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(54) **ANTIAROMATIC COMPOUNDS AND ORGANIC LIGHT-EMITTING DEVICES COMPRISING THE SAME**

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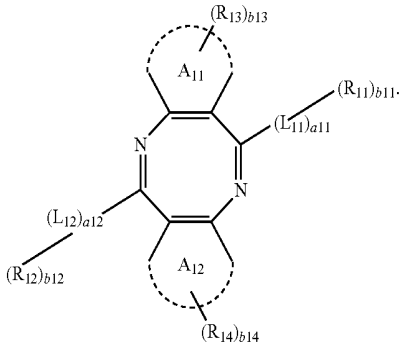
(57) **ABSTRACT**

An antiaromatic compound and an organic light-emitting device including the same. The antiaromatic compound is represented by Formula 1:

Formula 1



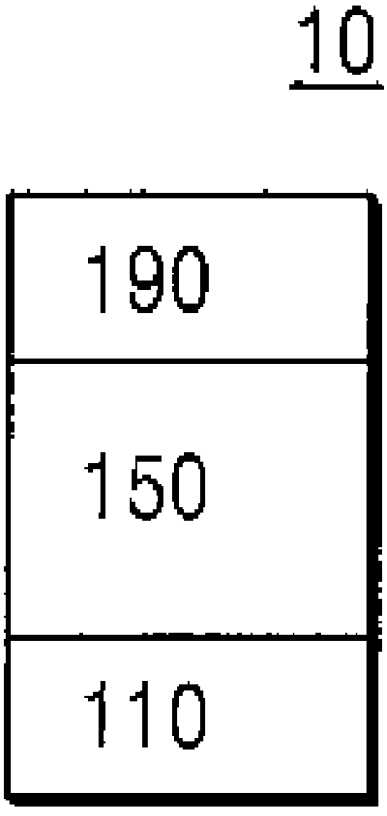


FIG. 1

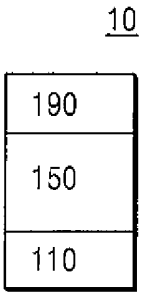

10
190
150
110

FIG. 2

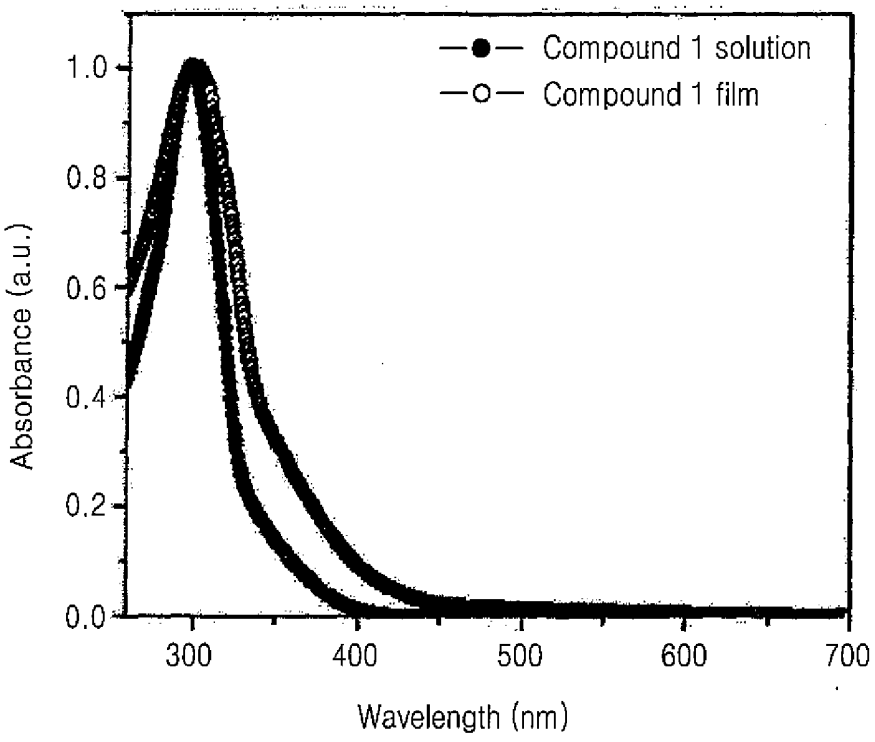

Compound 1 solution
Compound 1 film
Absorbance (a.u.)
1.0
0.8
0.6
0.4
0.2
0.0
300
400
500
600
700
Wavelength (nm)

FIG. 3

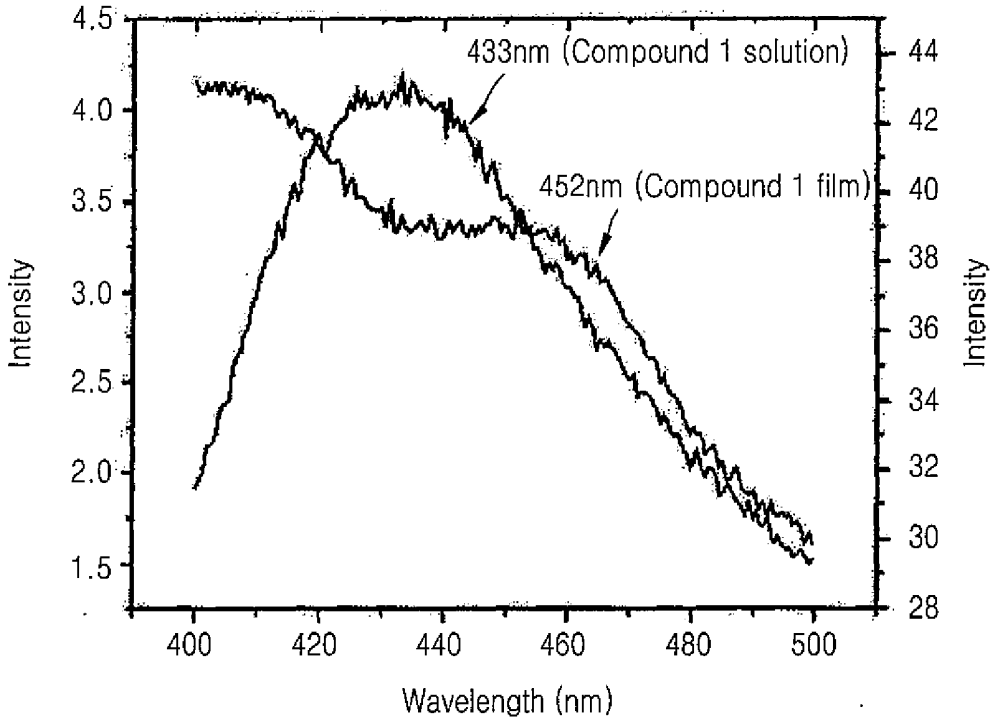

433nm (Compound 1 solution)
452nm (Compound 1 film)
Intensity
Intensity
Wavelength (nm)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
44
42
40
38
36
34
32
30
28
400
420
440
460
480
500

FIG. 4

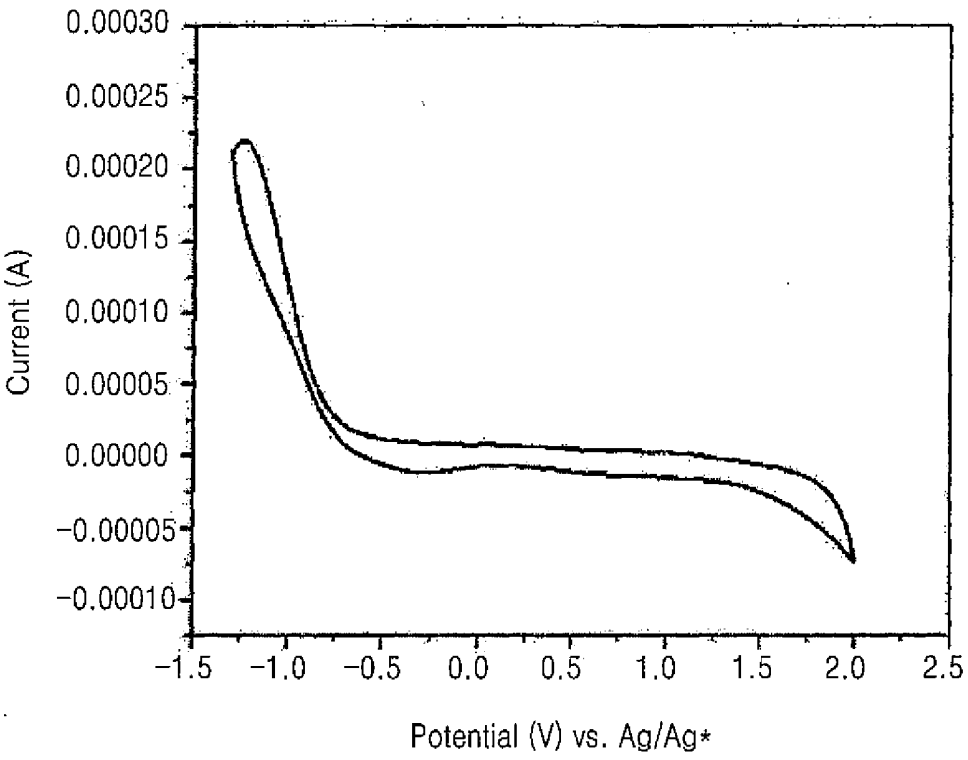

0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
-0.00005
-0.00010
Current (A)
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
Potential (V) vs. Ag/Ag+

FIG. 5

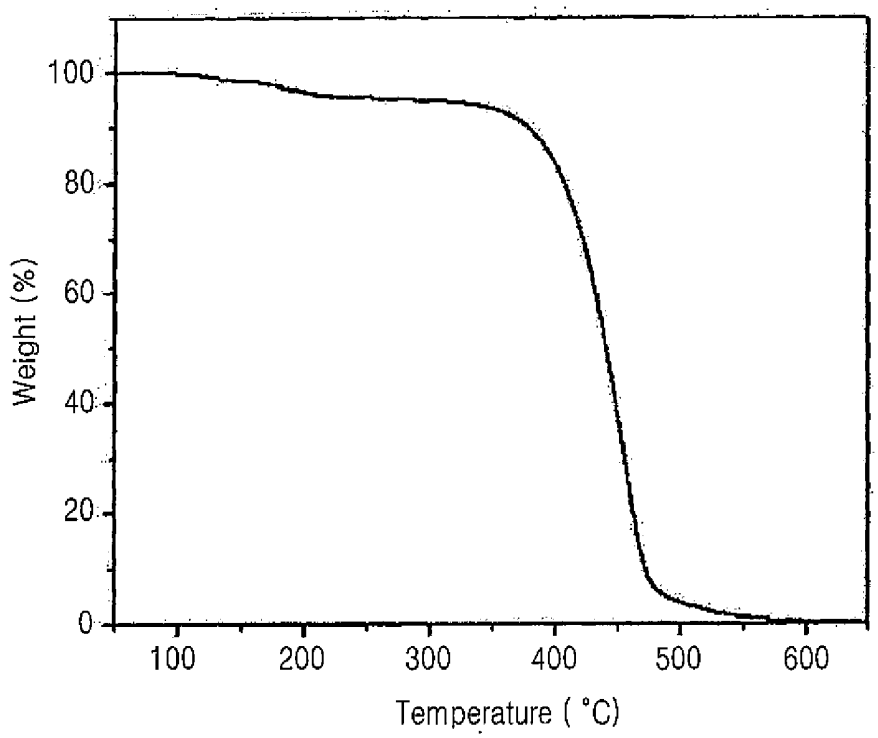


FIG. 6

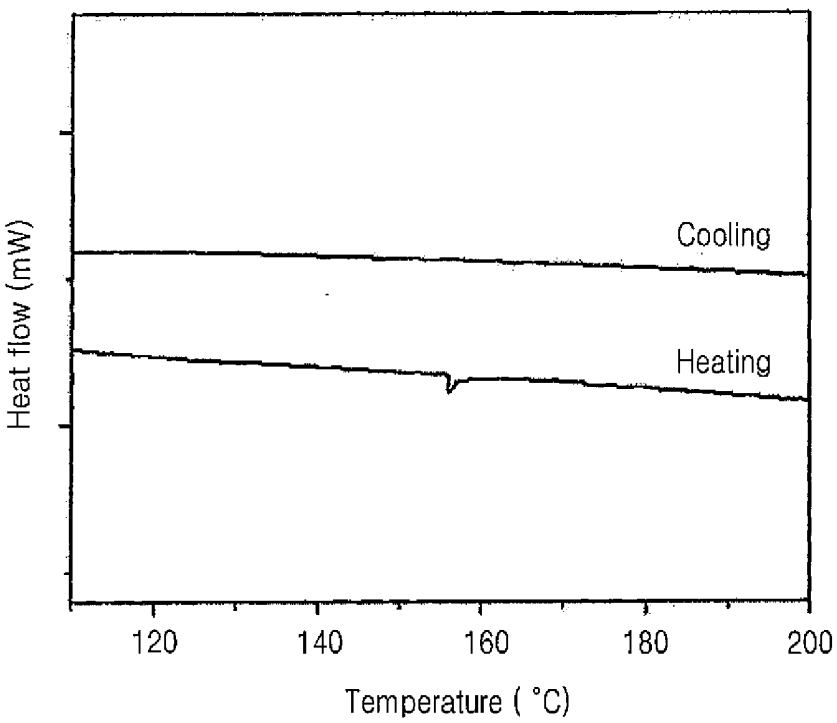

Heat flow (mW)
Cooling
Heating
120
140
160
180
200
Temperature (°C)

FIG. 7

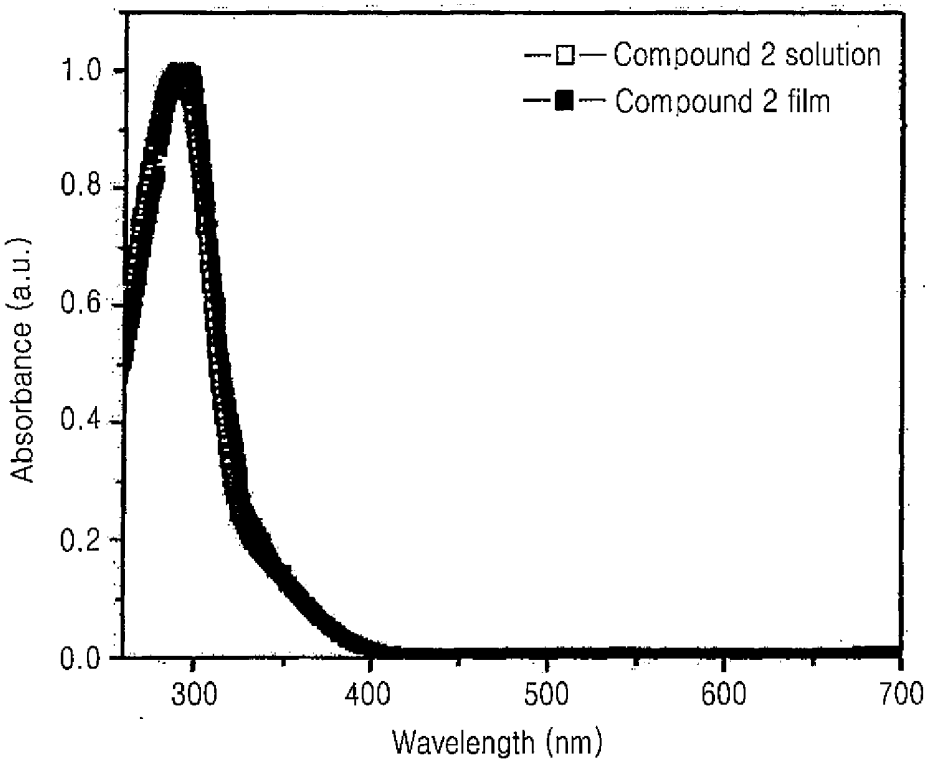

Compound 2 solution
Compound 2 film
Absorbance (a.u.)
1.0
0.8
0.6
0.4
0.2
0.0
300
400
500
600
700
Wavelength (nm)

FIG. 8

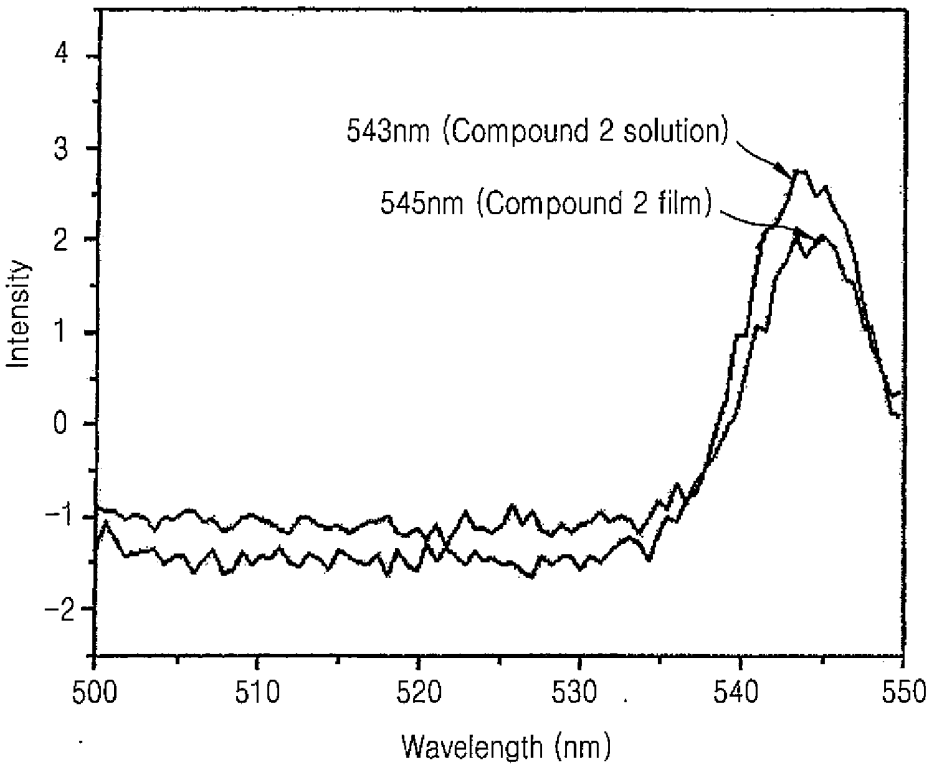

543nm (Compound 2 solution)
545nm (Compound 2 film)
Intensity
4
3
2
1
0
-1
-2
500
510
520
530
540
550
Wavelength (nm)

FIG. 9

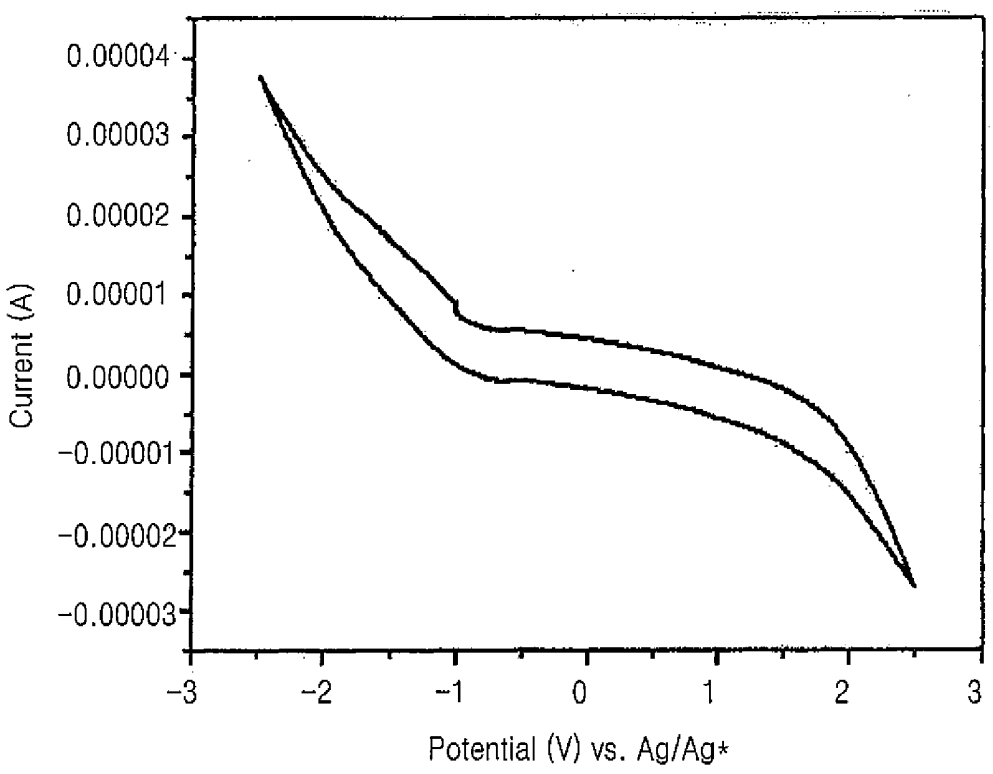

0.00004
0.00003
0.00002
0.00001
0.00000
-0.00001
-0.00002
-0.00003
Current (A)
-3
-2
-1
0
1
2
3
Potential (V) vs. Ag/Ag+

FIG. 10

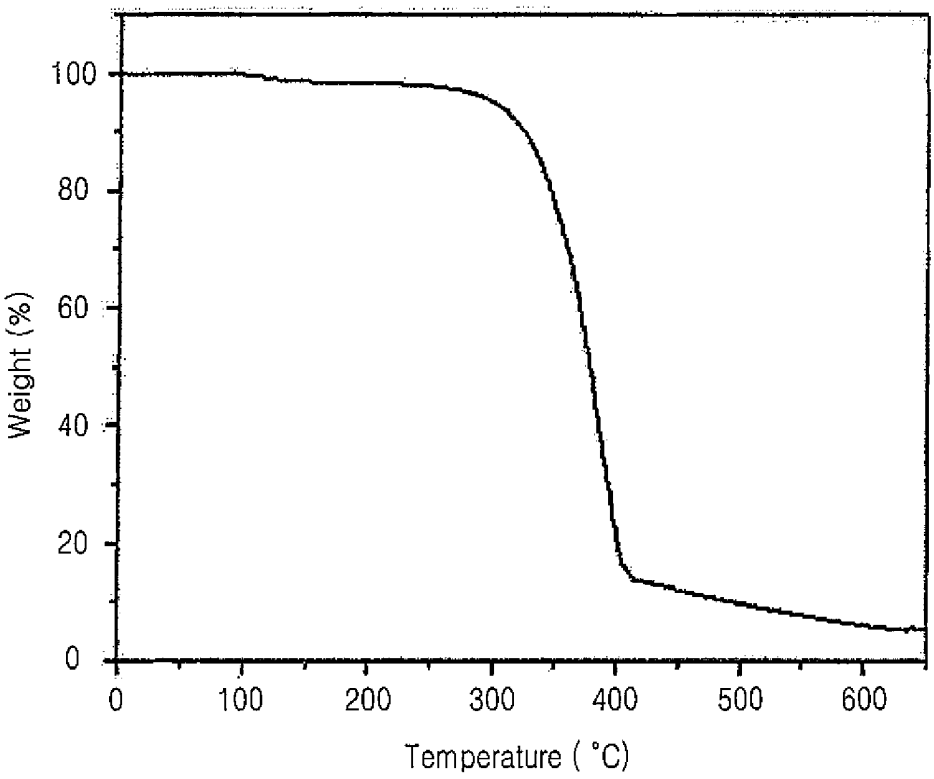


FIG. 11

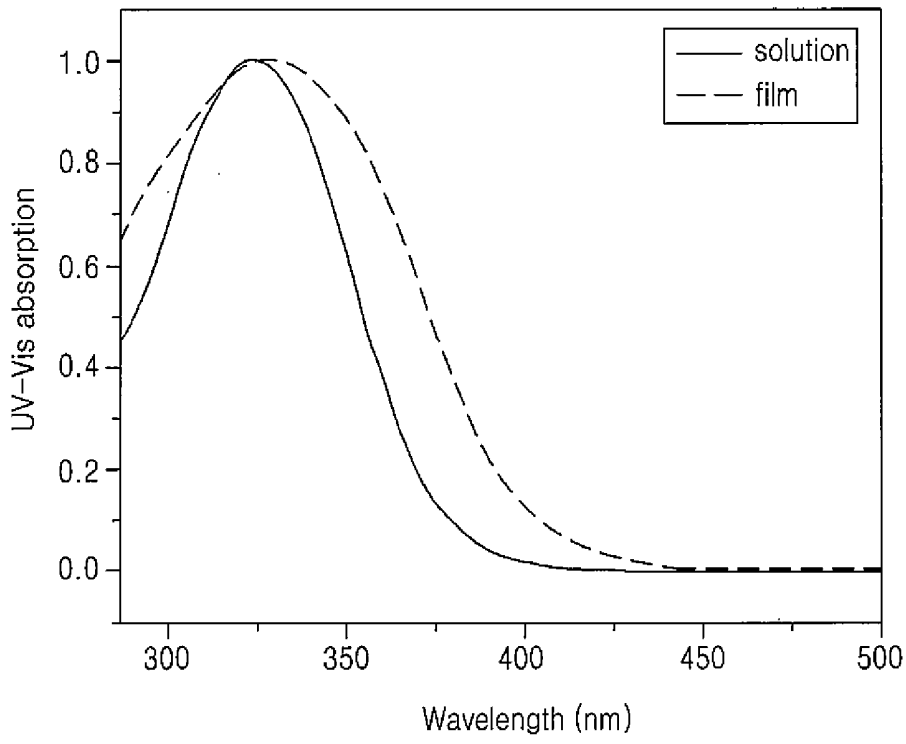

solution
film
1.0
0.8
0.6
0.4
0.2
0.0
UV-Vis absorption
300
350
400
450
500
Wavelength (nm)

FIG. 12

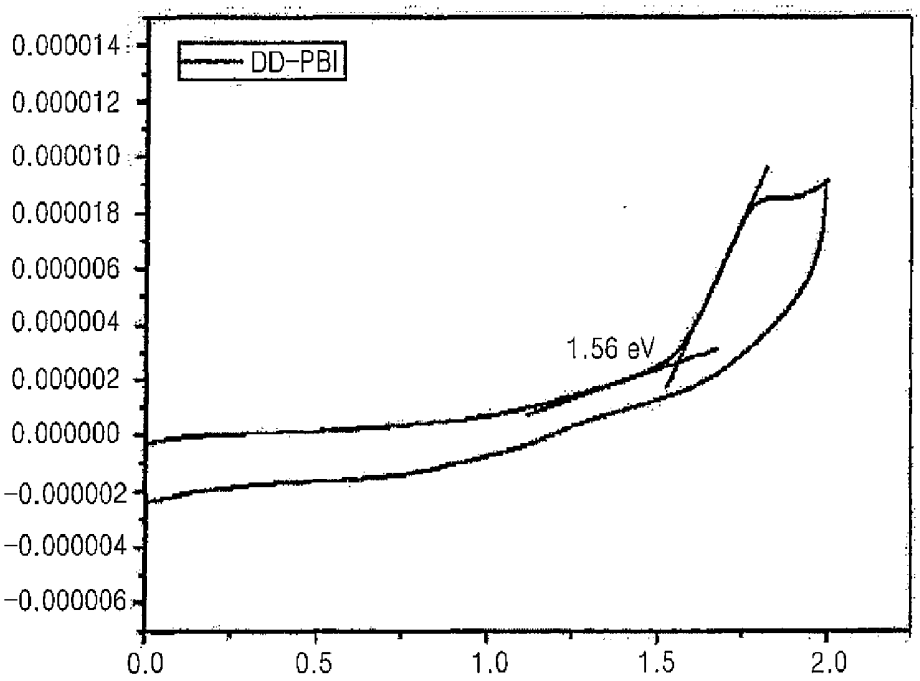

DD-PBI
1.56 eV
0.000014
0.000012
0.000010
0.000018
0.000006
0.000004
0.000002
0.000000
-0.000002
-0.000004
-0.000006
0.0
0.5
1.0
1.5
2.0

FIG. 13

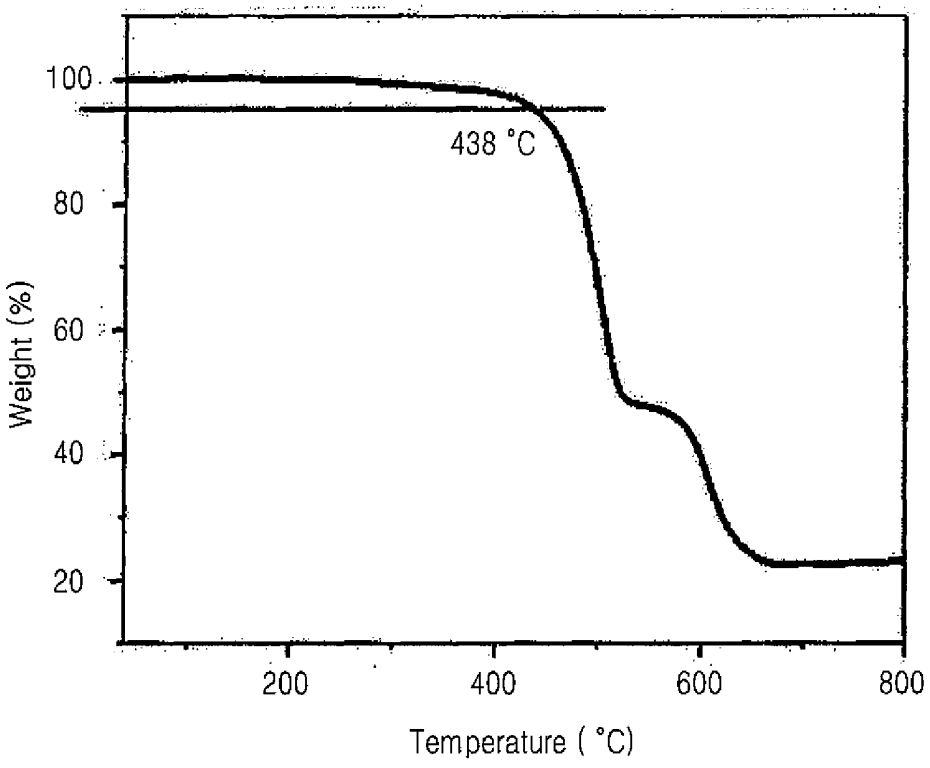


FIG. 14

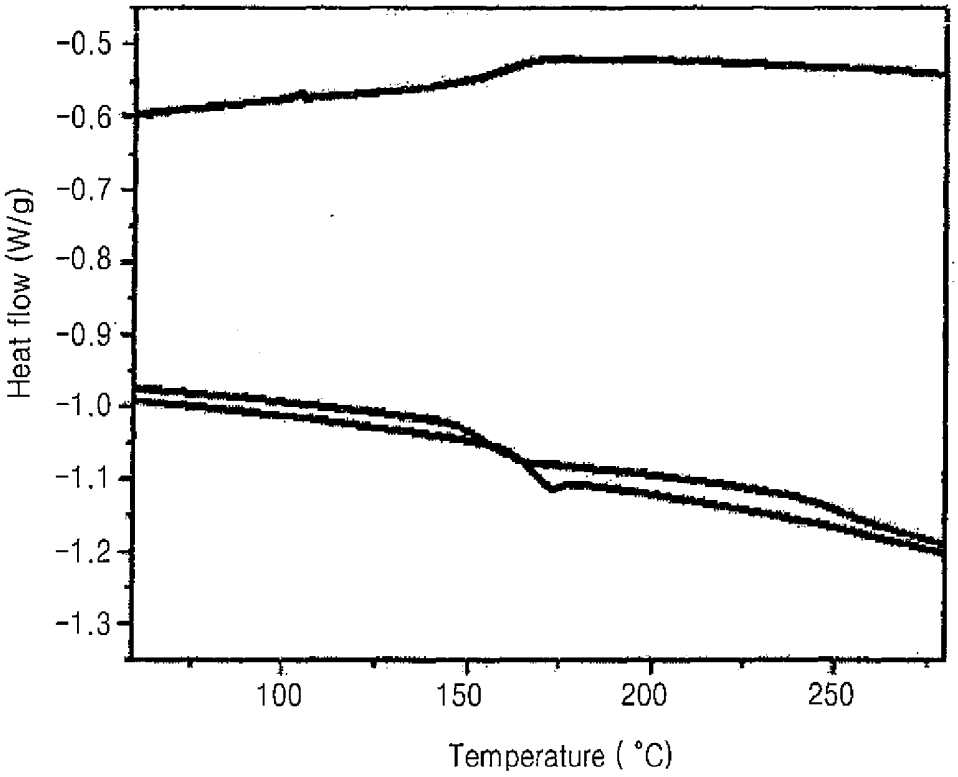

-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-1.1
-1.2
-1.3
Heat flow (W/g)
100
150
200
250
Temperature (°C)

FIG. 15

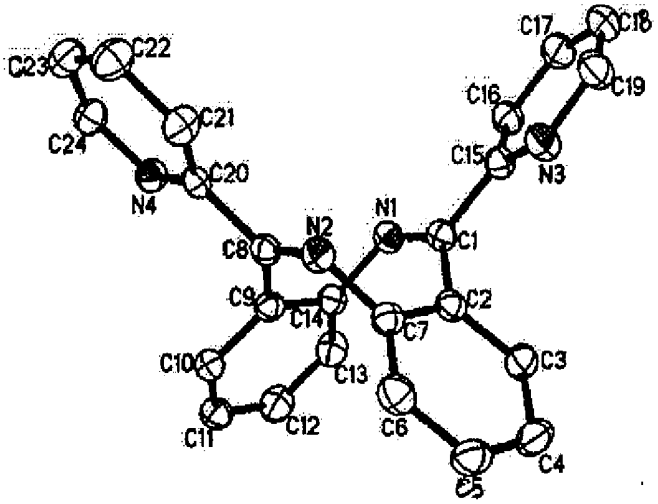

C17
C18
C23
C22
C19
C16
C21
C24
C15
N3
C20
N4
N2
N1
C8
C1
C9
C14
C2
C7
C10
C13
C3
C11
C12
C6
C4
C5

FIG. 16

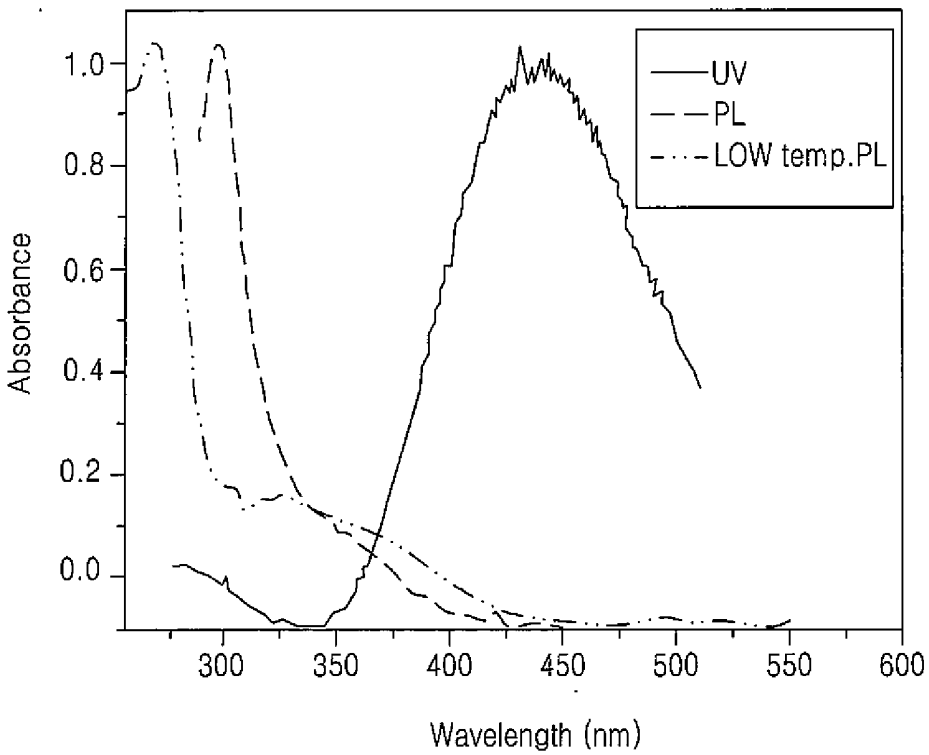

UV
PL
LOW temp.PL
Absorbance
1.0
0.8
0.6
0.4
0.2
0.0
300
350
400
450
500
550
600
Wavelength (nm)

FIG. 17

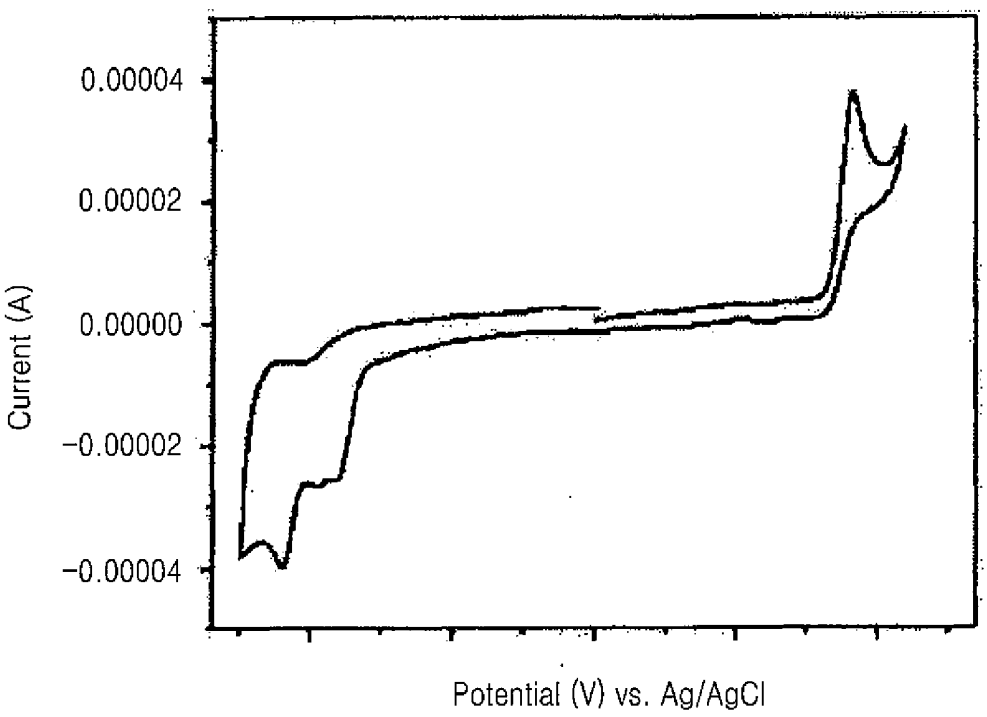

0.00004
0.00002
0.00000
-0.00002
-0.00004
Current (A)
Potential (V) vs. Ag/AgCl

FIG. 18

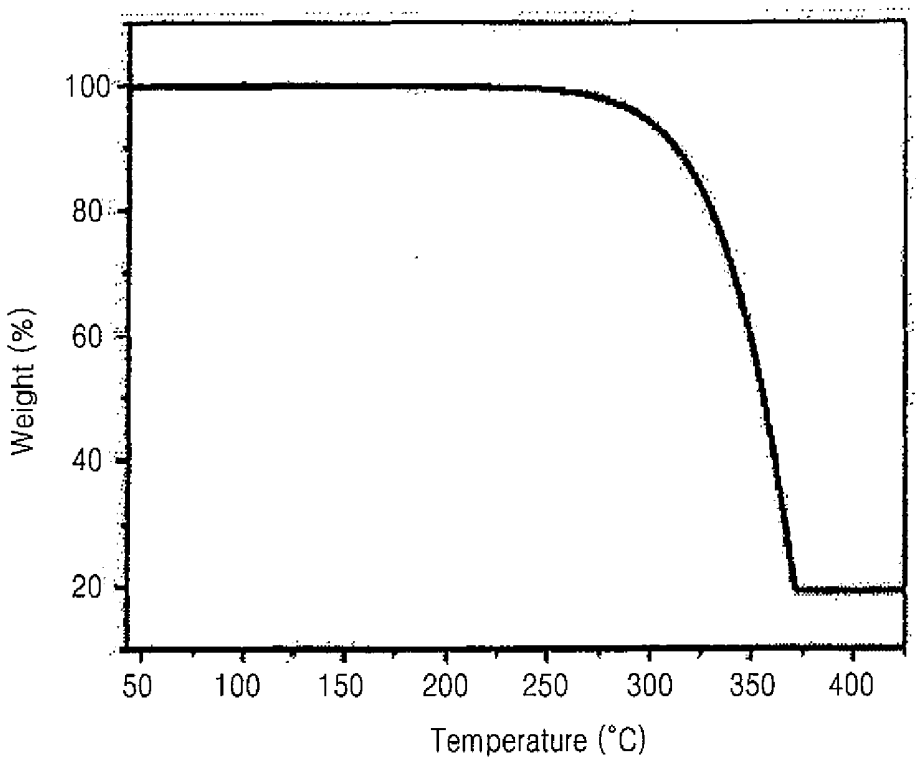

100
80
60
40
20
Weight (%)
50
100
150
200
250
300
350
400
Temperature (°C)

FIG. 19

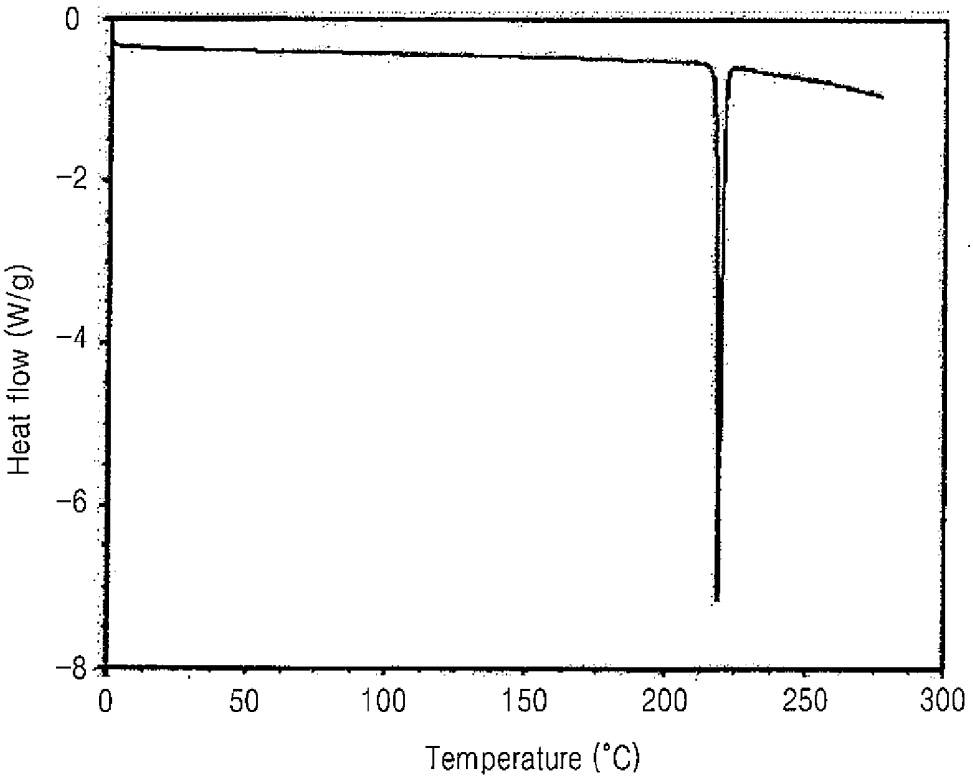


FIG. 20

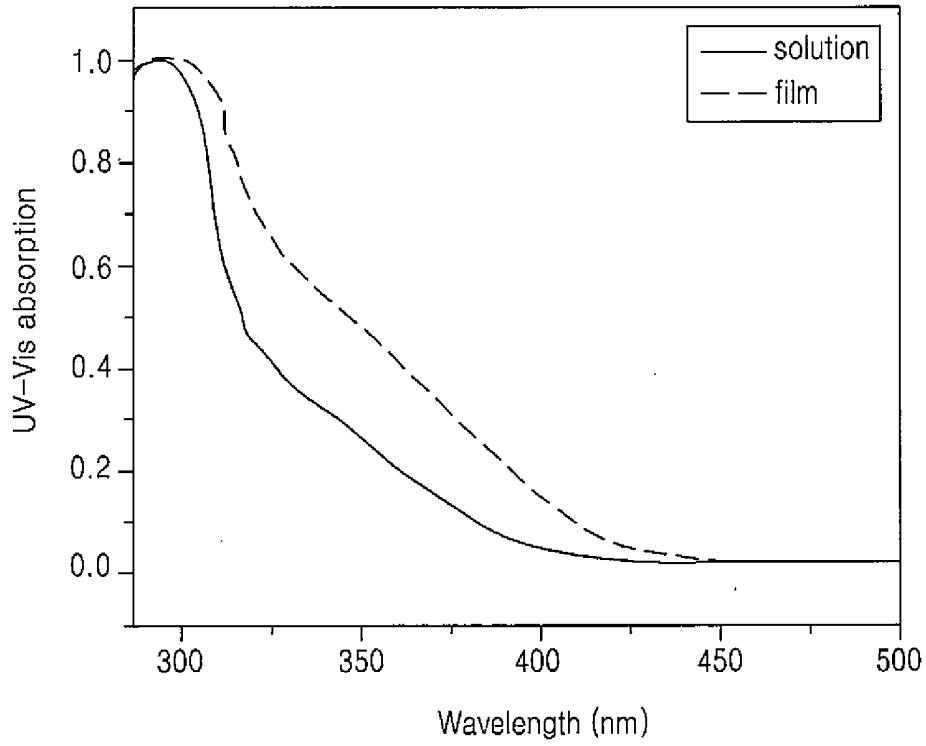

solution
film
1.0
0.8
0.6
0.4
0.2
0.0
UV-Vis absorption
300
350
400
450
500
Wavelength (nm)

FIG. 21

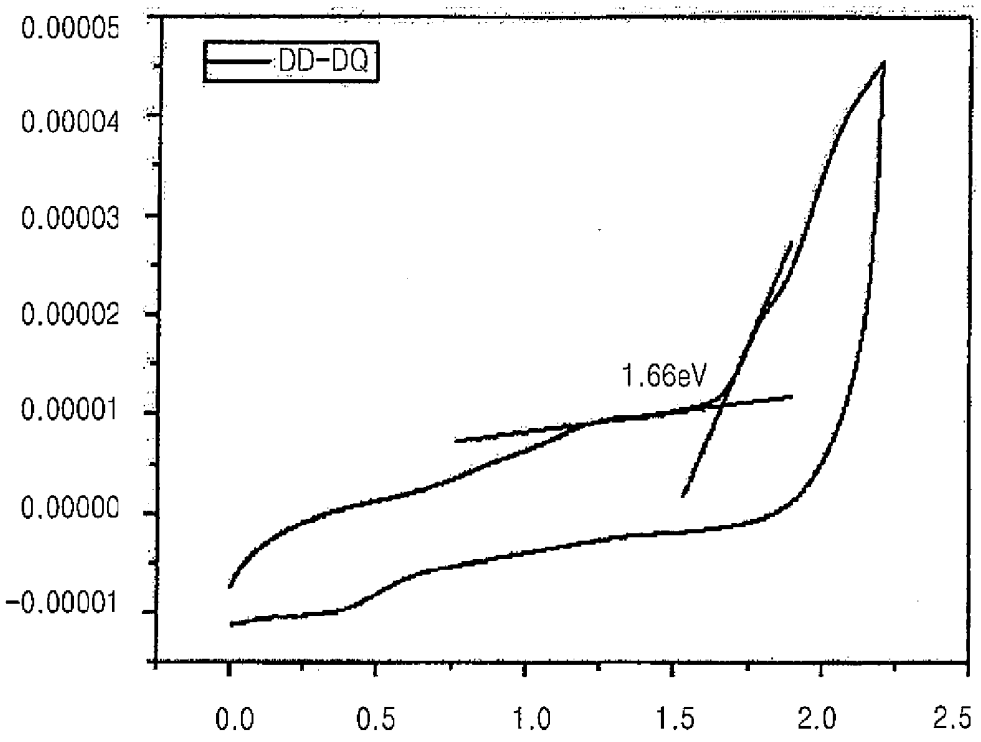

0.00005
0.00004
0.00003
0.00002
0.00001
0.00000
-0.00001
DD-DQ
1.66eV
0.0
0.5
1.0
1.5
2.0
2.5

FIG. 22

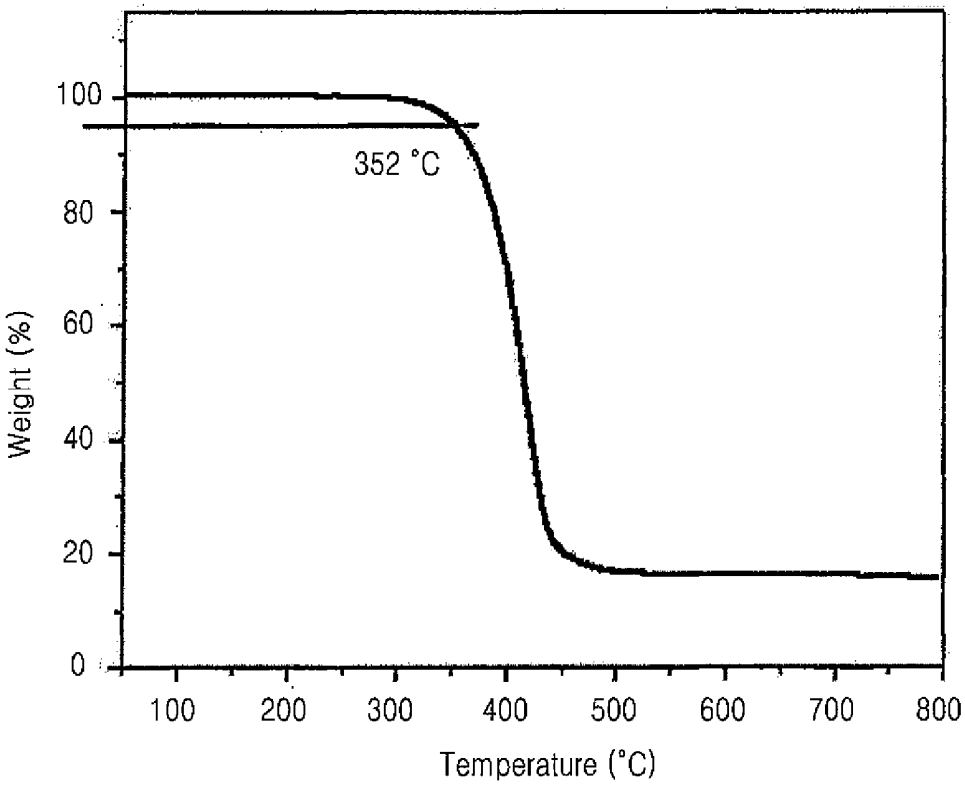
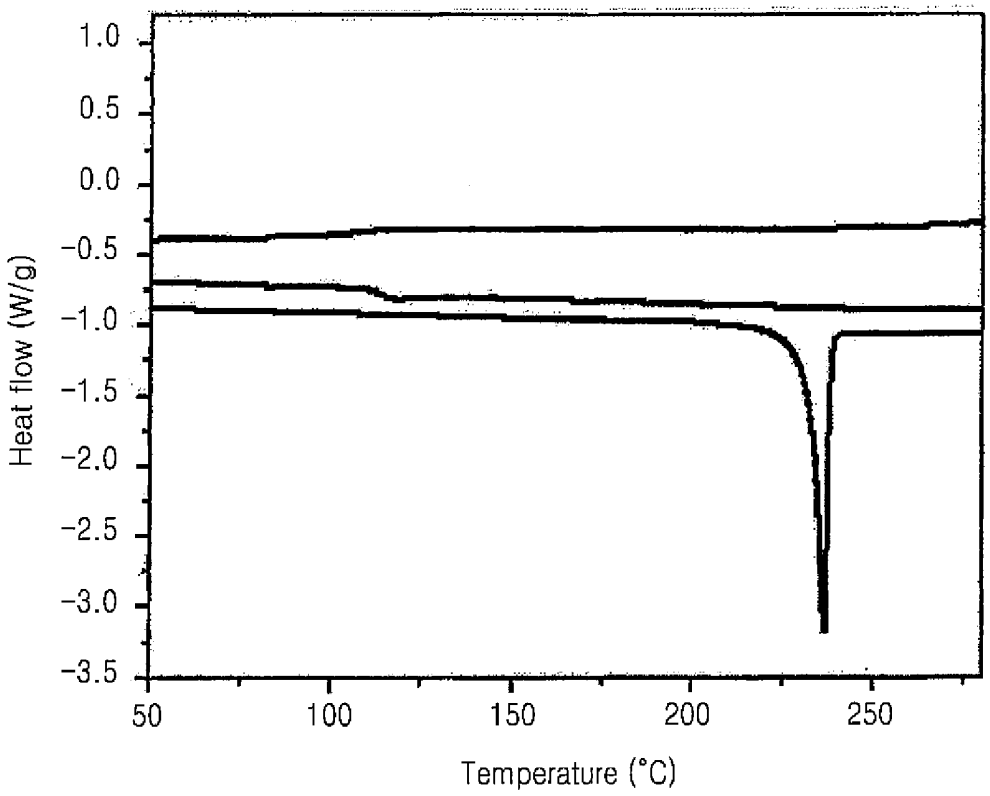

100
80
60
40
20
0
Weight (%)
352 °C
100
200
300
400
500
600
700
800
Temperature (°C)

FIG. 23


1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
Heat flow (W/g)
50
100
150
200
250
Temperature (°C)

ANTIAROMATIC COMPOUNDS AND ORGANIC LIGHT-EMITTING DEVICES COMPRISING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2014-0070265, filed on Jun. 10, 2014, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] One or more embodiments of the present disclosure relate to antiaromatic compounds and organic light-emitting devices including the same.

[0004] 2. Description of the Related Art

[0005] Organic light-emitting devices (OLEDs), which are self-emitting devices, have desired characteristics (such as wide viewing angles, excellent contrast, quick response, high brightness, or excellent driving voltage), and can provide multicolored images.

[0006] An organic light-emitting device may have a structure in which a first electrode, a hole transport region, an emission layer, an electron transport region, and a second electrode are sequentially disposed in this order on a substrate. Holes injected from the first electrode move to the emission layer via the hole transport region, while electrons injected from the second electrode move to the emission layer via the electron transport region. Carriers such as the holes and electrons recombine in the emission layer to generate excitons. When the excitons drop from an excited state to a ground state, light is emitted.

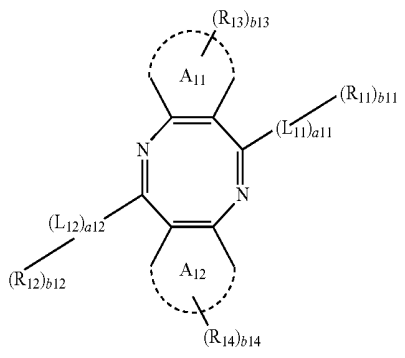
SUMMARY

[0007] Aspects according to one or more embodiments of the present disclosure are directed toward antiaromatic compounds and organic light-emitting devices including the same.

[0008] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0009] According to one or more embodiments of the present disclosure, an antiaromatic compound is represented by Formula 1:

Formula 1



[0010] wherein, in Formula 1,

[0011] A_{11} and A_{12} are each independently selected from a C_6-C_{60} arene and a C_1-C_{60} heteroarene;

[0012] L_{11} and L_{12} are each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted non-aromatic condensed polycyclic group, and a substituted or unsubstituted non-aromatic condensed heteropolycyclic group;

[0013] at least one substituent of the substituted C_3-C_{10} cycloalkylene group, the substituted C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted C_1-C_{10} heterocycloalkenylene group, the substituted C_6-C_{60} arylene group, the substituted C_1-C_{60} heteroarylene group, the substituted non-aromatic condensed polycyclic group, and the substituted non-aromatic condensed heteropolycyclic group is selected from:

[0014] a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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;

[0015] a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0016] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0017] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{60} 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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60}

heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0018] a11 and a12 are each independently selected from 0, 1, 2, 3, 4, 5 and 6;

[0019] R_{11} and R_{12} are each independently selected from a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted non-aromatic condensed polycyclic group, a substituted or unsubstituted non-aromatic condensed heteropolycyclic group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$P(Q_{16})(Q_{17})$;

[0020] Q_{11} to Q_{17} are each independently selected from a substituted or unsubstituted C_6-C_{60} aryl group, and a substituted or unsubstituted C_1-C_{60} heteroaryl group;

[0021] at least one substituent of the substituted C_6-C_{60} aryl group, the substituted C_1-C_{60}, the substituted non-aromatic condensed polycyclic group, and the substituted non-aromatic condensed heteropolycyclic group is selected from:

[0022] a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

[0023] a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0024] a C_3-C_{10} cycloalkyl group, a C_1-C_{60} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0025] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0026] b11 and b12 are each independently an integer selected from 1 to 3;

[0027] R_{13} and R_{14} are each independently selected from:

[0028] a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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;

[0029] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0030] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0031] a C_3-C_{10} cycloalkyl group, a C_1-C_{60} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{60} 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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0032] b13 and b14 are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10.

[0033] According to one or more embodiments of the present disclosure, an organic light-emitting device includes a first electrode, a second electrode facing the first electrode, and an organic layer between the first electrode and the second electrode, and including an emission layer, wherein the organic layer includes at least one of the antiaromatic compound of Formula 1 described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

[0035] FIG. **1** is a schematic view of a structure of an organic light-emitting device according to an embodiment of the present disclosure;

[0036] FIG. **2** illustrates the ultraviolet (UV) absorption spectra of Compound 1 in liquid state and in film form;

[0037] FIG. **3** illustrates the photoluminescence (PL) absorption spectra of Compound 1 in liquid state and in film form;

[0038] FIG. **4** is a plot of cyclic voltammetry (CV) results for Compound 1;

[0039] FIG. **5** is a plot of thermogravimetry (TGA) results for Compound 1;

[0040] FIG. **6** is a plot of differential scanning calorimetry (DSC) results for Compound 1;

[0041] FIG. **7** illustrates the UV absorption spectra of Compound 2 in liquid state and in film form;

[0042] FIG. **8** illustrates the PL absorption spectra of Compound 2 in liquid state and in film form;

[0043] FIG. **9** is a plot of CV results for Compound 2;

[0044] FIG. **10** is a plot of TGA results for Compound 2;

[0045] FIG. **11** illustrates the UV absorption spectra of Compound 18 in liquid state and in film form;

[0046] FIG. **12** is a plot of CV results for Compound 18;

[0047] FIG. **13** is a plot of TGA results for Compound 18;

[0048] FIG. **14** is a plot of DSC results for Compound 18;

[0049] FIG. **15** illustrates a crystalline structure of Compound 140;

[0050] FIG. **16** illustrates the UV absorption spectra of Compound 140 in liquid state and in film form;

[0051] FIG. **17** is a plot of CV results for Compound 140;

[0052] FIG. **18** is a plot of TGA results for Compound 140;

[0053] FIG. **19** is a plot of DSC results for Compound 140;

[0054] FIG. **20** illustrates the UV absorption spectra of Compound 39 in liquid state and in film form;

[0055] FIG. **21** is a plot of CV results for Compound 39;

[0056] FIG. **22** is a plot of TGA results for Compound 39; and

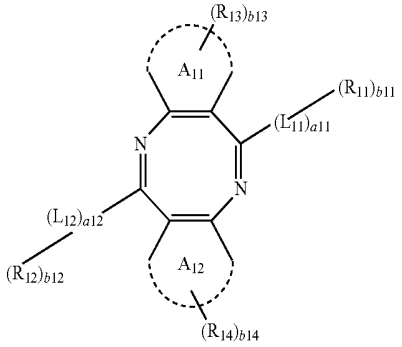
[0057] FIG. **23** is a plot of DSC results for Compound 39;

DETAILED DESCRIPTION

[0058] Reference will now be made in more detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. Further, the use of "may" when describing embodiments of the present invention refers to "one or more embodiments of the present invention."

[0059] According to an embodiment of the present disclosure, there is provided an antiaromatic compound represented by Formula 1:

Formula 1



[0060] In Formula 1, A_{11} and A_{12} may be each independently selected from a C_6-C_{60} arene and a C_1-C_{60} heteroarene.

[0061] In some embodiments, A_{11} and A_{12} in Formula 1 may be each independently selected from, but not limited to, a benzene, a naphthalene, a phenanthrene, an anthracene, a triphenylene, a pyrene, a chrysene, a pyrrole, a thiophene, a furan, an imidazole, a pyrazole, a thiazole, an oxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, an indole, a quinoline, an isoquinoline, a benzoquinoline, a naphthyridine, a quinoxaline, a quinazoline, a phenanthridine, an acridine, a phenanthroline, a phenazine, a benzimidazole, a benzofuran, a benzothiophene, a benzoxazole, a triazole, a triazine, a dibenzofuran, and a dibenzothiophene.

[0062] In some other embodiments, in Formula 1, A_{11} and A_{12} may be each independently selected from, but not limited to, a benzene, a naphthalene, a phenanthrene, an anthracene, a triphenylene, a pyridine, a quinoline, an isoquinoline, a naphthyridine, a quinoxaline, and a quinazoline.

[0063] In some other embodiments, in Formula 1, A_{11} and A_{12} may be each independently selected from, but not limited to, a benzene, a naphthalene, a pyridine, and a quinoline.

[0064] In Formula 1, L_{11} and L_{12} may be each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{60} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted non-aromatic condensed polycyclic group, and a substituted or unsubstituted non-aromatic condensed heteropolycyclic group;

[0065] at least one substituent of the substituted C_3-C_{10} cycloalkylene group, the substituted C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted C_1-C_{60} heterocycloalkenylene group, the substituted C_6-C_{60} arylene group, the substituted C_1-C_{60} heteroarylene group, the substituted non-aromatic condensed polycyclic group, and the substituted non-aromatic condensed heteropolycyclic group may be selected from:

[0066] a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and C_1-C_{60} alkoxy group;

[0067] a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0068] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{60} 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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0069] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{60} 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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group.

[0070] In some embodiments, L_{11} and L_{12} in Formula 1 may be each independently selected from, but not limited to,

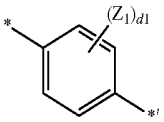
[0071] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thienylene group, a furanylene group, a silolylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, a benzofuranylene group, a benzothienylene group, a benzosilolylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, and a dibenzosilolylene group; and

[0072] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thienylene group, a furanylene group, a silolylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, a benzofuranylene group, a benzothienylene group, a benzosilolylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, and a dibenzosilolylene group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 cyclohexcenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thienyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a qui-

noxalinyl 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 benzofuryl group, a benzothienyl group, a benzosilolyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazole group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothienyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and a dibenzosilolyl group.

[0073] In some other embodiments, L_{11} and L_{12} in Formula 1 may be each independently a group represented by one of Formulae 3-1 to 3-32, but are not limited thereto:

3-1



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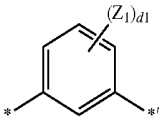

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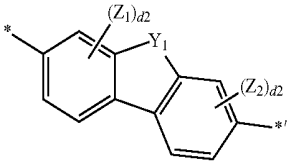

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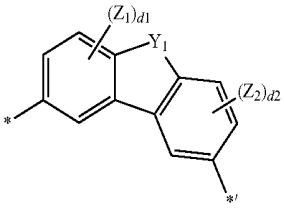

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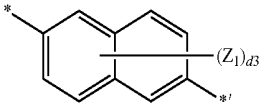

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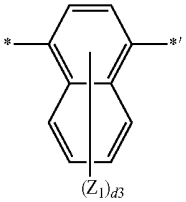

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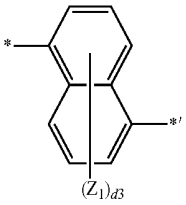

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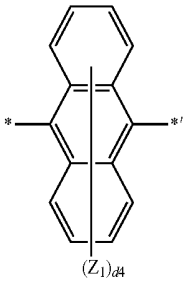
3-8



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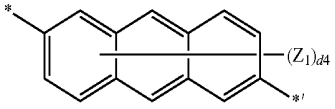

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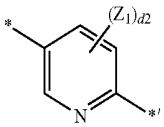

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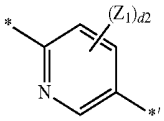

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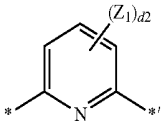

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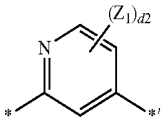
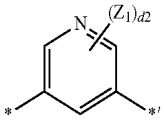


3-14



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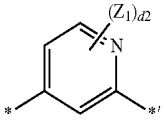

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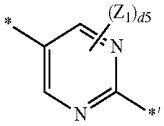

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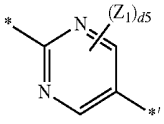

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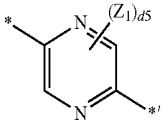

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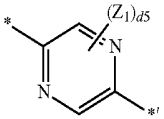

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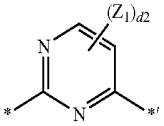

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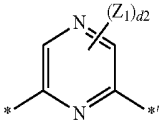

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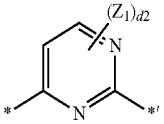

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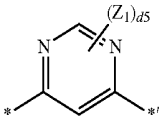

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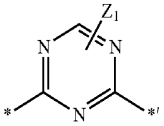

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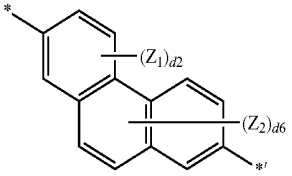

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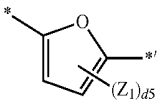
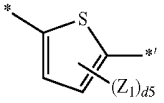
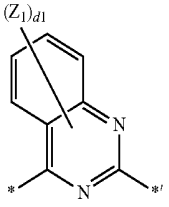


3-27



3-28



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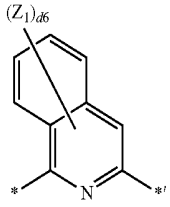
3-29



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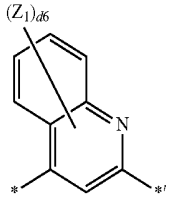

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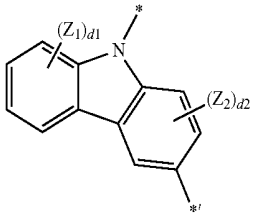
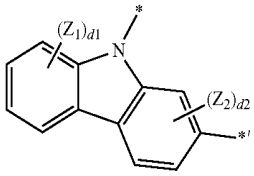


3-32



[0074] In Formulae 3-1 to 3-32,

[0075] Y_1 may be selected from $C(Q_{31})(Q_{32})$, $N(Q_{33})$, an oxygen atom, a sulfur atom, and $Si(Q_{34})(Q_{35})$;

[0076] Q_{31} to Q_{35} may be each independently selected from a hydrogen atom, a deuterium atom, a C_1-C_{20} alkyl group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

[0077] Z_1 and Z_2 may be each independently selected from a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

[0078] d1 may be an integer selected from 1 to 4;

[0079] d2 may be an integer selected from 1 to 3;

[0080] d3 may be an integer selected from 1 to 6;

[0081] d4 may be an integer selected from 1 to 8;

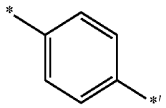
[0082] d5 may be 1 or 2;

[0083] d6 may be an integer selected from 1 to 5; and

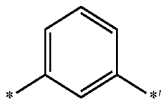
[0084] * and *' may be each independently a binding site with another atom.

[0085] In some other embodiments, in Formula 1, L_{11} and L_{12} may be each independently a group represented by one of Formulae 4-1 to 4-10, but are not limited thereto:

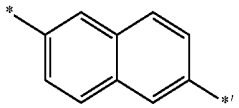
4-1



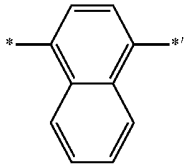
4-2



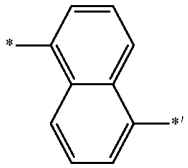
4-3



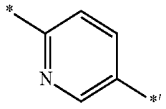
4-4



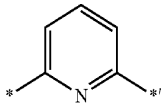
4-5



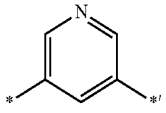
4-6



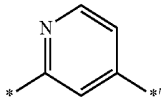
4-7



4-8



4-9



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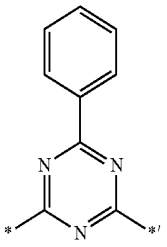
4-10



[0086] In Formulae 4-1 to 4-10, * and *' may be each independently a binding site with another atom.

[0087] In Formula 1, a11, which indicates the number of L_{11}s, may be an integer selected from 0 to 6. When a11 is an integer of 2 or more, a plurality of L_{11}s may be identical or different. When a11 is 0, $(L_{11})_{a11}$ may be a single bond.

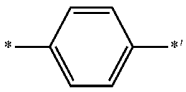
[0088] In some embodiments, in Formula 1, a11 may be 0 or 1, but is not limited thereto.

[0089] In Formula 1, a12, which indicates the number of L_{12}s, may be an integer selected from 0 to 6. When a12 is an integer of 2 or more, a plurality of L_{12}s may be identical or different. When a12 is 0, $(L_{12})_{a12}$ may be a single bond.

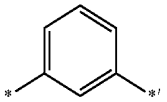
[0090] In some embodiments, in Formula 1, a12 may be 0 or 1, but is not limited thereto.

[0091] In some embodiments, in Formula 1, $(L_{11})_{a11}$ and $(L_{12})_{a12}$ may be each independently selected from, but not limited to, a single bond and a group represented by Formulae 4-21 to 4-32:

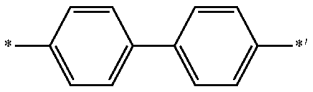
4-21



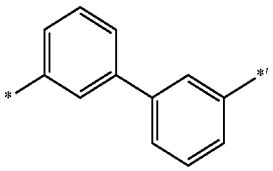
4-22



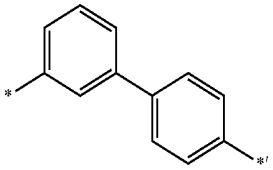
4-23



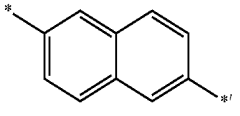
4-24



4-25



4-26



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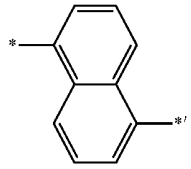
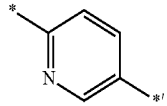
4-27



4-28



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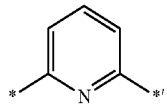

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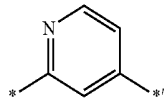
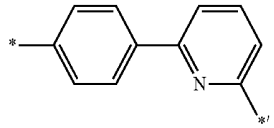
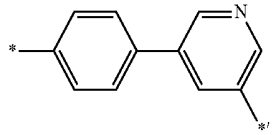


4-31



4-32



[0092] In Formulae 4-21 to 4-32,

[0093] * and *' may be each independently a binding site with another atom.

[0094] In Formula 1, R_{11} and R_{12} may be each independently selected from a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted non-aromatic condensed polycyclic group, a substituted or unsubstituted non-aromatic condensed heteropolycyclic group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$P(Q_{16})(Q_{17})$;

[0095] Q_{11} to Q_{17} may be each independently selected from a substituted or unsubstituted C_6-C_{60} aryl group and a substituted or unsubstituted C_1-C_{60} heteroaryl group;

[0096] at least one substituent of the substituted C_6-C_{60} aryl group, the substituted C_1-C_{60} heteroaryl group, the substituted non-aromatic condensed polycyclic group, and the substituted non-aromatic condensed heteropolycyclic group may be selected from:

[0097] a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

[0098] a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0099] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0100] a C_3-C_{10} cycloalkyl group, a C_1-C_{60} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{60} 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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group.

[0101] In some embodiments, in Formula 1, R_{11} and R_{12} may be each independently selected from:

[0102] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$P(Q_{16})(Q_{17})$; and

[0103] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl

group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 cyclohexcenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group; and

[0104] Q_{11} to Q_{17} may be each independently selected from:

[0105] a phenyl group, a naphthyl group, a fluorenyl group, an anthracenyl group, a pyrenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, and a triazinyl group; and

[0106] a phenyl group, a naphthyl group, a fluorenyl group, an anthracenyl group, a pyrenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 cyclohexcenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group. However, embodiments of the present disclosure are not limited thereto.

[0107] In some other embodiments, in Formula 1, R_{11} and R_{12} may be each independently selected from:

[0108] a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, an imidazole group, a benzimidazole group, a triazolyl group, a triazinyl group, an oxadiazolyl group, a quinolinyl group, an isoquinolinyl group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$P(Q_{16})(Q_{17})$;

[0109] a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, an imidazole group, a benzimidazole group, a triazole group, a triazine group, an oxadiazolyl group, a quinolinyl group, and an isoquinolinyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_1-C_{20} alkyl group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0110] Q_{11} to Q_{17} may be each independently selected from:

[0111] a phenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a carbazolyl group, and a triazinyl group; and

[0112] a phenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_1-C_{20} alkyl group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group.

[0113] In some other embodiments, R_{11} and R_{12} in Formula 1 may be each independently selected from, but not limited to, a group represented by Formulae 5-1 to 5-39:

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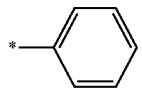

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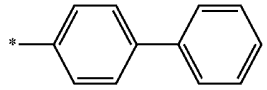

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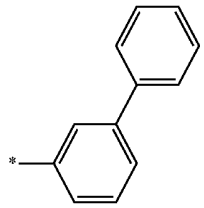

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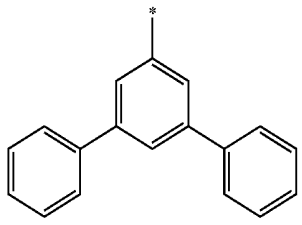

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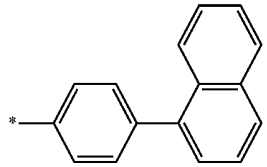

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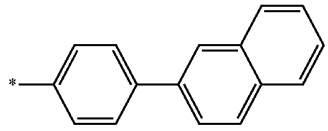

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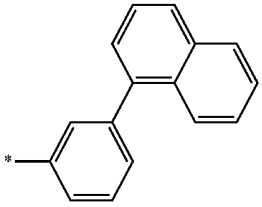

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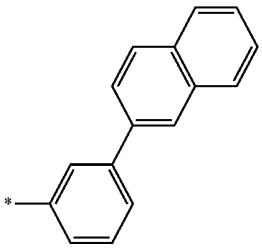

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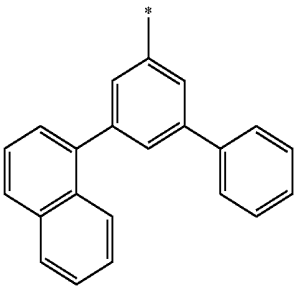

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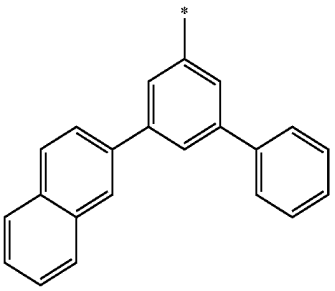

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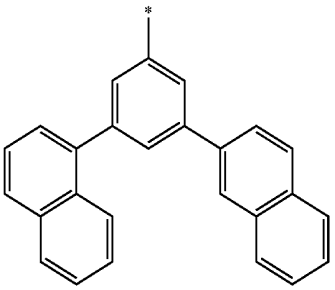

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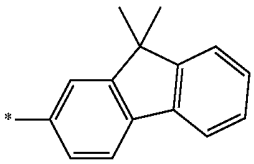

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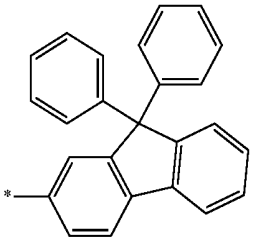

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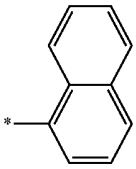

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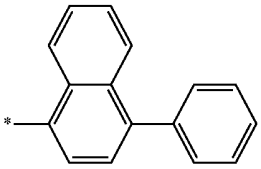

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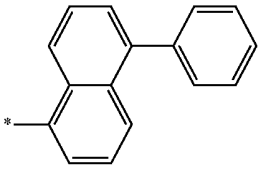

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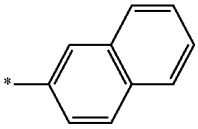

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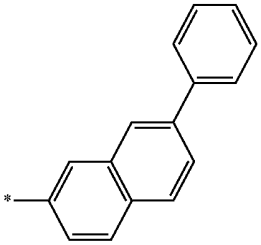

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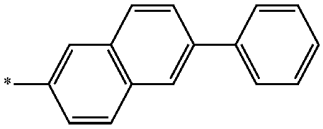

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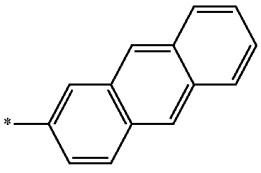

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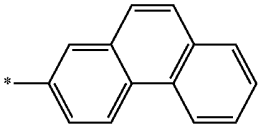

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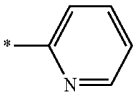

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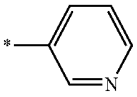

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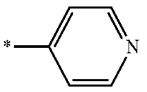

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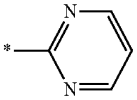

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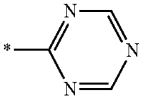

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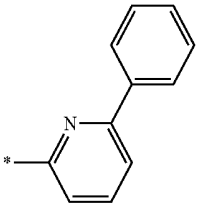

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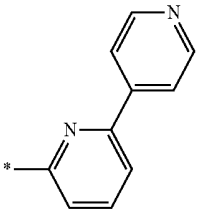

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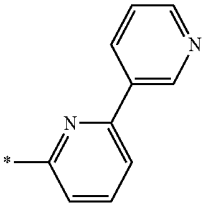

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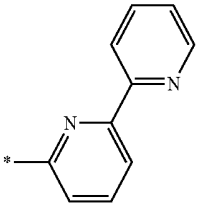

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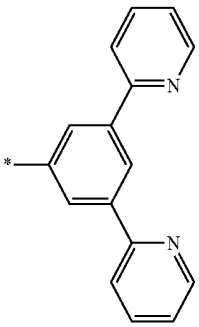

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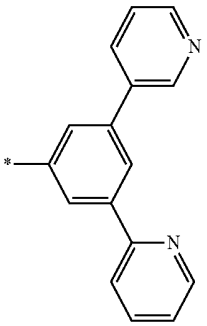

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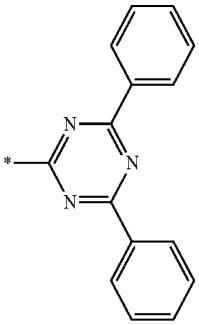

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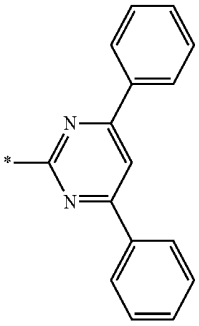

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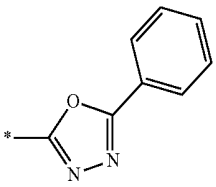

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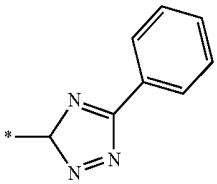

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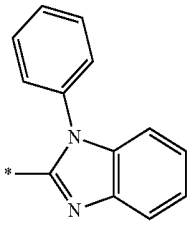

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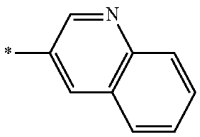

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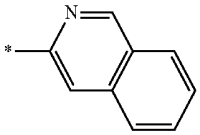


[0114] In Formulae 5-1 to 5-39, * may be each independently a binding site with another atom.

[0115] In Formula 1, b11, which indicates the number of R_{11}s, may be an integer selected from 1 to 3. When b11 is an integer of 2 or more, a plurality of R_{11}s may be identical or different.

[0116] For example, b11 may be an integer of 1, but is not limited thereto.

[0117] In Formula 1, b12, which indicates the number of R_{12}s, may be an integer selected from 1 to 3. When b12 is an integer of 2 or more, a plurality of R_{12}s may be identical or different.

[0118] For example, b12 may be 1, but is not limited thereto.

[0119] In Formula 1, R_{13} and R_{14} may be each independently selected from:

[0120] a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

[0121] a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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} 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} group, a

C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0122] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0123] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group.

[0124] In some embodiments, R_{13} and R_{14} in Formula 1 may be each independently selected from, but not limited to,

[0125] a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a nitro group, and a C_1-C_{60} alkyl group;

[0126] a C_1-C_{60} alkyl group substituted with at least one of a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

[0127] a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

[0128] a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_1-C_{60} alkyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group.

[0129] In some other embodiments, R_{13} and R_{14} in Formula 1 may be each independently selected from, but not limited to, a hydrogen atom, a methyl group, an ethyl group, a phenyl group, and a pyridinyl group.

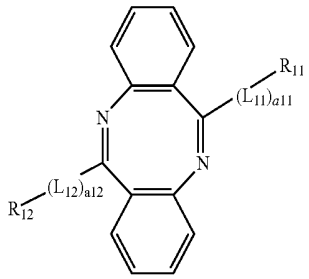
[0130] For example, each of R_{13} and R_{14} in Formula 1 may be a hydrogen atom, but R_{13} and R_{14} are not limited thereto.

[0131] In Formula 1, b13, which indicates the number of R_{13}s, may be an integer selected from 1 to 10. When b13 is an integer of 2 or more, a plurality of R_{13}s may be identical or different.

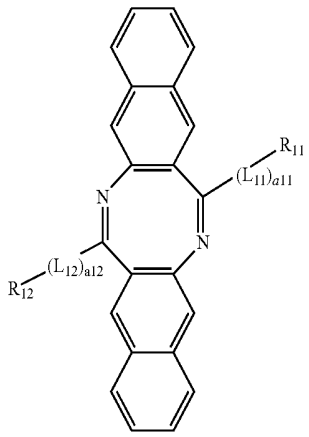
[0132] In Formula 1, b14, which indicates the number of R_{14}s, may be an integer selected from 1 to 10. When b14 is an integer of 2 or more, a plurality of R_{14}s may be identical or different.

[0133] In some embodiments, the antiaromatic compound of Formula 1 may be represented by one of Formulae 1A to 1E:

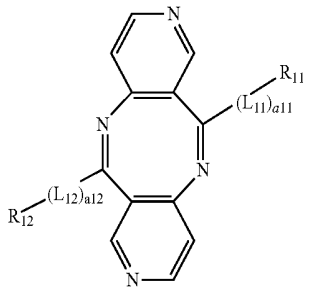
Formula 1A



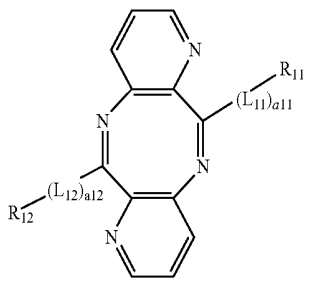
Formula 1B



Formula 1C



Formula 1D



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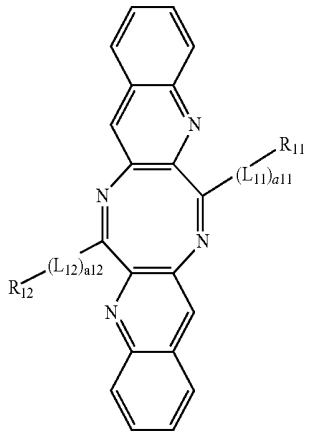
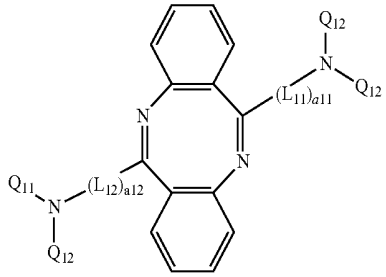
Formula 1E



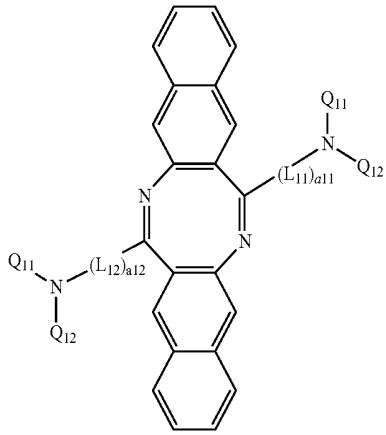
[0134] In Formulae 1A to 1E, L_{11}, L_{12}, a11, a12, R_{11}, and R_{12} may be the same as those defined above.

