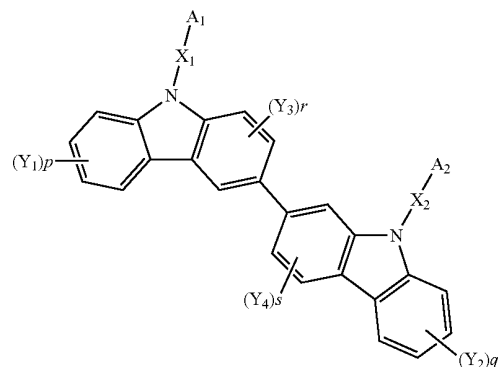
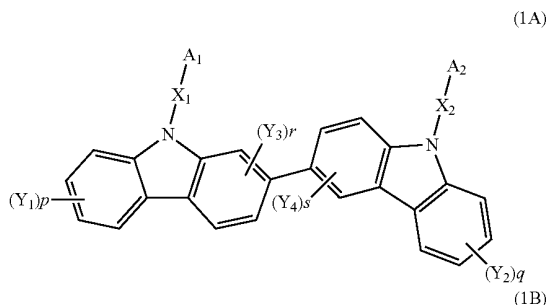




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(19) **United States**(12) **Patent Application Publication**
INOUE et al.(10) **Pub. No.: US 2011/0278555 A1**(43) **Pub. Date: Nov. 17, 2011**(54) **BISCARBAZOLE DERIVATIVE, MATERIAL
FOR ORGANIC ELECTROLUMINESCENCE
DEVICE AND ORGANIC
ELECTROLUMINESCENCE DEVICE USING
THE SAME**(57) **ABSTRACT**

A biscarbazole derivative of the invention is represented by a formula (1A) or (1B) below.

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(JP)(73) Assignee: **Idemitsu Kosan Co., Ltd.**(21) Appl. No.: **13/091,071**(22) Filed: **Apr. 20, 2011****Related U.S. Application Data**(60) Provisional application No. 61/353,047, filed on Jun.
9, 2010, provisional application No. 61/433,084, filed
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Dec. 27, 2010 (JP) 2010-291138**Publication Classification**(51) **Int. Cl.**
H01L 51/54 (2006.01)
C07D 209/82 (2006.01)(52) **U.S. Cl.** **257/40; 548/440; 257/E51.018**

In the formula (1A) or (1B): A₁ represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms; A₂ represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms; X₁ and X₂ each are a linking group; Y₁ to Y₄ each represent a substituent; p and q represent an integer of 1 to 4; and r and s represent an integer of 1 to 3.

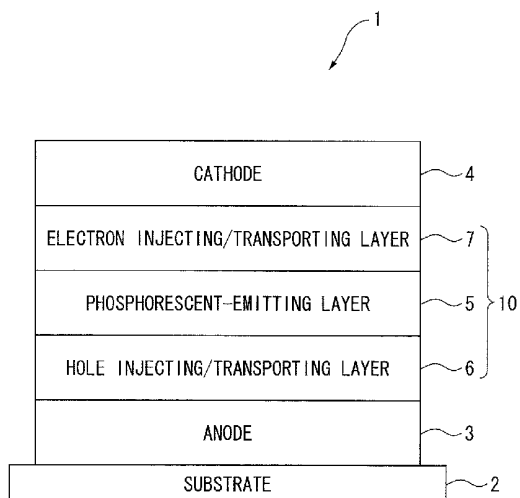
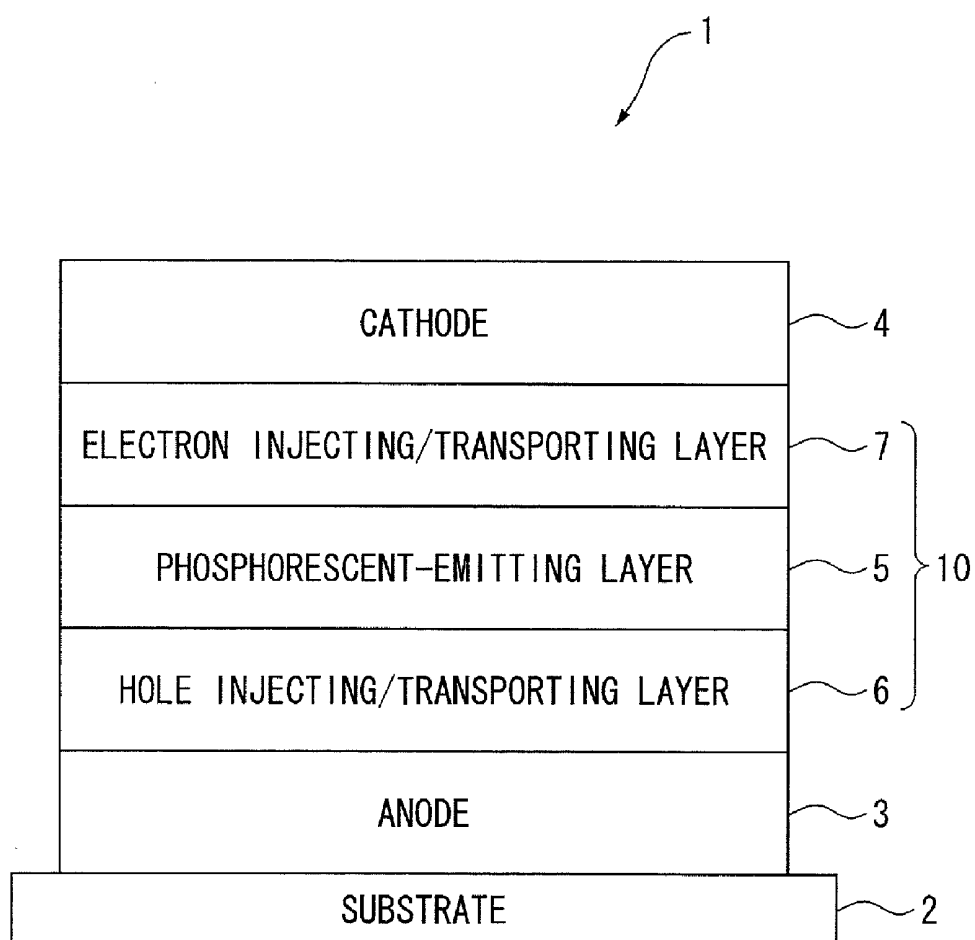


FIG. 1



**BISCARBAZOLE DERIVATIVE, MATERIAL
FOR ORGANIC ELECTROLUMINESCENCE
DEVICE AND ORGANIC
ELECTROLUMINESCENCE DEVICE USING
THE SAME**

[0001] The entire disclosure of Japanese Patent Application No. 2010-097317, filed Apr. 20, 2010, Japanese Patent Application No. 2010-291138, filed Dec. 27, 2010, U.S. Provisional Application No. 61/353,047, filed Jun. 9, 2010, and U.S. Provisional Application No. 61/433,084, filed Jan. 14, 2011, is expressly incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a biscarbazole derivative, a material for an organic electroluminescence device, and an organic electroluminescence device using those.

[0004] 2. Description of Related Art

[0005] A known organic electroluminescence device includes an organic thin-film layer between an anode and a cathode, the organic thin-film layer including an emitting layer, and emits light using exciton energy generated by a recombination of holes and electrons injected into the emitting layer (see Patent Literature 1: WO2003-080760, Patent Literature 2: Japanese Patent No. 3139321, Patent Literature 3: Japanese Patent No. 4357781, Patent Literature 4: JP-A-2003-151774, Patent Literature 5: JP-A-2008-135498, Patent Literature 6: JP-A-2009-21336, and Patent Literature 7: JP-A-2008-214307).

[0006] Such an organic electroluminescence device, which has the advantages as a self-emitting device, is expected to

serve as an emitting device excellent in luminous efficiency, image quality, power consumption and thin design.

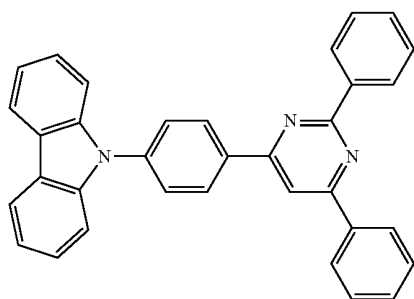
[0007] In forming the emitting layer, a doping method, according to which an emitting material (dopant) is doped to a host, has been known as a usable method.

[0008] The emitting layer formed by the doping method can efficiently generate excitons from electric charges injected into the host. With the exciton energy generated by the excitons being transferred to the dopant, the dopant can emit light with high efficiency.

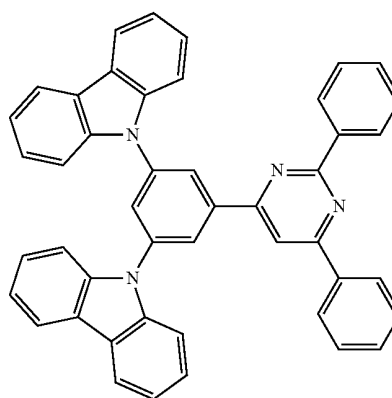
[0009] Recently, in order to improve performance of the organic electroluminescence device (hereinafter, occasionally referred to as an organic EL device), a doping method has been further studied to find a suitable host material.

[0010] Such a host material is disclosed in, for instance, Patent Literatures 1 to 7. Patent Literatures 1 to 7 disclose a compound including a carbazole skeleton and a nitrogen-containing aromatic ring in the same molecule and a compound including a plurality of carbazole skeletons in the same molecule, as shown in the following compounds I to VIII.

[0011] The compounds I and II disclosed in Patent Literature 1 each have a structure in which a carbazole skeleton is bonded to a benzene ring and an electron-deficient nitrogen-containing hetero aromatic ring structure. A carbazole skeleton, which is represented by polyvinyl carbazole, has been known as a main skeleton of a hole transporting material. In contrast, the electron-deficient nitrogen-containing hetero aromatic ring structure has been known as a structure having a high electron transporting capability. In other words, the compounds I and II disclosed in Patent Literature 1 are materials for balancing charge transportation by combining a hole transporting skeleton and an electron transporting skeleton.

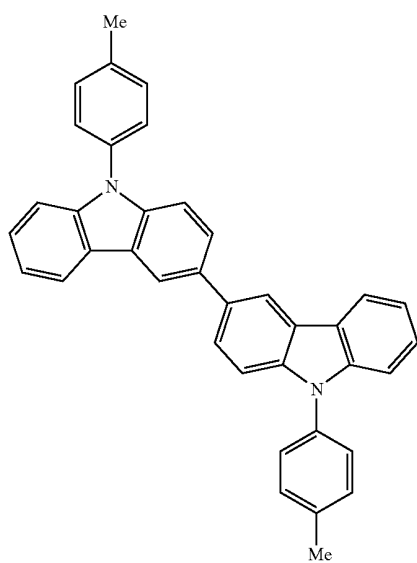


Compound I

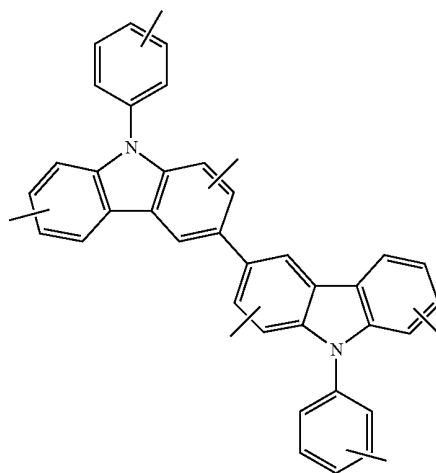


Compound II

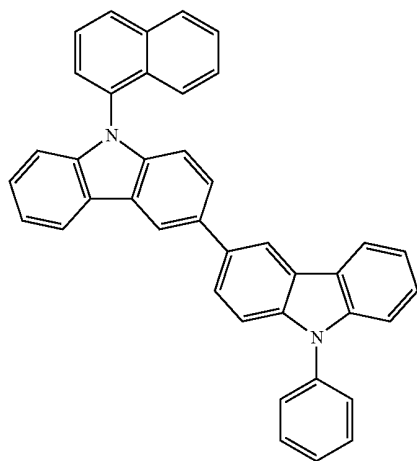
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Compound III



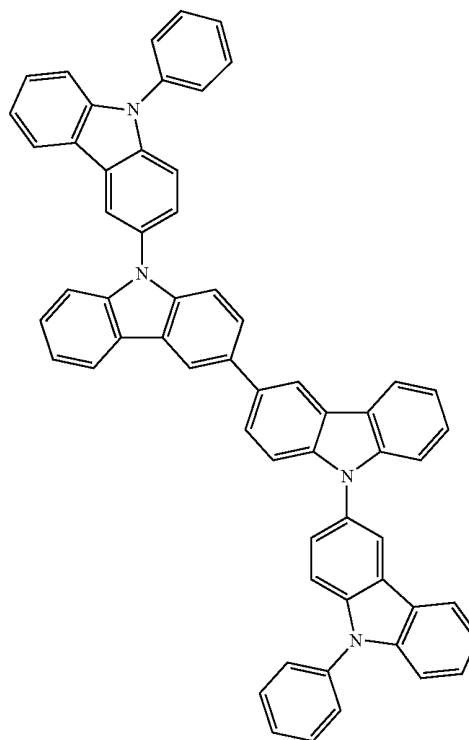
Compound IV



Compound V

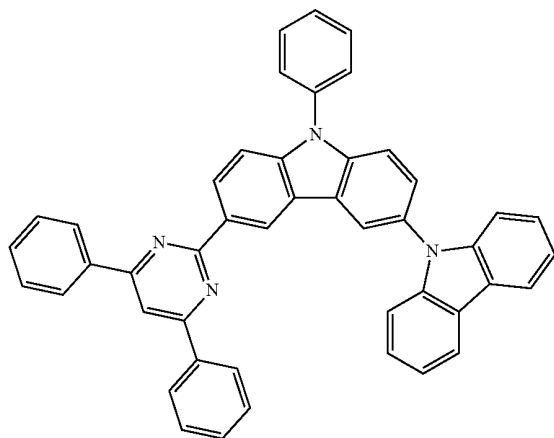


Compound VI

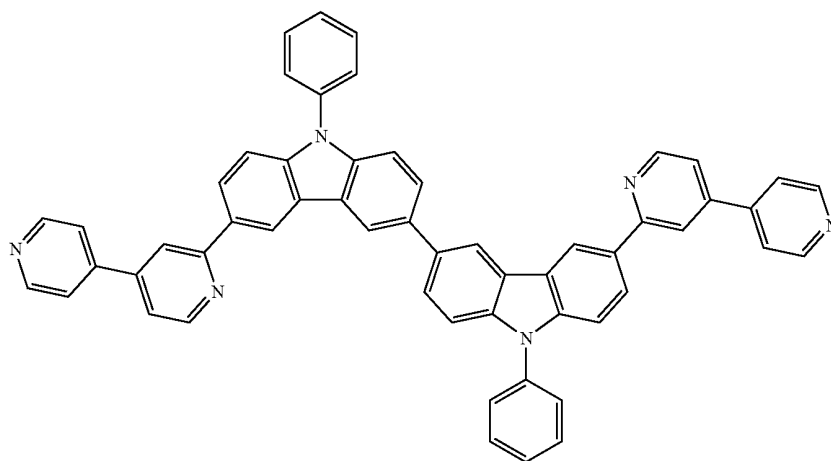


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Compound VII



Compound VIII



[0012] The compound I has only a single carbazole skeleton and lacks a hole transporting capability, so that a favorable luminescence property cannot be obtained. The compound II has two carbazolyl groups that are branched to left and right relative to a bond axis of a pyrimidine ring and a benzene ring (two conjugated aromatic ring). Accordingly, an overlapping margin of the carbazole skeleton between molecules is impaired, so that a hole transporting capability is insufficient and a re-bonding position of charges is likely to be closer to the anode. Consequently, favorable luminescence property and lifetime property cannot be obtained.

[0013] In order to enlarge the overlapping margin between the molecules and exhibit a sufficient hole transporting capability, it has been proposed to incorporate a structure in which carbazole skeletons are linked in the molecules. For instance, the compounds III to VI disclosed in Patent Literatures 2 to 5 have a structure in which two carbazole skeletons are linked. However, since none of the compounds III to VI has an electron-deficient nitrogen-containing hetero aromatic ring structure, adjustment of carrier balance between holes and electrons is difficult, so that a favorable luminescence property cannot be obtained.

[0014] The compound VII disclosed in Patent Literature 6 has an electron-deficient nitrogen-containing hetero aromatic ring structure and a carbazole-linking structure. However,

two carbazole skeletons are bonded to a carbon atom at 3-position by a nitrogen atom. In this structure, the two carbazole skeletons are twisted to each other to lose flatness. Accordingly, the overlapping margin between the molecules becomes small and a hole transporting capability becomes insufficient, so that favorable luminescence property and lifetime property cannot be obtained.

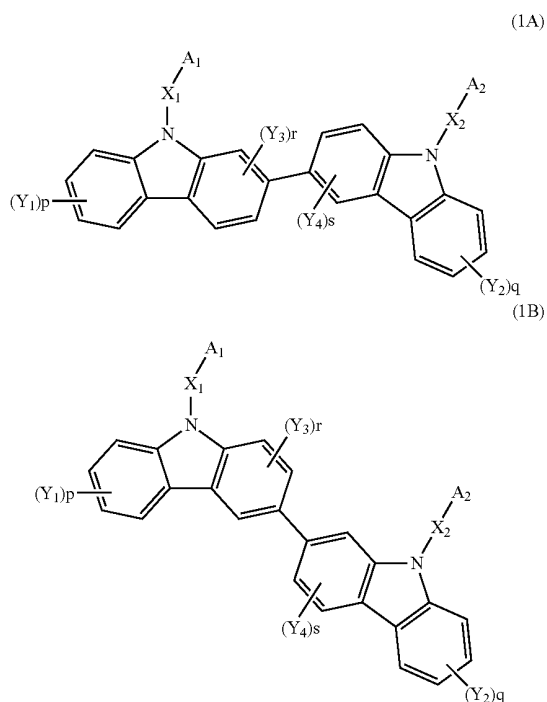
[0015] The compound VIII disclosed in Patent Literature 7 has a structure in which a bipyridyl group (a nitrogen-containing aromatic heterocyclic group) is bonded to a benzene ring of a carbazole skeleton. The compound is not disclosed as a phosphorescent host material although being used as a material for an electron transporting layer. However, since the compound is considered to exhibit a high electron transporting capability, when used as a host material, the compound provides a poor carrier balance within the emitting layer and fails to exhibit a favorable luminescence property.

SUMMARY OF THE INVENTION

[0016] Accordingly, an object of the invention is to provide a novel biscarbazole derivative having a hole transporting capability and an electron transporting capability and exhibiting an excellent carrier balance, a material for an organic EL device and a phosphorescent and long-life organic EL device using those.

[0017] After dedicated study to achieve the above object, the inventors found that a compound including two carbazolyl groups and a nitrogen-containing heterocyclic group effectively works for optimizing a carrier balance in the emitting layer of an organic EL device, and achieved the invention.

[0018] Specifically, a biscarbazole derivative according to an aspect of the invention is represented by a formula (1A) or (1B) below. Herein, "hydrogen" is meant to also include deuterium.



[0019] In the formulae (1A) and (1B): A_1 represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 carbon atoms forming a ring (hereinafter referred to as "ring carbon atoms");

[0020] A_2 represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0021] X_1 and X_2 each are a linking group and independently represent a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

[0022] Y_1 to Y_4 independently represent a hydrogen atom, fluorine atom, cyano group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl having 6 to 30 carbon atoms, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon

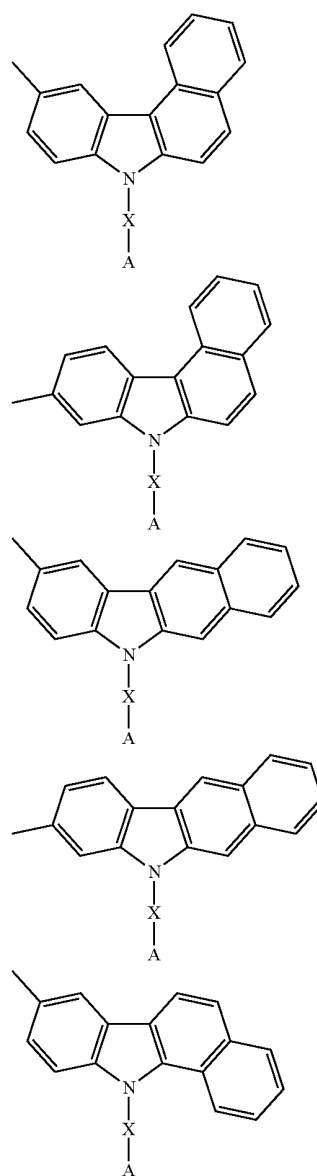
atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

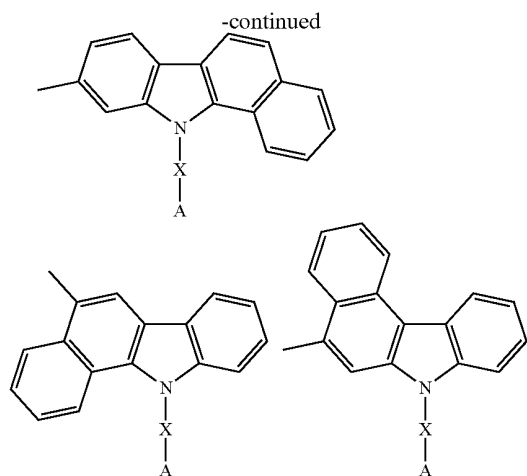
[0023] adjacent ones of Y_1 to Y_4 may be bonded to each other to form a ring structure;

[0024] p and q represent an integer of 1 to 4; r and s represent an integer of 1 to 3; and

[0025] when p and q are an integer of 2 to 4 and r and s are an integer of 2 to 3, a plurality of Y_1 to Y_4 may be the same or different.

[0026] When Y_1 to Y_4 are bonded to each other to form a ring structure, the ring structure is exemplified by structures represented by the following formulae.





[0027] Moreover, in the biscarbazole derivative according to the above aspect of the invention, A_1 in the formula (1A) or (1B) is preferably selected from the group consisting of a substituted or unsubstituted pyridine ring, substituted or unsubstituted pyrimidine ring and substituted or unsubstituted triazine ring, more preferably selected from a substituted or unsubstituted pyrimidine ring or substituted or unsubstituted triazine ring, particularly preferably a substituted or unsubstituted pyrimidine ring.

[0028] Moreover, in the biscarbazole derivative according to the above aspect of the invention, A_1 in the formula (1A) or (1B) is preferably a substituted or unsubstituted quinazoline ring.

[0029] A material for an organic EL device (hereinafter, occasionally referred to as an organic-EL-device material) according another aspect of the invention contains the biscarbazole derivative.

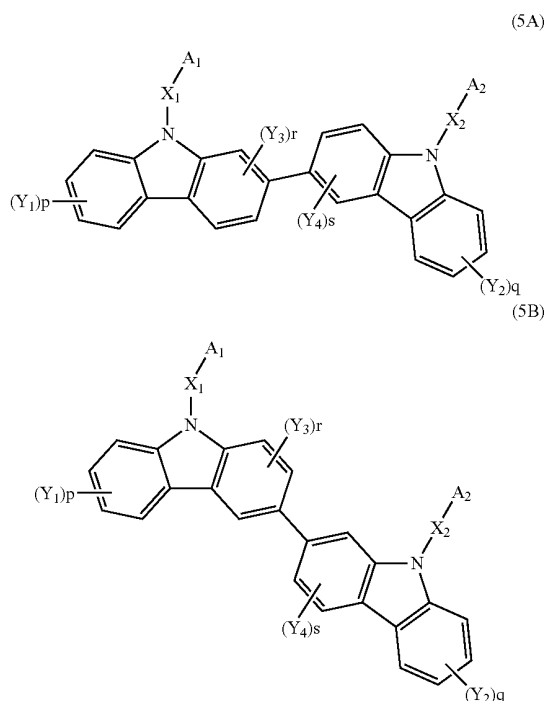
[0030] The organic EL device according to still another aspect of the invention includes: a cathode; an anode; and a plurality of organic thin-film layers provided between the cathode and the anode, and the organic thin-film layer including an emitting layer, in which at least one layer of the organic thin-film layers includes the above-described organic-EL-device material.

[0031] In the organic EL device according to the above aspect of the invention, the emitting layer preferably includes the organic-EL-device material according to the above aspect of the invention as a host material.

[0032] Also preferably in the above aspect of the invention, the emitting layer includes a phosphorescent material.

[0033] Further, the phosphorescent material is more preferably an ortho-metalated complex of a metal atom selected from iridium (Ir), osmium (Os) and platinum (Pt).

[0034] The organic EL device according to a further aspect of the invention includes: a cathode; an anode; and a plurality of organic thin-film layers provided between the cathode and the anode, and the organic thin-film layer includes an emitting layer, in which at least one of the organic thin-film layers is the emitting layer including a first host material, a second host material and a phosphorescent material providing phosphorescence, the first host material being a compound represented by a formula (5A) or (5B) below.



[0035] In the formulae (5A) and (5B): A_1 represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0036] A_2 represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0037] X_1 and X_2 each are a linking group and independently represent a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

[0038] Y_1 to Y_4 independently represent a hydrogen atom, fluorine atom, cyano group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

[0039] adjacent ones of Y_1 to Y_4 may be bonded to each other to form a ring structure;

[0040] p and q represent an integer of 1 to 4; r and s represent an integer of 1 to 3; and.

[0041] when p and q are an integer of 2 to 4 and r and s are an integer of 2 to 3, a plurality of Y₁ to Y₄ may be the same or different.

[0042] When Y₁ to Y₄ are bonded to each other to form a ring structure, the ring structure is exemplified by the same structures as ones listed when Y₁ to Y₄ are bonded to each other to form a ring structure in the formulae (1A) and (1B).

[0043] In the organic EL device according to the above aspect of the invention, the second host material is preferably represented by either one of a formula (6) or (7) below.



[0044] In the formulae (6) and (7): Cz represents a substituted or unsubstituted arylcarbazolyl group or carbazolyaryl group;

[0045] A³ represents a group represented by a formula (8A) or (8B) below; and

[0046] a and b each represent an integer of 1 to 3.



[0047] In the formula (8A): M¹ and M² each independently represent a substituted or unsubstituted nitrogen-containing aromatic heterocyclic ring or nitrogen-containing fused aromatic heterocyclic ring having 2 to 40 ring carbon atoms; M¹ and M² may be the same or different;

[0048] L⁵ represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 carbon atoms;

[0049] c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and c+e represents 1 or more.

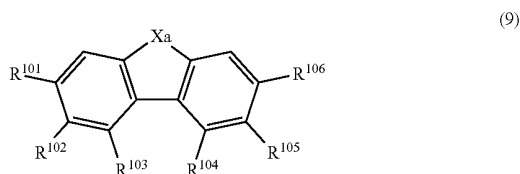


[0050] In the formula (8B): M³ and M⁴ each independently represent a substituted or unsubstituted aromatic hydrocarbon group having 6 to 40 ring carbon atoms; M³ and M⁴ may be the same or different;

[0051] L⁶ represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, or substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms;

[0052] c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and c+e represents 1 or more.

[0053] In the organic EL device according to the above aspect of the invention, the second host material is preferably represented by a formula (9) below.



[0054] In the formula (9): R¹⁰¹ to R¹⁰⁶ each independently represent a hydrogen atom, halogen atom, substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aryl group having 10 to 18 carbon atoms, substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted arylcarbonyl group having 7 to 40 carbon atoms, substituted or unsubstituted arylthio group having 6 to 20 carbon atoms, substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms or cyano group;

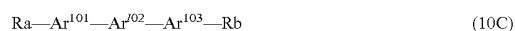
[0055] at least one of R¹⁰¹ to R¹⁰⁶ is a substituted or unsubstituted 9-carbazolyl group, substituted or unsubstituted azacarbazolyl group having 2 to 5 nitrogen atoms, or -L-9-carbazolyl group;

[0056] L represents a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted arylcarbonyl group having 7 to 40 carbon atoms, substituted or unsubstituted arylthio group having 6 to 20 carbon atoms, or substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms;

[0057] Xa represents a sulfur atom, oxygen atom or N—R¹⁰⁸; and

[0058] R¹⁰⁸ represents the same as R¹⁰¹ to R¹⁰⁶.

[0059] In the organic EL device according to the above aspect of the invention, the second host material is preferably a compound selected from the group consisting of polycyclic aromatic compounds represented by formulae (10A), (10B) and (10C) below.

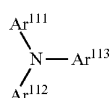


[0060] In formulae (10A) to (10C), Ar¹⁰¹, Ar¹⁰², Ar¹⁰³, Ra and Rb represent a polycyclic aromatic skeleton having 6 to 60 ring carbon atoms selected from a substituted or unsubstituted benzene ring, substituted or unsubstituted naphthalene ring, substituted or unsubstituted chrysene ring, substituted or unsubstituted fluoranthene ring, substituted or unsubstituted phenanthrene ring, substituted or unsubstituted benzophenanthrene ring, substituted or unsubstituted dibenzophenanthrene ring, substituted or unsubstituted triphenylene ring, substituted or unsubstituted benzo[a]

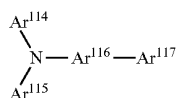
triphenylene ring, substituted or unsubstituted benzochrysene ring, substituted or unsubstituted benzo[b]fluoranthene ring, substituted or unsubstituted fluorene ring and substituted or unsubstituted picene ring.

[0061] Moreover, in the organic EL device according to the above aspect of the invention, in the formulae (10A) to (10C), either one or both of Ra and Rb are preferably selected from the group consisting of a substituted or unsubstituted phenanthrene ring, substituted or unsubstituted benzo[c]phenanthrene ring and substituted or unsubstituted fluoranthene ring.

[0062] In the organic EL device according to the above aspect of the invention, the second host material is preferably a monoamine derivative represented by any one of formulae (11) to (13) below.

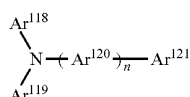


[0063] Ar¹¹¹, Ar¹¹² and Ar¹¹³ are a substituted or unsubstituted aryl group or heteroaryl group.



[0064] Ar¹¹¹, Ar¹¹² and Ar¹¹³ are a substituted or unsubstituted aryl group or heteroaryl group.

[0065] Ar¹¹⁶ is a substituted or unsubstituted arylene group or heteroarylene group.

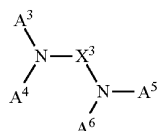


[0066] Ar¹¹⁸, Ar¹¹⁹ and Ar¹²¹ are a substituted or unsubstituted aryl group or heteroaryl group.

[0067] Ar¹²⁰ is a substituted or unsubstituted arylene group or heteroarylene group.

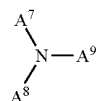
[0068] n is an integer of 2 to 5; when n is 2 or more, Ar¹²⁰ may be the same or different.

[0069] In the organic EL device according to the above aspect of the invention, the second host material is preferably represented by a formula (14) or (15) below.



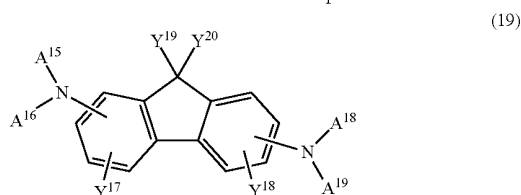
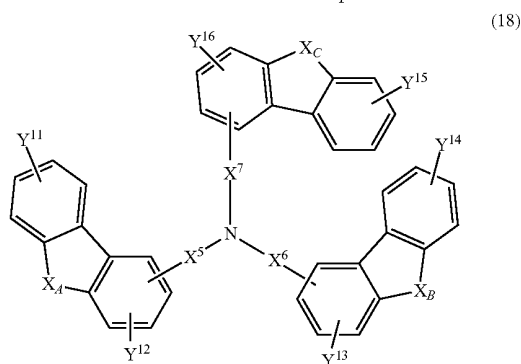
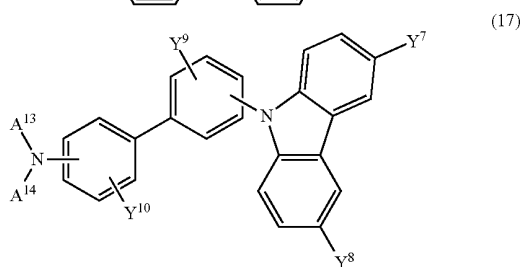
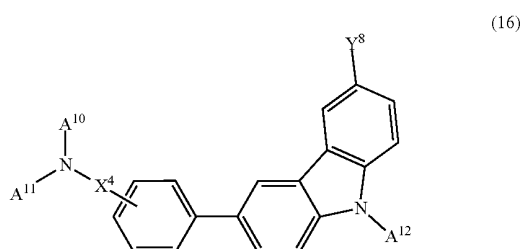
[0070] In the formula (14): X³ represents a substituted or unsubstituted arylene group having 10 to 40 ring carbon

atoms; and A³ to A⁶ represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms, or heteroaryl group having 6 to 60 atoms forming a ring (hereinafter referred to as "ring atoms").

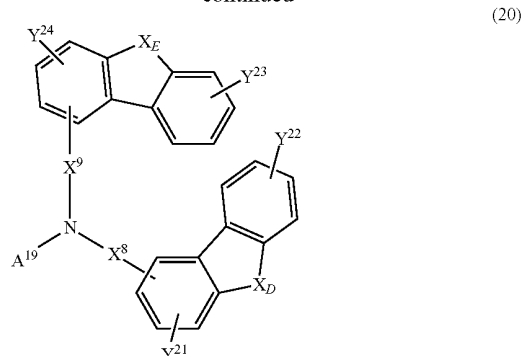


[0071] In the formula (15): A⁷ to A⁹ represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms, or heteroaryl group having 6 to 60 ring atoms.

[0072] In the organic EL device according to the above aspect of the invention, the second host material is more preferably represented by any one of formulae (16) to (20) below.



-continued



[0073] In the formulae (16) to (20), A¹⁰ to A¹⁹ each represent a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 40 carbon atoms, substituted or unsubstituted aryl group having 8 to 40 carbon atoms bonded with an aromatic amino group, or substituted or unsubstituted aryl group having 8 to 40 carbon atoms bonded with an aromatic heterocyclic group;

[0074] A¹⁰, A¹³, A¹⁵ and A¹⁷ are adapted to be respectively bonded to A¹¹, A¹⁴, A¹⁶ and A¹⁸ to form a ring;

[0075] X⁴ to X⁹ represent a single bond or a linking group having 1 to 30 carbon atoms;

[0076] Y⁶ to Y²⁴ represent a hydrogen atom, halogen atom, substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted alkenyl group having 2 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted alkylsilyl group having 3 to 20 carbon atoms, substituted or unsubstituted arylsilyl group having 8 to 40 carbon atoms, substituted or unsubstituted aralkylsilyl group having 8 to 40 carbon atoms, or substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms; and

[0077] X_A, X_B, X_C, X_D, X_E each represent a sulfur atom, an oxygen atom or a monoaryl-substituted nitrogen atom.

[0078] In the organic EL device according to the above aspect of the invention, it is preferable that the emitting layer includes a host material and a phosphorescent material, the phosphorescent material being an ortho-metalated complex of a metal atom selected from iridium (Ir), osmium (Os) and platinum (Pt).

[0079] In the organic EL device according to the above aspect of the invention, it is preferable that an electron injecting layer is provided between the cathode and the emitting layer and includes a nitrogen-containing cyclic derivative.

[0080] In the organic EL device according to the above aspect of the invention, it is preferable that an electron transporting layer is provided between the cathode and the emitting layer and includes the above-described organic-EL-device material.

[0081] In the organic EL device according to the invention, a reduction-causing dopant may be preferably present at an interfacial region between the cathode and the organic thin-film layer.

[0082] According to the above aspect of the invention, since the biscarbazole derivative is used as the organic-EL-device material, a long-life organic electroluminescence device can be provided. Moreover, the organic-EL-device material is effective as an organic-electron-device material for an organic solar cell, an organic semiconductor laser, a sensor using an organic substance and an organic TFT.

BRIEF DESCRIPTION OF THE DRAWINGS

[0083] FIG. 1 schematically shows an exemplary arrangement of an organic electroluminescence device according to an exemplary embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S)

[0084] The present invention will be described below in detail.

First Exemplary Embodiment

Arrangement of Organic EL Device

[0085] First of all, arrangement(s) of an organic EL device will be described below.

[0086] The followings are representative arrangement examples of an organic EL device:

- (1) anode/emitting layer/cathode;
- (2) anode/hole injecting layer/emitting layer/cathode;
- (3) anode/emitting layer/electron injecting*transporting layer/cathode;
- (4) anode/hole injecting layer/emitting layer/electron injecting*transporting layer/cathode;
- (5) anode/organic semiconductor layer/emitting layer/cathode;
- (6) anode/organic semiconductor layer/electron blocking layer/emitting layer/cathode;
- (7) anode/organic semiconductor layer/emitting layer/adhesion improving layer/cathode;
- (8) anode/hole injecting transporting layer/emitting layer/electron injecting transporting layer/cathode;
- (9) anode/insulating layer/emitting layer/insulating layer/cathode;
- (10) anode/inorganic semiconductor layer/insulating layer/emitting layer/insulating layer/cathode;
- (11) anode/organic semiconductor layer/insulating layer/emitting layer/insulating layer/cathode;
- (12) anode/insulating layer/hole injecting*transporting layer/emitting layer/insulating layer/cathode; and
- (13) anode/insulating layer/hole injecting*transporting layer/emitting layer/electron injecting*transporting layer/cathode.

[0087] The arrangement (8) is suitably used among the above, but the arrangement of the invention is not limited to the above arrangements.

[0088] FIG. 1 schematically shows an exemplary arrangement of an organic EL device according to a first exemplary embodiment of the invention.

[0089] The organic EL device 1 includes a transparent substrate 2, an anode 3, a cathode 4 and an organic thin-film layer 10 positioned between the anode 3 and the cathode 4.

[0090] The organic thin-film layer **10** includes a phosphorescent-emitting layer **5** containing a phosphorescent host (a host material) and a phosphorescent dopant (a phosphorescent material). A layer such as a hole injecting/transporting layer **6** may be provided between the phosphorescent-emitting layer **5** and the anode **3** while a layer such as an electron injecting/transporting layer **7** may be provided between the phosphorescent-emitting layer **5** and the cathode **4**.

[0091] In addition, an electron blocking layer may be provided to the phosphorescent-emitting layer **5** adjacent to the anode **3** while a hole blocking layer may be provided to the phosphorescent-emitting layer **5** adjacent to the cathode **4**.

[0092] With this arrangement, electrons and holes can be trapped in the phosphorescent-emitting layer **5**, thereby enhancing probability of exciton generation in the phosphorescent-emitting layer **5**.

[0093] It should be noted that a “fluorescent host” and a “phosphorescent host” herein respectively mean a host combined with a fluorescent dopant and a host combined with a phosphorescent dopant, and that a distinction between the fluorescent host and phosphorescent host is not unambiguously derived only from a molecular structure of the host in a limited manner.

[0094] In other words, the fluorescent host herein means a material for forming a fluorescent-emitting layer containing a fluorescent dopant, and does not mean a host that is only usable as a host of a fluorescent material.

[0095] Likewise, the phosphorescent host herein means a material for forming a phosphorescent-emitting layer containing a phosphorescent dopant, and does not mean a host that is only usable as a host of a phosphorescent material.

[0096] It should be noted that the “hole injecting/transporting layer” herein means “at least either one of a hole injecting layer and a hole transporting layer” while the “electron injecting/transporting layer” herein means “at least either one of an electron injecting layer and an electron transporting layer.”

Transparent Substrate

[0097] The organic EL device according to this exemplary embodiment is formed on a light-transmissive substrate. The light-transmissive plate, which supports the organic EL device, is preferably a smoothly-shaped substrate that transmits 50% or more of light in a visible region of 400 nm to 700 nm.

[0098] Specifically, a glass plate, a polymer plate, and the like are preferable.

[0099] For the glass plate, materials such as soda-lime glass, barium/strontium-containing glass, lead glass, aluminosilicate glass, borosilicate glass, barium borosilicate glass and quartz can be used.

[0100] For the polymer plate, materials such as polycarbonate, acryl, polyethylene terephthalate, polyether sulfide and polysulfone can be used.

Anode and Cathode

[0101] The anode of the organic EL device is used for injecting holes into the hole injecting layer, the hole transporting layer or the emitting layer. It is effective that the anode has a work function of 4.5 eV or more.

[0102] Exemplary materials for the anode are alloys of indium-tin oxide (ITO), tin oxide (NESA), indium zinc oxide, gold, silver, platinum and copper.

[0103] The anode may be made by forming a thin film from these electrode materials through methods such as vapor deposition and sputtering.

[0104] When light from the emitting layer is to be emitted through the anode as in this embodiment, the anode preferably transmits more than 10% of the light in the visible region. Sheet resistance of the anode is preferably several hundreds Ω /square or lower. Although depending on the material of the anode, thickness of the anode is typically in a range of 10 nm to 1 μ m, and preferably in a range of 10 to 200 nm.

[0105] The cathode is preferably formed of a material with smaller work function in order to inject electrons into the electron injecting layer, the electron transporting layer and the emitting layer.

[0106] Although a material for the cathode is subject to no specific limitation, examples of the material are indium, aluminum, magnesium, alloy of magnesium and indium, alloy of magnesium and aluminum, alloy of aluminum and lithium, alloy of aluminum, scandium and lithium, alloy of magnesium and silver and the like.

[0107] Like the anode, the cathode may be made by forming a thin film from the above materials through a method such as vapor deposition or sputtering. In addition, the light may be emitted through the cathode.

Emitting Layer

[0108] The emitting layer of the organic EL device is an organic thin-film layer having a function for providing conditions for recombination of the electrons and the holes to emit light.

[0109] Injectability of the holes may differ from that of the electrons and transporting capabilities of the hole and the electrons (represented by mobilities of the holes and the electrons) may differ from each other.

[0110] As a method of forming the emitting layer, known methods such as vapor deposition, spin coating and an LB method may be employed.

[0111] The emitting layer is preferably a molecular deposit film.

[0112] The molecular deposit film means a thin film formed by depositing a material compound in gas phase or a film formed by solidifying a material compound in a solution state or in liquid phase. The molecular deposit film is typically distinguished from a thin film formed by the LB method (molecular accumulation film) by differences in aggregation structures, higher order structures and functional differences arising therefrom.

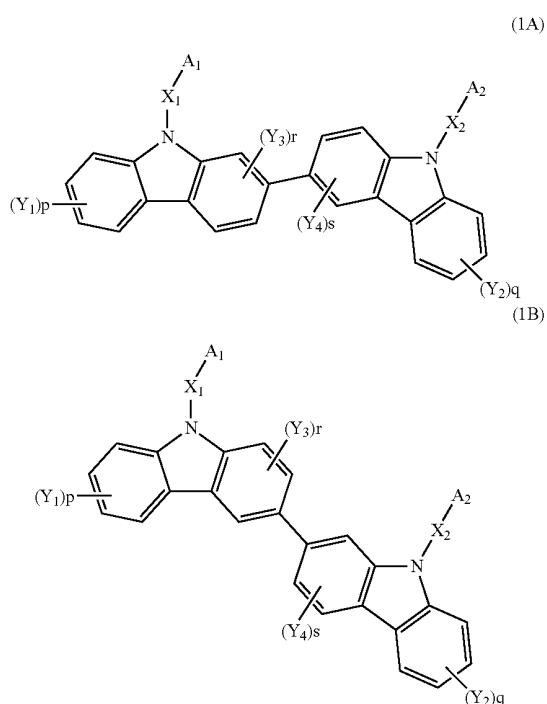
[0113] As disclosed in JP-A-57-51781, the emitting layer can be formed from a thin film formed by spin coating or the like, the thin film being formed from a solution prepared by dissolving a binder (e.g. a resin) and a material compound in a solvent.

[0114] An organic EL device according to this exemplary embodiment includes: a cathode; an anode; and a single or a plurality of organic thin-film layers provided between the cathode and the anode, in which the organic thin-film layer(s) includes at least one emitting layer, and at least one of the organic thin-film layers includes at least one phosphorescent material and, as an organic-EL-device material, at least one biscarbazole derivative according to this exemplary embodiment (described later). It is also preferable that at least one emitting layer includes the biscarbazole derivative according

to this exemplary embodiment as the organic-EL-device material and at least one phosphorescent material.

Biscarbazole Derivative

[0115] The biscarbazole derivative according to this exemplary embodiment is represented by a formula (1A) or (1B) below.



[0116] In the formula (1A) or (1B): A₁ represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0117] A₂ represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0118] X₁ and X₂ each are a linking group and independently represent a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

[0119] Y₁ to Y₄ independently represent a hydrogen atom, fluorine atom, cyano group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl group having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl group having 6 to 30 carbon atoms, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocar-

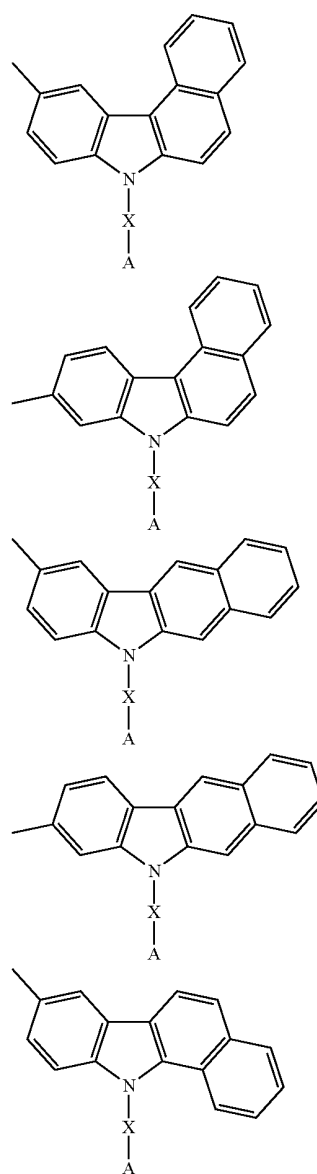
bon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

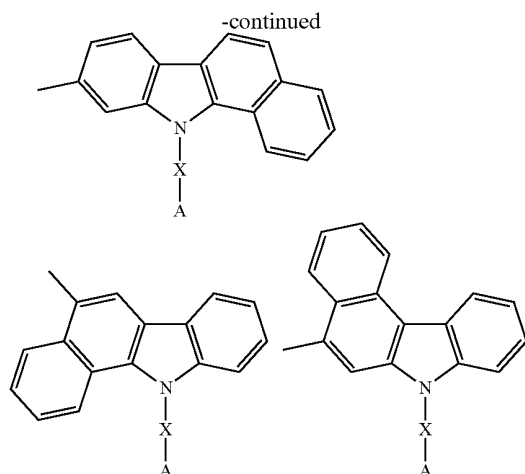
[0120] adjacent ones of Y₁ to Y₄ may be bonded to each other to form a ring structure;

[0121] p and q represent an integer of 1 to 4; r and s represent an integer of 1 to 3; and

[0122] when p and q are an integer of 2 to 4 and r and s are an integer of 2 to 3, a plurality of Y₁ to Y₄ may be the same or different.

[0123] When Y₁ to Y₄ are bonded to each other to form a ring structure, the ring structure is exemplified by structures represented by the following formulae.





[0124] Moreover, A_1 in the formula (1A) or (1B) is preferably selected from the group consisting of a substituted or unsubstituted pyridine ring, substituted or unsubstituted pyrimidine ring and substituted or unsubstituted triazine ring, more preferably selected from a substituted or unsubstituted pyrimidine ring or substituted or unsubstituted triazine ring.

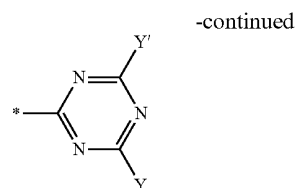
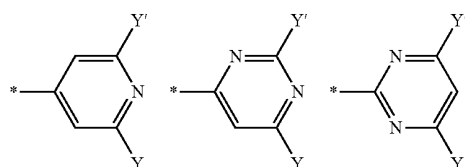
[0125] In the formula (1A) or (1B), A_1 is further preferably a substituted or unsubstituted pyrimidine ring.

[0126] In the formula (1A) or (1B), A_1 is preferably a substituted or unsubstituted quinazoline ring.

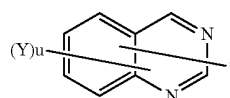
[0127] In the formula (1A) or (1B), X_1 is preferably a single bond or substituted or unsubstituted divalent aromatic hydrocarbon group having 6 to 30 ring carbon atoms, particularly preferably a benzene ring.

[0128] In the formula (1A) or (1B), when X_1 is a substituted or unsubstituted benzene ring, A_1 and the carbazolyl group, which are bonded to X_1 , are preferably in meta positions or para positions. Particularly preferably, X_1 is unsubstituted para-phenylene.

[0129] In the formula (1A) or (1B), the pyridine ring, pyrimidine ring and triazine ring are more preferably represented by the following formulae. In the formulae, Y and Y' represent a substituent. Examples of the substituent are the same groups as those represented by Y_1 to Y_4 as described above. Y and Y' may be the same or different. Preferred examples thereof are the substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, and the substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 ring carbon atoms. In the following formulae, * represents a bonding position to X_1 or X_2 .



[0130] In the formula (1A) or (1B), the quinazoline ring is represented by the following formula. Y represents a substituent. u represents an integer of 1 to 5. When u is an integer of 2 to 5, a plurality of Y may be the same or different. As the substituent Y, the same groups as those for the above Y_1 to Y_4 are usable, among which preferred examples thereof are the substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, and the substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 ring carbon atoms. Also in the following formulae, * represents a bonding position to X_1 or X_2 .



[0131] In the formulae (1A) to (1B), the alkyl group, alkoxy group, haloalkyl group, haloalkoxy group and alkylsilyl group, which are represented by Y_1 to Y_5 , may be linear, branched or cyclic.

[0132] In the formulae (1A) to (2B), examples of the alkyl group having 1 to 20 carbon atoms are a methyl group, ethyl group, propyl group, isopropyl group, n-butyl group, s-butyl group, isobutyl group, t-butyl group, n-pentyl group, n-hexyl group, n-heptyl group, n-octyl group, n-nonyl group, n-decyl group, n-undecyl group, n-dodecyl group, n-tridecyl group, n-tetradecyl group, n-pentadecyl group, n-hexadecyl group, n-heptadecyl group, n-octadecyl group, neo-pentyl group, 1-methylpentyl group, 2-methylpentyl group, 1-pentylhexyl group, 1-butylpentyl group, 1-heptyloctyl group, 3-methylpentyl group, cyclopentyl group, cyclohexyl group, cycloheptyl group, cyclooctyl group and 3,5-tetramethylcyclohexyl group. An alkyl group having 1 to 10 carbon atoms is preferable, examples of which are a methyl group, ethyl group, propyl group, isopropyl group, n-butyl group, s-butyl group, isobutyl group, t-butyl group, cyclopentyl group, cyclohexyl group and cycloheptyl group.

[0133] As the alkoxy group having 1 to 20 carbon atoms, an alkoxy group having 1 to 6 carbon atoms is preferable and specific examples thereof are a methoxy group, ethoxy group, propoxy group, butoxy group, pentyloxy group, and hexyloxy group.

[0134] The haloalkyl group having 1 to 20 carbon atoms is exemplified by a haloalkyl group provided by substituting the alkyl group having 1 to 20 carbon atoms with one or more halogen atoms. Preferred one of the halogen atoms is fluorine. The haloalkyl group is exemplified by a trifluoromethyl group and a 2,2,2-trifluoroethyl group.

[0135] The haloalkoxy group having 1 to 20 carbon atoms is exemplified by a haloalkoxy group provided by substituting

the alkoxy group having 1 to 20 carbon atoms with one or more halogen atoms. Preferred one of the halogen atoms is fluorine.

[0136] Examples of the alkylsilyl group having 1 to 10 carbon atoms are a trimethylsilyl group, triethylsilyl group, tributylsilyl group, dimethylethylsilyl group, dimethylisopropylsilyl group, dimethylpropylsilyl group, dimethylbutylsilyl group, dimethyl-tertiary-butylsilyl group and diethylisopropylsilyl group.

Examples of the arylsilyl group having 6 to 30 carbon atoms are a phenyldimethylsilyl group, diphenylmethylsilyl group, diphenyl-tertiary-butylsilyl group and triphenylsilyl group.

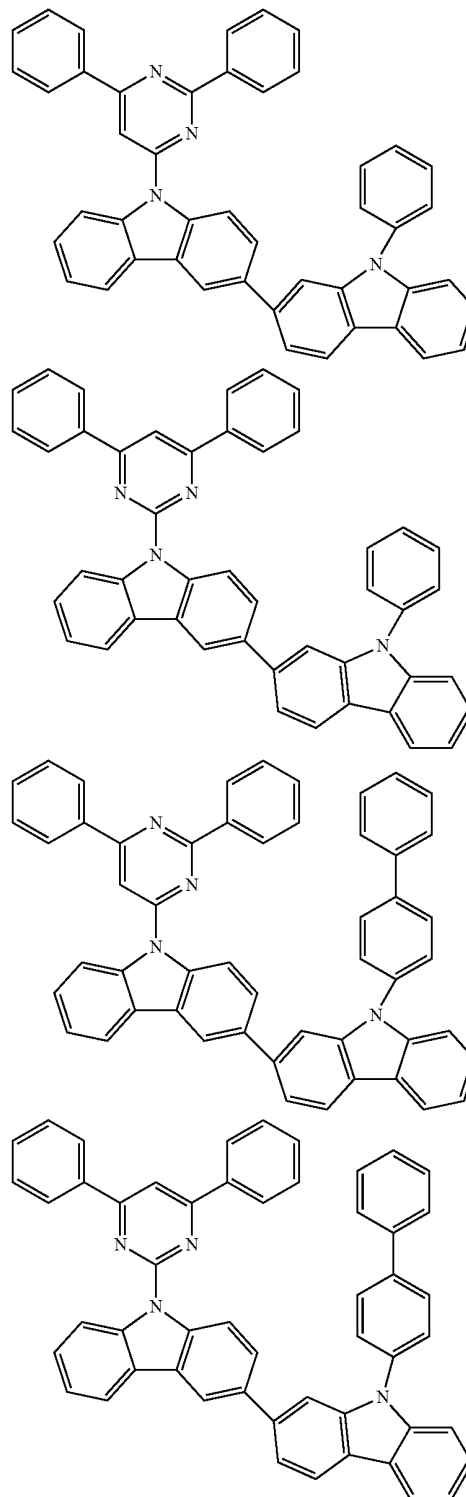
[0137] Examples of the aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 ring carbon atoms are a pyroryl group, pyrazinyl group, pyridinyl group, indolyl group, isoindolyl group, furyl group, benzofuranyl group, isobenzofuranyl group, dibenzofuranyl group, dibenzothiophenyl group, quinolyl group, isoquinolyl group, quinoxalinyl group, carbazolyl group, phenantridinyl group, acridinyl group, phenanthrolinyl group, thienyl group and a group formed from a pyridine ring, pyrazine ring, pyrimidine ring, pyridazine ring, triazine ring, indol ring, quinoline ring, acridine ring, pirrolidine ring, dioxane ring, piperidine ring, morpholine ring, piperadine ring, carbazole ring, furan ring, thiophene ring, oxazole ring, oxadiazole ring, benzoxoxazole ring, thiazole ring, thiadiazole ring, benzothiazole ring, triazole ring, imidazole ring, benzoimidazole ring, pyrane ring and dibenzofuran ring. Among the above, the aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 10 ring carbon atoms is preferable.

Examples of the aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms are a phenyl group, naphthyl group, phenanthryl group, biphenyl group, terphenyl group, quarterphenyl group, fluoranthenyl group, triphenylenyl group, phenanthrenyl group, pyrenyl group, chrysenyl group, fluorenyl group, and 9,9-dimethylfluorenyl group. Among the above, the aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 20 ring carbon atoms is preferable.

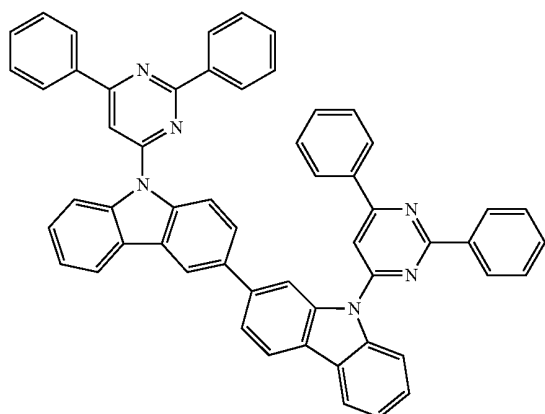
[0138] When A_1 , A_2 , X_1 , X_2 and Y_1 to Y_5 in the formula (1A) or (1B) each have one or more substituents, the substituents are preferably a linear, branched or cyclic alkyl group having 1 to 20 carbon atoms; linear, branched or cyclic alkoxy group having 1 to 20 carbon atoms; linear, branched or cyclic haloalkyl group having 1 to 20 carbon atoms; linear, branched or cyclic alkylsilyl group having 1 to 10 carbon atoms; arylsilyl group having 6 to 30 ring carbon atoms; cyano group; halogen atom; aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms; or aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 ring carbon atoms.

[0139] Examples of the linear, branched or cyclic alkyl group having 1 to 20 carbon atoms; linear, branched or cyclic alkoxy group having 1 to 20 carbon atoms; linear, branched or cyclic haloalkyl group having 1 to 20 carbon atoms; linear, branched or cyclic alkylsilyl group having 1 to 10 carbon atoms; arylsilyl group having 6 to 30 ring carbon atoms; aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms; and aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 ring carbon atoms are the above-described groups. The halogen atom is exemplified by a fluorine atom.

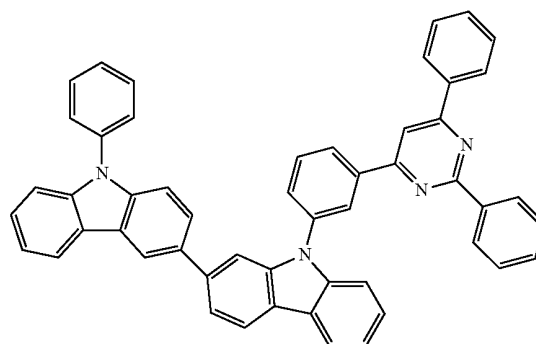
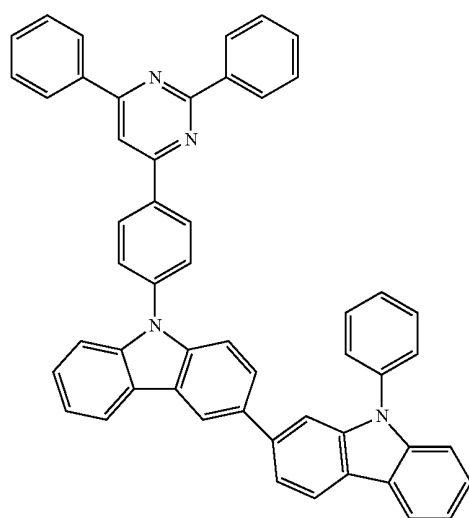
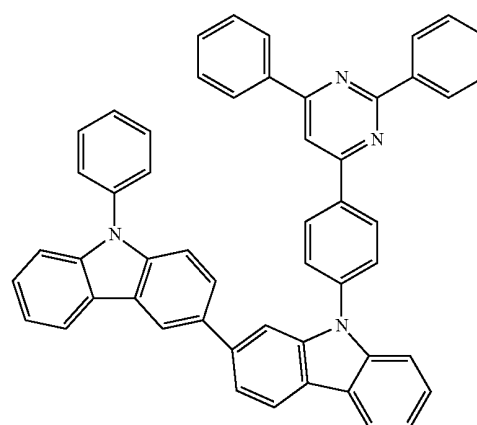
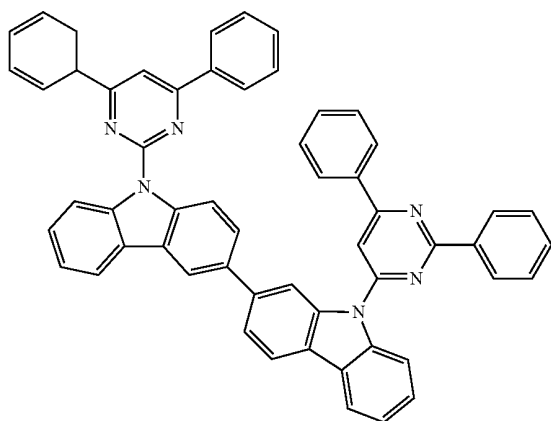
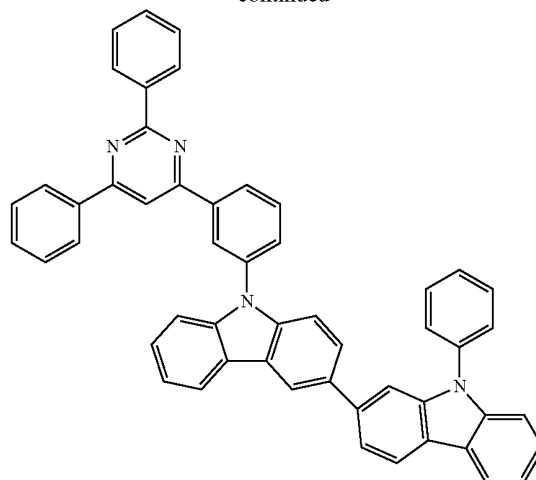
[0140] Examples of compounds for the biscarbazole derivative according to this exemplary embodiment represented by the formula (1A) or (1B) are as follows.



