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Kim et al.

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

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CPC ***H01L 51/0061*** (2013.01); ***C07D 209/80*** (2013.01); ***C07D 401/10*** (2013.01);
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(Continued)

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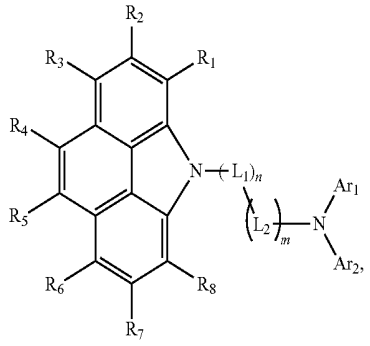
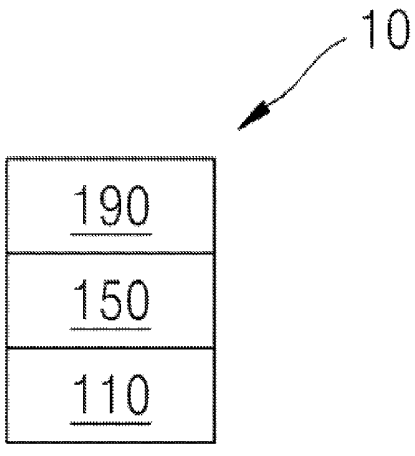
(57) **ABSTRACT**

A compound represented by Formula 1, and an organic light-emitting device including the compound:

Formula 1



In Formula 1, when L_1 and/or L_2 is a phenyl group, a pyridyl group, a pyrimidyl group, and/or a 1,3,5-triazinyl group having binding sites that are ortho- or meta- to each other, and the compound of Formula 1 is included the second hole transport layer (HTL2), the efficiency and luminance half-life of a device may increase due to the HTL2 having a
(Continued)



higher T_1 (e.g., triplet) energy level compared to examples in the related art using a para-substituted phenyl linker.

12 Claims, 1 Drawing Sheet

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C07D 401/10	(2006.01)
C07D 401/12	(2006.01)
C07D 403/10	(2006.01)
C07D 405/04	(2006.01)
C07D 405/10	(2006.01)
C07D 405/12	(2006.01)

(52) **U.S. Cl.**
CPC ***C07D 401/12*** (2013.01); ***C07D 403/10*** (2013.01); ***C07D 405/04*** (2013.01); ***C07D 405/10*** (2013.01); ***C07D 405/12*** (2013.01); ***H01L 51/006*** (2013.01); ***H01L 51/0052*** (2013.01); ***H01L 51/0058*** (2013.01); ***H01L 51/0059*** (2013.01); ***H01L 51/0067*** (2013.01); ***H01L 51/0072*** (2013.01); ***H01L 51/0073*** (2013.01); *H01L 51/5064* (2013.01)

(58) **Field of Classification Search**
CPC .. H01L 51/0012; C07C 211/54; C07C 211/58
See application file for complete search history.

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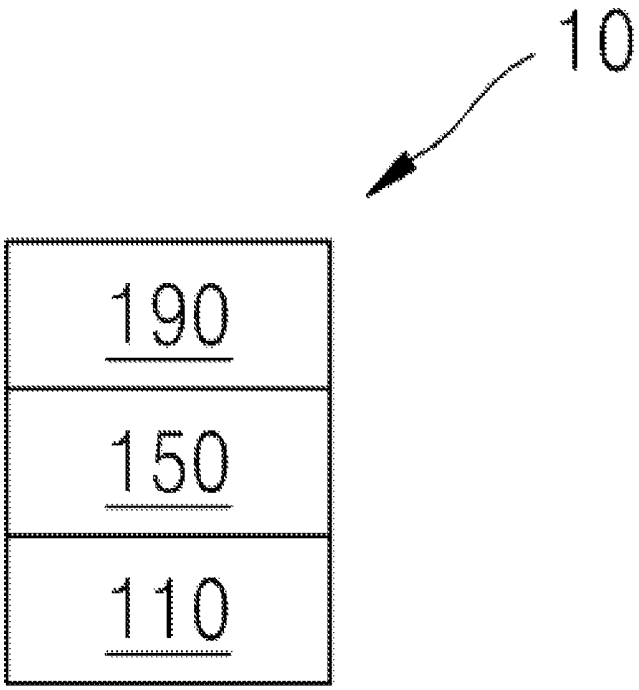
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COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2015-0129089, filed on Sep. 11, 2015, in the Korean Intellectual Property Office, the entire content of which is incorporated herein by reference.

BACKGROUND

1. Field

One or more aspects of example embodiments of the present disclosure are related to a compound and an organic light-emitting device including the compound.

2. Description of the Related Art

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

An organic light-emitting device may include a first electrode on a substrate, and a hole transport region, an emission layer, an electron transport region, and a second electrode sequentially positioned on the first electrode. Holes provided from the first electrode may move to the emission layer through the hole transport region, and electrons provided from the second electrode may move to the emission layer through the electron transport region. The holes and the electrons may recombine in the emission layer to produce excitons. These excitons change (e.g., decay or transition) from an excited state to a ground state to thereby generate light.

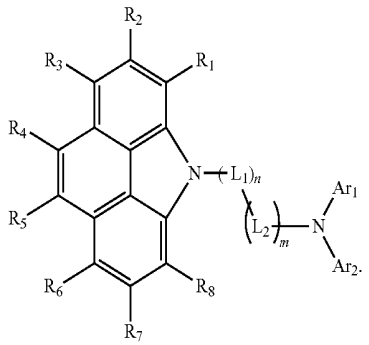
SUMMARY

One or more aspects of example embodiments of the present disclosure are directed toward a material to be included in a hole transport region, and an organic light-emitting device with improved characteristics as the result of using the material.

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.

One or more aspects of example embodiments of the present disclosure provide a compound represented by Formula 1:

Formula 1



In Formula 1,

R_1 to R_8 may each independently be selected from hydrogen, deuterium, a halogen, an amino group, a nitro group, a nitrile group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_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_1-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;

Ar_1 and Ar_2 may each independently be selected from 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_1-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;

L_1 and L_2 may each independently be selected from a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-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;

one selected from L_1 and L_2 may be a phenyl group, a pyridyl group, a pyrimidyl group, or a 1,3,5-triazinyl group, having binding sites that are ortho- or meta- to each other;

n and m may each independently be an integer selected from 0 to 2 (excluding that both n and m are 0);

when n is 2, each L_1 may be independently selected from the above groups;

when m is 2, each L_2 may be independently selected from the above groups;

at least one substituent of the substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_2-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_2-C_{10} heterocycloalkenyl group, substituted C_6-C_{60} aryl group, substituted C_6-C_{60} aryloxy group, substituted C_6-C_{60} arylthio group, substituted C_1-C_{60} heteroaryl group, substituted monovalent non-aromatic condensed polycyclic group, substituted monovalent non-aromatic condensed heteropolycyclic group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, and substituted divalent 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 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—B(Q_{16})(Q_{17})$,

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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group; and

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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one 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, 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{21})(Q_{22})$, $—Si(Q_{23})(Q_{24})(Q_{25})$, and $—B(Q_{26})(Q_{27})$,

wherein Q_{11} to Q_{17} and Q_{21} to Q_{27} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

According to one or more example 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.

According to one or more example embodiments of the present disclosure, a flat panel display device includes the organic light-emitting device, and a 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 example embodiments, taken in conjunction with the accompanying drawing,

which illustrates a schematic view of an organic light-emitting device according to an embodiment of the present disclosure.

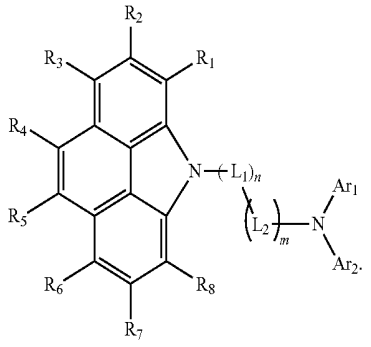
DETAILED DESCRIPTION

Reference will now be made in more detail to example embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout and duplicative descriptions will not be provided. In this regard, the present example embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the example 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 selected from "at least one selected from", "one of", "at least one selected from", and "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.

In the drawing, the thicknesses of layers, films, panels, regions, etc., may be exaggerated for clarity. It will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening element(s) may also be present. In contrast, when an element is referred to as being "directly on" another element, no intervening elements are present.

A compound according to an example embodiment of the present disclosure may be represented by Formula 1:

Formula 1



In Formula 1,

R_1 to R_8 may each independently be selected from hydrogen, deuterium, a halogen, an amino group, a nitro group, a nitrile group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group,

a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_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_1-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;

Ar_1 and Ar_2 may each independently be selected from 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_1-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;

L_1 and L_2 may each independently be selected from a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-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;

one selected from L_1 and L_2 may be a phenyl group, a pyridyl group, a pyrimidyl group, and/or a 1,3,5-triazinyl group, having binding sites that are ortho- or meta- to each other;

n and m may each independently be an integer selected from 0 to 2 (excluding that both n and m are 0);

when n is 2, each L_1 may be independently selected from the above groups;

when m is 2, each L_2 may be independently selected from the above groups;

at least one substituent of the substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_2-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_2-C_{10} heterocycloalkenyl group, substituted C_6-C_{60} aryl group, substituted C_6-C_{60} aryloxy group, substituted C_6-C_{60} arylthio group, substituted C_1-C_{60} heteroaryl group, substituted monovalent non-aromatic condensed polycyclic group, substituted monovalent non-aromatic condensed heteropolycyclic group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, and substituted divalent 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 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—B(Q_{16})(Q_{17})$,

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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group; and

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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one 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, 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{21})(Q_{22})$, $—Si(Q_{23})(Q_{24})(Q_{25})$, and $—B(Q_{26})(Q_{27})$,

wherein Q_{11} to Q_{17} and Q_{21} to Q_{27} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

In recent years, a method of using a first hole transport layer and a second hole transport layer having a triplet energy level higher than that previously used in the available art has been used to increase the production efficiency of singlet excitons by triplet-triplet fusion (TTF), such that excitons produced in an emission layer may be effectively utilized and the efficiency of a light-emitting device may be improved. Accordingly, various compounds having a high triplet energy level have been tested for use as a material of the second hole transport layer.

A compound including benzocarbazole and an amine linked via an aromatic linking group at its para positions has been disclosed in the related art. However, the performance characteristics of the compound are not sufficiently positive for application in an actual device.

In order to resolve the lack of production efficiency of the above compound, the triplet energy level of the compound needs to be increased. According to one or more embodiments of the present disclosure, the substitution geometry of the linking group in a compound may be changed to increase the triplet energy level of a molecule, and when the compound is applied to a top-emission device, the efficiency of the device may be improved.

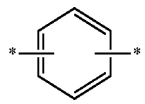
The substituents of the compound represented by Formula 1 will be described in more detail.

According to an example embodiment of the present disclosure, in Formula 1, R_1 to R_8 may each independently be selected from hydrogen, deuterium, and a phenyl group.

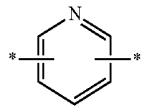
According to an example embodiment of the present disclosure, in Formula 1, R_1, R_4, R_5, and R_8 may each independently be selected from hydrogen and deuterium; and R_2, R_3, R_6, and R_7 may each independently be selected from hydrogen, deuterium, and a phenyl group. For example, R_1, R_3, R_4, R_5, R_6, and R_8 may each independently be selected from hydrogen and deuterium and R_2 and R_7 may each be a phenyl group; or R_1, R_2, R_4, R_5, R_7, and R_8 may each independently be selected from hydrogen and deuterium and R_3 and R_6 may each be a phenyl group.

In some embodiments, in Formula 1, L_1 and L_2 may each independently be one selected from Formulae 2a to 2e:

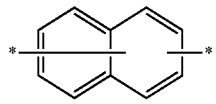
2a



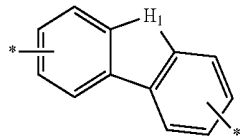
2b



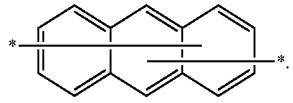
2c



2d



2e



In Formulae 2a to 2e,

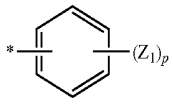
H_1 may be selected from O, S, NR_{11}, and $CR_{12}R_{13}$,

R_{11} to R_{13} may each independently be selected from hydrogen, deuterium, a halogen, a substituted or unsubstituted C_1-C_{20} alkyl group, a substituted or unsubstituted C_6-C_{20} aryl group, a substituted or unsubstituted C_1-C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and

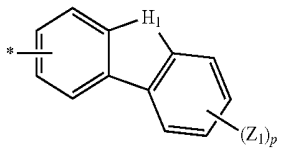
* may be a binding site.

In some embodiments, in Formula 1, Ar_1 and Ar_2 may each independently be one selected from Formulae 3a to 3d:

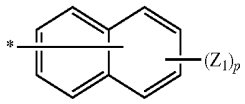
3a



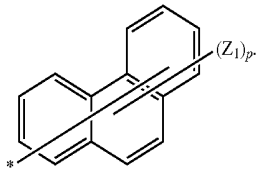
3b



3c



3d



In Formulae 3a to 3d,

H_1 may be selected from O, S, NR_{11}, and $CR_{12}R_{13}$,

R_{11} to R_{13} and Z_1 may each independently be selected from hydrogen, deuterium, a halogen, a substituted or unsubstituted C_1-C_{20} alkyl group, a substituted or unsubstituted C_6-C_{20} aryl group, a substituted or unsubstituted C_1-C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group;

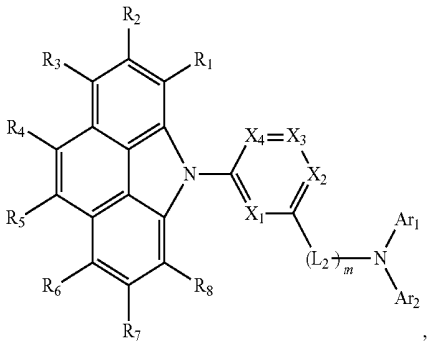
p may be an integer selected from 1 to 9;

when p is 2 or more, each Z_1 moiety may be independently selected from the above groups; and

* denotes a binding site.

In some embodiments, the compound represented by Formula 1 may be further represented by one selected from Formula 2, 3, and 4:

Formula 2



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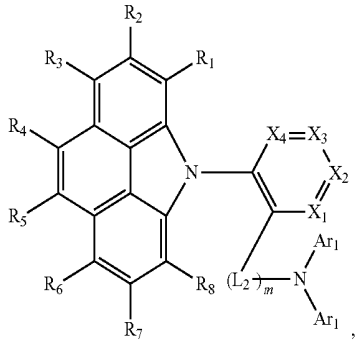
Formula 3



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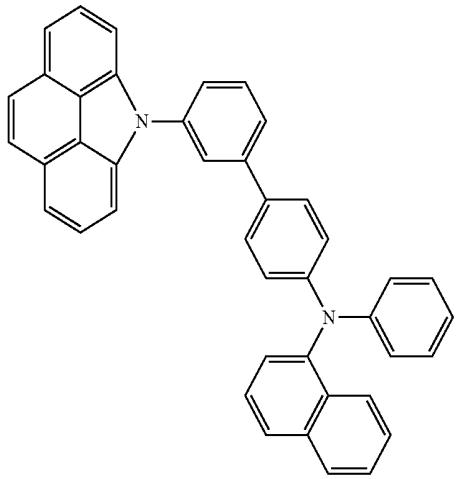
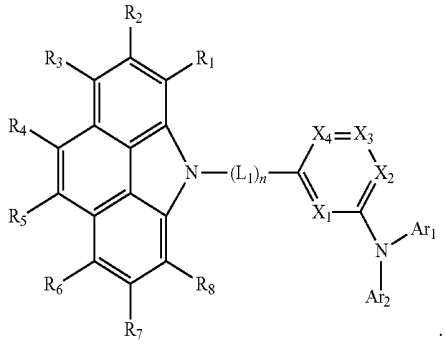
2



Formula 4



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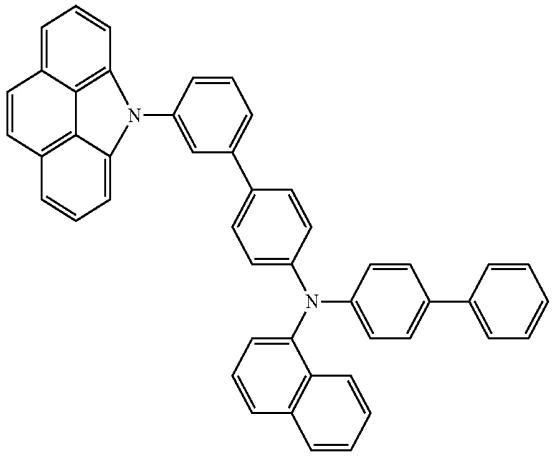
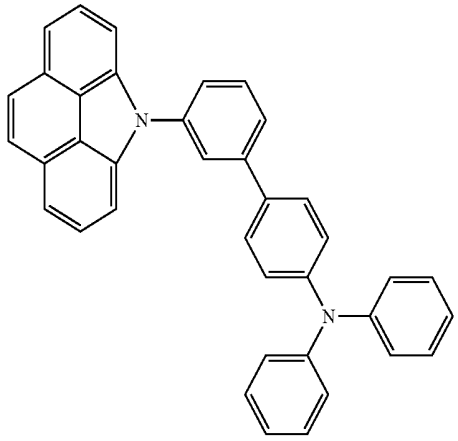


In Formulae 2, 3, and 4, X_1 to X_4 may each independently be selected from CH and nitrogen (N), and

R_1 to R_8, Ar_1 to Ar_2, L_1 to L_2, and n and m may each be the same as described herein in connection with Formula 1.

In some embodiments, the compound represented by Formula 1 may be one selected from Compounds 1 to 90:

1



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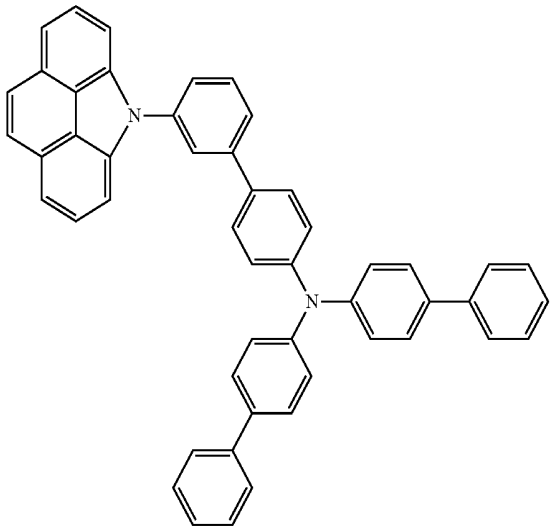

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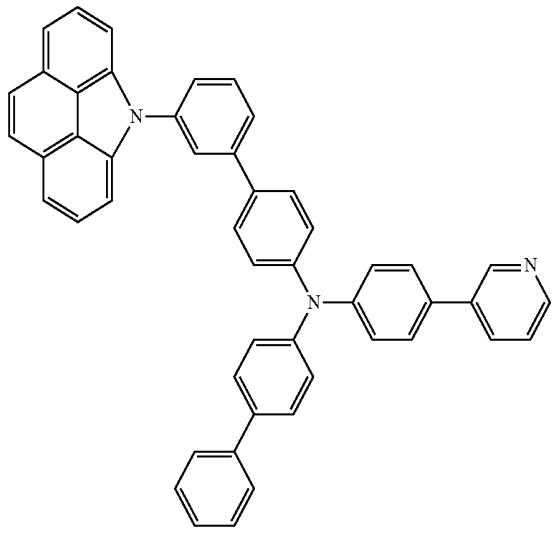

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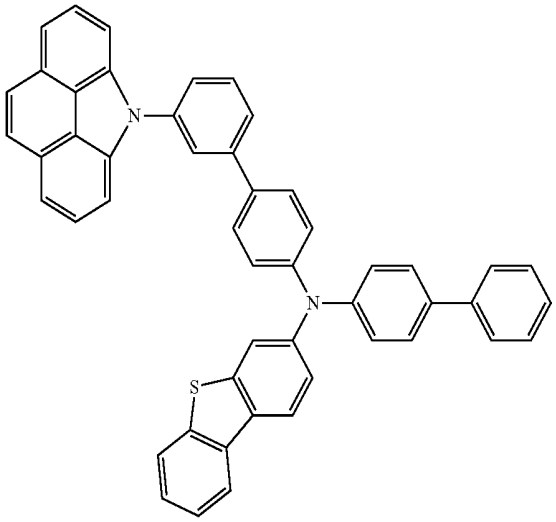

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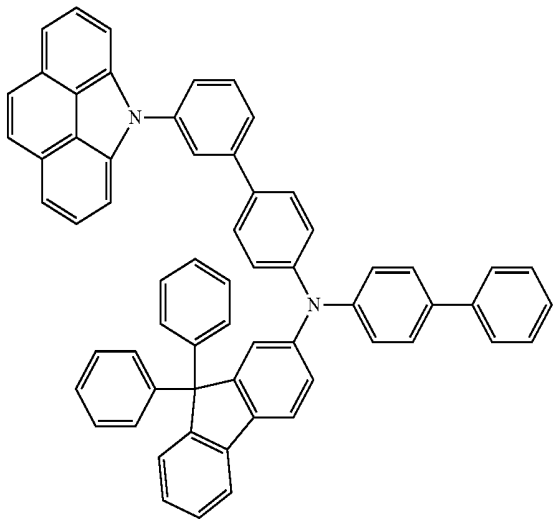

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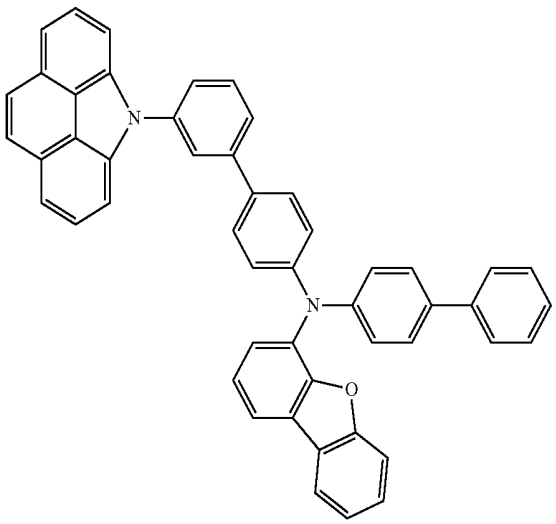

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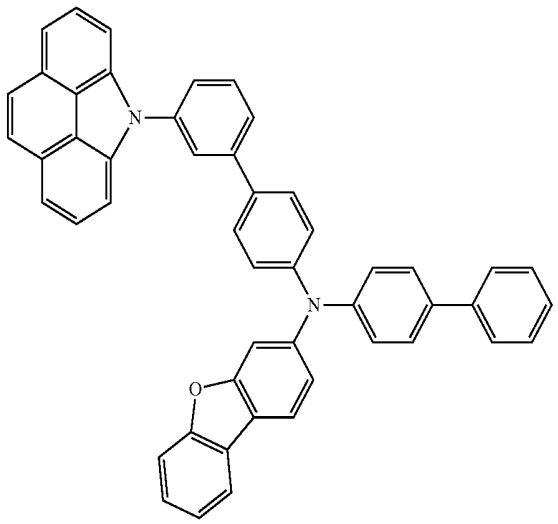

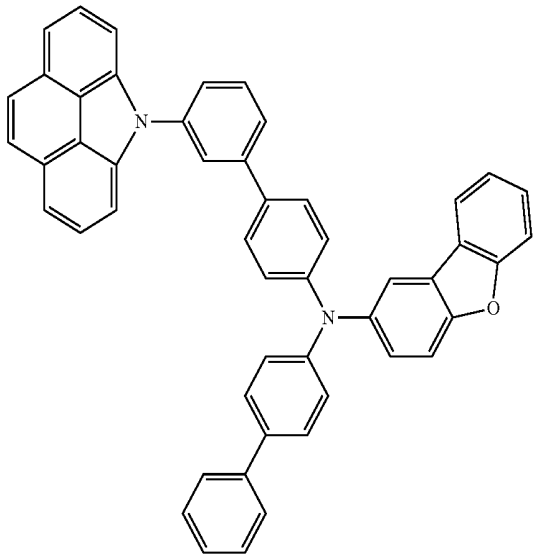

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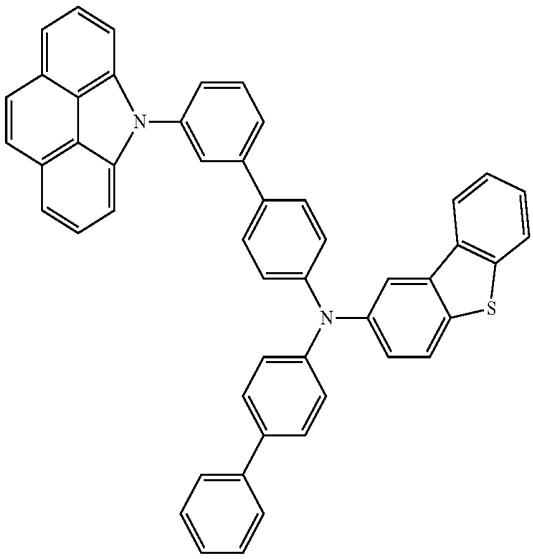

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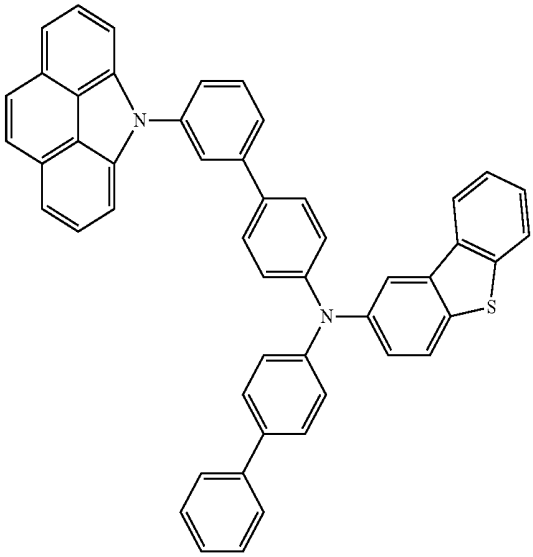

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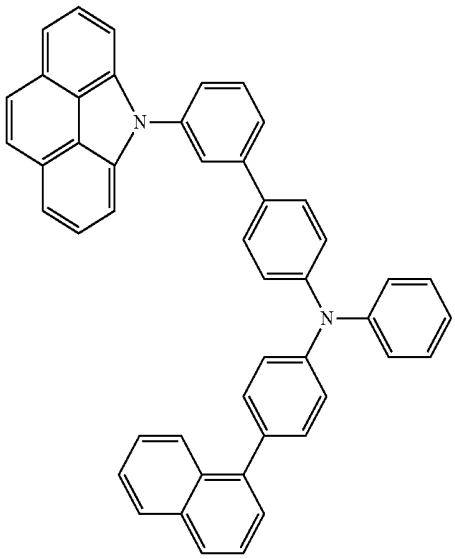

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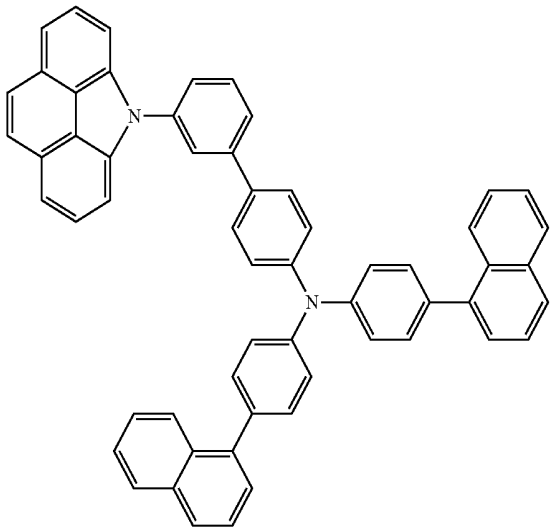

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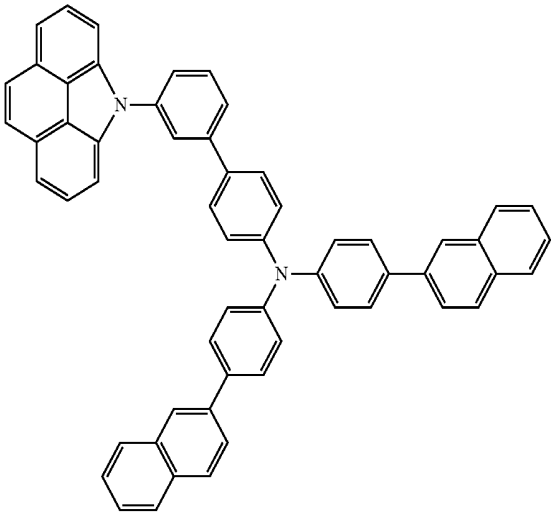

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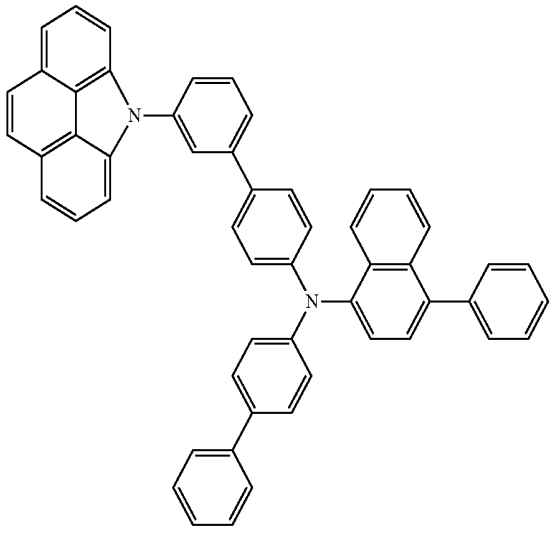

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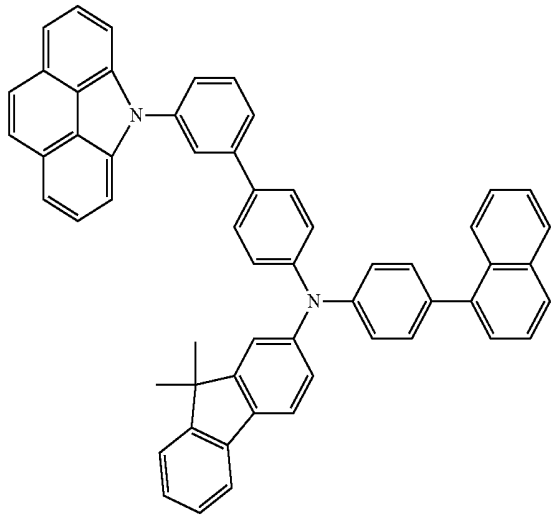

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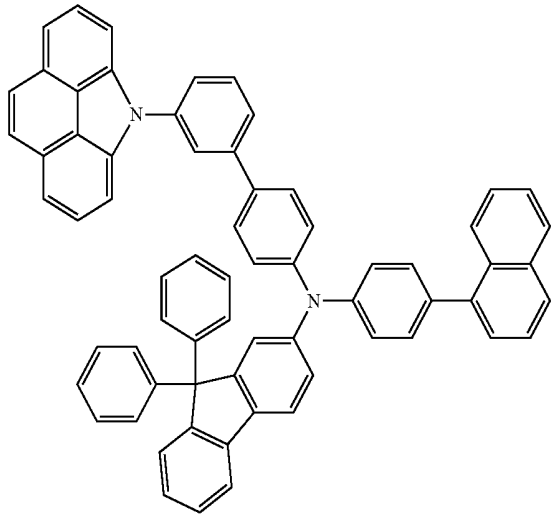

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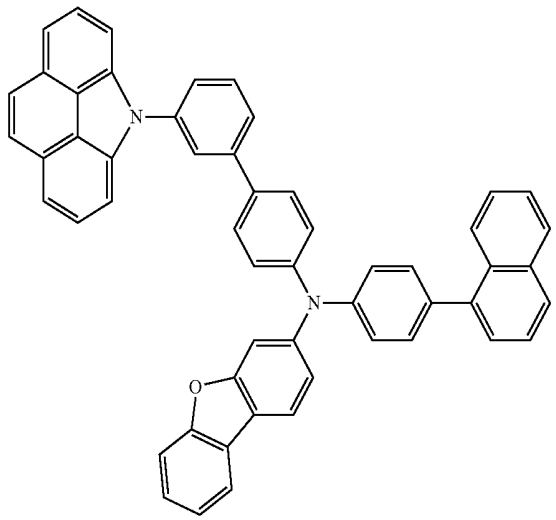

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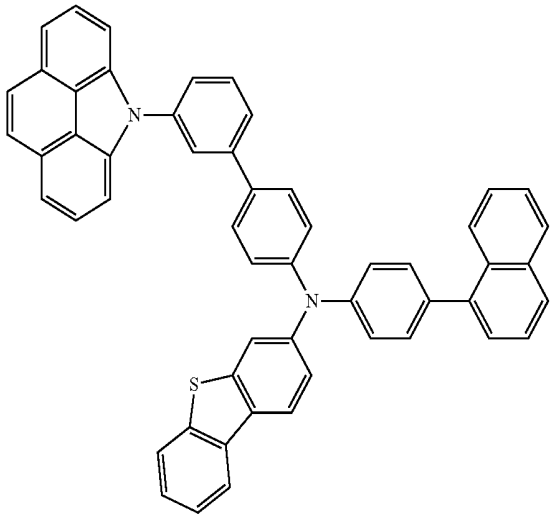

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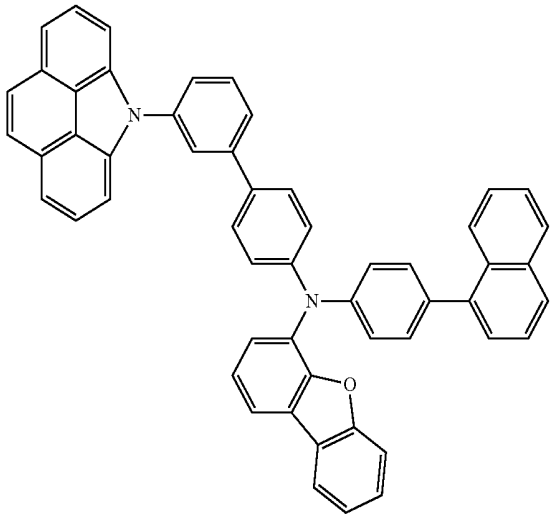

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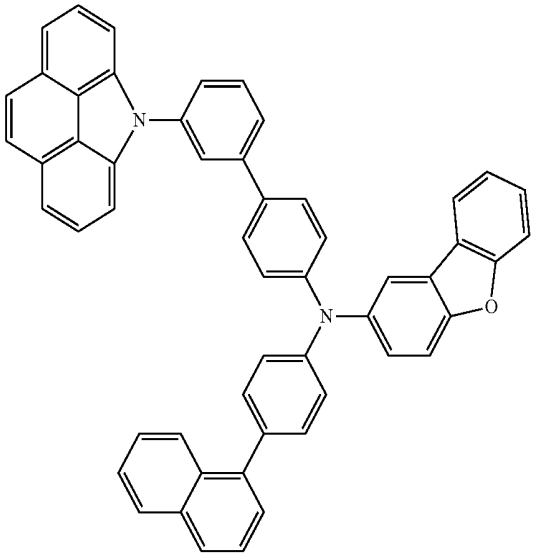

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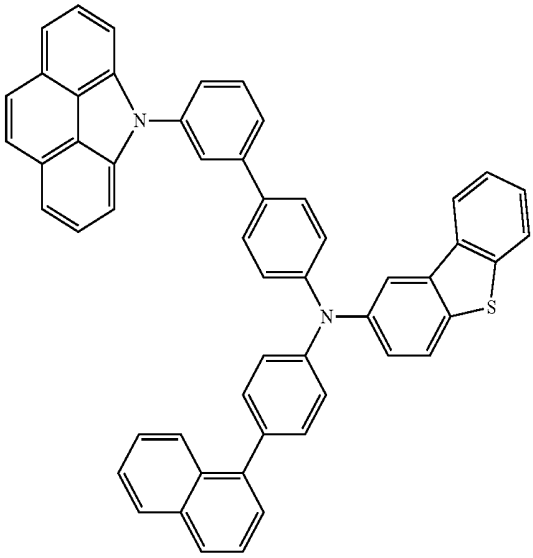

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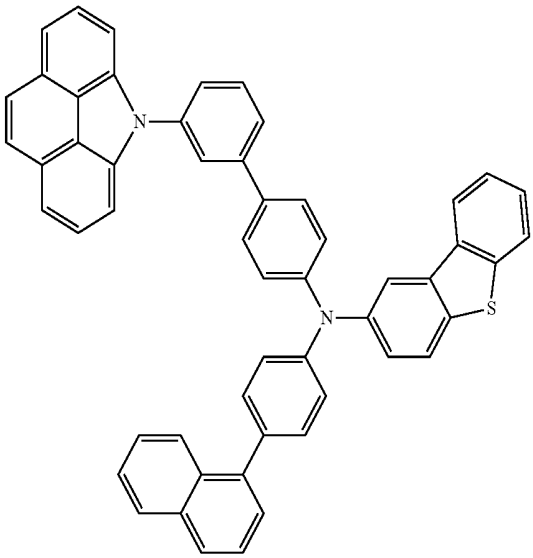

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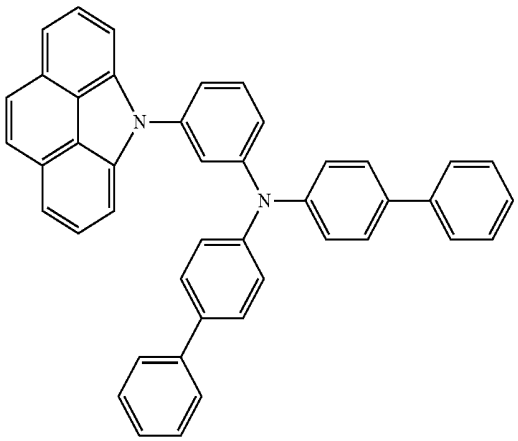

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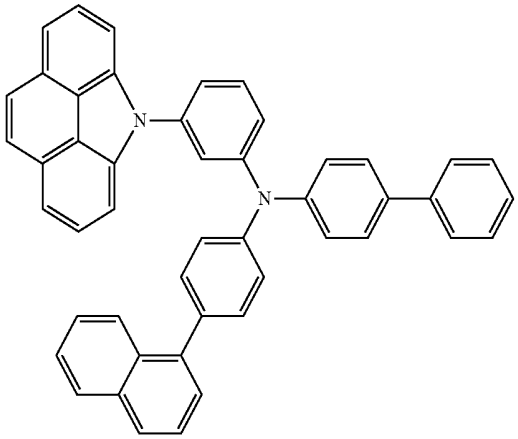

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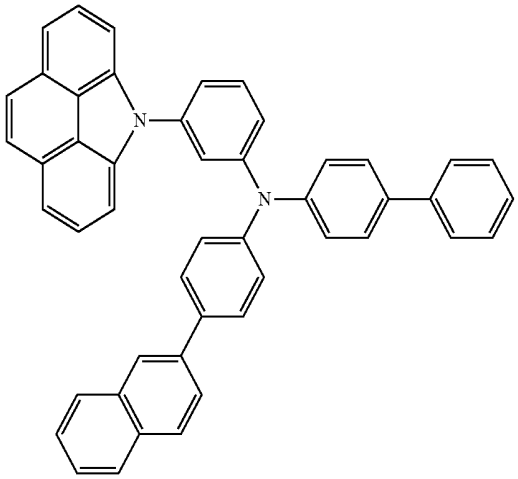

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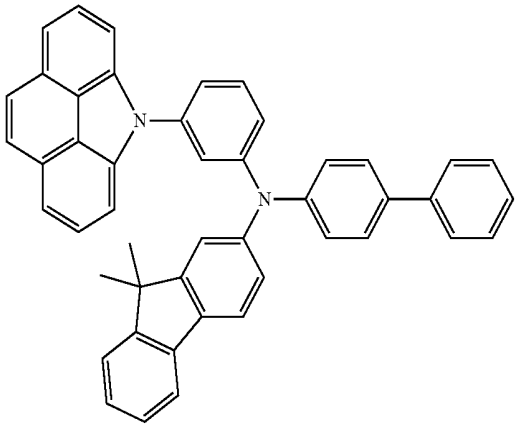

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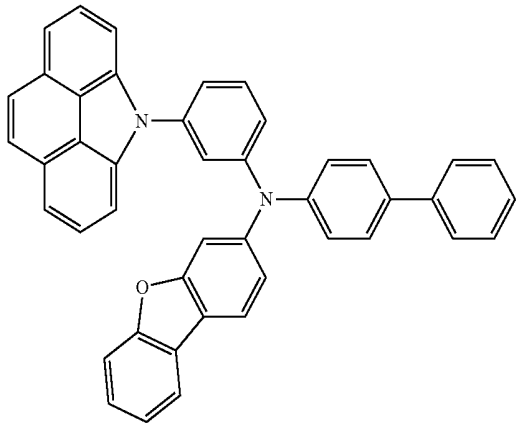

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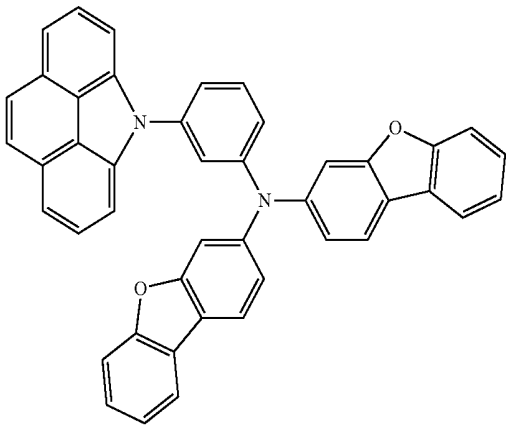

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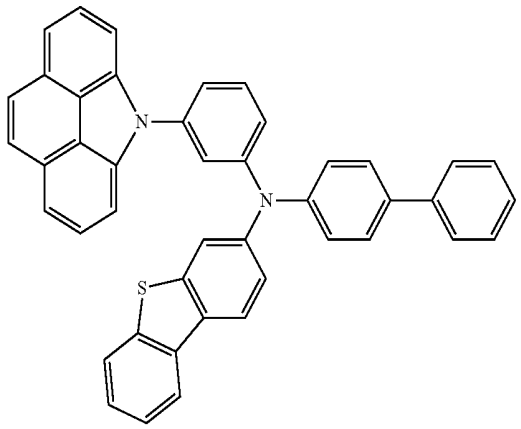

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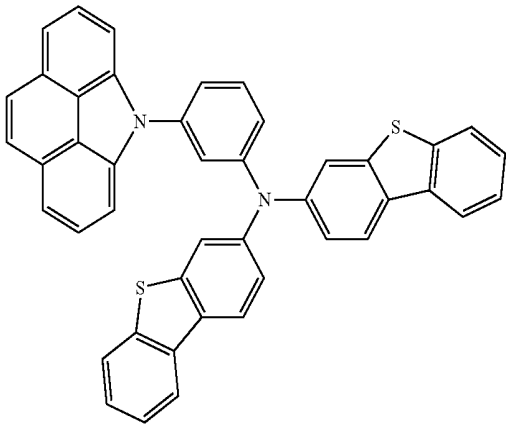

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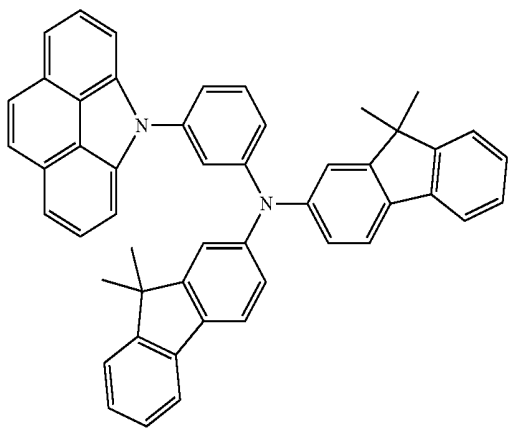

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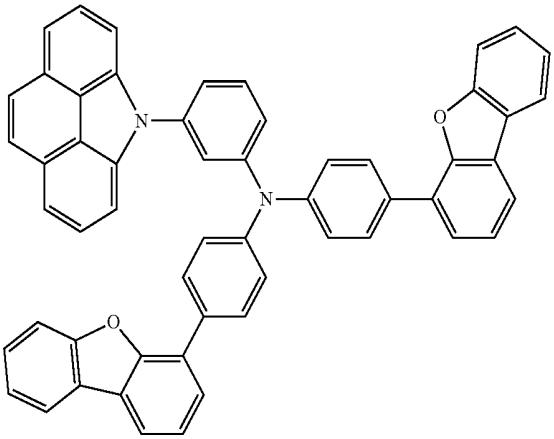

