 2, or 3, and

xc2 may be 0, 1, 2, or 3.

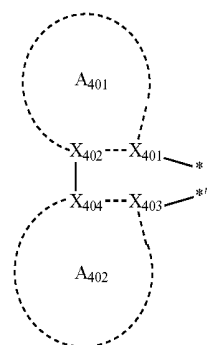
For example, L₄₀₁ may be a monovalent, divalent, or trivalent organic ligand. For example, L₄₀₁ may be selected from a halogen ligand (for example, Cl— and/or F—), a diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propanedionate, 2,2,6,6-tetramethyl-3,5-heptanedionate, and/or hexafluoroacetate), a carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazole carboxylate, and/or benzoate), a carbon monoxide ligand, an isonitrile ligand, a cyano ligand, and a phosphorous ligand (for example, phosphine or phosphite), but is not limited thereto

When A₄₀₁ in Formula 401 has at least two substituents, the at least two substituents of A₄₀₁ may be linked to each other to form a saturated or unsaturated ring.

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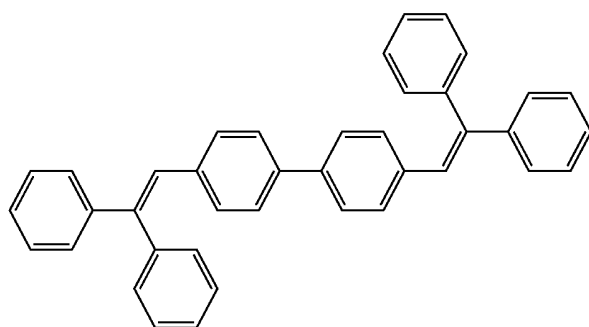
When A₄₀₂ in Formula 401 has at least two substituents, the at least two substituents of A₄₀₂ may be linked to each other to form a saturated or unsaturated ring.

When xc1 in Formula 401 is 2 or greater, the plurality of ligands in Formula 401, represented by

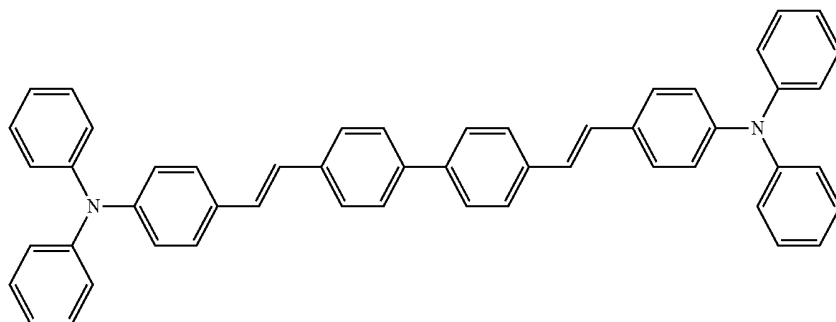


may be identical to or different from each other. When xc1 in Formula 401 is 2 or greater, A₄₀₁ and/or A₄₀₂ of one ligand may be respectively linked to A₄₀₁ and/or A₄₀₂ of another adjacent ligand directly (e.g., via a single bond) or via a linker (or linking group) (for example, a C_1 - C_5 alkylene group, —N(R')— (where R' is a C_1 - C_{10} alkyl group or a C_6 - C_{20} aryl group), and/or —C(=O)—).

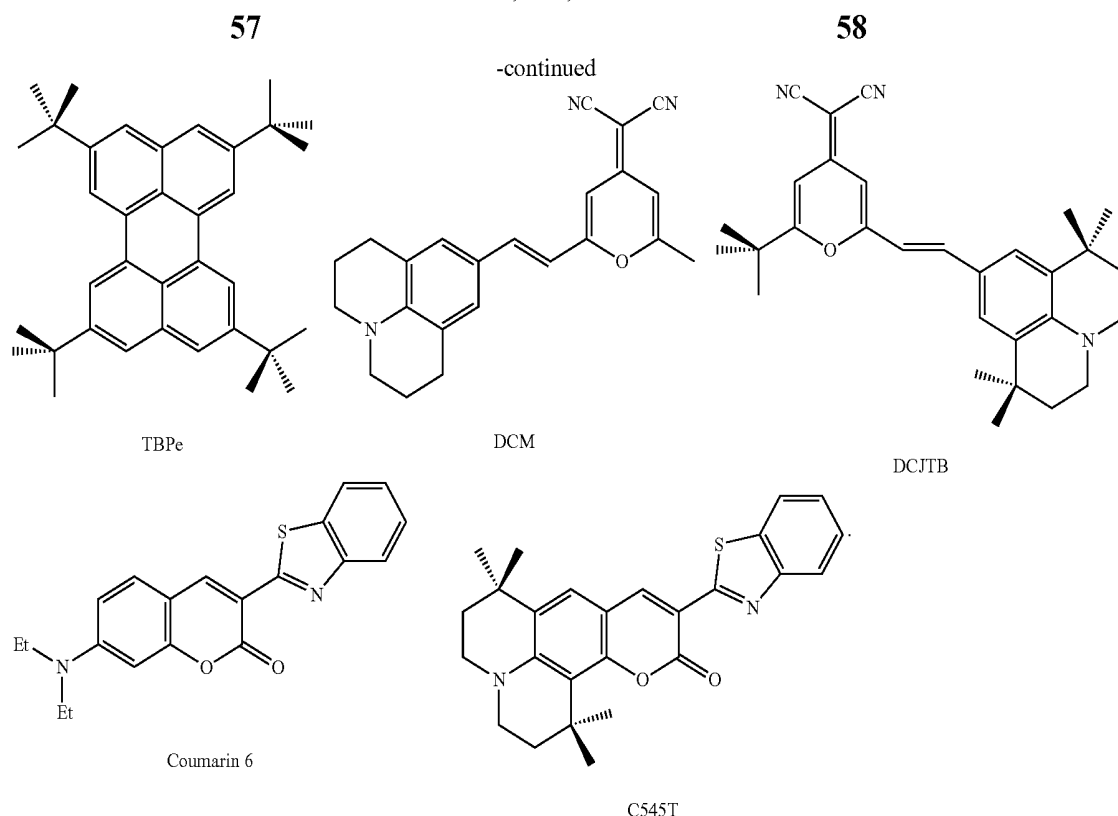
The fluorescent dopant may include at least one selected from DPVBi, DPAVBi, TBPe, DCM, DCJTb, Coumarin 6, and C545T.



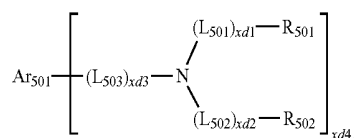
DPVBi



DPAVBi



For example, the fluorescent dopant may include a compound represented by Formula 501.



In Formula 501,

Ar_{501} may be selected from:

a naphthalene group, a heptalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzo-fluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, and an indenoanthracene group; and

a naphthalene group, a heptalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzo-fluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, and an indenoanthracene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio

group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q_{501})(Q_{502})(Q_{503}) (where Q_{501} to Q_{503} are each independently selected from hydrogen, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, and a $\text{C}_2\text{-C}_{60}$ heteroaryl group);

L_{501} to L_{503} may be defined as described herein in conjunction with L_{201} ;

R_{501} and R_{502} may be each independently selected from: a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothio-phenyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and a dibenzofuranyl group, and a dibenzothio-phenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl 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 phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a

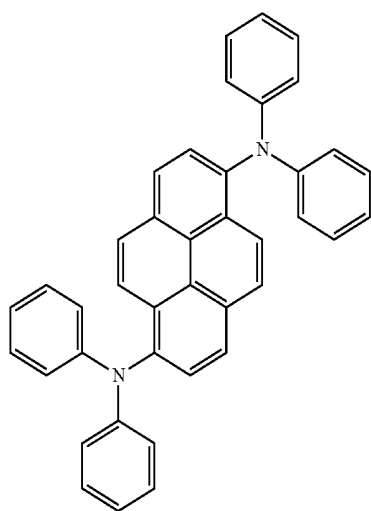
59

chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuran-
 5 nyl group, and a dibenzothiophenyl group,

xd1 to xd3 are each independently selected from 0, 1, 2, and 3, and

xb4 is selected from 1, 2, 3, and 4.

For example, the fluorescent dopant may include at least
 10 one selected from Compounds FD1 to FD8.



FD1

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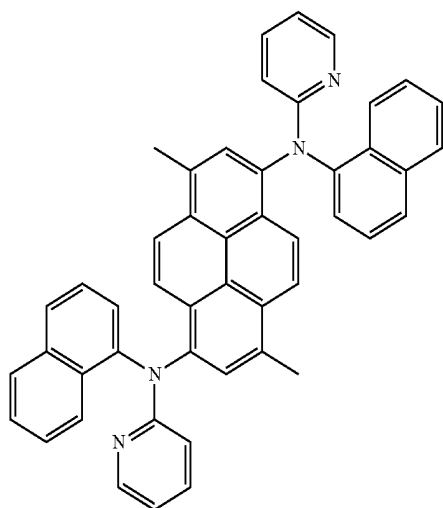
FD2

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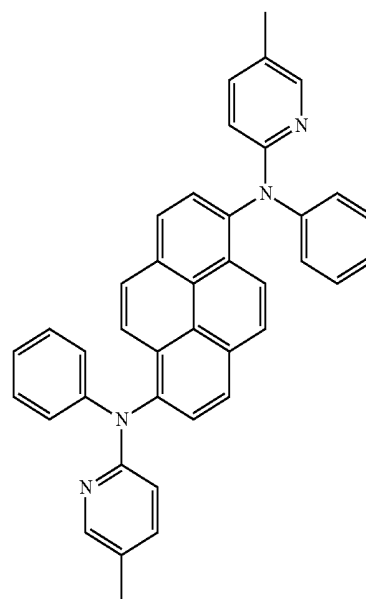
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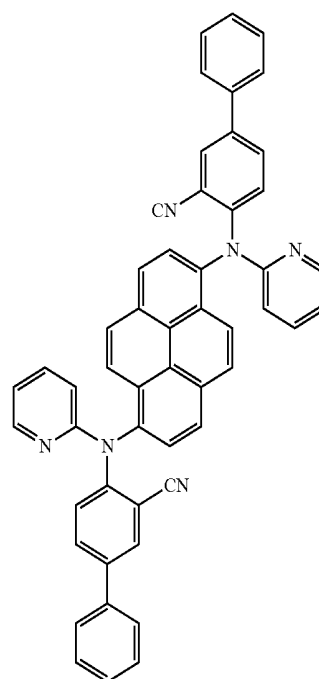
**60**

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FD3

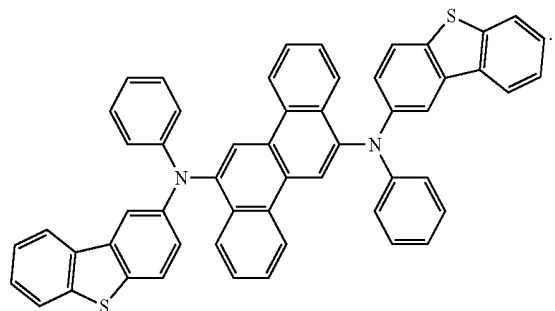
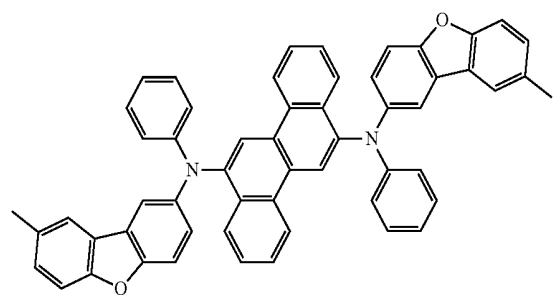
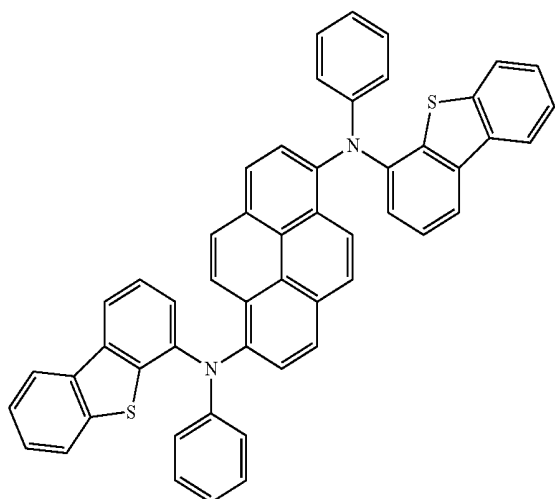
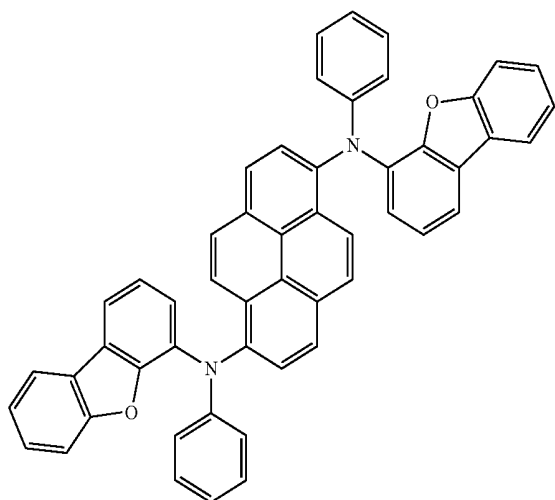


FD4



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An amount of the dopant in the EML may be from about 0.01 parts to about 15 parts by weight based on 100 parts by weight of the host, but is not limited to this range.