[0135] For example, the antiaromatic compound of Formula 1 may be represented by one of Formulae 1F to 1J:

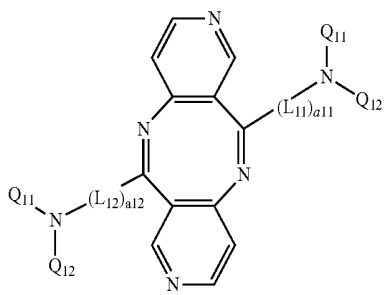
Formula 1F



Formula 1G



Formula 1H



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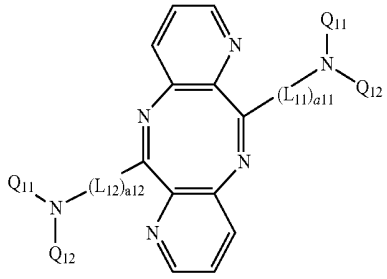
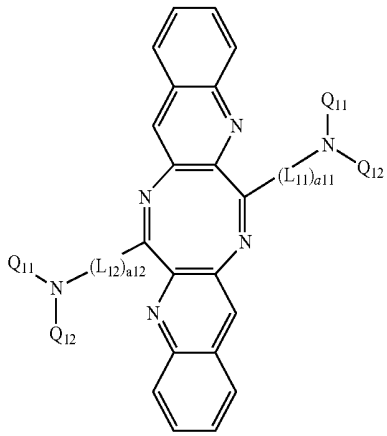
Formula 1I



Formula 1J



[0136] In Formulae 1F to 1 J, L_{11}, L_{12}, a11, a12, Q_{11}, and Q_{12} may be the same as those defined above.

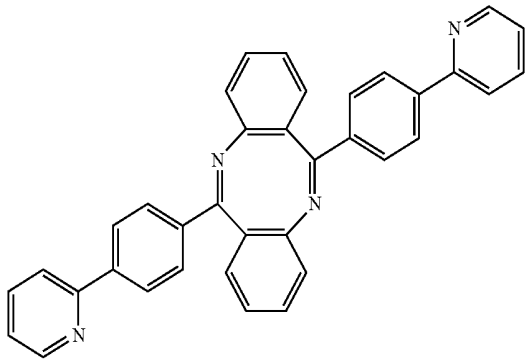
[0137] In some embodiments, the antiaromatic compound may be represented by one of Formulae 1A to 1E, wherein, in Formulae 1A to 1E, L_{11} and L_{12} may be each independently represented by one of Formulae 4-1 to 4-10; a11 and a12 may be each independently 0 or 1; and R_{11} and R_{12} may be each independently a group represented by one of Formulae 5-1 to 5-39. However, embodiments of the present disclosure are not limited thereto.

[0138] In some embodiments, the antiaromatic compound may be represented by one of Formulae 1A and 1B, wherein, in Formulae 1A and 1B, L_{11} and L_{12} may be each independently represented by one of Formulae 4-1 to 4-10; a11 and a12 may be each independently 0 or 1; and R_{11} and R_{12} may be each independently a group represented by one of Formulae 5-22 to 5-39. However, embodiments of the present disclosure are not limited thereto.

[0139] In some embodiments, the antiaromatic compound may be represented by one of Formulae 1C to 1E, wherein, in Formulae 1C to 1E, L_{11} and L_{12} may be each independently represented by one of Formulae 4-1 to 4-5; a11 and a12 may be each independently 0 or 1; and R_{11} and R_{12} may be each independently a group represented by one of Formulae 5-1 to 5-21. However, embodiments of the present disclosure are not limited thereto.

[0140] In some embodiments, the antiaromatic compound of Formula 1 may be one selected from the following compounds 1 to 247. However, embodiments of the present disclosure are not limited thereto:

1



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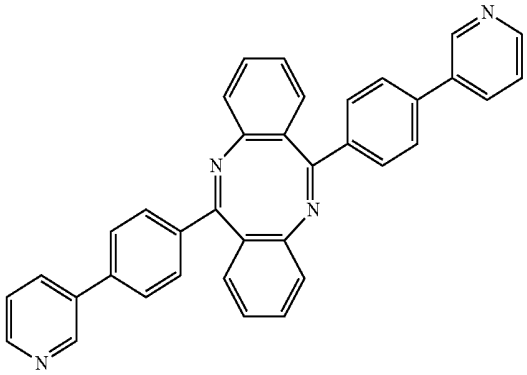

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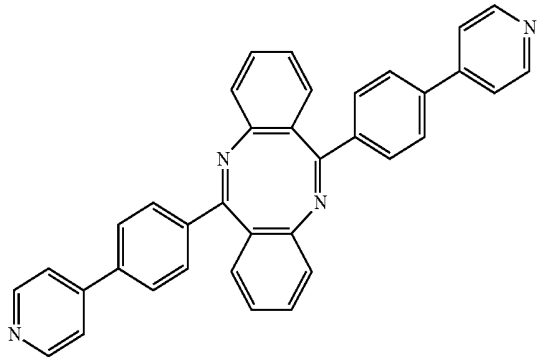

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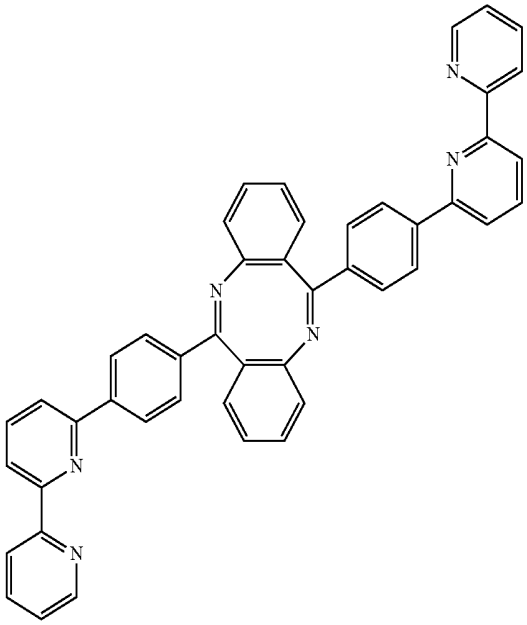

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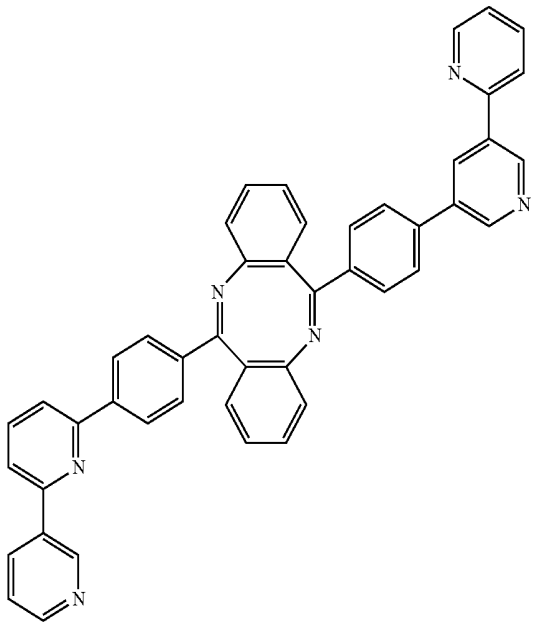

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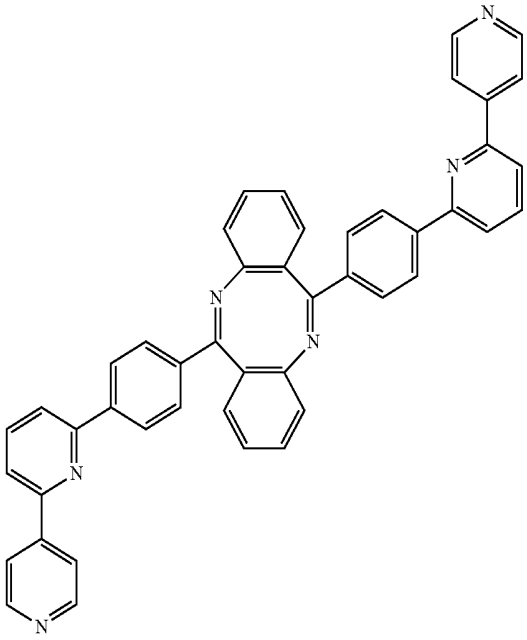

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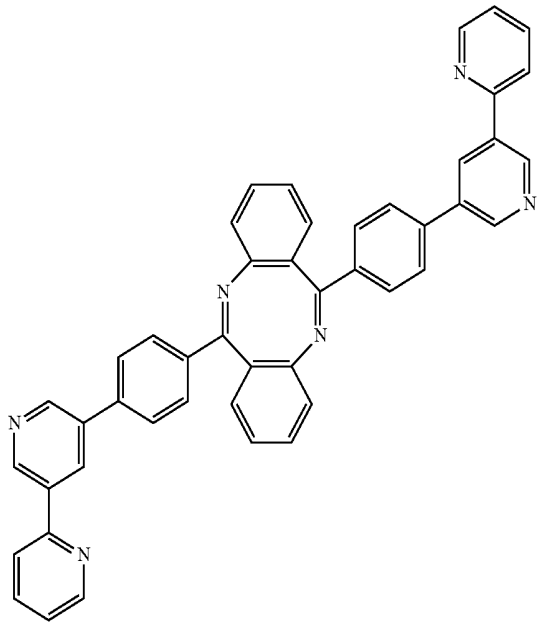

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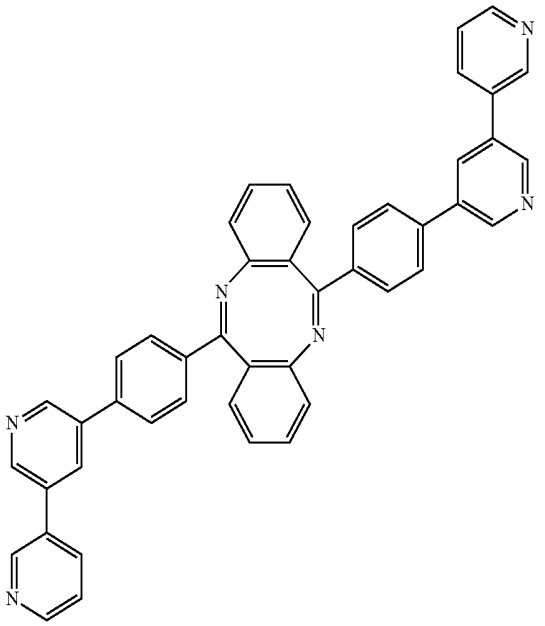

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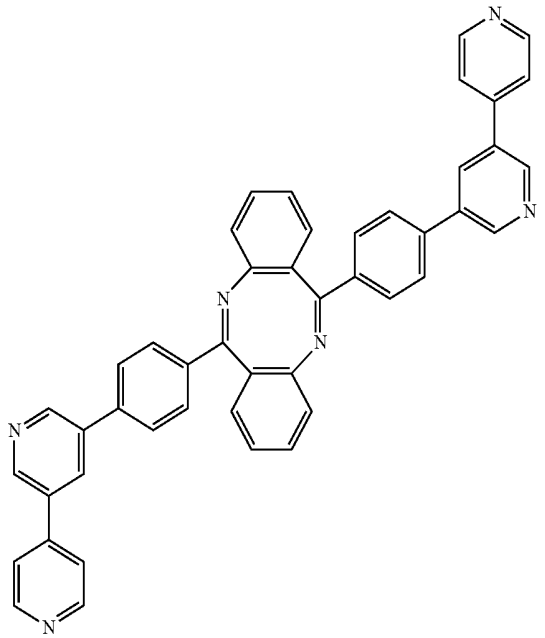

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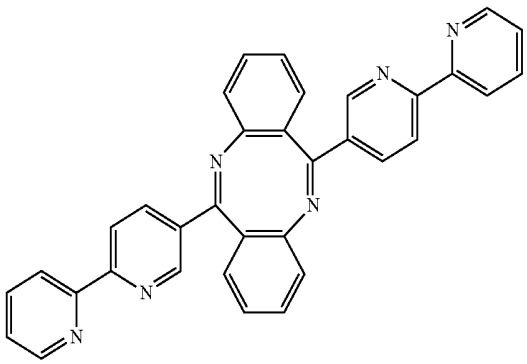

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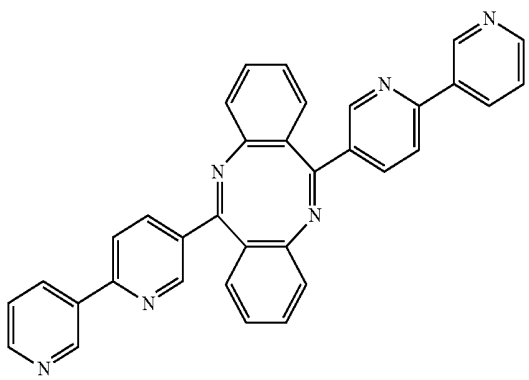

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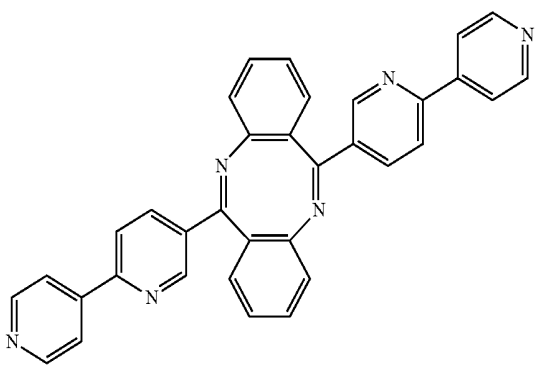

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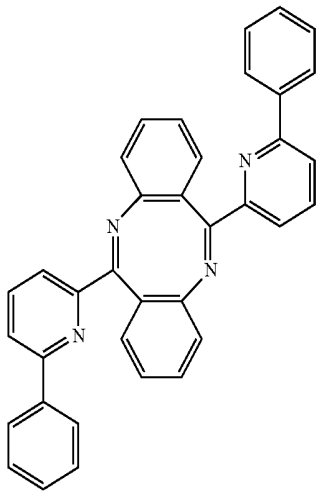

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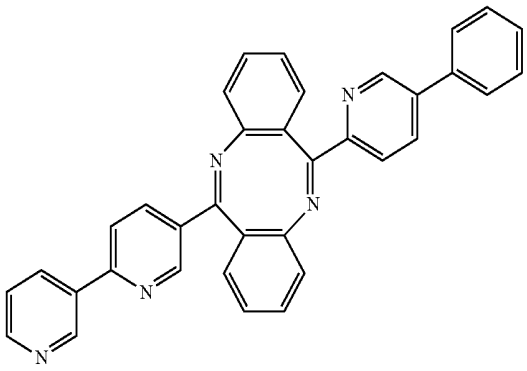

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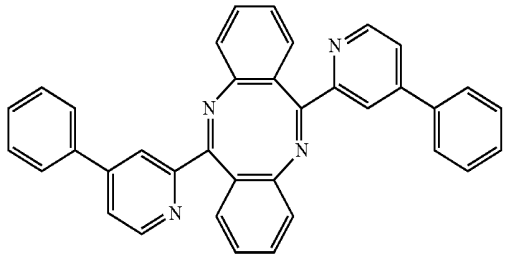

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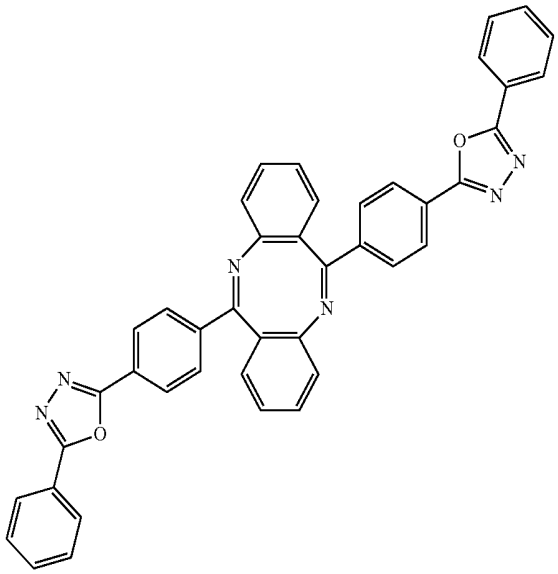

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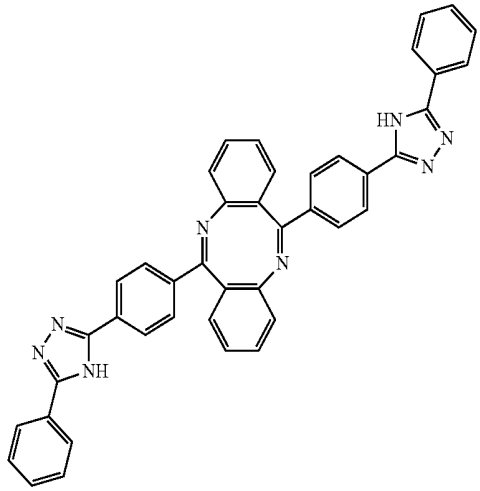

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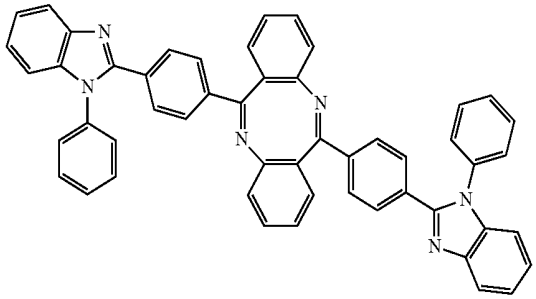

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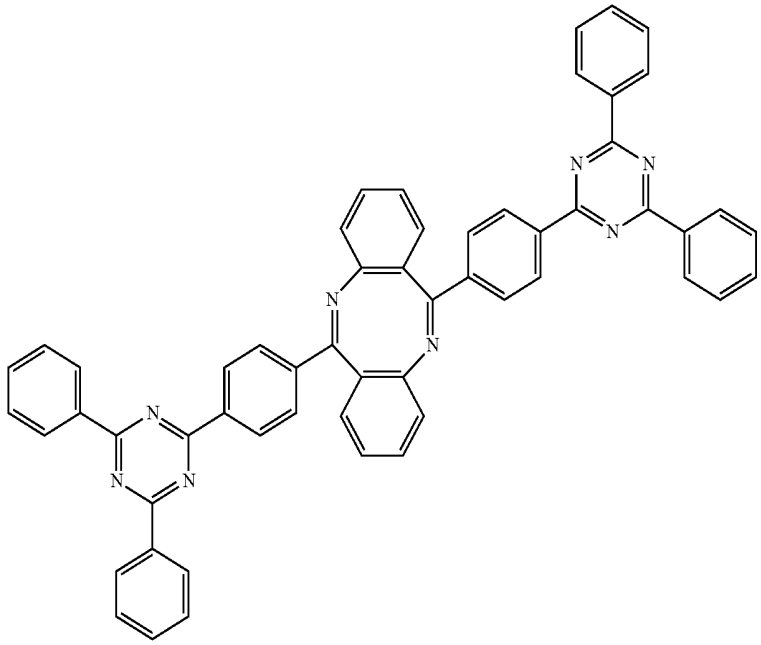

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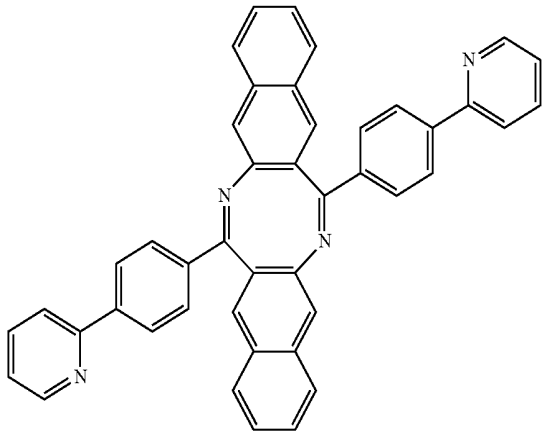

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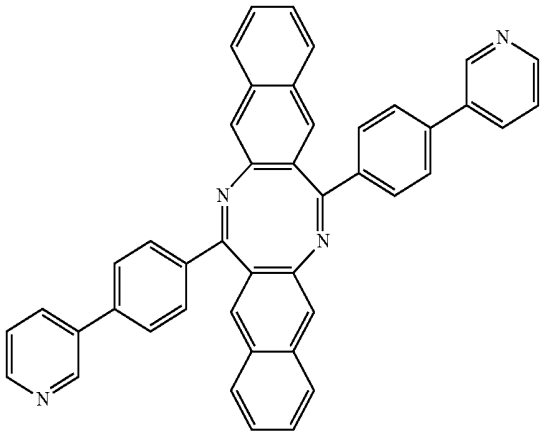

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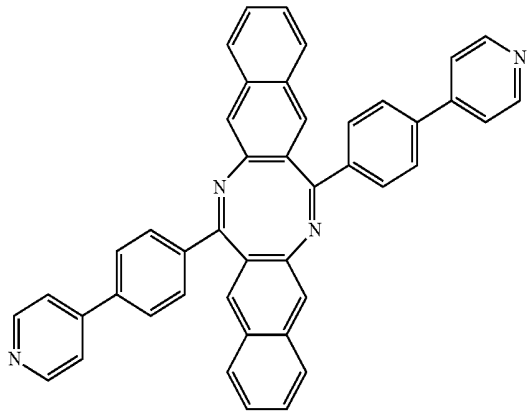

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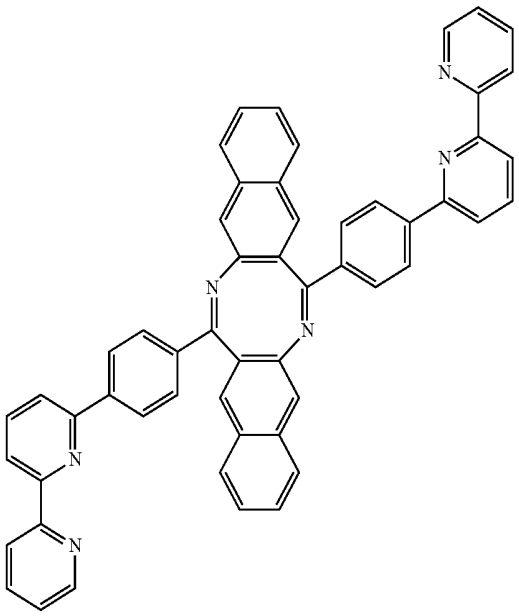

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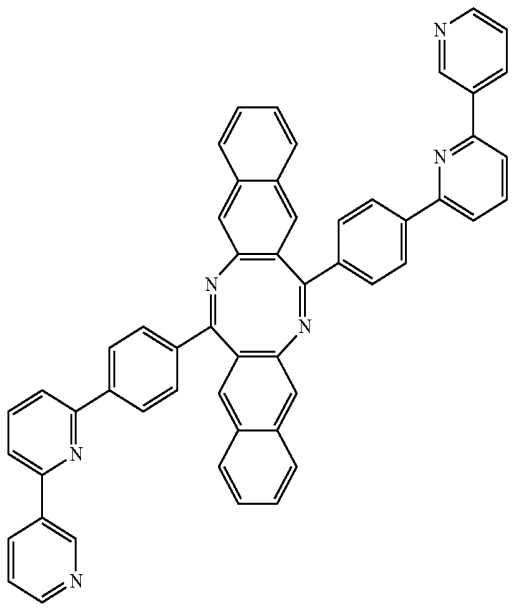

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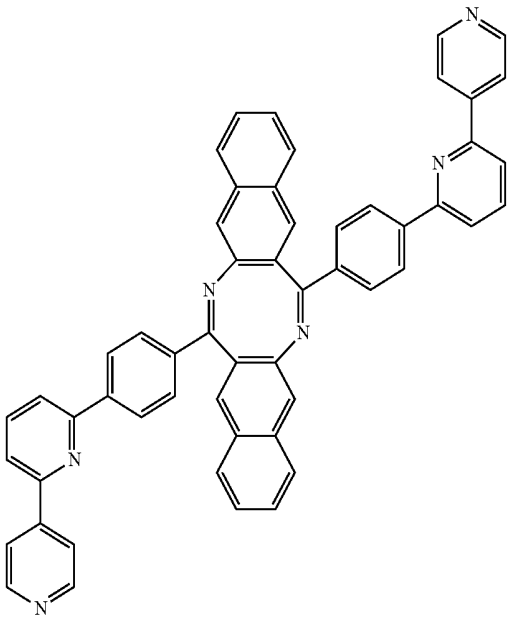

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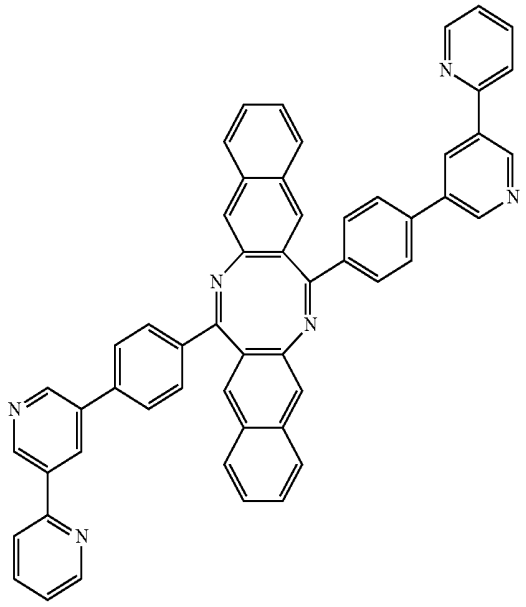

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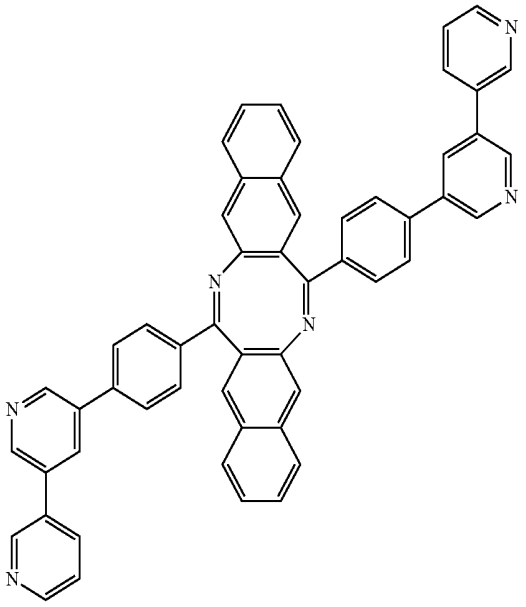

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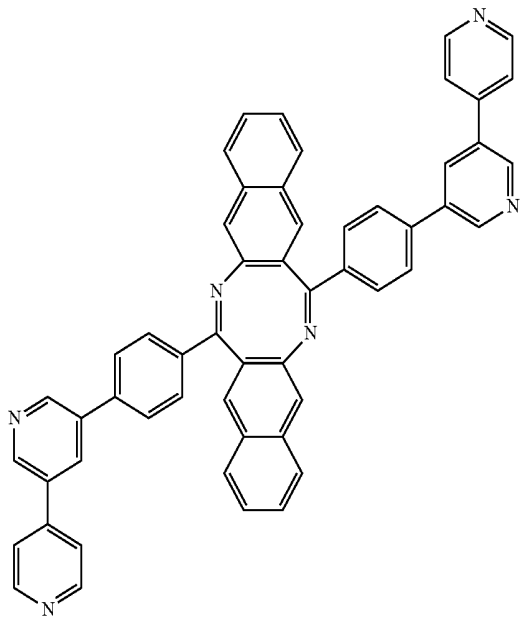

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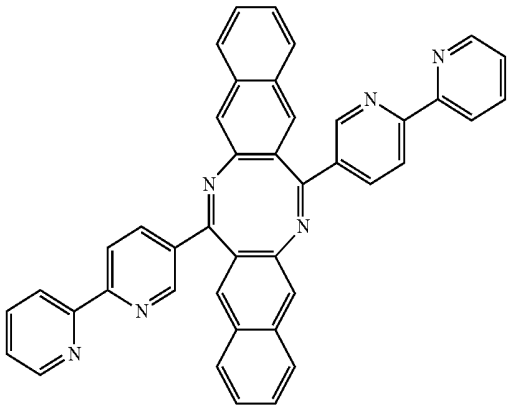

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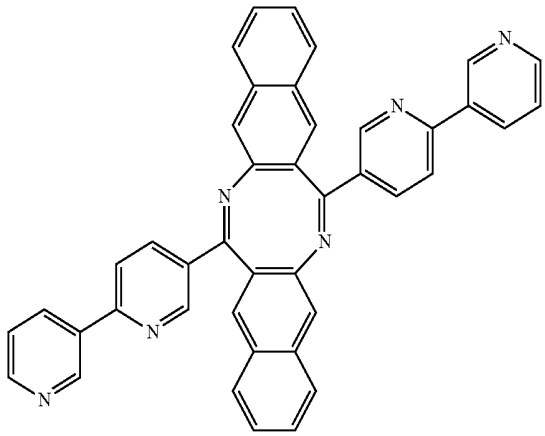

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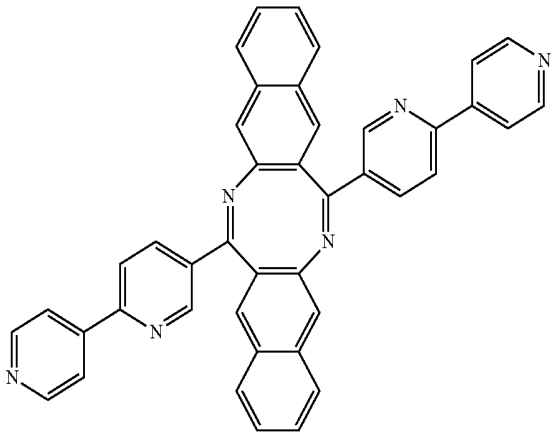

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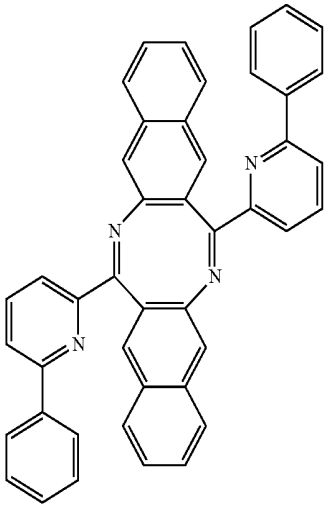

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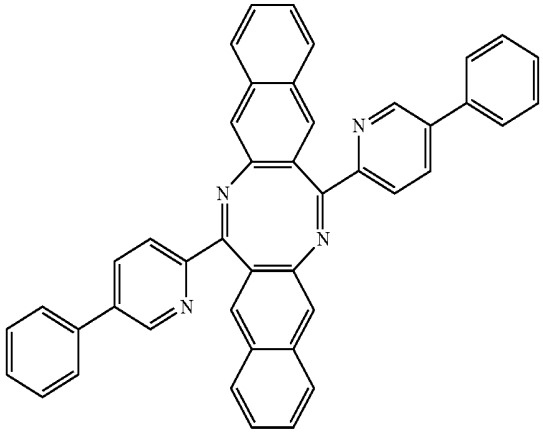

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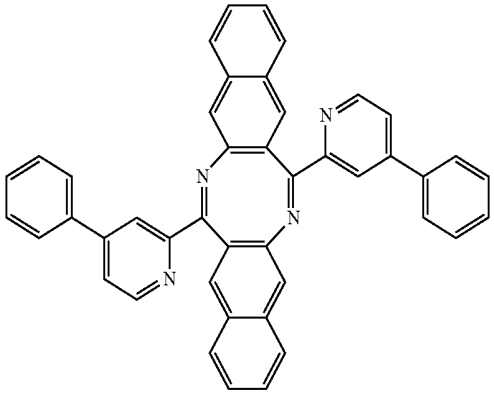

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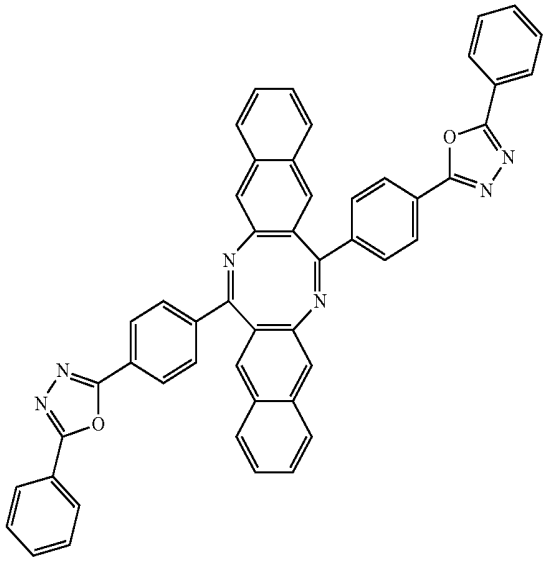

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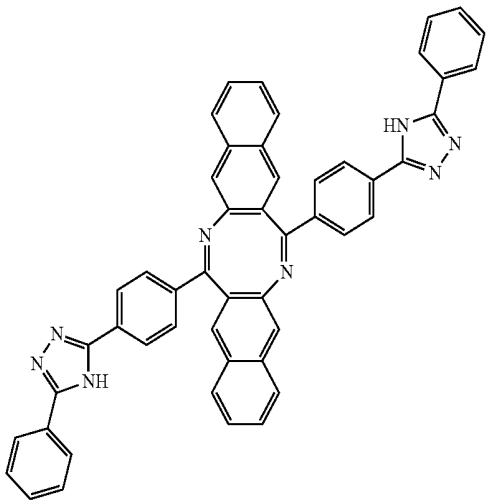

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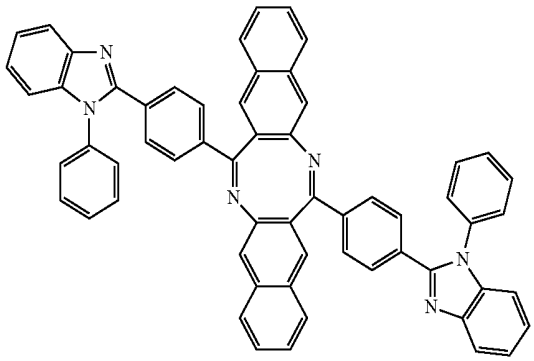

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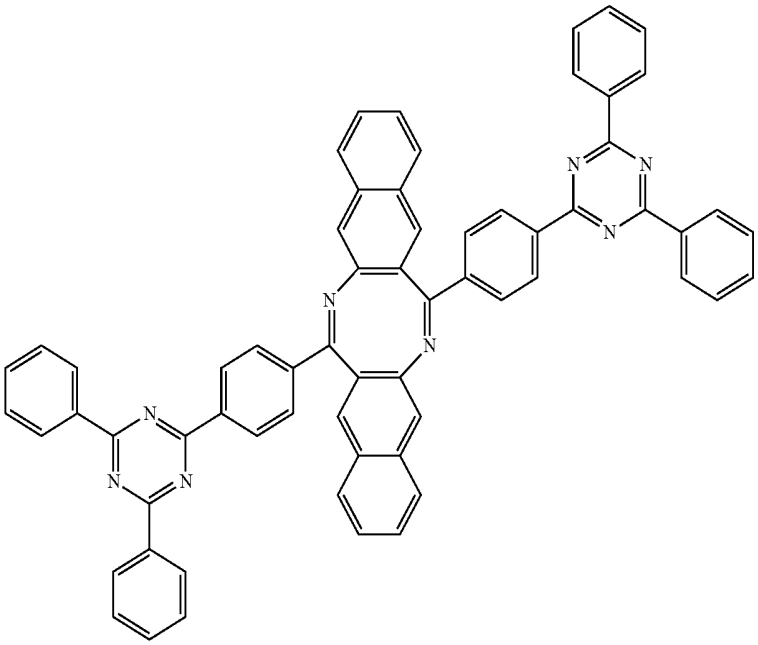

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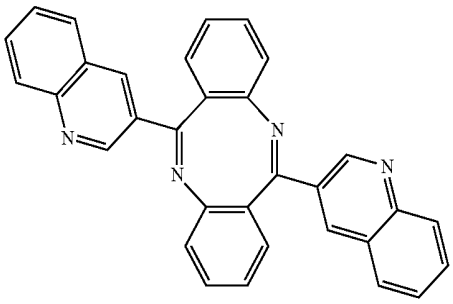

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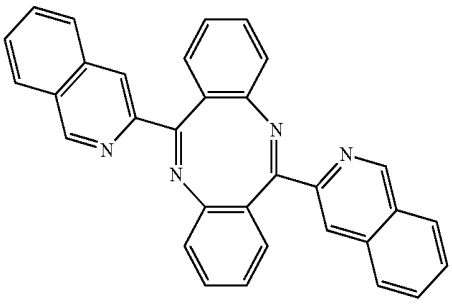

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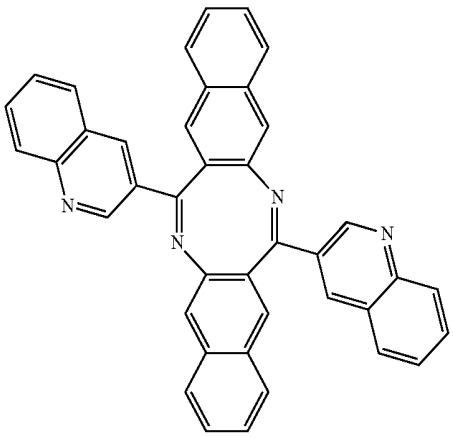

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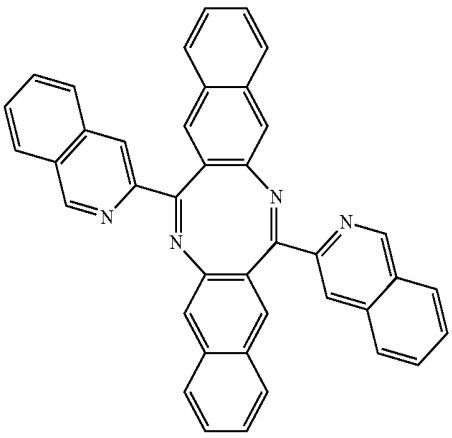

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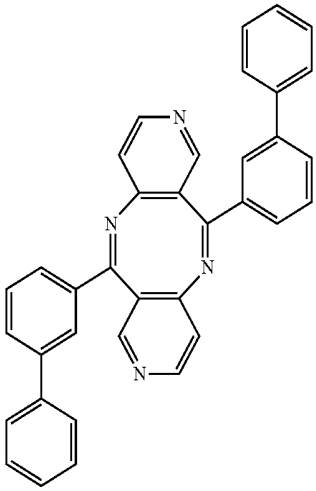

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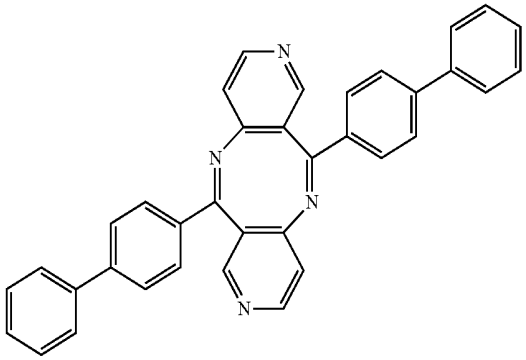

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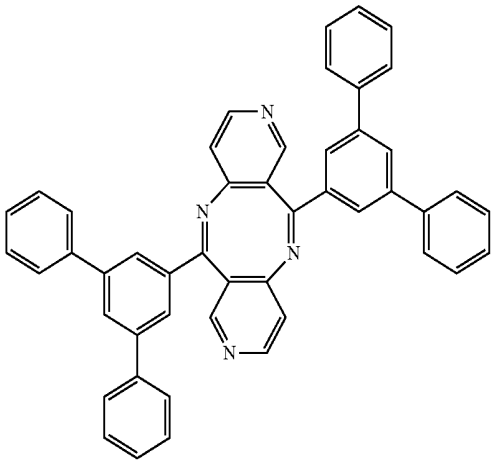

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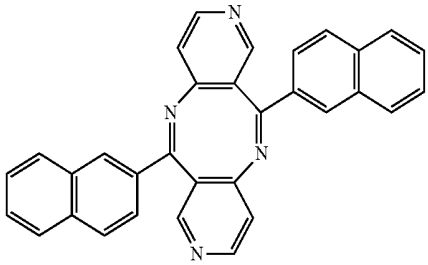

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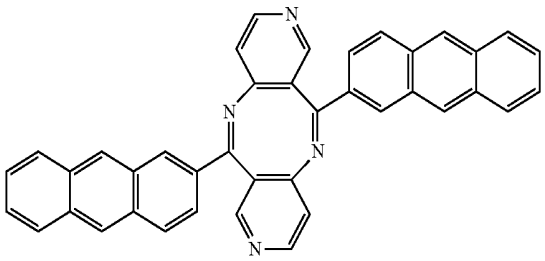

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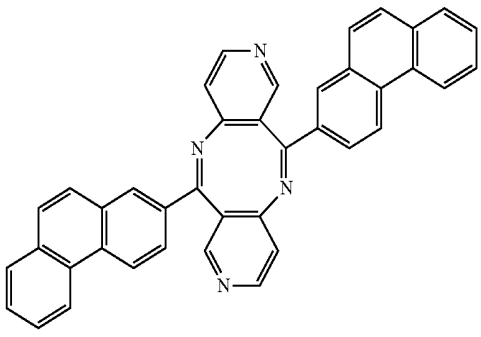

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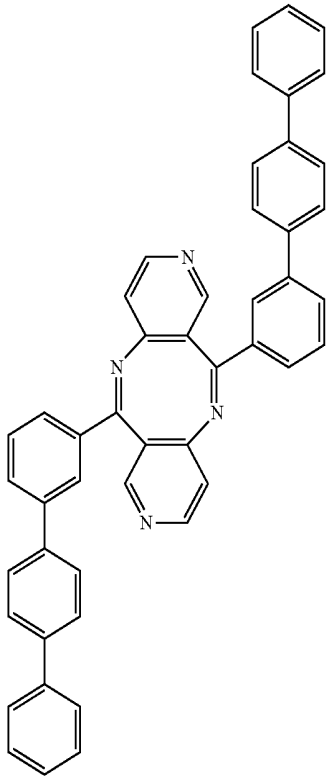

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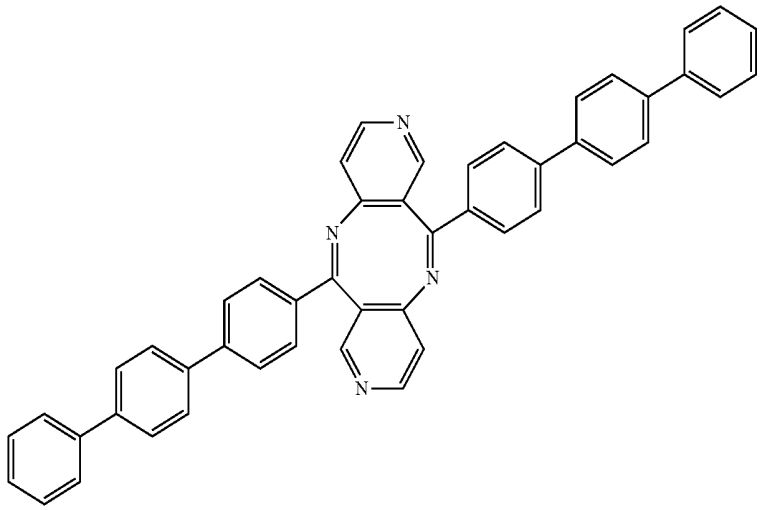

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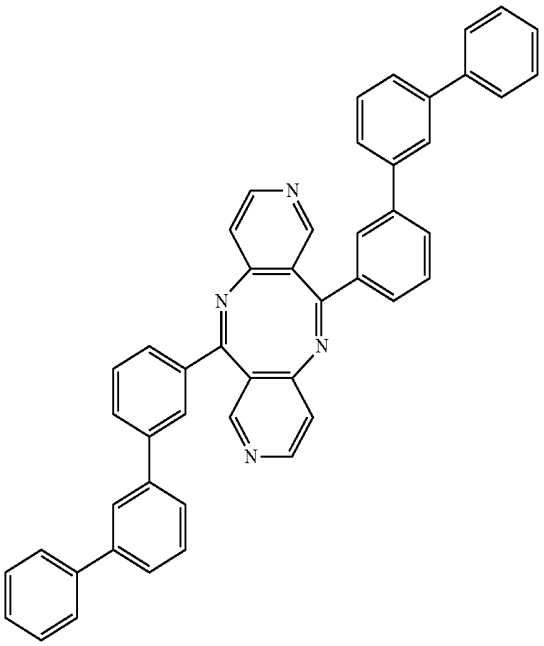

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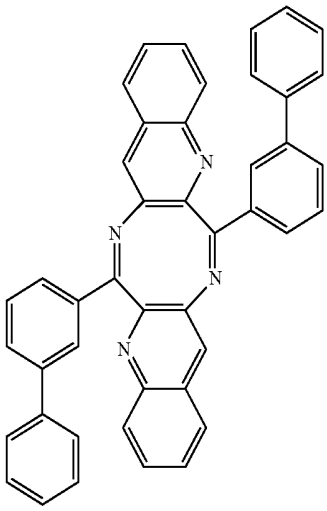

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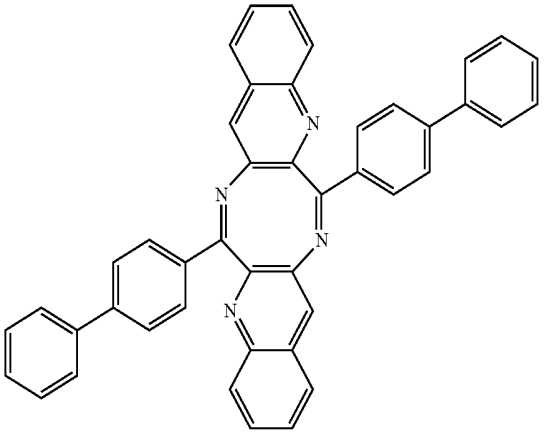

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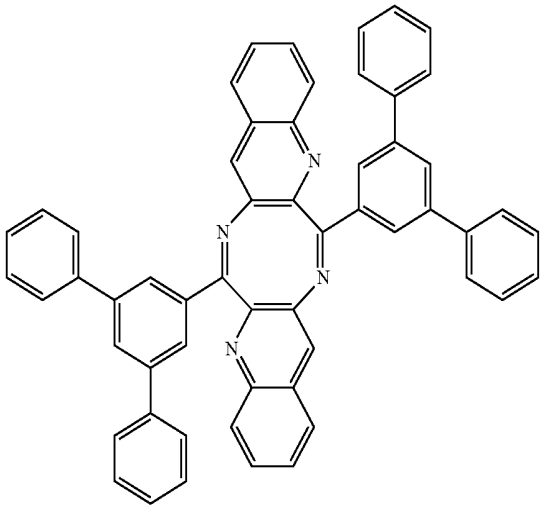

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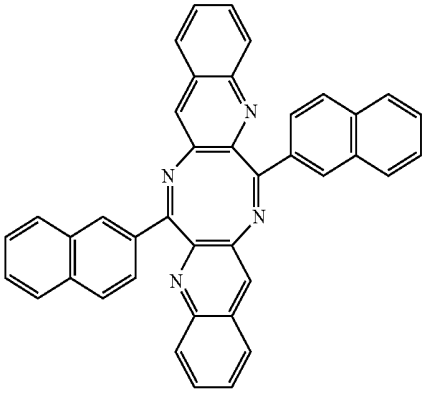

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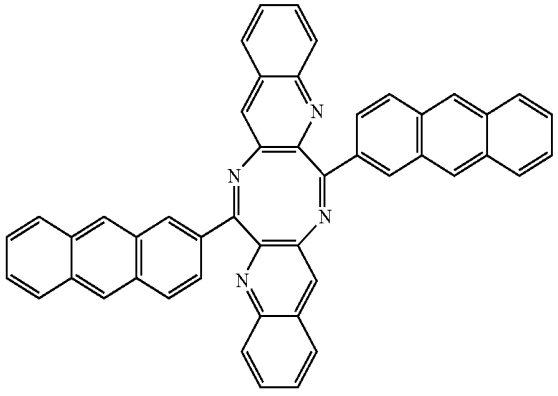

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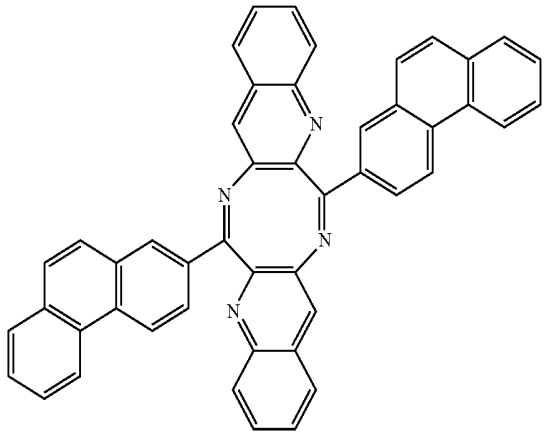

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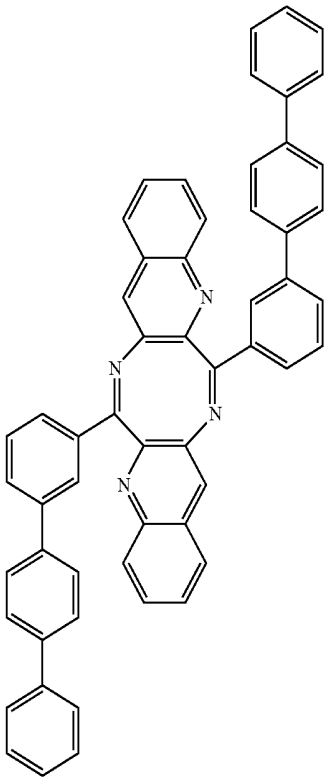

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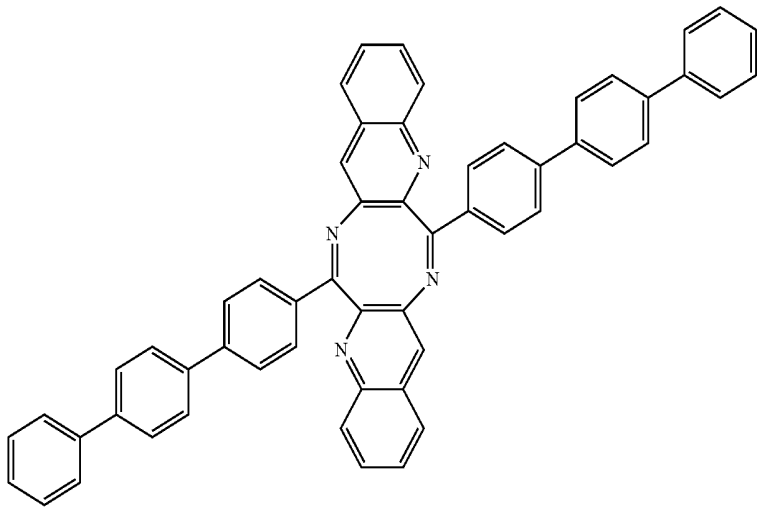

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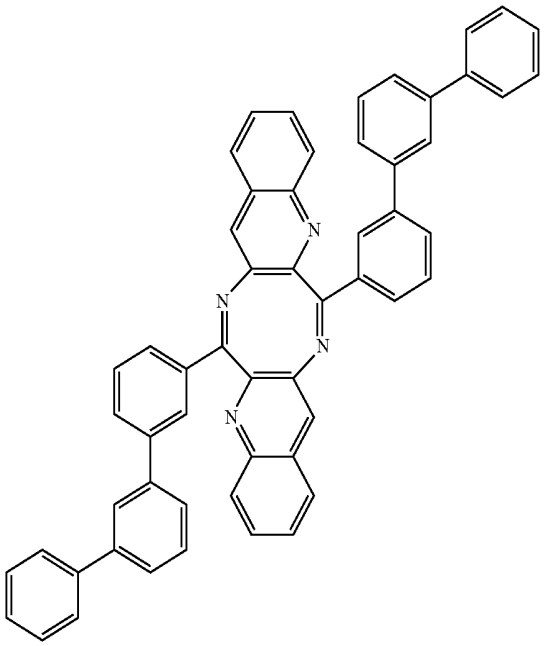

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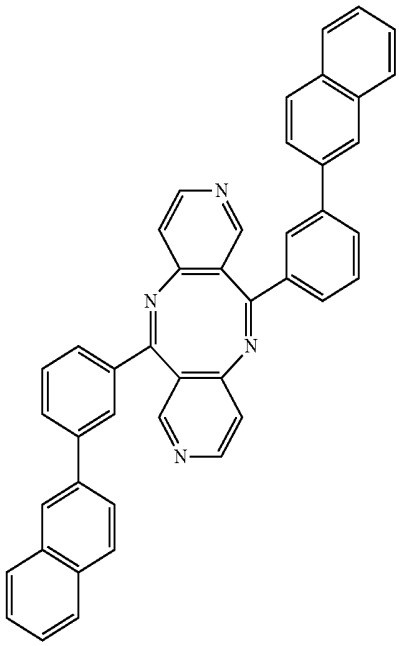

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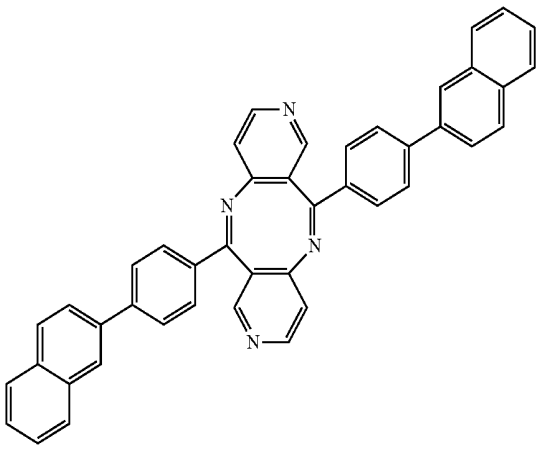

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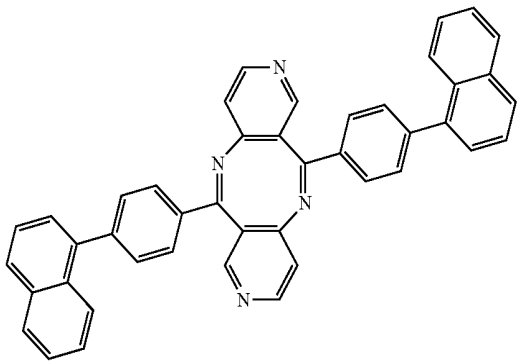

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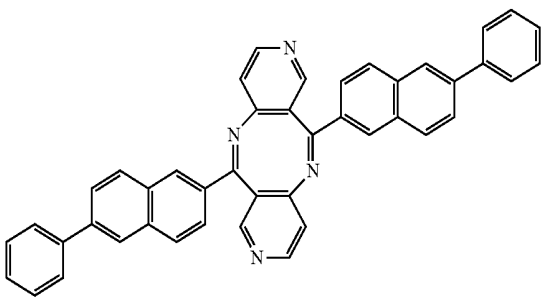

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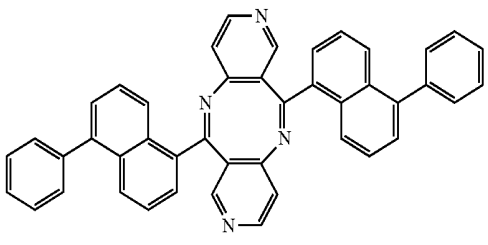

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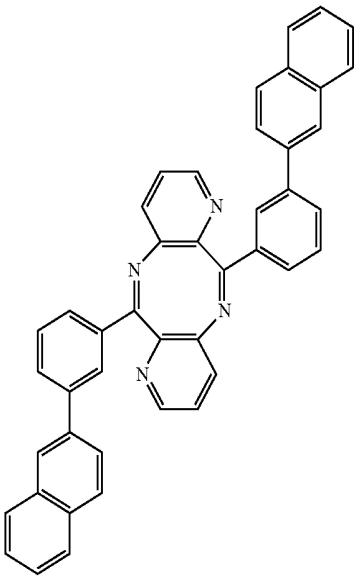

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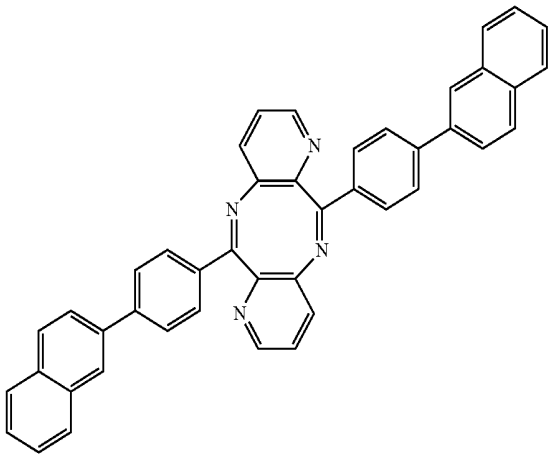

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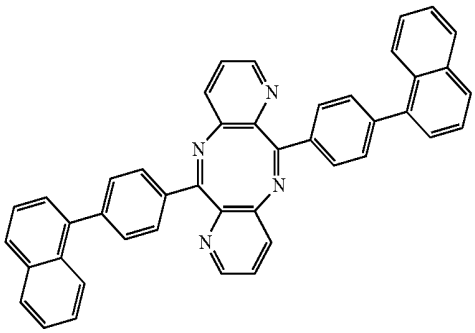

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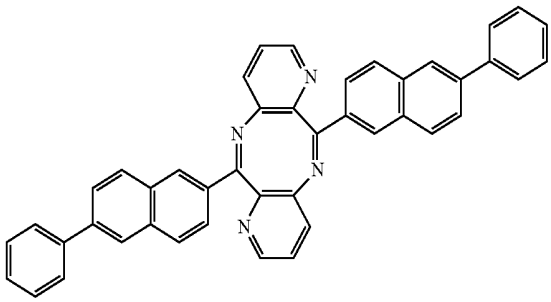

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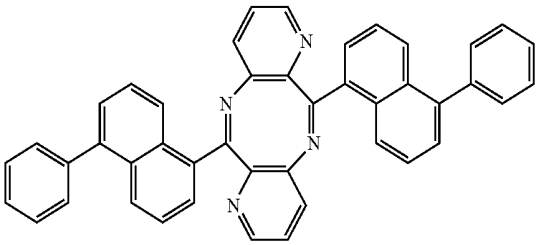

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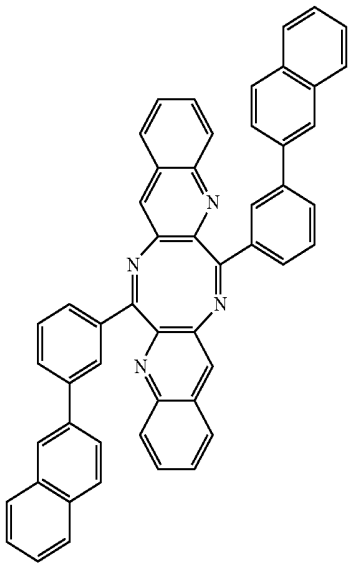

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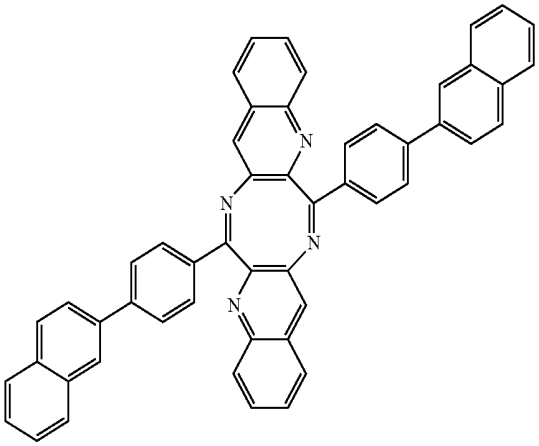

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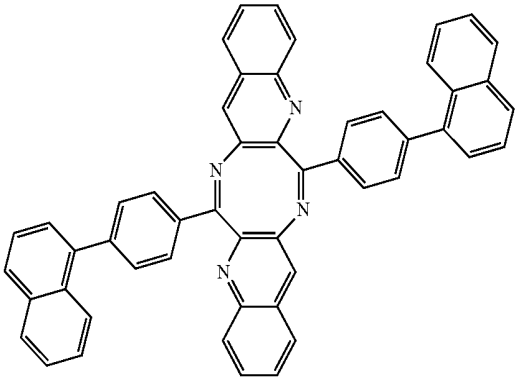

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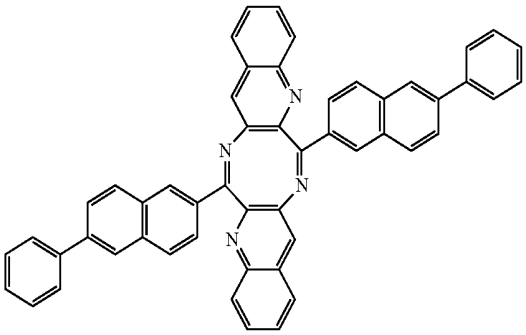

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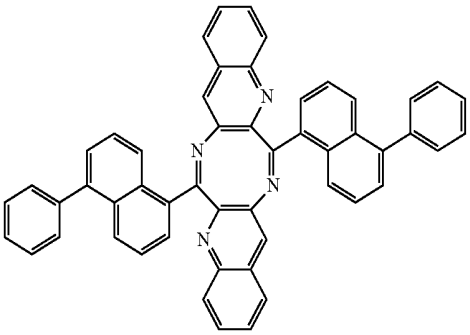

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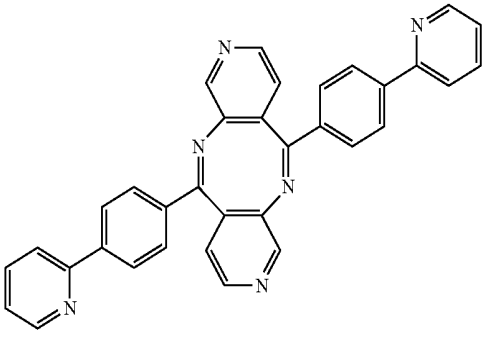

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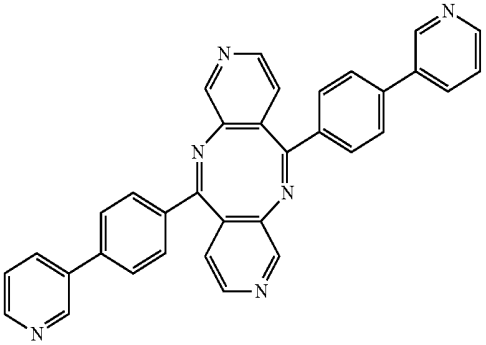

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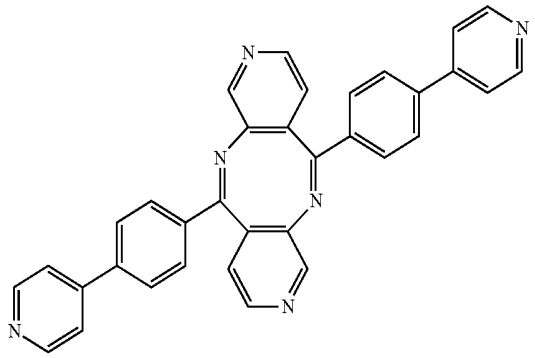

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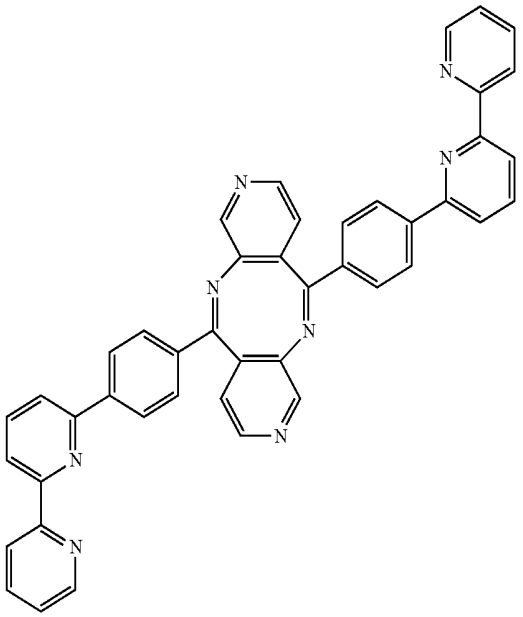

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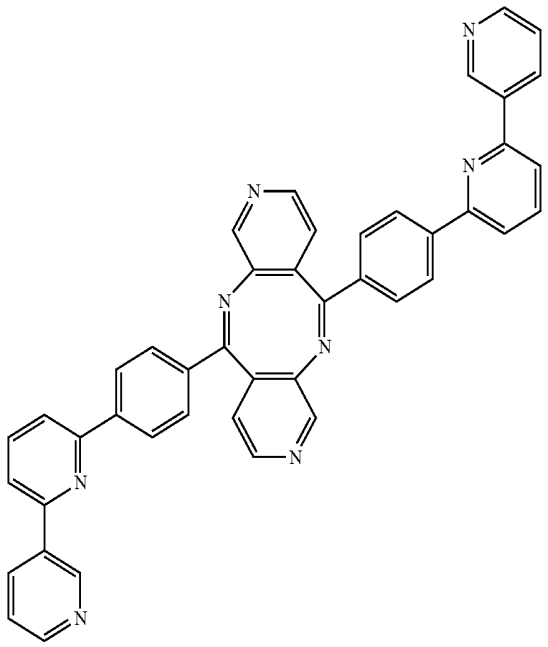

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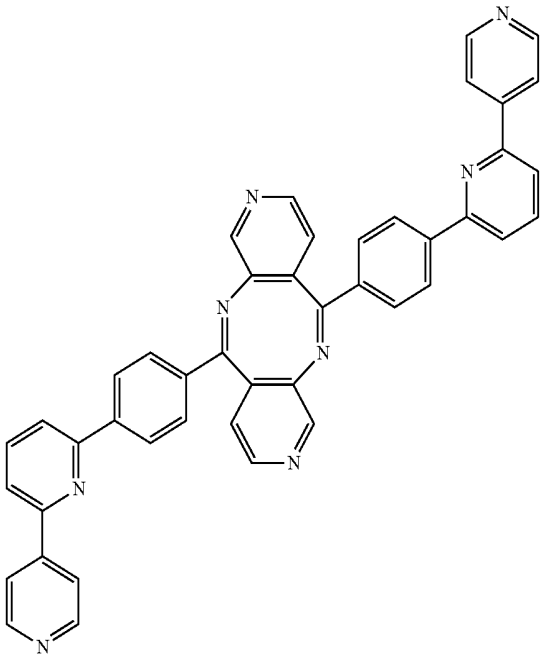

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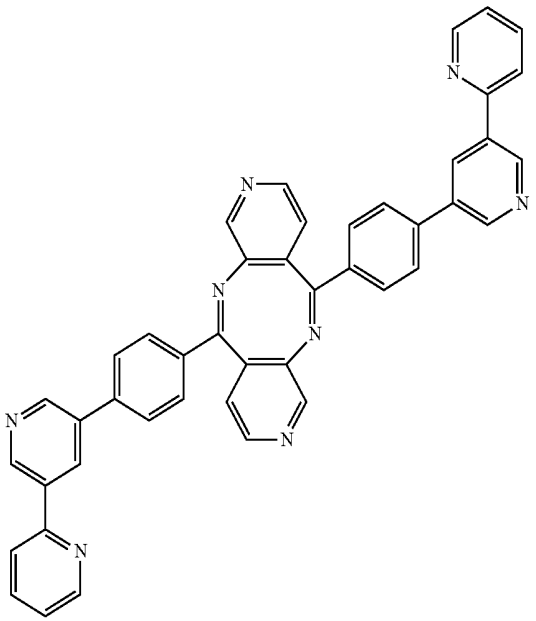

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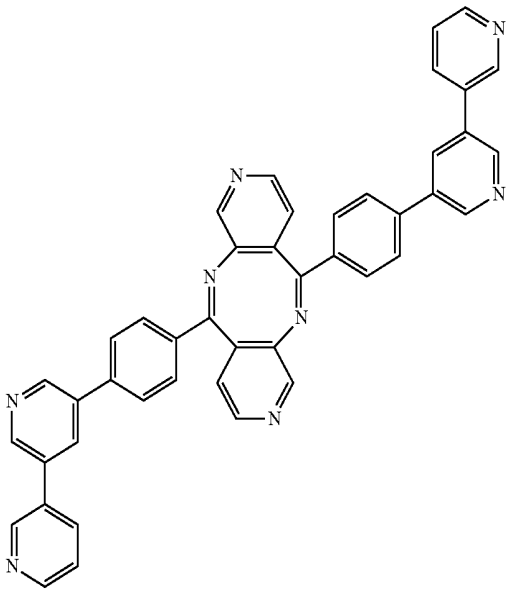

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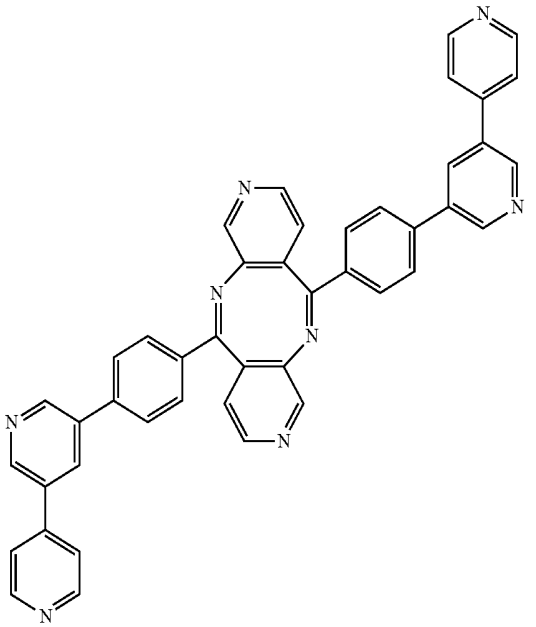

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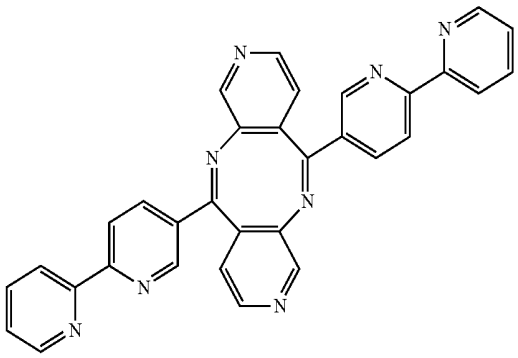

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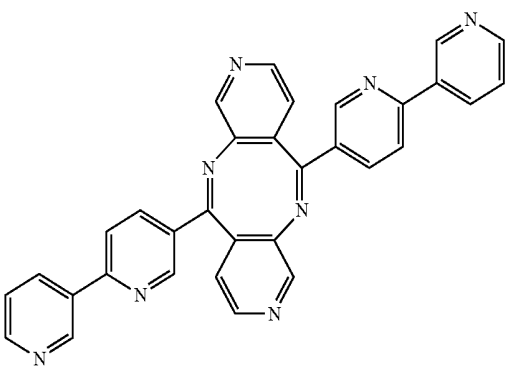

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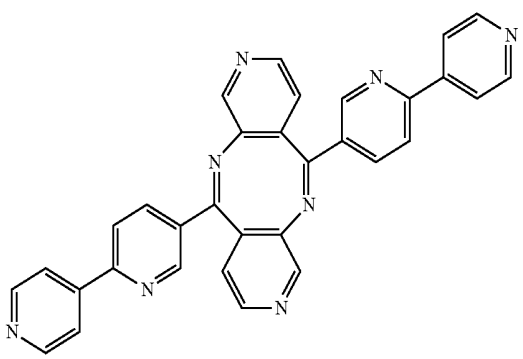

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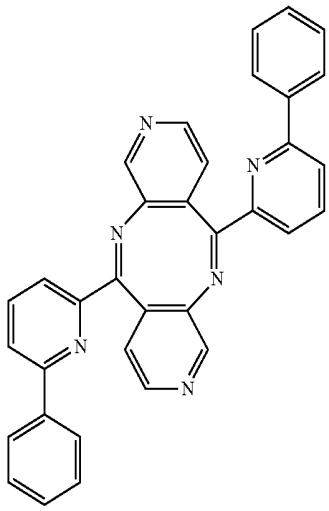

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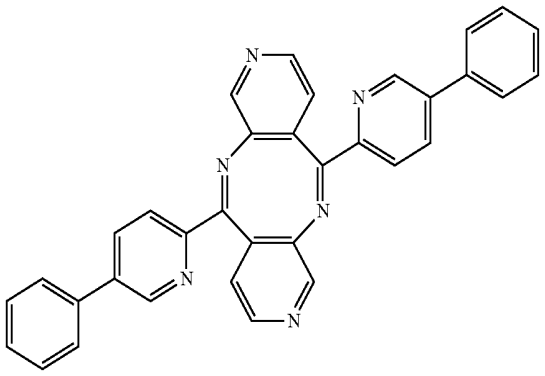

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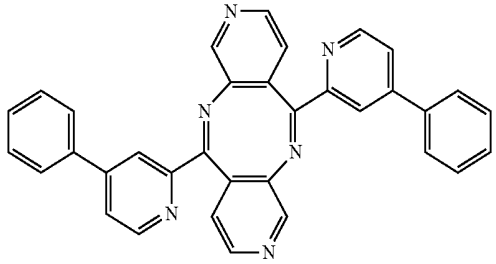

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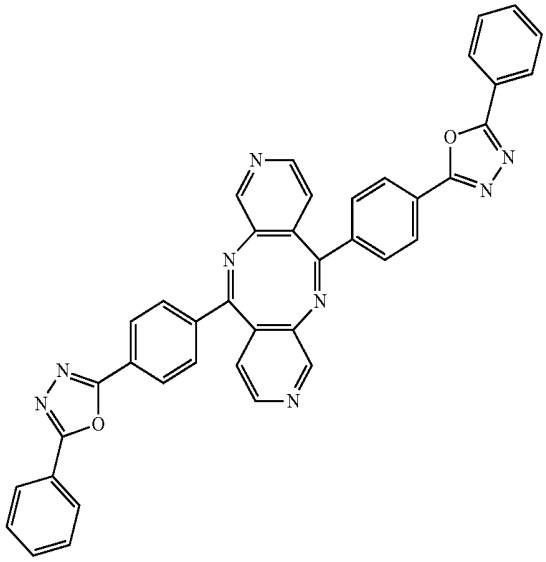

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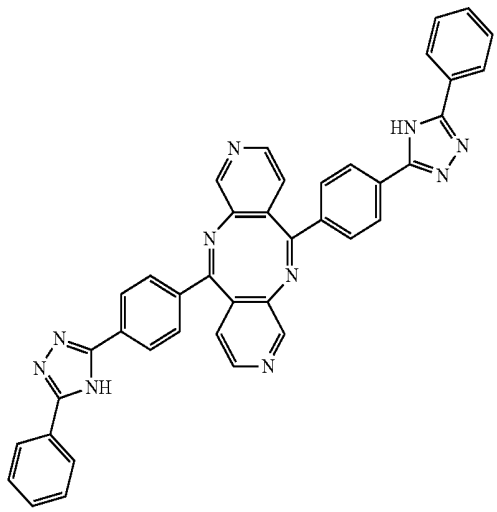

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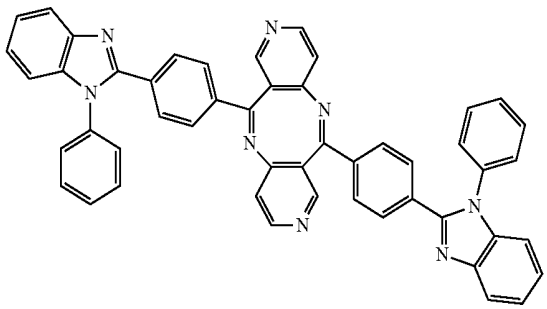

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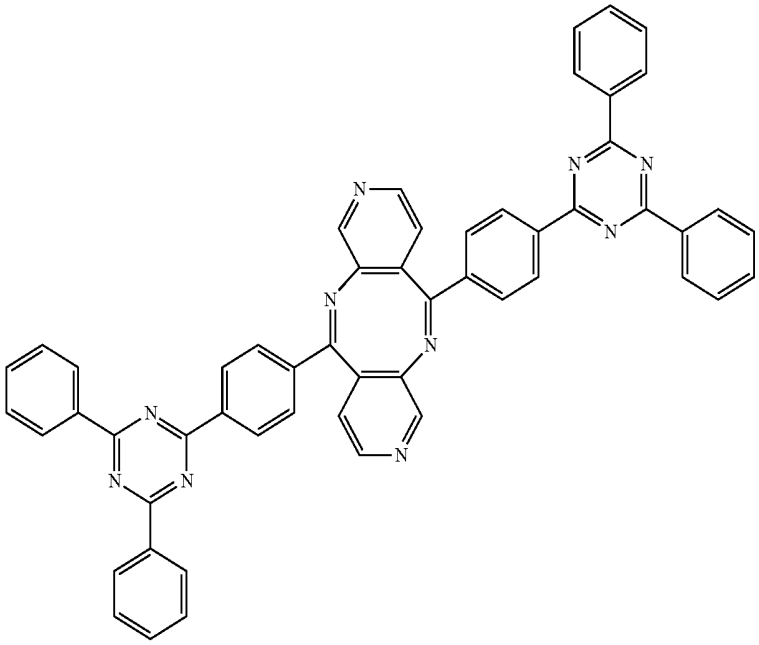

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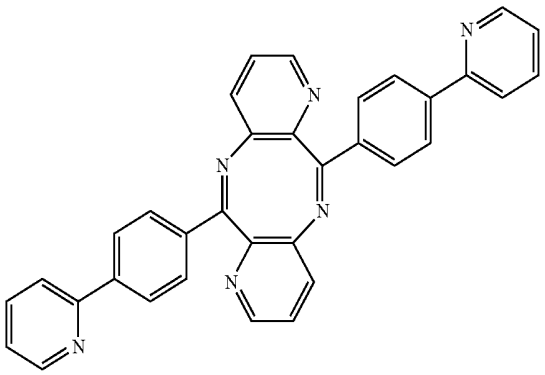

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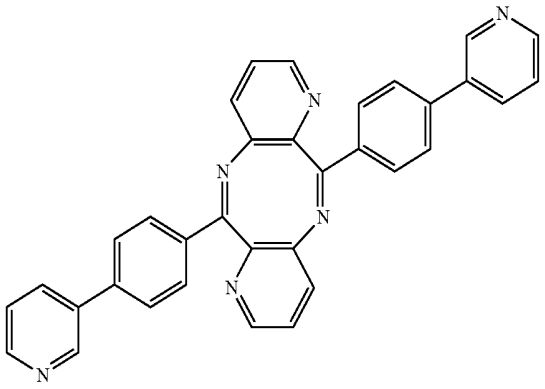

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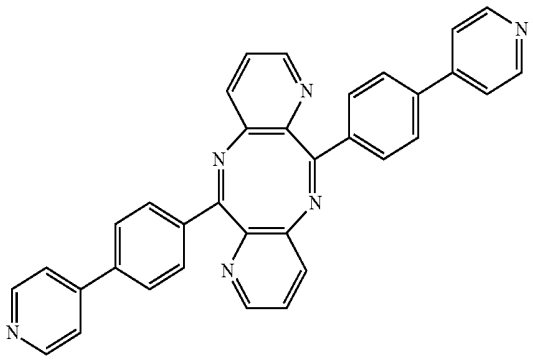

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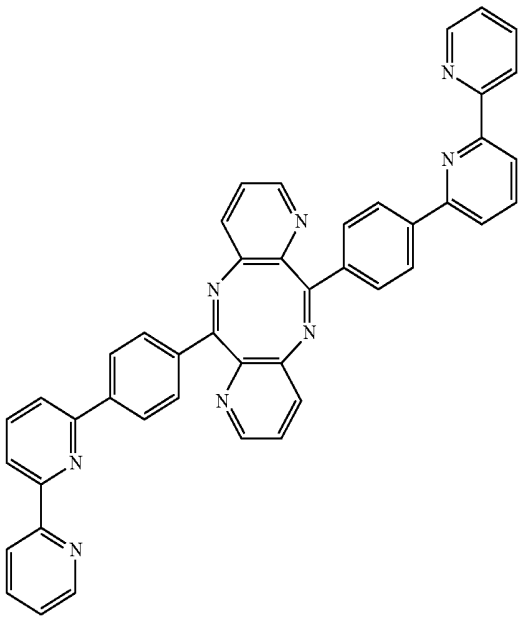

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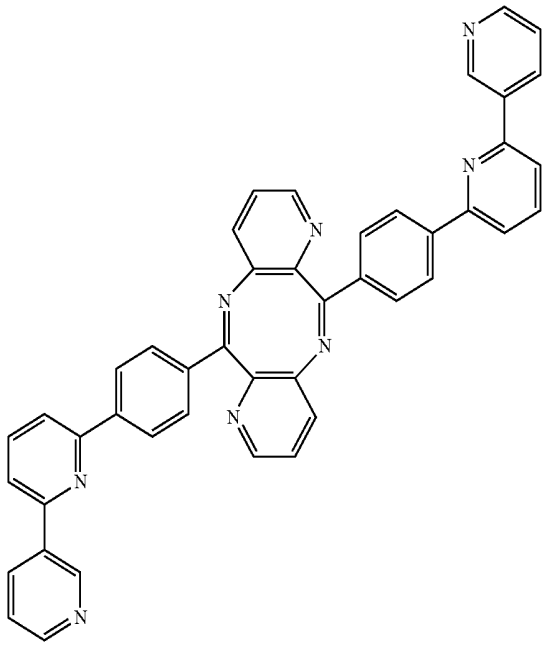

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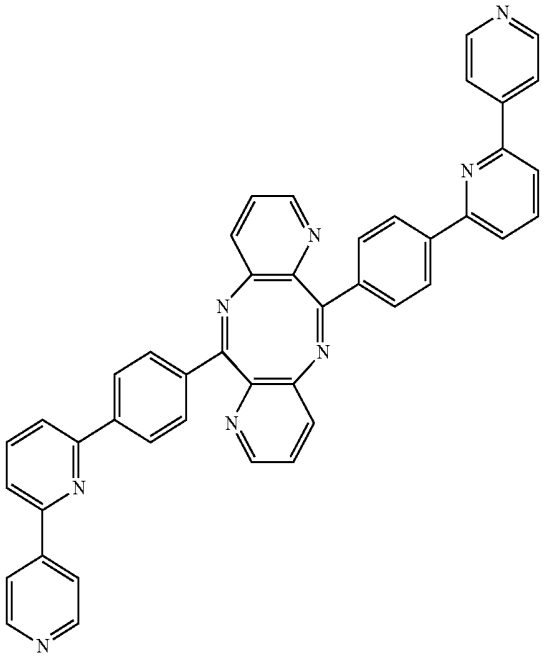