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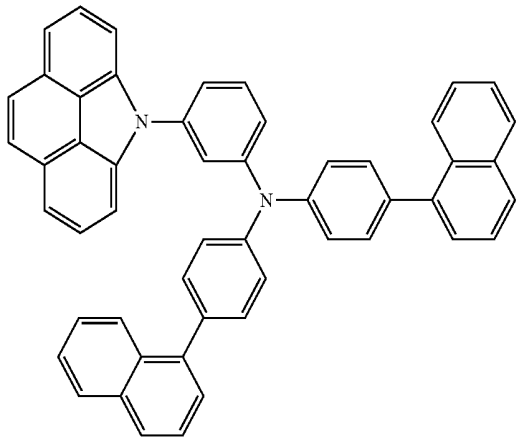

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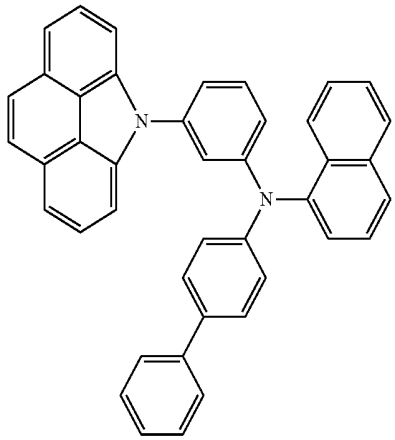

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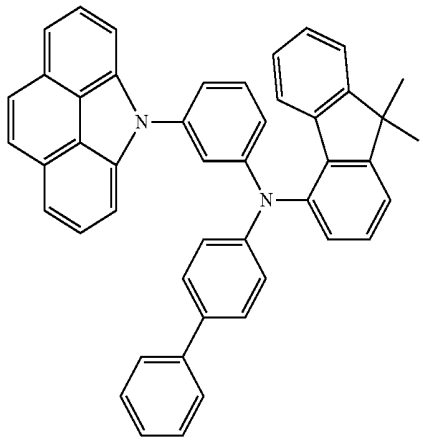

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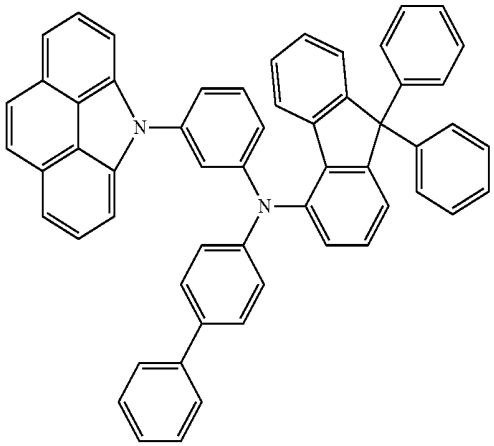

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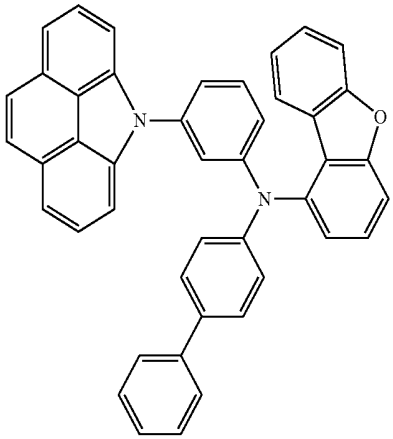

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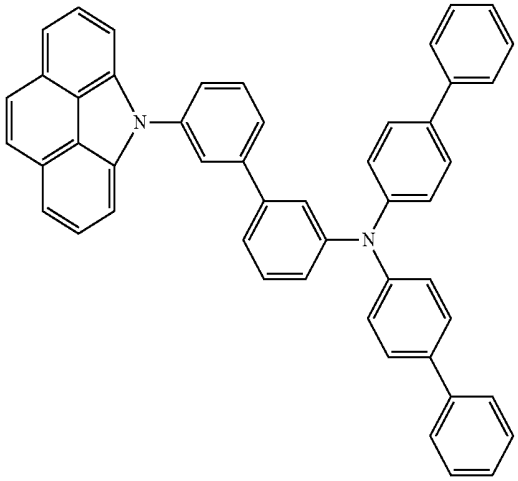

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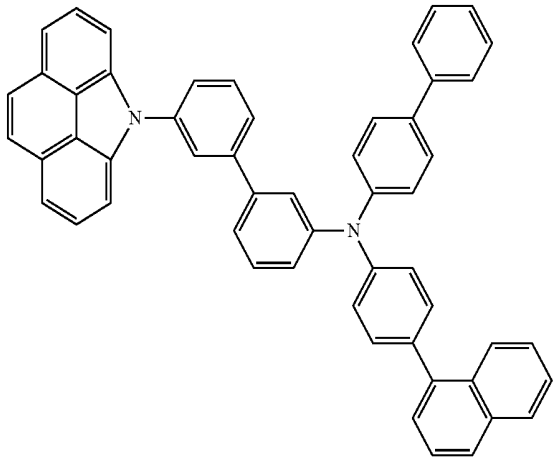

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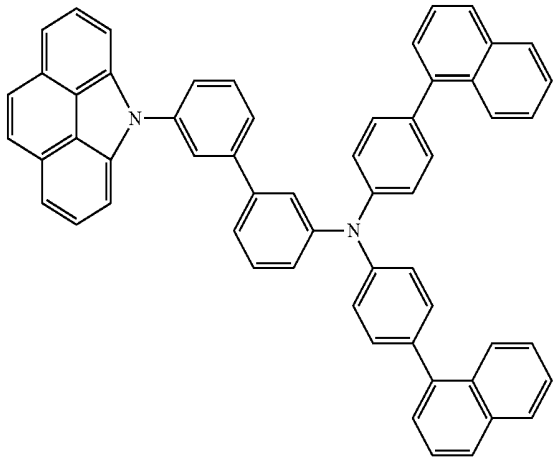

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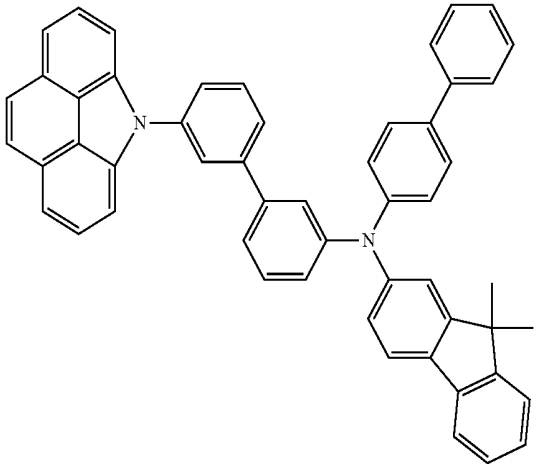

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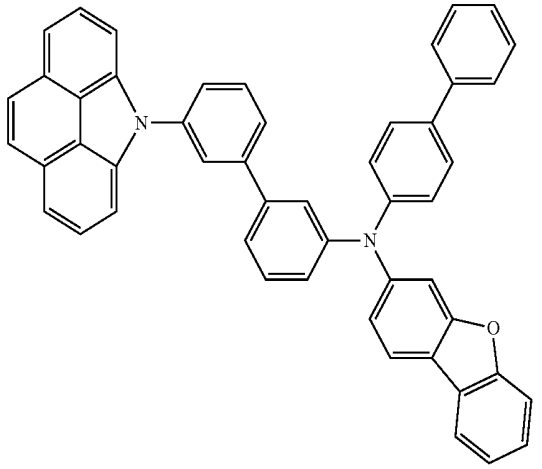

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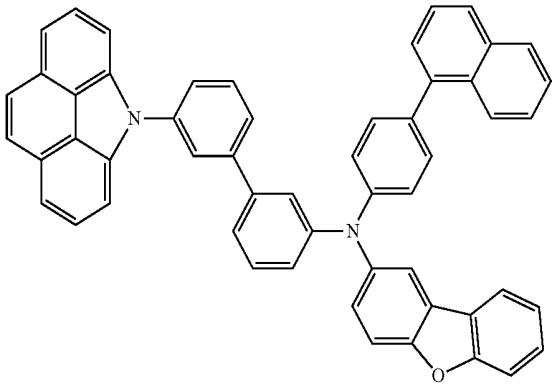

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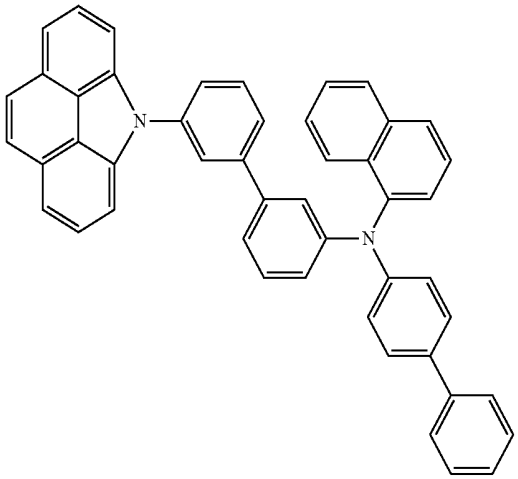

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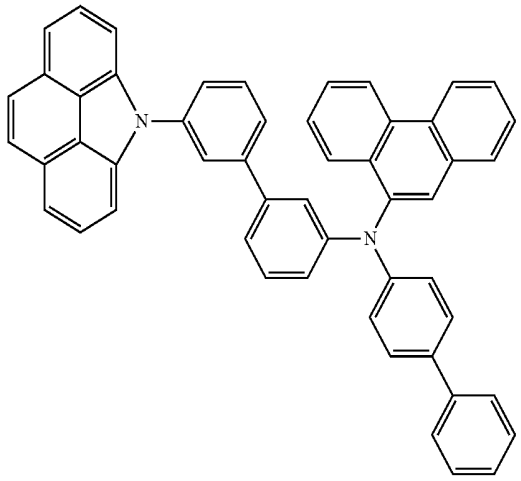

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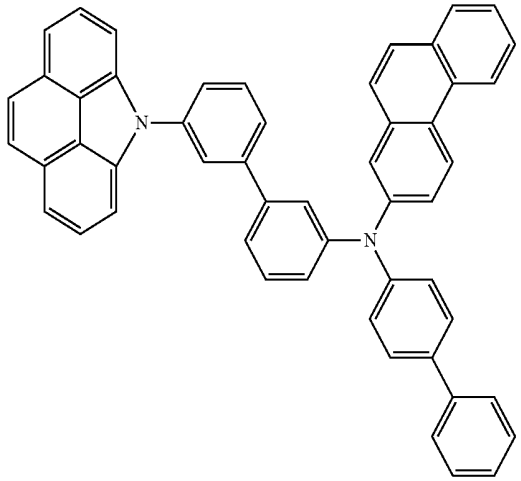

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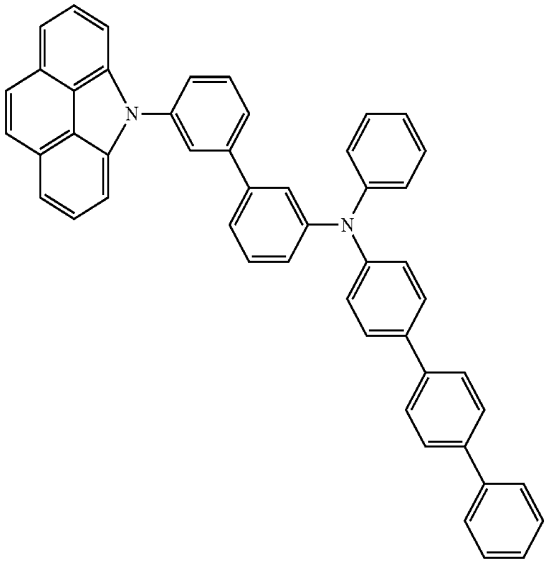

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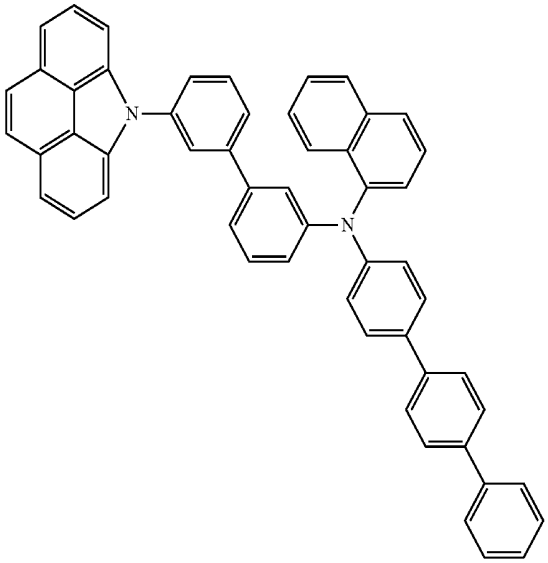

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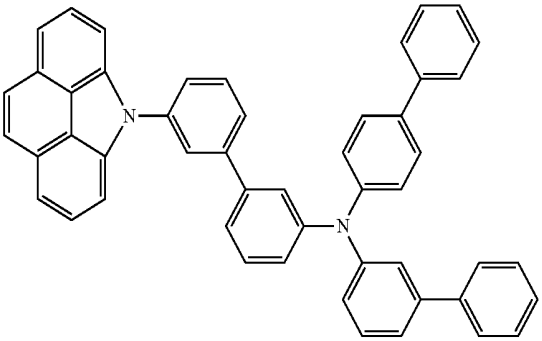

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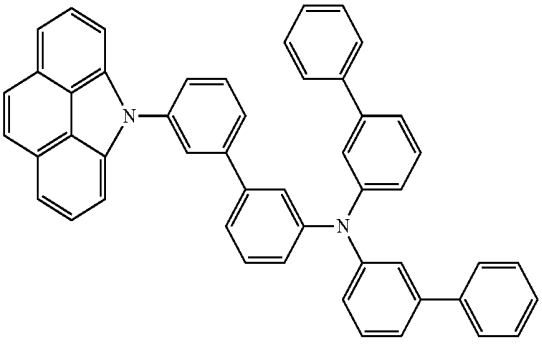

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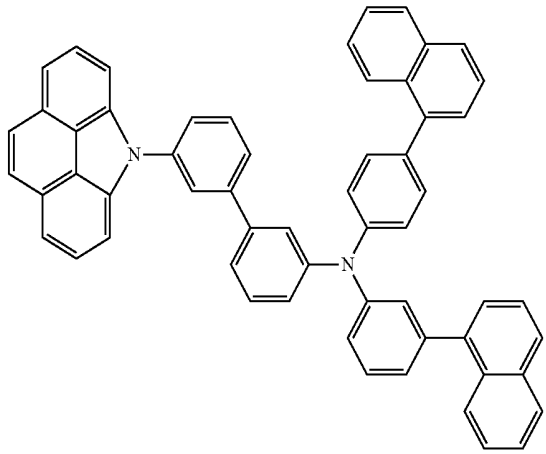

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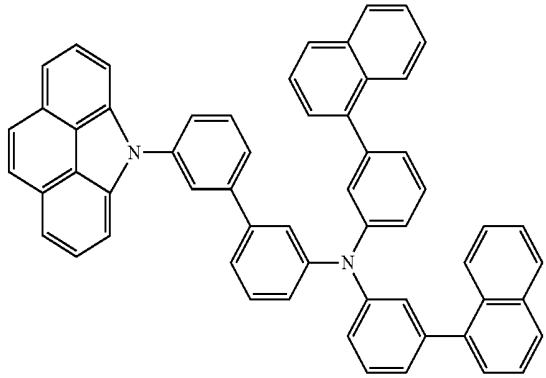

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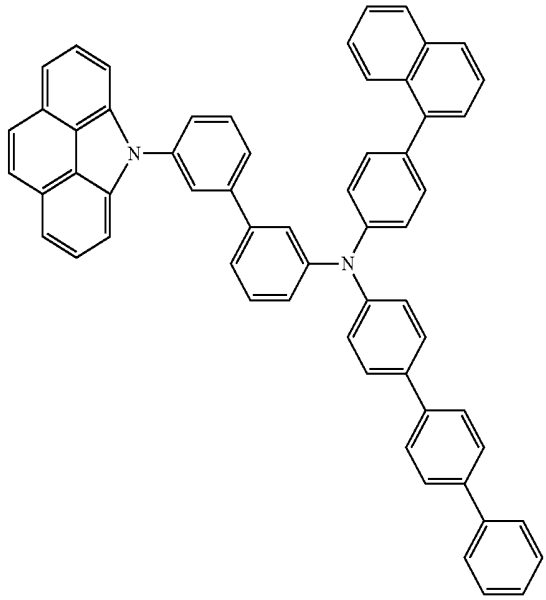

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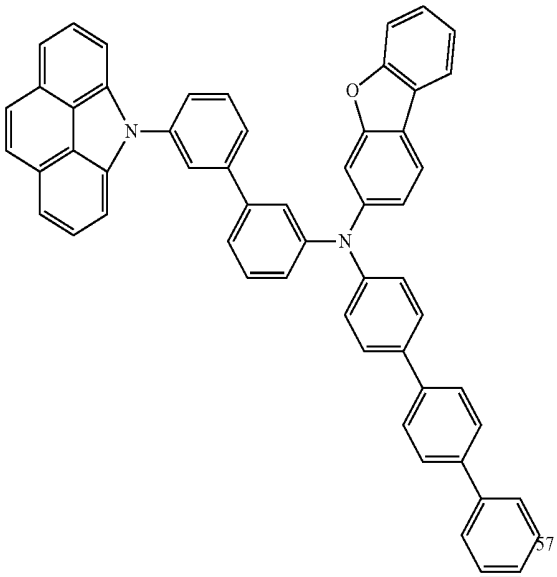

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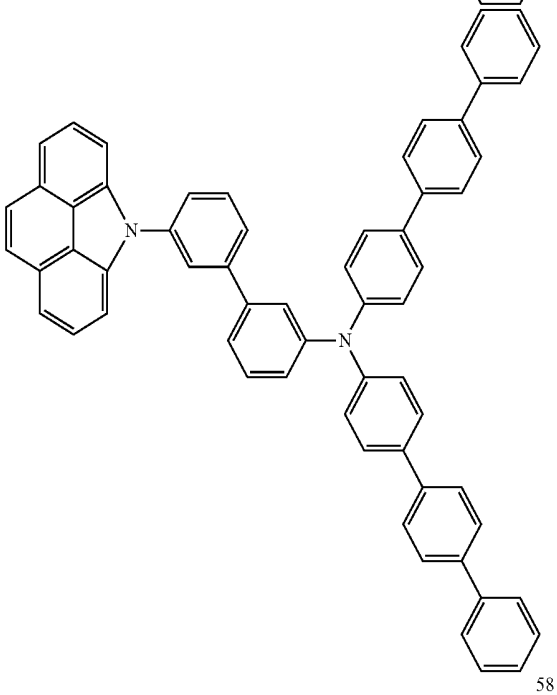

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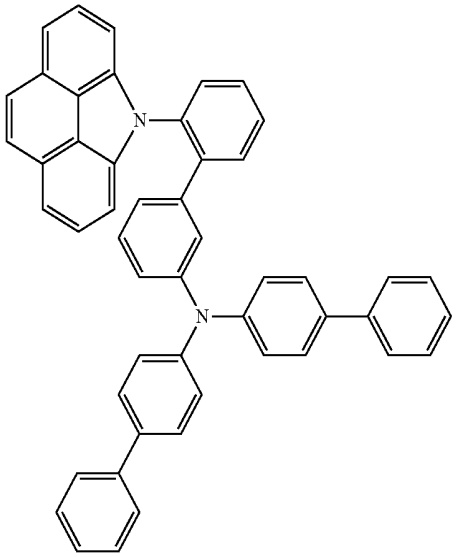

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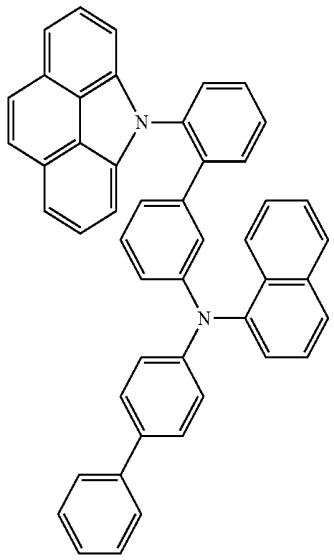

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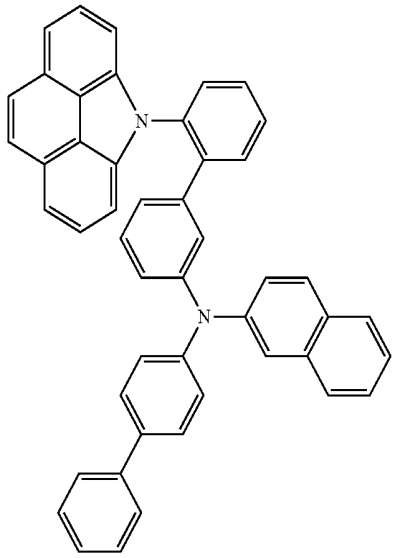

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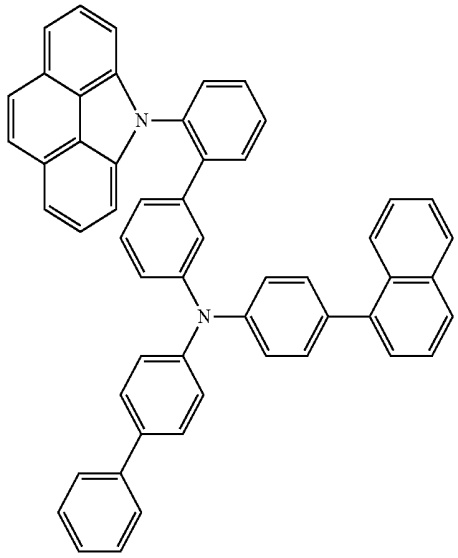

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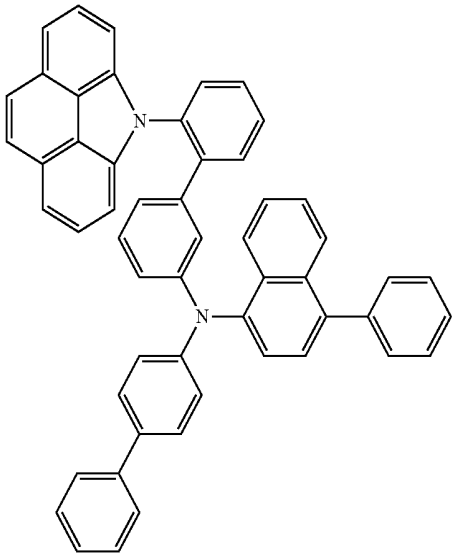

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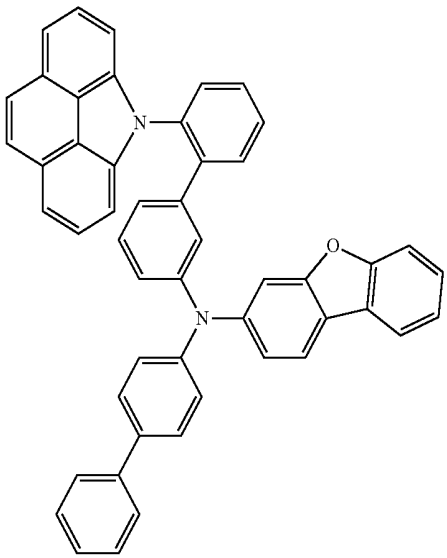

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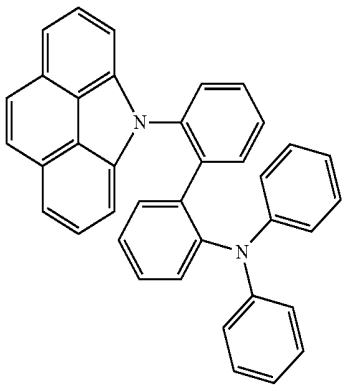

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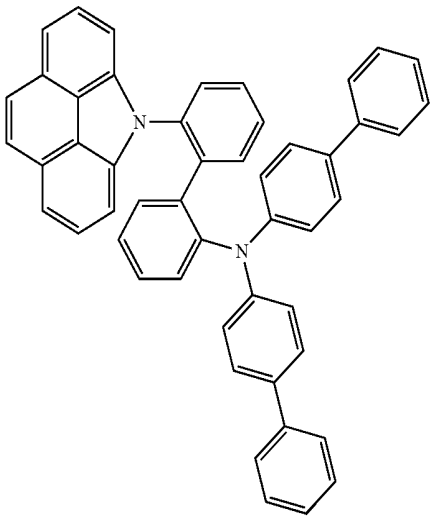

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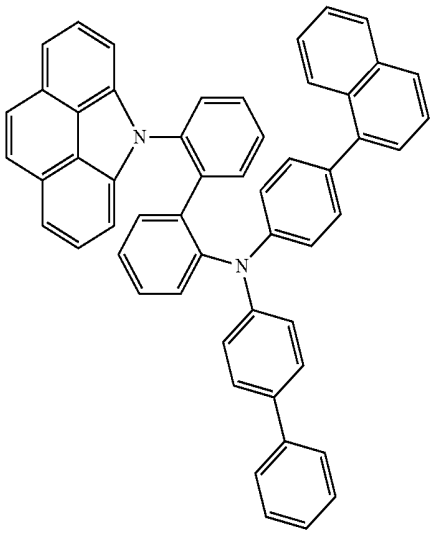

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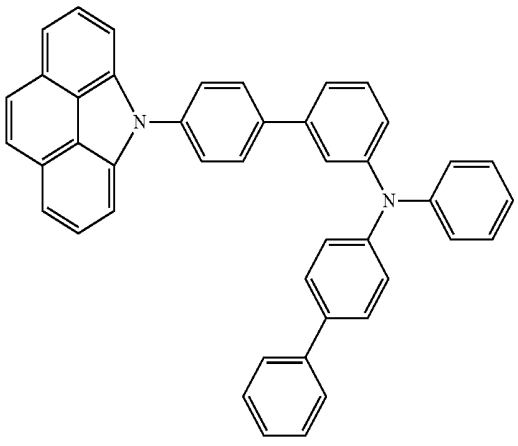

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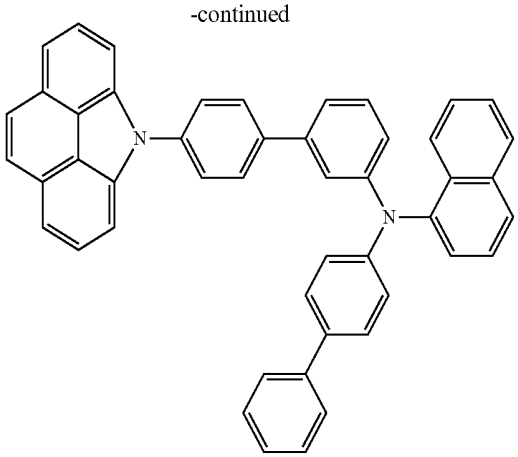

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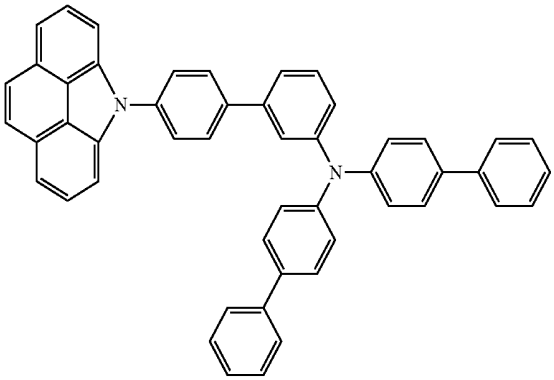

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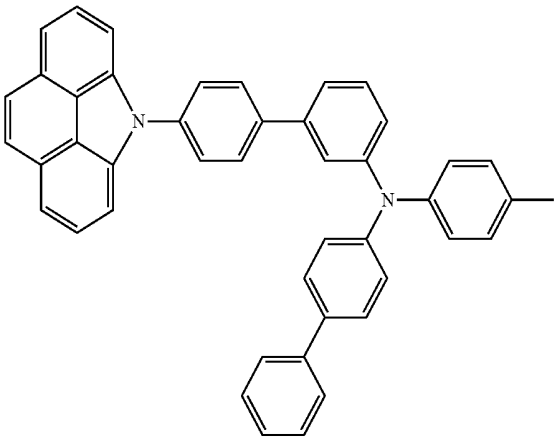

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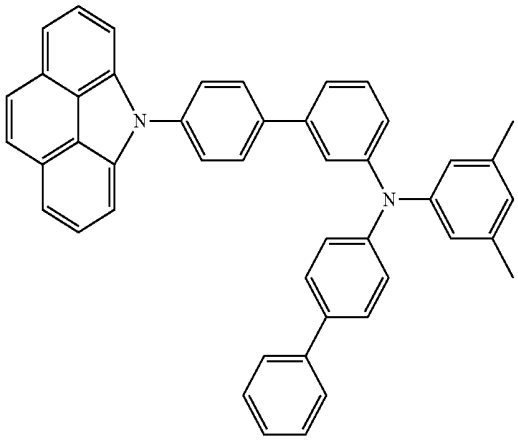

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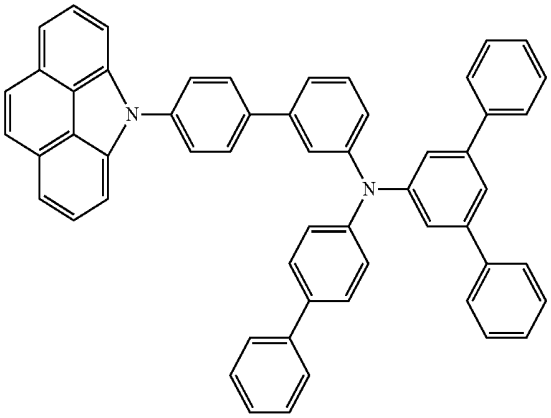

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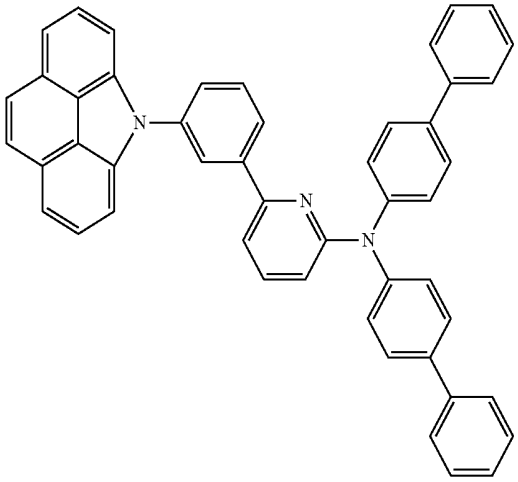

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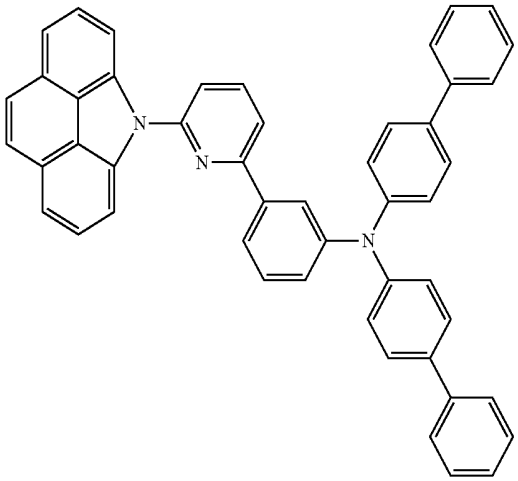

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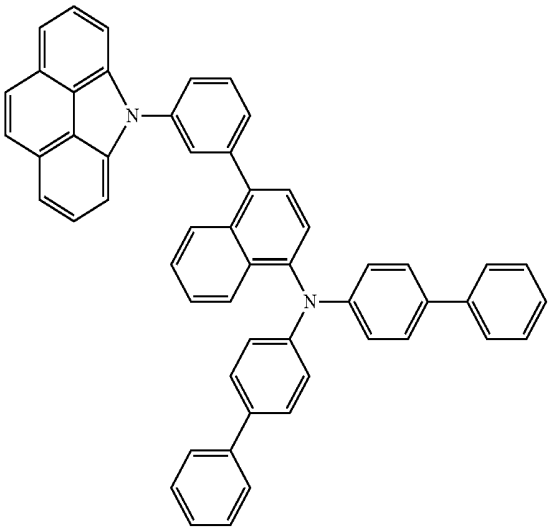

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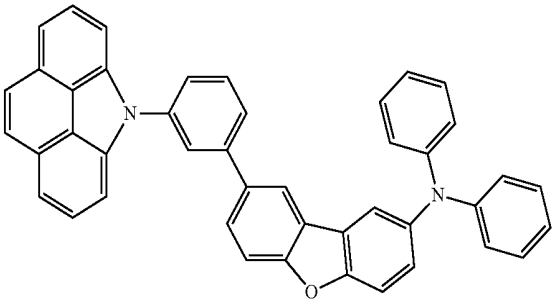

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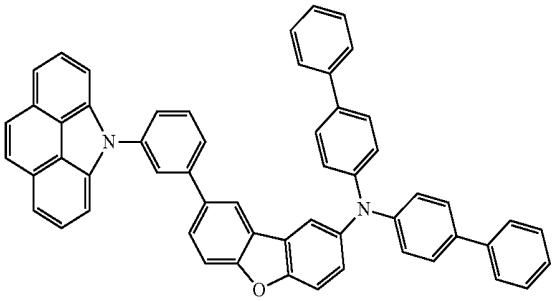

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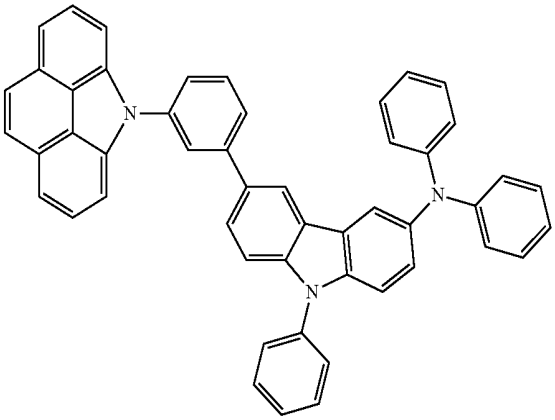

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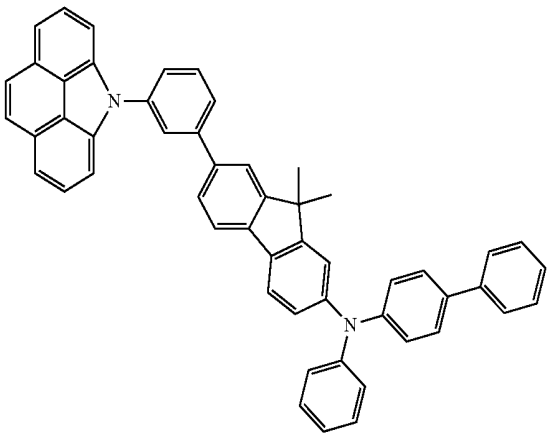

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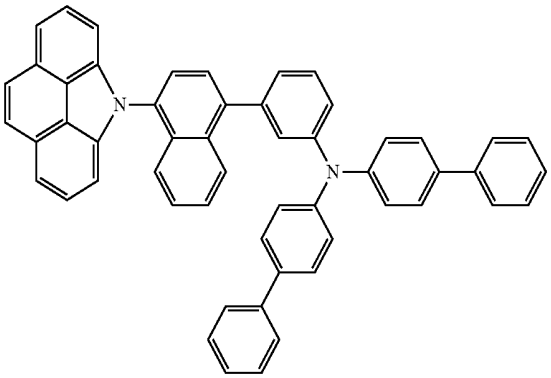

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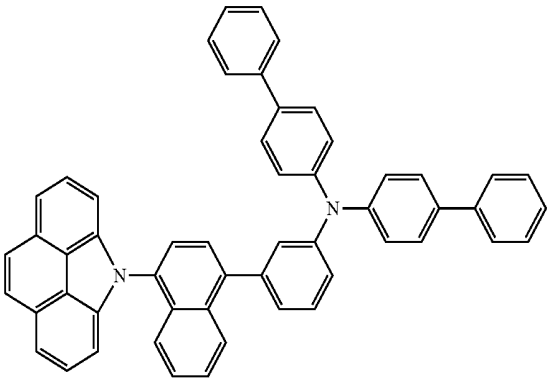

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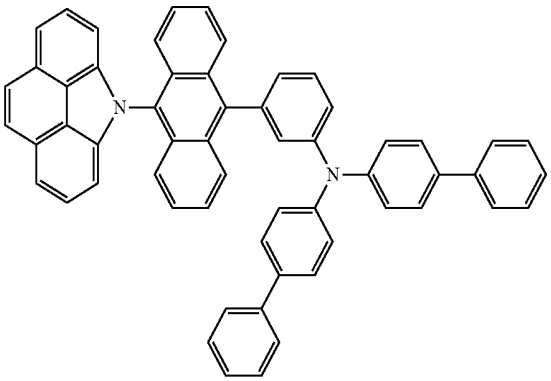

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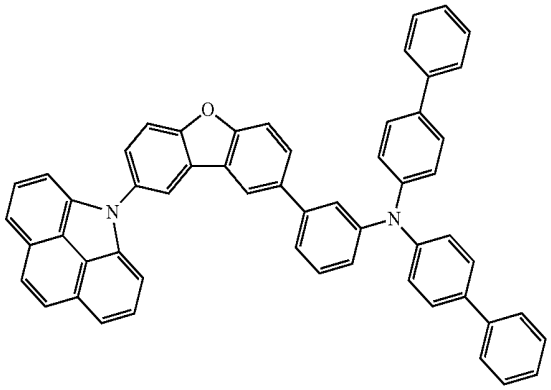

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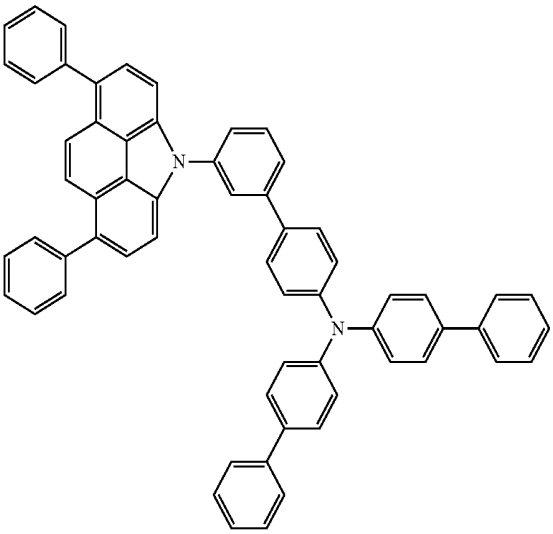

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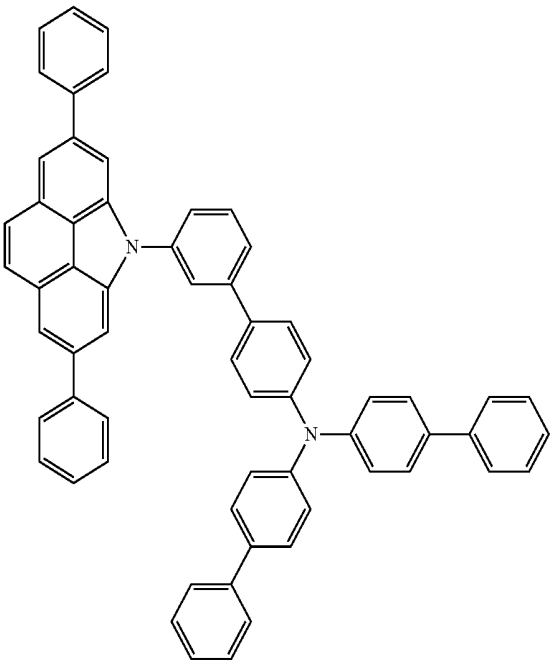

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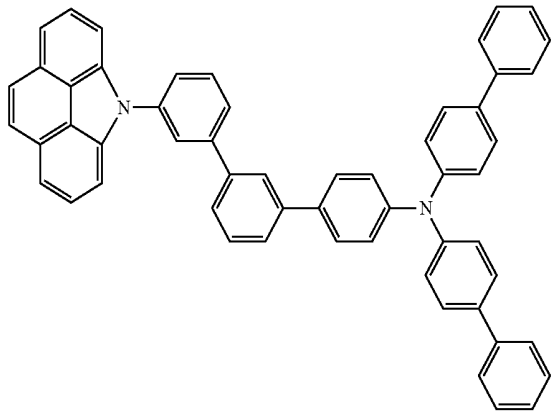

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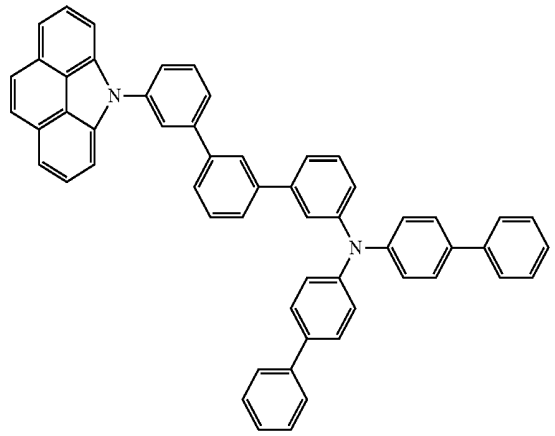

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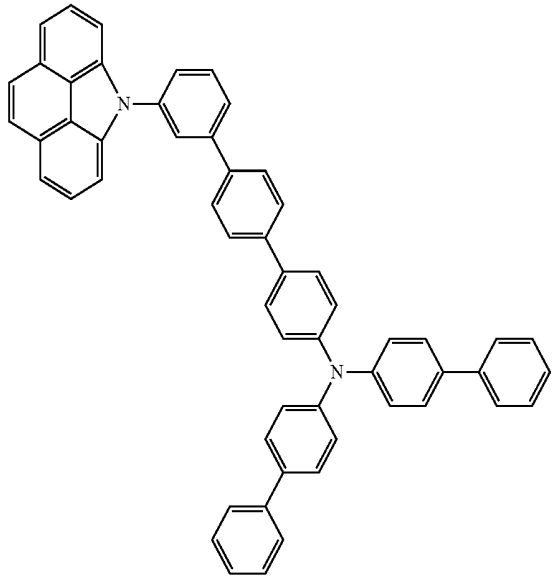

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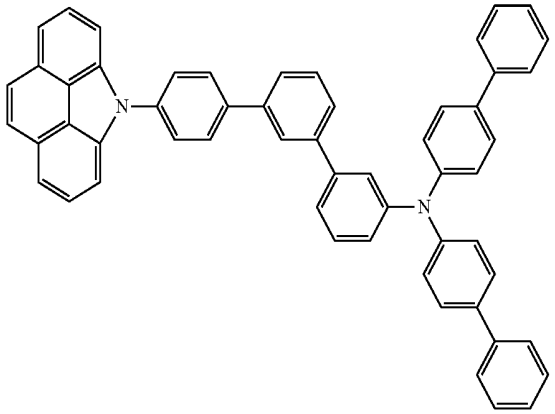

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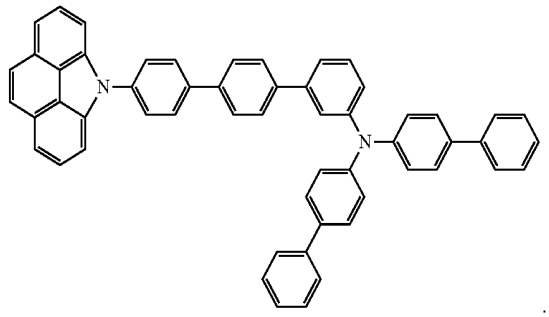


As used herein, the term "organic layer" may refer to a single layer and/or a plurality of layers between the first electrode and the second electrode in an organic light-emitting device. The material included in the organic layer is not limited to being an organic material.

The drawing is a schematic view of an organic light-emitting device **10** according to an embodiment of the present disclosure. The organic light-emitting device **10** includes a first electrode **110**, an organic layer **150**, and a second electrode **190** coupled to a thin film transistor.

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

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

The first electrode **110** may be formed by depositing and/or sputtering a material for forming the first electrode on the substrate. When the first electrode **110** is an anode, the material for the first electrode may be selected from materials with a high work function to facilitate easy injection of holes. The first electrode **110** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. The material for the first electrode may be a transparent and/or highly conductive material, and non-limiting examples of such a material may include indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), and zinc oxide (ZnO). When the first electrode **110** is a semi-transmissive electrode or a reflective electrode, at least one selected from magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—

In), and magnesium-silver (Mg—Ag) may be used as a material for forming the first electrode.

The first electrode **110** may have a single-layer structure and/or a multi-layer structure including a plurality of layers. For example, the first electrode **110** may have a triple-layer structure of ITO/Ag/ITO, but embodiments of the present disclosure are not limited thereto.