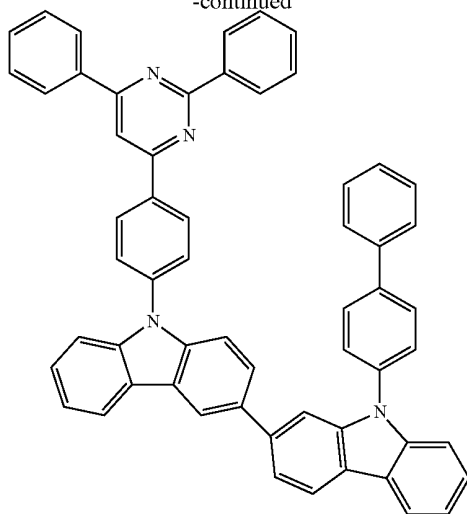
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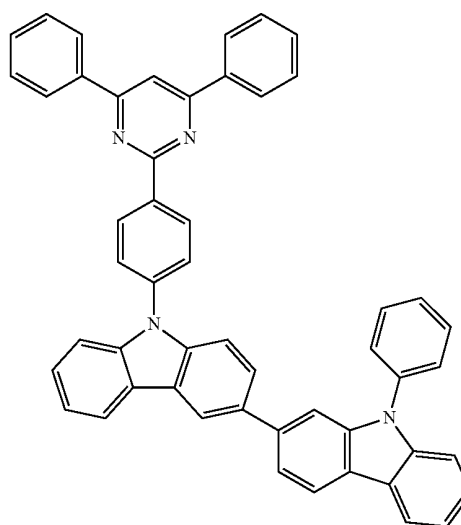
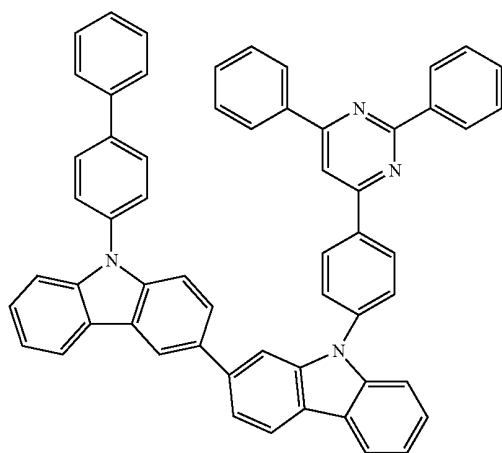
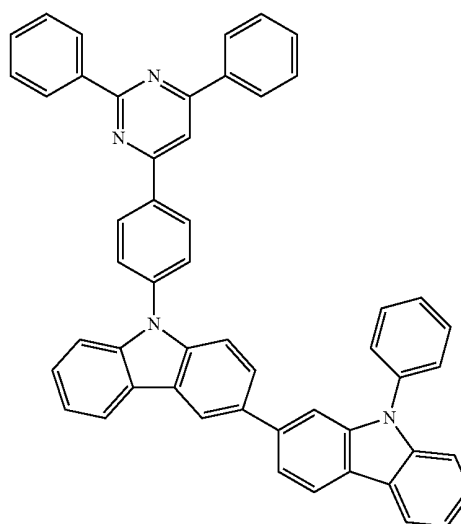
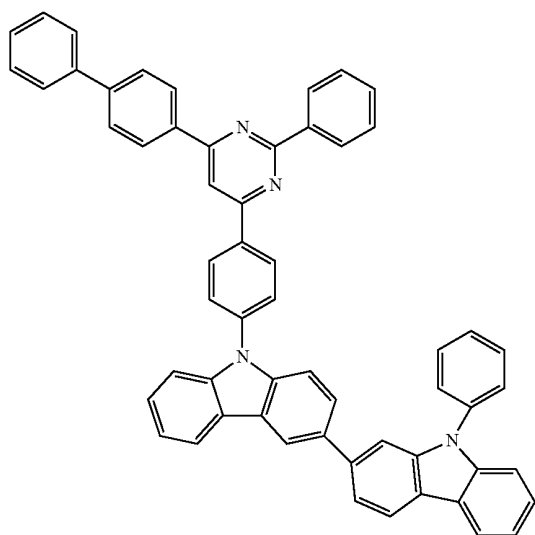
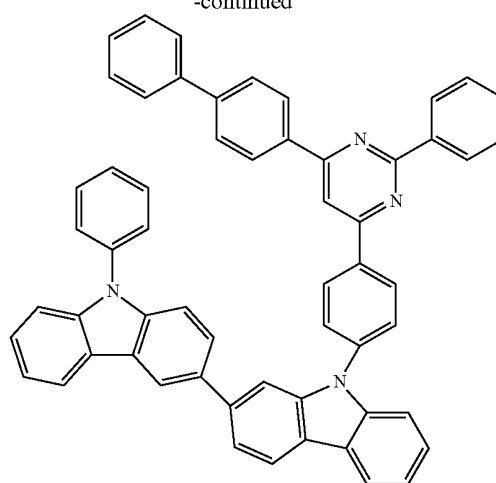
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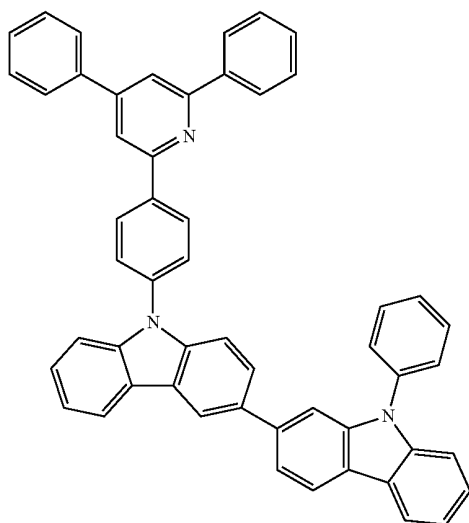
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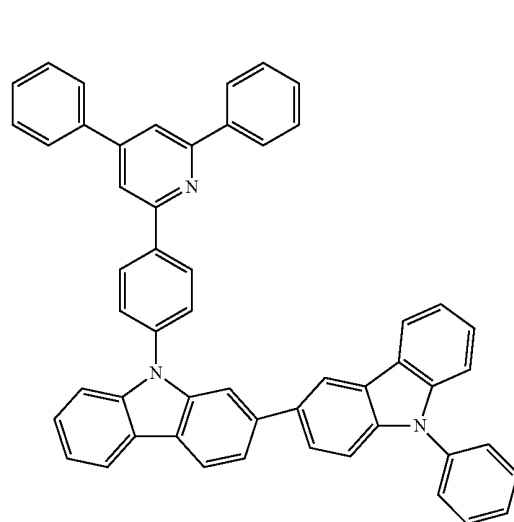
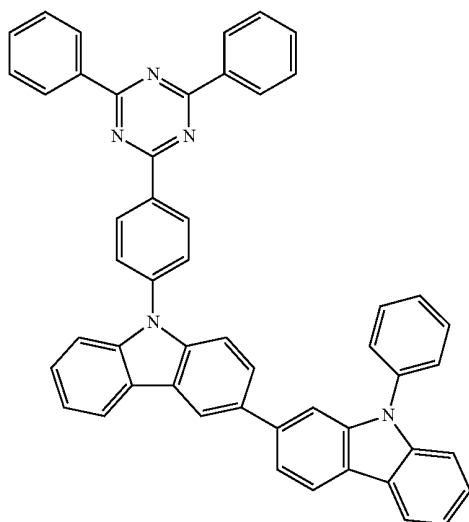
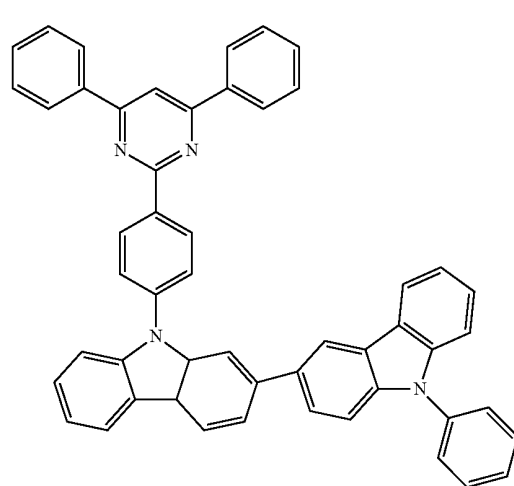
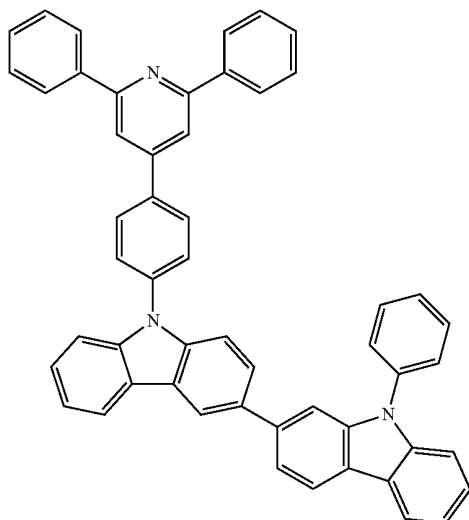
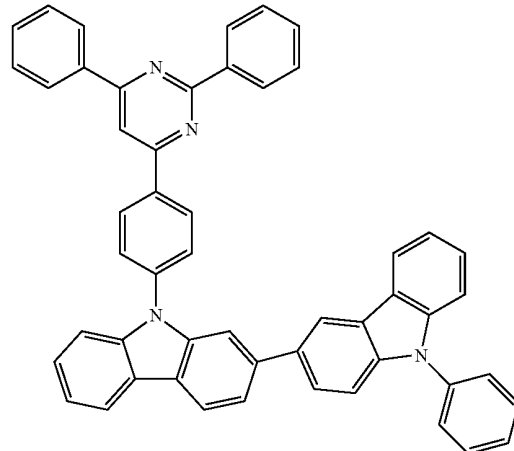
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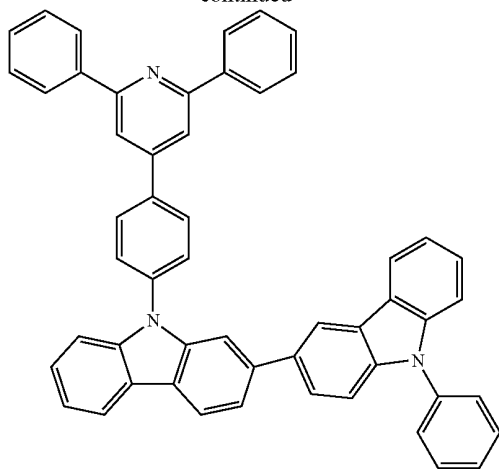
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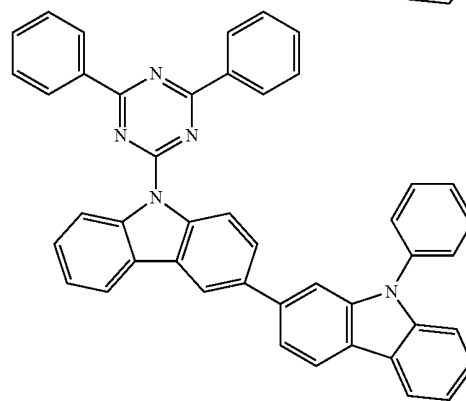
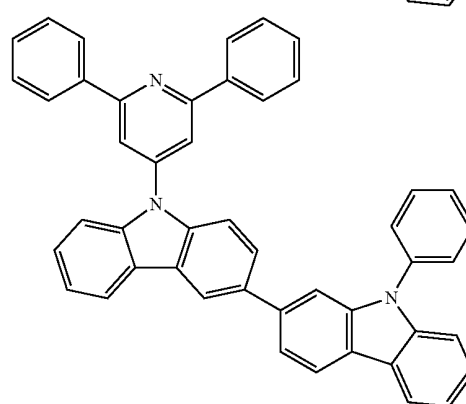
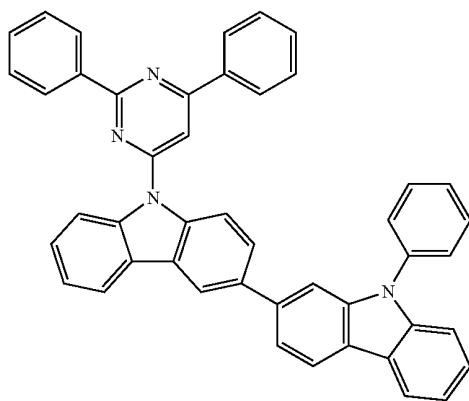
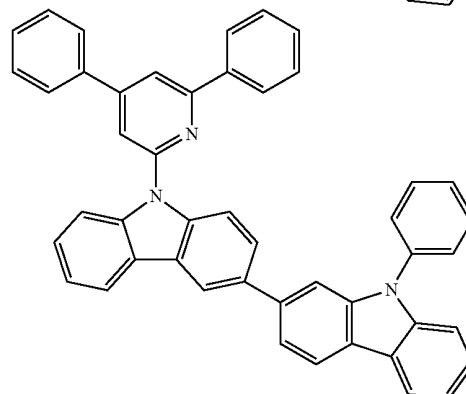
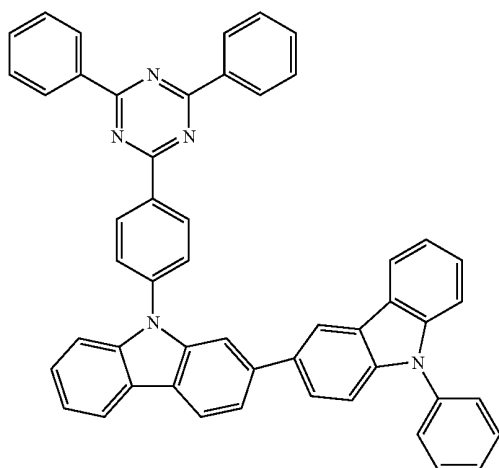
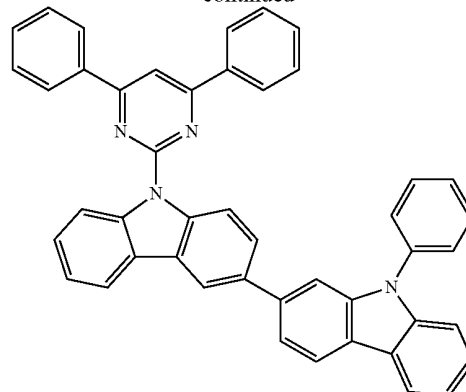
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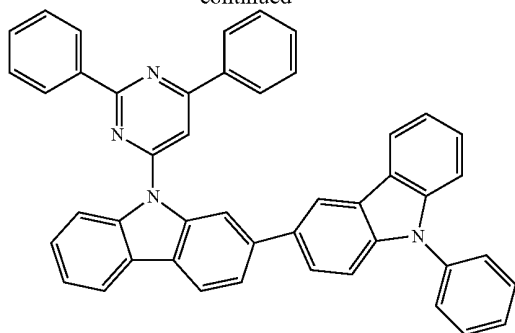
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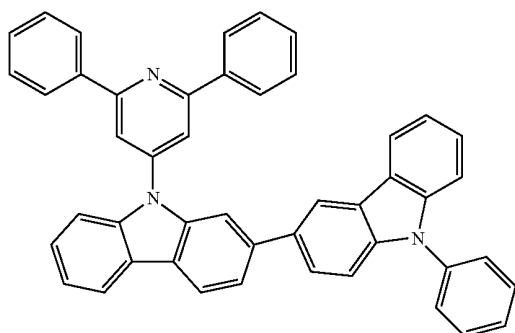
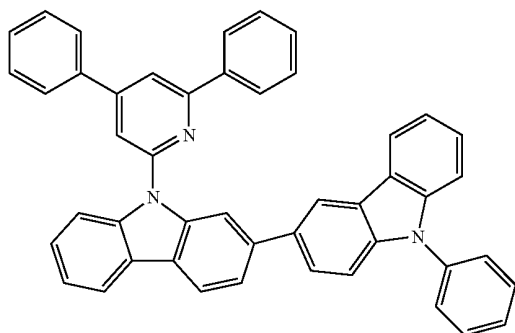
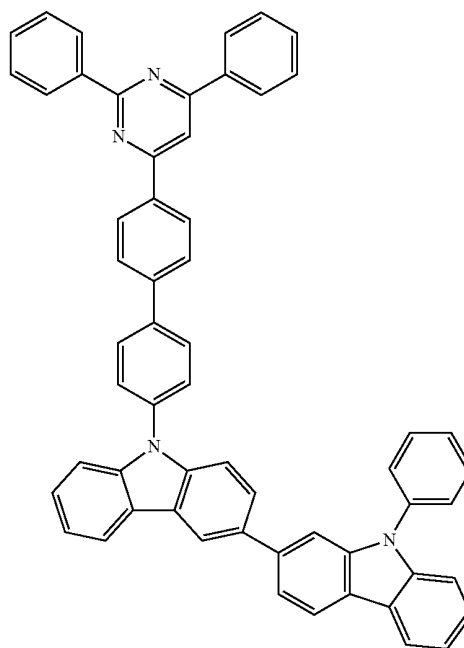
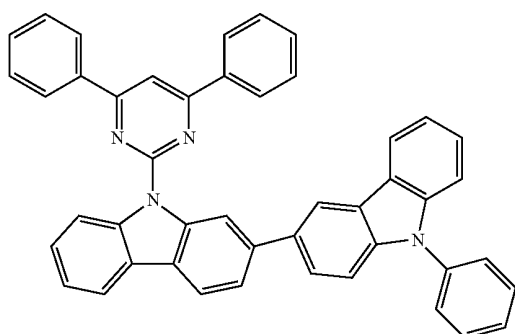
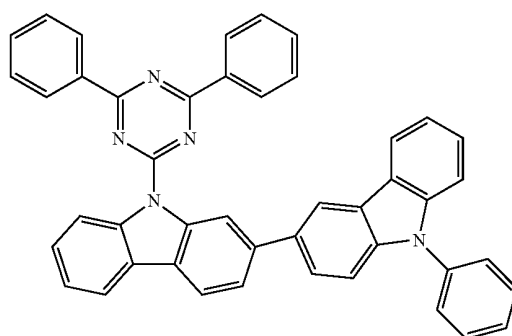
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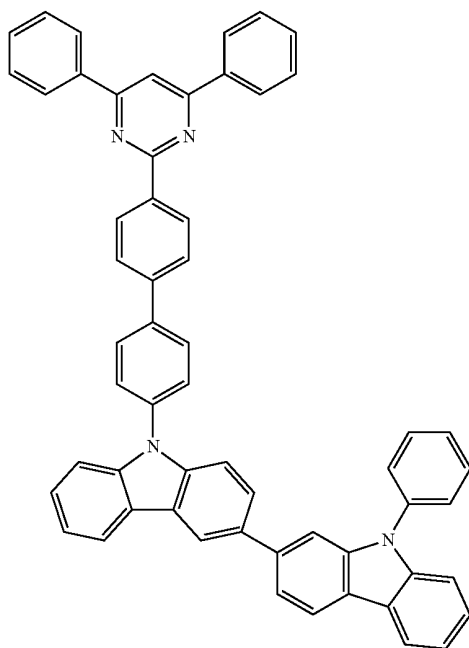
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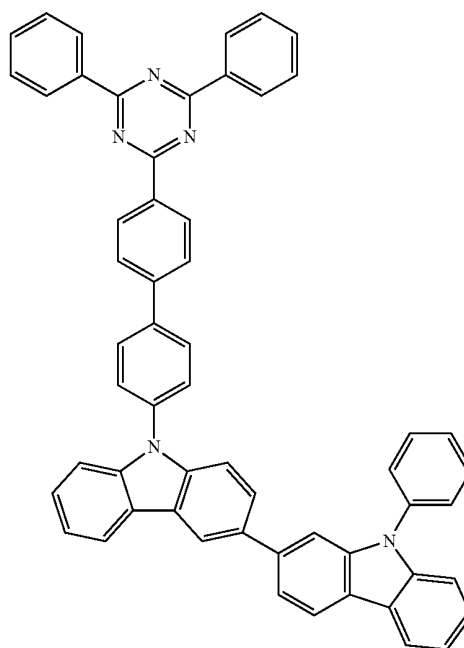
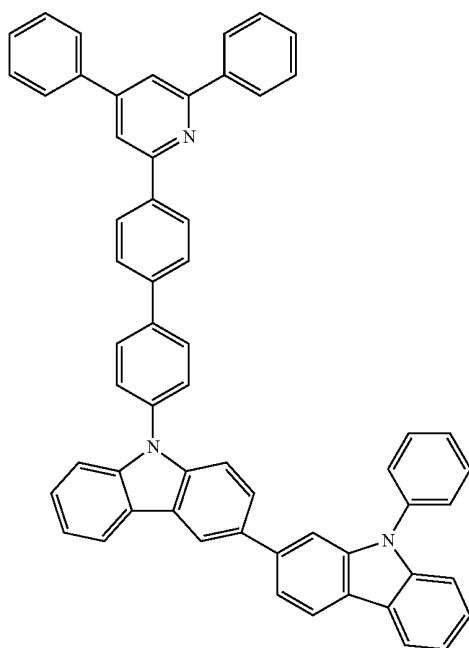
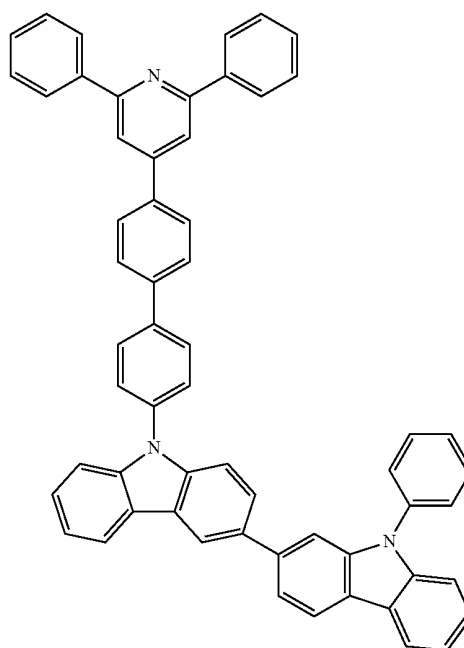
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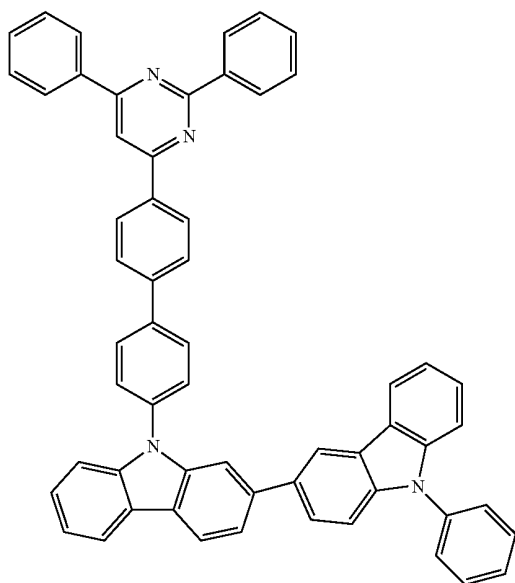
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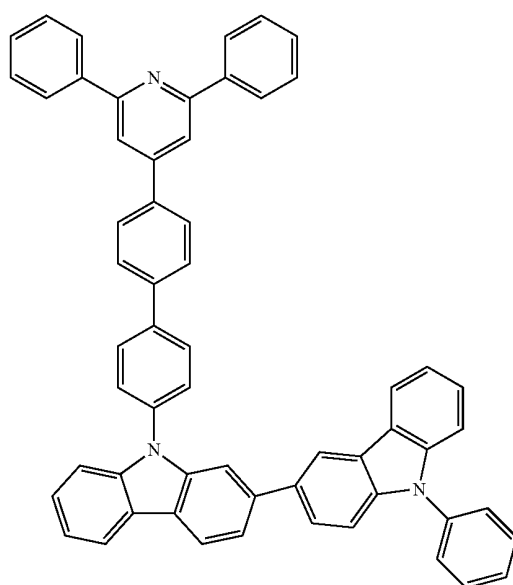
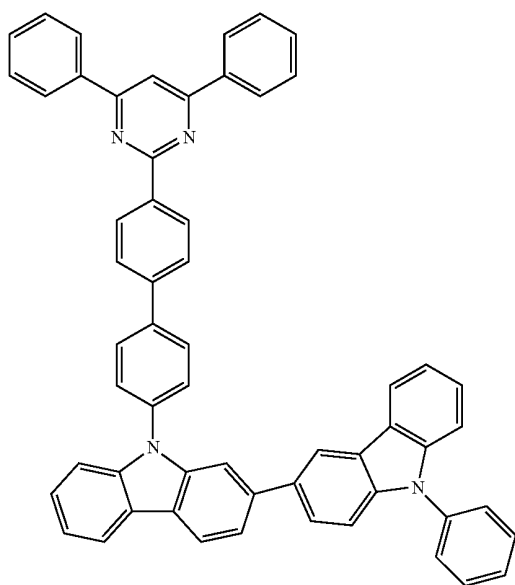
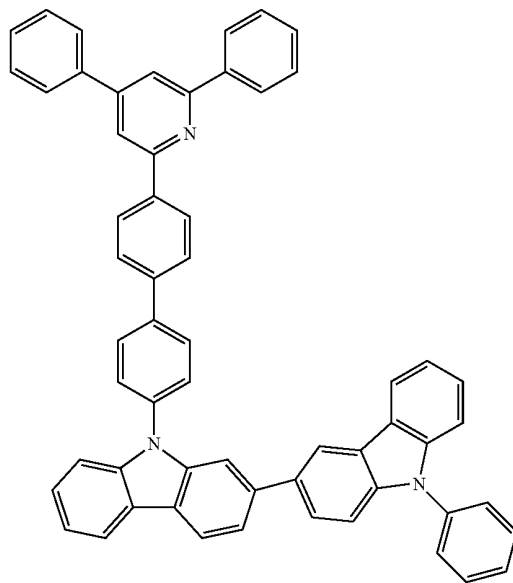
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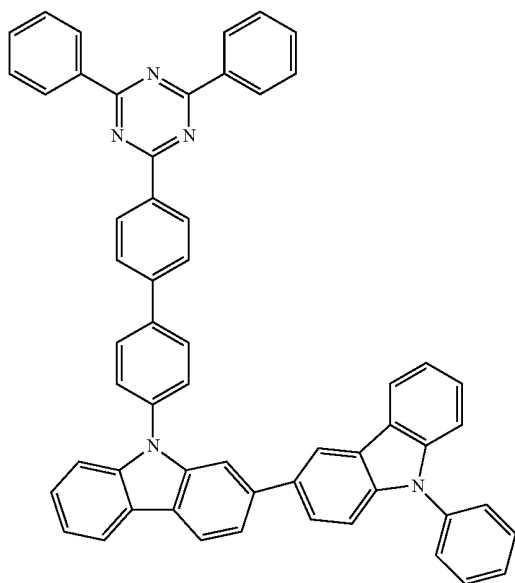
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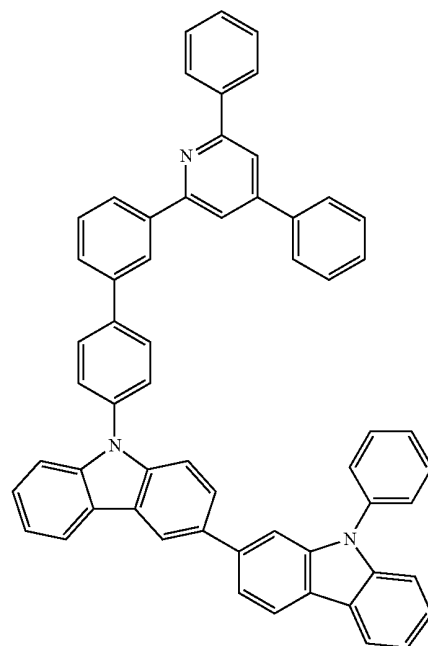
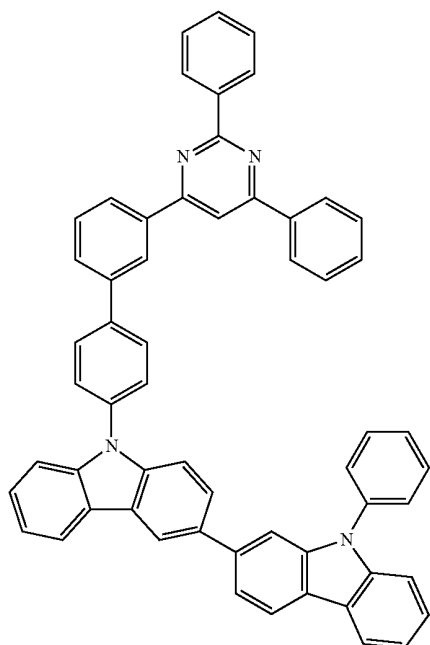
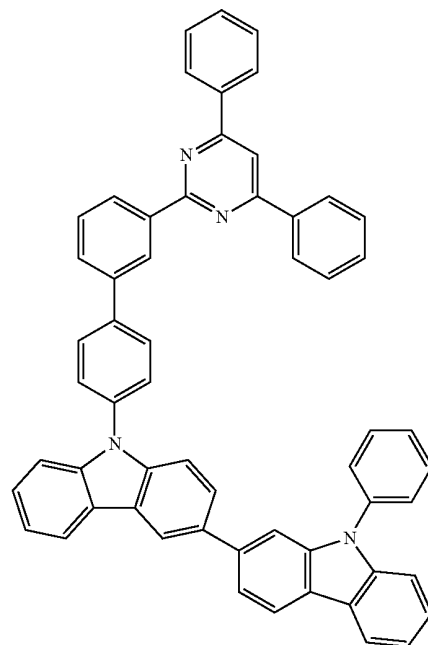
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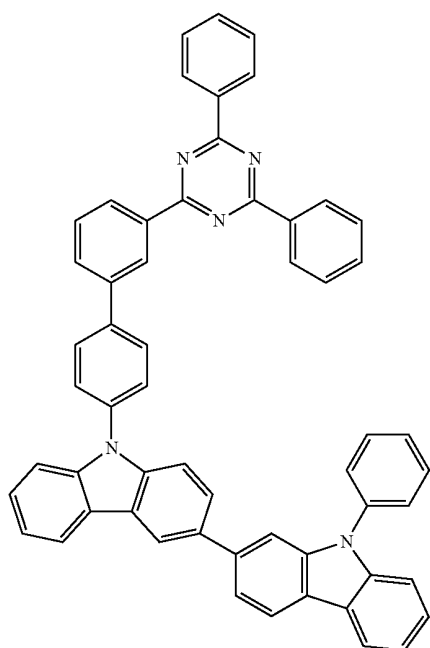
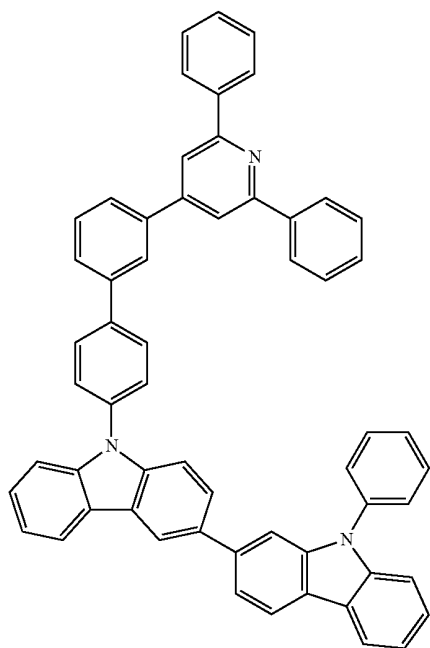
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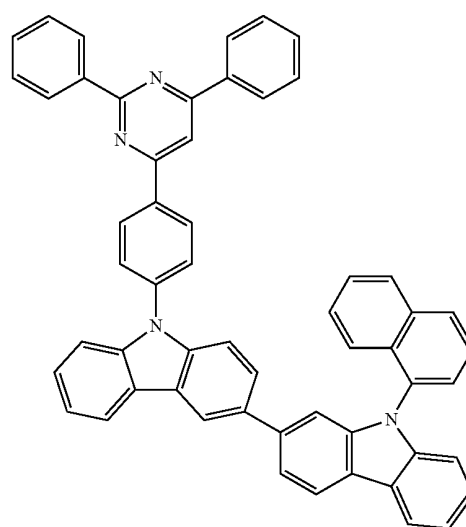
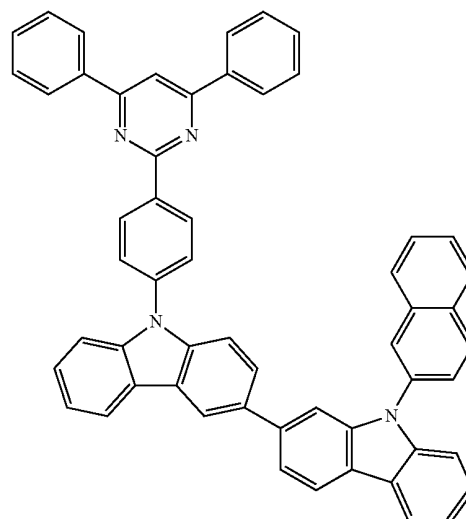
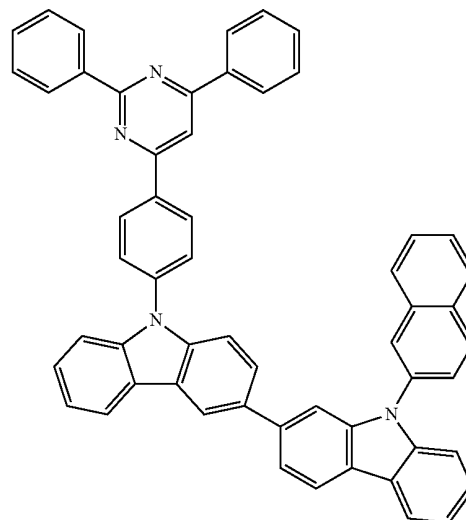
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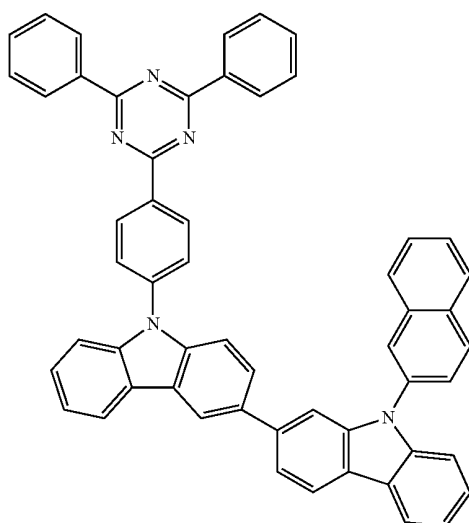
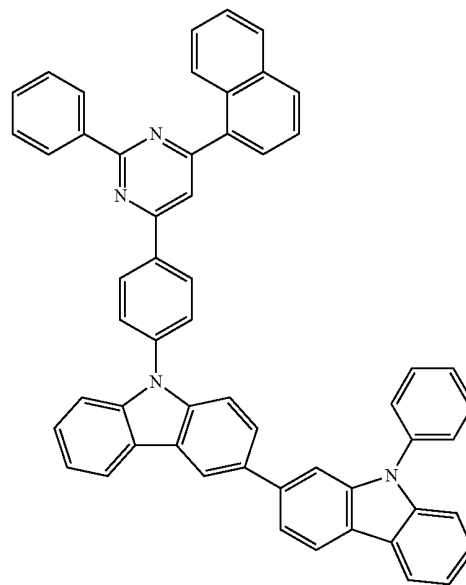
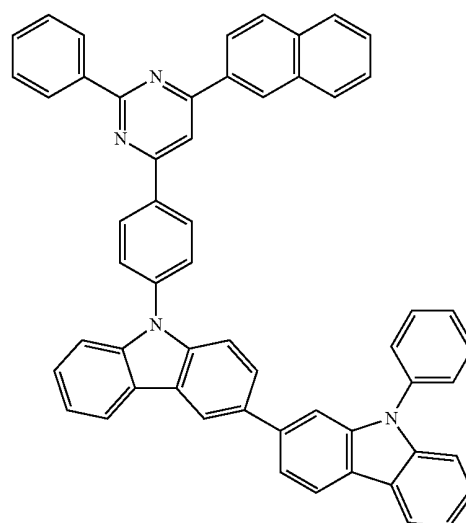
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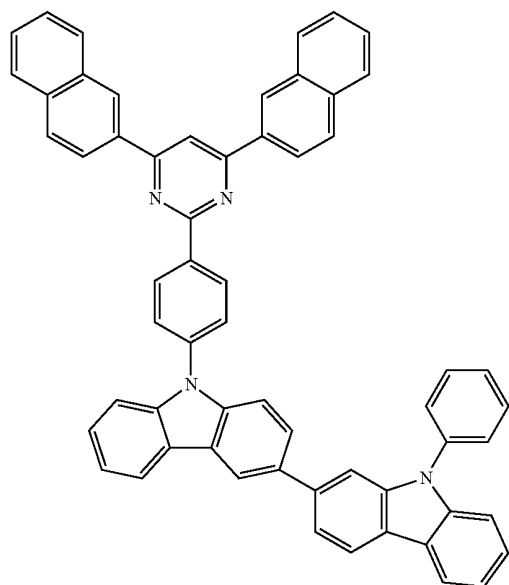
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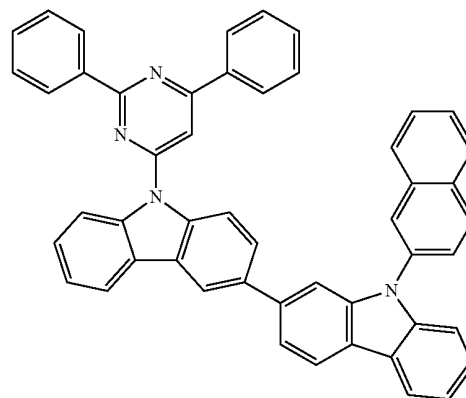
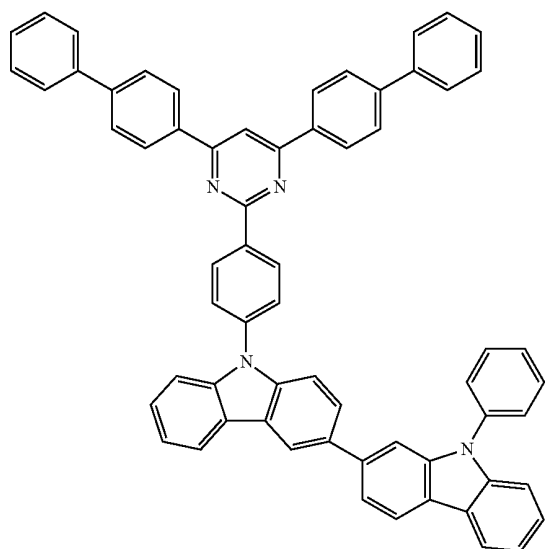
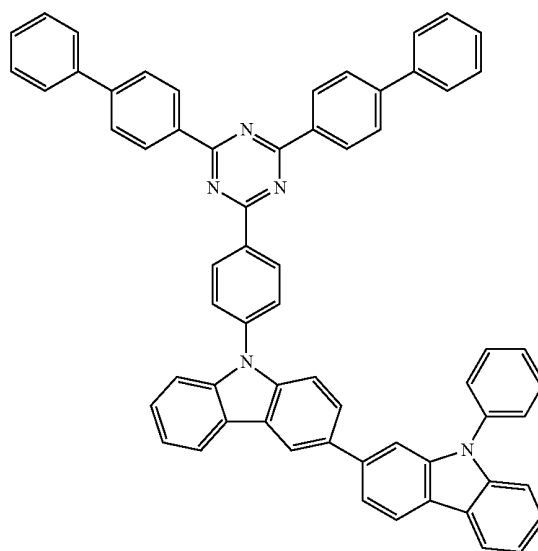
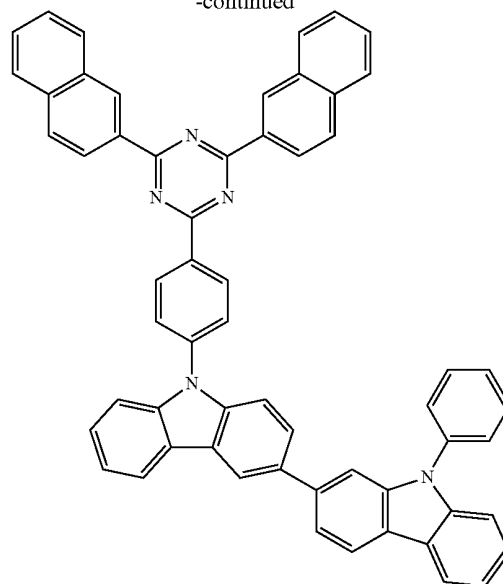
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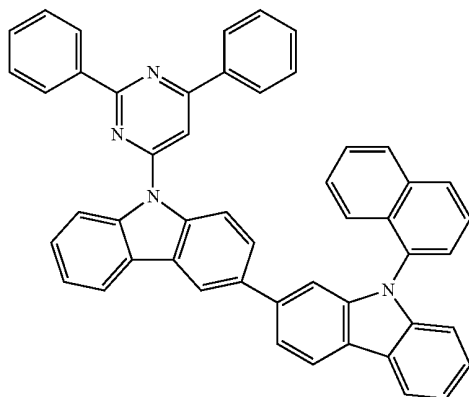
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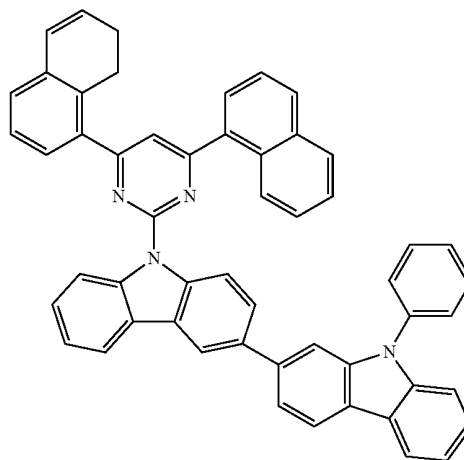
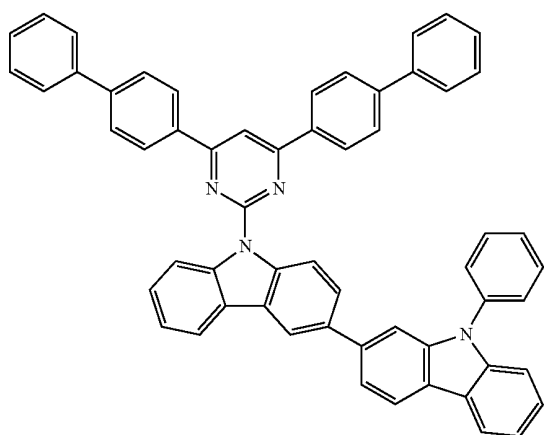
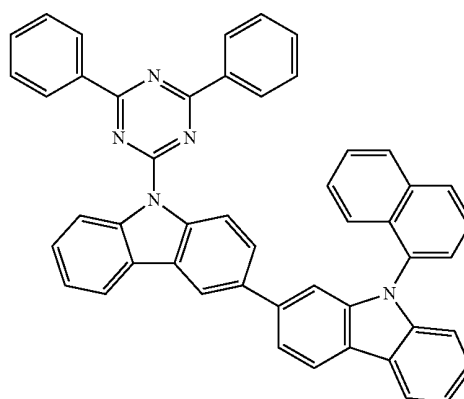
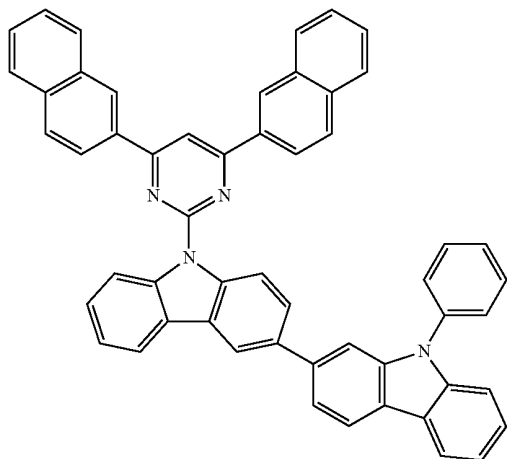
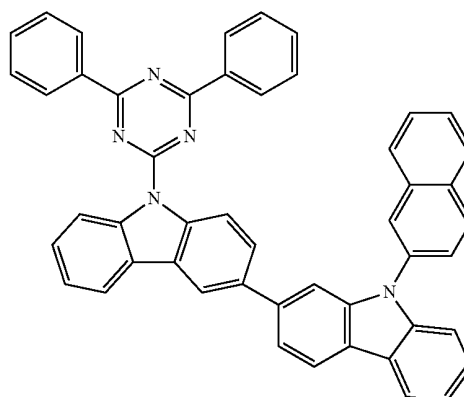
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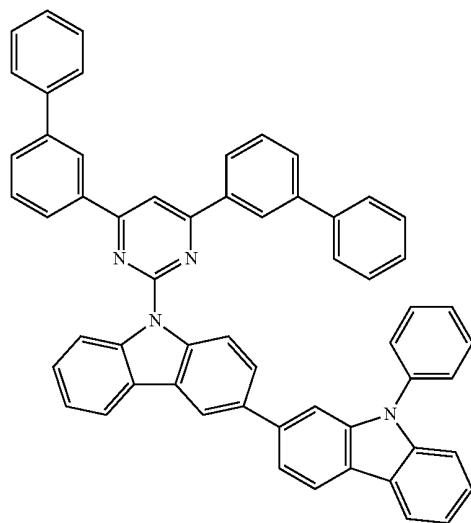
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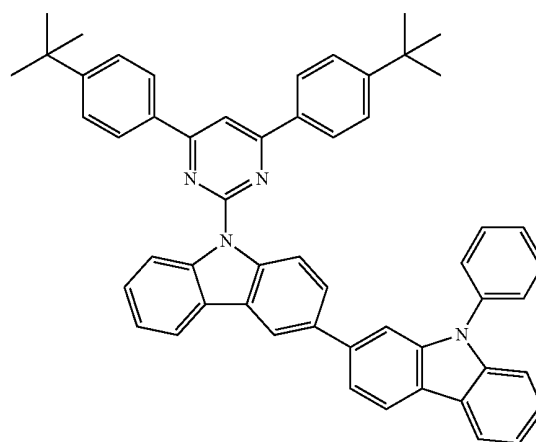
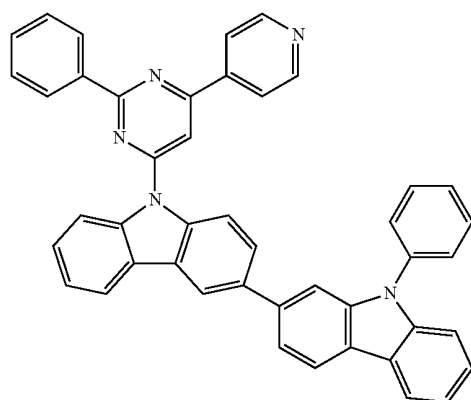
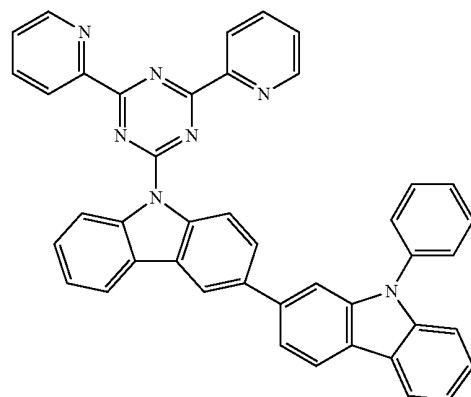
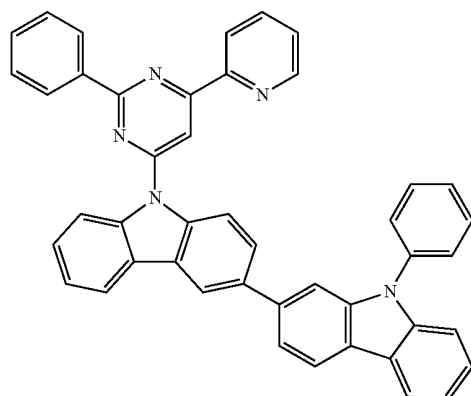
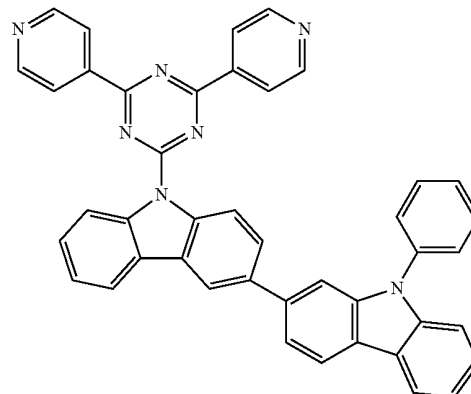
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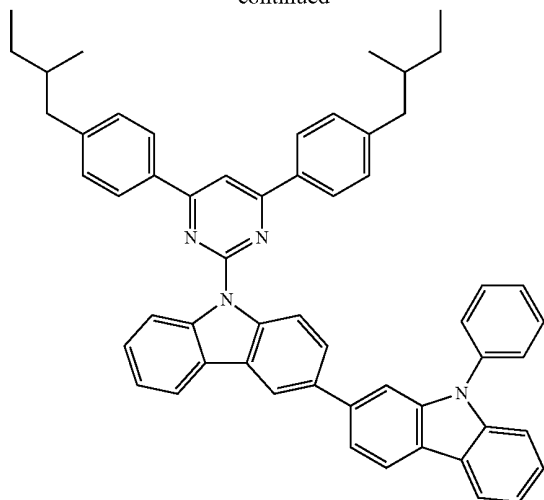
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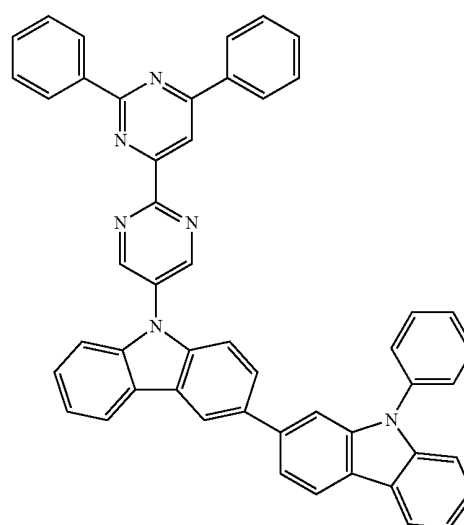
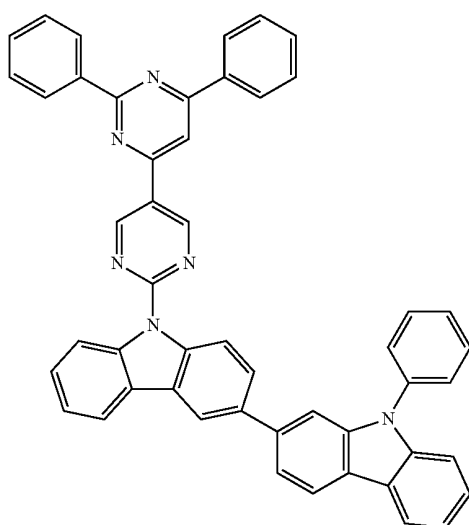
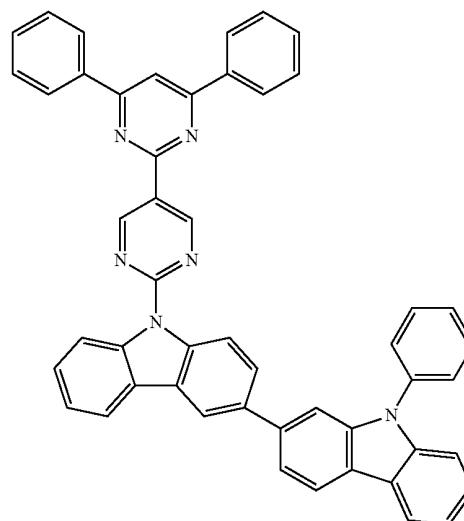
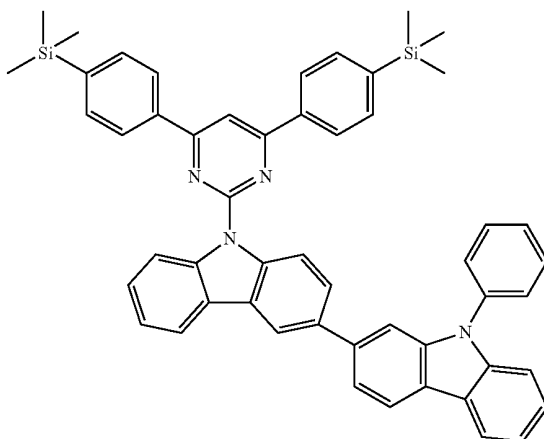
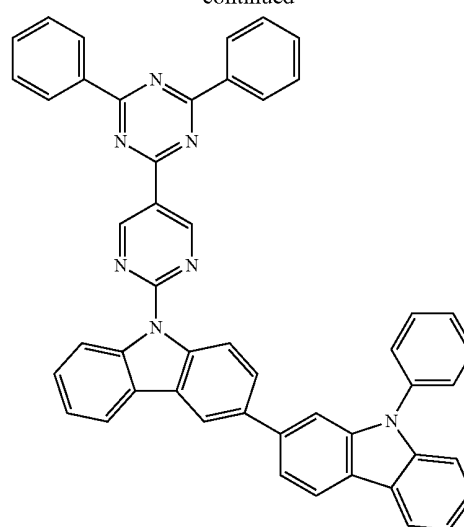
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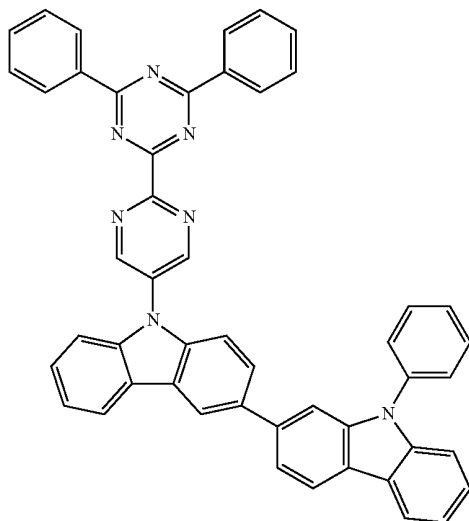
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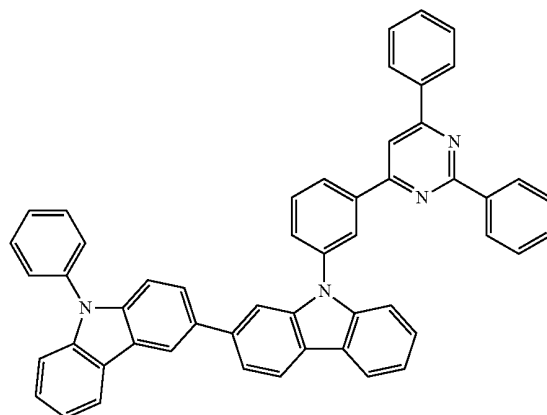
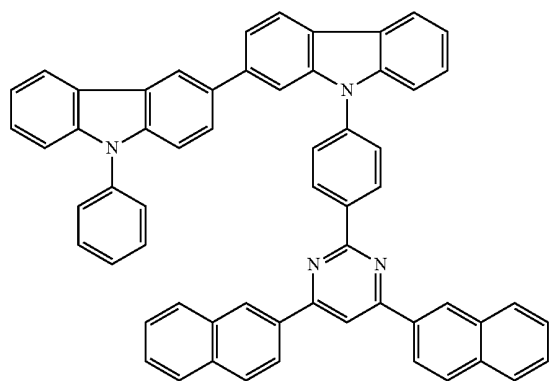
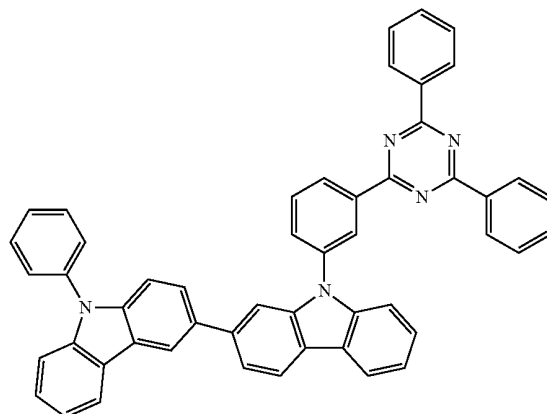
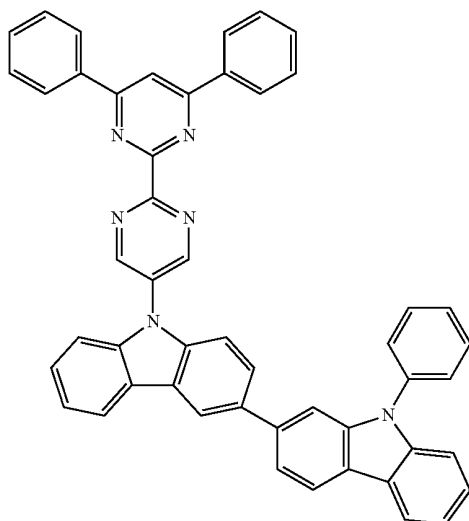
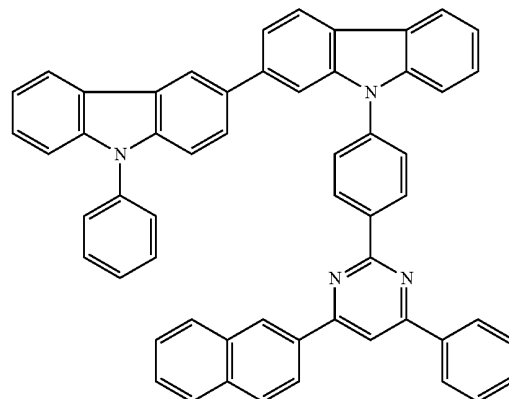
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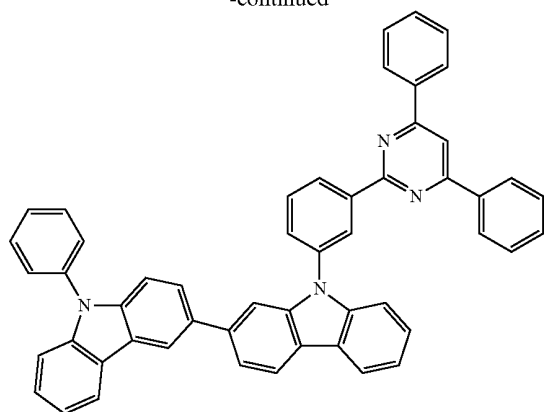
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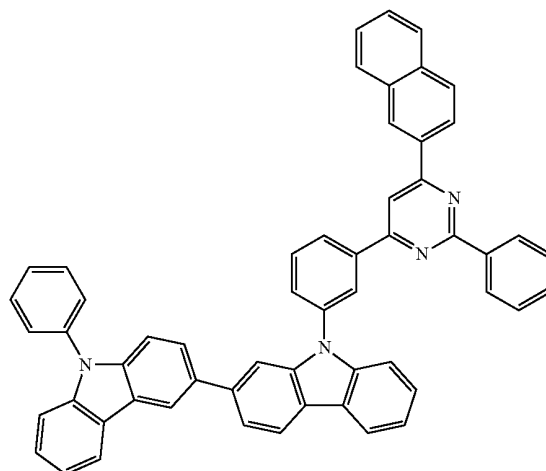
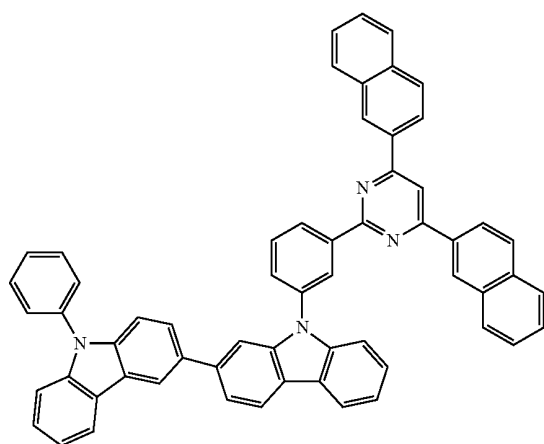
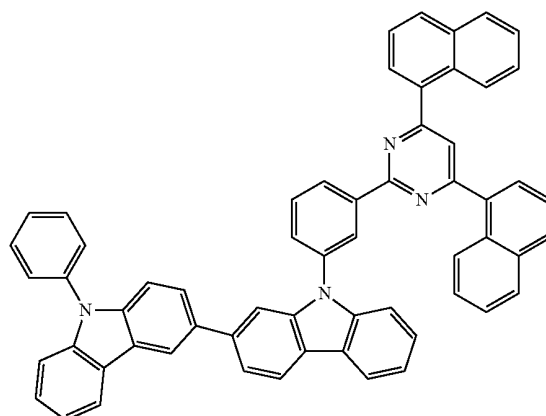
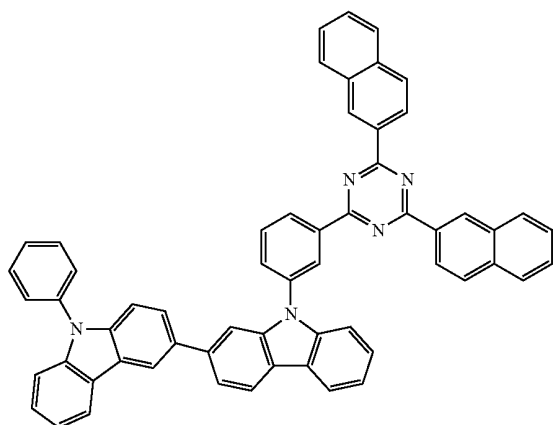
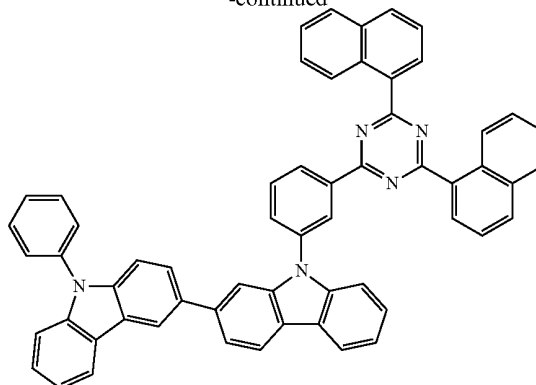
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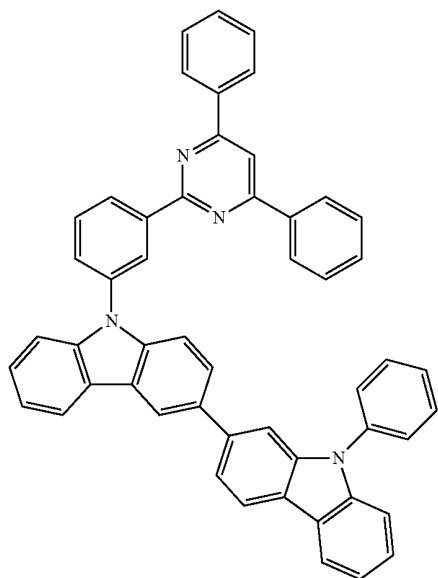
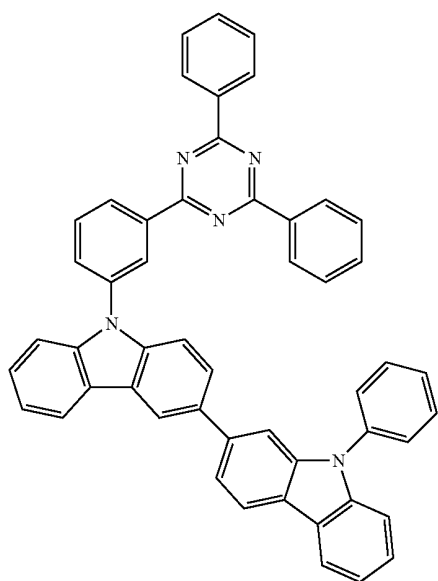
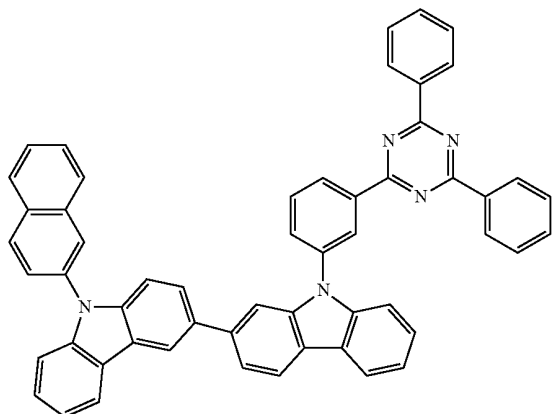
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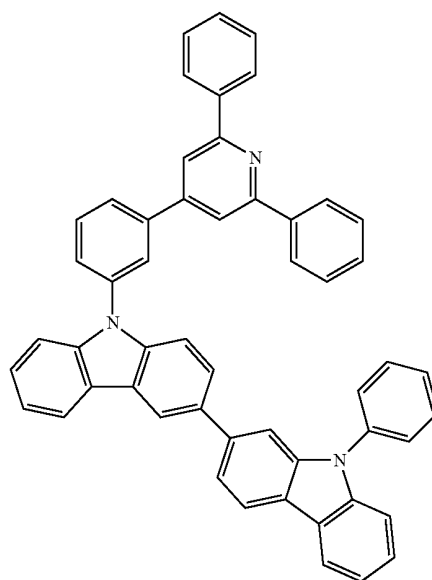
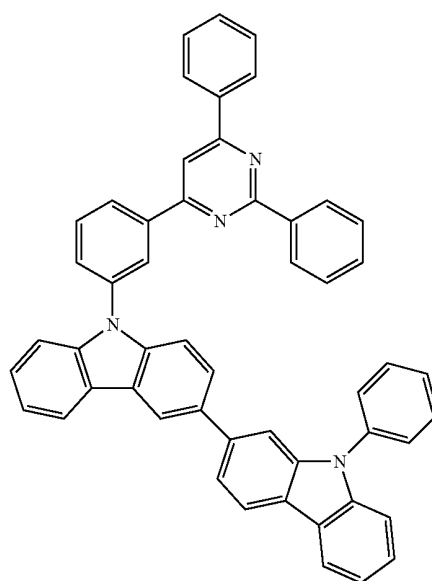
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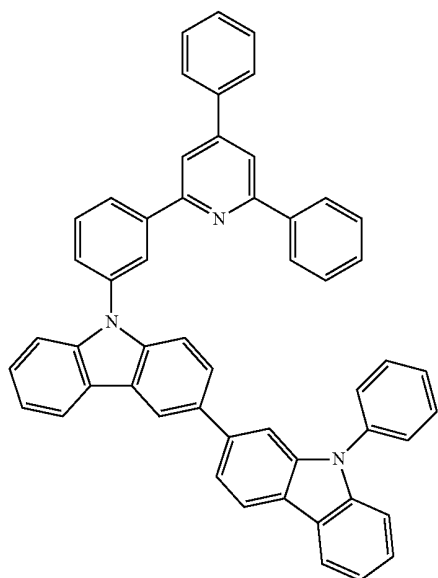
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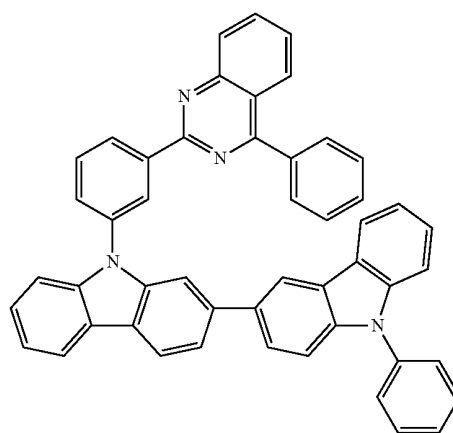
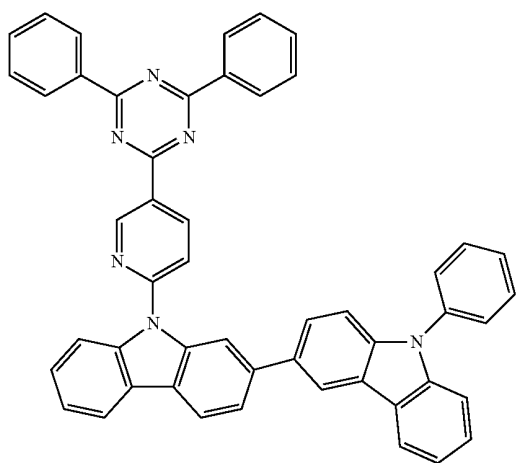
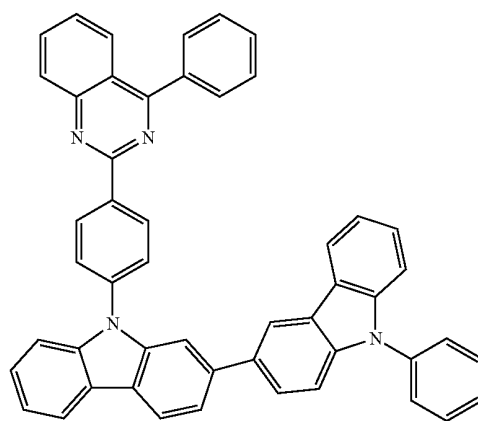
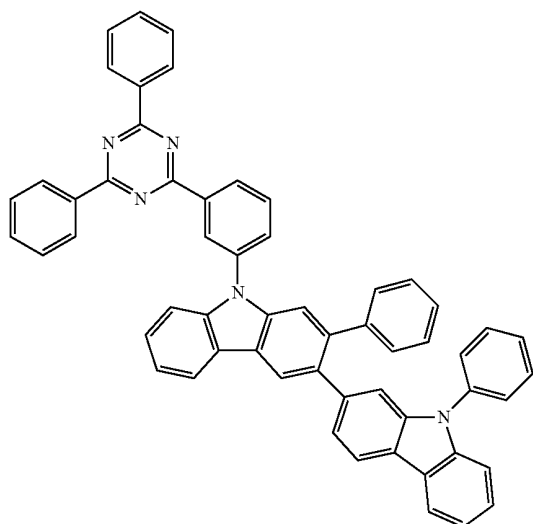
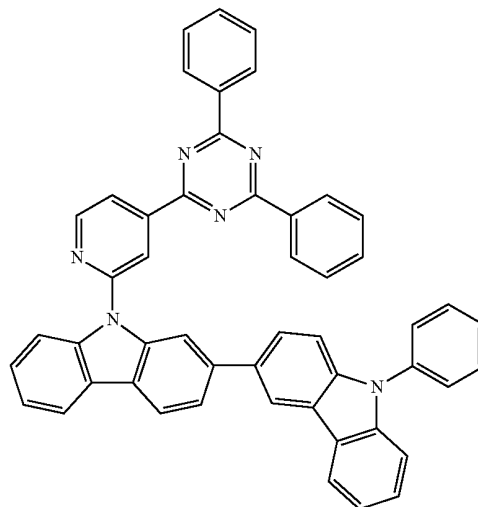
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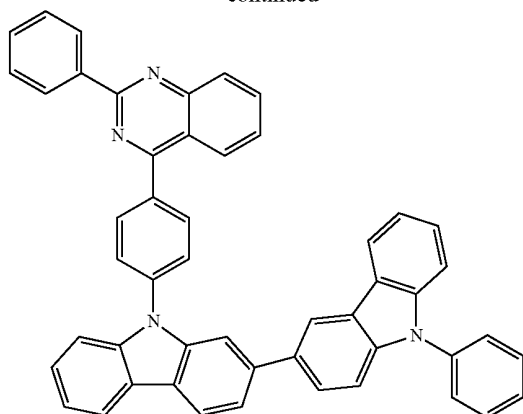
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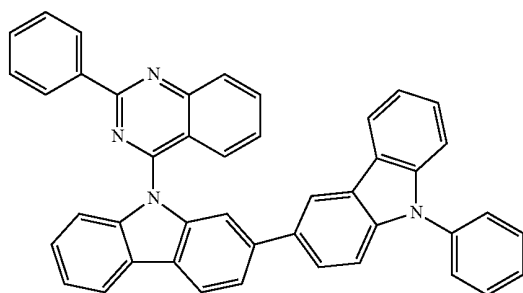
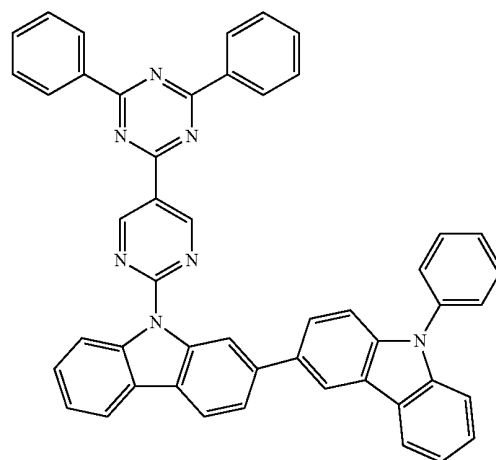
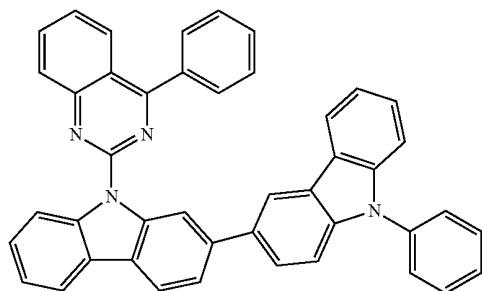
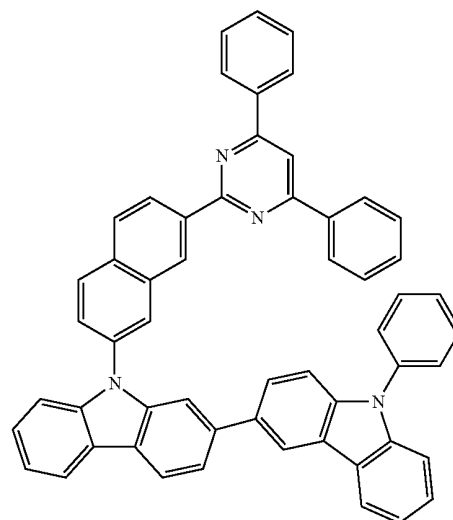
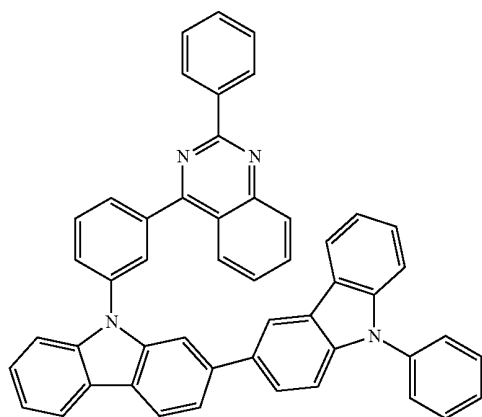
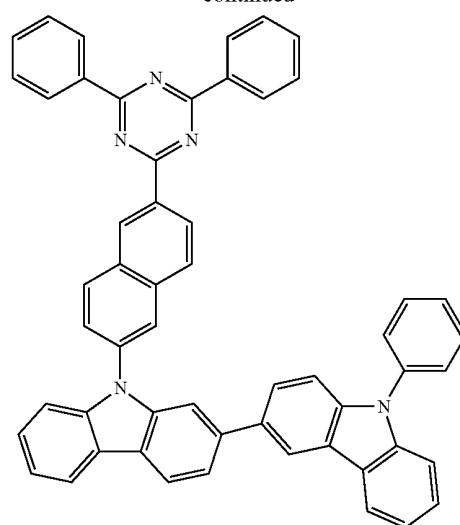
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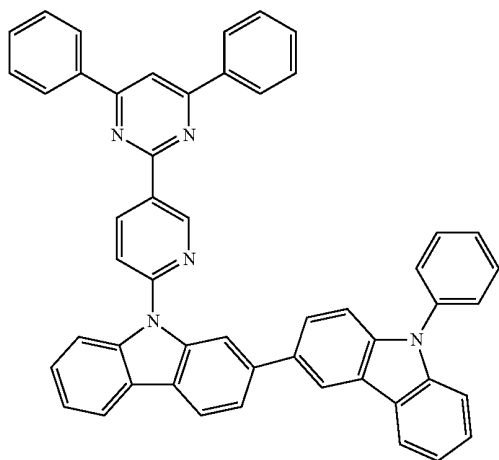
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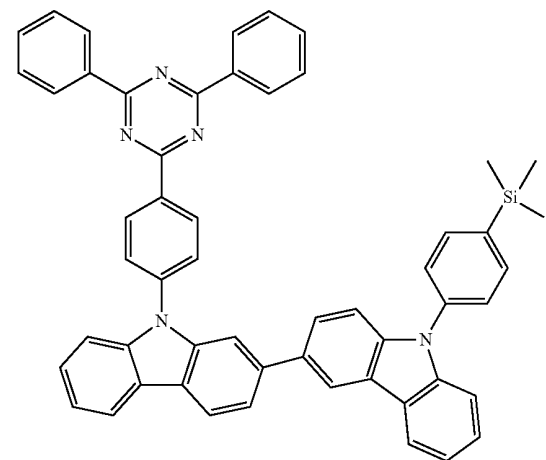
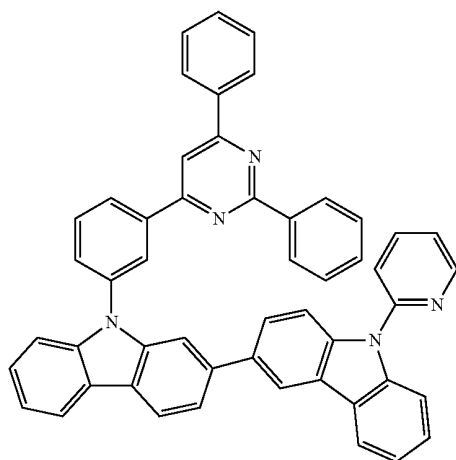
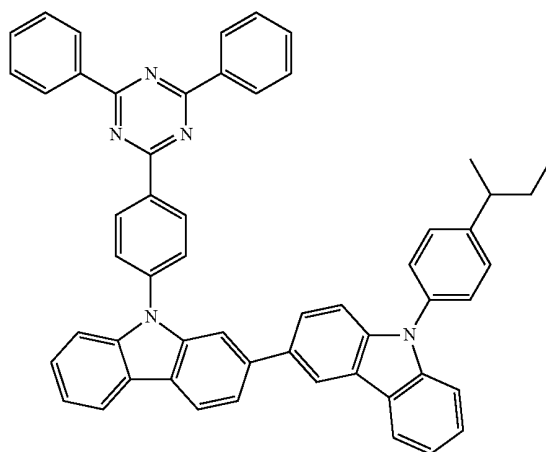
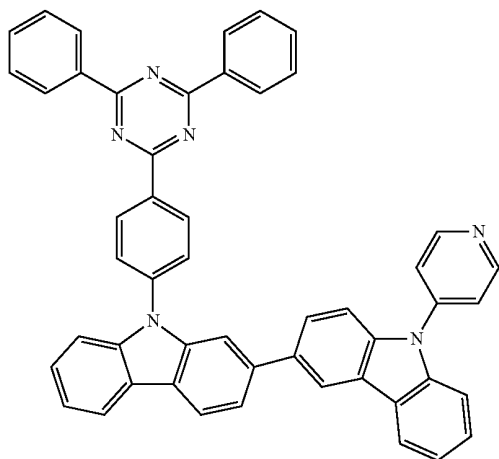
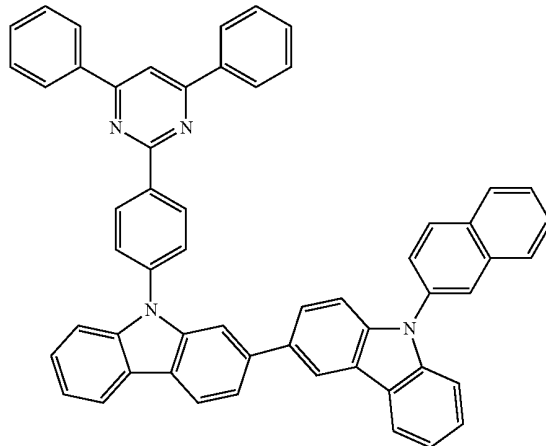
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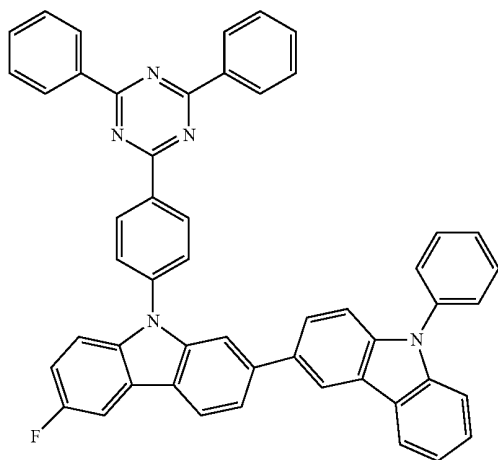
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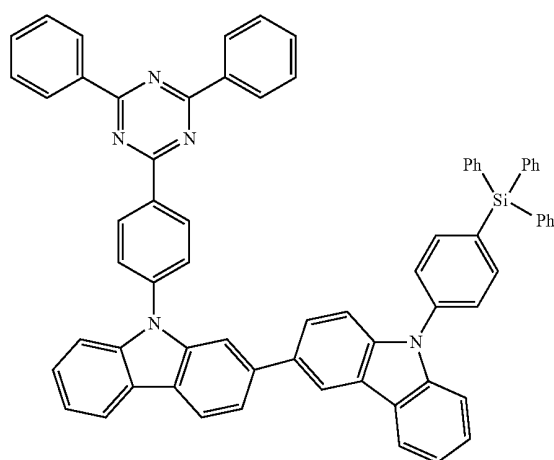
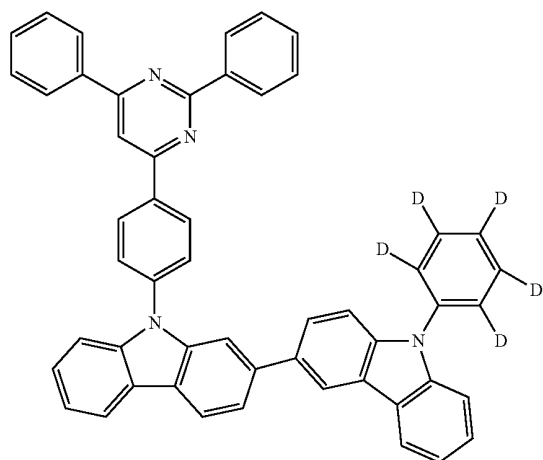
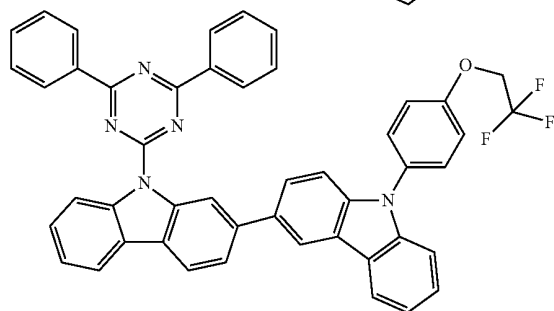
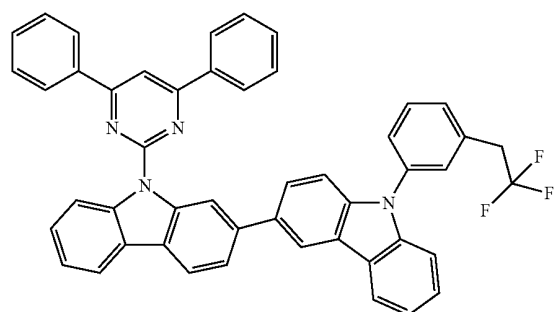
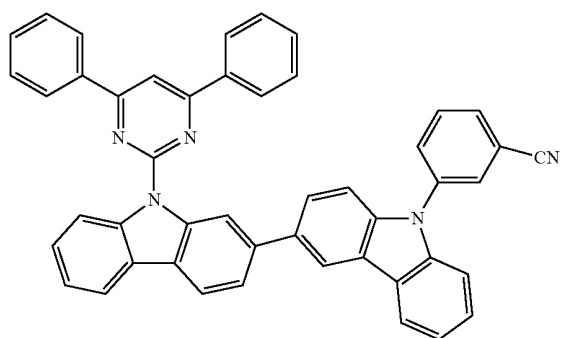
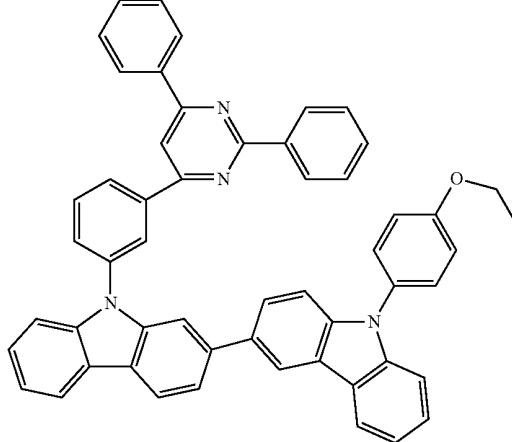
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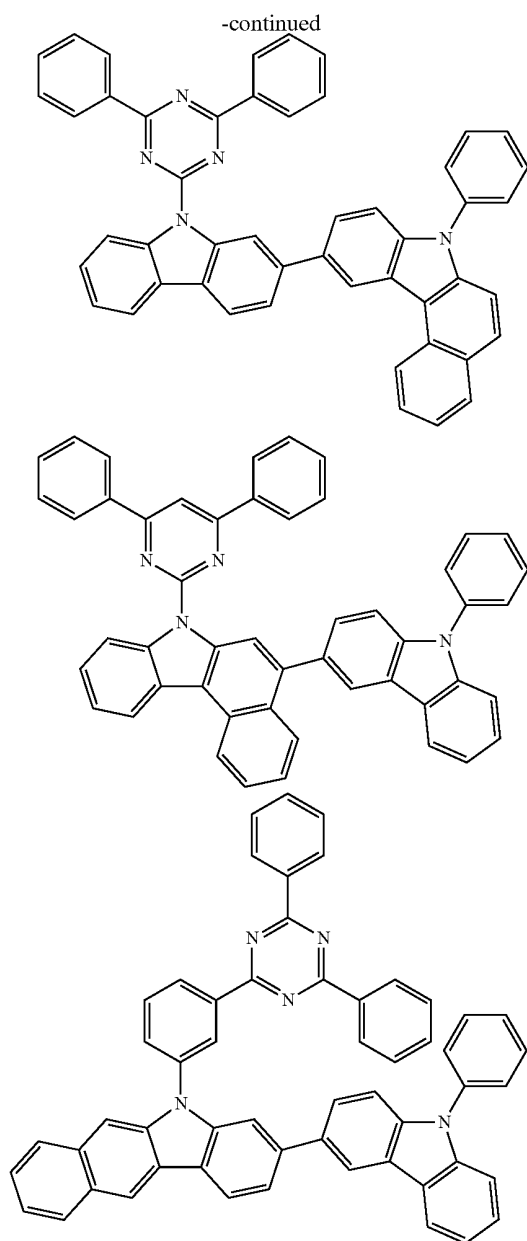


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[0141] The bis-carbazole derivative according to this exemplary embodiment represented by the formula (1A) or (1B) is a bis-carbazole derivative in which carbazole skeletons are bonded to each other respectively at a second position and a third position. In general, a reaction active position of carbazole is a third position, not a second position. For this reason, synthesis of carbazole derivatives having a substituent at a second position is more difficult than synthesis of carbazole derivatives having a substituent at a third position, e.g., synthesis of a bis-carbazole derivative in which carbazole skeletons are bonded to each other at their third positions. In this exemplary embodiment, these compounds are synthesized by a method described in Example described later.