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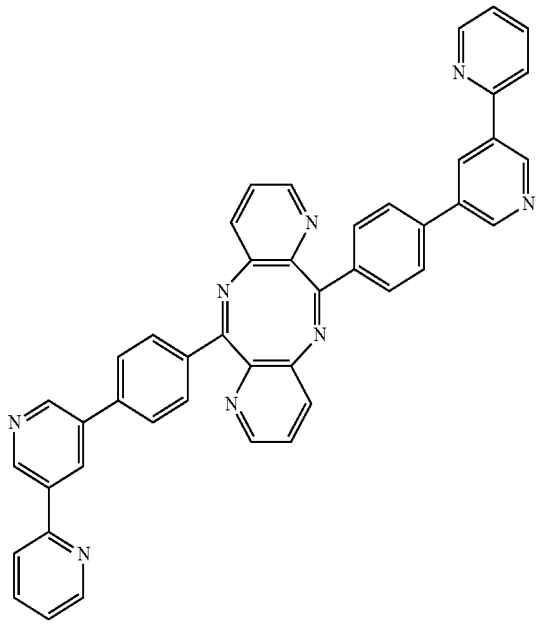

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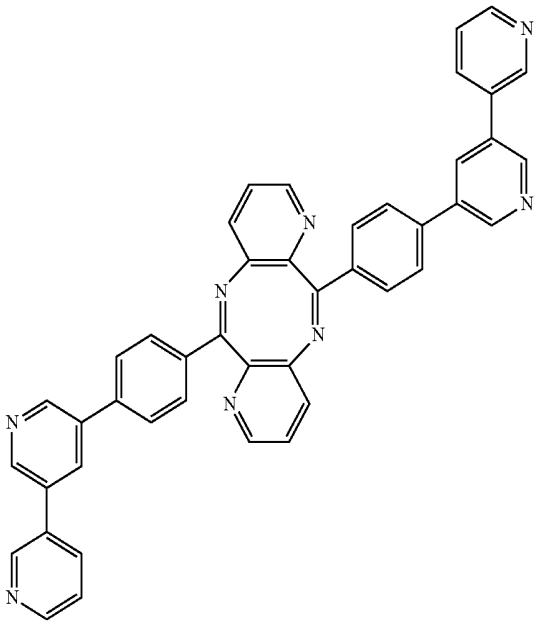

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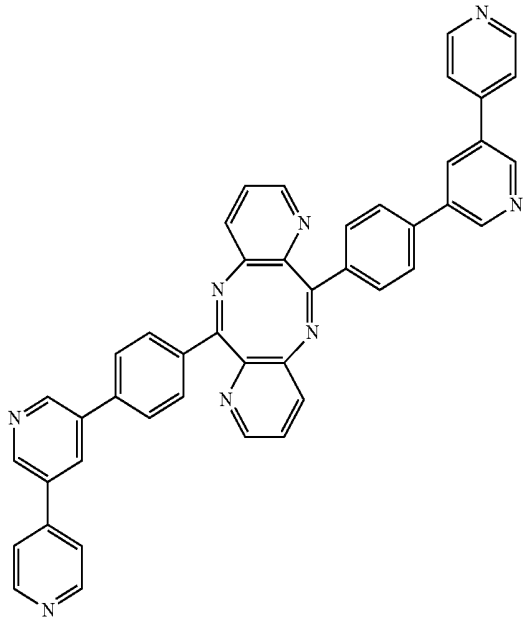

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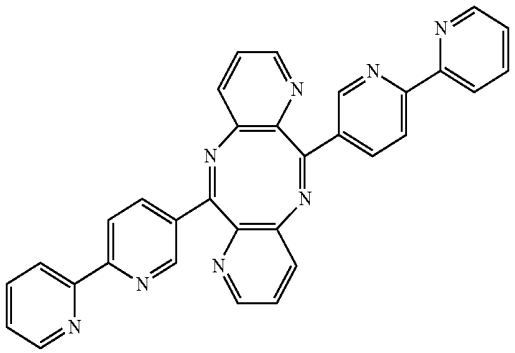

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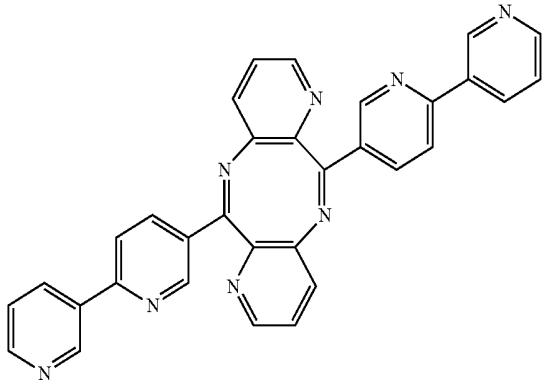

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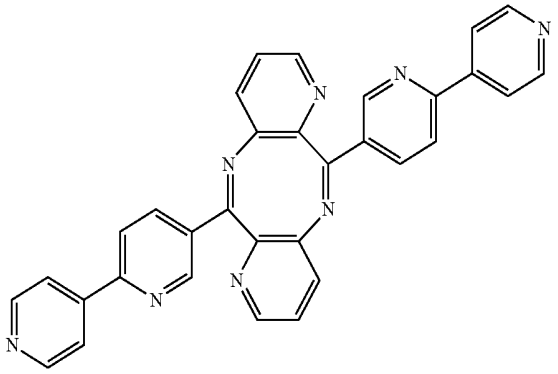

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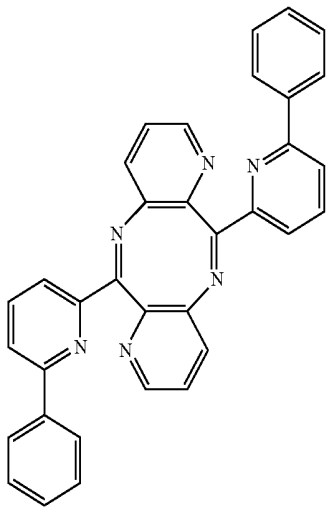

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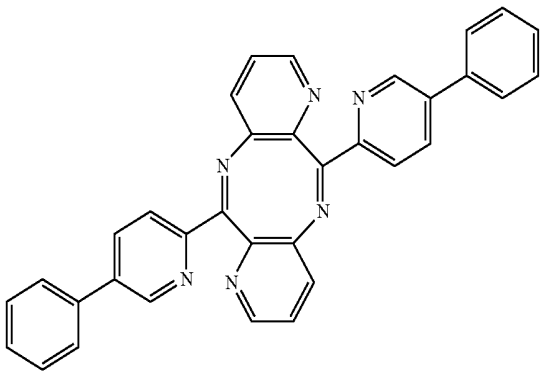

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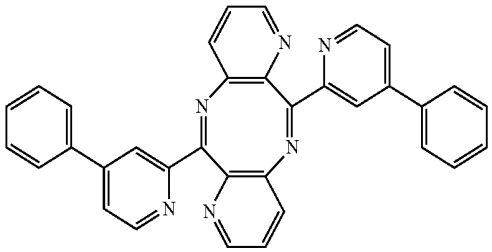

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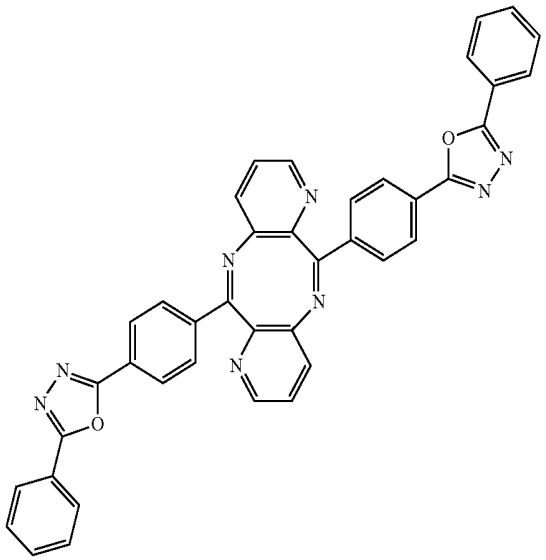

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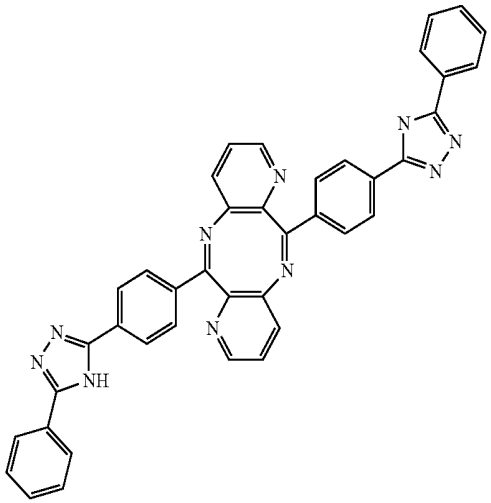

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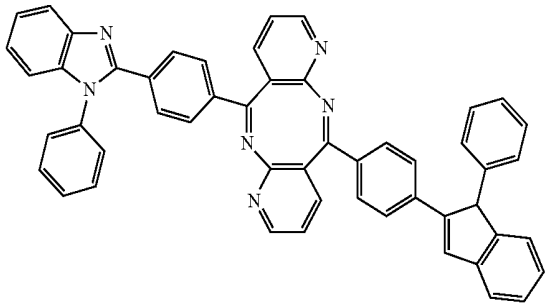

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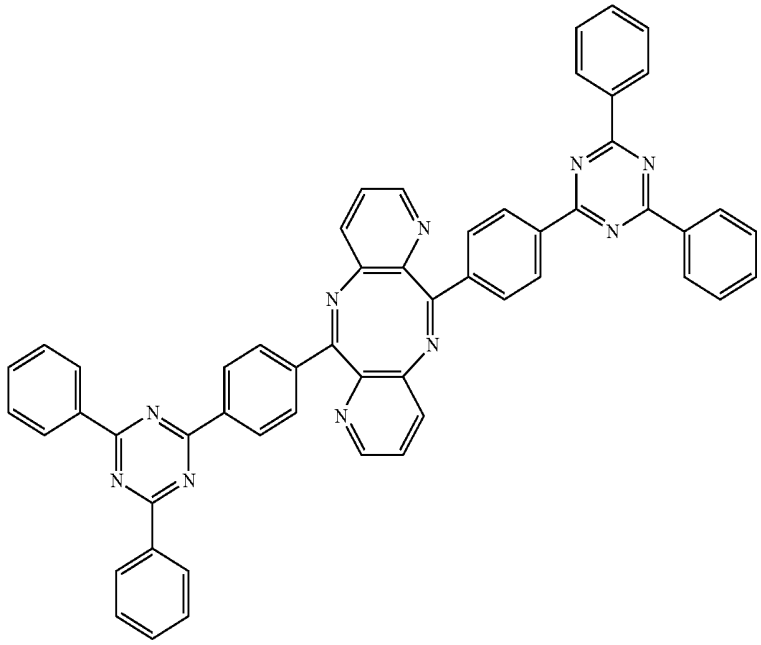

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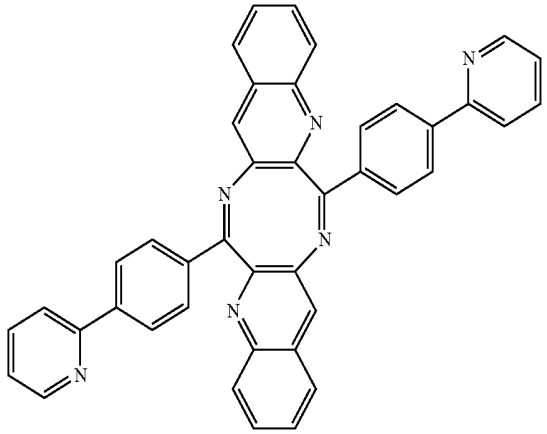

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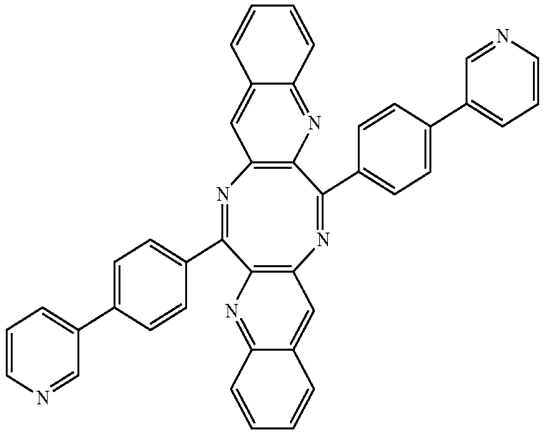

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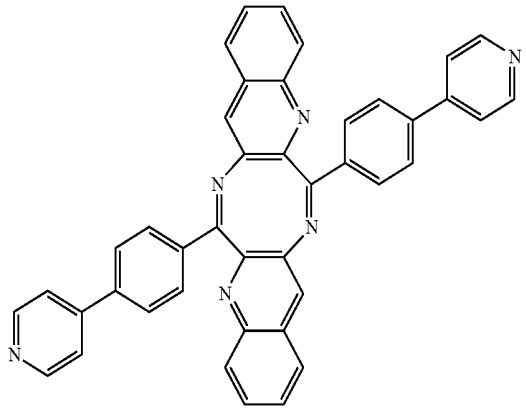

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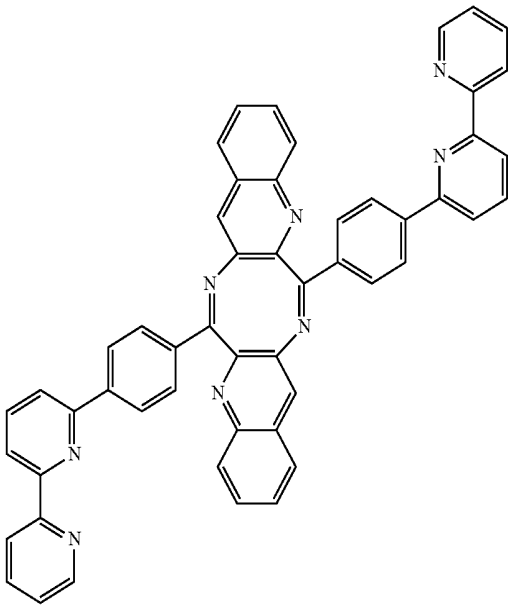

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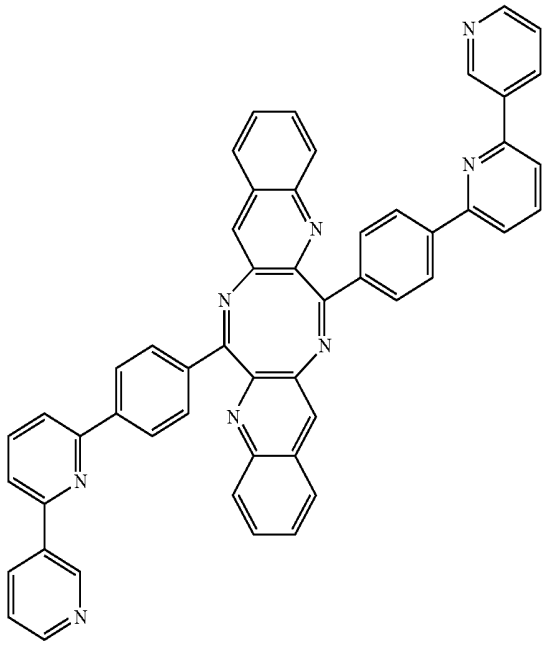

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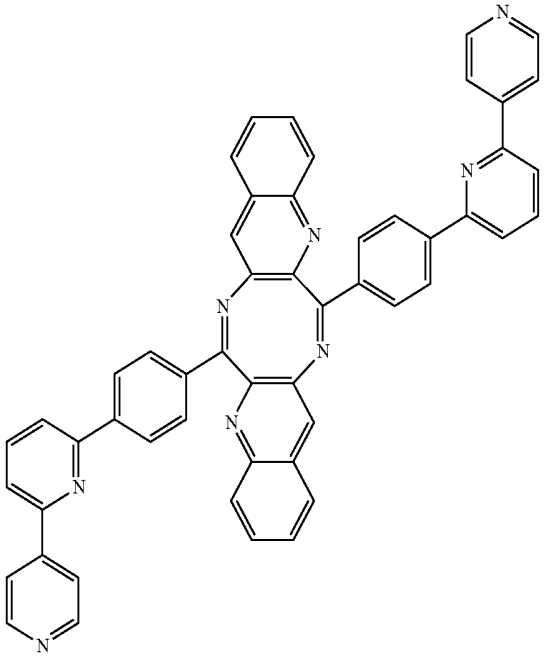

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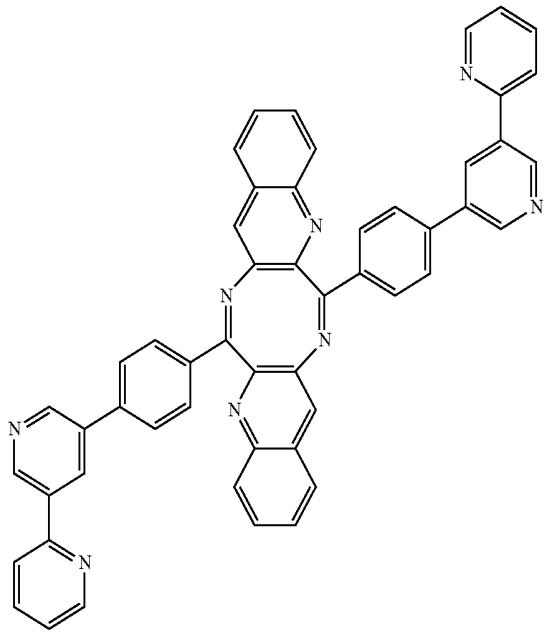

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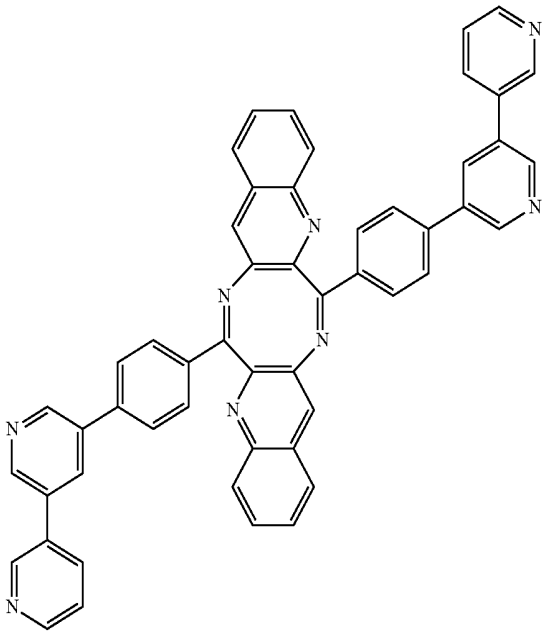

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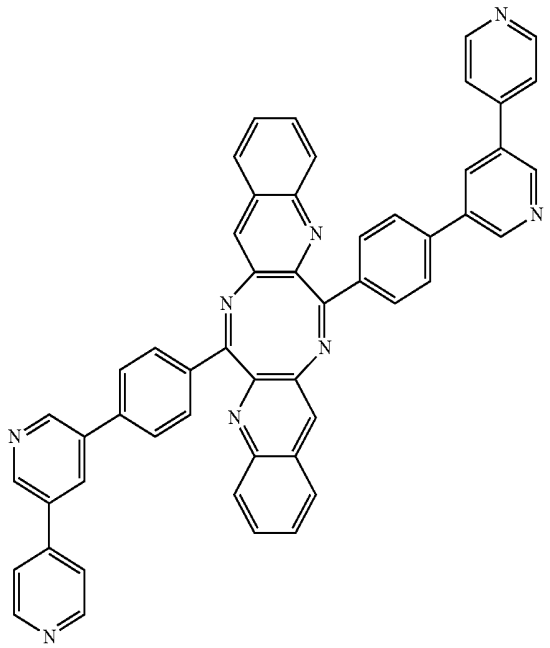

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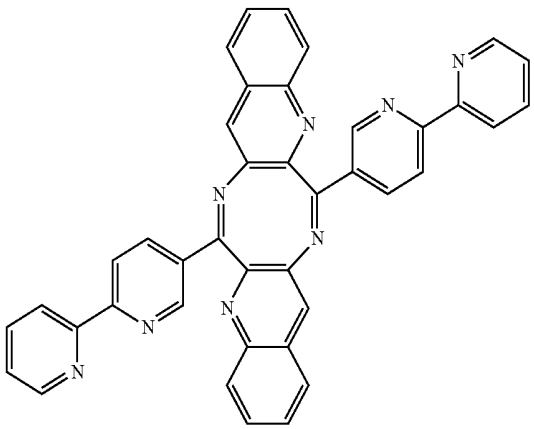

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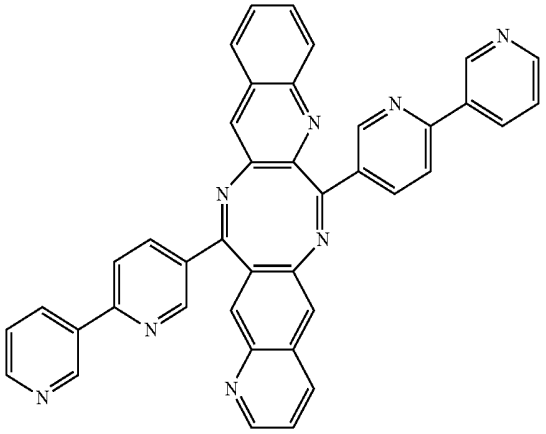

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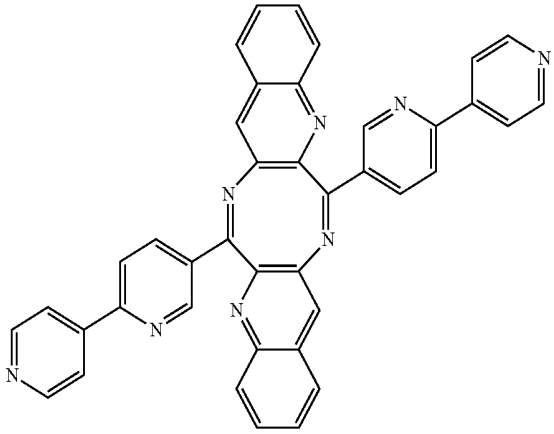

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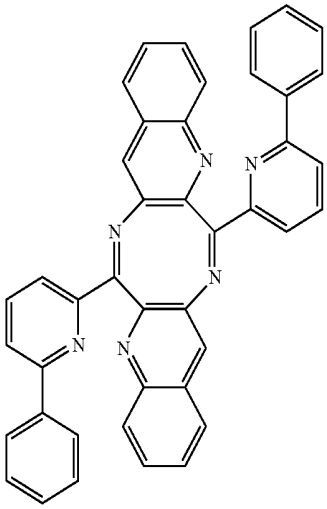

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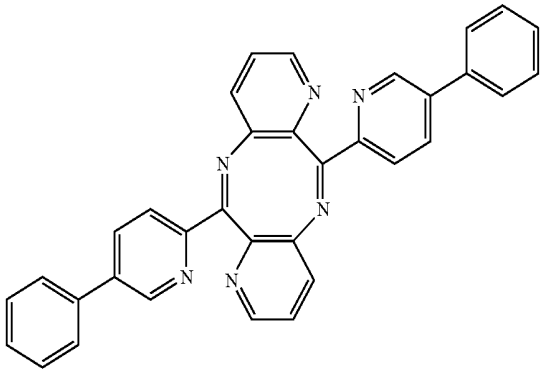

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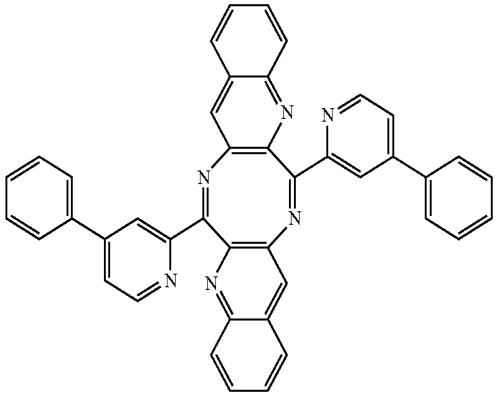

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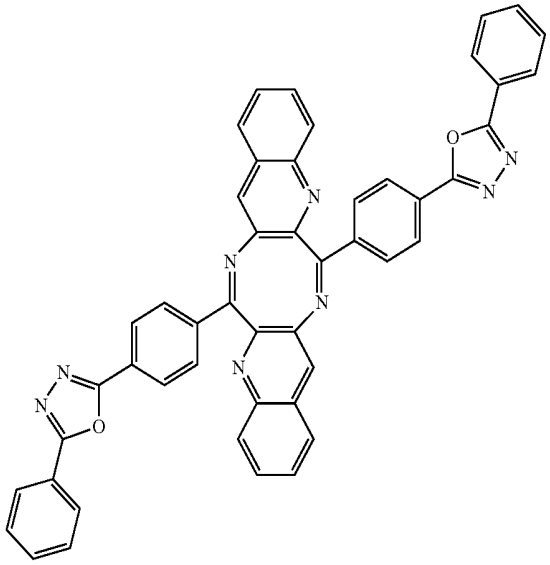

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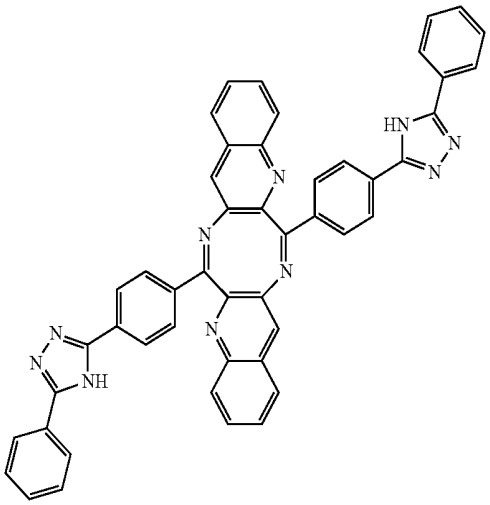

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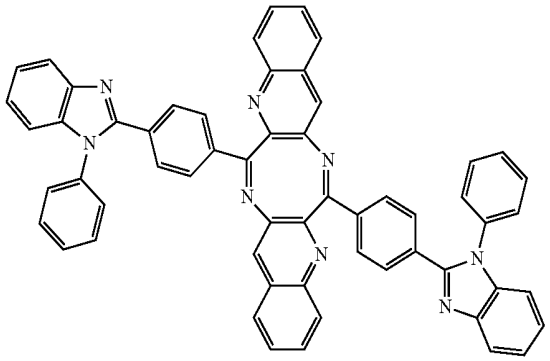

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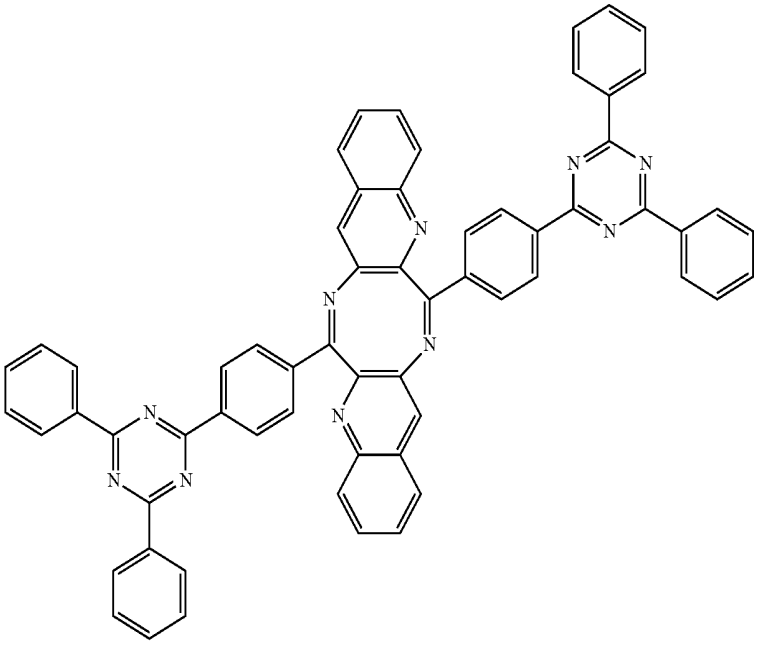

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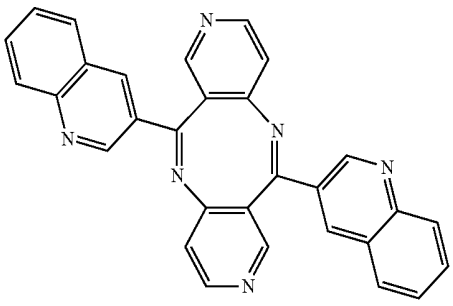

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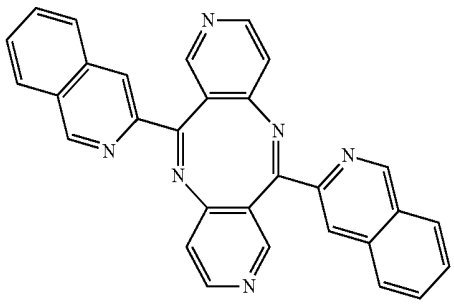

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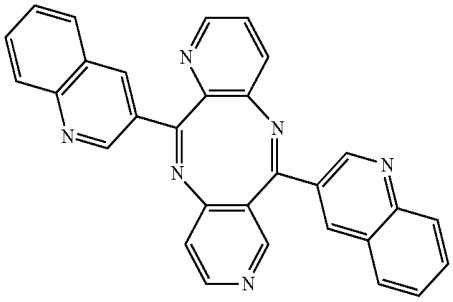

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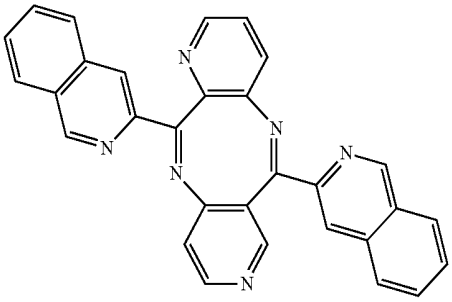

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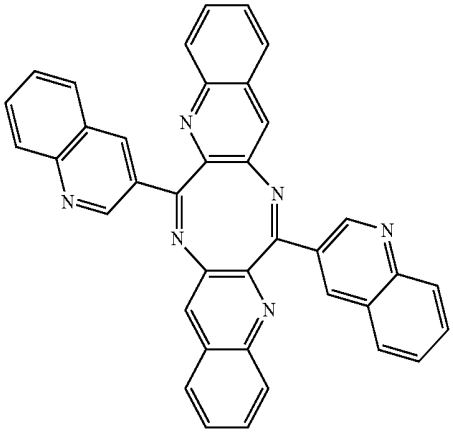

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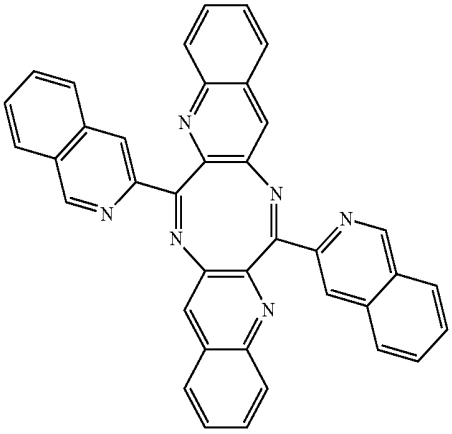

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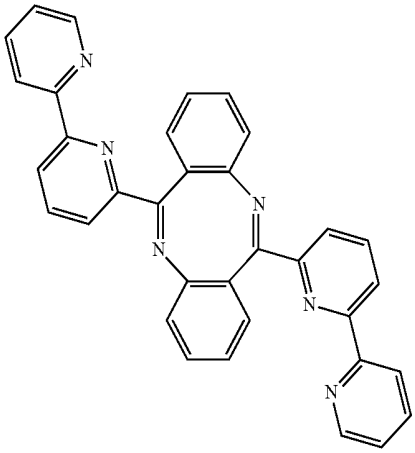

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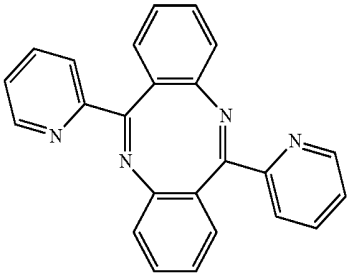

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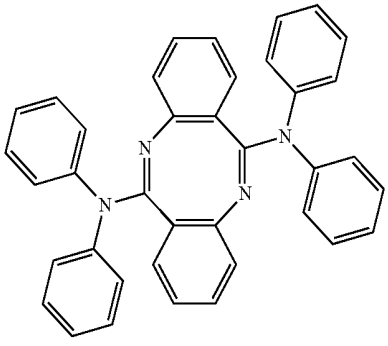

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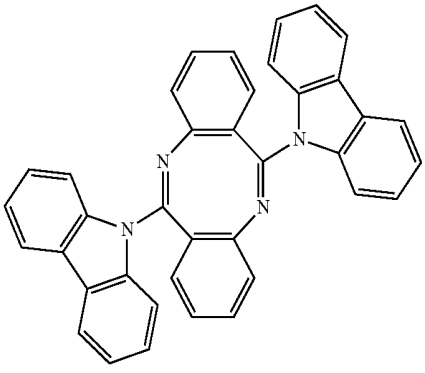

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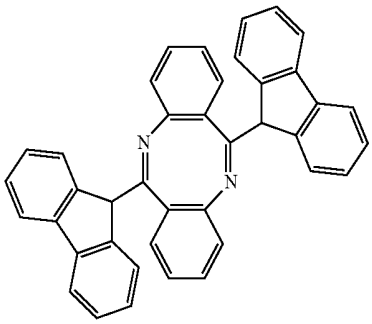

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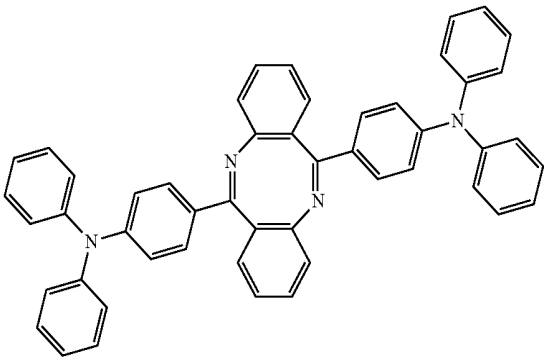

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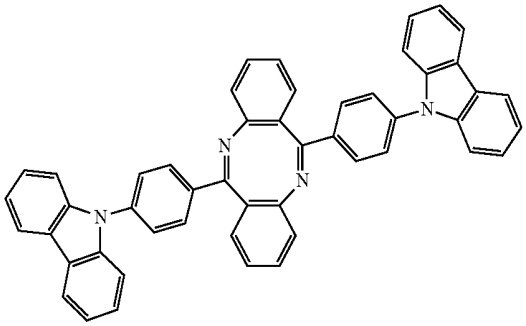

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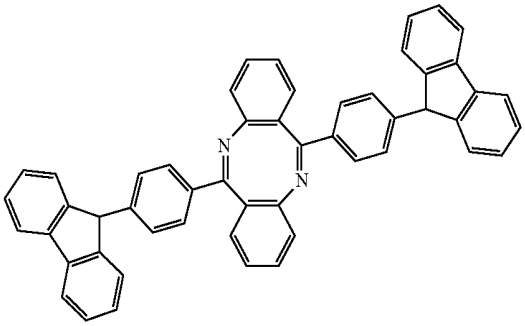

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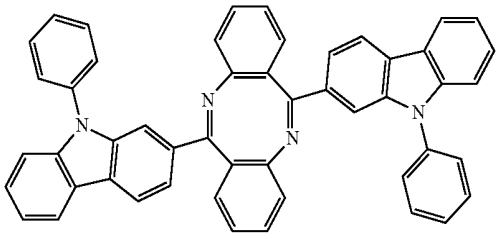

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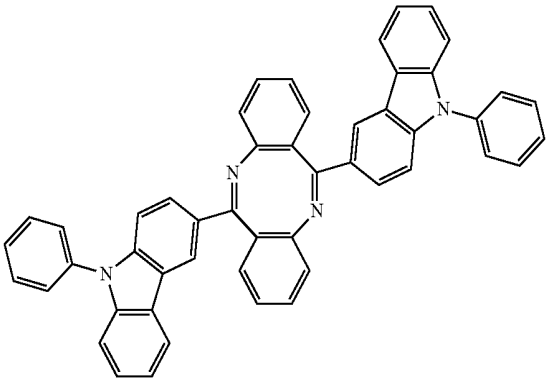

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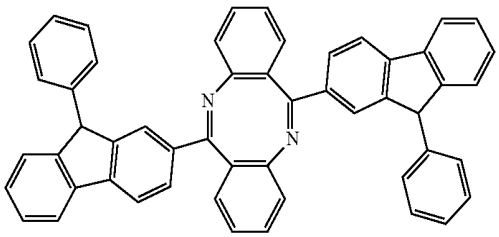

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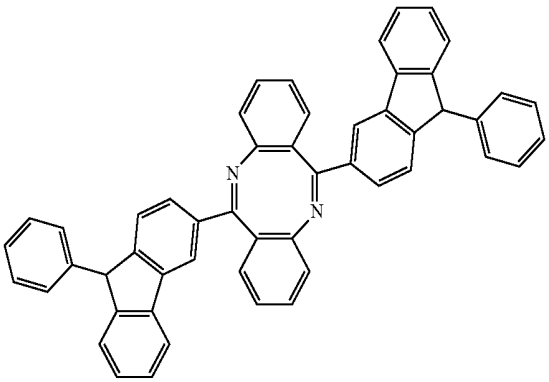

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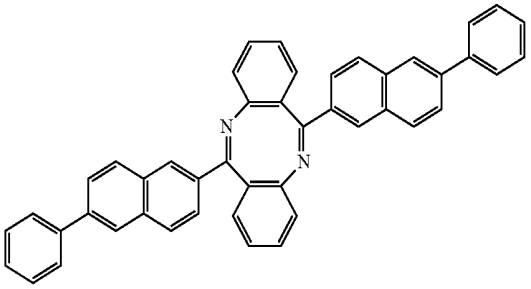

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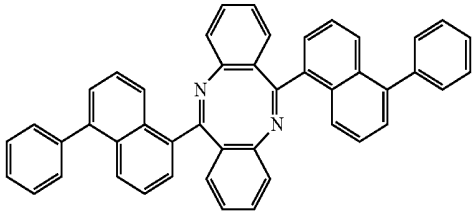

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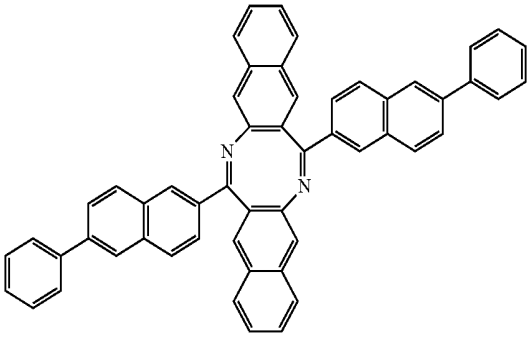

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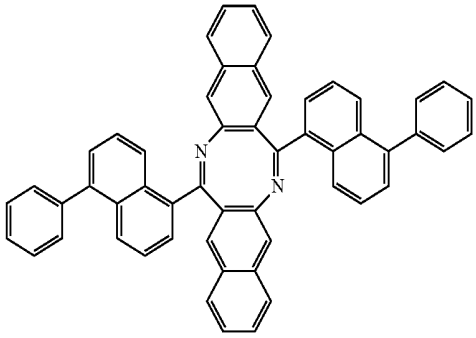

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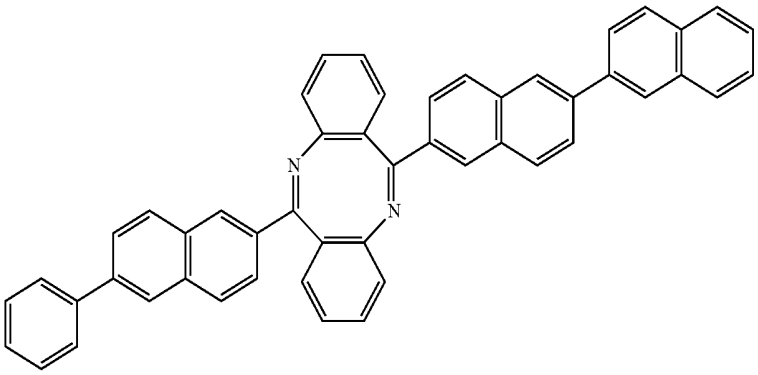

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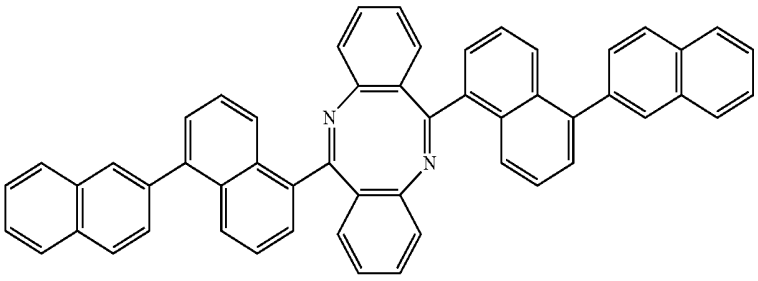

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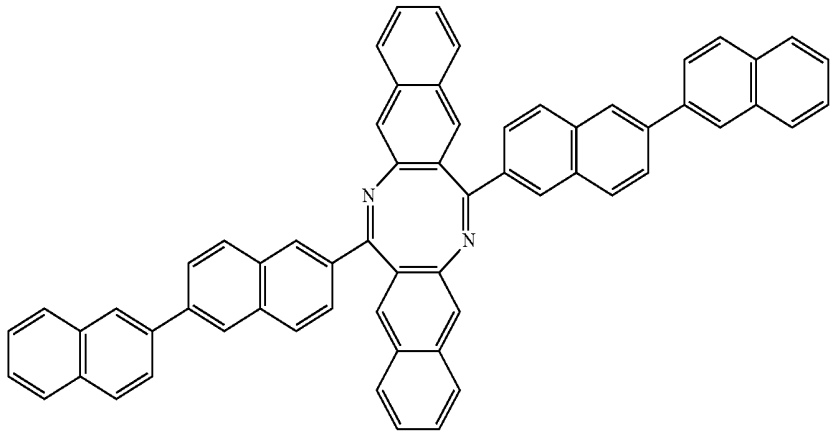

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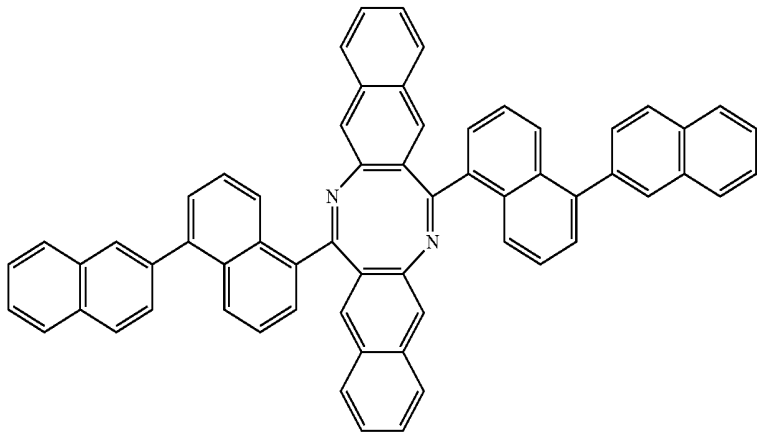

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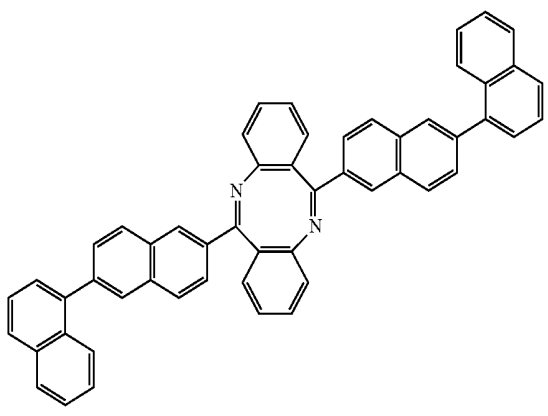

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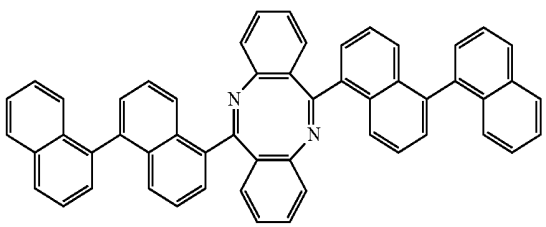

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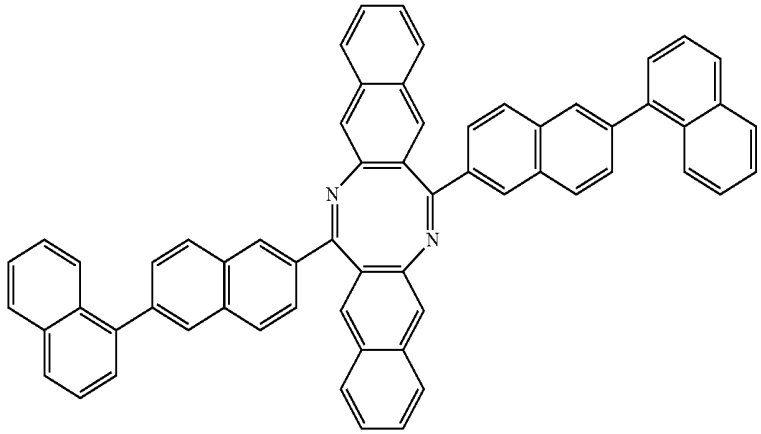

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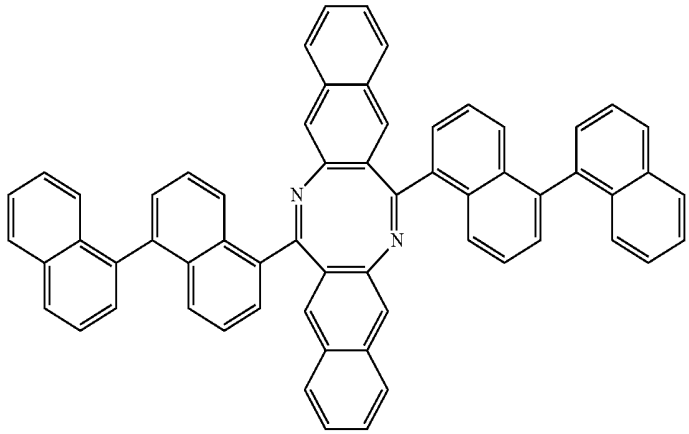

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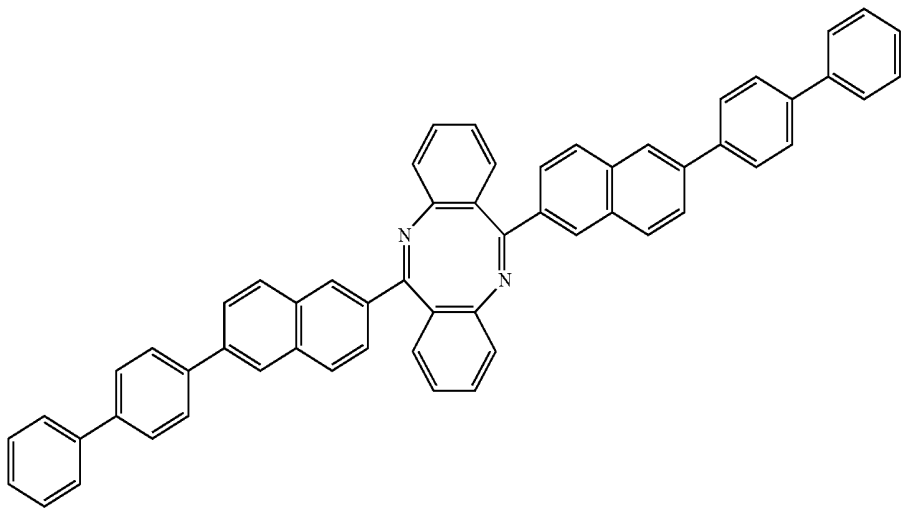

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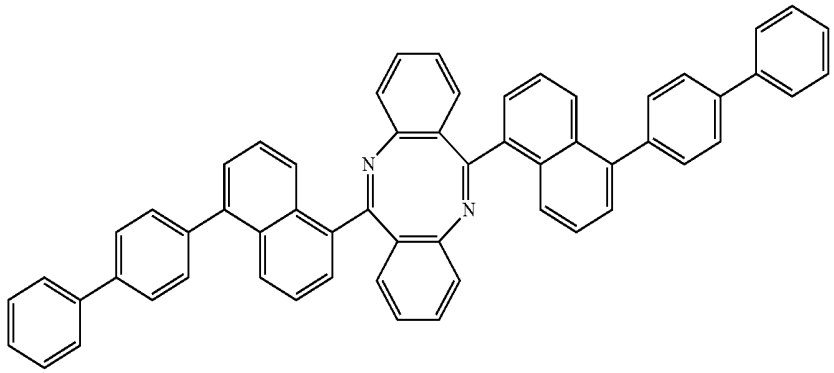

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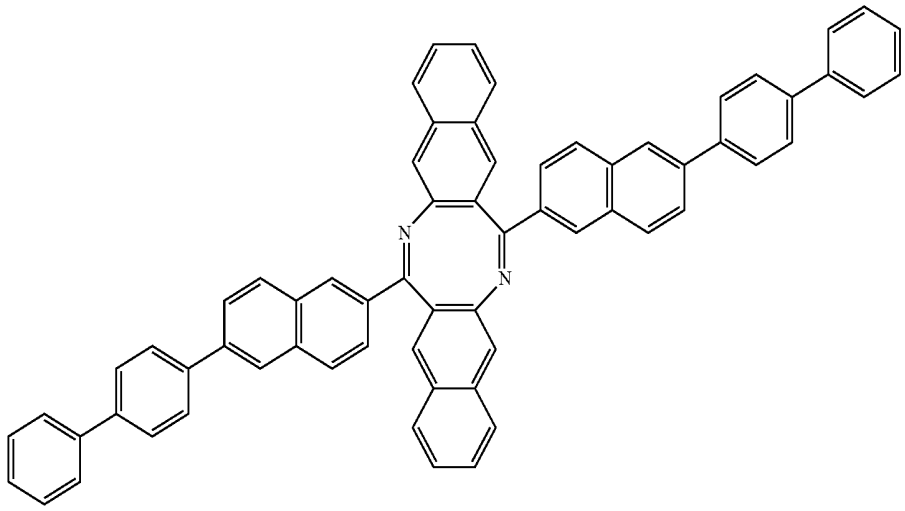

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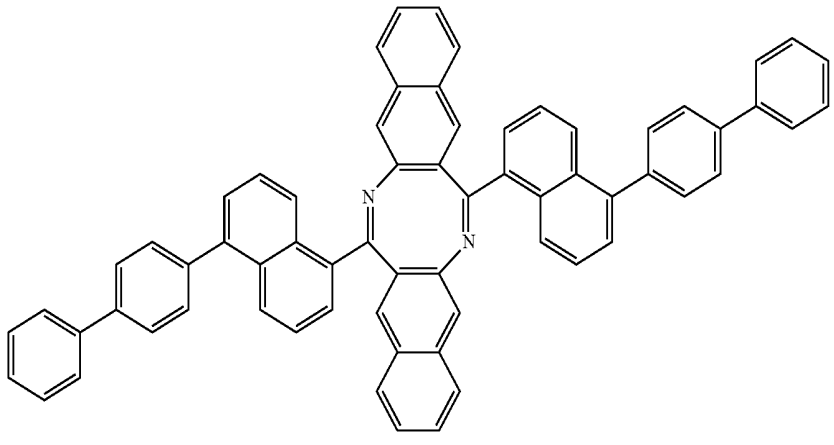

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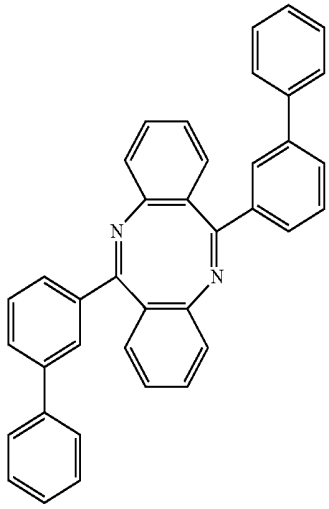

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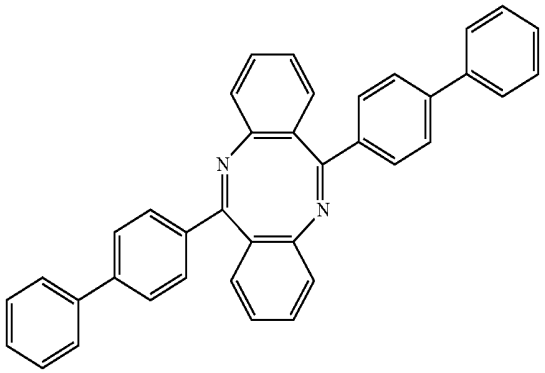

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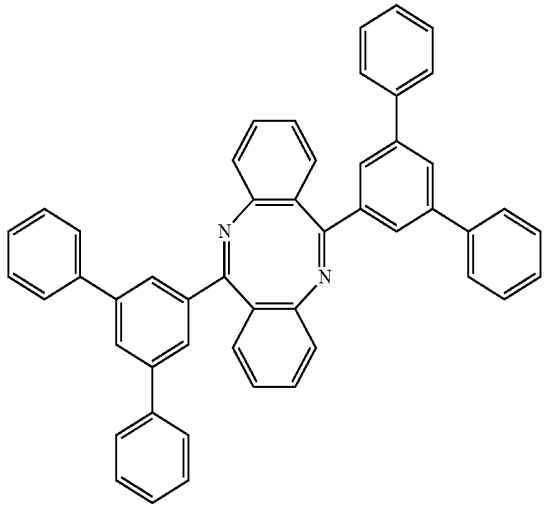

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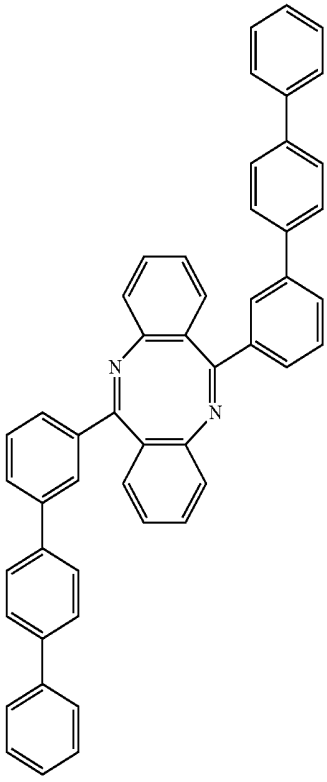

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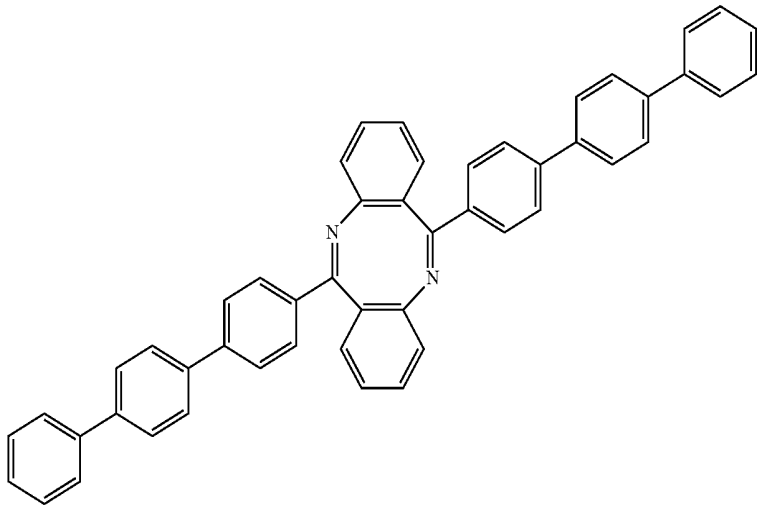

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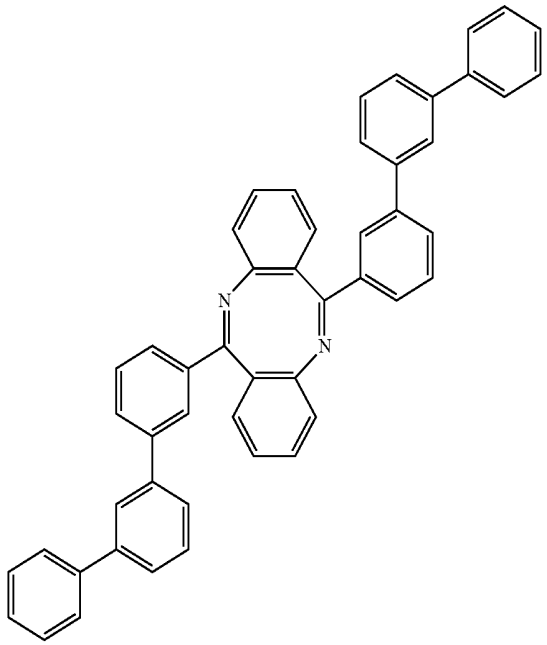

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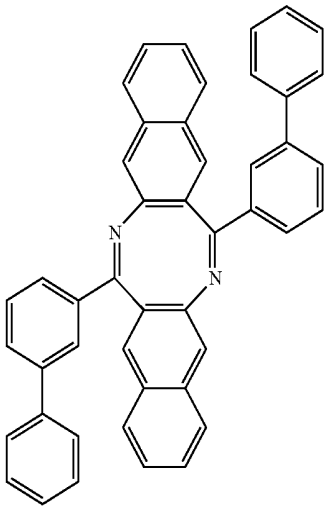

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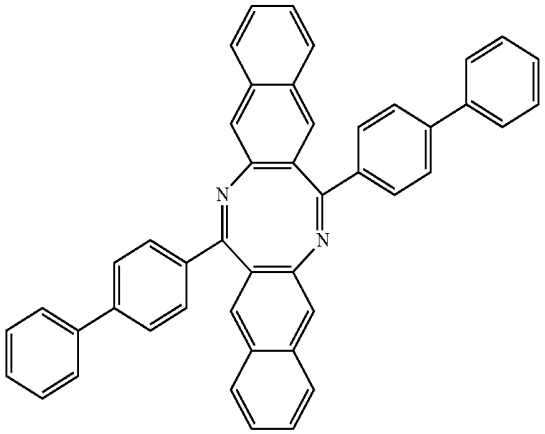

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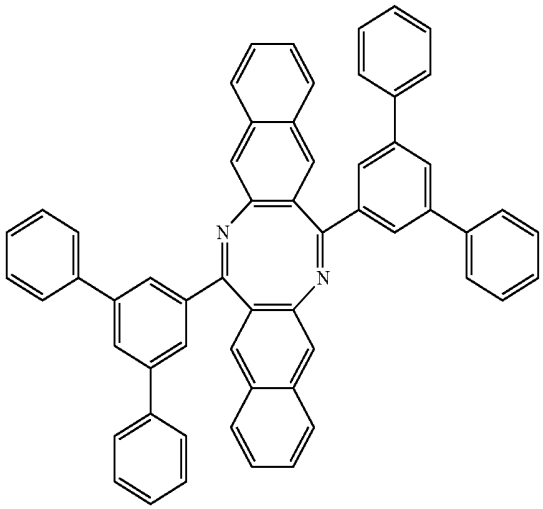

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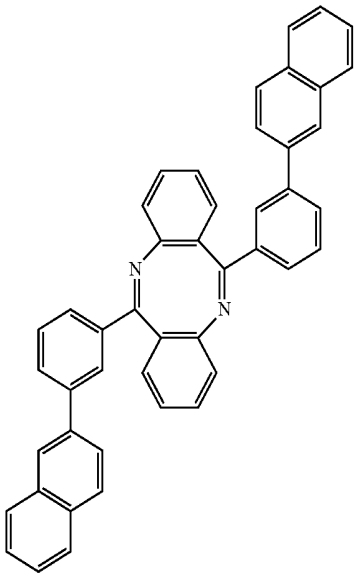

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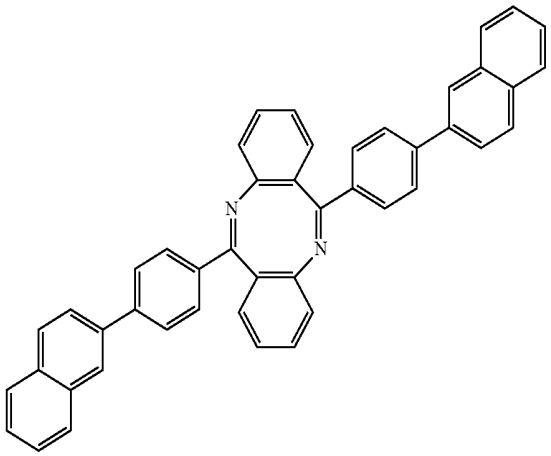

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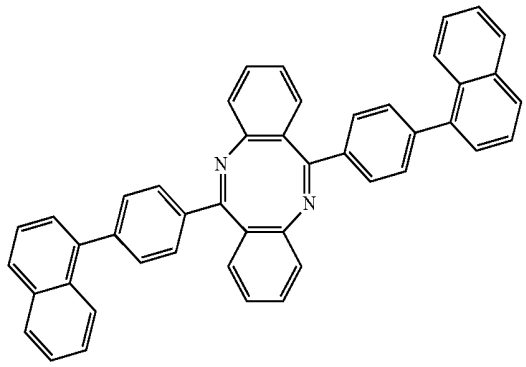

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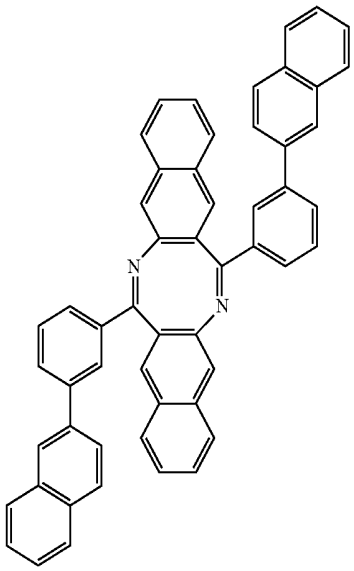

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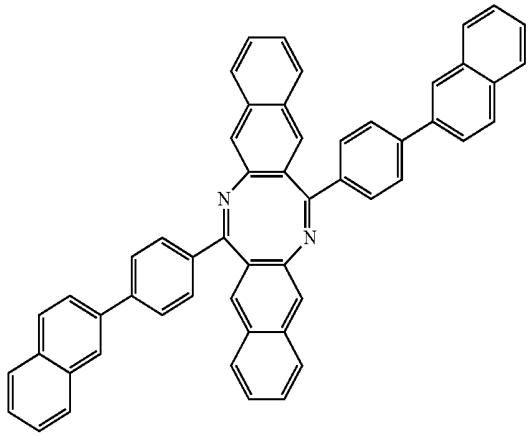

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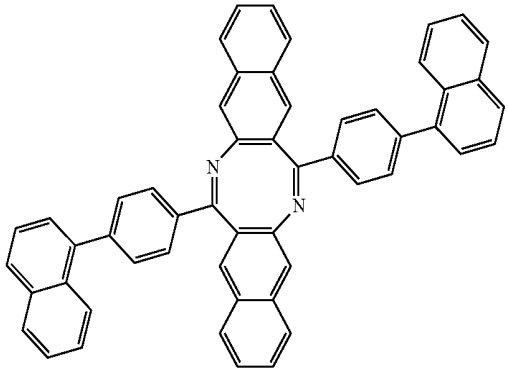

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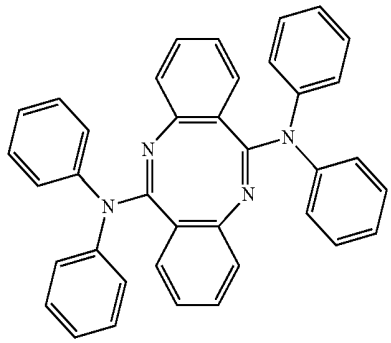

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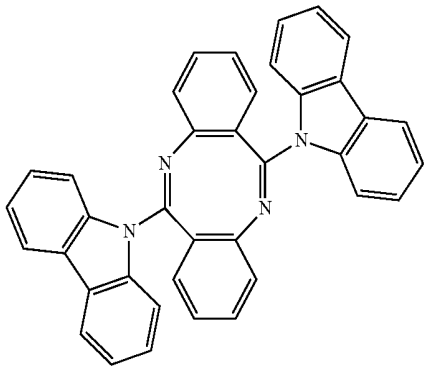

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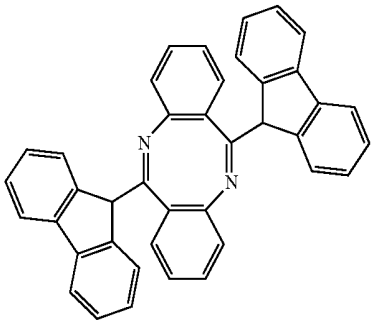

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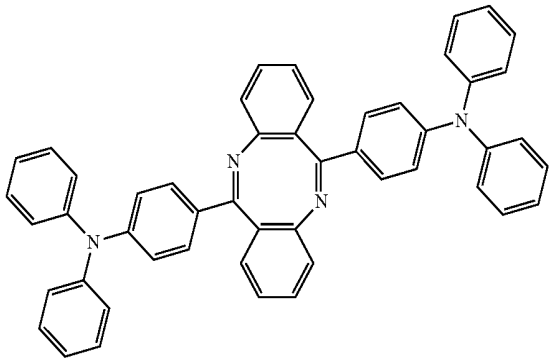

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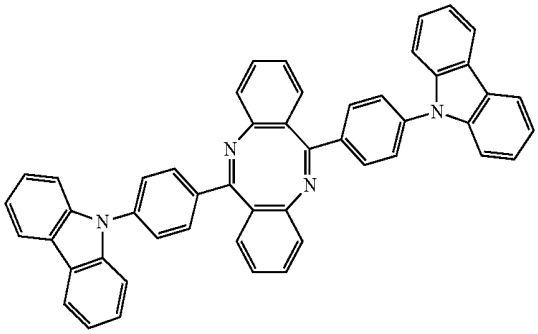

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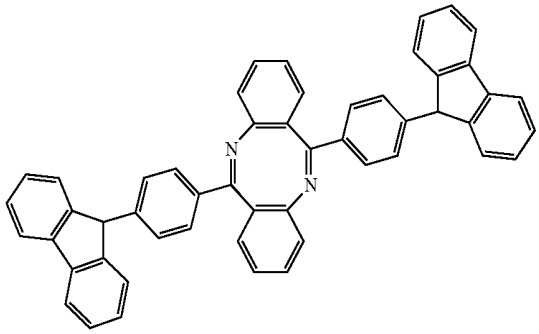

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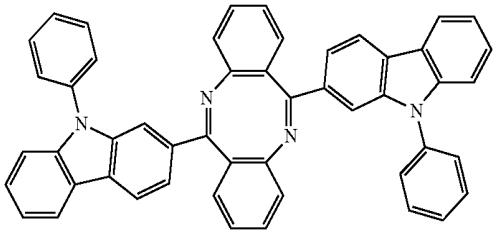

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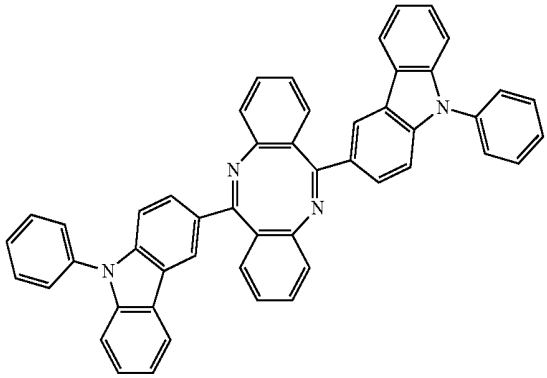

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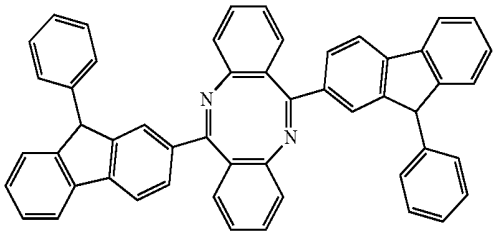

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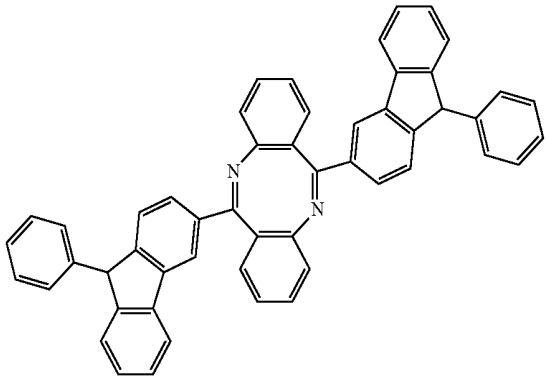

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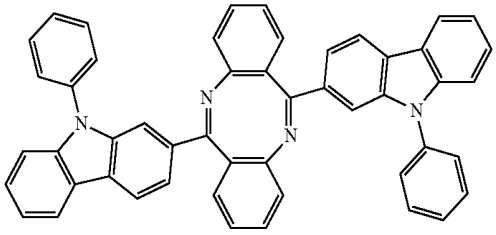

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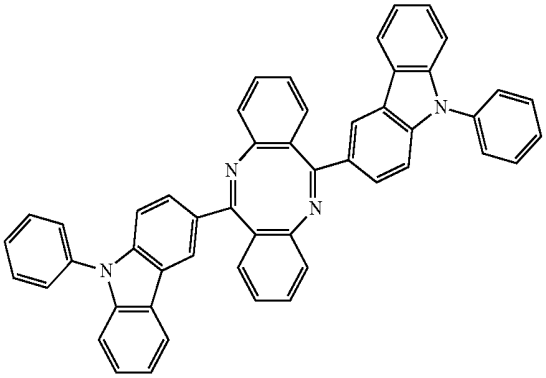

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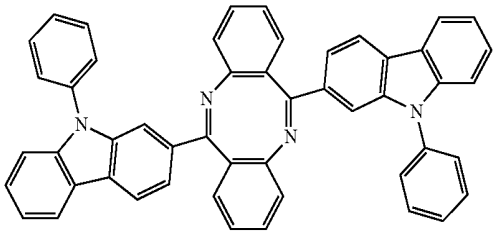

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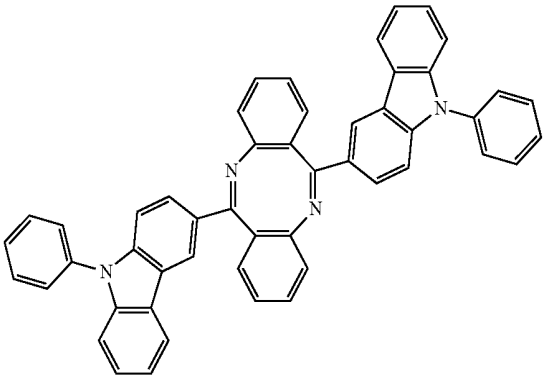

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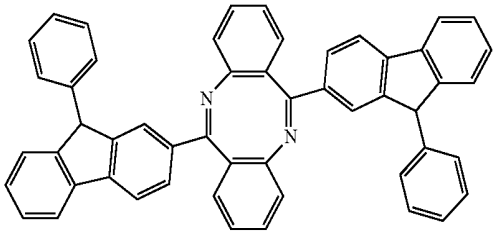

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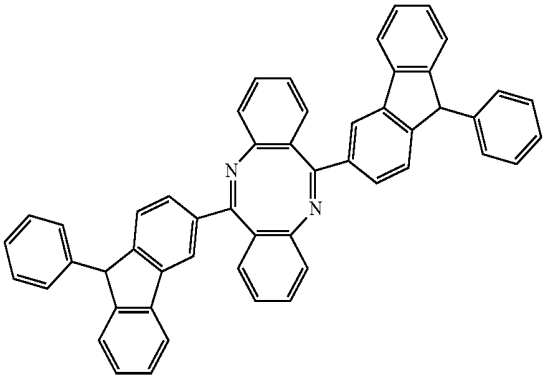

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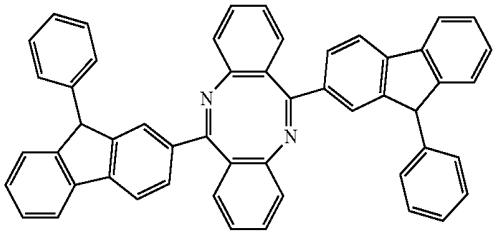

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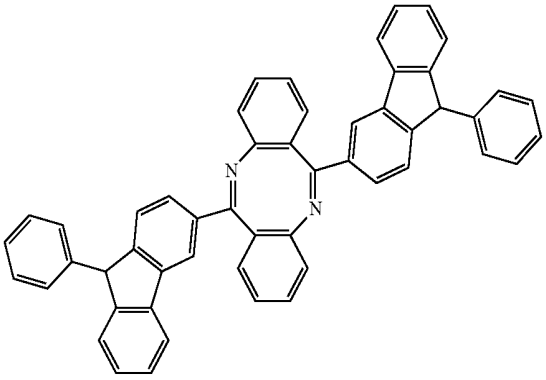

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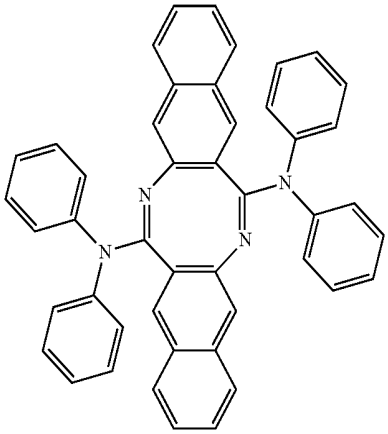

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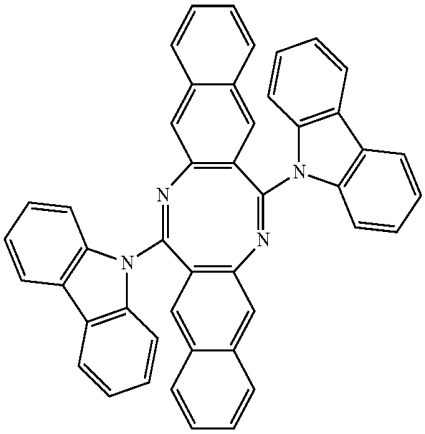

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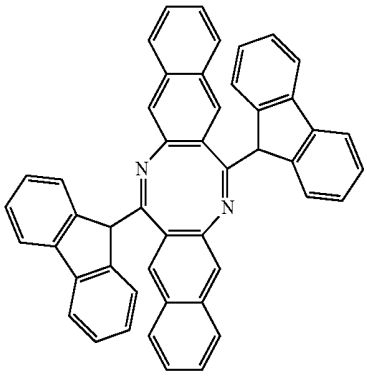

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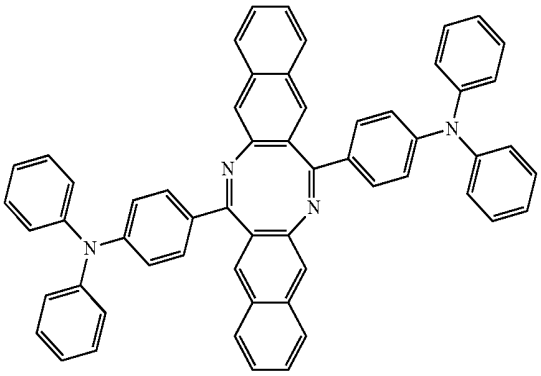

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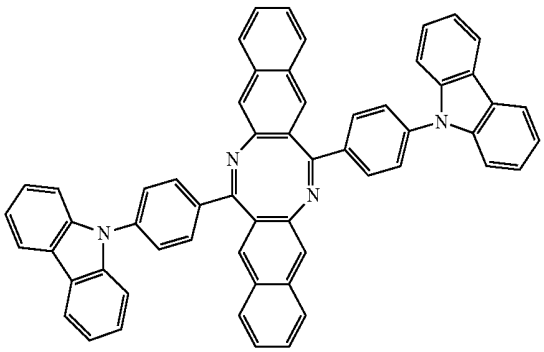

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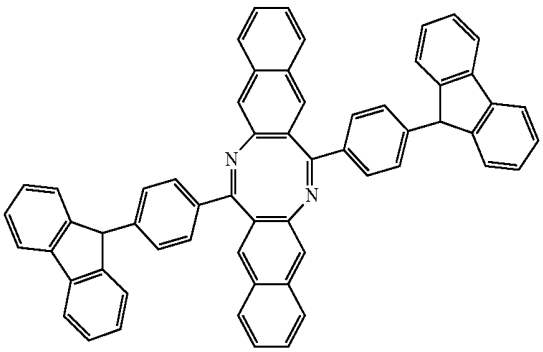

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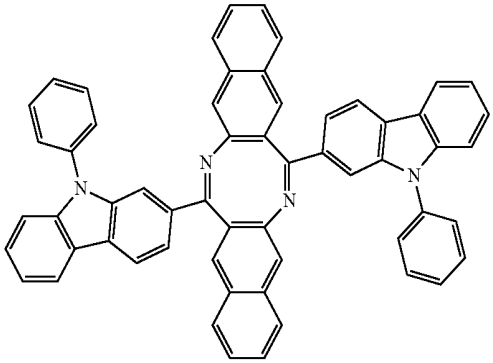

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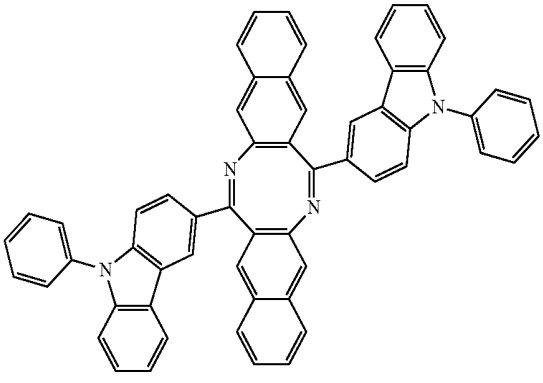

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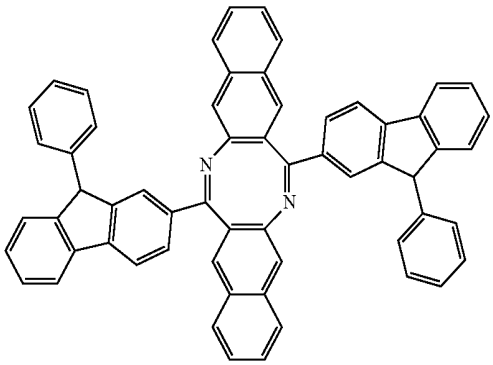

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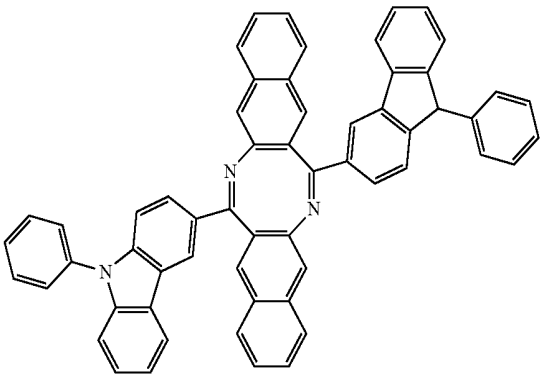

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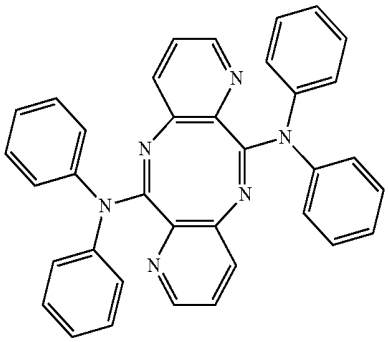

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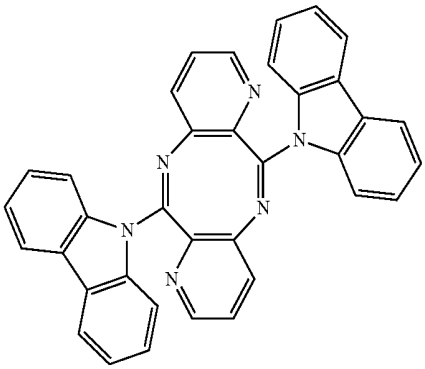

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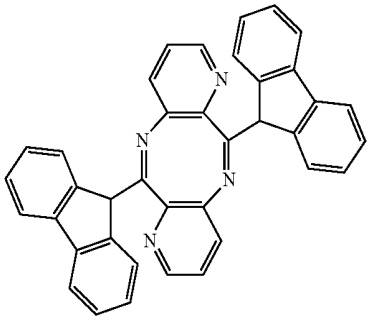

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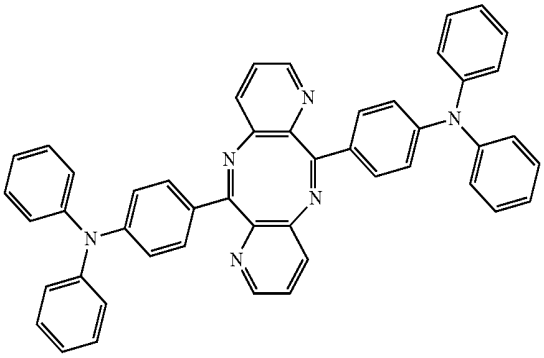

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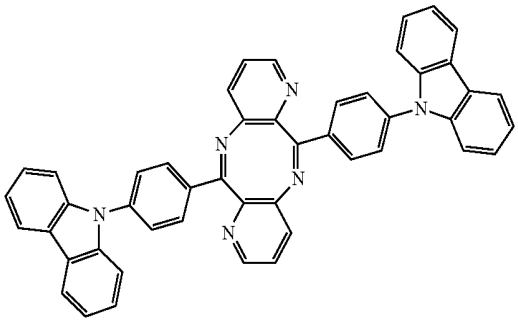

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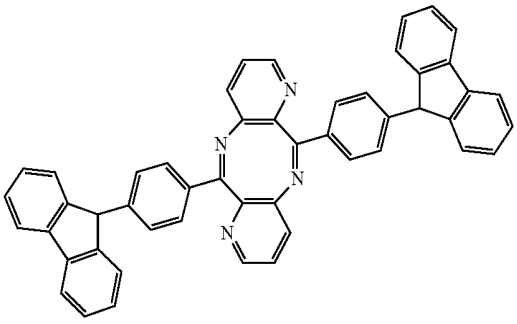

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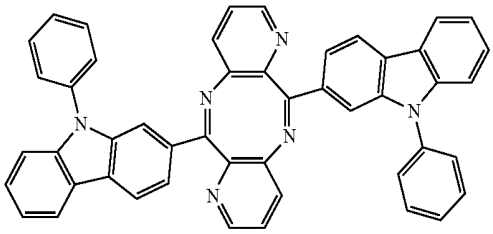