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

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

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

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

The hole transport layer may include a first hole transport layer and a second hole transport layer.

For example, the hole transport region may have a single-layered structure formed of a plurality of different materials, a structure of hole injection layer/hole transport layer, a structure of hole injection layer/first hole transport layer/second hole transport layer, a structure of hole injection layer/first hole transport layer/second hole transport layer/electron blocking layer, and/or a structure of hole injection layer/hole transport layer/electron blocking layer, wherein layers of each structure are sequentially stacked on the first electrode **110** in this stated order, but embodiments of the present disclosure are not limited thereto.

When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **110** using one or more suitable methods, such as vacuum-deposition, spin coating, casting, Langmuir-Blodgett (LB) method, ink-jet printing, laser-printing, and/or laser-induced thermal imaging (LITI).

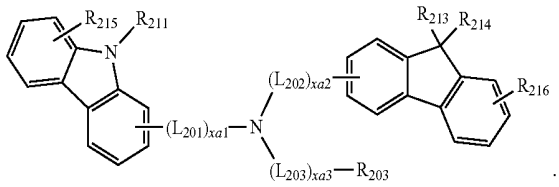
When the hole injection layer is formed by vacuum deposition, the deposition may be performed, e.g., at a deposition temperature of about 100° C. to about 500° C., at a vacuum degree of about 10^{-8} torr to about 10^{-3} torr, and a deposition rate of about 0.01 Å/sec to about 100 Å/sec, depending on the compound to be deposited in the hole injection layer and the structure of the hole injection layer to be formed.

When the hole injection layer is formed by spin coating, the coating may be performed, e.g., at a coating speed of about 2,000 rpm to about 5,000 rpm and at a temperature of about 80° C. to about 200° C., depending on the compound to be deposited in the hole injection layer and the structure of the hole injection layer to be formed.

When the hole transport region includes a hole transport layer, the hole transport layer may be formed on the first electrode **110** and/or on the hole injection layer using one or more suitable methods, such as vacuum-deposition, spin coating, casting, LB method, ink-jet printing, laser-printing, and/or LITI. When the hole transport layer is formed by vacuum-deposition and/or spin coating, the conditions for vacuum-deposition and coating may be similar to the above-described vacuum-deposition and coating conditions for forming the hole injection layer.

In some embodiments, the first hole transport layer may include a compound represented by Formula 201A:

Formula 201A



In Formulae 201A,

L_{201} to L_{203} may each independently 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, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene 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, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

xa1 to xa3 may each independently be selected from 0 and 1;

R_{203} and R_{211} may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

R_{213} and R_{214} may each independently be selected from:

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one 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 phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, C_1-C_{20} alkyl group, C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

R_{215} and R_{216} may each independently be selected from:

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

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one 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 phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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, and a triazinyl group; and

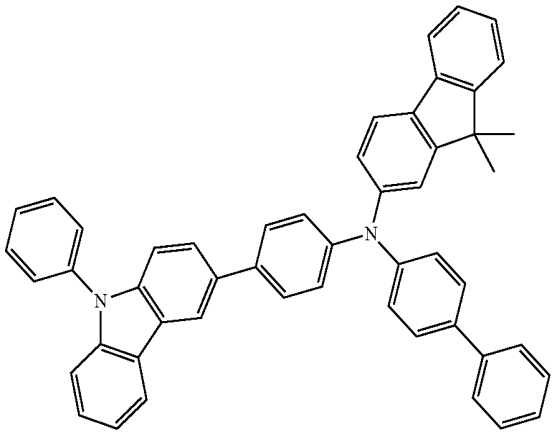
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, C_1-C_{20} alkyl group, C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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.

In some embodiments, R_{211} in Formula 201A may be selected from a substituted or unsubstituted phenyl group and a substituted or unsubstituted pyridyl group.

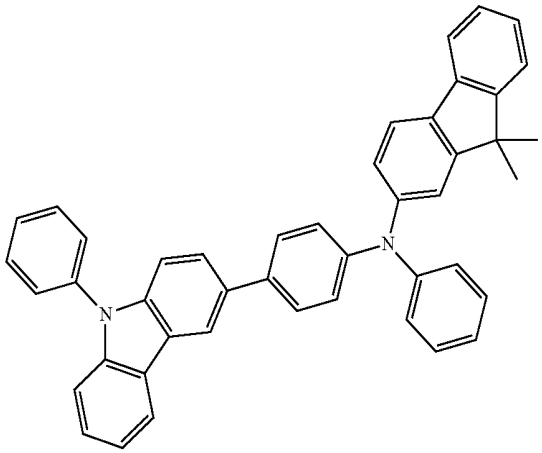
In some embodiments, R_{213} and R_{214} in Formula 201A may each independently be selected from a methyl group and a phenyl group.

In some embodiments, the compound represented by Formula 201A may be selected from Compounds HT1 to HT33 below:

HT1



HT2



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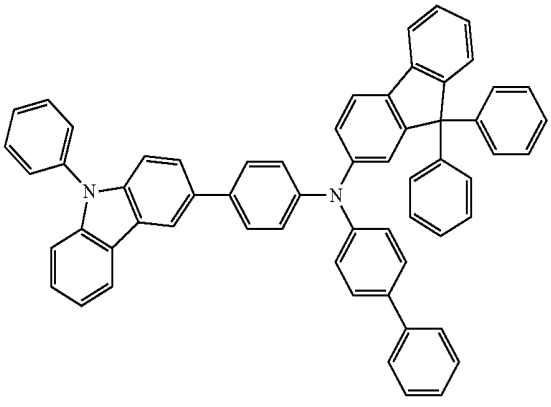

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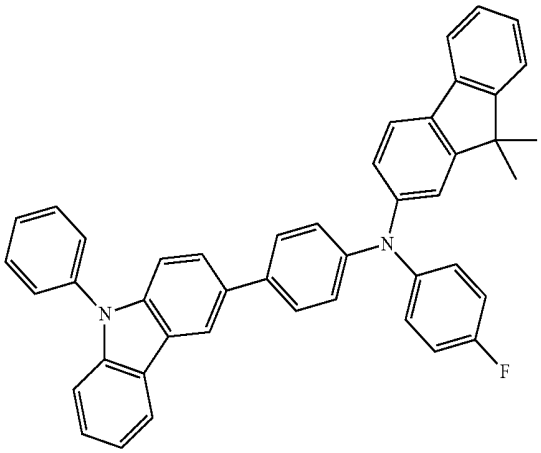
HT4



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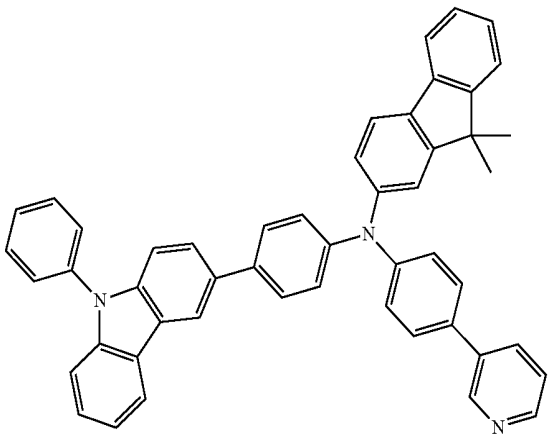

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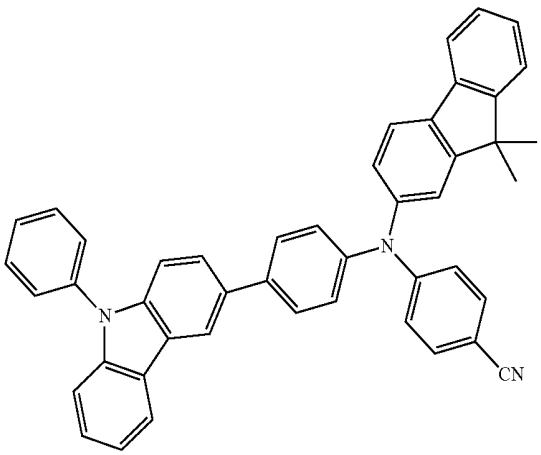

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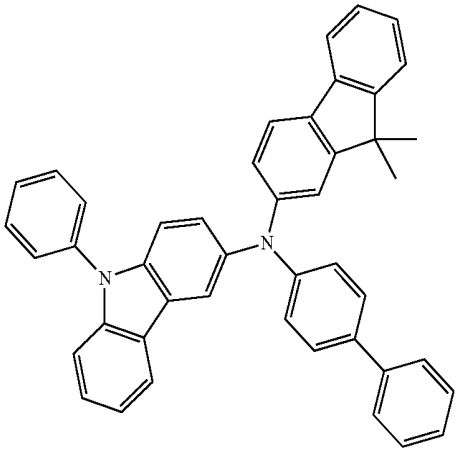
HT7



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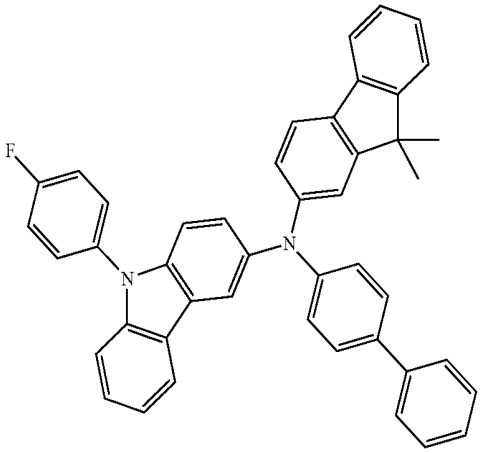

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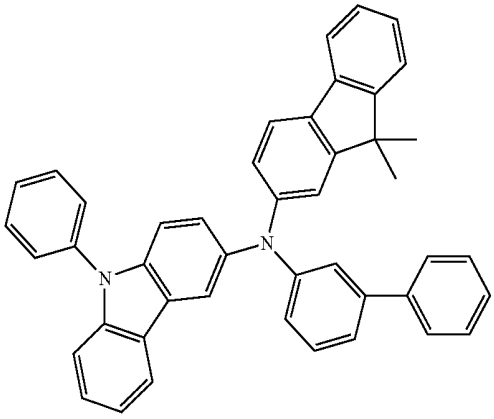

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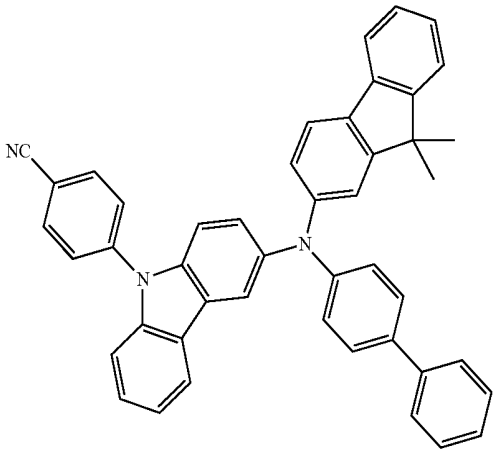

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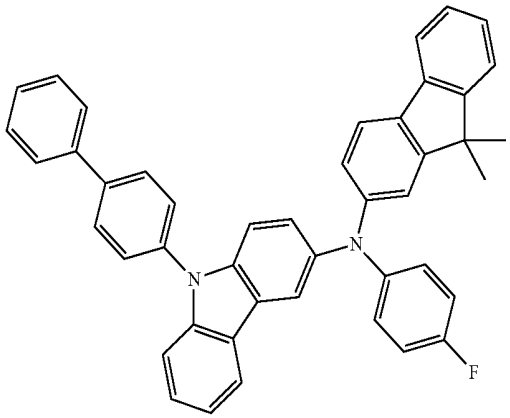

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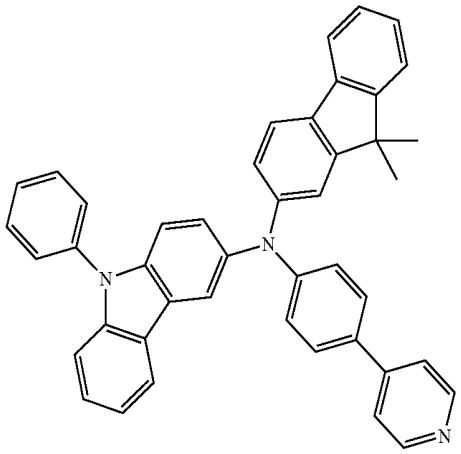

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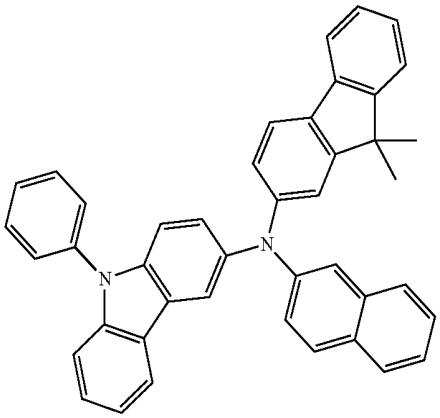
HT13



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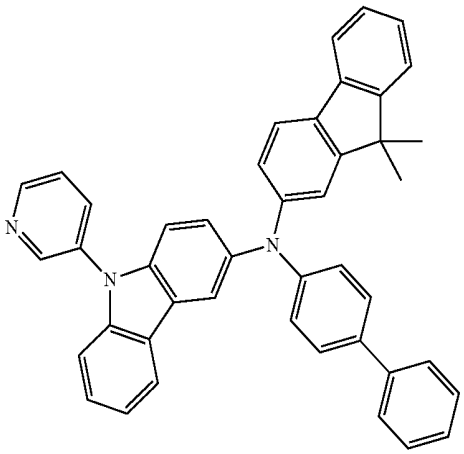

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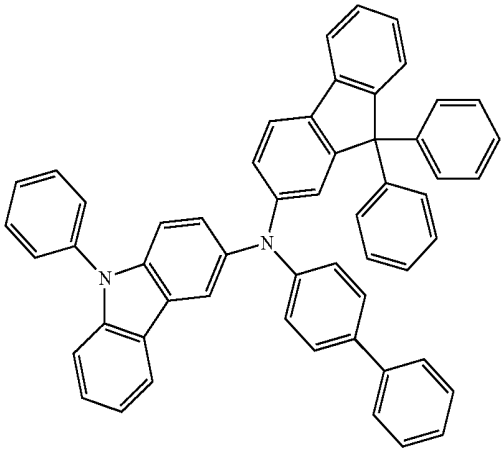

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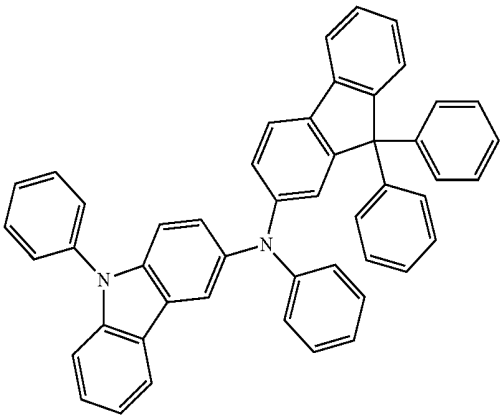

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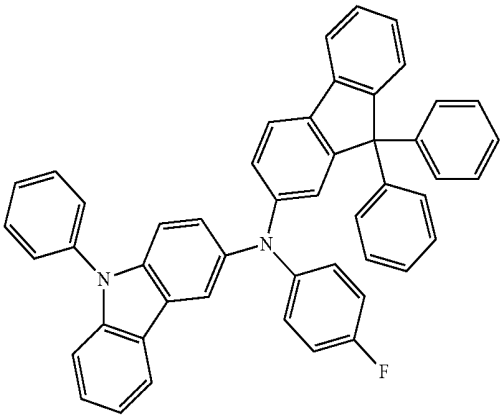

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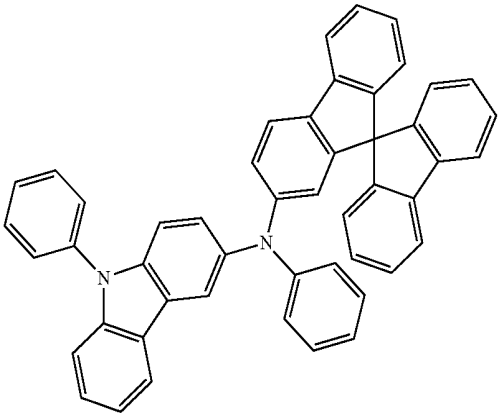

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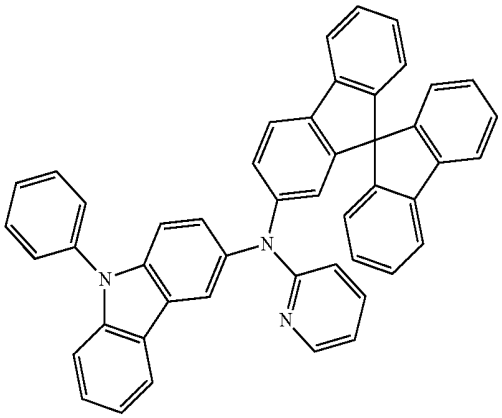

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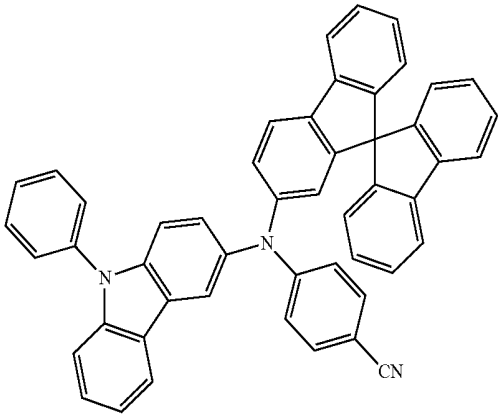

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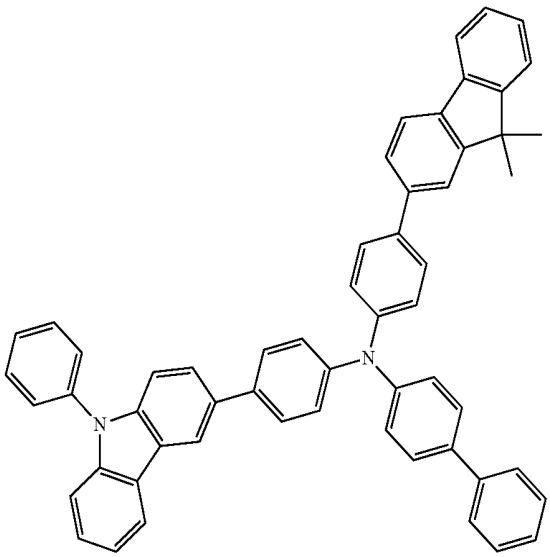

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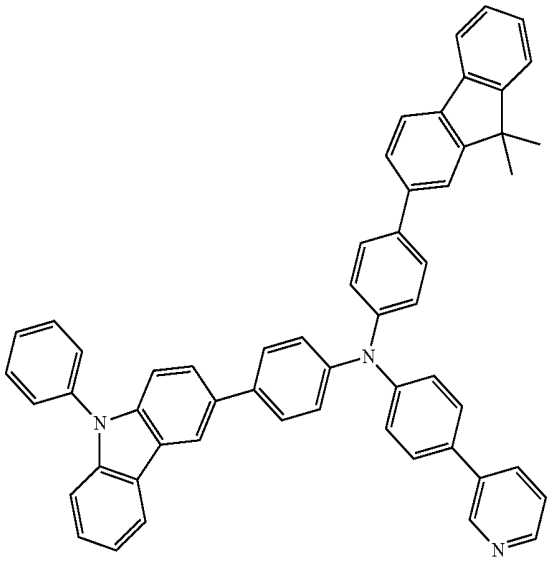

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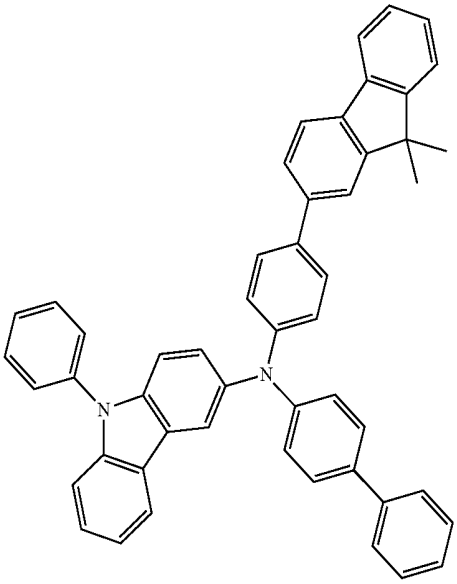

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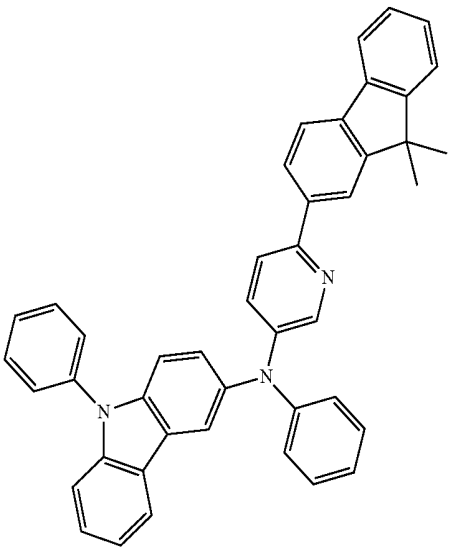

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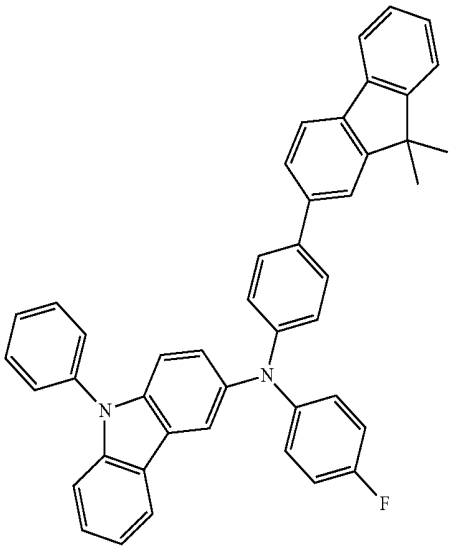

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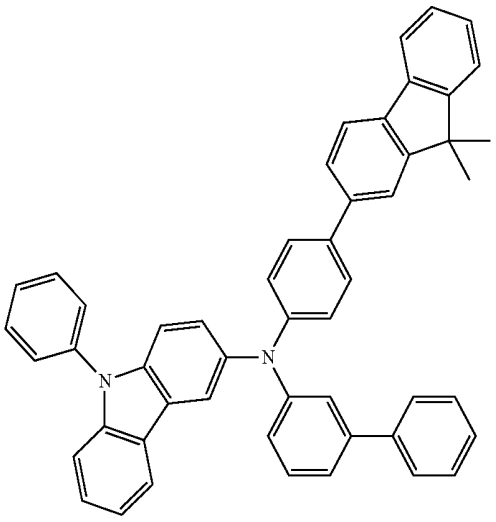

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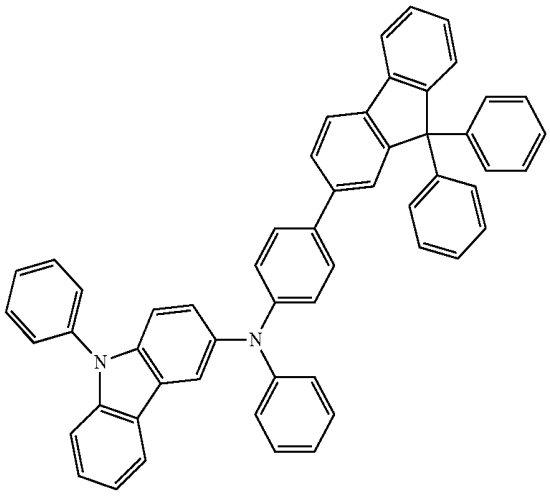

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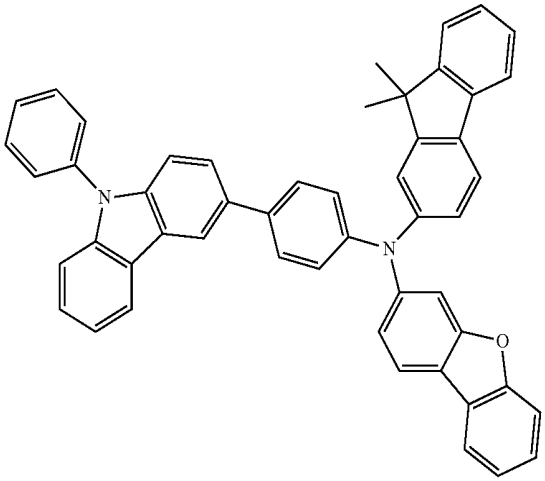
HT28



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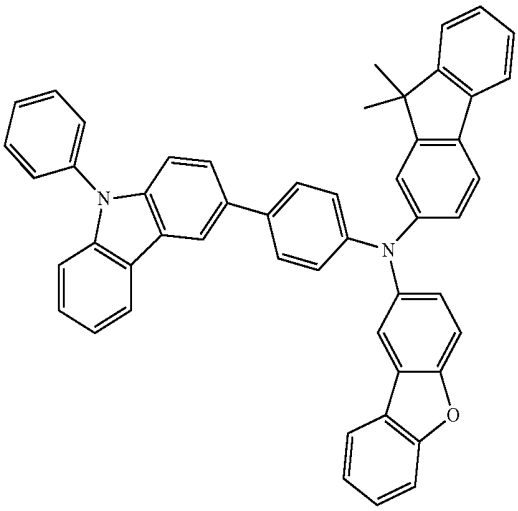
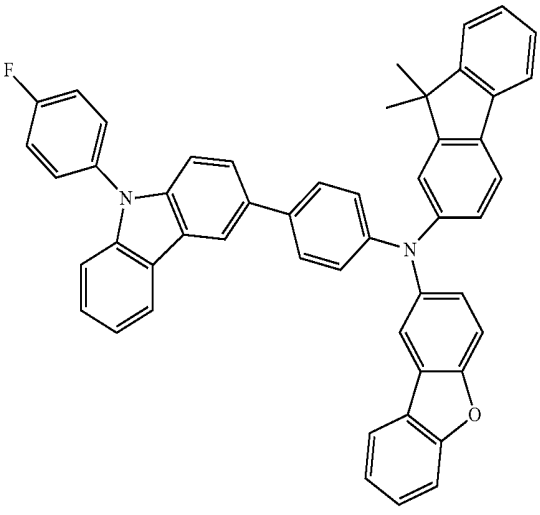


HT30



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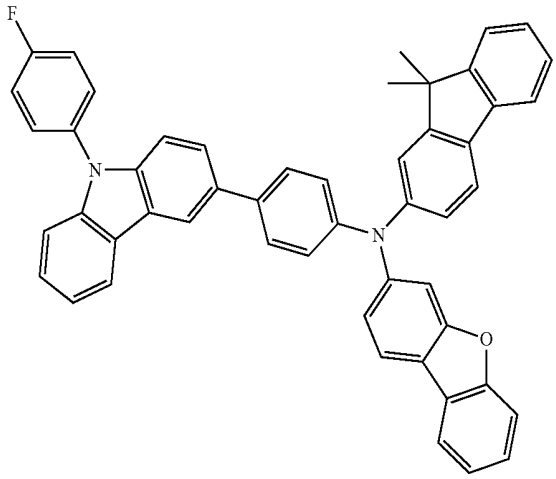
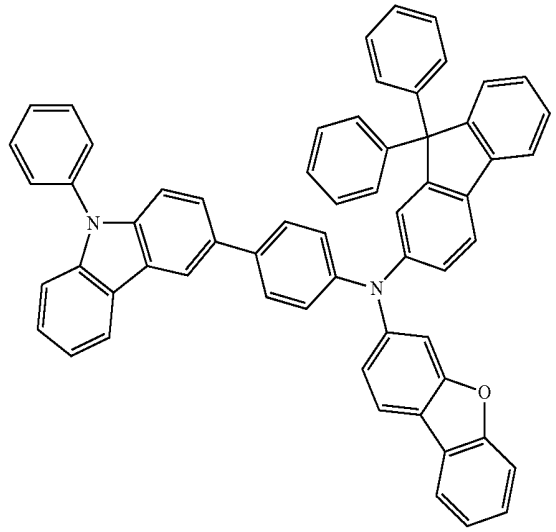
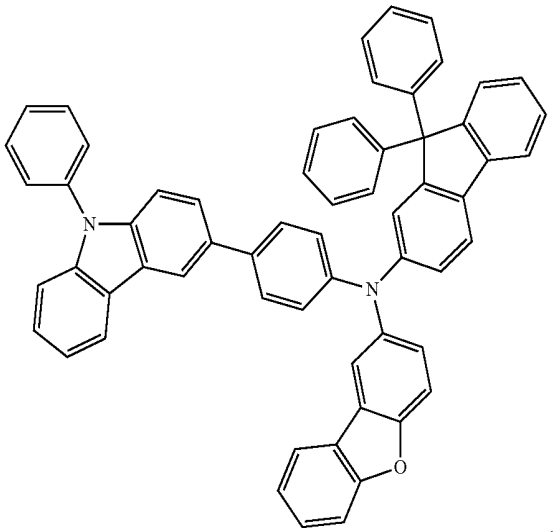
HT31



HT32



HT33



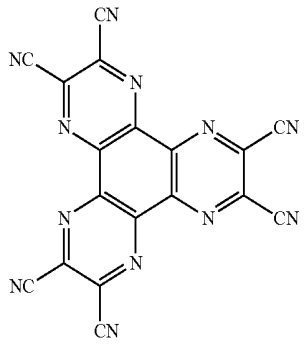
In some embodiments, the second hole transport layer may include the compound represented by Formula 1.

The thickness of the hole transport region may be about 100 Å to about 10,000 Å, and in some embodiments, about 100 Å to about 2,000 Å. When the hole transport region includes a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be about 100 Å to about 10,000 Å, and in some embodiments, about 100 Å to about 1,000 Å. The thickness of the hole transport layer including both thicknesses of the first hole transport layer and the second hole transport layer may be about 50 Å to about 2,000 Å, and in some embodiments, about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are each within these ranges, excellent hole transport characteristics may be obtained without a substantial increase in driving voltage.

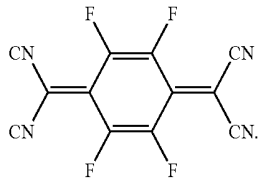
The hole transport region may further include, in addition to the abovementioned materials, a charge-generating material to improve conduction. The charge-generating material may be homogeneously or non-homogeneously dispersed throughout the hole transport region.

The charge-generating material may be, for example, a p-dopant. The p-dopant may be selected from a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto. Non-limiting examples of the p-dopant may include a quinone derivative (such as tetracyanoquinonedimethane (TCNQ) and/or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4-TCNQ)); a metal oxide (such as a tungsten oxide and/or a molybdenum oxide), and Compound HT-D1 (illustrated below), but embodiments of the present disclosure are not limited thereto.

Compound HT-D1



F4-TCNQ



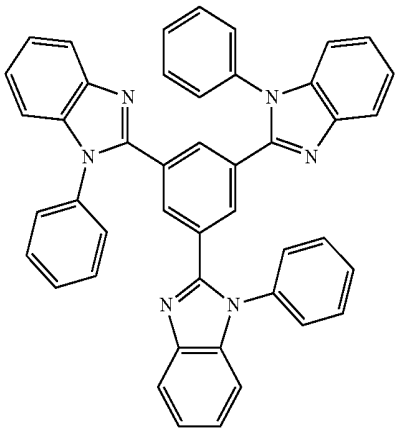
The hole transport region may further include a buffer layer as well as the electron blocking layer, hole injection layer, and/or hole transport layer described above. Since the buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer (e.g., be used to adjust the optical resonance distance to match the wavelength of light emitted from the emission layer), the light-emission efficiency of a formed organic light-emitting device may be improved. As a material included in the buffer layer, materials that are included in the hole transport region may be used. The electron blocking layer may prevent or reduce injection of electrons from the electron transport region.

An emission layer may be formed on the first electrode **110** and/or on the hole transport region using one or more suitable methods, such as vacuum-deposition, spin coating, casting, LB method, ink-jet printing, laser-printing, and/or LITI. When the emission layer is formed by vacuum-deposition and/or spin coating, the deposition and coating conditions for the emission layer may be similar to the deposition and coating conditions for the hole injection layer.

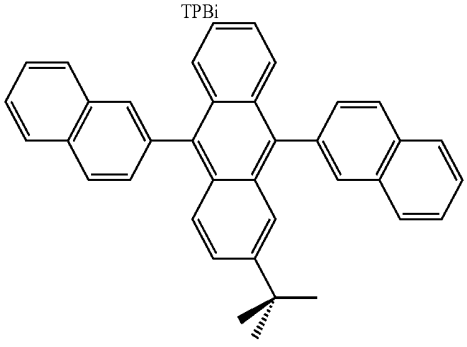
When the organic light-emitting device **10** is a full color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and/or a blue emission layer, according to a sub pixel. Alternatively, the emission layer may have a stacked structure of a red emission layer, a green emission layer, and a blue emission layer, or may include a red-light emission material, a green-light emission material, and a blue-light emission material, which are mixed together in a single layer to thereby emit white light.

The emission layer may include a host and a dopant.

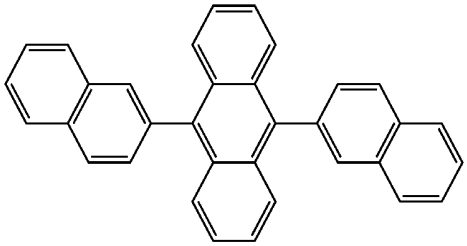
For example, the host may include at least one selected from TPBi, TBADN, ADN (also known as "DNA"), CBP, CDBP, and TCP:



TPBi



TBADN



ADN

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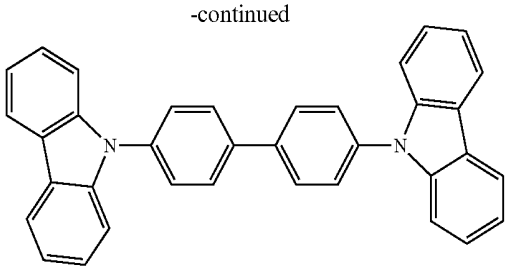
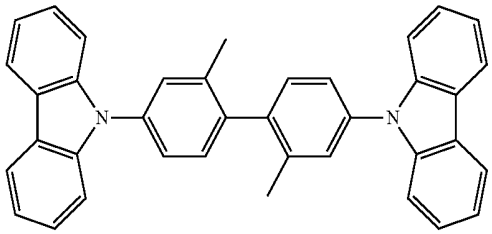
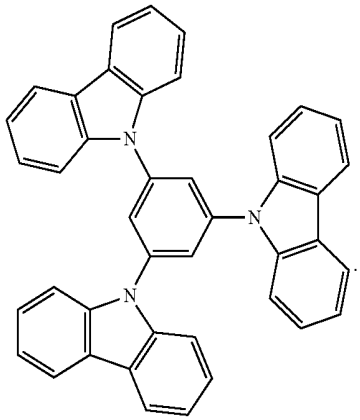


CBP



CDBP



TCP

Alternatively, the host may further include a compound represented by Formula 301:

$$Ar_{301}\text{-}[(L_{301})_{xb1}\text{-}R_{301}]_{xb2}. \qquad \text{Formula 301}$$

In Formula 301,

Ar_{301} may be selected from:

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

a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{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_1-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}) (wherein Q_{301} to Q_{303} may each independently be selected from hydrogen, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and a C_1-C_{60} heteroaryl group);

L_{301} may be selected from a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorene group, a dibenzofluorene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene 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, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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 quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

R_{301} may be selected from:

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one 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 phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 carbazole group, and a triazinyl group; and

a phenyl group, a biphenyl group, a terphenyl 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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, and

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

In some embodiments, in Formula 301,

L_{301} 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

R_{301} may be selected from:

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one 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 phenyl group, a biphenyl group, a terphenyl 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;

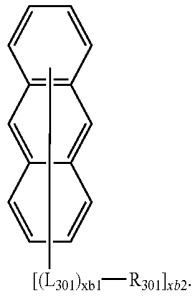
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group; and

a phenyl group, a biphenyl group, a terphenyl 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 carboxylic

acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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, but embodiments of the present disclosure are not limited thereto.

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

Formula 301A

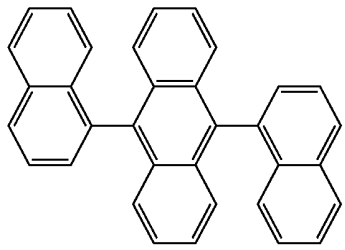


$[(L_{301})_{xb1}—R_{301}]_{xb2}$.

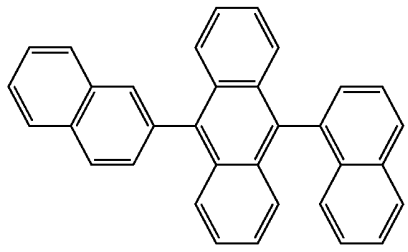
In Formula 301 Å, L301, R301, xb1, and xb2 may each be the same as described herein in connection with Formula 301.

The compound represented by Formula 301 may include at least one compound selected from Compounds H1 to H42, but embodiments of the present disclosure are not limited thereto:

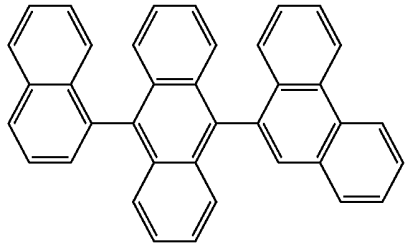
H1



H2



H3



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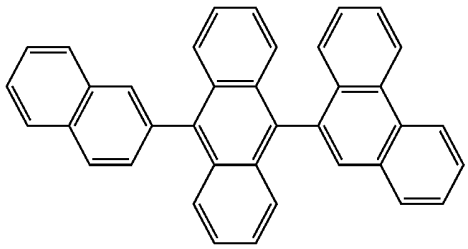
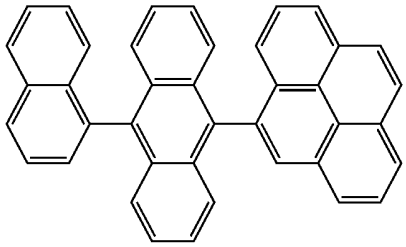
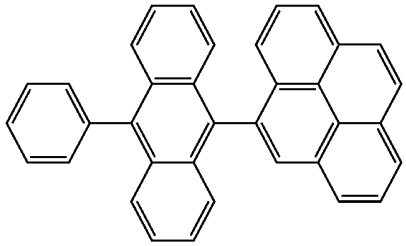
H4



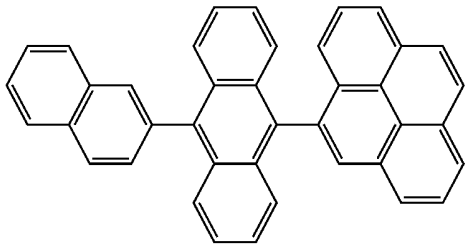
H5



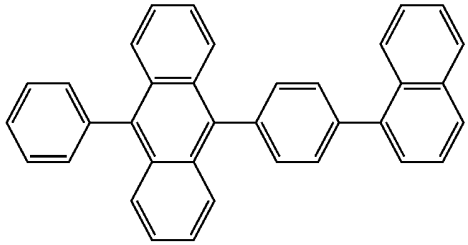
H6



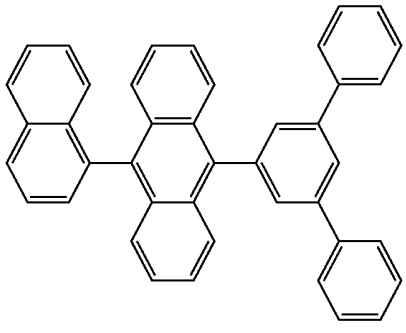
H7



H8



H9



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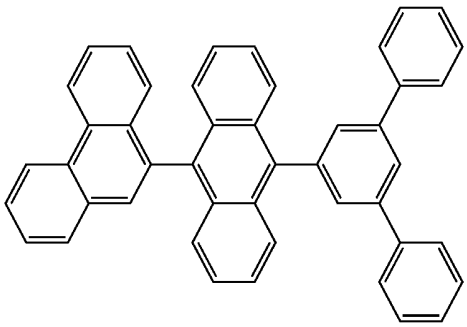
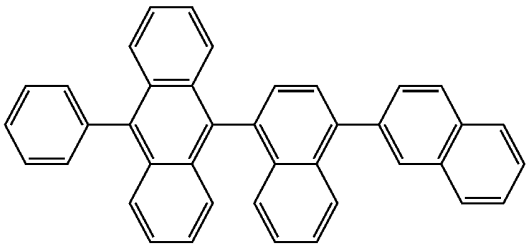
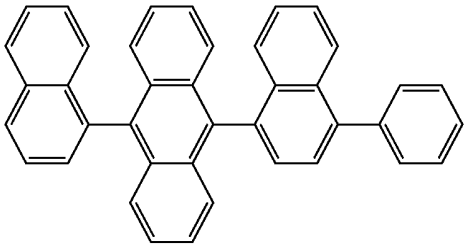
H10



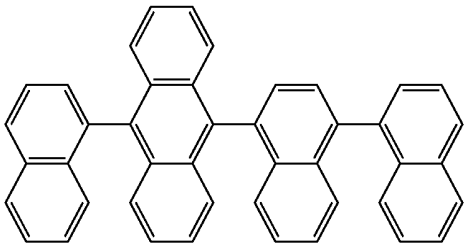
H11



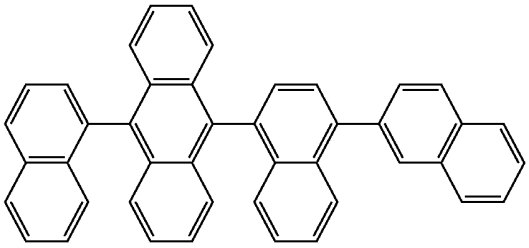
H12



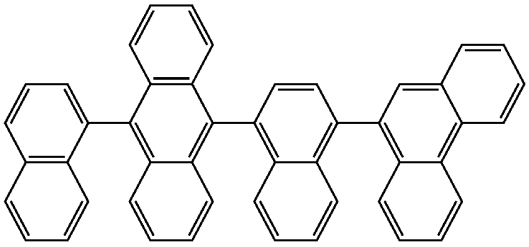
H13



H14



H15



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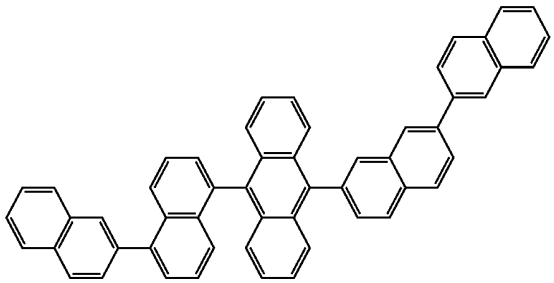
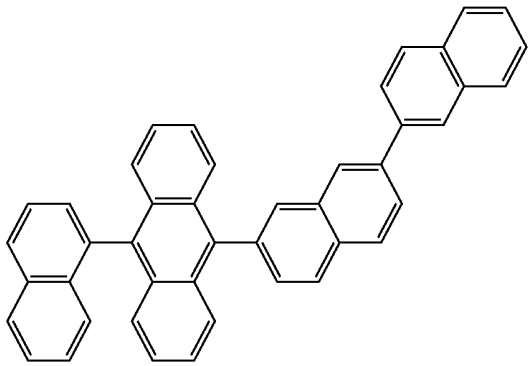
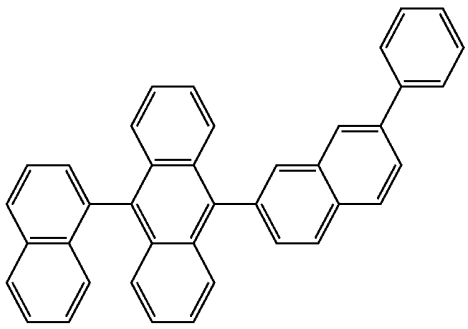
H16