A thickness of the EML may be about 100 Å to about 1000 Å, and in some embodiments, may be from about 200 Å to about 600 Å. When the thickness of the EML is within any of these ranges, the EML may have good light emitting ability without a substantial increase in driving voltage.

Next, the electron transport region may be formed on the EML.

The electron transport region may include at least one selected from a HBL, an ETL, and an EIL. However, embodiments of the present disclosure are not limited thereto.

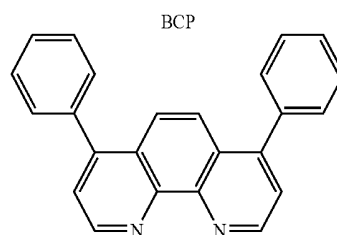
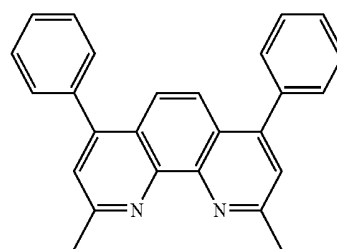
The electron transport region may include the compound of Formula 1 according to any of the above-described embodiments.

For example, the electron transport region may have a structure including ETL/EIL or a structure including HBL/ETL/EIL, wherein the layers forming each structure of the electron transport region may be sequentially stacked on the EML in the order stated above. However, embodiments of the present disclosure are not limited thereto.

When the ETL includes a phosphorescent dopant, the electron transport region may include a hole blocking layer (HBL). The HBL may be formed to prevent or substantially block diffusion of triplet excitons or holes into the ETL.

When the electron transport region includes a HBL, the HBL may be formed on the EML by using one or more suitable methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), and/or the like. When the HBL is formed using vacuum deposition and/or spin coating, the deposition and coating conditions for forming the HBL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

For example, the HBL may include at least one of BCP and Bphen. However, embodiments of the present disclosure are not limited thereto.



BCP

Bphen

A thickness of the HBL may be from about 20 Å to about 1,000 Å, and in some embodiments, from about 30 Å to

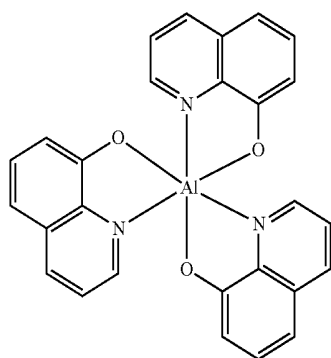
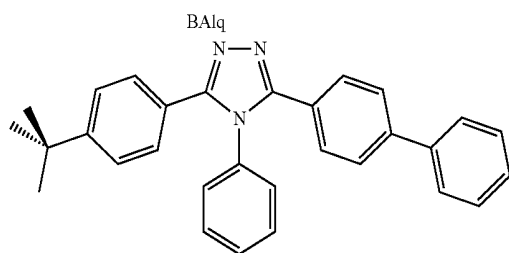
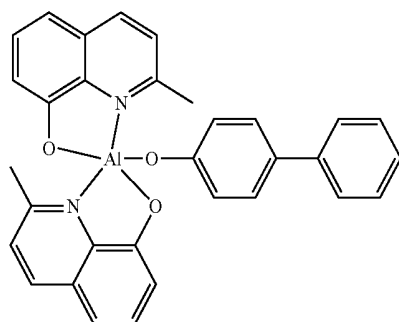
63

about 300 Å. When the thickness of the HBL is within any of these ranges, the HBL may have satisfactory hole blocking characteristics without a substantial increase in driving voltage.

The electron transport region may include an ETL. The ETL may be formed on the EML or the HBL by using one or more suitable methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), and/or the like. When the ETL is formed using vacuum deposition and/or spin coating, the deposition and coating conditions for forming the ETL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

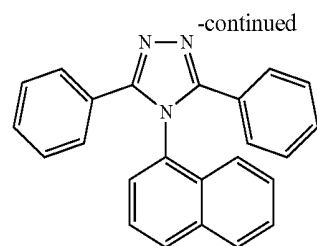
In some embodiments, the organic layer 150 of the organic light-emitting device 10 may include an electron transport region between the EML and the second electrode. The electron transport region may include at least one of an ETL and an EIL.

The ETL may include the compound of Formula 1 according to any of the above-described embodiments. The ETL may further include at least one selected from BCP, Bphen, Alq₃, Balq, TAZ, and NTAZ, in addition to the compound of Formula 1.

Alq₃

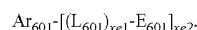
TAZ

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NTAZ

In some embodiments, the ETL may further include at least one selected from compounds represented by any one of Formulae 601 and 602.



Formula 601

In Formula 601,

Ar₆₀₁ may be selected from:

a naphthalene group, a heptalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, and an indenoanthracene group;

a naphthalene group, a heptalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, and an indenoanthracene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q₃₀₁)(Q₃₀₂)(Q₃₀₃) (where Q₃₀₁ to Q₃₀₃ are each independently selected from hydrogen, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₆-C₆₀ aryl group, and a C₂-C₆₀ heteroaryl group).

L₆₀₁ may be defined as described herein in conjunction with L₂₀₁,

E₆₀₁ may be selected from:

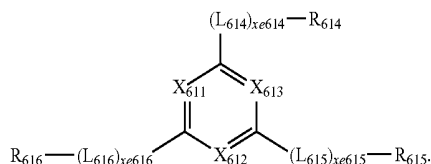
a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadi-

azolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

a pyrrollyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl 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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group,

xe1 may be selected from 0, 1, 2, and 3, and

xe2 may be selected from 1, 2, 3, and 4.



Formula 602

In Formula 602,

X_{611} may be N or C- $(L_{611})_{xe611}$ - R_{611} , X_{612} may be N or C- $(L_{612})_{xe612}$ - R_{612} , X_{613} may be N or C- $(L_{613})_{xe613}$ - R_{613} , and at least one of X_{611} to X_{613} may be N,

L_{611} to L_{616} may be defined as described above in conjunction L_{201} ,

R_{611} to R_{616} may be each independently selected from:

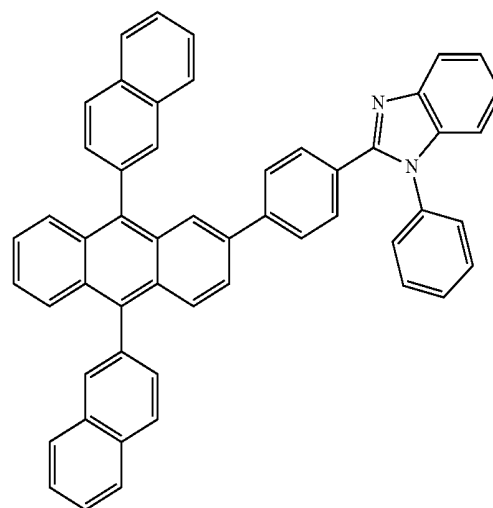
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl 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 azulenyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

xe611 to xe616 may be each independently selected from, 0, 1, 2, and 3.

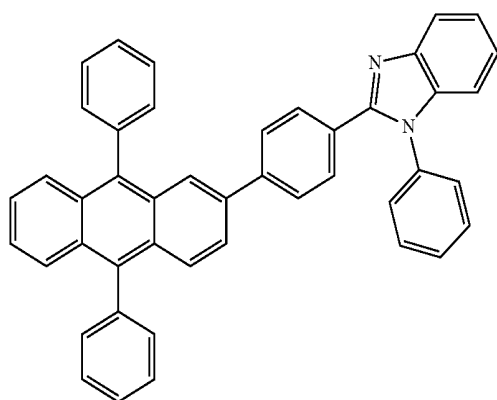
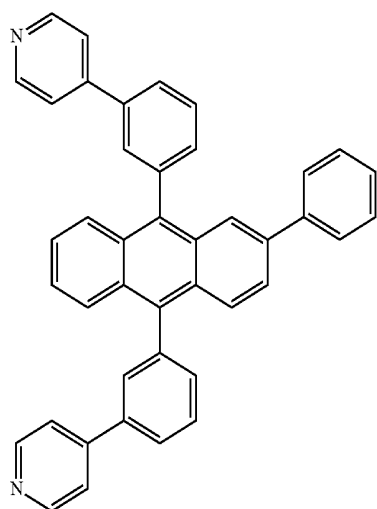
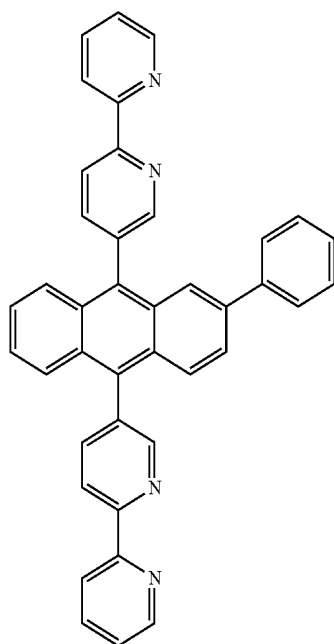
The compound of Formula 601 and the compound of Formula 602 may each independently be selected from Compounds ET1 to ET15.

ET1



67

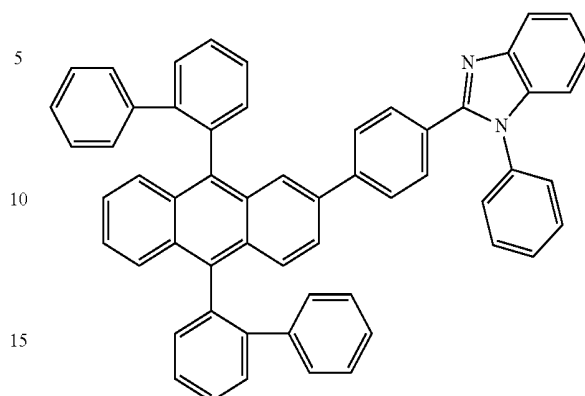
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**68**

-continued

ET2

ET5

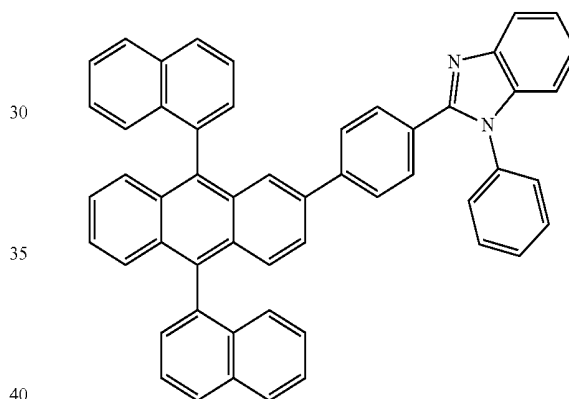


20

25

ET3

ET6

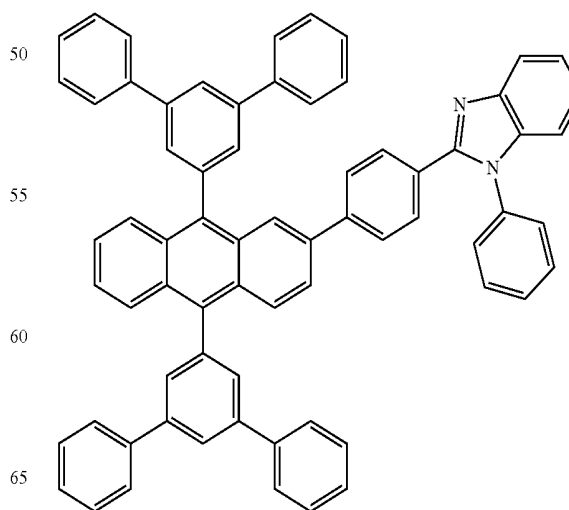


40

45

ET7

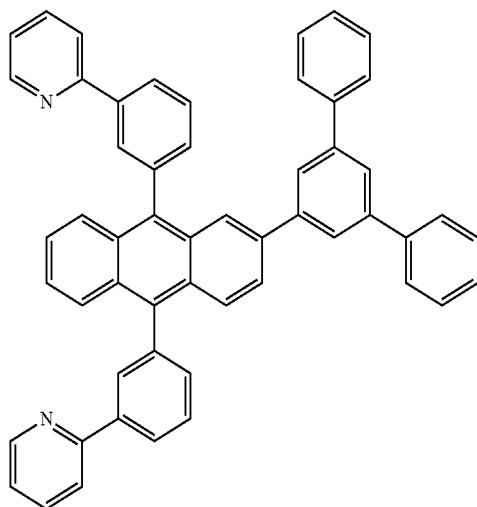
ET4



65

69

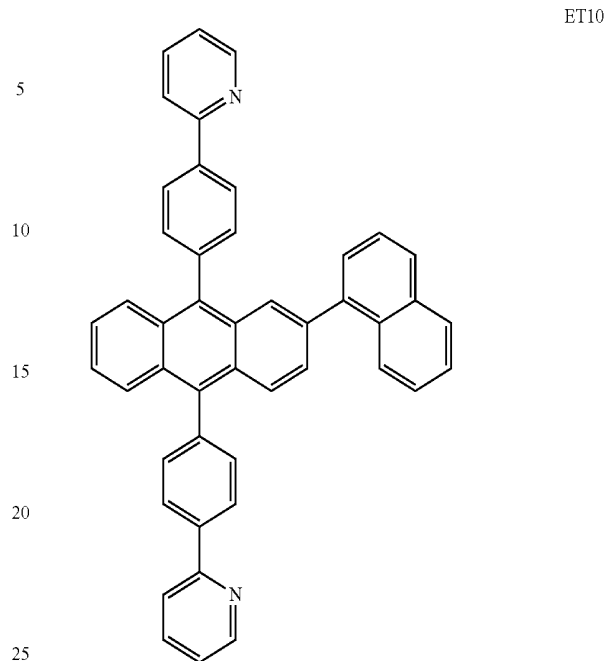
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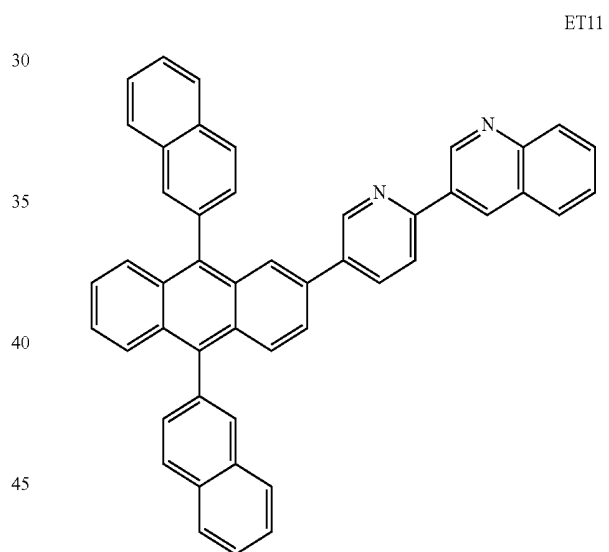
ET8