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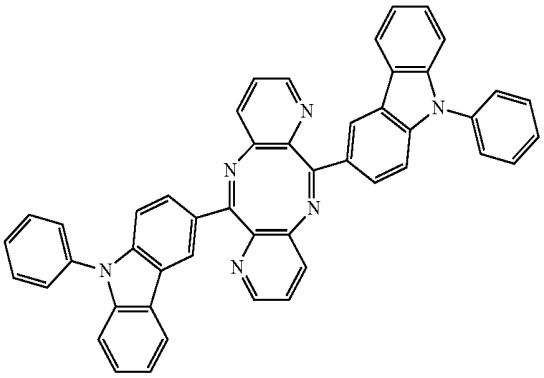

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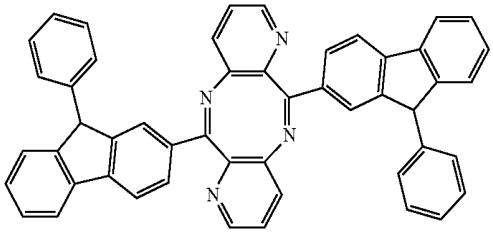

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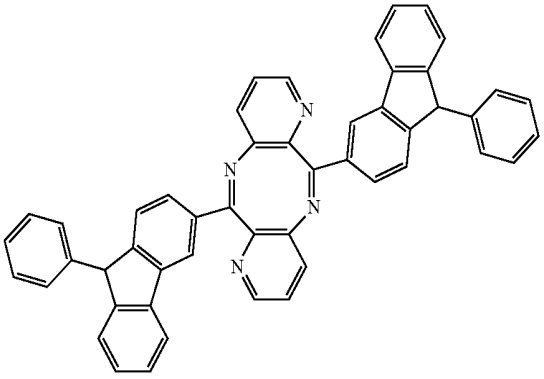

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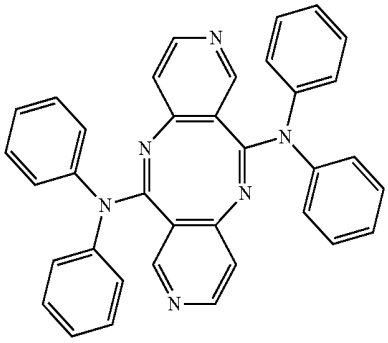

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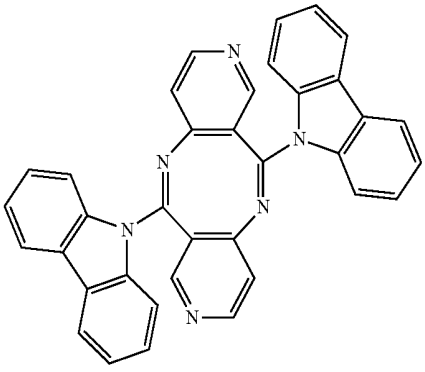

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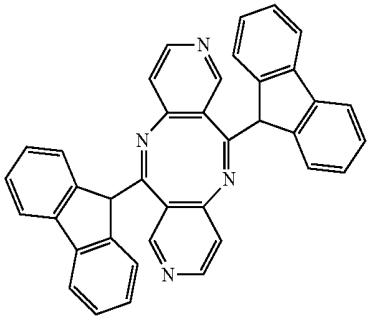

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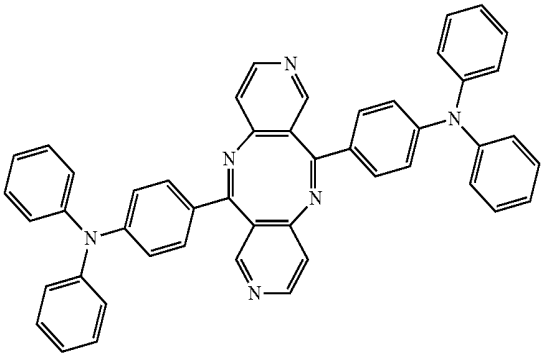

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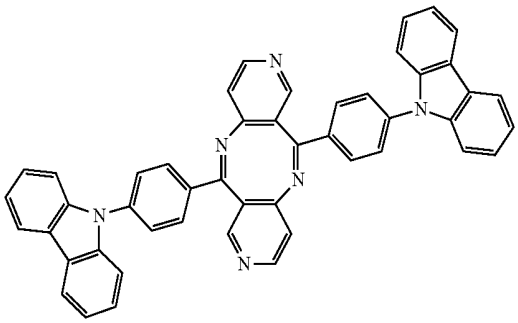

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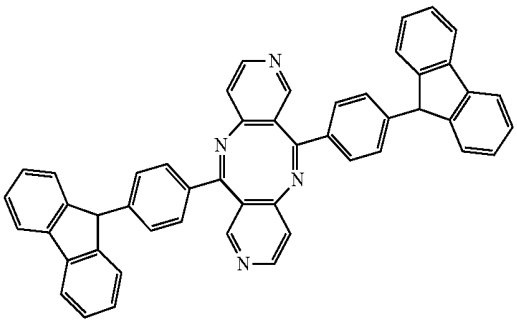

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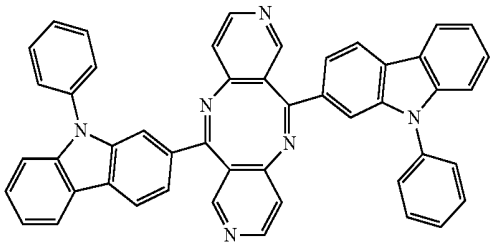

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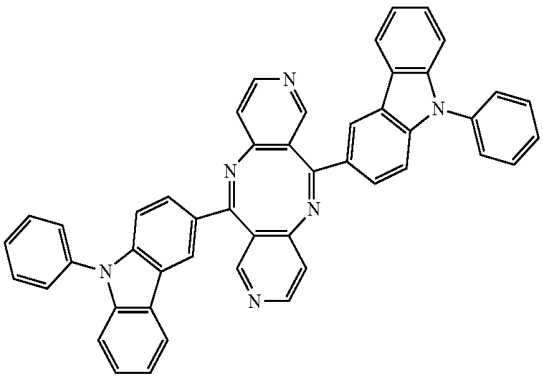

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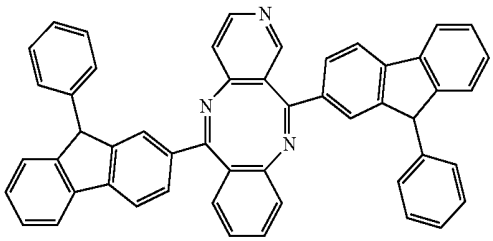

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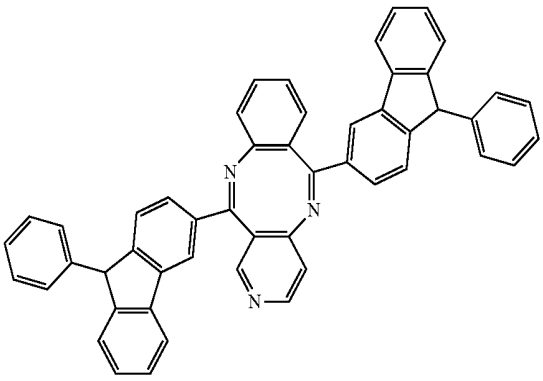

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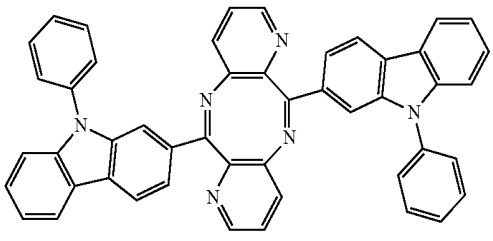

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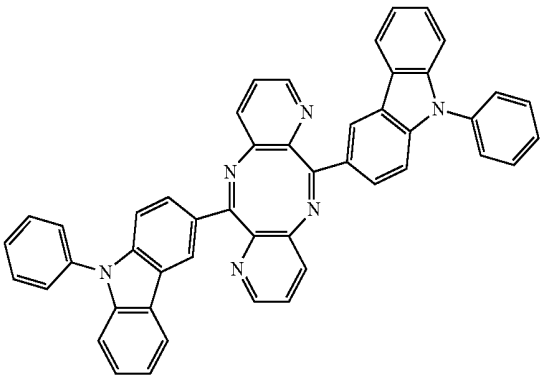

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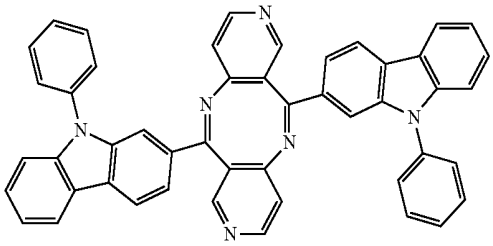

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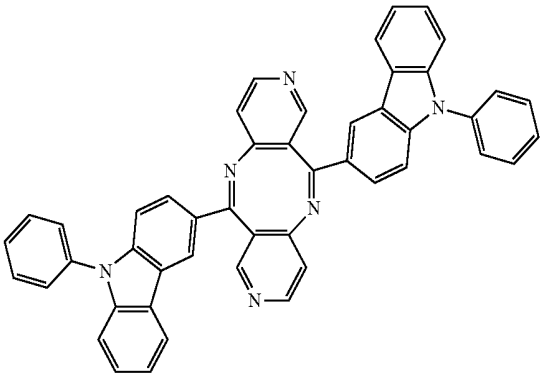

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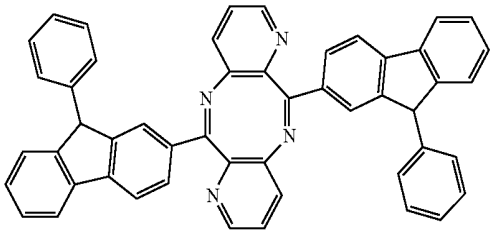

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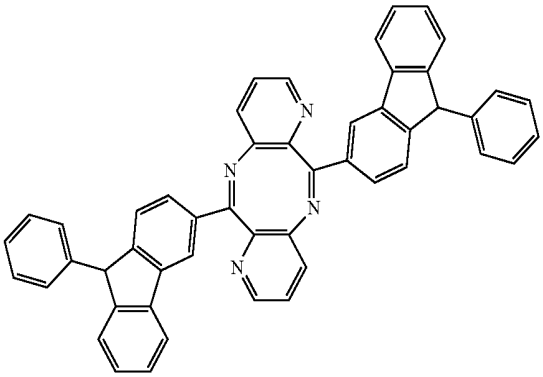

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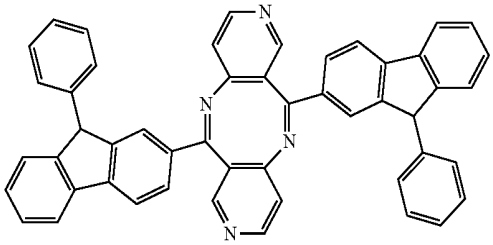

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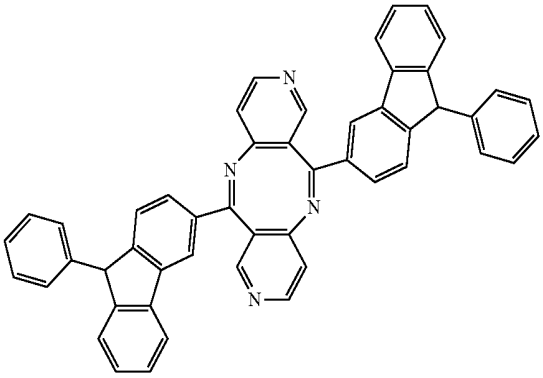

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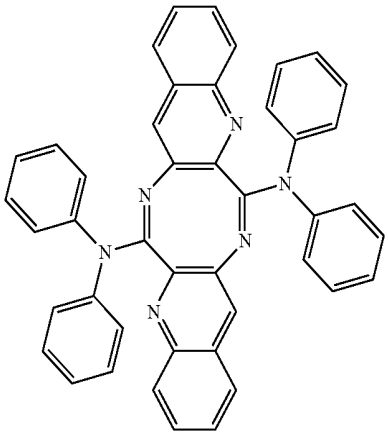

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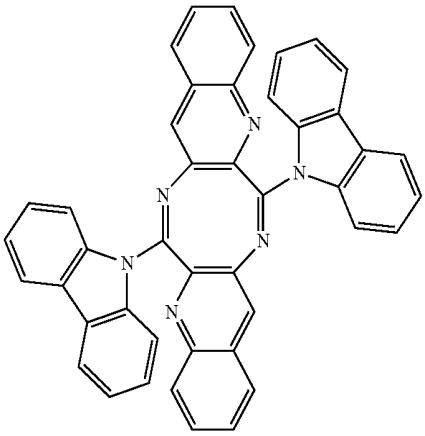

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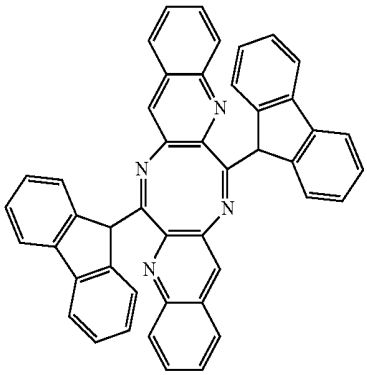

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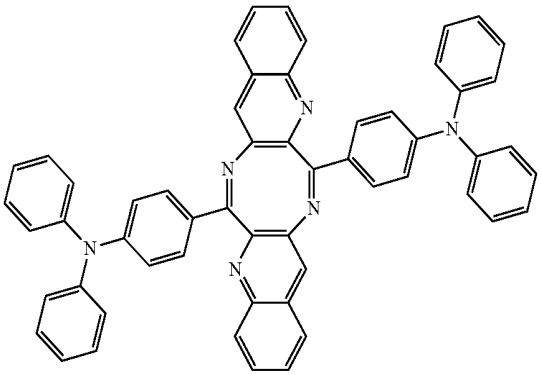

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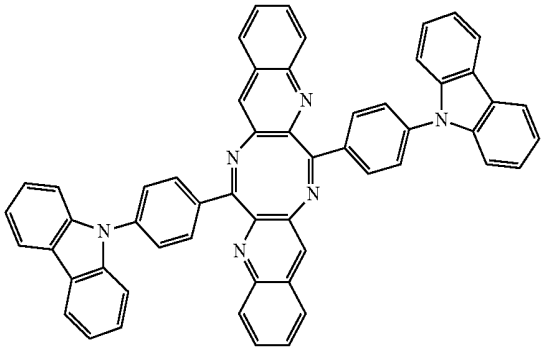

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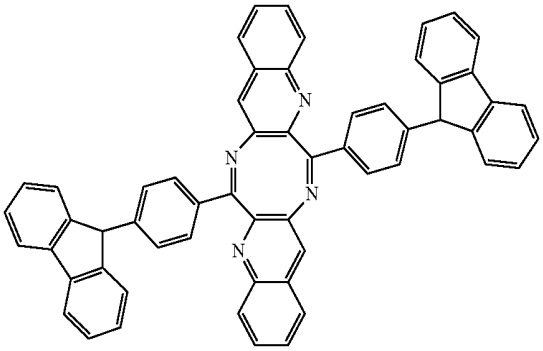

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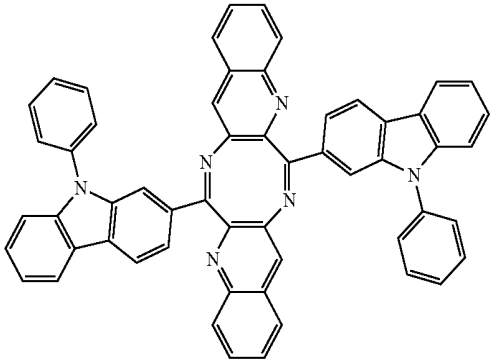

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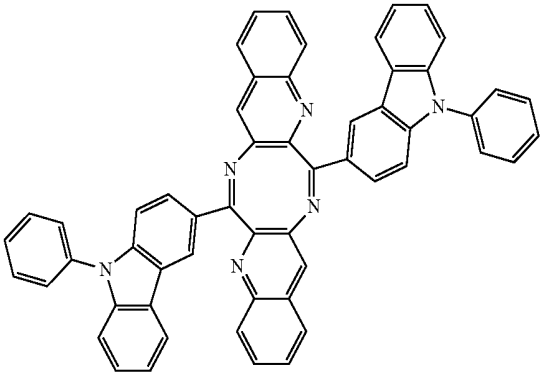

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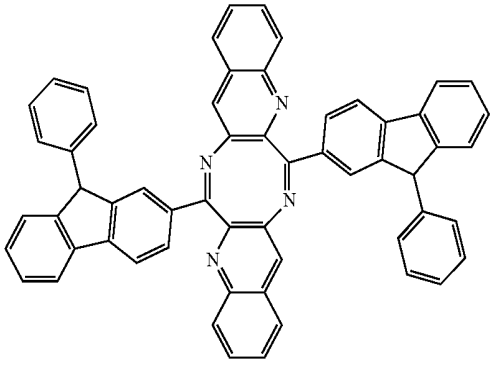

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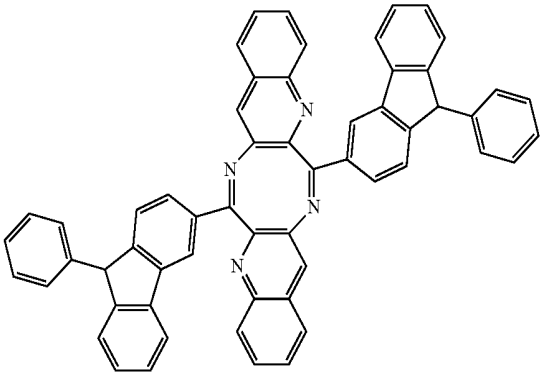


[0141] The antiaromatic compound represented by Formula 1 may have a nonplanar structure that is suitable for designing a structure in which a highest occupied molecular orbital (HOMO) energy level and a lowest unoccupied molecular orbital (LUMO) energy level do not overlap. In general, aromatic ring compounds have a perfect planar struc-

ture, and thus a substituent may cause less electrical change when formed into a thin film. However, antiaromatic compounds may undergo a large electrical change caused by a substituent when formed into a thin film due to the nonplanar structure thereof. In other words, a change in electrical characteristics of the antiaromatic compounds may be easily controllable with substituents. Due to the nonplanar structure, the antiaromatic compound represented by Formula 1 may have a lower crystallinity compared with aromatic ring compounds having a planar structure, and thus may be desired in terms of mass-production processibility. In general, highly crystalline compounds may cause unnecessary accumulation of materials or clogging of source during deposition processes.

[0142] Due to the ease of control of the electrical characteristics of the antiaromatic compound represented by Formula 1, an organic light-emitting device having a high efficiency and a high luminance may be implemented using (utilizing) the antiaromatic compound of Formula 1. In addition, due to the low crystallinity, the antiaromatic compound represented by Formula 1 may be desired in processibilty when used (utilized) to manufacture an organic light-emitting device.

[0143] Therefore, an organic light-emitting device using (utilizing) the antiaromatic compound represented by Formula 1 may have a low driving voltage, a high efficiency, and a high luminance.

[0144] The antiaromatic compound of Formula 1 may be synthesized using (utilizing) a suitable organic synthesis method. Methods of synthesizing the antiaromatic compound of Formula 1 may be understood by those of ordinary skill in the art based on the examples that will be described below.

[0145] The antiaromatic compound of Formula 1 may be used (utilized) between a pair of electrodes of an organic light-emitting device. For example, the antiaromatic compound of Formula 1 may be in an electron transport region, for example, in an electron transport layer.

[0146] According to another embodiment of the present disclosure, an organic light-emitting device includes a first electrode, a second electrode disposed opposite to the first electrode, and an organic layer disposed between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes at least one of the antiaromatic compounds of Formula 1 described above.

[0147] As used herein, the expression "(the organic layer) includes at least one (or at least one of the) antiaromatic compound(s)" refers to the situation where "(the organic layer) includes one of the antiaromatic compounds of Formula 1, or at least two antiaromatic compounds of Formula 1."

[0148] In some embodiments, the organic layer may include only Compound 1 as the antiaromatic compound. In this regard, Compound 1 may be present in the emission layer of the organic light-emitting device. In some embodiments, the organic layer may include Compounds 1 and 2 as the antiaromatic compounds. In this regard, Compounds 1 and 2 may be present both in the same layer (for example, in the emission layer) or may be present in different layers (for example, in the emission layer and the electron transport layer, respectively).

[0149] The organic layer may include i) a hole transport region disposed between the first electrode and the emission layer, and including at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer; and ii) an electron transport region disposed between the emission layer and the second electrode, and including at least one of a hole blocking layer, an electron transport layer, and an electron injection layer. The electron transport region may include the antiaromatic compound of Formula 1. For example, the electron transport region may include the electron transport layer, wherein the electron transport layer may include the antiaromatic compound of Formula 1.

[0150] As used herein, the term "organic layer" refers to a single layer and/or a plurality of layers disposed between the first and second electrodes of the organic light-emitting device. A material in the "organic layer" is not limited to an organic material.

[0151] Hereinafter, a structure of an organic light-emitting device according to an embodiment of the present disclosure and a method of manufacturing the same will now be described with reference to FIG. **1**.

[0152] FIG. **1** is a schematic sectional view of an organic light-emitting device **10** according to an embodiment of the present disclosure. Referring to FIG. **1**, the organic light-emitting device **10** includes a first electrode **110**, an organic layer **150**, and a second electrode **190**.

[0153] A substrate may be disposed under the first electrode **110** or on the second electrode **190** in FIG. **1**. The substrate may be a glass or transparent plastic substrate with good mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and/or water resistance.

[0154] For example, the first electrode **110** may be formed by depositing or sputtering a first electrode-forming material on the substrate **11**. When the first electrode **110** is an anode, a material having a high work function may be used (utilized) as the first electrode-forming material to facilitate hole injection. The first electrode **110** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. Transparent and conductive materials (such as ITO, IZO, SnO_2, or ZnO) may be used (utilized) to form the first electrode. The first electrode **110** as a semi-transmissive electrode or a reflective electrode may be formed of at least one material selected from magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag).

[0155] The first electrode **110** may have a single-layer structure or a multi-layer structure including a plurality of layers. For example, the first electrode **110** may have a three-layered structure of ITO/Ag/ITO, but is not limited thereto.

[0156] The organic layer **150** may be disposed on the first electrode **110**. The organic layer **150** may include an emission layer (EML).

[0157] The organic layer **150** may include a hole transport region disposed between the first electrode and the EML, and an electron transport region between the EML and the second electrode.

[0158] For example, the hole transport region may include at least one of a hole injection layer (HIL), a hole transport layer (HTL), a buffer layer, and an electron blocking layer (EBL). For example, the electron transport layer may include at least one of a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL). However, embodiments of the present disclosure are not limited thereto.

[0159] The hole transport region may have a single-layered structure including a single material, a single-layered structure including a plurality of materials, or a multi-layered structure including a plurality of layers including different materials.

[0160] In some embodiments, the electron transport region may have a single-layered structure including a plurality of materials, or a multi-layered structure of HIL/HTL, HIL/HTL/buffer layer, HIL/buffer layer, HTL/buffer layer, or HIL/HTL/EBL, wherein these layers forming the multi-layered structure are sequentially disposed on the first electrode **110** in the order stated above. However, embodiments of the present disclosure are not limited thereto.

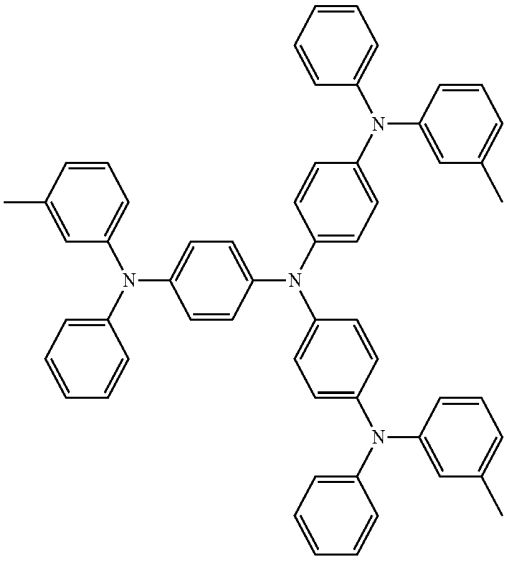
[0161] When the hole transport region includes an HIL, the HIL may be formed on the first electrode **110** by using (utilizing) any of a variety of suitable methods, for example, by using (utilizing) vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like.

[0162] When the HIL is formed using (utilizing) vacuum deposition, the deposition conditions may vary depending on the material that is used (utilized) to form the HIL and the structure of the HIL. For example, the deposition conditions may be selected from the following conditions: a deposition temperature of about 100° C. to about 500° C., a degree of vacuum of about 10^{-8} to about 10^{-3} torr, and a deposition rate of about 0.01 to 100 Å/sec.

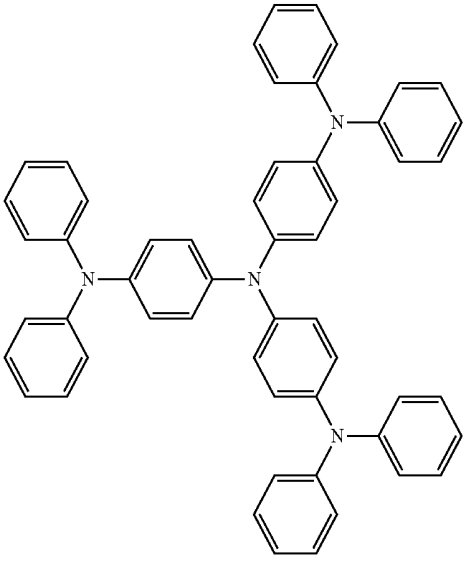
[0163] When the HIL is formed using (utilizing) spin coating, the coating conditions may vary depending on the material that is used (utilized) to form the HIL and the structure of the HIL. For example, the coating conditions may be selected from the following conditions: a coating rate of about 2,000 rpm to about 5,000 rpm, and a heat treatment temperature of about 800° C. to about 200° C.

[0164] When the hole transport region includes an HTL, the HTL may be formed on the first electrode **110** or the HIL by using (utilizing) any of a variety of suitable methods, for example, by using (utilizing) vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the HTL is formed using (utilizing) vacuum deposition or spin coating, the conditions for deposition and coating may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in more detail.

[0165] In some embodiments, the hole transport region may include at least one of m-MTDATA, TDATA, 2-TNATA, NPB, β-NPB, TPD, Spiro-TPD, Spiro-NPB, α-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202.



m-MTDATA



TDATA

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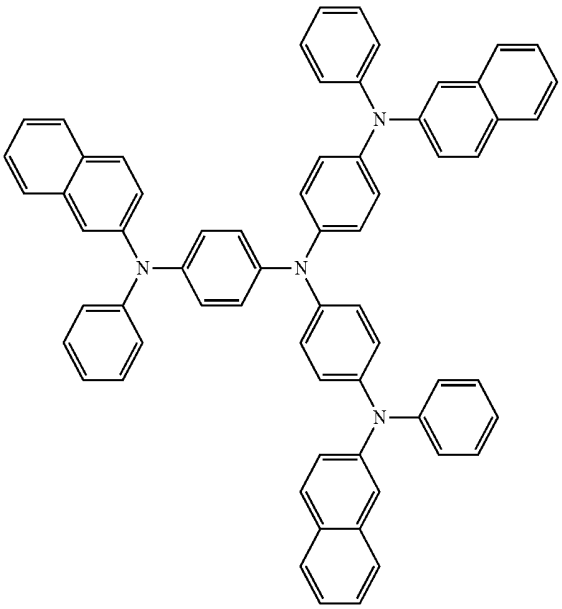
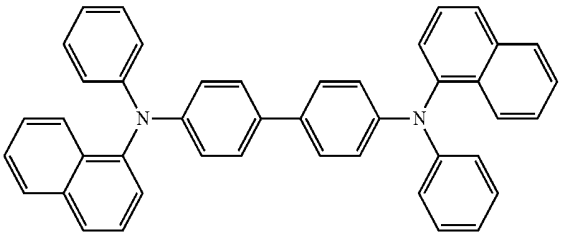
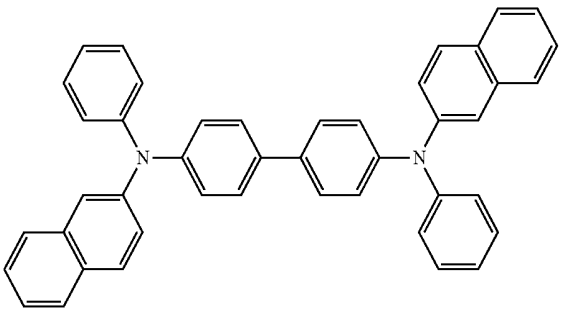


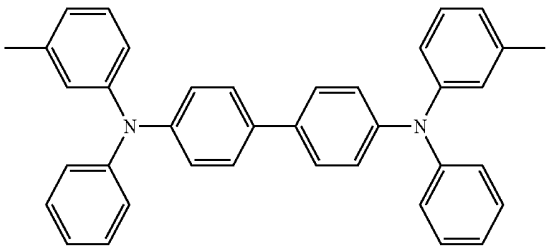
2-TNATA



NPB



β-NPB



TPD

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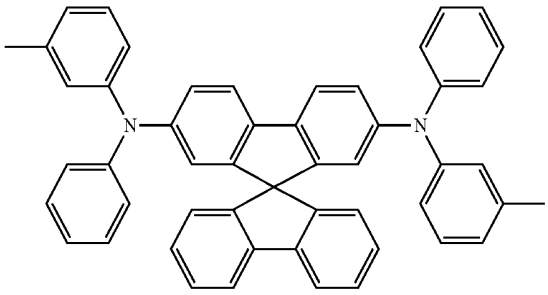
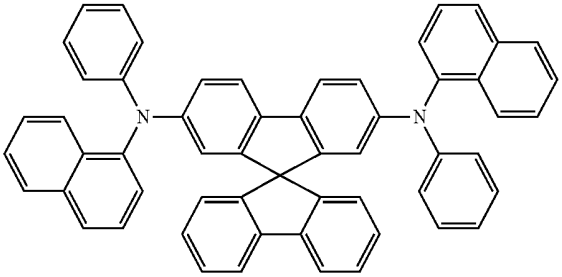
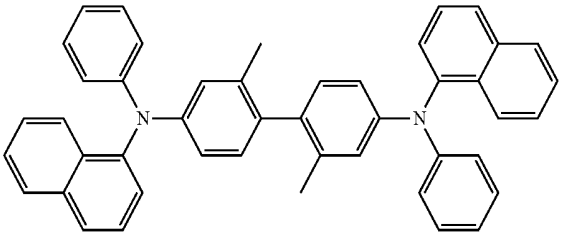


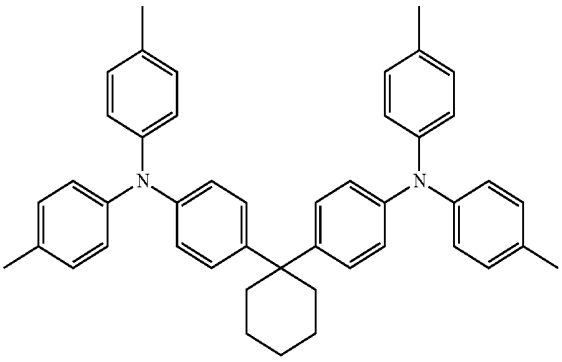
Spiro-TPD



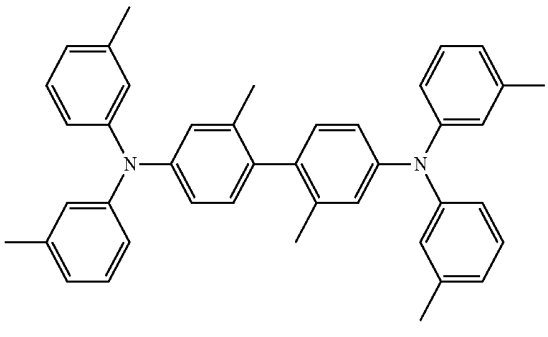
Spiro-NPB



α-NPB



TAPC



HMTPD

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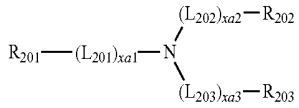
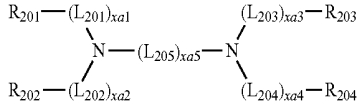
Formula 201



Formula 202



[0166] In Formulae 201 and 202,

[0167] descriptions for L_{201} to L_{205} may be each independently the same as the descriptions for L_1 in Formula 1;

[0168] xa1 to xa4 may be each independently selected from 0, 1, 2, and 3;

[0169] xa5 may be selected from 1, 2, 3, 4, and 5; and

[0170] descriptions for R_{201} to R_{205} may be each independently the same as the descriptions for R_{11} described above.

[0171] For example, in Formulae 201 and 202,

[0172] L_{201} to L_{205} may be each independently selected from:

[0173] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a fluorene group, a difluorene 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

[0174] 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 of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

[0175] xa1 to xa4 may be each independently 0, 1, or 2;

[0176] xa5 may be 1, 2, or 3;

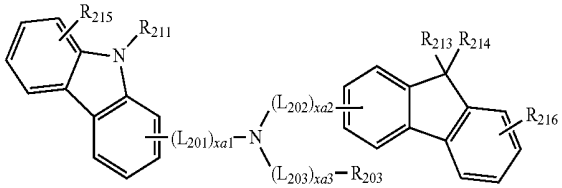
[0177] R_{201} to R_{205} may be each independently selected from:

[0178] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0179] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, an azulenyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group. However, embodiments of the present disclosure are not limited thereto.

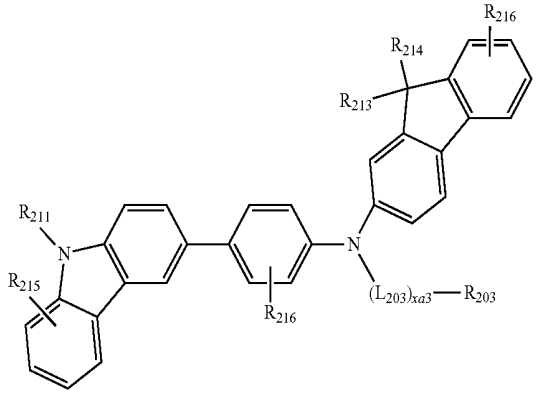
[0180] The compound of Formula 201 may be represented by Formula 201A:

Formula 201A



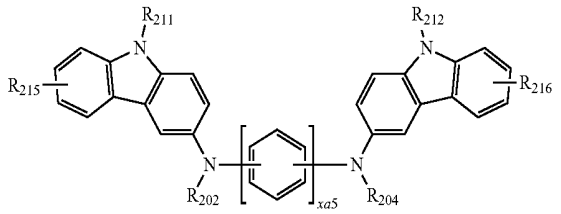
[0181] For example, the compound of Formula 201 may be represented by Formula 201A-1, but is not limited thereto:

Formula 201A-1



[0182] The compound of Formula 202 may be represented by Formula 202A, but is not limited thereto:

Formula 202A



[0183] In Formulae 201A, 201A-1, and 202A,

[0184] descriptions for L_{201} to L_{203}, xa1 to xa3, xa5, and R_{202} to R_{204} may be the same as those described in conjunction with Formula 201;

[0185] descriptions for R_{211} may be the same as the descriptions for R_{203} in Formula 201; and

[0186] R_{213} to R_{216} may be each independently selected from a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, 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_2-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group.

[0187] For example, in Formulae 201A, 201A-1, and 202A,

[0188] L_{201} to L_{203} may be each independently selected from:

[0189] 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

[0190] 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 a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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} group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

[0191] xa1 to xa3 may be each independently 0 or 1;

[0192] R_{203}, R_{211}, and R_{212} may be each independently selected from:

[0193] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0194] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a 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 a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

[0195] R_{213} and R_{214} may be each independently selected from:

[0196] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

[0197] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a 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;

[0198] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0199] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzof-

luorenyl 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 a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

[0200] R_{215} and R_{216} may be each independently selected from:

[0201] a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0202] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

[0203] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a 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;

[0204] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, and a triazinyl group; and

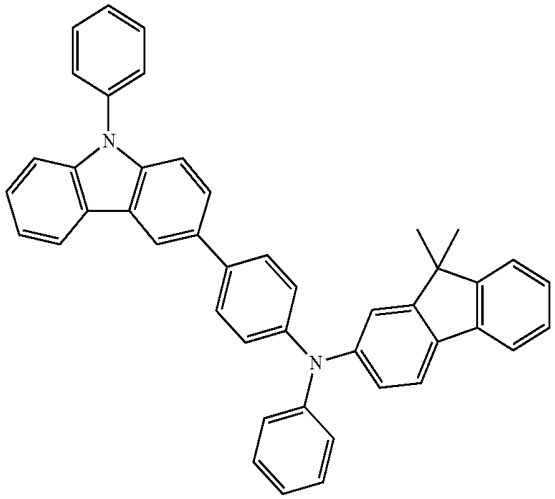
[0205] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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

[0206] xa5 may be 1 or 2.

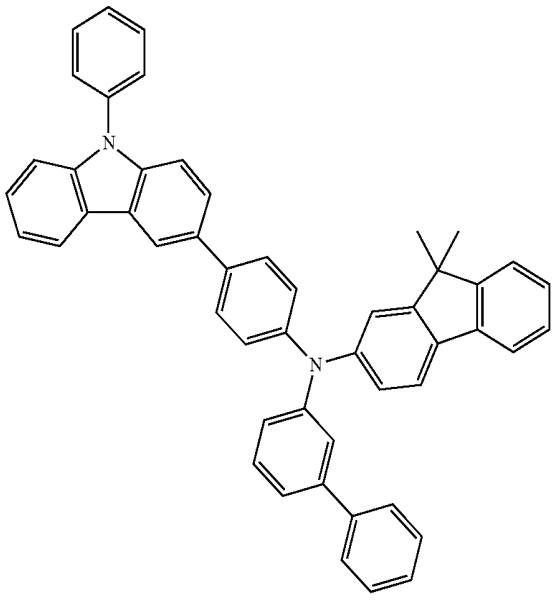
[0207] In Formulae 201A and 201A-1, R_{213} and R_{214} may be linked to each other to form a saturated or unsaturated ring.

[0208] The compound represented by Formula 201, and the compound represented by Formula 202 may be compounds HT1 to HT20 illustrated below, but they are not limited thereto.

HT1



HT2



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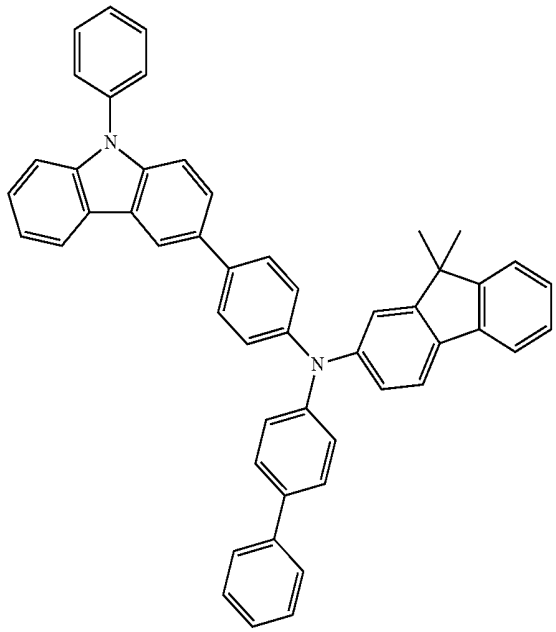
HT3



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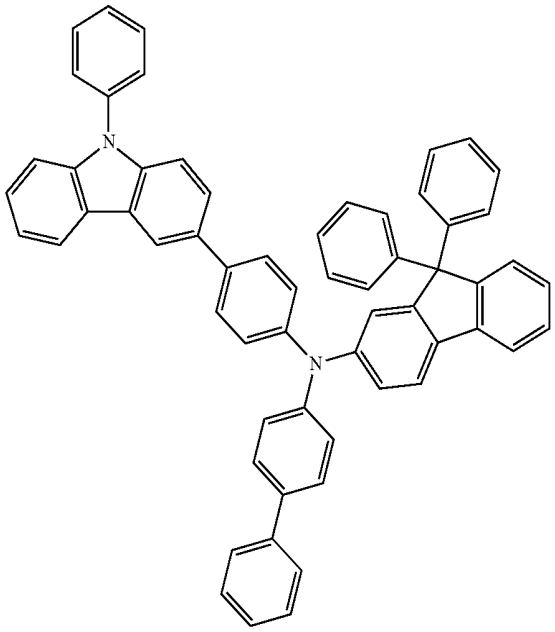
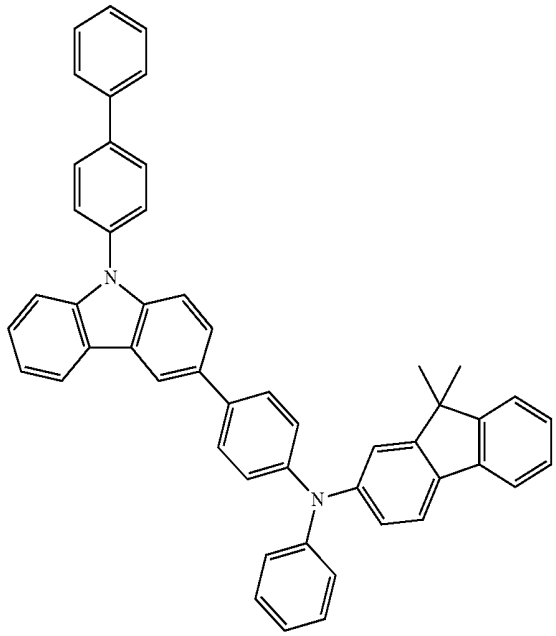
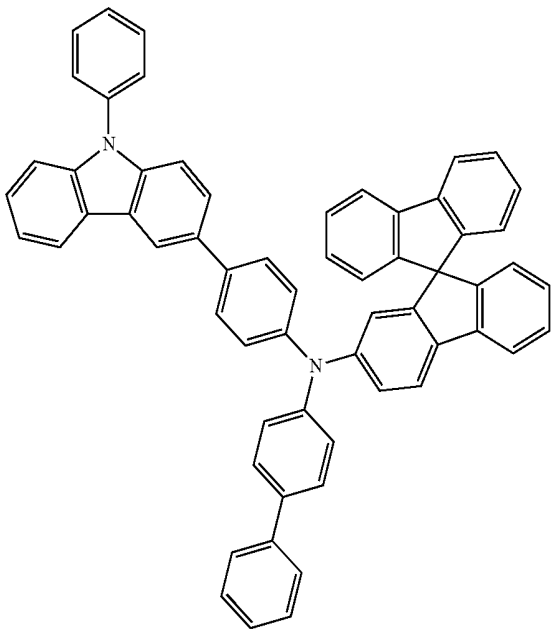
HT5



HT4



HT6



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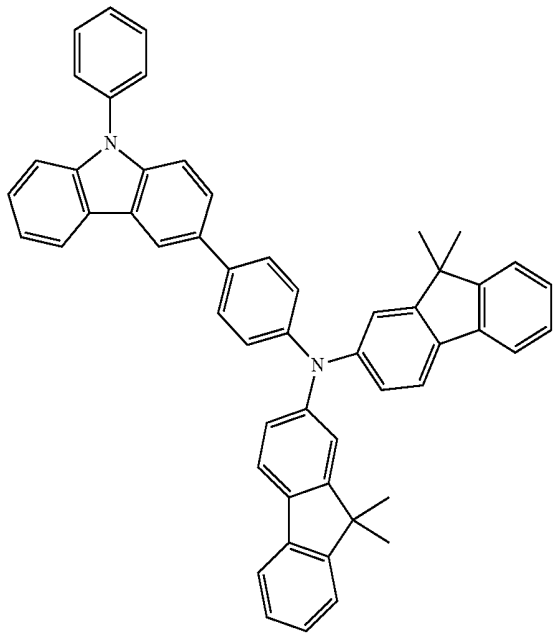

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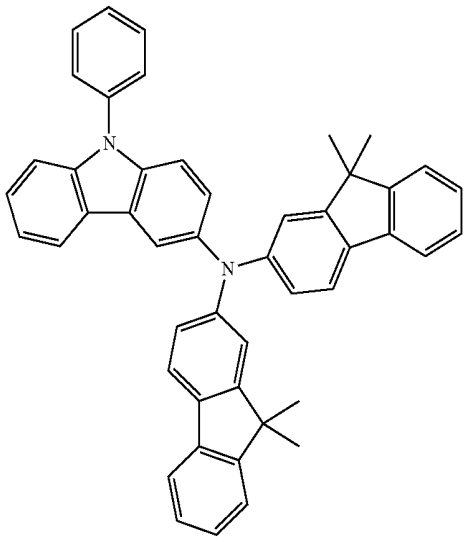

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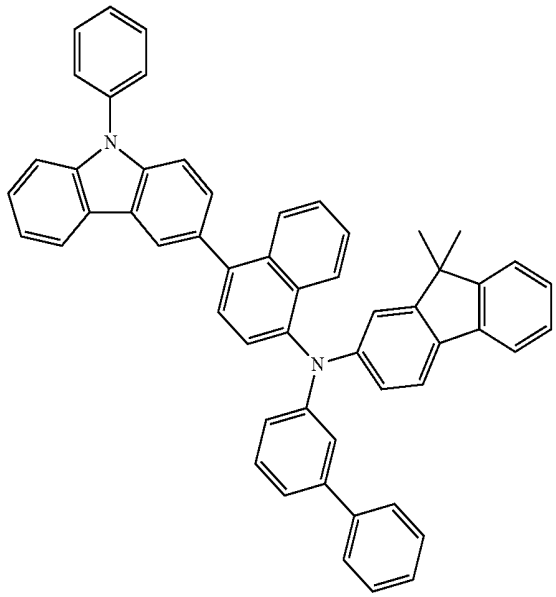

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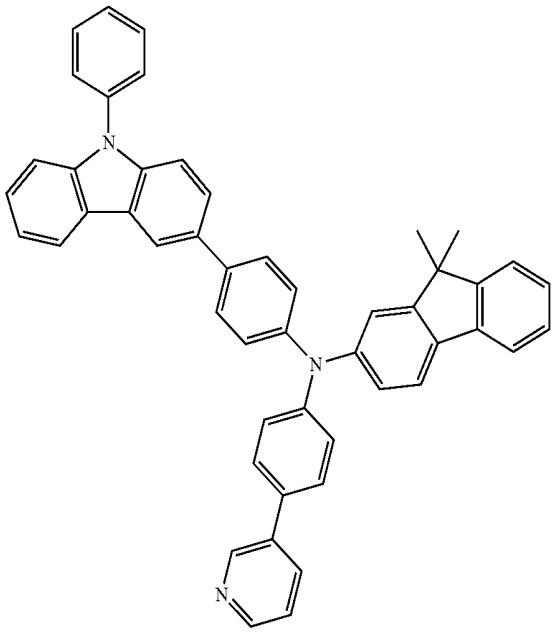

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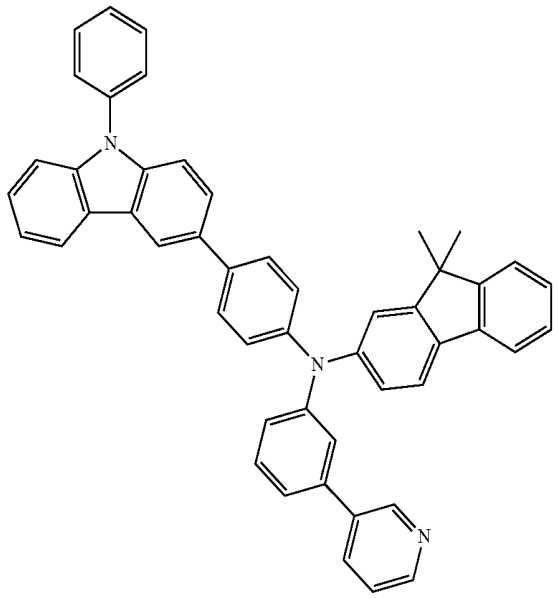

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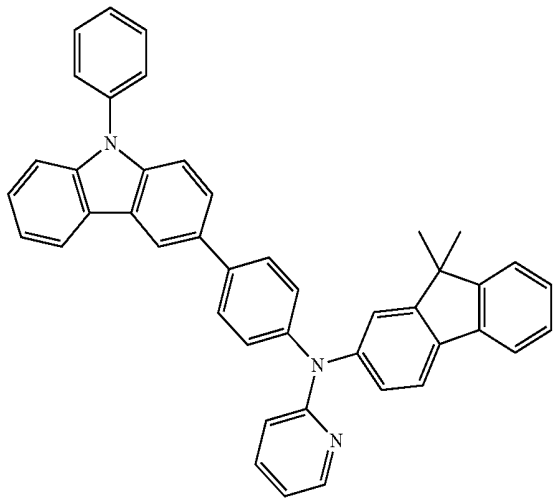

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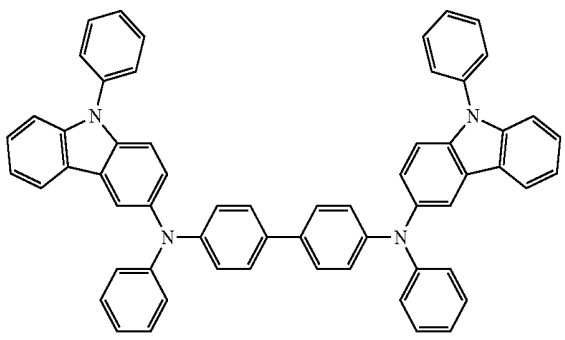

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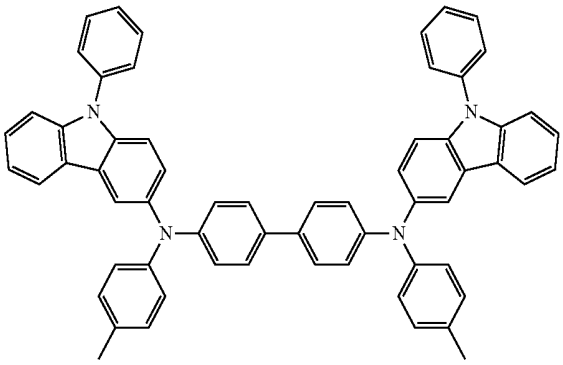
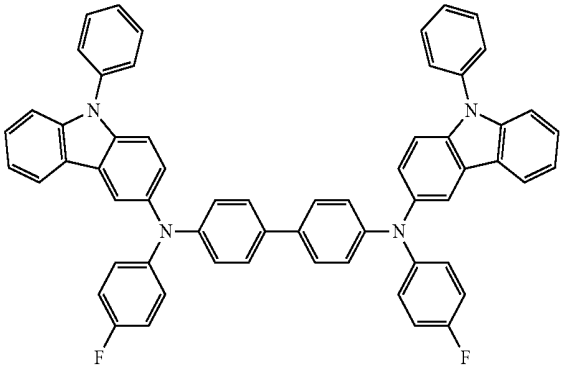
HT14



HT15



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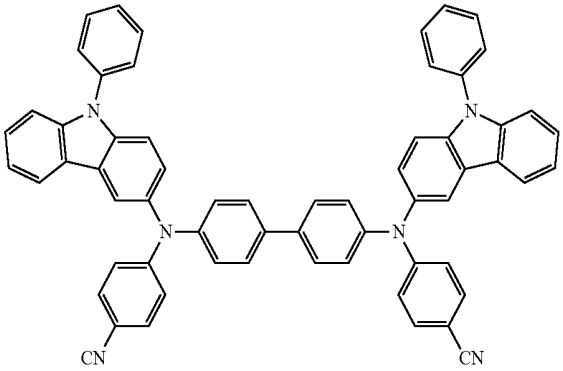
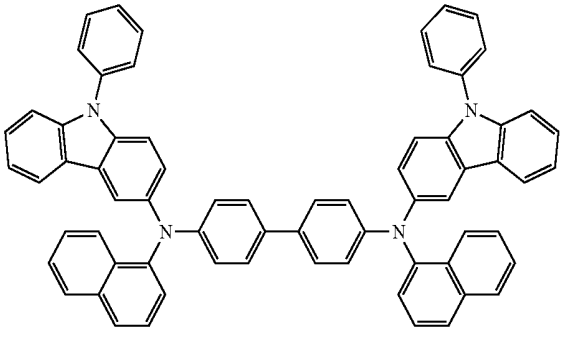


HT17



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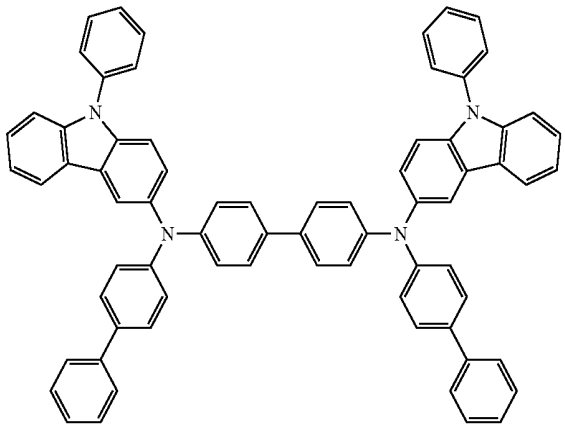
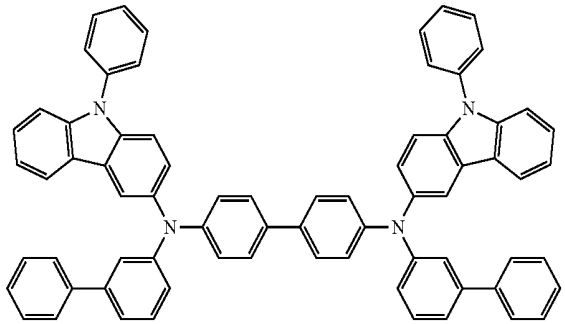
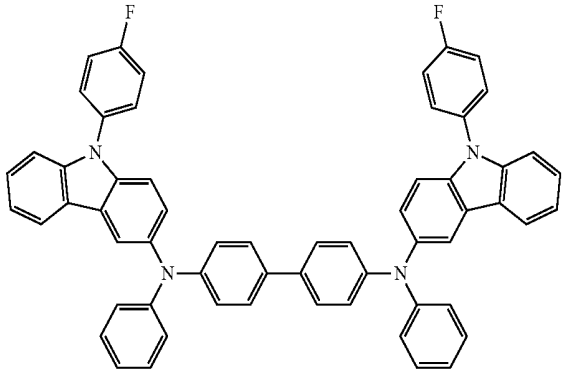
HT18



HT19



HT20

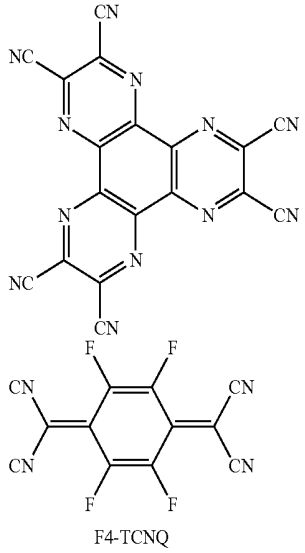


[0209] A thickness of the hole transport region may be from about 100 Å to about 10000 Å, and in some embodiments, from about 100 Å to about 1000 Å. When the hole transport region includes an HIL and an HTL, a thickness of the HIL may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 1,000 Å; and a thickness of the HTL may be from about 50 Å to about 2,000 Å, and in some embodiments, from about 100 Å to about 1,500 Å. In one embodiment, when the thicknesses of the hole transport region, the HIL, and the HTL are within these ranges, satisfactory hole transport characteristics are obtained without a substantial increase in driving voltage.

[0210] The hole transport region may further include a charge-generating material to improve the conductivity, in addition to the materials described above. The charge-generating material may be homogeneously or inhomogeneously dispersed in the hole transport region.

[0211] The charge-generating material may be, for example, a p-dopant. The p-dopant may be one of quinine derivatives, metal oxides, and compounds with a cyano group, but is not limited thereto. Non-limiting examples of the p-dopant are quinone derivatives such as tetracyanoquinonedimethane (TCNQ), 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4-TCNQ), or the like; metal oxides such as tungsten oxide, molybdenum oxide, or the like; and Compound HT-D1.

Compound HT-D1



F4-TCNQ

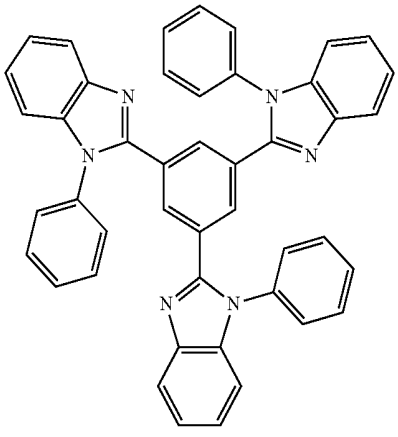
[0212] The hole transport region may further include at least one of a buffer layer and an EBL, in addition to the HIL and HTL described above. The buffer layer may compensate for an optical resonance distance of light according to a wavelength of the light emitted from the EML, and thus may improve the light-emission efficiency. A material in the buffer layer may be any suitable material used (utilized) in the hole transport region. The EBL may reduce or block migration of electrons from the electron transport region into the EML.

[0213] The EML may be formed on the first electrode **110** or the hole transport region by using (utilizing) any of a variety of suitable methods, for example, by using (utilizing) vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the EML is formed using (utilizing) vacuum deposition or spin coating, the deposition and coating conditions for forming the EML may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in more detail

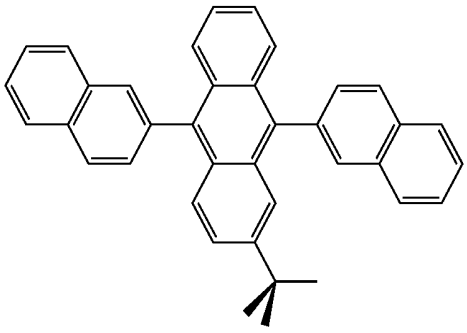
[0214] When the organic light-emitting device **10** is a full color organic light-emitting device, the EML may be patterned into a red emission layer, a green emission layer, and a blue emission layer to correspond to individual subpixels, respectively. In some embodiments, the EML may have a structure in which a red emission layer, a green emission layer and a blue emission layer are stacked upon one another; or a structure including a mixture of a red light-emitting material, a green light-emitting material, and a blue light-emitting material, and thus may emit white light.

[0215] The EML may include a host and a dopant.

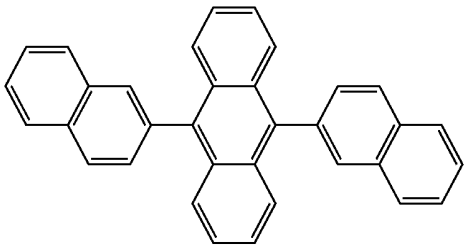
[0216] The host may include at least one selected from TPBi, TBADN, ADN (also referred to as "DNA"), CBP, CDBP, and TCP:



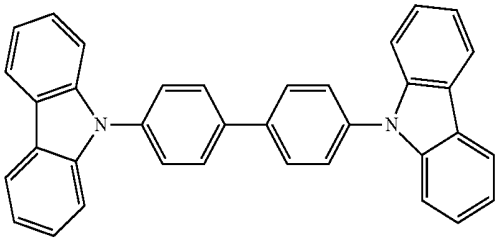
TPBi



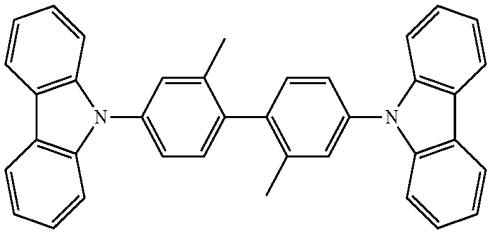
TBADN



ADN



CBP



CDBP

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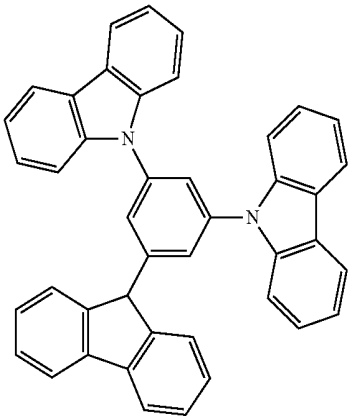


TCP

[0217] In some embodiments, the host may include a compound represented by Formula 301.

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

[0218] In Formula 301,

[0219] Ar_{301} may be selected from:

[0220] 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;

[0221] 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 a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, 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_2-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, a non-aromatic condensed heteropolycyclic group, and —$Si(Q_{301})(Q_{302})(Q_{303})$ (where Q_{301} to Q_{303} may be each independently selected from a hydrogen atom, a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and C_2-C_{60} heteroaryl group);

[0222] descriptions for L_{301} may be the same as the descriptions for L_{201} in Formula 201;

[0223] R_{301} may be selected from:

[0224] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

[0225] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a 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;

[0226] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazole group, and a triazinyl group; and

[0227] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

[0228] xb1 may be selected from 0, 1, 2, and 3; and

[0229] xb2 may be selected from 1, 2, 3, and 4.

[0230] For example, in Formula 301,

[0231] L_{301} may be selected from:

[0232] 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

[0233] 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 a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group; and

[0234] R_{301} may be selected from:

[0235] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group;

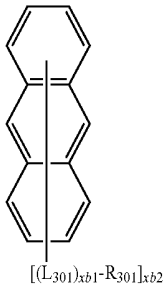
[0236] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a 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;

[0237] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group; and

[0238] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group. However, embodiments of the present disclosure are not limited thereto.

[0239] For example, the host may include a compound represented by Formula 301A:

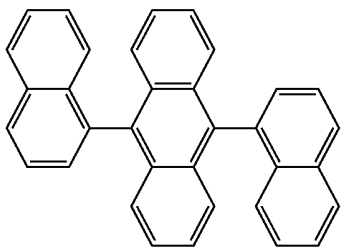
Formula 301A



[0240] Substituents in Formula 301A may be the same as those defined above herein.

[0241] The compound of Formula 301 may include at least one of Compounds H1 to H42, but is not limited thereto:

H1



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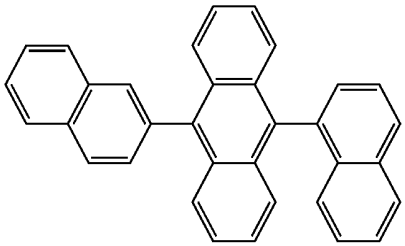
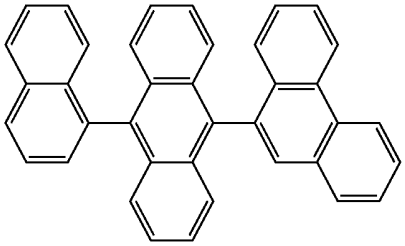
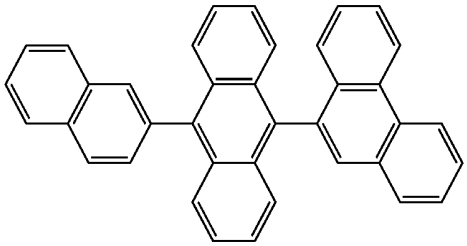
H2



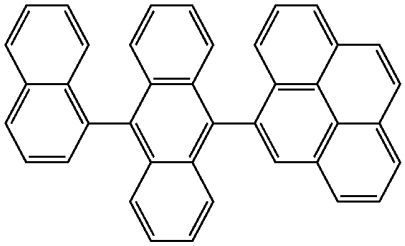
H3



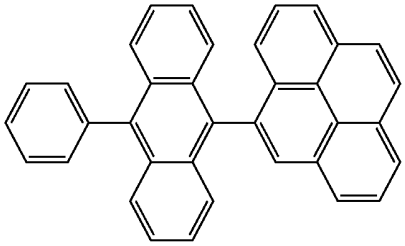
H4



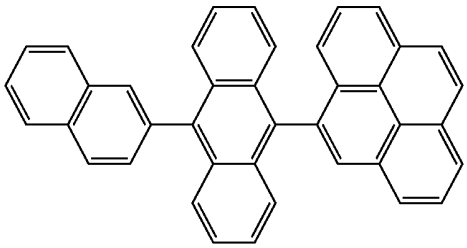
H5



H6



H7



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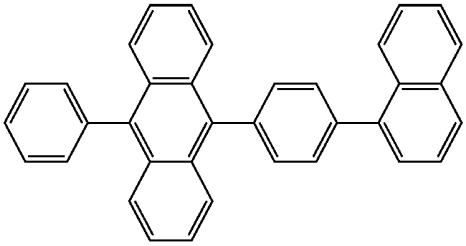
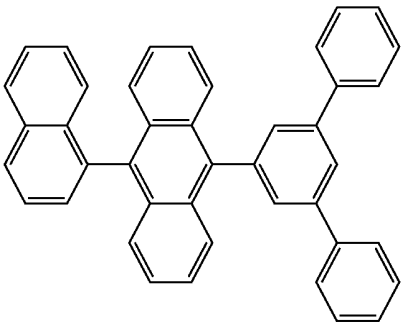
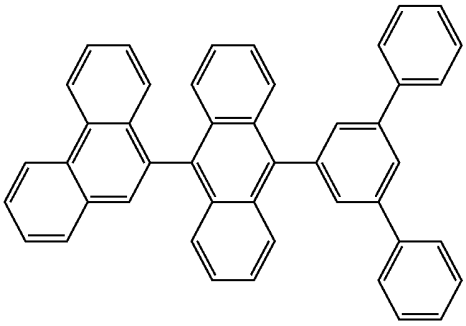
H8



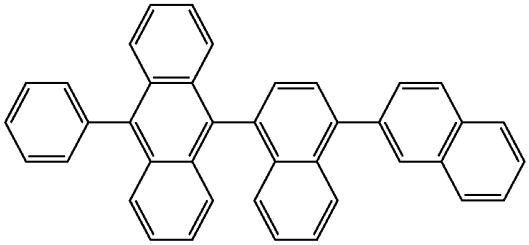
H9



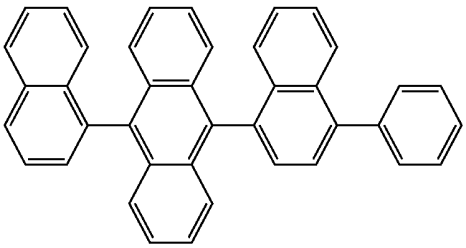
H10



H11



H12



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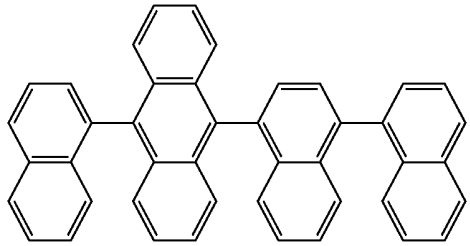

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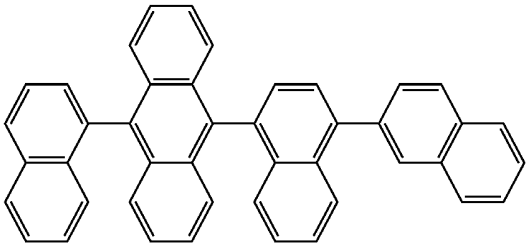

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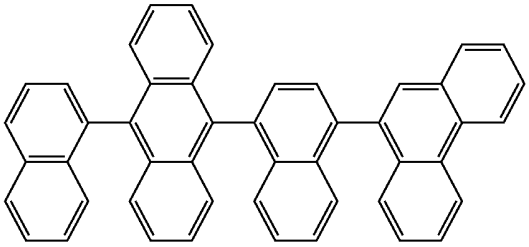

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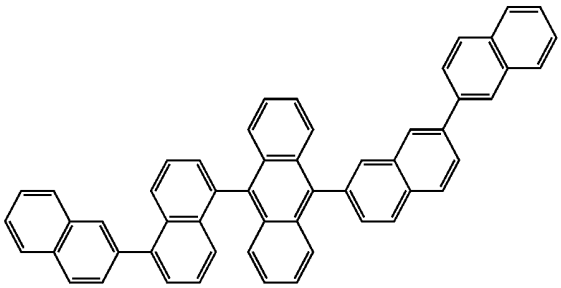

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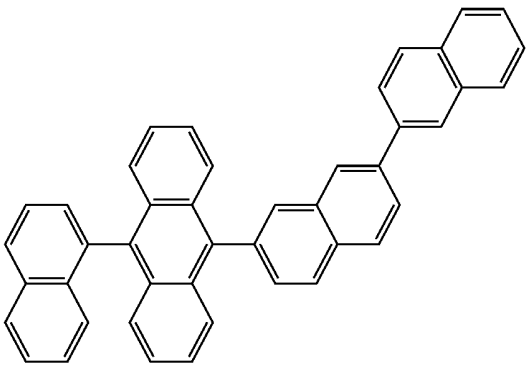

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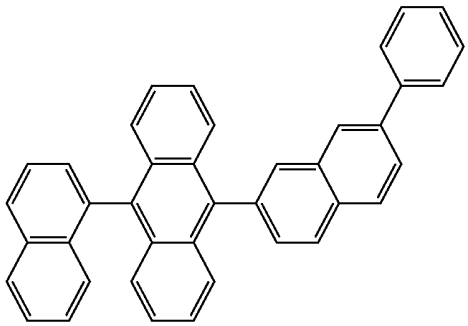

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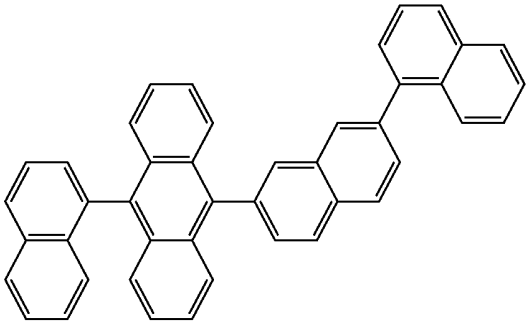

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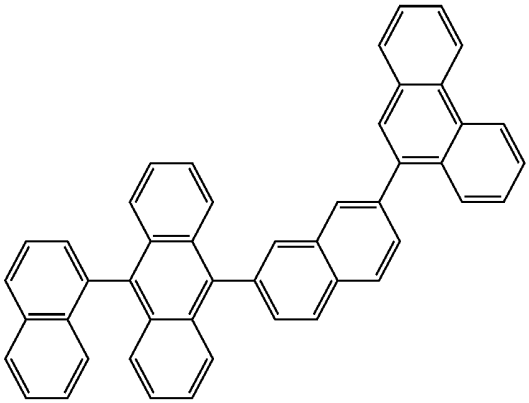

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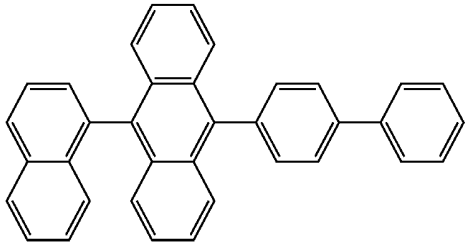

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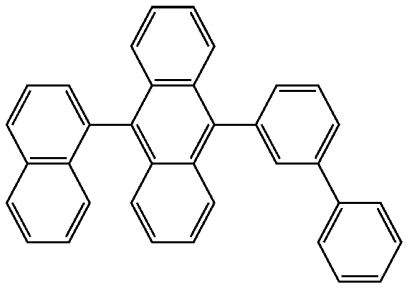

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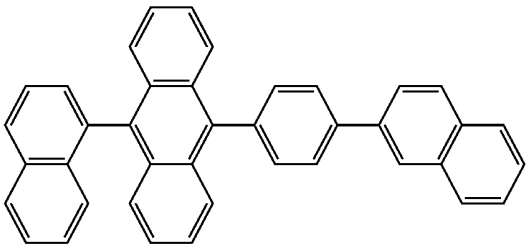

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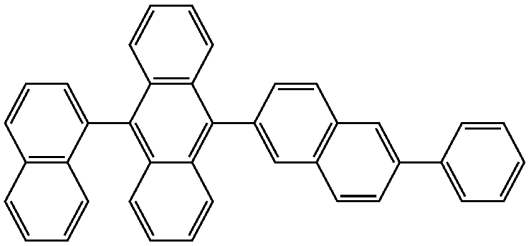

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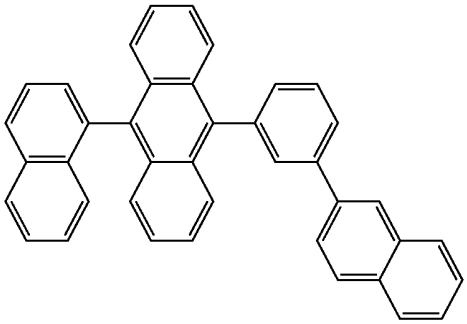

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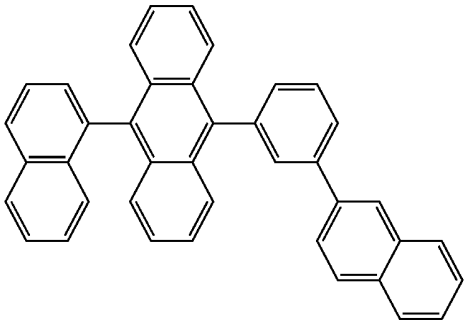

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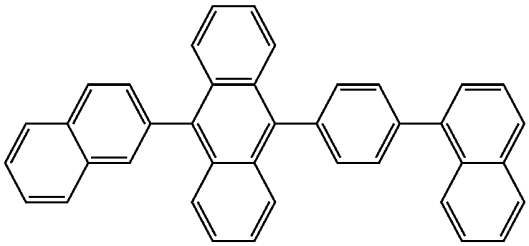

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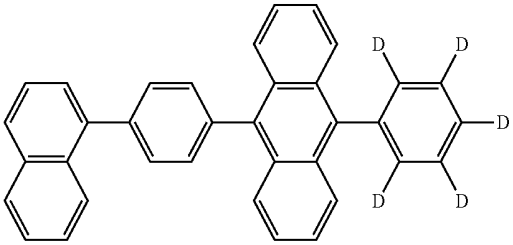

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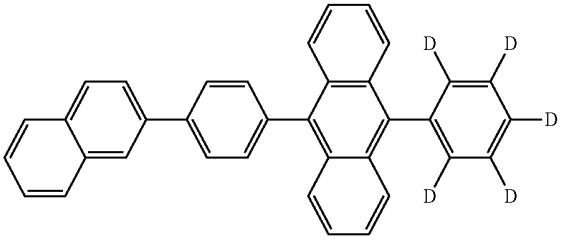

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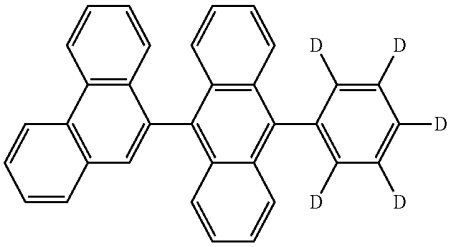

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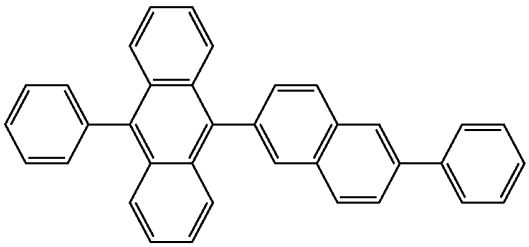

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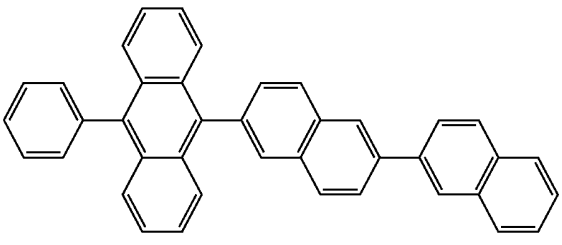

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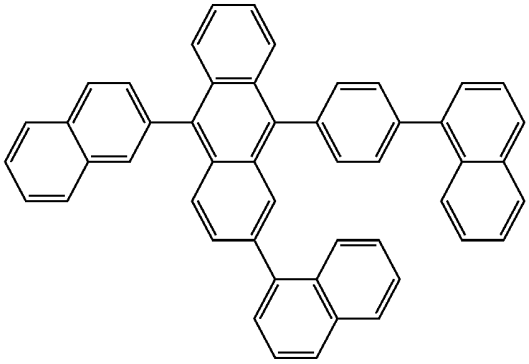

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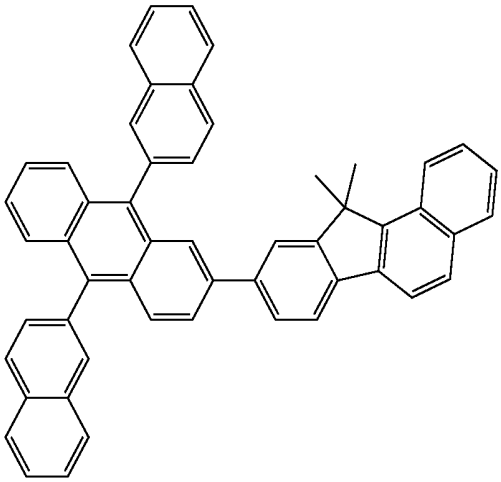

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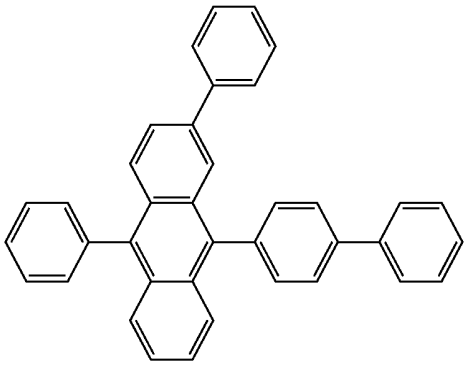

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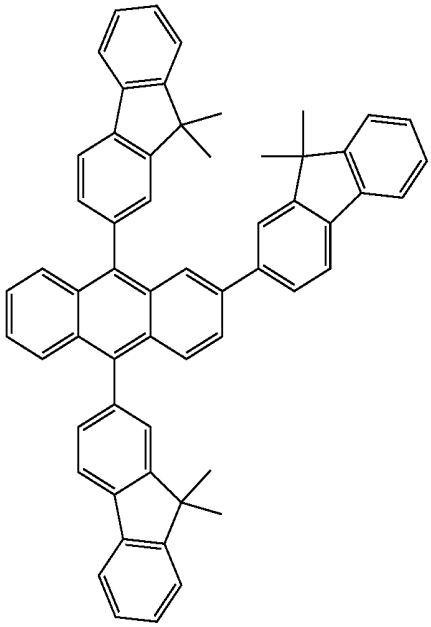

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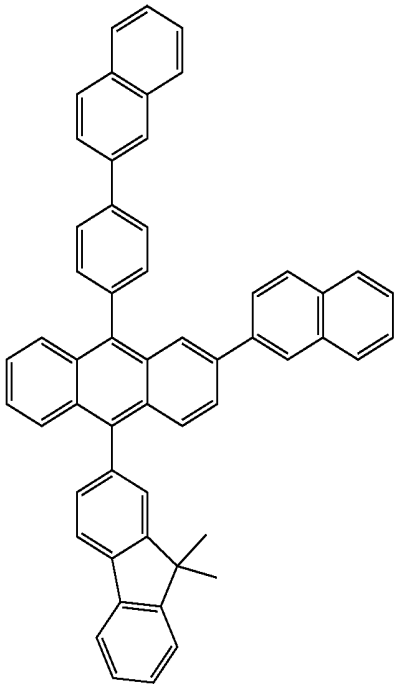

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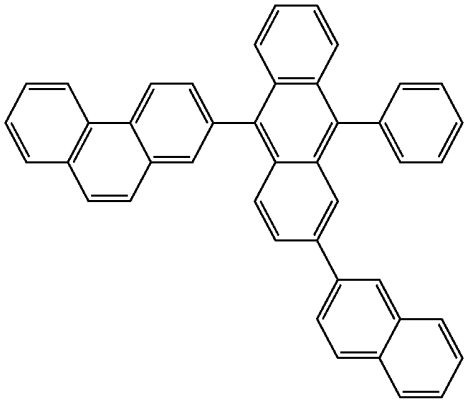

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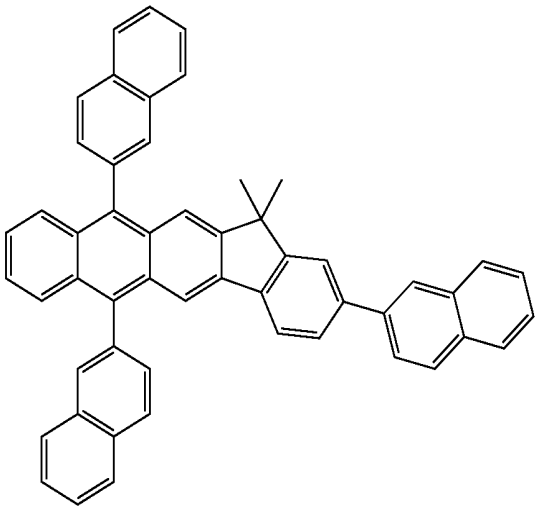

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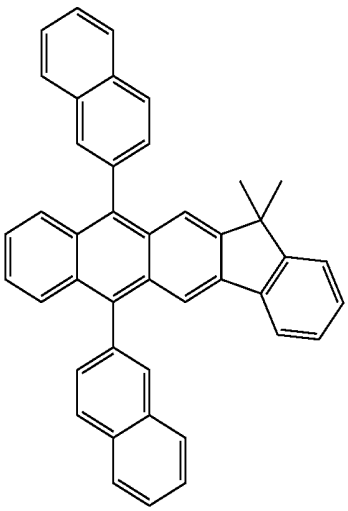

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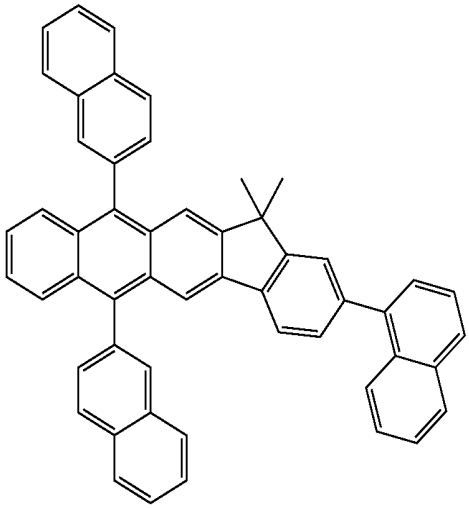

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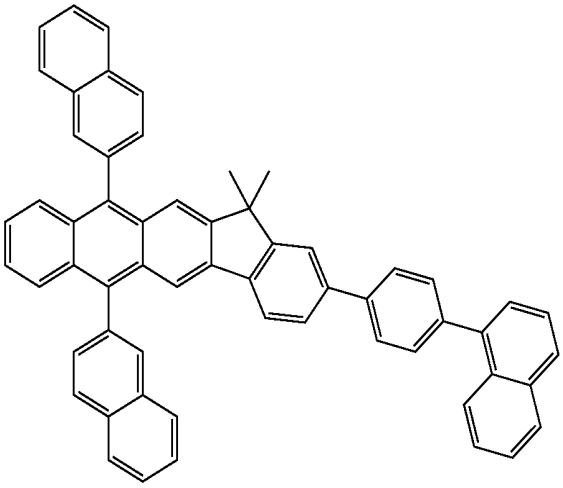
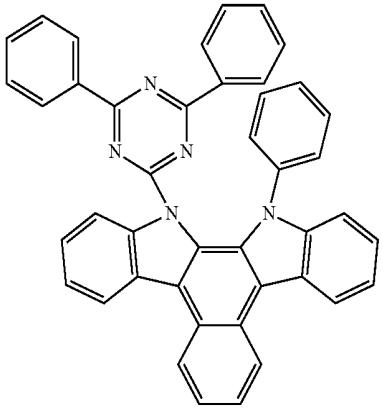


[0242] In some embodiments, the host may include at least one of Compounds H43 to H49, but is not limited thereto:

H43



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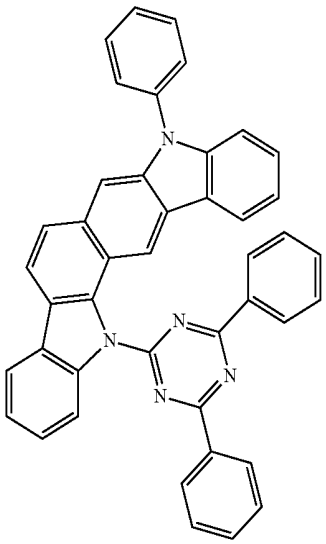

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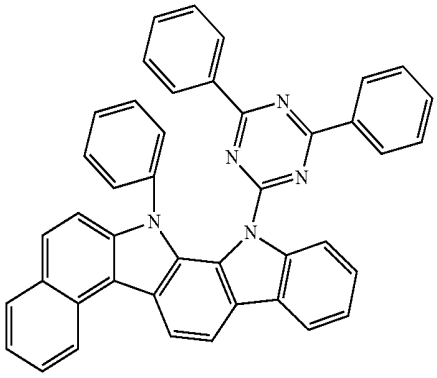
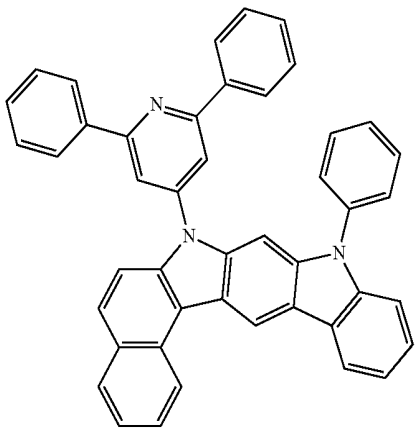


H46



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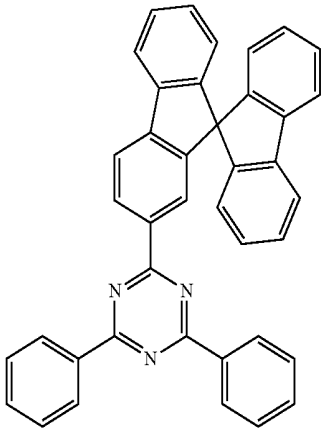
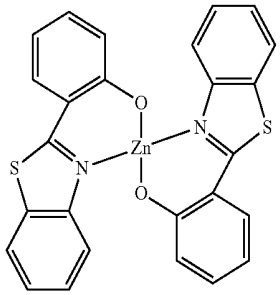
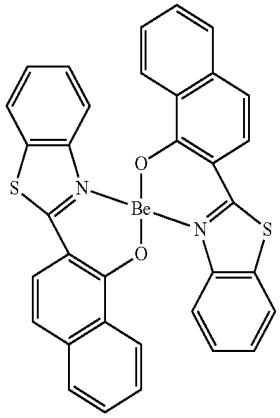


H48



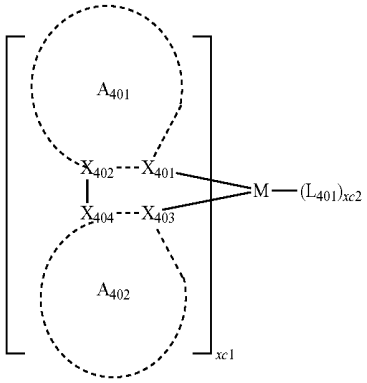
H49



[0243] The dopant may include at least one of a fluorescent dopant and a phosphorescent dopant.