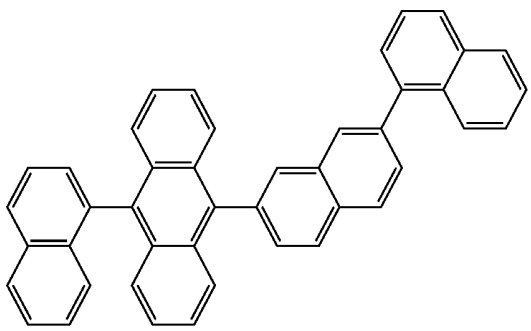
H17



H18



H19



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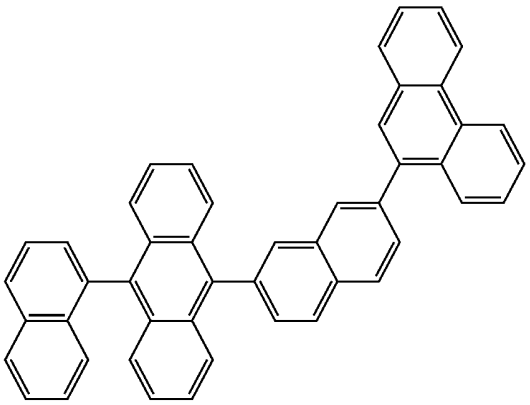
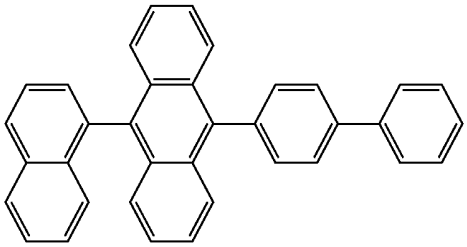
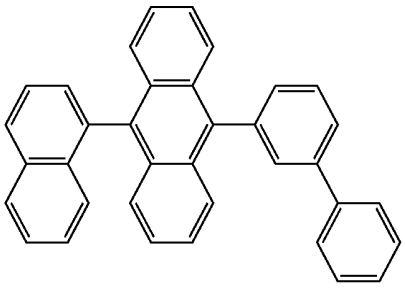
H20



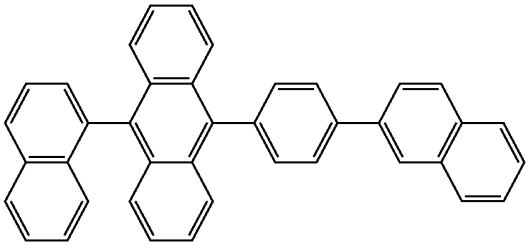
H21



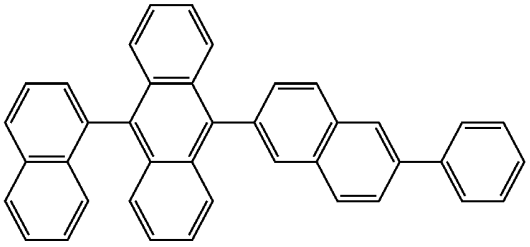
H22



H23



H24



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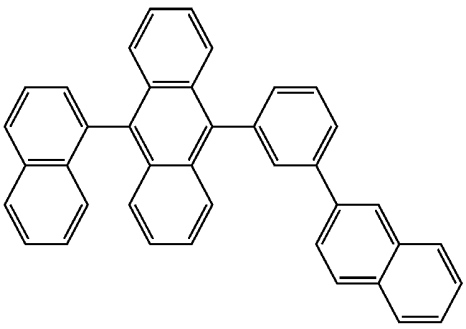
H25



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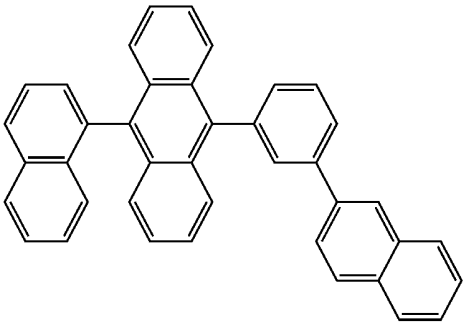

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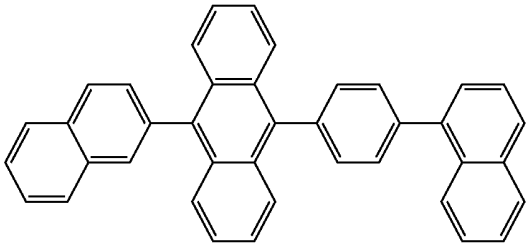

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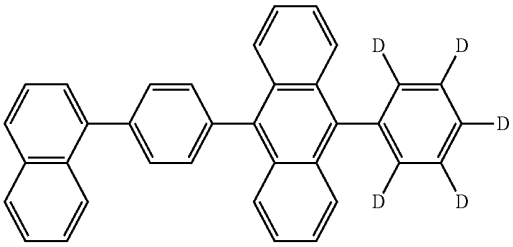

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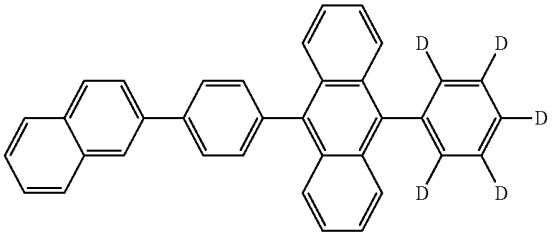

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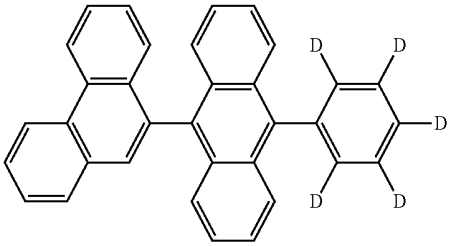

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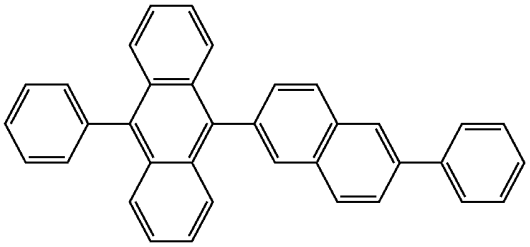

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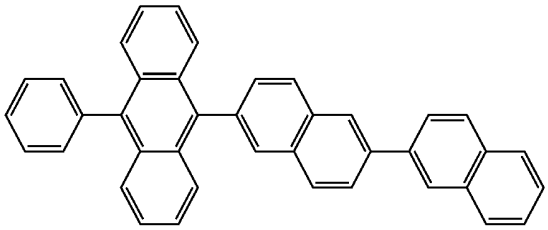

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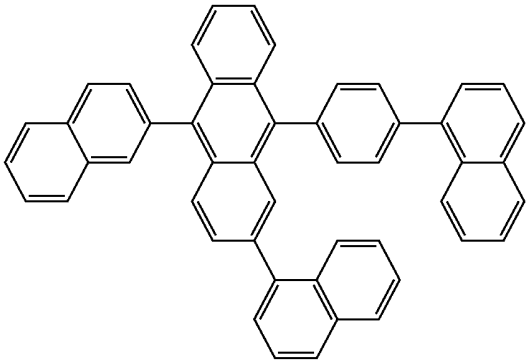

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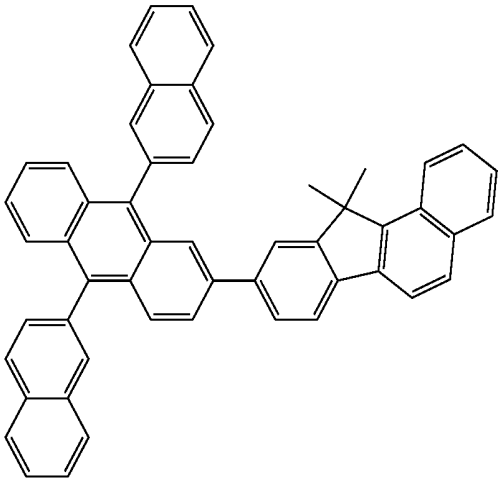

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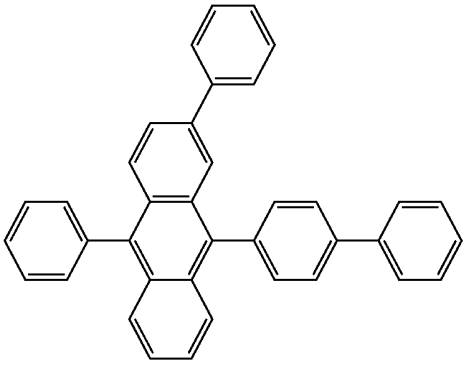

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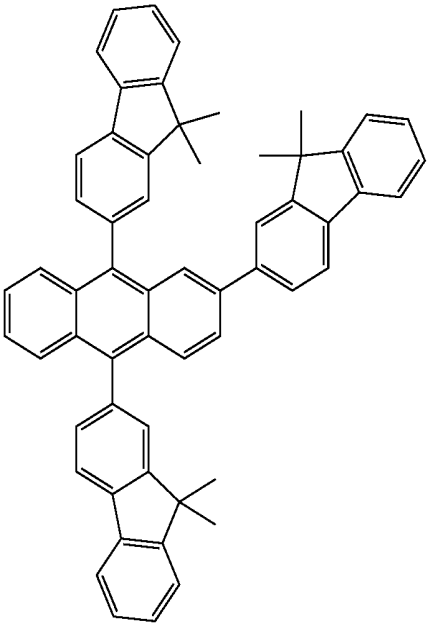

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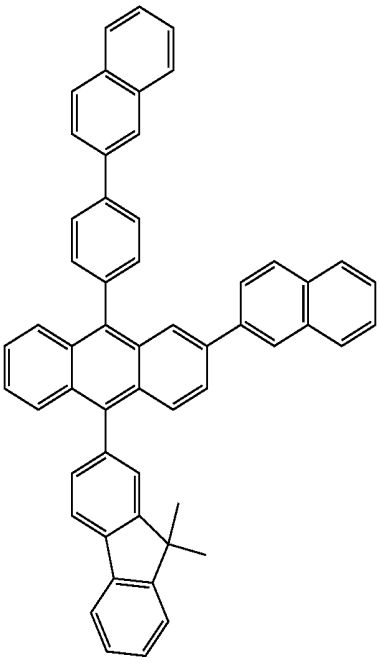

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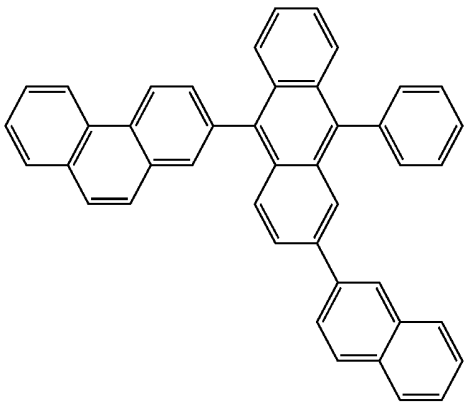
H38



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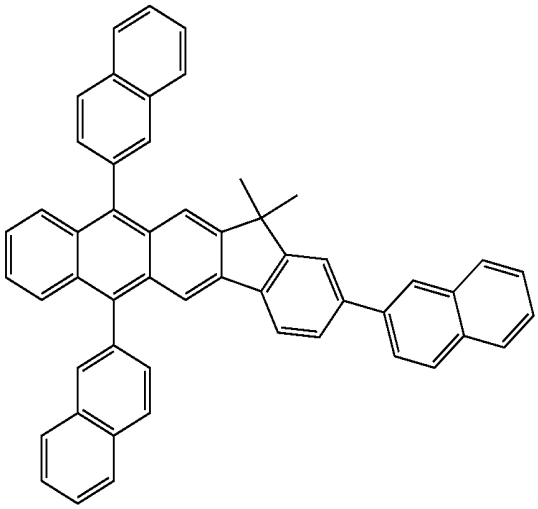

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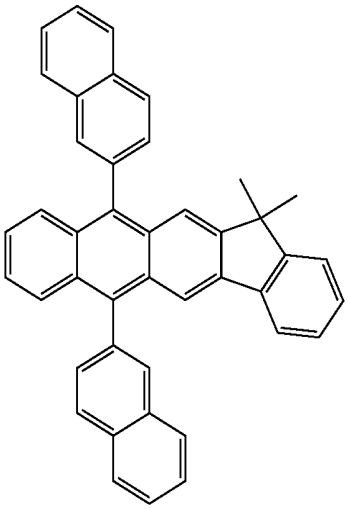

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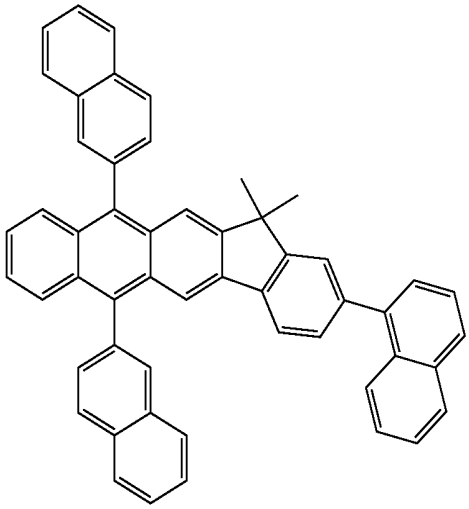
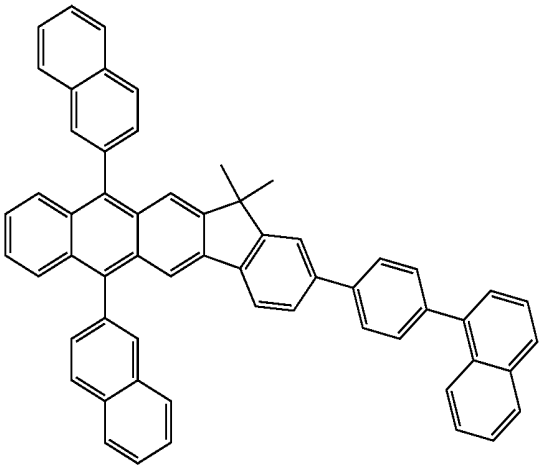
H41

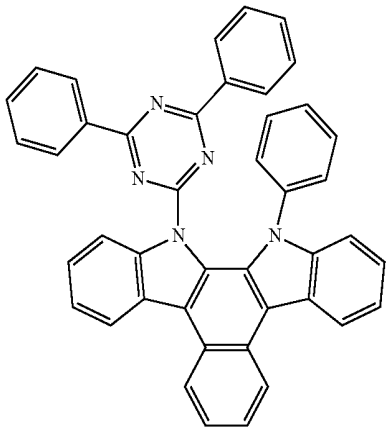


H42



In some embodiments, the host may include at least one selected from Compounds H43 to H49, but embodiments of the present disclosure are not limited thereto:

H43



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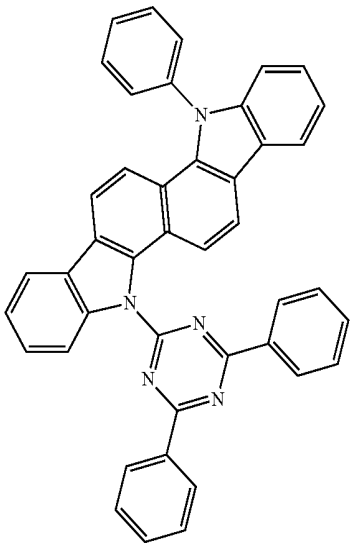
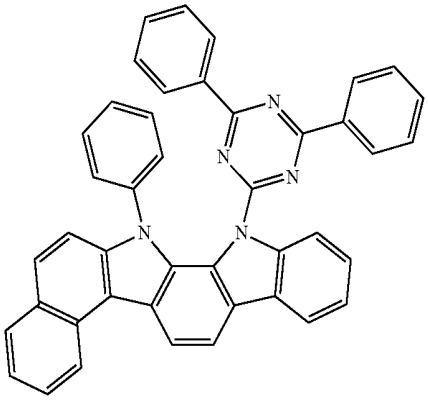
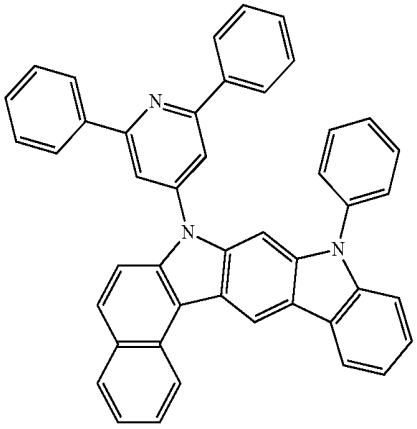
H44



H45



H46



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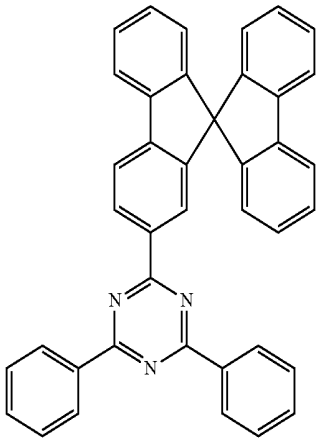
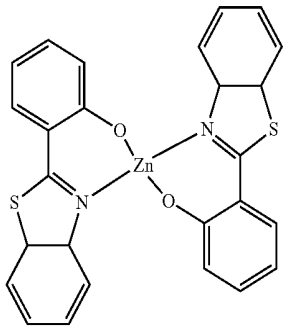
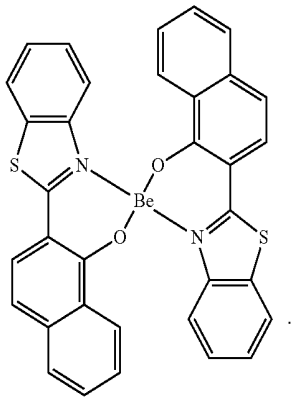
H47



H48



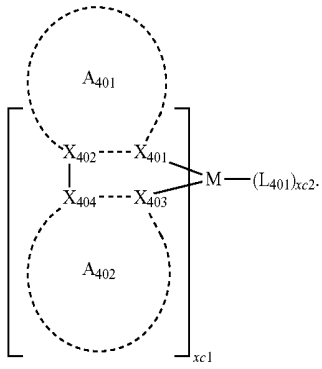
H49



The dopant may include at least one selected from a fluorescent dopant available in the related art and a phosphorescent dopant available in the related art.

The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:

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);

X_{401} to X_{404} may each independently be selected from nitrogen and carbon;

rings A_{401} and A_{402} may each independently be selected from a substituted or unsubstituted benzene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted fluorene, a substituted or unsubstituted spiro-fluorene, a substituted or unsubstituted indene, a substituted or unsubstituted pyrrole, a substituted or unsubstituted thiophene, a substituted or unsubstituted furan, a substituted or unsubstituted imidazole, a substituted or unsubstituted pyrazole, a substituted or unsubstituted thiazole, a substituted or unsubstituted isothiazole, a substituted or unsubstituted oxazole, a substituted or unsubstituted isoxazole, a substituted or unsubstituted pyridine, a substituted or unsubstituted pyrazine, a substituted or unsubstituted pyrimidine, a substituted or unsubstituted pyridazine, a substituted or unsubstituted quinoline, a substituted or unsubstituted isoquinoline, a substituted or unsubstituted benzoquinoline, a substituted or unsubstituted quinoxaline, a substituted or unsubstituted quinazoline, a substituted or unsubstituted carbazole, a substituted or unsubstituted benzimidazole, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted isobenzothiophene, a substituted or unsubstituted benzoxazole, a substituted or unsubstituted isobenzoxazole, a substituted or unsubstituted triazole, a substituted or unsubstituted oxadiazole, a substituted or unsubstituted triazine, a substituted or unsubstituted dibenzofuran, and a substituted or unsubstituted dibenzothiophene;

at least one substituent of the substituted benzene, substituted naphthalene, substituted fluorene, substituted spiro-fluorene, substituted indene, substituted pyrrole, substituted thiophene, substituted furan, substituted imidazole, substituted pyrazole, substituted thiazole, substituted isothiazole, substituted oxazole, substituted isoxazole, substituted pyridine, substituted pyrazine, substituted pyrimidine, substituted pyridazine, substituted quinoline, substituted isoquinoline, substituted benzoquinoline, substituted quinoxaline, substituted quinazoline, substituted carbazole, substituted benzimidazole, substituted benzofuran, substituted benzothiophene, substituted isobenzothiophene, substituted benzoxazole, substituted isobenzoxazole, substituted triazole, substituted oxadiazole, substituted triazine, substituted dibenzofuran, and substituted dibenzothiophene 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 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{401})(Q_{402})$, —$Si(Q_{403})(Q_{404})(Q_{405})$, and —$B(Q_{406})(Q_{407})$,

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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

a C_3-C_{10} cycloalkyl group, a C_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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one 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, 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{411})(Q_{412})$, —$Si(Q_{413})(Q_{414})(Q_{415})$, and —$B(Q_{416})(Q_{417})$, and

—$N(Q_{421})(Q_{422})$, —$Si(Q_{423})(Q_{424})(Q_{425})$, and —$B(Q_{426})(Q_{427})$,

L_{401} may be an organic ligand;

xc1 may be selected from 1, 2, and 3; and

xc2 may be selected from 0, 1, 2, and 3,

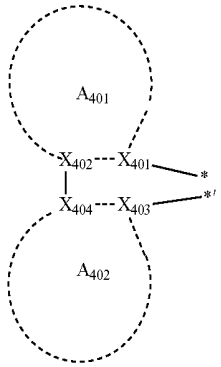
wherein Q_{401} to Q_{407}, Q_{411} to Q_{417}, and Q_{421} to Q_{427} may each be the same as described herein in connection with Q_{11}.

L_{401} may be a monovalent, a divalent, or a trivalent organic ligand. In some embodiments, L_{401} may be selected from a halogen ligand (e.g., Cl or F), a diketone ligand (e.g., acetylacetonate, 1,3-diphenyl-1,3-propane dionate, 2,2,6,6-tetramethyl-3,5-heptanedionate, or hexafluoroacetonate), a carboxylic acid ligand (e.g., picolinate, dimethyl-3-a pyrazolecarboxylate, or benzoate), a carbon monoxide ligand, an isonitrile ligand, a cyano group ligand, and a phosphorus ligand (e.g., phosphine or phosphite), but embodiments are not limited thereto.

When A_{401} in Formula 401 has a plurality of substituents, the plurality of substituents of A_{401} may bind to each other to form a saturated or unsaturated ring.

When A_{402} in Formula 401 has a plurality of substituents, the plurality of substituents of A_{402} may bind to each other to form a saturated or unsaturated ring.

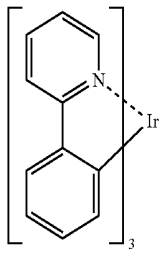
When xc1 in Formula 401 is two or more, a plurality of ligands



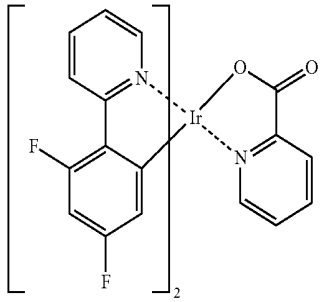
in Formula 401 may be identical to or different from each other. In Formula 401, when xc1 is 2 or more, A_{401} and A_{402} may each be directly connected (e.g., by a bond) or connected via a linking group (for example, a C_1-C_5 alkylene group, —N(R')— (here, R' may be a C_1-C_{10} alkyl group or a C_6-C_{20} aryl group), and/or —C(=O)—) to A_{401} and A_{402}, respectively, of another adjacent ligand.

The phosphorescent dopant may include at least one selected from Compounds PD1 to PD74, but embodiments of the present disclosure are not limited thereto:

PD1



PD2



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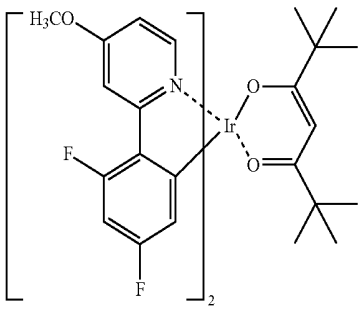
PD3



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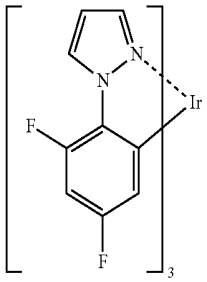
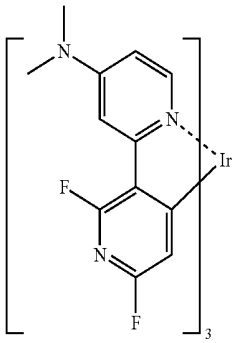
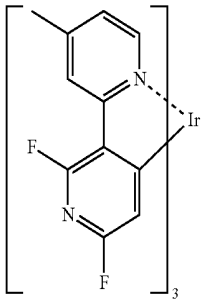


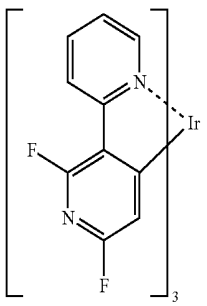
PD5



PD6



PD7



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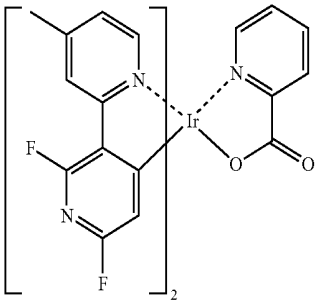
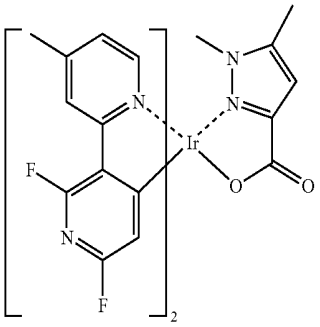
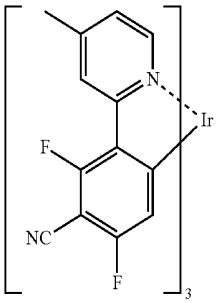
PD8



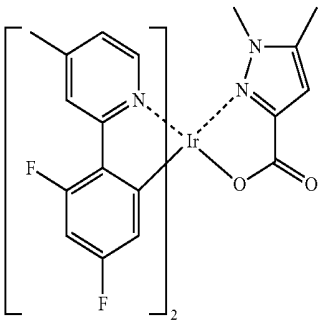
PD9



PD10



PD11



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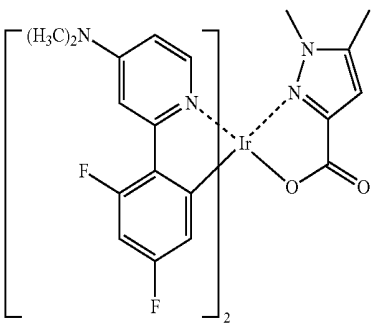

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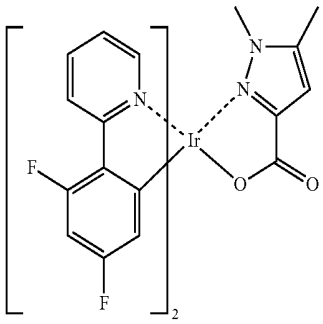
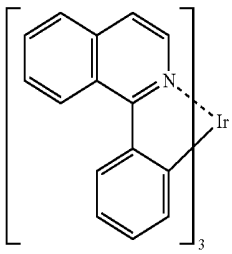
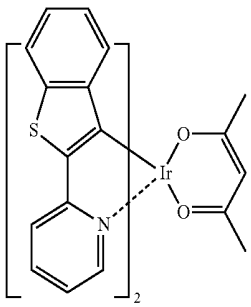
PD13



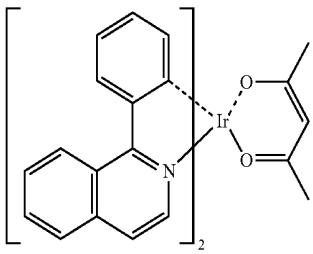
PD14



PD15



PD16



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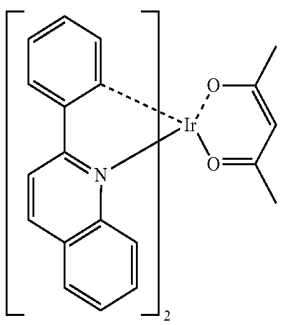

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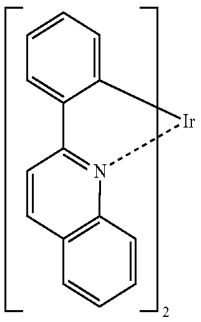

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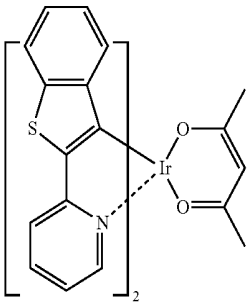

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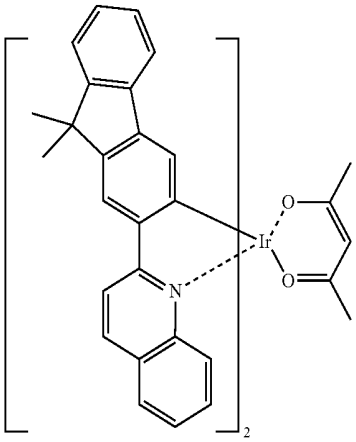

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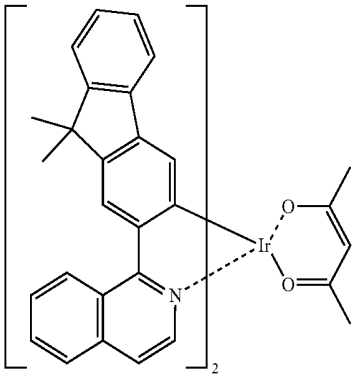

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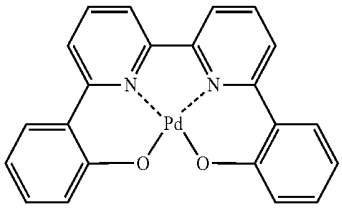

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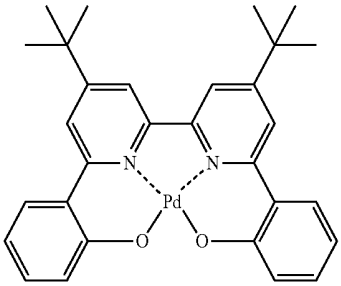

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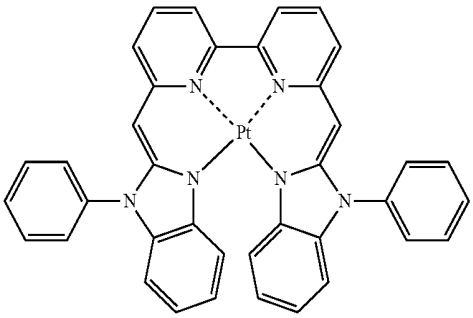

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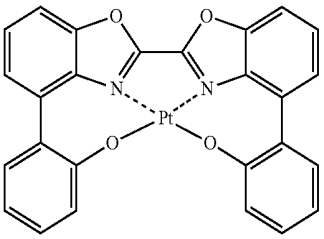

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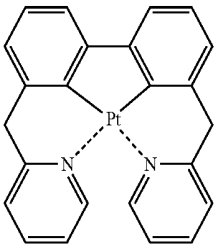

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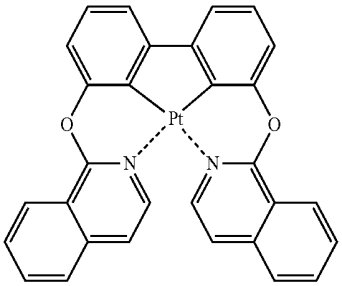

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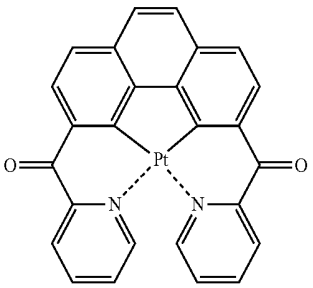

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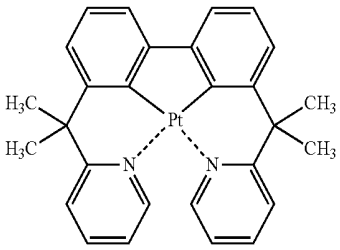

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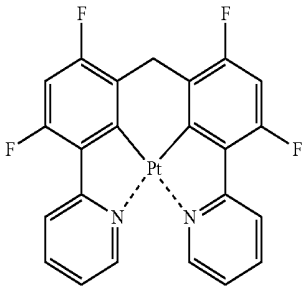

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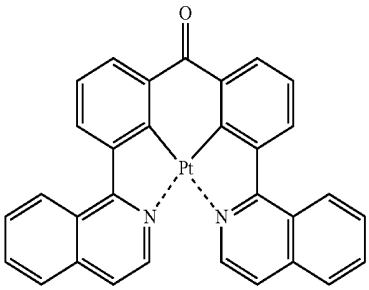

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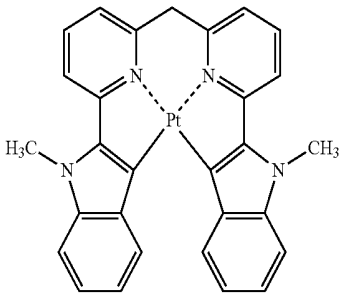

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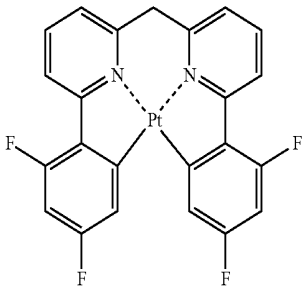

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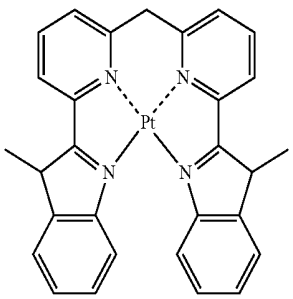

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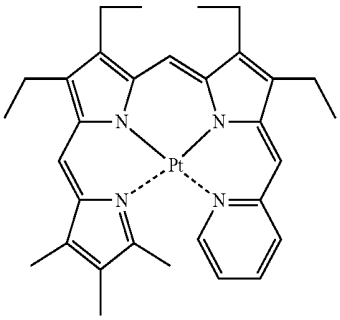

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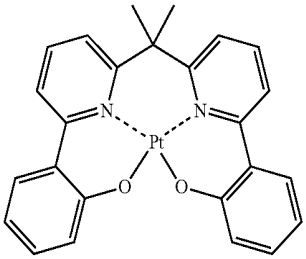

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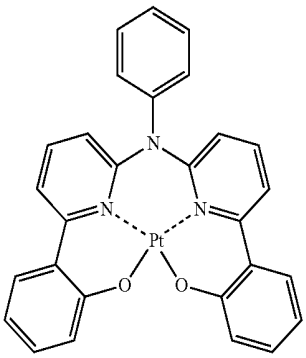

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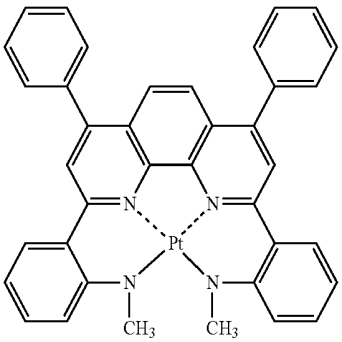

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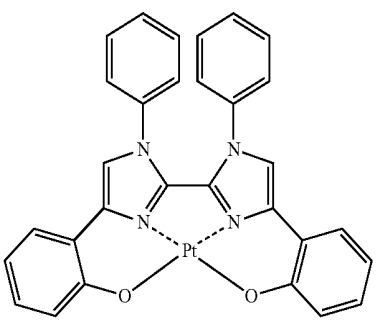

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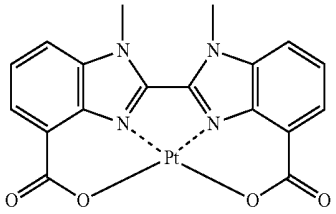

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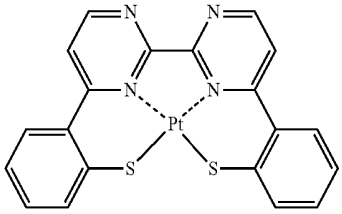

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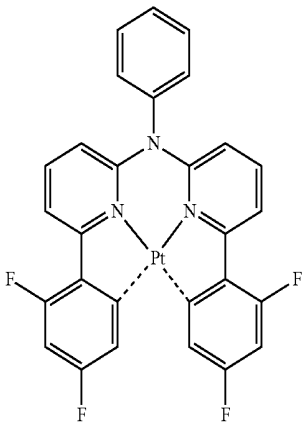

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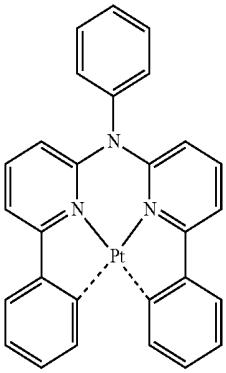

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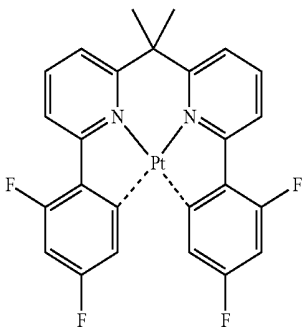

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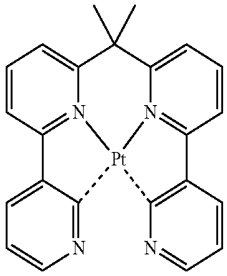

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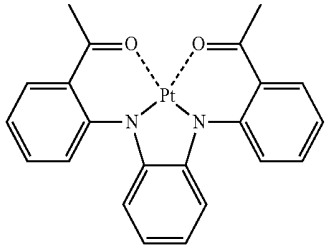

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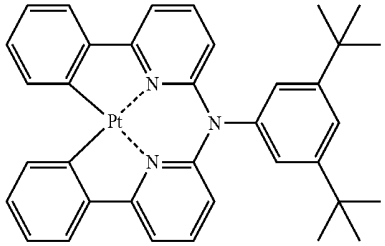

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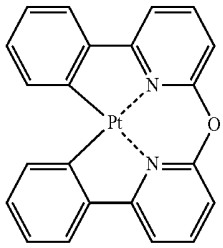

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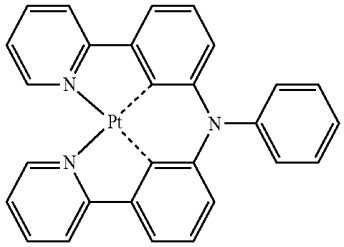

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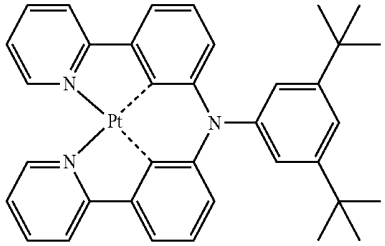

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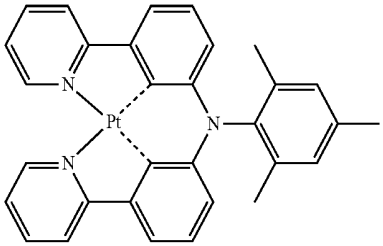

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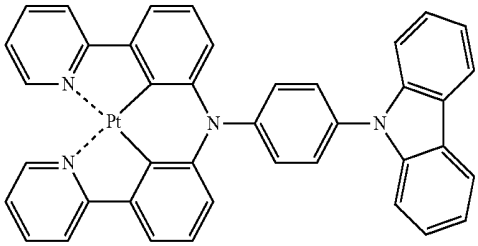

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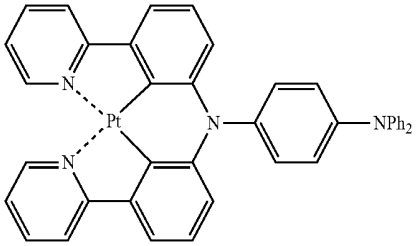

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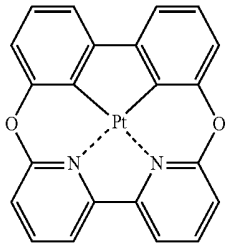

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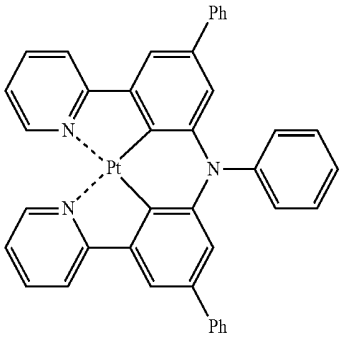

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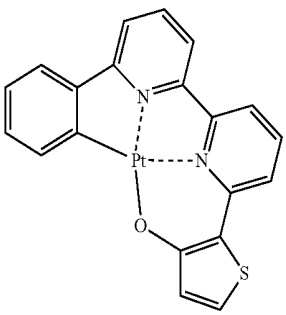

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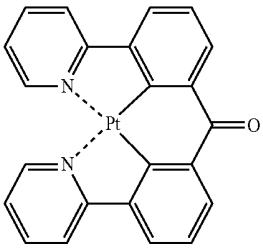

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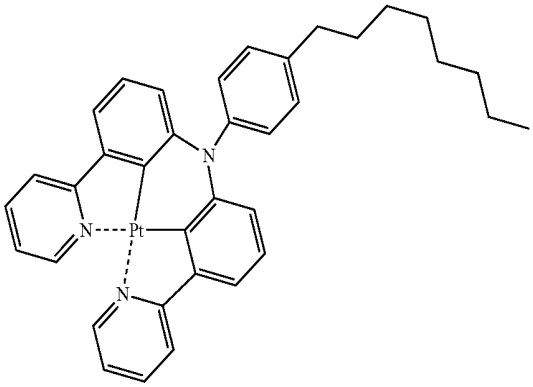

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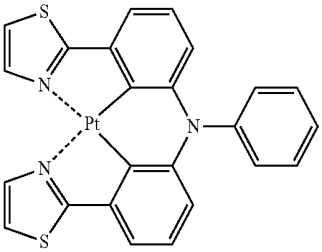

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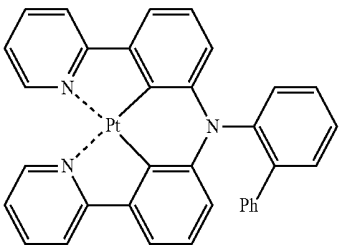

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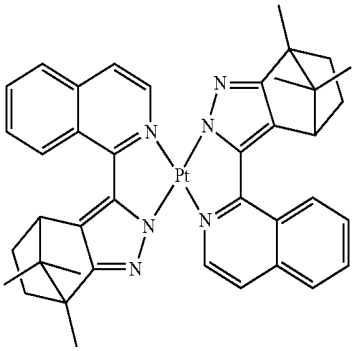

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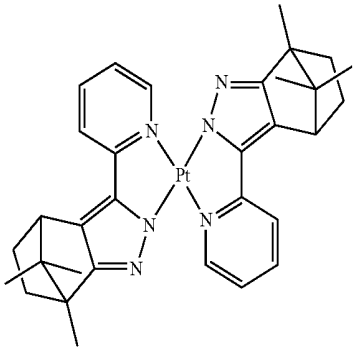

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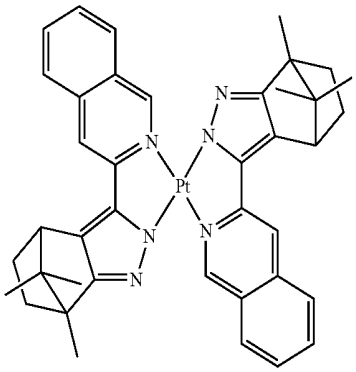

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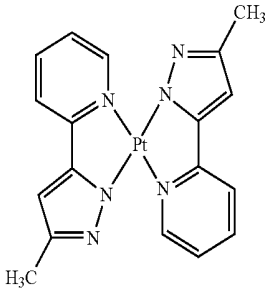

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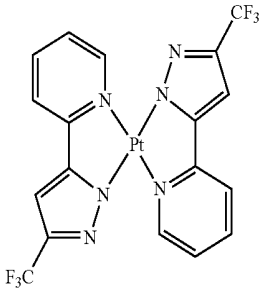

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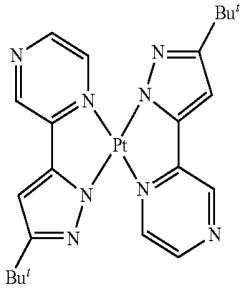

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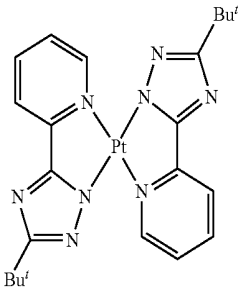

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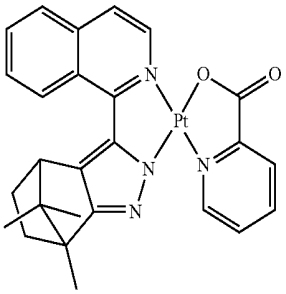

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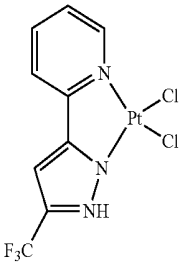

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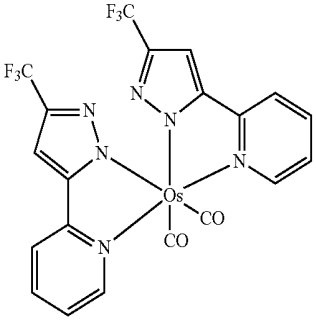