[0142] The organic-EL-device material according to this exemplary embodiment includes the above bis-carbazole derivative.

[0143] The organic-EL-device material according to this exemplary embodiment contains the bis-carbazole derivative represented by the formula (1A) or (1B).

[0144] The organic EL device according to this exemplary embodiment includes a cathode, an anode, and an organic layer between the cathode and the anode, in which the organic layer includes a bis-carbazole derivative of the formula (1A) or (1B).

[0145] In the organic EL device according to this exemplary embodiment, the emitting layer may preferably contain the organic-EL-device material according to this exemplary embodiment.

[0146] The organic EL device according to this exemplary embodiment may preferably contain the electron injecting/transporting layer that contains the organic-EL-device material according to this exemplary embodiment.

[0147] The organic EL device according to this exemplary embodiment may preferably contain at least one of the electron injecting/transporting layer and the hole blocking layer that contains the organic-EL-device material according to this exemplary embodiment.

[0148] The organic EL device according to this exemplary embodiment may preferably include the hole transporting layer (hole injecting layer) that contains the organic-EL-device material according to this exemplary embodiment.

[0149] The carbazole derivative represented by the formula (1A) or (B) according to this exemplary embodiment tends to have a smaller ionization potential (IP) than, for instance, a bis-carbazole derivative in which carbazole skeletons are bonded to each other at their third positions. When the carbazole derivative according to this exemplary embodiment is used as an organic-EL-device material, the carbazole derivative is expected to have a higher hole injectivity.

[0150] Moreover, in the bis-carbazole derivative, to change a bonding position between carbazoles means to change a conjugated system. For instance, when a bis-carbazole derivative in which carbazole skeletons are bonded to each other at their third positions is changed to the carbazole derivative according to the exemplary embodiment of the invention in which carbazole skeletons are bonded to each other respectively at a second position and a third position, a conjugated system is cut off to increase a singlet energy gap (SI) and lower affinity (Af). Accordingly, it is expected that such a change of the bonding position from the third positions to the second and third positions enables control of electron injectability into the carbazole derivative.

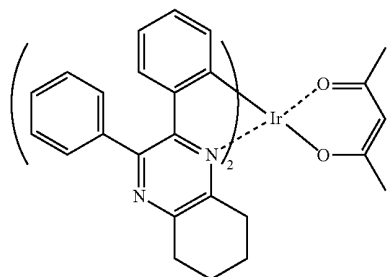
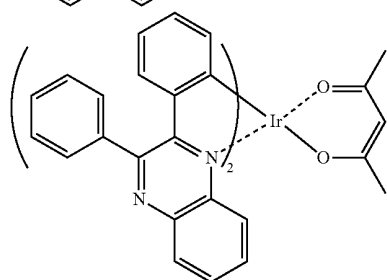
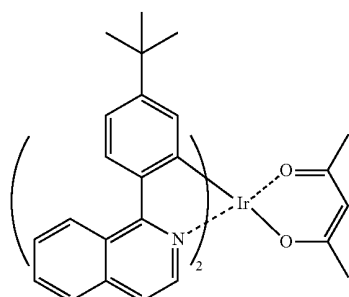
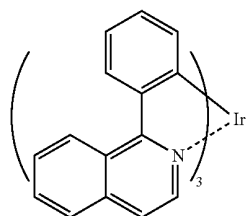
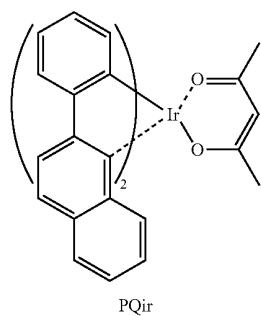
Phosphorescent Material

[0151] In the exemplary embodiment, the phosphorescent material preferably contains a metal complex, and the metal complex preferably has a metal atom selected from Ir, Pt, Os, Au, Cu, Re and Ru, and a ligand. Particularly, the ligand preferably has an ortho-metal bond.

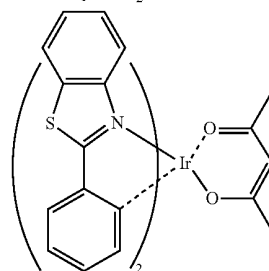
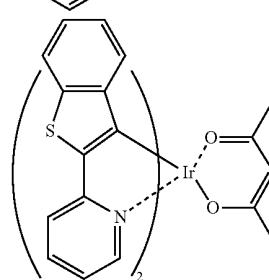
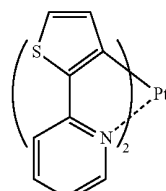
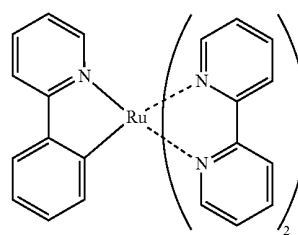
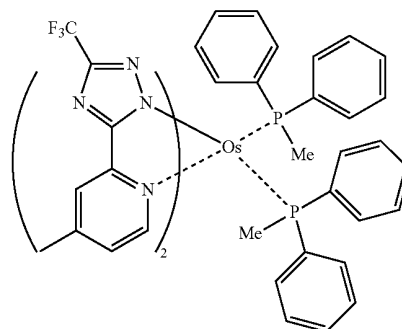
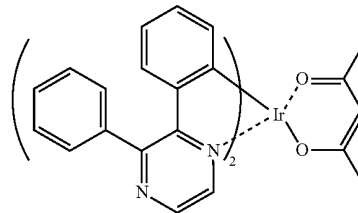
[0152] The phosphorescent material is preferably a compound containing a metal selected from iridium (Ir), osmium (Os) and platinum (Pt) because such a compound, which exhibits high phosphorescence quantum yield, can further enhance external quantum efficiency of the emitting device. The phosphorescent material is more preferably a metal complex such as an iridium complex, osmium complex or platinum complex, among which an iridium complex and plati-

num complex are more preferable and ortho metalation of an iridium complex is the most preferable.

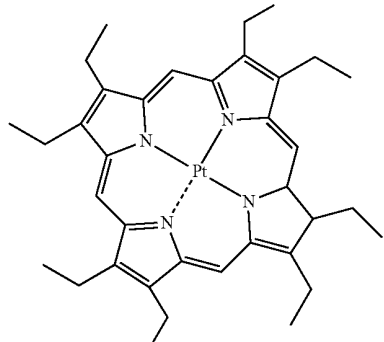
[0153] Examples of such a preferable metal complex are shown below.



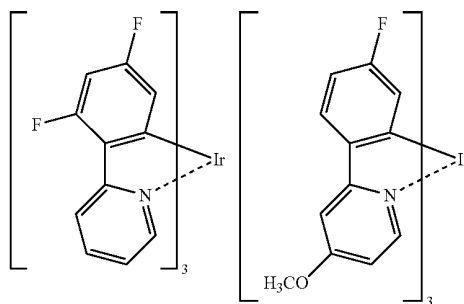
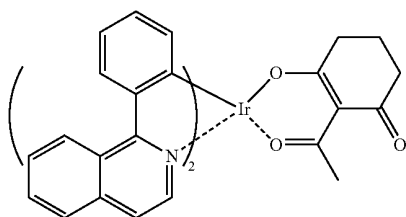
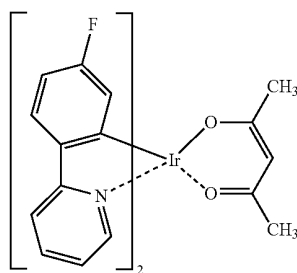
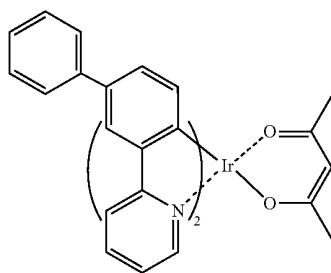
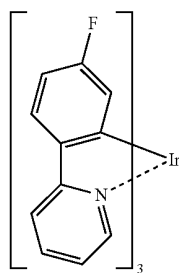
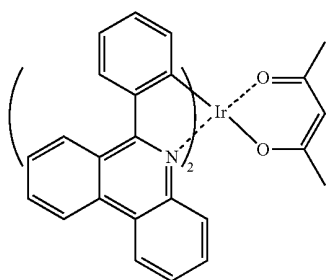
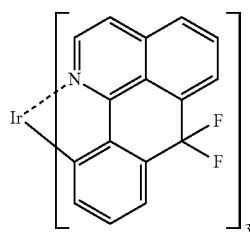
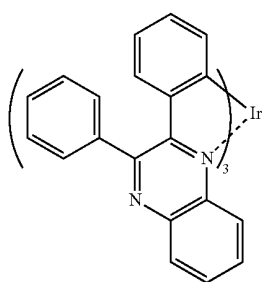
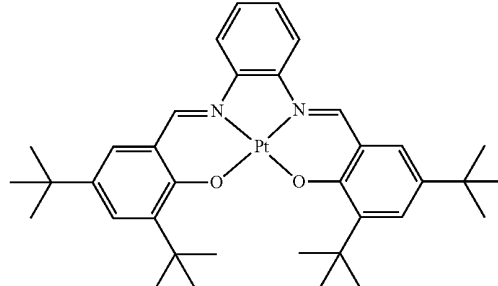
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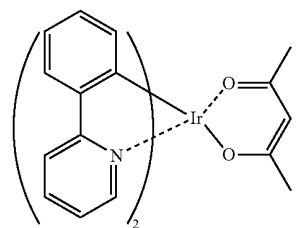
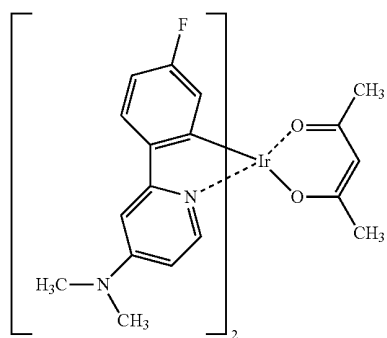
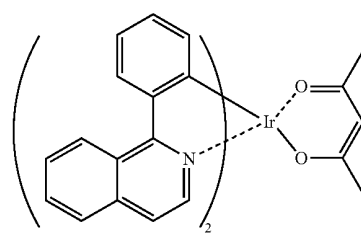
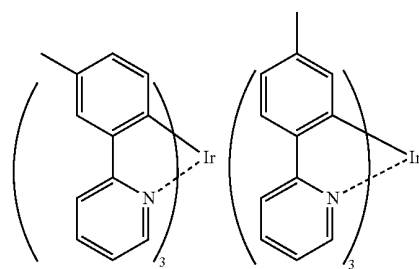
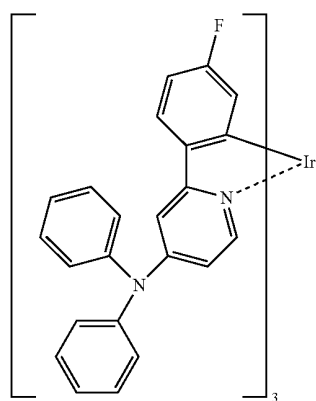
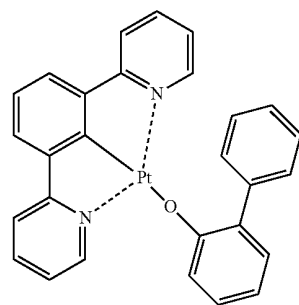
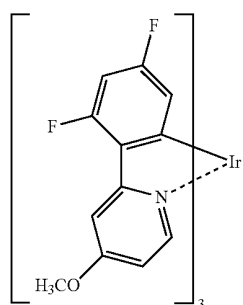
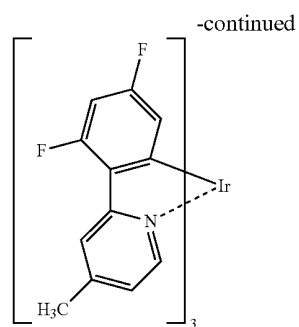
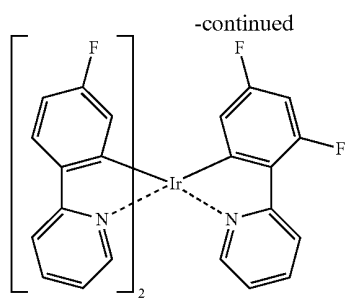


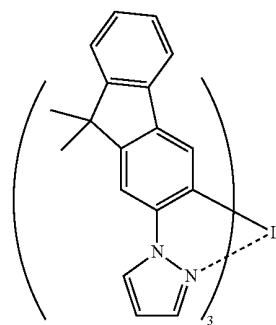
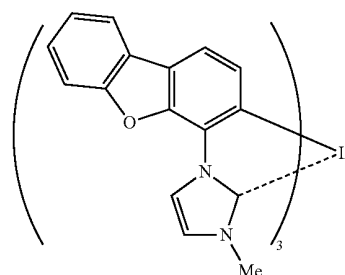
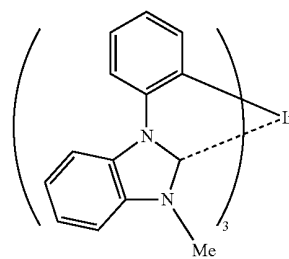
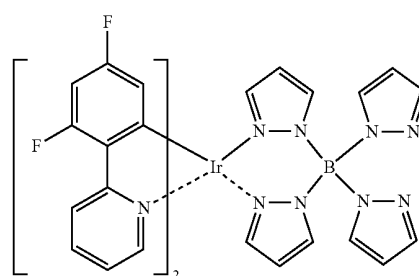
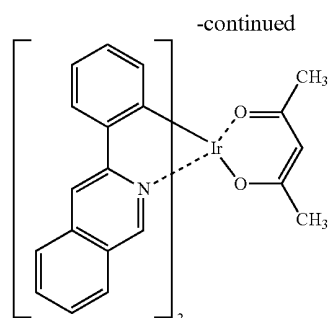
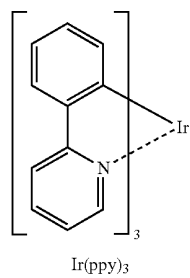
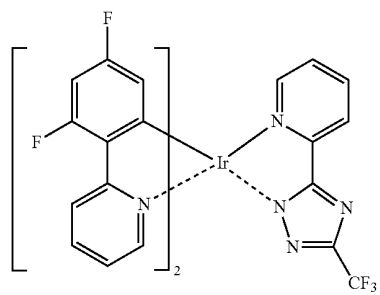
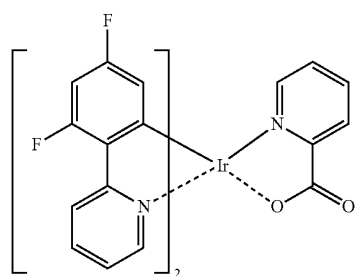
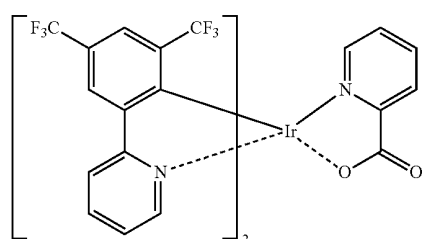
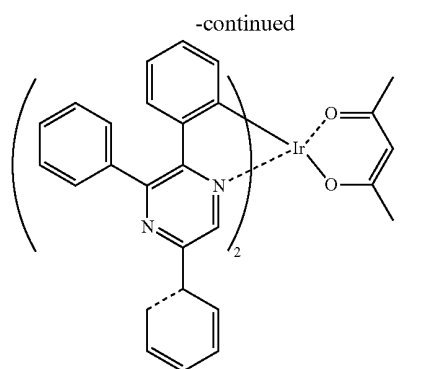
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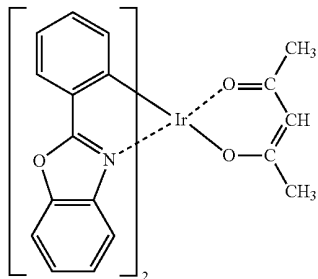
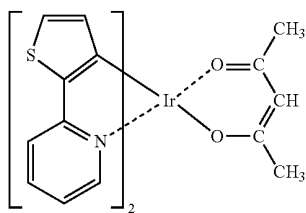
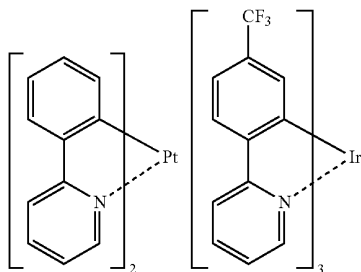
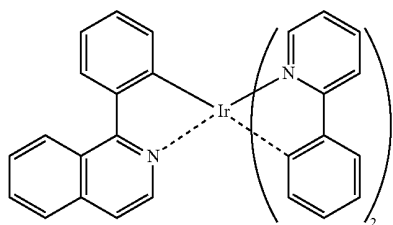
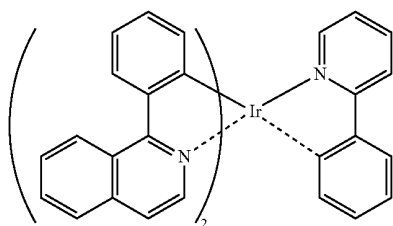
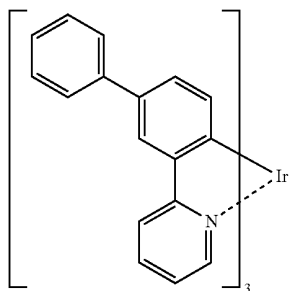
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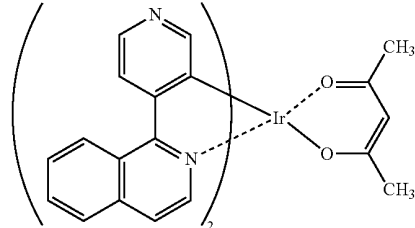
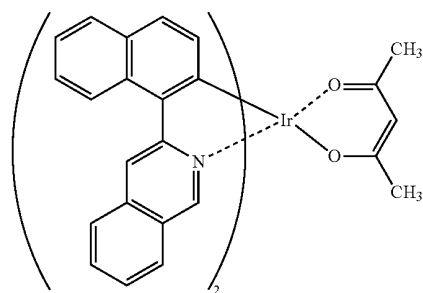
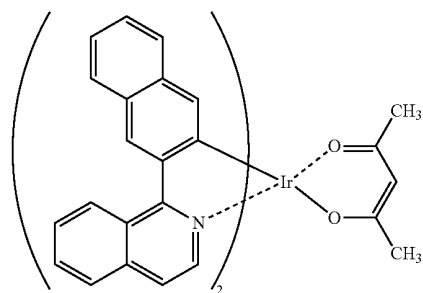
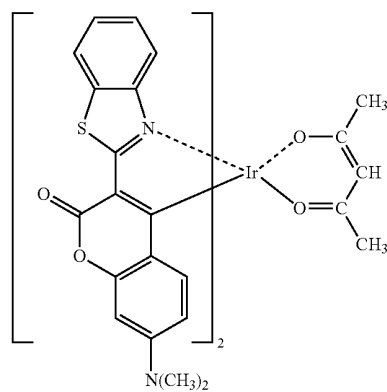
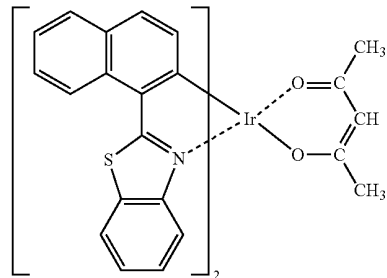


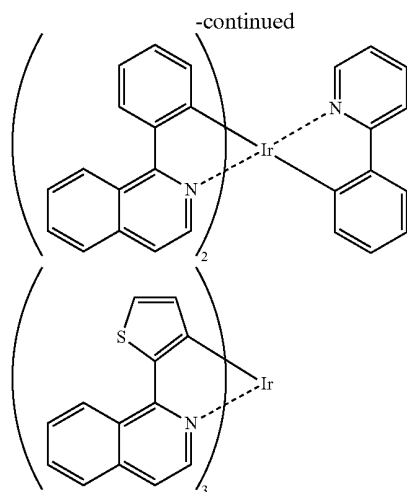


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[0154] In the exemplary embodiment, at least one of the phosphorescent material contained in the emitting layer preferably emits light with the maximum wavelength of 450 nm to 720 nm.

By doping the phosphorescent material (phosphorescent dopant) having such an emission wavelength to the specific host material used in this exemplary embodiment so as to form the emitting layer, the organic EL device can exhibit high efficiency.

Reduction-Causing Dopant

[0155] In the organic EL device according to this exemplary embodiment, a reduction-causing dopant may be preferably contained in an interfacial region between the cathode and the organic thin-film layer.

[0156] With this arrangement, the organic EL device can emit light with enhanced luminance intensity and have a longer lifetime.

[0157] The reduction-causing dopant may be at least one compound selected from an alkali metal, alkali metal complex, alkali metal compound, alkali earth metal, alkali earth metal complex, alkali earth metal compound, rare-earth metal, rare-earth metal complex, rare-earth metal compound and the like.

[0158] Examples of the alkali metal are Na (work function: 2.36 eV), K (work function: 2.28 eV), Rb (work function: 2.16 eV), Cs (work function: 1.95 eV) and the like, among which a substance having a work function of 2.9 eV or less is particularly preferable. Among the above, the reduction-causing dopant is preferably K, Rb or Cs, more preferably Rb or Cs, the most preferably Cs.

[0159] Examples of the alkali earth metal are Ca (work function: 2.9 eV), Sr (work function: 2.0 to 2.5 eV), Ba (work function: 2.52 eV) and the like, among which a substance having a work function of 2.9 eV or less is particularly preferable.

[0160] Examples of the rare-earth metal are Sc, Y, Ce, Tb, Yb and the like, among which a substance having a work function of 2.9 eV or less is particularly preferable.

[0161] Since the above preferred metals have particularly high reducibility, addition of a relatively small amount of the

metals to an electron injecting zone can enhance luminance intensity and lifetime of the organic EL device.

[0162] Examples of the alkali metal compound include an alkali oxide such as Li_2O , Cs_2O and K_2O , and an alkali halide such as LiF, NaF, CsF and KF, among which LiF, Li_2O , and NaF are preferable.

[0163] Examples of the alkali earth metal compound include BaO, SrO, CaO and their mixture such as $\text{Ba}_x\text{Sr}_{1-x}\text{O}$ ($0 < x < 1$) and $\text{Ba}_x\text{Ca}_{1-x}\text{O}$ ($0 < x < 1$). BaO, SrO, and CaO are preferable.

[0164] Examples of the rare earth metal compound include YbF_3 , ScF_3 , ScO_3 , Y_2O_3 , Ce_2O_3 , GdF_3 and TbF_3 , YbF_3 , ScF_3 , and TbF_3 are preferable.

[0165] The alkali metal complex, alkali earth metal complex and rare earth metal complex are not specifically limited as long as they contain at least one metal ion of an alkali metal ion, an alkali earth metal ion and a rare earth metal ion. A ligand for each of the complexes is preferably quinolinol, benzoquinolinol, acridinol, phenanthridinol, hydroxyphenyl oxazole, hydroxyphenyl thiazole, hydroxydiaryl oxadiazole, hydroxydiaryl thiadiazole, hydroxyphenyl pyridine, hydroxyphenyl benzoimidazole, hydroxybenzo triazole, hydroxy fluorane, bipyridyl, phenanthroline, phthalocyanine, porphyrin, cyclopentadiene, β -diketones, azomethines, or a derivative thereof, but the ligand is not limited thereto.

[0166] The reduction-causing dopant is added to preferably form a layer or an island pattern in the interfacial region. The layer of the reduction-causing dopant or the island pattern of the reduction-causing dopant is preferably formed by depositing the reduction-causing dopant by resistance heating deposition while an emitting material for forming the interfacial region or an organic substance as an electron-injecting material are simultaneously deposited, so that the reduction-causing dopant is dispersed in the organic substance. Dispersion concentration at which the reduction-causing dopant is dispersed in the organic substance is a mole ratio (organic substance to reduction-causing dopant) of 100:1 to 1:100, preferably 5:1 to 1:5.

[0167] When the reduction-causing dopant forms the layer, the emitting material or the electron injecting material for forming the organic layer of the interfacial region is initially layered, and the reduction-causing dopant is subsequently deposited singularly thereon by resistance heating deposition to form a preferably 0.1 nm- to 15 nm-thick layer.

[0168] When the reduction-causing dopant forms the island pattern, the emitting material or the electron injecting material for forming the organic layer of the interfacial region is initially formed in an island shape, and the reduction-causing dopant is subsequently deposited singularly thereon by resistance heating deposition to form a preferably 0.05 nm- to 1 nm-thick island shape.

[0169] A ratio of the main component to the reduction-causing dopant in the organic EL device according to this exemplary embodiment is preferably a mole ratio (main component to reduction-causing dopant) of 5:1 to 1:5, more preferably 2:1 to 1:2.

Electron Injecting Layer and Electron Transporting Layer

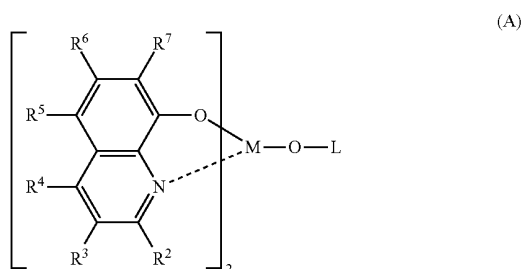
[0170] The electron injecting layer or the electron transporting layer, which aids injection of the electrons into the emitting layer, has a large electron mobility. The electron injecting layer is provided for adjusting energy level, by which, for instance, sudden changes of the energy level can be reduced.

[0171] The organic EL device according to this exemplary embodiment preferably includes the electron injecting layer between the emitting layer and the cathode, and the electron injecting layer preferably contains a nitrogen-containing cyclic derivative as the main component. The electron injecting layer may serve as the electron transporting layer.

[0172] It should be noted that "as the main component" means that the nitrogen-containing cyclic derivative is contained in the electron injecting layer at a content of 50 mass % or more.

[0173] A preferable example of an electron transporting material for forming the electron injecting layer is an aromatic heterocyclic compound having in the molecule at least one heteroatom. Particularly, a nitrogen-containing cyclic derivative is preferable. The nitrogen-containing cyclic derivative is preferably an aromatic ring having a nitrogen-containing six-membered or five-membered ring skeleton, or a fused aromatic cyclic compound having a nitrogen-containing six-membered or five-membered ring skeleton.

[0174] The nitrogen-containing cyclic derivative is preferably exemplified by a nitrogen-containing cyclic metal chelate complex represented by the following formula (A).



[0175] R^2 to R^7 in the formula (A) each independently represent a hydrogen atom, a halogen atom, an oxy group, an amino group, a hydrocarbon group having 1 to 40 carbon atoms, an alkoxy group, an aryloxy group, an alkoxycarbonyl group, or an aromatic heterocyclic group. These groups may be substituted or unsubstituted.

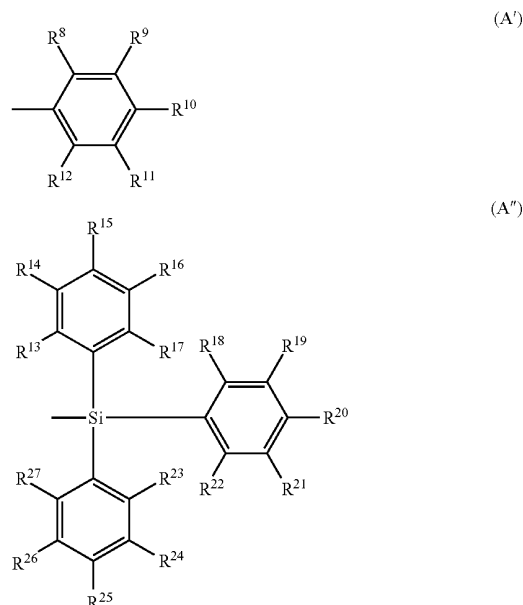
[0176] Examples of the halogen atom include fluorine, chlorine, bromine, and iodine. In addition, examples of the substituted or unsubstituted amino group include an alkylamino group, an arylamino group, and an aralkylamino group.

[0177] The alkoxycarbonyl group is represented by $-\text{COOY}'$. Examples of Y' are the same as the examples of the alkyl group. The alkylamino group and the aralkylamino group are represented by $-\text{NQ}^1\text{Q}^2$. Examples for each of Q^1 and Q^2 are the same as the examples described in relation to the alkyl group and the aralkyl group, and preferred examples for each of Q^1 and Q^2 are also the same as those described in relation to the alkyl group and the aralkyl group. Either one of Q^1 and Q^2 may be a hydrogen atom.

[0178] The arylamino group is represented by $-\text{NAr}^1\text{Ar}^2$. Examples for each of Ar^1 and Ar^2 are the same as the examples described in relation to the non-fused aromatic hydrocarbon group and the fused aromatic hydrocarbon group. Either one of Ar^1 and Ar^2 may be a hydrogen atom.

[0179] M represents aluminum (Al), gallium (Ga) or indium (In), among which In is preferable.

[0180] L in the formula (A) represents a group represented by a formula (A') or (A'') below.



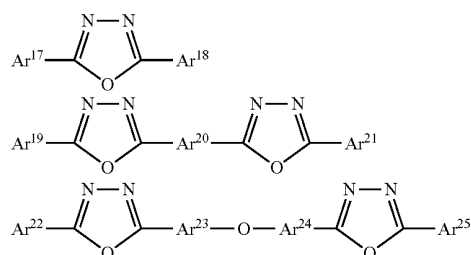
[0181] In the formula (A'), R^8 to R^{12} each independently represent a hydrogen atom or a substituted or unsubstituted hydrocarbon group having 1 to 40 carbon atoms. Adjacent groups may form a cyclic structure. In the formula (A''), R^{13} to R^{27} each independently represent a hydrogen atom or a substituted or unsubstituted hydrocarbon group having 1 to 40 carbon atoms. Adjacent groups may form a cyclic structure.

[0182] Examples of the hydrocarbon group having 1 to 40 carbon atoms represented by each of R^8 to R^{12} and R^{13} to R^{27} in the formulae (A') and (A'') are the same as those of R^2 to R^7 in the formula (A).

[0183] Examples of a divalent group formed when an adjacent set of R^8 to R^{12} and R^{13} to R^{27} forms a cyclic structure are a tetramethylene group, a pentamethylene group, a hexamethylene group, a diphenylmethane-2,2'-diyl group, a diphenylethane-3,3'-diyl group, a diphenylpropane-4,4'-diyl group and the like.

[0184] Moreover, in this exemplary embodiment, the electron transporting layer may contain the biscarbazole derivatives represented by the formulae (1) to (3) (or the formulae (4) to (6)).

As an electron transporting compound for the electron injecting layer or the electron transporting layer, 8-hydroxyquinoline or a metal complex of its derivative, an oxadiazole derivative and a nitrogen-containing heterocyclic derivative are preferable. A specific example of the 8-hydroxyquinoline or the metal complex of its derivative is a metal chelate oxinoid compound containing a chelate of oxine (typically 8-quinolinol or 8-hydroxyquinoline). For instance, tris(8-quinolinol) aluminum can be used. Examples of the oxadiazole derivative are as follows.



[0185] In the formula, Ar¹⁷, Ar¹⁸, Ar¹⁹, Ar²¹, Ar²² and Ar²⁵ each represent a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms. Ar¹⁷, Ar¹⁹ and Ar²² may be the same as or different from Ar¹⁸, Ar²¹ and Ar²⁵ respectively. Examples of the aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms are a phenyl group, biphenyl group, anthranil group, perylenyl group and pyrenyl group. Examples of the substituent therefor are an alkyl group having 1 to 10 carbon atoms, alkoxy group having 1 to 10 carbon atoms and cyano group. Ar²⁰, Ar²³ and Ar²⁴ each represent a substituted or, unsubstituted divalent aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms. Ar²³ and Ar²⁴ may be mutually the same or different.

[0186] Examples of the divalent aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms are a phenylene group, naphthylene group, biphenylene group, anthranylene group, perylenylene group and pyrenylene group. Examples of the substituent therefor are an alkyl group having 1 to 10 carbon atoms, alkoxy group having 1 to 10 carbon atoms and cyano group.

[0187] Such an electron transport compound is preferably an electron transport compound that can be favorably formed into a thin film(s). Examples of the electron transporting compounds are as follows.

[0188] An example of the nitrogen-containing heterocyclic derivative as the electron transporting compound is a nitrogen-containing compound that is not a metal complex, the derivative being formed of an organic compound represented by one of the following general formulae. Examples of the nitrogen-containing heterocyclic derivative are a five-membered ring or six-membered ring derivative having a skeleton represented by the following formula (A) and a derivative having a structure represented by the following formula (B).



(A)



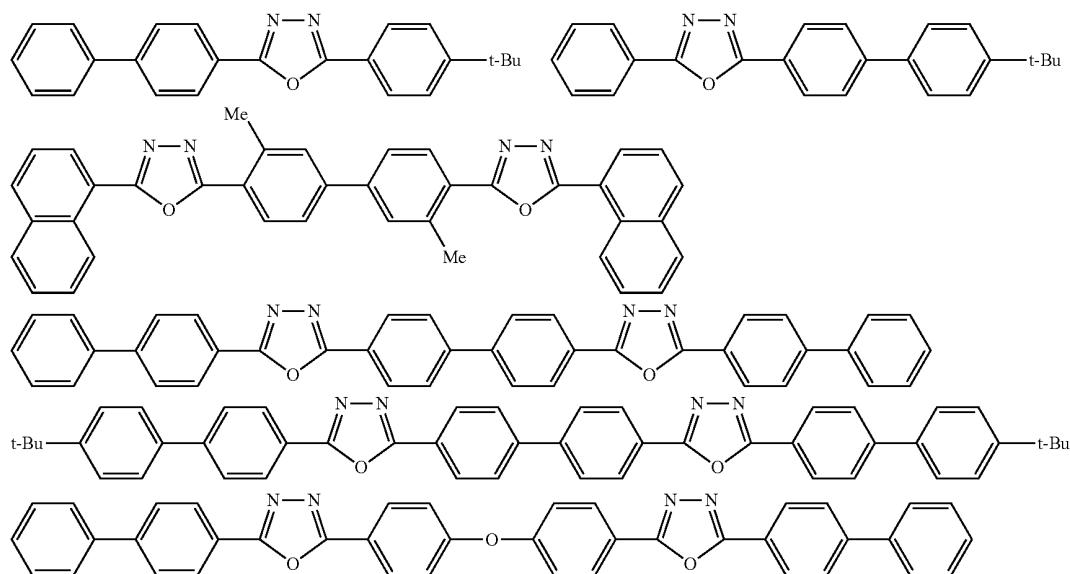
(B)

[0189] In the formula (B), X represents a carbon atom or a nitrogen atom. Z₁ and Z₂ each independently represent a group of atoms capable of forming a nitrogen-containing heterocycle.

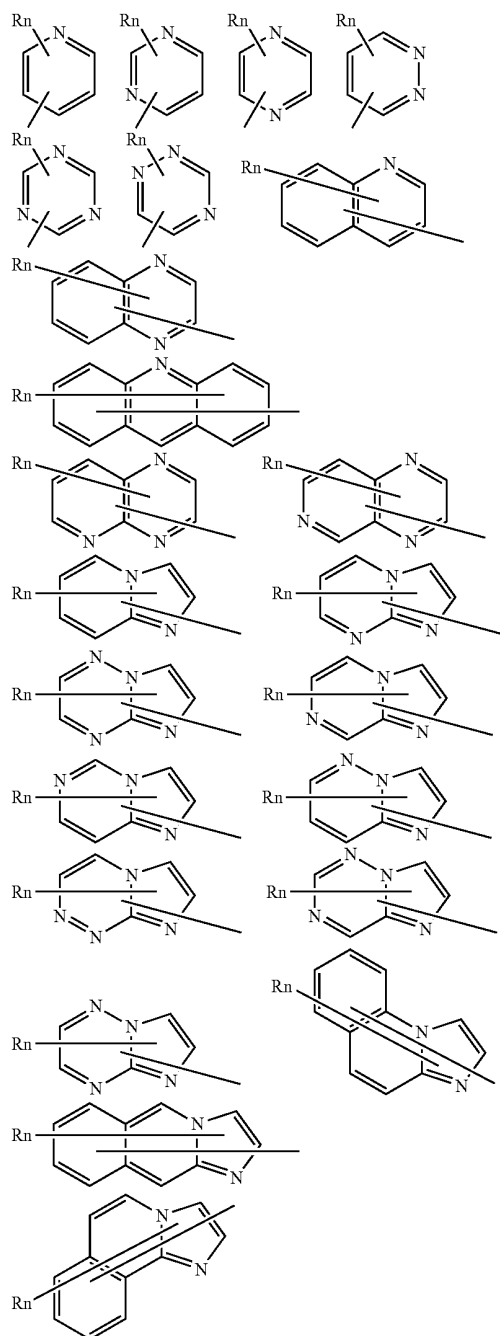
[0190] Preferably, the nitrogen-containing heterocyclic derivative is an organic compound having a nitrogen-containing aromatic polycyclic group having a five-membered ring or six-membered ring. When the nitrogen-containing heterocyclic derivative includes such nitrogen-containing aromatic polycyclic series having plural nitrogen atoms, the nitrogen-containing heterocyclic derivative may be a nitrogen-containing aromatic polycyclic organic compound having a skeleton formed by a combination of the skeletons respectively represented by the formulae (A) and (B), or by a combination of the skeletons respectively represented by the formulae (A) and (C).



(C)



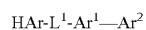
[0191] A nitrogen-containing group of the nitrogen-containing aromatic polycyclic organic compound is selected from nitrogen-containing heterocyclic groups respectively represented by the following general formulae.



[0192] In the formulae: R represents an aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms; aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 40 ring carbon atoms; alkyl group having 1 to 20 carbon atoms or alkoxy

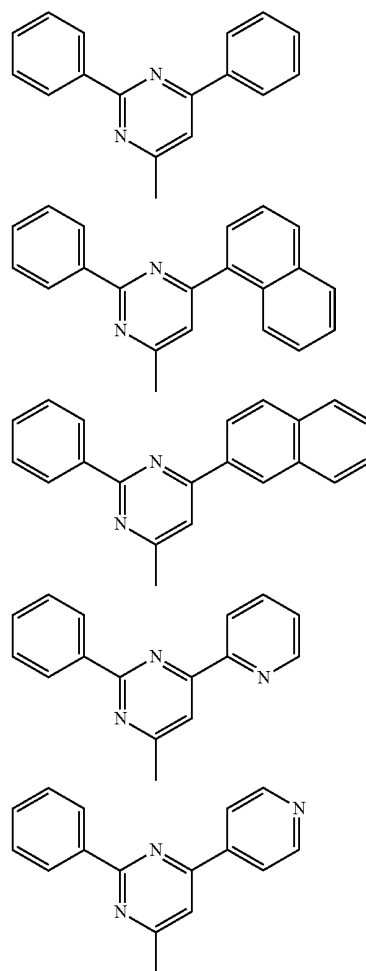
group having 1 to 20 carbon atoms; and n represents an integer in a range of 0 to 5. When n is an integer of 2 or more, plural R may be mutually the same or different.

[0193] A preferable specific compound is a nitrogen-containing heterocyclic derivative represented by the following formula.

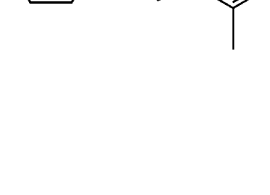
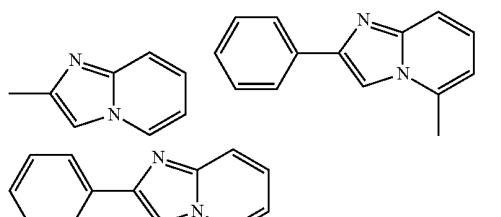
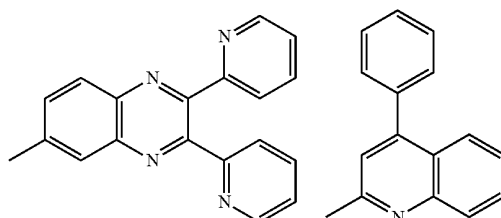
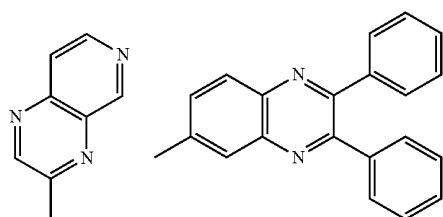
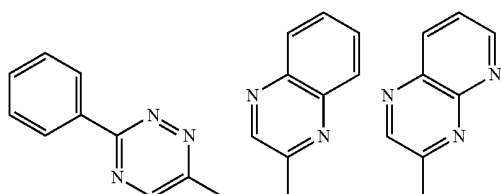
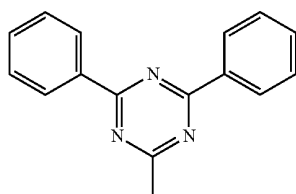
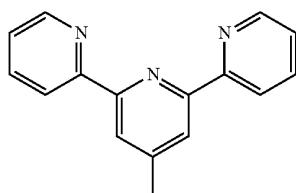
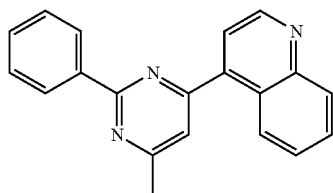


[0194] In the formula: HAr represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 40 ring carbon atoms; L^1 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms, or substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 40 ring carbon atoms; Ar^1 represents a substituted or unsubstituted divalent aromatic hydrocarbon group having 6 to 40 ring carbon atoms; and Ar^2 represents a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms, or substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 40 ring carbon atoms.

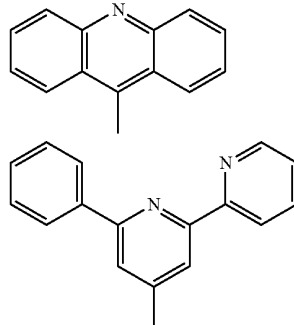
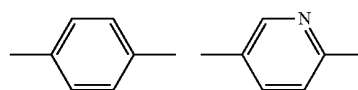
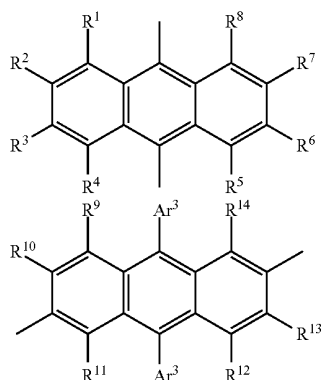
[0195] HAr is exemplarily selected from the following group.



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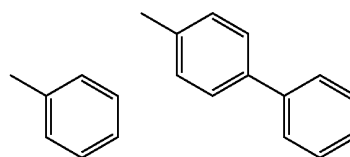
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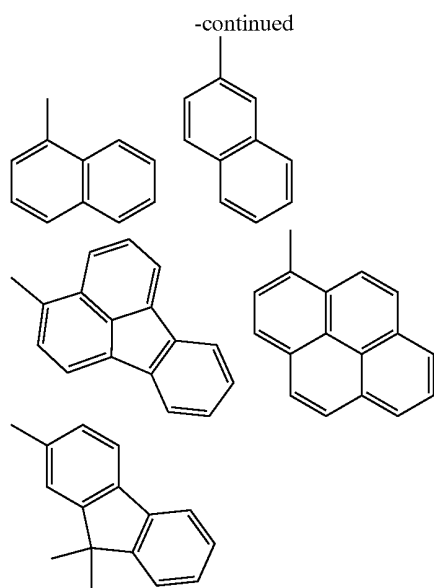
[0196] L¹ is exemplarily selected from the following group.[0197] Ar¹ is exemplarily selected from the following arylanthranil groups.

[0198] In the formulae, R¹ to R¹⁴ each independently represent a hydrogen atom, halogen atom, alkyl group having 1 to 20 carbon atoms, alkoxy group having 1 to 20 carbon atoms, aryloxy group having 6 to 40 ring carbon atoms, substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms, or aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 40 ring carbon atoms; and Ar³ represents aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 40 ring carbon atoms, or aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 40 ring carbon atoms.

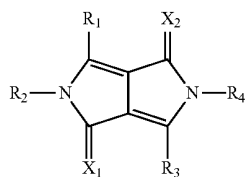
[0199] All of R¹ to R⁸ of a nitrogen-containing heterocyclic derivative may be hydrogen atoms.

[0200] Ar² is exemplarily selected from the following group.



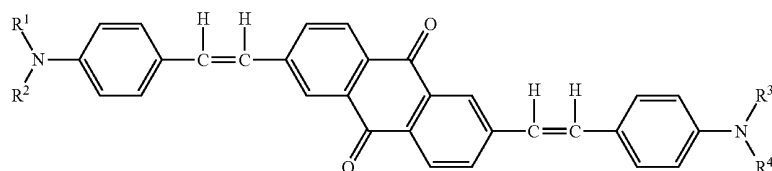


[0201] Other than the above, the following compound (see JP-A-9-3448) can be favorably used for the nitrogen-containing aromatic polycyclic organic compound as the electron transporting compound.

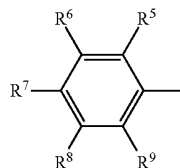


[0202] In the formula: R_1 to R_4 each independently represent a hydrogen atom, substituted or unsubstituted aliphatic group, substituted or unsubstituted alicyclic group, substituted or unsubstituted carbocyclic aromatic cyclic group or substituted or unsubstituted heterocyclic group; and X_1 and X_2 each independently represent an oxygen atom, sulfur atom or dicyanomethylene group.

[0203] Alternatively, the following compound (see JP-A-2000-173774) can also be favorably used for the electron transporting compound.



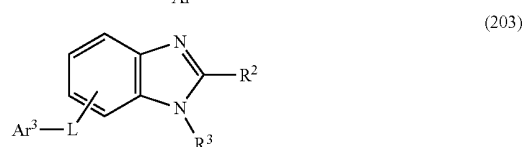
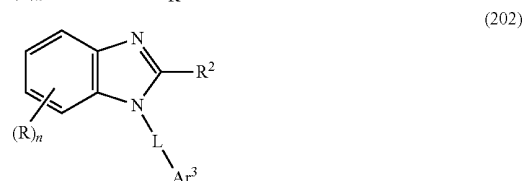
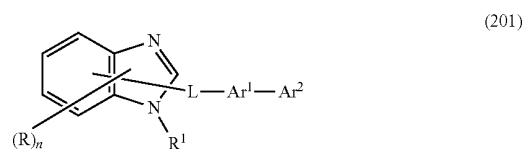
[0204] In the formula, R^1 , R^2 , R^3 and R^4 , which may be mutually the same or different, each represent an aromatic hydrocarbon group or fused aromatic hydrocarbon group represented by the following formula.



[0205] In the formula, R^5 , R^6 , R^7 , R^8 and R^9 , which may be mutually the same or different, each represent a hydrogen atom, a saturated or unsaturated alkoxy group, alkyl group, amino group or alkylamino group. At least one of R^5 , R^6 , R^7 , R^8 and R^9 represents a saturated or unsaturated alkoxy group, alkyl group, amino group or alkylamino group.

[0206] A polymer compound containing the nitrogen-containing heterocyclic group or a nitrogen-containing heterocyclic derivative may be used for the electron transporting compound.

[0207] The electron transporting layer preferably contains at least one of nitrogen-containing heterocycle derivatives respectively represented by the following formulae (201) to (203).



[0208] In the formulae (201) to (203): R represents a hydrogen atom, substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridyl group,

substituted or unsubstituted quinolyl group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms; n is an integer in a range of 0 to 4;

[0209] R^1 represents a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridyl group, substituted or unsubstituted quinolyl group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or alkoxy group having 1 to 20 carbon atoms; R^2 and R^3 each independently represent a hydrogen atom, substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridyl group, substituted or unsubstituted quinolyl group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms;

[0210] L represents a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridinylene group, substituted or unsubstituted quinolylene group, or substituted or unsubstituted fluorenylene group;

[0211] Ar^1 represents a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridinylene group, substituted or unsubstituted quinolyl group. Ar^2 represents a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridyl group, substituted or unsubstituted quinolyl group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms; and

[0212] Ar^3 represents a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridyl group, substituted or unsubstituted quinolyl group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms or group represented by $-Ar^1-Ar^2$ (Ar^1 and Ar^2 may be the same as the above).

[0213] In the formulae (201) to (203), R represents a hydrogen atom, a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 60 ring carbon atoms, substituted or unsubstituted pyridyl group, substituted or unsubstituted quinolyl group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms.

[0214] Although a thickness of the electron injecting layer or the electron transporting layer is not specifically limited, the thickness is preferably 1 nm to 100 nm.

[0215] The electron injecting layer preferably contains an inorganic compound such as an insulator or a semiconductor in addition to the nitrogen-containing cyclic derivative. Such an insulator or a semiconductor, when contained in the electron injecting layer, can effectively prevent a current leak, thereby enhancing electron capability of the electron injecting layer.

[0216] As the insulator, it is preferable to use at least one metal compound selected from the group consisting of an alkali metal chalcogenide, an alkali earth metal chalcogenide, a halogenide of alkali metal and a halogenide of alkali earth metal. By forming the electron injecting layer from the alkali metal chalcogenide or the like, the electron injecting capability can preferably be further enhanced. Specifically, preferred examples of the alkali metal chalcogenide are Li_2O , K_2O , Na_2S , Na_2Se and Na_2O , while preferable example of the alkali earth metal chalcogenide are CaO , BaO , SrO , BeO , BaS and $CaSe$. Preferred examples of the halogenide of the alkali metal are LiF , NaF , KF , $LiCl$, KCl and $NaCl$. Preferred

examples of the halogenide of the alkali earth metal are fluorides such as CaF_2 , BaF_2 , SrF_2 , MgF_2 and BeF_2 , and halogenides other than the fluoride.

[0217] Examples of the semiconductor are one of or a combination of two or more of an oxide, a nitride or an oxidized nitride containing at least one element selected from Ba, Ca, Sr, Yb, Al, Ga, In, Li, Na, Cd, Mg, Si, Ta, Sb and Zn. An inorganic compound for forming the electron injecting layer is preferably a microcrystalline or amorphous semiconductor film. When the electron injecting layer is formed of such insulator film, more uniform thin film can be formed, thereby reducing pixel defects such as a dark spot. Examples of such an inorganic compound are the above-described alkali metal chalcogenide, alkali earth metal chalcogenide, halogenide of the alkali metal and halogenide of the alkali earth metal.

[0218] When the electron injecting layer contains such an insulator or such a semiconductor, a thickness thereof is preferably in a range of approximately 0.1 nm to 15 nm. The electron injecting layer in this exemplary embodiment may preferably contain the above-described reduction-causing dopant.

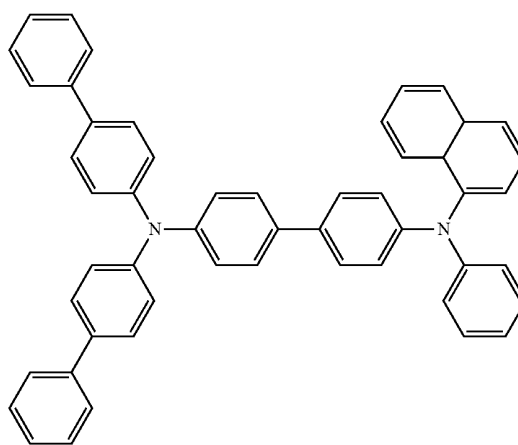
Hole Injecting Layer and Hole Transporting Layer

[0219] The hole injecting layer or the hole transporting layer (including the hole injecting/transporting layer) may contain an aromatic amine compound such as an aromatic amine derivative represented by the following formula (I).

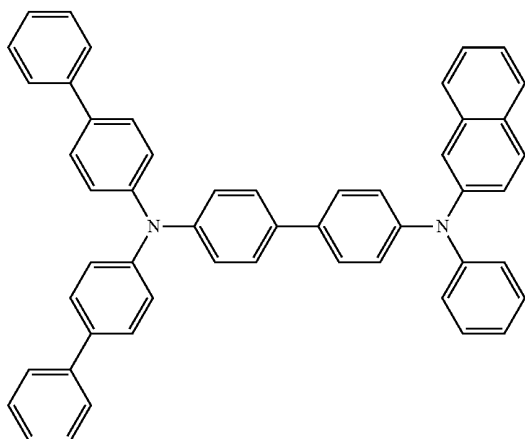


[0220] In the formula (I), Ar^1 to Ar^4 each represent a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 50 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 40 ring carbon atoms, or a group formed by combining the aromatic hydrocarbon group or the fused aromatic hydrocarbon group with the aromatic heterocyclic group or fused aromatic heterocyclic group.

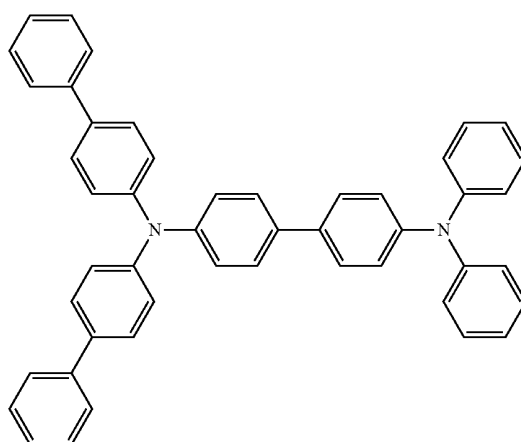
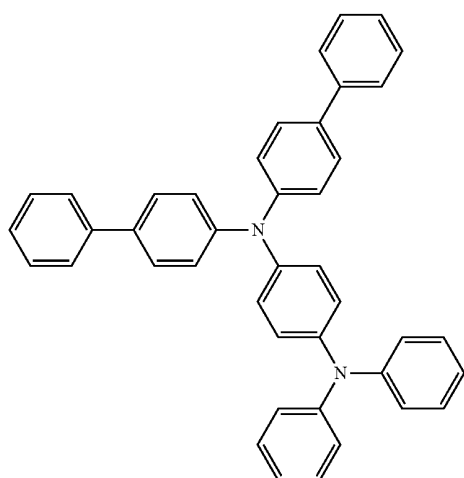
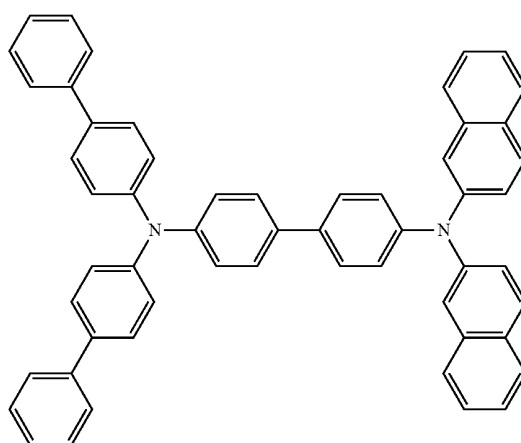
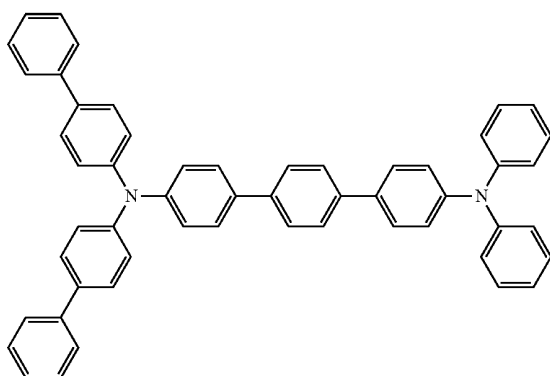
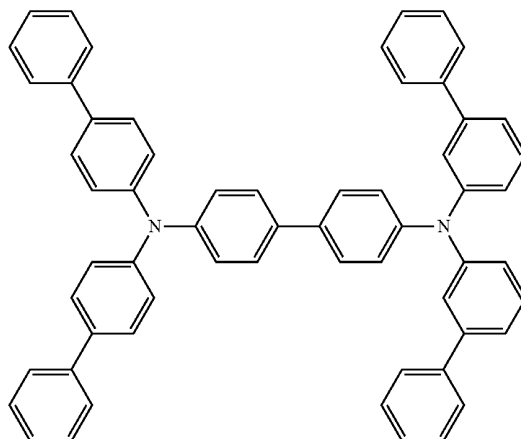
[0221] Examples of the compound represented by the formula (I) are shown below. However, the compound represented by the formula (I) is not limited thereto.