[0244] The phosphorescent dopant may include an organometallic complex represented by Formula 401:

Formula 401



[0245] In Formula 401,

[0246] M may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), and thulium (Tm);

[0247] X_{401} to X_{404} may be each independently a nitrogen or a carbon;

[0248] rings A_{401} and A_{402} may be each independently 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 benzoimidazole, 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;

[0249] at least one substituent of the substituted benzene, the substituted naphthalene, the substituted fluorene, the substituted spiro-fluorene, the substituted indene, the substituted pyrrole, the substituted thiophene, the substituted furan, the substituted imidazole, the substituted pyrazole, the substituted thiazole, the substituted isothiazole, the substituted oxazole, the substituted isoxazole, the substituted pyridine, the substituted pyrazine, the substituted pyrimidine, the substituted pyridazine, the substituted quinoline, the substituted isoquinoline, the substituted benzoquinoline, the substituted quinoxaline, the substituted quinazoline, the substituted carbazole, the substituted benzoimidazole, the substituted benzofuran, the substituted benzothiophene, the substituted isobenzothiophene, the substituted benzoxazole, the substituted isobenzoxazole, the substituted triazole, the substituted oxadiazole, the substituted triazine, the substituted dibenzofuran, and the substituted dibenzothiophene may be selected from:

[0250] a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group;

[0251] a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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} 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, C_2-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, —$N(Q_{401})(Q_{402})$, —$Si(Q_{403})(Q_{404})(Q_{405})$, and —$B(Q_{406})(Q_{407})$,

[0252] a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_2-C_{60} heteroaryl group, and a non-aromatic condensed polycyclic group;

[0253] 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, C_2-C_{60} heteroaryl group, and a non-aromatic condensed polycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, 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, C_2-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, —$N(Q_{411})(Q_{412})$, —$Si(Q_{413})(Q_{414})(Q_{415})$, and —$B(Q_{416})(Q_{417})$; and

[0254] —$N(Q_{421})(Q_{422})$, —$Si(Q_{423})(Q_{424})(Q_{425})$, and —$B(Q_{426})(Q_{427})$;

[0255] L_{401} may be an organic ligand;

[0256] xc1 may be 1, 2, or 3; and

[0257] xc2 may be 0, 1, 2, or 3.

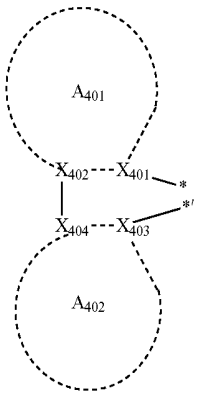
[0258] Q_{401} to Q_{407}, Q_{411} to Q_{417} and Q_{421} to Q_{427} may be each independently selected from a hydrogen atom, a C_1-C_{60}alkyl group, a C_2-C_{60}alkenyl group, a C_6-C_{60} aryl group, and C_2-C_{60} heteroaryl group.

[0259] For example, in Formula 401, L_{401} may be a monovalent, divalent, or trivalent organic ligand. For example, L_{401} in Formula 401 may be selected from a halogen ligand (for example, Cl or F), a diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propanedionate, 2,2,6,6-tetramethyl-3,5-heptanedionate, or hexafluoroacetonate), a carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazolecarboxylate, or benzoate), a carbon monoxide ligand, an isonitrile ligand, a cyano ligand, and a phosphorous ligand (for example, phosphine or phosphite). However, embodiments of the present disclosure are not limited thereto.

[0260] When A_{401} in Formula 401 has at least two substituent groups, the at least two substituent groups of A_{401} may be linked to each other to form a saturated or unsaturated ring.

[0261] When A_{402} in Formula 401 has at least two substituent groups, the at least two substituent groups of A_{402} may be linked to each other to form a saturated or unsaturated ring.

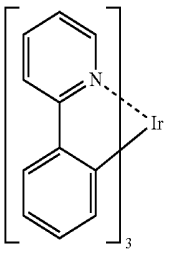
[0262] When xc1 in Formula 401 is 2 or greater, a plurality of ligands



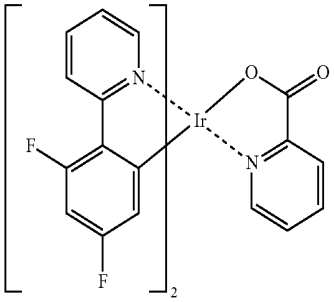
in Formula 401 may be identical to or different from each other. When xc1 in Formula 401 is 2 or greater, A_{401} and A_{402} may be linked to A_{401} and A_{402} of another adjacent ligand, respectively, directly or via a linking group (for example, a C_1-C_5 alkylene group, —N(R')— (where R' is a C_1-C_{10} alkyl group or a C_6-C_{20} aryl group), or C(=O)—).

[0263] The phosphorescent dopant may include at least one of Compounds PD1 to PD74, but is not limited thereto.

PD1



PD2



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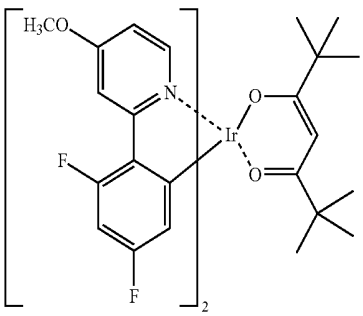

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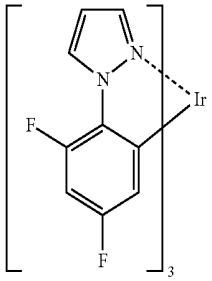

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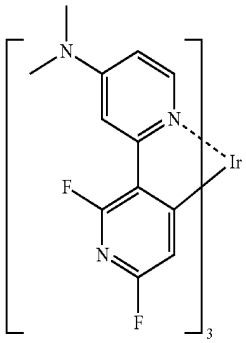

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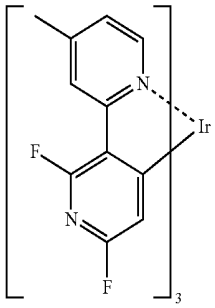

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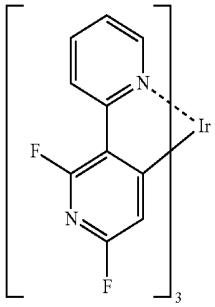

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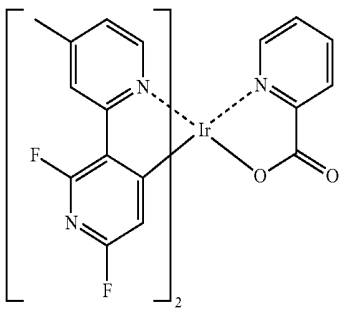

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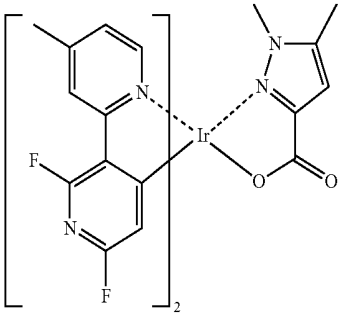

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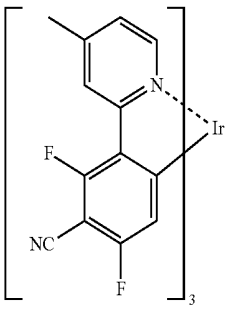

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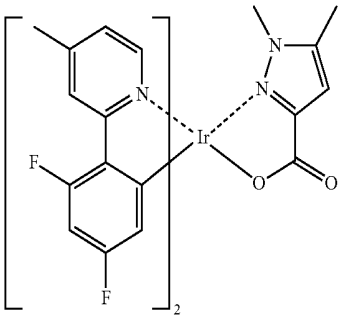

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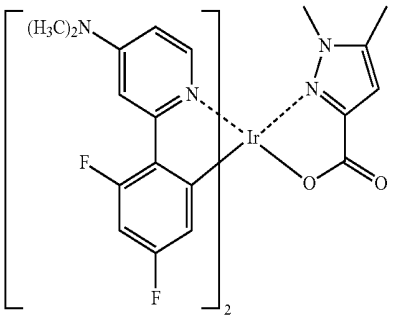

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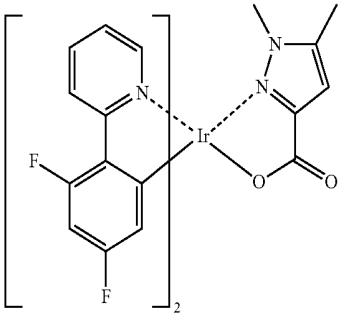

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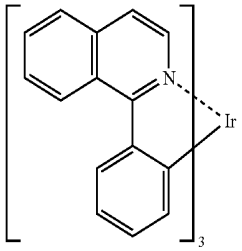

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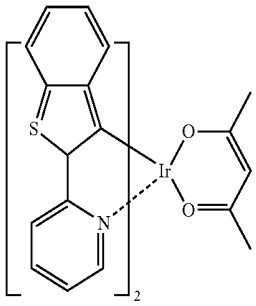

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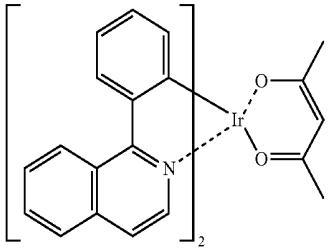

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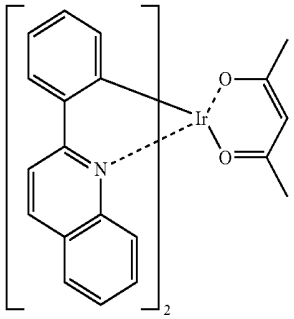

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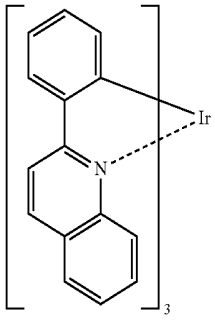

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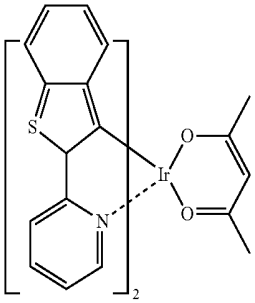

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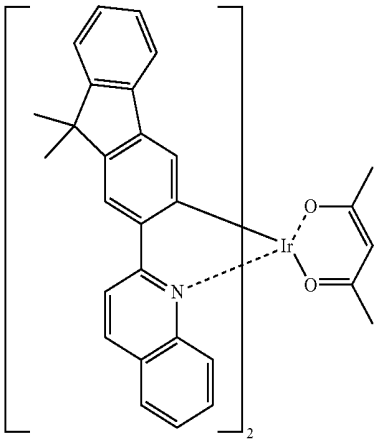

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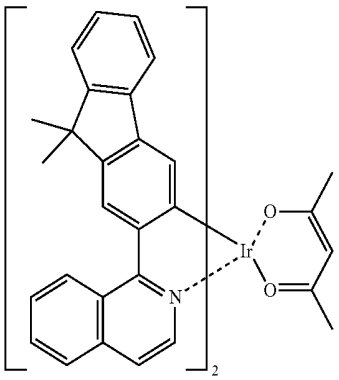

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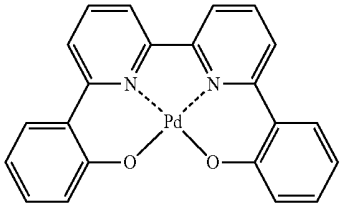

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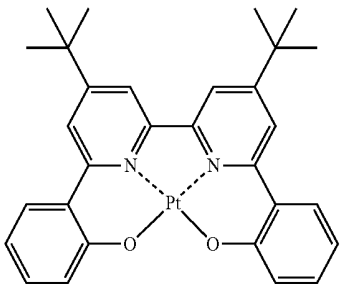

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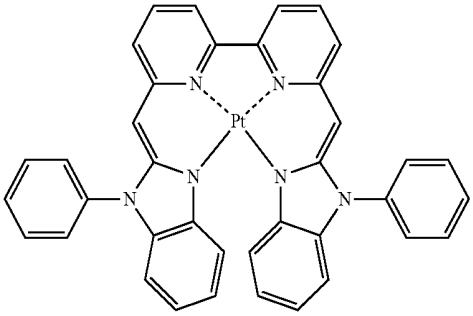

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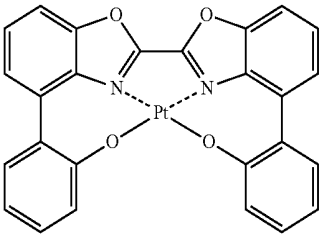

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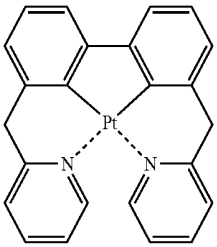

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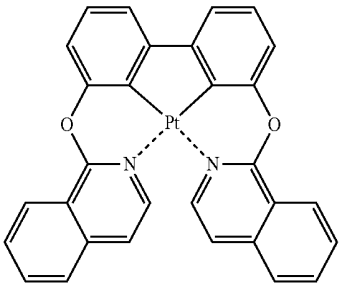

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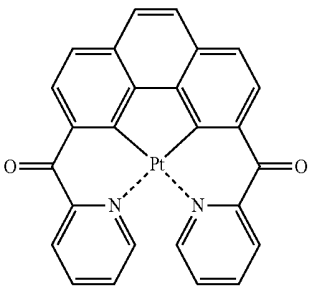

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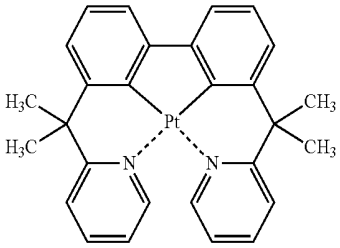

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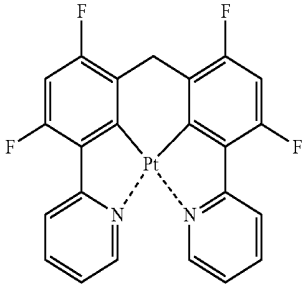

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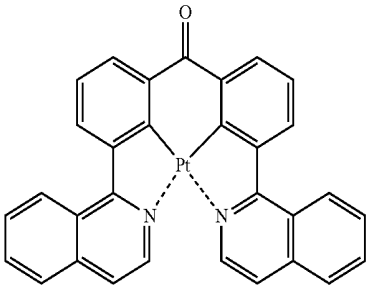

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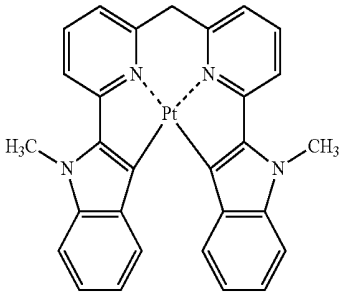

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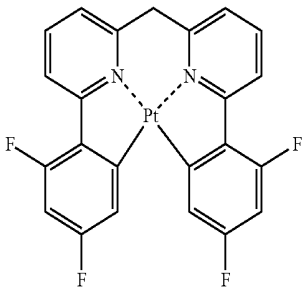

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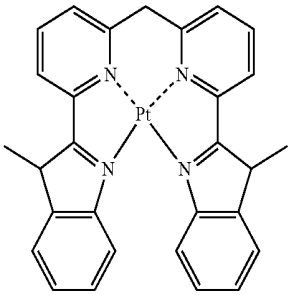

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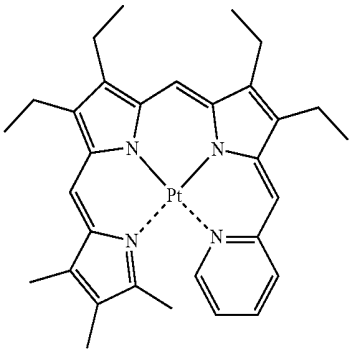

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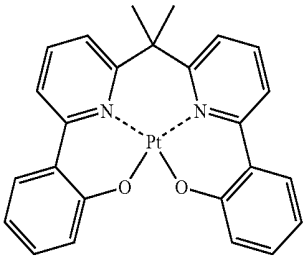

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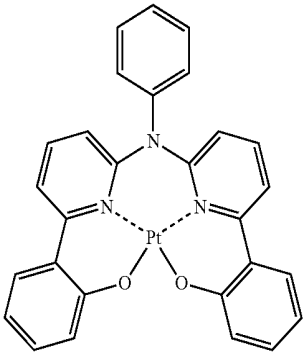

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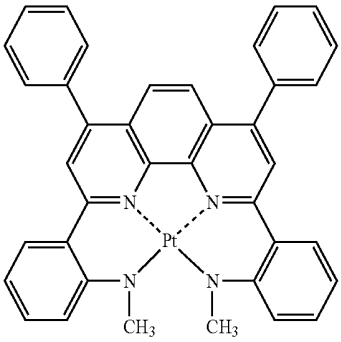

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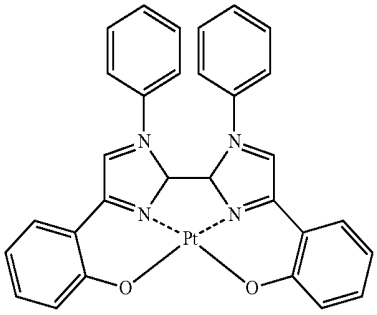

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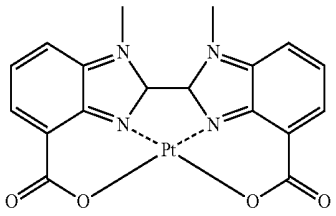

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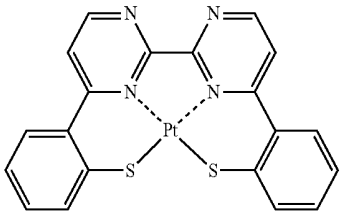

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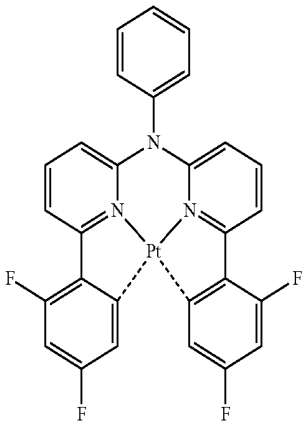

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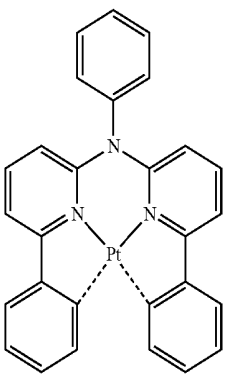

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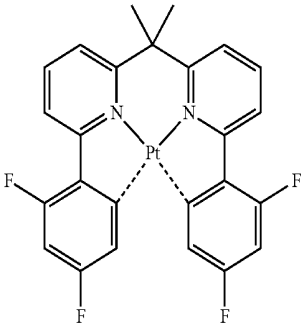

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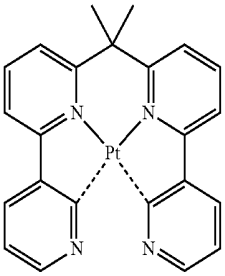

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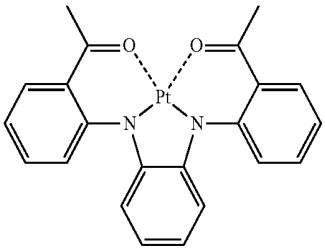

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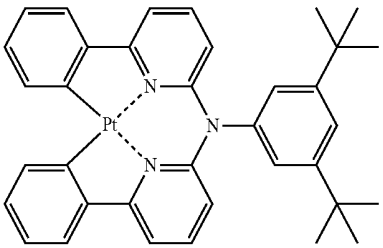

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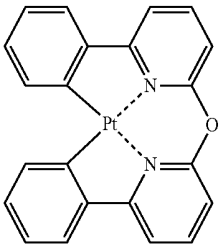

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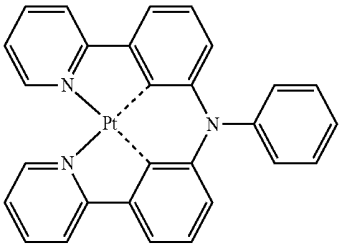

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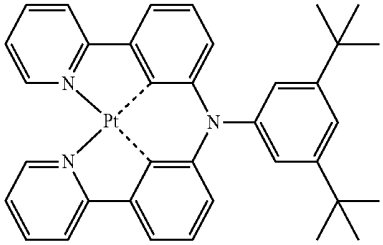

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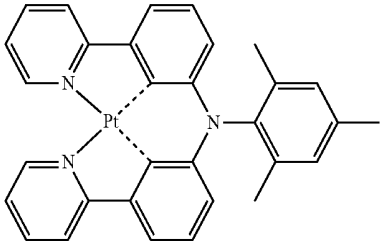

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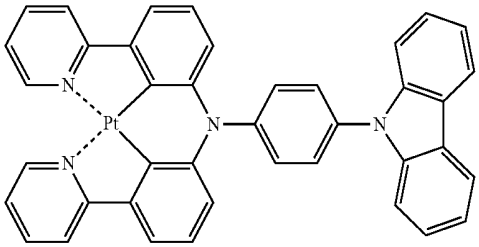

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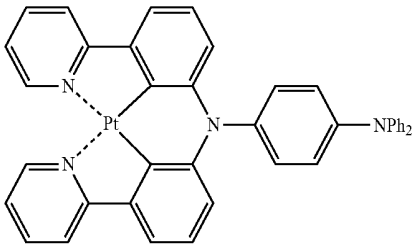

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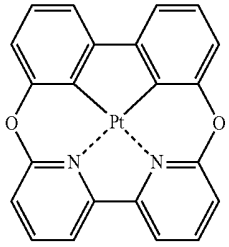

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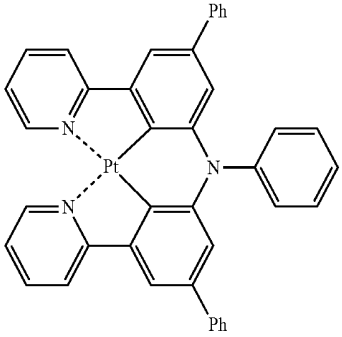

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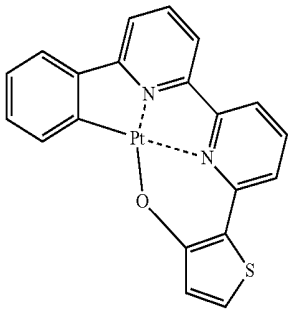

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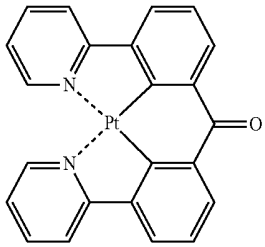

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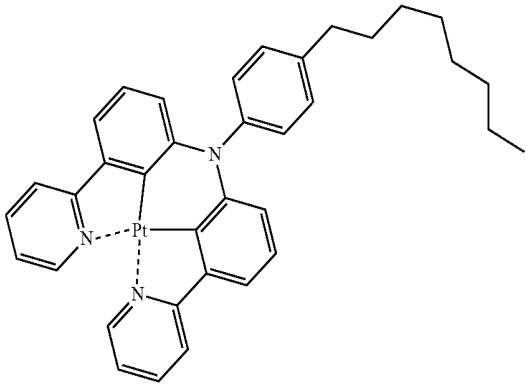

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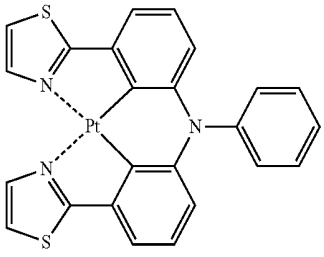

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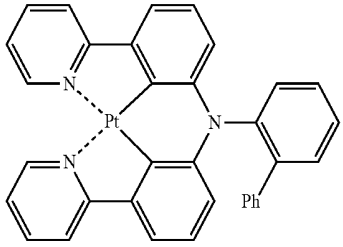

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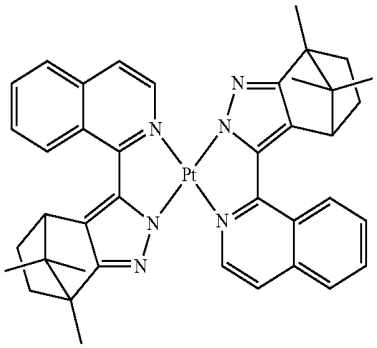

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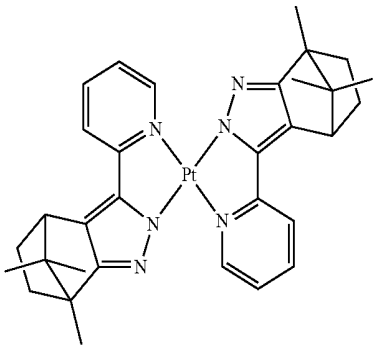

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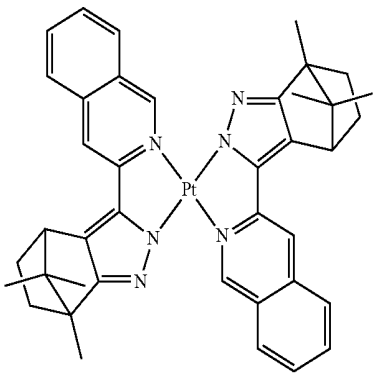

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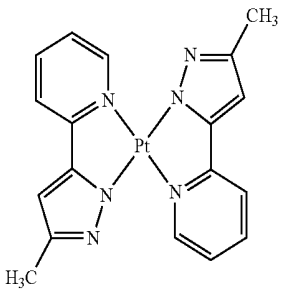

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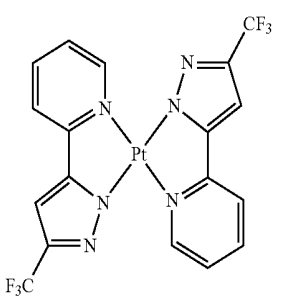

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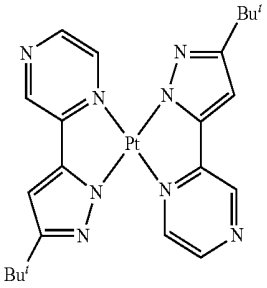
PD66



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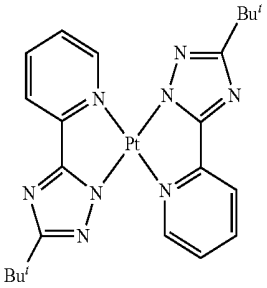

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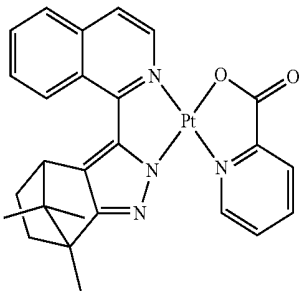

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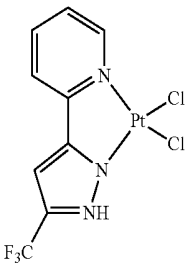
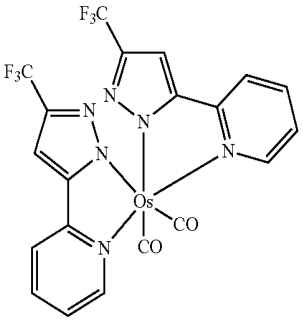


PD70



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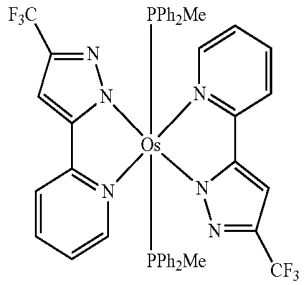
PD71



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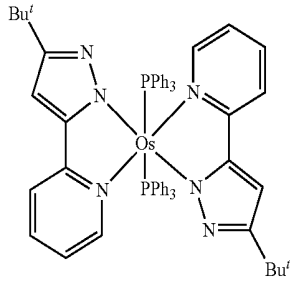

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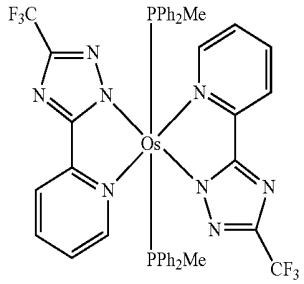

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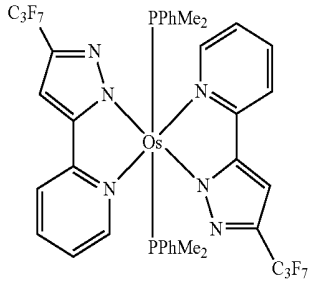
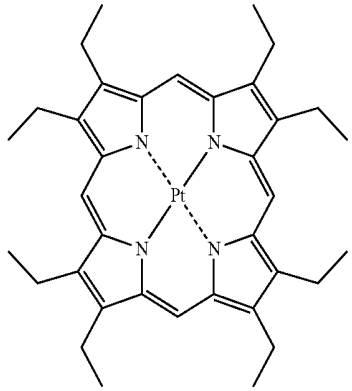
PD74

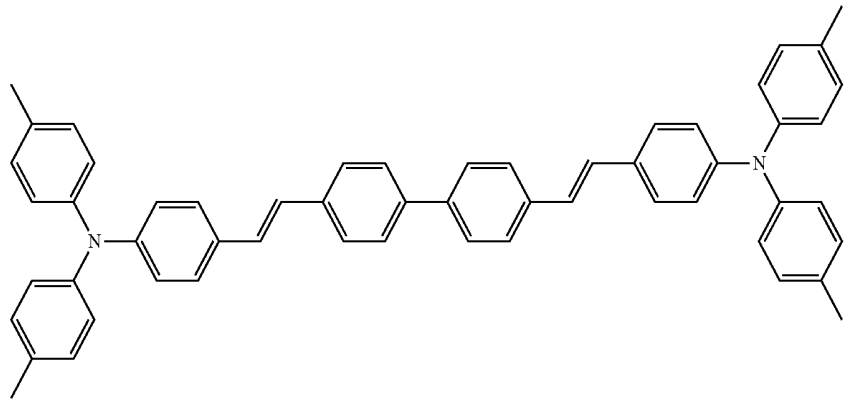


[0264] For example, the phosphorescent dopant may include PtOEP.



PtOEP

[0265] For example, the fluorescent dopant may further include at least one of DPAVBi, BDAVBi, TBPe, DCM, DCJTB, Coumarin 6, and C545T.



DPAVBi

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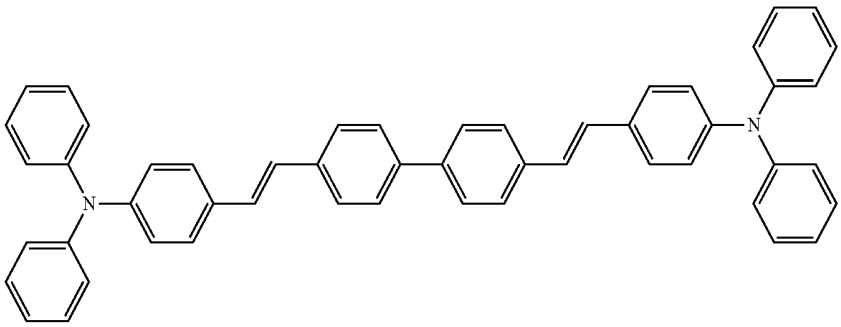
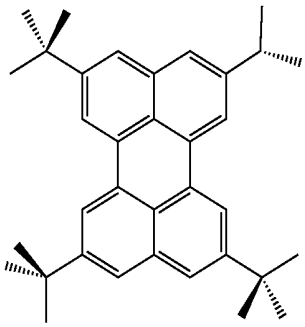
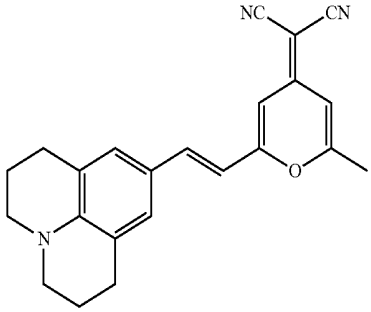


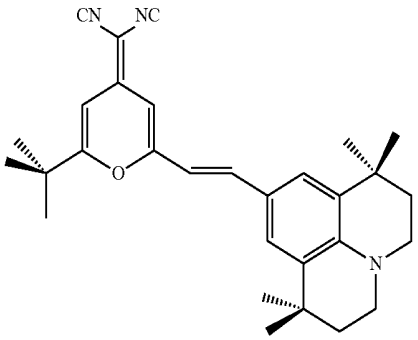
BDAVBi



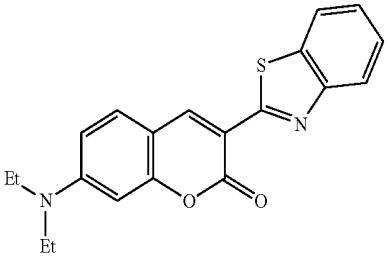
TBPe



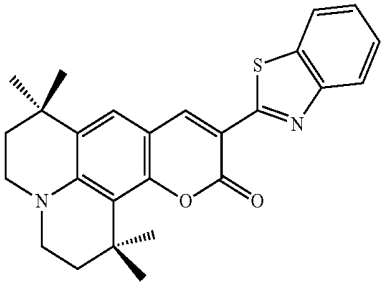
DCM



DCJTB



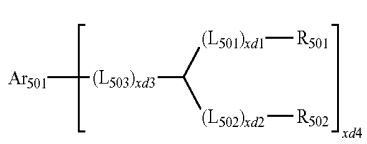
Coumarin 6



C545T

[0266] For example, the fluorescent dopant may include a compound represented by Formula 501.

Formula 501



[0267] In Formula 501,

[0268] Ar_{501} may be selected from:

[0269] 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;

[0270] 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 a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, 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_2-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and —$Si(Q_{501})(Q_{502})(Q_{503})$ (where Q_{501} to Q_{503} may be each independently selected from a hydrogen atom, a C_1-C_{60} alkyl group, a C_2-C_{60} group, a C_6-C_{60} aryl group, and a C_2-C_{60} heteroaryl group);

[0271] descriptions for L_{501} to L_{503} may be each independently the same as the descriptions for L_{201} defined herein;

[0272] R_{501} and R_{502} may be each independently selected from:

[0273] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazole group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

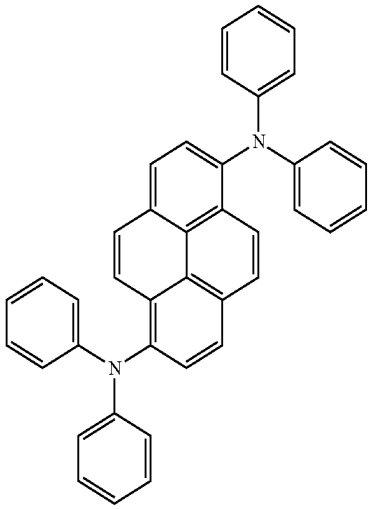
[0274] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

[0275] xd1 to xd3 may be each independently selected from 0, 1, 2, and 3; and

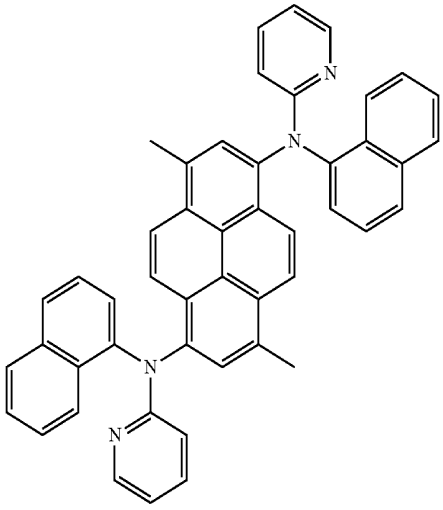
[0276] xb4 may be selected from 1, 2, 3, and 4.

[0277] For example, the fluorescent dopant may include at least one of Compounds FD1 to FD8.

FD1



FD2



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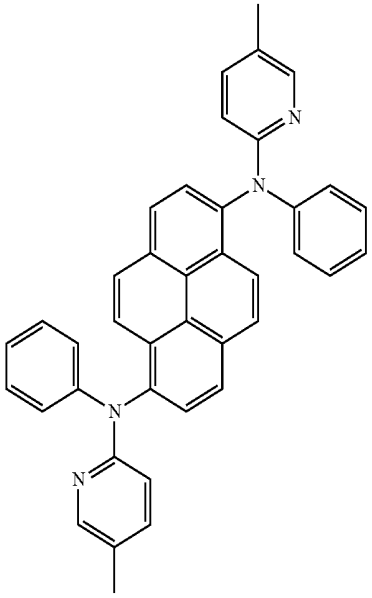
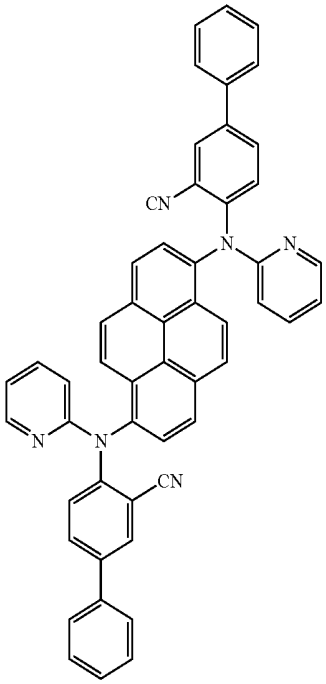
FD3



FD4



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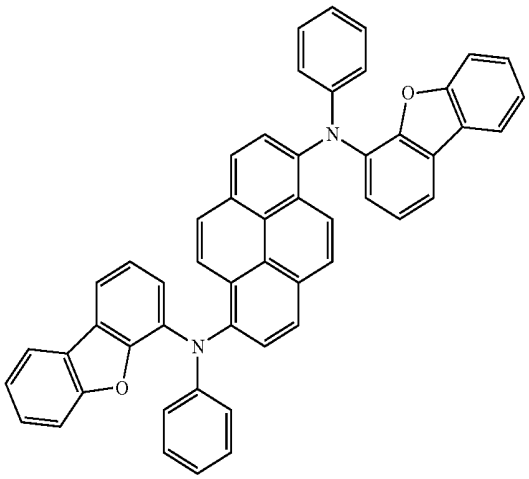
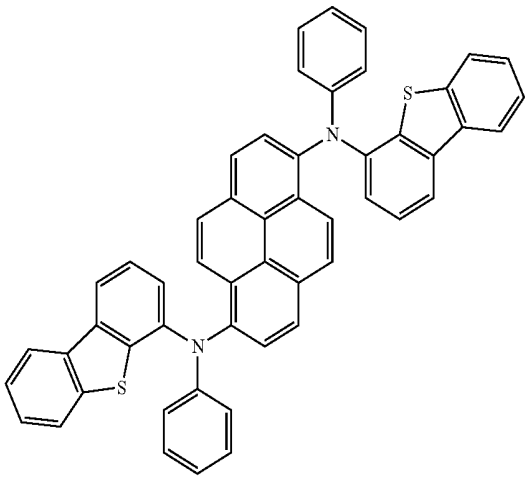
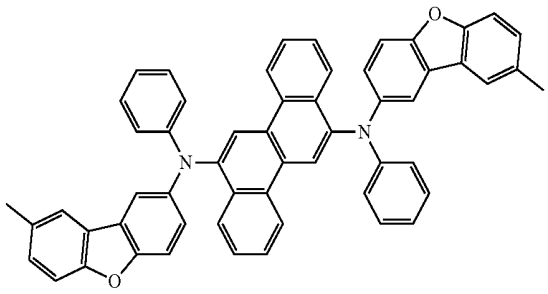
FD5



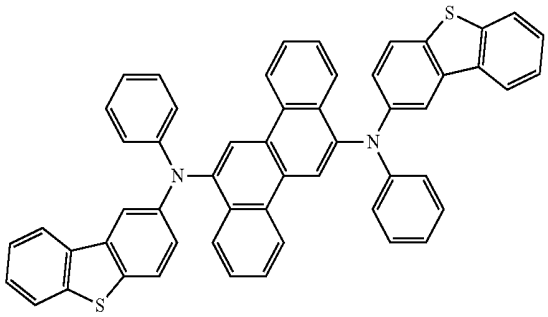
FD6



FD7



FD8



[0278] An amount of the dopant in the EML may be from about 0.01 parts to about 15 parts by weight based on 100 parts by weight of the host, but is not limited to this range.

[0279] The thickness of the EML may be about 100 Å to about 1000 Å, and in some embodiments, may be from about 200 Å to about 600 Å. In one embodiment, when the thickness of the EML is within these ranges, the EML has good light emitting ability without a substantial increase in driving voltage.

[0280] Next, the electron transport region may be disposed on the EML.

[0281] The electron transport region may include at least one of an HBL, an ETL, and an EIL. However, embodiments of the present disclosure are not limited thereto.

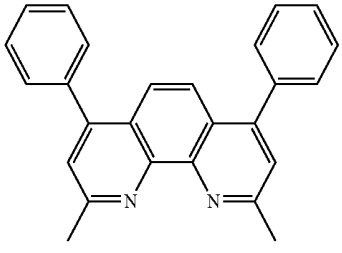
[0282] In some embodiments, the electron transport region may have a structure including an ETL/EIL, or an HBL/ETL/EIL, wherein the layers forming a structure of the electron transport region may be sequentially stacked on the EML in the order stated above. However, embodiments of the present disclosure are not limited thereto.

[0283] In some embodiments, the organic layer **150** of the organic light-emitting device **10** may include the electron transport region between the EML and the second electrode **190**, and the antiaromatic compound of Formula 1 may be in the electron transport region.

[0284] The electron transport region may include an HBL. When the EML includes a phosphorescent dopant, the HBL may reduce or prevent diffusion of triplet excitons or holes into the ETL from the EML.

[0285] When the electron transport region includes an HBL, the HBL may be formed on the EML by using (utilizing) any of a variety of suitable methods, for example, by using (utilizing) vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the HBL is formed using (utilizing) vacuum deposition or spin coating, the deposition and coating conditions for forming the HBL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in more detail.

[0286] For example, the HBL may include at least one of BCP below and Bphen below. However, embodiments of the present disclosure are not limited thereto.



BCP

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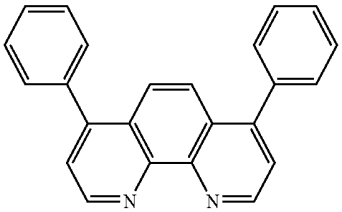


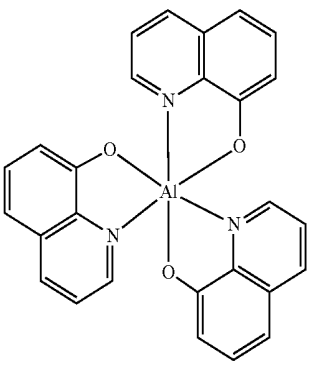
Bphen

[0287] A thickness of the HBL may be from about 20 Å to about 1,000 Å, and in some embodiments, from about 30 Å to about 300 Å. In one embodiment, when the thickness of the HBL is within these ranges, the HBL has improved hole blocking ability without a substantial increase in driving voltage.

[0288] The electron transport region may include an ETL. The ETL may be formed on the EML or the HBL by using (utilizing) any of a variety of suitable methods, for example, by using (utilizing) vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the ETL is formed using (utilizing) vacuum deposition or spin coating, the deposition and coating conditions for forming the ETL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in more detail.

[0289] In some embodiments, the organic layer **150** of the organic light-emitting device may include an electron transport region between the EML and the second electrode **190**, wherein the electron transport region may include an ETL, and the ETL may include the antiaromatic compound of Formula 1.

[0290] The ETL may further include at least one of BCP, Bphen Alq_3, Balq, TAZ, and NTAZ, in addition to the antiaromatic compound of Formula 1.



Alq_3

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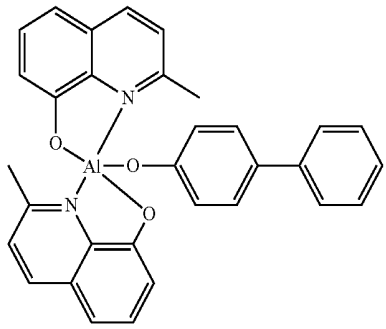
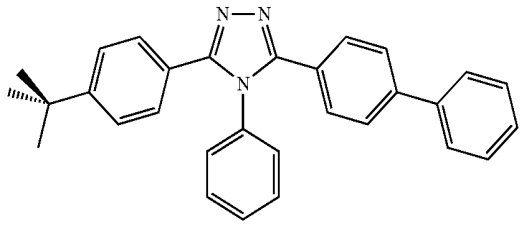
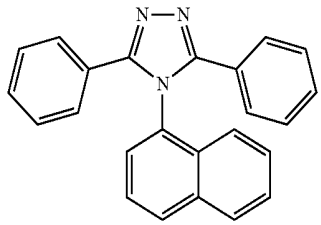


BAlq



TAZ

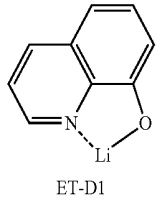


NTAZ

[0291] A thickness of the ETL may be from about 100 Å to about 1,000 Å, and in some embodiments, from about 150 Å to about 500 Å. In one embodiment, when the thickness of the ETL is within these ranges, the ETL has satisfactory electron transporting ability without a substantial increase in driving voltage.

[0292] In some embodiments the ETL may further include a metal-containing material, in addition to the above-described materials.

[0293] The metal-containing material may include a lithium (Li) complex. Non-limiting examples of the Li complex are compound ET-D1 below (lithium quinolate (LiQ)), or compound ET-D2.



ET-D1

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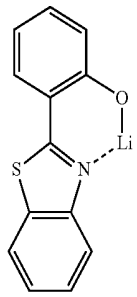


ET-D2

[0294] The electron transport region may include an EIL that may facilitate injection of electrons from the second electrode **190**.

[0295] The EIL may be formed on the ETL by using (utilizing) any of a variety of suitable methods, for example, by using (utilizing) vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the EIL is formed using (utilizing) vacuum deposition or spin coating, the deposition and coating conditions for forming the EIL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described in more detail.

[0296] The EIL may include at least one selected from LiF, NaCl, CsF, Li_2O, BaO, and LiQ.

[0297] A thickness of the EIL may be from about 1 Å to about 100 Å, and in some embodiments, from about 3 Å to about 90 Å. In one embodiment, when the thickness of the EIL is within these ranges, the EIL has satisfactory electron injection ability without a substantial increase in driving voltage.

[0298] The second electrode **190** may be disposed on the organic layer **150**, as described above. The second electrode **190** may be a cathode as an electron injecting electrode. A material for forming the second electrode **190** may be a metal, an alloy, an electrically conductive compound, which have a low-work function, or a mixture thereof. Non-limiting examples of materials for forming the second electrode **190** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, a material for forming the second electrode **190** may be ITO or IZO. The second electrode **190** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

[0299] Although the organic light-emitting device of FIG. **1** is described above, embodiments of the present disclosure are not limited thereto.

[0300] As used herein, a C_1-C_{60} alkyl group refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms. Non-limiting examples of the C_1-C_{60} alkyl group include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. A C_1-C_{60} alkylene group refers to a divalent group having the same structure as the C_1-C_{60} alkyl.

[0301] As used herein, a C_1-C_{60} alkoxy group refers to a monovalent group represented by —OA_{101} (where A_{101} is a C_1-C_{60} alkyl group as described above). Non-limiting

examples of the C_1-C_{60} alkoxy group are a methoxy group, an ethoxy group, and an isopropyloxy group.

[0302] As used herein, a C_2-C_{60} alkenyl group refers to a hydrocarbon group including at least one carbon double bond in the middle or terminal of the C_2-C_{60} alkyl group. Non-limiting examples of the C_2-C_{60} alkenyl group are an ethenyl group, a propenyl group, and a butenyl group. A C_2-C_{60} alkylene group refers to a divalent group having the same structure as the C_2-C_{60} alkenyl group.

[0303] As used herein, C_2-C_{60} alkynyl group refers to a hydrocarbon group including at least one carbon triple bond in the middle or terminal of the C_2-C_{60} alkyl group. Non-limiting examples of the C_2-C_{60} alkynyl group are an ethynyl group and a propynyl group. A C_2-C_{60} alkynylene group used herein refers to a divalent group having the same structure as the C_2-C_{60} alkynyl group.

[0304] As used herein, a C_3-C_{10} cycloalkyl group refers to a monovalent, monocyclic hydrocarbon group having 3 to 10 carbon atoms. Non-limiting examples of the C_3-C_{10} group are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C_3-C_{10} cycloalkylene group refers to a divalent group having the same structure as the C_3-C_{10} cycloalkyl group.

[0305] As used herein, a C_3-C_{10} heterocycloalkyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C_3-C_{10} heterocycloalkyl group are a tetrahydrofuranyl group and a tetrahydrothiophenyl group. A C_3-C_{10} heterocycloalkylene group refers to a divalent group having the same structure as the C_3-C_{10} heterocycloalkyl group.

[0306] As used herein, a C_3-C_{10} cycloalkenyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms that includes at least one double bond in the ring but does not have aromacity. Non-limiting examples of the C_3-C_{10} cycloalkenyl group are a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C_3-C_{10} cycloalkenylene group refers to a divalent group having the same structure as the C_3-C_{10} cycloalkenyl group.

[0307] As used herein, a C_3-C_{10} heterocycloalkenyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms that includes at least one double bond in the ring and in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C_3-C_{10} group are a 2,3-hydrofuranyl group and a 2,3-hydrothiophenyl group. A C_3-C_{10} heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C_3-C_{10} heterocycloalkenyl group.

[0308] As used herein, a C_6-C_{60} aryl group refers to a monovalent, aromatic carbocyclic aromatic group having 6 to 60 carbon atoms, and a C_6-C_{60} arylene group refers to a divalent, aromatic carbocyclic group having 6 to 60 carbon atoms. Non-limiting examples of the C_6-C_{60} aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6-C_{60} aryl group and the C_6-C_{60} arylene group include at least two rings, the rings may be fused to each other.

[0309] As used herein, a C_2-C_{60} heteroaryl group refers to a monovalent, aromatic carbocyclic aromatic group having 2 to 60 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. A C_2-C_{60} group refers to a divalent, aromatic carbocyclic group having 2 to 60 atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C_2-C_{60} heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_2-C_{60} heteroaryl and the C_2-C_{60} heteroarylene include at least two rings, the rings may be fused to each other.

[0310] As used herein, a C_6-C_{60} aryloxy group refers to a group represented by —OA_{102} (where A_{102} is a C_6-C_{60} aryl group as described above), and a C_6-C_{60} arylthio group refers to a group represented by —SA_{103} (where A_{103} is a C_6-C_{60} aryl group as described above).

[0311] As used herein, a monovalent non-aromatic condensed polycyclic group refers to a monovalent group having at least two rings condensed to each other, in which only carbon atoms are exclusively included as ring-forming atoms and the entire molecule has non-aromacity. A non-limiting example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0312] As used herein, a monovalent non-aromatic condensed heteropolycyclic group refers to a monovalent group having at least two rings condensed to each other, in which carbon atoms and at least one hetero atom selected from N, O, P, and S are the ring-forming atoms and the entire molecule has non-aromacity. A non-limiting example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0313] The acronym "Ph" used herein refers to phenyl, the acronym "Me" used herein refers to methyl, the acronym "Et" used herein refers to ethyl, and the acronym "ter-Bu" or "Bu^t" used herein refers to tert-butyl.

[0314] One or more embodiments of the present disclosure, which include condensed cyclic compounds, and organic light-emitting devices including the same, will now be described in more detail with reference to the following examples. However, these examples are only for illustrative purposes and are not intended to limit the scope of the one or more embodiments of the present disclosure. In the following synthesis example, the expression that "'B' instead of 'A' was used (utilized)" means that the amounts of 'B' and 'A' were the same in equivalent amounts.

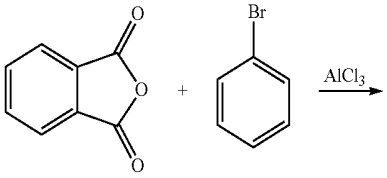
EXAMPLES

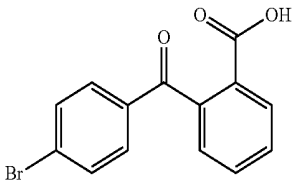
Synthesis Example 1

Synthesis of Compound 1

Synthesis of Intermediate 1-(1)

[0315]





1-(1)

[0316] 10 g (67.52 mmol) of phthalic anhydride, 8.54 mL (81.02 mmol) of bromobenzene, and 18.14 g (135.04 mmol) of $AlCl_3$ were added into a high-pressure reactor, and stirred at about 180° C. for about 1 hour. Ice water was added to the resulting mixture to terminate the reaction, followed by extraction with dichloromethane. The resulting organic layer was separated and then washed with 10% aqueous sulfuric acid solution. After adding a saturated Na_2CO_3 solution into the organic layer, an aqueous layer was separated and then neutralized with 10% aqueous sulfuric acid solution, followed by extraction with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, and recrystallization with ethyl acetate to obtain 12.7 g of Intermediate 1-(1) as a white solid (Yield: 66%).

[0317] IR (KBr, cm-1): 3193-3298 (O—H), 3020-2970 (sp3 C—H), 1665 (C═O), 1598 (C═O);

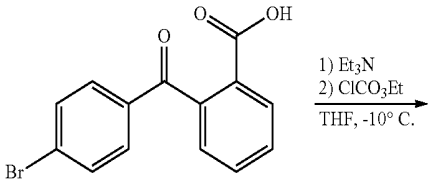
[0318] 1H-NMR (300 MHz, CDCl3, ppm): δ 8.11 (dd, 1H, J=0.2 Hz, J=0.2 Hz), 7.70 (ddd, 1H, J=0.2 Hz, J=0.2 Hz, J=0.2 Hz), 7.61 (dd, 1H, J=0.25 Hz, J=0.25 Hz), 7.57 (s, 4H), 7.36 (dd, 1H, J=0.2 Hz, J=0.2 Hz);

[0319] 13C-NMR (300 MHz, CDCl3, ppm): δ 135.84, 133.47, 131.82, 130.73, 127.65;

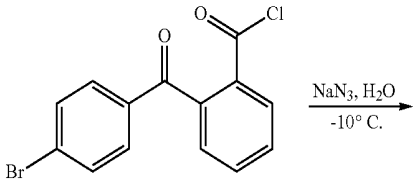
[0320] EI, MS m/z (%): 304 (100, M+)

Synthesis of Intermediate 1-(3)

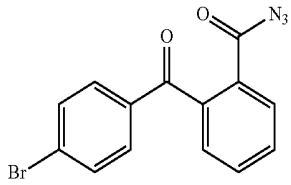
[0321]



1-(1)



1-(2)

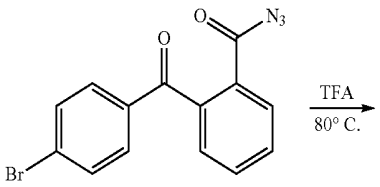


1-(3)

[0322] 12 g (40 mmol) of Intermediate 1-(1) was dissolved in 160 mL of tetrahydrofuran (THF) in a 2-necked round-bottom flask, and the temperature of the reaction flask was maintained at about −10° C. After slowly adding 6.1 mL (44 mmol) of triethylamine to the reaction solution, 6.96 mL (44 mmol) of ethyl chloroformate was slowly added thereto and stirred at about −10° C. for about 1 hour. 3.12 g (44 mmol) of sodium azide dissolved in 110 mL of distilled water was slowly added to the reaction solution and stirred at about −10° C. for about 3 hours. After termination of the reaction, the reaction solution was evaporated under reduced pressure to remove the solvent (THF). The remaining aqueous layer was extracted with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, and to obtain 12.75 g of Intermediate 1-(3). This Intermediate 1-(3) was used (utilized) for the next reaction without purification.

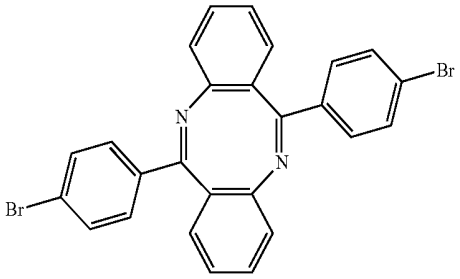
Synthesis of Intermediate 1-(4)

[0323]



1-(3)

-continued



1-(4)

[0324] 12.75 g (38.62 mmol) of Intermediate 1-(3) was dissolved in 19 mL of trifluoro acetic acid and 19 mL of acetic acid in a 2-necked round-bottom flask, and then stirred at about 80° C. After 2 hours, the reaction mixture was cooled down to room temperature, a saturated Na_2CO_3 solution was added thereto for neutralization, followed by extraction with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, drying, and recrystallization with ethyl acetate to obtain 3.59 g of Intermediate 1-(4) as a yellow solid (Yield: 36%).

[0325] IR (KBr, cm-1): 2983-3081 (sp2=C—H), 1625 (C═N), 1583 (C═C), 1425 (C═C), 1392 (C—N);

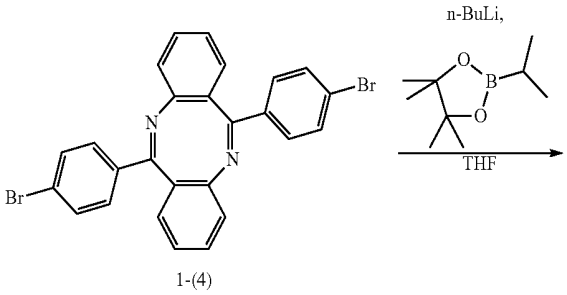
[0326] 1H-NMR (300 MHz, CDCl3, ppm): δ 7.64 (d, 4H, J=2.9 Hz), 7.47 (d, 4H, J=2.9 Hz), 7.34 (q, 2H, J=5.1 Hz), 7.03 (d, 4H, J=2.6 Hz), 6.95 (d, 2H, J=2.5 Hz);

[0327] 13C-NMR (300 MHz, CDCl3, ppm): δ 156.36, 153.19, 146.78, 136.67, 129.74, 129.19, 128.69, 128.49, 127.26, 122.41, 117.00;

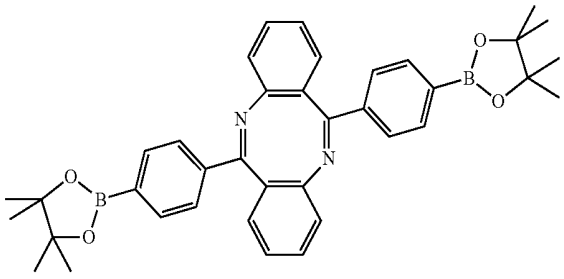
[0328] EI, MS m/z (%): 516 (100, M+)

Synthesis of Intermediate 1-(5)

[0329]



1-(4)

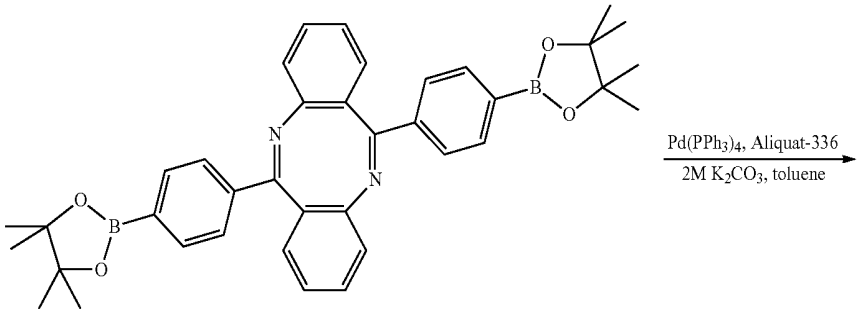


1-(5)

[0330] 2 g (3.88 mmol) of Intermediate 1-(4) was dissolved in 20 mL of THF in a 2-necked round-bottom flask, and the temperature of the reaction vessel flask was cooled down to about −78° C. 4.66 mL (11.64 mmol) of n-BuLi (2.5 M in hexane) was slowly added thereto and stirred at the same temperature for 1 hour. 2.36 mL (11.64 of 2-isopropyl-4,4,5,5-tetramethyl-1,3,2-dioxaborolane was added thereto and stirred at about −78° C. for about 1 hour, and then at room temperature for about 12 hours. The reaction mixture was evaporated under reduced pressure, and separated with column chromatography (hexane:ethyl acetate=4:1 by v/v) to obtain 2.3 g of Intermediate 1-(5) as a white solid (Yield: 97%).

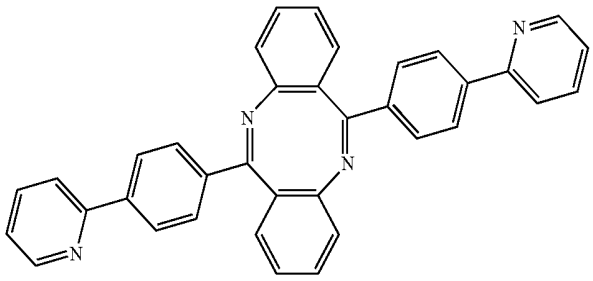
Synthesis of Compound 1

[0331]



1-(5)

-continued



1

[0332] 2 g (3.88 mmol) of Intermediate I-(5), 0.9 mL (9.43 mmol) of 2-bromopyridine, 5.65 mL (11.31 mmol) of 2M K_2CO_3, 0.068 mL (0.15 mmol) of Aliquat®336, and toluene were mixed in a 2-necked round-bottom flask. After degassing, 0.35 g (0.3 mmol) of $Pd(PPh_3)_4$ was added thereto, and stirred at about 80° C. for about 24 hours. Excess water was added to terminate the reaction, followed by extraction with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, drying, and separation by column chromatography (hexane:ethyl acetate=2:1 by v/v) to obtain 1.3 g of Compound 1 as a yellow solid (Yield: 67%).

[0333] IR (KBr, cm-1): 3006-3050 (sp2=C—H), 1619 (C═N), 1585 (C═C), 1465 (C═C), 1402 (C—N);

[0334] 1H-NMR (300 MHz, CDCl3, ppm): δ 8.71 (tt, 2H, J=0.9 Hz, J=0.9 Hz), 8.00 (dd, 4H, J=0.6 Hz, J=0.6 Hz), 7.90 (dd, 4H, J=0.6 Hz, J=0.6 Hz), 7.77-7.74 (m, 4H), 7.37 (ddd, 2H, J=0.7 Hz, J=0.7 Hz, J=0.7 Hz), 7.27-7.23 (m, 2H), 7.11-7.03 (m, 6H);

[0335] 13C-NMR (300 MHz, CDCl3, ppm): δ 156.59, 156.34, 149.79, 151.75, 136.74, 131.93, 129.88, 129.73, 129.15, 127.58, 126.69, 120.98, 188.44, 114.79;

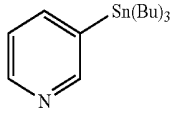
[0336] EI, MS m/z (%): 512 (100, M+)

Synthesis Example 2

Synthesis of Compound 2

Synthesis of Intermediate 2-(1)

[0337]



8-(1)

[0338] 0.5 mL (5.19 mmol) of 3-bromopyridine was dissolved in 25 mL of Et_2O in a 2-necked round-bottom flask, and the temperature of the flask was cooled down to about −78° C. 3.89 mL (6.23 mmol) of n-BuLi (1.6 M in hexane) was slowly added thereto and stirred at the same temperature for 3 hours. After adding 1.55 mL (5.71 of tributyltin chloride, the resulting reaction mixture was stirred at about −78° C. for about 30 minutes and then at room temperature for about 12 hours, followed by adding a saturated aqueous NH_4Cl solution, and extraction with Et_2O. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, and separation by column chromatography (hexane: ethyl acetate=9:1 by v/v) to obtain 1.58 g of Intermediate 2-(1) as transparent oil (Yield: 83%).

Synthesis of Compound 2

[0339] 1 g (1.94 mmol) of Intermediate 1-(4), 1.6 g (4.26 mmol) of Intermediate 8-(1), and 0.08 g (0.04 mmol) of $Pd(PPh_3)_4$ were dissolved in 10 mL of toluene in a 2-necked round-bottom flask, and stirred at about 80° C. for 3 days. Excess water was added to terminate the reaction, followed by extraction with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, and separation by column chromatography (hexane:ethyl acetate=1:1 by v/v) to obtain 0.43 g of Compound 1 as a yellow solid (Yield: 44%).

[0340] IR (KBr, cm-1): 3027-3052 (sp2=C—H), 1619 (C═N), 1600 (C═C), 1475 (C═C), 1392 (C—N);

[0341] 1H-NMR (300 MHz, CDCl3, ppm): δ 8.85 (s, 2H), 8.60 (d, 2H, J=3.6 Hz) 7.88 (q, 6H, J=7.1 Hz) 7.57 (d, 4H, J=8.7 Hz) 7.37 (q, 4H, J=5.6 Hz) 7.11-7.02 (m, 6H, J=6.3 Hz);

[0342] 13C-NMR (300 MHz, CDCl3, ppm): δ 169.02, 164.56, 164.02, 151.84, 148.25, 140.38, 137.66, 135.82, 134.40, 130.21, 129.84, 127.48, 127.04, 126.90, 126.63, 125.54, 123.62, 123.58, 120.99, 118.69;

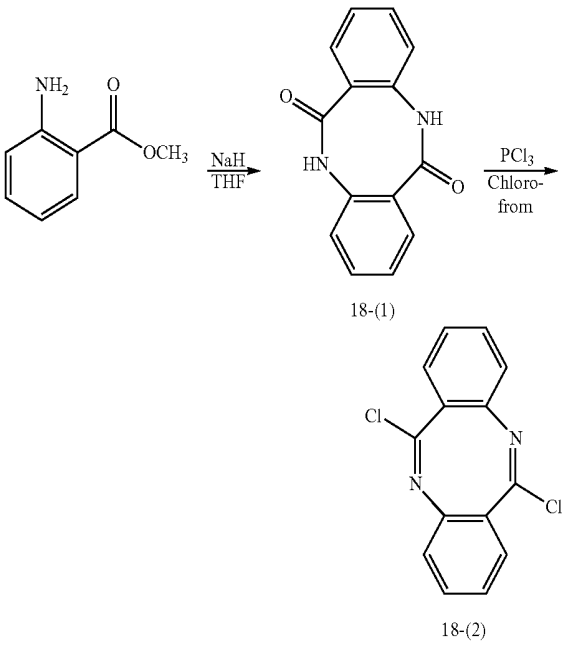
[0343] EI, MS m/z (%): 512 (100, M+)

Synthesis Example 3

Synthesis of Compound 18

Synthesis of Intermediate 18-(2)

[0344]



18-(1)

18-(2)

[0345] After 20 g (0.13 mol) of methyl 2-aminobenzoate was put into a 500 mL of flask and then dissolved with THF, 6 g (0.26 mol) of sodium hydride was added thereto. The resulting mixture was stirred at about 50° C. for about 48 hours, 0.1M HCl was added thereto to terminate the reaction, followed by extraction with dichlorimethane. The resulting organic layer was separated, and dried under reduced pressure to remove the solvent. The residue was washed with water and methanol, and dried for about 24 hours to obtain 23 g of Intermediate 18-(1) (Yield: 75%).

[0346] 1H NMR (300 MHz, DMSO), δ (ppm): δ 10.20 (s, 2H), 7.32 (m, 6H), 7.07 (d, 2H).

[0347] 13C NMR (300 MHz, DMSO), δ (ppm): 126.13, 127.68, 128.59, 130.95, 135.18, 169.69.

[0348] IR: V max (cm-1), 3400 (—N—H), 3168, 3041 (═C—H), 1647 (—C═O), 1499 1443, 1400, 1070, 1140 (—C═C).

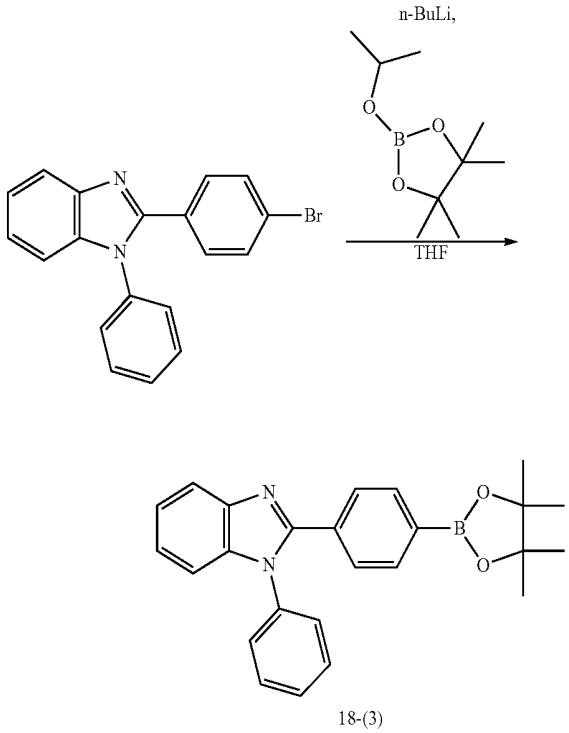
[0349] After dissolving 5 g (0.02 mol) of Intermediate 18-(1) in chloroform, 11 g (0.05 mol) of PCl_5 was added thereto. After stirring the mixture at about 100° C. for about 24 hours, water was added to the mixture to terminate the reaction, followed by extraction with ethyl acetate, and drying under reduced pressure to remove the solvent, thereby obtaining 5 g of Intermediate 18-(2) (Yield: 55%).

[0350] 1H-NMR (300 MHz, CD2Cl2): δ 7.41-7.36 (m, 4H), 7.19 (t, 2H), 7.01-6.98 (m, 2H).

[0351] 13C NMR (300 MHz, CD2Cl2), δ (ppm): 155.93, 145.32, 131.58, 127.00, 125.36, 121.78.

Synthesis of Intermediate 18-(3)

[0352]



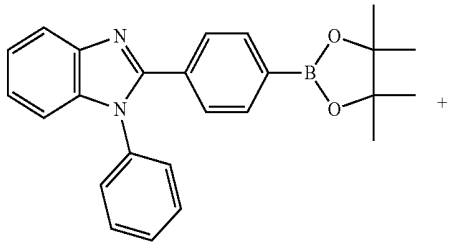
18-(3)

[0353] 4 g (0.011 mol) of 2-(4-bromophenyl)-1-phenyl-1H-benzo[d]imidazole was put into a 250 mL flask, and dissolved with THF. 6 mL (0.013 mol) of n-BuLi was slowly added thereto at about −78° C., and the temperature was maintained for about 1 hour. 3 g (0.013 mol) of 2-isopropoxy-4,4,5,5-tetramethyl-1,3,2-dioxaborolane was slowly added thereto at about −78° C., and reacted at room temperature for about 12 or longer. Water was added to terminate the reaction, followed by extraction with ethyl acetate, and purification to obtain 3 g of Intermediate 18-(3) (Yield: 66%).

[0354] 1H NMR (300 MHz, CDCl3): δ 7.9 (d, 1H), 7.77 (d, 2H), 7.60-7.52 (m, 2H), 7.50 (d, 3H). 7.37-7.26 (m, 5H), 1.35 (s, 12H).

Synthesis of Compound 18

[0355]



18-(3)

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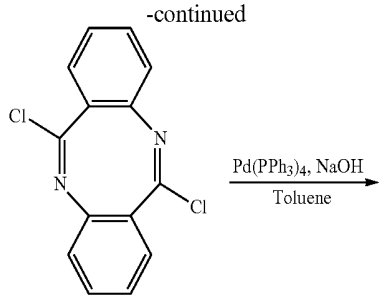
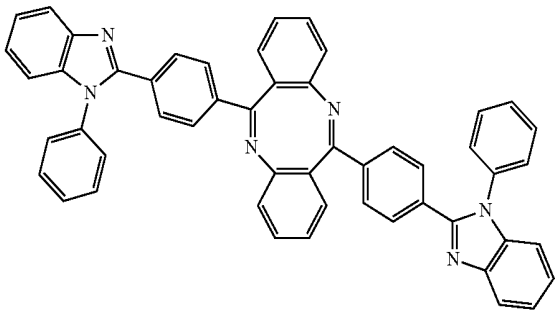


18-(2)



18

[0356] 1 g (5 mmol) of Intermediate 18-(2) and 4 g (10 mmol) of Intermediate 18-(3) were dissolved in 50 mL of toluene in a 100-mL 3-necked round-bottom flask by using (utilizing) a torch. 10 mL of 2M NaOH was added thereto and stirred for about 30 while supplying nitrogen thereto. After adding 0.4 g (0.40 mmol) of $Pd(PPh_3)_4$ and a temperature increase to about 100° C., the mixture was stirred for about 24 hours. The mixture was cooled down to room temperature, and 2M HCl was added thereto to terminate the reaction, followed by extraction with ethyl acetate. The resulting organic layer was dried using (utilizing) anhydrous $MgSO_4$, and the solvent was removed using (utilizing) a rotary evaporator, followed by separation by column chromatography (hexane:ethyl acetate=10:1 by v/v), and recrystallization with ethyl acetate and ethanol to obtain 1.5 g of Compound 18 (Yield; 70%).

[0357] 1H-NMR (300 MHz, CD2Cl2): δ 7.86-7.84 (m, 2H), 7.72-7.60 (m, 4H), 7.55-7.53 (m, 10H), 7.40-7.25 (m, 12H), 7.10-6.99 (m, 6H).

[0358] 13C NMR (300 MHz, CD2Cl2), δ (ppm): 167.80, 151.72, 150.00, 149.03, 130.86, 130.34, 130.22, 129.24, 128.82, 127.52, 127.09, 126.95, 125.73, 121.12.

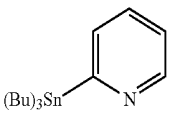
Synthesis Example 4

Synthesis of Compound 139

Synthesis of Intermediate 139-(1)

[0359]

139-(1)

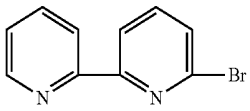


[0360] 1.5 mL (15.57 mmol) of 2-bromopyridine was dissolved in 15 mL of THF in a 2-necked round-bottom flask, and the temperature of the flask was cooled down to about −78° C. 11.67 mL (18.69 mmol) of n-BuLi (1.6 M in hexane) was slowly added thereto and stirred at the same temperature for about 2 hours. After adding 4.65 mL (17.13 mmol) of tributyltin chloride, the resulting reaction mixture was stirred at about −78° C. for about 30 minutes and then at room temperature for about 12 hours, followed by adding a saturated aqueous NH_4Cl solution, and extraction with diethyl ether. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, drying, and separation by column chromatography (hexane:ethyl acetate=9:1 by v/v) to obtain 3.23 g of Intermediate 139-(1) as transparent oil (Yield: 93%).

Synthesis of Intermediate 139-(2)

[0361]

139-(2)



[0362] 1.5 g (6.33 mmol) of 2,6-dibromopyridine, 3.48 g (9.48 mmol) of Intermediate 139-(1), and 0.15 g (0.06 mmol) of $Pd(PPh_3)_4$ were dissolved in 15 mL of toluene in a 2-necked round-bottom flask, and stirred at about 80° C. for about 24 hours. After evaporation under reduced pressure to remove the solvent, the resulting residue was dissolved in dichloromethane, followed by extraction with 6M HCl. The aqueous layer was separated and collected, and ammonia water was added thereto, followed by extraction with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, by drying, and by separation with column chromatography (hexane: ethyl acetate=5:1 by v/v) to obtain 0.9 g of Intermediate 139-(2) as white solid (Yield: 61%).

[0363] 1H-NMR (300 MHz, CDCl3, ppm): δ 8.68 (tt, 1H, J=1 Hz, J=0.6 Hz), 8.41 (dd, 2H, J=9 Hz, J=9 Hz), 7.84 (ttt, 1H, J=0.6 Hz, J=0.5 Hz, J=0.6 Hz), 7.69 (t, 1H, J=7.65 Hz), 7.51 (t, 1H, J=3.9 Hz), 7.35 (q, 1H, J=4.5 Hz);

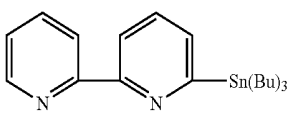
[0364] 13C-NMR (300 MHz, CDCl3, ppm): δ 156.21, 155.78, 149.30, 143.28, 141.05, 137.87, 125.88, 123.24, 123.52, 120.64;

[0365] EI, MS m/z (%): 234 (100, M+)

Synthesis of Intermediate 139-(3)

[0366]

139-(3)

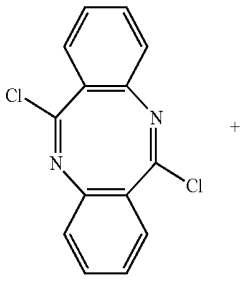


[0367] 0.9 g (3.81 mmol) of Intermediate 139-(2) was dissolved in 15 mL of THF in a 2-necked round-bottom flask,

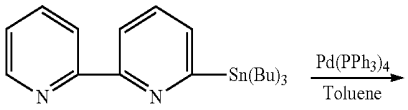
and the temperature of the reaction flask was cooled down to about −78° C. 1.74 mL (2.82 mmol) of n-BuLi (1.6 M in hexane) was slowly added thereto and stirred at the same temperature for 1 hour. After adding 4.65 mL (17.13 mmol) of tributyltin chloride, the resulting reaction mixture was stirred at about −78° C. for about 30 minutes and then at room temperature for about 12 hours, followed by adding a saturated aqueous NH_4Cl solution, and extraction with ethyl acetate. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, drying, and separation by column chromatography (hexane:ethyl acetate=5:1 by v/v) to obtain 0.75 g of Intermediate 139-(3) as transparent oil (Yield: 45%).

Synthesis of Compound 139

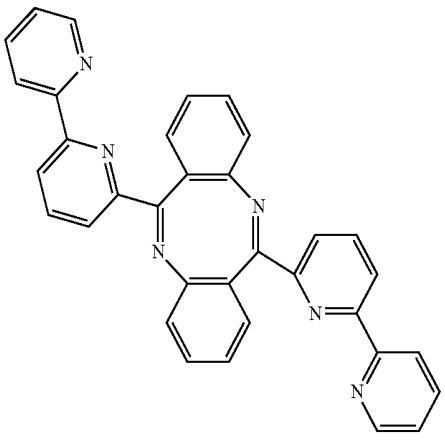
[0368]



18-(2)



139-(3)



139

[0369] 0.2 g (0.8 mmol) of Intermediate 18-(2), 0.75 g (1.5 mmol) of Intermediate 139-(3), and 0.04 g (0.04 mmol) of $Pd(PPh_3)_4$ were dissolved in 2 mL of toluene in a 2-necked round-bottom flask, and stirred at about 80° C. for about 24 hours. Excess water was added to terminate the reaction, followed by extraction with dichloromethane. The resulting organic layer was separated and then dried with anhydrous $MgSO_4$, followed by evaporation under reduced pressure to remove the solvent, drying, and separation by column chromatography (hexane:ethyl acetate=5:1 by v/v) to obtain 0.16 g of Compound 16 as yellow solid (Yield: 43%).

[0370] 1H-NMR (300 MHz, CDCl3, ppm): δ 8.86 (t, 1H, J=1, 2 Hz), 8.62 (q, 1H, J=2.1 Hz) 7.90 (t, 2H, J=4.3 Hz) 7.70 (q, 2H, J=21.1 Hz) 7.39-7.33 (m, 6H) 7.09-7.01 (m, 8H);

[0371] 13C-NMR (300 MHz, CDCl3, ppm): δ 163.93, 159.77, 151.80, 140.32, 129.41, 128.22, 126.96, 123.63, 123.45, 120.99, 120.88, 116.92;

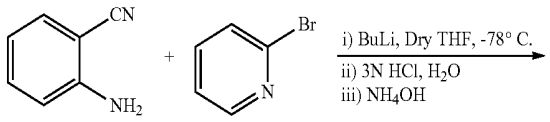
[0372] EI, MS m/z (%): 514 (100, M+)

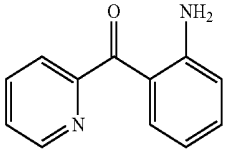
Synthesis Example 5

Synthesis of Compound 140

Synthesis of Intermediate 20-(1)

[0373]





140-(1)

[0374] 5.57 mL (5.84 mmol, 2.3 eq) of 2-bromopyridine and 50 mL of purified toluene were put into a 100-mL 1-necked-round-bottom flask, and stirred in an argon atmosphere. The temperature of the resulting reaction mixture was cooled down to −78° C. by using (utilizing) a cooling bath (EtOAc/Liquid N2 bath), followed by adding 22.37 mL of n-BuLi (5.58 mmol, 2.5 M in hexane, 2.2 eq) thereto, and stirring in an argon atmosphere for about 30 minutes. 3 g (2.54 mmol, 1 eq) of 2-aminobenzonitrile dissolved in purified toluene (25 mL) was slowly added to the resulting reaction mixture and stirred for about 30 minutes. After a slow temperature increase to room temperature, the reaction mixture was stirred for about 2 hour, and termination of the reaction was identified by thin-layer chlomatography (TLC).