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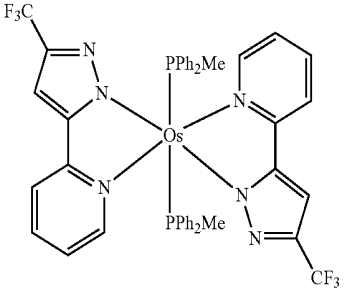

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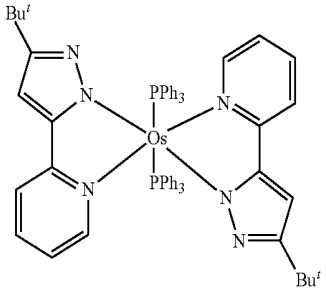

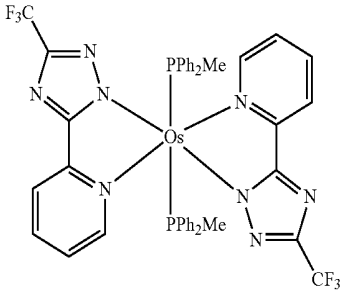

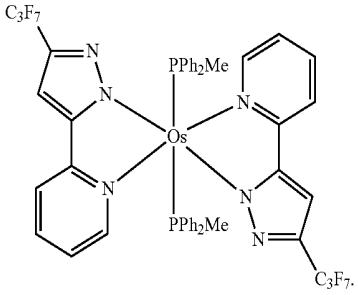

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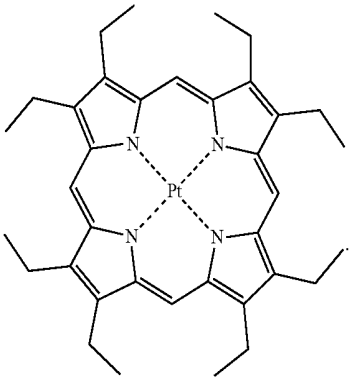
PD73

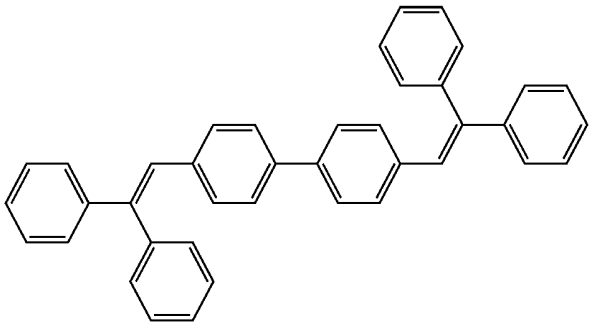
PD74

In some embodiments, the phosphorescent dopant may include PtOEP:

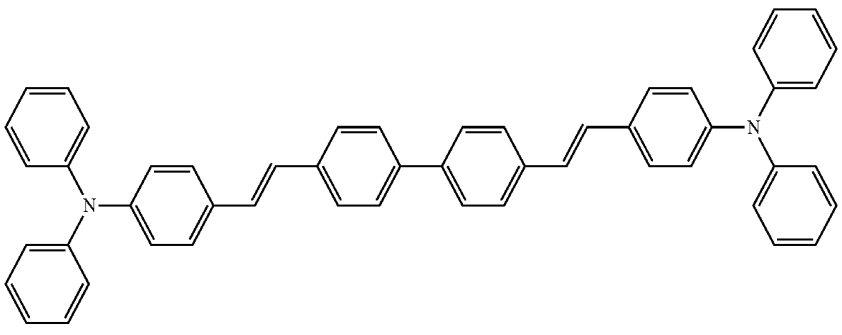


PtOEP

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



DPVBi



DPAVBi

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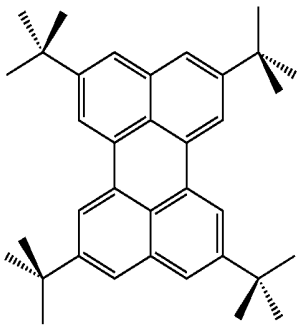
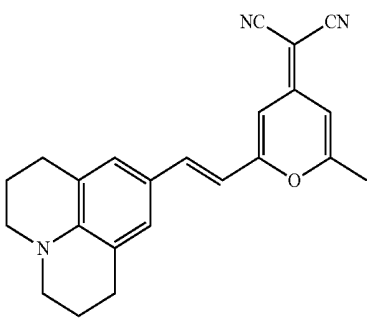
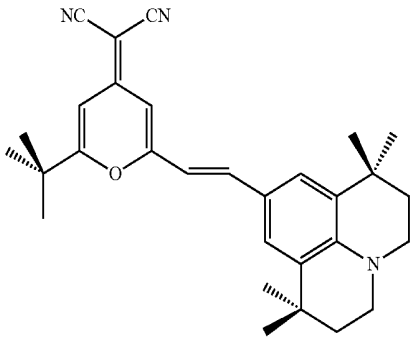


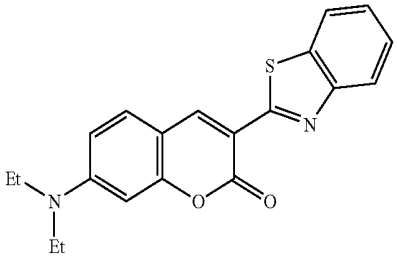
TBPe



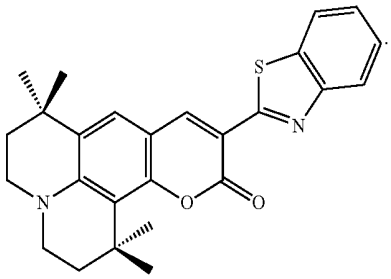
DCM



DCJTB



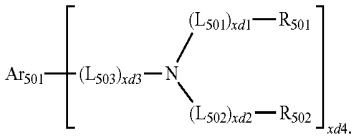
Coumarin 6



C545T

Alternatively, the fluorescent dopant may include a compound represented by Formula 501:

Formula 501



In Formula 501,

Ar_{501} may be selected from:

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

a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{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_1-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 C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and a C_1-C_{60} heteroaryl group);

L_{501} to L_{503} may each be the same as described herein in connection with L_{301};

R_{501} and R_{502} may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl 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 carbazole group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

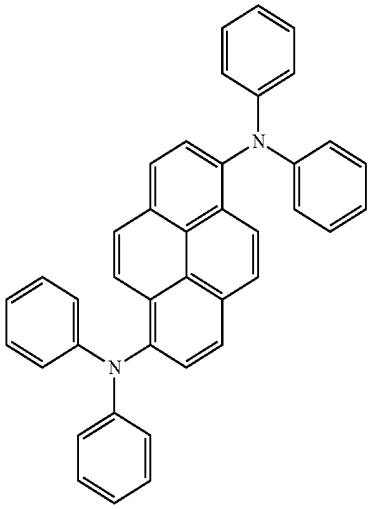
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group and a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

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

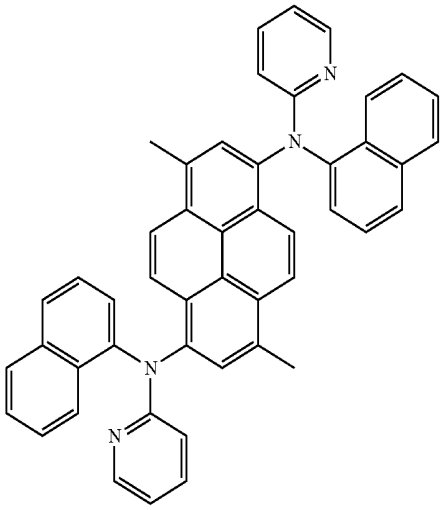
xd4 may be selected from 1, 2, 3, and 4.

The fluorescent host may include at least one selected from compounds FD1 to FD8:

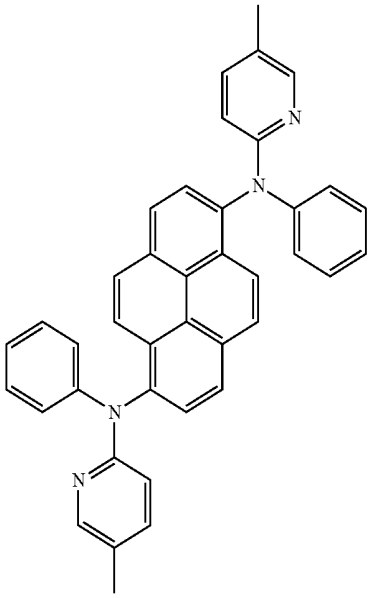
FD1



FD2



FD3



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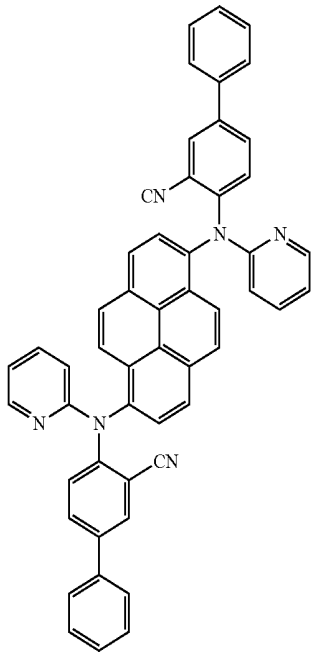
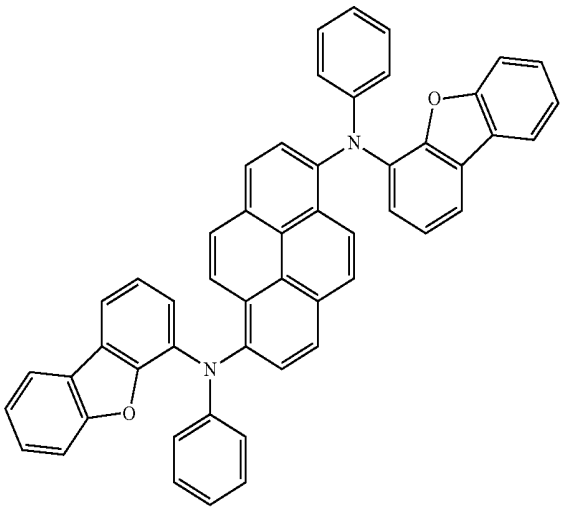
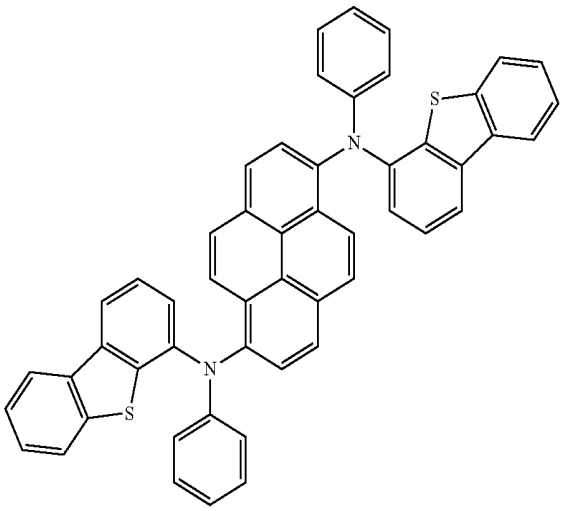
FD4



FD5



FD6



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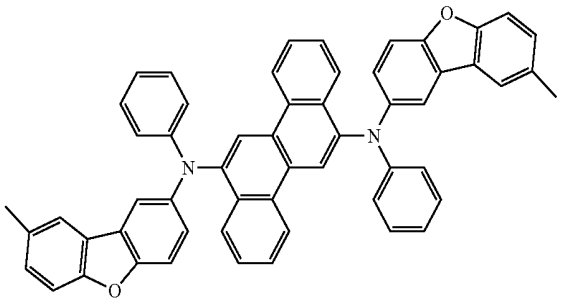
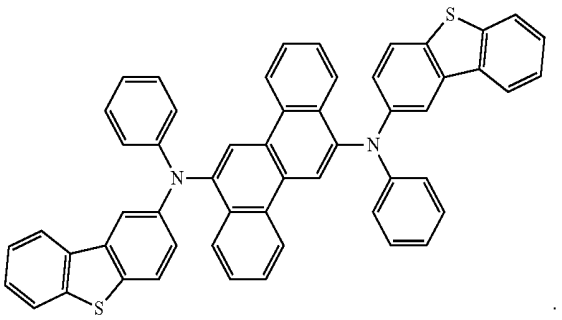
FD7



FD8



The amount of the dopant in the emission layer may be about 0.01 part to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

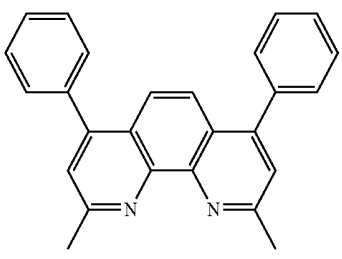
The thickness of the emission layer may be about 100 Å to about 1,000 Å, and in some embodiments, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

An electron transport region may be on the emission layer.

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

When the electron transport region includes a hole blocking layer, the hole blocking layer may be formed on the emission layer using one or more suitable methods, such as vacuum-deposition, spin coating, casting, LB method, ink-jet printing, laser-printing, and/or LITI. When the hole blocking layer is formed by vacuum-deposition and/or spin coating, the deposition and coating conditions for the hole blocking layer may be similar to the deposition and coating conditions for the hole injection layer.

The hole blocking layer may include, for example, at least one selected from BCP and Bphen, but embodiments of the present disclosure are not limited thereto:



BCP

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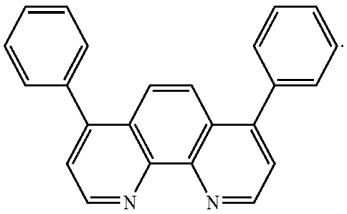


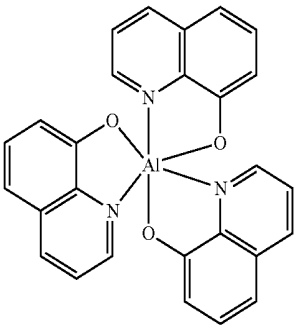
Bphen

The thickness of the hole blocking layer may be about 20 Å to about 1,000 Å, and in some embodiments, about 30 Å to about 300 Å. When the thickness of the hole blocking layer is within this range, excellent hole blocking characteristics may be obtained without a substantial increase in driving voltage.

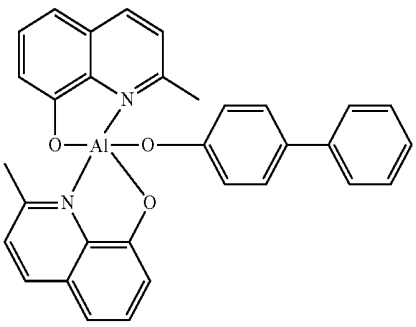
The electron transport region may have a structure of electron transport layer/electron injection layer or a structure of hole blocking layer/electron transport layer/electron injection layer, wherein layers of each structure are sequentially stacked on the emission layer in the stated order, but embodiments of the present disclosure are not limited thereto.

In some embodiments, the organic layer **150** of the organic light-emitting device includes an electron transport region between the emission layer and the second electrode **190**, wherein the electron transport region may include an electron transport layer. The electron transport layer may be a plurality of layers. In some embodiments, the electron transport region may include a first electron transport layer and a second electron transport layer.

The electron transport layer may include at least one selected from BCP, Bphen, Alq_3, BAlq, TAZ, and NTAZ.



Alq_3



BAlq

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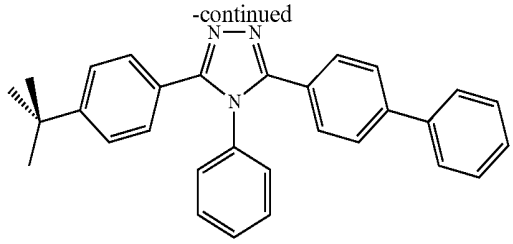
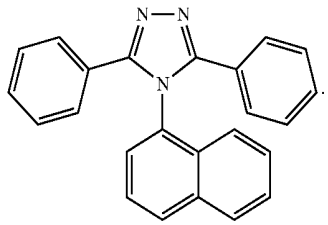


TAZ



NTAZ

In some embodiments, the electron transport layer may include at least one compound selected from a compound represented by Formula 601 and a compound represented by Formula 602:

$$Ar_{601}\text{-}[(L_{601})_{xe1}\text{-}E_{601}]_{xe2}\text{-} \quad \text{Formula 601}$$

In Formula 601,

Ar_{601} may be selected from:

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

a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —$Si(Q_{301})(Q_{302})(Q_{303})$ (wherein Q_{301} to Q_{303} may each independently be selected from hydrogen, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and a C_1-C_{60} heteroaryl group);

L_{601} may be the same as described herein in connection with L_{301};

E_{601} may be selected from:

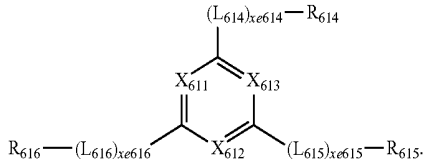
a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl 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 benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

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 benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, 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 C_1-C_{20} alkyl group, a C_1-C_{20} 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 dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, 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 selected from N and C-$(L_{611})_{xe611}$-R_{611}, X_{612} may be selected from N and C-$(L_{612})_{xe612}$-R_{612}, X_{613} may be selected from N and C-$(L_{613})_{xe613}$-R_{613}, and at least one selected from X_{611} to X_{613} may be N;

L_{611} to L_{616} may each be the same as described herein in connection with L_{301};

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

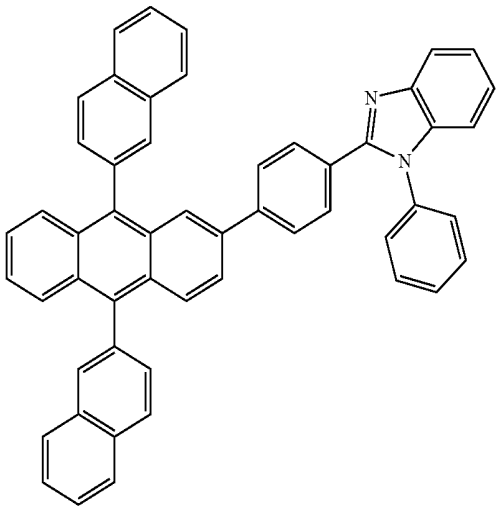
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, 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 biphenyl group, a terphenyl 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

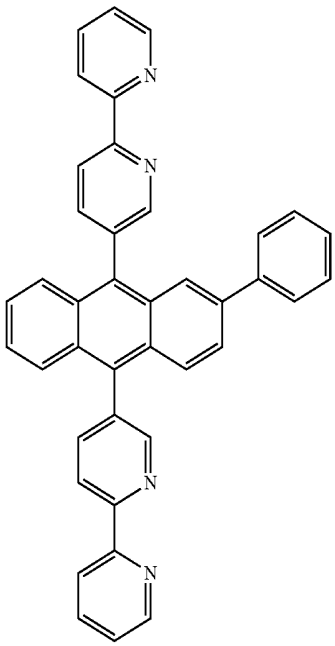
xe611 to xe616 may each independently be selected from 0, 1, 2, and 3.

The compound represented by Formula 601 and the compound represented by Formula 602 may each be selected from Compounds ET1 to ET15:

ET1



ET2



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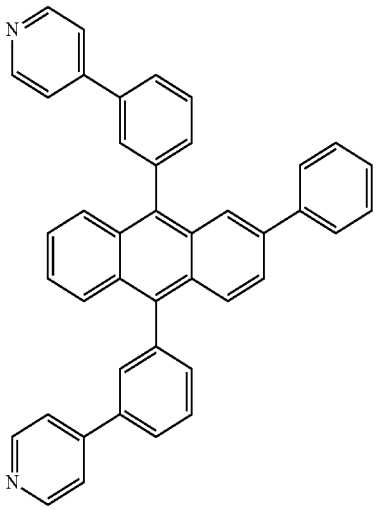

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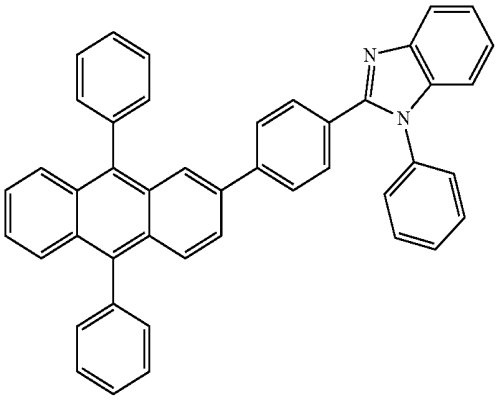

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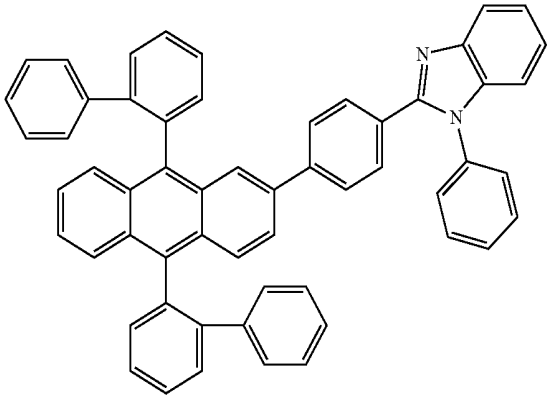

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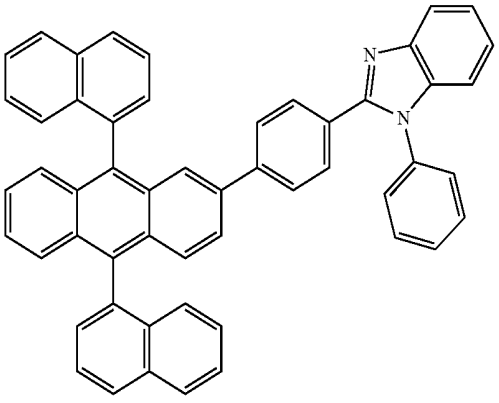

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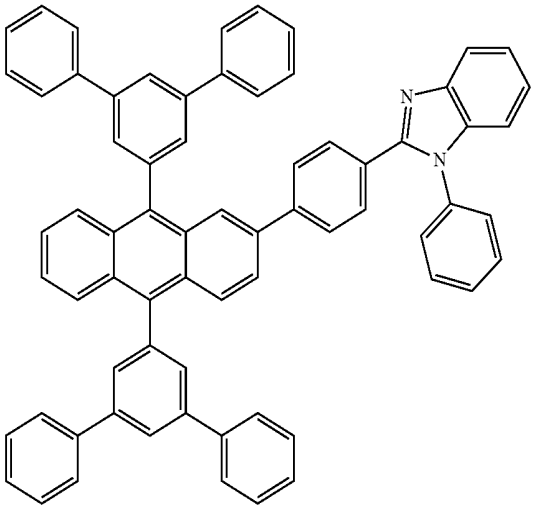
ET7



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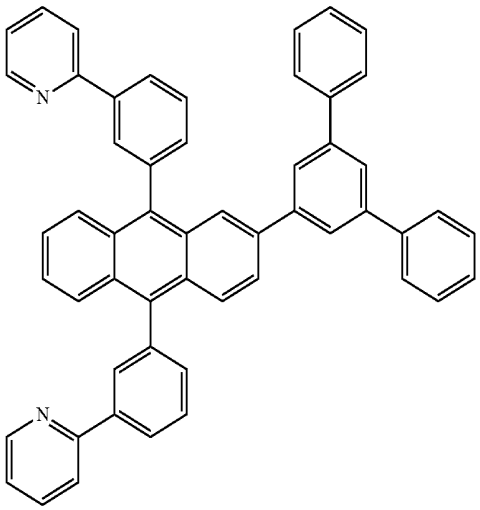

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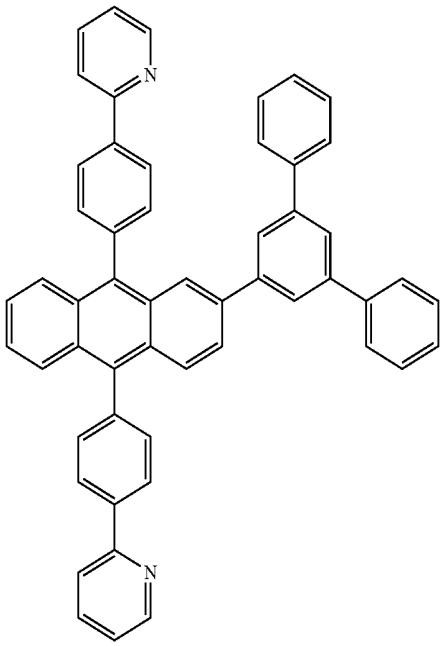

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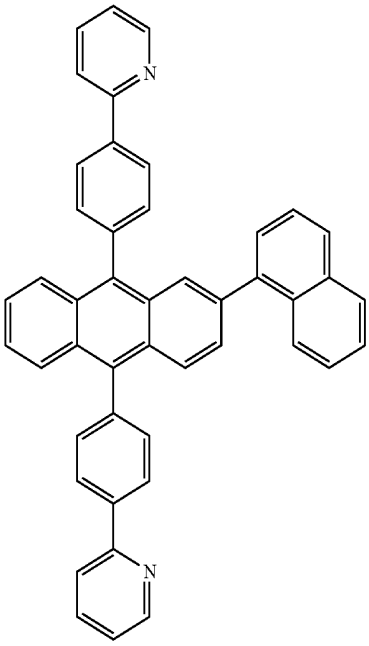
ET10



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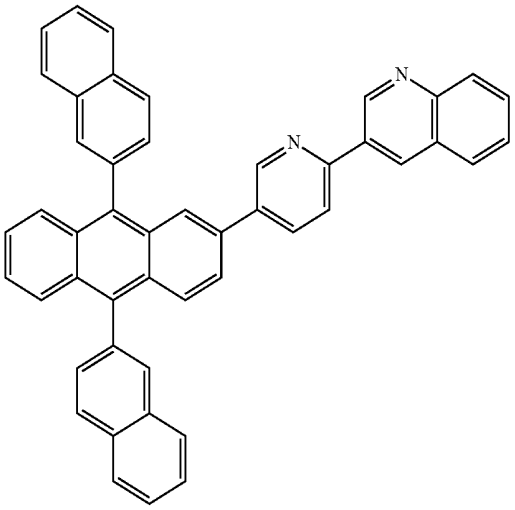

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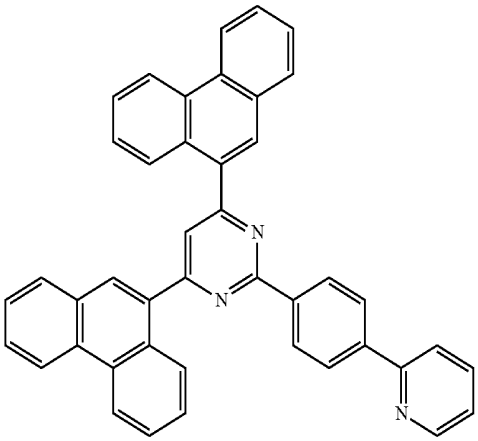

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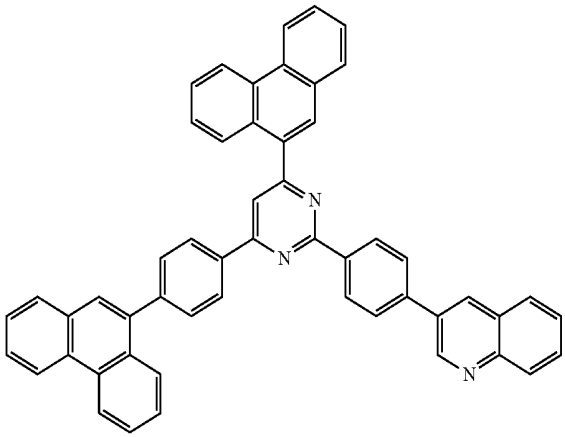
ET13



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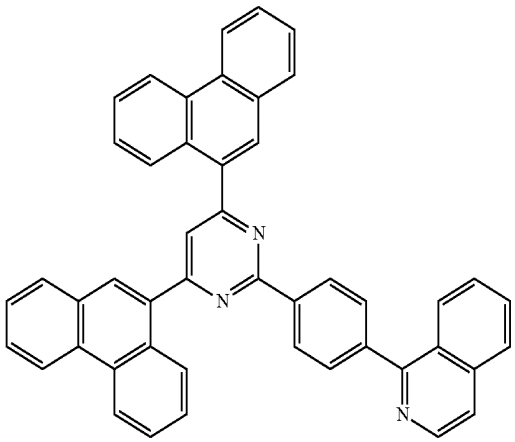
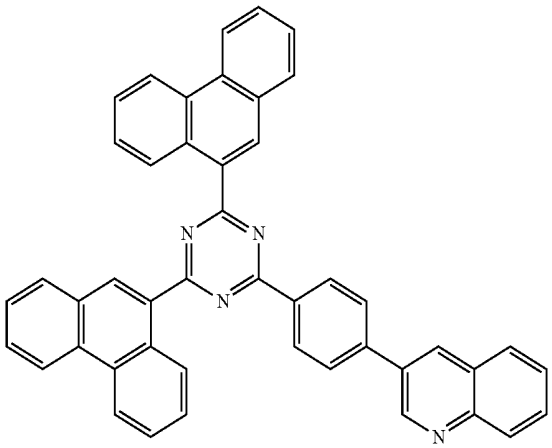


ET15

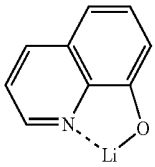


The thickness of the electron transport layer may be about 100 Å to about 1,000 Å, and in some embodiments, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within this range, excellent electron transport characteristics may be obtained without a substantial increase in driving voltage.

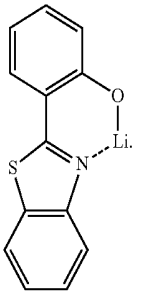
The electron transport layer may further include a metal-containing material in addition to the materials described above.

The metal-containing material may include a Li complex. The Li complex may include, for example, one selected from Compound ET-D1 (lithium quinolate, LiQ) and ET-D2.

ET-D1



ET-D2



The electron transport region may include an electron injection layer that facilitates electron injection from the second electrode **190**.

The electron injection layer may be formed on the electron transport layer using one or more suitable methods, such as vacuum-deposition, spin coating, casting, LB method, ink-jet printing, laser-printing, and/or LITI. When the electron injection layer is formed by vacuum-deposition and/or spin coating, the vacuum-deposition and coating conditions for the electron injection layer may be similar to the vacuum-deposition and coating conditions for the hole injection layer.

The electron injection layer may include at least one selected from, LiF, NaCl, CsF, Li_2O, BaO, and LiQ.

The thickness of the electron injection layer may be about 1 Å to about 100 Å, and in some embodiments, about 3 Å to about 90 Å. When the thickness of the electron injection layer is within this range, excellent electron injection characteristics may be obtained without a substantial increase in driving voltage.

The second electrode **190** is on the organic layer **150**. The second electrode **190** may be a cathode that is an electron injection electrode, and in this regard, a material for forming the second electrode **190** may be a material having a low work function. Non-limiting examples of such a material may include metal, alloy, an electrically conductive compound, and mixtures thereof. Non-limiting examples of the material for forming the second electrode **190** may include lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, the material for forming the second electrode **190** may be ITO and/or IZO. The second electrode **190** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

The organic layer of the organic light-emitting device according to an embodiment of the present disclosure may be formed by vacuum-depositing the compound according to an embodiment of the present disclosure and/or by using a wet method in which the compound is prepared in the form of solution, and the solution of the compound is used for coating.

The organic light-emitting device according to an embodiment of the present disclosure may be suitably included in one or more types or kinds of flat panel display apparatuses, for example, a passive matrix organic light-emitting display apparatus and an active matrix organic light-emitting display apparatus. For example, when the organic light-emitting device is included in an active matrix organic light-emitting display apparatus, a first electrode on a substrate may be a pixel electrode, and the first electrode may be electrically connected to a source electrode or drain electrode of a thin film transistor. In some embodiments, the organic light-emitting device may be included in a flat panel display apparatus that may display images on both sides.

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

Hereinafter, definitions of substituents used herein will be presented. The number of carbons used to restrict a substituent is not limited, and does not limit the properties of the substituent, and unless defined otherwise, the definition of the substituent is consistent with a general definition thereof.

The term "C_1-C_{60} alkyl group" as used herein refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and non-limiting examples thereof may 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. The term "C_1-C_{60} alkylene group" as used herein refers to a divalent group having substantially the same structure as a C_1-C_{60} alkyl group.

The term "C_1-C_{60} alkoxy group" as used herein refers to a monovalent group represented by —O-A_{101} (wherein A_{101} is the C_1-C_{60} alkyl group), and non-limiting examples thereof may include a methoxy group, an ethoxy group, and an isopropyloxy group.

The term "C_2-C_{60} alkenyl group" as used herein refers to a hydrocarbon group formed by substituting at least one carbon double bond in the middle or at the terminal of the C_2-C_{60} alkyl group, and non-limiting examples thereof may include an ethenyl group, a propenyl group, and a butenyl group. The term "C_2-C_{60} alkenylene group" as used herein refers to a divalent group having substantially the same structure as a C_2-C_{60} alkenyl group.

The term "C_2-C_{60} alkynyl group" as used herein refers to a hydrocarbon group formed by substituting at least one carbon triple bond in the middle or at the terminal of the C_2-C_{60} alkyl group, and non-limiting examples thereof may include an ethynyl group and a propynyl group. The term "C_2-C_{60} alkynylene group" as used herein refers to a divalent group having substantially the same structure as a C_2-C_{60} alkynyl group.

The term "C_3-C_{10} cycloalkyl group" as used herein refers to a monovalent monocyclic saturated hydrocarbon group including 3 to 10 carbon atoms, and non-limiting examples thereof may include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term "C_3-C_{10} cycloalkylene group" as used herein refers to a divalent group having substantially the same structure as a C_3-C_{10} cycloalkyl group.

The term "C_1-C_{10} heterocycloalkyl group" as used herein refers to a monovalent monocyclic group including at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 1 to 10 carbon atoms. Non-limiting examples thereof may include a tetrahydrofuranyl group and a tetrahydrothiophenyl group. The term "C_2-C_{10} heterocycloalkylene group" as used herein refers to a divalent group having substantially the same structure as a C_2-C_{10} heterocycloalkyl group.

The term "C_3-C_{10} cycloalkenyl group" as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one double bond in its ring, and

which is not aromatic. Non-limiting examples thereof may include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term "C_3-C_{10} cycloalkenylene group" as used herein refers to a divalent group having substantially the same structure as a C_3-C_{10} cycloalkenyl group.

The term "C_2-C_{10} heterocycloalkenyl group" as used herein refers to a monovalent monocyclic group including at least one heteroatom selected from N, O, P, and S as a ring-forming atom, 2 to 10 carbon atoms, and at least one double bond in its ring. Non-limiting examples of the C_2-C_{10} heterocycloalkenyl group may include a 2,3-hydrofuranyl group and a 2,3-hydrothiophenyl group. The term "C_2-C_{10} heterocycloalkenylene group" as used herein refers to a divalent group having substantially the same structure as a C_2-C_{10} heterocycloalkenyl group.

The term "C_6-C_{60} aryl group" as used herein refers to a monovalent group including a carbocyclic aromatic system having 6 to 60 carbon atoms, and the term "C_6-C_{60} arylene group" as used herein refers to a divalent group including a carbocyclic aromatic system having 6 to 60 carbon atoms. Non-limiting examples of the C_6-C_{60} aryl group may include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6-C_{60} aryl group and the C_6-C_{60} arylene group each include a plurality of rings, the rings may be fused to each other.

The term "C_1-C_{60} heteroaryl group" as used herein refers to a monovalent group having a carbocyclic aromatic system including at least one hetero atom selected from N, O, P, and S as a ring-forming atom and 1 to 60 carbon atoms. The term "C_1-C_{60} heteroarylene group" as used herein refers to a divalent group having a carbocyclic aromatic system including at least one hetero atom selected from N, O, P, and S as a ring-forming atom and 1 to 60 carbon atoms. Non-limiting examples of the C_1-C_{60} heteroaryl group may include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1-C_{60} heteroaryl group and the C_1-C_{60} heteroarylene group each include a plurality of rings, the rings may be fused to each other.

The term "C_6-C_{60} aryloxy group" as used herein indicates —O-A_{102} (wherein A_{102} is the C_6-C_{60} aryl group), and a C_6-C_{60} arylthio group used herein indicates —S-A_{103} (wherein A_{103} is the C_6-C_{60} aryl group).

The term "monovalent non-aromatic condensed polycyclic group" as used herein refers to a monovalent group that has two or more rings condensed to each other, and has only carbon atoms as ring forming atoms (for example, the number of carbon atoms may be 8 to 60), wherein the molecular structure as a whole is non-aromatic in the entire molecular structure (e.g., the entire group is not aromatic). A non-limiting example of the monovalent non-aromatic condensed polycyclic group may include a fluorenyl group. The term "divalent non-aromatic condensed polycyclic group" as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

The term "monovalent non-aromatic condensed heteropolycyclic group" as used herein refers to a monovalent group that has two or more rings condensed to each other, and has a heteroatom selected from N, O, P, and S, and 2 to 60 carbon atoms as ring-forming atoms, wherein the molecular structure as a whole is non-aromatic in the entire molecular structure (e.g., the entire group is not aromatic). The term "divalent non-aromatic condensed hetero-polycyclic group" as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

At least one substituent of the substituted C_3-C_{10} cycloalkylene group, substituted C_2-C_{10} heterocycloalkylene group, substituted C_3-C_{10} cycloalkenylene group, substituted C_2-C_{10} heterocycloalkenylene group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, substituted divalent non-aromatic condensed heteropolycyclic group, substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_2-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_2-C_{10} heterocycloalkenyl group, substituted C_6-C_{60} aryl group, substituted C_6-C_{60} aryloxy group, substituted C_6-C_{60} arylthio group, substituted C_1-C_{60} heteroaryl group, substituted monovalent non-aromatic condensed polycyclic group, and 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 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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$B(Q_{16})(Q_{17})$,

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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

a C_3-C_{10} cycloalkyl group, a C_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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one 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, 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_1-C_{60} heteroaryl

group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, and —$B(Q_{26})(Q_{27})$; and

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

wherein Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_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_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

In some embodiments, at least one substituent of the substituted C_3-C_{10} cycloalkylene group, substituted C_2-C_{10} heterocycloalkylene group, substituted C_3-C_{10} cycloalkenylene group, substituted C_2-C_{10} heterocycloalkenylene group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, substituted divalent non-aromatic condensed heteropolycyclic group, substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_2-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_2-C_{10} heterocycloalkenyl group, substituted C_6-C_{60} aryl group, substituted C_6-C_{60} aryloxy group, substituted C_6-C_{60} arylthio group, substituted C_1-C_{60} heteroaryl group, substituted monovalent non-aromatic condensed polycyclic group, and 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 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 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 thioohenyl 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 benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group. —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$B(Q_{16})(Q_{17})$;

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 phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, 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 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 phenan-

thridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, 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 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 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 croup, 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 benzimidazolyl group, a benzofuran/l group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazol/l 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. —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, and —$B(Q_{26})(Q_{27})$; and —$N(Q_{31})(Q_{32})$, —$Si(Q_{33})(Q_{34})(Q_{35})$, and —$B(Q_{36})(Q_{37})$.

wherein Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_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 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 phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

As used herein, "Ph" refers to a phenyl group, "Me" refers to a methyl group, "Et" refers to an ethyl group, and "ter-Bu" or "Bu^t" refers to a tert-butyl group.

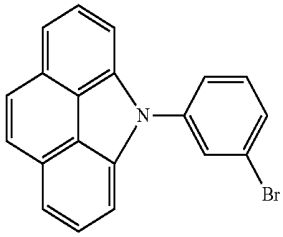
Hereinafter, an organic light-emitting device according to an embodiment of the present disclosure will be described in more detail with reference to Examples.

Synthesis Example

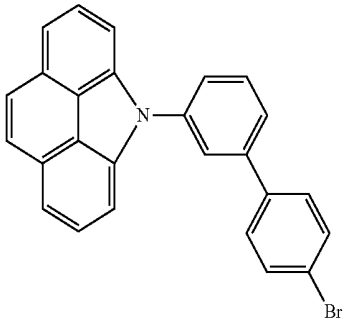
Intermediates I-1 to I-17 and I-18 to I-29, used as precursors for synthesizing the compound according to an example embodiment of the present disclosure, were synthesized as follows:

Synthesis of Intermediates I-1 to I-17

I-1



I-2



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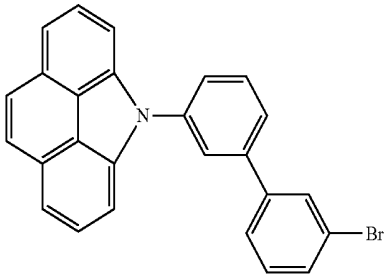
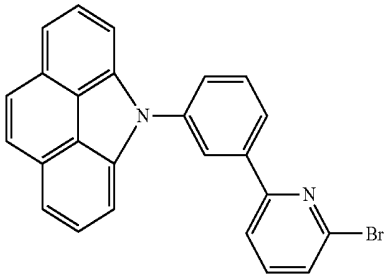
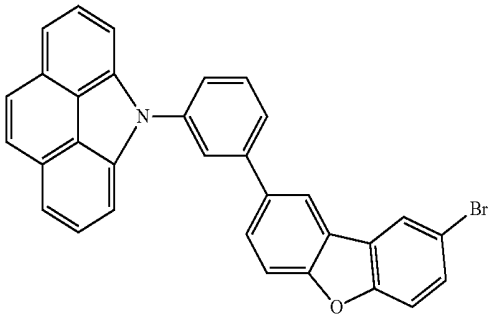
I-3



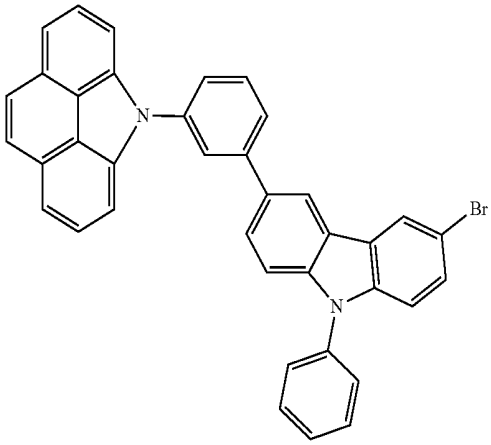
I-4



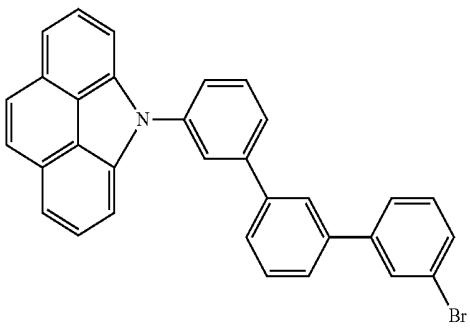
I-5



I-6



I-7



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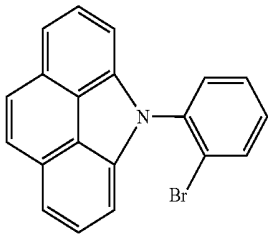
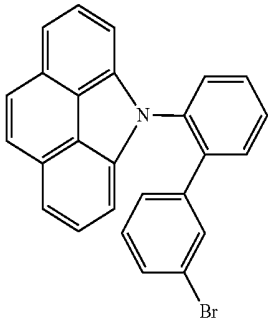
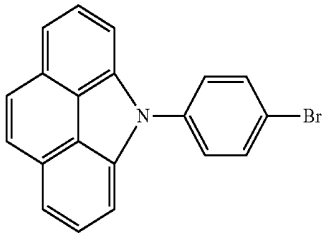
I-8



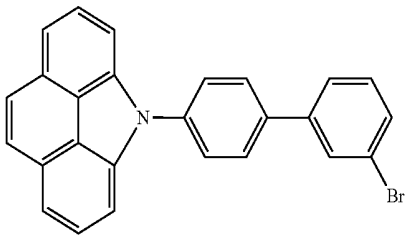
I-9



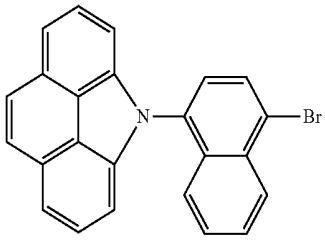
I-10



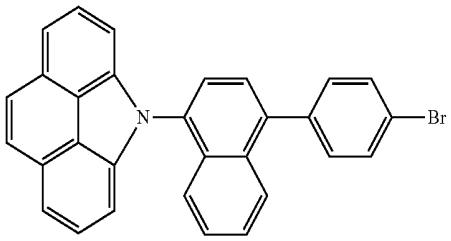
I-11



I-12



I-13



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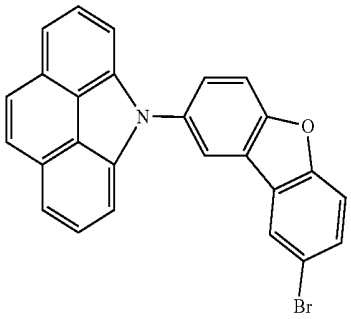
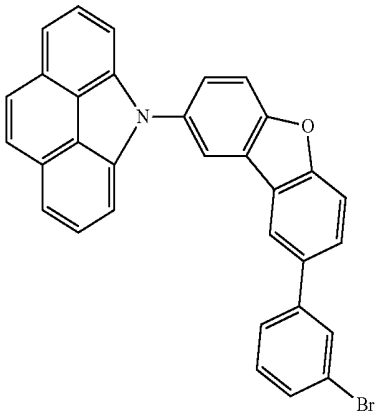
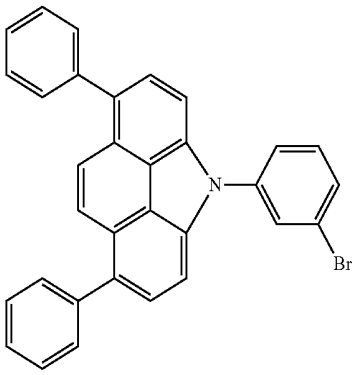
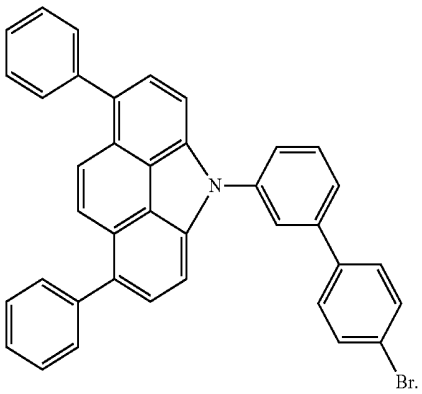


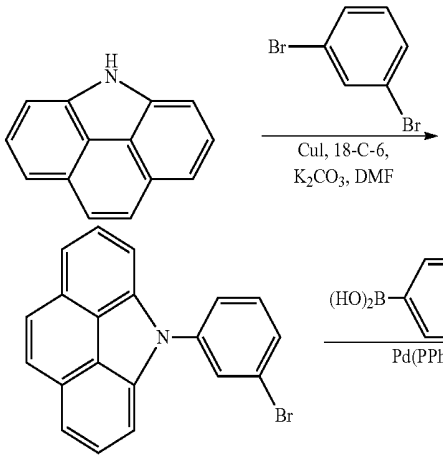




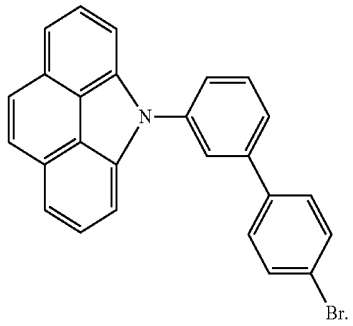


Synthesis of Intermediate I-1

I-14



I-15



I-16

I-17

19.1 g (100.0 mmol) of 4H-benzo[def]carbazole, 28.3 g (120.0 mmol) of 1-bromo-3-iodobenzene, 1.91 g (10.0 mmol) of CuI, 2.43 g (10.0 mmol) of 18-Crown-6, and 41.5 g (300.0 mmol) of K_2CO_3 were dissolved in 300 mL of DMF, and the reaction solution was stirred at 140° C. for 12 hours. The reaction solution was then cooled to room temperature, 300 mL of water was added thereto, and an organic layer was collected by repeated extraction using 300 mL of diethyl ether three times. The organic layer thus collected was dried with magnesium sulfate, the magnesium sulfate was removed by filtration, and the residue obtained after evaporating a solvent therefrom was separated and purified using silica gel column chromatography to obtain 31.5 g of Intermediate I-1 (yield: 91%). The compound thus produced was identified by liquid chromatography-mass spectrometry (LC-MS).