70

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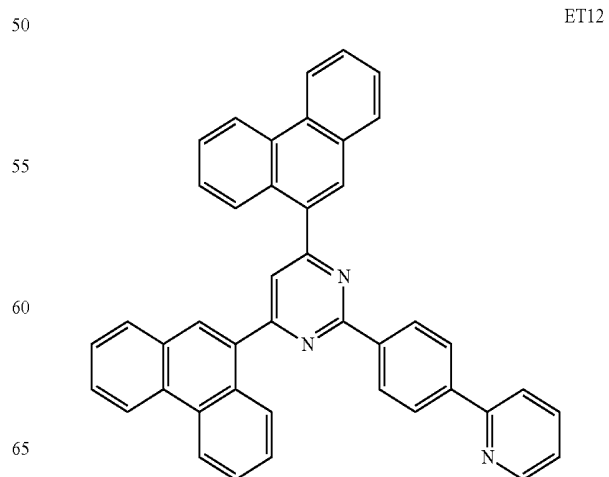
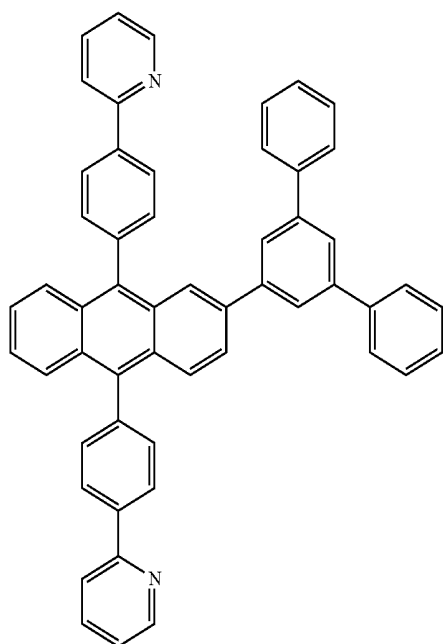


ET10



ET11

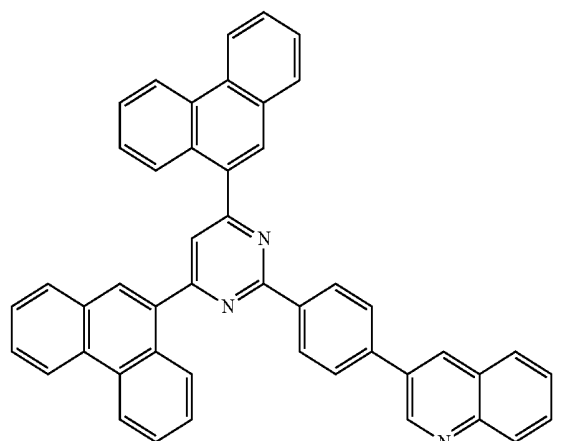
ET9



ET12

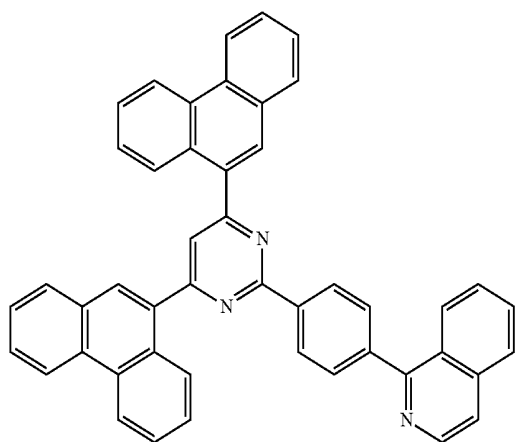
71

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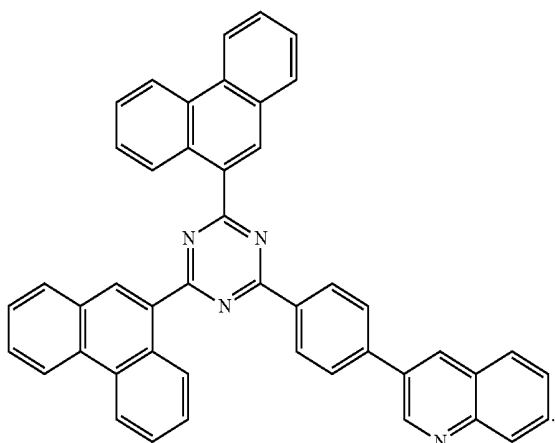


ET13

ET14



ET15



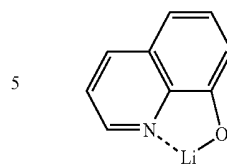
A thickness of the ETL may be from about 100 Å to about 1,000 Å, and in some embodiments, from about 150 Å to about 500 Å. When the thickness of the ETL is within any of these ranges, the ETL may have satisfactory electron transporting ability without a substantial increase in driving voltage.

In some embodiments the ETL may further include a metal-containing material, in addition to the above-described materials.

The metal-containing material may include a lithium (Li) complex. Non-limiting examples of the Li complex include compound ET-D1 (lithium quinolate (LiQ)), and compound ET-D2.

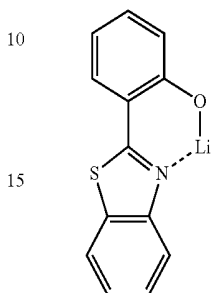
72

ET-D1



5

ET-D2



10

15

20

The electron transport region may include an EIL that may facilitate injection of electrons from the second electrode **190**.

The EIL may be formed on the ETL by using one or more suitable methods, for example, by using vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), and/or the like. When the EIL is formed using vacuum deposition and/or spin coating, the deposition and coating conditions for forming the EIL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

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

A thickness of the EIL may be from about 1 Å to about 100 Å, and in some embodiments, from about 3 Å to about 90 Å. When the thickness of the EIL is within any of these ranges, the EIL may have satisfactory electron injection ability without a substantial increase in driving voltage.

The second electrode **190** may be positioned on the organic layer **150**, as described above. The second electrode **190** may be a cathode (i.e., an electron injecting electrode). A material for forming the second electrode **190** may be a metal, an alloy, an electrically conductive compound, which all have a low-work function, or a mixture thereof. Non-limiting examples of materials for forming the second electrode **190** include lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, a material for forming the second electrode **190** may be ITO or IZO. The second electrode **190** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

Although the organic light-emitting device of the drawing is described above, embodiments of the present disclosure are not limited thereto.

Hereinafter, substituents described with reference to the formulae will be described in more detail. In this regard, the numbers of carbon atoms in substituents are presented only for illustrative purposes and do not limit the characteristics of the substituents. The substituents not defined herein are construed as having common meanings that should be apparent to one of ordinary skill in the art.

As used herein, a C₁-C₆₀ alkyl group refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms in the main chain. Non-limiting

examples of the C₁-C₆₀ alkyl group 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 iso-amyl group, and a hexyl group. A C₁-C₆₀ alkylene group refers to a divalent group having the same structure as the C₁-C₆₀ alkyl group.

As used herein, a C₁-C₆₀ alkoxy group refers to a monovalent group represented by —OA₁₀₁ (where A₁₀₁ is the C₁-C₆₀ alkyl group, as described above). Non-limiting examples of the C₁-C₆₀ alkoxy group include a methoxy group, an ethoxy group, and an isopropoxy group.

As used herein, a C₂-C₆₀ alkenyl group refers to a hydrocarbon group including at least one carbon-carbon double bond at one or more positions along a carbon chain of the C₂-C₆₀ alkyl group (e.g., in the middle or at either terminal end of the C₂-C₆₀ alkyl group). Non-limiting examples of the C₂-C₆₀ alkenyl group include an ethenyl group, a propenyl group, and a butenyl group. A C₂-C₆₀ alkylene group refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

As used herein, a C₂-C₆₀ alkynyl group refers to a hydrocarbon group including at least one carbon-carbon triple bond at one or more positions along a carbon chain of the C₂-C₆₀ alkyl group (e.g., in the middle or at either terminal end of the C₂-C₆₀ alkyl group). Non-limiting examples of the C₂-C₆₀ alkynyl group include an ethynyl group and a propynyl group. A C₂-C₆₀ alkynylene group used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkynyl group.

As used herein, a C₃-C₁₀ cycloalkyl group refers to a monovalent, monocyclic hydrocarbon group having 3 to 10 carbon atoms as ring-forming atoms. Non-limiting examples of the C₃-C₁₀ cycloalkyl group include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C₃-C₁₀ cycloalkylene group refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkyl group.

As used herein, a C₂-C₁₀ heterocycloalkyl group refers to a monovalent monocyclic group having 2 to 10 carbon atoms as ring-forming atoms and at least one hetero atom selected from N, O, P, and S as a ring-forming atom. Non-limiting examples of the C₂-C₁₀ heterocycloalkyl group include a tetrahydrofuranyl group and a tetrahydrothiophenyl group. A C₂-C₁₀ heterocycloalkylene group refers to a divalent group having the same structure as the C₂-C₁₀ heterocycloalkyl group.

As used herein, a C₃-C₁₀ cycloalkenyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms as ring-forming atoms, and at least one double bond in the ring but does not have aromaticity. Non-limiting examples of the C₃-C₁₀ cycloalkenyl group include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C₃-C₁₀ cycloalkenylene group refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkenyl group.

As used herein, a C₂-C₁₀ heterocycloalkenyl group used herein refers to a monovalent monocyclic group having 2 to 10 carbon atoms as ring-forming atoms, at least one double bond in the ring, and at least one hetero atom selected from N, O, P, and S as a ring-forming atom. Non-limiting examples of the C₂-C₁₀ heterocycloalkenyl group include a 2,3-hydrofuranyl group, and a 2,3-hydrothiophenyl group. A C₂-C₁₀ heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C₂-C₁₀ heterocycloalkenyl group.

As used herein, a C₆-C₆₀ aryl group refers to a monovalent, aromatic carbocyclic aromatic group having 6 to 60 carbon atoms as ring-forming atoms, and a C₆-C₆₀ arylene

group refers to a divalent, aromatic carbocyclic group having 6 to 60 carbon atoms as ring-forming 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/or the C₆-C₆₀ arylene group include at least two rings, the rings may be fused to each other.

As used herein, a C₁-C₆₀ heteroaryl group refers to a monovalent, aromatic carbocyclic aromatic group having at least one hetero atom selected from N, O, P, and S as a ring-forming atom, and 1 to 60 carbon atoms as the remaining ring-forming atoms. A C₁-C₆₀ heteroarylene group refers to a divalent, aromatic carbocyclic group having at least one hetero atom selected from N, O, P, and S as a ring-forming atom, and 1 to 60 carbon atoms as the remaining ring-forming 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/or the C₁-C₆₀ heteroarylene group include at least two rings, the rings may be fused to each other.

As used herein, a C₆-C₆₀ aryloxy group refers to a group represented by —OA₁₀₂ (where A₁₀₂ is the C₆-C₆₀ aryl group, as described above), and a C₆-C₆₀ arylthio group refers to a group represented by —SA₁₀₃ (where A₁₀₃ is the C₆-C₆₀ aryl group, as described above).

As used herein, a monovalent non-aromatic condensed polycyclic group (including, for example, 8 to 60 carbon atoms) refers to a monovalent group that includes at least two rings condensed to each other and includes only carbon atoms as ring-forming atoms, and does not have overall aromaticity. A non-limiting example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. As used herein, a divalent non-aromatic condensed polycyclic group refers to a divalent group with the same structure as the monovalent non-aromatic condensed polycyclic group.