[0375] After 80 g of cracked ice was put into a 250-mL beaker, the reaction mixture was slowly added thereto while stirring, and then further stirred at room temperature for about 1 hour. After discarding the aqueous layer by using (utilizing) a separatory funnel, 40 mL of HCl was added to the remaining organic layer to obtain a salt form of the desired product, and then the aqueous layer including the same was collected. The collected aqueous layer was washed with 20 mL of toluene, followed by pH adjustment with NH_4OH (25% aqueous solution). The pH-adjusted aqueous layer was stirred for about 1 hour, and the resulting solid was filtered under reduced pressure, and washed with cold water (20 mL). The resulting yellow solid was purified by column chromatography (eluent;

EtOAc) to obtain 3.80 g of Intermediate 140-(1) as a yellow solid compound (Yield: 75%).

[0376] mp 140-142° C.

[0377] 1H NMR (300 MHz, CDCl3) δ 6.31 (bs, 2H, D2O exchangeable), 6.59-6.64 (m, 1H), 6.71-6.74 (m, 1H), 7.27-7.33 (m, 1H), 7.40-7.45 (m, 1H), 7.64-7.67 (m, 1H), 7.76 (d, 1H, J=7.8 Hz), 7.84-7.89 (m, 1H), 8.71 (d, 1H, 4.7 Hz).

Synthesis of Compound 140

[0378] 1 g (5.04 mmol, 1 eq) of Intermediate 140-(1) and 0.1 g (0.50 mmol, 0.1 eq) of p-toluenesulfonic acid were put into a 30-mL culture test tube, and the culture test tube was capped and stirred in a 150° C. oil bath for about 4 hours. The reaction mixture was cooled down to room temperature, and dissolved with 5 mL of dichloromethane. The reaction mixture was washed with water (20 mL×5 times), and the aqueous layer was collected, followed by extraction with dichloromethane (20 mL×2 times). The organic layer was collected, dried with anhydrous $MgSO_4$, and evaporated under reduced pressure. 3 mL of CH_2Cl_2 was added to the residue, followed by filtration under reduced pressure and further washing with 2 mL of CH_2Cl_2 to obtain 0.83 g of compound 140 as a yellow solid (Yield: 92%).

[0379] mp 214-216° C.

[0380] 1H NMR (300 MHz, CDCl3) δ 7.02-7.09 (m, 6H), 7.25-7.35 (m, 4H), 7.64-7.70 (m, 2H), 7.97 (d, 2H, J=7.94 Hz), 8.64-8.66 (m, 2H).

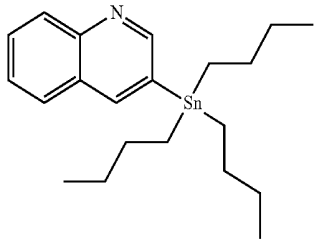
[0381] 13C NMR (75 MHz, CDCl3) δ 120.7, 123.6, 124.3, 124.9, 126.0, 127.8, 136.4, 149.5, 151.2, 155.3, 168.8. HRMS (m/z): [M]+ calcd for C24H16N4 360.1375. Found: 360.1375.

Synthesis Example 6

Synthesis of Compound 39

Synthesis of Intermediate 39-(1)

[0382]



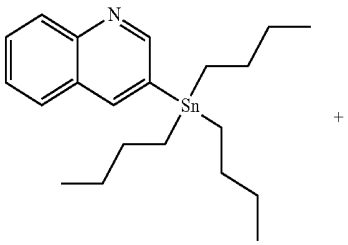
39-(1)

[0383] 10 g (0.048 mol) of 3-bromoquinoline was put into a 250-mL flask, and dissolved with THF. 21 mL (0.052 mol) of n-BuLi was slowly added to the mixture at about −78° C., and the temperature was maintained for about 1 hour. 19 g (0.057 mol) of tributyltin chloride was slowly added thereto at about −78° C., and reacted at room temperature for about 12 hours or longer. Water was added thereto to terminate the reaction, followed by extraction with ethyl acetate to obtain 14 g of Intermediate 39-(1) (Yield: 70%).

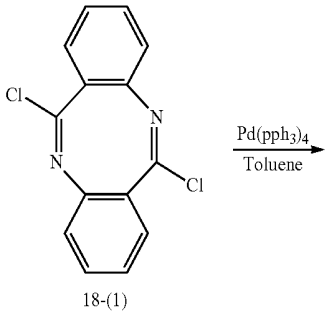
[0384] 1H NMR (300 MHz, CDCl3): δ 8.95-8.94 (d, 1H), 8.25 (s, 1H), 8.10-807 (m, 1H), 7.81-7.77 (m, 1H), 7.73-7.67 (m, 1H), 7.54-7.51 (m, 1H), 1.63-1.54 (m, 6H), 1.41-1.35 (m, 6H), 1.21-1.16 (m, 6H), 0.93-0.88 (m, 12H).

Synthesis of Compound 39

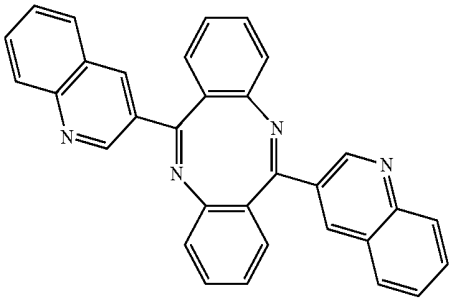
[0385]



39-(1)



18-(1)



39

[0386] 1 g (5 mmol) of Intermediate 39-(1), 4 g (10 mmol) of Intermediate 18-(1), and 0.2 g (0.2 mmol) of $Pd(PPh_3)_4$ were dissolved in 50 mL of toluene in a torch dried 100-mL 3-necked round-bottom flask. After a temperature increase to about 100° C., the resulting mixture was stirred for about 24 hours. The mixture was cooled down to room temperature, and water was added thereto to terminate the reaction, followed by extraction with ethyl acetate. The organic layer was collected, and dried using (utilizing) $MgSO_4$ to remove water. The remaining solvent was removed using (utilizing) a rotary evaporator, followed by drying and separation by column chromatography (hexane:ethyl acetate 10:1 by v/v), and recrystallization with ethyl acetate and ethanol to obtain 1.6 g of Compound 39 (Yield: 80%).

[0387] mp: 237° C.,

[0388] 1H NMR (300 MHz, DMSO, ppm): 9.42 (s, 2H), 8.32 (s, 2H), 8.08-8.06 (m, 4H), 7.86-7.83 (t, 2H), 7.66-7.63 (t, 2H), 7.50-7.47 (m, 2H), 7.47-7.17 (m, 6H).

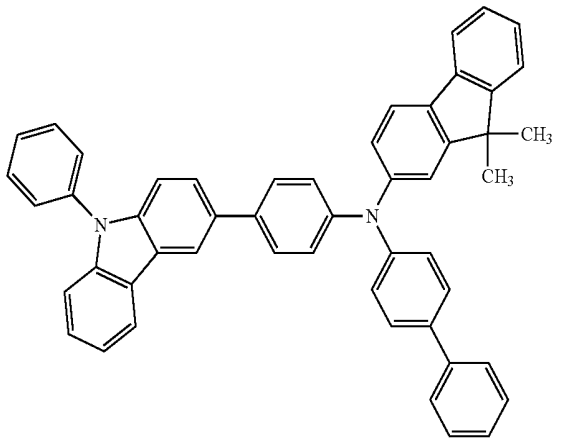
[0389] 13C NMR (300 MHz, CD2Cl2), δ (ppm): 167.80, 151.72, 150.00, 149.03, 130.86, 130.34, 130.22, 129.24, 128.82, 127.52, 127.09, 126.95, 125.73, 121.12.

Example 1

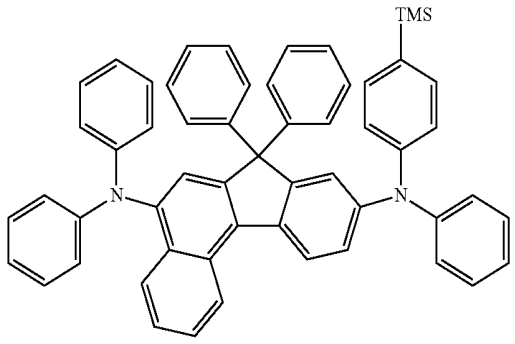
[0390] An ITO/Ag/ITO anode was sonicated in isopropyl alcohol for about 5 minutes and pure water for about 5 minutes, and then cleaned by irradiation of ultraviolet rays for about 10 minutes and exposure to ozone. The resulting substrate was loaded into a vacuum deposition device.

[0391] After Compound A was deposited on the anode to form an HIL having a thickness of 600 Å, Compound B was deposited on the HIL to form an HTL having a thickness of about 550 Å, and then ADN (host) and Compound B (dopant) were co-deposited in a weight ratio of 200:3 on the HTL to form an EML having a thickness of about 200 Å. After Compound 1 and lithium quinolate (LiQ) were co-deposited in a weight ratio of 5:5 on the EML to form an ETL having a thickness of about 300 Å, LiQ was deposited on the ETL to form an EIL having a thickness of about 10 Å, and Mg and Ag were deposited in a weight ratio of 90:10 on the EIL to form a cathode having a thickness of about 120 Å, thereby manufacturing an organic light-emitting device.

Compound A



Compound B



Example 2

[0392] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 2 instead of Compound 1 was used (utilized) to form the ETL.

Example 3

[0393] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 18 instead of Compound 1 was used (utilized) to form the ETL.

Example 4

[0394] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 139 instead of Compound 1 was used (utilized) to form the ETL.

Example 5

[0395] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 140 instead of Compound 1 was used (utilized) to form the ETL.

Example 6

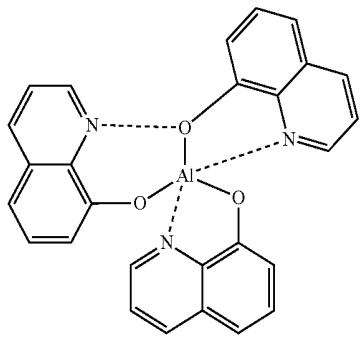
[0396] An organic light-emitting device was manufactured in the same manner as in Example 6, except that Compound 114 instead of Compound 1 was used (utilized) to form the ETL.

Example 7

[0397] An organic light-emitting device was manufactured in the same manner as in Example 6, except that Compound 131 instead of Compound 1 was used (utilized) to form the ETL.

Comparative Example 1

[0398] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Alq_3, instead of Compound 1, was used (utilized) to form the ETL.

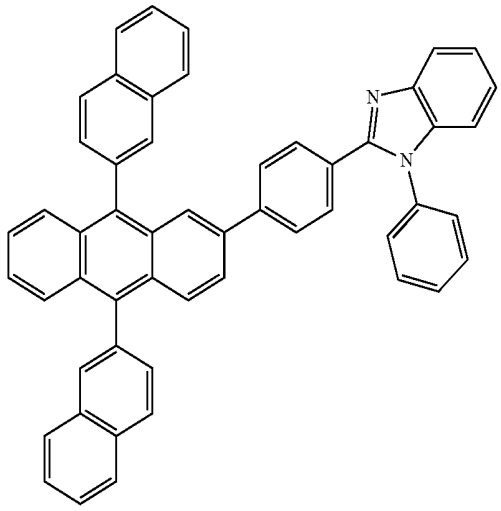


Alq3

Comparative Example 2

[0399] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound C, instead of Compound 1, was used (utilized) to form the ETL.

Compound C



Evaluation Example 1

[0400] Driving voltages, current densities, luminances, efficiencies, and half-lifetimes of the organic light-emitting devices of Examples 1 to 7 and Comparative Examples 1 and 2 were evaluated using (utilizing) a Kethley Source-Measure Unit (SMU 236) and a PR650 (Spectroscan) Source Measurement Unit (available from Photo Research, Inc.). The results are shown in Table 1.

TABLE 1

Example	ETL	Driving voltage (V)	Current density (mA/cm^2)	Luminance (cd/m^2)	Efficiency (cd/A)	CIE_x	CIE_y
Example 1	Compound 1	5.2	12.5	600	6.2	0.137	0.055
Example 2	Compound 2	5.5	9.2	600	6.5	0.140	0.055
Example 3	Compound 18	5.1	9.1	600	6.7	0.139	0.055
Example 4	Compound 139	5.8	10.3	600	5.8	0.136	0.050
Example 5	Compound 140	5.7	11.3	600	5.3	0.145	0.050
Example 6	Compound 114	5.1	9.2	600	6.5	0.139	0.051
Example 7	Compound 131	5.6	9.1	600	6.6	0.141	0.057
Comparative Example 1	Alq_3	7.7	21.8	600	3.2	0.141	0.060
Comparative Example 2	Compound C	5.2	21.4	600	2.8	0.139	0.053

[0401] Referring to Table 1, the organic light-emitting devices of Examples 1 to 7 were found to have improved driving voltages, improved current densities, improved luminances, improved efficiencies, and improved half-lifetimes, compared to those of the organic light-emitting devices of Comparative Examples 1 and 2.

Evaluation Example 2

[0402] Compounds 1, 2, and 18 were analyzed by UV spectroscopy, photoluminescence (PL) spectroscopy, cyclic voltammetry (CV), thermogravimetry (TGA), and differential scanning calorimetry (DSC). The results are shown in FIGS. **2** to **14** and Tables 2 to 4.

TABLE 2

	Uv-vis.		PL						
	λ_{max} (nm)		λ? $_{max}$ (nm)		E_g	LUMO	HOMO	T_d	T_m
	solution	film	solution	film	(eV)	(eV)	(eV)	(° C.)	(° C.)
Compound 1	298	300	433	452	3.02	−3.62	−6.04	295	156

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TABLE 3

	Uv-vis.		PL						
	λ_{max} (nm)		λ? $_{max}$ (nm)		E_g	LUMO	HOMO	T_d	T_m
	solution	film	solution	film	(eV)	(eV)	(eV)	(° C.)	(° C.)
Compound 2	289	295	543	545	3.32	−3.52	−6.84	299	

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TABLE 4

	Uv-vis.		PL						
	λ_{max} (nm)		λ? $_{max}$ (nm)		E_g	LUMO	HOMO	T_d	T_m
	solution	film	solution	film	(eV)	(eV)	(eV)	(° C.)	(° C.)
Compound 18	323	328	—	—	3.12	−2.84	−5.96	438	—

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[0403] As described above, according to the one or more of the above embodiments of the present disclosure, an organic light-emitting device including an antiaromatic compound of Formula 1 may have a high efficiency and improved lifetime characteristics.

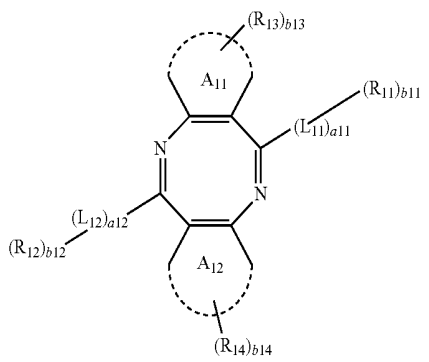
[0404] It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0405] While one or more embodiments of the present disclosure have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the following claims, and equivalents thereof.

What is claimed is:

1. An antiaromatic compound represented by Formula 1:

Formula 1



wherein, in Formula 1,

A_{11} and A_{12} are each independently selected from a C_6-C_{60} arene and a C_1-C_{60} heteroarene;

L_{11} and L_{12} are each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted non-aromatic condensed polycyclic group, and a substituted or unsubstituted non-aromatic condensed heteropolycyclic group;

at least one substituent of the substituted C_3-C_{10} cycloalkylene group, the substituted C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted C_1-C_{10} heterocycloalkenylene group, the substituted C_6-C_{60} arylene group, the substituted C_1-C_{60} heteroarylene group, the substituted non-aromatic condensed polycyclic group, and the substituted non-aromatic condensed heteropolycyclic group is selected from:

a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and C_1-C_{60} alkoxy group;

a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

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

a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocy-

cloalkenyl 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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

a11 and a12 are each independently selected from 0, 1, 2, 3, 4, 5 and 6;

R_{11} and R_{12} are each independently selected from a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted non-aromatic condensed polycyclic group, a substituted or unsubstituted non-aromatic condensed heteropolycyclic group, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$P(Q_{16})(Q_{17})$;

Q_{11} to Q_{17} are each independently selected from a substituted or unsubstituted C_6-C_{60} aryl group, and a substituted or unsubstituted C_1-C_{60} heteroaryl group;

at least one substituent of the substituted C_6-C_{60} aryl group, the substituted C_1-C_{60} heteroaryl group, the substituted non-aromatic condensed polycyclic group, and the substituted non-aromatic condensed heteropolycyclic group is selected from:

a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

a C_1-C_{60} alkyl group, C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

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

a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

b11 and b12 are each independently an integer selected from 1 to 3;

R_{13} and R_{14} are each independently selected from:

a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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_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 non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

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

a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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, C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{60} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60}

aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

b13 and b14 are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10.

2. The antiaromatic compound of claim **1**, wherein A_{11} and A_{12} are each independently selected from a benzene, a naphthalene, a phenanthrene, an anthracene, a triphenylene, a pyrene, a chrysene, a pyrrole, a thiophene, a furan, an imidazole, a pyrazole, a thiazole, an oxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, an indole, a quinoline, an isoquinoline, a benzoquinoline, a naphthyridine, a quinoxaline, a quinazoline, a phenanthridine, an acridine, a phenanthroline, a phenazine, a benzimidazole, a benzofuran, a benzothiophene, a benzoxazole, a triazole, a triazine, a dibenzofuran, and a dibenzothiophene.

3. The antiaromatic compound of claim **1**, wherein A_{11} and A_{12} are each independently selected from a benzene, a naphthalene, a phenanthrene, an anthracene, a triphenylene, a pyridine, a quinoline, an isoquinoline, a naphthyridine, a quinoxaline, and a quinazoline.

4. The antiaromatic compound of claim **1**, wherein L_{11} and L_{12} are each independently selected from:

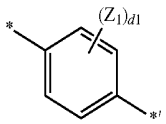
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spirofluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thienylene group, a furanylene group, a silolylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, a benzofuranylene group, a benzothienylene group, a benzosilolylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, and a dibenzosilolylene group; and

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spirofluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thienylene group, a furanylene group, a silolylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, a benzofuranylene group, a benzothienylene group, a benzosilolylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, and a dibenzosilolylene group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 cyclohexcenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thienyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothienyl group, a benzosilolyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazole group, an oxadiaz-

olyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothienyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and a dibenzosilolyl group.

5. The antiaromatic compound of claim **1**, wherein L_{11} and L_{12} are each independently a group represented by one of Formulae 3-1 to 3-32:

3-1



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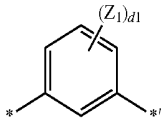

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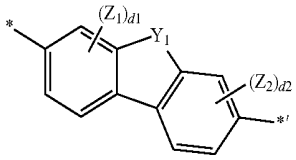

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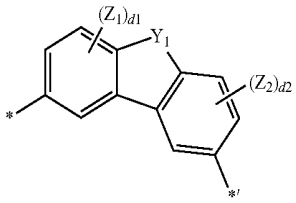

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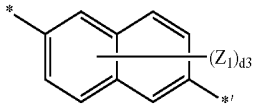

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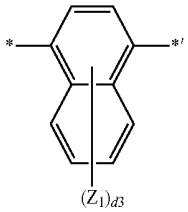

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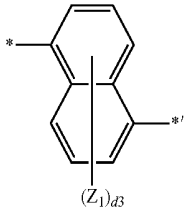

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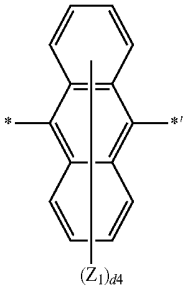

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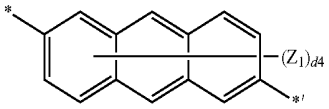

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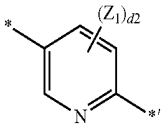

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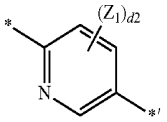

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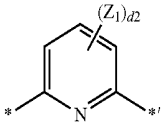

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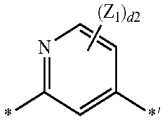

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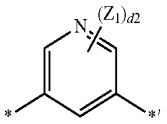

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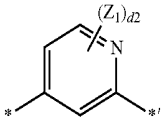

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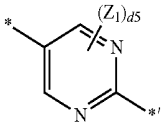

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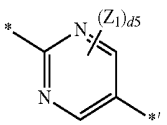

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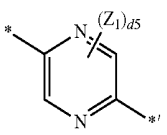

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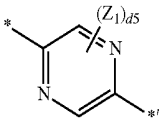
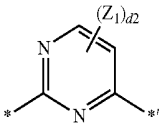
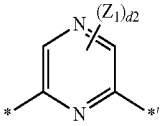


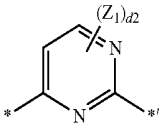
3-20



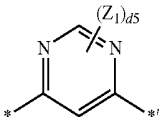
3-21



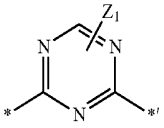
3-22



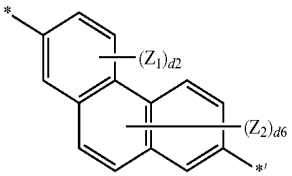
3-23



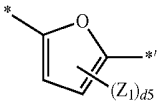
3-24



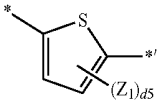
3-25



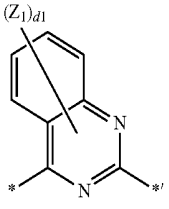
3-26



3-27



3-28



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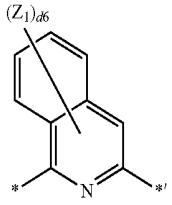
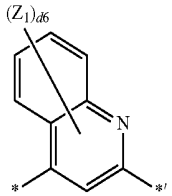
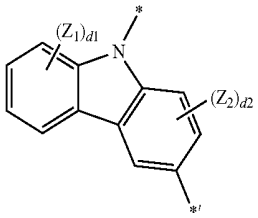
3-29



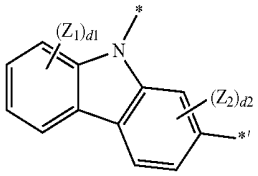
3-30



3-31



3-32



wherein, in Formulae 3-1 to 3-32,

Y_1 is selected from $C(Q_{31})(Q_{32})$, $N(Q_{33})$, an oxygen atom, a sulfur atom, and $Si(Q_{34})(Q_{35})$;

Q_{31} to Q_{35} are each independently selected from a hydrogen atom, a deuterium atom, a C_1-C_{20} alkyl group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

Z_1 and Z_2 are each independently selected from a hydrogen atom, a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a 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;

d1 is an integer selected from 1 to 4;

d2 is an integer selected from 1 to 3;

d3 is an integer selected from 1 to 6;

d4 is an integer selected from 1 to 8;

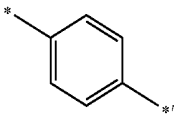
d5 is 1 or 2;

d6 is an integer selected from 1 to 5; and

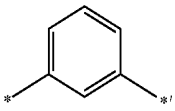
* and *' are each independently a binding site with another atom.

6. The antiaromatic compound of claim **1**, wherein L_{11} and L_{12} are each independently a group represented by one of Formulae 4-1 to 4-10:

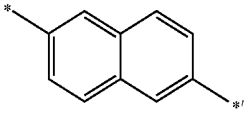
4-1



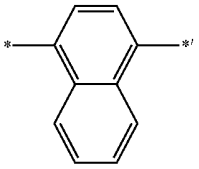
4-2



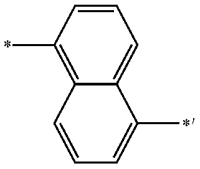
4-3



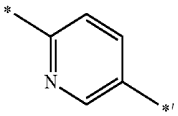
4-4



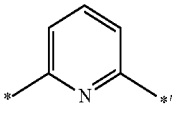
4-5



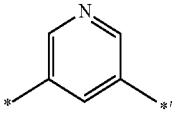
4-6



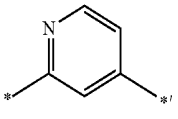
4-7



4-8



4-9



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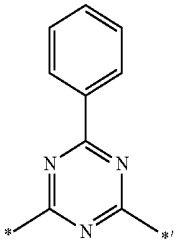
4-10

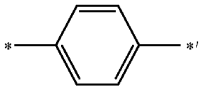


wherein, in Formulae 4-1 to 4-10, * and *' are each independently a binding site with another atom.

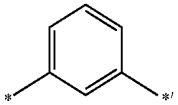
7. The antiaromatic compound of claim **1**, wherein a11 and a12 are each independently 0 or 1.

8. The antiaromatic compound of claim **1**, wherein $(L_{11})_{a11}$ and $(L_{12})_{a12}$ are each independently selected from a single bond and groups represented by Formulae 4-21 to 4-32:

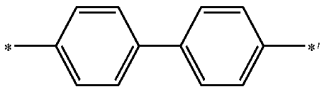
4-21



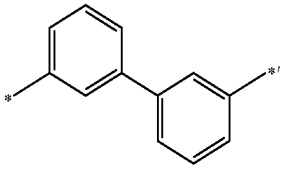
4-22



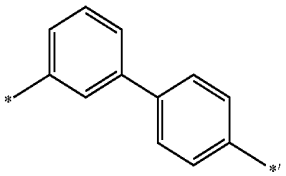
4-23



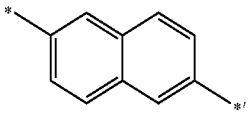
4-24



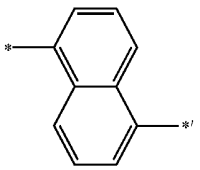
4-25



4-26



4-27



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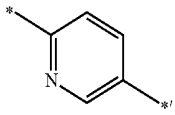
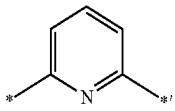
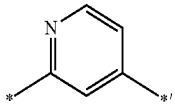
4-28



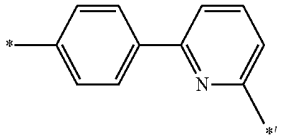
4-29



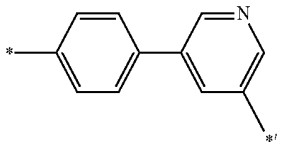
4-30



4-31



4-32



wherein, in Formulae 4-21 to 4-32,

* and *' are each independently a binding site with another atom.

9. The antiaromatic compound of claim **1**, wherein R_{11} and R_{12} are each independently selected from:

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—P(Q_{16})(Q_{17})$; and

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl

group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group; and

Q_{11} to Q_{17} are each independently selected from:

a phenyl group, a naphthyl group, a fluorenyl group, an anthracenyl group, a pyrenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, an anthracenyl group, a pyrenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one of a deuterium atom, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 cyclohexcenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coroneryl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuryl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group.

10. The antiaromatic compound of claim **1**, wherein R_{11} and R_{12} are each independently selected from:

a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, an imidazole group, a benzimidazole group, a triazole group, a triazine group, an oxadiazolyl group, a quinolinyl group, an isoquinolinyl group, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—P(Q_{16})(Q_{17})$;

a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, an imidazole group, a benzimidazole group, a triazole group, a triazine group, an oxadiazolyl group, a quinolinyl group, and an isoquinolinyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_1-C_{20} alkyl group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

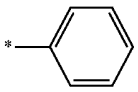
Q_{11} to Q_{17} are each independently selected from:

a phenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a carbazolyl group, and a triazinyl group; and

a phenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a carbazolyl group, and a triazinyl group, each substituted with at least one selected from a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_1-C_{20} alkyl group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group.

11. The antiaromatic compound of claim **1**, wherein R_{11} and R_{12} are each independently selected from a group represented by Formulae 5-1 to 5-39:

5-1



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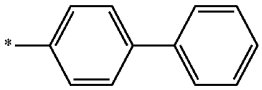

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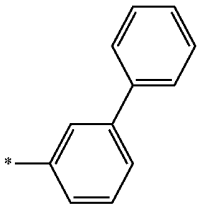

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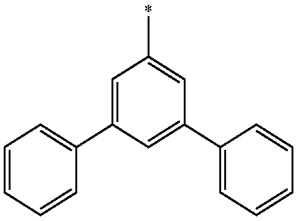

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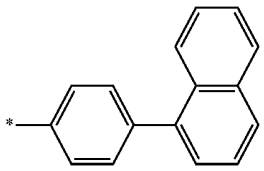

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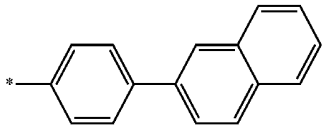

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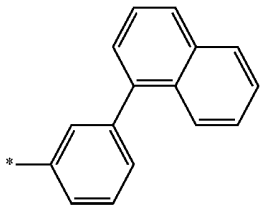

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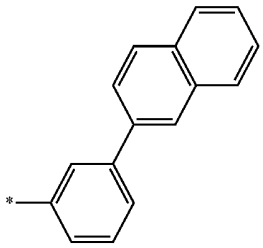

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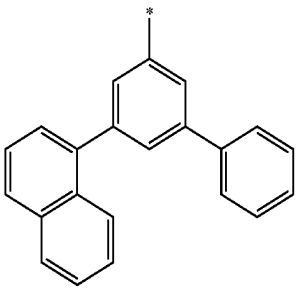

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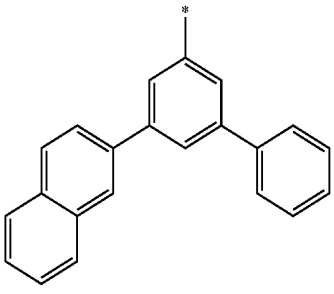

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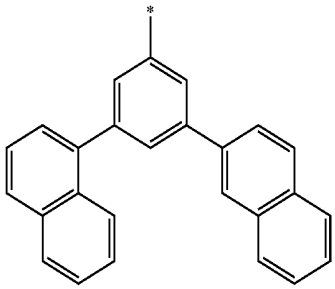

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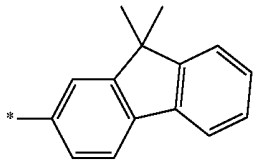

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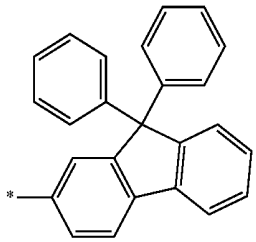

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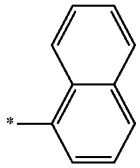

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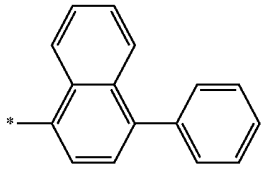

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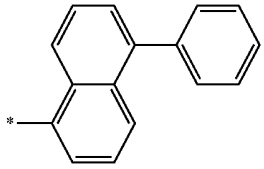

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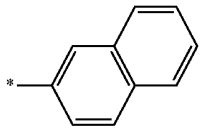

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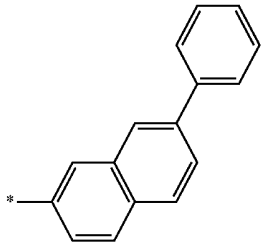

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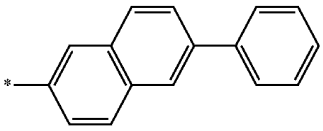

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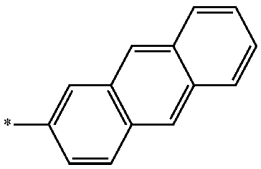

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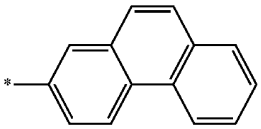

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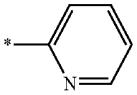

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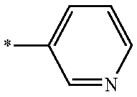

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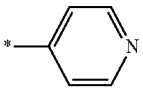

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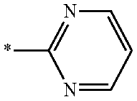

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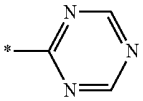

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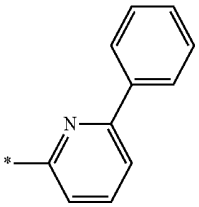

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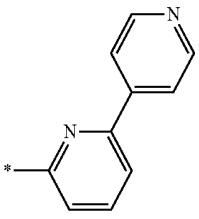

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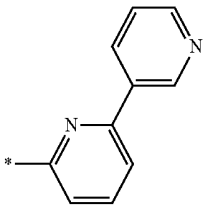

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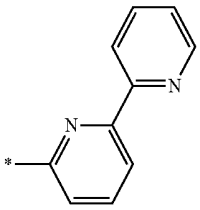

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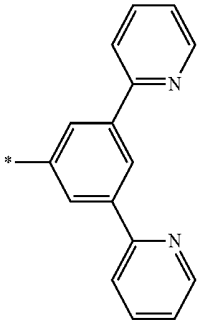

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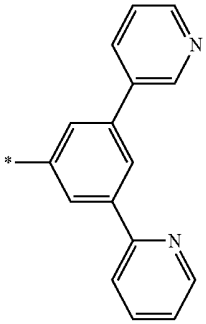

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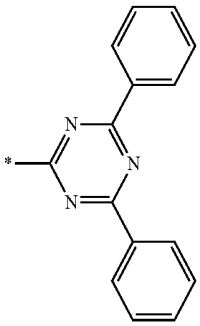

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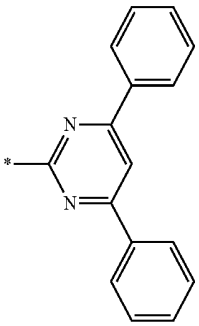

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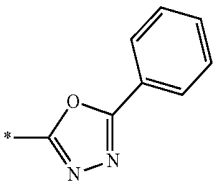

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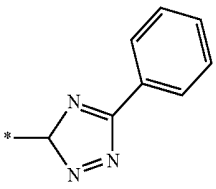

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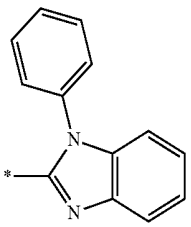

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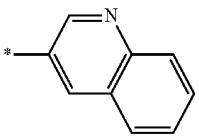

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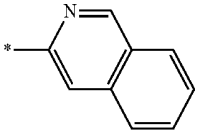


wherein, in Formulae 5-1 to 5-39,

* is each independently a binding site with another atom.

12. The antiaromatic compound of claim **1**, wherein each of b11 and b12 is 1.

13. The antiaromatic compound of claim **1**, wherein R_{13} and R_{14} are each independently selected from:

a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a nitro group, and a C_1-C_{60} alkyl group;

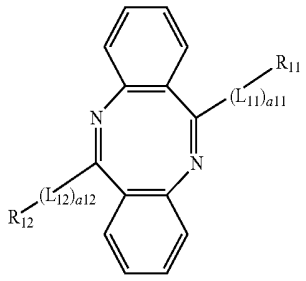
a C_1-C_{60} alkyl group substituted with at least one of a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group;

a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group; and

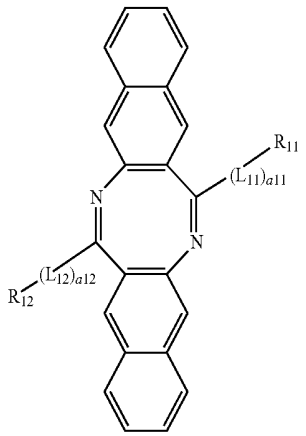
a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium atom, a halogen atom, a cyano group, a nitro group, a C_1-C_{60} alkyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a non-aromatic condensed polycyclic group, and a non-aromatic condensed heteropolycyclic group.

14. The antiaromatic compound of claim **1**, wherein the antiaromatic compound is represented by one of Formulae 1A to 1E:

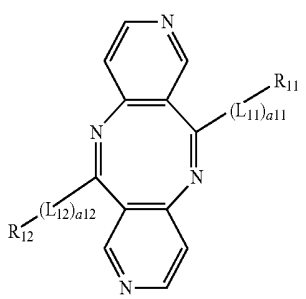
Formula 1A



Formula 1B



Formula 1C



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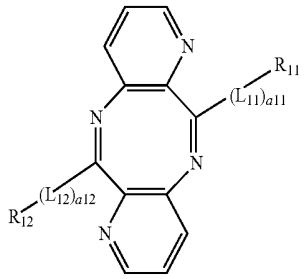
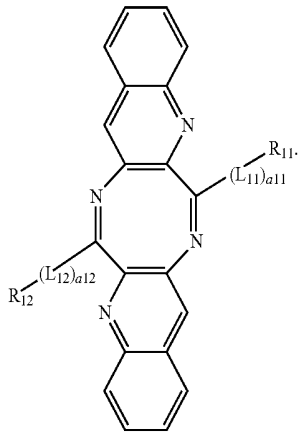
Formula 1D

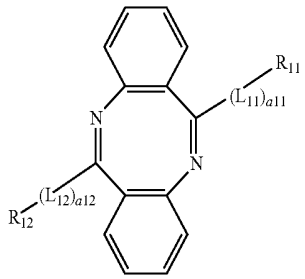


Formula 1E

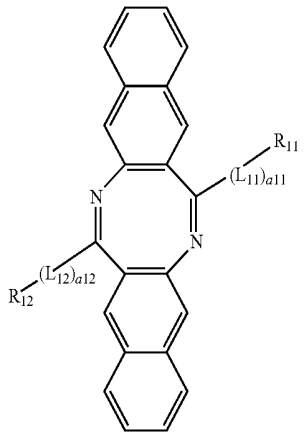


15. The antiaromatic compound of claim **1**, wherein the antiaromatic compound is represented by one of Formulae 1A to 1E:

Formula 1A



Formula 1B



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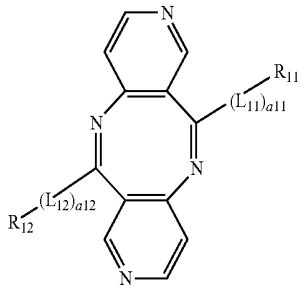
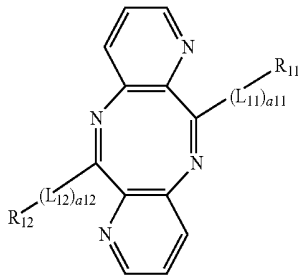
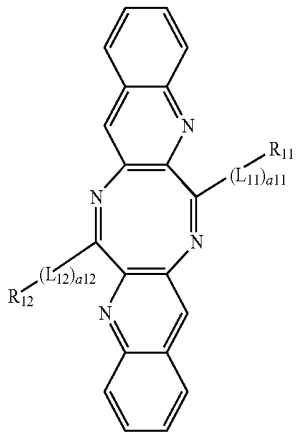
Formula 1C



Formula 1D



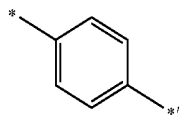
Formula 1E



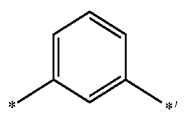
wherein, in Formulae 1A to 1E,

L_{11} and L_{12} are each independently a group represented by one of Formulae 4-1 to 4-10;

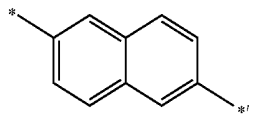
4-1



4-2



4-3



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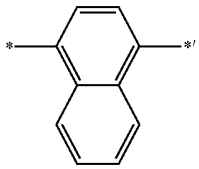
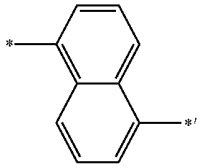
4-4



4-5



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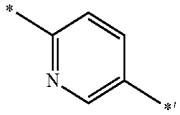

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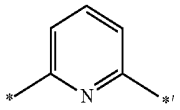

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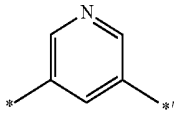
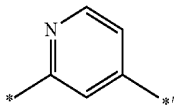
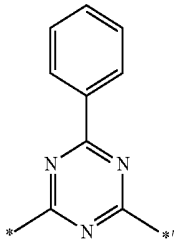


4-9



4-10



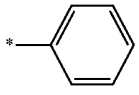
wherein, in Formulae 4-1 to 4-10,

* and *' are each independently a binding site with another atom;

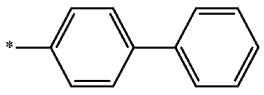
a11 and a12 are each independently 0 or 1;

R_{11} and R_{12} are each independently a group represented by one of Formulae 5-1 to 5-39;

5-1



5-2



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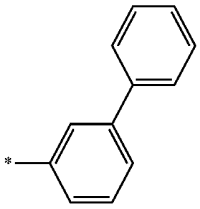

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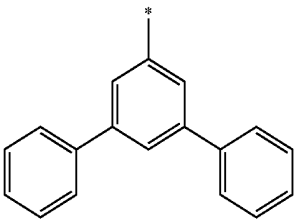

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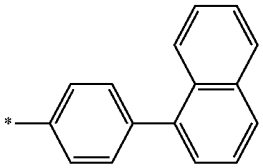
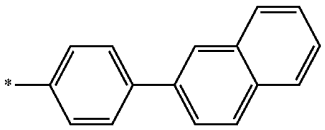


5-6



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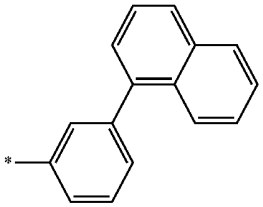

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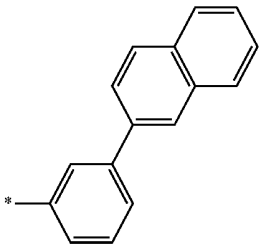

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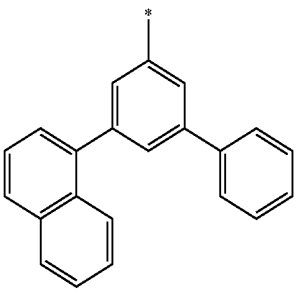

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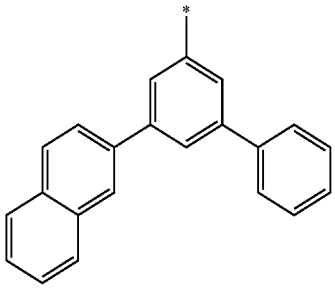
5-10



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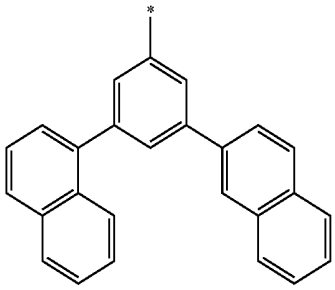

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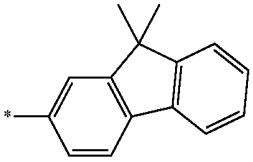

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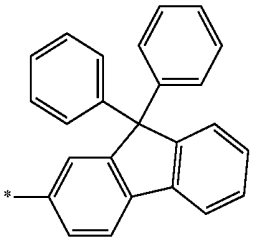

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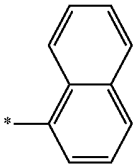

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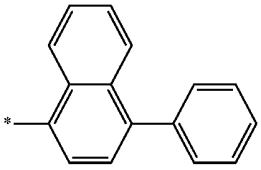

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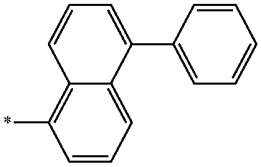

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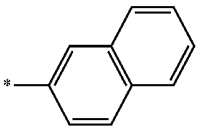

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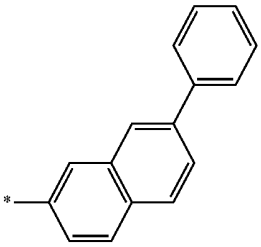

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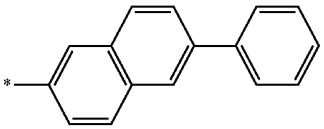

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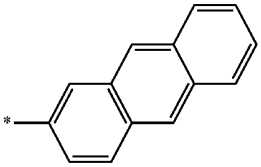

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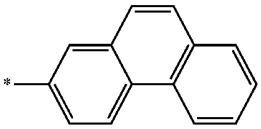

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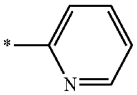

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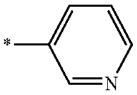

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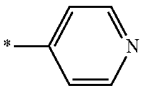

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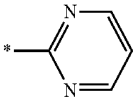

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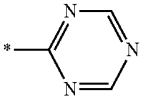

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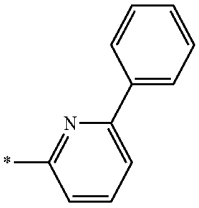

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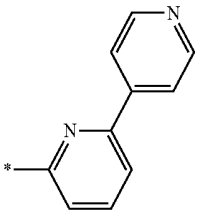

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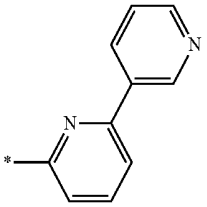

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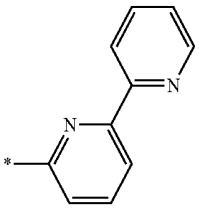
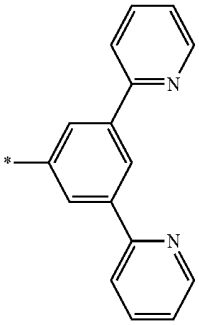
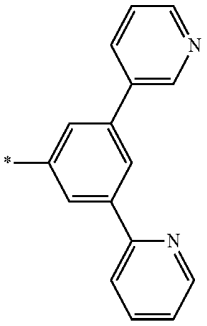


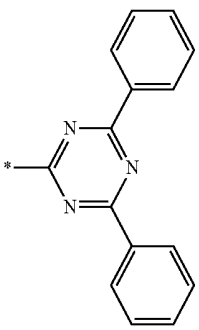
5-31



5-32



5-33



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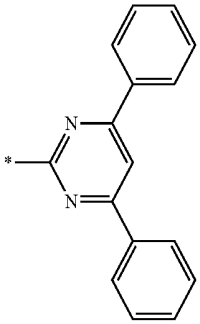
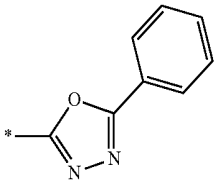
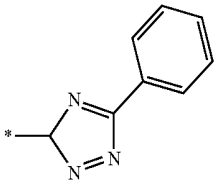
5-34



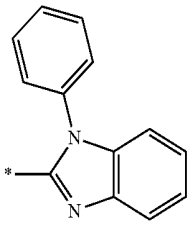
5-35



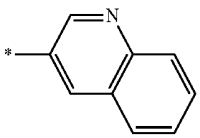
5-36



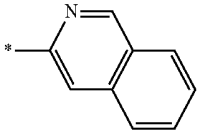
5-37



5-38



5-39

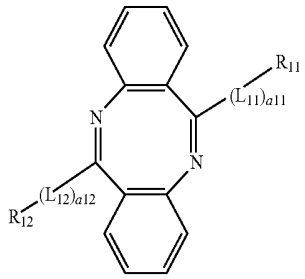


wherein, Formulae 5-1 to 5-39,

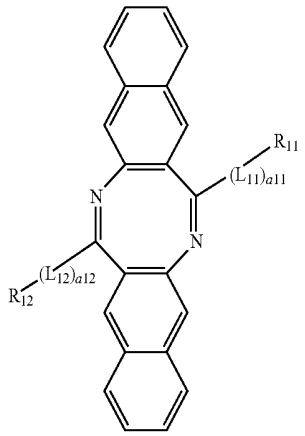
* is each independently a binding site with another atom.

16. The antiaromatic compound of claim **1**, wherein the antiaromatic compound is represented by one of Formulae 1A to 1E:

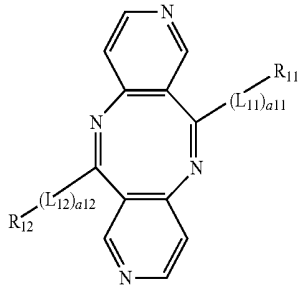
Formula 1A



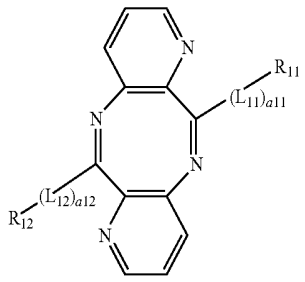
Formula 1B



Formula 1C



Formula 1D



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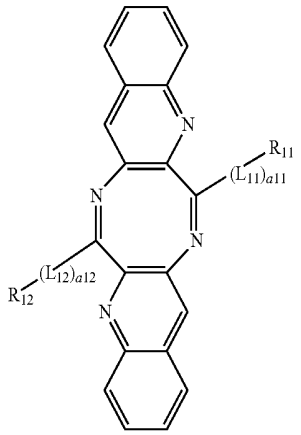
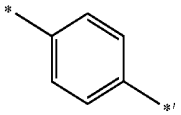
Formula 1E

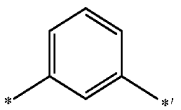


wherein, in Formulae 1A and 1B, L_{11} and L_{12} are each independently a group represented by one of Formulae 4-1 to 4-10:

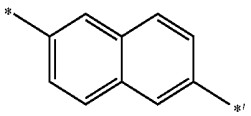
4-1



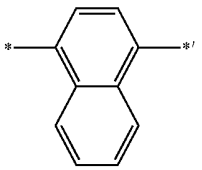
4-2



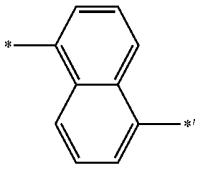
4-3



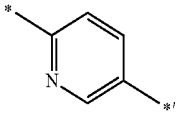
4-4



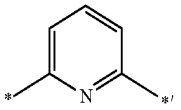
4-5



4-6



4-7



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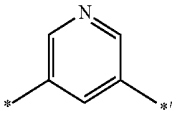
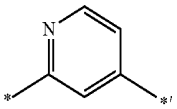
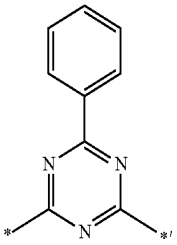
4-8



4-9



4-10



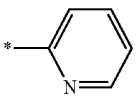
wherein, in Formulae 4-1 to 4-10,

* and *' are each independently a binding site with another atom;

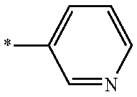
a11 and a12 are each independently 0 or 1; and

R_{11} and R_{12} are each independently a group represented by one of Formulae 5-22 to 5-39:

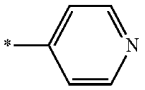
5-22



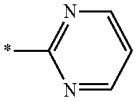
5-23



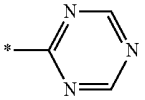
5-24



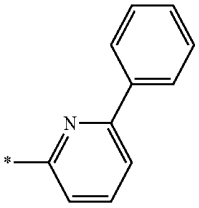
5-25



5-26



5-27



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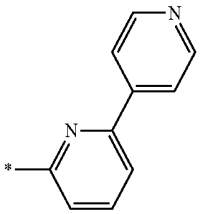
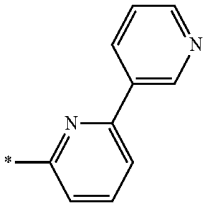
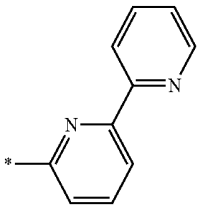
5-28



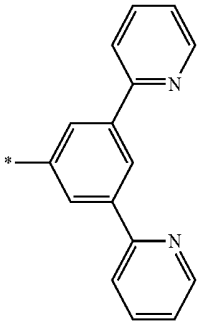
5-29



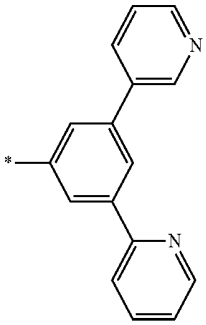
5-30



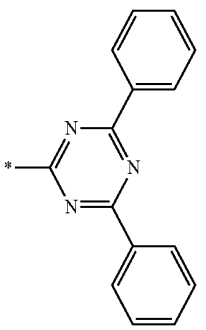
5-31



5-32



5-33



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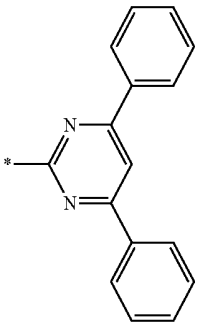
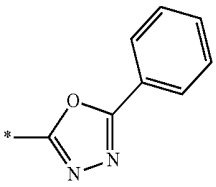
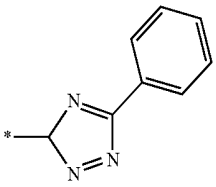
5-34



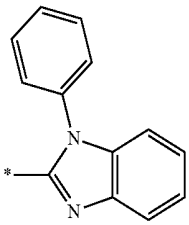
5-35



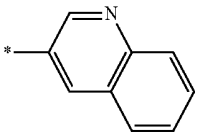
5-36



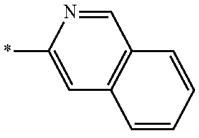
5-37



5-38



5-39

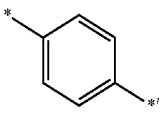


wherein, in Formulae 5-1 to 5-39, * is each independently a binding site with another atom; and

in Formulae 1C to 1E,

L_{11} and L_{12} are each independently a group represented by one of Formulae 4-1 to 4-5:

4-1



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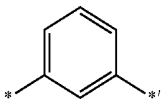
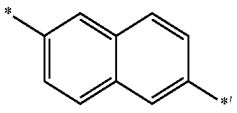
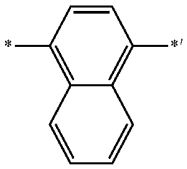
4-2



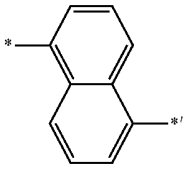
4-3



4-4



4-5



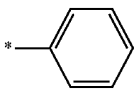
wherein, in Formulae 4-1 to 4-5,

* and *' are each independently a binding site with another atom;

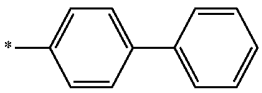
a11 and a12 are each independently 0 or 1; and

R_{11} and R_{12} are each independently a group represented by one of Formulae 5-1 to 5-21:

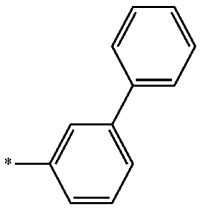
5-1



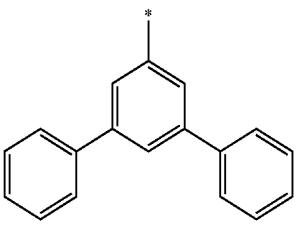
5-2



5-3



5-4



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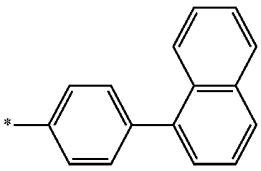
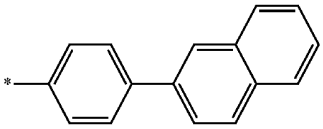
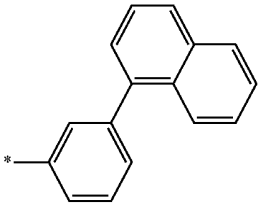
5-5



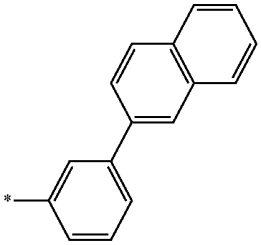
5-6



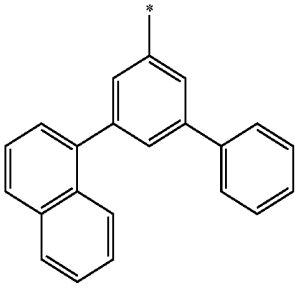
5-7



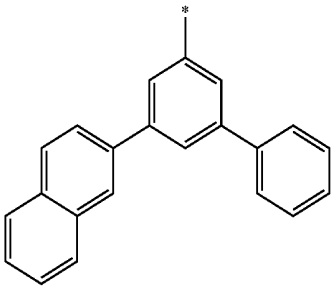
5-8



5-9



5-10



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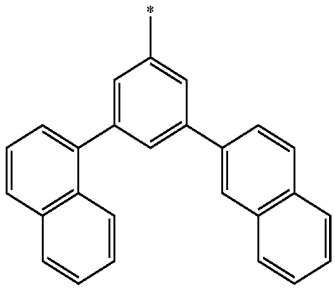
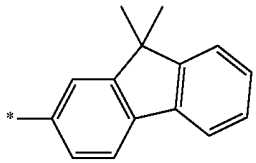
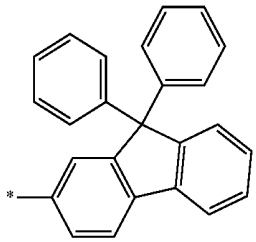
5-11



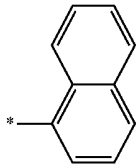
5-12



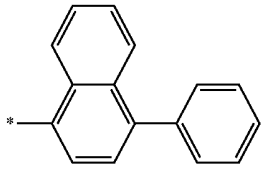
5-13



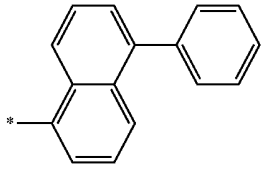
5-14



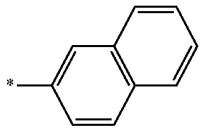
5-15



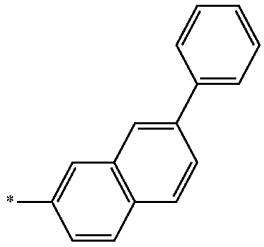
5-16



5-17



5-18



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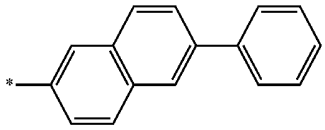
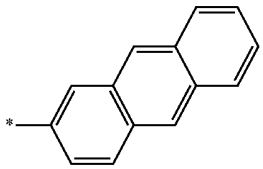
5-19



5-20



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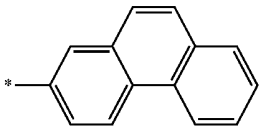
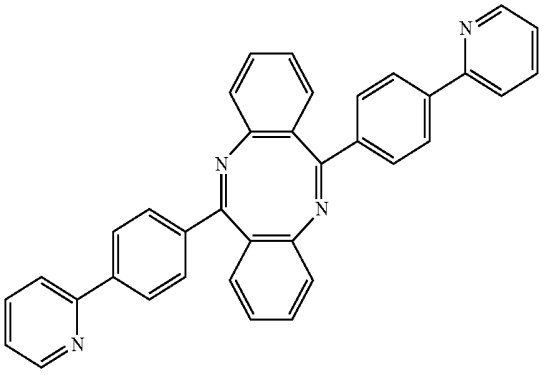
5-21



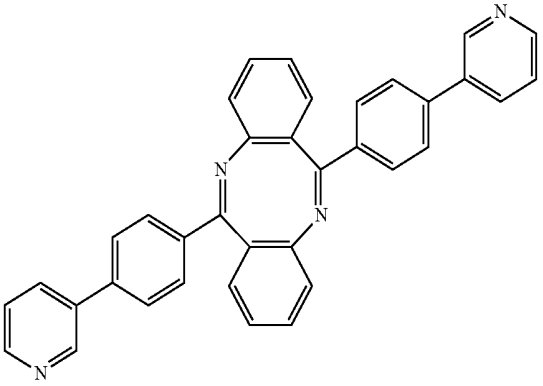
wherein, in Formulae 5-1 to 5-21, * is each independently a binding site with another atom.

17. The antiaromatic compound of claim **1**, wherein the antiaromatic compound is selected from one of the following compounds 1 to 247:

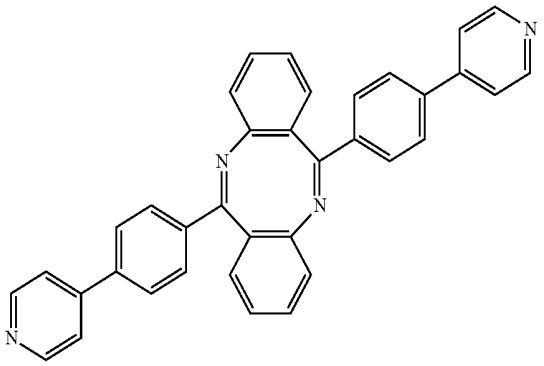
1



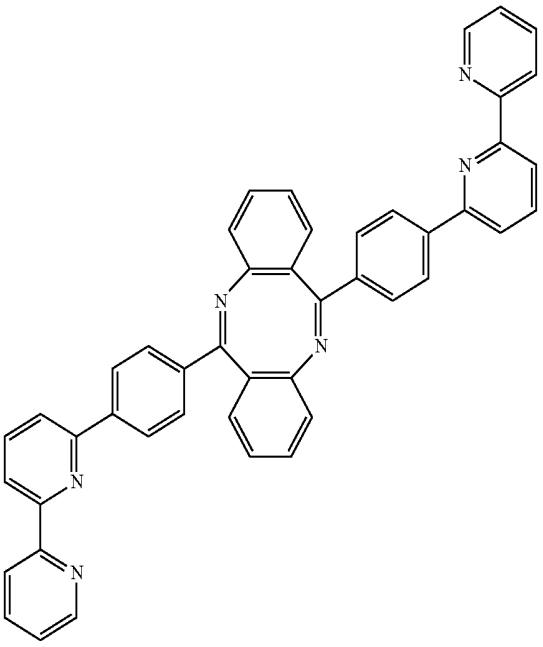
2



3



4



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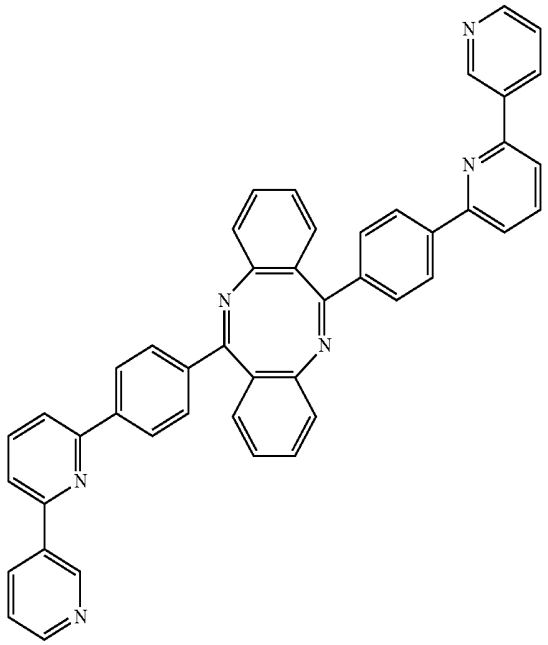
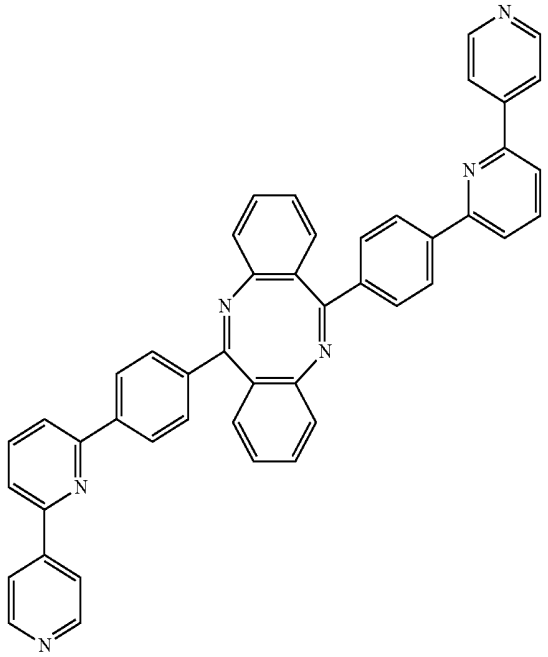
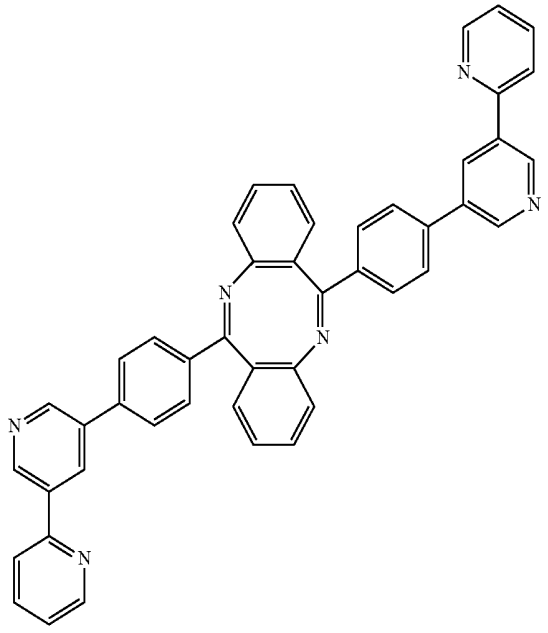
5



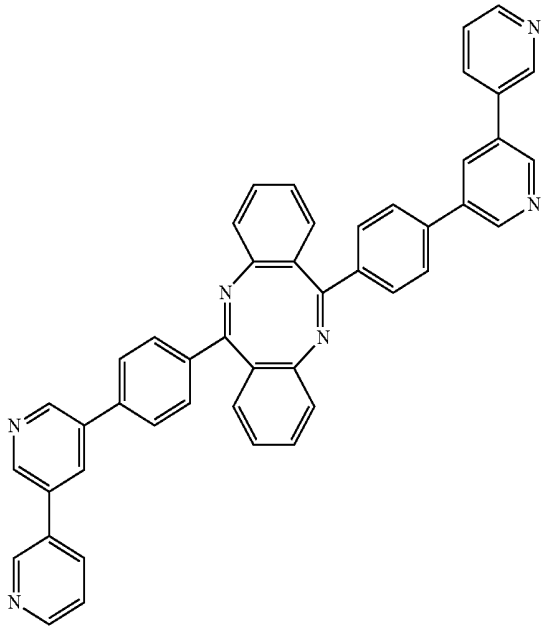
6



7



8



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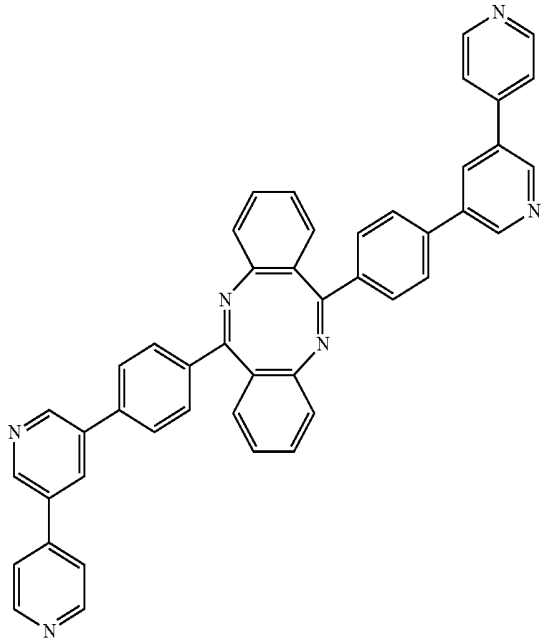
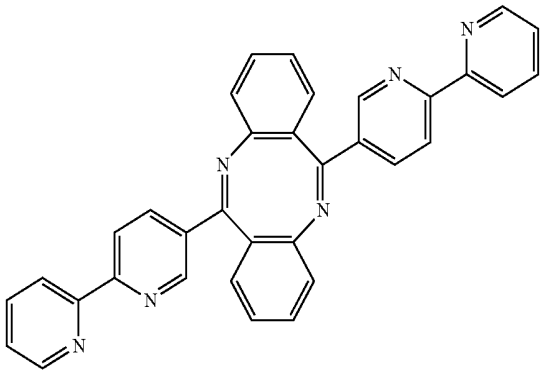
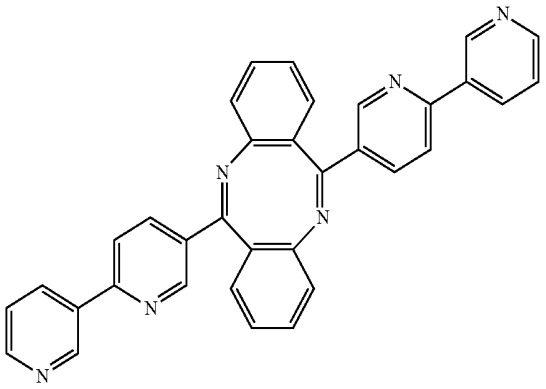
9



10



11



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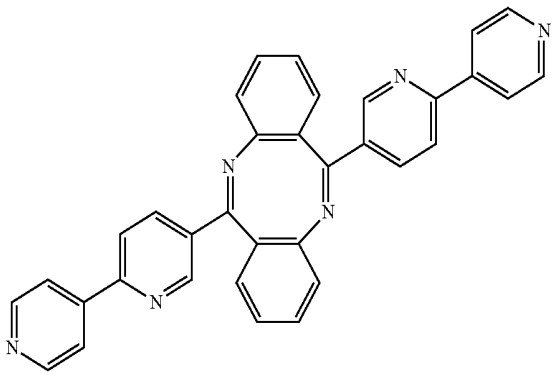

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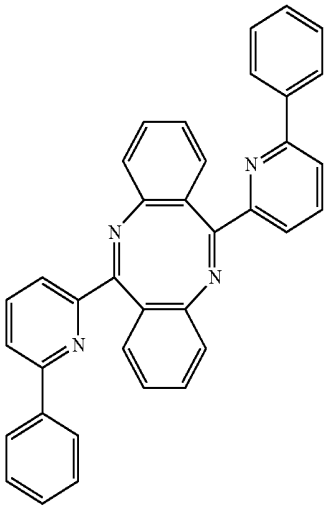

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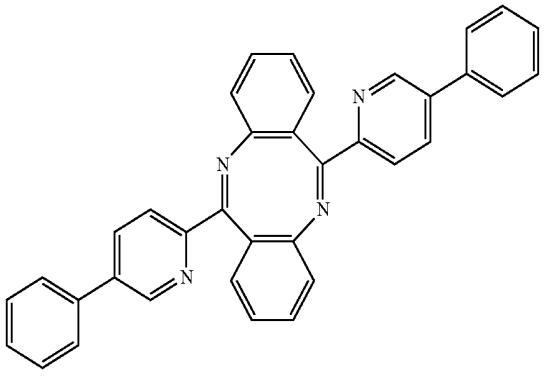

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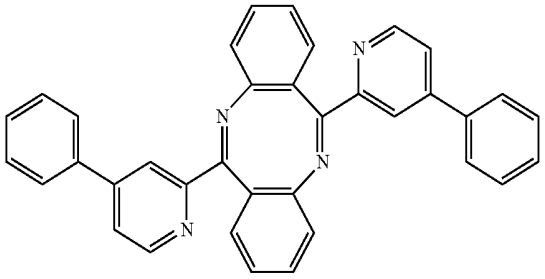

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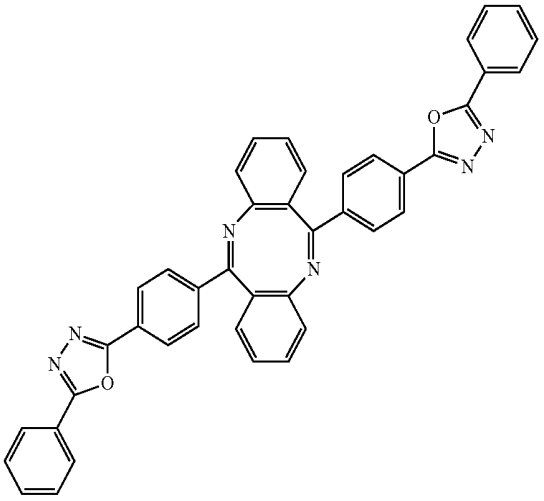

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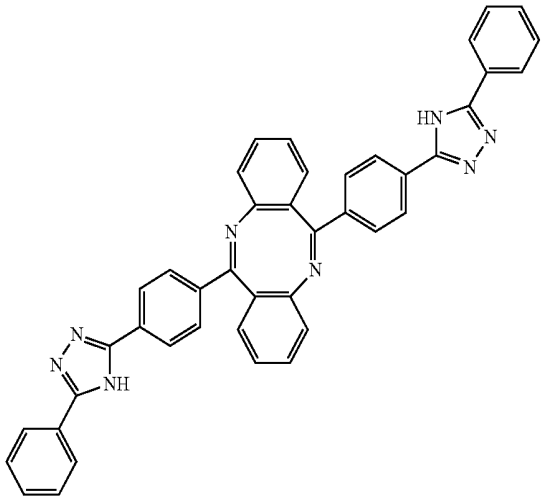

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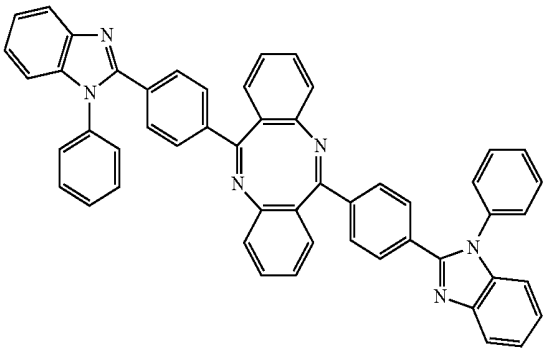

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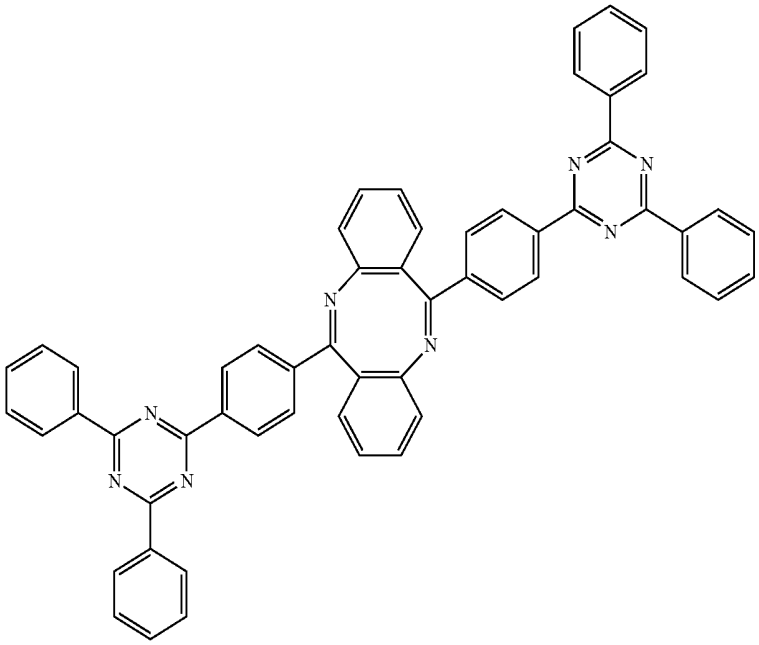

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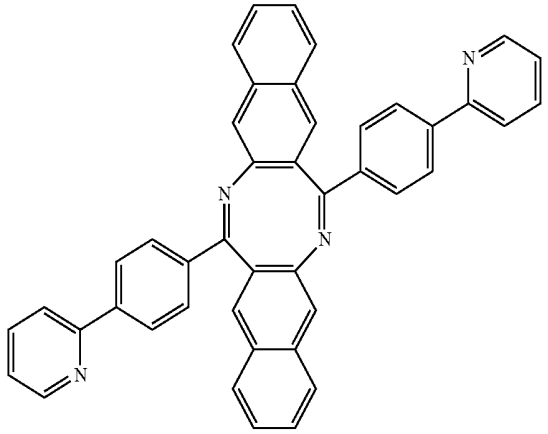

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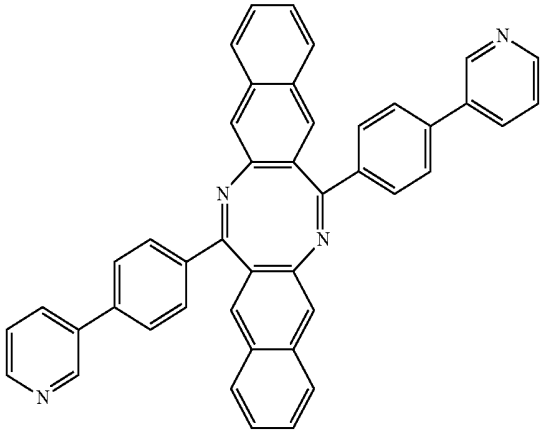

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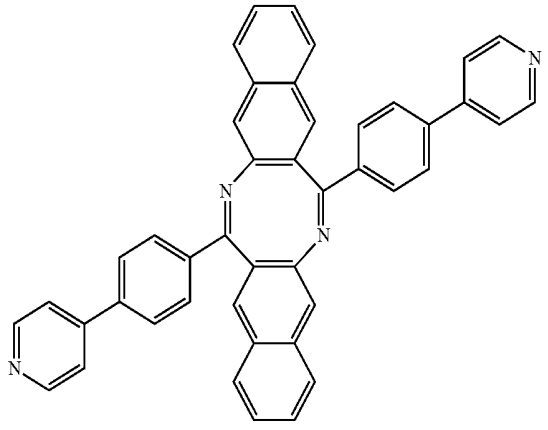

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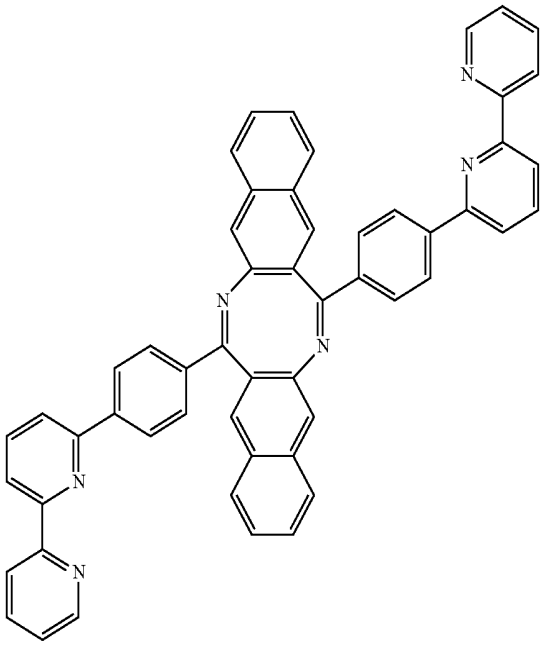

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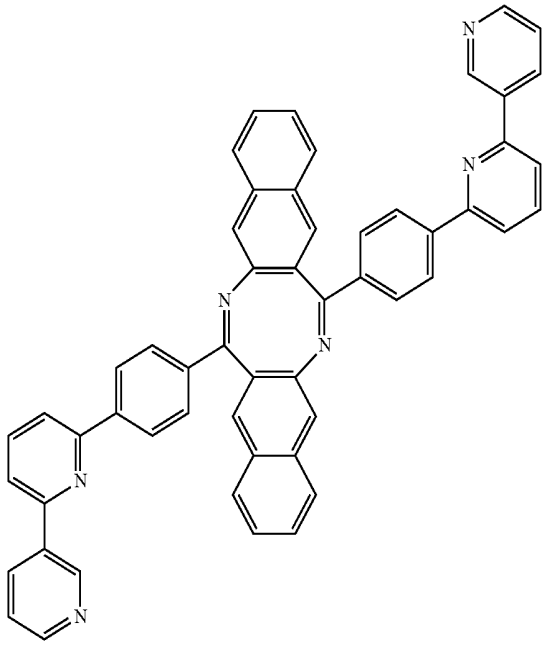

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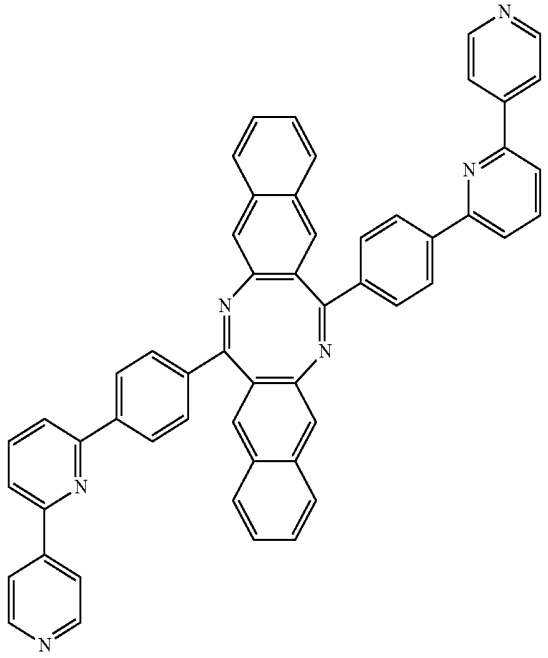

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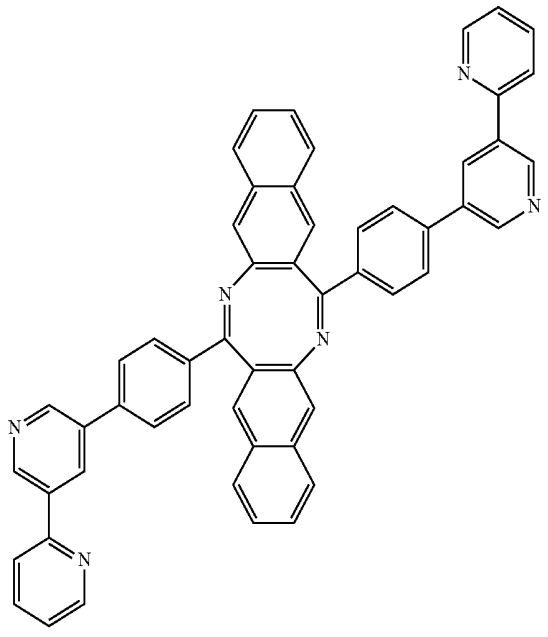

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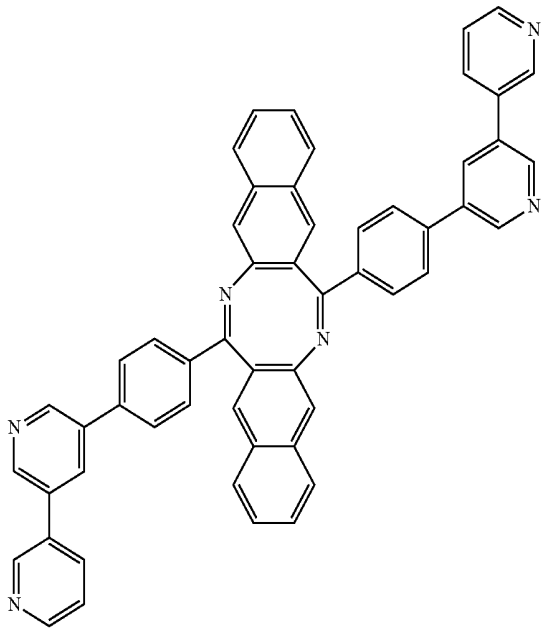