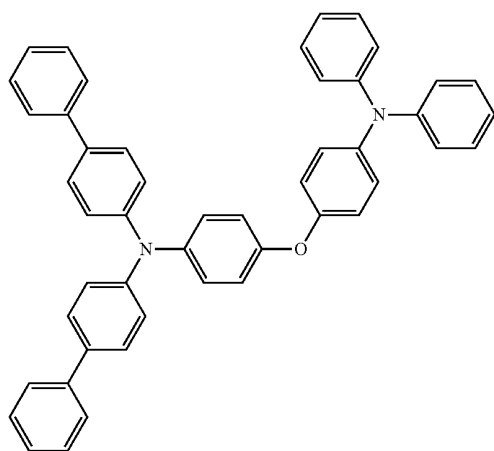
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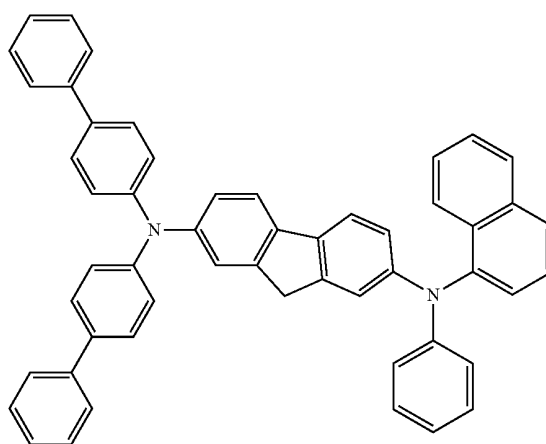
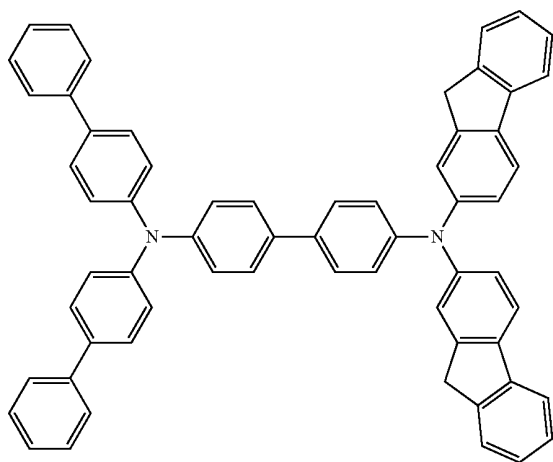
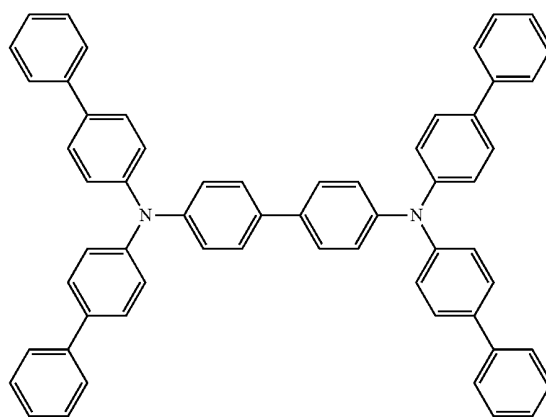
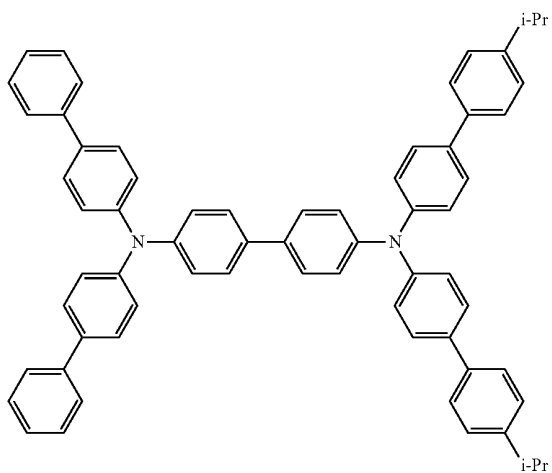
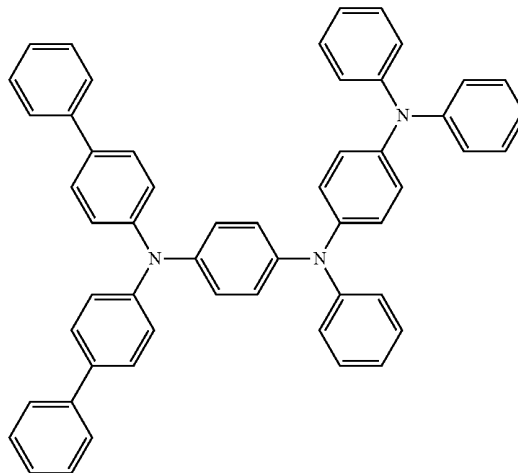
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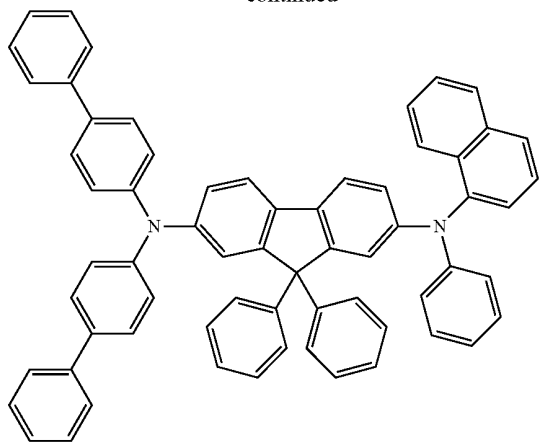
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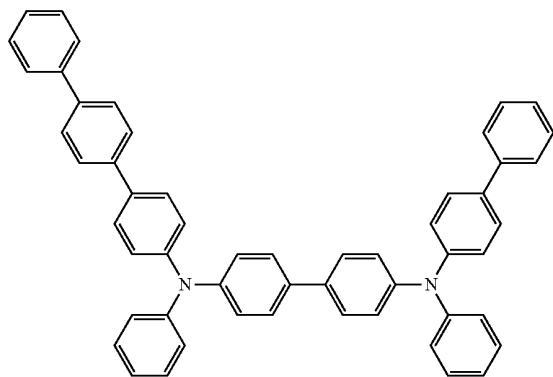
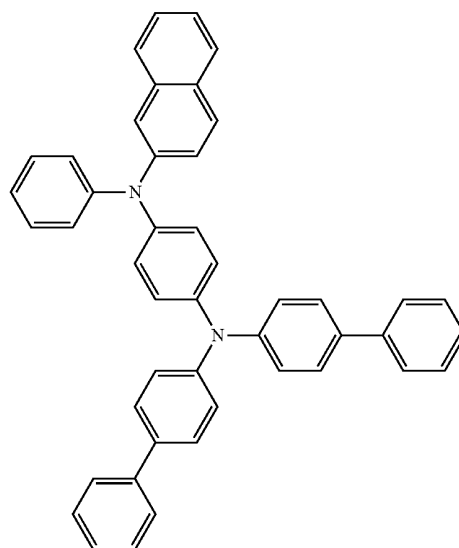
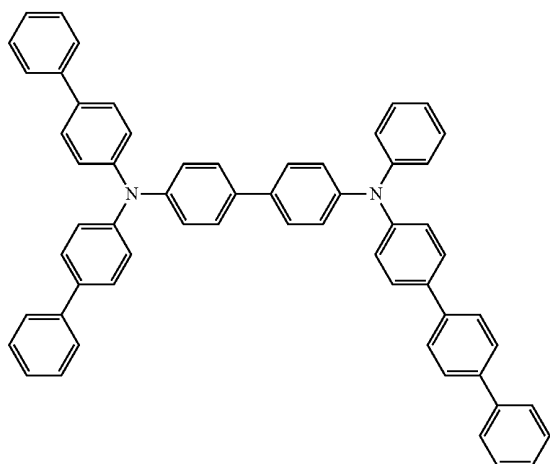
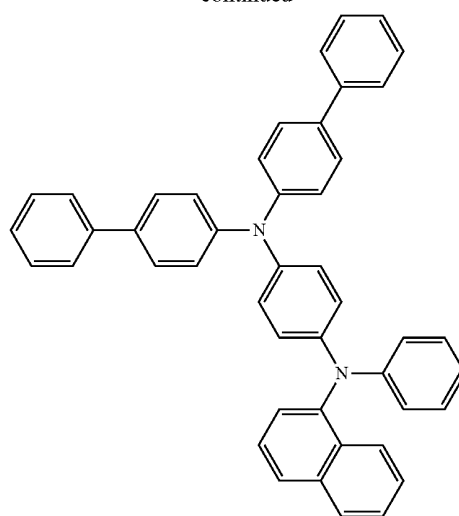
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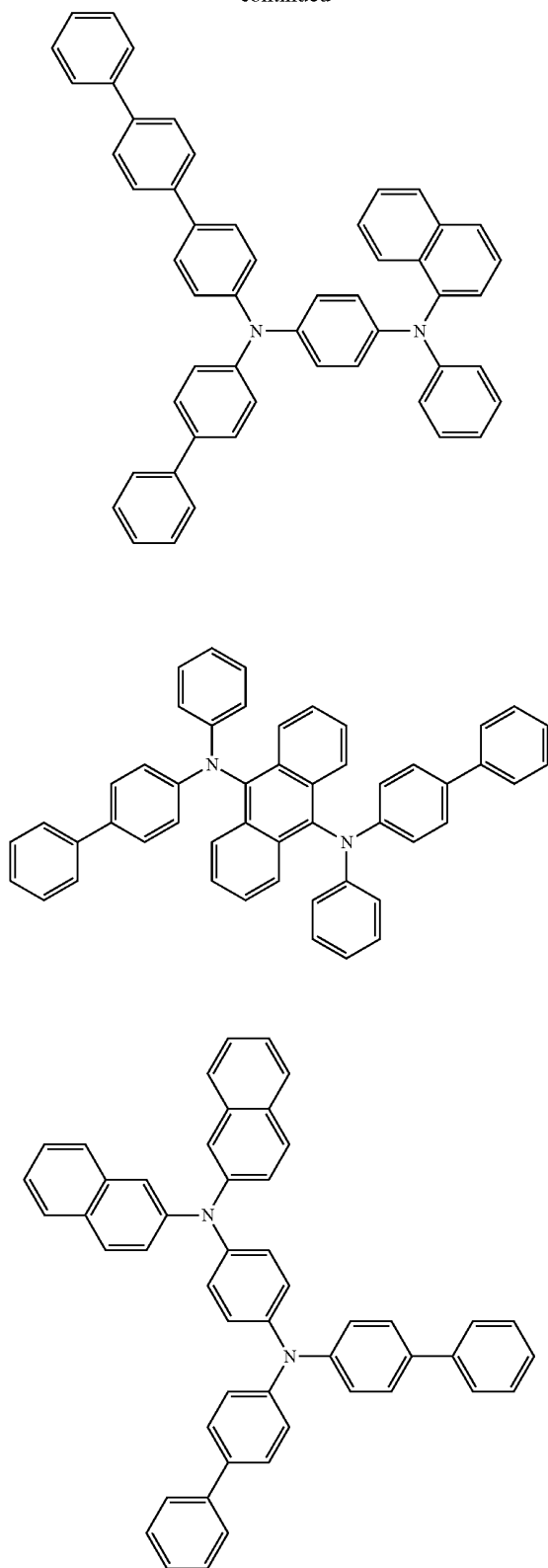
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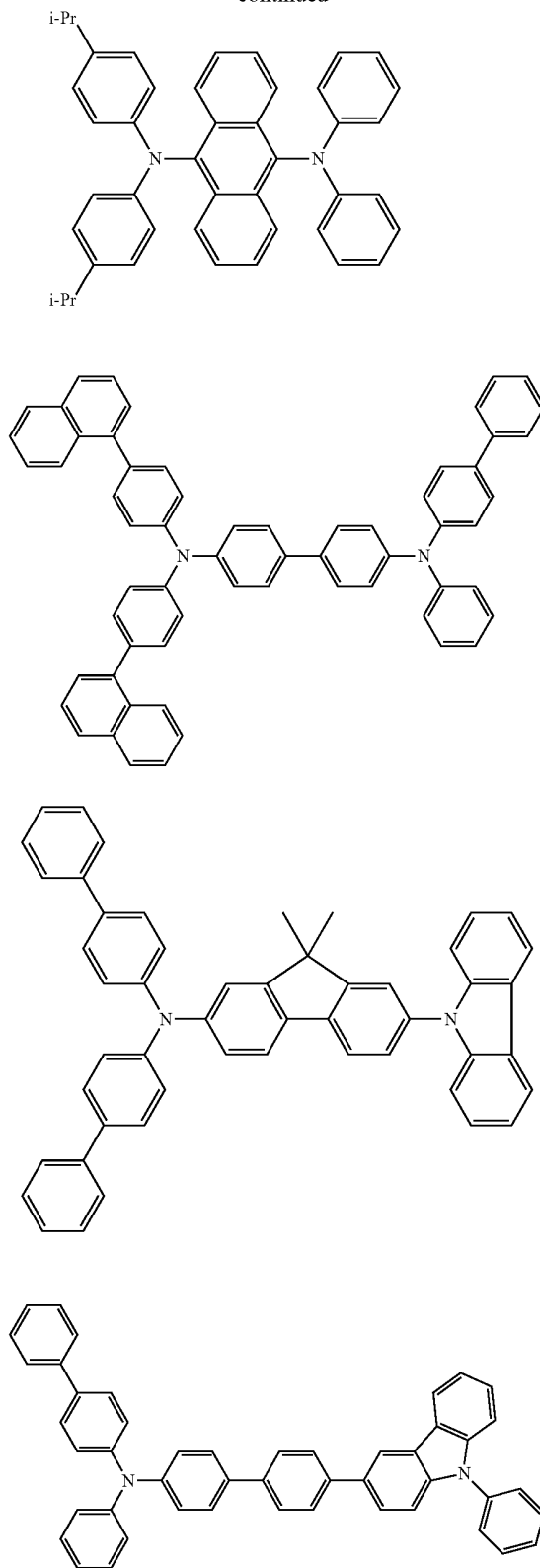
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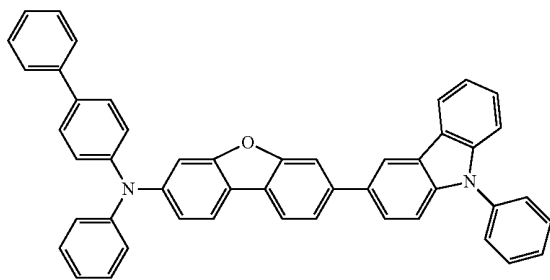
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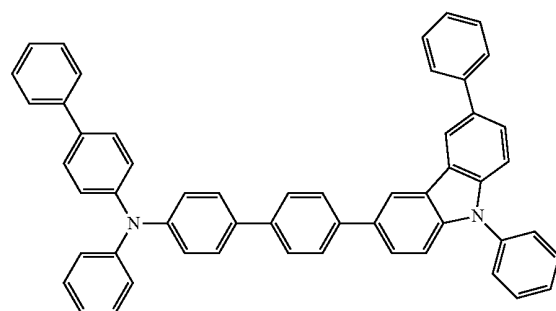
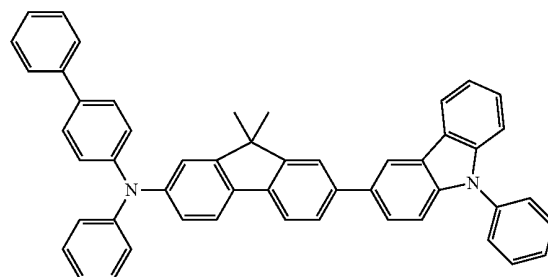
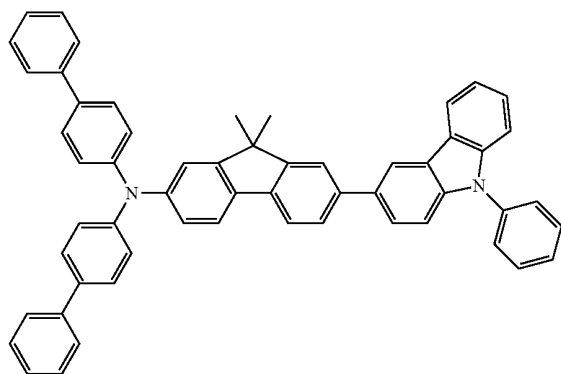
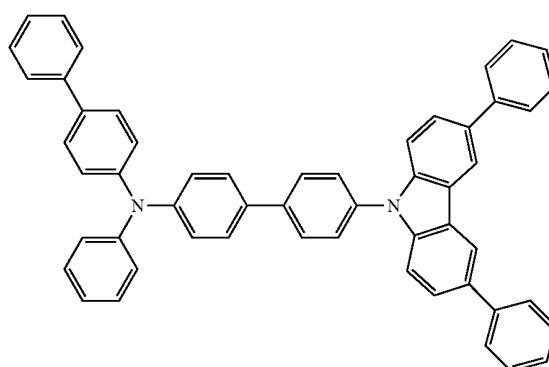
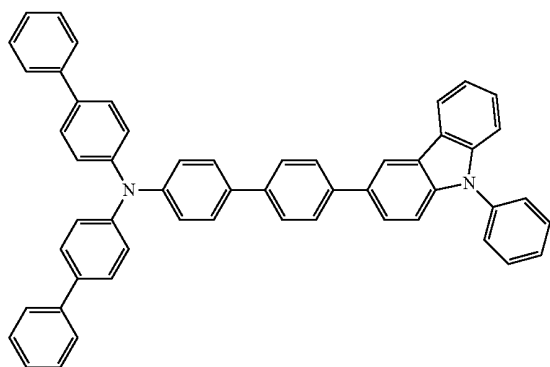
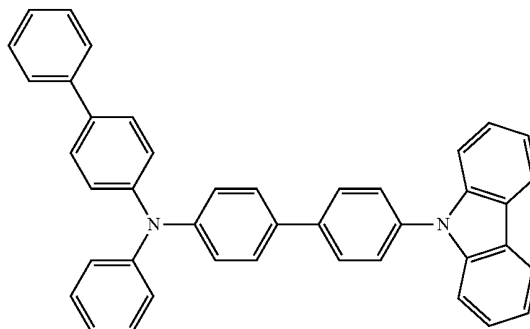
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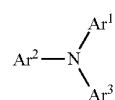
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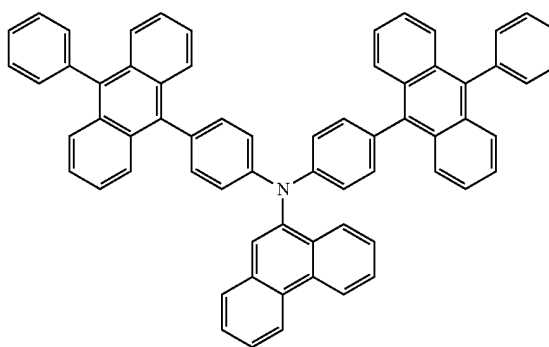
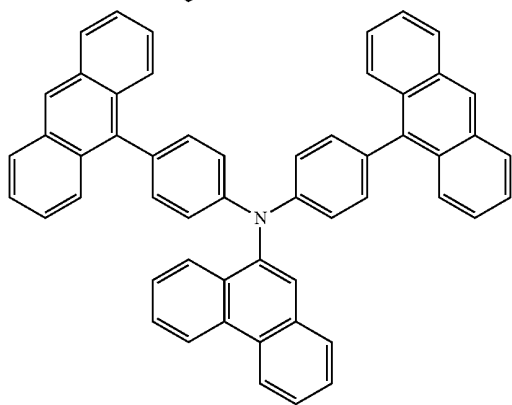
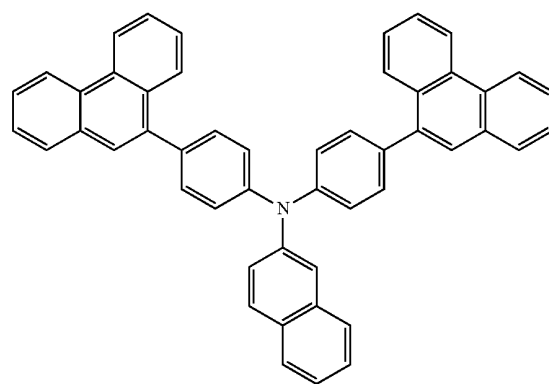
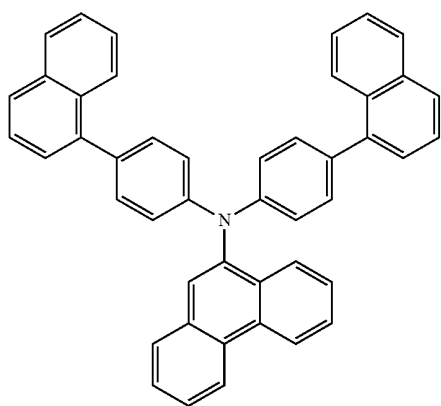
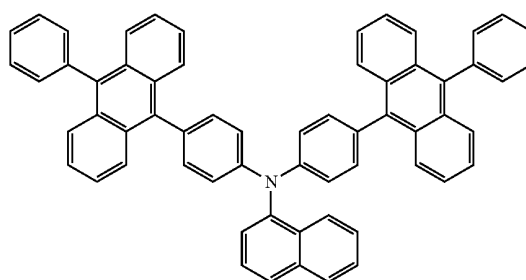
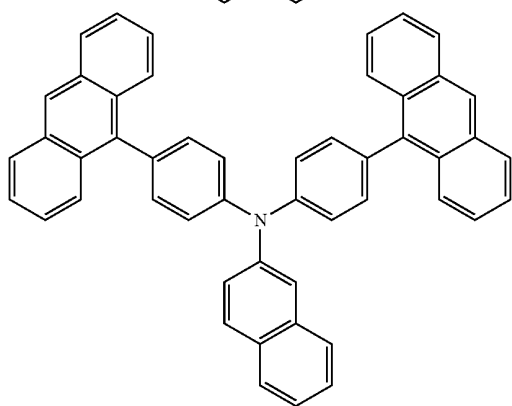
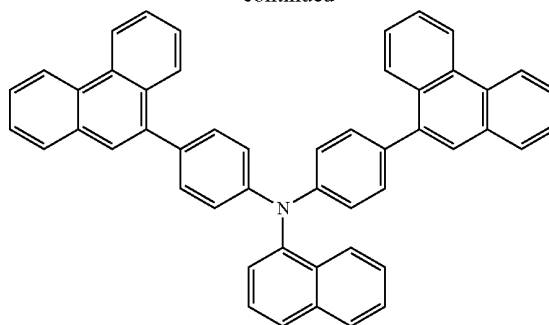
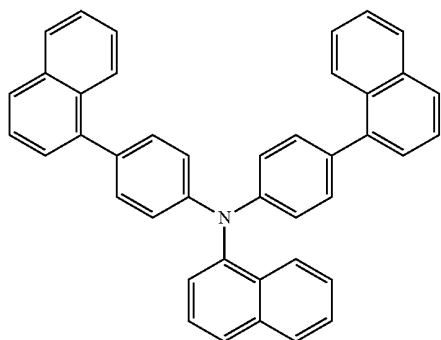
[0222] Aromatic amine represented by the following formula (II) can also be preferably used for forming the hole injecting layer or the hole transporting layer.



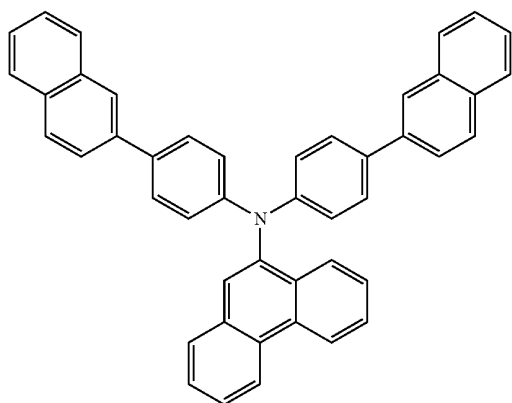
(II)

[0223] In the formula (II), Ar¹ to Ar³ each represent the same as Ar¹ to Ar⁴ of the above (I). Examples of the compound represented by the general formula (II) are shown below. However, the compound represented by the formula (II) is not limited thereto.

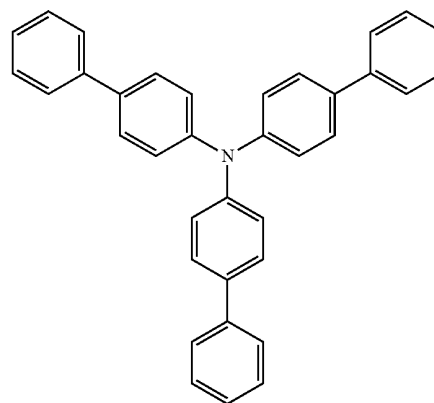
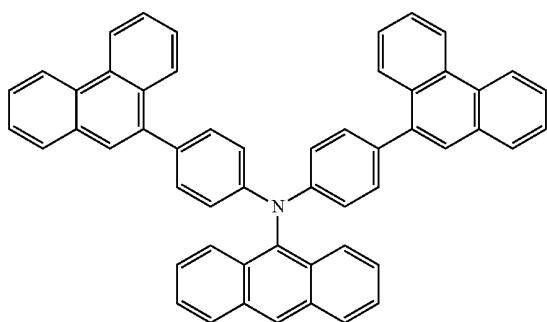
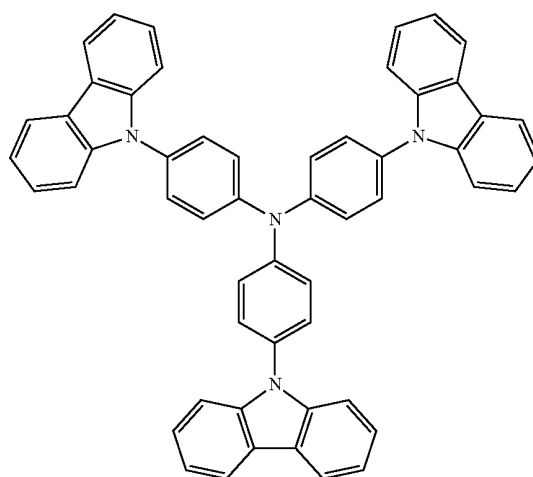
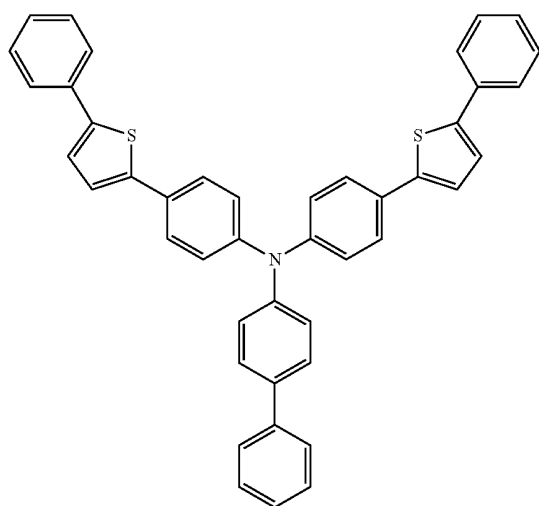
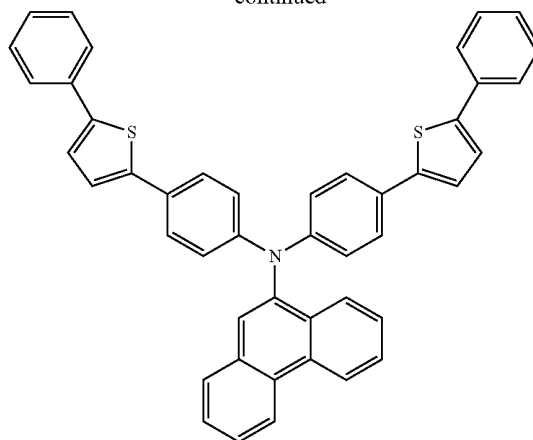
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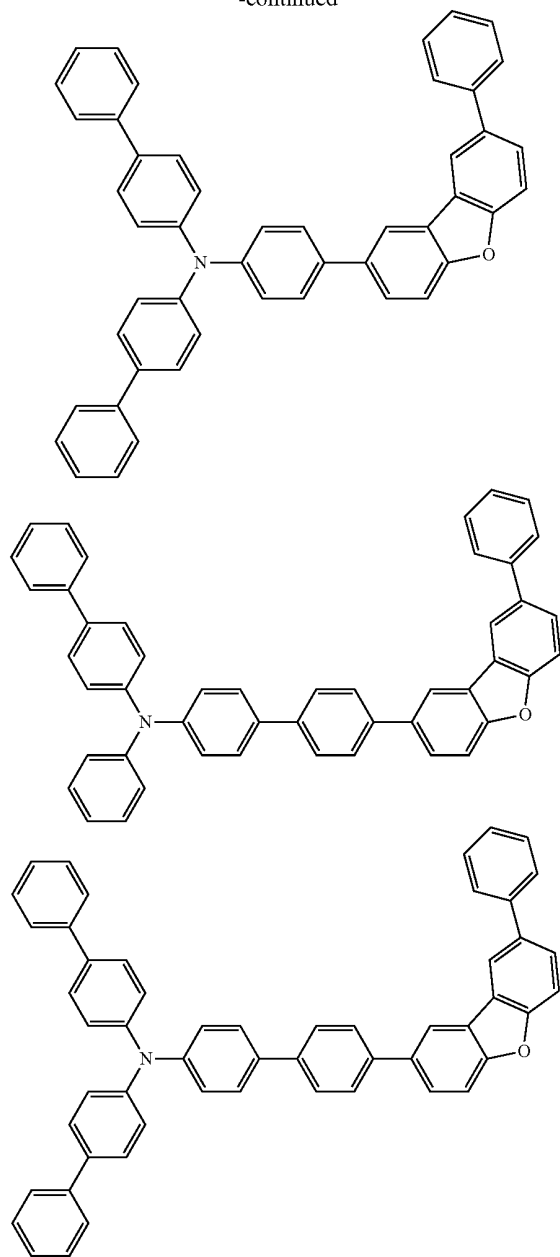
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[0224] A method of forming each of the layers in the organic EL device according to this exemplary embodiment is not particularly limited. A conventionally-known methods such as vacuum deposition or spin coating may be employed for forming the layers. The organic thin-film layer containing the compound represented by the formula (1A) or (1B), which is used in the organic EL device according to this exemplary embodiment, may be formed by a conventional coating method such as vacuum deposition, molecular beam epitaxy (MBE method) and coating methods using a solution such as a dipping, spin coating, casting, bar coating, and roll coating.

[0225] Although the thickness of each organic layer of the organic EL device according to this exemplary embodiment

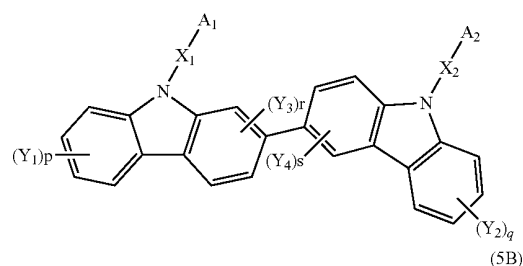
is not particularly limited, the thickness is generally preferably in a range of several nanometers to 1 μm because an excessively-thinned film likely entails defects such as a pin hole while an excessively-thickened film requires high voltage to be applied and deteriorates efficiency.

Second Exemplary Embodiment

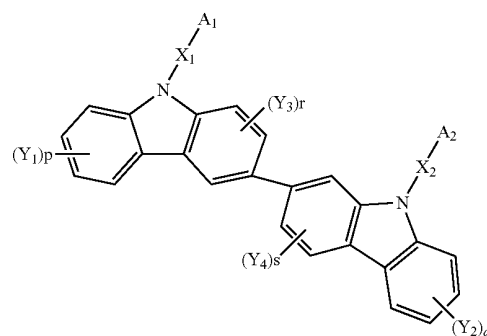
[0226] Next, an organic EL device according to a second exemplary embodiment will be described below.

[0227] The organic EL device according to the second exemplary embodiment is different in that the emitting layer includes the first host material, the second host material and the phosphorescent material. In this case, the first host material is the bis-carbazole derivative according to the exemplary embodiment represented by the formulae (5A) and (5B).

(5A)



(5B)



[0228] In the formulae (5A) and (5B): A_1 represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0229] A_2 represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

[0230] X_1 and X_2 each are a linking group and independently represent a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

[0231] Y_1 to Y_4 independently represent a hydrogen atom, fluorine atom, cyano group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl having 6 to 30 carbon atoms, substituted or unsubstituted

aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

[0232] adjacent ones of Y_1 to Y_4 may be bonded to each other to form a ring structure;

[0233] p and q represent an integer of 1 to 4; r and s represent an integer of 1 to 3; and

[0234] when p and q are an integer of 2 to 4 and r and s are an integer of 2 to 3, a plurality of Y_1 to Y_4 may be the same or different.

[0235] When Y_1 to Y_4 are bonded to each other to form a ring structure, the ring structure is exemplified by the same structures as ones listed when Y_1 to Y_4 are bonded to each other to form a ring structure in the formulae (1A) and (1B). A substituted or unsubstituted nitrogen-containing heterocyclic group is preferably ones other than a substituted or unsubstituted carbazolyl group and a substituted or unsubstituted indolyl group.

[0236] The organic-EL-device material represented by the formulae (5A) and (5B) has a biscarbazole skeleton having an excellent hole transporting capability and a heterocyclic skeleton having an excellent electron transporting capability, which leads to a bi-polar performance sufficient for functioning as a single host. However, a luminous efficiency and a lifetime of the multilayered organic EL device depend on a carrier balance of an entire organic EL device. Main factors for controlling the carrier balance are carrier transporting capability of each of the organic layers and carrier injecting capability in the interfacial region of separate organic layers. In order to balance the carrier injecting capability to neighboring layers in the emitting layer (recombination region), it is preferable to adjust the carrier balance not by a single host material but by a plurality of host materials. Specifically, it is preferable that, in addition to the first host material, the second host material is suitably selected as a co-host and used in the emitting layer.

[0237] When a material having a poor electron injecting capability (e.g., metal chelate complex) is used as the cathode, a carrier balance in the emitting layer becomes shifted toward the cathode. For improving such a disadvantage, it is preferable to select a material having a high electron transporting capability as the second host material. Specifically, the host material of the exemplary embodiment is preferably represented by a formula (6) or (7).



[0238] In the formulae (6) and (7): Cz represents a substituted or unsubstituted arylcarbazolyl group or carbazolylaryl group;

[0239] A^3 represents a group represented by a formula (8A) below; and

[0240] a and b each represent an integer of 1 to 3.



[0241] In the formula (8A): M^1 and M^2 each independently represent a substituted or unsubstituted nitrogen-containing aromatic heterocyclic ring or nitrogen-containing fused aromatic heterocyclic ring having 2 to 40 ring carbon atoms; M^1 and M^2 may be the same or different;

[0242] L^5 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 carbon atoms;

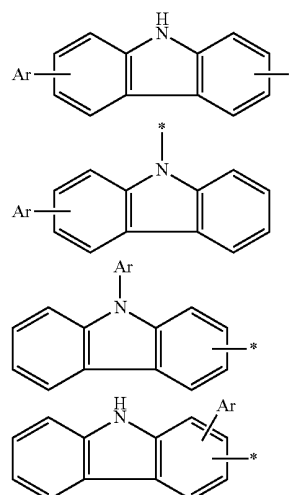
[0243] c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and c+e represents 1 or more.

With Respect to Compounds Represented by Formulae (6) and (7)

[0244] Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

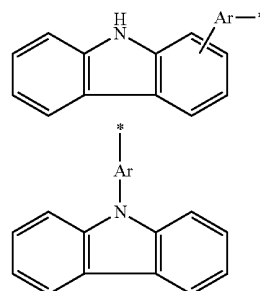
[0245] An arylcarbazolyl group means a carbazolyl group having at least one aryl group or heteroaryl group as a substituent, in which a position where the aryl group or heteroaryl group is substituted does not matter.

[0246] Specific examples are as follows. In the following chemical formulae, Ar represents an aryl group or heteroaryl group. * represents a position where another group is bonded.



[0247] A carbazolylaryl group means an aryl group having at least one carbazolyl group as a substituent, in which a position where the aryl group is substituted does not matter.

[0248] Specific examples are as follows. In the following chemical formulae, Ar represents an aryl group. * represents a position where another group is bonded.



[0249] A substituted arylcarbazolyl group means the arylcarbazolyl group having at least one substituent irrespective of a substitution position. A substituted carbazolyaryl group means the carbazolyaryl group having at least one substituent irrespective of a substitution position.

[0250] In the formulae (6) and (7), a and b each represent an integer of 1 to 3.

[0251] An aryl group in the arylcarbazolyl group or carbazolyaryl group preferably has 6 to 30 carbon atoms. Examples of the aryl group are a phenyl group, naphthyl group, anthryl group, phenanthryl group, naphthacenyl group, pyrenyl group, fluorenyl group, biphenyl group and terphenyl group, among of which a phenyl group, naphthyl group, biphenyl group and terphenyl group are preferable. Examples of the heteroaryl group in the arylcarbazolyl group are groups formed based on rings of pyridine, pyrimidine, pyrazine, triazine, aziridine, azaindolizine, indolizine, imidazoles, indole, isoindole, indazole, purine, pteridine, β -carboline, naphthyridine, quinoxaline, terpyridine, bipyridine, acridine, phenanthroline, phenazine and imidazopyridine, among which rings of pyridine, terpyridine, pyrimidine, imidazopyridine and triazine are preferable.

[0252] A in the formulae (6) and (7) represents the groups represented by the formula (8A).

[0253] In the formula (8A), M¹ and M² each independently represent a substituted or unsubstituted nitrogen-containing heterocyclic group having 2 to 40 ring carbon atoms. M¹ and M² may be the same or different.

[0254] Examples of the nitrogen-containing heterocyclic ring in the arylcarbazolyl group are groups formed based on rings of pyridine, pyrimidine, pyrazine, triazine, aziridine, azaindolizine, indolizine, imidazoles, indole, isoindole, indazole, purine, pteridine, P-carboline, naphthyridine, quinoxaline, terpyridine, bipyridine, acridine, phenanthroline, phenazine and imidazopyridine, among which rings of pyridine, terpyridine, pyrimidine, imidazopyridine and triazine are preferable.

[0255] L⁵ represents a single bond, substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms, or substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[0256] c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and c+e represents 1 or more.

[0257] Examples of the aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms are a phenyl group, biphenyl group, terphenyl group, naphthyl group, anthranil group, phenanthryl group, pyrenyl group, crycenyl group, fluoranthenyl group and perfluoroaryl group, fluorenyl group, and 9,9-dimethylfluorenyl group, among which a phenyl group, biphenyl group, terphenyl group and perfluoroaryl group are preferable.

[0258] Examples of the cycloalkylene group having 5 to 30 carbon atoms are cyclopentyl group, cyclohexylene group, and cycloheptylene group, among which a cyclohexylene group is preferable.

[0259] Examples of the aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms are 1-pyrrolyl group, 2-pyrrolyl group, 3-pyrrolyl group, pyrazinyl group, 2-pyridinyl group, 3-pyridinyl group, 4-pyridinyl group, 1-indolyl group, 2-indolyl group, 3-in-

dolyl group, 4-indolyl group, 5-indolyl group, 6-indolyl group, 7-indolyl group, 1-isoindolyl group, 2-isoindolyl group, 3-isoindolyl group, 4-isoindolyl group, 5-isoindolyl group, 6-isoindolyl group, 7-isoindolyl group, 2-furyl group, 3-furyl group, 2-benzofuranyl group, 3-benzofuranyl group, 4-benzofuranyl group, 5-benzofuranyl group, 6-benzofuranyl group, 7-benzofuranyl group, 1-isobenzofuranyl group, 3-isobenzofuranyl group, 4-isobenzofuranyl group, 5-isobenzofuranyl group, 6-isobenzofuranyl group, 7-isobenzofuranyl group, 2-quinolyl group, 3-quinolyl group, 4-quinolyl group, 5-quinolyl group, 6-quinolyl group, 7-quinolyl group, 8-quinolyl group, 1-isoquinolyl group, 3-isoquinolyl group, 4-isoquinolyl group, 5-isoquinolyl group, 6-isoquinolyl group, 7-isoquinolyl group, 8-isoquinolyl group, 2-quinoxalinyl group, 5-quinoxalinyl group, 6-quinoxalinyl group, 1-carbazolyl group, 2-carbazolyl group, 3-carbazolyl group, 4-carbazolyl group, 9-carbazolyl group, 1-phenanthridinyl group, 2-phenanthridinyl group, 3-phenanthridinyl group, 4-phenanthridinyl group, 6-phenanthridinyl group, 7-phenanthridinyl group, 8-phenanthridinyl group, 9-phenanthridinyl group, 10-phenanthridinyl group, 1-acridinyl group, 2-acridinyl group, 3-acridinyl group, 4-acridinyl group, 9-acridinyl group, 1,7-phenanthroline-2-yl group, 1,7-phenanthroline-3-yl group, 1,7-phenanthroline-4-yl group, 1,7-phenanthroline-5-yl group, 1,7-phenanthroline-6-yl group, 1,7-phenanthroline-8-yl group, 1,7-phenanthroline-9-yl group, 1,7-phenanthroline-10-yl group, 1,8-phenanthroline-2-yl group, 1,8-phenanthroline-3-yl group, 1,8-phenanthroline-4-yl group, 1,8-phenanthroline-5-yl group, 1,8-phenanthroline-6-yl group, 1,8-phenanthroline-7-yl group, 1,8-phenanthroline-9-yl group, 1,8-phenanthroline-10-yl group, 1,9-phenanthroline-2-yl group, 1,9-phenanthroline-3-yl group, 1,9-phenanthroline-4-yl group, 1,9-phenanthroline-5-yl group, 1,9-phenanthroline-6-yl group, 1,9-phenanthroline-7-yl group, 1,9-phenanthroline-8-yl group, 1,9-phenanthroline-10-yl group, 1,10-phenanthroline-2-yl group, 1,10-phenanthroline-3-yl group, 1,10-phenanthroline-4-yl group, 1,10-phenanthroline-5-yl group, 2,9-phenanthroline-1-yl group, 2,9-phenanthroline-3-yl group, 2,9-phenanthroline-4-yl group, 2,9-phenanthroline-5-yl group, 2,9-phenanthroline-6-yl group, 2,9-phenanthroline-7-yl group, 2,9-phenanthroline-8-yl group, 2,9-phenanthroline-10-yl group, 2,8-phenanthroline-1-yl group, 2,8-phenanthroline-3-yl group, 2,8-phenanthroline-4-yl group, 2,8-phenanthroline-5-yl group, 2,8-phenanthroline-6-yl group, 2,8-phenanthroline-7-yl group, 2,8-phenanthroline-9-yl group, 2,8-phenanthroline-10-yl group, 2,7-phenanthroline-1-yl group, 2,7-phenanthroline-3-yl group, 2,7-phenanthroline-4-yl group, 2,7-phenanthroline-5-yl group, 2,7-phenanthroline-6-yl group, 2,7-phenanthroline-8-yl group, 2,7-phenanthroline-9-yl group, 2,7-phenanthroline-10-yl group, 1-phenazinyl group, 2-phenazinyl group, 1-phenothiazinyl group, 2-phenothiazinyl group, 3-phenothiazinyl group, 4-phenothiazinyl group, 10-phenothiazinyl group, 1-phenoxazinyl group, 2-phenoxazinyl group, 3-phenoxazinyl group, 4-phenoxazinyl group, 10-phenoxazinyl group, 2-oxazolyl group, 4-oxazolyl group, 5-oxazolyl group, 2-oxadiazolyl group, 5-oxadiazolyl group, 3-furazanyl group, 2-thienyl group, 3-thienyl group, 2-methylpyrrol-1-yl group, 2-methylpyrrol-3-yl group, 2-methylpyrrol-4-yl group, 2-methylpyrrol-5-yl group, 3-methylpyrrol-1-yl group, 3-methylpyrrol-2-yl group, 3-methylpyrrol-4-yl group, 3-methylpyrrol-5-yl group, 2-t-butylpyrrol-4-yl group, 3-(2-phenylpropyl)pyrrol-1-yl group, 2-methyl-1-indolyl group, 4-methyl-1-indolyl group, 2-methyl-3-indolyl group, 4-me-

thyl-3-indolyl group, 2-t-butyl-1-indolyl group, 4-t-butyl-1-indolyl group, 2-t-butyl-3-indolyl group, and 4-t-butyl-3-indolyl group, among which a pyridinyl group and quinolyl group are preferable.

[0260] Examples of the substituents for Cz, M¹ and M² in the formulae (6), (7) and (8A) are a halogen atom such as chlorine, bromine and fluorine, carbazole group, hydroxyl group, substituted or unsubstituted amino group, nitro group, cyano group, silyl group, trifluoromethyl group, carbonyl group, carboxyl group, substituted or unsubstituted alkyl group, substituted or unsubstituted alkenyl group, substituted or unsubstituted arylalkyl group, substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group, substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group, substituted or unsubstituted aralkyl group, substituted or unsubstituted aryloxy group, and substituted or unsubstituted alkyloxy group. Among these, a fluorine atom, methyl group, perfluorophenylene group, phenyl group, naphthyl group, pyridyl group, pyrazil group, pyrimidyl group, adamantyl group, benzyl group, cyano group and silyl group are preferable.

[0261] Bonding patterns of the compound represented by the formula (6) or (7) are shown in Table 1 below in accordance with values of a and b.

TABLE 1

a = b = 1	a = 2	a = 3	b = 2	b = 3
Cz—A ³	Cz—A ³ —Cz	Cz—A ³ —Cz Cz	A ³ —Cz—A ³	A ³ —Cz—A ³ A ³

[0262] Bonding patterns of the compound represented by the formula (8A) are shown in Tables 2 and 3 below in accordance with values of c, d and e.

TABLE 2

No	c	d	e	Bonding Patterns
(1)	0	1	1	L ⁵ —M ²
(2)	0	1	2	L ⁵ —M ² —M ² , M ² —L ⁵ —M ²
(3)	0	2	1	L ⁵ —L ⁵ —M ² , L ⁵ —M ² —L ⁵
(4)	0	2	2	L ⁵ —L ⁵ —M ² —M ² , M ² —L ⁵ —L ⁵ —M ² , $\begin{array}{c} \text{L}^5-\text{M}^2-\text{M}^2-\text{L}^5, \\ \text{L}^5 \quad \text{L}^5 \end{array} \quad \begin{array}{c} \text{M}^2-\text{L}^5-\text{M}^2, \\ \text{L}^5 \end{array} \quad \begin{array}{c} \text{L}^5-\text{M}^2-\text{L}^5 \\ \text{M}^2 \end{array}$
(5)	1	1	0	the same as [1] (M ² is replaced with M ¹)
(6)	1	1	1	M ¹ —L ⁵ —M ²
(7)	1	1	2	M ¹ —L ⁵ —M ² —M ² , M ¹ —L ⁵ —M ² $\begin{array}{c} \text{M}^2 \\ \\ \text{M}^2 \end{array}$
(8)	1	2	0	the same as [3] (M ² is replaced with M ¹)
(9)	1	2	1	M ¹ —L ⁵ —L ⁵ —M ² , L ⁵ —M ¹ —L ⁵ —M ² , L ⁵ —M ¹ —L ⁵ —M ²
(10)	1	2	2	M ¹ —L ⁵ —L ⁵ —M ² —M ² , M ² —L ⁵ —M ¹ —L ⁵ —M ² , $\begin{array}{c} \text{M}^2-\text{M}^2-\text{L}^5-\text{M}^1-\text{L}^5, \text{M}^1-\text{L}^5-\text{L}^5 \\ \text{M}^2 \quad \text{M}^2 \end{array}$
				$\begin{array}{c} \text{M}^1-\text{L}^5-\text{L}^5-\text{M}^2, \\ \text{M}^2 \end{array} \quad \begin{array}{c} \text{L}^5-\text{L}^5-\text{M}^2-\text{M}^2, \\ \text{M}^1 \end{array}$

TABLE 2-continued

No	c	d	e	Bonding Patterns
				$\begin{array}{c} \text{L}^5-\text{M}^1-\text{L}^5-\text{L}^5-\text{M}^2, \\ \text{M}^2 \end{array} \quad \begin{array}{c} \text{M}^2 \\ \\ \text{M}^1-\text{L}^5-\text{L}^5, \\ \text{M}^2 \end{array}$
(11)	2	1	0	the same as [2] (M ² is replaced with M ¹)
(12)	2	1	1	the same as [7] (M ² is replaced with M ¹)
(13)	2	1	2	M ¹ —M ¹ —L ⁵ —M ² —M ² , $\begin{array}{c} \text{M}^2 \\ \\ \text{M}^1-\text{L}^5-\text{M}^1, \\ \text{M}^2 \end{array}$ $\begin{array}{c} \text{M}^1-\text{L}^5-\text{M}^2-\text{M}^2 \\ \text{M}^1 \end{array}$

TABLE 3

No	c	d	e	Bonding Patterns
(14)	2	2	0	the same as [4] (M ² is replaced with M ¹)
(15)	2	2	1	the same as [10] (M ² is replaced with M ¹)
(16)	2	2	2	M ¹ —M ¹ —L ⁵ —L ⁵ —M ² —M ² , M ¹ —M ¹ —L ⁵ —M ² —M ² $\begin{array}{c} \text{L}^5 \end{array}$ $\begin{array}{c} \text{M}^1-\text{L}^5-\text{L}^5-\text{M}^2-\text{M}^2, \\ \text{M}^1 \end{array} \quad \begin{array}{c} \text{M}^1 \\ \\ \text{M}^1-\text{L}^5-\text{L}^5, \\ \text{M}^2 \quad \text{M}^2 \end{array}$ $\begin{array}{c} \text{M}^1-\text{M}^1-\text{L}^5-\text{L}^5-\text{M}^2, \\ \text{M}^2 \end{array} \quad \begin{array}{c} \text{M}^1 \\ \\ \text{L}^5-\text{L}^5-\text{M}^2-\text{M}^2, \\ \text{M}^1 \end{array}$ $\begin{array}{c} \text{M}^1-\text{L}^5-\text{L}^5-\text{M}^1 \\ \text{M}^2 \quad \text{M}^2 \end{array}$

[0263] Cz bonded to A may be bonded to any one of M¹, L⁵ and M² of the formula (8A) representing A.

[0264] For instance, when a=b=1 and Cz—A³—Cz are given in the formula (6) or (7) and [6] (c=d=e=1) of Table 2 is given in the formula (A), three bonding patterns of Cz—M¹—L⁵—M², M¹—L⁵(Cz)—M², and M¹—L⁵—M²—Cz are listed.

[0265] Moreover, for instance, when a=2 and Cz—A³—Cz are given in the formula (6) and [7] (c=d=1, e=2) Table 2 is given in the formula (8A), the following bonding patterns are listed.

[0266] In the bonding patterns of the formulae (6), (7) and (8A) and exemplary combinations of the groups as described above, compounds represented by [1] to [4] below are preferable.

[1] a=1 is given in the formula (6) and c=1 and d=0 are given in the formula (8A).

[0267] In the formula (6), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazoylaryl group.

[0268] In the formula (8A): M^1 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^5 is a substituted or unsubstituted aryl group or aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[2] $a=2$ is given in the formula (6) and $c=1$ and $e=0$ are given in the formula (8A).

[0269] In the formula (6), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

[0270] In the formula (8A): M^1 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^5 is a substituted or unsubstituted aryl group or aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[3] $a=1$ is given in the formula (6) and $c=2$ and $e=0$ are given in the formula (8A).

[0271] In the formula (6), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

[0272] In the formula (8A): M^1 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^5 is a substituted or unsubstituted aryl group or aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[4] $b=2$ is given in the formula (7) and $c=d=1$ is given in the formula (8A).

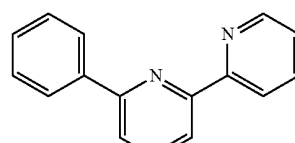
[0273] In the formula (7), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

[0274] In the formula (8A): M^1 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^5 is a substituted or unsubstituted aryl group or aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

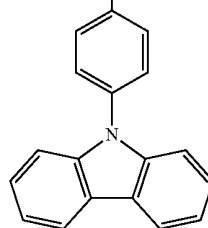
[0275] In the formulae (6) and (7), Cz is preferably a substituted or unsubstituted arylcarbazolyl group, more prefer-

ably phenylcarbazolyl group. Moreover, an aryl site of the arylcarbazolyl group is preferably substituted by a carbazolyl group.

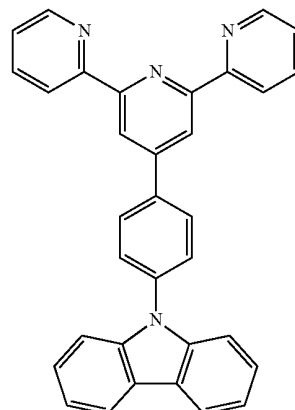
[0276] Specific examples of the compound represented by the formula (6) according to this exemplary embodiment are shown below, but the compound represented by the formula (6) is not limited thereto.



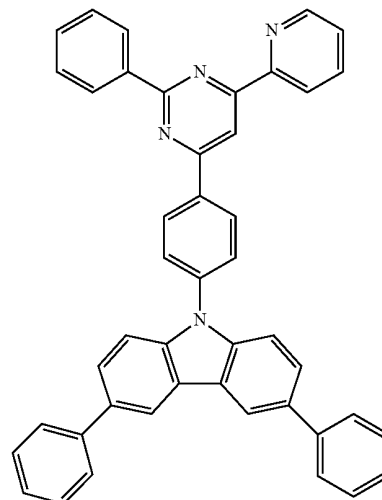
(A1)



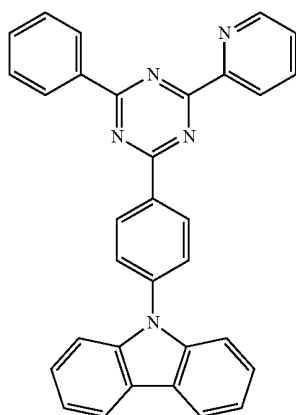
(A2)



(A3)

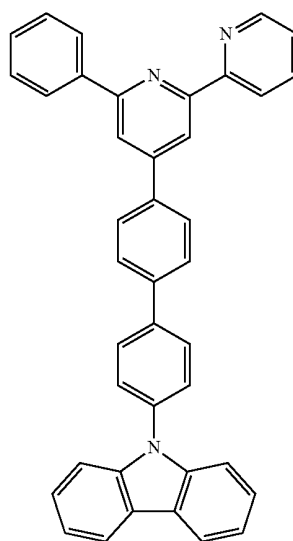


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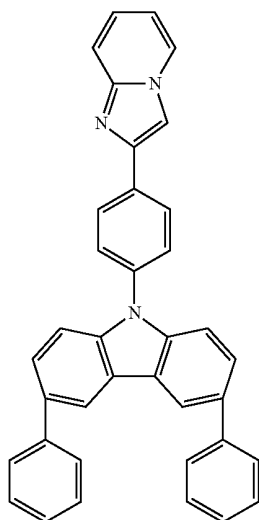
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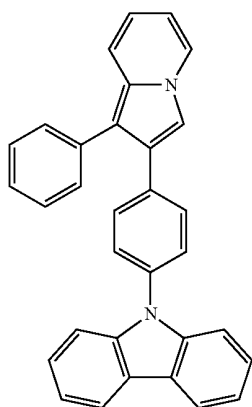


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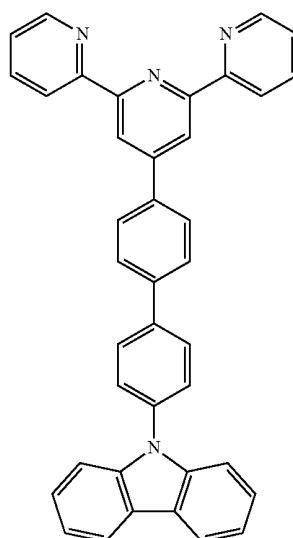
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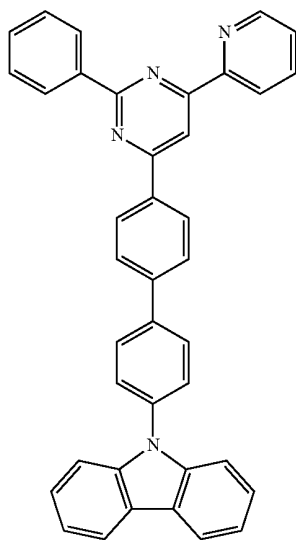
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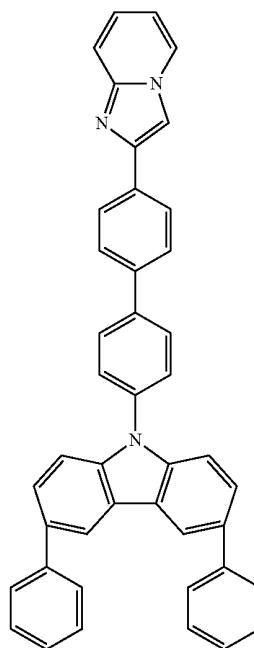
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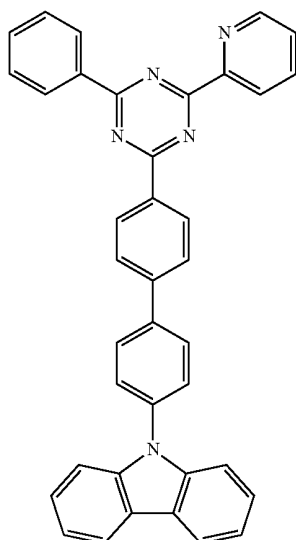
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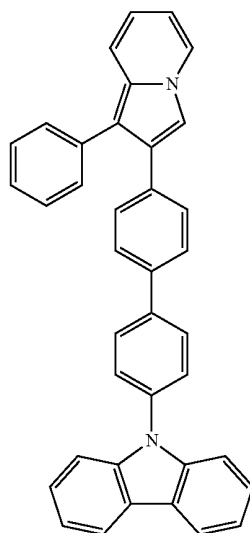
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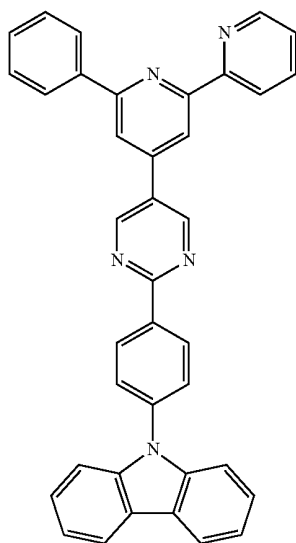
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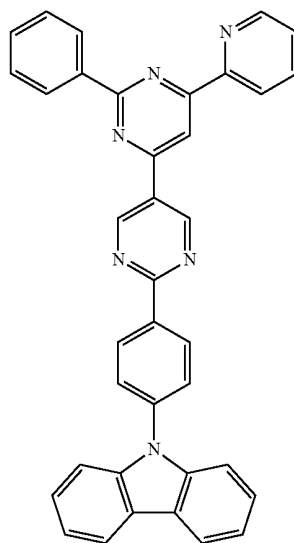


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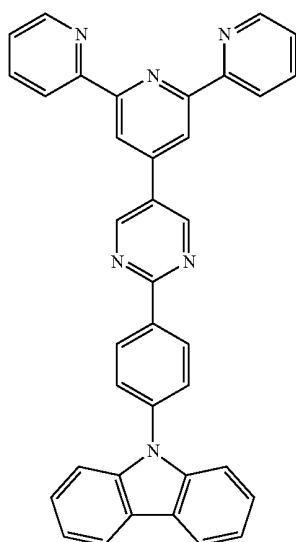


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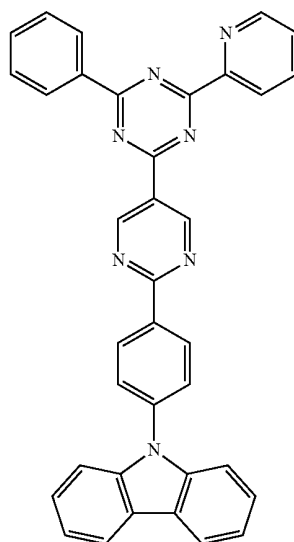
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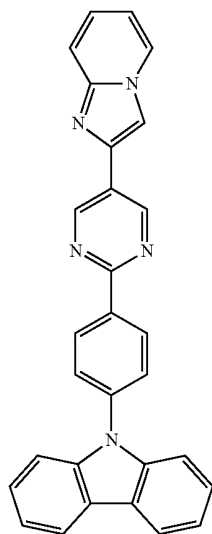


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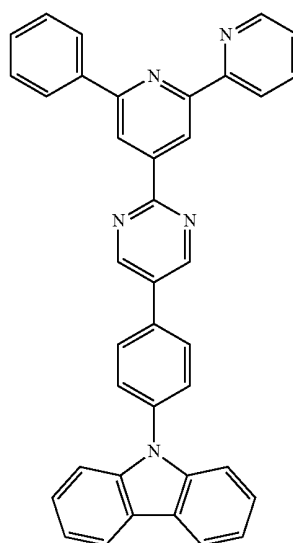
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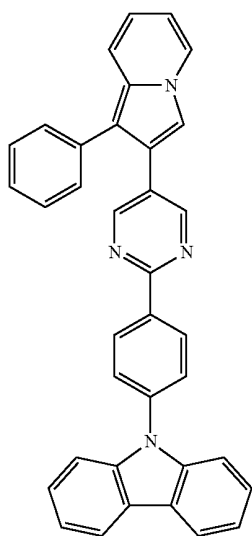


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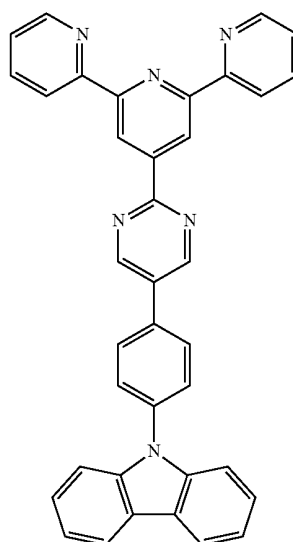
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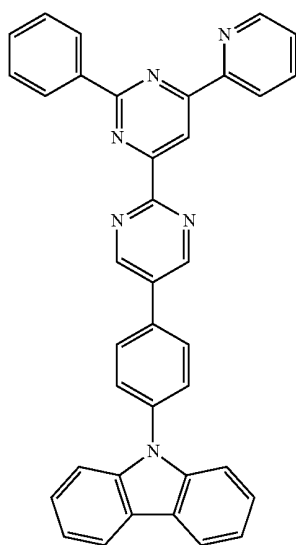


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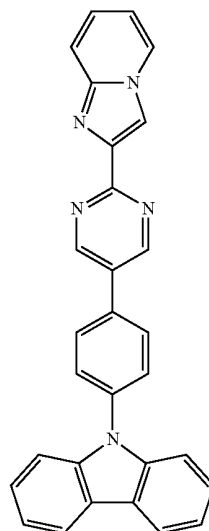
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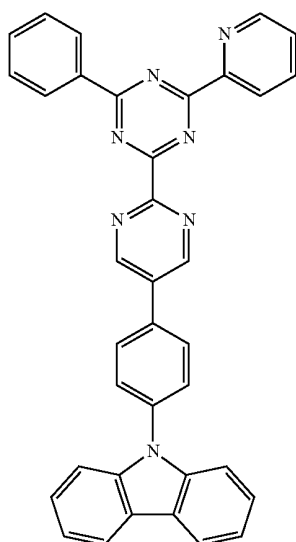


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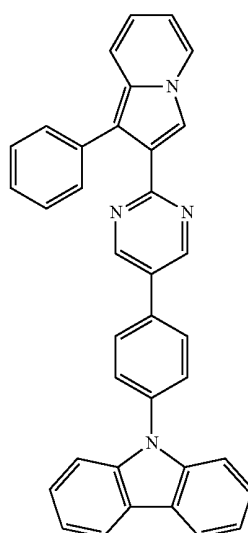
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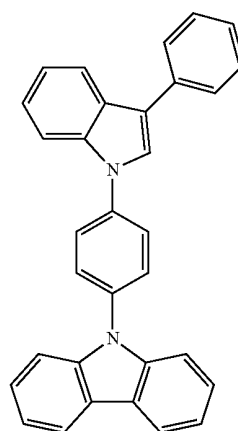
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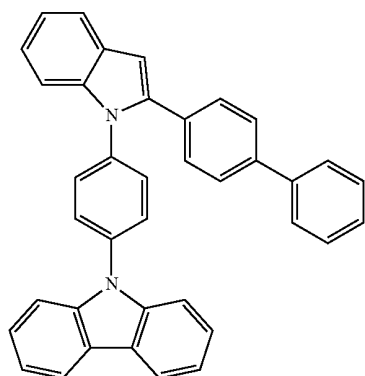


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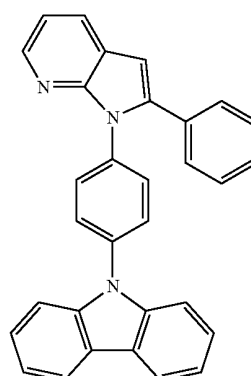
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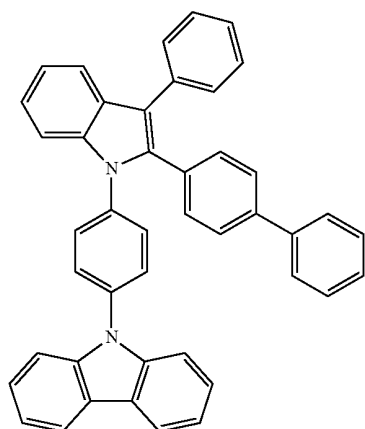


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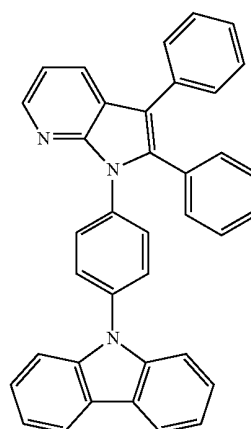
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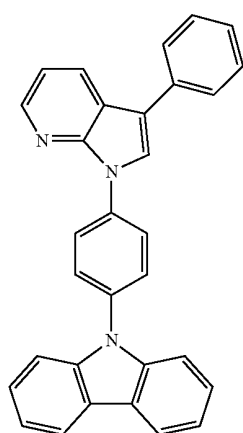
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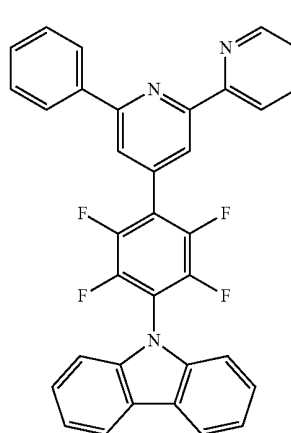
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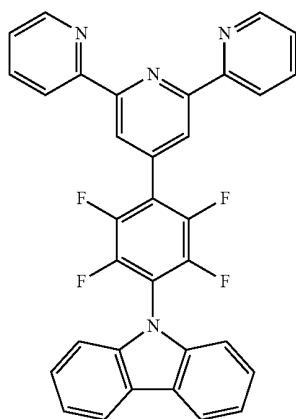


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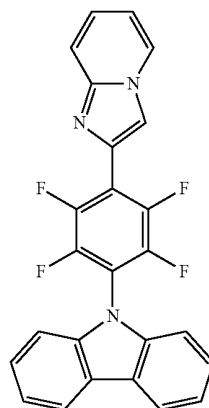
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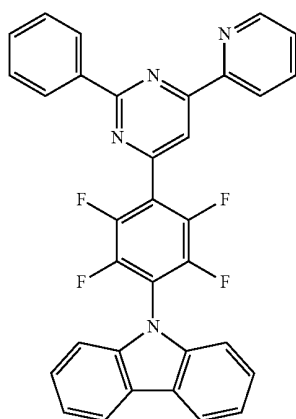


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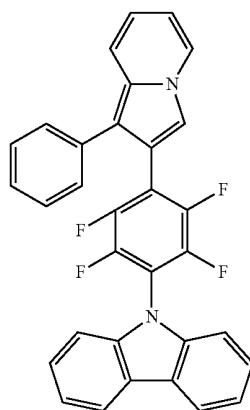
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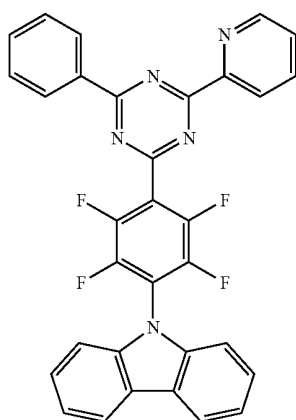
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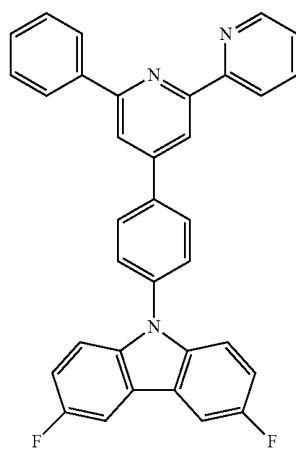
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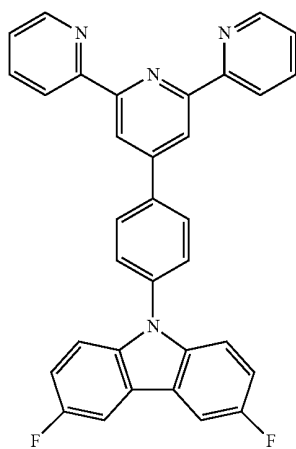


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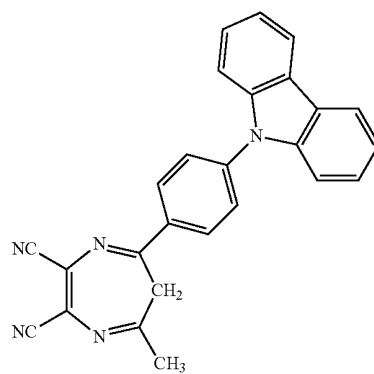
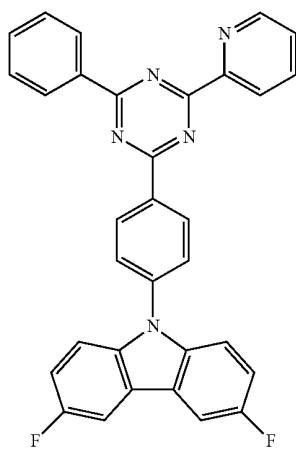
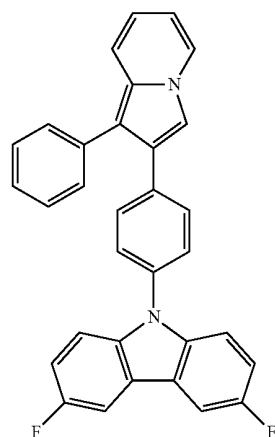
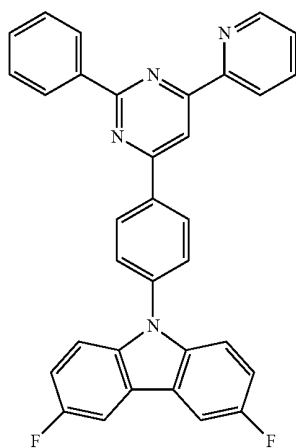
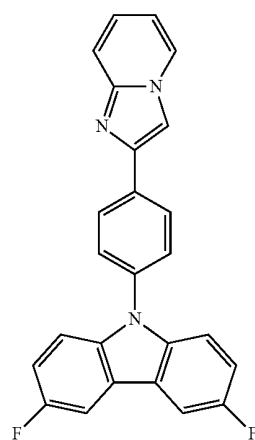


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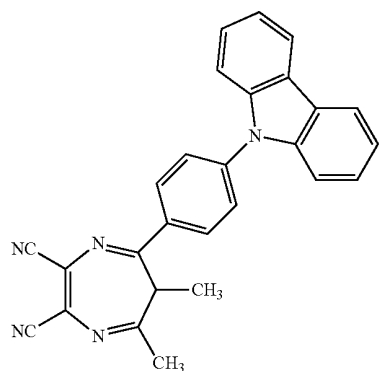
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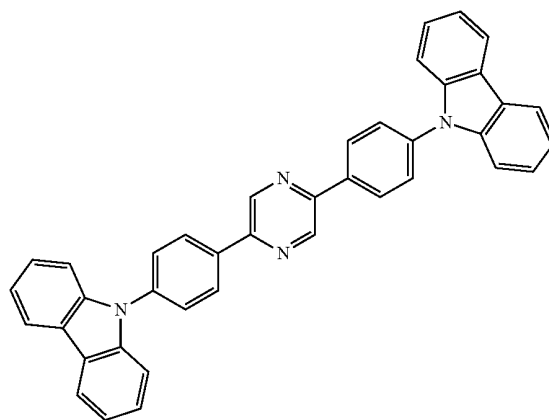


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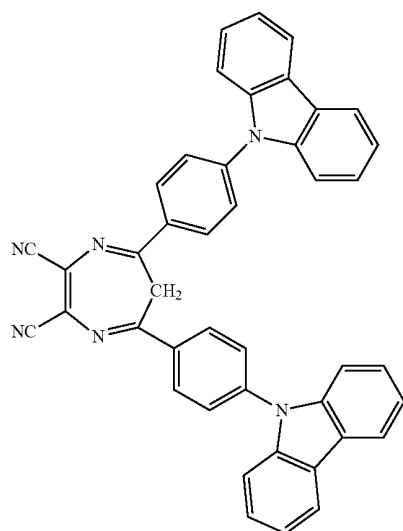
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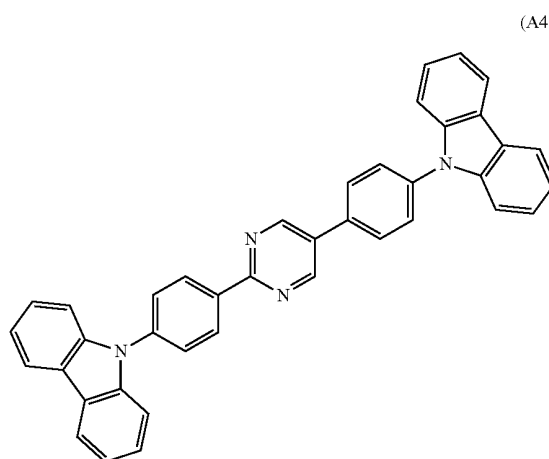


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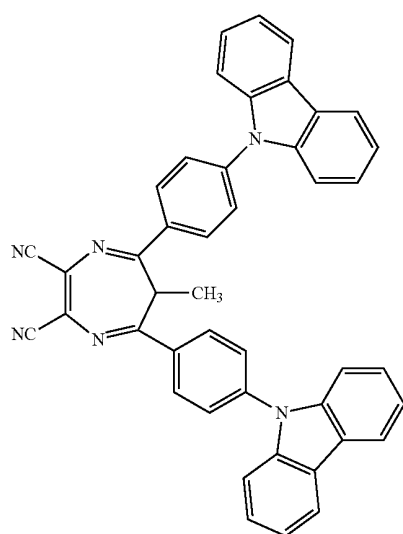
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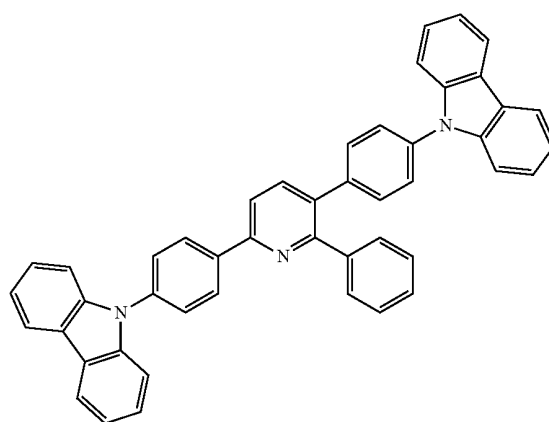
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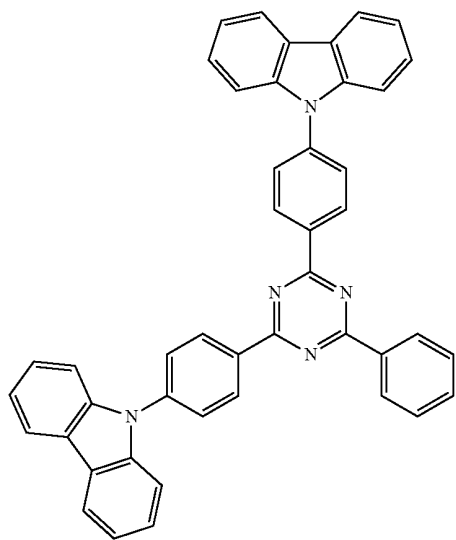