$C_{20}H_{12}BrN$: M+1 346.0

Synthesis of Intermediate I-2

31.1 g (90.0 mmol) of Intermediate I-1, 19.9 g (99.0 mmol) of (4-bromophenyl)boronic acid, 5.20 g (4.5 mmol) of $Pd(PPh_3)_4$, and 37.3 g (270.0 mmol) of K_2CO_3 were dissolved in 270 mL of a mixture of THF/H_2O (1:1), and the reaction solution was stirred at 60° C. for 4 hours. The reaction solution was then cooled to room temperature, 270 mL of water was added thereto, and an organic layer was collected by repeated extraction using 250 mL of diethyl ether three times. The organic layer thus collected was dried with magnesium sulfate, the magnesium sulfate was removed by filtration, and the residue obtained after evapo-

rating a solvent therefrom was separated and purified using silica gel column chromatography to obtain 25.0 g of Intermediate I-2 (yield: 79%). The compound thus produced was identified by LC-MS.

$C_{26}H_{16}BrN$: M+1 422.0

Synthesis of Intermediate I-3

Intermediate I-3 (yield: 78%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-1 and (3-bromophenyl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{26}H_{16}BrN$: M+1 422.0

Synthesis of Intermediate I-4

Intermediate I-4 (yield: 73%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-1 and (6-bromopyridin-2-yl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{25}H_{15}BrN_2$: M+1 423.0

Synthesis of Intermediate I-5

Intermediate I-5 (yield: 81%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-1 and (8-bromodibenzo[b,d]furan-2-yl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{32}H_{18}BrNO$: M+1 512.1

Synthesis of Intermediate I-6

Intermediate I-6 (yield: 78%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-1 and (6-bromo-9-phenyl-9H-carbazol-3-yl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{38}H_{23}BrN_2$: M+1 587.1

Synthesis of Intermediate I-7

Intermediate I-7 (yield: 79%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-1 and (3'-bromo-[1,1'-biphenyl]-3-yl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{32}H_{20}BrN$: M+1 498.1

Synthesis of Intermediate I-8

Intermediate I-8 (yield: 92%) was synthesized in substantially the same manner as Intermediate I-1 using 4H-benzo[def]carbazole and 1-bromo-3-iodobenzene. The compound thus produced was identified by LC-MS.

$C_{20}H_{12}BrN$: M+1 346.0

Synthesis of Intermediate I-9

Intermediate I-9 (yield: 79%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-8 and (3-bromophenyl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{26}H_{16}BrN$: M+1 422.0

Synthesis of Intermediate I-10

Intermediate I-10 (yield: 92%) was synthesized in substantially the same manner as Intermediate I-1 using 4H-benzo[def]carbazole and 1-bromo-4-iodobenzene. The compound thus produced was identified by LC-MS.

$C_{20}H_{12}BrN$: M+1 346.0

Synthesis of Intermediate I-11

Intermediate I-11 (yield: 80%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-10 and (3-bromophenyl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{26}H_{16}BrN$: M+1 422.0

Synthesis of Intermediate I-12

Intermediate I-12 (yield: 81%) was synthesized in substantially the same manner as Intermediate I-1 using 4H-benzo[def]carbazole and 1,4-dibromonaphthalene. The compound thus produced was identified by LC-MS.

$C_{22}H_{14}BrN$: M+1 396.0

Synthesis of Intermediate I-13

Intermediate I-13 (yield: 77%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-12 and (4-bromophenyl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{30}H_{18}BrN$: M+1 472.1

Synthesis of Intermediate I-14

Intermediate I-14 (yield: 76%) was synthesized in substantially the same manner as Intermediate I-1 using 4H-benzo[def]carbazole and 2,8-dibromodibenzo[b,d]furan. The compound thus produced was identified by LC-MS.

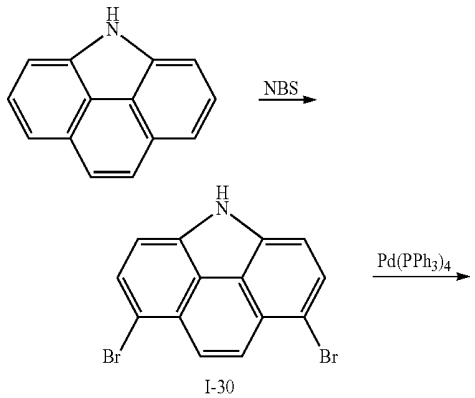
$C_{26}H_{14}BrNO$: M+1 436.0

Synthesis of Intermediate I-15

Intermediate I-15 (yield: 75%) was synthesized in substantially the same manner as Intermediate I-2 using Intermediate I-14 and (3-bromophenyl)boronic acid. The compound thus produced was identified by LC-MS.

$C_{32}H_{18}BrNO$: M+1 512.1

Synthesis of Intermediates I-16 and I-17



I-30

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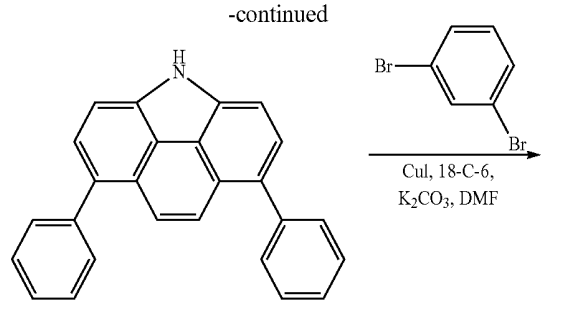
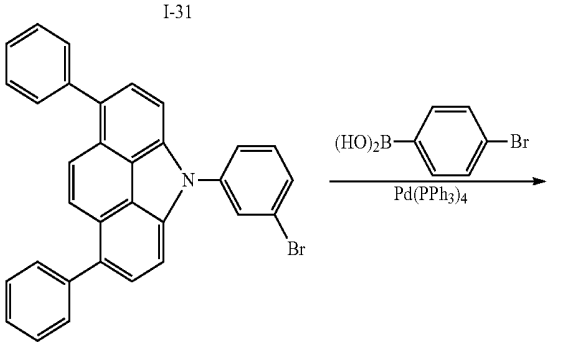
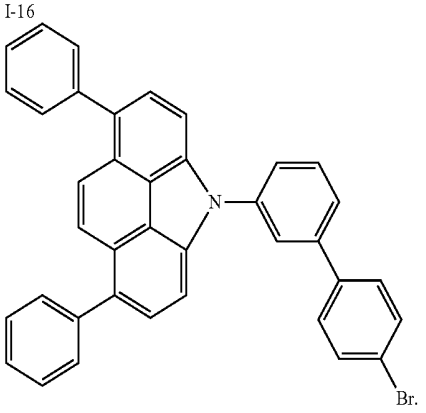


I-31



I-16



I-17

Synthesis of Intermediate I-30

7.82 g (44.0 mmol) of N-bromosuccinimide was added to a solution prepared by completely dissolving 3.82 g (20.0 mmol) of 6H-benzo[def]carbazole in 100 mL of carbon tetrachloride (CCl_4), and the mixture was stirred at a temperature of 80° C. for 30 minutes. The reaction solution was cooled to room temperature and stirred for 30 minutes to precipitate crystals. The crystals were collected using reduced-pressure filtration and washed with methanol, and thus 3.82 g of Intermediate I-3 (yield: 55%) was obtained as white crystals. The compound thus produced was identified by LC-MS.

$C_{14}H_7Br_2N$: M+1 346.9

Synthesis of Intermediate I-31

3.49 g (10.0 mmol) of Intermediate I-3, 2.68 g (22.0 mmol) of phenylboronic acid, 1.15 g (1.0 mmol) of $Pd(PPh_3)_4$, and 4.14 g (30.0 mmol) of K_2CO_3 were dissolved in 40 mL of a mixture of THF/H_2O (2:1), and the reaction solution was stirred at 80° C. for 5 hours. The reaction solution was cooled to room temperature, 40 mL of water was added thereto, and an organic layer was collected by repeated extraction using 50 mL of diethyl ether three times. The organic layer thus collected was dried with magnesium sulfate, the magnesium sulfate was removed by filtration, and the residue obtained after evaporating a solvent therefrom was separated and purified using silica gel column chromatography to obtain 2.61 g of Intermediate I-4 (yield: 76%). The compound thus produced was identified by LC-MS.

$C_{26}H_{17}N$: M+1 343.1

Synthesis of Intermediate I-16

Intermediate I-16 (yield: 89%) was synthesized in the same manner as Intermediate I-1 using Intermediate I-31 and 1-bromo-3-iodobenzene. The compound thus produced was identified by LC-MS.

$C_{32}H_{20}BrN$: M+1 498.1

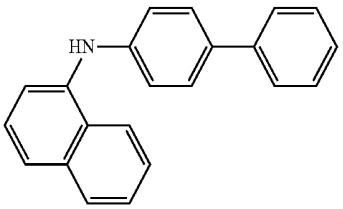
Synthesis of Intermediate I-17

Intermediate I-17 (yield: 73%) was synthesized in the same manner as Intermediate I-2 using Intermediate I-16 and (4-bromophenyl)boronic acid. The compound thus produced was identified by LC-MS.

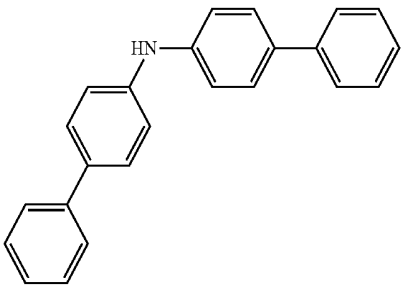
$C_{38}H_{24}BrN$: M+1 574.1

Synthesis of Intermediates I-18 to I-29

I-18



I-19



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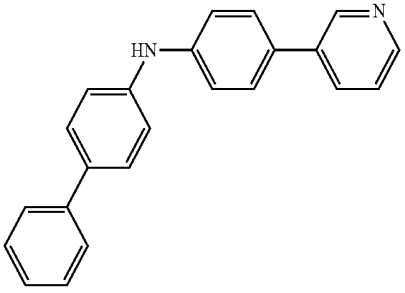

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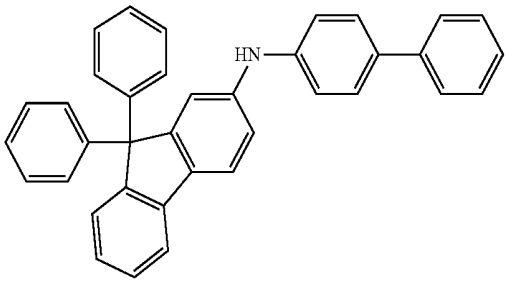

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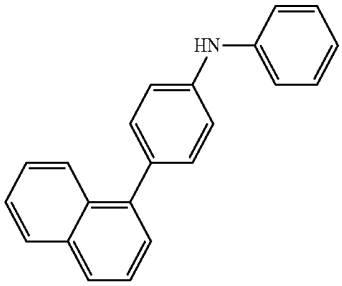

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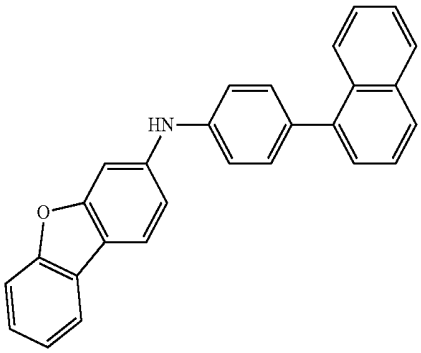

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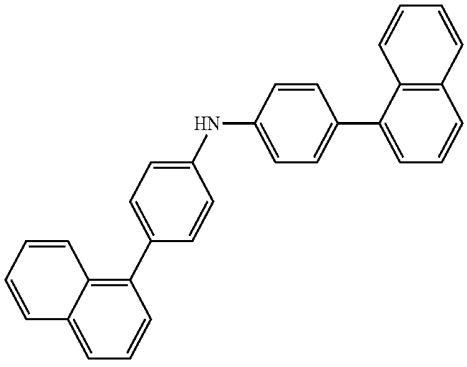

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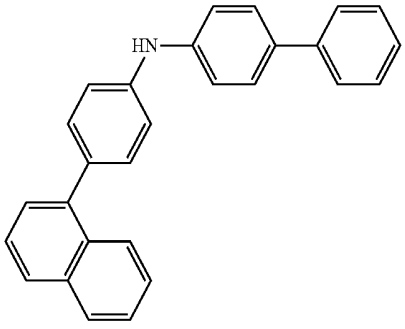

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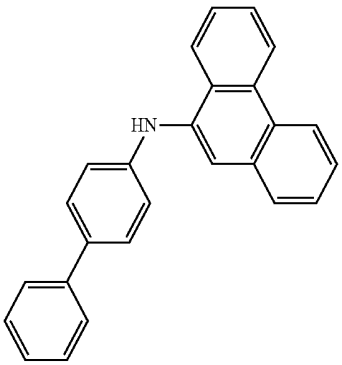
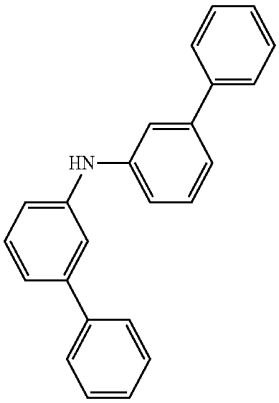
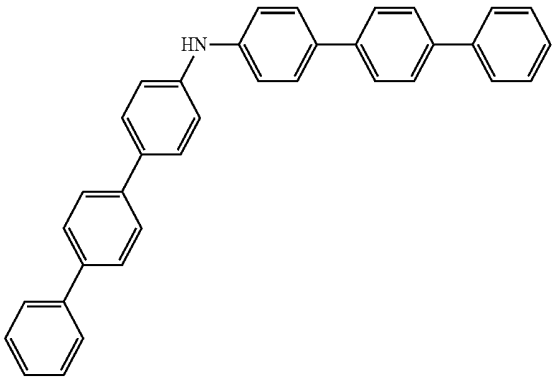
I-26



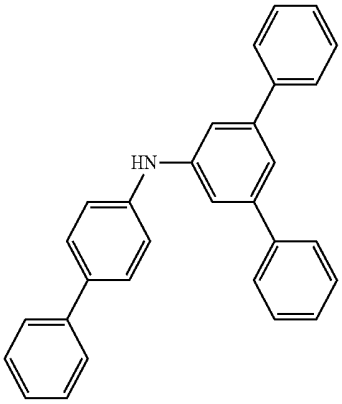
I-27



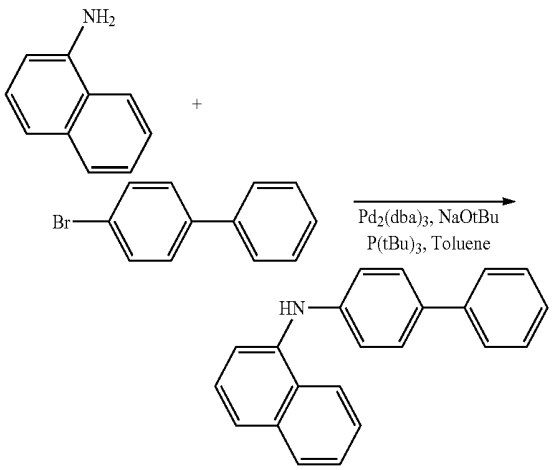
I-28



I-29



Synthesis of Intermediate I-18



I-18

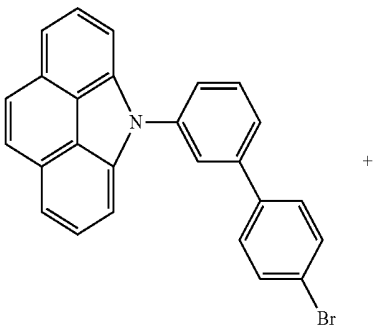
14.3 g (100.0 mmol) of 1-aminonaphthalene, 23.3 g (100.0 mmol) of 4-bromobiphenyl, 4.6 g (5.0 mmol) of $Pd_2(dba)_3$, 1.0 g (5.0 mmol) of $P(tBu)_3$, and 14.4 g (150.0 mol) of NaOtBu were dissolved in 300 mL of toluene, and the reaction solution was stirred at 80° C. for 5 hours. The reaction solution was cooled to room temperature, 300 mL of water was added thereto, and an organic layer was extracted using 300 mL of diethyl ether three times. The organic layer thus collected was dried with magnesium sulfate, the magnesium sulfate was removed by filtration, and the residue obtained after evaporating a solvent therefrom was separated and purified using silica gel column chromatography to obtain 26.0 g of Intermediate I-18 (yield: 88%). The compound thus produced was identified by LC-MS.

$C_{22}H_{17}N$: M+1 296.1

Intermediates I-19 to I-29 were synthesized in substantially the same manner as Intermediate I-18 using appropriate or suitable amine and halide intermediates in an amination method using a Pd catalyst.

Representative Synthesis Example

Synthesis of Compound 3



I-2

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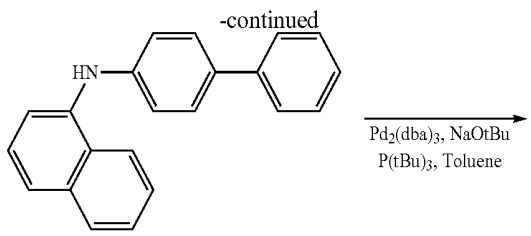
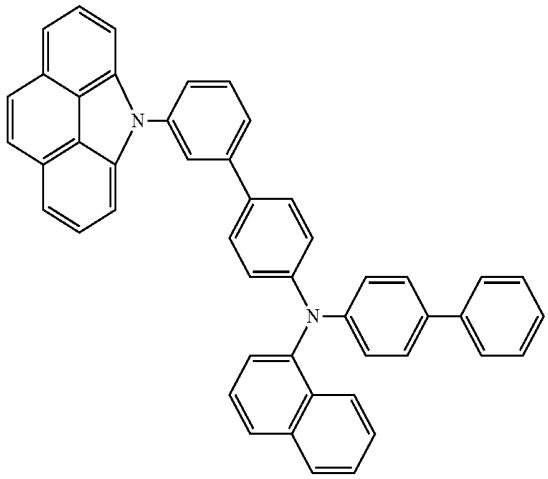


I-18



3

4.2 g (10.0 mmol) of Intermediate I-2, 2.9 g (10.0 mmol) of Intermediate I-18, 0.46 g (0.5 mmol) of $Pd_2(dba)_3$, 0.1 g (0.5 mmol) of $P(tBu)_3$, and 1.44 g (15.0 mol) of NaOtBu were dissolved in 30 mL of toluene, and the reaction solution was stirred at 80° C. for 5 hours. The reaction solution was cooled to room temperature, 30 mL of water was added thereto, and an organic layer was collected by repeated extraction using 30 mL of diethyl ether three times. The organic layer thus collected was dried with magnesium sulfate, the magnesium sulfate was removed by filtration, and the residue obtained after evaporating a solvent therefrom was separated and purified using silica gel column chromatography to obtain 5.5 g of Compound 3 (yield: 86%). The compound thus produced was identified by LC-MS and ^1H NMR.

$C_{48}H_{32}N_2$: M+1 637.3

^1H NMR (300 MHz, $CDCl_3$) δ 8.13 (dd, 1H), 7.84 (d, 1H), 7.76 (d, 2H), 7.64-7.58 (m, 3H), 7.54-7.33 (m, 18H), 7.25-7.21 (m, 2H), 6.95-6.86 (m, 3H), 6.82-6.78 (m, 2H)

Compounds 4 to 87 were synthesized by reacting appropriate or suitable Intermediate precursors (selected from Intermediates I-1 to I-17 and Intermediates I-18 to I-29) for each of Compounds 4 to 87 in the same manner as used in the synthesis of Compound 3. The compounds thus produced were confirmed by LC-MS and ^1H NMR. The results are shown in Table 1.

TABLE 1

Compound	Molecular formula	LC-MS (M + 1)	^{1}H NMR (300 MHz, $CDCl_3$) δ
4	$C_{50}H_{34}N_2$	663.3	7.77 (d, 2H), 7.63-7.59 (m, 5H), 7.54-7.33 (m, 20H), 7.25-7.21 (m, 1H), 6.96-6.92 (m, 4H), 6.85-6.82 (m, 2H)
5	$C_{49}H_{33}N_3$	664.3	8.90 (s, 1H), 8.59 (dt, 1H), 7.92 (dd, 1H), 7.78 (d, 2H), 7.66-7.61 (m, 3H), 7.52-7.23 (m, 19H), 6.97-6.93 (m, 2H), 6.86-6.78 (m, 4H)
6	$C_{63}H_{42}N_2$	827.3	7.85 (d, 1H), 7.77 (d, 2H), 7.65-7.32 (m, 20H), 7.26-7.13 (m, 12H), 6.94 (d, 1H), 6.90-6.84 (m, 3H), 6.81-6.78 (m, 2H), 6.72 (d, 1H)
13	$C_{48}H_{32}N_2$	637.3	7.83-7.76 (m, 4H), 7.62-7.59 (m, 2H), 7.54-7.34 (m, 14H), 7.26-.22 (m, 2H), 7.18-6.96 (m, 5H), 6.84-6.82 (m, 3H), 6.73-6.69 (m, 2H)
19	$C_{54}H_{34}N_2O_2$	727.3	7.82-7.7.72 (m, 6H), 7.64-7.60 (m, 3H), 7.56-7.32 (m, 16H), 7.23-7.20 (m, 2H), 7.13-7.01 (m, 5H), 6.79-6.3 (m, 2H)
35	$C_{52}H_{34}N_2$	687.3	8.82-7.74 (m, 6H), 7.62 (d, 2H), 7.56-7.42 (m, 14H), 7.29-7.13 (m, 5H), 7.03-6.94 (m, 6H), 6.76-6.71 (m, 1H)
41	$C_{54}H_{36}N_2$	713.3	7.85-7.81 (m, 2H), 7.76 (d, 2H), 7.65-7.57 (m, 4H), 7.55-7.32 (m, 18H), 7.26-7.15 (m, 3H), 7.11-7.01 (m, 4H), 6.90-6.86 (m, 2H), 6.78 (d, 1H)
47	$C_{52}H_{34}N_2$	687.3	8.59 (d, 1H), 8.20-8.16 (m, 1H), 7.97-7.92 (m, 1H), 7.77 (d, 2H), 7.71-7.31 (m, 22H), 7.21-7.17 (m, 2H), 7.12 (s, 1H), 7.02 (t, 1H), 6.85-6.82 (m, 2H), 6.74 (dd, 1H)
52	$C_{50}H_{34}N_2$	663.3	7.75 (d, 2H), 7.59-7.35 (m, 20H), 7.28 (dt, 2H), 7.22-7.12 (m, 4H), 7.06-7.01 (m, 3H), 6.78 (dt, 1H), 6.69 (dd, 2H)
57	$C_{62}H_{42}N_2$	815.3	7.76 (d, 2H), 7.71-7.57 (m, 13H), 7.56-7.31 (m, 19H), 7.26-7.19 (m, 2H), 7.09 (dd, 1H), 6.89-6.84 (m, 4H), 6.74 (dt, 1H)
58	$C_{50}H_{34}N_2$	663.3	7.81 (d, 2H), 7.66-7.62 (m, 4H), 7.53-7.33 (m, 17H), 7.27-7.23 (m, 2H), 7.19-7.14 (m, 2H), 7.05-7.01 (m, 1H), 6.95 (dd, 1H), 6.93-6.85 (m, 4H), 6.79 (dd, 1H)
69	$C_{50}H_{34}N_2$	663.3	7.75 (d, 2H), 7.65-7.60 (m, 4H), 7.54-7.37 (m, 20H), 7.31 (dt (1H), 7.23-7.18 (m, 2H), 6.97-6.92 (m, 4H), 6.82 (dt, 1H)
72	$C_{56}H_{38}N_2$	739.3	7.74 (d, 2H), 7.66-7.58 (m, 6H), 7.52-7.31 (m, 22H), 7.29 (dt, 1H), 7.19 (t, 1H), 7.10 (dd, 1H), 7.03 (s, 2H), 6.93-6.89 (m, 2H), 6.72 (dt, 1H)
73	$C_{49}H_{33}N_3$	664.3	7.96 (dt, 1H), 7.75 (d, 2H), 7.68-7.60 (m, 6H), 7.58-7.45 (m, 16H), 7.42-7.38 (m, 2H), 7.24-7.16 (m, 2H), 6.86-6.82 (m, 4H)
77	$C_{56}H_{36}N_2O$	753.3	8.32 (s, 1H), 7.86 (d, 1H), 7.76 (d, 2H), 7.68-7.58 (m, 7H), 7.52-7.34 (m, 19H), 7.26 (t, 1H), 7.17 (d, 1H), 6.91-6.86 (m, 4H)
78	$C_{50}H_{33}N_3$	676.3	8.23 (s, 1H), 7.77-7.65 (m, 5H), 7.53-7.22 (m, 16H), 7.19-7.14 (m, 4H), 7.06 (d, 1H), 6.97-6.92 (m, 2H), 6.78-6.72 (m, 4H)
80	$C_{54}H_{36}N_2$	713.3	7.80-7.75 (m, 3H), 7.63-7.56 (m, 6H), 7.52-7.36 (m, 19H), 7.28-7.19 (m, 3H), 6.90-6.86 (m, 4H), 6.73 (dt (1H)
83	$C_{56}H_{36}N_2O$	753.3	8.31 (s, 1H), 7.75-7.60 (m, 9H), 7.52-7.38 (m, 17H), 7.30-7.17 (m, 3H), 7.12 (dd, 1H), 6.93-6.88 (m, 4H), 6.74 (dd, 1H)
84	$C_{62}H_{42}N_2$	815.3	8.14-8.11 (m, 4H), 7.69-7.61 (m, 7H), 7.52-7.32 (m, 22H), 7.24 (t, 1H), 7.04 (s, 2H), 6.93-6.87 (m, 4H), 6.82-6.78 (m, 2H)
87	$C_{56}H_{38}N_2$	739.3	7.82-7.78 (m, 3H), 7.68-7.59 (m, 6H), 7.50-7.27 (m, 20H), 7.23-7.07 (m, 3H), 7.01 (dd, 1H), 6.87-6.82 (m, 4H), 6.74 (dd, 1H)

EXAMPLE

Example 1

A glass substrate of ITO/Ag/ITO of 70/1000/70 Å was cut to a size of 50 mm×50 mm×0.5 mm, sonicated in isopropyl alcohol and pure water for 5 minutes, and then cleaned with UV and ozone for 30 minutes to prepare an anode. The glass substrate was then mounted on a vacuum depositor.

N-([1,1'-biphenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine (HT1) and F4-TCNQ were vacuum co-deposited on the ITO substrate at a weight ratio of 98:2 to form a hole injection layer having a thickness of 100 Å. Compound HT1 was vacuum deposited on the hole injection layer to form a first hole transport layer having a thickness of 1,200 Å, and Compound 3 was vacuum deposited on the first hole transport layer to form a second hole transport layer having a thickness of 100 Å.

9,10-di-naphthalene-2-yl-anthracene (ADN) as a blue host and N,N,N',N'-tetraphenyl-pyrene-1,6-diamine (TPD) as a blue dopant were co-deposited on the second hole transport layer at a weight ratio of 98:2 to form an emission layer having a thickness of 300 Å. Then, 2-(4-(9,10-di(naphthalen-2-yl)anthracen-2-yl)phenyl)-1-phenyl-1H-benzo[d]imidazole (L201) was deposited on the emission layer to form an electron transport layer having a thickness of 300 Å. LiF, which is a halogenated alkali metal, was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and MgAg was vacuum deposited at a weight ratio of 90:10 to form a cathode electrode having a thickness of 120 Å, thereby completing the manufacture of an organic light-emitting device.

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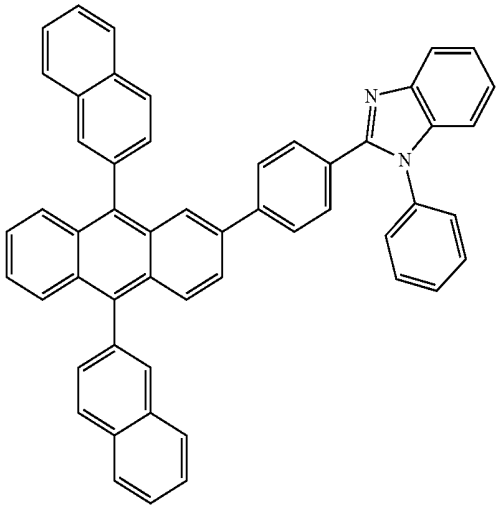
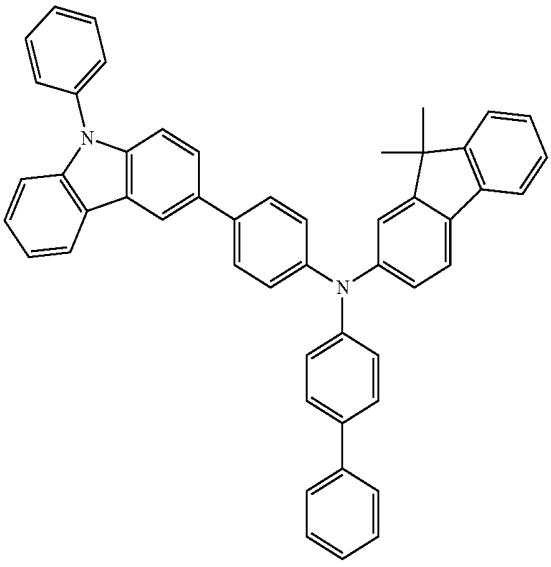
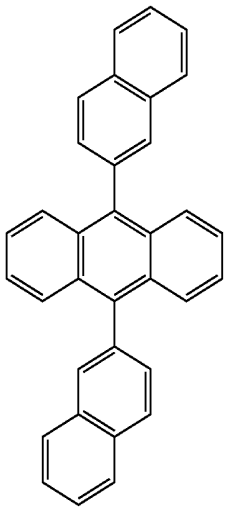


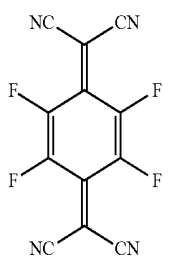
L201



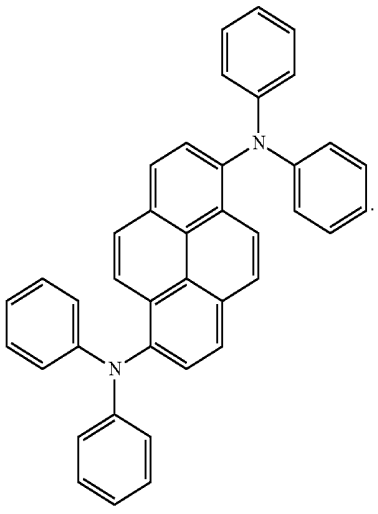
HT1



ADN



F4-TCNQ



TPD

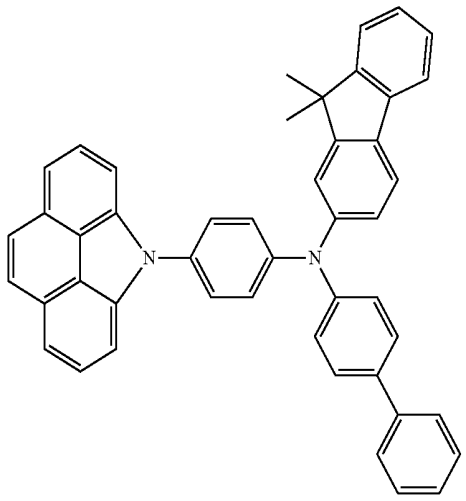
Examples 2 to 21

Additional organic light-emitting devices were manufactured as examples in substantially the same manner as in Example 1, except that each of Compounds 4 to 87 was used instead of Compound 3 in the formation of the second hole transport layer.

Comparative Examples 1 and 2

Additional organic light-emitting devices were manufactured as comparative examples in substantially the same manner as in Example 1, except that each of Compounds A and B was used instead of Compound 3 in the formation of the second hole transport layer.

A



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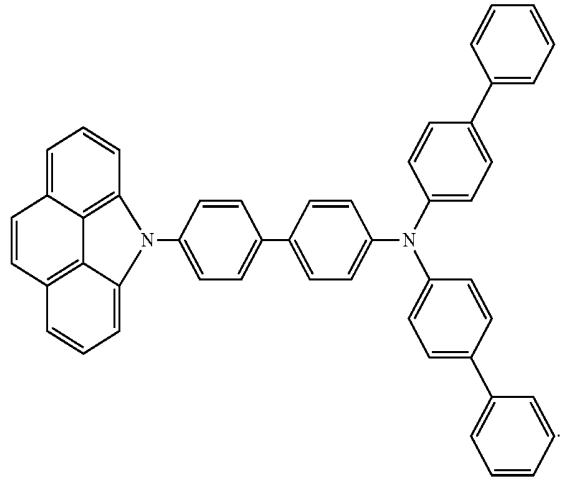
B



Device performance characteristics (driving voltage, luminance, efficiency, and color coordinate) during device operation at a current density of 10 mA/cm^2, as well as the time elapsed for luminance to reduce to half of the initial luminance at a current density of 50 mA/cm^2 are shown in Table 2 for each of the manufactured organic light-emitting devices.

As shown in Table 2, when the compound having a phenyl group, a pyridyl group, a pyrimidyl group, and/or a 1,3,5-triazinyl group linker having binding sites that are ortho- or meta- to each other is included in the second hole transport layer, the efficiency and luminance half-life of a device may increase due to having a T_1 (e.g., triplet) energy level higher than in the Comparative Examples including Compounds A and B, which have a para-substituted phenyl linker.

TABLE 2

	Second hole transport layer	Driving voltage (V)	Current density (mA/cm^2)	Efficiency (cd/A)	Color coordinate CIE(x, y)	Half lifespan (@1.0 mA/cm^2)
Example 1	Compound 3	4.51	10	5.21	0.140, 0.051	194
Example 2	Compound 4	4.52	10	5.34	0.141, 0.052	213
Example 3	Compound 5	4.52	10	5.32	0.141, 0.050	192
Example 4	Compound 6	4.51	10	5.33	0.140, 0.052	195
Example 5	Compound 13	4.52	10	5.42	0.141, 0.052	211
Example 6	Compound 19	4.50	10	5.37	0.141, 0.052	173
Example 7	Compound 35	4.52	10	5.36	0.142, 0.051	199
Example 8	Compound 41	4.51	10	5.41	0.140, 0.053	207
Example 9	Compound 47	4.51	10	5.39	0.141, 0.052	186
Example 10	Compound 52	4.51	10	5.34	0.141, 0.052	166
Example 11	Compound 57	4.51	10	5.33	0.141, 0.051	174
Example 12	Compound 58	4.52	10	5.29	0.141, 0.053	157
Example 13	Compound 69	4.51	10	5.32	0.140, 0.052	188
Example 14	Compound 72	4.51	10	5.30	0.140, 0.053	179
Example 15	Compound 73	4.50	10	5.28	0.141, 0.052	90
Example 16	Compound 77	4.50	10	5.04	0.141, 0.052	156
Example 17	Compound 78	4.52	10	4.97	0.141, 0.051	142
Example 18	Compound 80	4.51	10	5.11	0.141, 0.051	148
Example 19	Compound 83	4.50	10	5.06	0.141, 0.052	159
Example 20	Compound 84	4.52	10	5.32	0.140, 0.053	196
Example 21	Compound 87	4.51	10	5.37	0.140, 0.052	168
Comparative Example 1	A	4.52	10	4.61	0.140, 0.052	115
Comparative Example 2	B	4.52	10	4.63	0.141, 0.051	60

As described above, according to the above embodiments of the present disclosure, an organic light-emitting device including the compound represented by Formula 1 may have an increased T_1 energy level, and thus the characteristics of the organic light-emitting device may be improved.

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

As used herein, the terms "use", "using", and "used" may be considered synonymous with the terms "utilize", "utilizing", and "utilized", respectively. Further, the use of "may" when describing embodiments of the present disclosure refers to "one or more embodiments of the present disclosure".

As used herein, the terms "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 sub-ranges 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.