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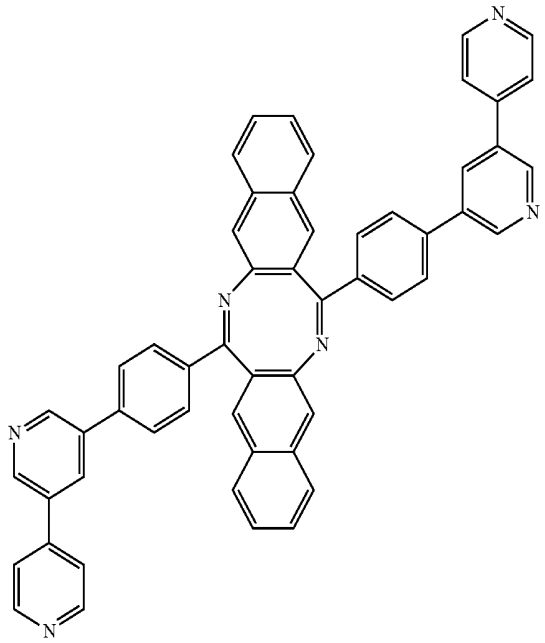

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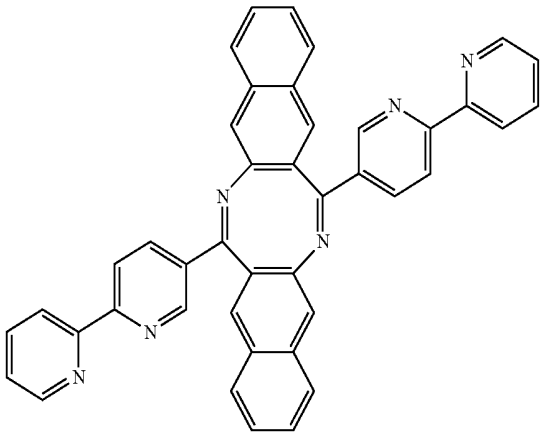

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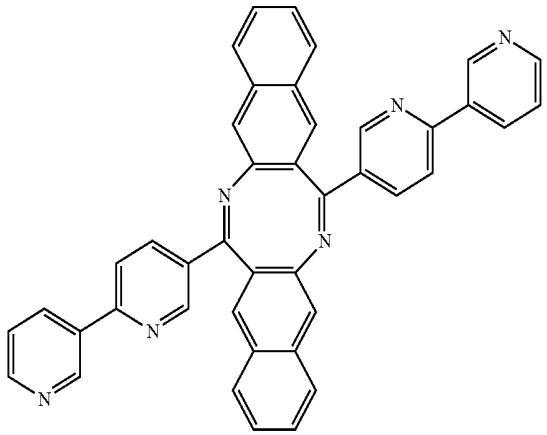

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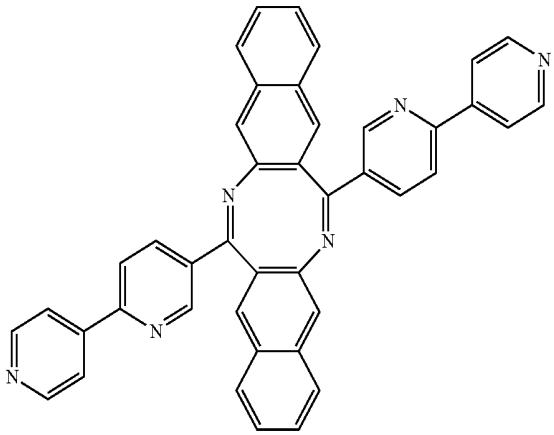

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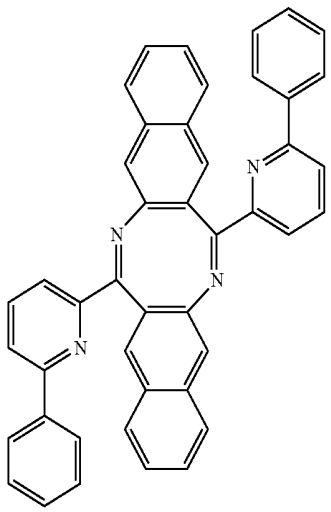

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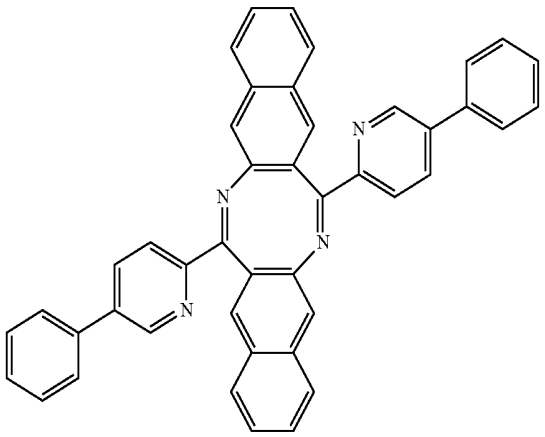

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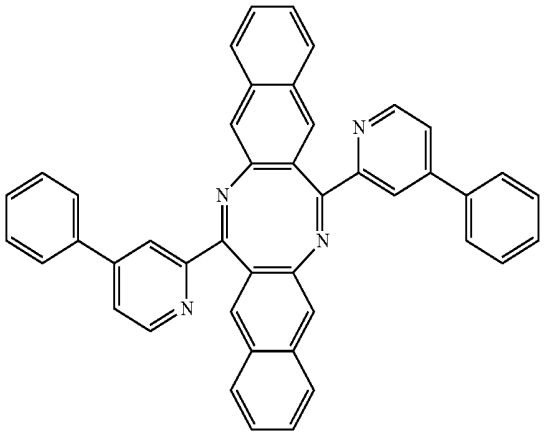

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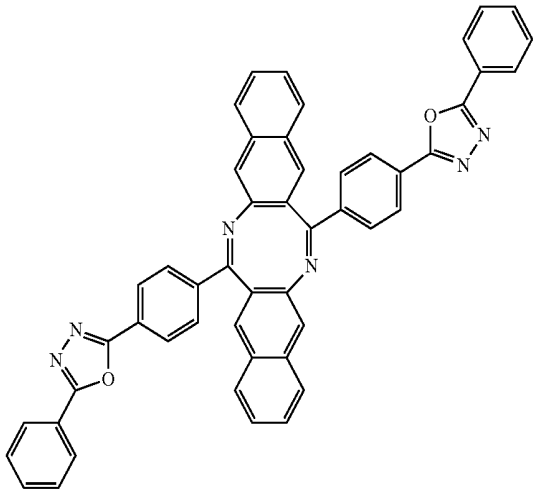

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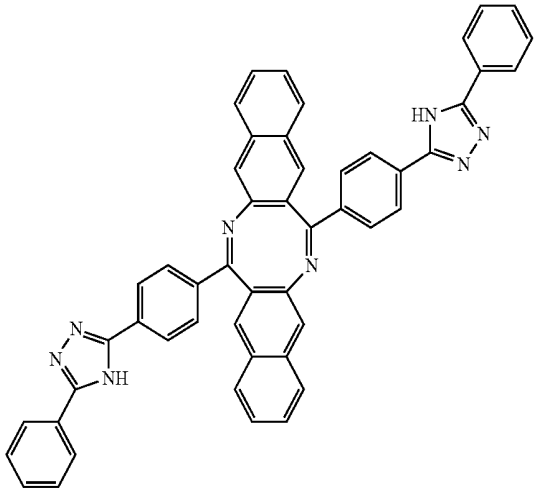

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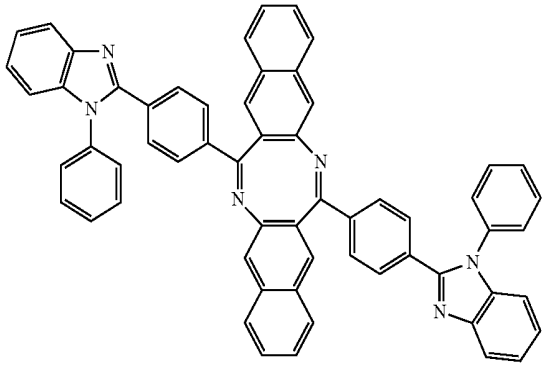

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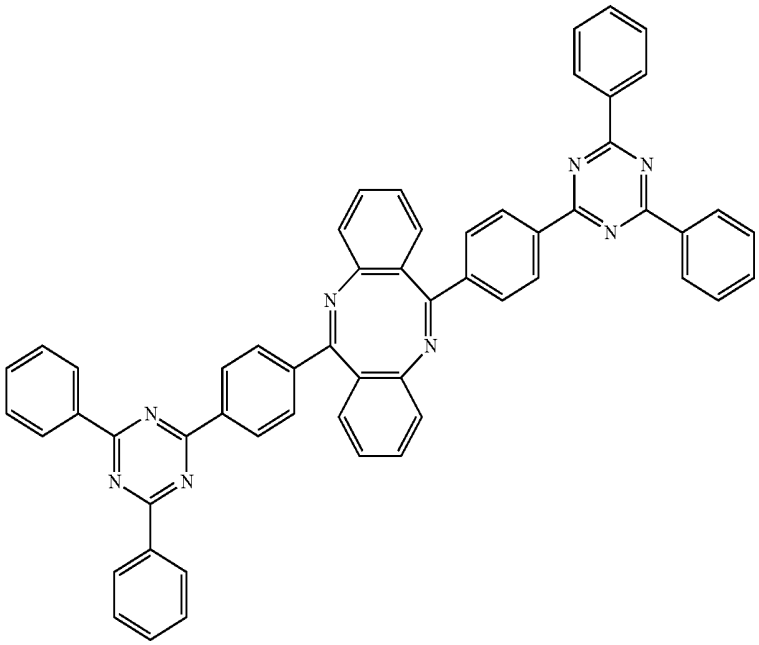

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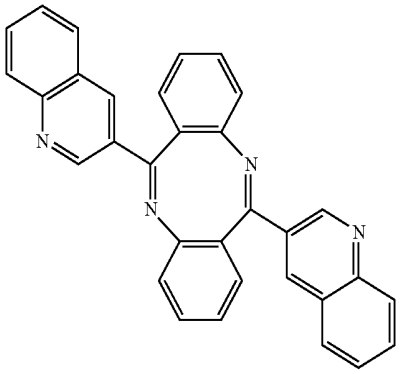

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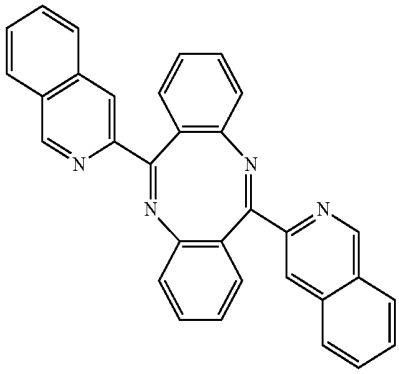

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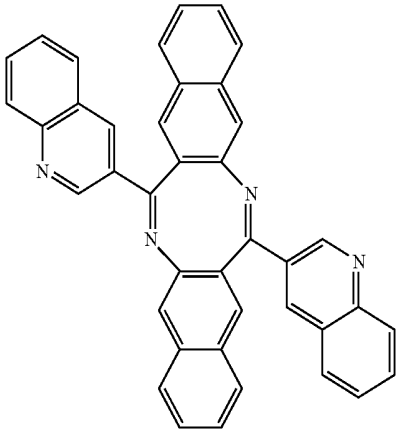

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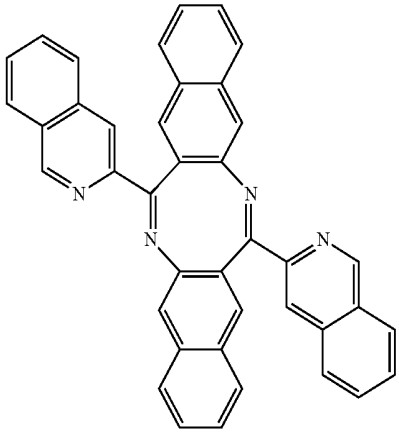

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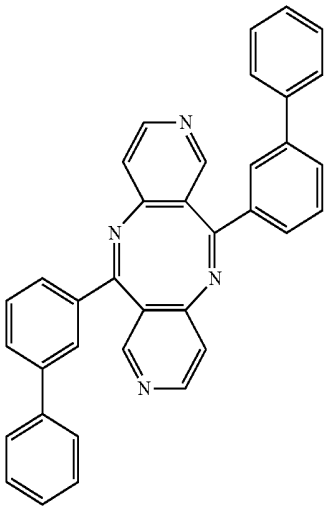

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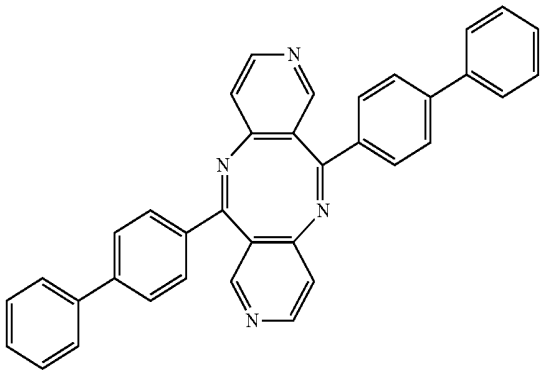

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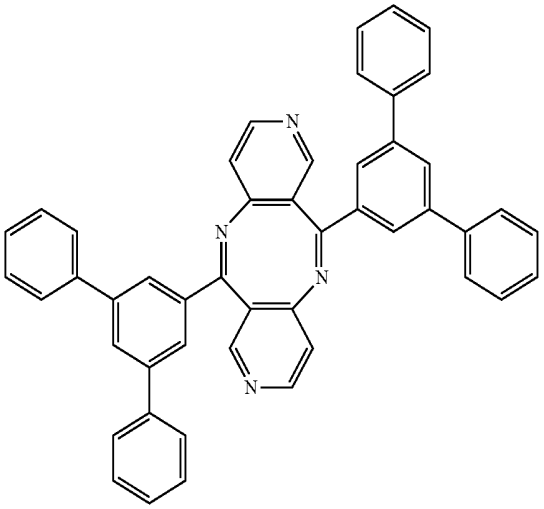

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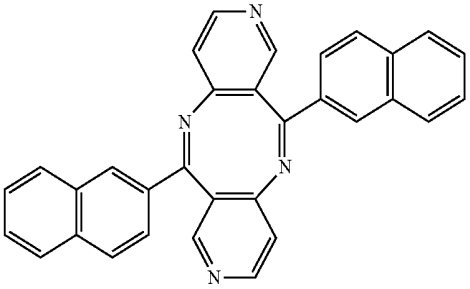

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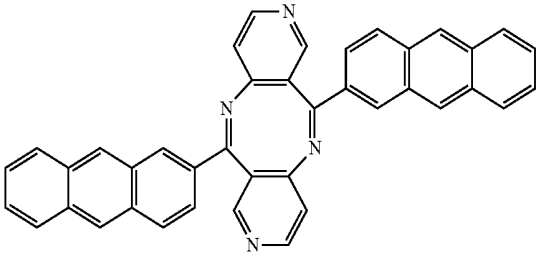

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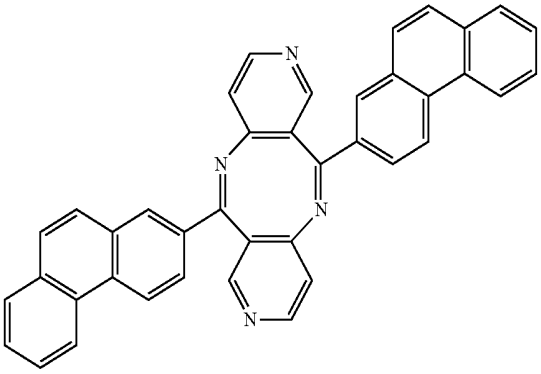

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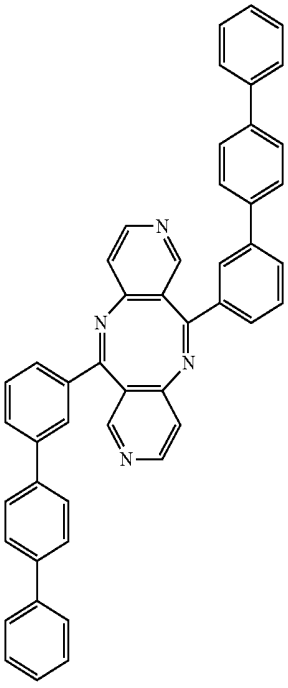

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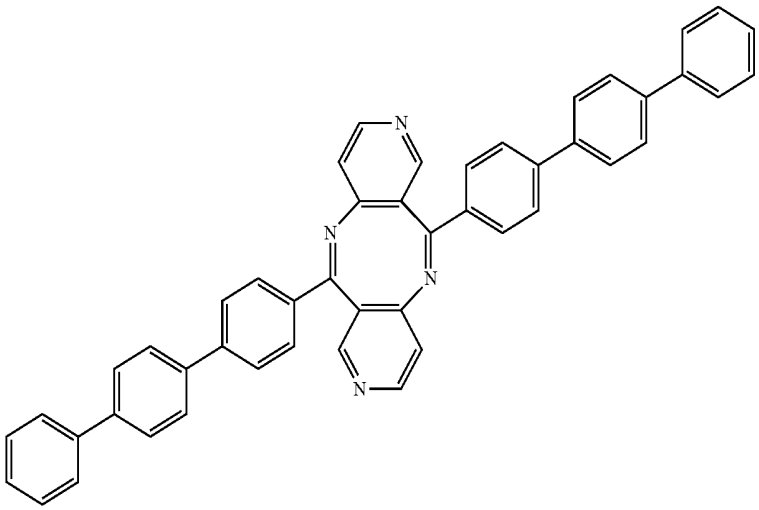

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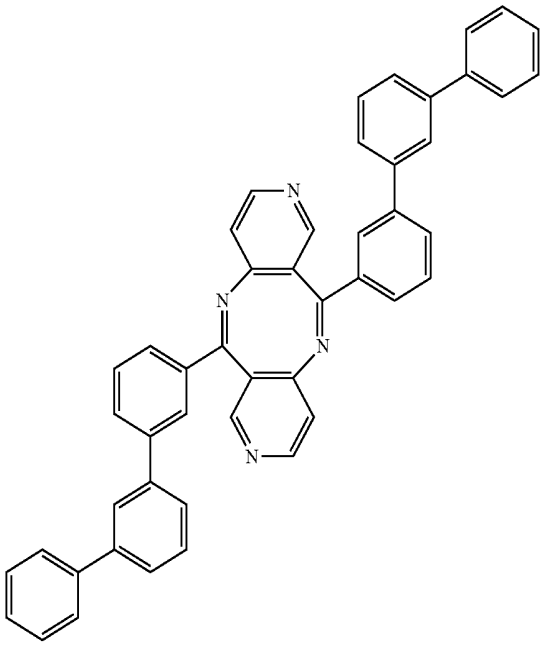

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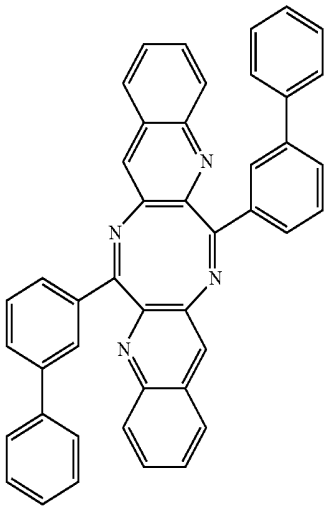

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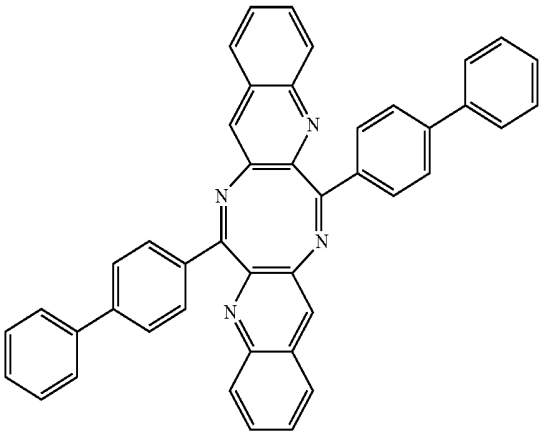

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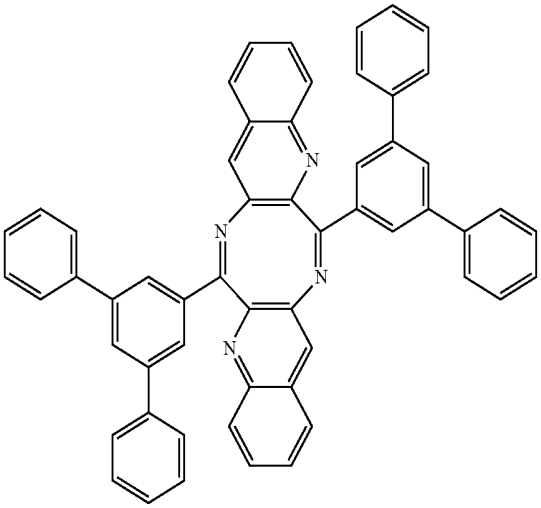

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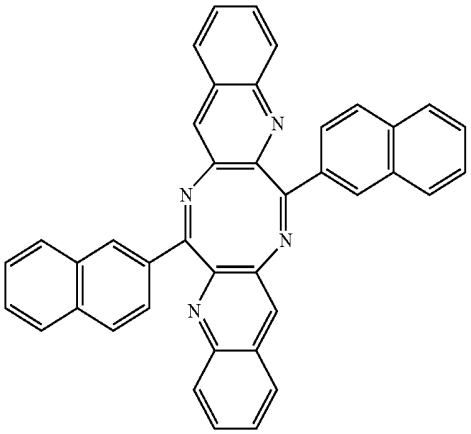

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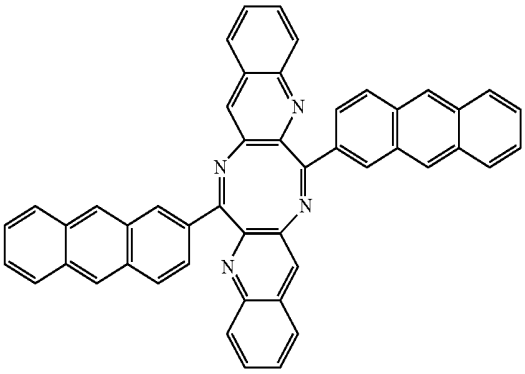

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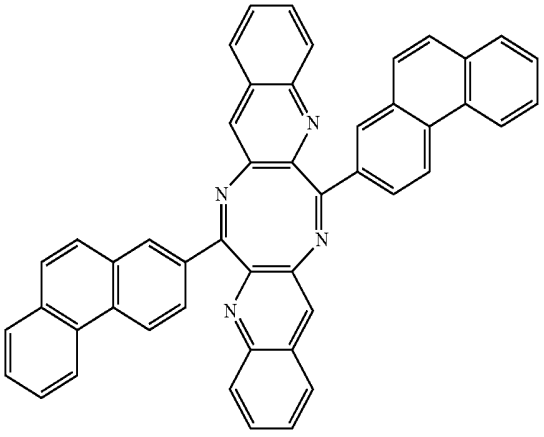

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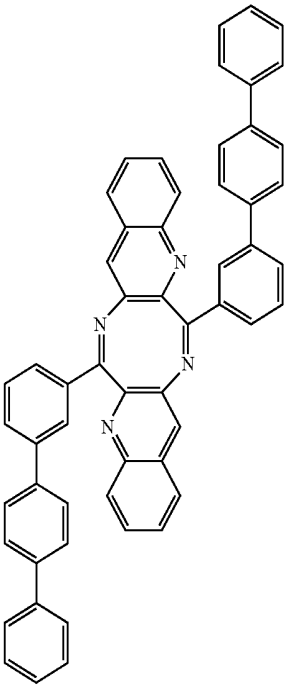

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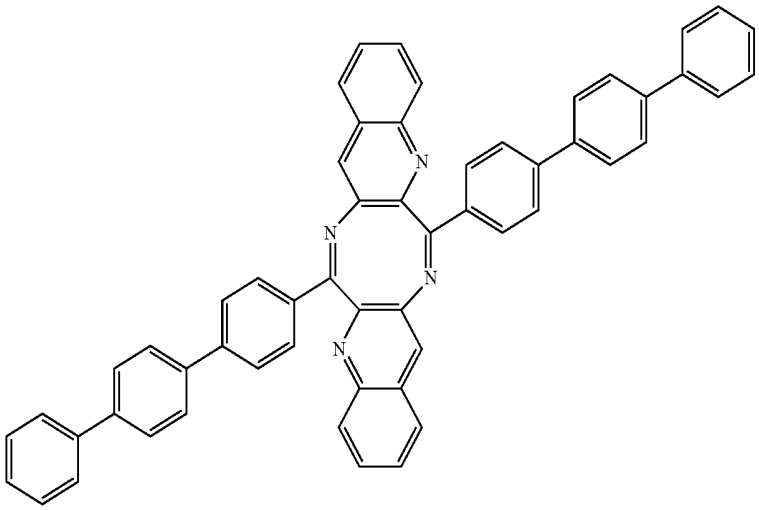

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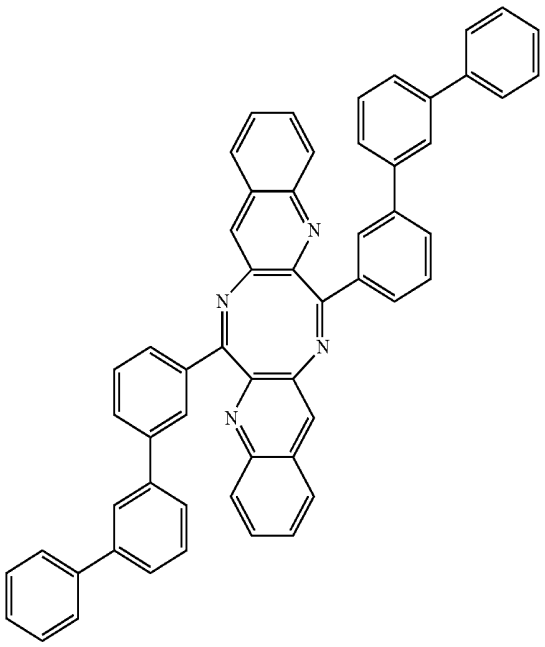

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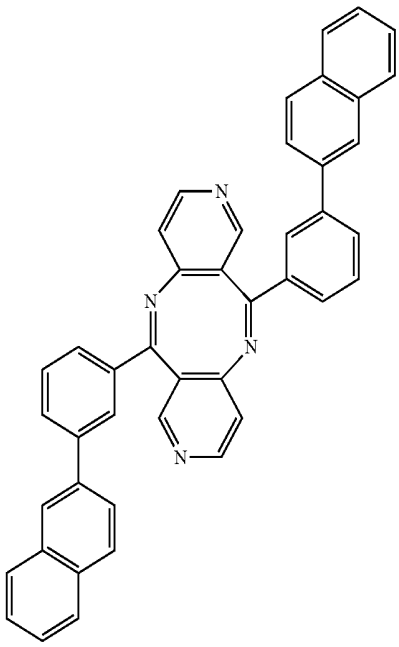

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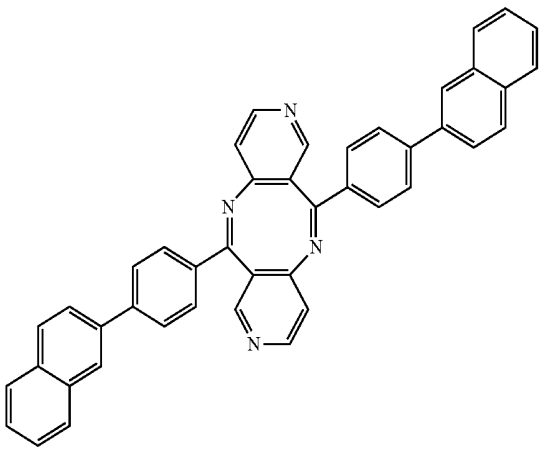

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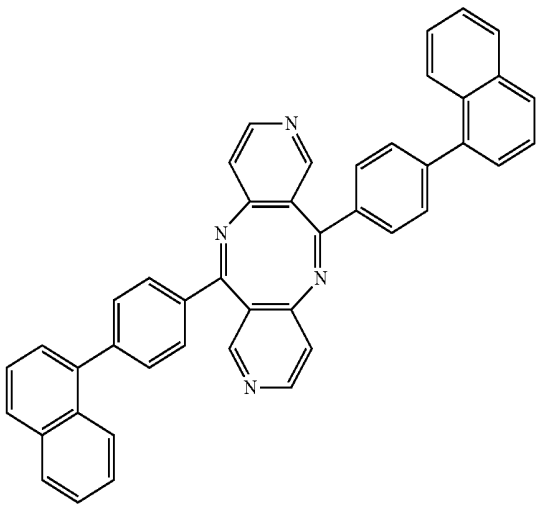

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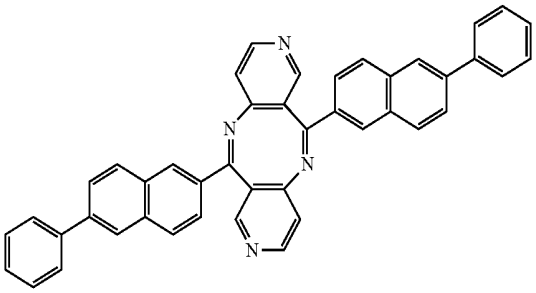

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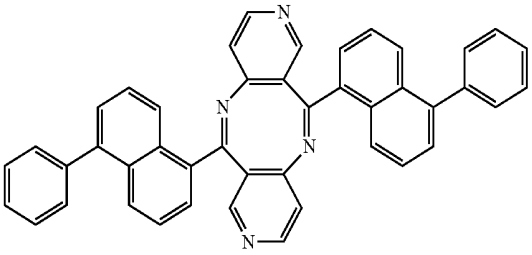

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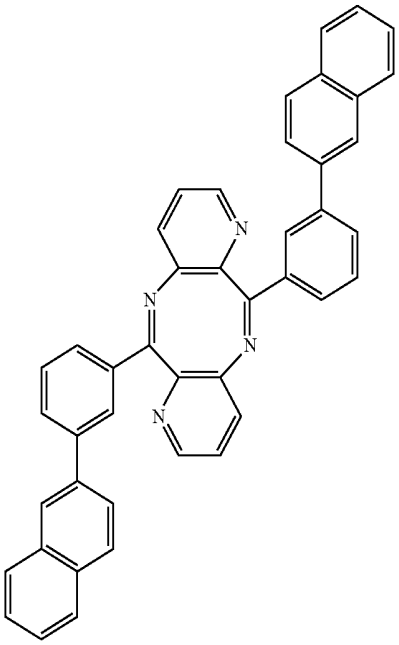

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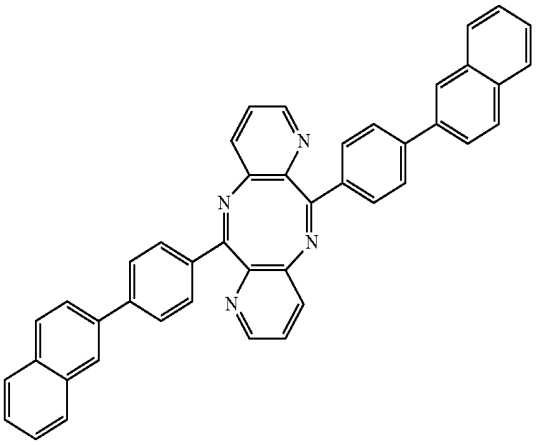

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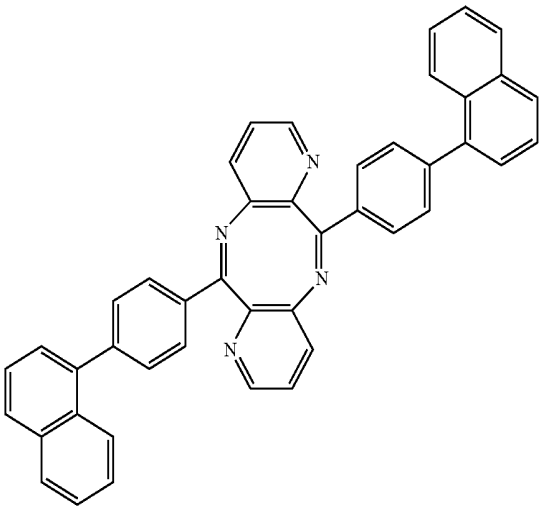

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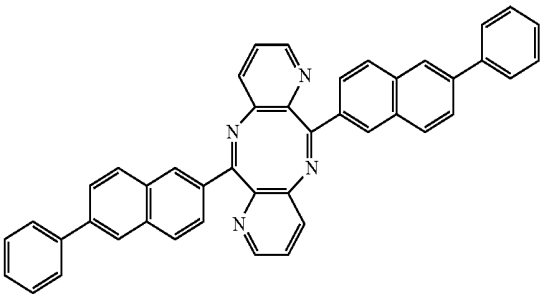

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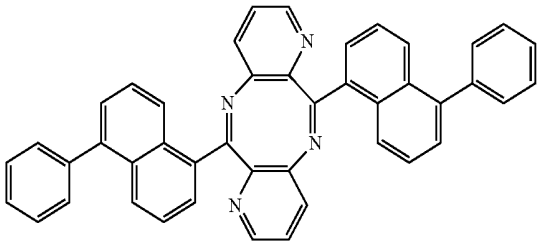

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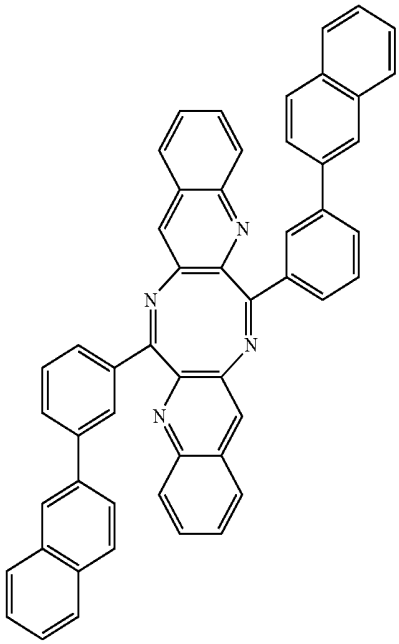

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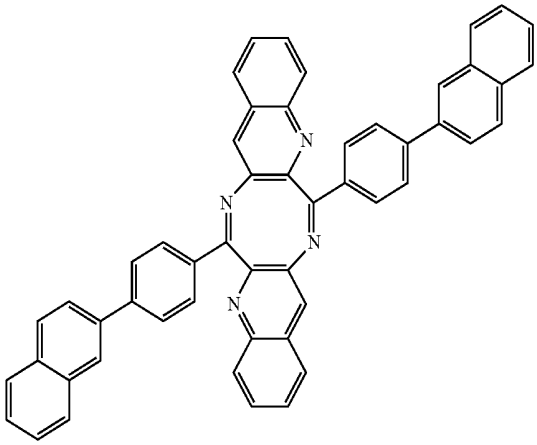

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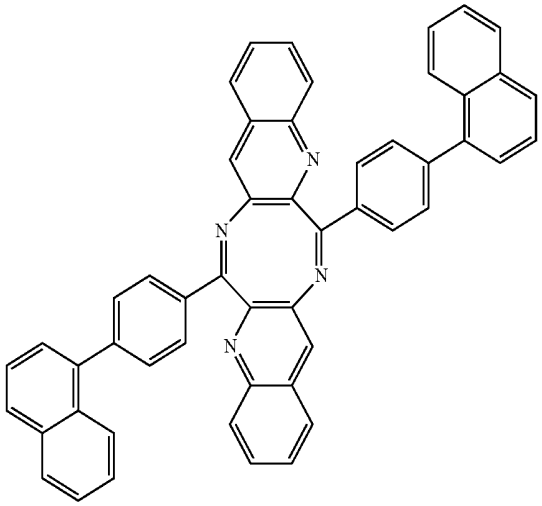

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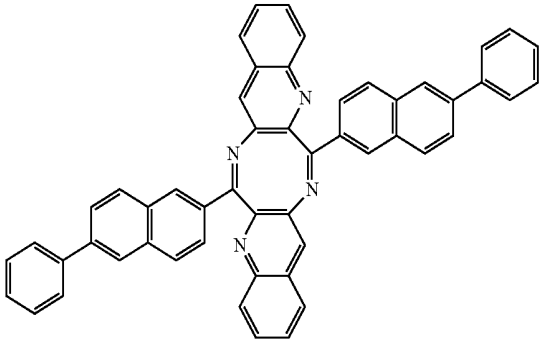

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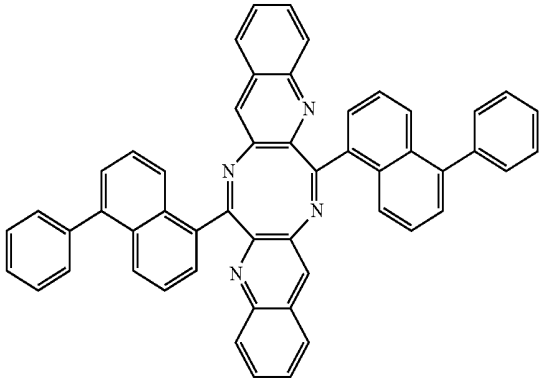

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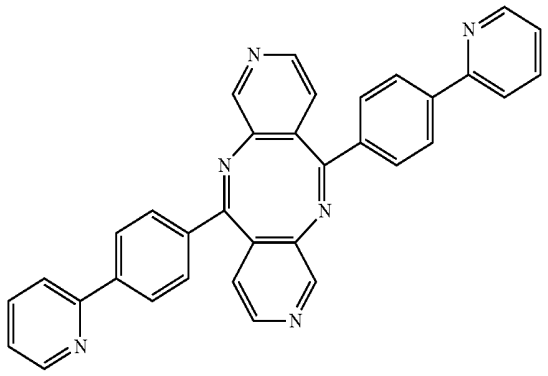

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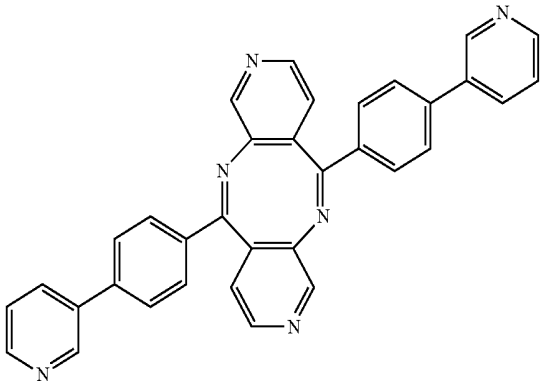

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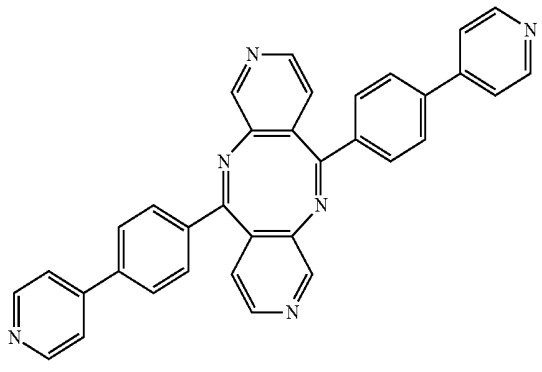

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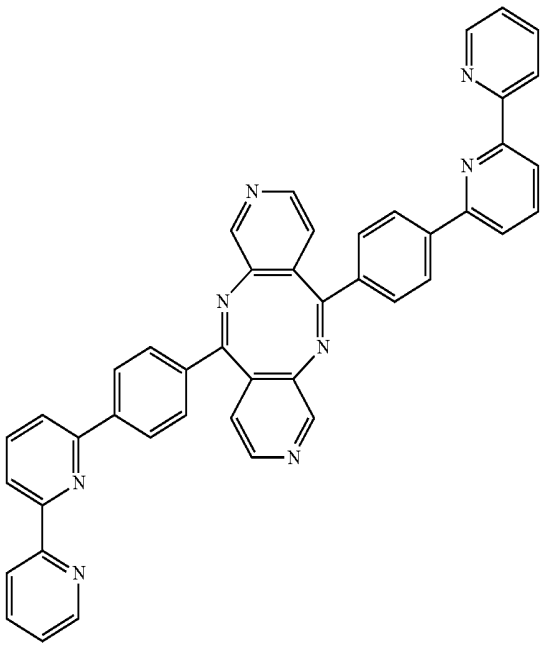

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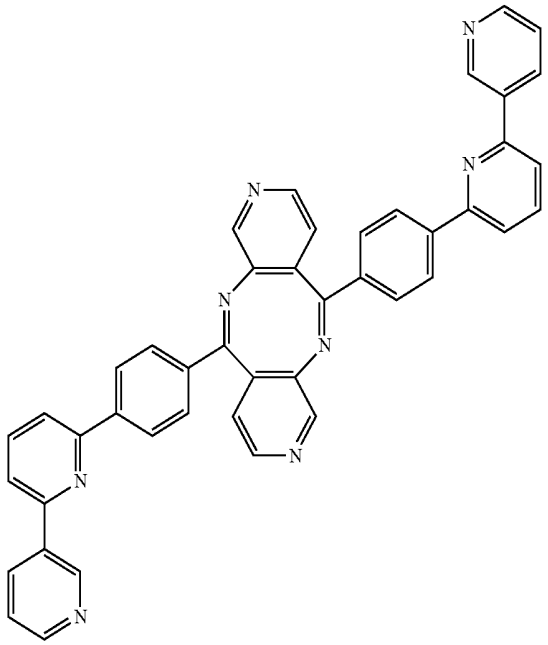

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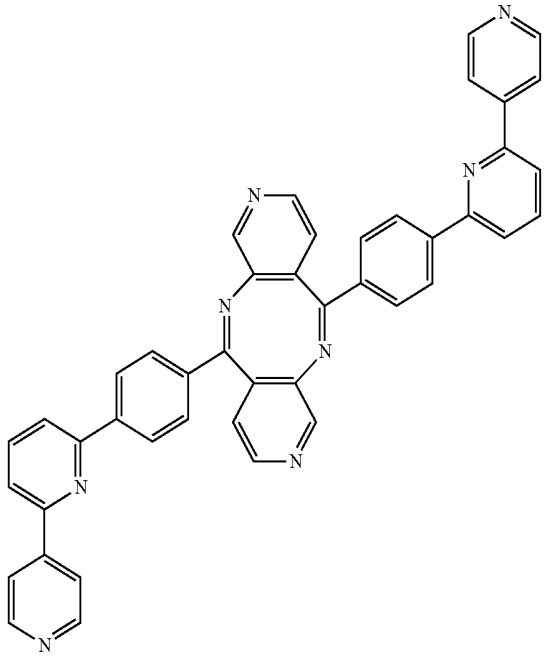

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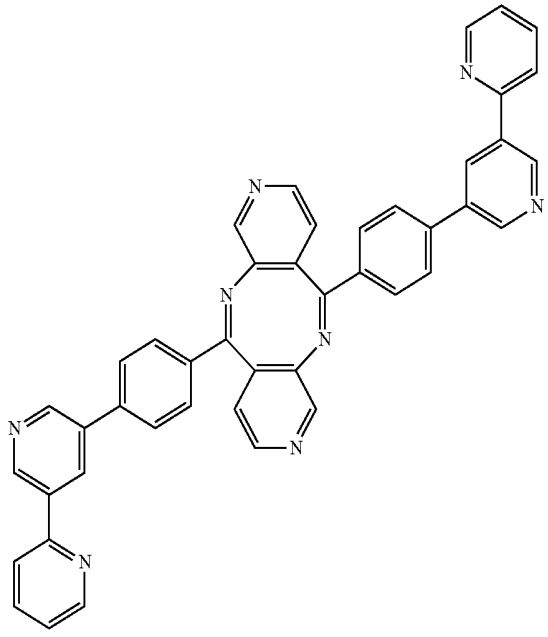

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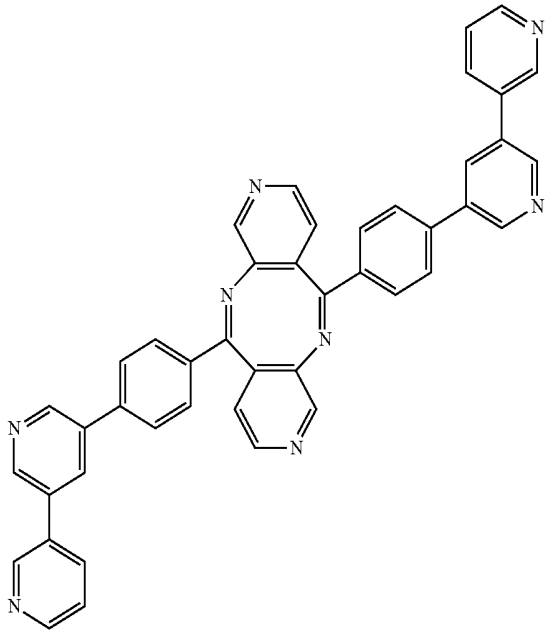

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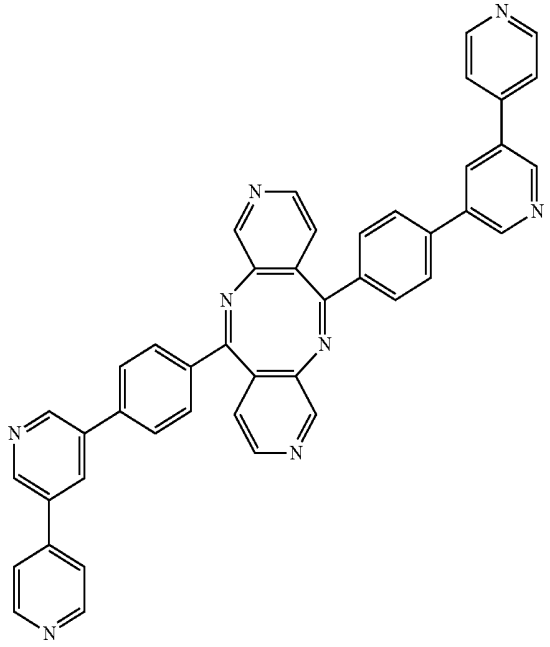

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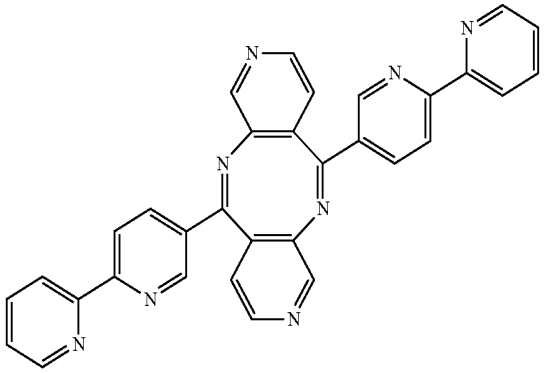

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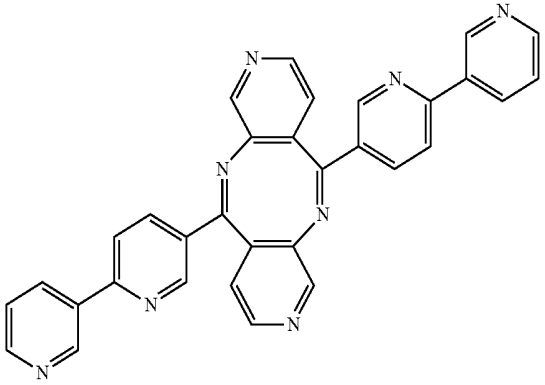

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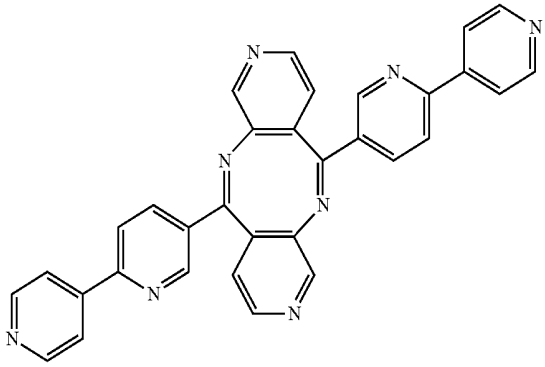

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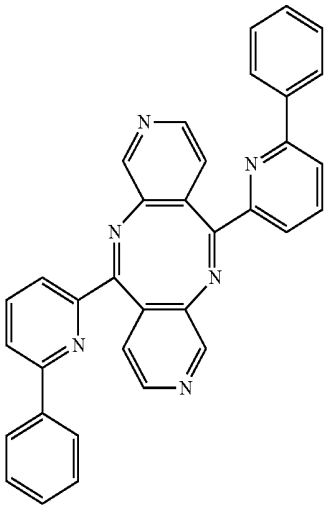

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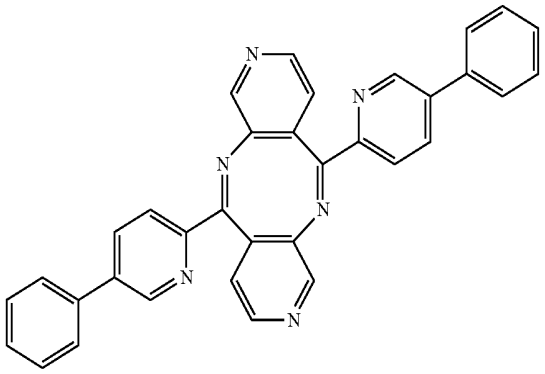

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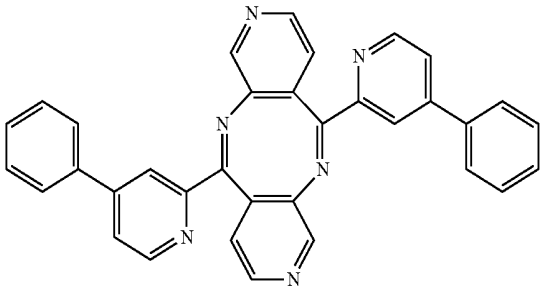

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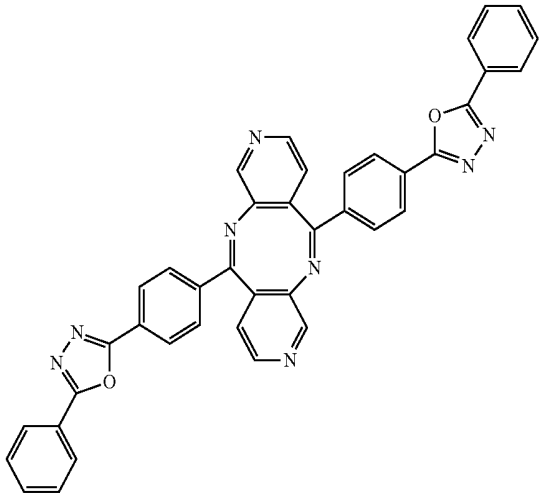

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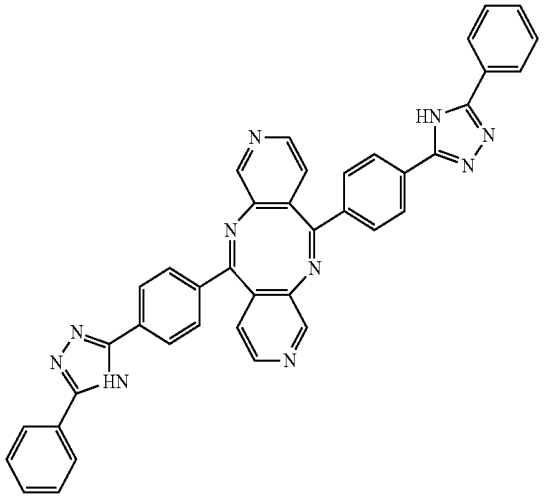

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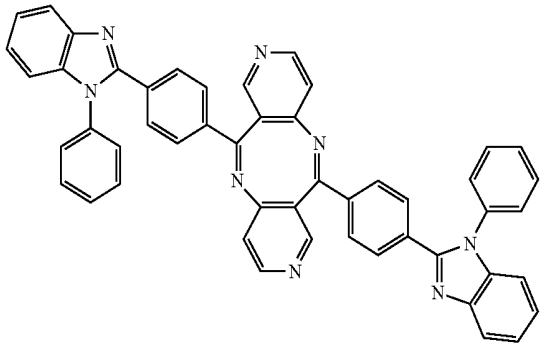

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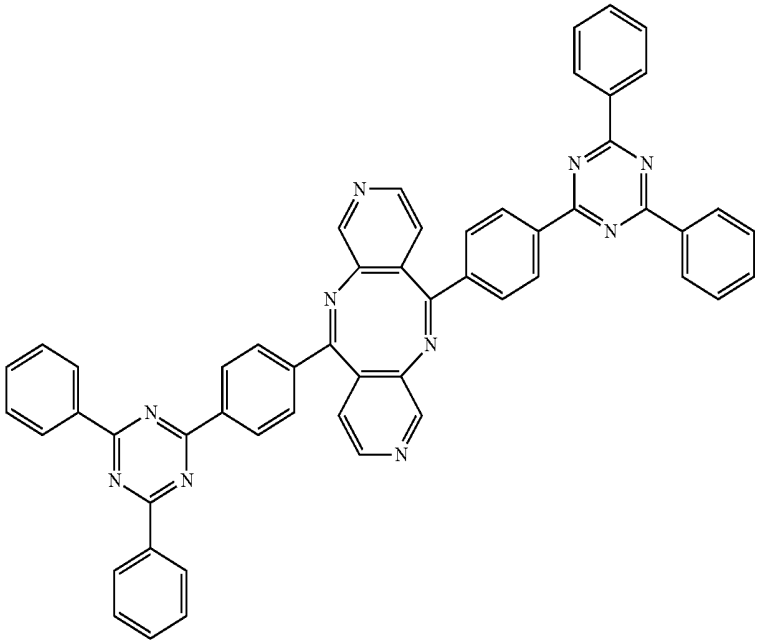

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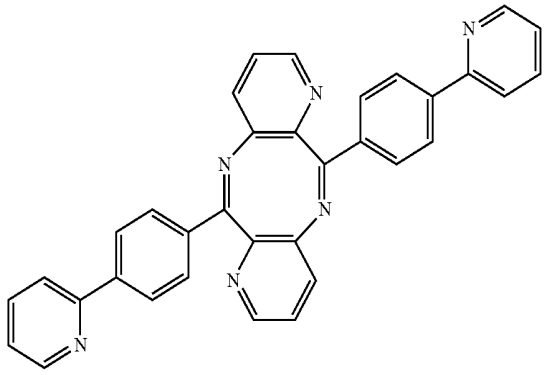

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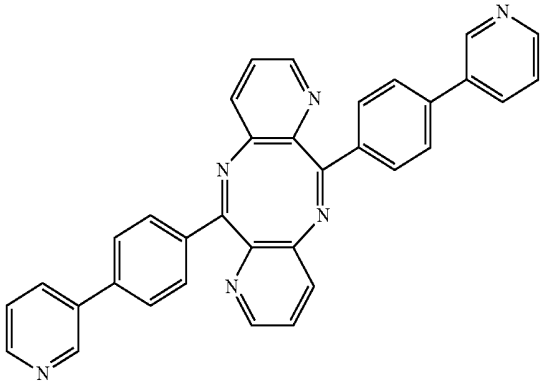

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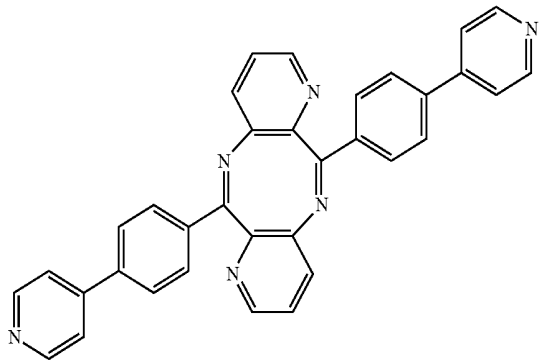

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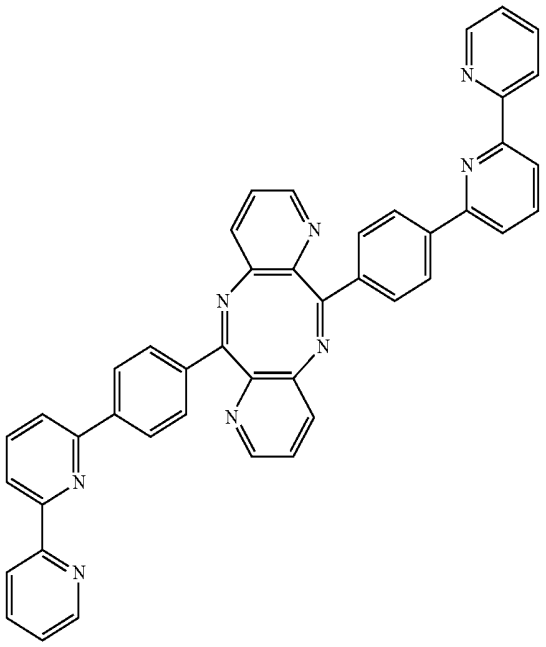

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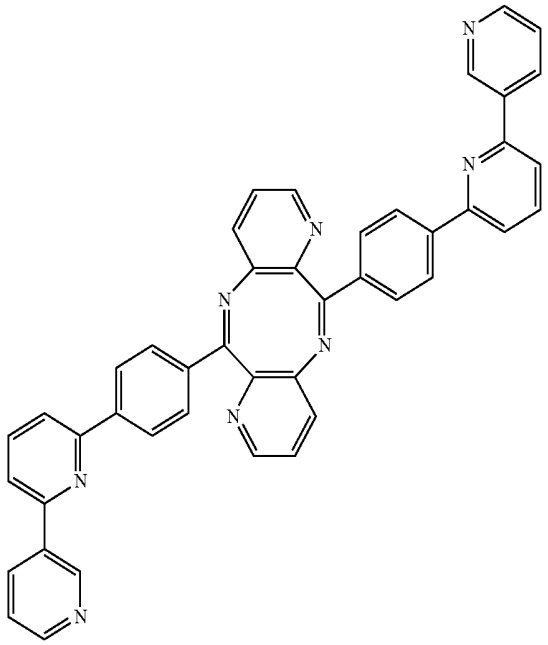

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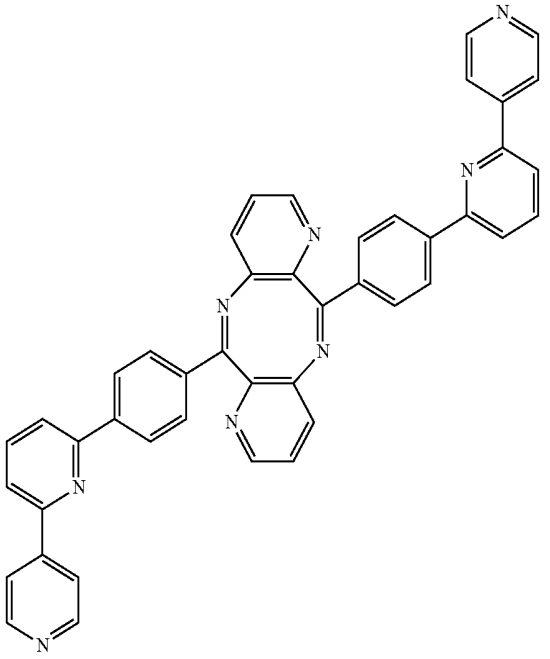

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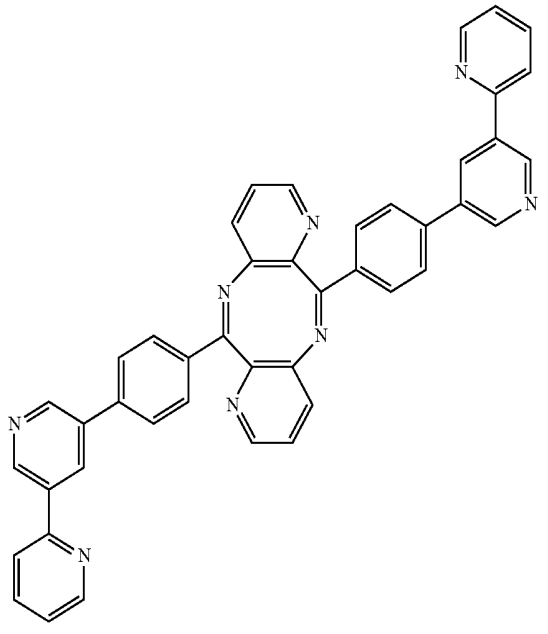

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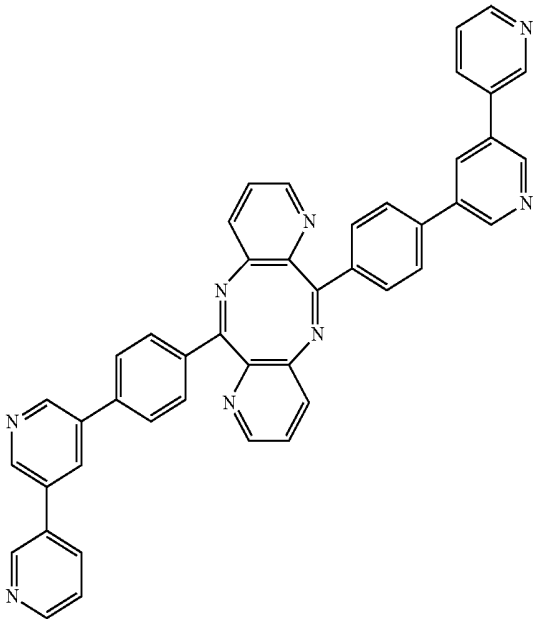

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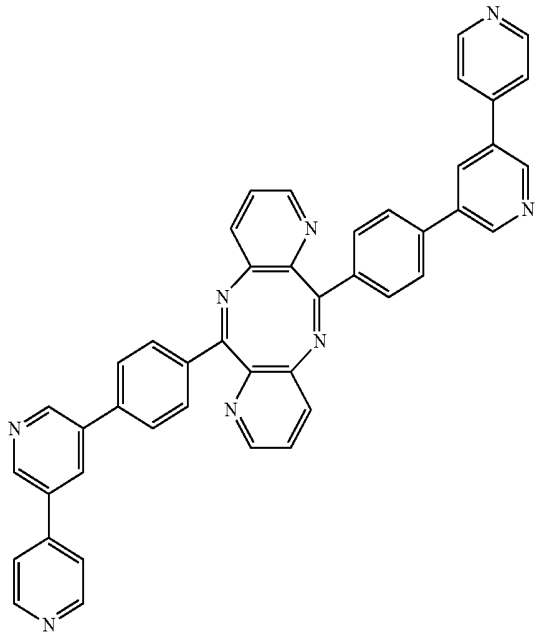

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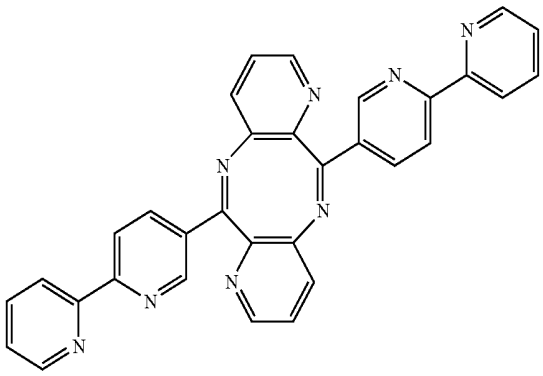

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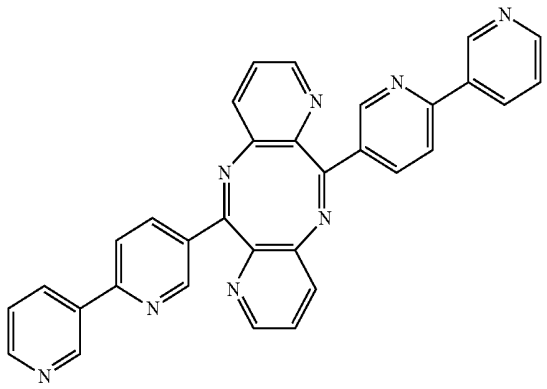

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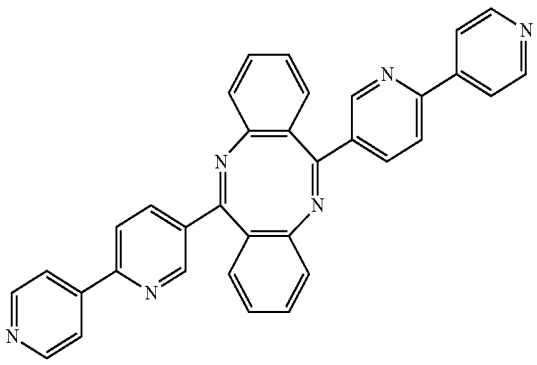

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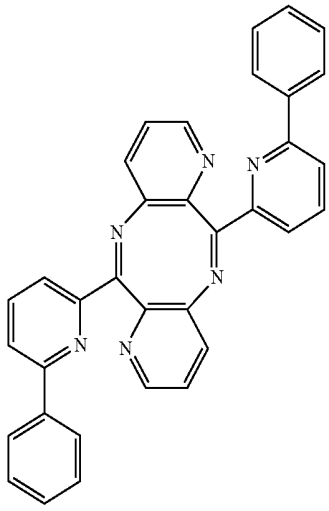

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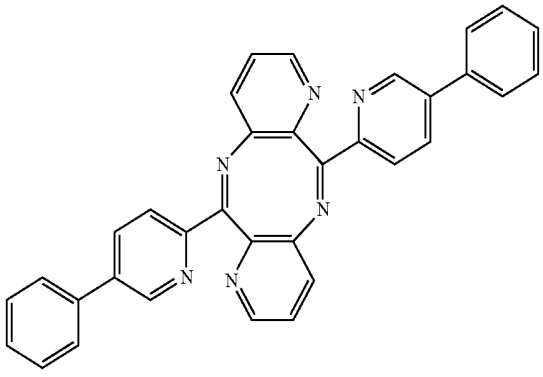

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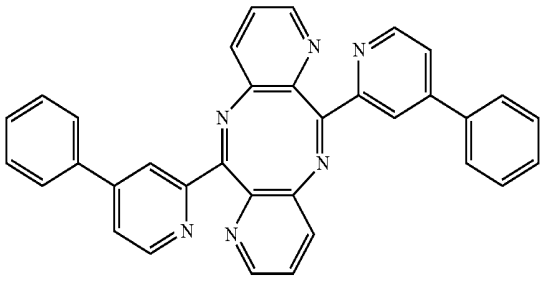

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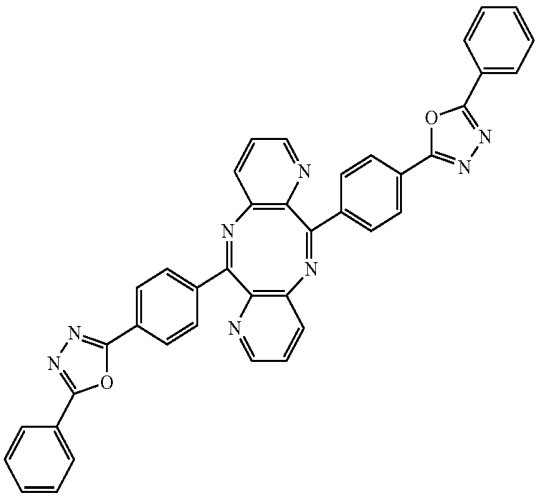

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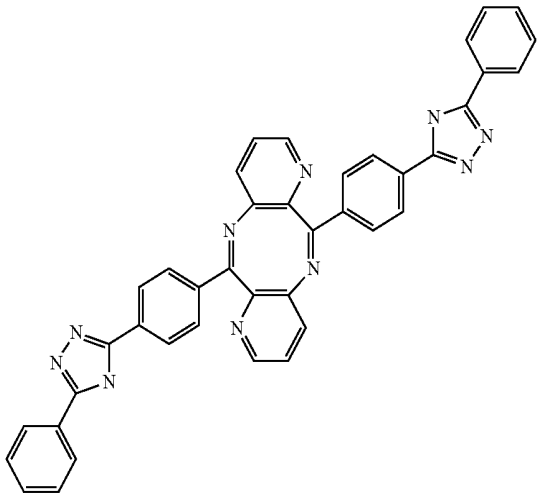

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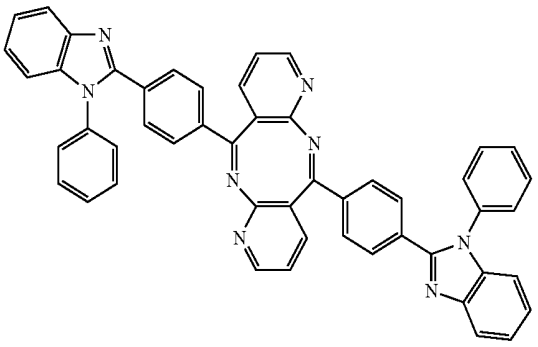

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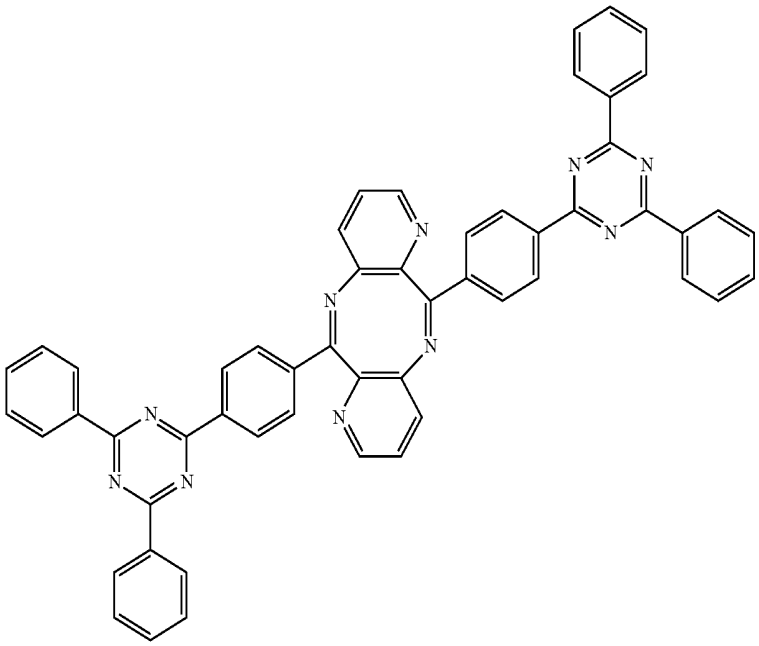

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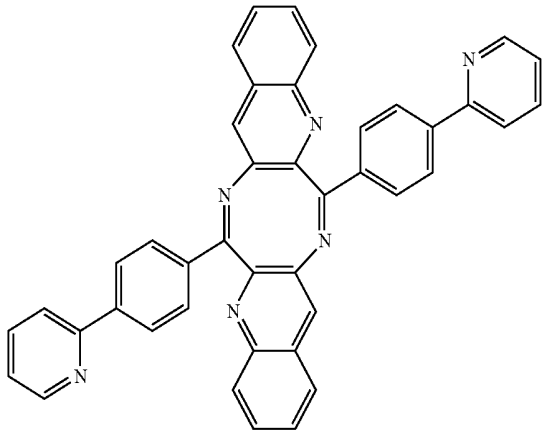

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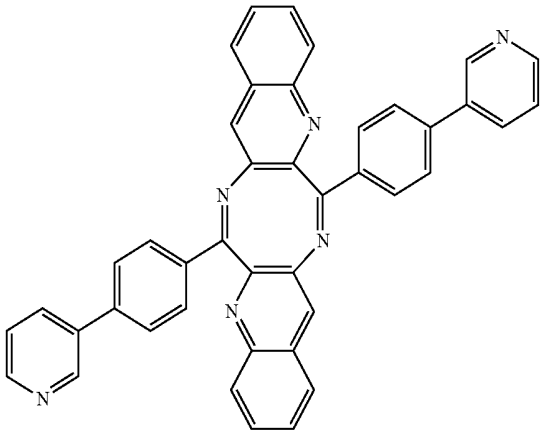

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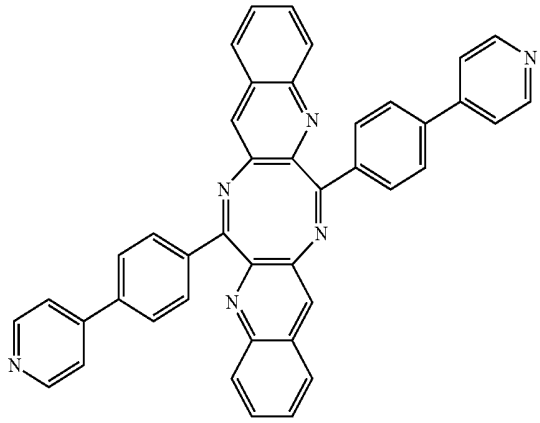

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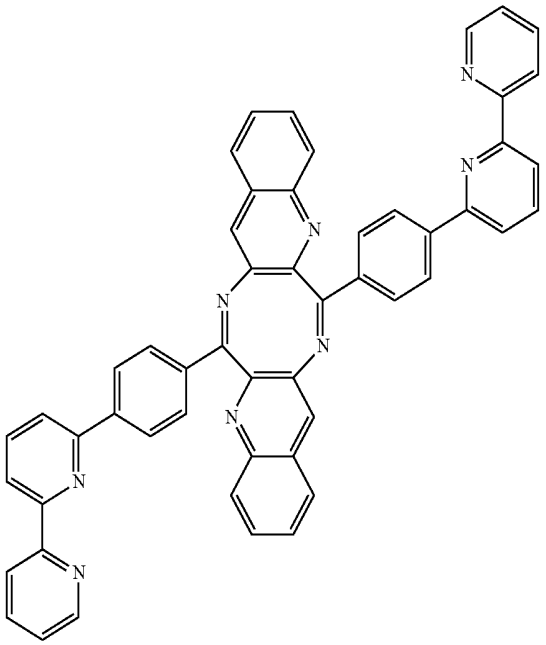

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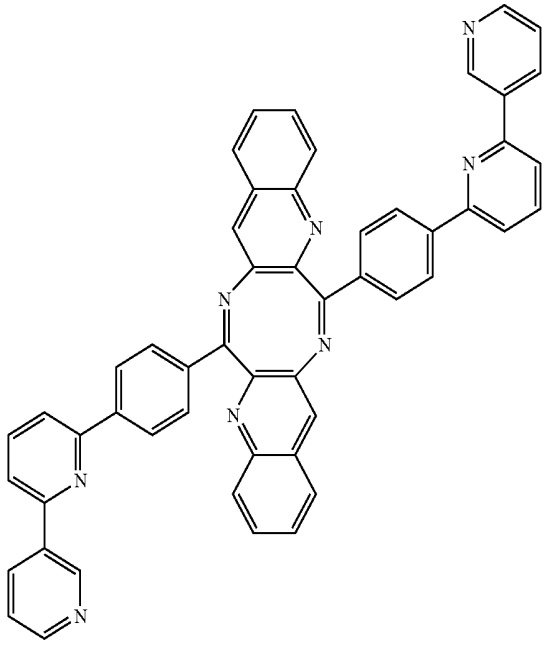

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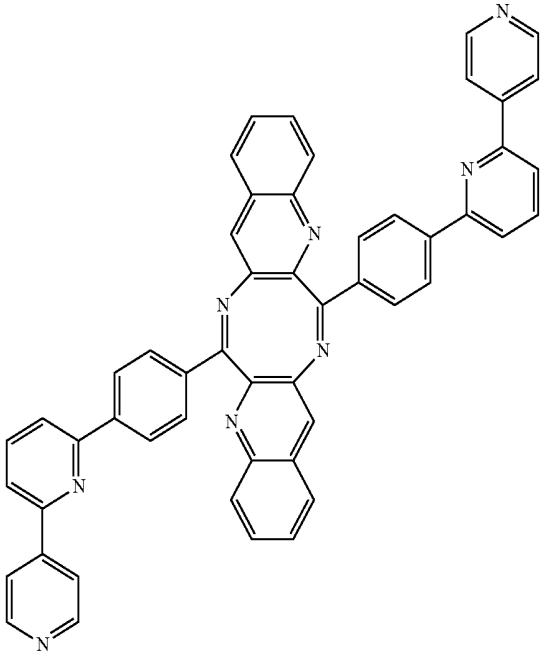

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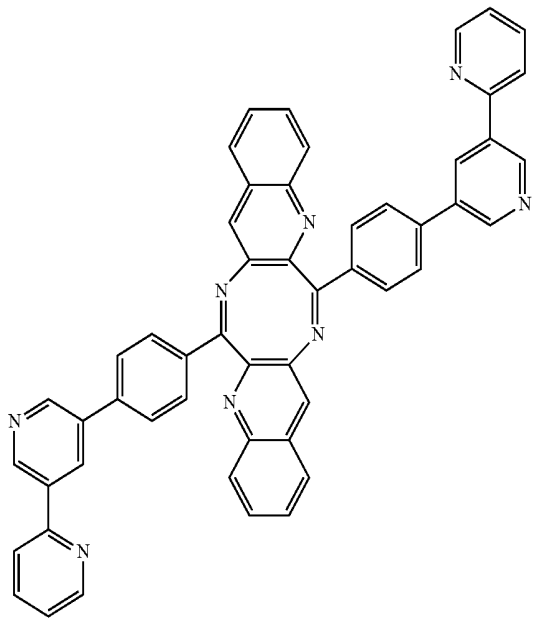

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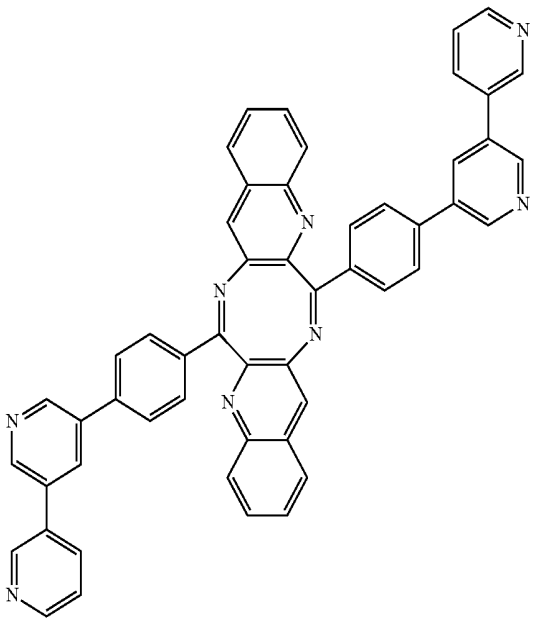

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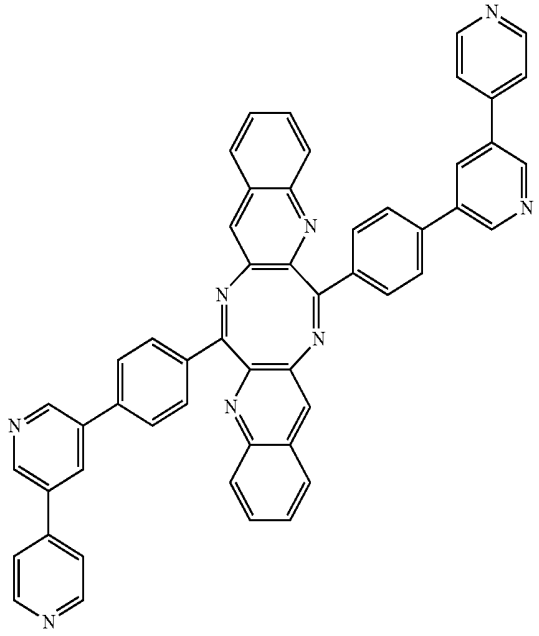

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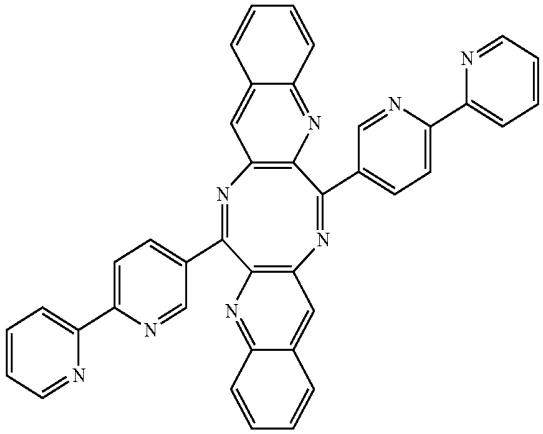

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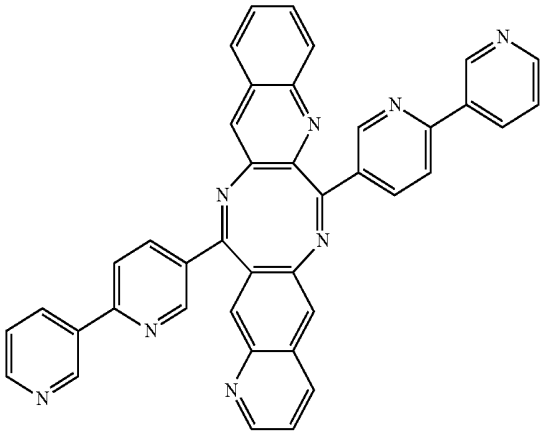

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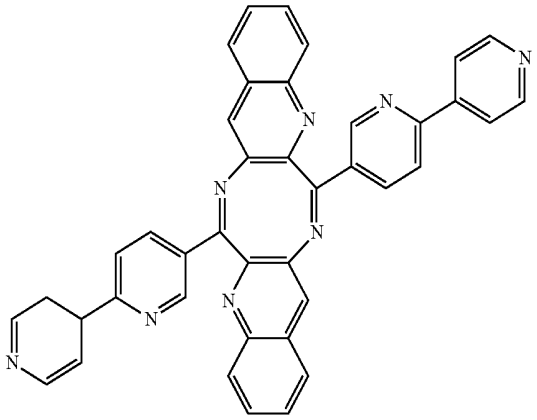

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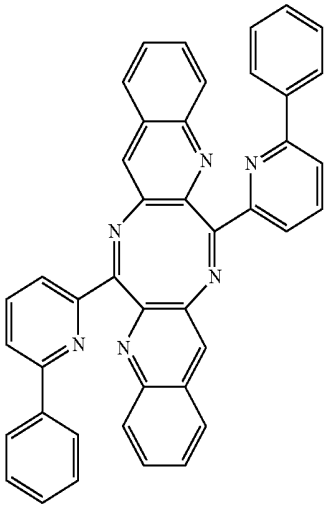

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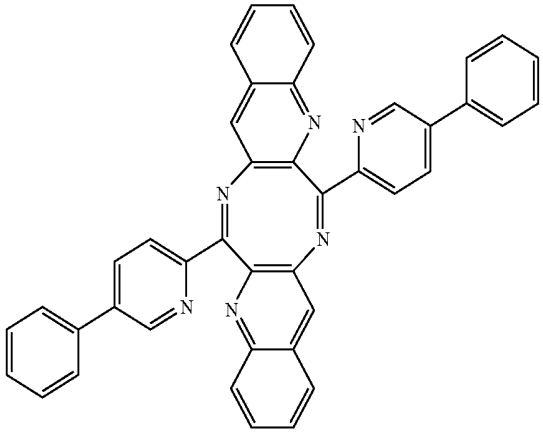

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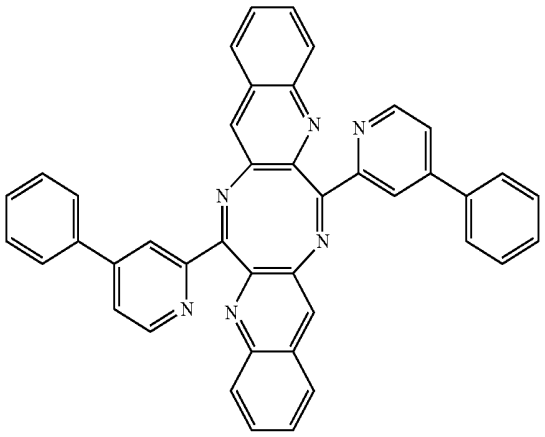