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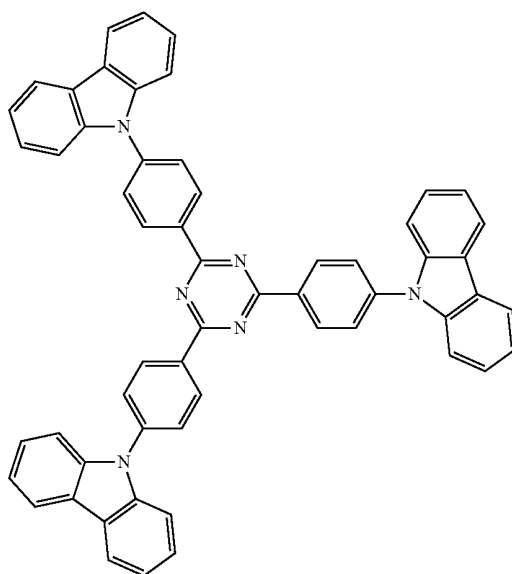
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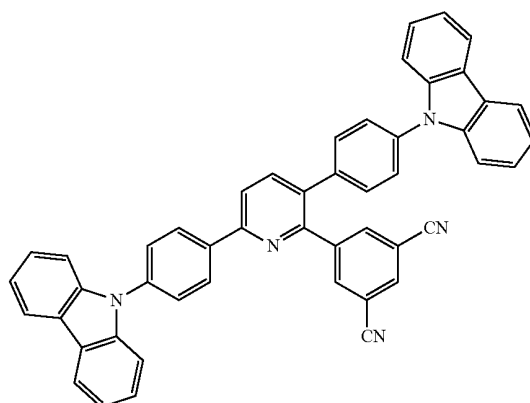


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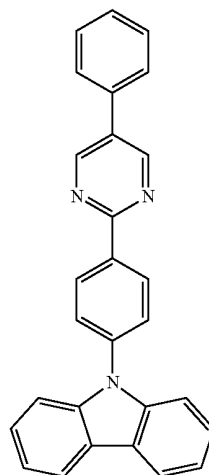
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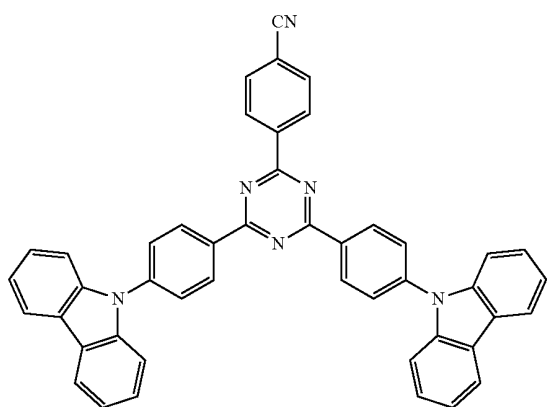
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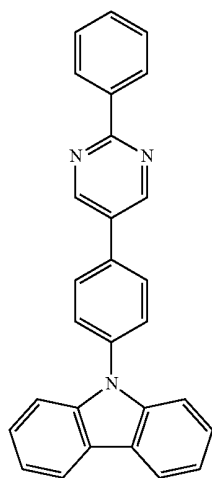
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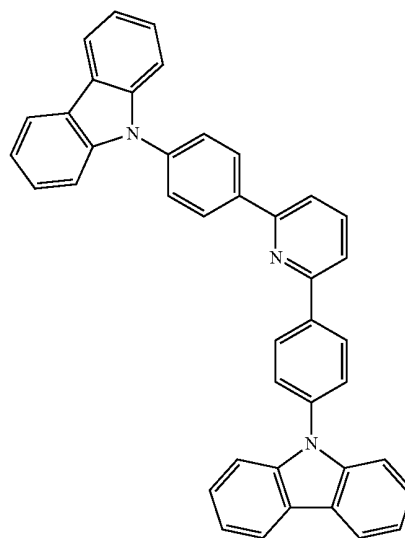
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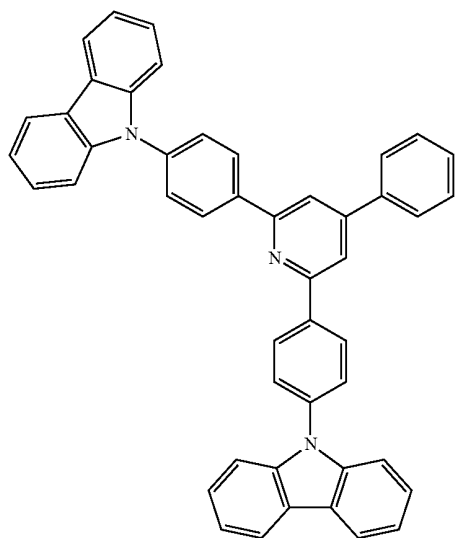
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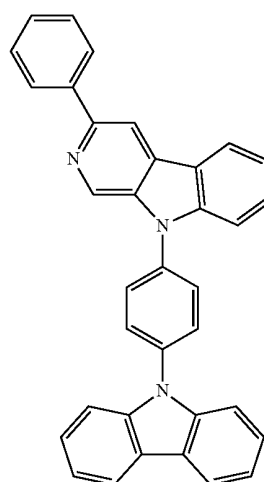
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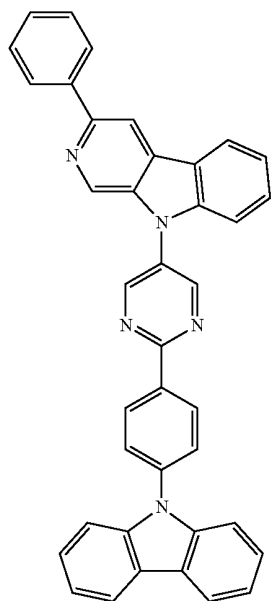
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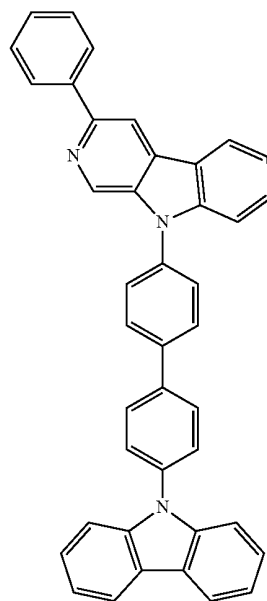


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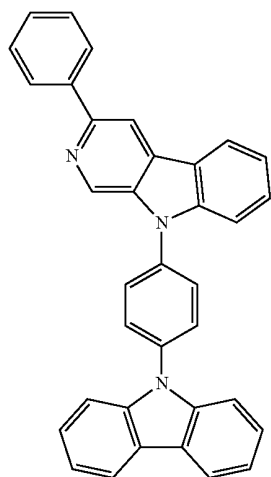


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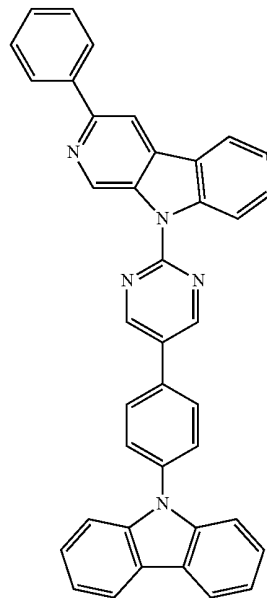
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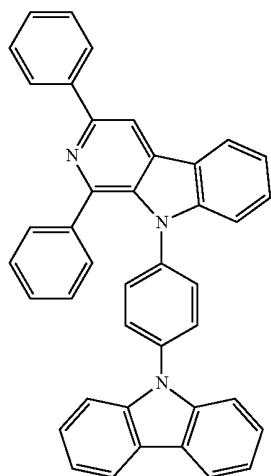


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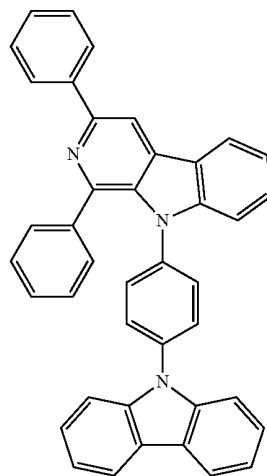
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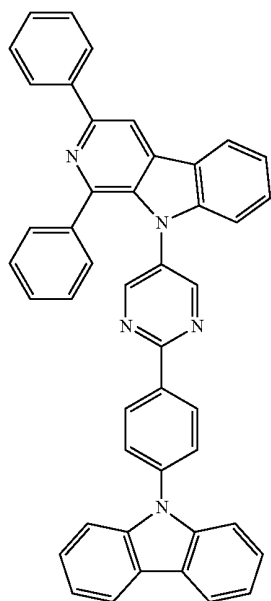


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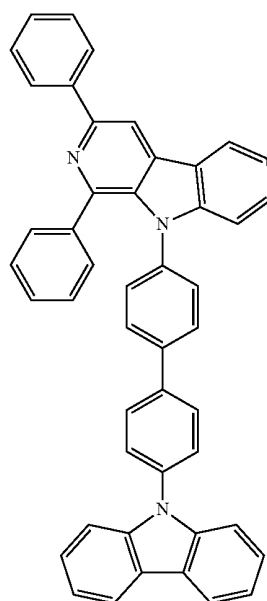
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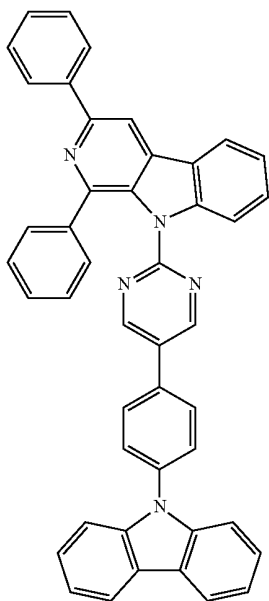
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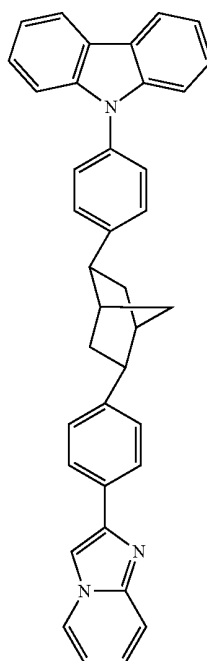
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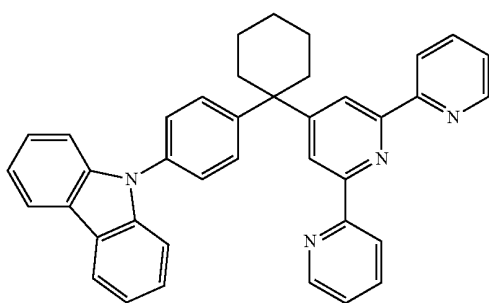


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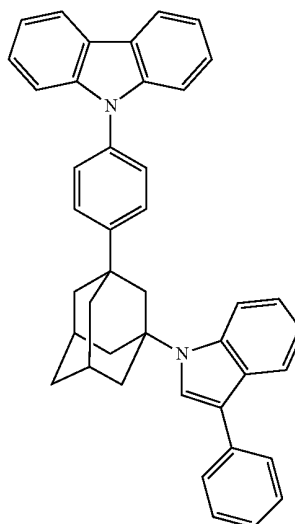
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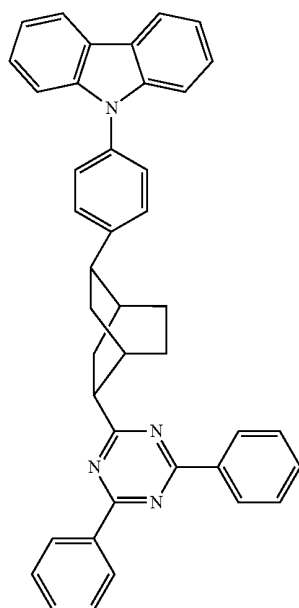
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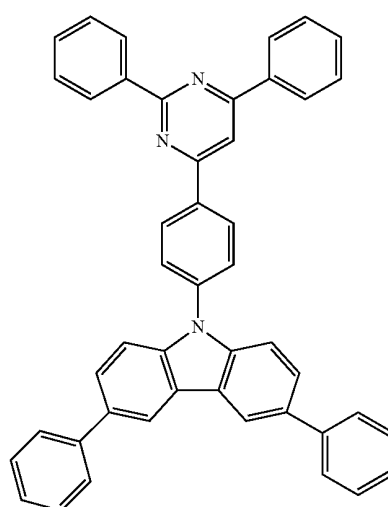


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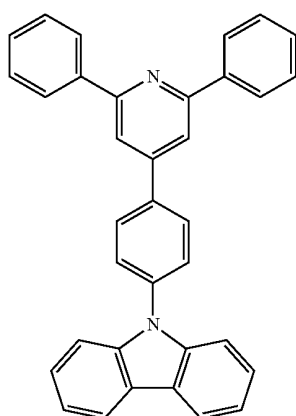


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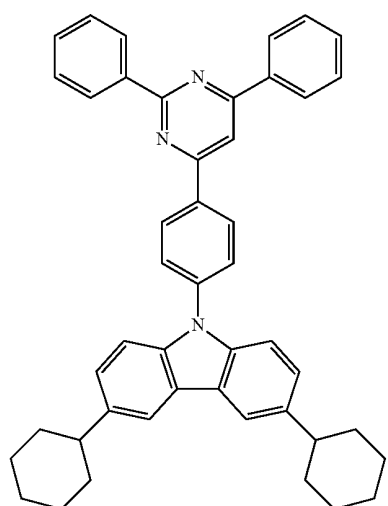
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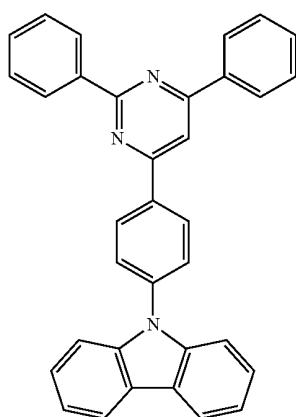
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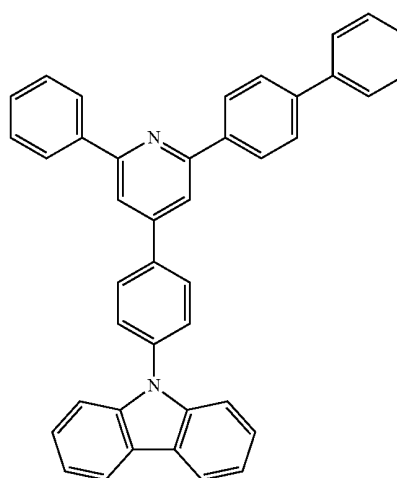
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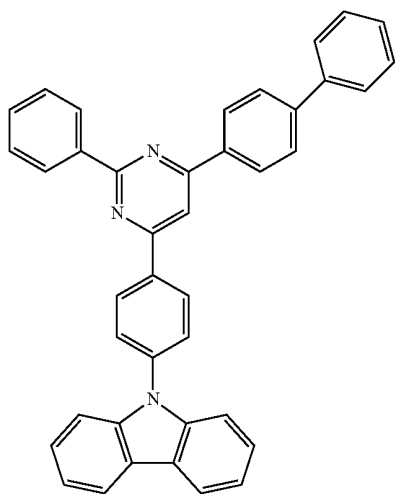
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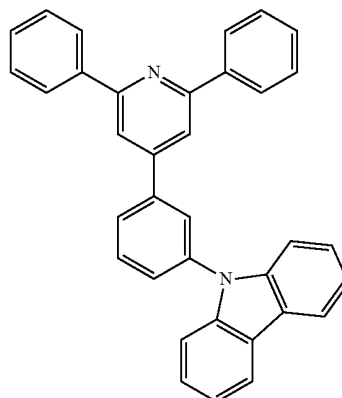
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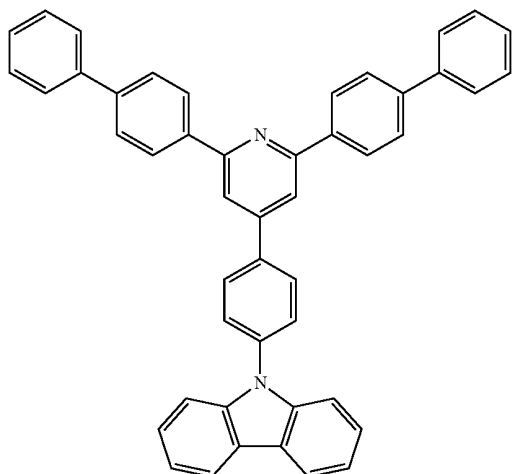


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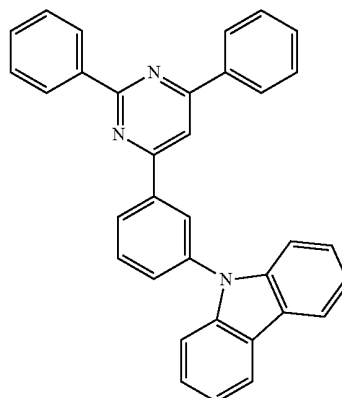
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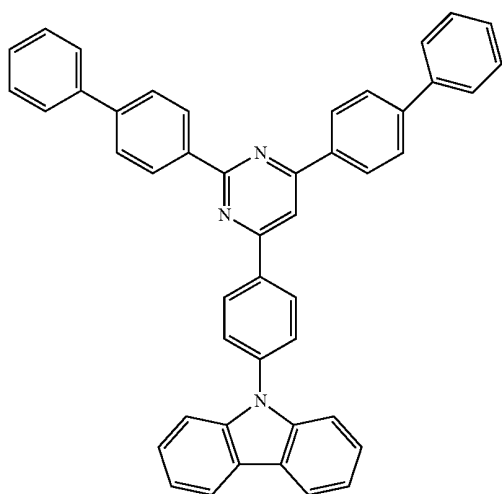
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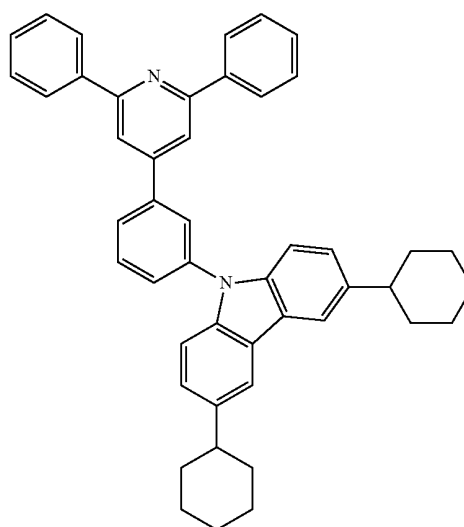
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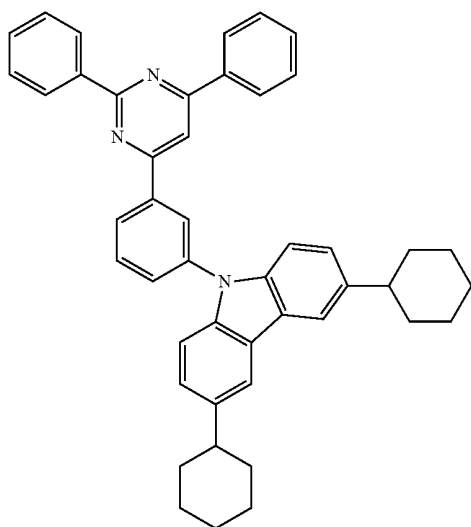


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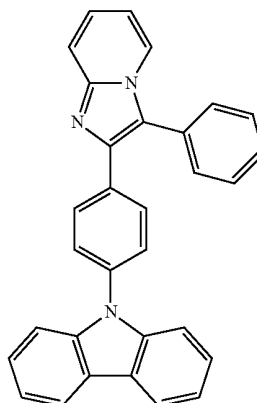
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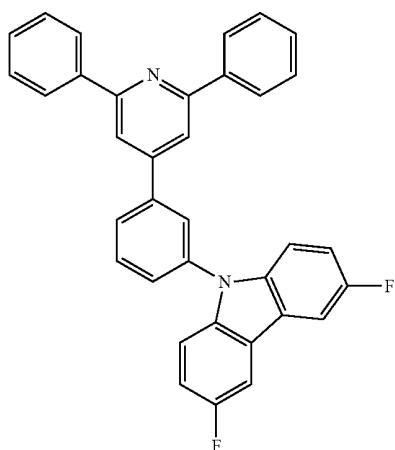


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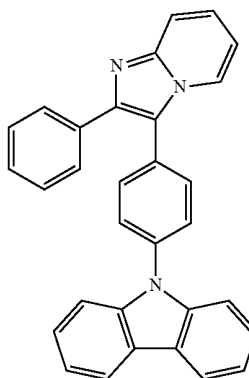
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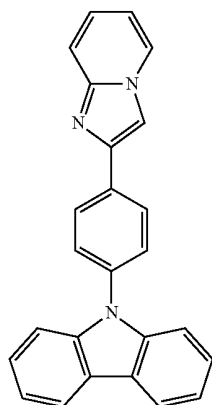
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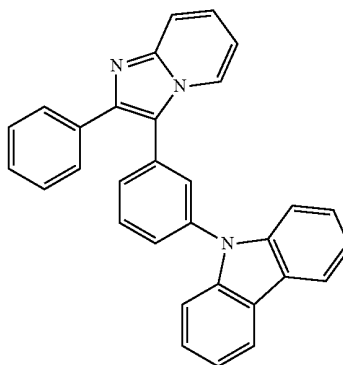
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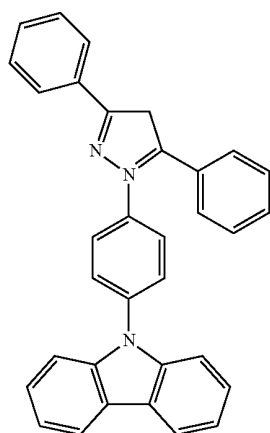
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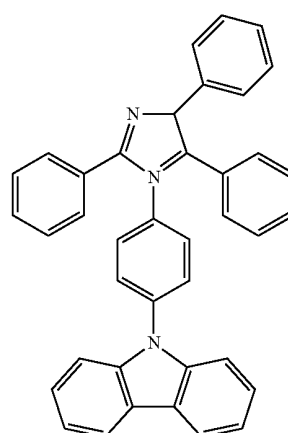


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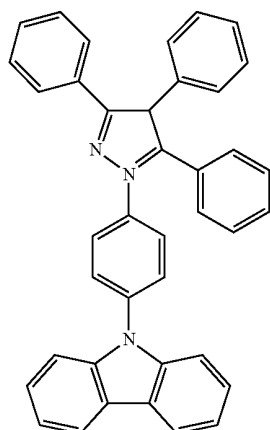


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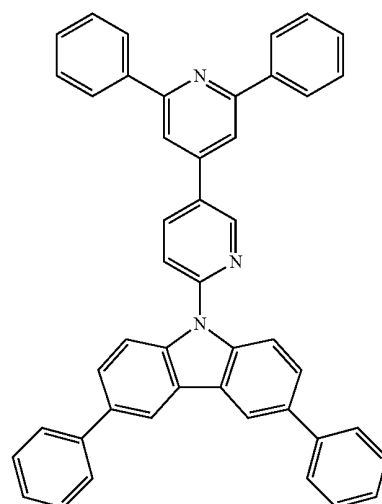
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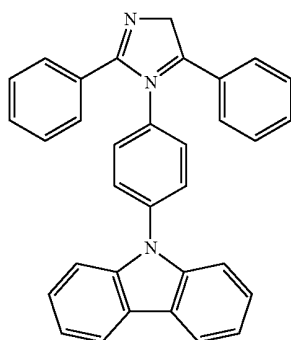
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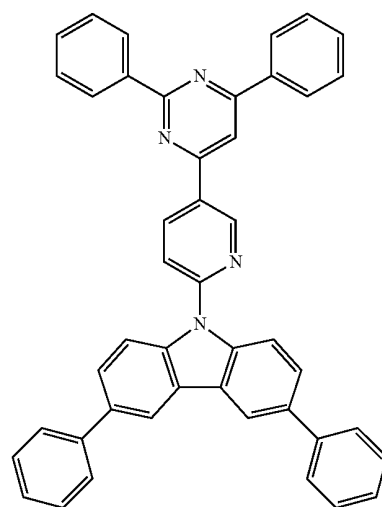
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(A93)



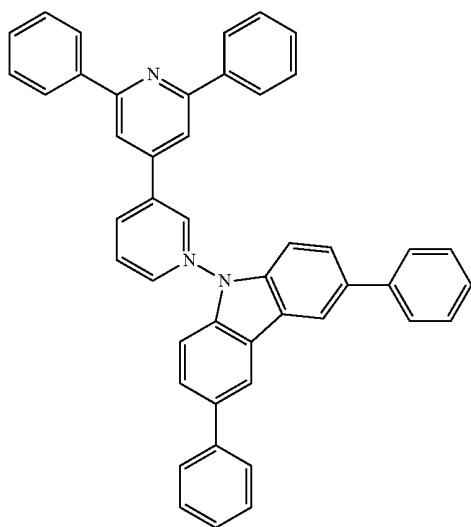
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(A94)

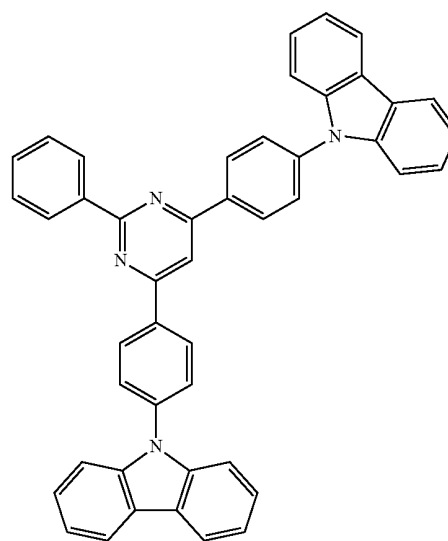
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(A95)

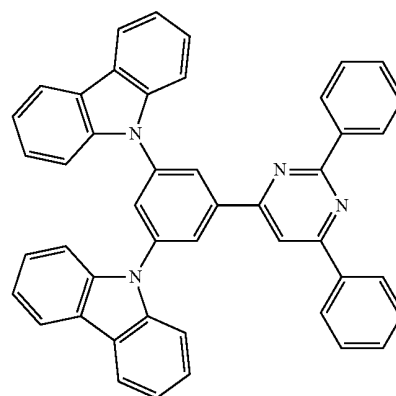


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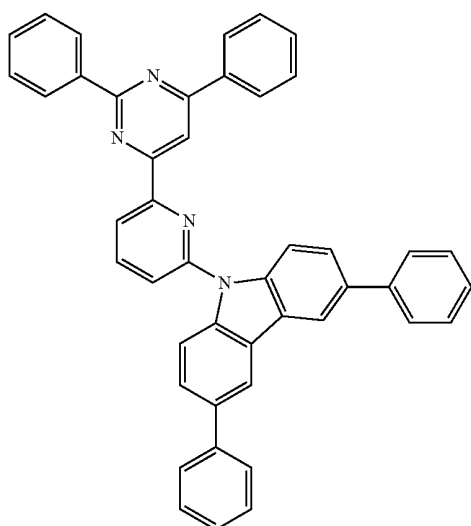
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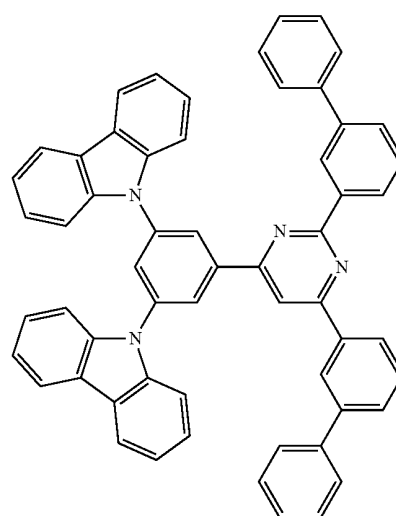
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(A96)

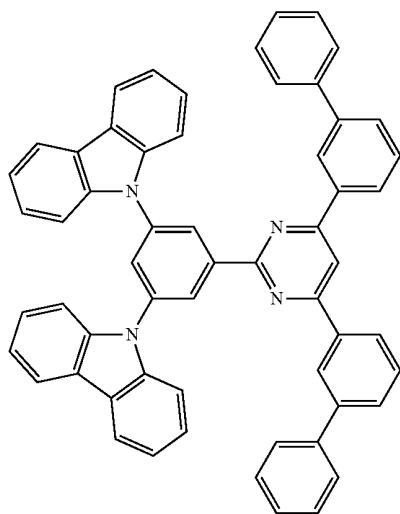


(A99)



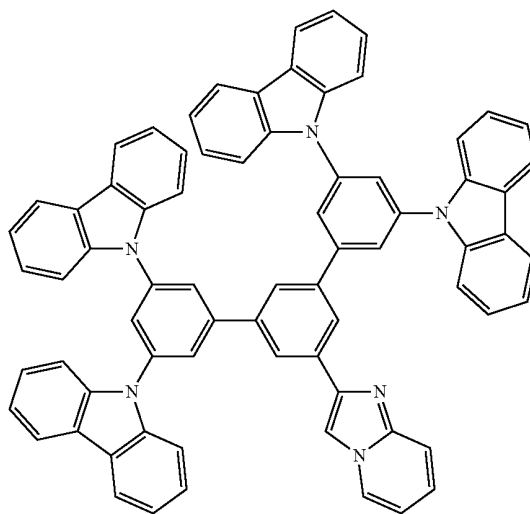
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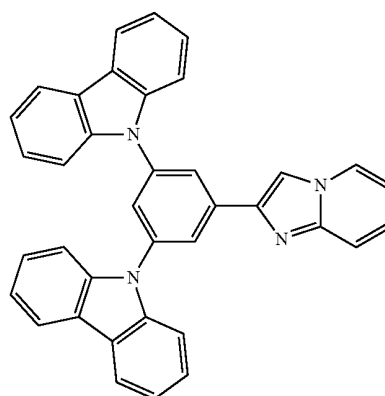


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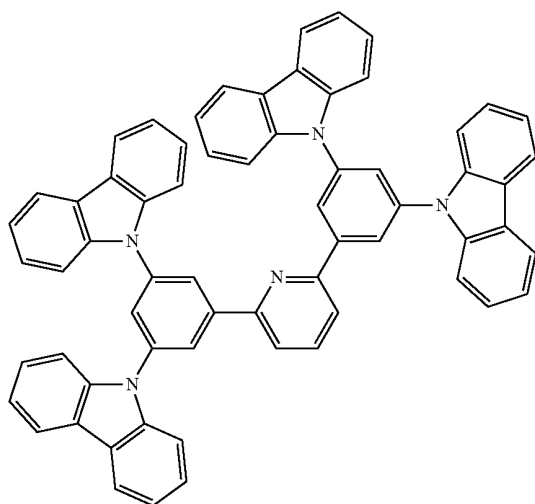
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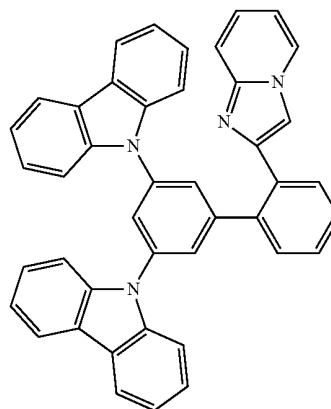
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(A101)

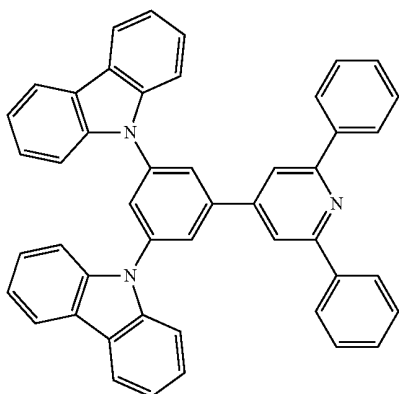


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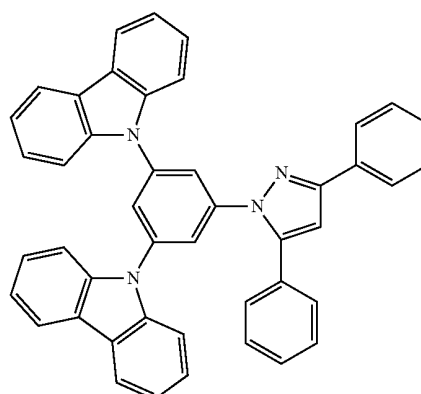
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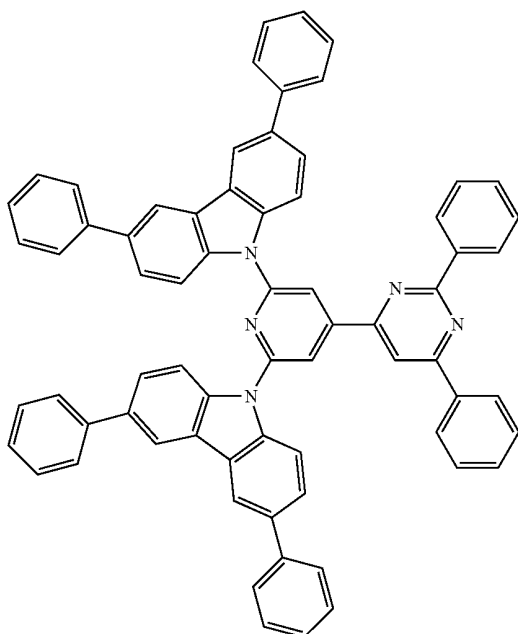


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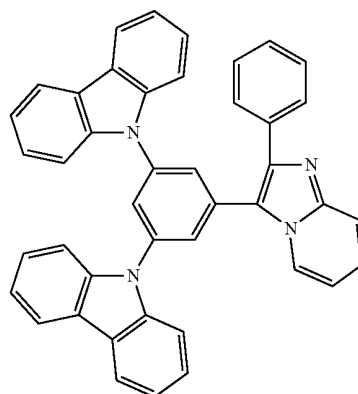
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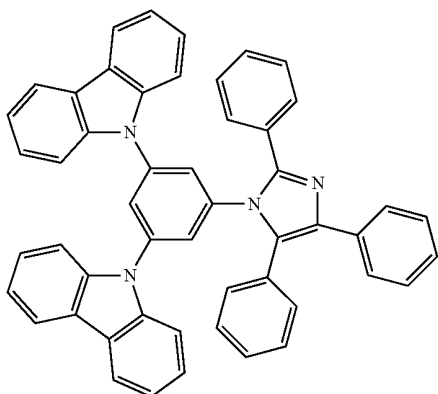
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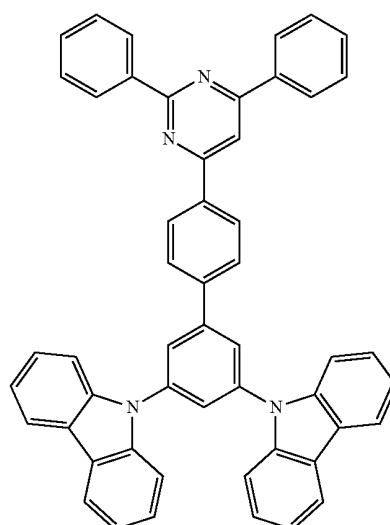
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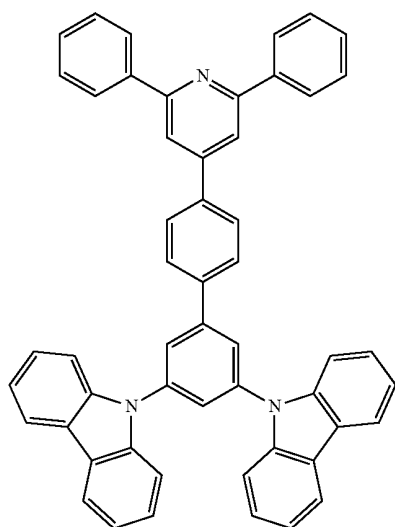
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(A110)

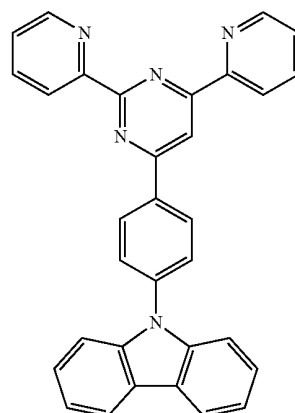


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(A111)

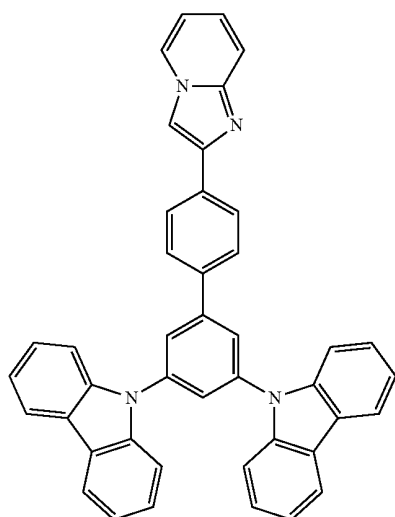
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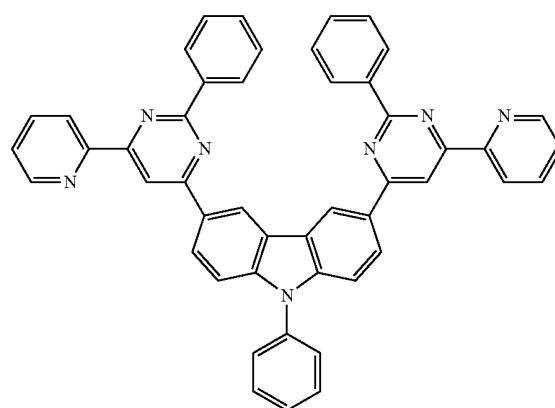
(A114)

[0277] Specific examples of the compound represented by the formula (7) are shown below, but the compound represented by the formula (7) is not limited thereto.

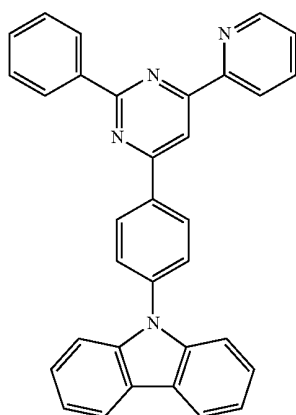
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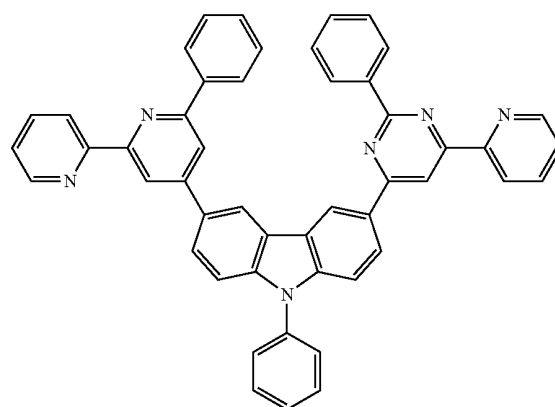
(B1)



(A113)

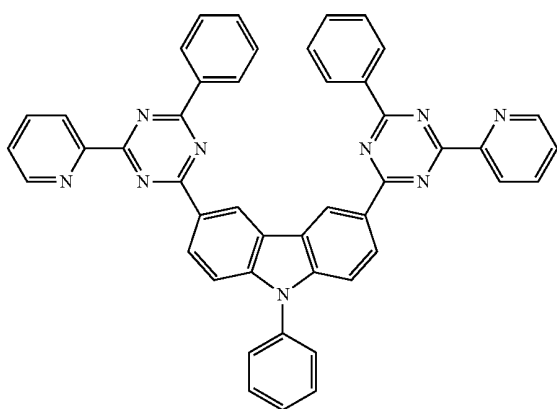


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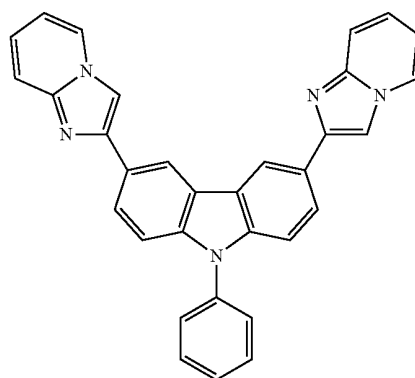
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(B3)



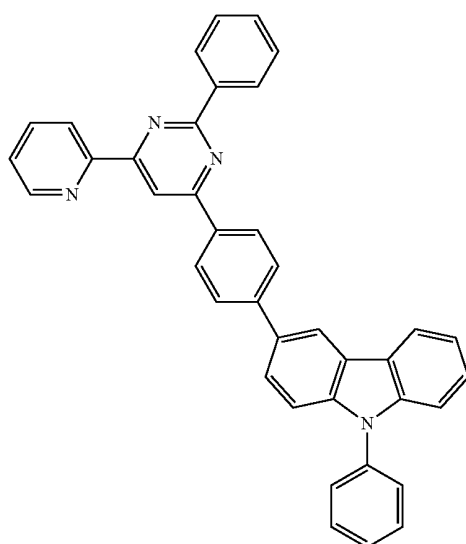
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(B6)

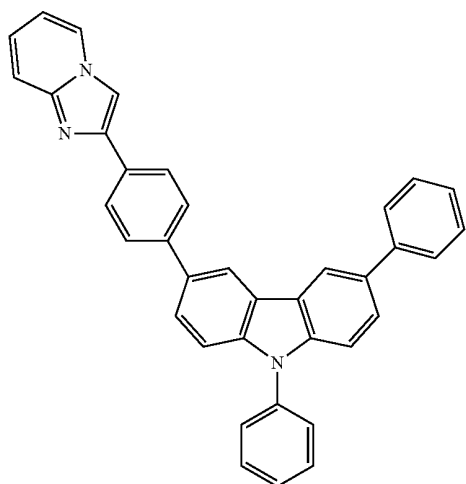


(B7)

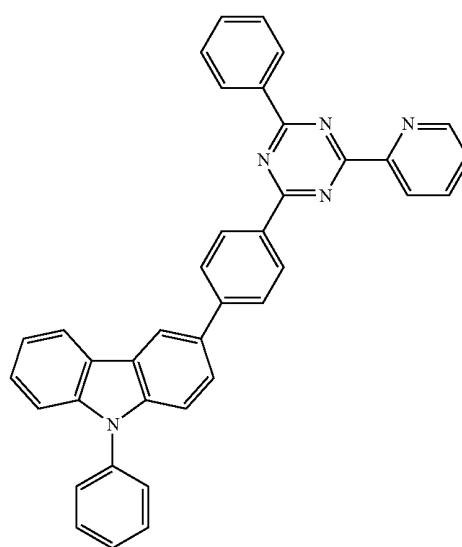
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(B5)

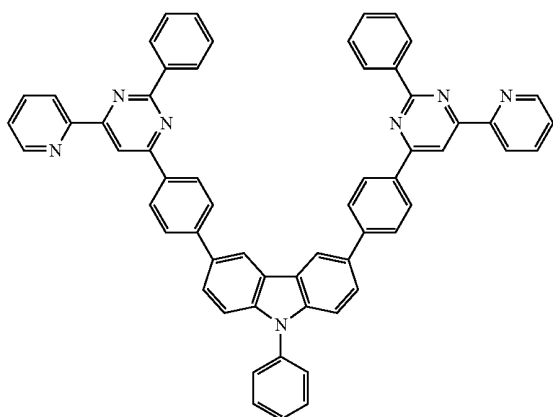


(B8)



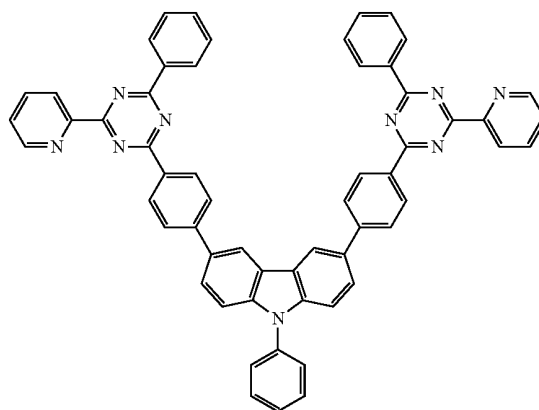
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(B9)

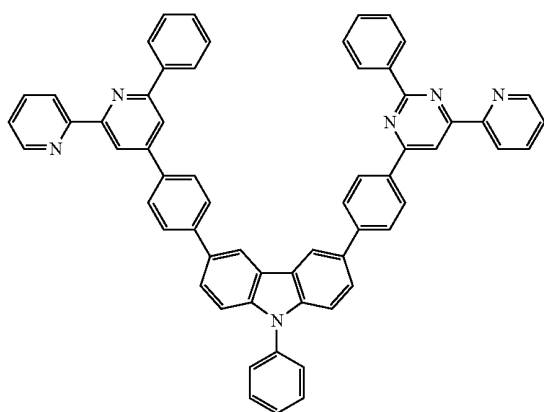


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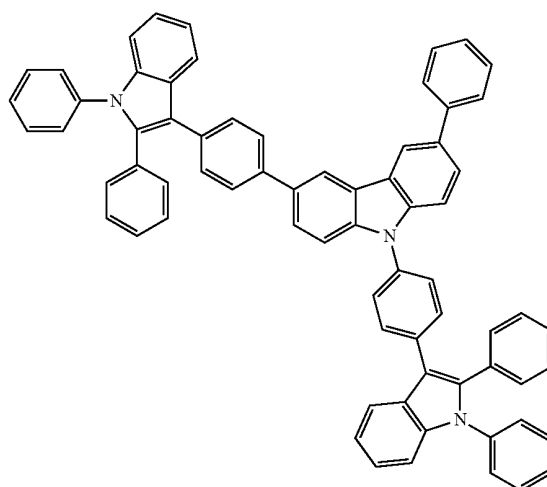
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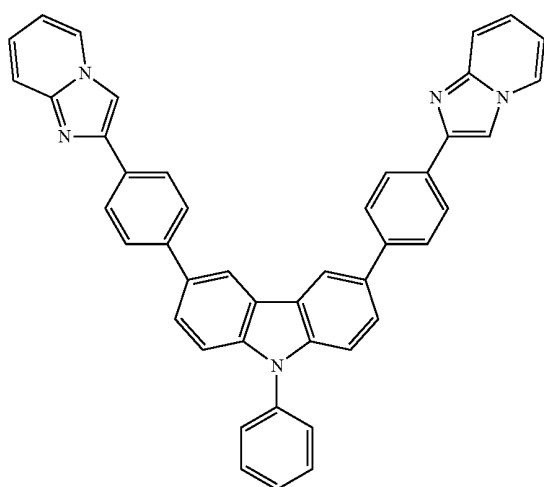
(B10)



(B13)

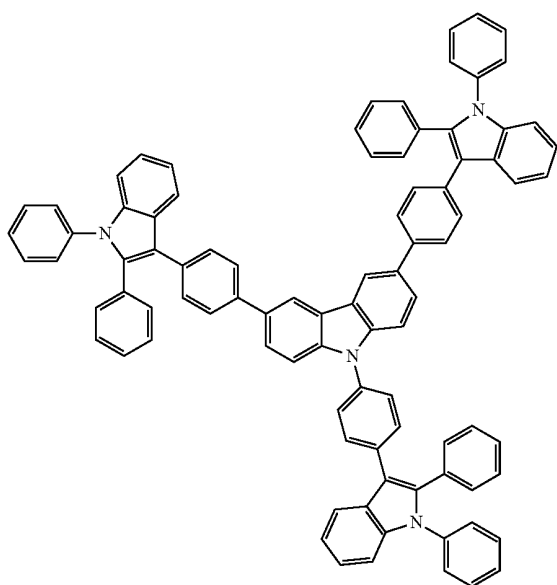


(B11)



-continued

(B14)



[0278] The compound represented by the formula (6) or (7) in this exemplary embodiment has triplet energy gap of 2.5 eV to 3.3 eV, preferably 2.5 eV to 3.2 eV.

[0279] The compound represented by the formula (6) or (7) in this exemplary embodiment has singlet energy gap of 2.8 eV to 3.8 eV, preferably 2.9 eV to 3.7 eV.

Third Exemplary Embodiment

[0280] An organic EL device according to a third exemplary embodiment is different from the organic EL device according to the second exemplary embodiment in that a material having a poor electron capability is used as the second material.

[0281] When a material having an excellent electron injecting capability from the electrode (e.g., LiF) is used as the cathode, a carrier balance in the emitting layer becomes shifted toward the anode. For improving such a disadvantage, it is preferable to select a material having a poor electron injecting capability as the second host material. Specifically, the second host material of this exemplary embodiment is preferably a compound in which A^3 is a group represented by the following formula (8B) in the formula (6) or (7).



[0282] In the formula (8B): M^3 and M^4 each independently represent a substituted or unsubstituted aromatic hydrocarbon group having 6 to 40 ring carbon atoms; M^3 and M^4 may be the same or different;

[0283] L^6 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, or substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms;

c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and $c+e$ represents 1 or more.

[0284] In the formula (8B), as the aromatic hydrocarbon group for M^3 and M^4 and the aromatic hydrocarbon group, fused aromatic hydrocarbon group and cycloalkylene group for L^6 , those represented by the formula (8A) can be used. As bonding patterns of the groups represented by the formula (8B), the same bonding patterns as those of the formula (8A) can be used. Specifically, in the bonding patterns of the formula (8A), M^1 , L^5 and M^2 may be respectively replaced with M^3 , L^6 and M^4 .

[0285] In the bonding patterns of the formulae (6), (7) and (8B) and exemplary combinations of the groups as described above, compounds represented by [5] to [8] below are preferable.

[5] $a=1$ is given in the formula (6) and $c=1$ and $d=0$ are given in the formula (8B).

[0286] In the formula (6), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

[0287] In the formula (8B): M^3 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^6 is a substituted or unsubstituted aryl group or aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[6] $a=2$ is given in the formula (6) and $c=1$ and $e=0$ are given in the formula (8B).

[0288] In the formula (6), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

[0289] In the formula (8B): M^3 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^6 is a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[7] $a=1$ is given in the formula (6) and $c=2$ and $e=0$ are given in the formula (8B).

[0290] In the formula (6), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

[0291] In the formula (8B): M^3 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^6 is a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30

carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

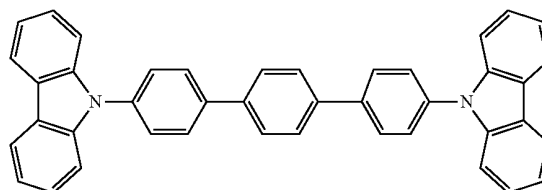
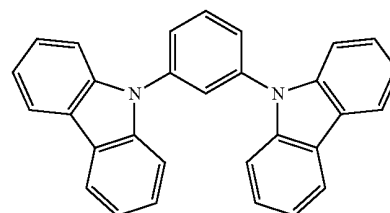
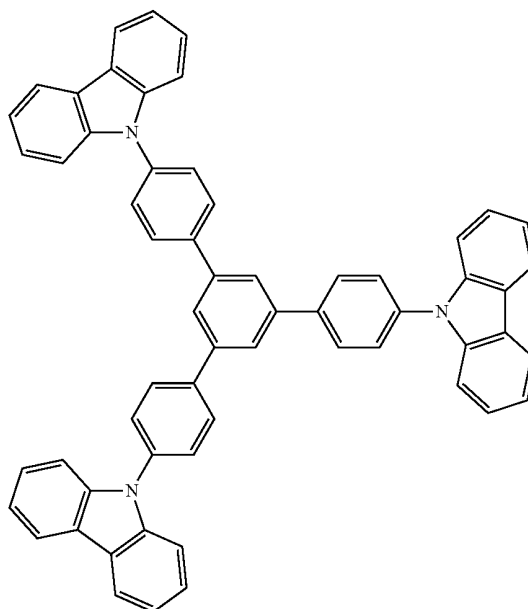
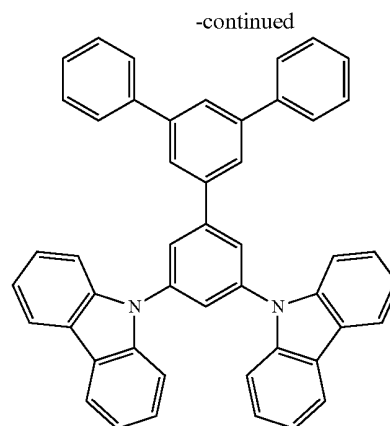
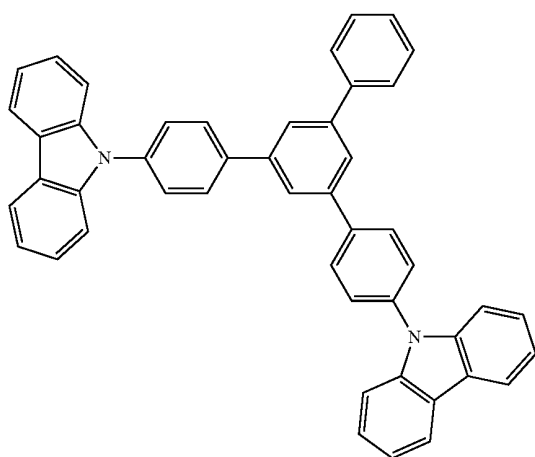
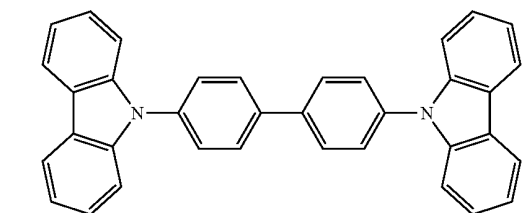
[8] $b=2$ is given in the formula (7) and $c=d=1$ is given in the formula (8B).

[0292] In the formula (7), Cz is a substituted or unsubstituted arylcarbazolyl group or substituted or unsubstituted carbazolylaryl group.

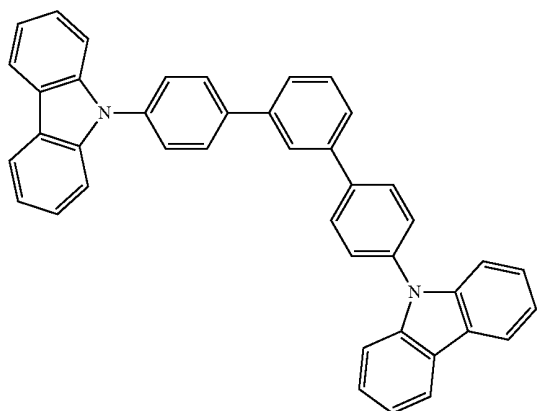
[0293] In the formula (8B): M^3 is a substituted or unsubstituted nitrogen-containing six-membered or seven-membered hetero ring having 4 to 5 ring carbon atoms, substituted or unsubstituted nitrogen-containing five-membered hetero ring having 2 to 4 ring carbon atoms, substituted or unsubstituted nitrogen-containing hetero ring having 8 to 11 ring carbon atoms, substituted or unsubstituted imidazopyridinyl ring; and L^6 is a substituted or unsubstituted aromatic hydrocarbon group or fused aromatic hydrocarbon group having 6 to 30 carbon atoms and substituted or unsubstituted aromatic heterocyclic group or fused aromatic heterocyclic group having 2 to 30 carbon atoms.

[0294] In the formulae (6) and (7), Cz is preferably a substituted or unsubstituted arylcarbazolyl group, more preferably phenylcarbazolyl group. Moreover, an aryl site of the arylcarbazolyl group is preferably substituted by a carbazolyl group.

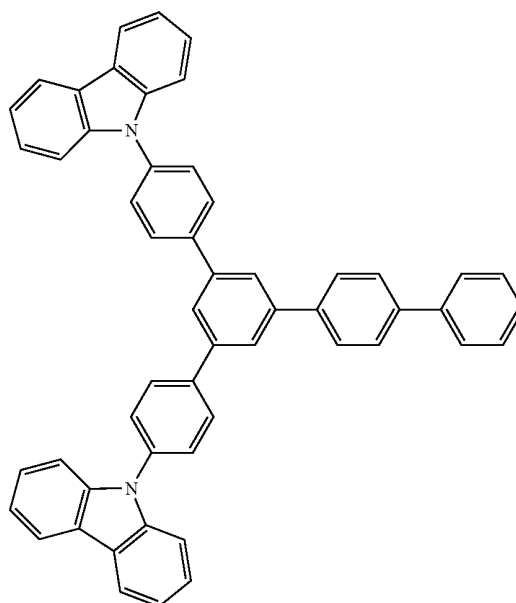
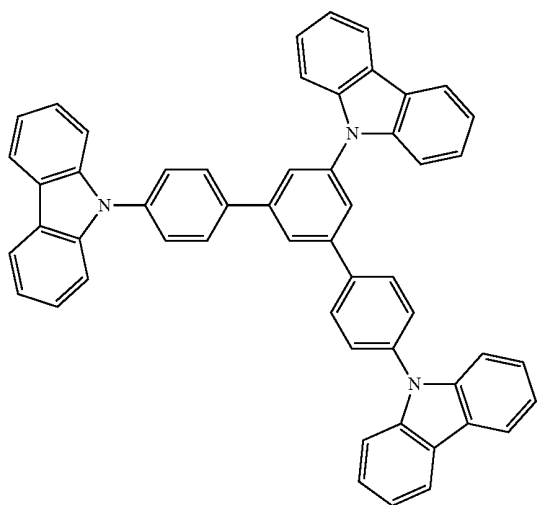
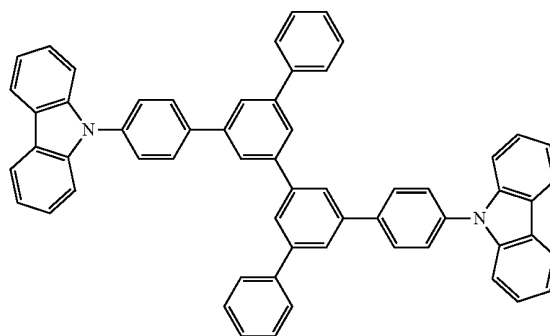
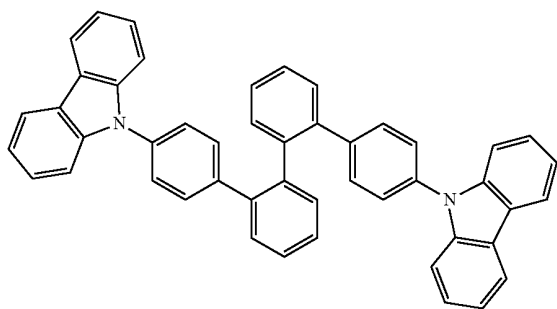
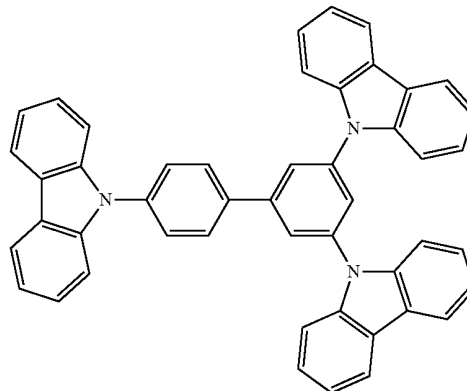
[0295] Examples of the compound in which A^3 is a group represented by the following formula (8B) in the formula (6) or (7) are listed below.



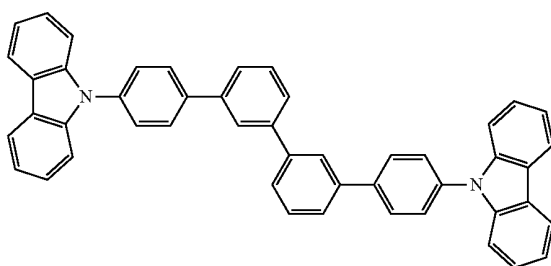
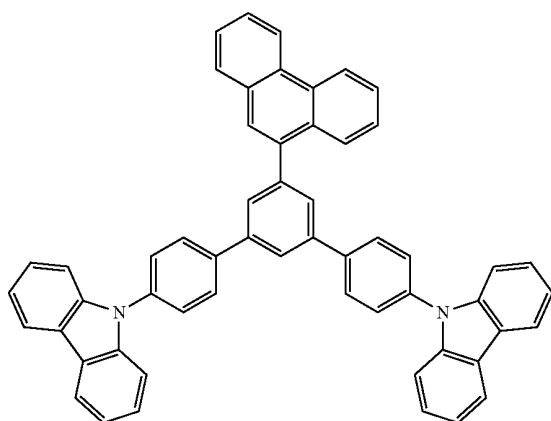
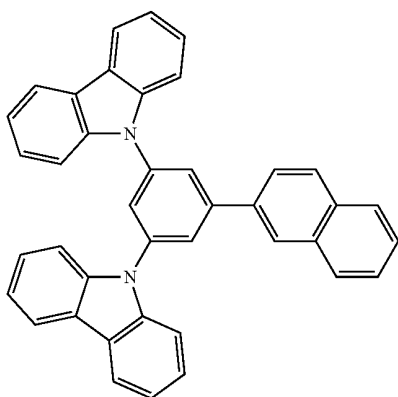
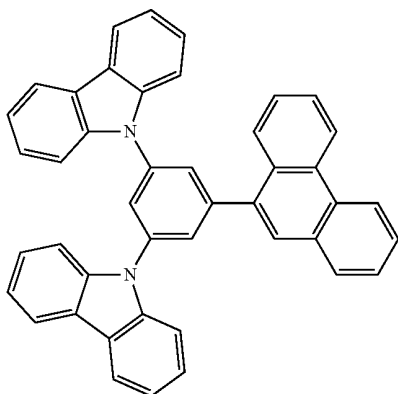
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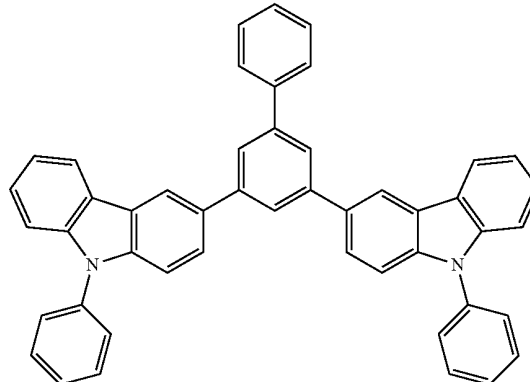
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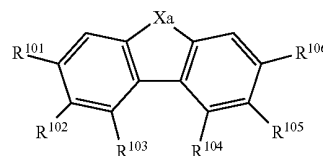


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[0296] As the second host material of this exemplary embodiment, a compound represented by a formula (9) below may be used.

(9)



[0297] In the formula (9): R^{101} to R^{106} each independently represent a hydrogen atom, halogen atom, substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted arylcarbonyl group having 7 to 40 carbon atoms, substituted or unsubstituted arylthio group having 6 to 20 carbon atoms, substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms or cyano group;

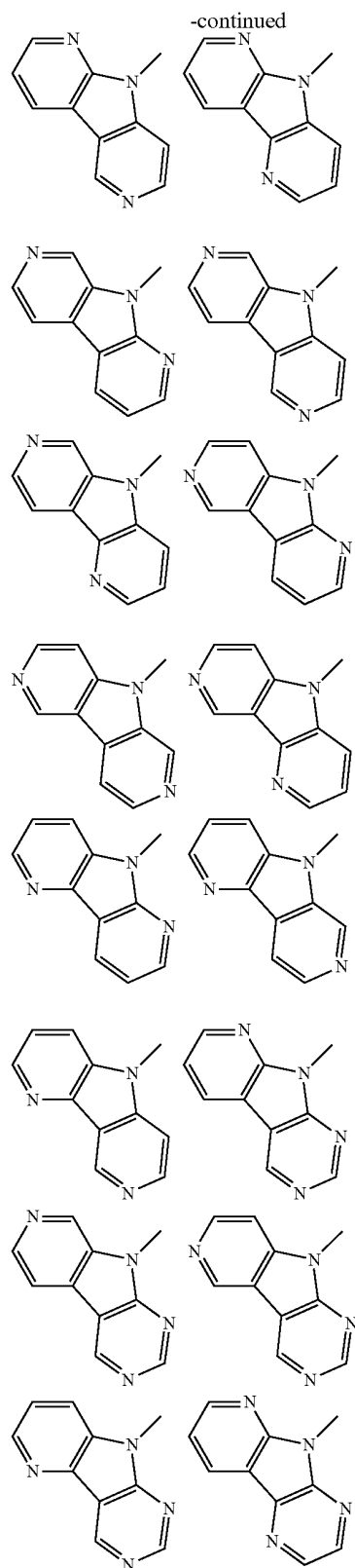
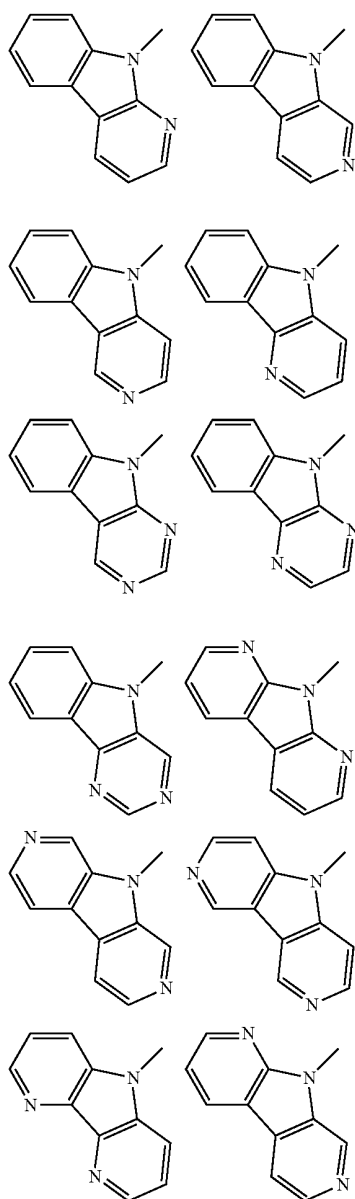
[0298] at least one of R^{101} to R^{106} represents a substituted or unsubstituted 9-carbazolyl group, substituted or unsubstituted azacarbazolyl group having 2 to 5 nitrogen atoms, or -L-9-carbazolyl group; L represents an alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms, substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms,

substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted arylthio group having 6 to 20 carbon atoms, substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms or cyano group;

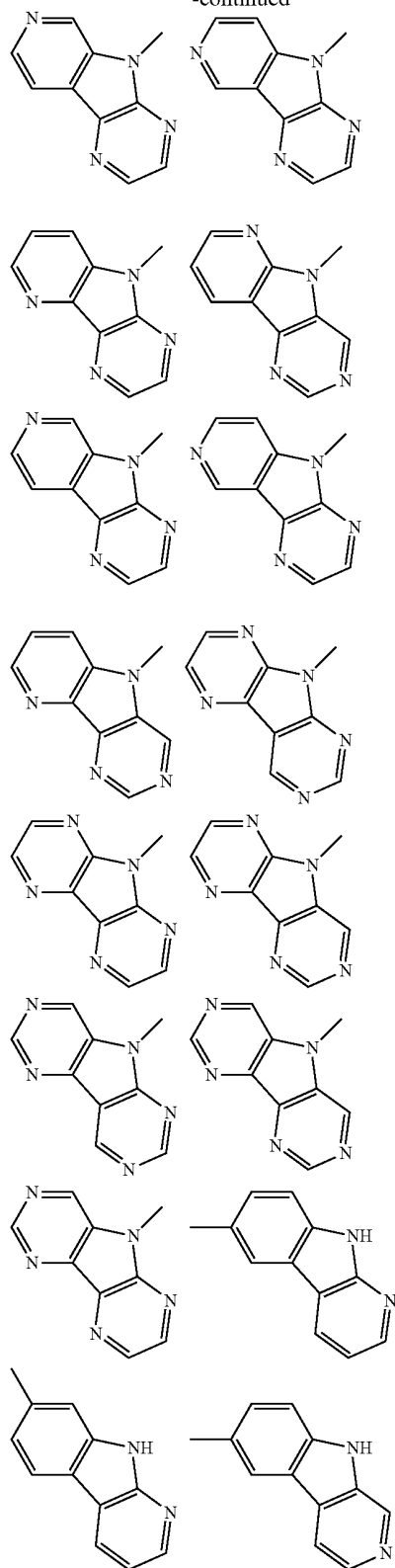
[0299] Xa represents a sulfur atom, oxygen atom or N—R¹⁰⁸; and

[0300] R¹⁰⁸ represents the same as R¹⁰¹ to R¹⁰⁶.

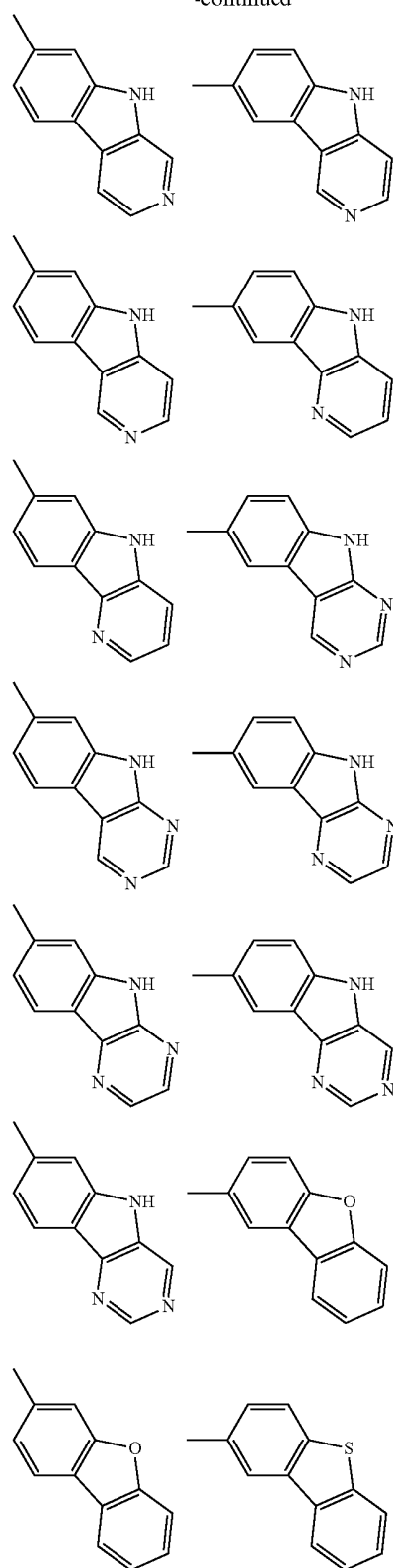
[0301] Specific examples of the substituted or unsubstituted azacarbazoyl group having 2 to 5 nitrogen atoms are shown below (in which any substituent is omitted), but the substituted or unsubstituted azacarbazoyl group is not limited thereto.