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

What is claimed is:

1. A compound selected from Compounds 1 to 2, 4 to 7, 9, 10, 13 to 19, 21, 22, 25 to 29, 31, 32, 34 to 78, 80, 81, and 83 to 90:

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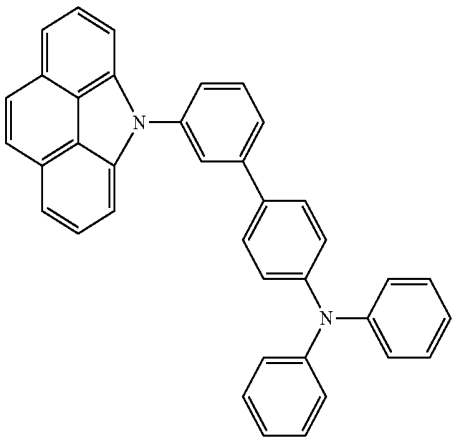

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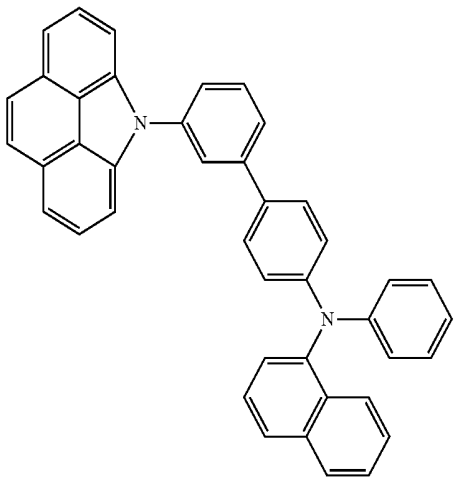

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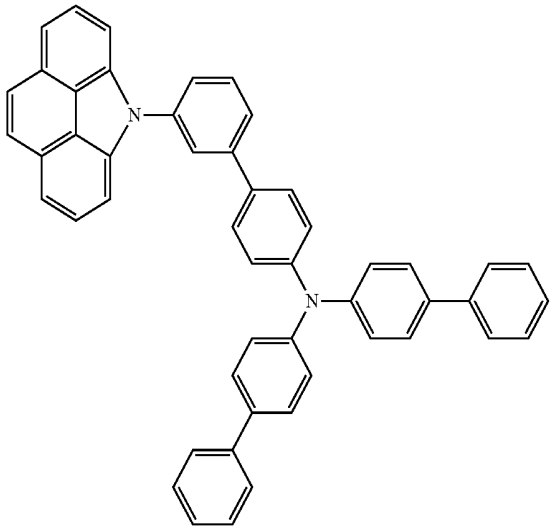

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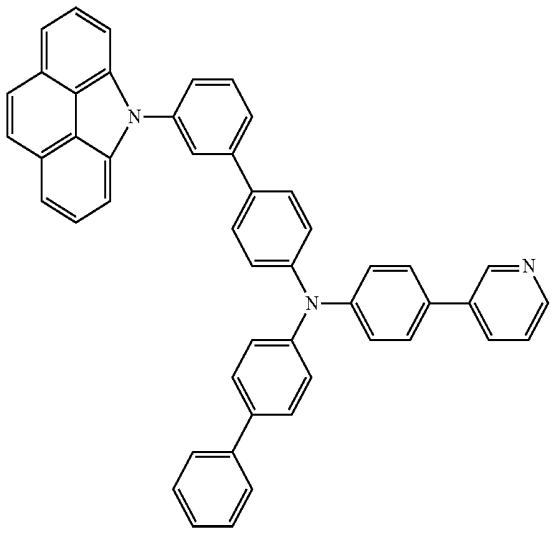

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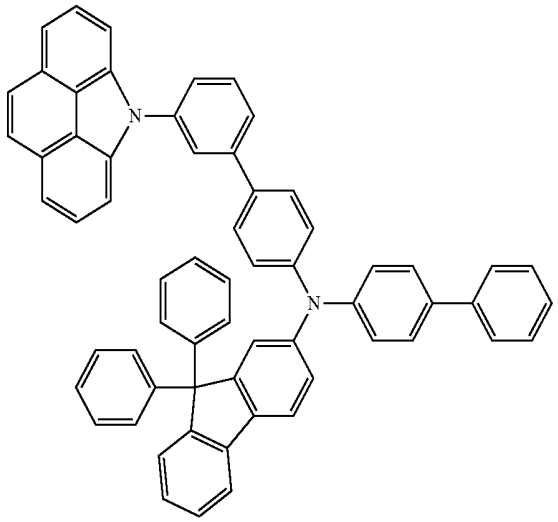

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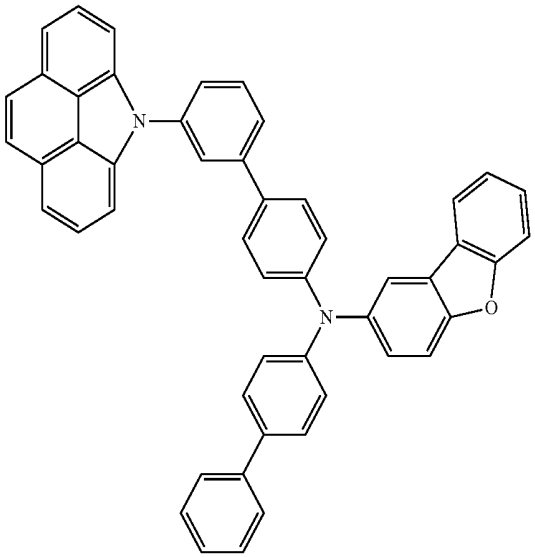

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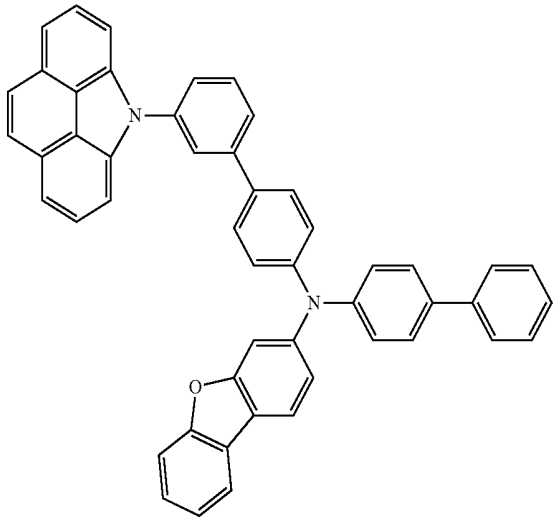

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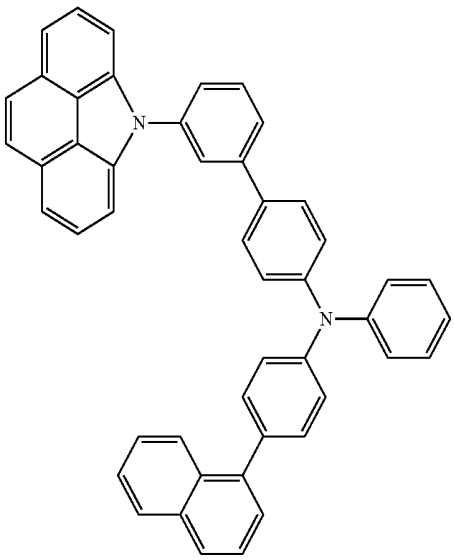

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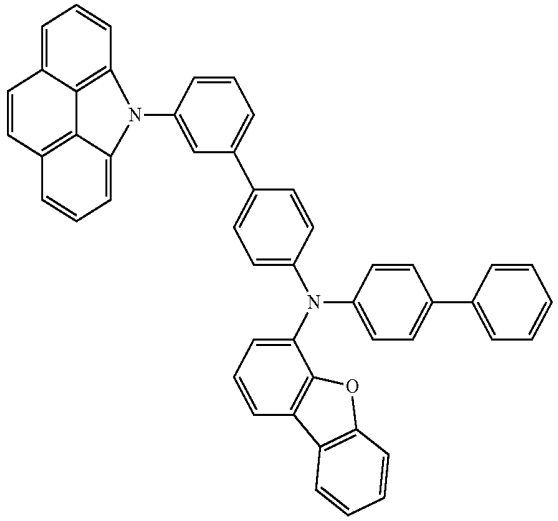

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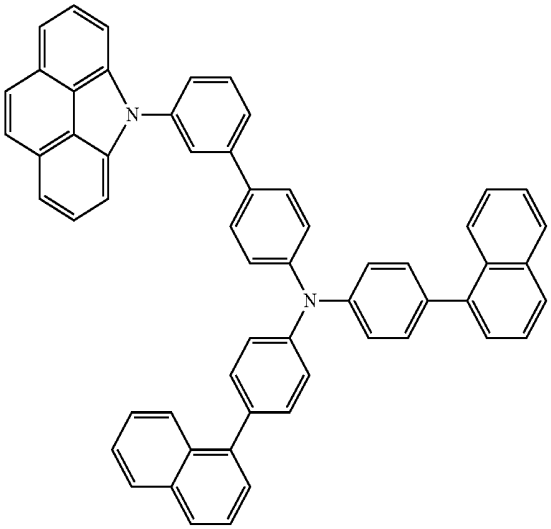

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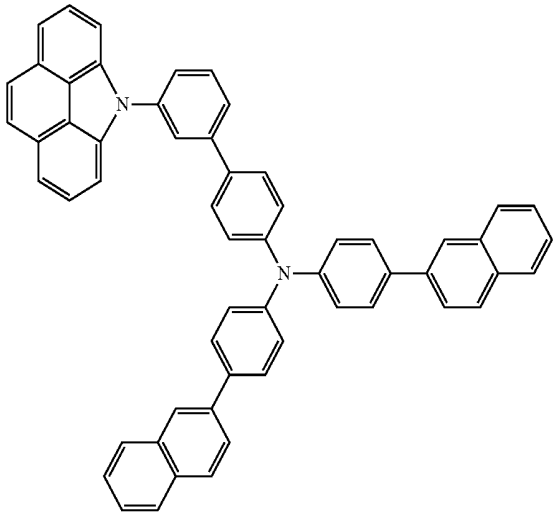

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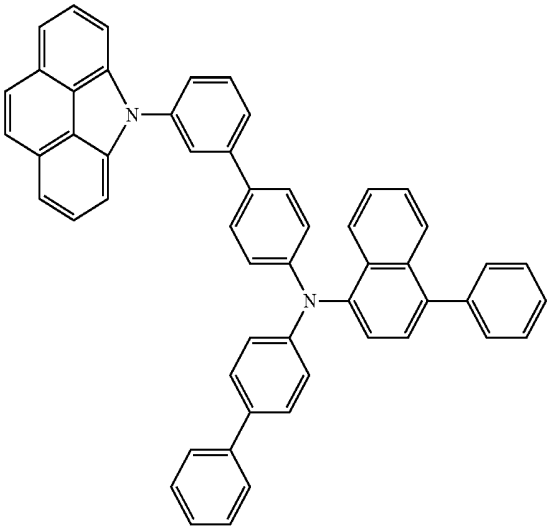

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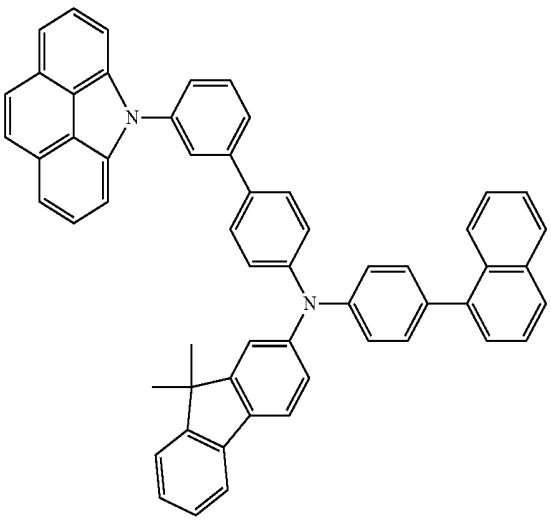

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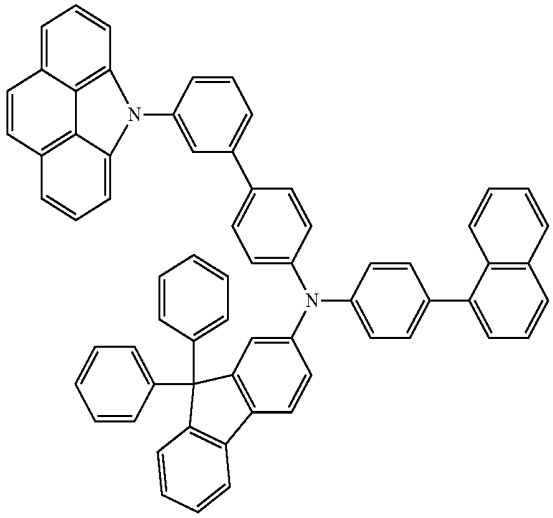

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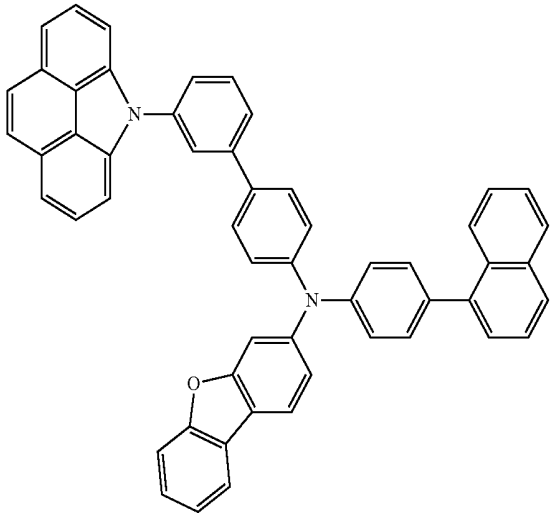

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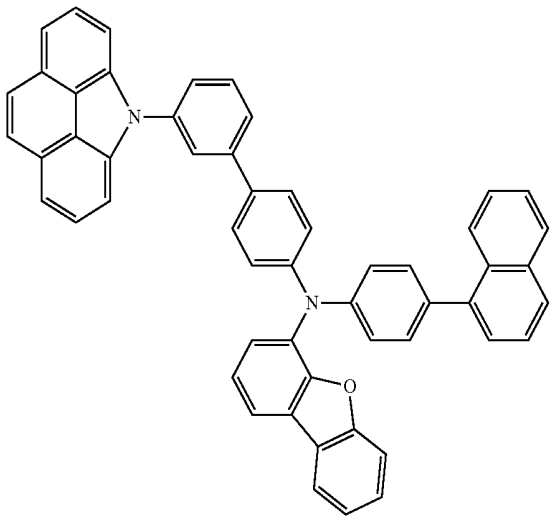

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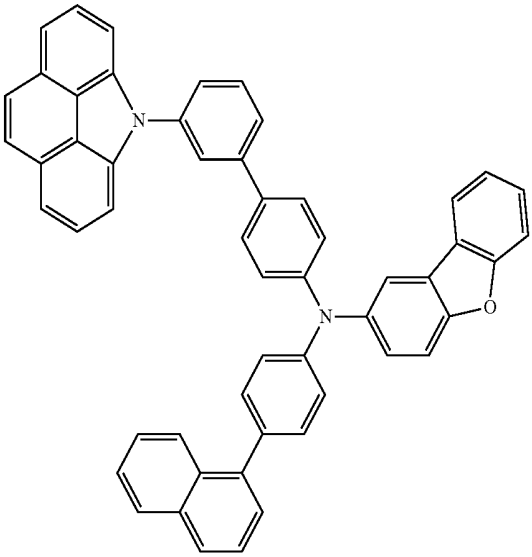

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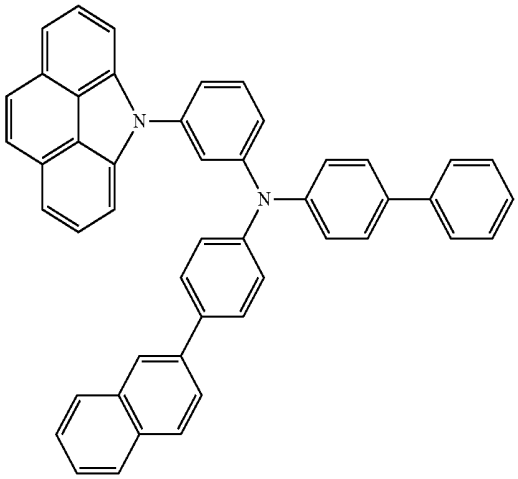

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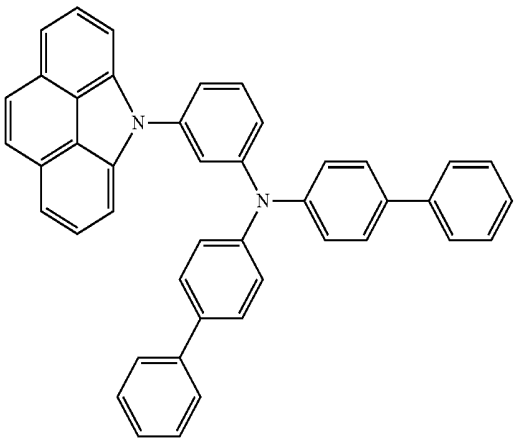

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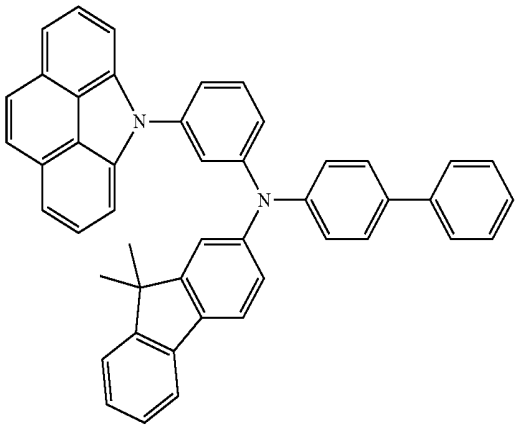

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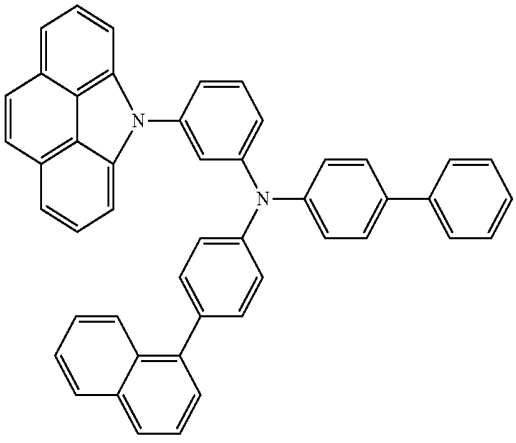

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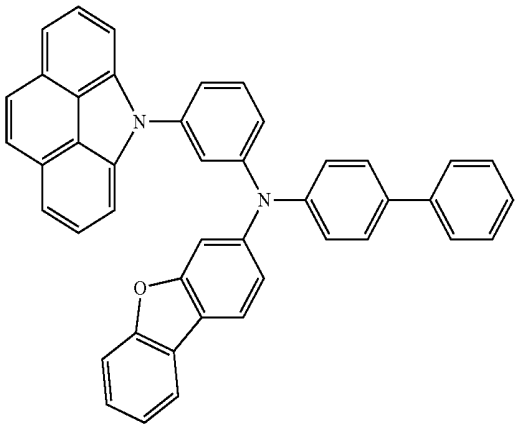

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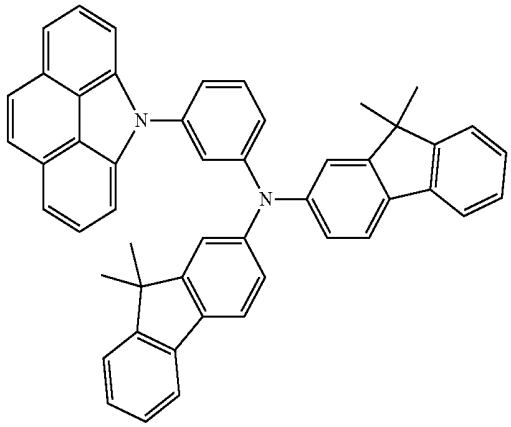

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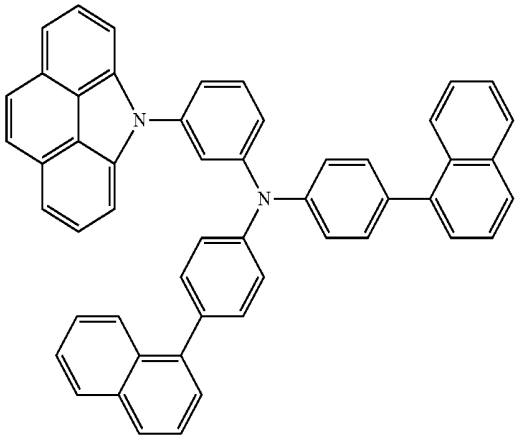

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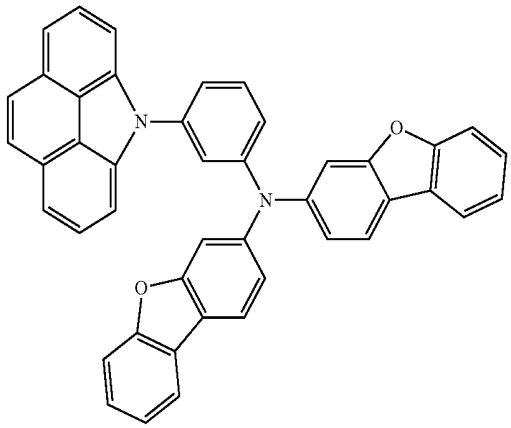

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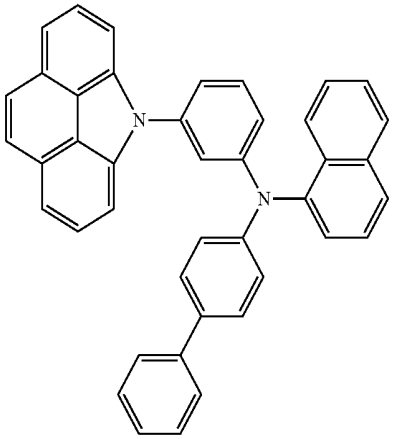

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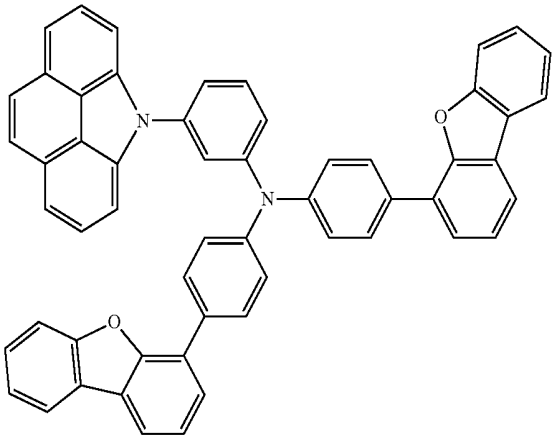

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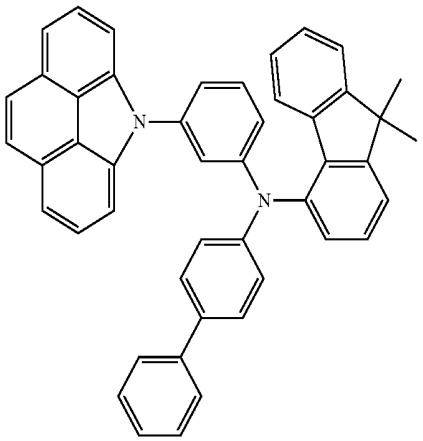

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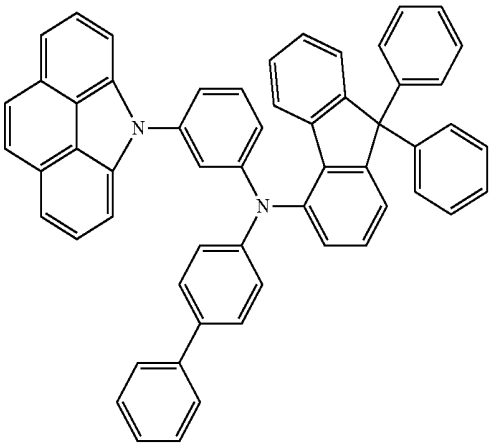

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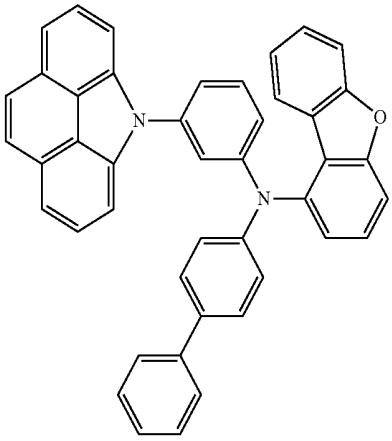

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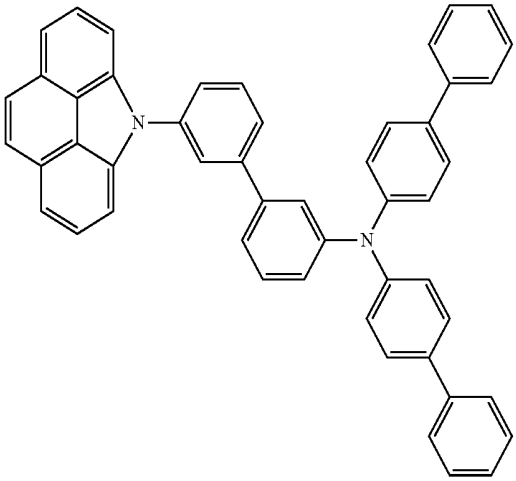

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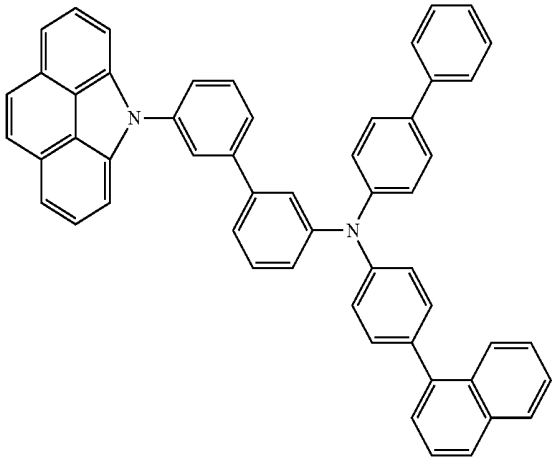

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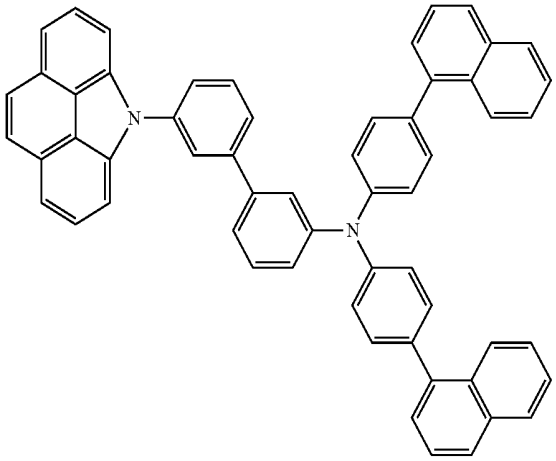

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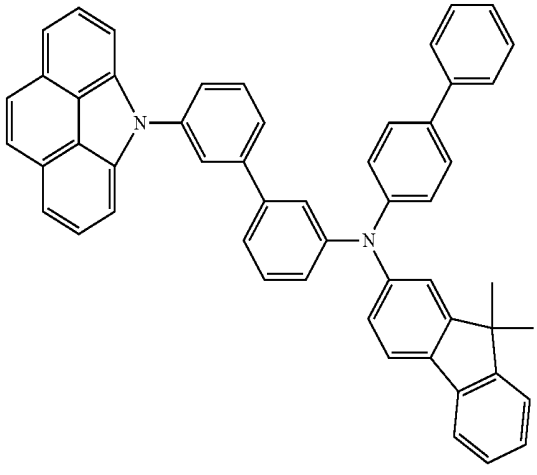

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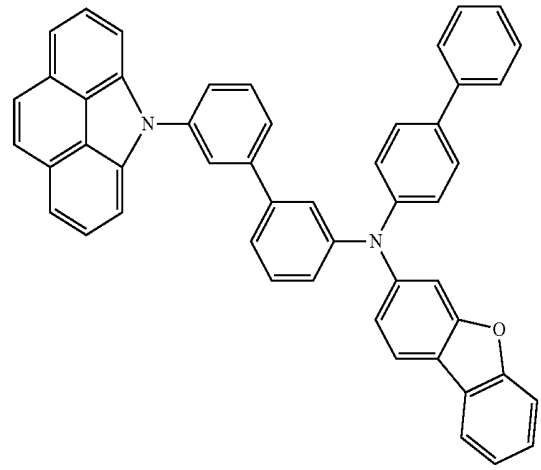

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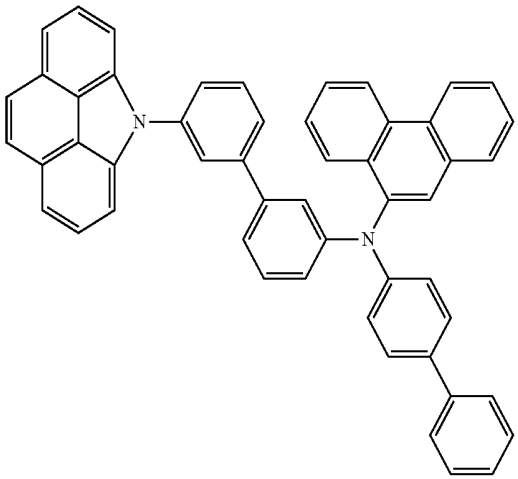

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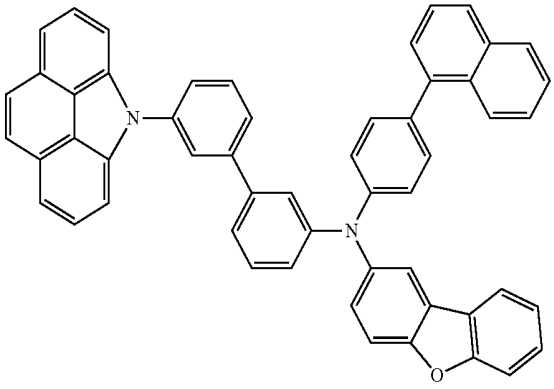

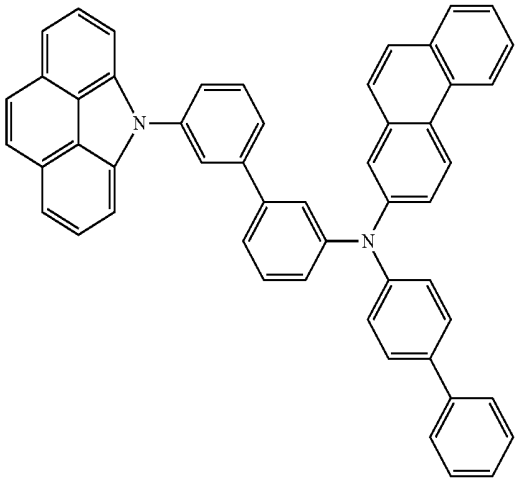

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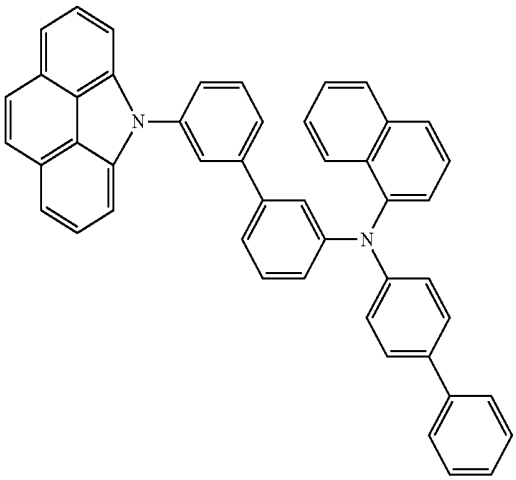

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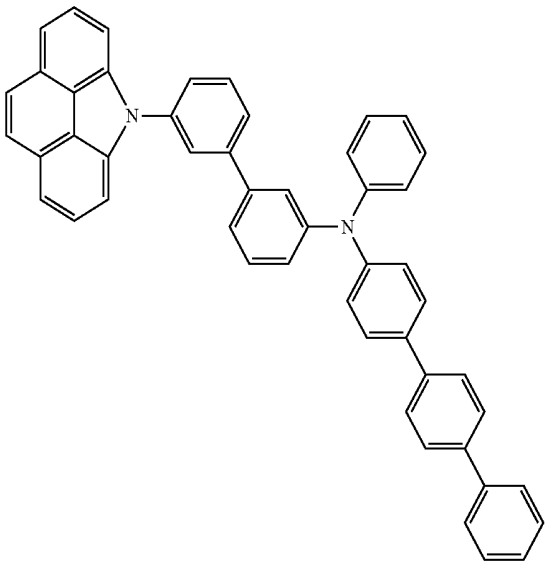

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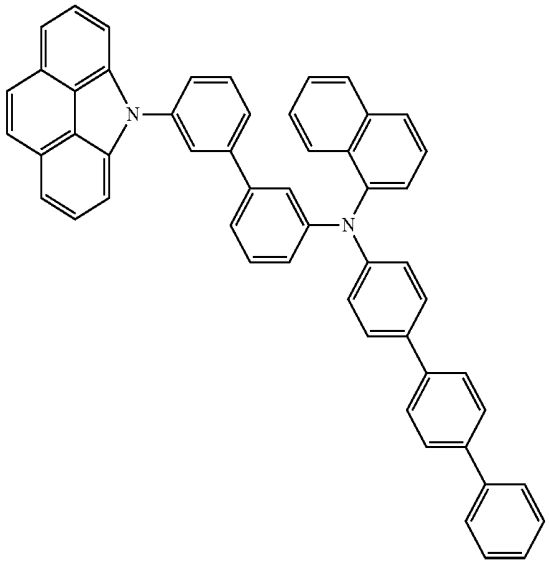

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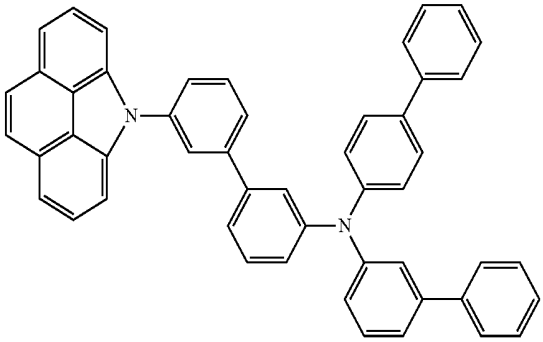

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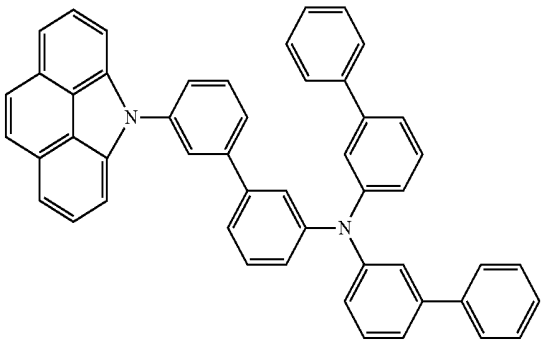

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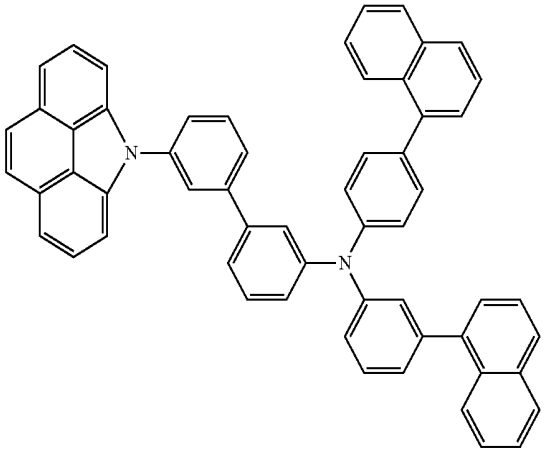

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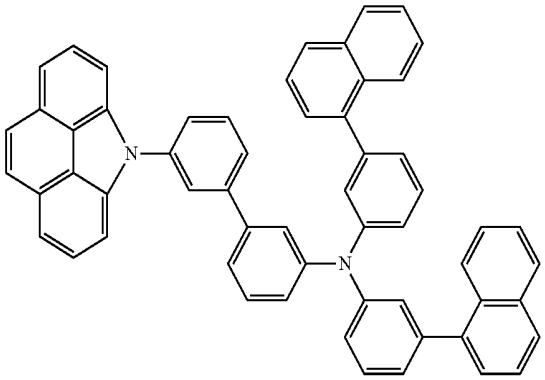

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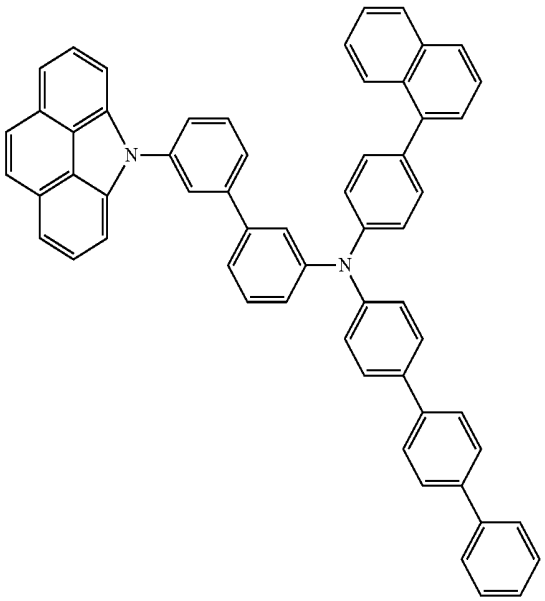

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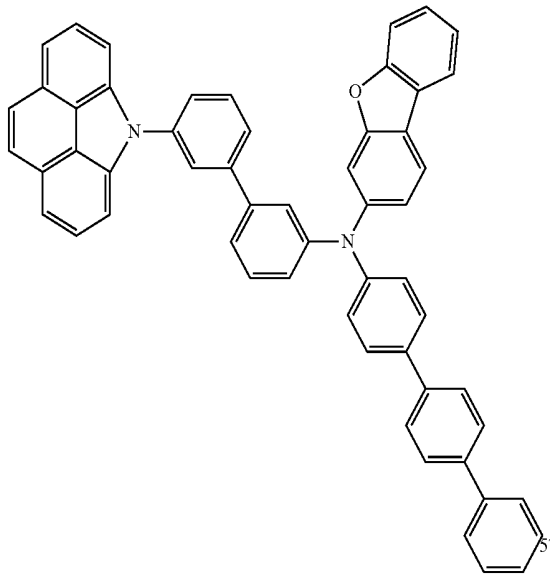

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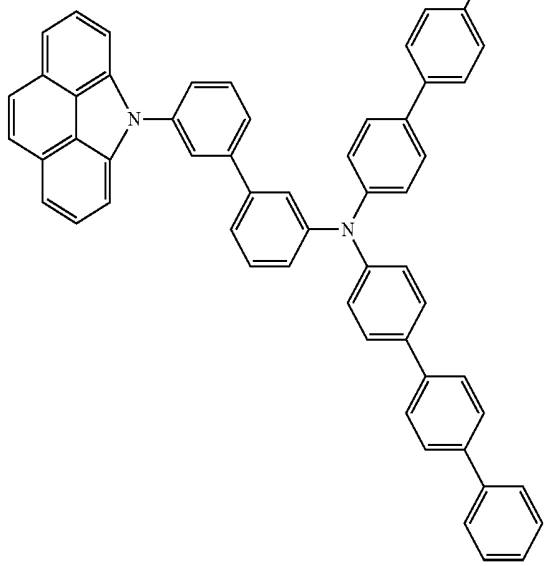

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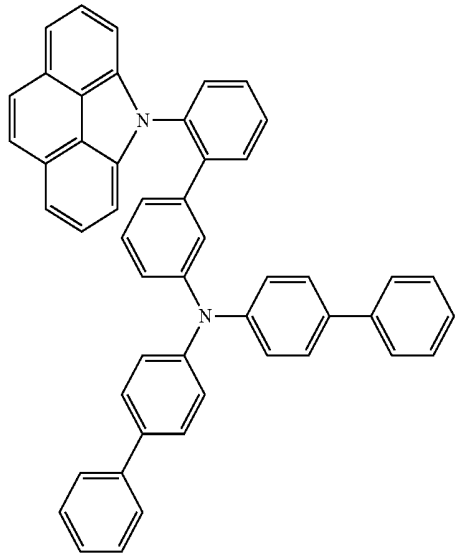

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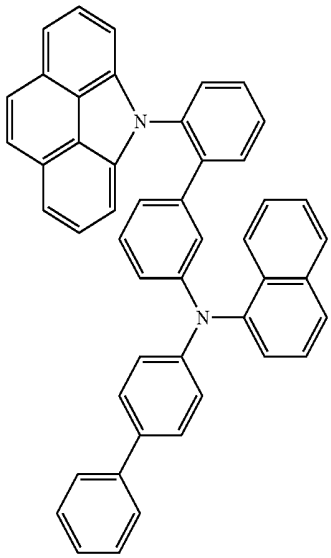

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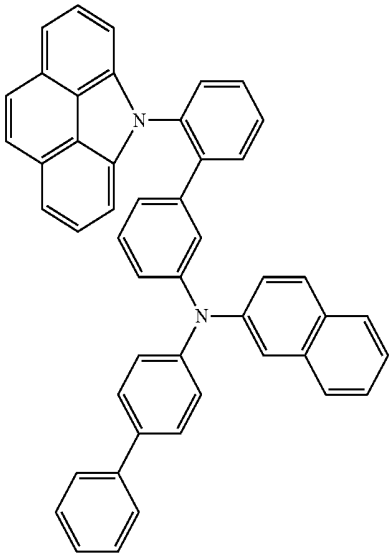

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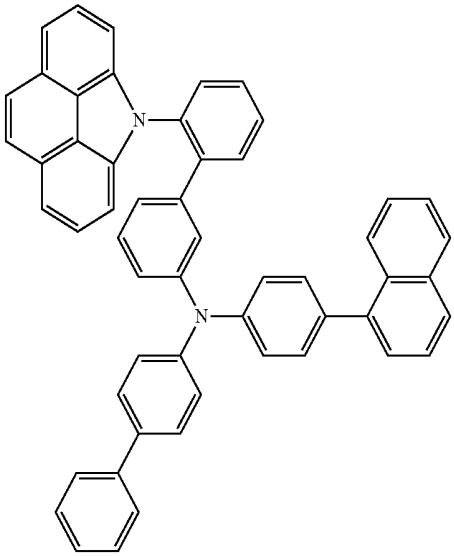

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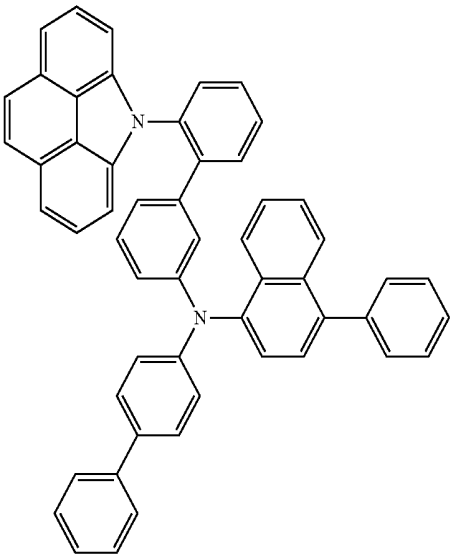

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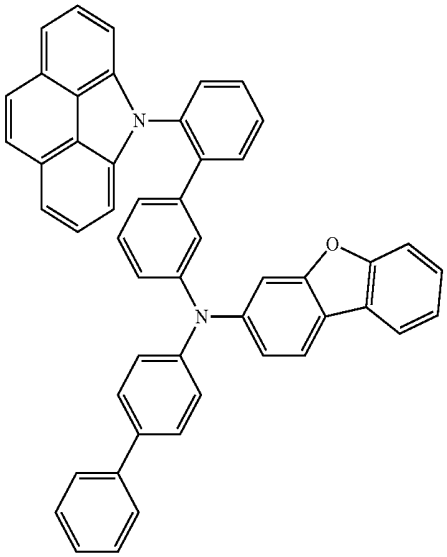

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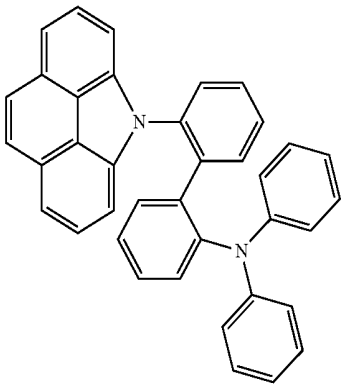

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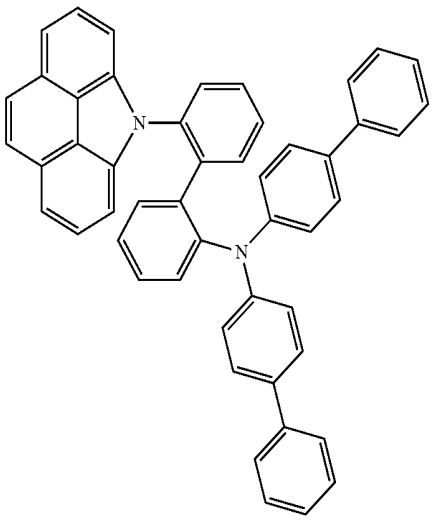

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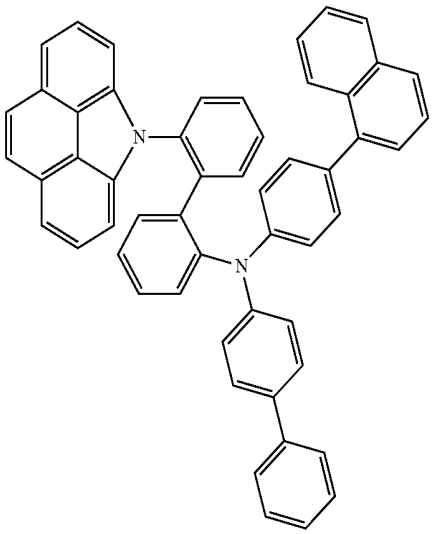

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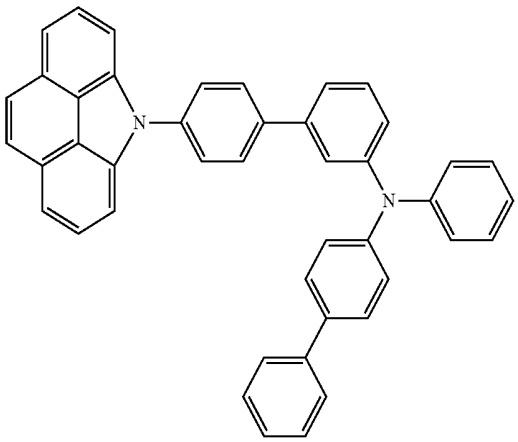

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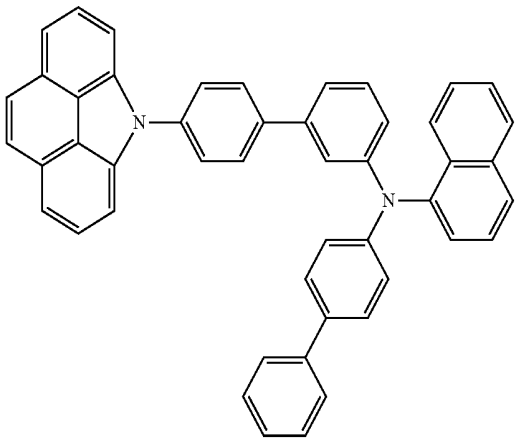

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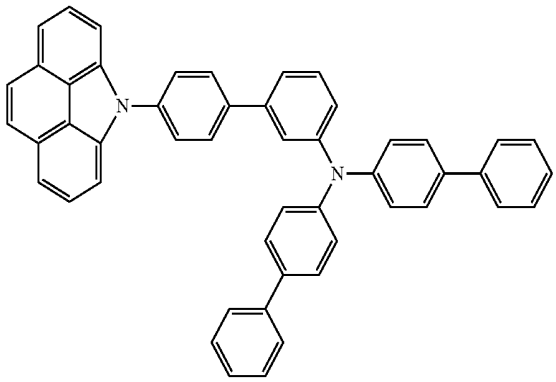

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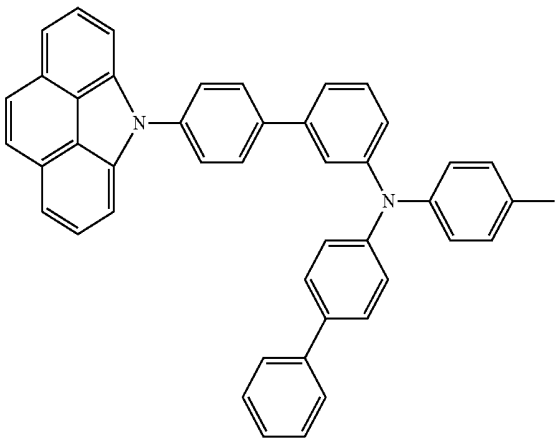

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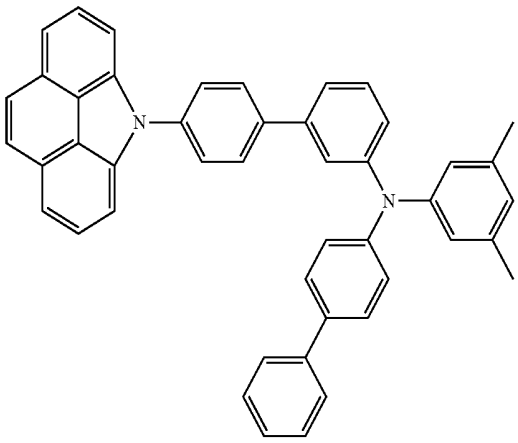