As used herein, a monovalent non-aromatic condensed heteropolycyclic group (including, for example, 2 to 60 carbon atoms) refers to a monovalent group that includes at least two rings condensed to each other and includes carbon atoms and at least one hetero atom selected from N, O, P and S as ring-forming atoms, and does not have overall aromaticity. A non-limiting example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazoyl group. As used herein, a divalent non-aromatic condensed heteropolycyclic group refers to a divalent group with the same structure as the monovalent non-aromatic condensed polycyclic group.

As used herein, at least one of substituents of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₂-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₂-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic 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 C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀

heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

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

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

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

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

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

wherein Q₁₁ to Q₁₇, Q₂₁ to Q₂₇ and Q₃₁ to Q₃₇ may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₂-C₆₀ heteroaryl

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

For example, at least one substituent of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₂-C₁₀ heterocycloalkylene group, substituted C₃-C₁₀ cycloalkenylene group, the substituted C₂-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic 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 C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

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

a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli- nyl group, a phenazinyl group, a benzoimidazolyl 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 dibenzofuran group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇),

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, 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, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group,

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, 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, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₁-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a cyclopentyl

group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, 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, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅) and —B(Q₂₆)(Q₂₇), and —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

wherein Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a

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triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

According to one or more embodiments of the present disclosure, the organic light-emitting device may be included in various types (or kinds) of flat panel display devices, such as in a passive matrix organic light-emitting display device or in an active matrix organic light-emitting display device. For example, referring back to the drawing, when the organic light-emitting device is included in an active matrix organic light-emitting display device including a thin-film transistor, the first electrode on the substrate may function as a pixel electrode, electrically connected to a source electrode or a drain electrode of the thin-film transistor. Moreover, the organic light-emitting device may also be included in a flat panel display devices having a double-sided screen.

In some embodiments, the organic layer of the organic light-emitting device may be formed of any compound according to the above-described embodiments by using a deposition method or may be formed using a wet method of coating a solution of any compound according to the above-described embodiments.

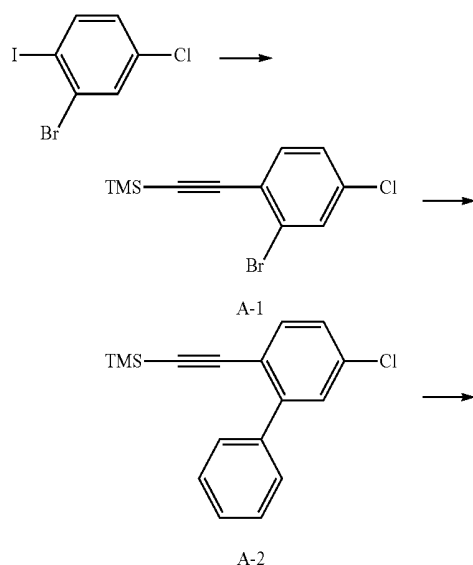
As used herein, "Ph" denotes a phenyl group, "Me" denotes a methyl group, "Et" denotes an ethyl group, "ter-Bu" or "Bu" denotes a tert-butyl group.

One or more embodiments of the present disclosure will now be described with reference to the following examples including synthesis examples. However, these examples are only for illustrative purposes and are not intended to limit the scope of the one or more embodiments of the present disclosure.

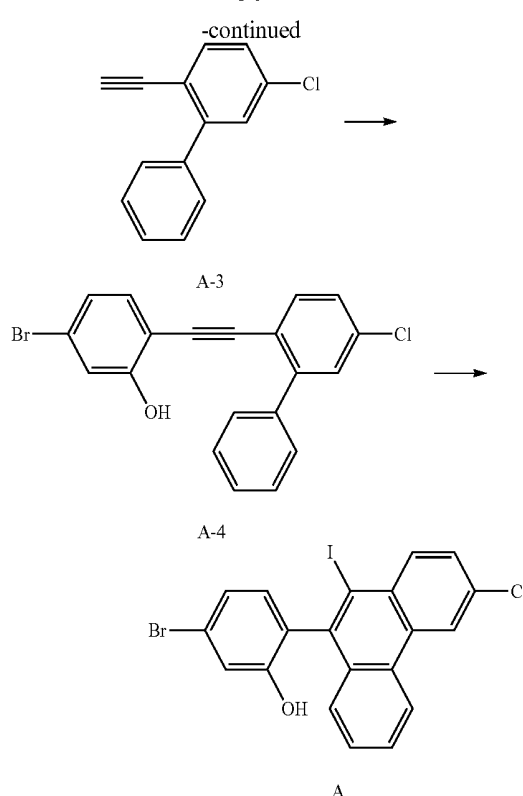
EXAMPLES

Synthesis Example 1

Synthesis of Intermediate A



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Synthesis of Intermediate A-1

6.34 g (20 mmol) of 2-bromo-4-chloro-1-iodobenzene, 0.190 g (1 mmol) of CuI, 1.155 g (1 mmol) of $(\text{Ph}_3)_4\text{Pd}$, 1.96 g (20 mmol) of ethynyltrimethylsilane were dissolved in 200 mL of anhydrous tetrahydrofuran (THF) under a nitrogen atmosphere, and then 3.066 g (30 mmol) of triethylamine was dropwise added thereto. After 3 hours, the resulting reaction solution was subjected to extraction three times with 100 mL of water and 10 mL of diethyl ether. An organic phase was collected and dried using magnesium sulfate, followed by evaporating the solvent. The resulting residue was purified using silica gel column chromatography to obtain 5.113 g (18 mmol, Yield: 90%) of Intermediate A-1.

Synthesis of Intermediate A-2

5.113 g (18 mmol) of Intermediate A-1, 2.44 g (20 mmol) of phenylboronic acid, 1.155 g (1 mmol) of $\text{Pd}(\text{PPh}_3)_4$, and 2.762 g (20 mmol) of K_2CO_3 were dissolved in 200 mL of a mixed solution of THF and H_2O (2:1 by volume) under a nitrogen atmosphere and stirred at about 80°C . for about 12 hours. The resulting reaction solution was cooled down to room temperature, followed by adding 50 mL of water thereto and extraction three times with 150 mL of ethyl ether. An organic phase was collected and dried using magnesium sulfate, followed by evaporating the solvent. The resulting residue was purified using silica gel column chromatography to obtain 4.26 g (15 mmol, Yield: 83%) of Intermediate A-2.

Synthesis of Intermediate A-3

4.26 g (15 mmol) of Intermediate A-2 and 0.800 g (20 mmol) of sodium hydroxide were dissolved in 100 mL of methanol and the resulting solution was stirred at about 60°

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C. for about 1 hour, followed by adding 50 mL of water to the resulting reaction solution and extraction three times with 50 mL of ethyl ether. An organic phase was collected and dried using magnesium sulfate, followed by evaporating the solvent. The resulting residue was purified using silica gel column chromatography to obtain 2.968 g (14 mmol, Yield: 93%) of Intermediate A-3.

Synthesis of Intermediate A-4

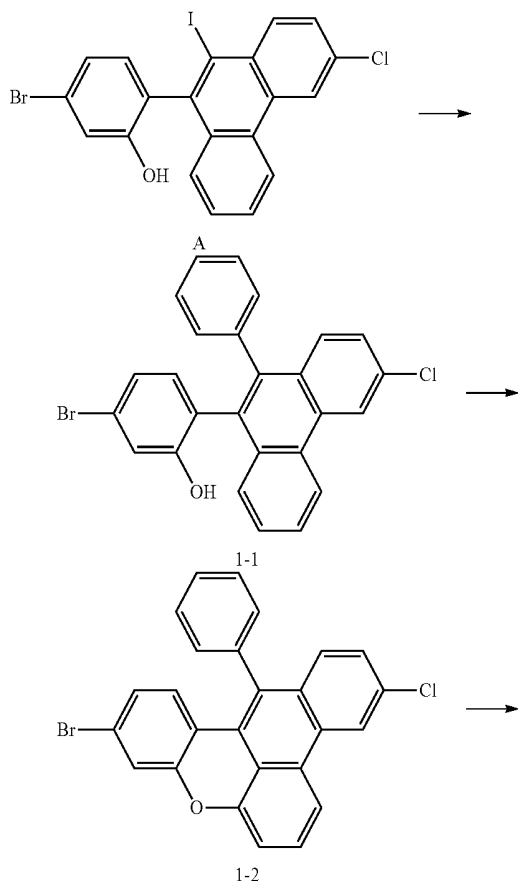
3.836 g (10 mmol, Yield: 71%) of Intermediate A-4 was synthesized in the same (or substantially the same) manner as in the synthesis of Intermediate A-1 of Synthesis Example 1, except that 5-bromo-2-iodo-phenol and Intermediate A-3, instead of 2-bromo-4-chloro-1-iodobenzene and ethynyltrimethylsilane, respectively, were used.

Synthesis of Intermediate A

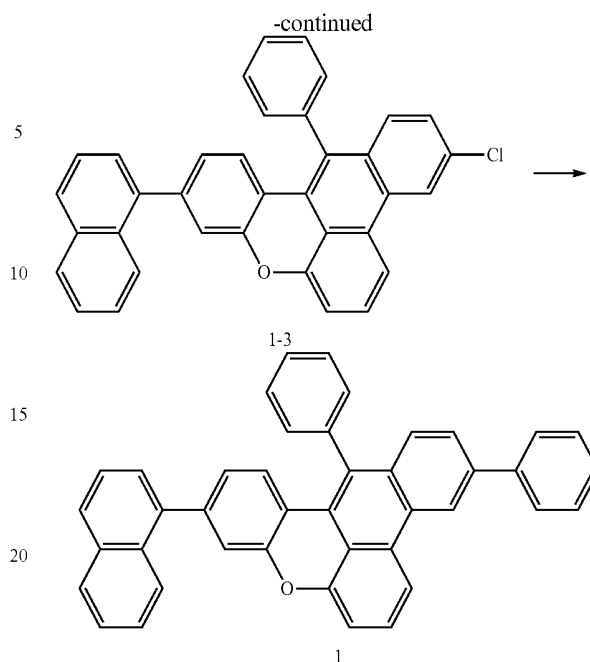
3.836 g (10 mmol) of Intermediate A-4 was dissolved in 100 mL of dichloromethane, and then 1.622 g of ICl was dropwise added thereto, followed by adding 50 mL of water to the resulting reaction solution and extraction three times with 10 mL of dichloromethane. An organic phase was collected and dried using magnesium sulfate, followed by evaporating the solvent. The resulting residue was purified using silica gel column chromatography to obtain 2.968 g (14 mmol, Yield: 93%) of Intermediate A.

Synthesis Example 2

Synthesis of Compound 1



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Synthesis of Intermediate 1-1

2.545 g (5 mmol) of Intermediate A was dissolved in 500 mL of anhydrous THF under a nitrogen atmosphere, and then the temperature was cooled down to about -78°C . After 1 hour, 0.785 g (5 mmol) of bromobenzene was slowly dropwise added to the resulting mixture, the temperature was increased to room temperature, and 50 mL of 1N HCl was dropwise added thereto and then stirred for about 1 hour, followed by extraction three times with 100 mL of water and 10 mL of diethyl ether. An organic phase was collected and dried using magnesium sulfate, followed by evaporating the solvent. The resulting residue was purified using silica gel column chromatography to obtain 1.836 g (4 mmol, Yield: 80%) of Intermediate 1-1.

Synthesis of Intermediate 1-2

1.836 g (4 mmol) of Intermediate 1-1 and 1.56 g (20 mmol) of CuO were dissolved in 50 mL of nitrobenzene and stirred at about 180°C for about 24 hours. The resulting reaction solution was cooled down to room temperature, and 50 mL of water was added thereto, followed by extraction three times with 150 mL of ethyl ether. An organic phase was collected and dried using magnesium sulfate, followed by evaporating the solvent. The resulting residue was purified using silica gel column chromatography to obtain 1.810 g (4 mmol, Yield: 100%) of Intermediate 1-2.

Synthesis of Intermediate 1-3

1.767 g (3.5 mmol, Yield: 87%) of Intermediate 1-3 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate A-2 in Synthesis Example 1, except that Intermediate 1-2 and 1-naphthaleneboronic acid, instead of Intermediate A-1 and phenylboronic acid, respectively, were used.