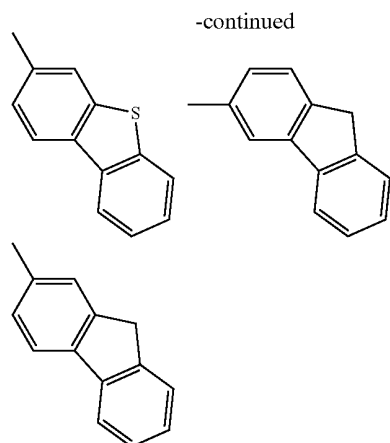


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[0302] Examples of the halogen atom include fluorine, chlorine, bromine, and iodine.

[0303] Examples of the substituted or unsubstituted alkyl group having 1 to 40 carbon atoms include a methyl group, an ethyl group, a propyl group, an isopropyl group, an n-butyl group, an s-butyl group, an isobutyl group, a t-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-nonyl group, an n-decyl group, an n-undecyl group, an n-dodecyl group, an n-tridecyl group, an n-tetradecyl group, an n-pentadecyl group, an n-hexadecyl group, an n-heptadecyl group, an n-octadecyl group, a neopentyl group, a 1-methylpentyl group, a 2-methylpentyl group, a 1-pentylhexyl group, a 1-butylpentyl group, a 1-heptyloctyl group, a 3-methylpentyl group, a hydroxymethyl group, a 1-hydroxyethyl group, a 2-hydroxyethyl group, a 2-hydroxyisobutyl group, a 1,2-dihydroxyethyl group, a 1,3-dihydroxyisopropyl group, a 2,3-dihydroxy-t-butyl group, a 1,2,3-trihydroxypropyl group, a chloromethyl group, a 1-chloroethyl group, a 2-chloroethyl group, a 2-chloroisobutyl group, a 1,2-dichloroethyl group, a 1,3-dichloroisopropyl group, a 2,3-dichloro-t-butyl group, a 1,2,3-trichloropropyl group, a bromomethyl group, a 1-bromoethyl group, a 2-bromoethyl group, a 2-bromoisobutyl group, a 1,2-dibromoethyl group, a 1,3-dibromoisopropyl group, a 2,3-dibromo-t-butyl group, a 1,2,3-tribromopropyl group, an iodoethyl group, a 1-iodoethyl group, a 2-iodoethyl group, a 2-iodoisobutyl group, a 1,2-diiodoethyl group, a 1,3-diiodoisopropyl group, a 2,3-diiodo-t-butyl group, a 1,2,3-triiodopropyl group, an aminomethyl group, a 1-aminoethyl group, a 2-aminoethyl group, a 2-aminoisobutyl group, a 1,2-diaminoethyl group, a 1,3-diaminoisopropyl group, a 2,3-diamino-t-butyl group, a 1,2,3-triaminopropyl group, a cyanomethyl group, a 1-cyanoethyl group, a 2-cyanoethyl group, a 2-cyanoisobutyl group, a 1,2-dicyanoethyl group, a 1,3-dicyanoisopropyl group, a 2,3-dicyano-t-butyl group, a 1,2,3-tricyanopropyl group, a nitromethyl group, a 1-nitroethyl group, a 2-nitroethyl group, a 1,2-dinitroethyl group, a 2,3-dinitro-t-butyl group, and a 1,2,3-trinitropropyl group, among of which a methyl group, an ethyl group, a propyl group, an isopropyl group, an n-butyl group, an s-butyl group, an isobutyl group, a t-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-nonyl group, an n-decyl group, an n-undecyl group, an n-dodecyl group, an n-tridecyl group, an n-tetradecyl group, an n-pentadecyl group, an n-hexadecyl group, an

n-heptadecyl group, an n-octadecyl group, a neopentyl group, a 1-methylpentyl group, a 1-pentylhexyl group, a 1-butylpentyl group, a 1-heptyloctyl group are preferable. The alkyl group (excluding a substituent) preferably has 1 to 10 carbon atoms.

[0304] Examples of the substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms include a cyclopentyl group, cyclohexyl group, cyclooctyl group, and 3,5,5,5-tetramethylcyclohexyl group. A cyclohexyl group, cyclooctyl group, and 3,5-tetramethylcyclohexyl group are preferable. The cycloalkyl group (excluding a substituent) preferably has 3 to 12 carbon atoms.

[0305] Examples of the substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms are a 1-pyroryl group, 2-pyroryl group, 3-pyroryl group, pyrazinyl group, 2-pyridinyl group, 1-imidazolyl, 2-imidazolyl, 1-pyrazolyl, 1-indolidinyl, 2-indolidinyl, 3-indolidinyl, 5-indolidinyl, 6-indolidinyl, 7-indolidinyl, 8-indolidinyl, 2-imidazopyridinyl, 3-imidazopyridinyl, 5-imidazopyridinyl, 6-imidazopyridinyl, 7-imidazopyridinyl, 8-imidazopyridinyl, 3-pyridinyl group, 4-pyridinyl group, 1-indolyl group, 2-indolyl group, 3-indolyl group, 4-indolyl group, 5-indolyl group, 6-indolyl group, 7-indolyl group, 1-isoindolyl group, 2-isoindolyl group, 3-isoindolyl group, 4-isoindolyl group, 5-isoindolyl group, 6-isoindolyl group, 7-isoindolyl group, 2-furyl group, 3-furyl group, 2-benzofuranyl group, 3-benzofuranyl group, 4-benzofuranyl group, 5-benzofuranyl group, 6-benzofuranyl group, 7-benzofuranyl group, 1-isobenzofuranyl group, 3-isobenzofuranyl group, 4-isobenzofuranyl group, 5-isobenzofuranyl group, 6-isobenzofuranyl group, 7-isobenzofuranyl group, 2-quinolyl group, 3-quinolyl group, 4-quinolyl group, 5-quinolyl group, 6-quinolyl group, 7-quinolyl group, 8-quinolyl group, 1-isoquinolyl group, 3-isoquinolyl group, 4-isoquinolyl group, 5-isoquinolyl group, 6-isoquinolyl group, 7-isoquinolyl group, 8-isoquinolyl group, 2-quinoxaliny group, 5-quinoxaliny group, 6-quinoxaliny group, 1-carbazolyl group, 2-carbazolyl group, 3-carbazolyl group, 4-carbazolyl group, 9-carbazolyl group, azacarbazolyl-1-yl, azacarbazolyl-2-yl, azacarbazolyl-3-yl, azacarbazolyl-4-yl, azacarbazolyl-5-yl, azacarbazolyl-6-yl, azacarbazolyl-7-yl, azacarbazolyl-8-yl, azacarbazolyl-9-yl, 1-phenanthrydinyl group, 2-phenanthrydinyl group, 3-phenanthrydinyl group, 4-phenanthrydinyl group, 6-phenanthrydinyl group, 7-phenanthrydinyl group, 8-phenanthrydinyl group, 9-phenanthrydinyl group, 10-phenanthrydinyl group, 1-acridinyl group, 2-acridinyl group, 3-acridinyl group, 4-acridinyl group, 9-acridinyl group, 1,7-phenanthroline-2-yl group, 1,7-phenanthroline-3-yl group, 1,7-phenanthroline-4-yl group, 1,7-phenanthroline-5-yl group, 1,7-phenanthroline-6-yl group, 1,7-phenanthroline-8-yl group, 1,7-phenanthroline-9-yl group, 1,7-phenanthroline-10-yl group, 1,8-phenanthroline-2-yl group, 1,8-phenanthroline-3-yl group, 1,8-phenanthroline-4-yl group, 1,8-phenanthroline-5-yl group, 1,8-phenanthroline-6-yl group, 1,8-phenanthroline-7-yl group, 1,8-phenanthroline-9-yl group, 1,8-phenanthroline-10-yl group, 1,9-phenanthroline-2-yl group, 1,9-phenanthroline-3-yl group, 1,9-phenanthroline-4-yl group, 1,9-phenanthroline-5-yl group, 1,9-phenanthroline-6-yl group, 1,9-phenanthroline-7-yl group, 1,9-phenanthroline-8-yl group, 1,9-phenanthroline-10-yl group, 1,10-phenanthroline-2-yl group, 1,10-phenanthroline-3-yl group, 1,10-phenanthroline-4-yl group, 1,10-phenanthroline-5-yl group, 2,9-phenanthroline-1-yl group, 2,9-phenanthroline-3-yl group, 2,9-phenanthroline-4-yl

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Among the above, the heterocyclic group is preferably a 2-pyridinyl group, 1-indolidinyl, 2-indolidinyl, 3-indolidinyl, 5-indolidinyl, 6-indolidinyl, 7-indolidinyl, 8-indolidinyl, 2-imidazopyridinyl, 3-imidazopyridinyl, 5-imidazopyridinyl, 6-imidazopyridinyl, 7-imidazopyridinyl, 8-imidazopyridinyl, 3-pyridinyl group, 4-pyridinyl group, 1-indolyl group, 2-indolyl group, 3-indolyl group, 4-indolyl group, 5-indolyl group, 6-indolyl group, 7-indolyl group, 1-isindolyl group, 2-isindolyl group, 3-isindolyl group, 4-isindolyl group, 5-isindolyl group, 6-isindolyl group, 7-isindolyl group, 9-carbazolyl group, 1-dibenzofuranyl group, 2-dibenzofuranyl group, 3-dibenzofuranyl group, 4-dibenzofuranyl group, 1-dibenzothiophenyl group, 2-dibenzothiophenyl group, 3-dibenzothiophenyl group, 4-dibenzothiophenyl group, 1-silafluorenyl group, 2-silafluorenyl group, 3-silafluorenyl group, 4-silafluorenyl group, 1-germafluorenyl group, 2-germafluorenyl group, 3-germafluorenyl group, 4-germafluorenyl group, azacarbazolyl-1-yl group, azacarbazolyl-2-yl group, azacarbazolyl-3-yl group, azacarbazolyl-4-yl group, azacarbazolyl-5-yl group, azacarbazolyl-6-yl group, azacarbazolyl-7-yl group, azacarbazolyl-8-yl group, and azacarbazolyl-9-yl group. The heterocyclic group (excluding a substituent) preferably has 3 to 14 carbon atoms.

[0306] The substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms is a group represented by —OY. Examples of Y are the same as those described in relation to the alkyl group. Preferred examples are also the same.

[0307] Examples of the substituted or unsubstituted aryl group having 6 to 40 carbon atoms (including a fused aro-

matic hydrocarbon group and a ring assembly aromatic hydrocarbon group) are a phenyl group, 2-biphenyl group, 3-biphenyl group, 4-biphenyl group, p-terphenyl-4-yl group, p-terphenyl-3-yl group, p-terphenyl-2-yl group, m-terphenyl-4-yl group, m-terphenyl-3-yl group, m-terphenyl-2-yl group, o-tolyl group, m-tolyl group, p-tolyl group, p-t-butylphenyl group, p-(2-phenylpropyl)phenyl group, 4'-methylbiphenyl group, 4"-t-butyl-p-terphenyl-4-yl group, o-cumenyl group, m-cumenyl group, p-cumenyl group, 2,3-xylyl group, 3,4-xylyl group, 2,5-xylyl group, mesityl group and m-quarter-phenyl group. Among the above, the substituted or unsubstituted aryl group is preferably a phenyl group, 2-biphenyl group, 3-biphenyl group, 4-biphenyl group, m-terphenyl-4-yl group, m-terphenyl-3-yl group, m-terphenyl-2-yl group, p-tolyl group, 3,4-xylyl group, m-quarter-phenyl-2-yl group, 1-naphthyl group, 2-naphthyl group, 1-phenanthrenyl group, 2-phenanthrenyl group, 3-phenanthrenyl group, 4-phenanthrenyl group, 9-phenanthrenyl group, 1-triphenylenyl group, 2-triphenylenyl group, 3-triphenylenyl group, 4-triphenylenyl group, 1-chrysenyl group, 2-chrysenyl group, 3-chrysenyl group, 4-chrysenyl group, 5-chrysenyl group, and 6-chrysenyl group. The aryl group (excluding a substituent) preferably has 6 to 24 carbon atoms. The aryl group preferably further includes a 9-carbazolyl group as a substituent.

[0308] The substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms is a group represented by —OAr. Examples of Ar are the same as those described in relation to the aryl group. Preferred examples are also the same.

[0309] Examples of the substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms are a benzyl group, 1-phenylethyl group, 2-phenylethyl group, 1-phenylisopropyl group, 2-phenylisopropyl group, phenyl-t-butyl group, α -naphthylmethyl group, 1- α -naphthylethyl group, 2- α -naphthylethyl group, 1- α -naphthylisopropyl group, 2- α -naphthylisopropyl group, β -naphthylmethyl group, 1- β -naphthylethyl group, 2- β -naphthylethyl group, 1- β -naphthylisopropyl group, 2- β -naphthylisopropyl group, 1-pyrorlylmethyl group, 2-(1-pyrorlyl)ethyl group, p-methylbenzyl group, m-methylbenzyl group, o-methylbenzyl group, p-chlorobenzyl group, m-chlorobenzyl group, o-chlorobenzyl group, p-bromobenzyl group, m-bromobenzyl group, o-bromobenzyl group, p-iodobenzyl group, m-iodobenzyl group, o-iodobenzyl group, p-hydroxybenzyl group, m-hydroxybenzyl group, o-hydroxybenzyl group, p-aminobenzyl group, m-aminobenzyl group, o-aminobenzyl group, p-nitrobenzyl group, m-nitrobenzyl group, o-nitrobenzyl group, p-cyanobenzyl group, m-cyanobenzyl group, o-cyanobenzyl group, 1-hydroxy-2-phenylisopropyl group, 1-chloro-2-phenylisopropyl group and the like. Among these, preferred are a benzyl group, a p-cyanobenzyl group, m-cyanobenzyl group, o-cyanobenzyl group, 1-phenylethyl group, 2-phenylethyl group, 1-phenylisopropyl group, and 2-phenylisopropyl group. An alkyl portion of the aralkyl group preferably has 1 to 8 carbon atoms. An aryl portion thereof (including heteroaryl) preferably has 6 to 18 carbon atoms.

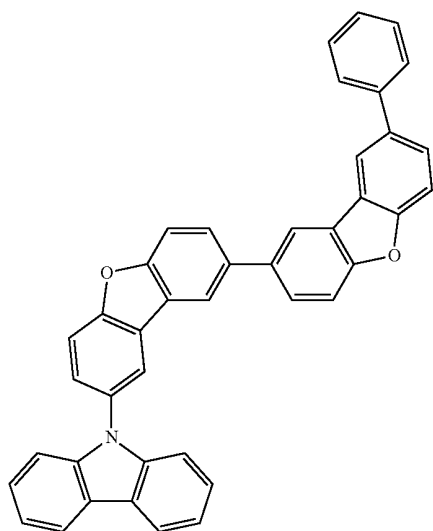
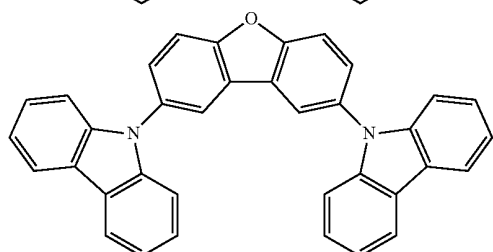
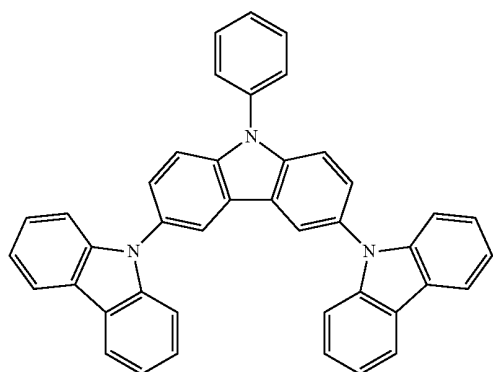
[0310] The substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, the substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, and the substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms each are represented by —NQ¹Q². Examples of Q¹ and Q² each are independently the same as those described in relation to the alkyl group, aryl group and aralkyl group. Preferred examples are also the same.

[0311] The substituted or unsubstituted arylcarbonyl group having 7 to 40 carbon atoms is represented by —COAr^2 . Examples of Ar^2 are the same as those described in relation to the aryl group. Preferred examples are also the same.

[0312] The substituted or unsubstituted arylthio group having 6 to 20 carbon atoms is exemplified by a group obtained by replacing an oxygen atom of the aryloxy group represented by —OAr with a sulfur atom. Preferred examples are also the same.

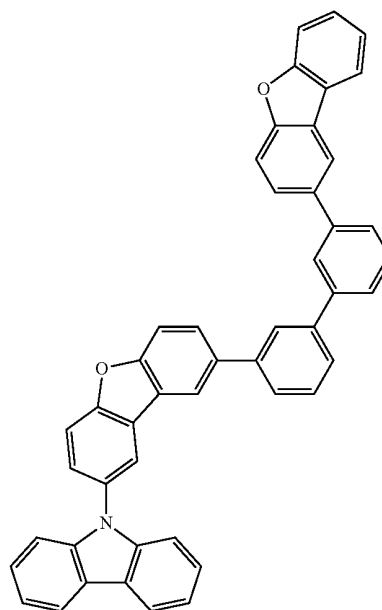
[0313] The substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms is exemplified by a halogenated alkyl group in which at least one hydrogen atom of the alkyl group is substituted by a halogen atom. Preferred examples are also the same.

[0314] The compound represented by the general formula (9) preferably has triplet energy gap of 2.2 eV to 3.2 eV. Specific examples of the formula (9) are shown below.

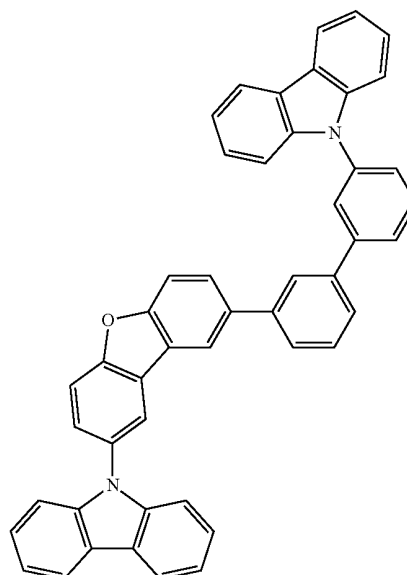


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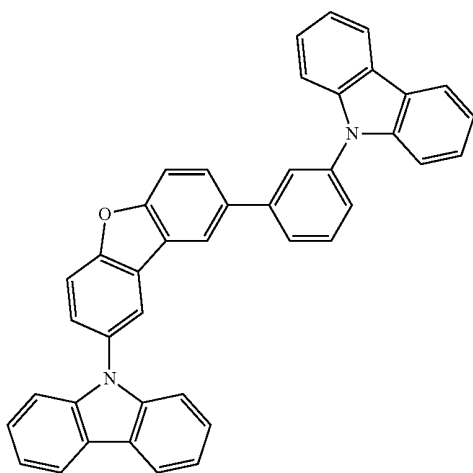
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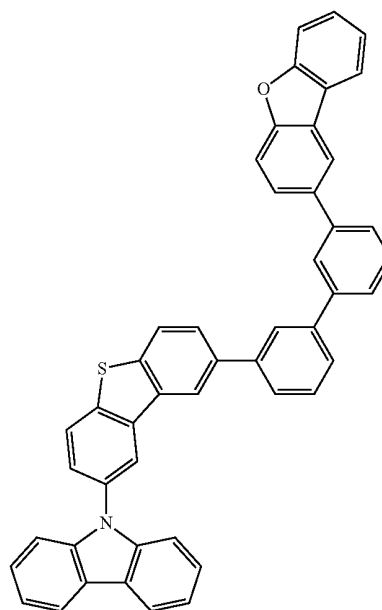
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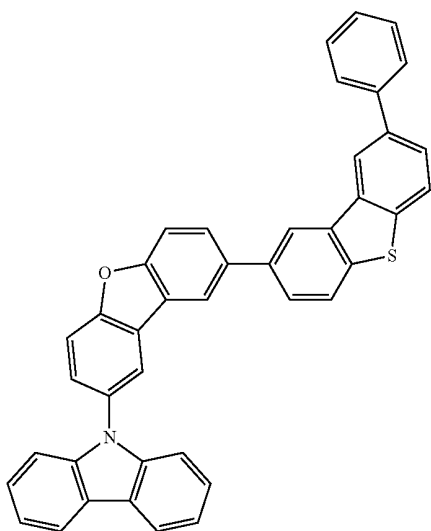


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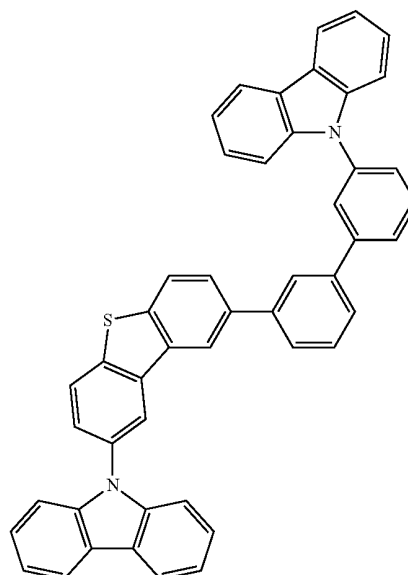
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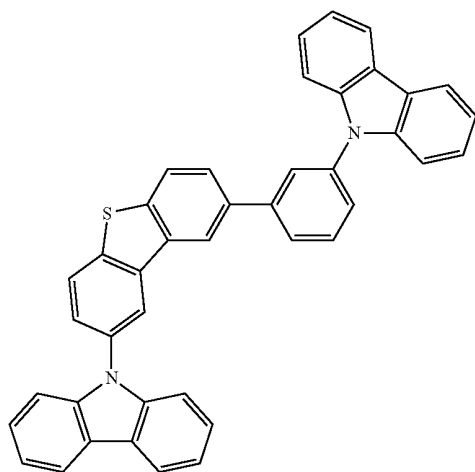


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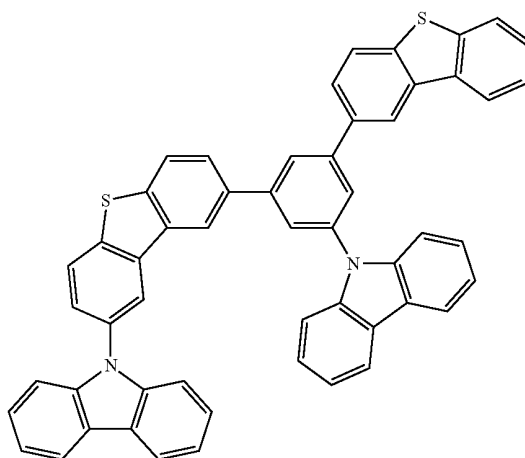
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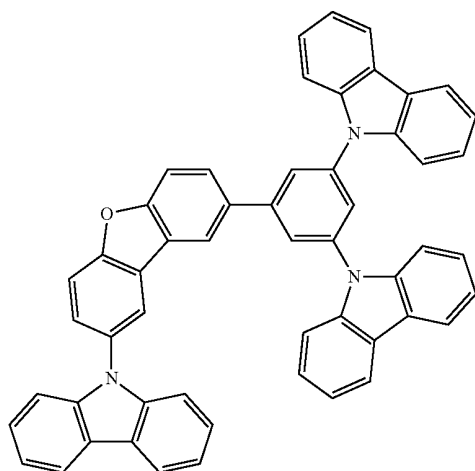


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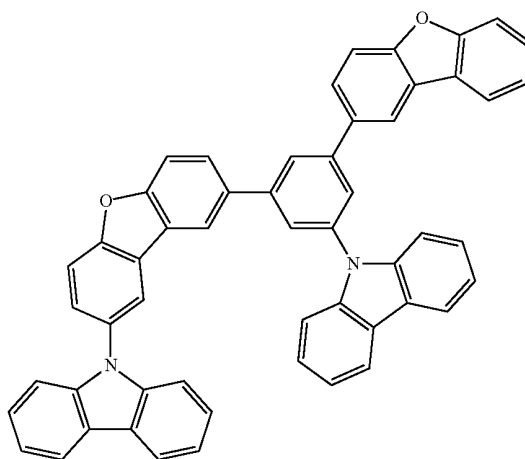
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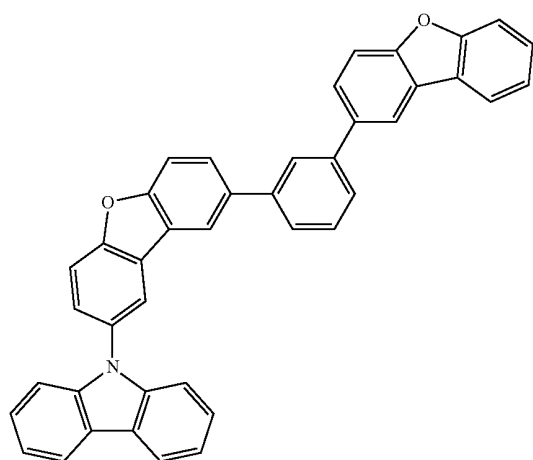
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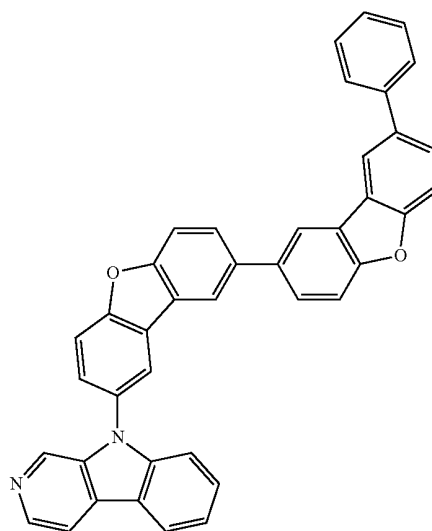
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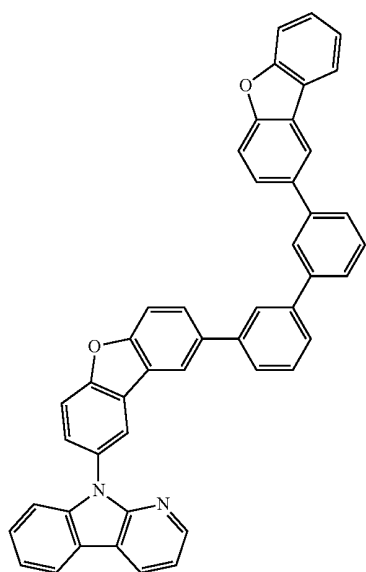
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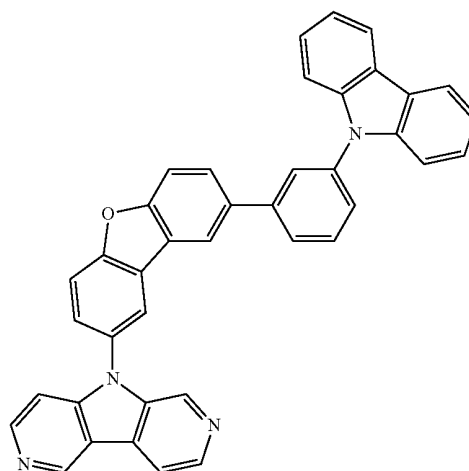


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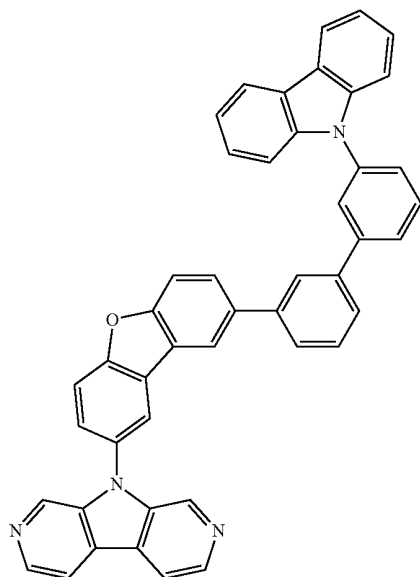
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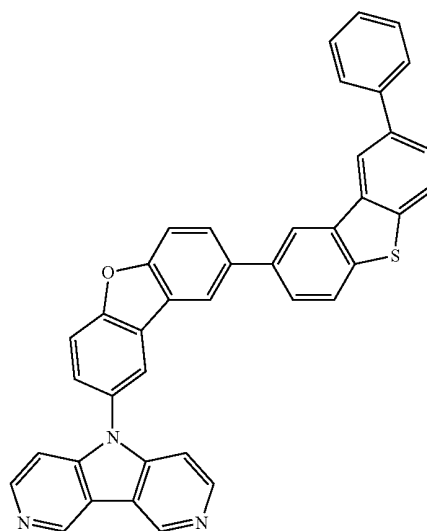


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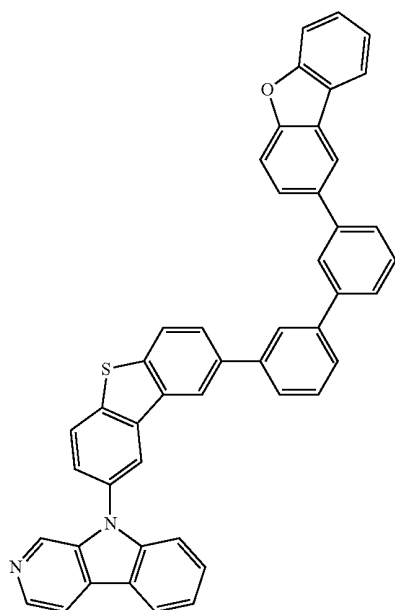
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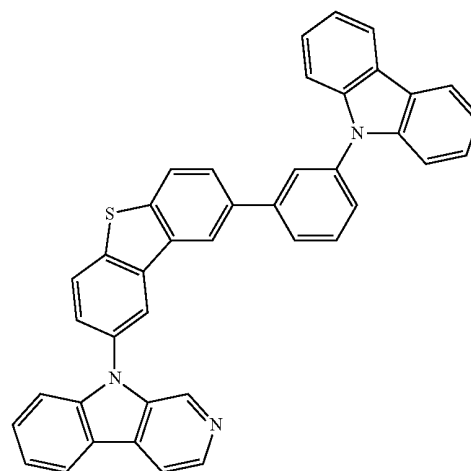


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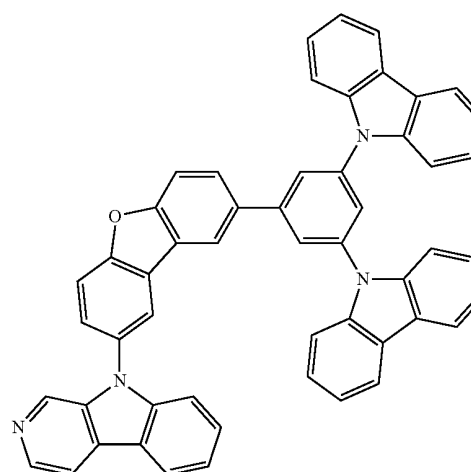
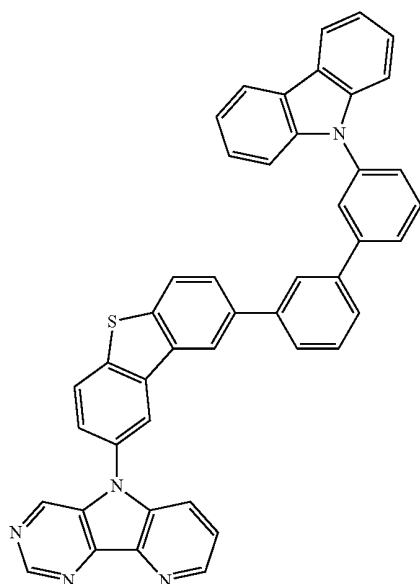
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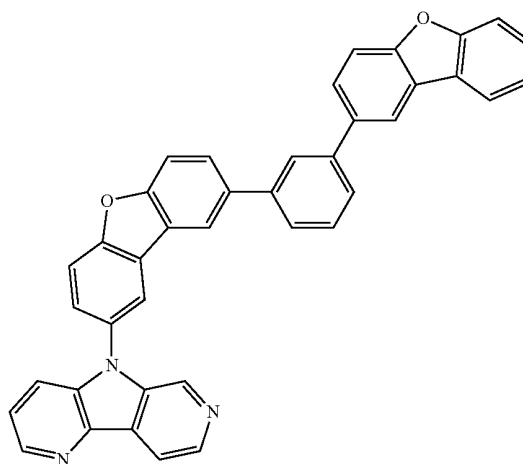
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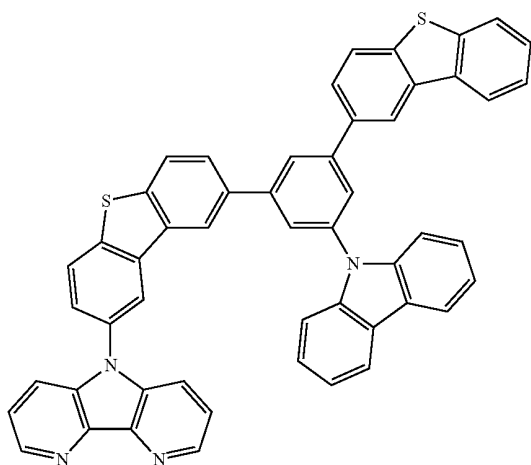
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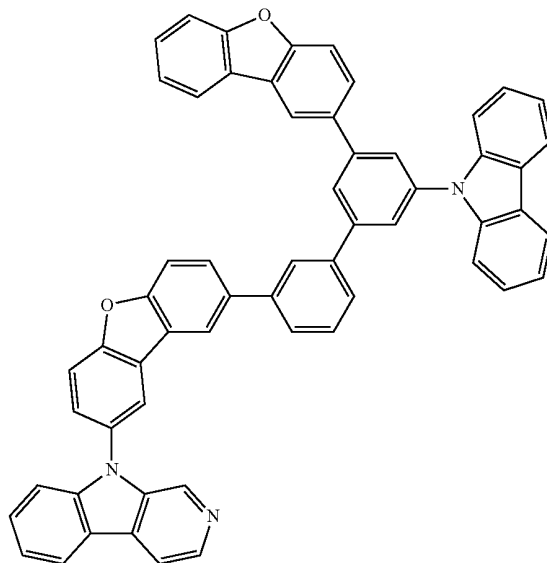
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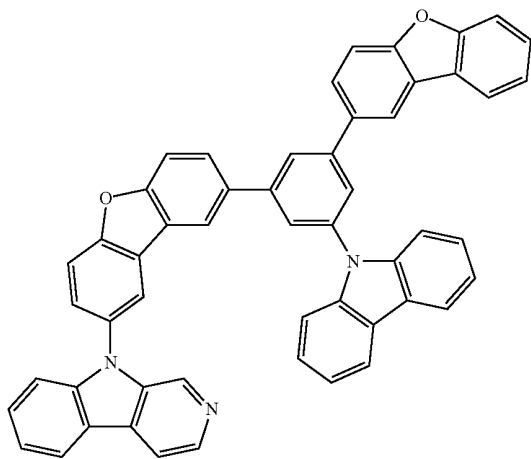


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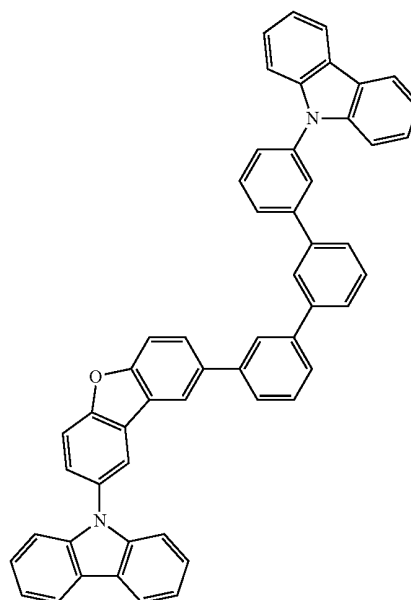
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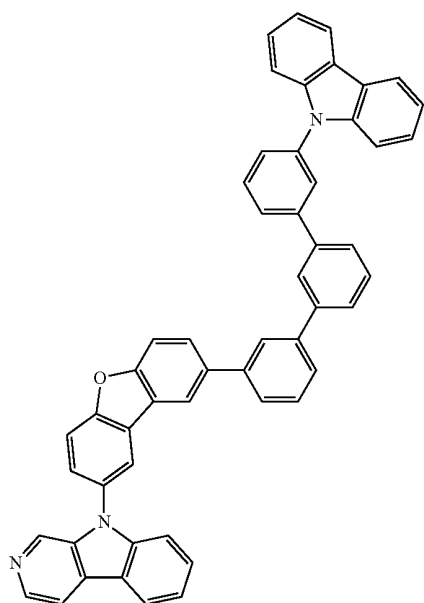


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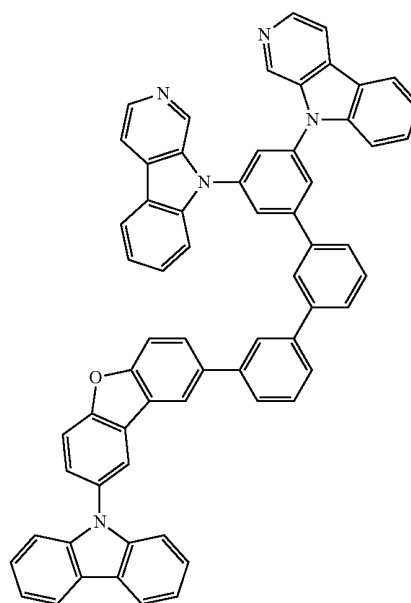
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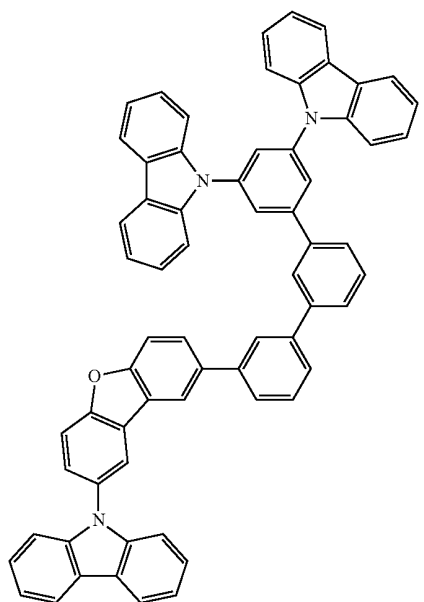


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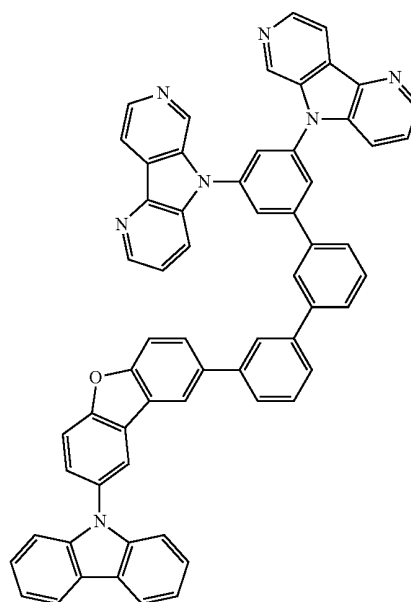
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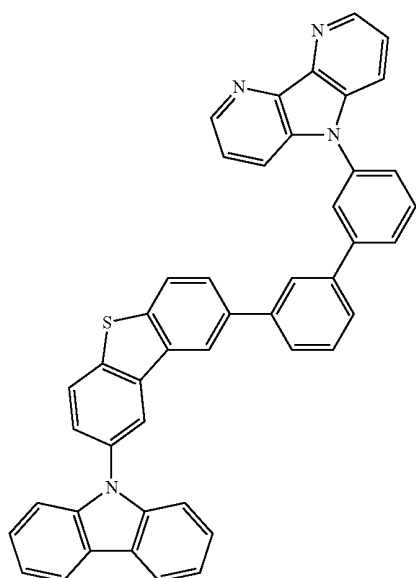


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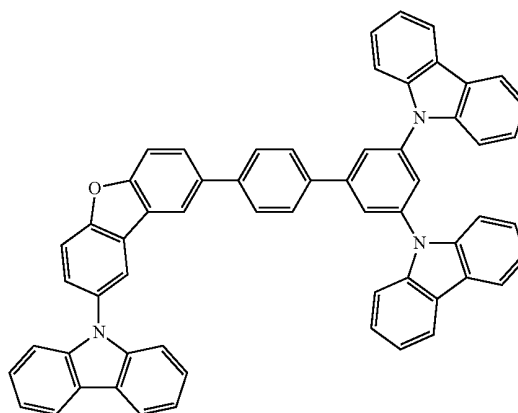
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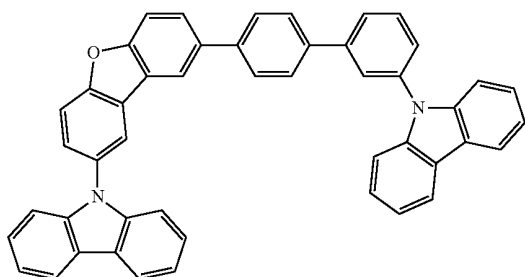


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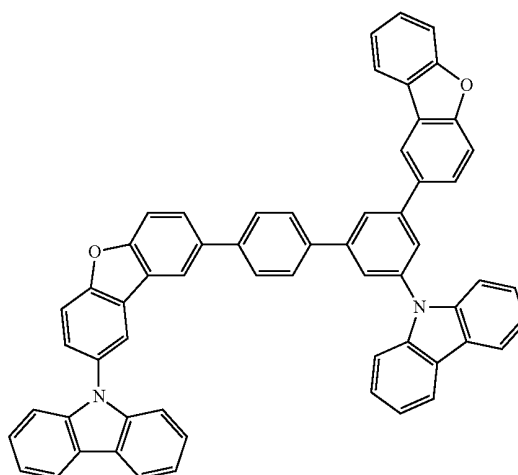
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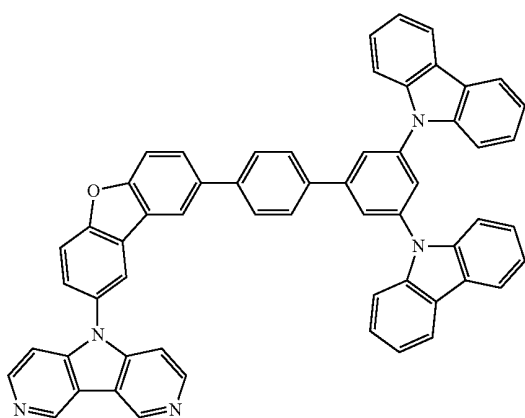
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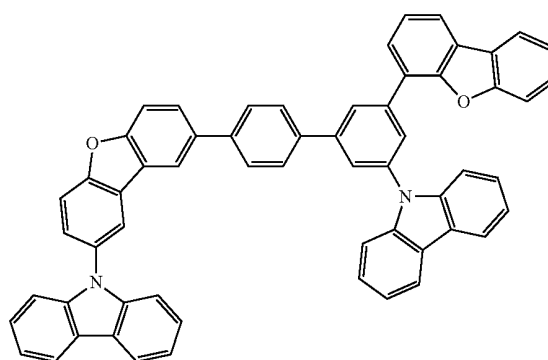
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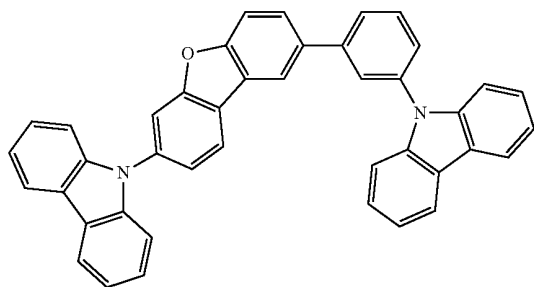


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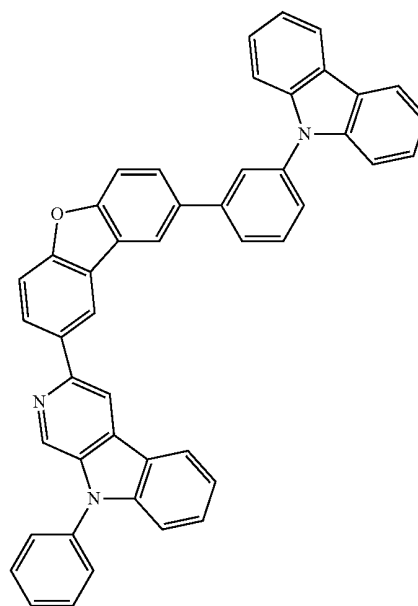
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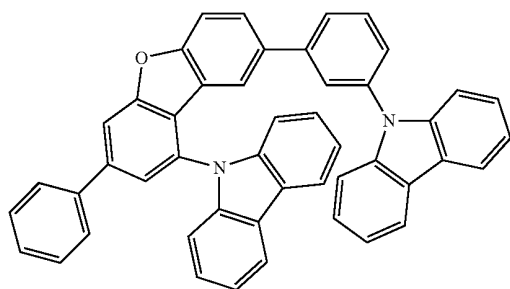


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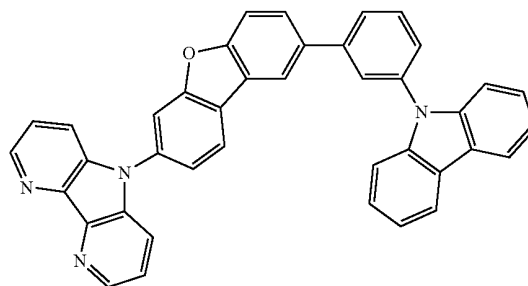
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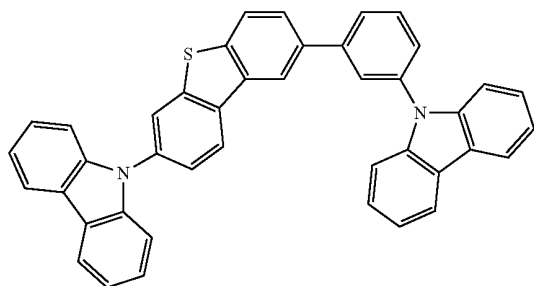
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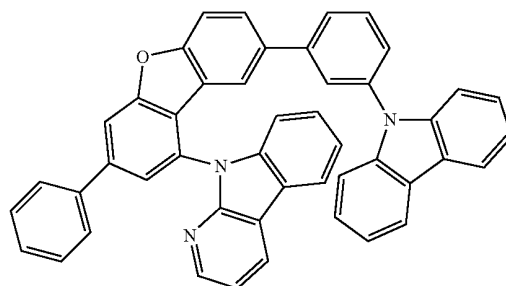
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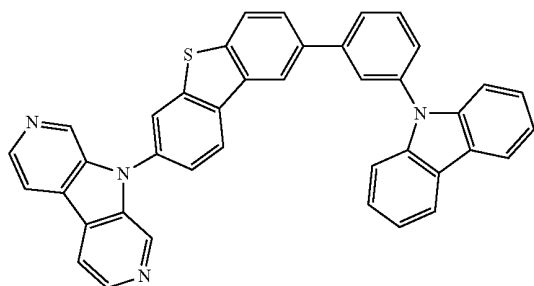


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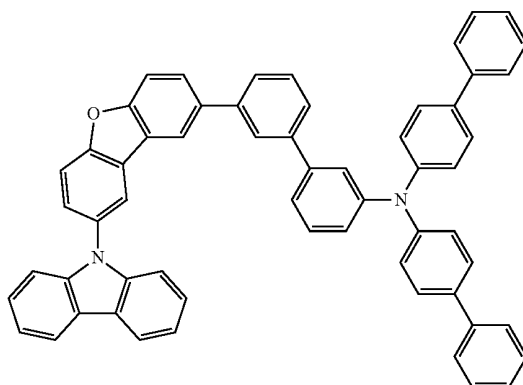
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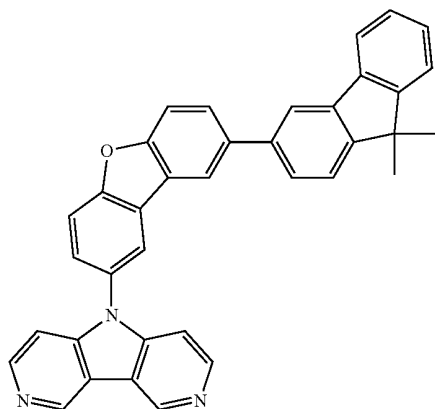


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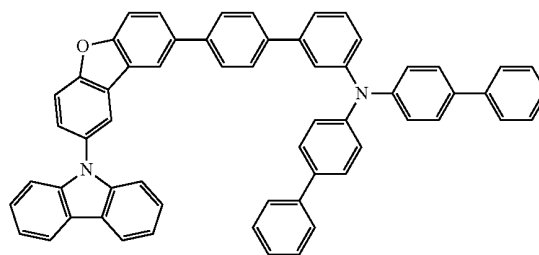
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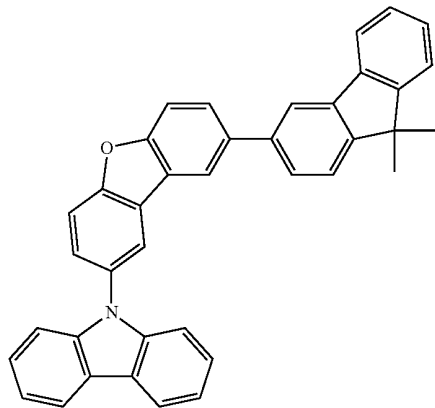
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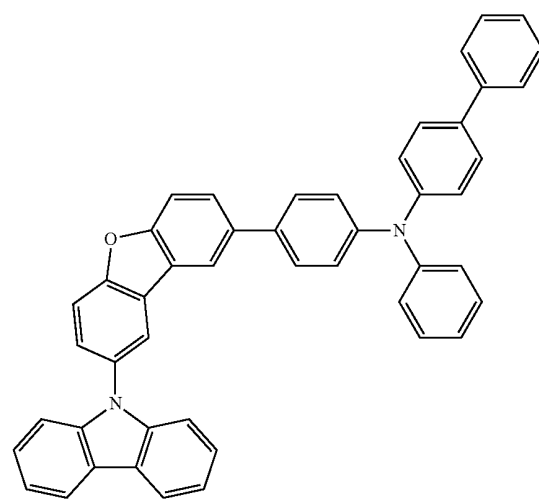
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No.50

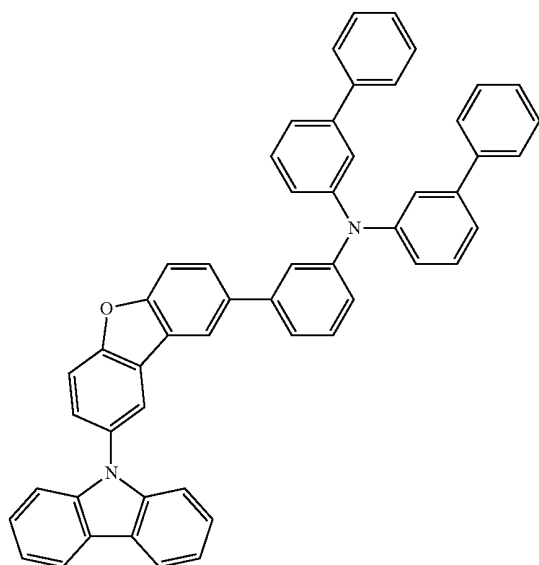


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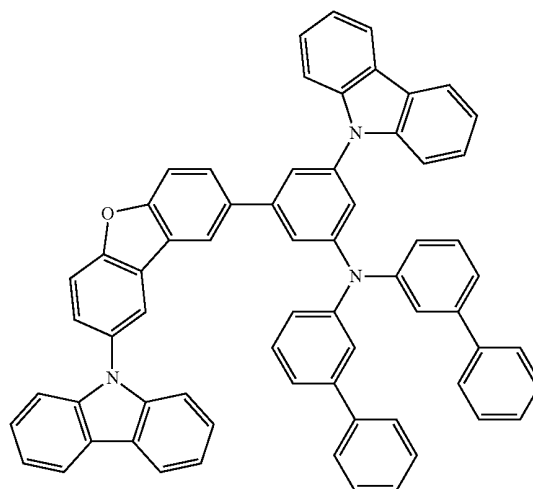
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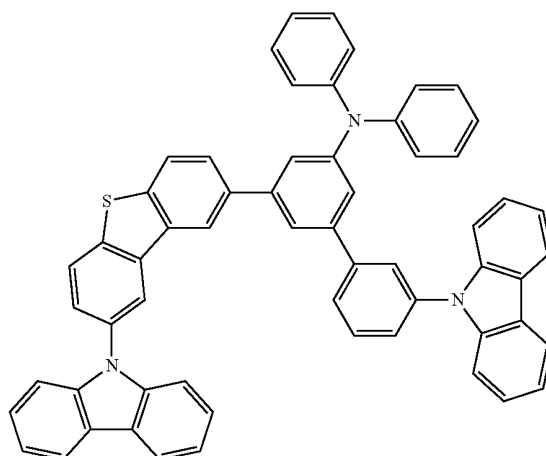


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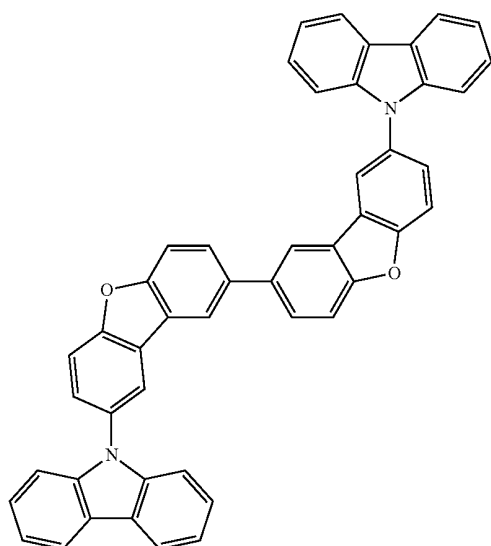
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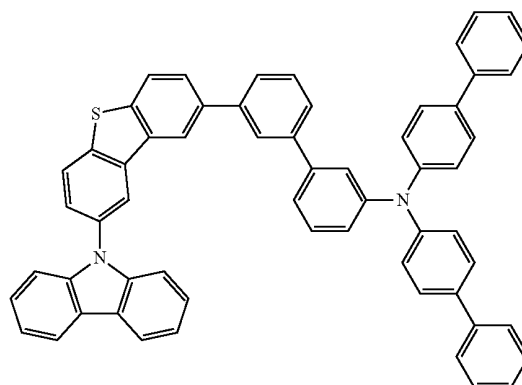
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No.55

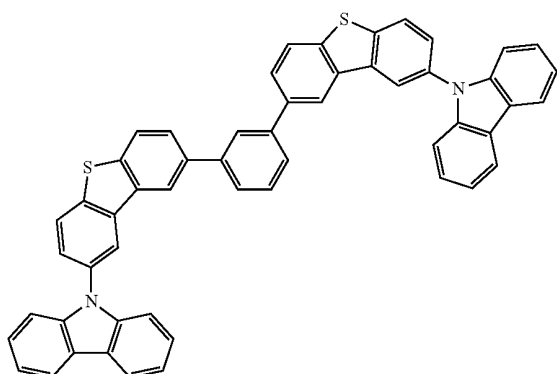


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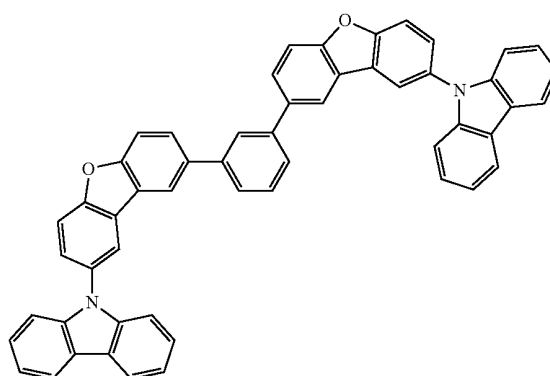
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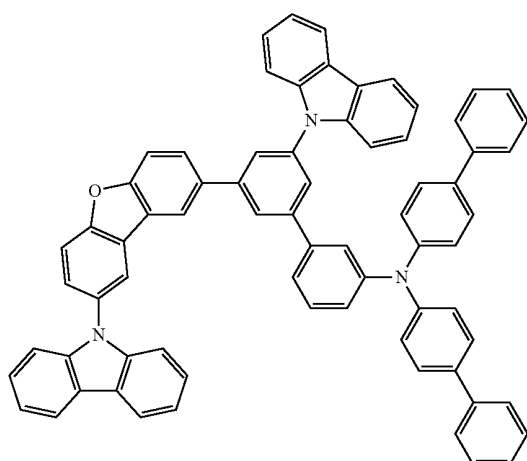


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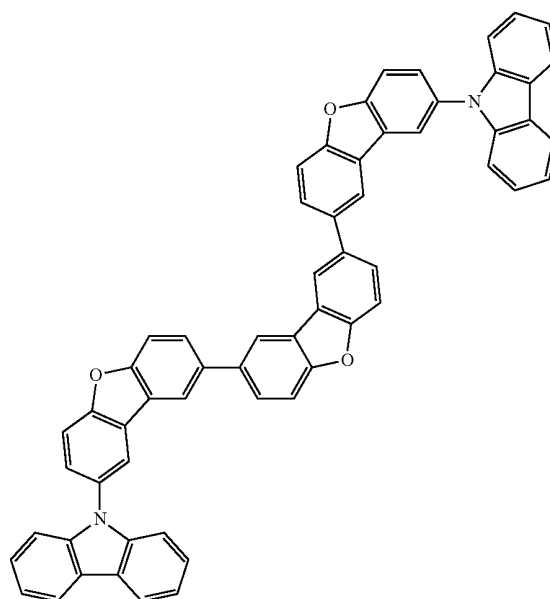
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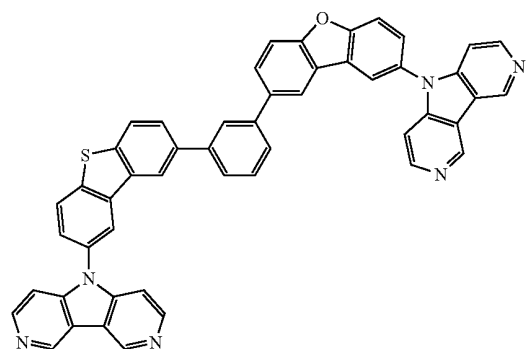
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No.65

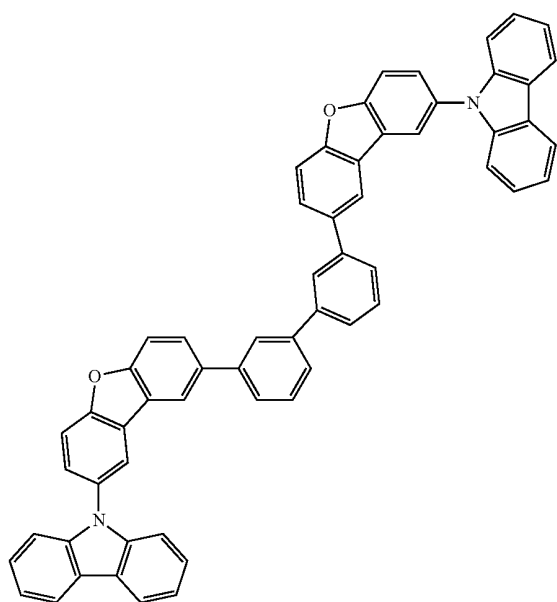


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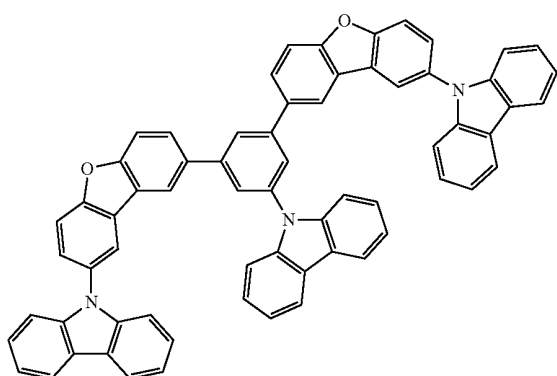


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No.66



No.67



Fourth Exemplary Embodiment

[0315] An organic EL device according to a fourth exemplary embodiment is different from the organic EL devices according to the second and third exemplary embodiments in being a red phosphorescent device.

[0316] The compound according to this exemplary embodiment is not disclosed as a phosphorescent host material of which color is specified. However, since having a high resistance against oxidation and reduction, the compound is also applicable to a red phosphorescent device. As a red phosphorescent device, a hydrocarbon material, which exhibits a small triplet energy and broad π electron clouds compared with a green phosphorescent material, can be used. Although the hydrocarbon material is difficult to be used as a green phosphorescent material because of its small triplet energy, the hydrocarbon material is highly appropriate as a red phosphorescent host material because of its high oxidation and reduction. Accordingly, by using the hydrocarbon material as the second host material, a red phosphorescent device can become highly efficient.

[0317] The second host material is preferably a compound selected from the group consisting of polycyclic aromatic compounds represented by formulae (10A), (10B) and (10C) below.



[0318] In the formulae (10A) to (10C), Ar^{101} , Ar^{102} , Ar^{103} , Ra and Rb represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms.

Ar^{101} , Ar^{102} , Ar^{103} , Ra and Rb preferably represent a polycyclic aromatic skeleton selected from a substituted or unsubstituted benzene ring, substituted or unsubstituted naphthalene ring, substituted or unsubstituted chrysene ring, substituted or unsubstituted fluoranthene ring, substituted or unsubstituted phenanthrene ring, substituted or unsubstituted benzophenanthrene ring, substituted or unsubstituted dibenzophenanthrene ring, substituted or unsubstituted triphenylene ring, substituted or unsubstituted benzo[a]triphenylene ring, substituted or unsubstituted benzochrysene ring, substituted or unsubstituted benzo[b]fluoranthene ring, substituted or unsubstituted fluorene ring and substituted or unsubstituted picene ring.

[0319] Further, it is preferable that a substituent for each of Ra and Rb is not an aryl group and that Ar^{101} , Ar^{102} , Ar^{103} , Ra and Rb are not substituted or unsubstituted benzene ring at the same time.

[0320] Moreover, in the formulae (10A) to (10C), either one or both of Ra and Rb are preferably selected from the group consisting of a substituted or unsubstituted phenanthrene ring, substituted or unsubstituted benzo[c]phenanthrene ring and substituted or unsubstituted fluoranthene ring.

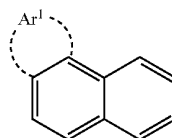
[0321] The polycyclic aromatic skeleton of the polycyclic aromatic compound may be substituted.

[0322] Examples of the substituent for the polycyclic aromatic skeleton are a halogen atom, hydroxyl group, substituted or unsubstituted amino group, nitro group, cyano group, substituted or unsubstituted alkyl group, substituted or unsubstituted alkenyl group, substituted or unsubstituted cycloalkyl group, substituted or unsubstituted alkoxy group, substituted or unsubstituted aromatic hydrocarbon group, substituted or unsubstituted aromatic heterocyclic group, substituted or unsubstituted aralkyl group, substituted or unsubstituted aryloxy group, substituted or unsubstituted alkoxy carbonyl group, and carboxyl group. Preferred examples of the aromatic hydrocarbon group are naphthalene, phenanthrene, fluorene, chrysene, fluoranthene and triphenylene.

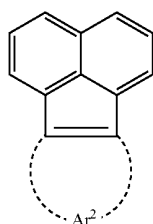
[0323] When the polycyclic aromatic skeleton has a plurality of substituents, the substituents may form a ring.

[0324] The polycyclic aromatic skeleton is preferably any one selected from the group consisting of compounds represented by formulae (10-1) to (10-4) below.

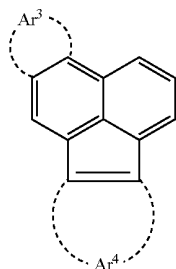
(10-1)



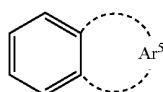
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(10-2)



(10-3)



(10-4)

[0325] In the formulae (10-1) to (10-4), Ar¹ to Ar⁵ each represent a substituted or unsubstituted fused ring structure having 4 to 16 ring carbon atoms.

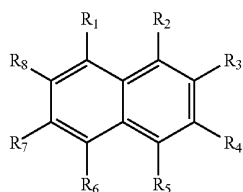
[0326] Examples of the compound represented by the formula (10-1) are elementary substances or derivatives of substituted or unsubstituted phenanthrene and chrysene.

[0327] Examples of the compound represented by the formula (10-2) are elementary substances or derivatives of substituted or unsubstituted acenaphthylene, acenaphthene and fluorene.

[0328] Examples of the compound represented by the formula (10-3) are elementary substances or derivatives of substituted or unsubstituted benzo[fluorene].

[0329] Examples of the compound represented by the formula (10-4) are elementary substances or derivatives of substituted or unsubstituted benzo[fluorene].

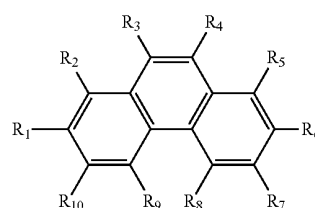
[0330] The naphthalene derivative is exemplified by a formula (10-5) below.



(10-5)

[0331] In the formula (10-5), R₁ to R₈ each independently represent a hydrogen atom, or a substituent consisting of one of or a combination of two or more of substituted or unsubstituted aryl group having 5 to 30 ring carbon atoms, branched or linear alkyl group having 1 to 30 carbon atoms and substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms.

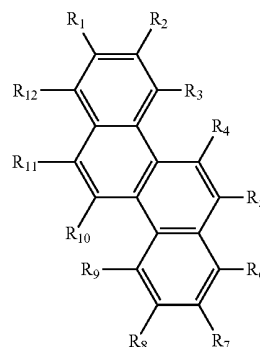
[0332] The naphthalene derivative is exemplified by a formula (10-6) below.



(10-6)

[0333] In the formula (10-6), R₁ to R₁₀ each independently represent a hydrogen atom, or a substituent consisting of one of or a combination of two or more of substituted or unsubstituted aryl group having 5 to 30 ring carbon atoms, branched or linear alkyl group having 1 to 30 carbon atoms and substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms.

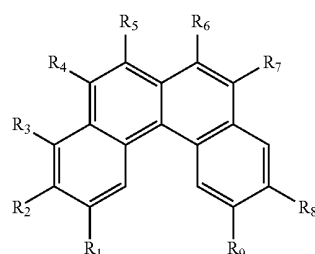
[0334] The chrysene derivative is exemplified by a formula (10-7) below.



(10-7)

[0335] In the formula (10-7), R₁ to R₁₂ each independently represent a hydrogen atom, or a substituent consisting of one of or a combination of two or more of substituted or unsubstituted aryl group having 5 to 30 ring carbon atoms, branched or linear alkyl group having 1 to 30 carbon atoms and substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms.

[0336] The polyaromatic skeleton is preferably benzo[c]phenanthrene or its derivative. The benzo[c]phenanthrene derivative is exemplified by a formula (10-8) below.

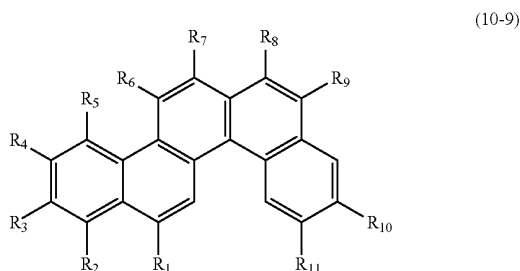


(10-8)

[0337] In the formula (10-8), R₁ to R₉ each independently represent a hydrogen atom, or a substituent consisting of one of or a combination of two or more of substituted or unsub-

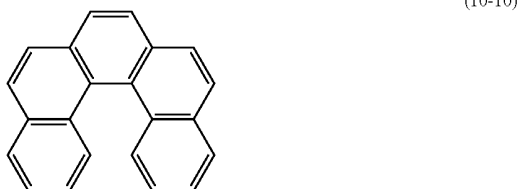
stituted aryl group having 5 to 30 ring carbon atoms, branched or linear alkyl group having 1 to 30 carbon atoms and substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms.

[0338] The polycyclic aromatic skeleton is preferably benzo[c]chrysene or its derivative. The benzo[c]phenanthrene derivative is exemplified by a formula (10-9) below.

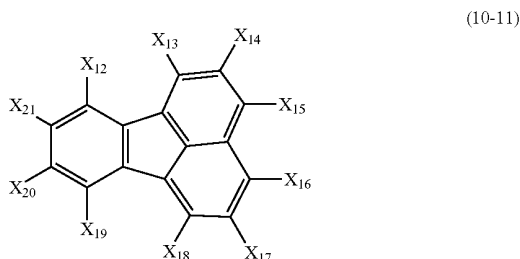


[0339] In the formula (10-9), R_1 to R_{11} each independently represent a hydrogen atom, or a substituent consisting of one of or a combination of two or more of substituted or unsubstituted aryl group having 5 to 30 ring carbon atoms, branched or linear alkyl group having 1 to 30 carbon atoms and substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms.

[0340] The polycyclic aromatic skeleton is preferably dibenzo[c,g]phenanthrene represented by a formula (10-10) below or its derivative.

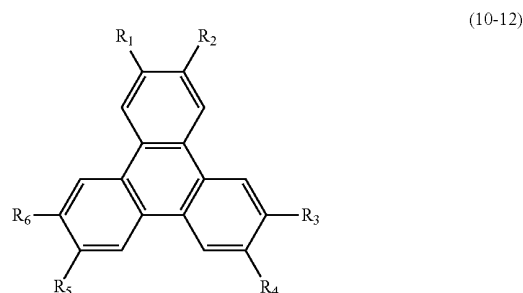


[0341] The polycyclic aromatic skeleton is preferably fluoanthrene or its derivative. The fluoanthrene derivative is exemplified by a formula (10-11) below.