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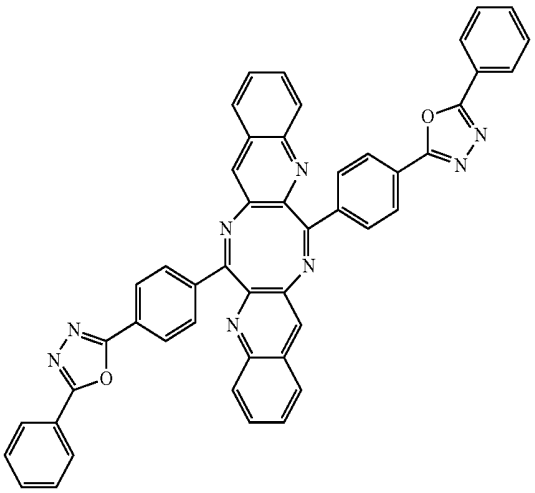

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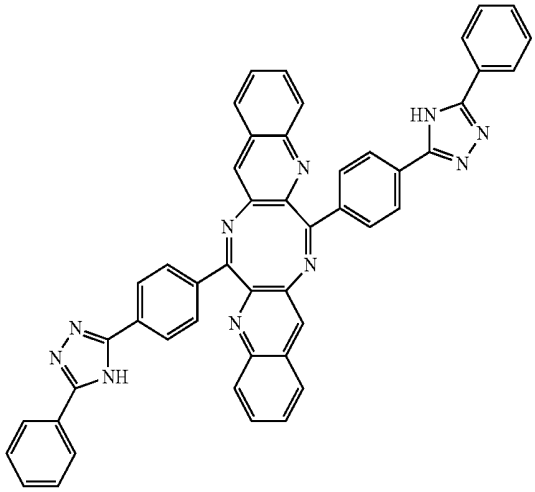

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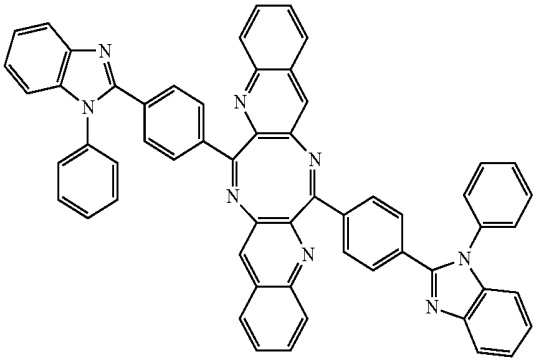

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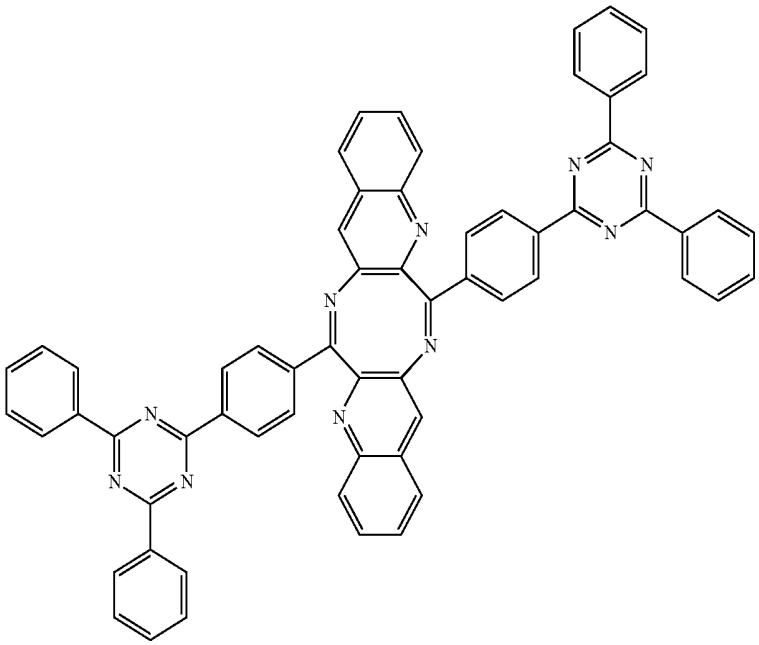

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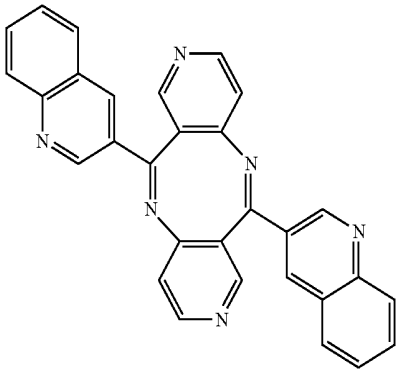

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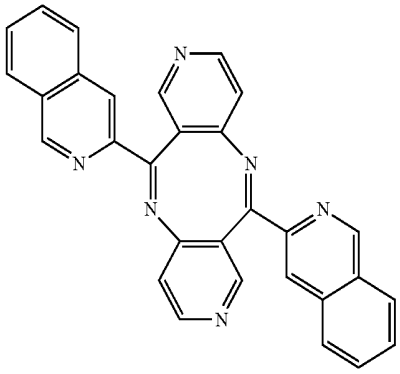

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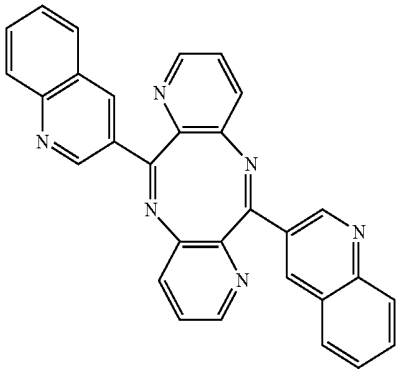

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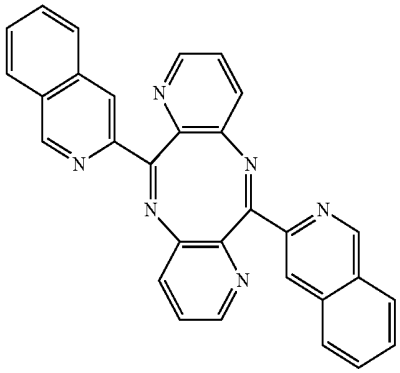

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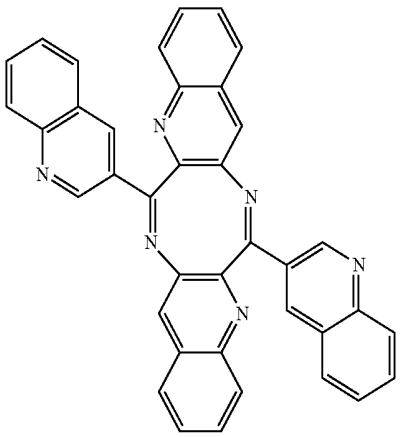

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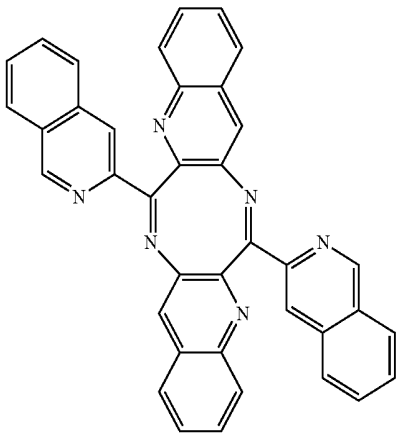

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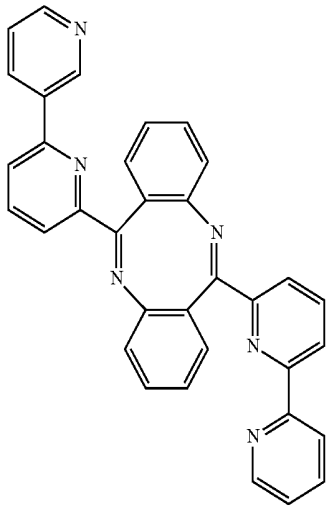

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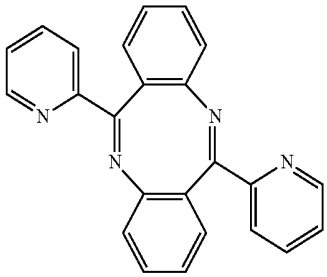

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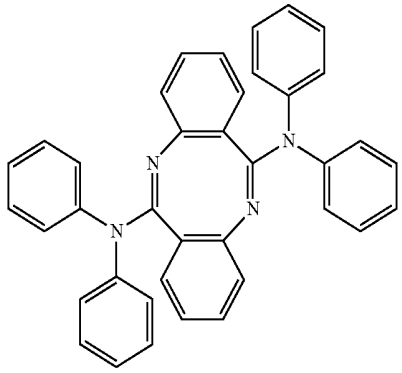

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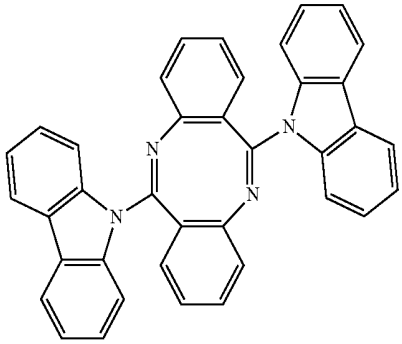

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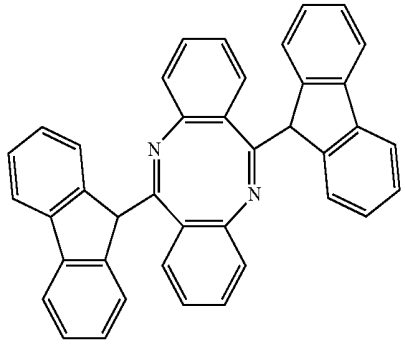

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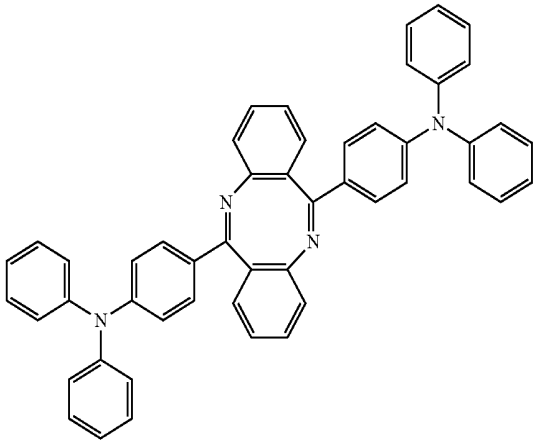

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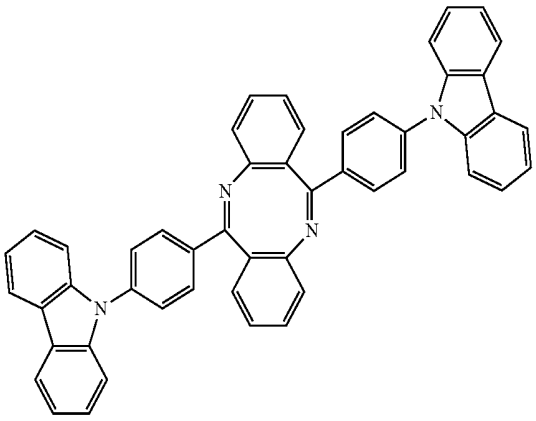

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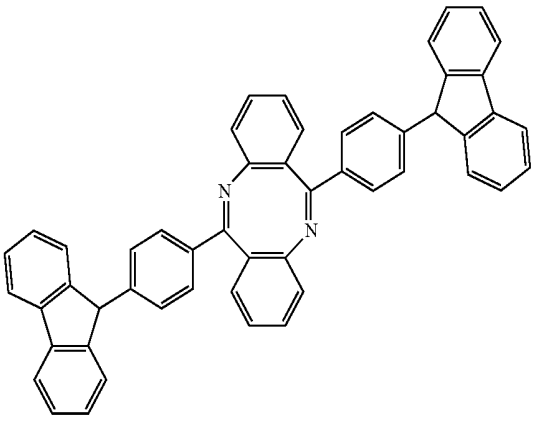

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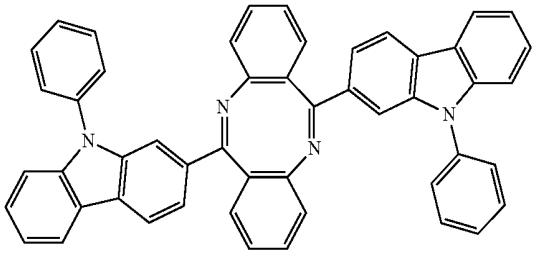

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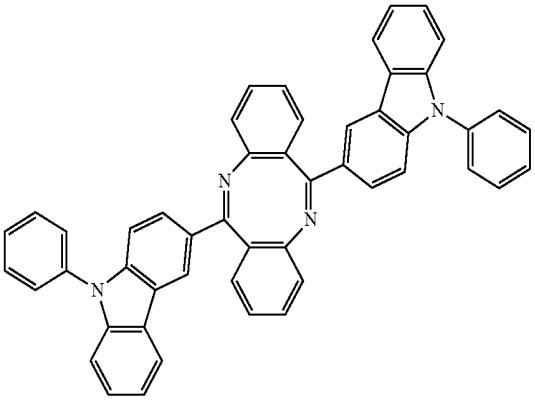

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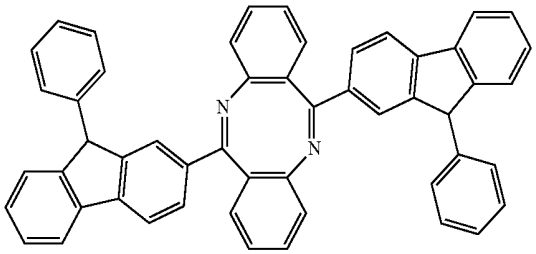

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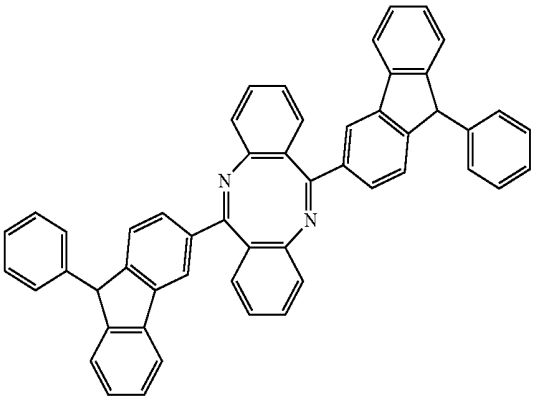

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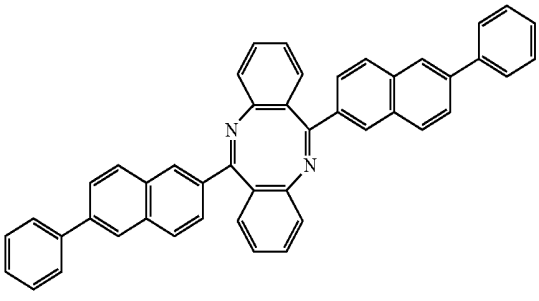

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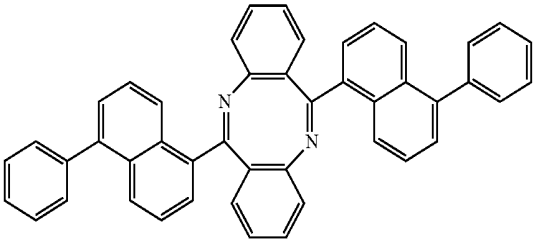

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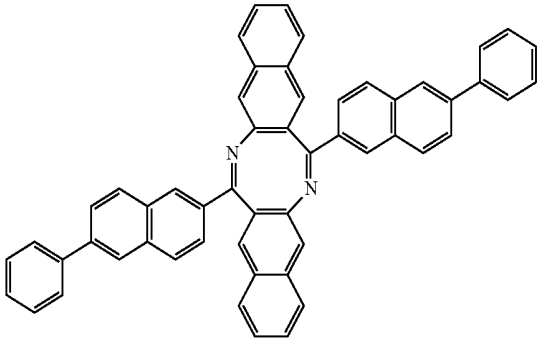

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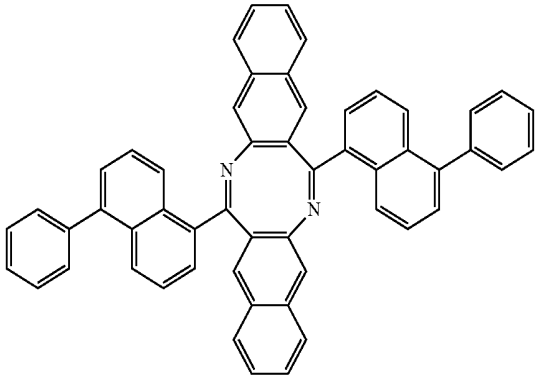

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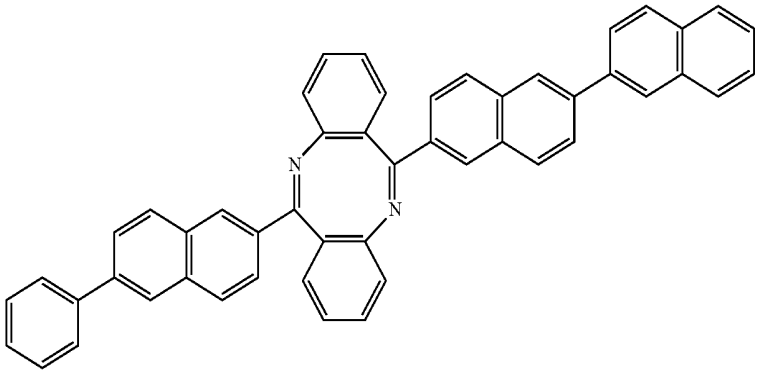

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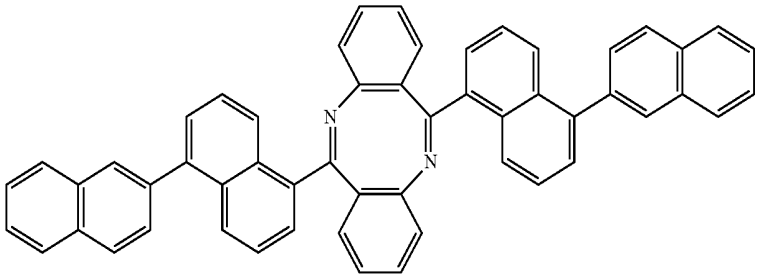

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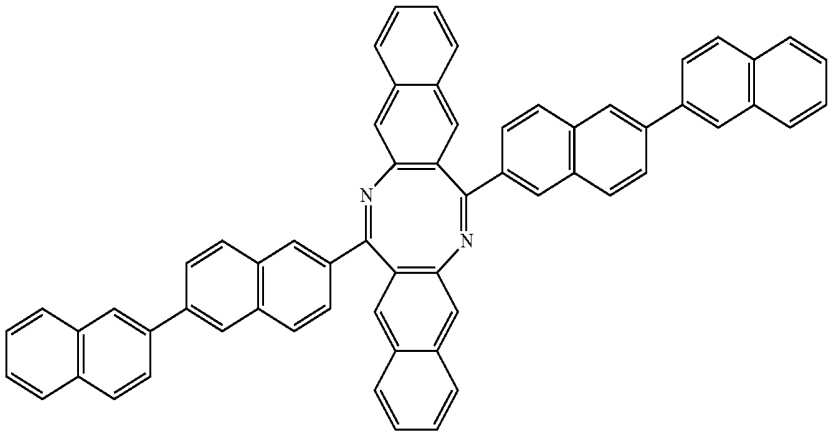

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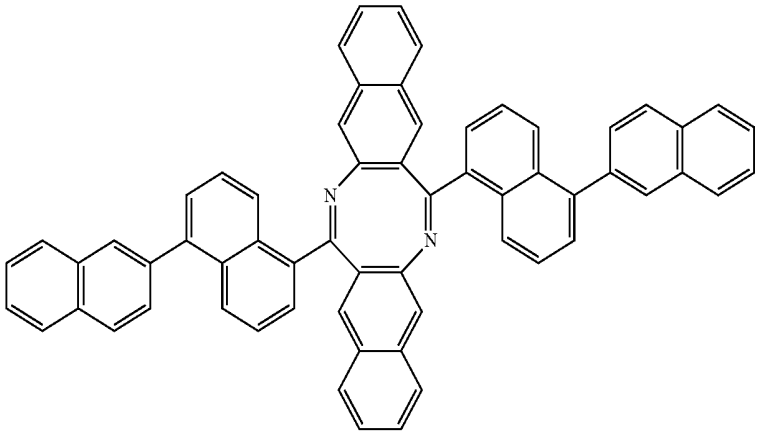

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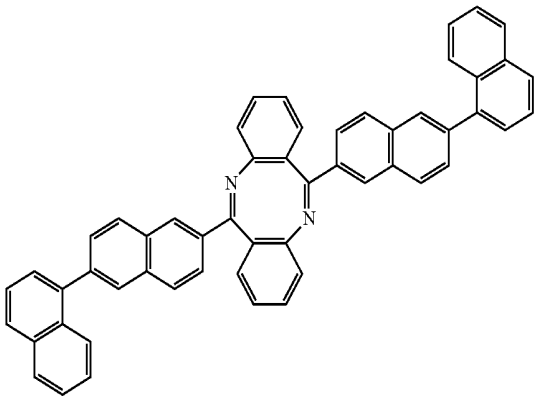

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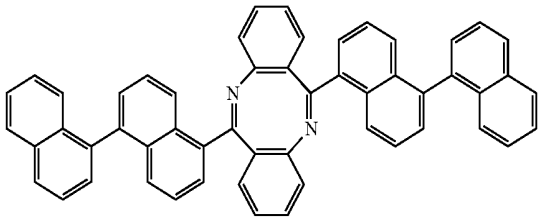

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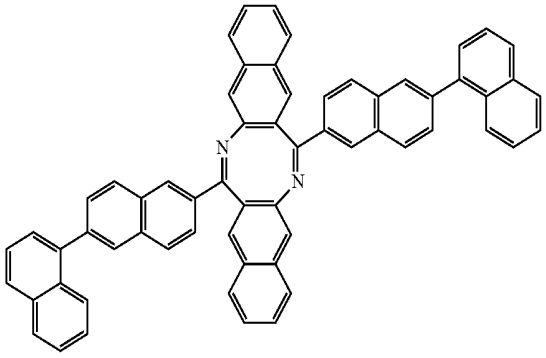

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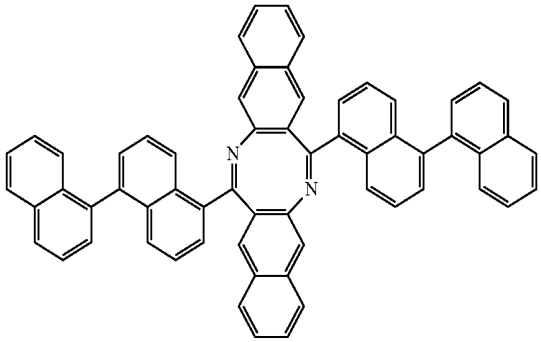

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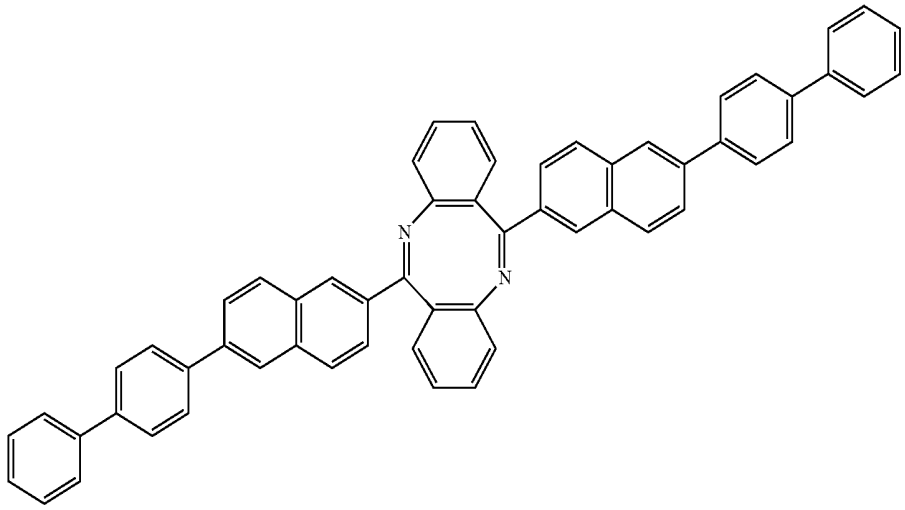

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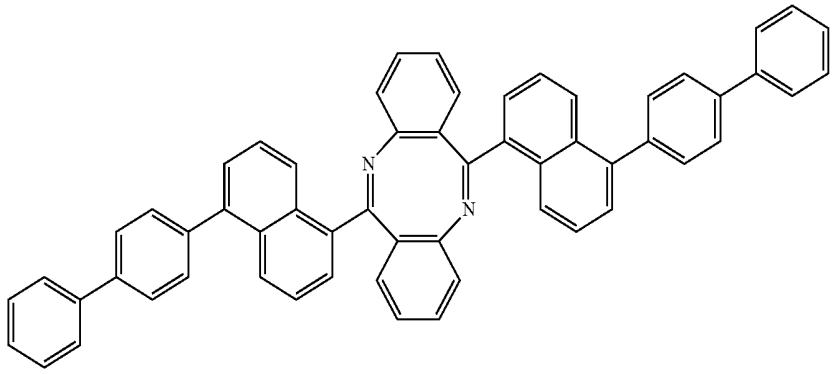

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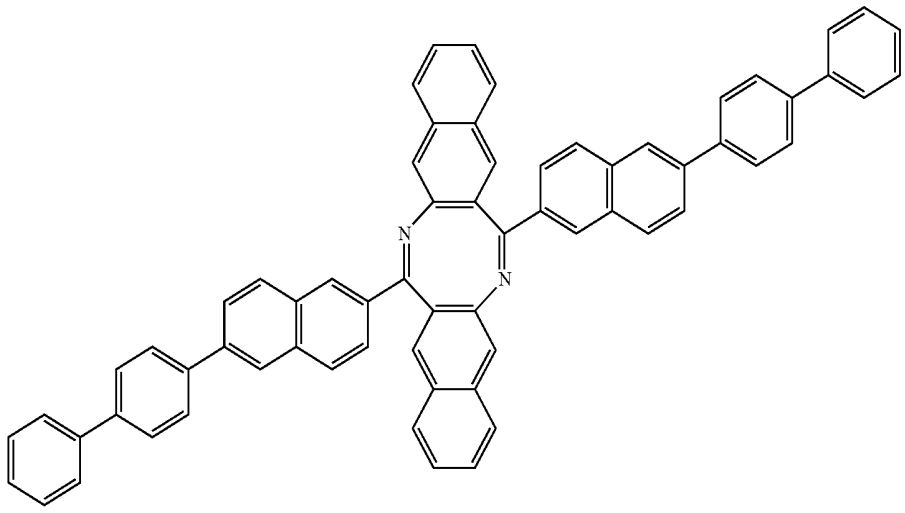

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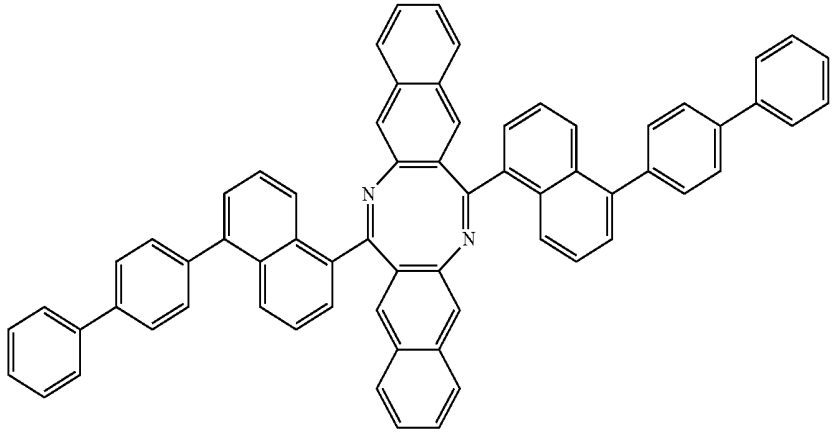

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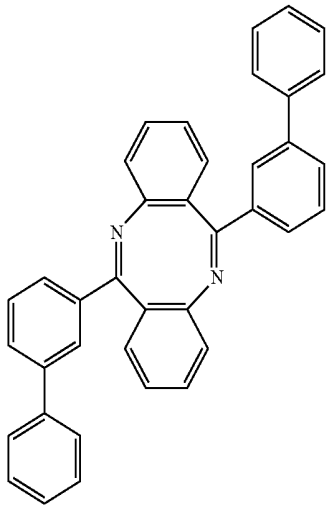

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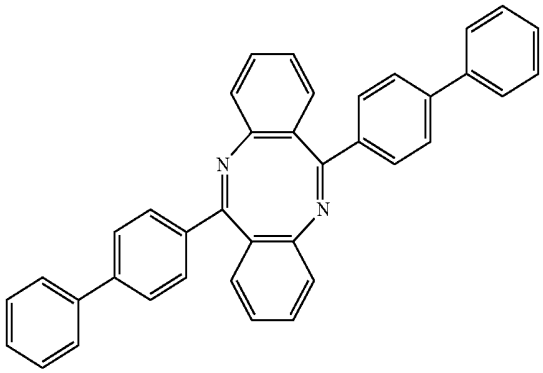

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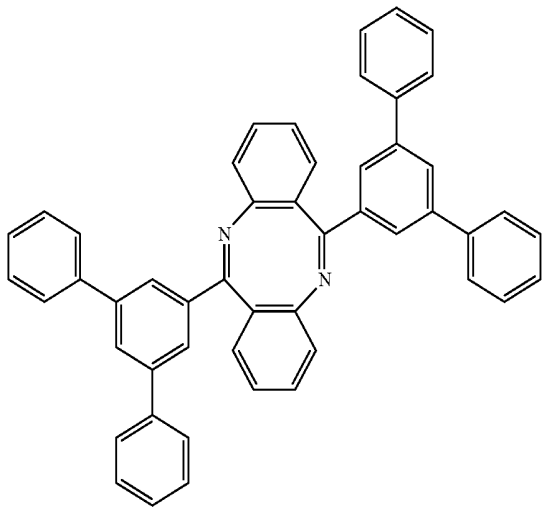

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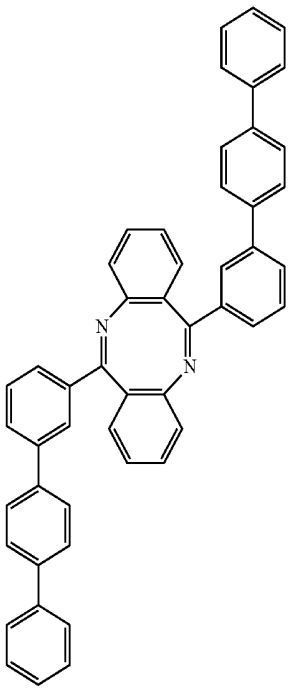

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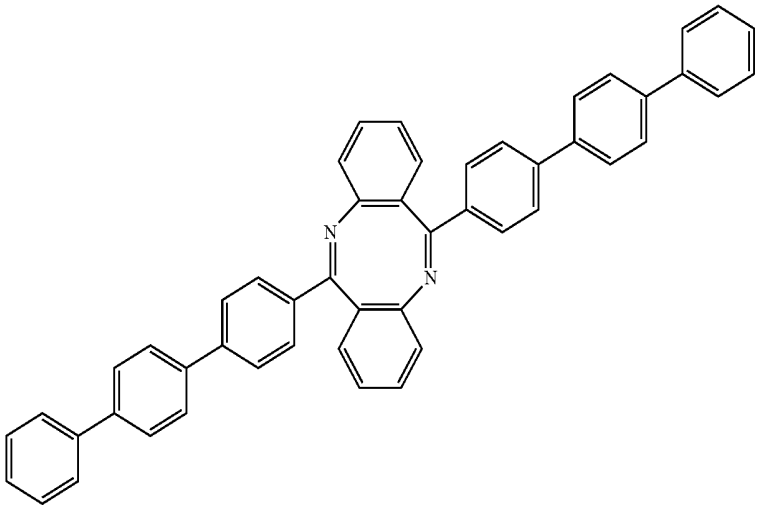

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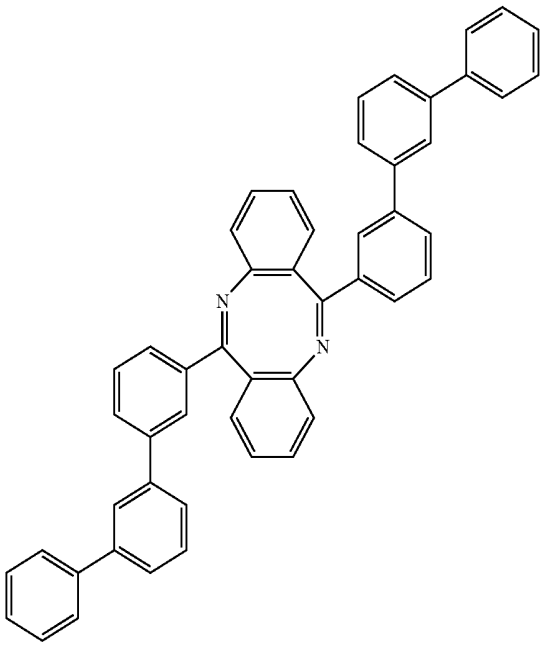

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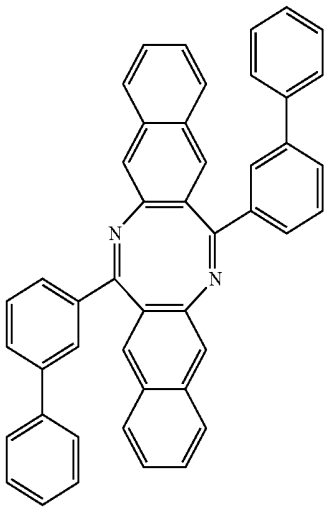

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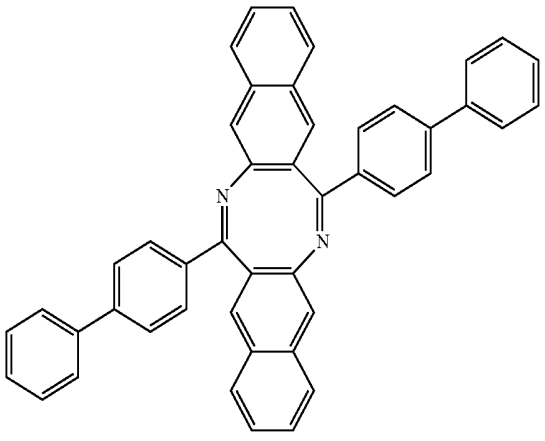

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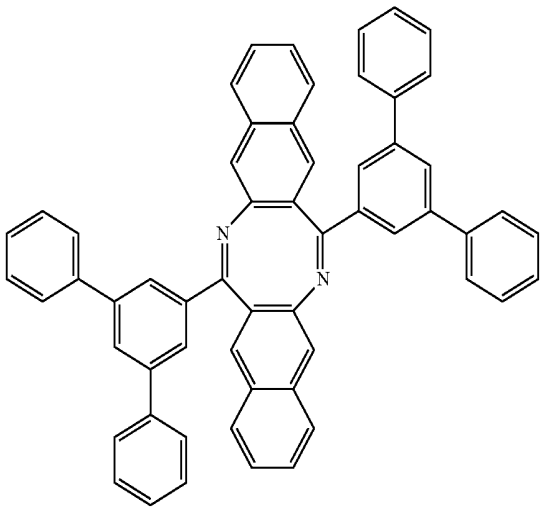

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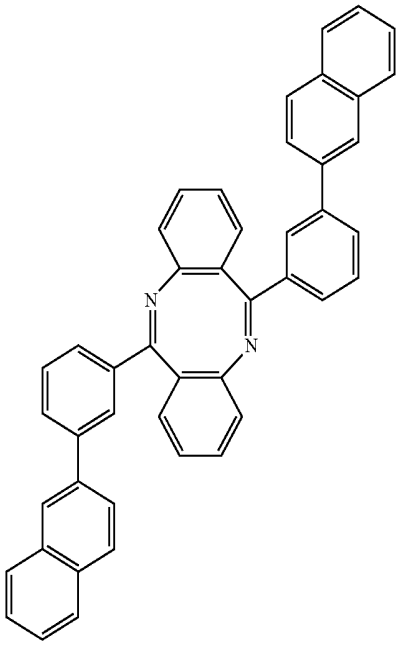

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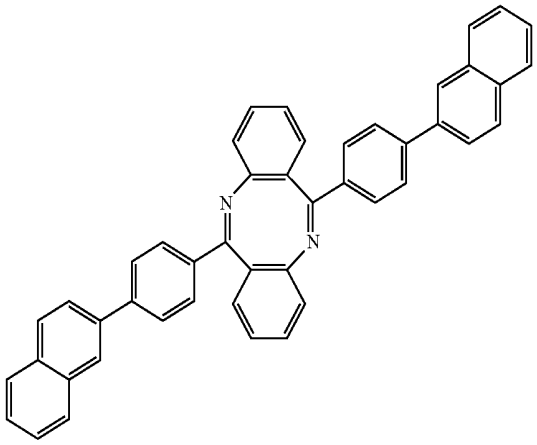

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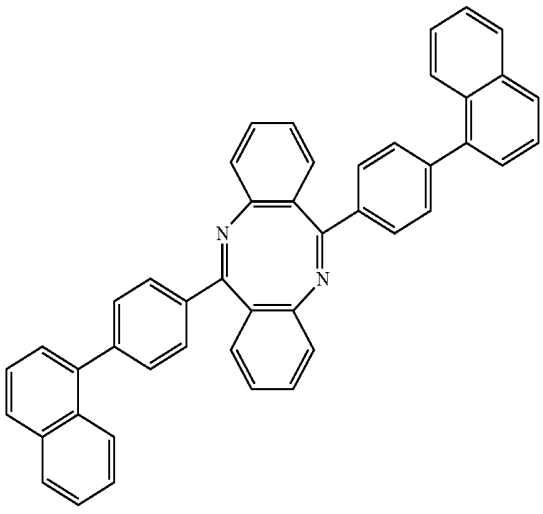

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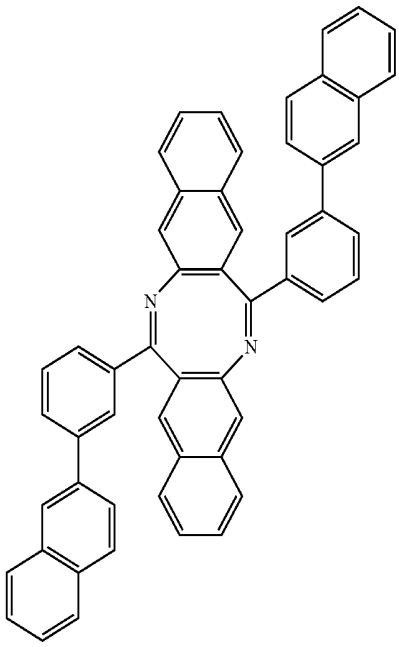

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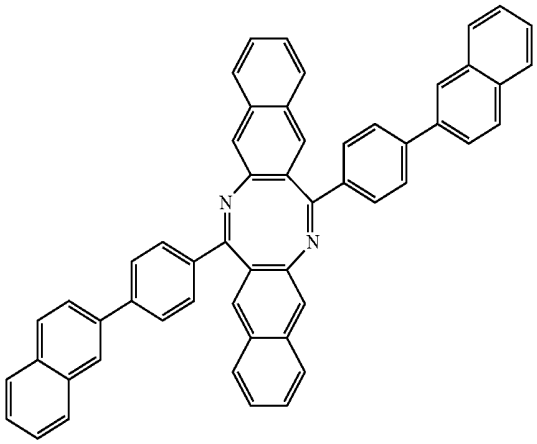

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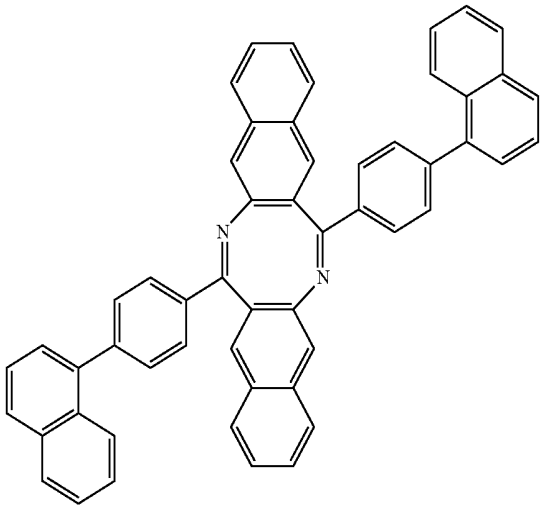

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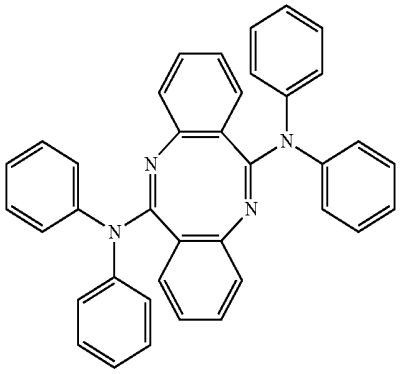

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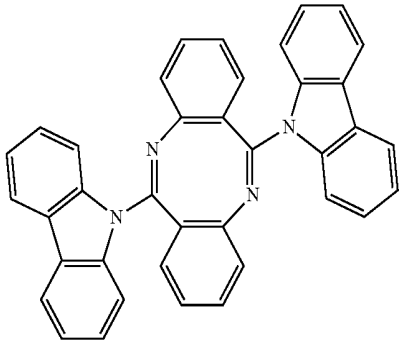

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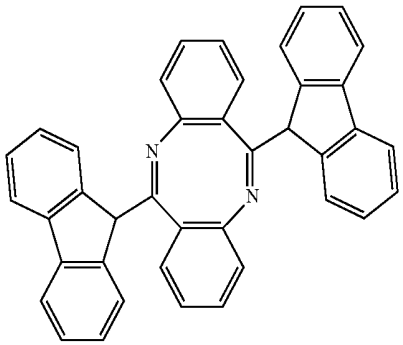

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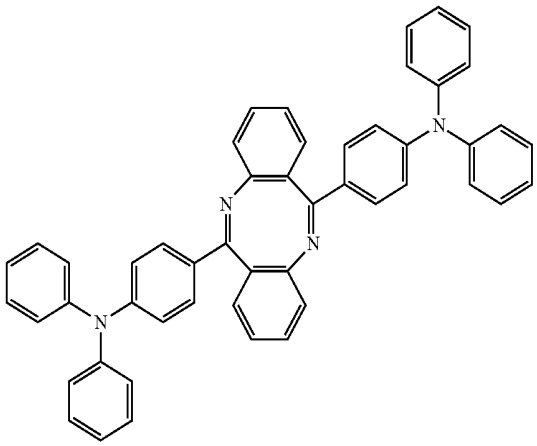

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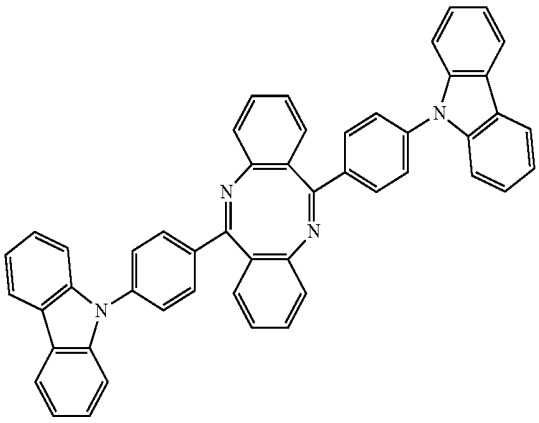

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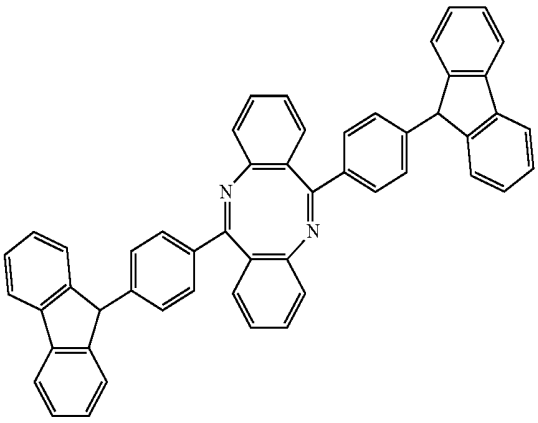

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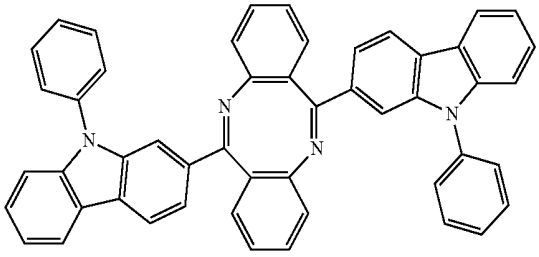

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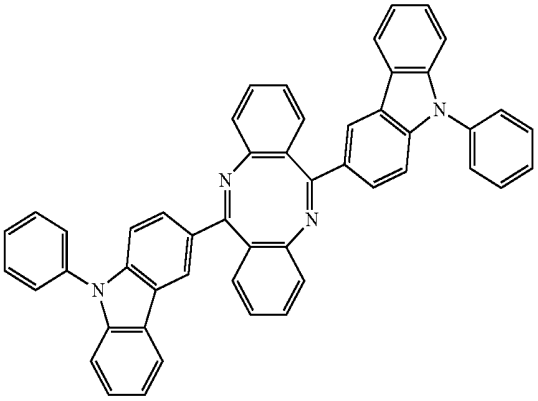

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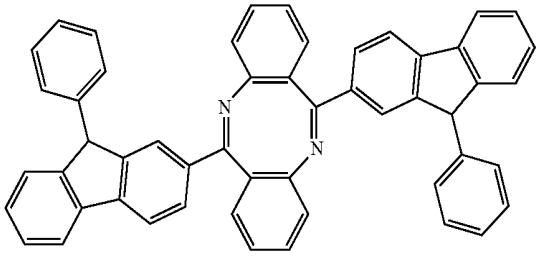

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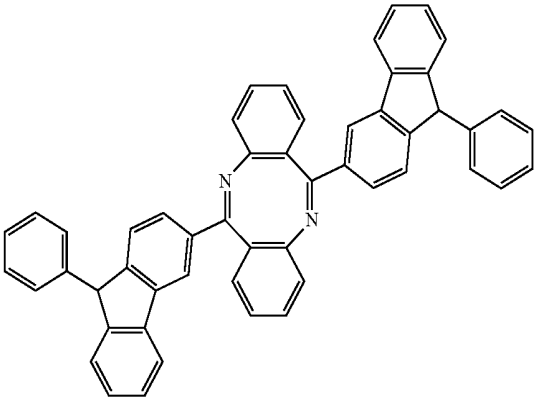

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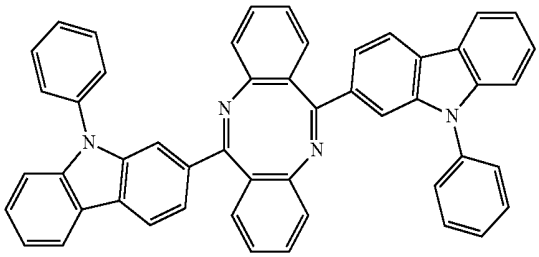

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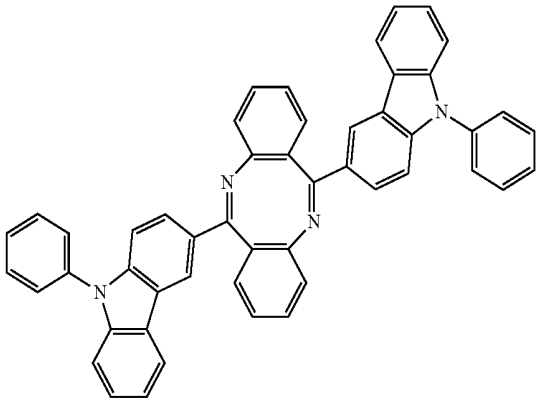

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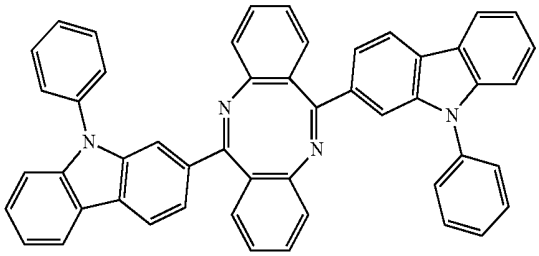

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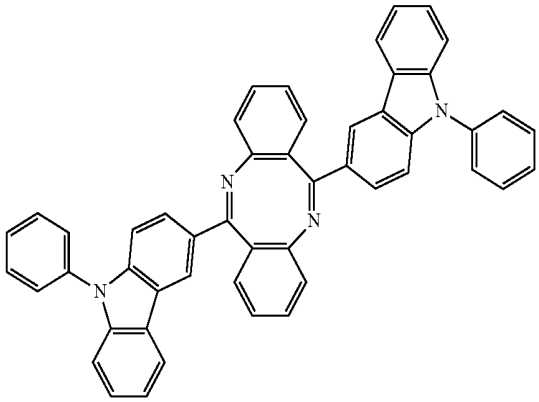

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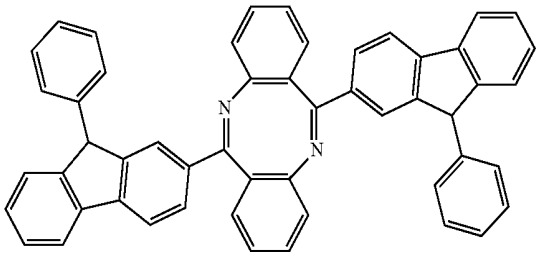

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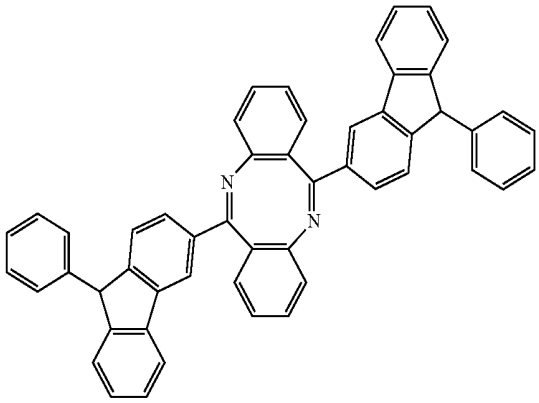

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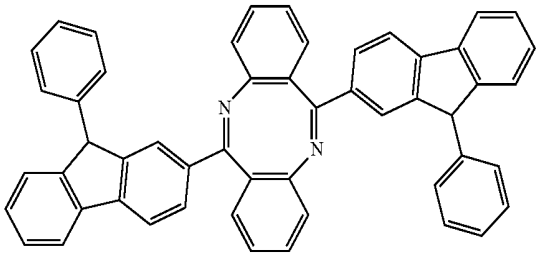

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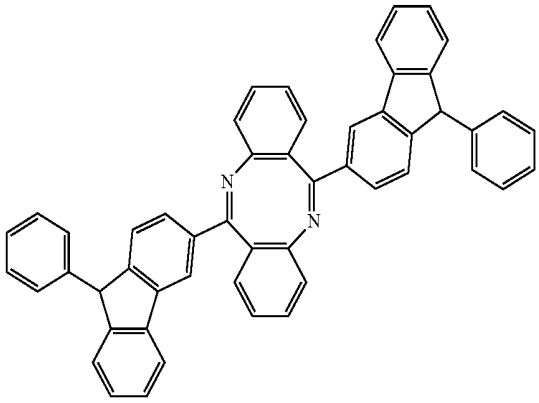

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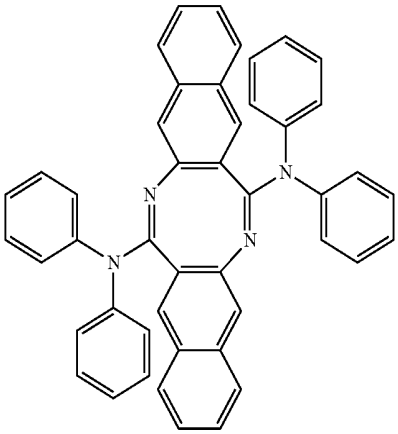

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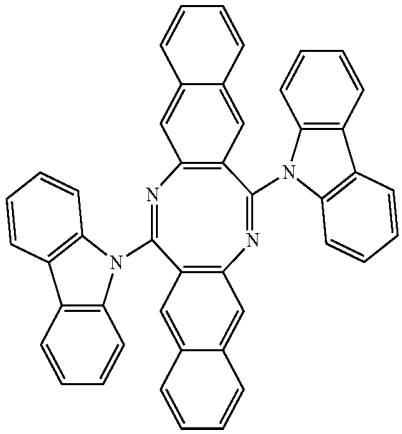

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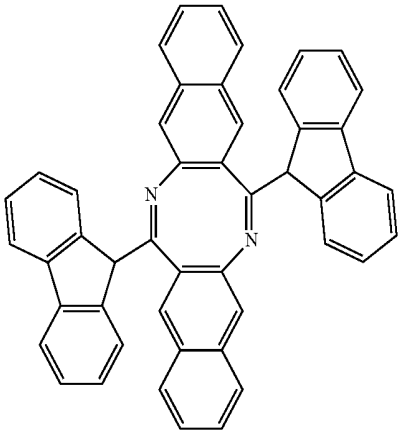

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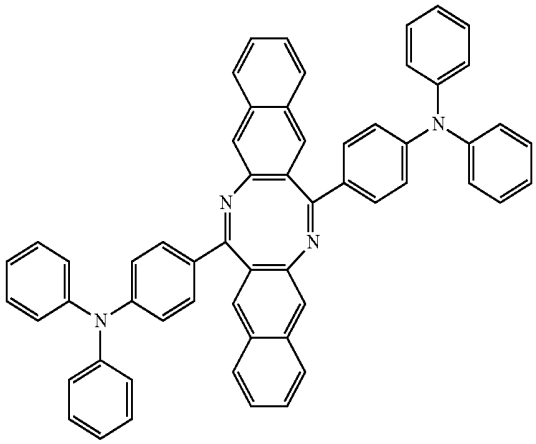

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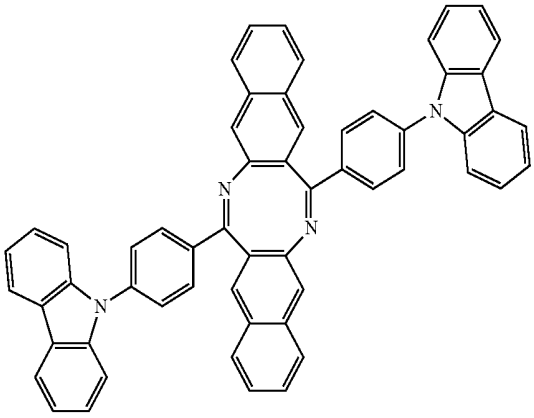

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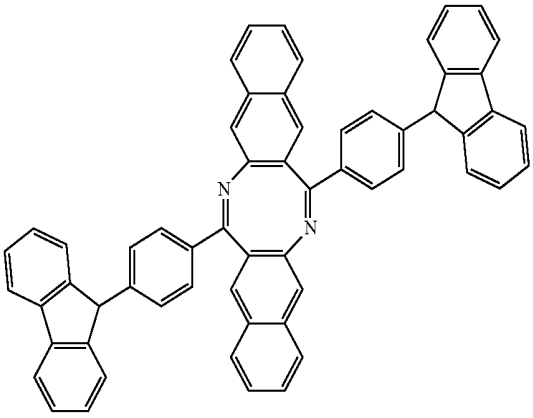

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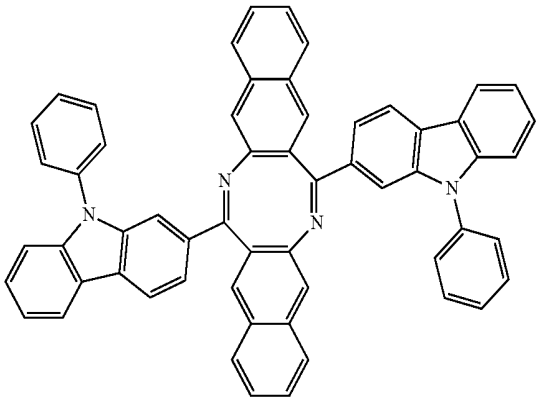

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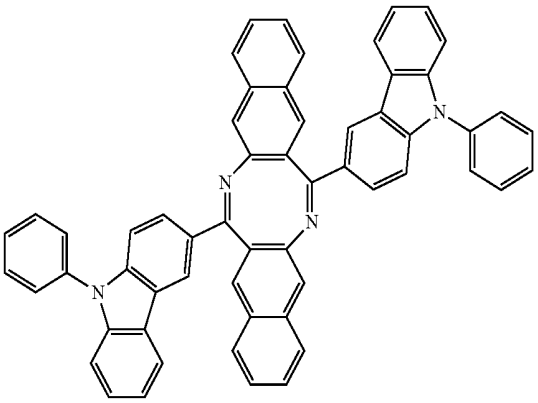

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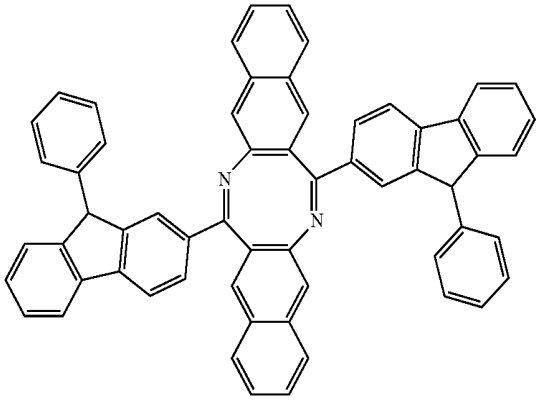

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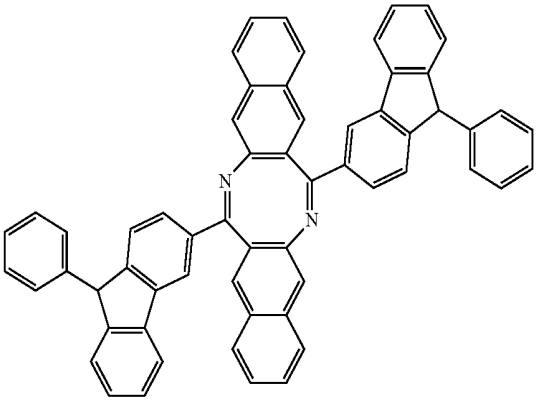

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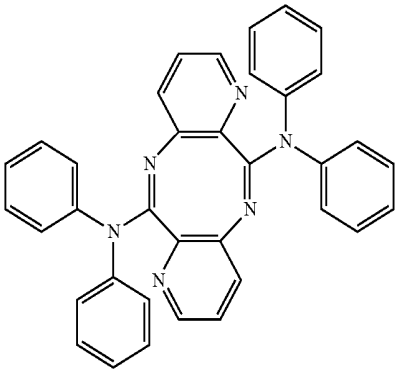

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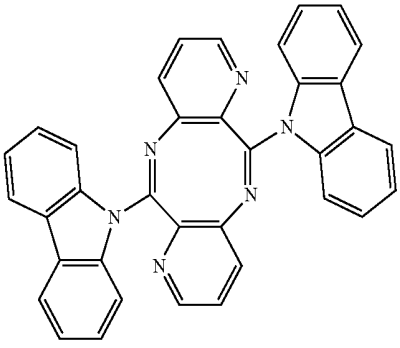

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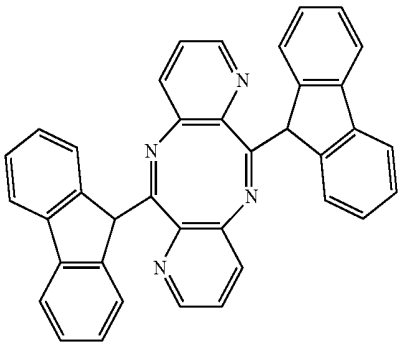

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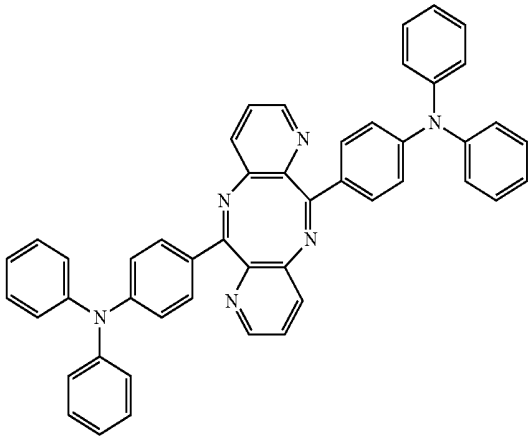

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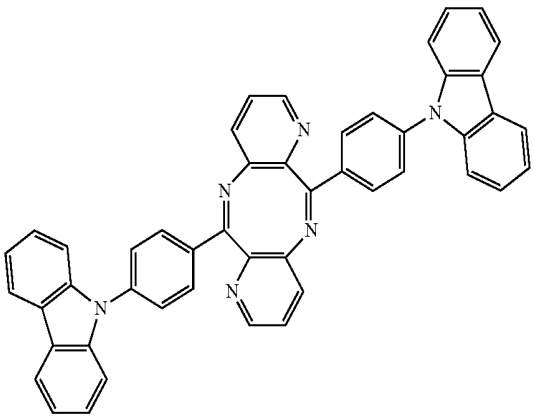

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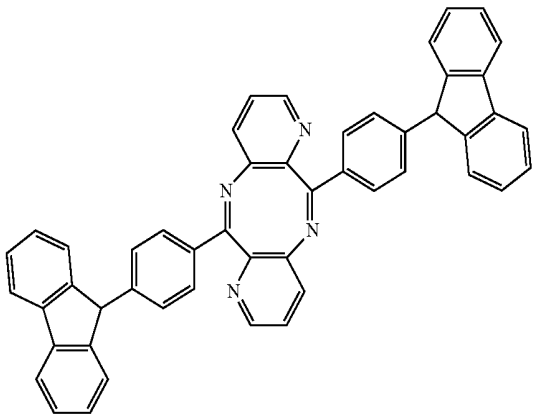

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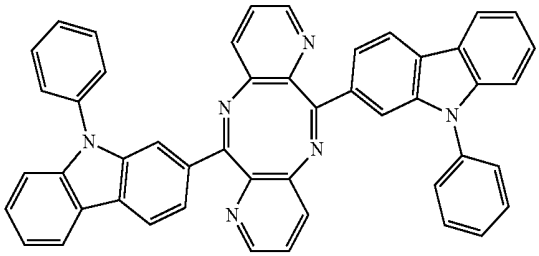

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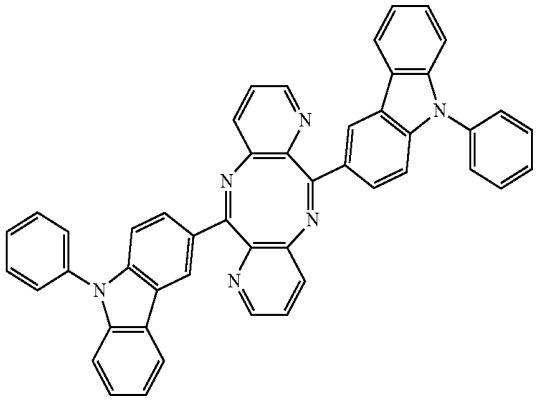

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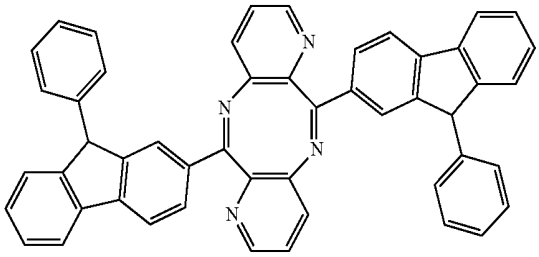

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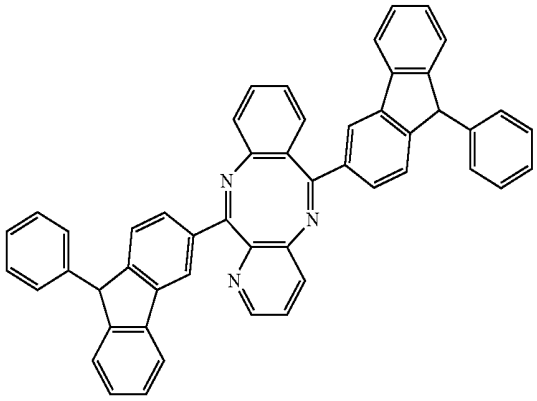

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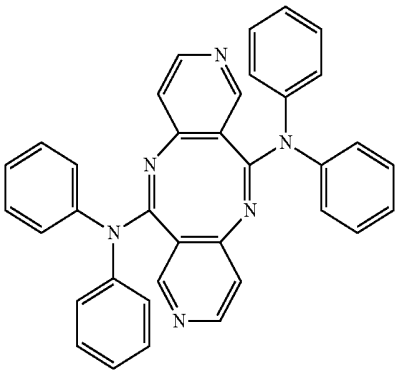

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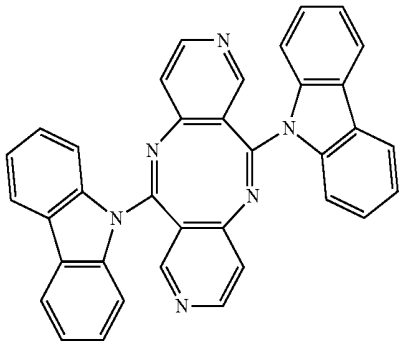

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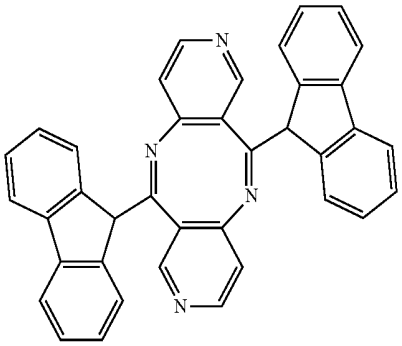

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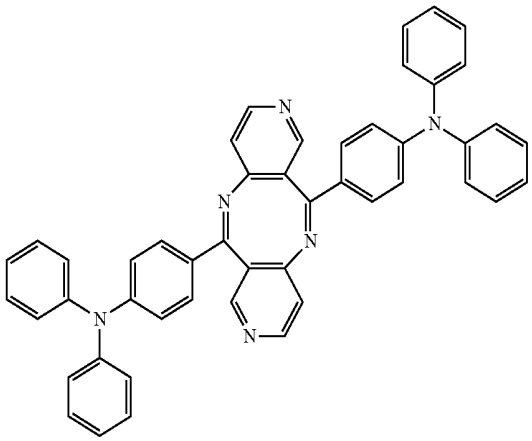

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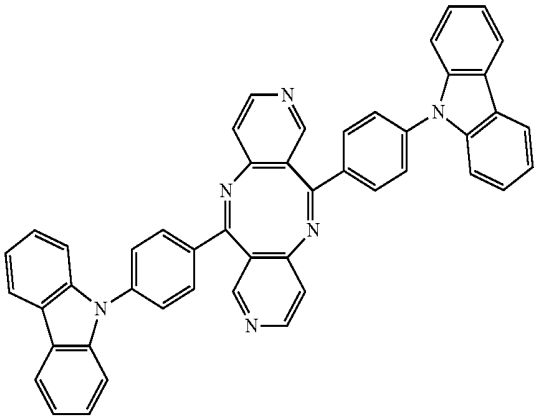

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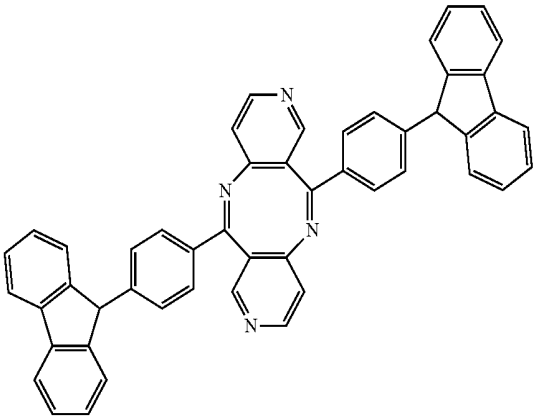

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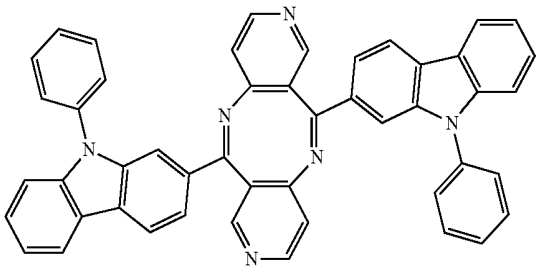

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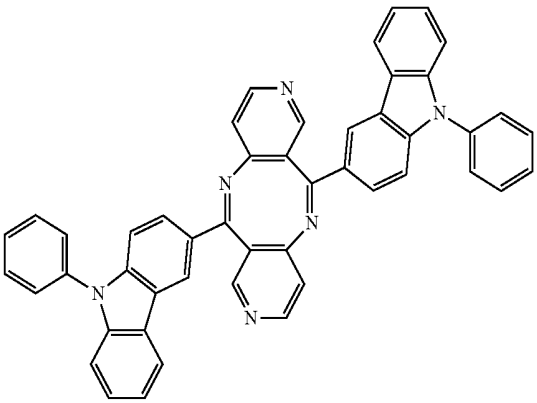

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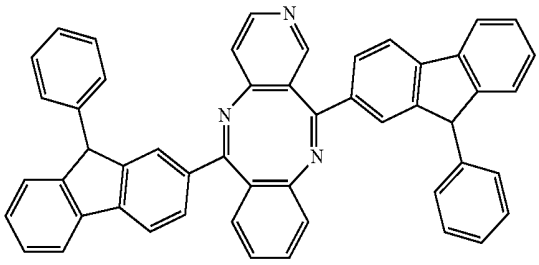

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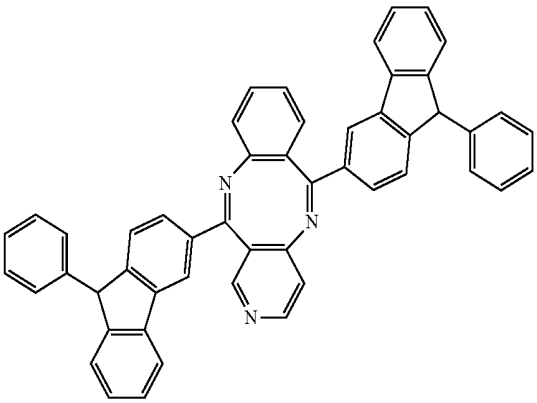

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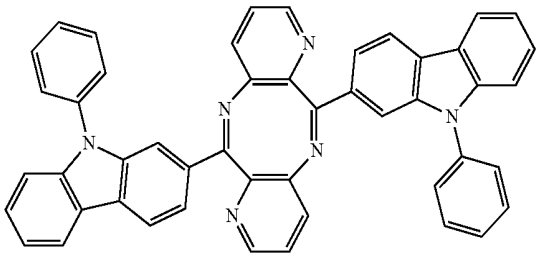

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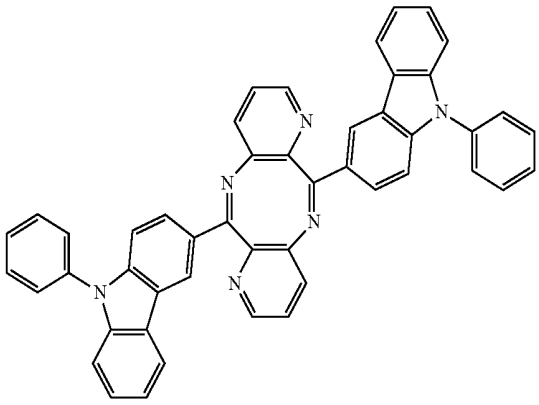

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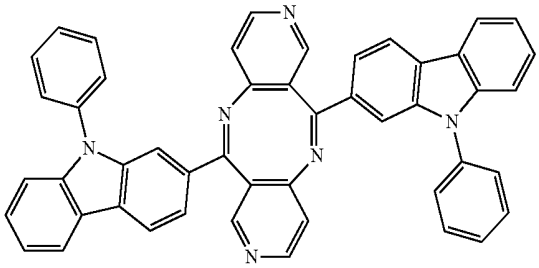

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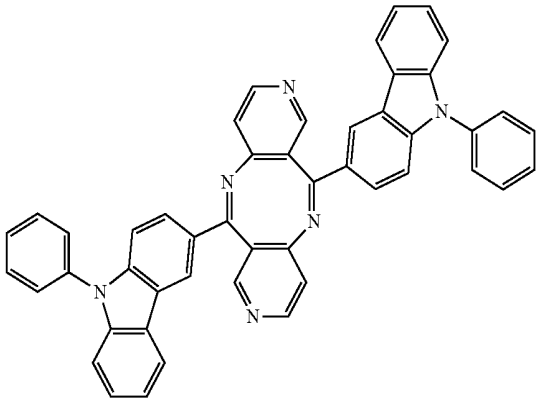

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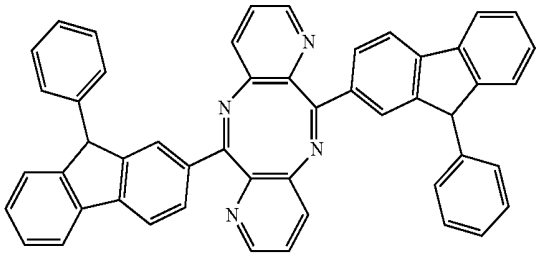

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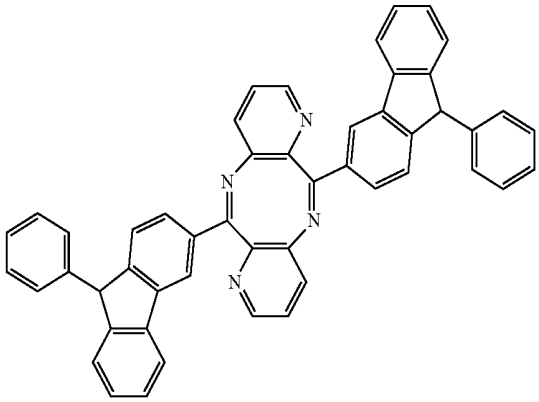

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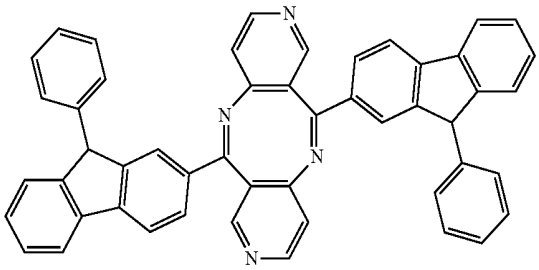

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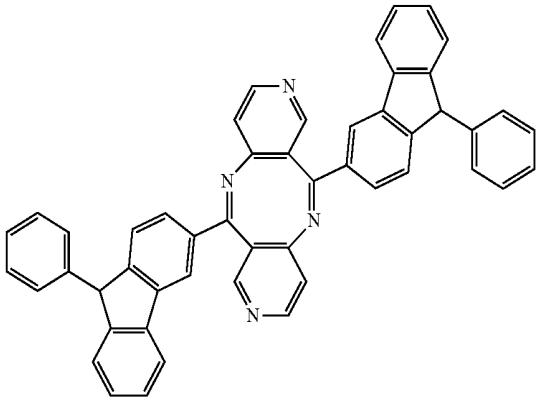

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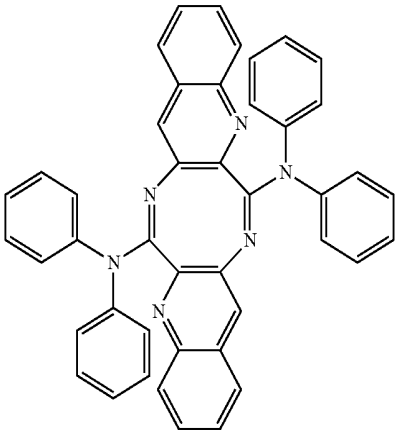

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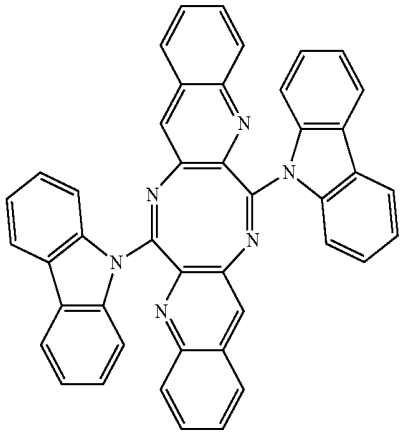

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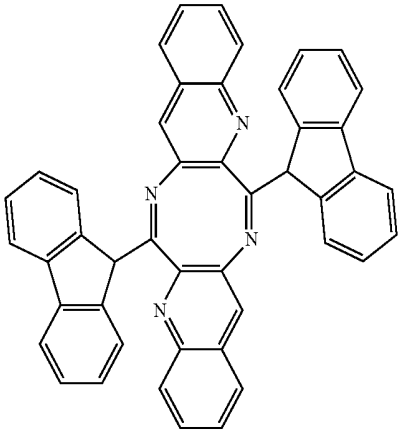

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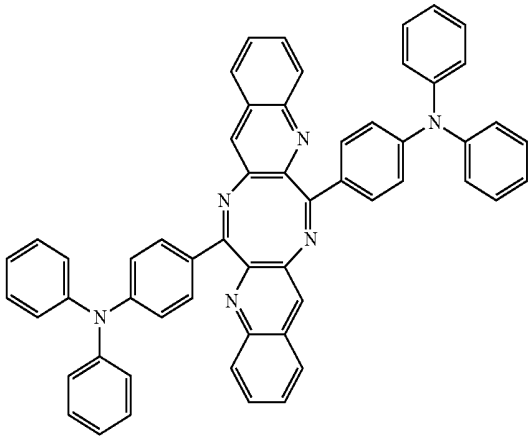

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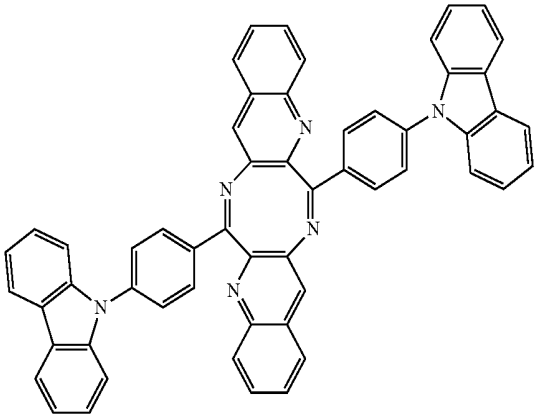

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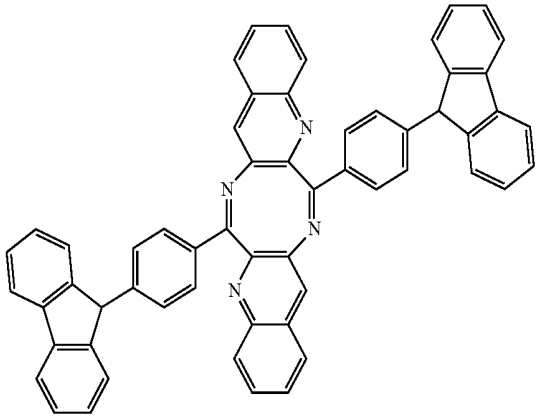

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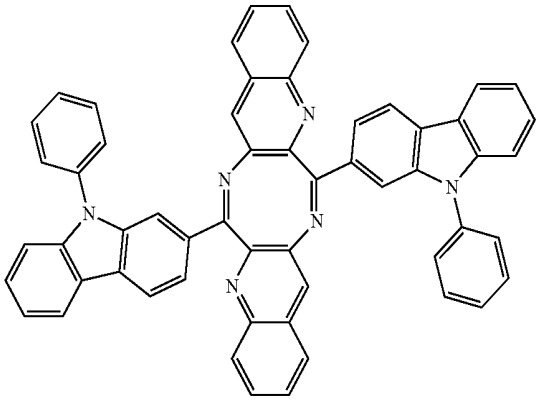

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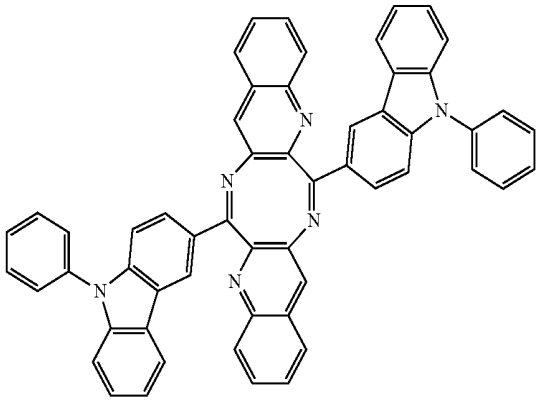

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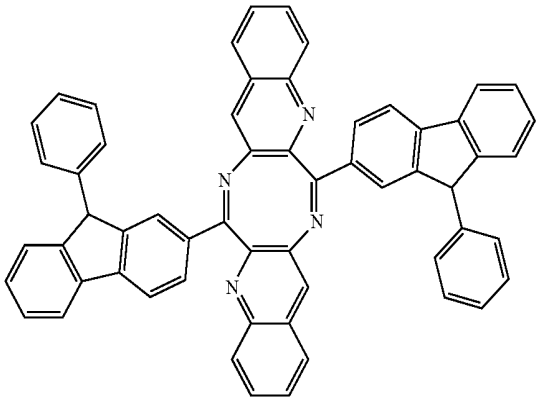

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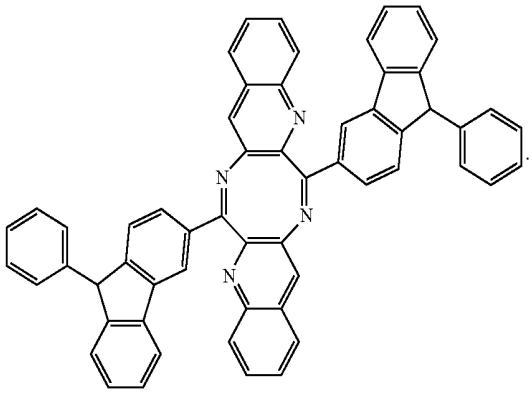

18. An organic light-emitting device comprising:

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 at least one of the antiaromatic compound of claim **1**.

19. The organic light-emitting device of claim **18**, wherein the organic layer comprises an electron transport region between the emission layer and the second electrode, and the electron transport region comprises the antiaromatic compound.

20. The organic light-emitting device of claim **19**, wherein the electron transport region comprises an electron transport layer, and the electron transport layer comprises the antiaromatic compound.

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专利名称(译)	抗芳族化合物和包含其的有机发光装置		
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摘要(译)

抗芳香族化合物和包含其的有机发光装置。抗芳香化合物由式1表示：