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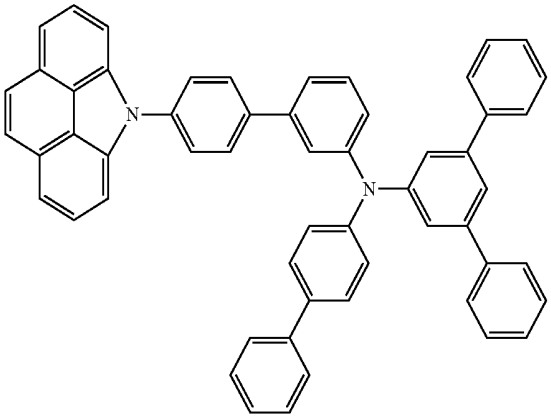

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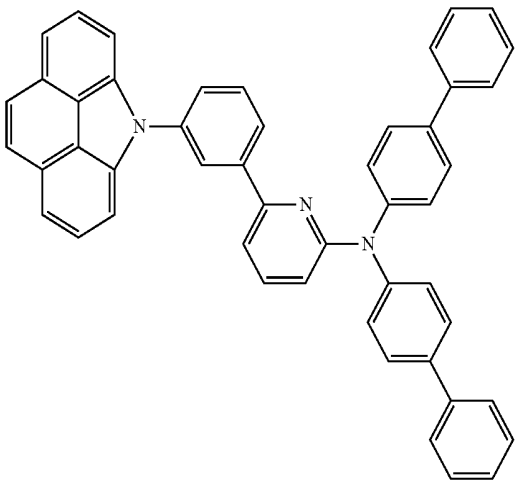

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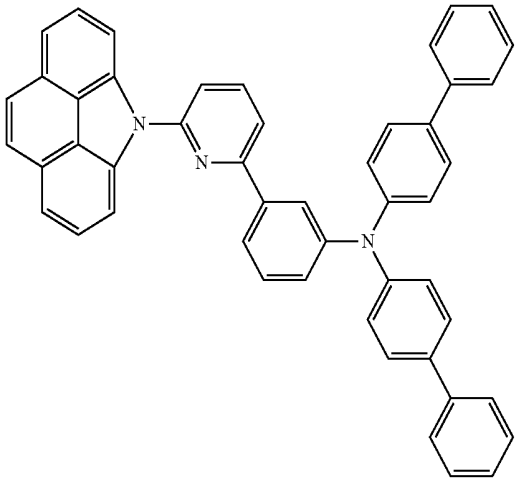

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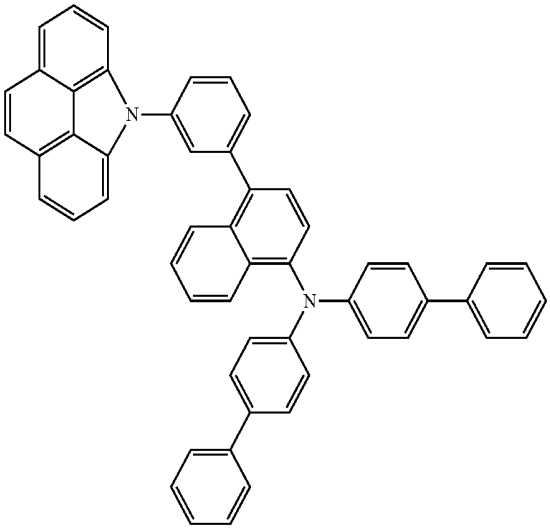

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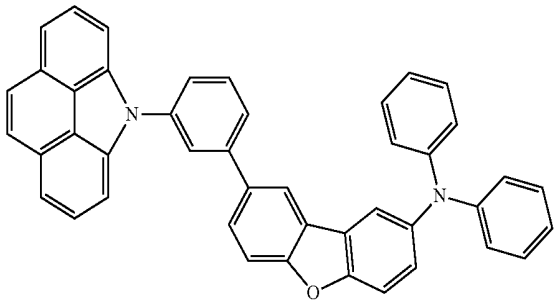

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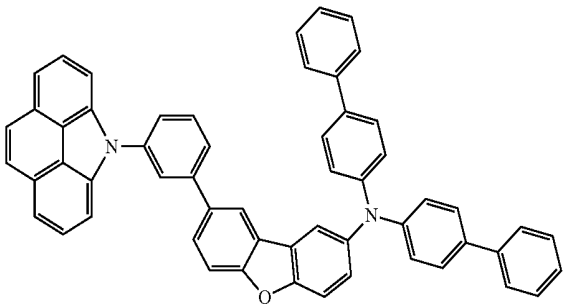

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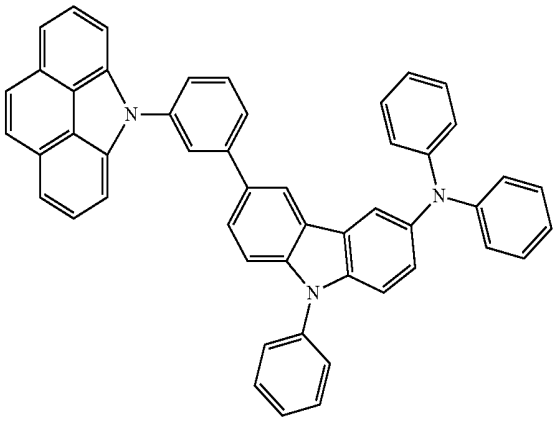

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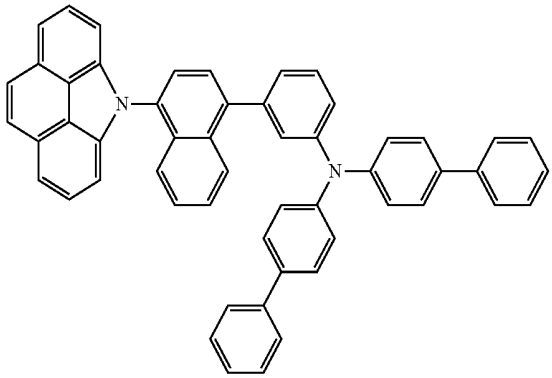

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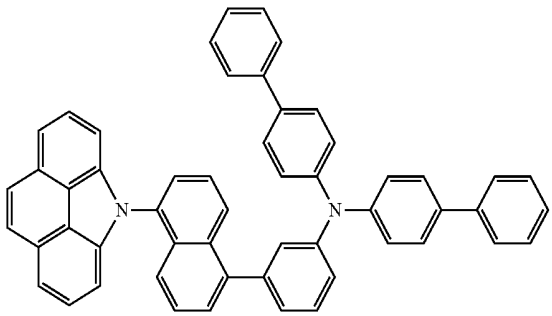

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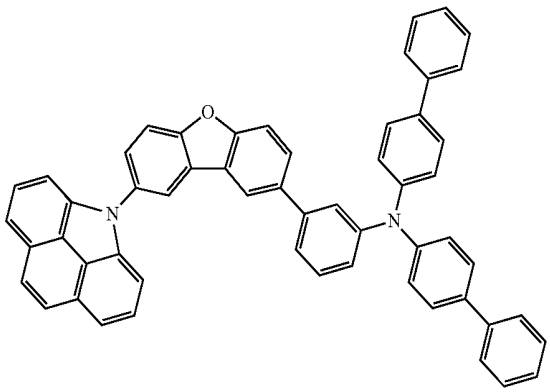

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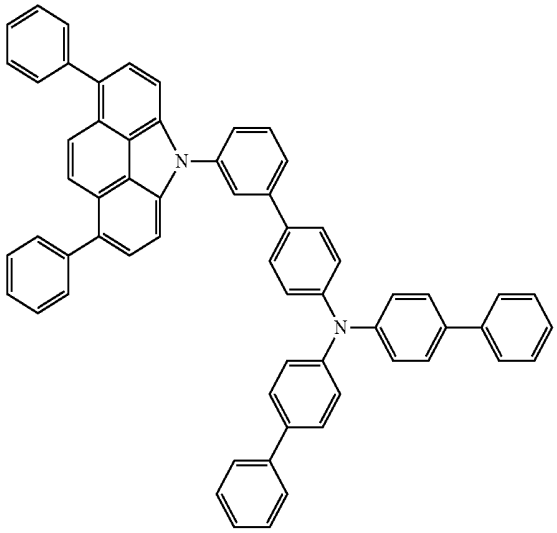

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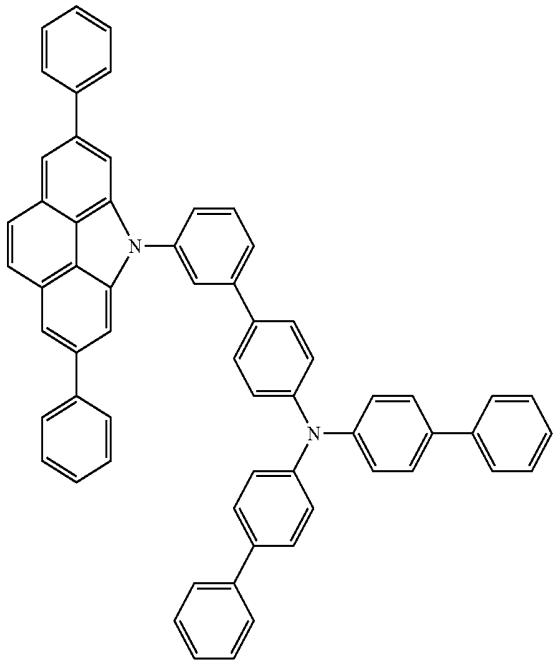

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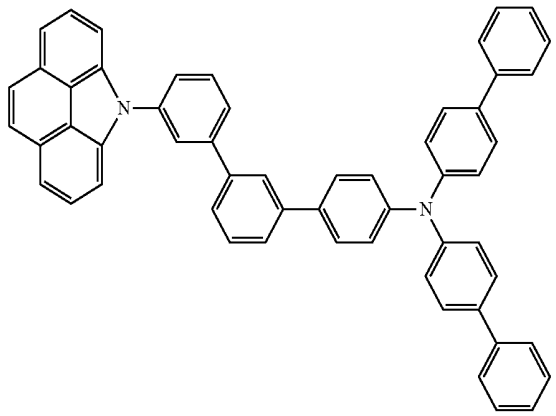

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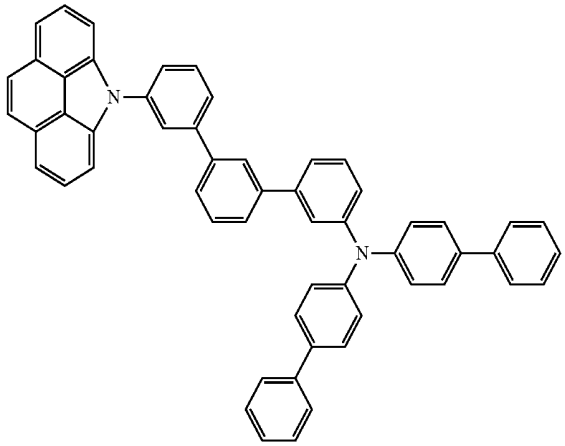

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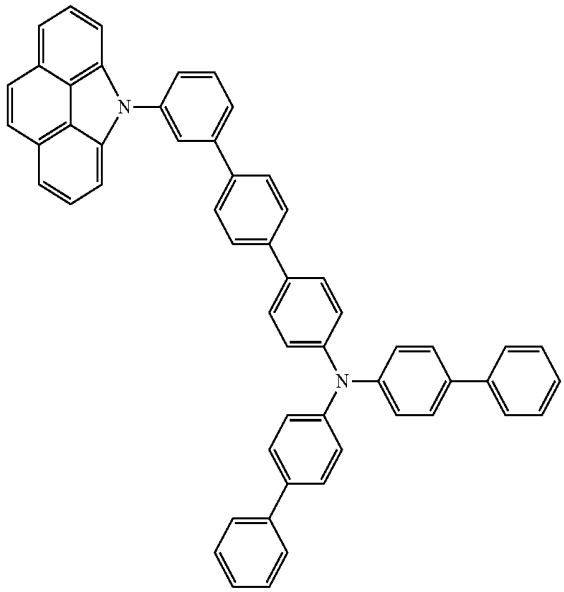

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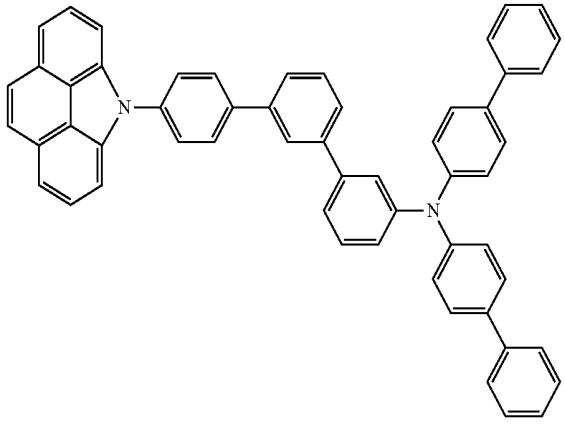

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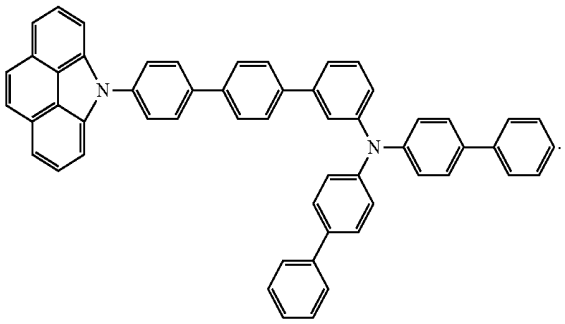


2. An organic light-emitting device comprising:

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 claim 1.

3. The organic light-emitting device of claim 2, wherein the first electrode is an anode, the second electrode is a cathode, and the organic layer comprises:

i) a hole transport region between the first electrode and the emission layer and comprising a hole transport layer and at least one selected from a hole injection layer and an electron blocking layer; and

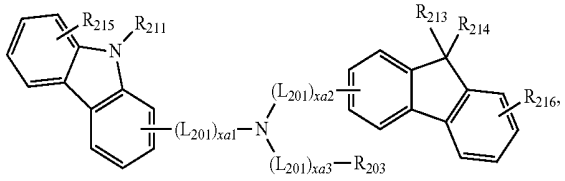
ii) an electron transport region between the emission layer and the second electrode and comprising at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

4. The organic light-emitting device of claim 3, wherein the hole transport layer comprises a first hole transport layer and a second hole transport layer.

5. The organic light-emitting device of claim 4, wherein the second hole transport layer comprises the compound represented by Formulae 2, 3, or 4.

6. The organic light-emitting device of claim 4, wherein the first hole transport layer comprises a compound represented by Formula 201A:

Formula 201A



wherein, in Formula 201A,

L_{201} to L_{203} are 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 anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene 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, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

xa1 to xa3 are each independently selected from 0 and 1;

R_{203} and R_{211} are each independently selected from:

a phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

R_{213} and R_{214} are each independently selected from:

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one 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 phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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;

R_{215} and R_{216} 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 C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;

a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one 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 phenyl group, a biphenyl group, a terphenyl 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 biphenyl group, a terphenyl 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, and a triazinyl group; and

a phenyl group, a biphenyl group, a terphenyl 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 carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl 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.

7. The organic light-emitting device of claim **6**, wherein R_{211} in Formula 201A is selected from a substituted or unsubstituted phenyl group and a substituted or unsubstituted pyridyl group.

8. The organic light-emitting device of claim **6**, wherein R_{213} and R_{214} in Formula 201A are each independently selected from a methyl group and a phenyl group.

9. The organic light-emitting device of claim **6**, wherein the compound represented by Formula 201A is one selected from Compounds HT1 to HT33 below:

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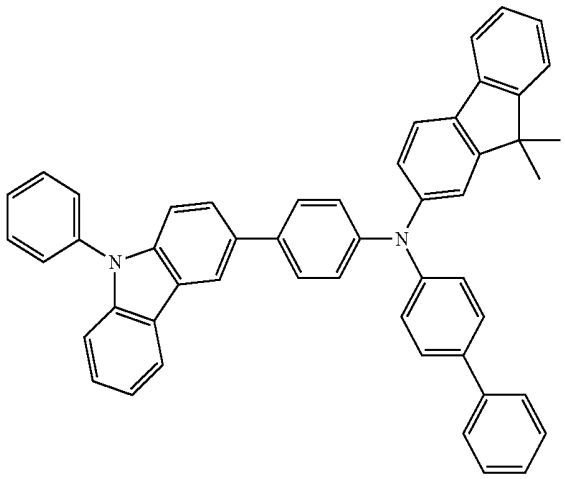
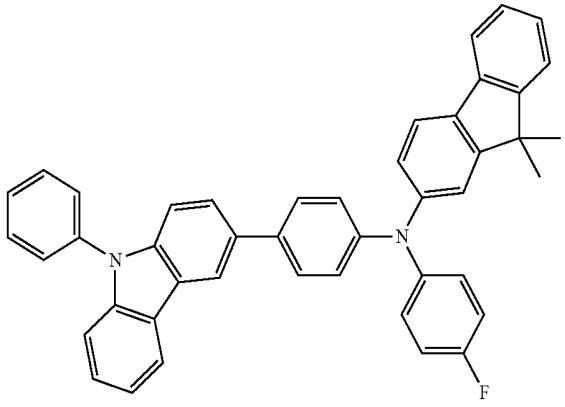
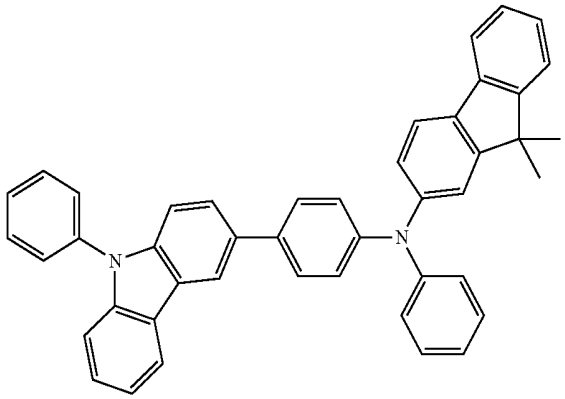
HT1



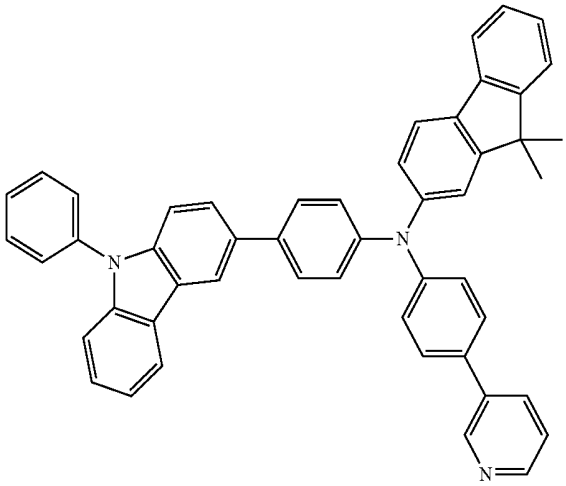
HT4



HT2



HT5



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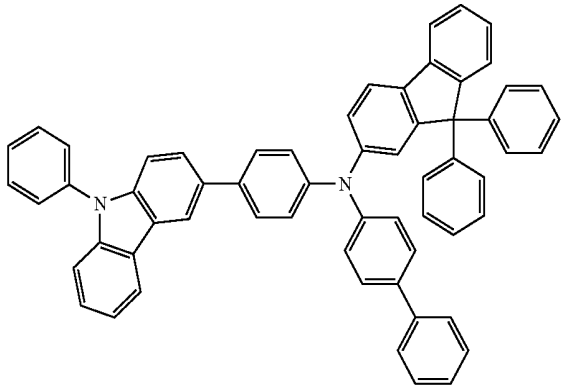
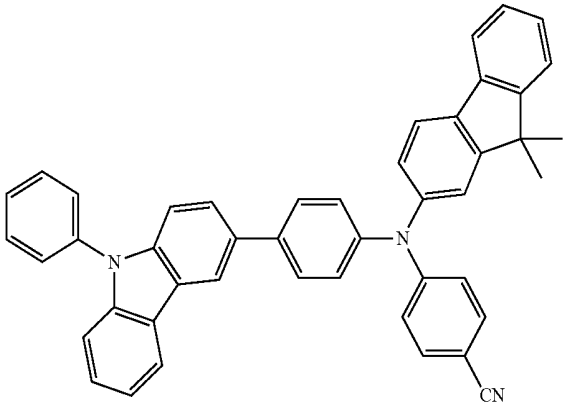


HT6



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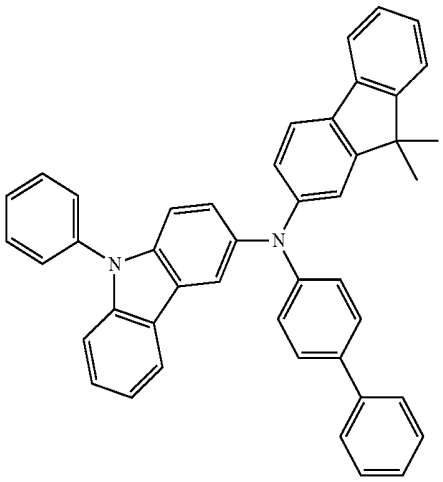
HT7



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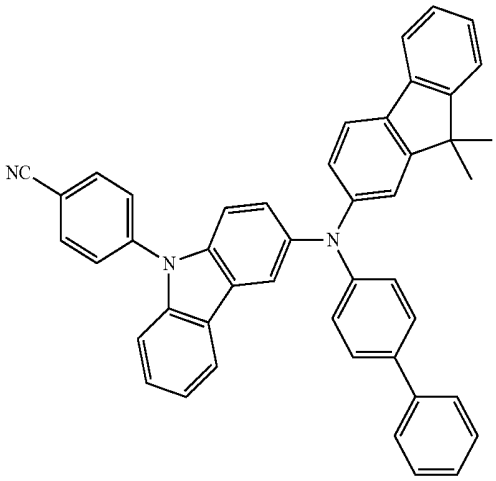
HT10



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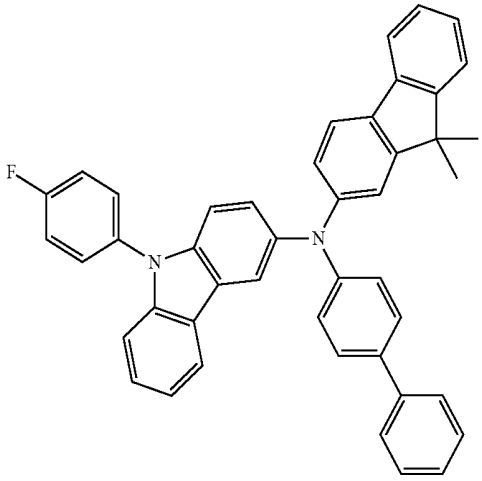

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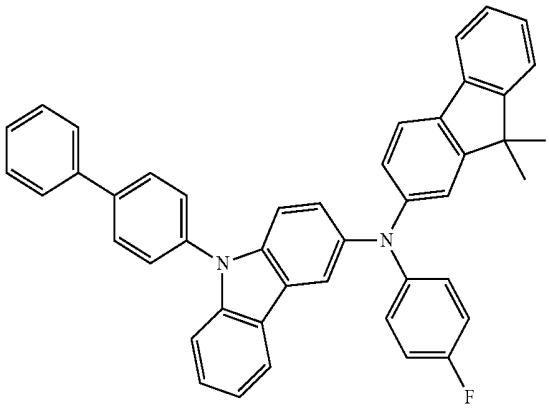

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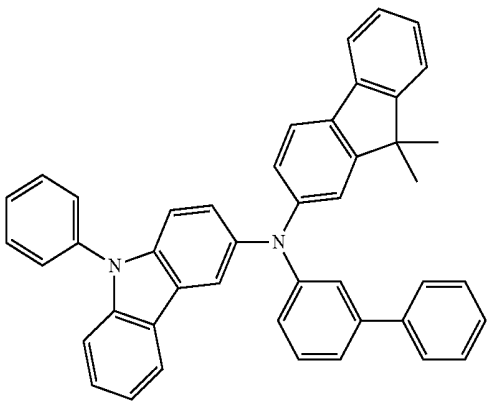

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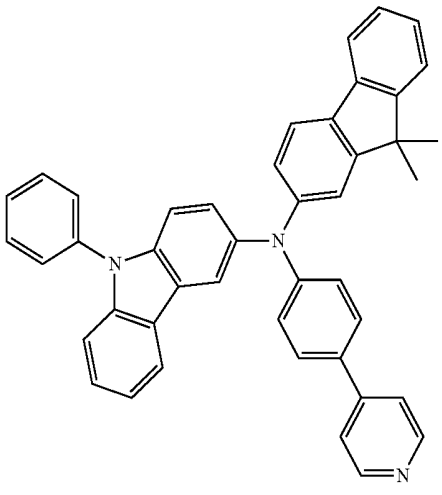

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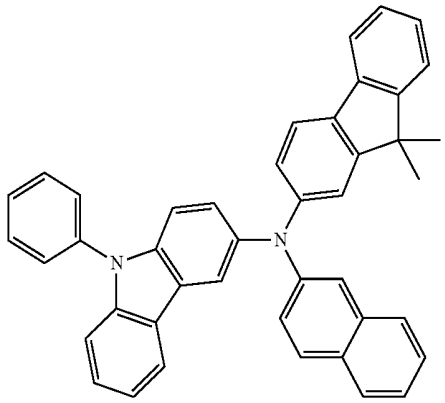

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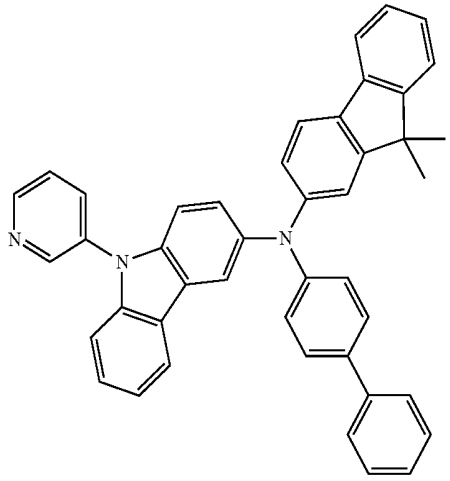

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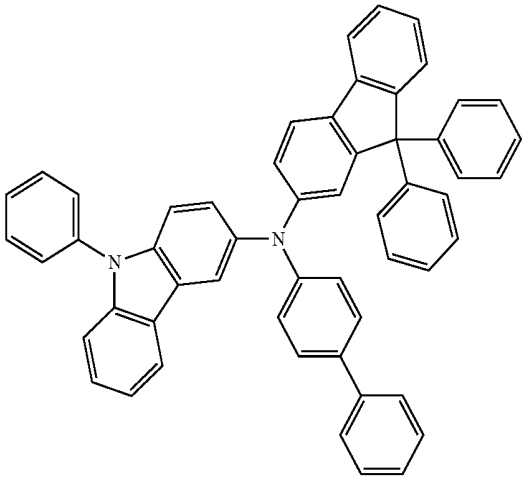

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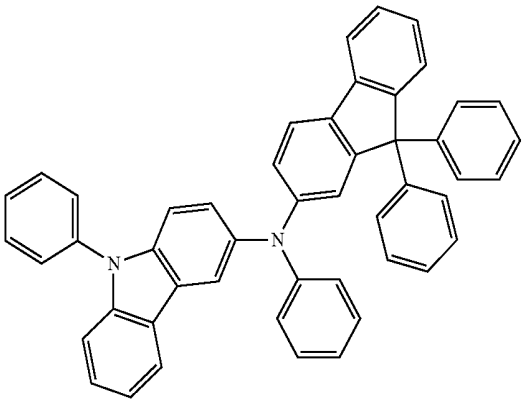

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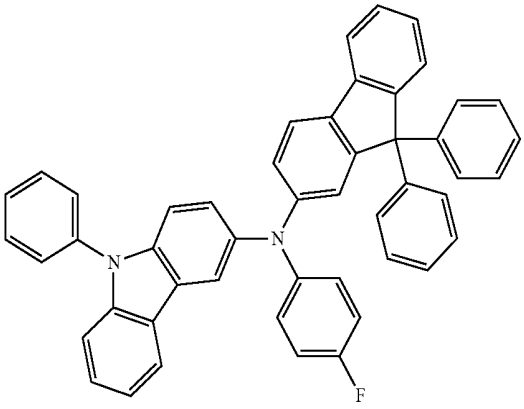

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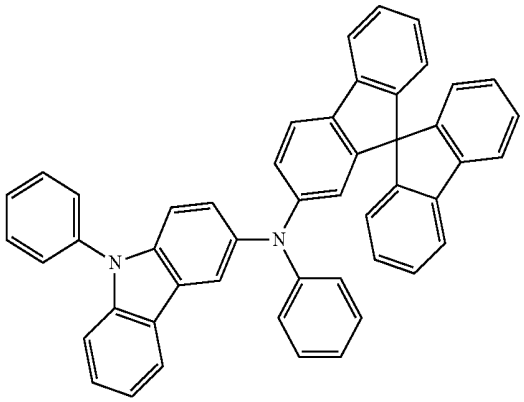

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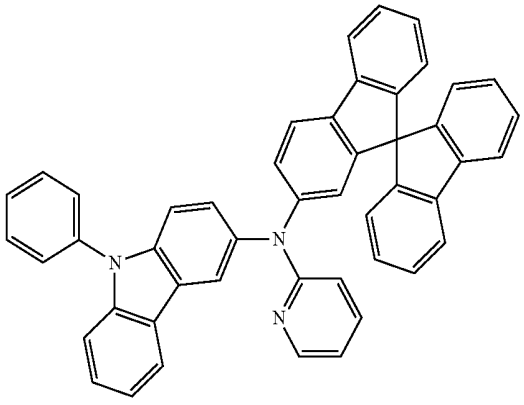

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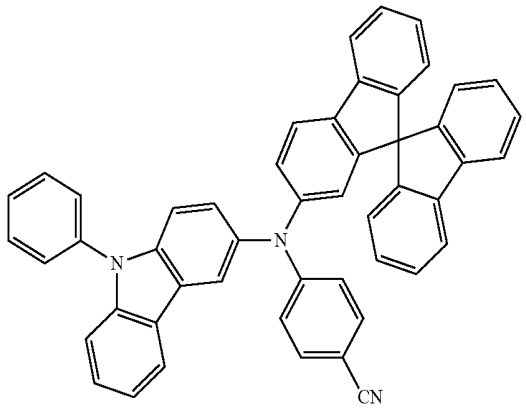

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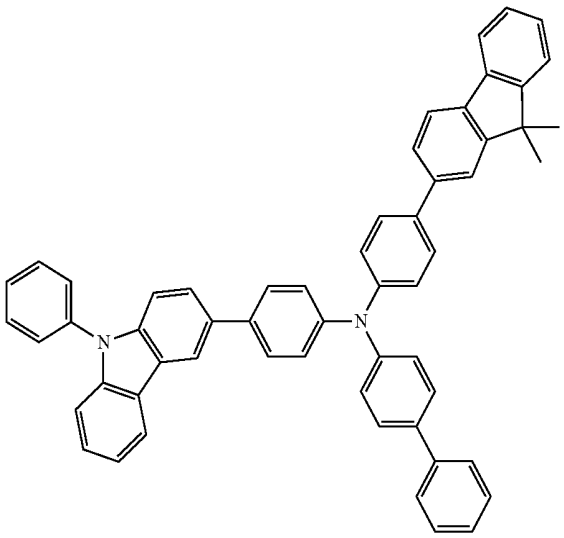

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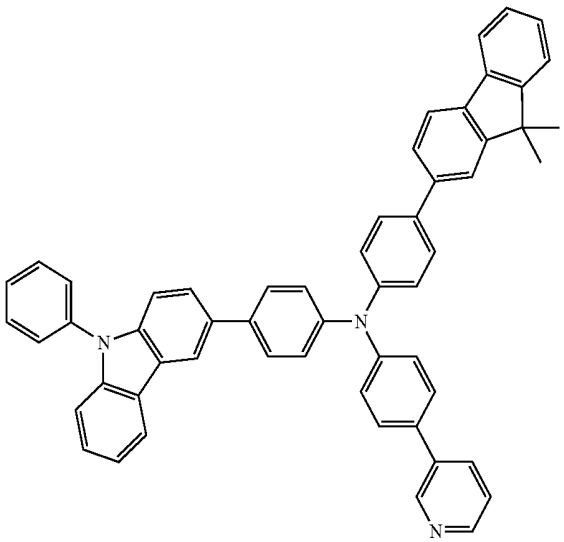

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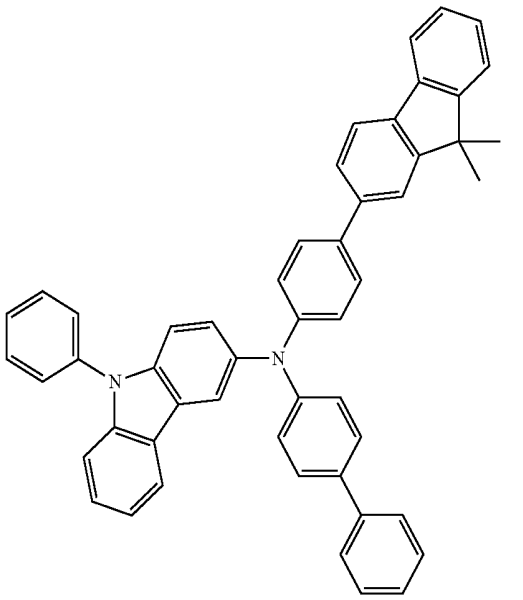

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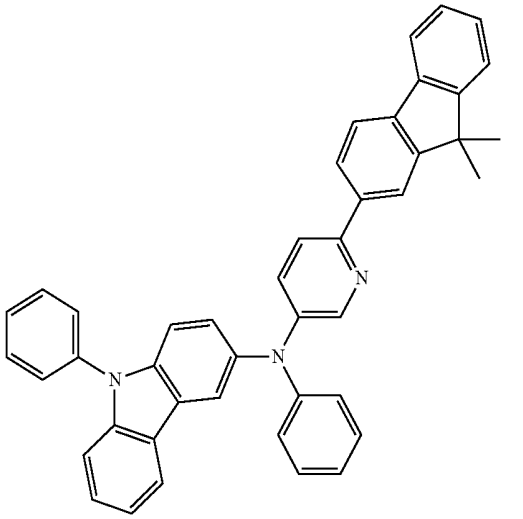

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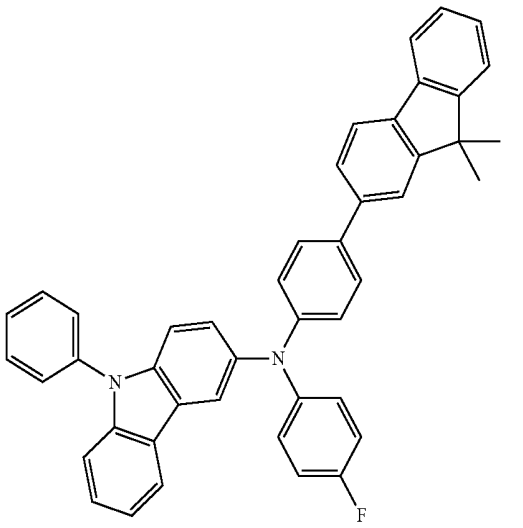

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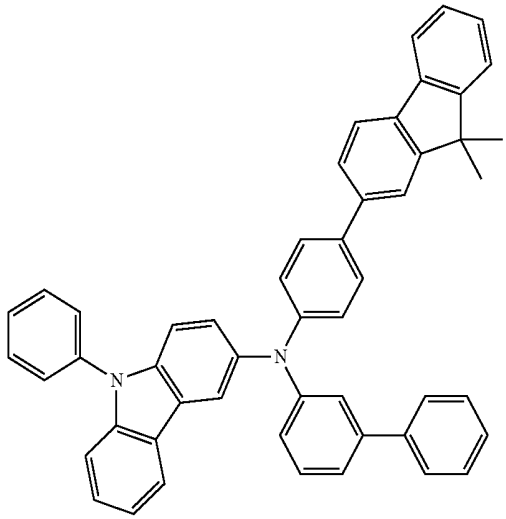

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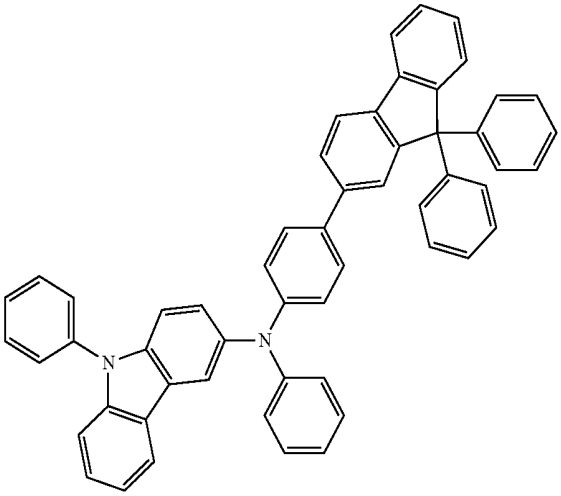

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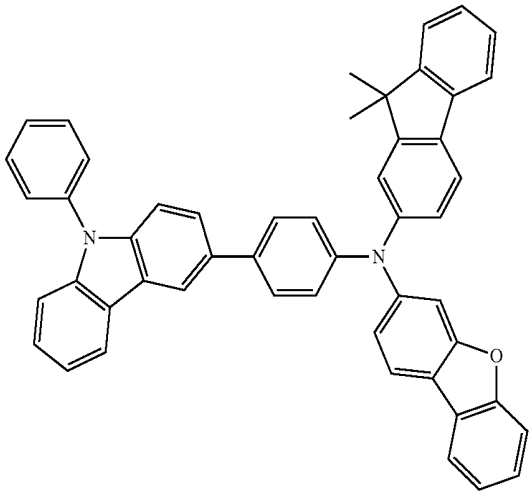

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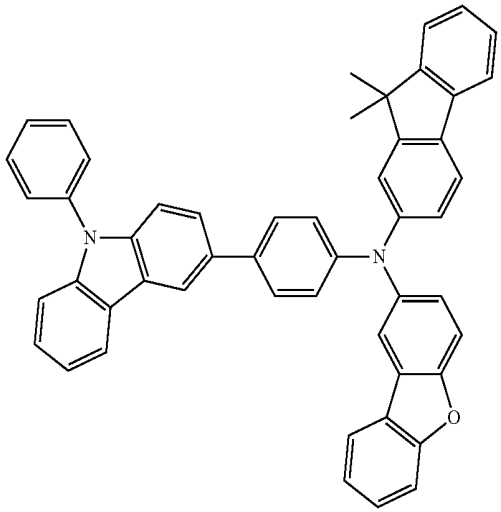

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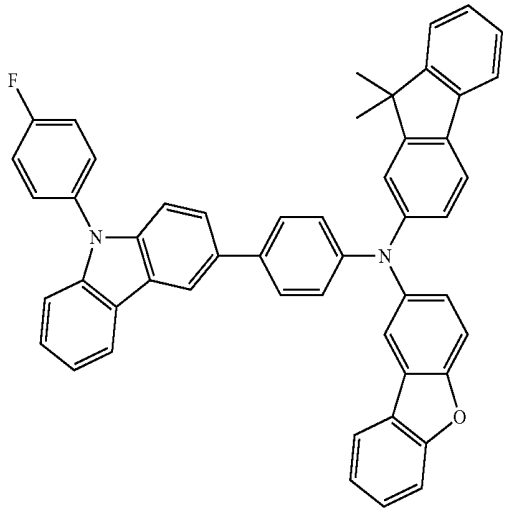

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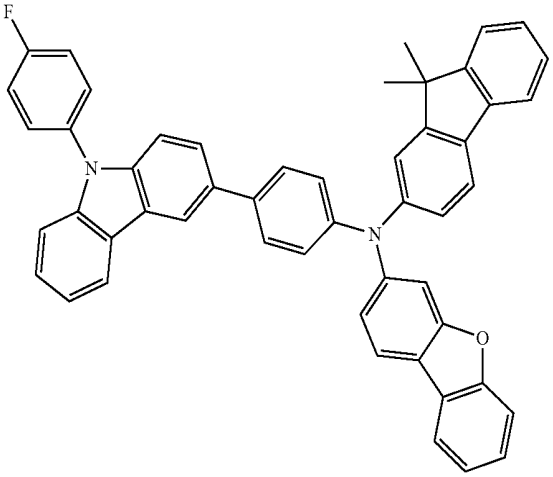

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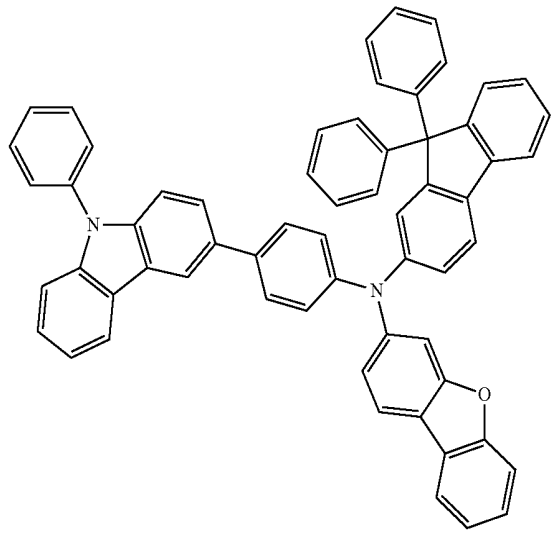

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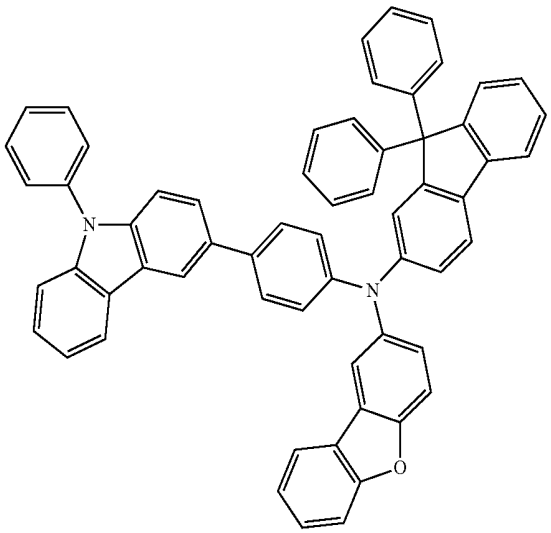
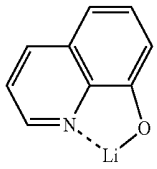


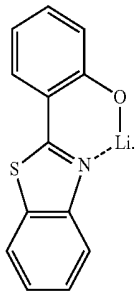
10. The organic light-emitting device of claim **3**, wherein the electron transport layer comprises a metal-containing material.

11. The organic light-emitting device of claim **3**, wherein the electron transport layer comprises one selected from ET-D1 and ET-D2:

ET-D1



ET-D2



12. A flat panel display device that comprises the organic light-emitting device of claim **2**, wherein a first electrode of the organic light-emitting device is electrically connected to a source electrode or a drain electrode of a thin film transistor.

* * * * *

专利名称(译)	包含其的化合物和有机发光装置		
公开(公告)号	US10340462	公开(公告)日	2019-07-02
申请号	US15/085729	申请日	2016-03-30
[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	KIM YOUNGKOOK KIM KWANGHYUN KIM JONGWOO HWANG SEOKHWAN		
发明人	KIM, YOUNGKOOK KIM, KWANGHYUN KIM, JONGWOO HWANG, SEOKHWAN		
IPC分类号	H01L51/00 H01L51/50 C07D209/80 C07D401/10 C07D401/12 C07D405/12 C07D405/10 C07D405/04 C07D403/10		
CPC分类号	H01L51/0061 C07D401/10 C07D401/12 C07D403/10 C07D405/04 C07D405/10 C07D405/12 H01L51/006 H01L51/0052 H01L51/0058 H01L51/0059 H01L51/0067 H01L51/0072 H01L51/0073 C07D209/80 H01L51/5064		
审查员(译)	FANG，SHANE		
优先权	1020150129089 2015-09-11 KR		
其他公开文献	US20170077411A1		
外部链接	Espacenet		

摘要(译)

由式1表示的化合物，和包含该化合物的有机发光装置： 在式1中，当L 1 和/或L 2 是苯基时，吡啶基，嘧啶基和/或1,3,5-三嗪基具有彼此邻位或间位的结合位点的基团，并且式1的化合物包括在第二空穴传输层（HTL2）中，由于HTL2具有的结构，装置的效率和亮度半衰期可能增加与使用对位取代的苯基连接基的相关技术中的实例相比，更高的T 1（例如，三重态）能级。