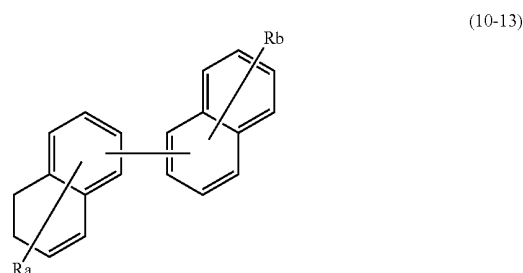
[0342] In the formula (10-11), X_{12} to X_{21} each represent a hydrogen atom; halogen atom; linear, branched or cyclic alkyl group; linear, branched or cyclic alkoxy group; substituted or unsubstituted aryl group; or substituted or unsubstituted heteroaryl group.

[0343] The polycyclic aromatic skeleton is preferably triphenylene or its derivative. The triphenylene derivative is exemplified by a formula (10-12) below.



[0344] In the formula (10-12), R_1 to R_6 each independently represent a hydrogen atom, or a substituent consisting of one of or a combination of two or more of substituted or unsubstituted aryl group having 5 to 30 ring carbon atoms, branched or linear alkyl group having 1 to 30 carbon atoms and substituted or unsubstituted cycloalkyl group having 3 to 20 carbon atoms.

[0345] The polycyclic aromatic compound may be represented by a formula (10-13) below.



[0346] In the formula (10-13), R_a and R_b represent the same as R_a and R_b in the formulae (10A) to (10C). When R_a , R_b and the naphthalene ring have a single or plural substituent(s), the single or plural substituent(s) are an alkyl group having 1 to 20 carbon atoms, haloalkyl group having 1 to 20 carbon atoms, cycloalkyl group having 5 to 18 carbon atoms, silyl group having 3 to 20 carbon atoms, cyano group or halogen atom, while substituents for the naphthalene rings other than R_a and R_b are further allowed to be an aryl group having 6 to 22 carbon atoms.

[0347] In the formula (10-13), R_a and R_b each preferably represent a group selected from fluorene ring, phenanthrene ring, triphenylene ring, benzophenanthrene ring, dibenzophenanthrene ring, benzotriphenylene ring, fluoanthrene ring, benzochrysene ring, benzo[b]fluoanthrene ring and picene ring.

Fifth Exemplary Embodiment

[0348] The second host material is preferably a monoamine derivative represented by any one of formulae (11) to (13) below.



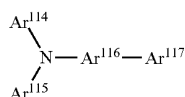
[0349] In the formula (11), Ar¹¹¹, Ar¹¹² and Ar¹¹³ each are a substituted or unsubstituted aryl group or heteroaryl group.

[0350] The aryl group has 6 to 50 ring carbon atoms (preferably 6 to 30 ring carbon atoms, more preferably 6 to 20 ring carbon atoms). Examples of the aryl group are a phenyl group, naphthyl group, phenanthrenyl group, benzophenanthrenyl group, dibenzophenanthrenyl group, benzochrysenyl group, dibenzochrysenyl group, fluoranthenyl group, benzofluoranthenyl group, triphenylenyl group, benzotriphenylenyl group, dibenzotriphenylenyl group, picenyl group, benzopicenyl group, dibenzopicenyl group, phenalenyl group, acenaphthenyl group, and diazaphenanthrenyl group. Among the above, a phenyl group or naphthyl group is preferable.

[0351] The heteroaryl group has 5 to 50 ring atoms (preferably 6 to 30 ring atoms, more preferably 6 to 20 ring atoms). Examples of the heteroaryl group are a pyrimidyl group and diazaphenanthrenyl group.

[0352] At least one of Ar¹¹¹, Ar¹¹² and Ar¹¹³ is preferably a fused aromatic hydrocarbon group selected from a phenanthrenyl group, benzophenanthrenyl group, dibenzophenanthrenyl group, benzochrysenyl group, dibenzochrysenyl group, fluoranthenyl group, benzofluoranthenyl group, triphenylenyl group, benzotriphenylenyl group, dibenzotriphenylenyl group, picenyl group, benzopicenyl group, dibenzopicenyl group, phenalenyl group, and diazaphenanthrenyl group. Among the above, a benzochrysenyl group, triphenylenyl group, or phenanthrenyl group is more preferable. Preferably, the fused aromatic hydrocarbon is unsubstituted.

[0353] In the monoamine derivative represented by the formula (11), Ar¹¹¹ and Ar¹¹² each are preferably a phenyl group or naphthyl group, and Ar¹¹³ is preferably a benzochrysenyl group, triphenylenyl group, or phenanthrenyl group.



[0354] In the formula (12), Ar¹¹⁴, Ar¹¹⁵ and Ar¹¹⁷ each are a substituted or unsubstituted aryl group or heteroaryl group.

[0355] Examples of the aryl group or heteroaryl group are the same as those defined as the aryl group or heteroaryl group for Ar¹¹¹, among which a phenyl group or naphthyl group is preferable.

[0356] Ar¹¹⁶ is a substituted or unsubstituted arylene group or heteroarylene group.

[0357] The arylene group has 6 to 50 ring carbon atoms (preferably 6 to 30 ring carbon atoms, more preferably 6 to 20 ring carbon atoms). Examples of the arylene group are a phenylene group, naphthylene group, phenanthrenylene group, naphthacenylenylene group, pyrenylene group, biphenylene group, terphenylenylene group, benzophenanthrenylene group, dibenzophenanthrenylene group, benzochrysenylene group, dibenzochrysenylene group, fluoranthenylenylene group, benzofluoranthenylenylene group, triphenylenylene group, benzotriphenylenylene group, dibenzotriphenylenylene group, picenylene group, benzopicenylene group, and dibenzopicenylene group. Among the above, a phenylene group or naphthylene group is preferable.

[0358] The heteroaryl group has 5 to 50 ring atoms (preferably 6 to 30 ring atoms, more preferably 6 to 20 ring atoms).

Examples of the heteroaryl group are a pyridylene group, pyrimidylene group, dibenzofuranylene group, and dibenzothiophenylenylene group.

[0359] Ar¹¹⁷ is preferably a fused aromatic hydrocarbon group selected from a phenanthrenyl group, benzophenanthrenyl group, dibenzophenanthrenyl group, benzochrysenyl group, dibenzochrysenyl group, fluoranthenyl group, benzofluoranthenyl group, triphenylenyl group, benzotriphenylenyl group, dibenzotriphenylenyl group, picenyl group, benzopicenyl group, and dibenzopicenyl group. Among the above, a benzochrysenyl group, triphenylenyl group, or phenanthrenyl group is more preferable. Preferably, the fused aromatic hydrocarbon is unsubstituted.

[0360] In the monoamine derivative of the formula (12), more preferably, Ar¹¹⁴ and Ar¹¹⁵ each are a phenyl group or naphthyl group, Ar¹¹⁶ is a phenyl group or naphthyl group, and Ar¹¹⁷ is a benzochrysenyl group, triphenylenyl group, or phenanthrenyl group.



[0361] In the formula (13), Ar¹¹⁸, Ar¹¹⁹ and Ar¹²¹ are a substituted or unsubstituted aryl group or heteroaryl group.

[0362] Examples of the aryl group or heteroaryl group are the same as those defined as the aryl group or heteroaryl group for Ar¹¹¹ and are preferably a phenyl group.

[0363] Ar¹²⁰ is a substituted or unsubstituted arylene group or heteroarylene group and the same as those defined as the arylene group or heteroarylene group for Ar¹¹⁶.

[0364] Ar¹²⁰ is preferably a phenylene group or naphthylene group.

[0365] n is an integer of 2 to 5, preferably 2 to 4, more preferably 2 to 3. When n is 2 or more, Ar¹²⁰ may be mutually the same or different.

[0366] Ar¹²¹ is preferably a fused aromatic hydrocarbon group selected from a phenyl group, naphthyl group, phenanthrenyl group, benzophenanthrenyl group, dibenzophenanthrenyl group, benzochrysenyl group, dibenzochrysenyl group, fluoranthenyl group, benzofluoranthenyl group, triphenylenyl group, benzotriphenylenyl group, dibenzotriphenylenyl group, picenyl group, benzopicenyl group, dibenzopicenyl group, phenalenyl group, and diazaphenanthrenyl group. Among the above, a benzochrysenyl group, triphenylenyl group, or phenanthrenyl group is more preferable.

[0367] In this exemplary embodiment, for the second host material in the formula (13), Ar¹¹⁸ and Ar¹¹⁹ each are preferably a phenyl group or naphthyl group; Ar¹²⁰ is preferably a phenylene group or naphthylene group; and Ar¹²¹ is preferably a benzochrysenyl group, triphenylenyl group, or phenanthrenyl group.

[0368] When Ar¹⁰¹ to Ar¹²¹ have substituent(s), the substituent(s) is preferably an alkyl group having 1 to 20 carbon atoms, haloalkyl group having 1 to 20 carbon atoms, cycloalkyl group having 3 to 18 carbon atoms, aryl group having 6 to 30 ring carbon atoms, silyl group having 3 to 20 carbon atoms, cyano group, and halogen atom.

[0369] Examples of the alkyl group are a methyl group, ethyl group, propyl group, isopropyl group, n-butyl group, 1-methylpropyl group and 1-propylbutyl group.

[0370] Examples of the aryl group are the same as those for Ar¹⁰¹.

[0371] The haloalkyl group is exemplified by a 2,2,2-trifluoroethyl group.

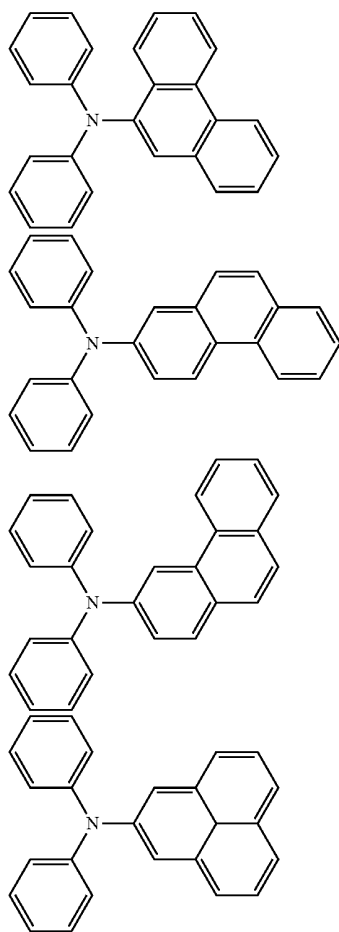
[0372] Examples of the cycloalkyl group are a cyclopropyl group, cyclobutyl group, cyclopentyl group, cyclohexyl group and cyclooctyl group.

[0373] Examples of the silyl group are a trimethylsilyl group and triethylsilyl group.

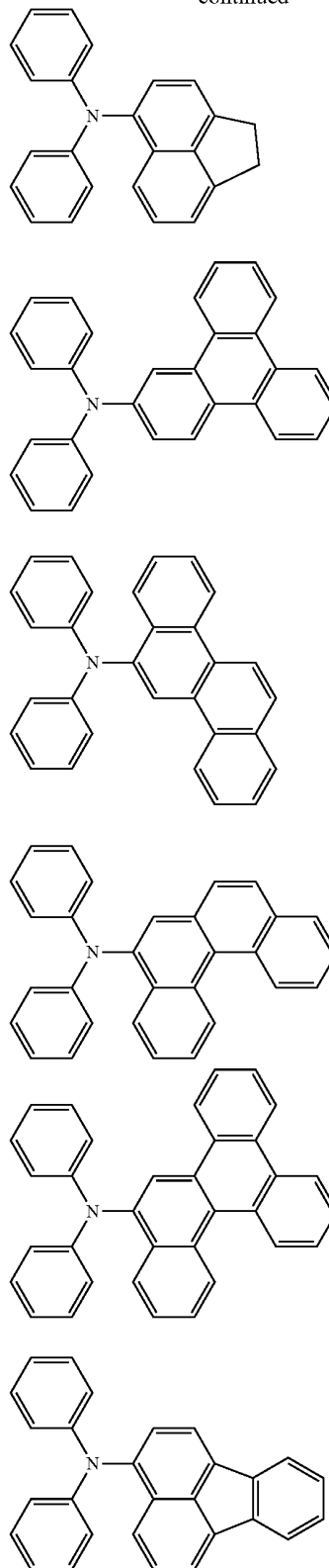
[0374] Examples of the halogen atom are fluorine, chlorine, bromine, and iodine.

[0375] When the monoamine derivatives represented by the formulae (11) to (13) are not substituted, it is meant that a hydrogen atom is substituted. The hydrogen atom of the monoamine derivatives represented by the formulae (11) to (13) includes light hydrogen and deuterium. "Carbon atoms forming a ring (ring carbon atoms)" mean carbon atoms forming a saturated ring, unsaturated ring, or aromatic ring. "Atoms forming a ring (ring atoms)" mean carbon atoms and hetero atoms forming a ring including a saturated ring, unsaturated ring, or aromatic ring.

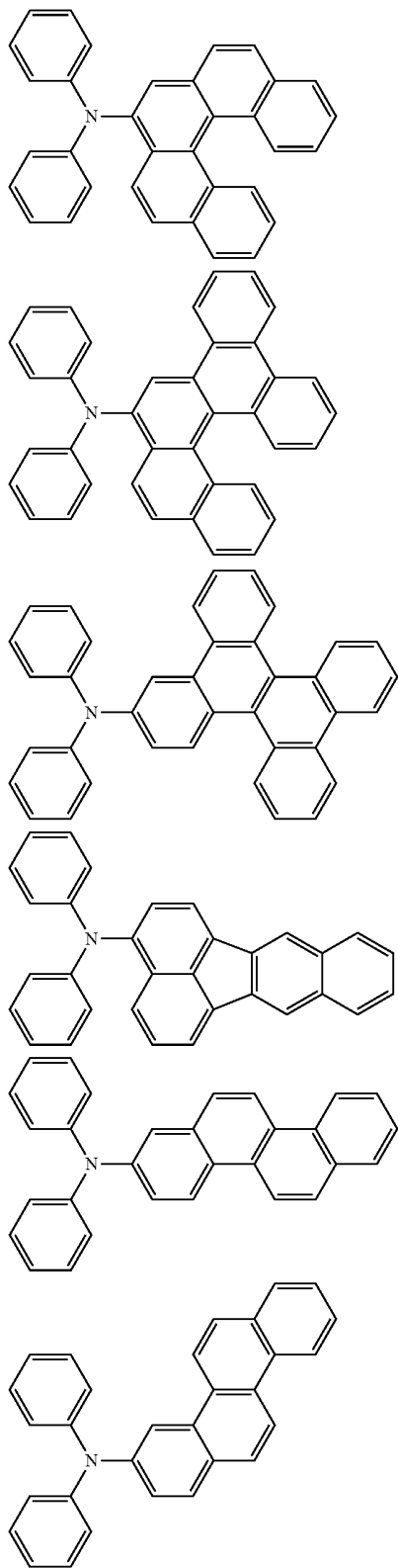
[0376] Specific examples of the monoamine derivatives represented by the formula (11) are shown below.



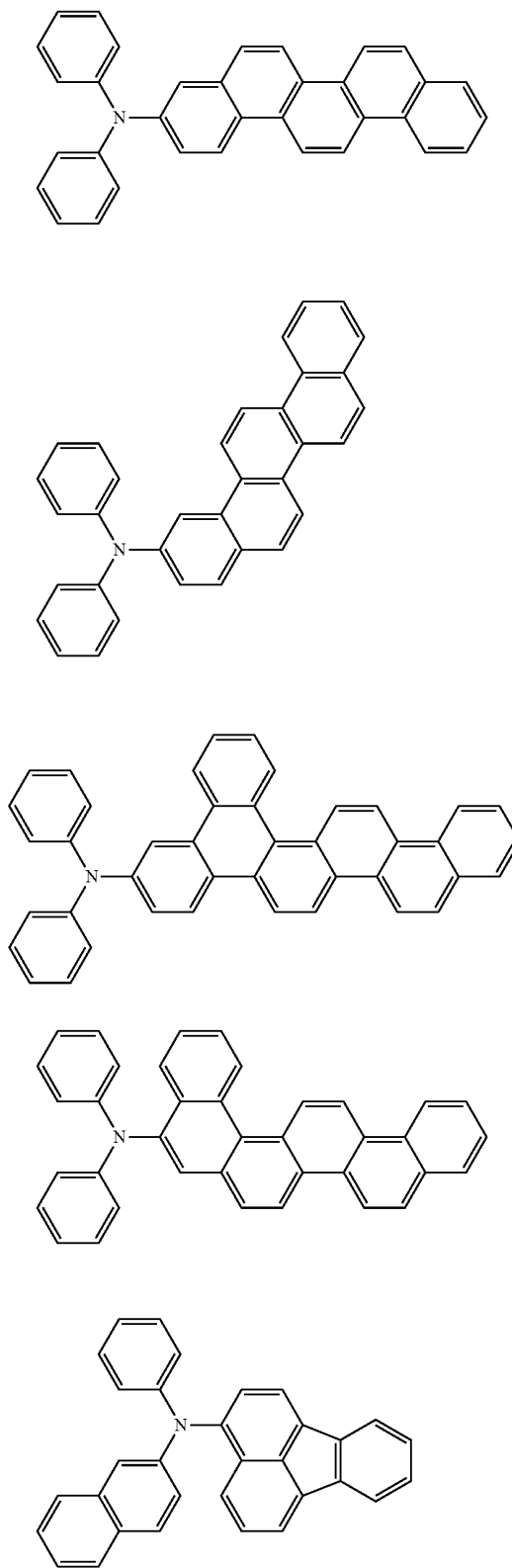
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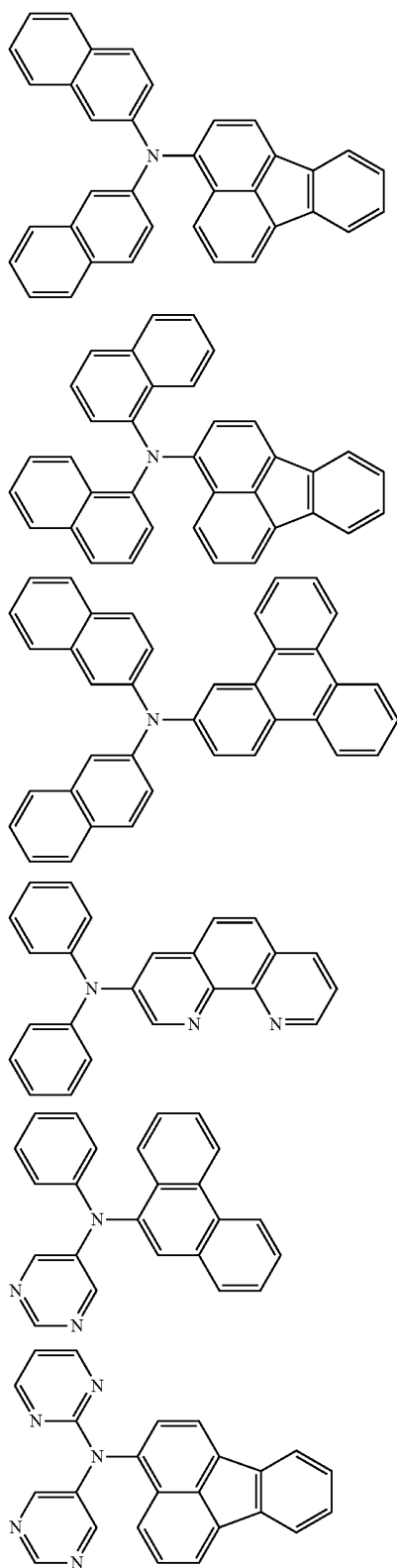
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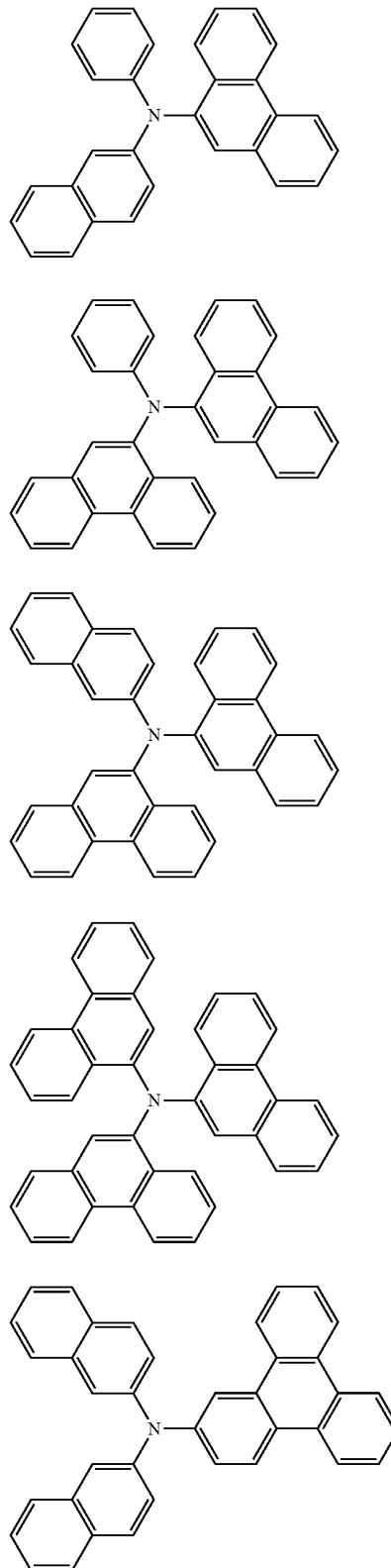
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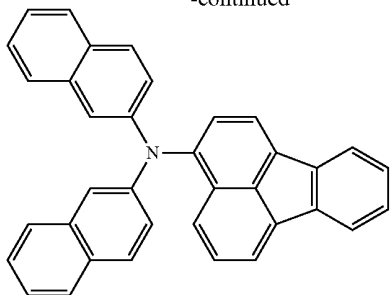
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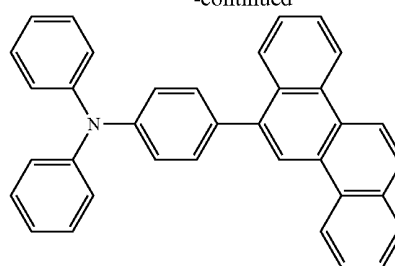
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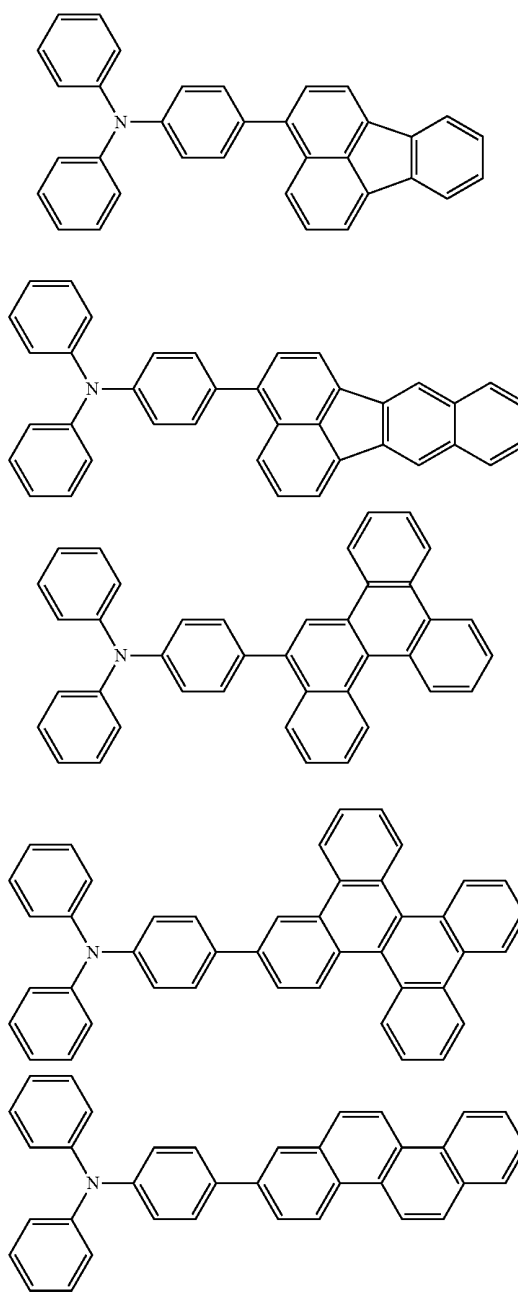
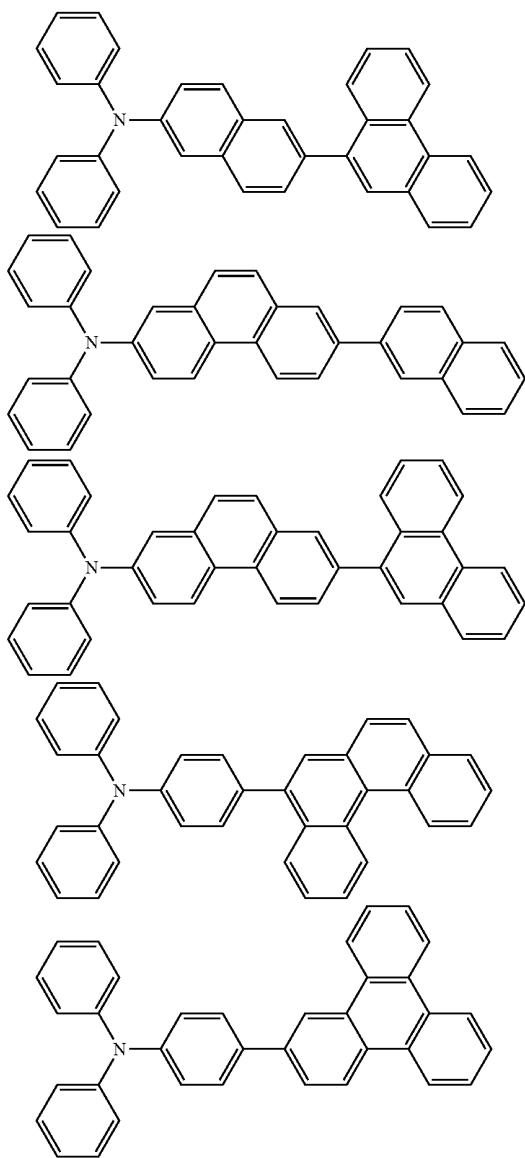
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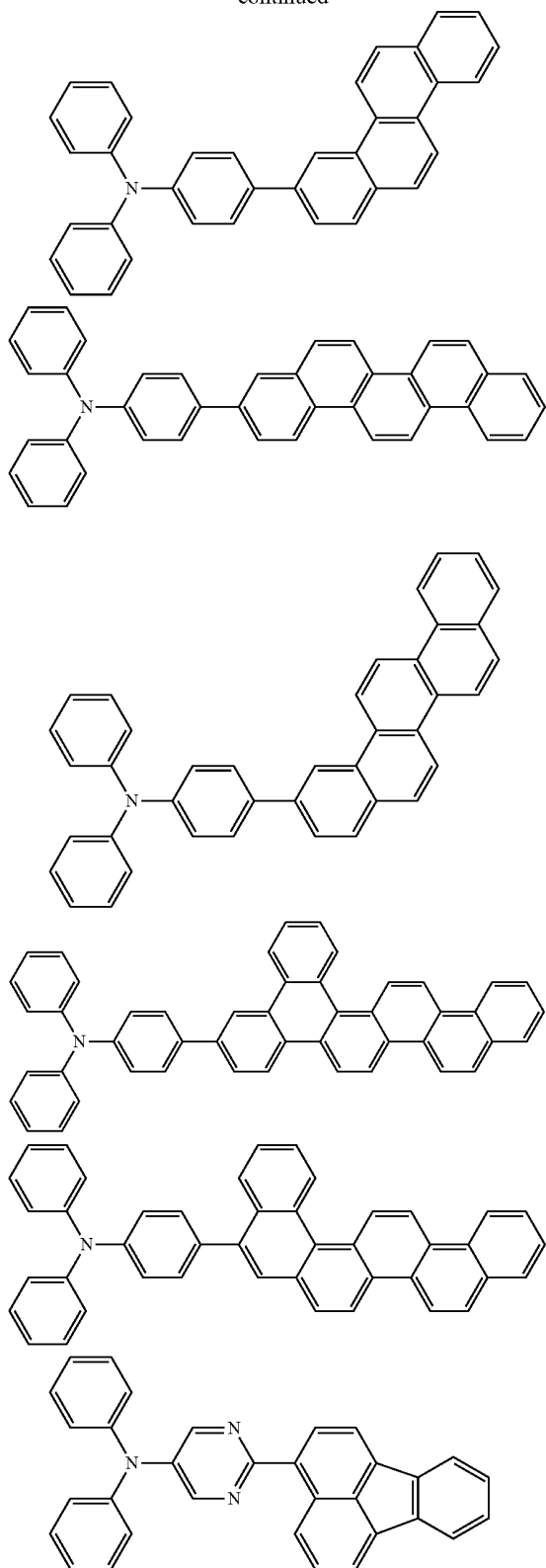
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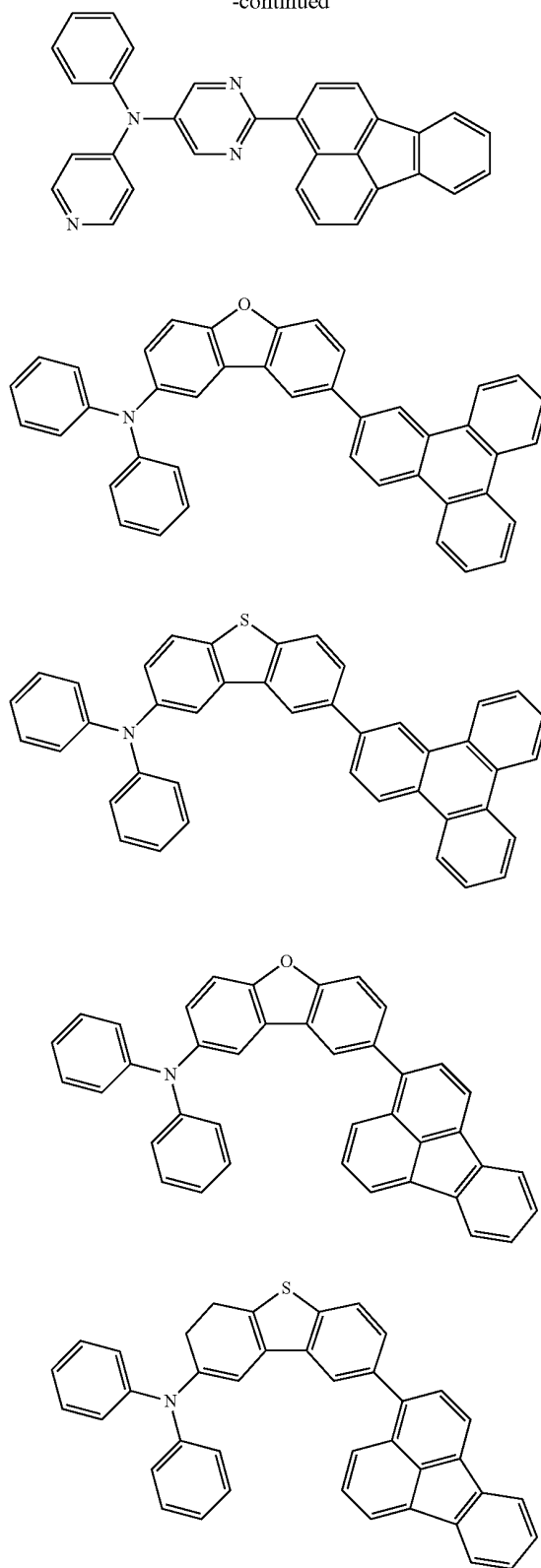
[0377] Specific examples of the monoamine derivatives represented by the formula (12) are shown below.



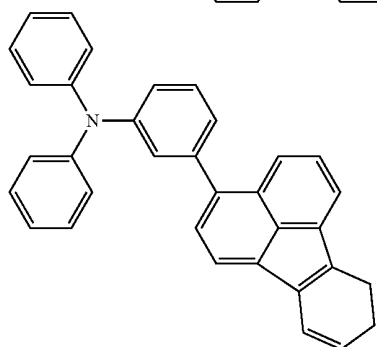
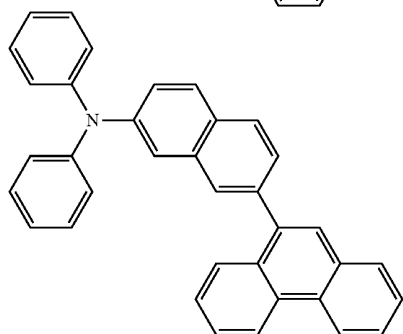
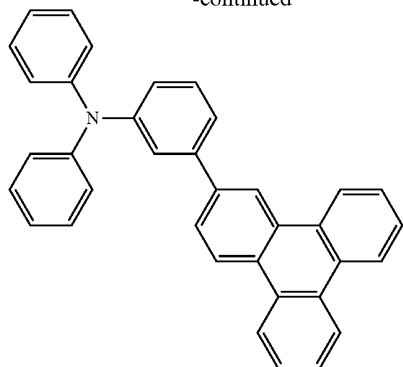
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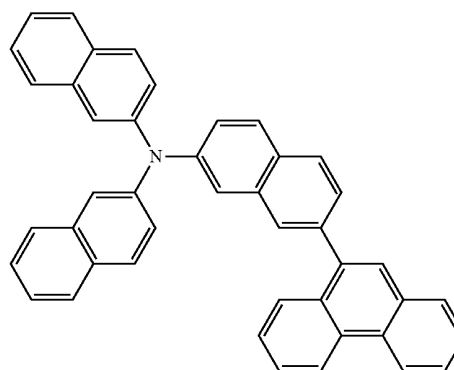
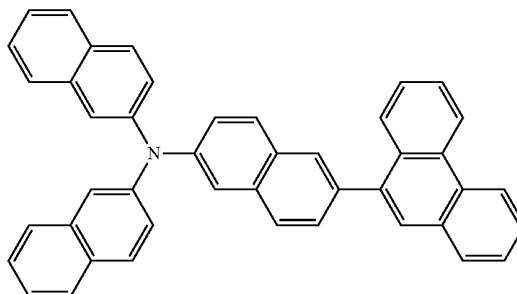
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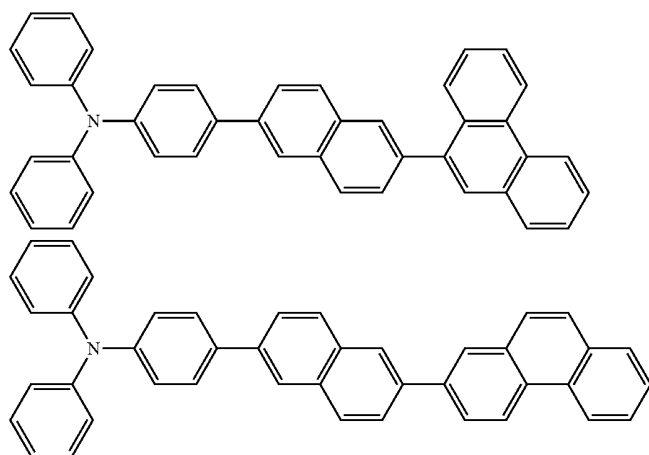
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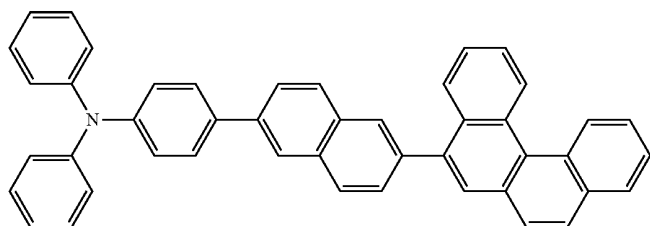
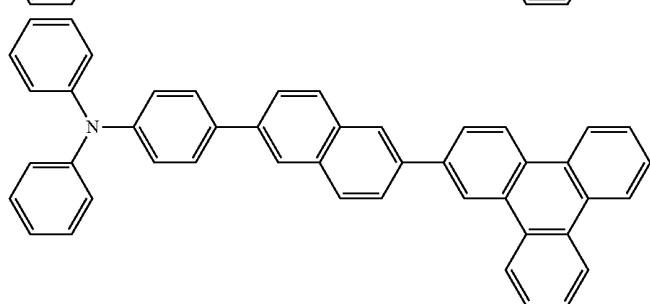
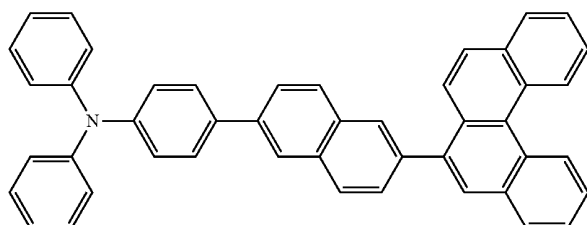
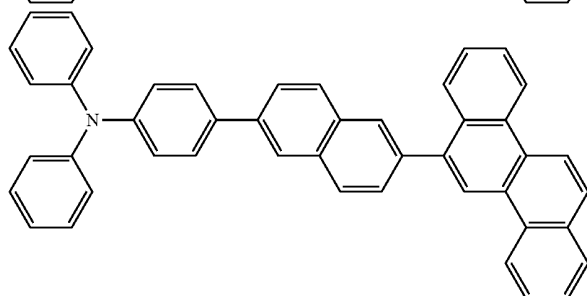
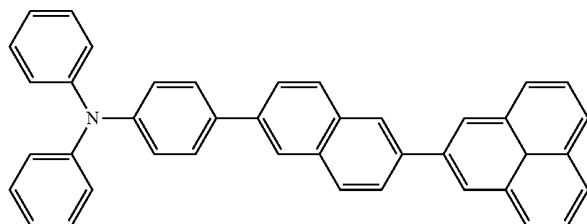
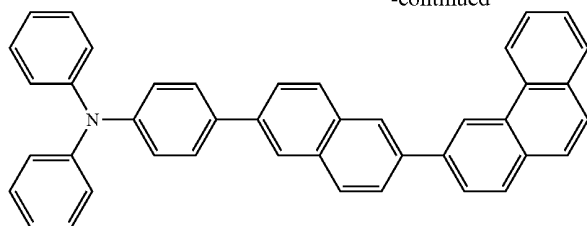
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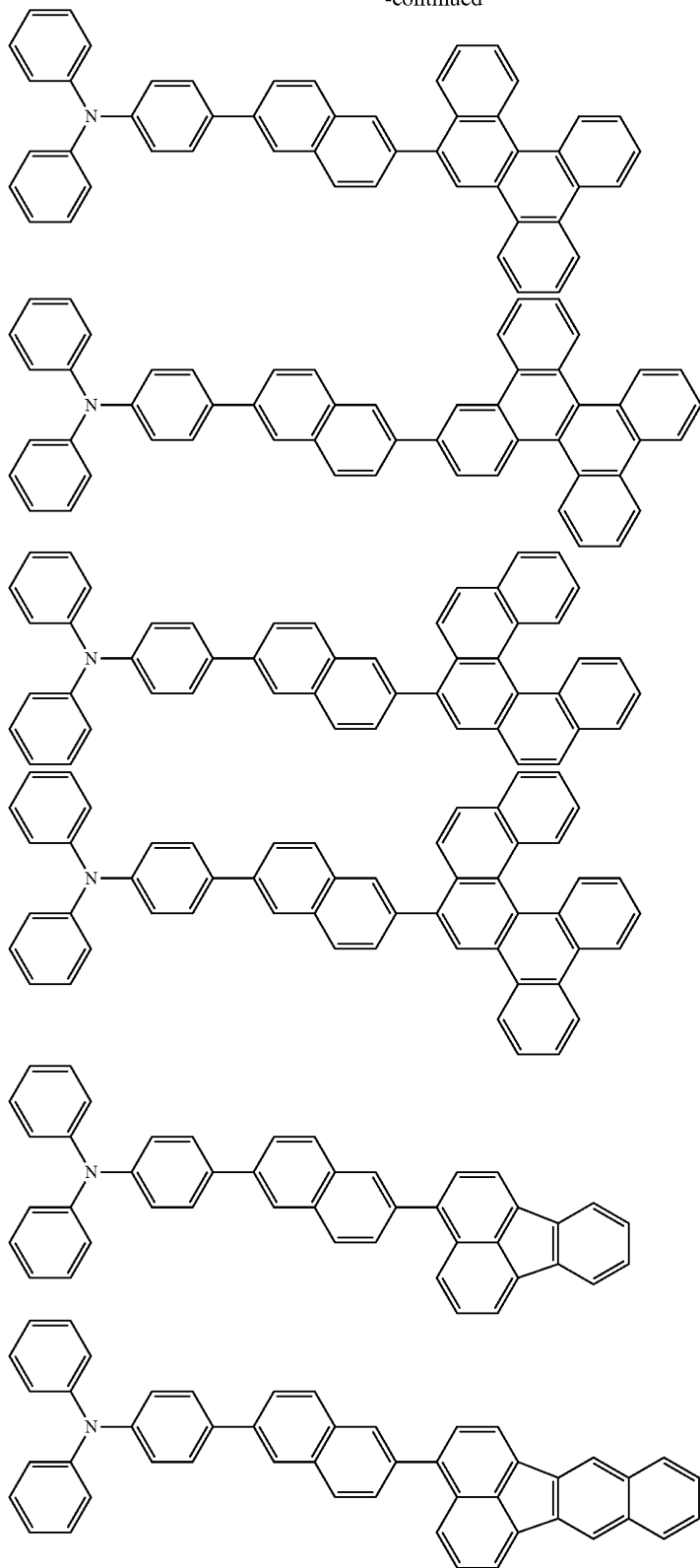
[0378] Specific examples of the monoamine derivatives represented by the formula (13) are shown below.



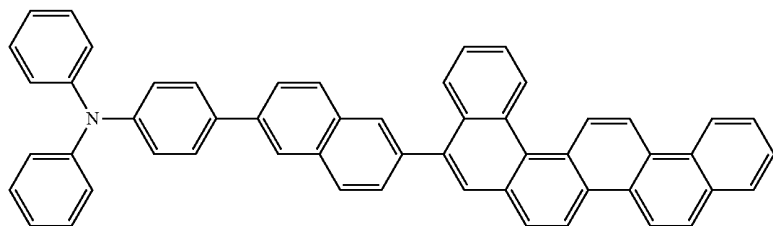
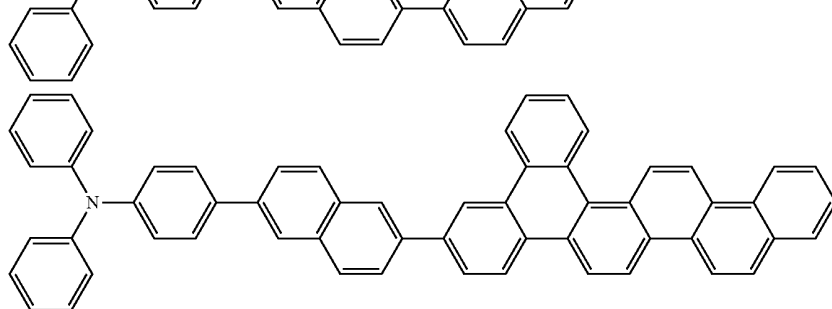
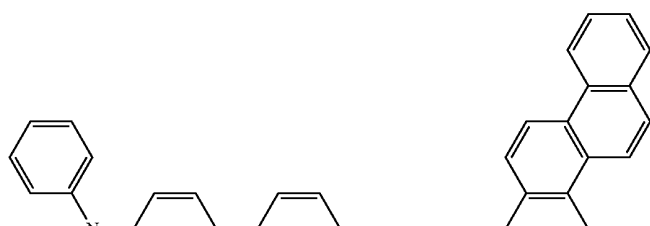
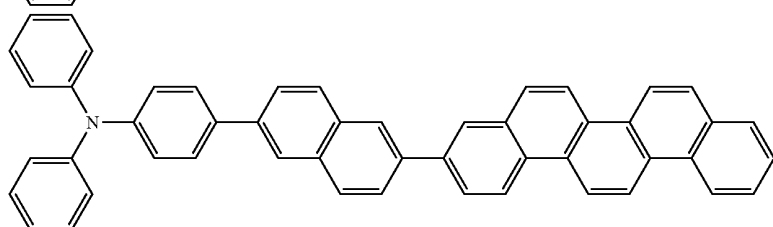
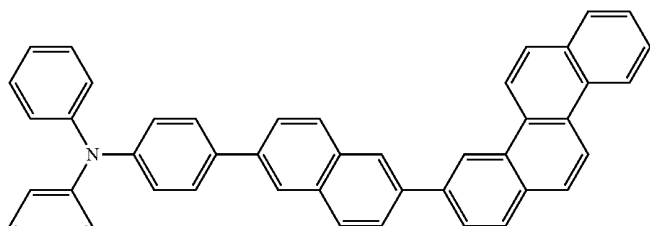
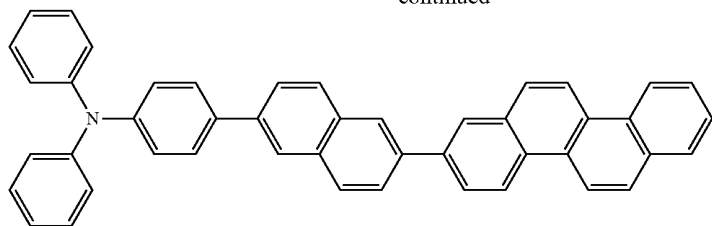
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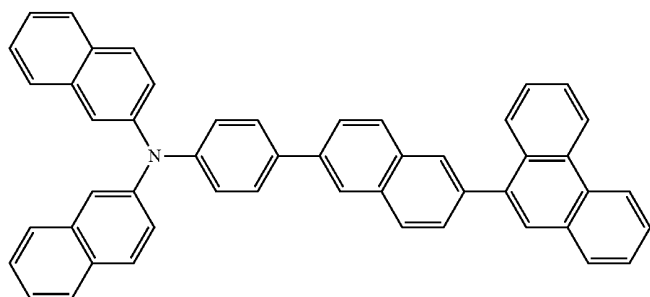
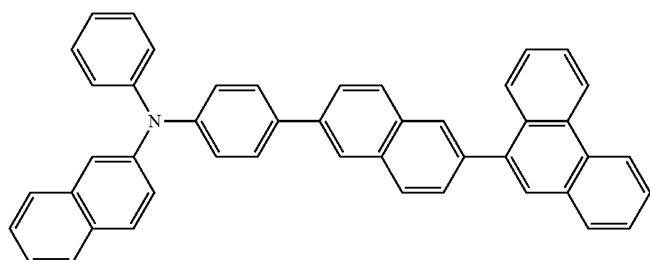
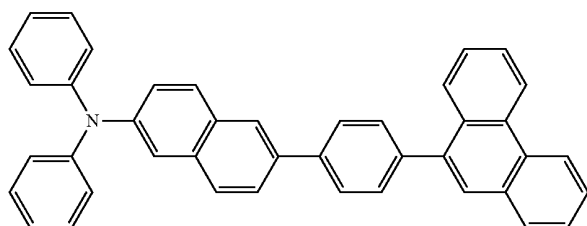
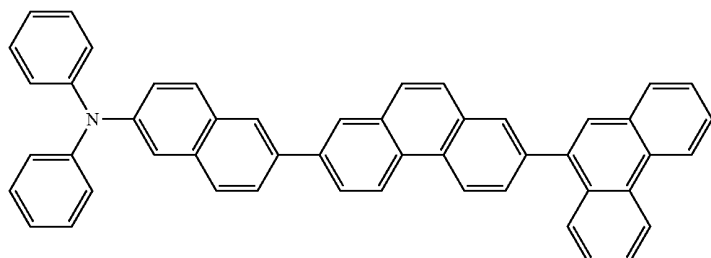
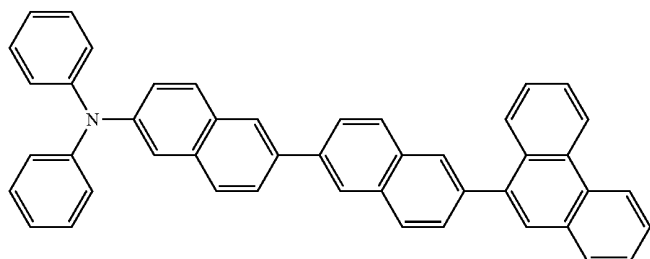
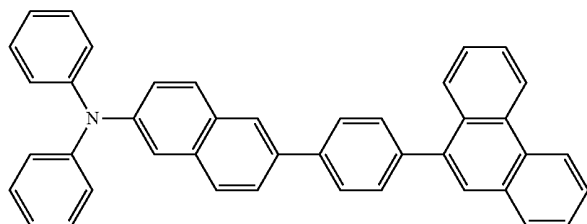
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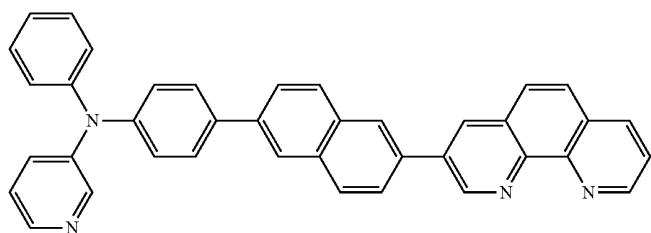
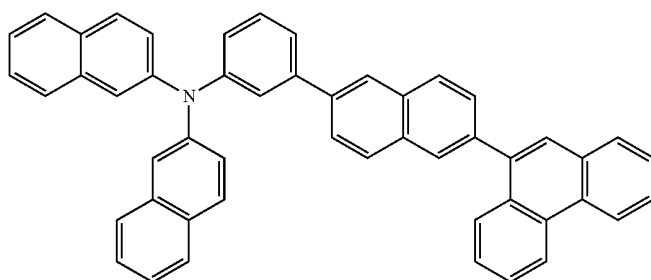
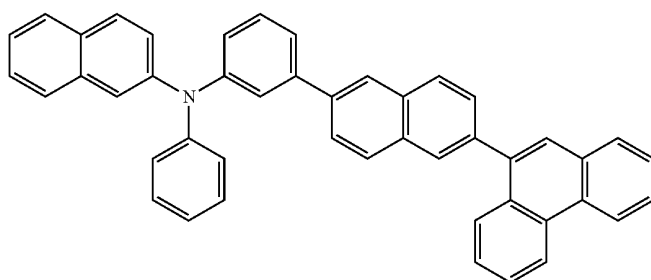
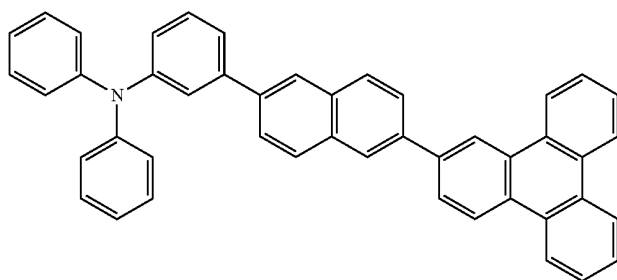
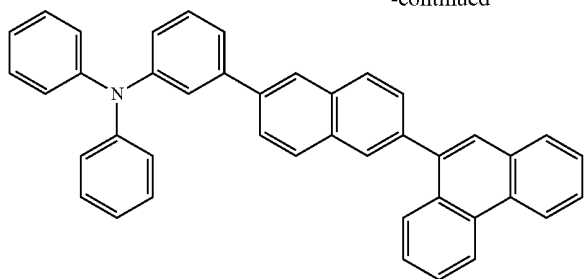
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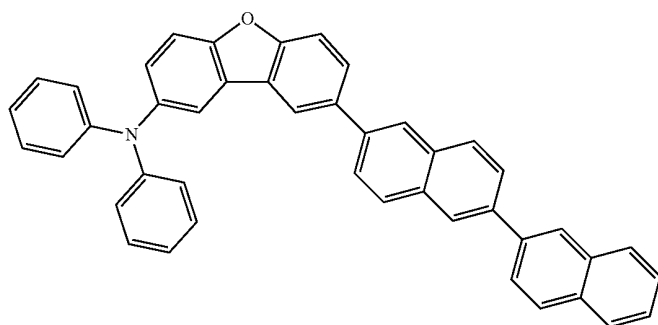
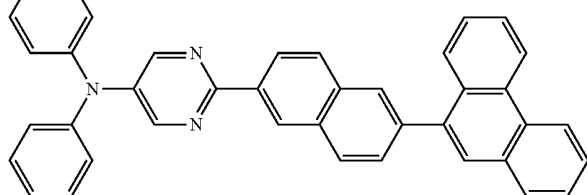
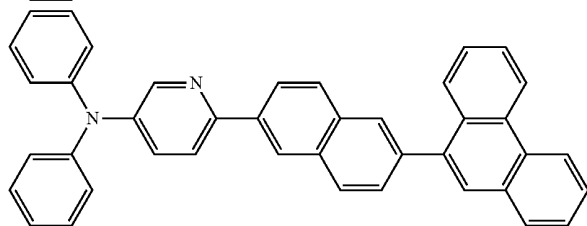
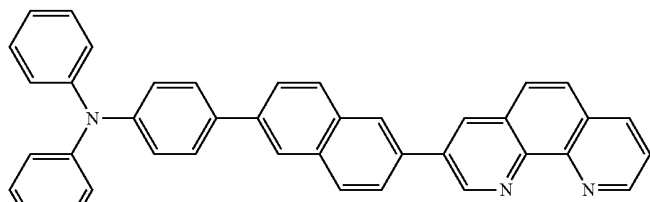
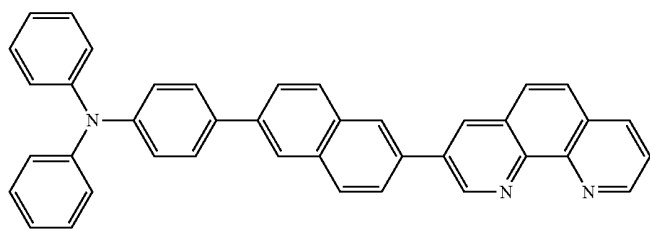
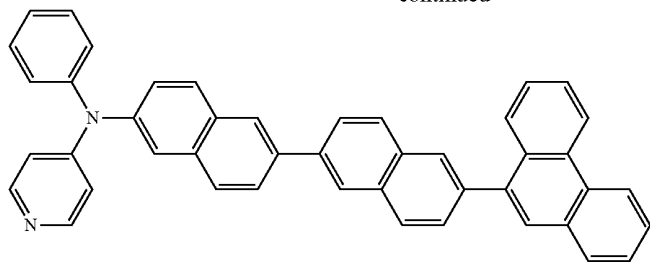
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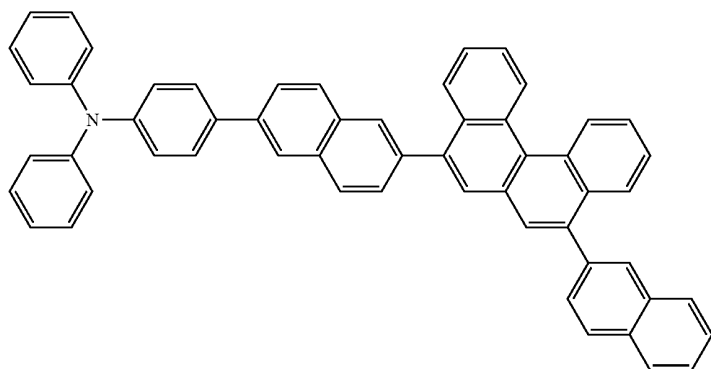
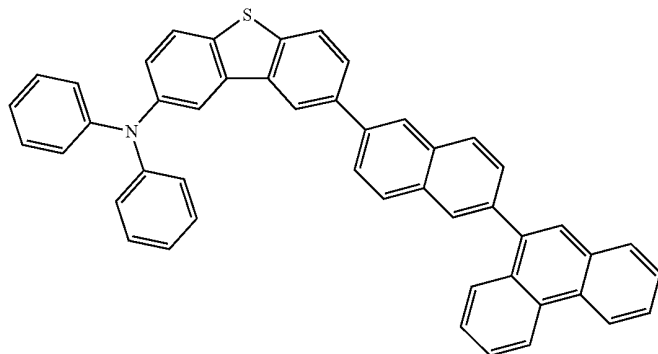
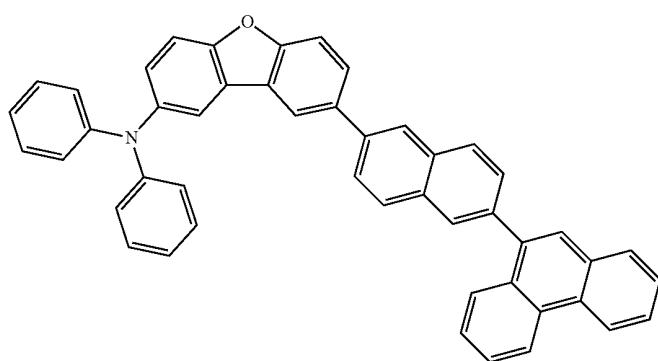
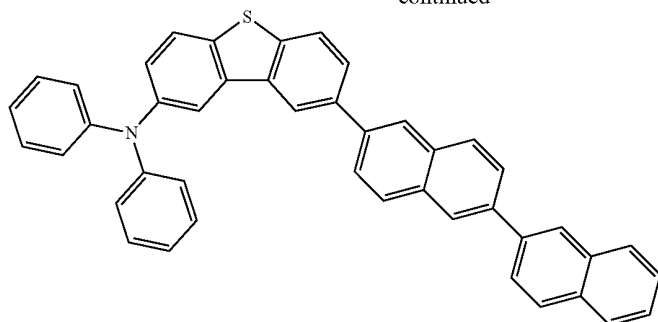
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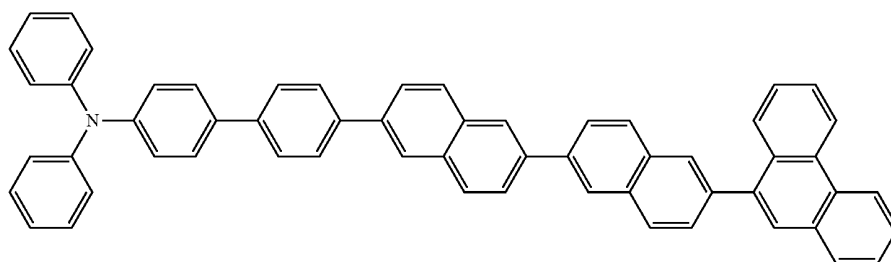
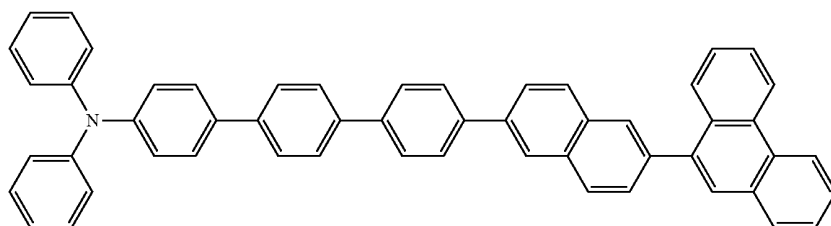
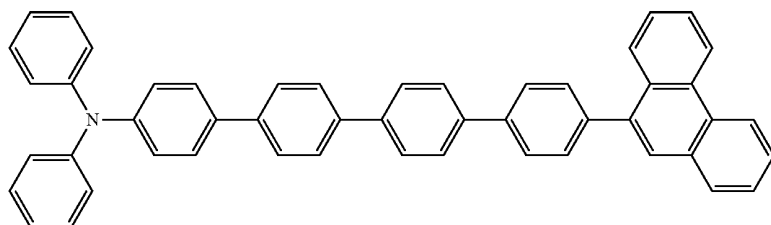
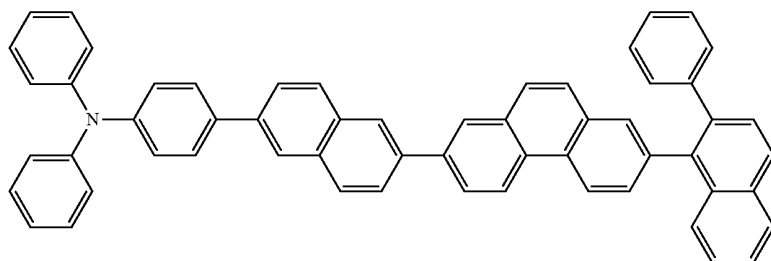
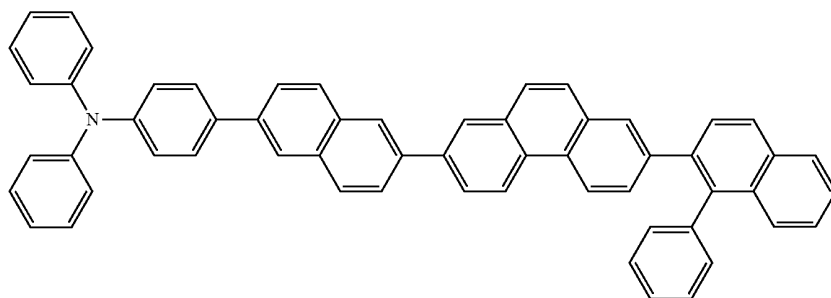
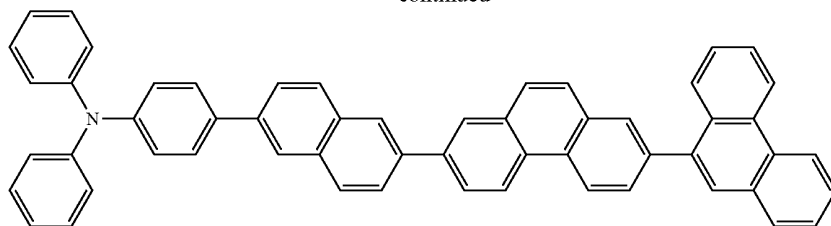
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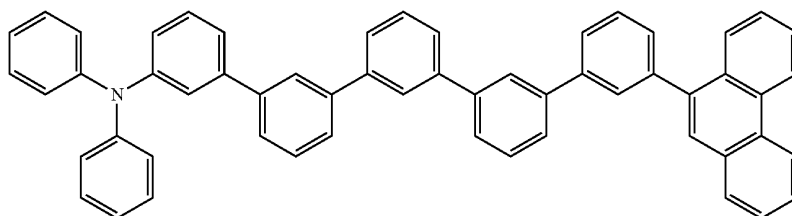
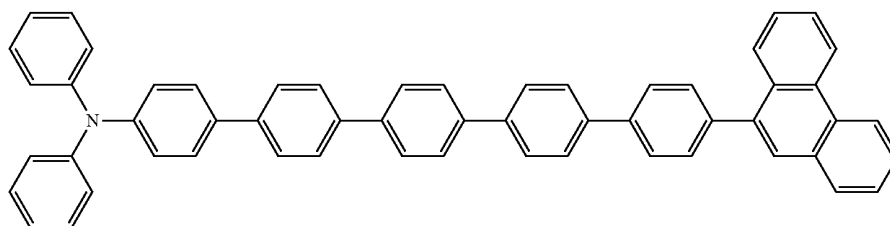
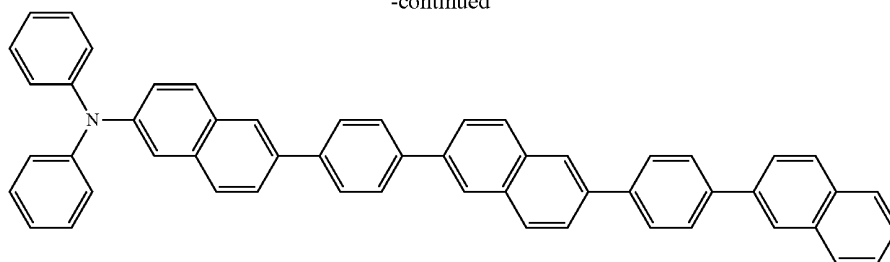
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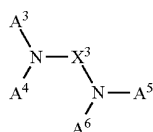
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Sixth Exemplary Embodiment

[0379] In an organic EL device according to a sixth exemplary embodiment, an aromatic amine compound is used as the second host material.

[0380] An example of the aromatic amine compound is preferably a compound represented by a formula (14) or (15) below.



(14)

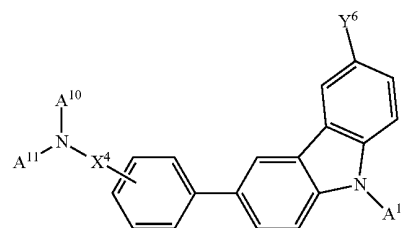
[0381] In the formula (14): X^3 represents a substituted or unsubstituted arylene group having 10 to 40 ring carbon atoms; and A^3 to A^6 represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms, or heteroaryl group having 6 to 60 ring atoms.



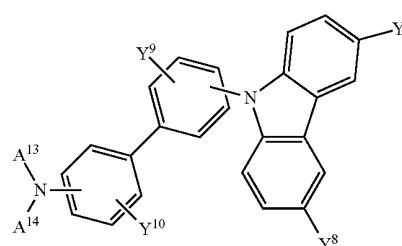
(15)

[0382] In the formula (15), A^7 to A^9 represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms, or heteroaryl group having 6 to 60 ring atoms.

[0383] The second host material represented by the formula (14) or (15) is preferably represented by formulae (16) to (20).

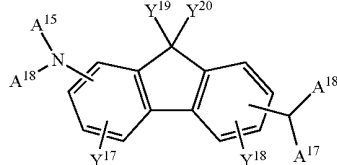


(16)



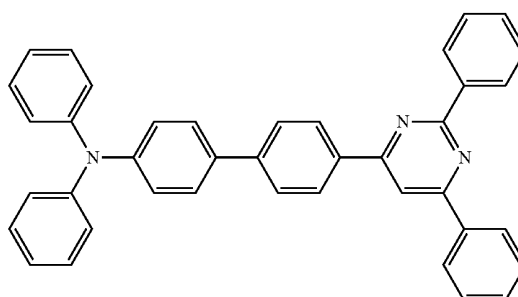
(17)

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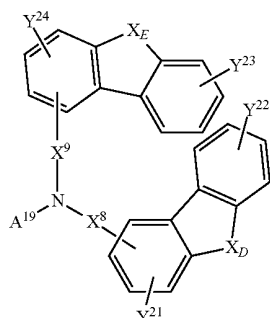


(19)

HT-1



(20)



[0384] In the formulae (16) to (20): A¹⁰ to A¹⁹ each represent a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 40 carbon atoms, substituted or unsubstituted aryl group having 8 to 40 carbon atoms bonded with an aromatic amino group, or substituted or unsubstituted aryl group having 8 to 40 carbon atoms bonded with an aromatic heterocyclic group;

[0385] A¹⁰, A¹³, A¹⁵ and Aⁿ are adapted to be respectively bonded to A¹¹, A¹⁴, A¹⁶ and A¹⁸ to form a ring;

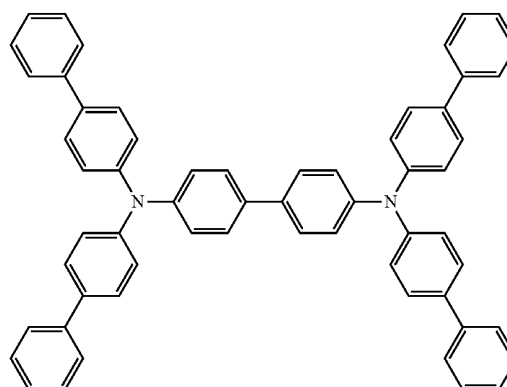
[0386] X⁴ to X⁹ represent a single bond or a linking group having 1 to 30 carbon atoms;

[0387] Y⁶ to Y²⁴ represent a hydrogen atom, halogen atom, substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted alkenyl group having 2 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted alkylsilyl group having 3 to 20 carbon atoms, substituted or unsubstituted arylsilyl group having 8 to 40 carbon atoms, substituted or unsubstituted aralkylsilyl group having 8 to 40 carbon atoms, or substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms; and

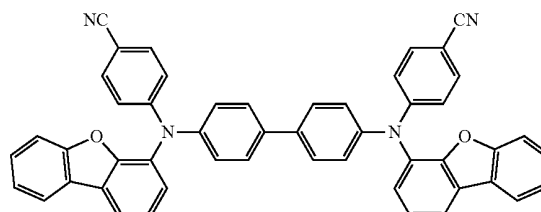
[0388] X_A, X_B, X_C, X_D, X_E each represent a sulfur atom, an oxygen atom or a monoaryl-substituted nitrogen atom.

[0389] Examples of compounds represented by the formulae (14), (15), and (16) to (20) are as follows.