Synthesis of Compound 1

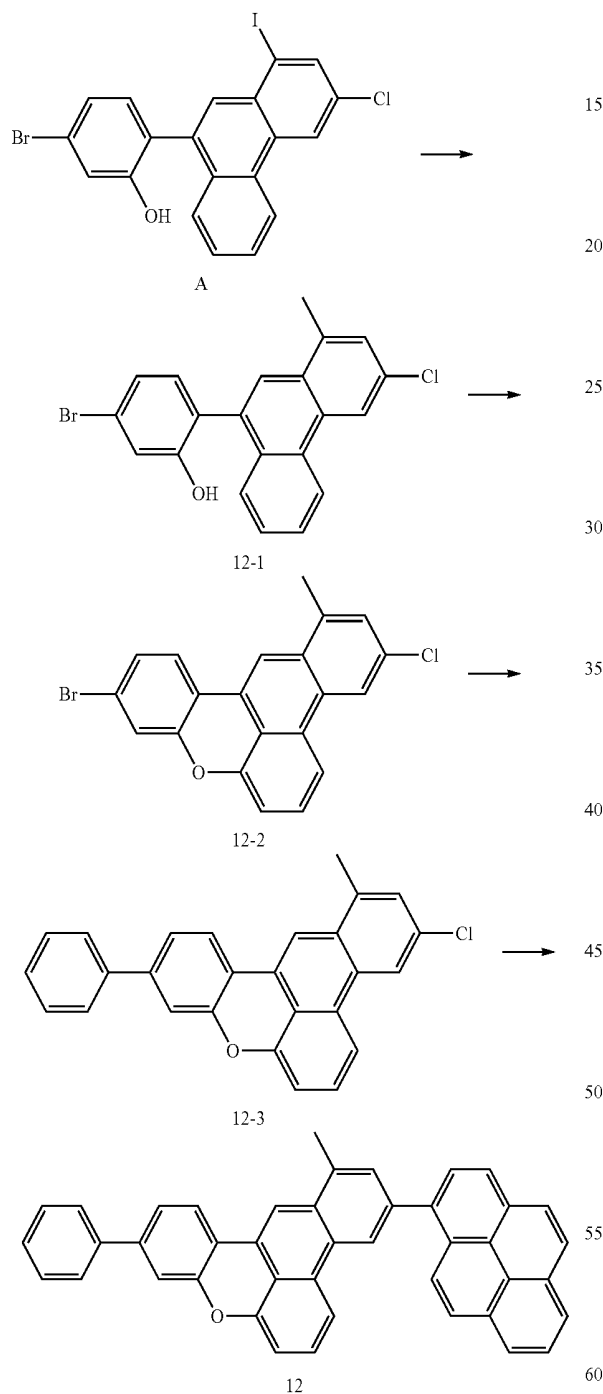
1.638 g (3 mmol, Yield: 85%) of Compound 1 was obtained in the same (or substantially the same) manner as

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in the synthesis of Intermediate 1-3 in Synthesis Example 2, except that Intermediate 1-3 and phenylboronic acid, instead of Intermediate 1-2 and 1-naphthaleneboronic acid, respectively, were used.

Synthesis Example 3

Synthesis of Compound 12



Synthesis of Intermediate 12-1

2.765 g (7.0 mmol, Yield: 70%) of Intermediate 12-1 was obtained in the same (or substantially the same) manner as

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in the synthesis of Intermediate 1-1 in Synthesis Example 2, except that iodomethane, instead of bromobenzene, was used.

Synthesis of Intermediate 12-2

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2.212 g (5.6 mmol, Yield: 80%) of Intermediate 12-2 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate 1-2 in Synthesis Example 2, except that Intermediate 12-1, instead of Intermediate 1-1, was used.

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Synthesis of Intermediate 12-3

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1.568 g (4.0 mmol, Yield: 71%) of Intermediate 12-3 was obtained in the same (or substantially the same) manner as in the synthesis of Compound 1 in Synthesis Example 2, except that Intermediate 12-2, instead of Intermediate 1-3, was used.

Synthesis of Compound 12

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1.674 g (3 mmol, Yield: 75%) of Compound 12 was obtained in the same (or substantially the same) manner as in the synthesis of Compound 1 in Synthesis Example 2, except that Intermediate 12-3 and 1-pyrene boronic acid, instead of Intermediate 1-3 and 1-naphthaleneboronic acid, respectively, were used.

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Synthesis Example 4

Synthesis of Intermediate B

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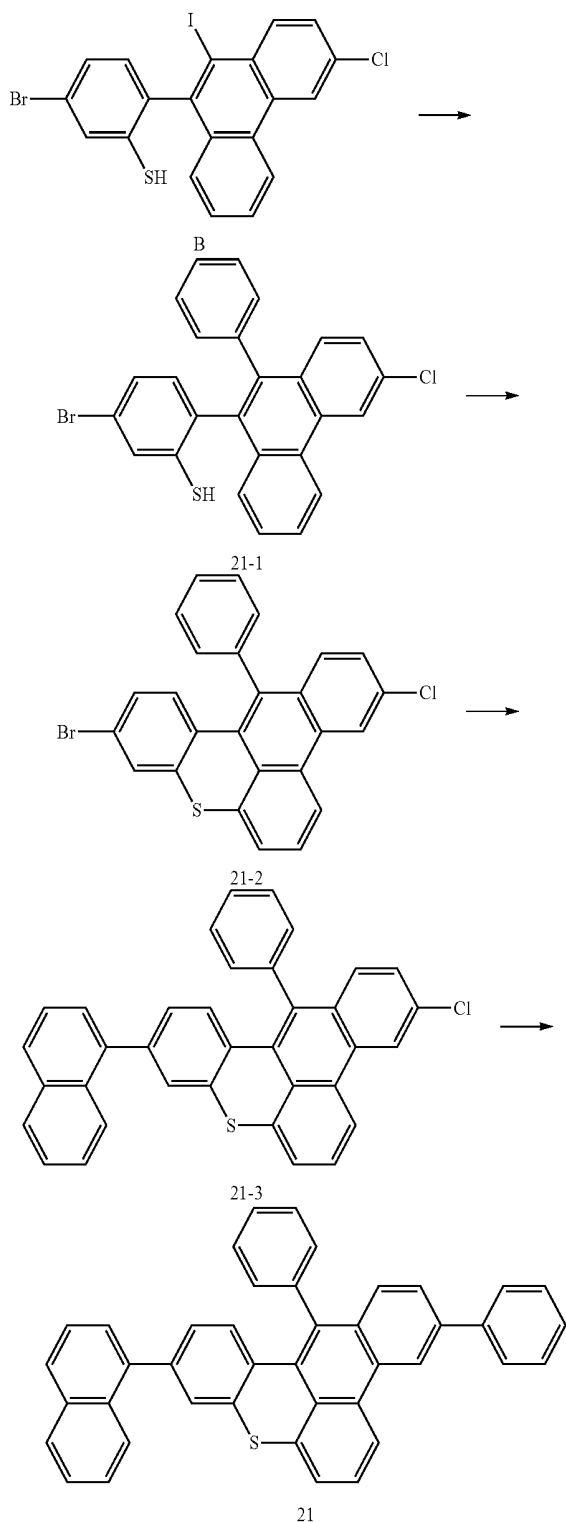
85

Synthesis of Intermediate B

2.864 g (5.455 mmol, Yield: 90%) of Intermediate B was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate A in Synthesis Example 1, except that Intermediate B-1, instead of Intermediate A-4, was used.

Synthesis Example 5

Synthesis of Compound 21



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Synthesis of Intermediate 21-1

2.137 g (4.5 mmol, Yield: 75%) of Intermediate 21-1 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate 1-1 in Synthesis Example 2, except that Intermediate B, instead of Intermediate A, was used.

Synthesis of Intermediate 21-2

1.702 g (36 mmol, Yield: 90%) of Intermediate 21-2 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate 1-2 in Synthesis Example 2, except that Intermediate 21-1, instead of Intermediate 1-1, was used.

Synthesis of Intermediate 21-3

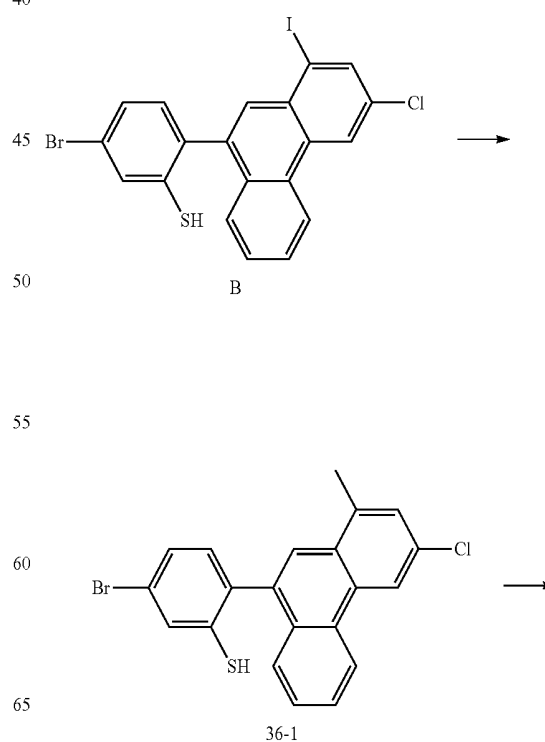
1.596 g (3 mmol, Yield: 85%) of Intermediate 21-3 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate 1-3 in Synthesis Example 2, except that Intermediate 21-2, instead of Intermediate 1-2, was used.

Synthesis of Compound 21

1.573 g (2.8 mmol, Yield: 93%) of Compound 21 was obtained in the same (or substantially the same) manner as in the synthesis of Compound 1 in Synthesis Example 2, except that Intermediate 21-3, instead of Intermediate 1-3, was used.

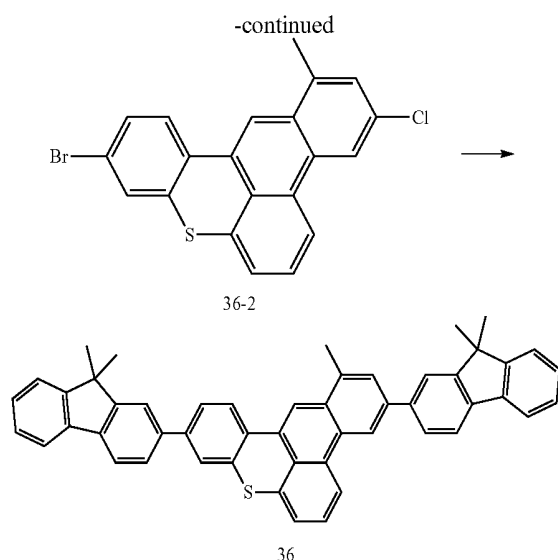
Synthesis Example 6

Synthesis of Compound 36



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-continued



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Synthesis of Compound 36

1.674 g (3 mmol, Yield: 75%) of Compound 36 was obtained in the same (or substantially the same) manner as in the synthesis of Compound 1 in Synthesis Example 2, except that Intermediate 36-2 and 9,9-methylfluorene-2-boronic acid, instead of Intermediate 1-3 and phenylboronic acid, respectively, were used.

Additional compounds were also synthesized using appropriate intermediate materials in the same (or substantially the same) manner according to the same (or substantially the same) synthetic pathway as described above.

Synthesis methods of additional compounds other than the above-described compounds should be apparent to those skilled in the art based on the above-described synthetic pathway and source materials used in the above examples.

Example 1

Synthesis of Intermediate 36-1

3.370 g (8.2 mmol, Yield: 82%) of Intermediate 36-1 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate 12-1 in Synthesis Example 3, except that Intermediate B, instead of Intermediate A, was used.

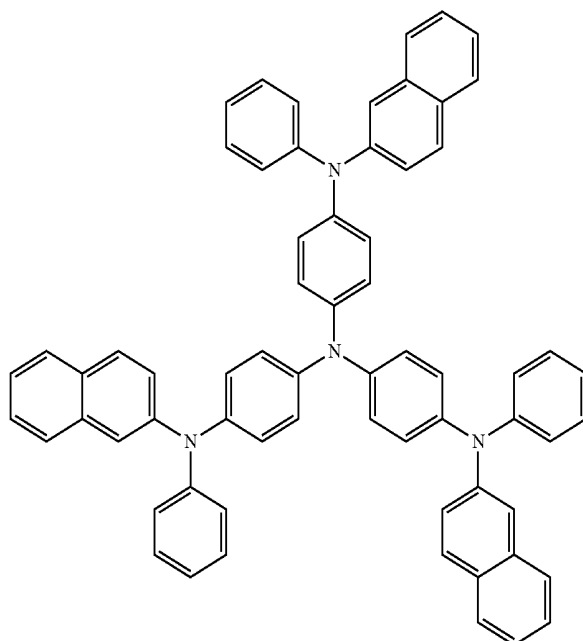
Synthesis of Intermediate 36-2

2.548 g (6.2 mmol, Yield: 75%) of Intermediate 36-2 was obtained in the same (or substantially the same) manner as in the synthesis of Intermediate 1-2 in Synthesis Example 2, except that Intermediate 36-1, instead of Intermediate 1-1, was used.

A 15 Ω /cm² ITO glass substrate (having a thickness of 1200 Å, available from Corning) was cut to a size of 50 mm $\times$ 50 mm $\times$ 0.7 mm and then sonicated in isopropyl alcohol and pure water, each for five minutes, and then cleaned by irradiation of ultraviolet rays for 30 minutes and exposure to ozone. The resulting glass substrate with an ITO anode was mounted into a vacuum deposition device.

2-TNATA was vacuum-deposited on the ITO anode of the glass substrate to form an HIL having a thickness of 600 Å, and 4,4'-bis[N-(1-naphthyl)-N-phenylamino]biphenyl (hereinafter, "NPB") as a hole transport compound was vacuum-deposited on the HIL to form a HTL having a thickness of about 300 Å.

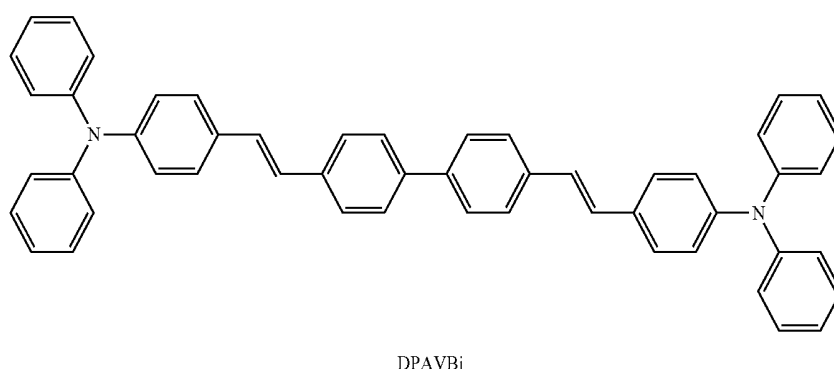
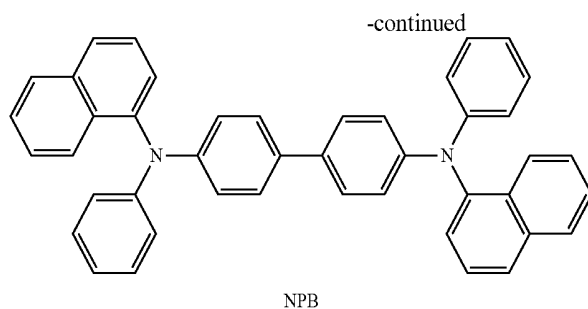
Next, Compound 1 as a blue phosphorescent host and 4,4'-bis[2-(4-(N,N-diphenylamino)phenyl)vinyl]biphenyl (hereinafter, "DPAVB") as a known blue fluorescent opant were co-deposited on the HTL in a weight ratio of about 98:2 to form an EML having a thickness of about 300 Å.



2-TNATA

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Alq₃ was deposited on the EML to form an ETL having a thickness of about 300 Å. Subsequently, LiF as a halogenated alkali metal was deposited on the ETL to form an EIL having a thickness of about 10 Å, and then Al was vacuum-deposited on the EIL to form a cathode (a LiF/Al electrode) having a thickness of about 3000 Å, thereby manufacturing an organic light-emitting device.

Example 2

An organic light-emitting device was manufactured in the same (or substantially the same) manner as in Example 1, except that Compound 12 instead of Compound 1 was used to form the EML.

Example 3

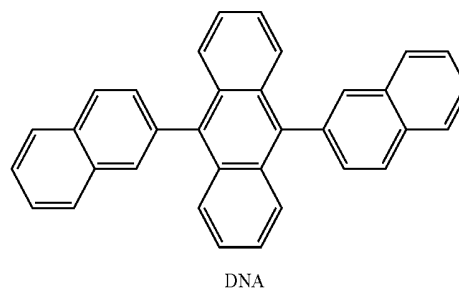
An organic light-emitting device was manufactured in the same (or substantially the same) manner as in Example 1, except that Compound 21 instead of Compound 1 was used to form the EML.

Example 4

An organic light-emitting device was manufactured in the same (or substantially the same) manner as in Example 1, except that Compound 36 instead of Compound 1 was used to form the EML.

Comparative Example 1

An organic light-emitting device was manufactured in the same (or substantially the same) manner as in Example 1, except that DNA (also referred to herein as "ADN") as a blue phosphorescent host, instead of Compound 1, was used to form the EML.



Example 5

An organic light-emitting device was manufactured in the same (or substantially the same) manner as in Comparative Example 1, except that Compound 1 instead of Alq₃ was used to form the ETL.

The organic light-emitting devices of Examples 1, 2, 3, and 4 manufactured using Compounds 1, 12, 21, and 36, respectively, as a host material for the blue EML layer or as a material for the ETL (as described in, for example, Example 5) were found to have improved driving voltages, improved I-V-L characteristics with improved efficiency, and remarkably improved life time characteristics, compared to the organic light-emitting device of Comparative Example 1 using DNA as a known host material. Some representative characteristics and lifetime (lifespan) characteristics of the organic light-emitting devices of Examples 1 to 5 and Comparative Example 1 are shown in Table 1:

TABLE 1

Example	Material	Driving voltage (V)	Current density (mA/cm ²)	Luminance (cd/m ²)	Efficiency (cd/A)	Emission color	Half-life span (hr@100 mA/cm ²)
Example 1	Compound 1	5.96	50	3005	6.01	blue	315
Example 2	Compound 12	6.02	50	2995	5.99	blue	320
Example 3	Compound 21	5.99	50	3108	6.21	blue	305
Example 4	Compound 36	6.24	50	3069	6.1484	blue	335
Comparative Example 1	DNA	7.01	50	2645	5.29	blue	258
Example 5	Compound 1	6.55	50	2890	5.78	blue	320

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As described above, according to the one or more of the above embodiments of the present disclosure, a compound represented by Formula 1 as described above may have good emission characteristics and improved charge transporting ability, and thus may be used as a light-emitting material or electron-transporting material for fluorescent or phosphorescent light-emitting devices of any color, including but not limited to red, green, blue, and white. An organic light-emitting device having improved efficiency, low driving voltage, improved luminance, and improved lifetime may be manufactured by using the compound of Formula 1.

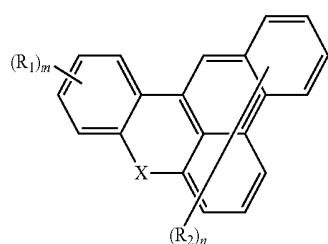
It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation.

Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

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

What is claimed is:

1. A compound represented by Formula 1:



Formula 1

wherein, in Formula 1,

R_1 is selected from a substituted or unsubstituted C_6 - C_{60} aryl group and a substituted or unsubstituted C_2 - C_{60} heteroaryl group;

R_2 is selected from F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy

group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_3)(Q_4)(Q_5), and —B(Q_6)(Q_7);

X is O, S, Se, Te, or Po; and

m and n are each independently an integer selected from 1 to 8, wherein when m is 2 or more, R_1 s are the same as or different from each other, and when n is 2 or more, R_2 s are the same as or different from each other, wherein at least one substituent of the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_2 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_2 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_2 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

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

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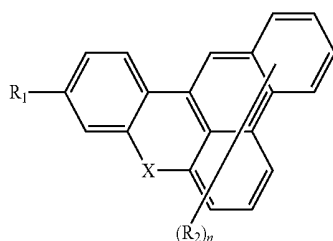
polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_{11})(\text{Q}_{12})$, $-\text{Si}(\text{Q}_{13})(\text{Q}_{14})(\text{Q}_{15})$, and $-\text{B}(\text{Q}_{16})(\text{Q}_{17})$,

a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{N}(\text{Q}_{21})(\text{Q}_{22})$, $-\text{Si}(\text{Q}_{23})(\text{Q}_{24})(\text{Q}_{25})$, and $-\text{B}(\text{Q}_{26})(\text{Q}_{27})$, and $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$, and $-\text{B}(\text{Q}_{36})(\text{Q}_{37})$;

Q_3 to Q_7 , Q_{11} to Q_{17} , Q_{21} to Q_{27} , and Q_{31} to Q_{37} are each independently selected from 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, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

2. The compound of claim 1, wherein the compound of Formula 1 is represented by Formula 2:

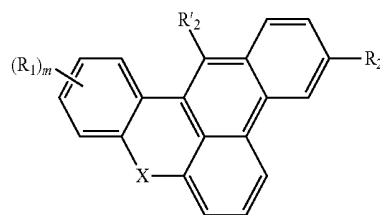


Formula 2

3. The compound of claim 1, wherein the compound of Formula 1 is represented by Formula 3:

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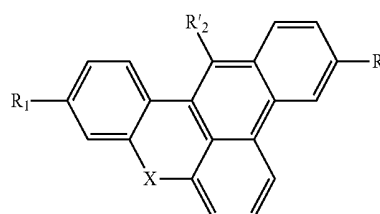
Formula 3



wherein, in Formula 3, definition of R'_2 is the same as the definition of R_2 .

4. The compound of claim 1, wherein the compound of Formula 1 is represented by Formula 4:

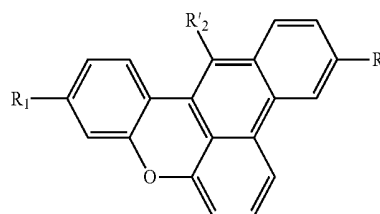
Formula 4



wherein, in Formula 4, definition of R'_2 is the same as the definition of R_2 .

5. The compound of claim 1, wherein the compound of Formula 1 is represented by Formula 5:

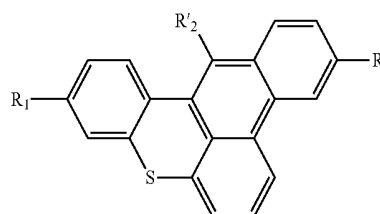
Formula 5



wherein, in Formula 5, definition of R'_2 is the same as the definition of R_2 .

6. The compound of claim 1, wherein the compound of Formula 1 is represented by Formula 6:

Formula 6



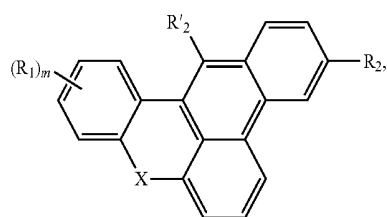
wherein, in Formula 6, definition of R'_2 is the same as the definition of R_2 .

7. The compound of claim 1, wherein X is O or S.

8. The compound of claim 1, wherein R_2 is selected from a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ aryl group, a substituted or unsubstituted $\text{C}_2\text{-C}_{60}$ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

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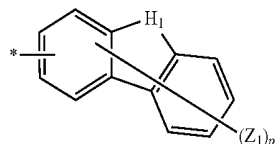
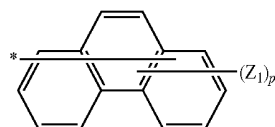
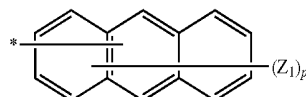
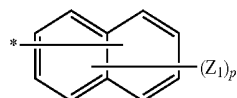
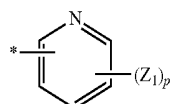
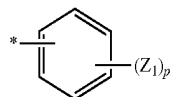
9. The compound of claim 1, wherein the compound of Formula 1 is represented by Formula 3:



Formula 3

Wherein R'_2 is selected from hydrogen, deuterium, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, and a substituted or unsubstituted C_2 - C_{60} heteroaryl group.

10. The compound of claim 1, wherein R_1 is a group represented by any one of Formulae 2a to 2f:



wherein, in Formulae 2a to 2f, Z_1 is selected from hydrogen, deuterium, a substituted or unsubstituted C_1 to C_{20} alkyl group, a substituted or unsubstituted C_6 to C_{20} aryl group, a substituted or unsubstituted C_2 to C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, a halogen group, a cyano group, a nitro group, a hydroxyl group, and a carboxyl group;

H_1 is $-O-$, or $-CR_{51}R_{52}-$;

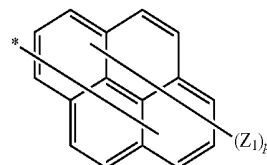
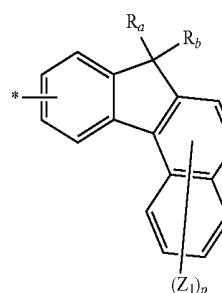
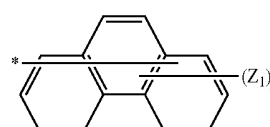
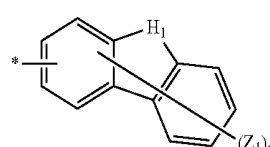
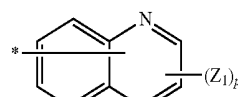
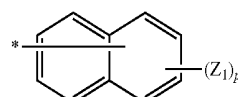
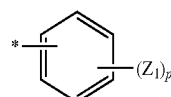
p is an integer selected from 1 to 10, wherein when p is 2 or more, a plurality of Z_1 s are the same as or different from each other;

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R_{51} and R_{52} are each independently selected from a substituted or unsubstituted C_1 to C_{20} alkyl group, a substituted or unsubstituted C_6 to C_{20} aryl group, and a substituted or unsubstituted C_2 to C_{20} heteroaryl group; and

* indicates a binding site.

11. The compound of claim 1, wherein R_2 is a group represented by any one of Formulae 3a to 3g:



wherein, in Formulae 3a to 3g, Z_1 is selected from hydrogen, deuterium, a substituted or unsubstituted C_1 to C_{20} alkyl group, a substituted or unsubstituted C_6 to C_{20} aryl group, a substituted or unsubstituted C_2 to C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, a halogen group, a cyano group, a nitro group, a hydroxyl group, and a carboxyl group;

H_1 is $-O-$, $-S-$, $-CR_{51}R_{52}-$, or $-SiR_{61}R_{62}-$;

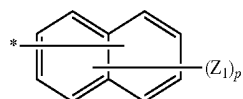
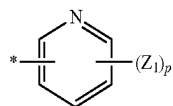
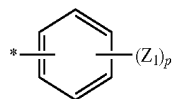
p is an integer selected from 1 to 9, wherein when p is 2 or more, Z_1 s are the same as or different from each other;

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R_{51} , R_{52} , R_{61} , R_{62} , R_a , and R_b are each independently selected from a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, and a substituted or unsubstituted C2 to C20 heteroaryl group; and

* indicates a binding site.

12. The compound of claim 9, wherein R'_2 is selected from hydrogen, deuterium, and groups represented by any one of Formulae 4a to 4e:



4a

15

4b

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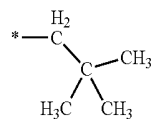
4c

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4d

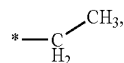


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4d

4e



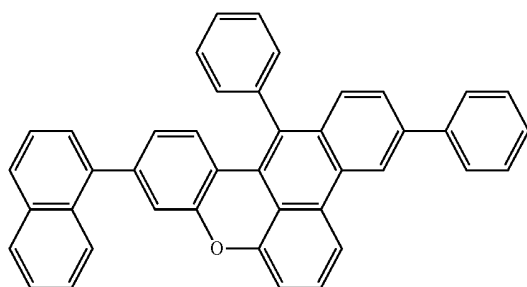
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wherein, in Formulae 4a to 4e, Z_1 is selected from hydrogen, deuterium, a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted C2 to C20 heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, a halogen group, a cyano group, a nitro group, a hydroxyl group, and a carboxyl group;

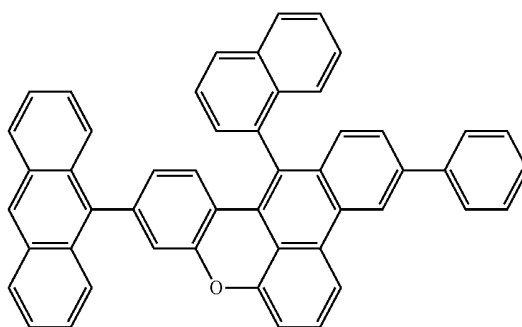
p is an integer selected from 1 to 7, wherein when p is 2 or more, Z_1 s are the same as or different from each other; and

* indicates a binding site.

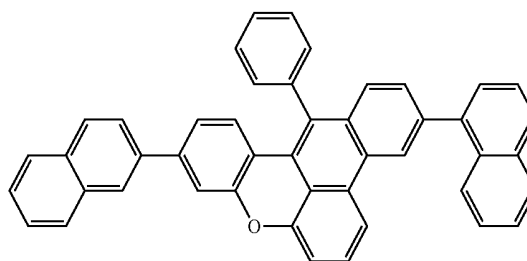
13. The compound of claim 1, wherein the compound of Formula 1 is selected from Compounds 1 to 40:



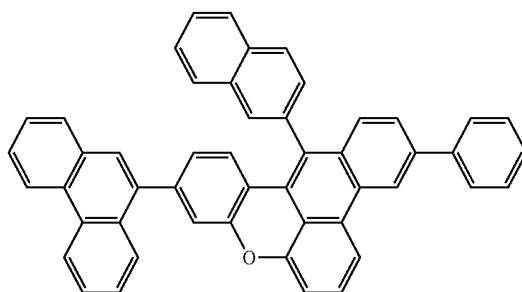
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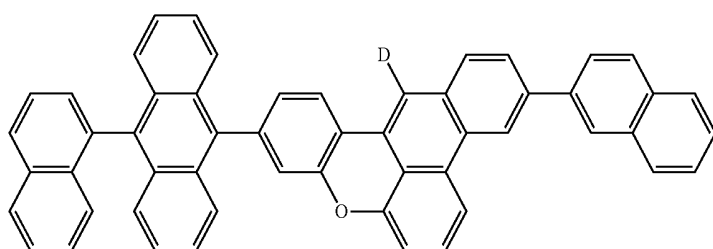
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3



4



5

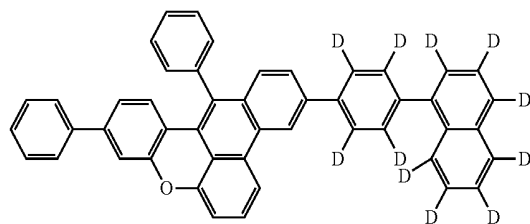
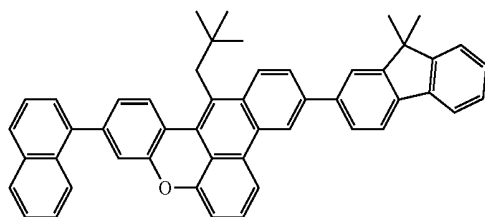
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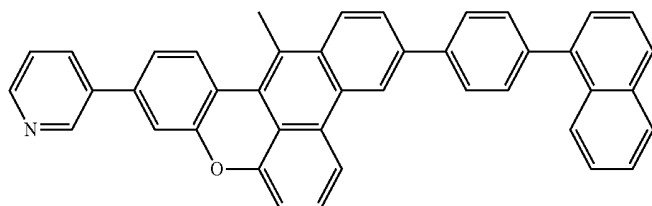
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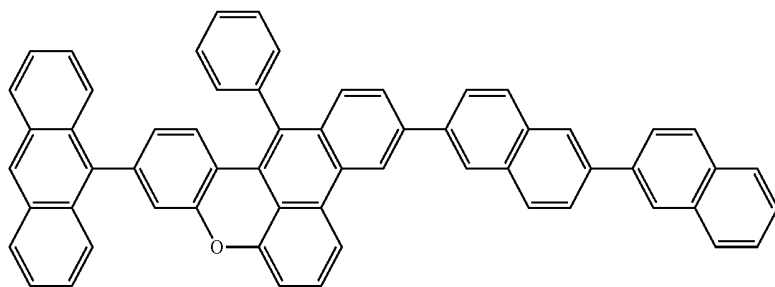
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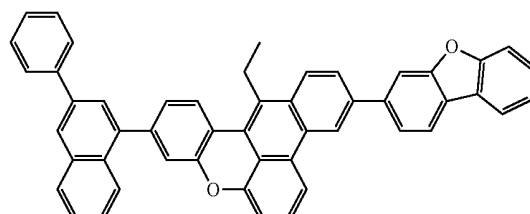
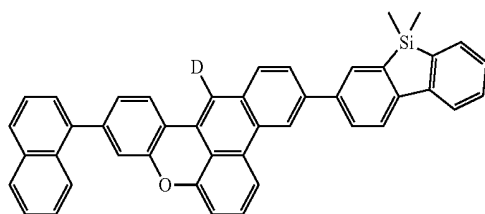


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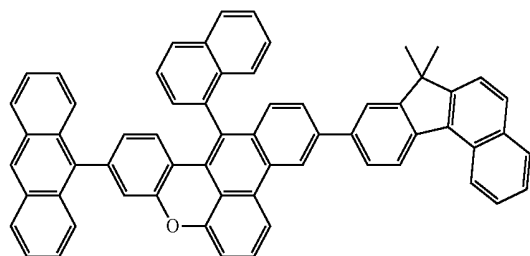
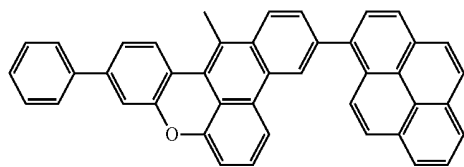
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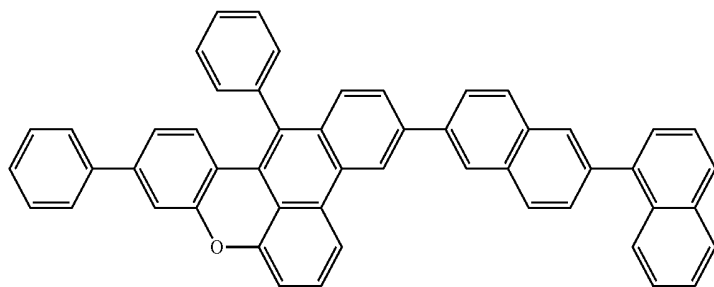


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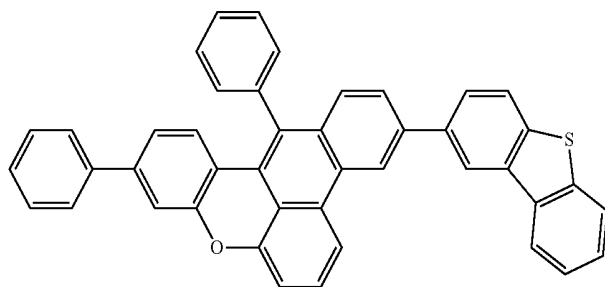


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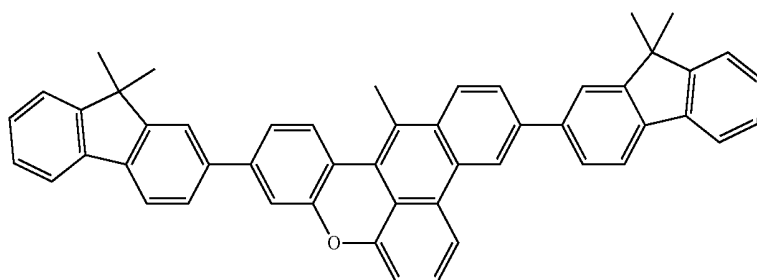
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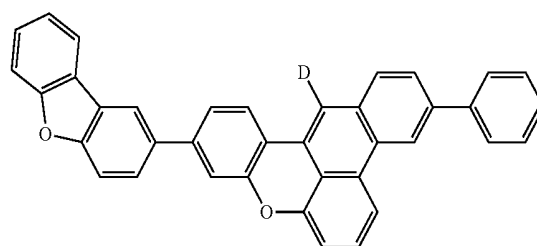
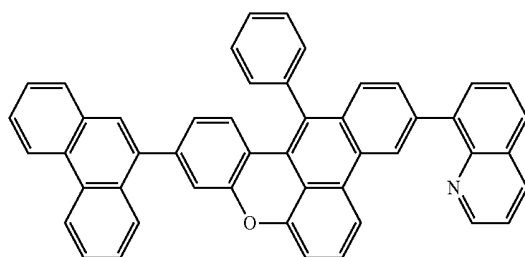


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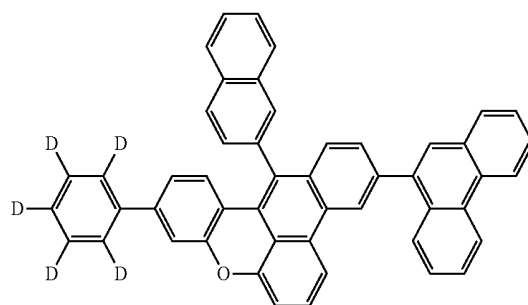
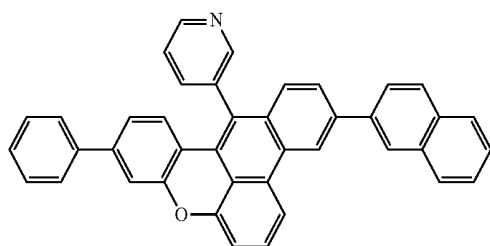
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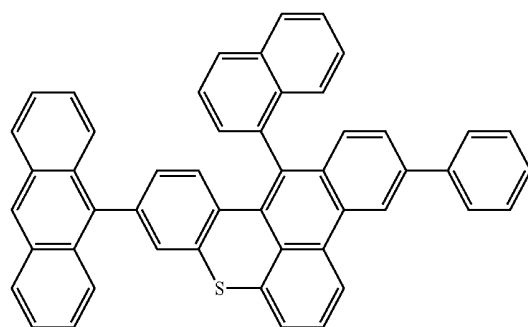
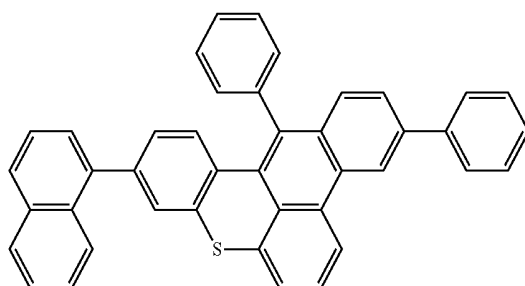
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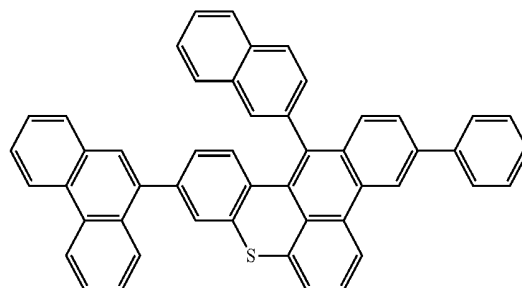
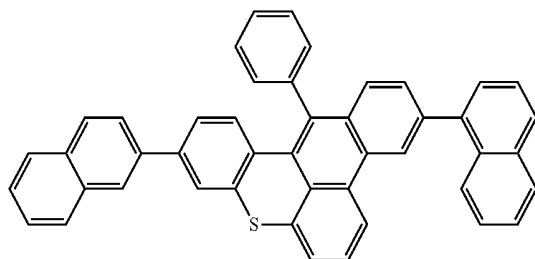
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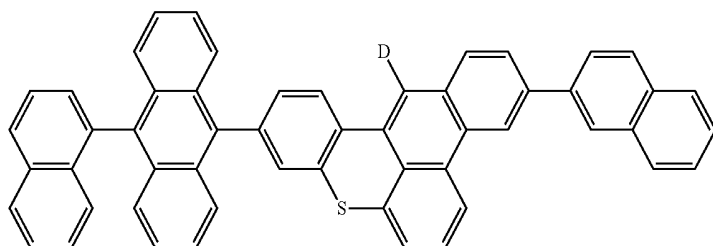
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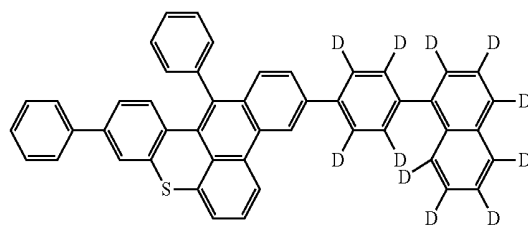
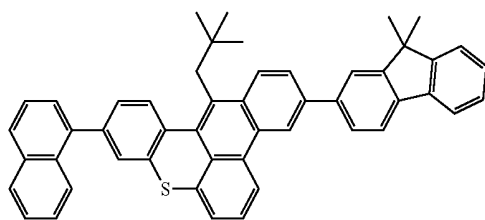


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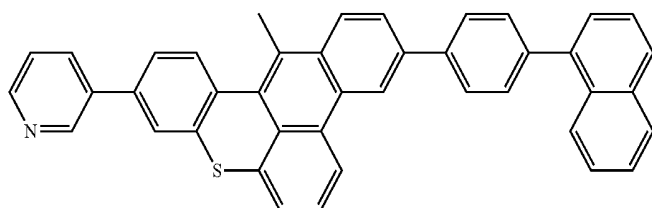


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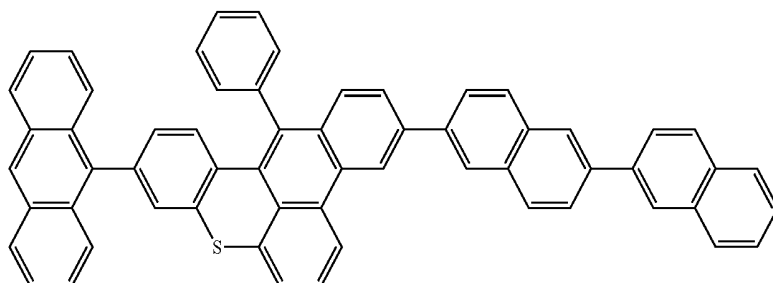
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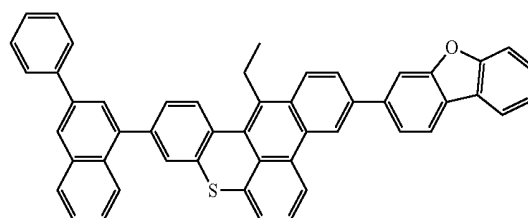
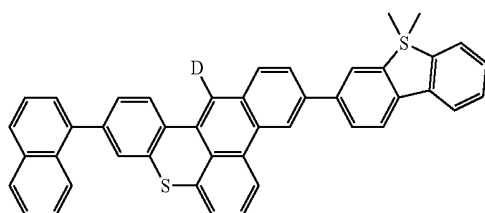


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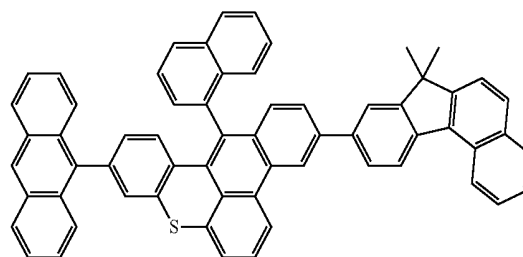
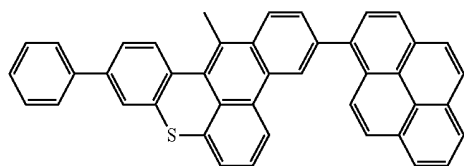
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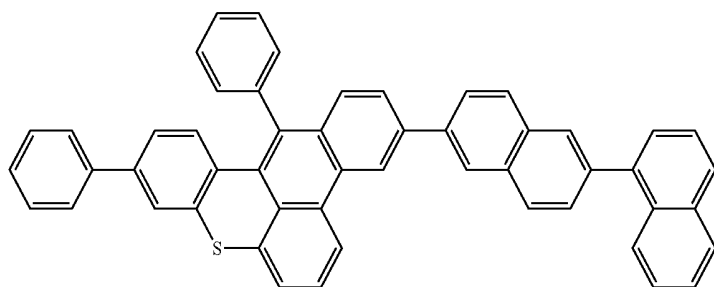
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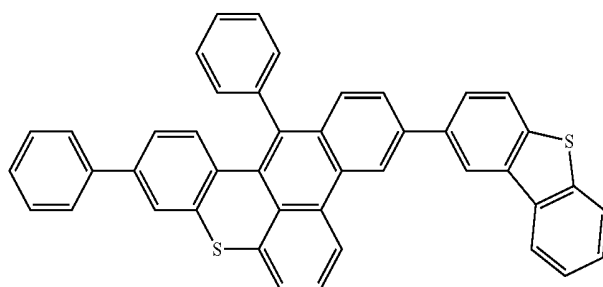
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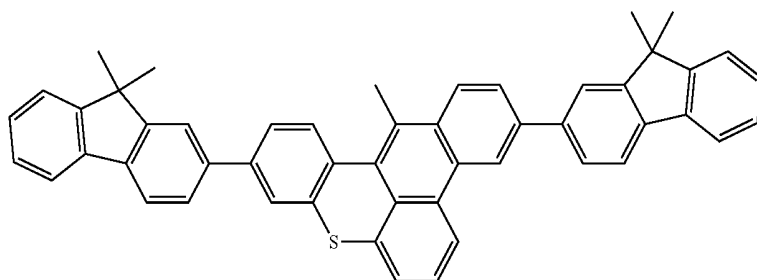
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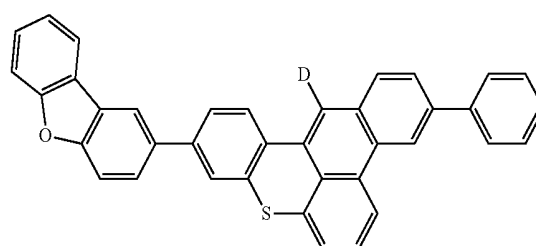
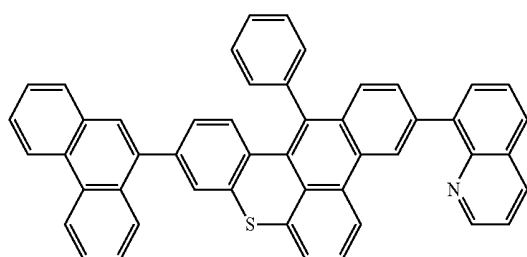


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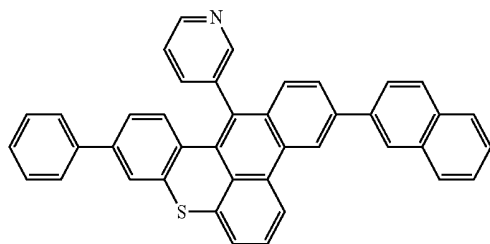


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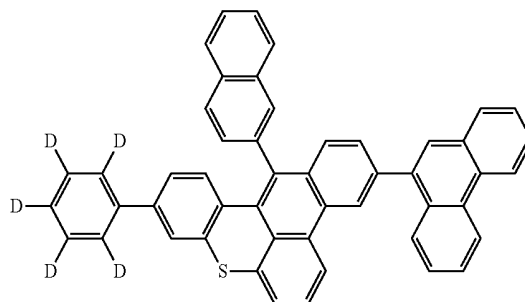
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14. An organic light-emitting device comprising:
a first electrode;

a second electrode facing the first electrode; and

an organic layer between the first electrode and the second
electrode and comprising an emission layer,

wherein the organic layer comprises the compound of
Formula 1 of claim 1.

15. The organic light-emitting device of claim 14, wherein
the emission layer comprises the compound of Formula 1.

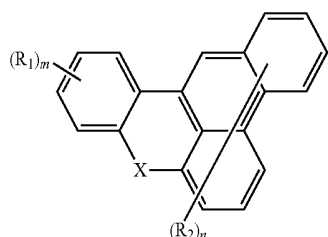
16. An organic light-emitting device comprising:

a first electrode;

a second electrode facing the first electrode; and

an organic layer between the first electrode and the second
electrode and comprising an emission layer,

wherein the emission layer comprises a compound of
Formula 1 as a blue host:



Formula 1

wherein, in Formula 1,

R_1 and R_2 are each independently selected from hydrogen,
deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a
cyano group, a nitro group, an amino group, an amidino
group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid
group or a salt thereof, a phosphoric acid group or a salt
thereof, a substituted or unsubstituted C_1 - C_{60} alkyl
group, a substituted or unsubstituted C_2 - C_{60} alkenyl
group, a substituted or unsubstituted C_2 - C_{60} alkynyl
group, a substituted or unsubstituted C_1 - C_{60} alkoxy
group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl
group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10}
cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted
 C_6 - C_{60} aryl group, a substituted or unsubstituted
 C_6 - C_{60} aryloxy group, a substituted or unsubstituted
 C_6 - C_{60} arylthio group, a substituted or unsubstituted
 C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted mon-

ovalent non-aromatic condensed heteropolycyclic
group, —Si(Q_3)(Q_4)(Q_5), and —B(Q_6)(Q_7);

X is O, S, Se, Te, or Po; and

m and n are each independently an integer selected from

1 to 8, wherein when m is 2 or more, R_1 s are the same
as or different from each other, and when n is 2 or more,

R_2 s are the same as or different from each other, and

wherein at least one substituent of the substituted C_1 - C_{60}

alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted

C_2 - C_{60} alkynyl group, the substituted

C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl

group, the substituted C_2 - C_{10} heterocycloalkyl group,

the substituted C_3 - C_{10} cycloalkenyl group, the substituted

C_2 - C_{10} heterocycloalkenyl group, the substituted

C_6 - C_{60} aryl group, substituted C_6 - C_{60} aryloxy group,

the substituted C_6 - C_{60} arylthio group, the substituted

C_2 - C_{60} heteroaryl group, the substituted monovalent

non-aromatic condensed polycyclic group, and the substituted

monovalent non-aromatic condensed heteropolycyclic group is selected from:

deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a

cyano group, a nitro group, an amino group, an amidino

group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid

group or a salt thereof, a phosphoric acid group or a salt thereof,

a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group,

a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group,

a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60}

alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted

with at least one selected from deuterium, —F,

—Cl, —Br, —I, a hydroxyl group, a cyano group, a

nitro group, an amino group, an amidino group, a

hydrazine group, a hydrazone group, a carboxylic acid

group or a salt thereof, a sulfonic acid group or a salt thereof,

a phosphoric acid group or a salt thereof, a

C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl

group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} hetero-

cycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60}

aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl

group, a monovalent non-aromatic condensed

polycyclic group, a monovalent non-aromatic condensed

heteropolycyclic group, —N(Q_{11})(Q_{12}),

13 Si(Q_{13})(Q_{14})(Q_{15}), and —B(Q_{16})(Q_{17}).

a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl

group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} hetero-

cycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60}

aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl

group, a monovalent non-aromatic condensed

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

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a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇); Q₃ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

17. The organic light-emitting device of claim 16, wherein the emission layer comprises the compound of Formula 1 as a blue fluorescent host.

18. The organic light-emitting device of claim 14, wherein the first electrode is an anode, the second electrode is a cathode, and the organic layer comprises:

a hole transport region between the first electrode and the emission layer, the hole transport region comprising at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer, and an electron transport region between the emission layer and the second electrode, the electron transport region comprising at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

19. An organic light-emitting device comprising:

a first electrode as an anode; a second electrode as a cathode, the second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode and comprising an emission layer, wherein the organic layer further comprises: a hole transport region between the first electrode and the emission layer, the hole transport region com-

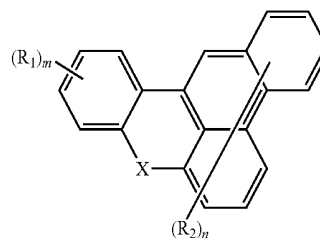
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prising at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer, and

an electron transport region between the emission layer and the second electrode, the electron transport region comprising at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer,

wherein the electron transport region comprises the compound of Formula 1:

Formula 1



wherein, in Formula 1,

R₁ and R₂ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₃)(Q₄)(Q₅), and —B(Q₆)(Q₇);

X is O, S, Se, Te, or Po; and

m and n are each independently an integer selected from 1 to 8, wherein when m is 2 or more, R₁s are the same as or different from each other, and when n is 2 or more, R₂s are the same as or different from each other, and wherein at least one substituent of the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

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

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group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, 5
 a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇), 10
 a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, 15
 a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, 20
 a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, 25
 a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, 30
 a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, 35

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hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and 5
 —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇); Q₃ to Q₇, Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group. 10
 20. The organic light-emitting device of claim 19, wherein the electron transport layer comprises the compound of Formula 1. 15
 21. A flat panel display device comprising the organic light-emitting device of claim 14, wherein the first electrode of the organic light-emitting device is electrically connected to a source electrode or a drain electrode of a thin-film transistor. 20
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专利名称(译)	包含该化合物的化合物和有机发光装置		
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申请号	US14/790855	申请日	2015-07-02
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	HAN SANGHYUN KIM KWANGHYUN KIM SOOYON KIM HAEJIN KIM YOUNGKOOK HWANG SEOKHWAN KIM JONGWOO		
发明人	HAN, SANGHYUN KIM, KWANGHYUN KIM, SOOYON KIM, HAEJIN KIM, YOUNGKOOK HWANG, SEOKHWAN KIM, JONGWOO		
IPC分类号	H01L51/00 C09K11/02 C09K11/06 H05B33/20 C07D311/78 C07D409/04 C07D407/04 C07F7/08 C07D335/04 C07D405/04 H01L51/50		
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摘要(译)

有机发光装置包括第一电极;面向第一电极的第二电极;在第一电极和第二电极之间并包括发光层的有机层, 其中有机层包括式1的化合物: 其中式1中的R₁, R₂, X, m和n如说明书中所定义。