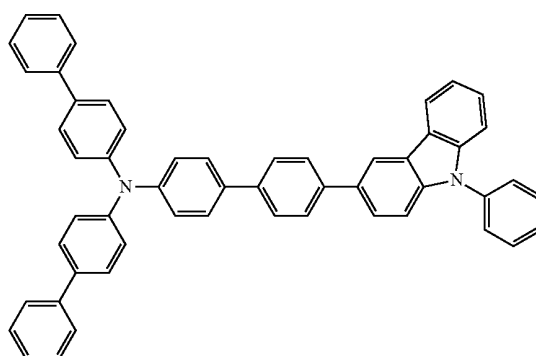
HT-2



HT-3

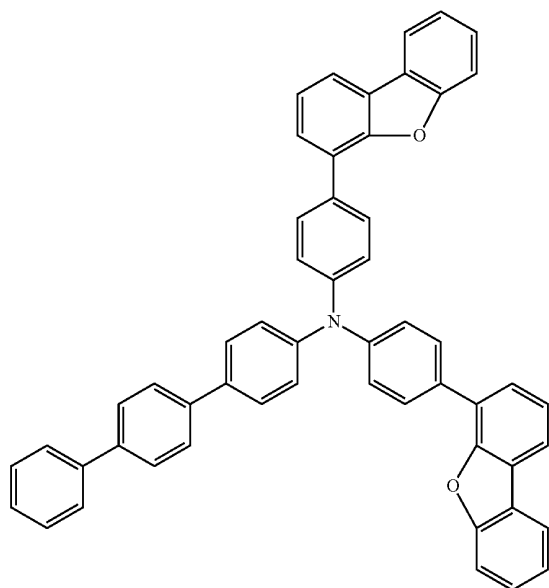


HT-4

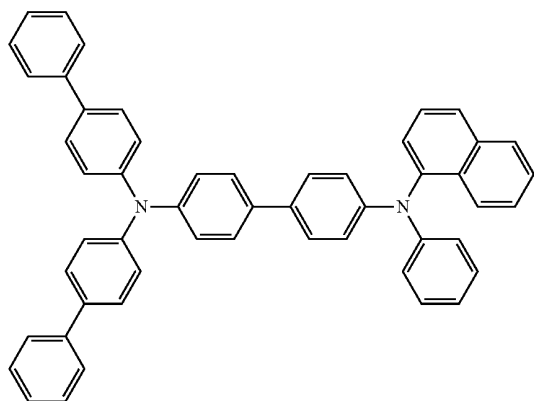


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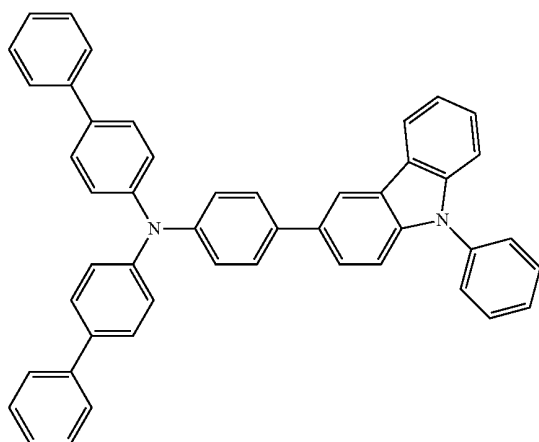
HT-5



HT-6

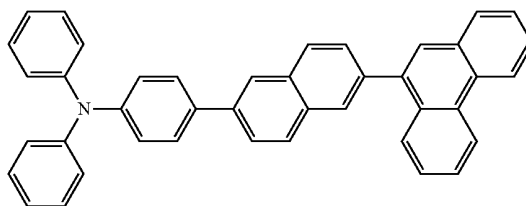


HT-7

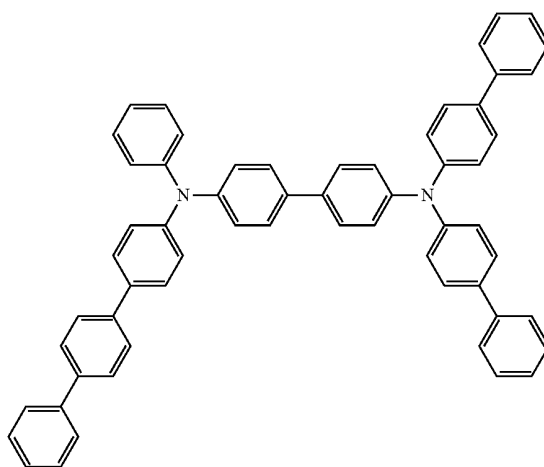


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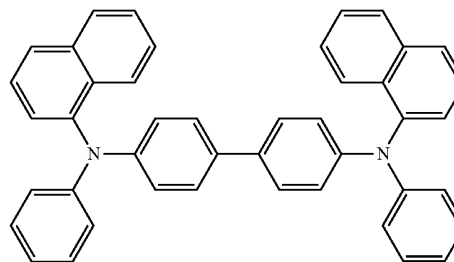
HT-8



HT-9



HT-10



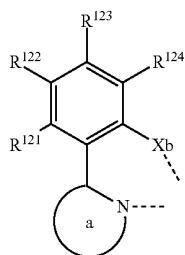
Seventh Exemplary Embodiment

[0390] An organic EL device according to a seventh exemplary embodiment preferably contains a metal complex as the second host material.

[0391] The metal complex is preferably represented by a formula (21) below.



[0392] In the formula: ligands L^{11} , L^{12} and L^{13} are independently selected from a structure represented by a formula (22) below; M^{11} is a divalent metal; and Q^{11} is a monovalent anion induced from inorganic or organic acids.



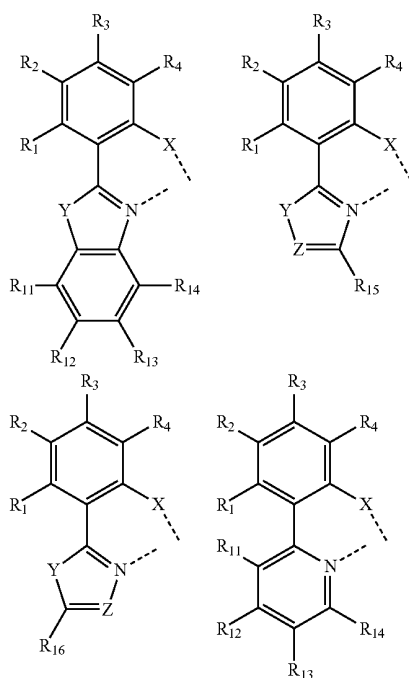
(22)

[0393] In the ligands: Xb is O, S or Se; a-ring is oxazole, thiazole, imidazoles, oxadiazole, thiadiazole, benzoxazole, benzothiazole, benzoimidazole, pyridine, or quinoline; and R^{121} to R^{124} are independently hydrogen, an alkyl group having 1 to 5 carbon atoms, halogen, silyl group or aryl group having 6 to 20 carbon atoms, which may be bonded to an adjacent substituent via alkylene or alkenylene to form a fused ring.

The pyridine and quinoline may be bonded to R^1 to form a fused ring.

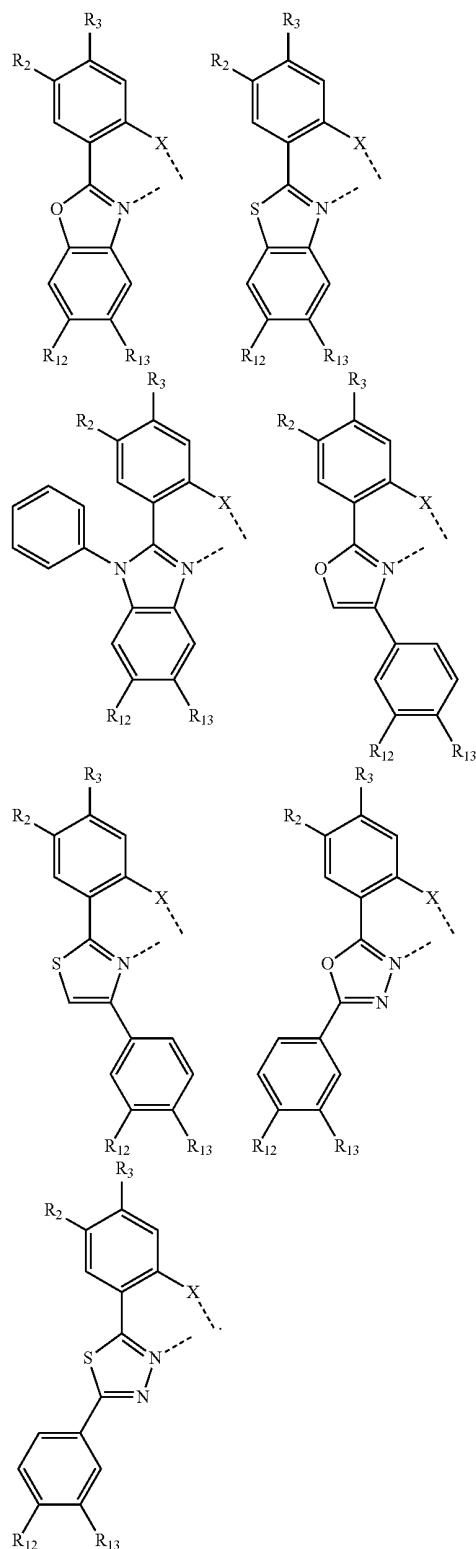
The a-ring and the aryl group for R^{121} to R^{124} may be further substituted by a C1-C5 alkyl group, halogen, C1-C5 alkyl group having a halogen substituent, phenyl group, naphthyl group, silyl group, or amino group.

[0394] The ligands L^{11} , L^{12} and L^{13} are independently selected from the following structures.



[0395] In the ligands: X and R_1 to R_4 represent the same as Xb and R^{121} to R^{124} in the formula (22); Y is O, S or NR_{21} ; Z is CH or N; R_{11} to R_{16} are independently hydrogen, a C1-C5 alkyl group, halogen, C1-C5 alkyl group having a halogen substituent, phenyl group, naphthyl group, silyl group, or amino group; and R_{11} to R_{14} may be bonded to an adjacent substituent via alkylene or alkenylene to form a fused ring.

[0396] The ligands L^{11} , L^{12} and L^{13} of the compound may be the same and can be selected from the following structures.

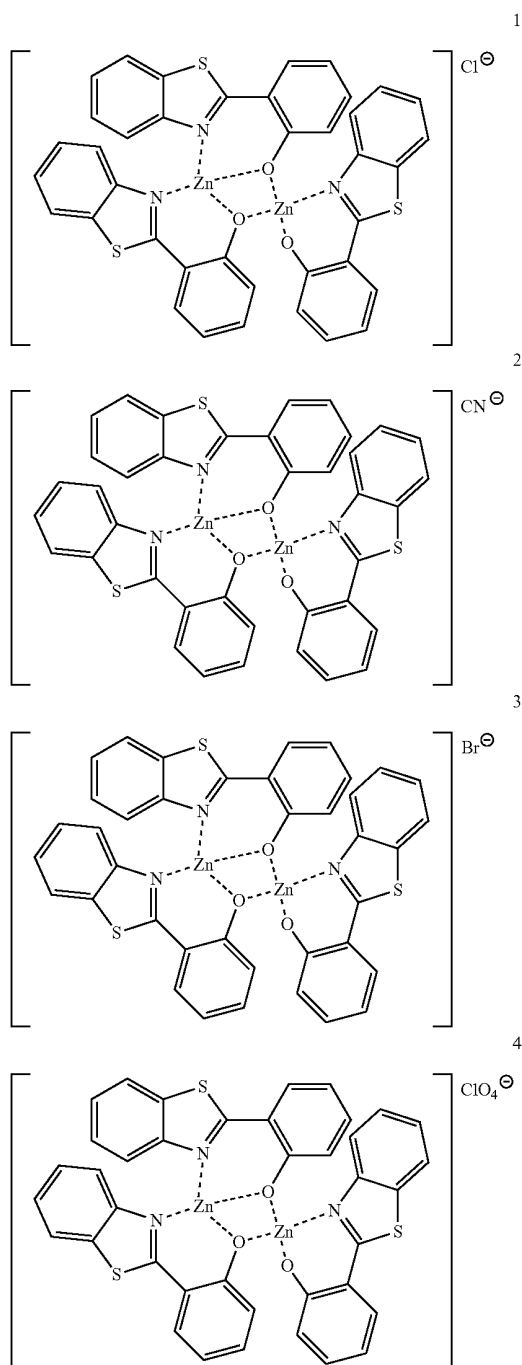


[0397] In the ligands: X is O, S or Se; R_2 , R_3 , R_{12} and R_{13} are independently hydrogen, methyl, ethyl, n-propyl, isopropyl, fluorine, chlorine, trifluoromethyl, phenyl, naphthyl,

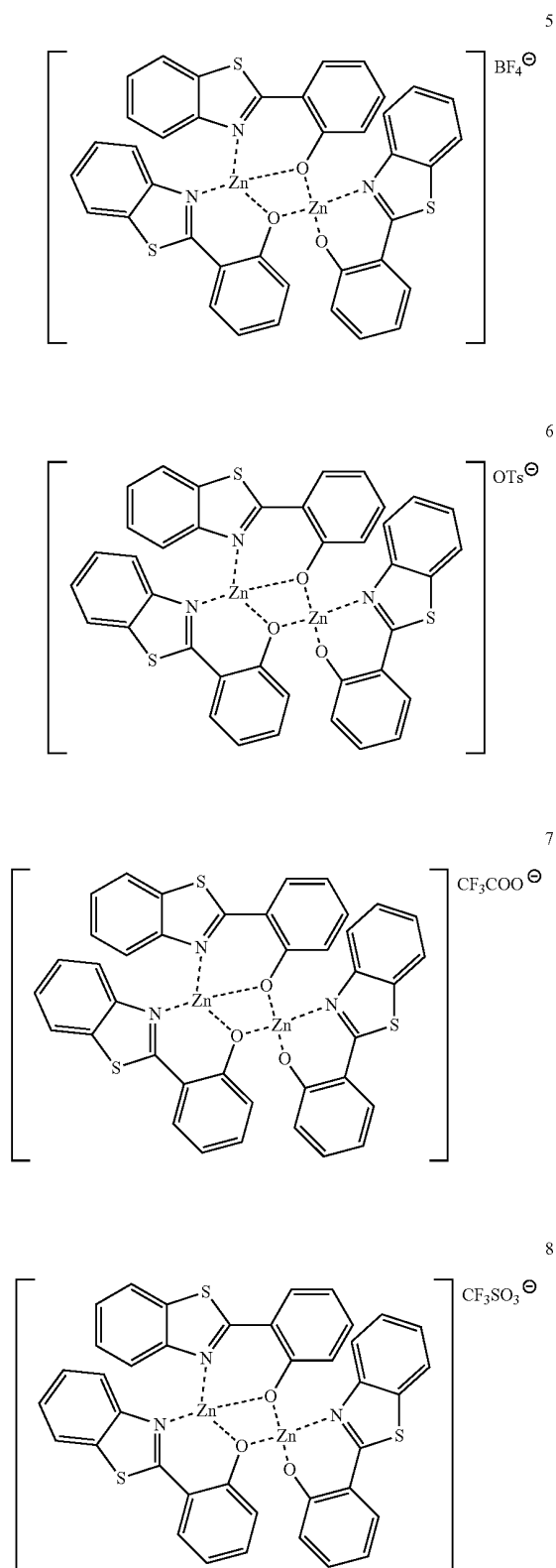
fluorenyl, trimethylsilyl, triphenylsilyl, t-butyltrimethylsilyl, dimethylamine, diethylamine, or diphenylamine.

[0398] The phenyl, naphthyl, fluorenyl are further substituted by fluorine, chlorine, trimethylsilyl, triphenylsilyl, t-butyltrimethylsilyl, dimethylamine, diethylamine, or diphenylamine.

[0399] Furthermore, in this exemplary embodiment, the metal complex is preferably a zinc complex. Examples of such a preferable zinc complex are shown below.

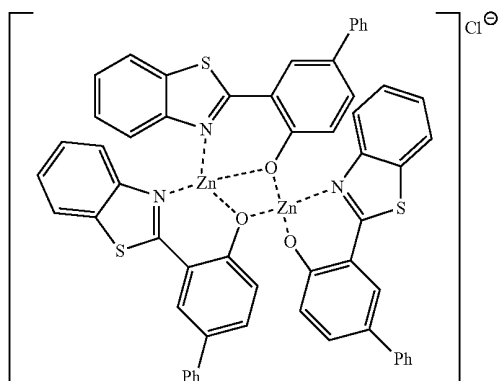


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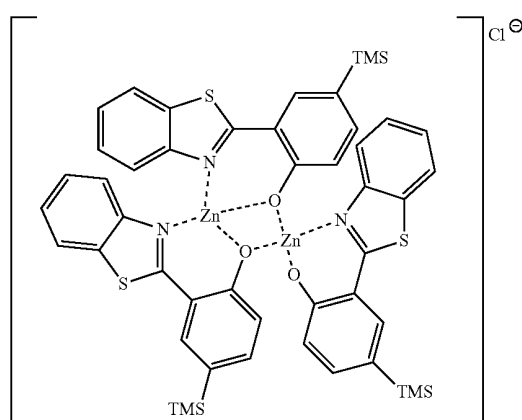
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9

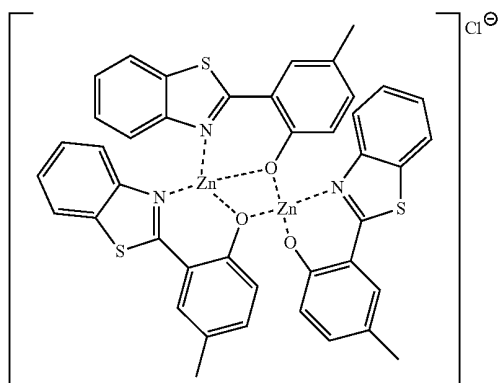


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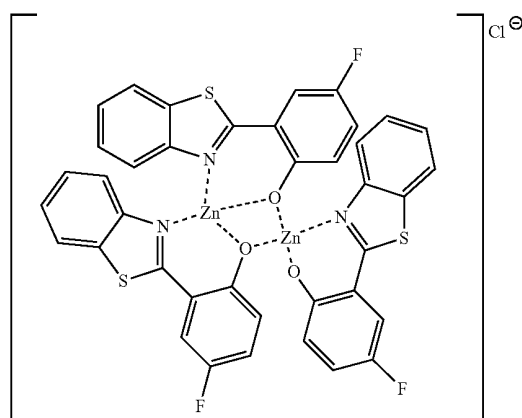
12



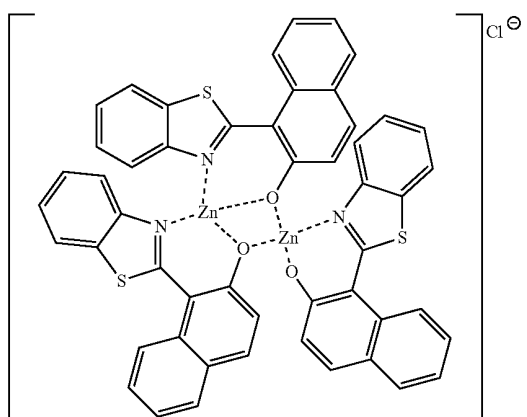
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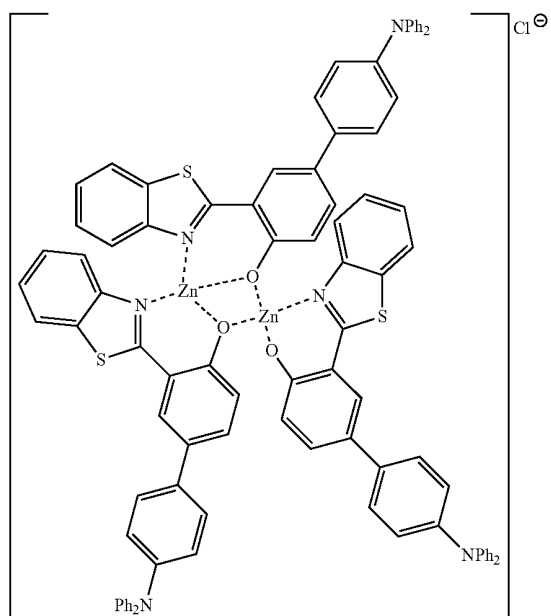
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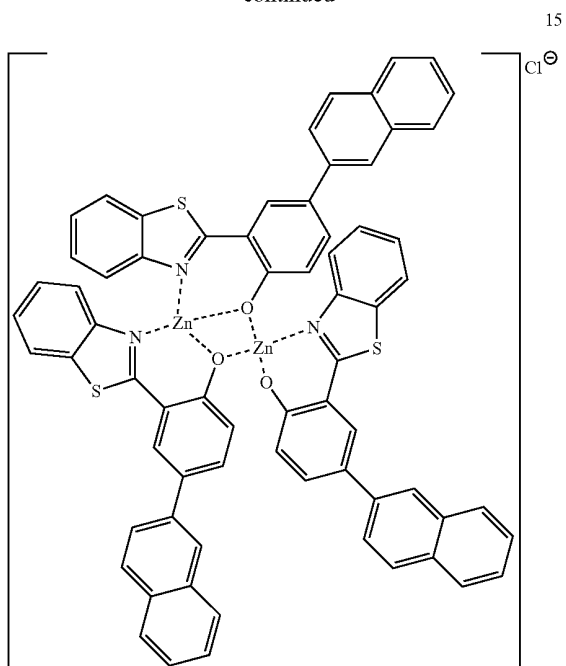
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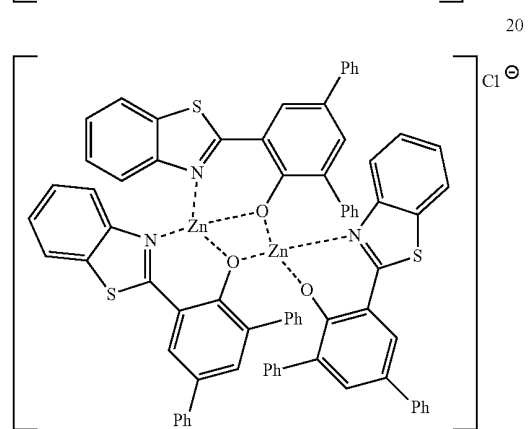
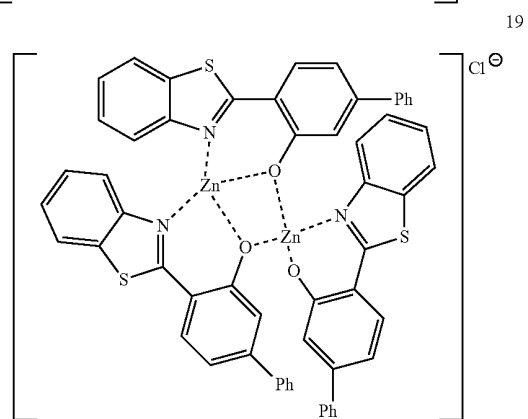
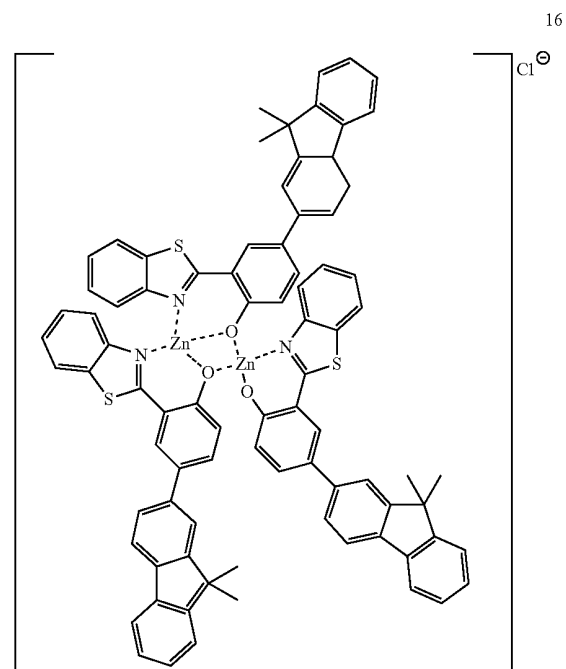
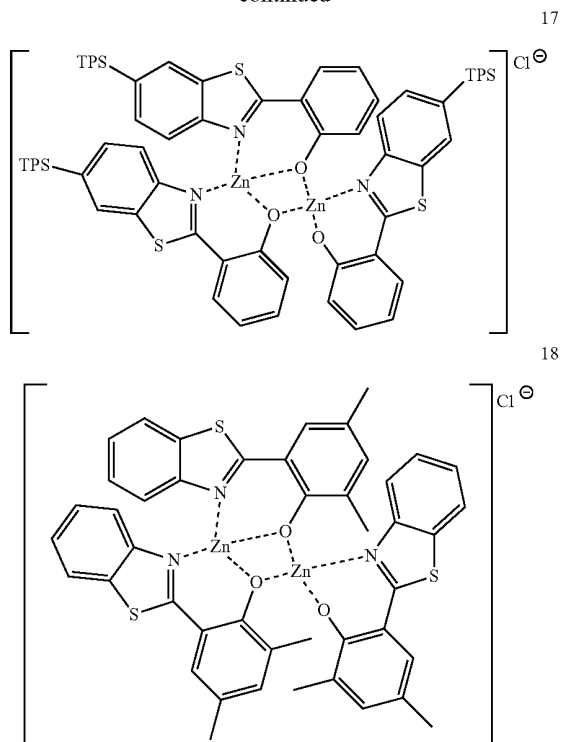
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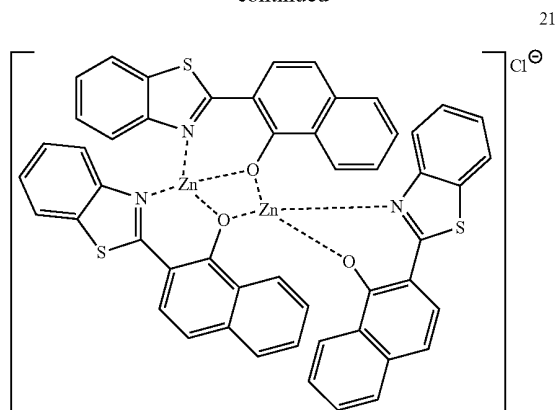
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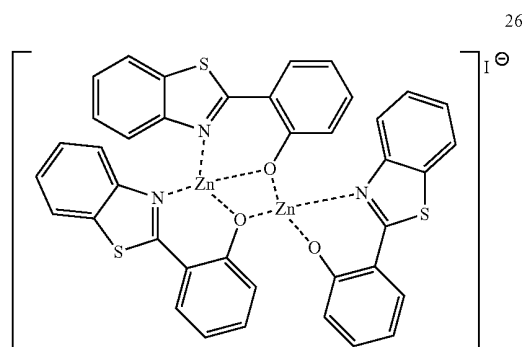
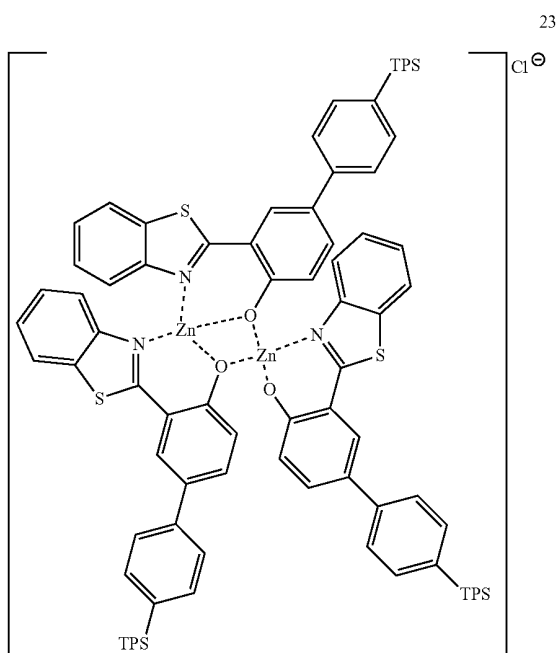
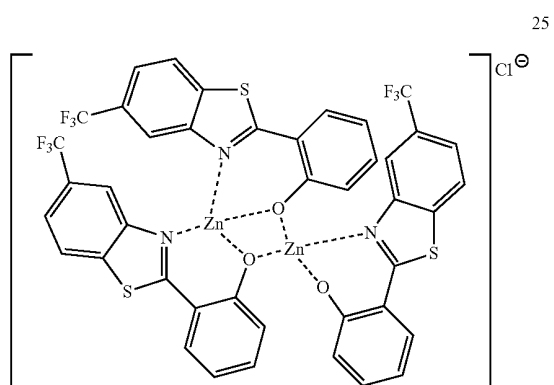
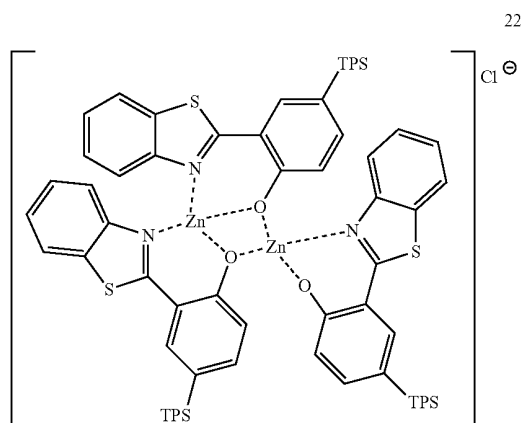
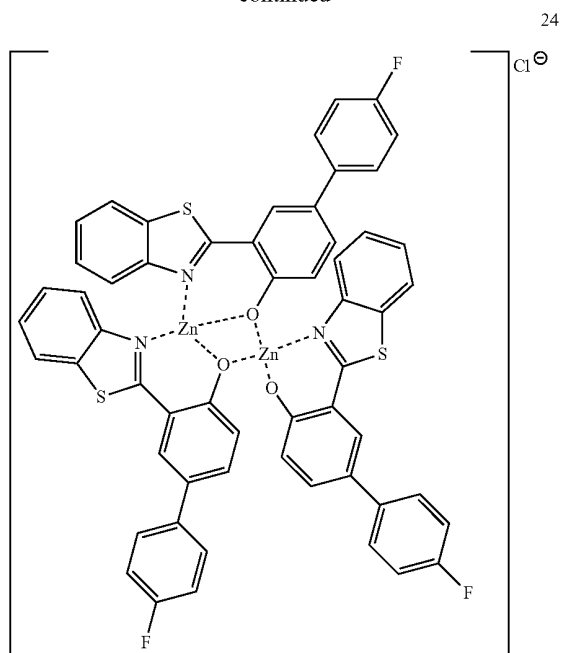
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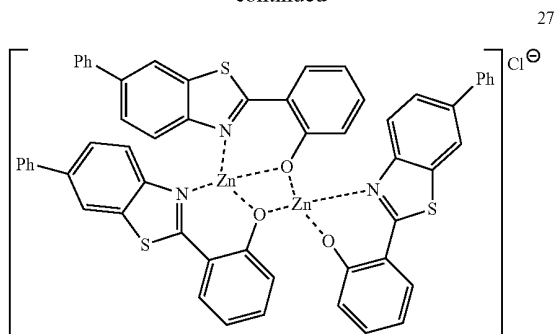
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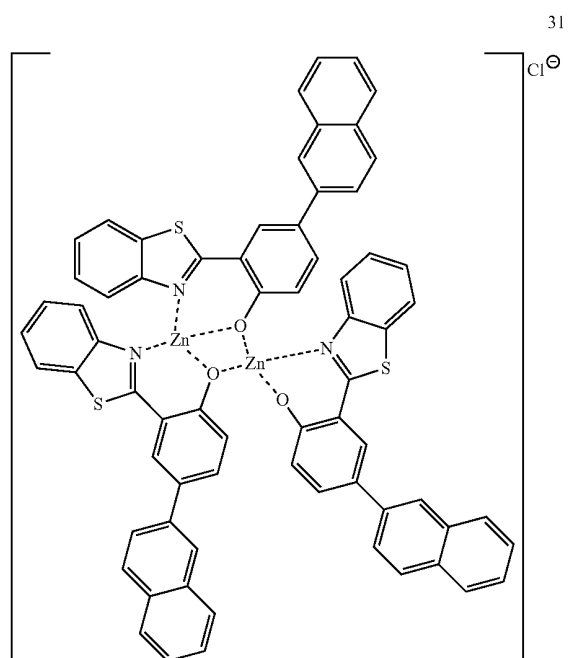
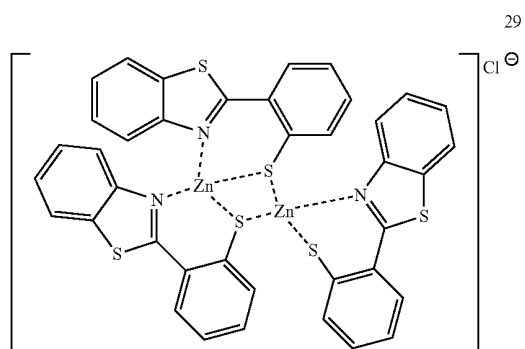
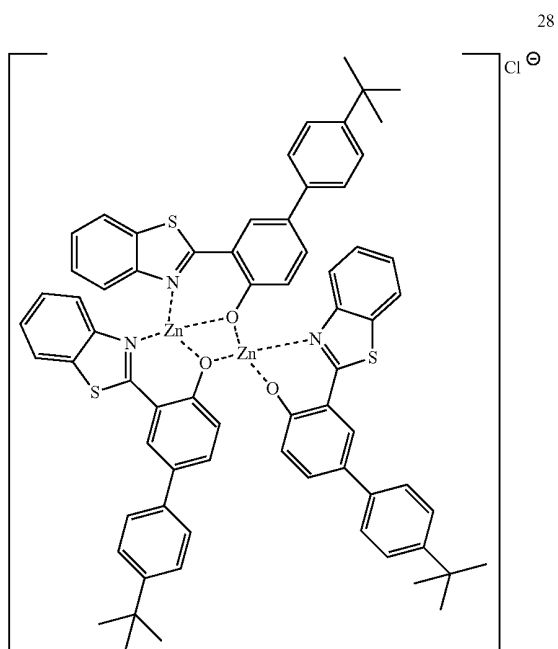
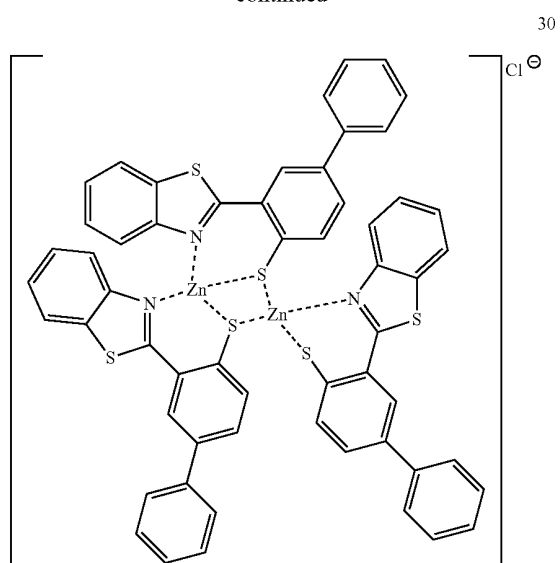
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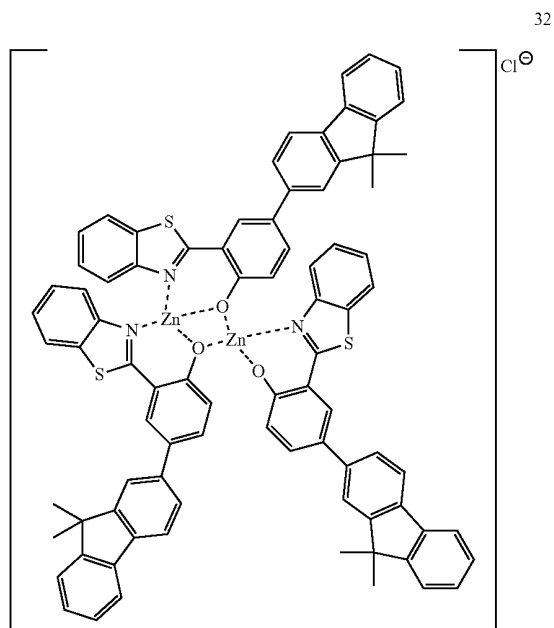
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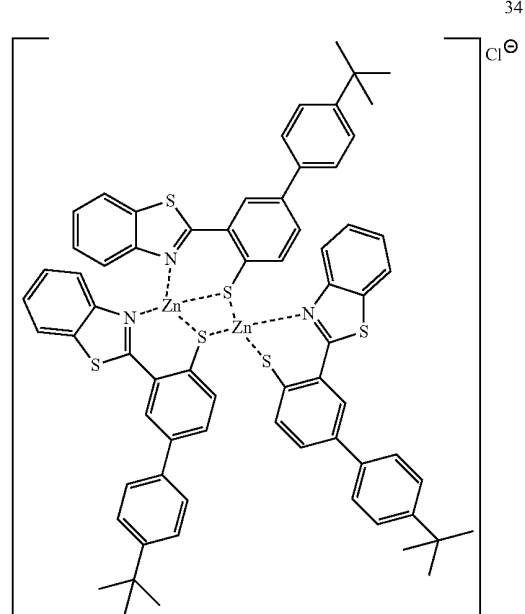
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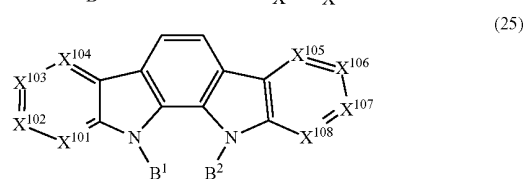
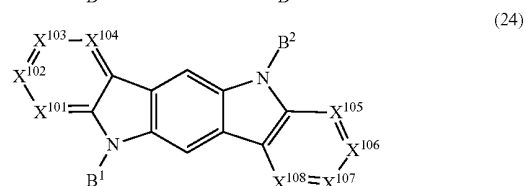
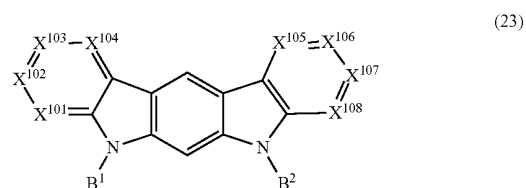


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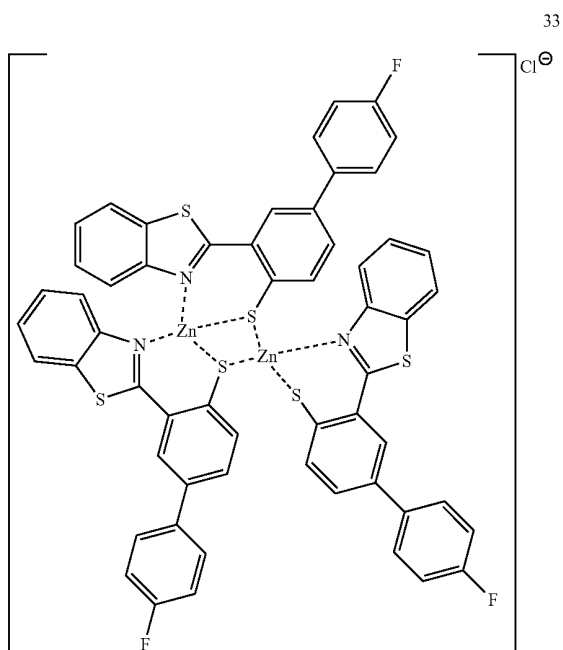
Eighth Exemplary Embodiment

[0400] The second host material may be compounds represented by formulae (23) to (25) below.



[0401] In the formulae (23) to (25): X^{101} to X^{108} are a nitrogen atom or $C-Ar^{131}$.

[0402] Ar^{131} represent a hydrogen atom, a fluorine atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl having 6



to 30 carbon atoms, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms.

[0403] Adjacent ones of X^{101} to X^{108} may be bonded to each other to form a ring structure.

[0404] B^1 and B^2 represent a group represented by a formula (26A) or (26B) below.



[0405] In the formula (26A): M^1 and M^2 each independently represent a substituted or unsubstituted nitrogen-containing aromatic heterocyclic ring or nitrogen-containing fused aromatic heterocyclic ring having 2 to 40 ring carbon atoms; M^1 and M^2 may be the same or different;

[0406] L^5 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 carbon atoms;

[0407] c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and $c+e$ represents 1 or more.

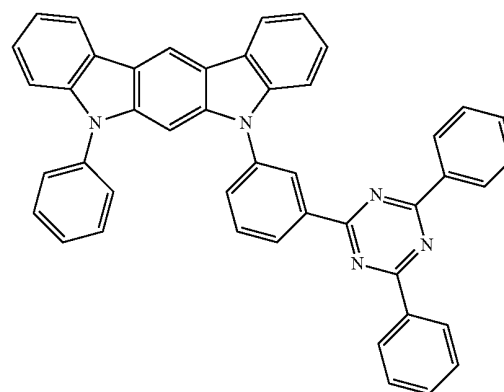
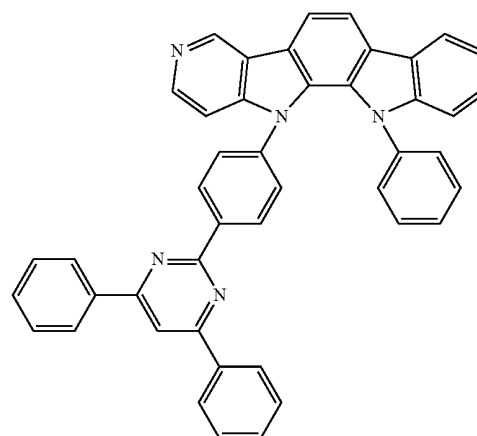
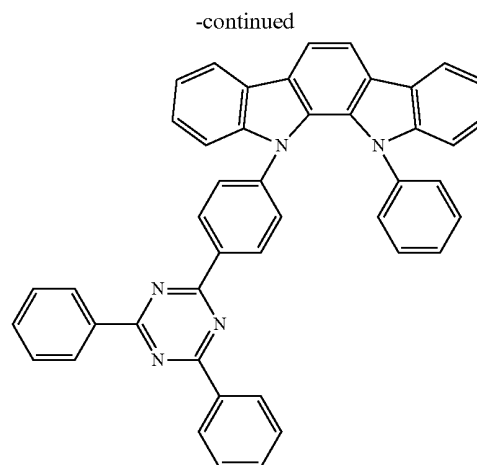
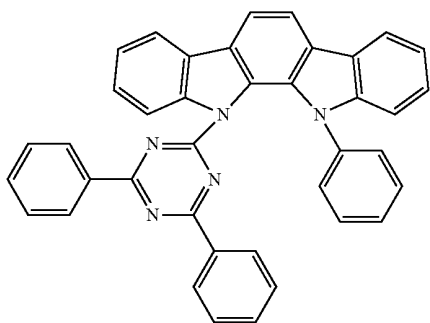


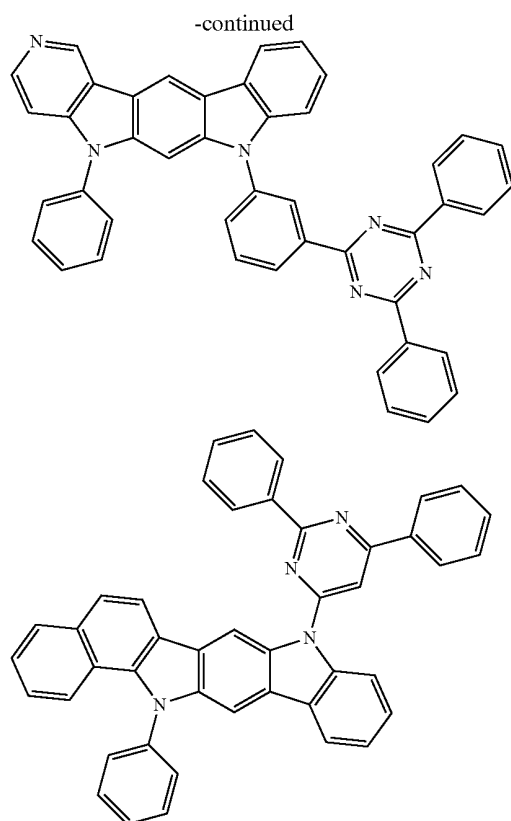
[0408] In the formula (26B): M^3 and M^4 each independently represent a substituted or unsubstituted aromatic hydrocarbon group having 2 to 40 ring carbon atoms; M^3 and M^4 may be the same or different; L^6 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, or substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms;

[0409] c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and $c+e$ represents 1 or more.

[0410] The formulae (26A) and (8A) are respectively the same as the formulae (26B) and (8B). M^1 to M^4 and L^5 to L^6 are the same as those described in relation to the formulae (8A) and (8B).

[0411] Specific examples of compounds represented by the formulae (23) to (25) are shown.

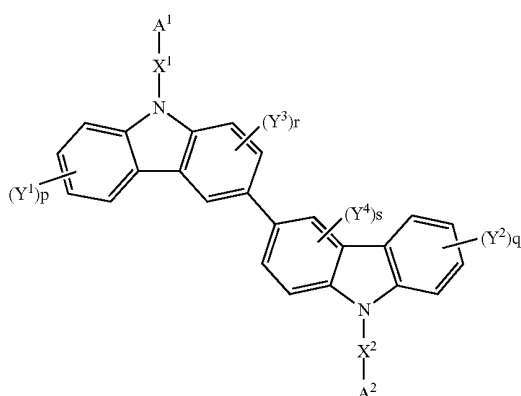




Ninth Exemplary Embodiment

[0412] The second host material may be compounds represented by a formula (27) below.

(27)



[0413] In the formula (27), A^1 , A^2 , X^1 , X^2 , Y^1 to Y^4 , p , q , r and s represent the same as A_1 , A_2 , X_1 , X_2 , Y_1 to Y_4 , p , q , r and s in the formulae (1A) and (1B).

[0414] In the formula (27), examples of A^1 , A^2 , X^1 , X^2 , Y^1 to Y^4 are the same as those of A_1 , A_2 , X_1 , X_2 , Y_1 to Y_4 , in the formulae (1A) and (1B).

[0415] It should be noted that the invention is not limited to the above description but may include any modification as long as such modification stays within a scope and a spirit of the invention.

[0416] For instance, the following is a preferable example of such modification made to the invention.

[0417] In the invention, the emitting layer may also preferably contain an assistance material for assisting injection of charges.

[0418] When the emitting layer is formed of a host material that exhibits a wide energy gap, a difference in ionization potential (I_p) between the host material and the hole injecting/transporting layer etc. becomes so large that injection of the holes into the emitting layer becomes difficult, which may cause a rise in a driving voltage required for providing sufficient luminance.

[0419] In the above instance, introducing a hole-injectable/transportable assistance material for assisting injection of charges in the emitting layer can contribute to facilitation of the injection of the holes into the emitting layer and to reduction of the driving voltage.

[0420] As the assistance material for assisting the injection of charges, for instance, a typical hole injecting/transporting material or the like can be used.

[0421] Specific examples of the assistance material for assisting the injection of charges are a triazole derivative, oxadiazole derivative, imidazole derivative, polyaryalkane derivative, pyrazoline derivative, pyrazolone derivative, phenylenediamine derivative, arylamine derivative, amino-substituted chalcone derivative, oxazole derivative, styrylanthracene derivative, fluorenone derivative, hydrazone derivative, silazane derivative, polysilane copolymer, aniline copolymer, and conductive polymer oligomer (particularly, a thiophene oligomer).

[0422] The hole injecting material is exemplified by the above. The hole injecting material is preferably a porphyrin compound, aromatic tertiary amine compound and styryl amine compound, particularly preferably aromatic tertiary amine compound.

[0423] In addition, 4,4'-bis(N-(1-naphthyl)-N-phenylamino)biphenyl (hereinafter, abbreviated as NPD) having two fused aromatic rings in a molecule, or 4,4',4''-tris(N-(3-methylphenyl)-N-phenylamino)triphenylamine (hereinafter, abbreviated as MTDATA) in which three triphenylamine units are bonded in a starburst form as disclosed and the like may also be used.

[0424] Moreover, a hexaazatriphenylene derivative and the like may be also preferably used as the hole injecting material.

[0425] Alternatively, inorganic compounds such as p-type Si and p-type SiC may also be used as the hole-injecting material.

EXAMPLES

[0426] Next, the invention will be described in further detail by exemplifying Example(s) and Comparison(s). However, the invention is not limited by the description of Example(s).

Synthesis Example 1

Synthesis of Compound 1

[0427] Under a nitrogen atmosphere, trichloropyrimidine (10 g, 54.5 mmol), phenylboronic acid (13.3 g, 109 mmol), palladium acetate (0.3 g, 1.37 mmol), triphenylphosphine (0.72 g, 2.73 mmol), dimethoxyethane (150 mL) and an aqueous solution of 2M sodium carbonate (170 mL) were added together in sequential order, and heated to reflux for 8 hours.

[0428] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure.

The obtained residue was refined by silica-gel column chromatography, whereby an intermediate body 1-1 (9.2 g, a yield of 63%) was obtained.

[0429] Under a nitrogen atmosphere, 2-nitro-1,4-dibromobenzene (11.2 g, 40 mmol), phenylboronic acid (4.9 g, 40 mmol), tetrakis(triphenylphosphine)palladium (1.39 g, 1.2 mmol), toluene (120 mL) and an aqueous solution of 2M sodium carbonate (60 mL) were added together in sequential order, and heated to reflux for 8 hours.

[0430] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby an intermediate body 1-2 (6.6 g, a yield of 59%) was obtained.

[0431] Subsequently, under an argon gas atmosphere, the intermediate body 1-2 (6.6 g, 23.7 mmol), triphenylphosphine (15.6 g, 59.3 mmol), and o-dichlorobenzene (24 mL) were added together in sequential order, and heated to reflux at 180 degrees C. for 8 hours.

[0432] After cooled down to the room temperature, the reaction solution was refined by silica-gel column chromatography, whereby an intermediate body 1-3 (4 g, a yield of 68%) was obtained.

[0433] Under a nitrogen atmosphere, the intermediate body 1-3 (4 g, 16 mmol), N-phenylcarbazolyl-3-boronic acid (5.1

g, 17.8 mmol), tetrakis(triphenylphosphine)palladium (0.56 g, 0.48 mmol), toluene (50 mL) and an aqueous solution of 2M sodium carbonate (24 mL) were added together in sequential order, and heated to reflux for 8 hours.

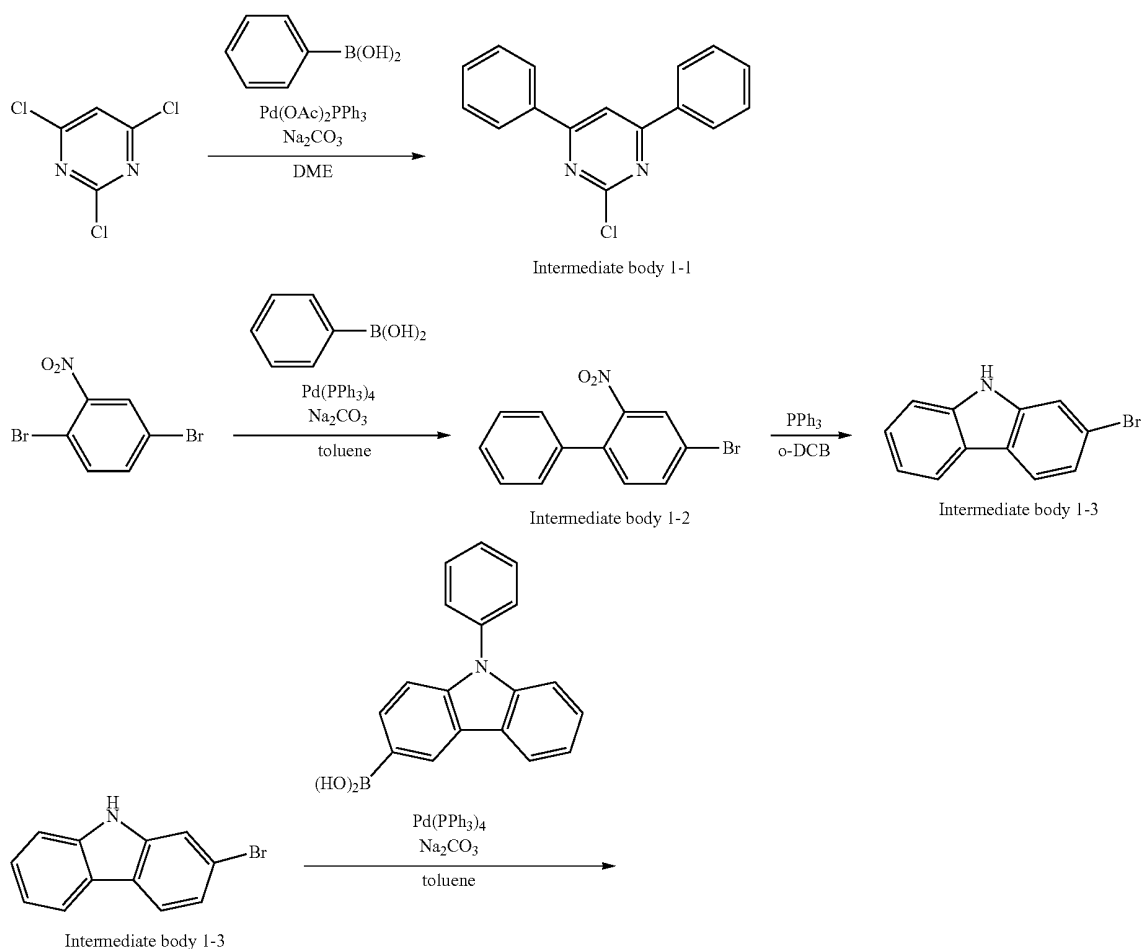
[0434] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby an intermediate body 1-4 (3.2 g, a yield of 49%) was obtained.

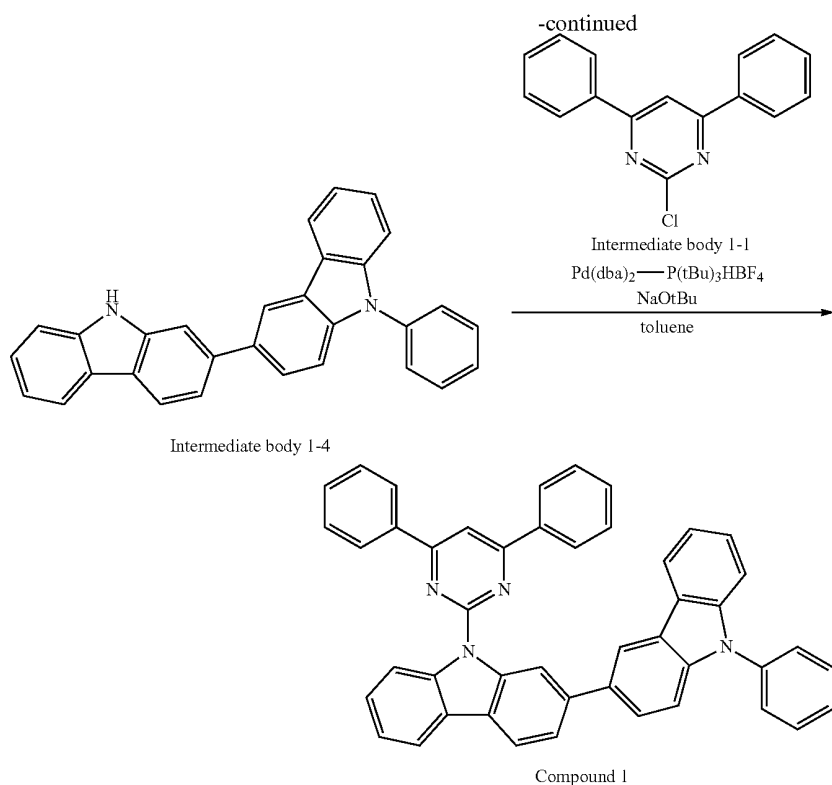
[0435] Under an argon gas atmosphere, the intermediate body 1-4 (1.6 g, 3.9 mmol), the intermediate body 1-1 (1.0 g, 3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-t-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium t-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours.

[0436] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 1 (2.4 g, a yield of 95%) was obtained.

[0437] FD-MS analysis consequently showed that m/e was equal to 638 while a calculated molecular weight was 638.

[0438] A synthesis scheme of the compound 1 is shown below.





Synthesis Example 2

Synthesis of Compound 2

[0439] 4-bromobenzaldehyde (25 g, 135 mmol) and acetophenone (16.2 g, 135 mmol) were added to ethanol (200 mL). An aqueous solution of 3M potassium hydrate (60 mL) was further added thereto and stirred at room temperature for 7 hours. A precipitated solid was separated by filtration. Then, the obtained solid was washed with methanol. A white solid intermediate body 2-1 (28.3 g, a yield rate 73%) was obtained.

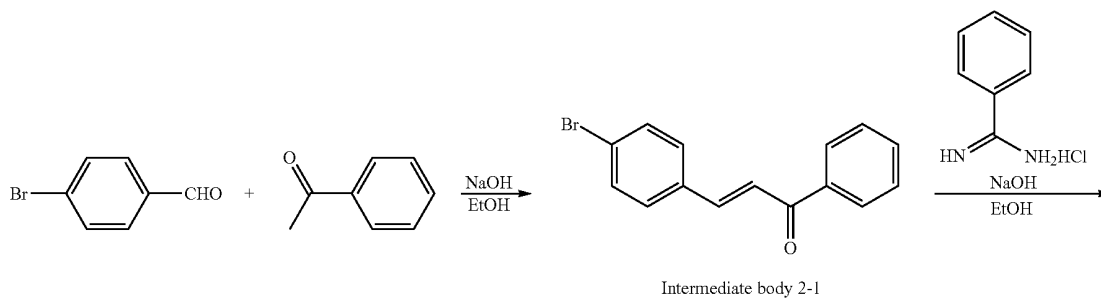
[0440] The intermediate body 2-1 (20 g, 69.7 mmol) and benzamidine hydrochloride (10.8 g, 69.7 mmol) were added to ethanol (300 mL). Sodium hydroxide (5.6 g, 140 mmol) was further added thereto and heated to reflux at room temperature for 8 hours. A precipitated solid was separated by filtration. Then, the obtained solid was washed with hexane. A white solid intermediate body 2-2 (10.3 g, a yield rate 38%) was obtained.

[0441] Under an argon gas atmosphere, the intermediate body 1-4 (1.6 g, 3.9 mmol), the intermediate body 2-2 (1.5 g, 3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-*t*-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium *t*-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours.

After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 2 (2.2 g, a yield of 80%) was obtained.

[0442] FD-MS analysis consequently showed that *m/e* was equal to 714 while a calculated molecular weight was 714.

[0443] A synthesis scheme of the compound 2 is shown below.



Brc1ccc(cc1)-c2ccnc(c2)c3ccccc3

The chemical structure shows two benzimidazole units connected at their 5,5' positions. Each benzimidazole unit consists of a benzene ring fused to an imidazole ring. A phenyl group is attached to the nitrogen atom of each imidazole ring. The two units are linked at their 5,5' positions, which are the carbons adjacent to the nitrogen atoms in the imidazole rings.

c1ccc(cc1)-c2cc(ccc2)-c3cc(ccc3)-c4cc(ccc4)-c5cc(ccc5)-c6cc(ccc6)-c7cc(ccc7)-c8cc(ccc8)-c9cc(ccc9)-c10cc(ccc10)-c11cc(ccc11)-c12cc(ccc12)-c13cc(ccc13)-c14cc(ccc14)-c15cc(ccc15)-c16cc(ccc16)-c17cc(ccc17)-c18cc(ccc18)-c19cc(ccc19)-c20cc(ccc20)-c21cc(ccc21)-c22cc(ccc22)-c23cc(ccc23)-c24cc(ccc24)-c25cc(ccc25)-c26cc(ccc26)-c27cc(ccc27)-c28cc(ccc28)-c29cc(ccc29)-c30cc(ccc30)-c31cc(ccc31)-c32cc(ccc32)-c33cc(ccc33)-c34cc(ccc34)-c35cc(ccc35)-c36cc(ccc36)-c37cc(ccc37)-c38cc(ccc38)-c39cc(ccc39)-c40cc(ccc40)-c41cc(ccc41)-c42cc(ccc42)-c43cc(ccc43)-c44cc(ccc44)-c45cc(ccc45)-c46cc(ccc46)-c47cc(ccc47)-c48cc(ccc48)-c49cc(ccc49)-c50cc(ccc50)-c51cc(ccc51)-c52cc(ccc52)-c53cc(ccc53)-c54cc(ccc54)-c55cc(ccc55)-c56cc(ccc56)-c57cc(ccc57)-c58cc(ccc58)-c59cc(ccc59)-c60cc(ccc60)-c61cc(ccc61)-c62cc(ccc62)-c63cc(ccc63)-c64cc(ccc64)-c65cc(ccc65)-c66cc(ccc66)-c67cc(ccc67)-c68cc(ccc68)-c69cc(ccc69)-c70cc(ccc70)-c71cc(ccc71)-c72cc(ccc72)-c73cc(ccc73)-c74cc(ccc74)-c75cc(ccc75)-c76cc(ccc76)-c77cc(ccc77)-c78cc(ccc78)-c79cc(ccc79)-c80cc(ccc80)-c81cc(ccc81)-c82cc(ccc82)-c83cc(ccc83)-c84cc(ccc84)-c85cc(ccc85)-c86cc(ccc86)-c87cc(ccc87)-c88cc(ccc88)-c89cc(ccc89)-c90cc(ccc90)-c91cc(ccc91)-c92cc(ccc92)-c93cc(ccc93)-c94cc(ccc94)-c95cc(ccc95)-c96cc(ccc96)-c97cc(ccc97)-c98cc(ccc98)-c99cc(ccc99)-c100cc(ccc100)-c101cc(ccc101)-c102cc(ccc102)-c103cc(ccc103)-c104cc(ccc104)-c105cc(ccc105)-c106cc(ccc106)-c107cc(ccc107)-c108cc(ccc108)-c109cc(ccc109)-c110cc(ccc110)-c111cc(ccc111)-c112cc(ccc112)-c113cc(ccc113)-c114cc(ccc114)-c115cc(ccc115)-c116cc(ccc116)-c117cc(ccc117)-c118cc(ccc118)-c119cc(ccc119)-c120cc(ccc120)-c121cc(ccc121)-c122cc(ccc122)-c123cc(ccc123)-c124cc(ccc124)-c125cc(ccc125)-c126cc(ccc126)-c127cc(ccc127)-c128cc(ccc128)-c129cc(ccc129)-c130cc(ccc130)-c131cc(ccc131)-c132cc(ccc132)-c133cc(ccc133)-c134cc(ccc134)-c135cc(ccc135)-c136cc(ccc136)-c137cc(ccc137)-c138cc(ccc138)-c139cc(ccc139)-c140cc(ccc140)-c141cc(ccc141)-c142cc(ccc142)-c143cc(ccc143)-c144cc(ccc144)-c145cc(ccc145)-c146cc(ccc146)-c147cc(ccc147)-c148cc(ccc148)-c149cc(ccc149)-c150cc(ccc150)-c151cc(ccc151)-c152cc(ccc152)-c153cc(ccc153)-c154cc(ccc154)-c155cc(ccc155)-c156cc(ccc156)-c157cc(ccc157)-c158cc(ccc158)-c159cc(ccc159)-c160cc(ccc160)-c161cc(ccc161)-c162cc(ccc162)-c163cc(ccc163)-c164cc(ccc164)-c165cc(ccc165)-c166cc(ccc166)-c167cc(ccc167)-c168cc(ccc168)-c169cc(ccc169)-c170cc(ccc170)-c171cc(ccc171)-c172cc(ccc172)-c173cc(ccc173)-c174cc(ccc174)-c175cc(ccc175)-c176cc(ccc176)-c177cc(ccc177)-c178cc(ccc178)-c179cc(ccc179)-c180cc(ccc180)-c181cc(ccc181)-c182cc(ccc182)-c183cc(ccc183)-c184cc(ccc184)-c185cc(ccc185)-c186cc(ccc186)-c187cc(ccc187)-c188cc(ccc188)-c189cc(ccc189)-c190cc(ccc190)-c191cc(ccc191)-c192cc(ccc192)-c193cc(ccc193)-c194cc(ccc194)-c195cc(ccc195)-c196cc(ccc196)-c197cc(ccc197)-c198cc(ccc198)-c199cc(ccc199)-c200cc(ccc200)-c201cc(ccc201)-c202cc(ccc202)-c203cc(ccc203)-c204cc(ccc204)-c205cc(ccc205)-c206cc(ccc206)-c207cc(ccc207)-c208cc(ccc208)-c209cc(ccc209)-c210cc(ccc210)-c211cc(ccc211)-c212cc(ccc212)-c213cc(ccc213)-c214cc(ccc214)-c215cc(ccc215)-c216cc(ccc216)-c217cc(ccc217)-c218cc(ccc218)-c219cc(ccc219)-c220cc(ccc220)-c221cc(ccc221)-c222cc(ccc222)-c223cc(ccc223)-c224cc(ccc224)-c225cc(ccc225)-c226cc(ccc226)-c227cc(ccc227)-c228cc(ccc228)-c229cc(ccc229)-c230cc(ccc230)-c231cc(ccc231)-c232cc(ccc232)-c233cc(ccc233)-c234cc(ccc234)-c235cc(ccc235)-c236cc(ccc236)-c237cc(ccc237)-c238cc(ccc238)-c239cc(ccc239)-c240cc(ccc240)-c241cc(ccc241)-c242cc(ccc242)-c243cc(ccc243)-c244cc(ccc244)-c245cc(ccc245)-c246cc(ccc246)-c247cc(ccc247)-c248cc(ccc248)-c249cc(ccc249)-c250cc(ccc250)-c251cc(ccc251)-c252cc(ccc252)-c253cc(ccc253)-c254cc(ccc254)-c255cc(ccc255)-c256cc(ccc256)-c257cc(ccc257)-c258cc(ccc258)-c259cc(ccc259)-c260cc(ccc260)-c261cc(ccc261)-c262cc(ccc262)-c263cc(ccc263)-c264cc(ccc264)-c265cc(ccc265)-c266cc(ccc266)-c267cc(ccc267)-c268cc(ccc268)-c269cc(ccc269)-c270cc(ccc270)-c271cc(ccc271)-c272cc(ccc272)-c273cc(ccc273)-c274cc(ccc274)-c275cc(ccc275)-c276cc(ccc276)-c277cc(ccc277)-c278cc(ccc278)-c279cc(ccc279)-c280cc(ccc280)-c281cc(ccc281)-c282cc(ccc282)-c283cc(ccc283)-c284cc(ccc284)-c285cc(ccc285)-c286cc(ccc286)-c287cc(ccc287)-c288cc(ccc288)-c289cc(ccc289)-c290cc(ccc290)-c291cc(ccc291)-c292cc(ccc292)-c293cc(ccc293)-c294cc(ccc294)-c295cc(ccc295)-c296cc(ccc296)-c297cc(ccc297)-c298cc(ccc298)-c299cc(ccc299)-c300cc(ccc300)-c301cc(ccc301)-c302cc(ccc302)-c303cc(ccc303)-c304cc(ccc304)-c305cc(ccc305)-c306cc(ccc306)-c307cc(ccc307)-c308cc(ccc308)-c309cc(ccc309)-c310cc(ccc310)-c311cc(ccc311)-c312cc(ccc312)-c313cc(ccc313)-c314cc(ccc314)-c315cc(ccc315)-c316cc(ccc316)-c317cc(ccc317)-c318cc(ccc318)-c319cc(ccc319)-c320cc(ccc320)-c321cc(ccc321)-c322cc(ccc322)-c323cc(ccc323)-c324cc(ccc324)-c325cc(ccc325)-c326cc(ccc326)-c327cc(ccc327)-c328cc(ccc328)-c329cc(ccc329)-c330cc(ccc330)-c331cc(ccc331)-c332cc(ccc332)-c333cc(ccc333)-c334cc(ccc334)-c335cc(ccc335)-c336cc(ccc336)-c337cc(ccc337)-c338cc(ccc338)-c339cc(ccc339)-c340cc(ccc340)-c341cc(ccc341)-c342cc(ccc342)-c343cc(ccc343)-c344cc(ccc344)-c345cc(ccc345)-c346cc(ccc346)-c347cc(ccc347)-c348cc(ccc3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carbonate (130 mL) were added together in sequential order, and heated to reflux for 8 hours. After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby an intermediate body 3-1 (8.2 g, a yield of 71%) was obtained.

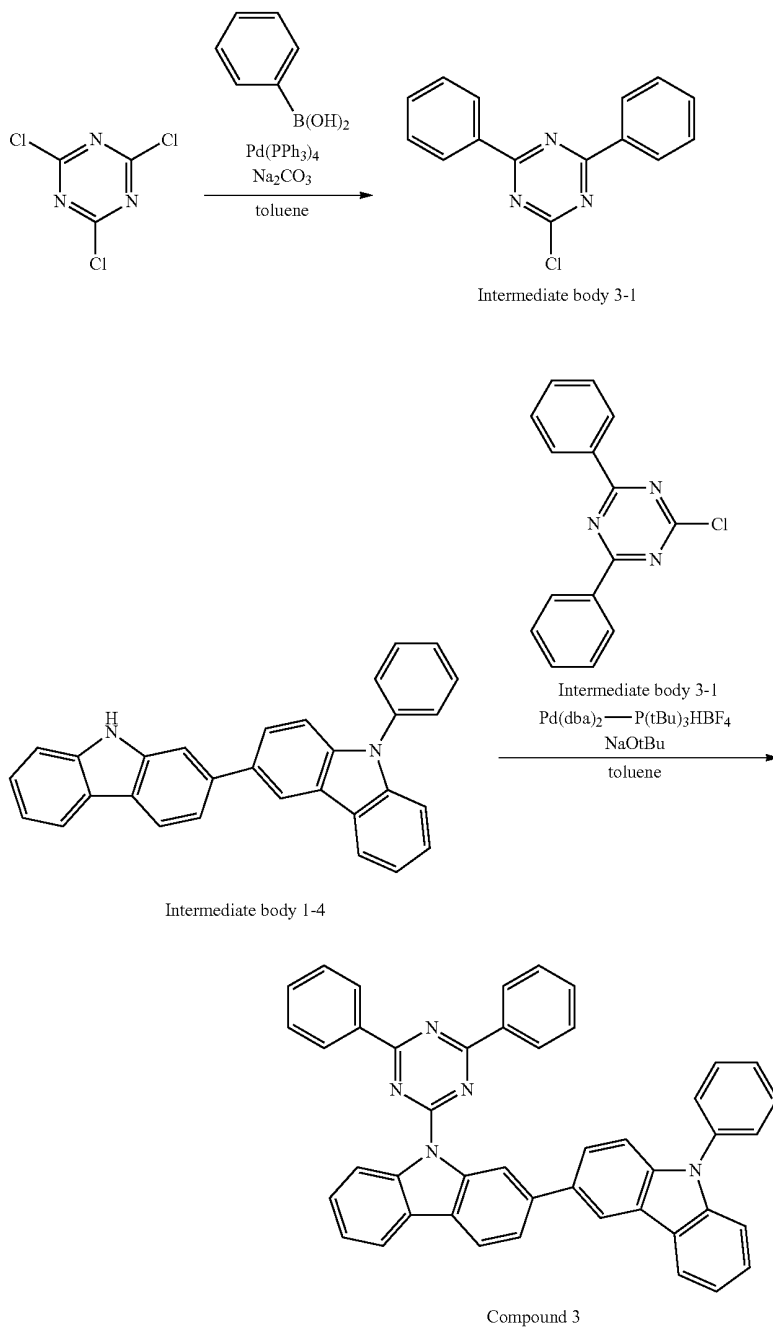
[0445] Under an argon gas atmosphere, the intermediate body 1-4 (1.6 g, 3.9 mmol), the intermediate body 3-1 (1.5 g, 3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-*t*-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium *t*-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours.

After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic

solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 3 (2.2 g, a yield of 80%) was obtained.

[0446] FD-MS analysis consequently showed that *m/e* was equal to 639 while a calculated molecular weight was 639.

[0447] A synthesis scheme of the compound 3 is shown below.



Synthesis Example 4

Synthesis of Compound 4

[0448] Under a nitrogen atmosphere, intermediate body 3-1 (8 g, 29.9 mmol), p-chlorophenylboronic acid (5.1 g, 32.9 mmol), tetrakis(triphenylphosphine)palladium (0.63 g, 0.6 mmol), toluene (60 mL) and an aqueous solution of 2M sodium carbonate (30 mL) were added together in sequential order, and heated to reflux for 8 hours.

[0449] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby an intermediate body 4-1 (7.0 g, a yield of 68%) was obtained.

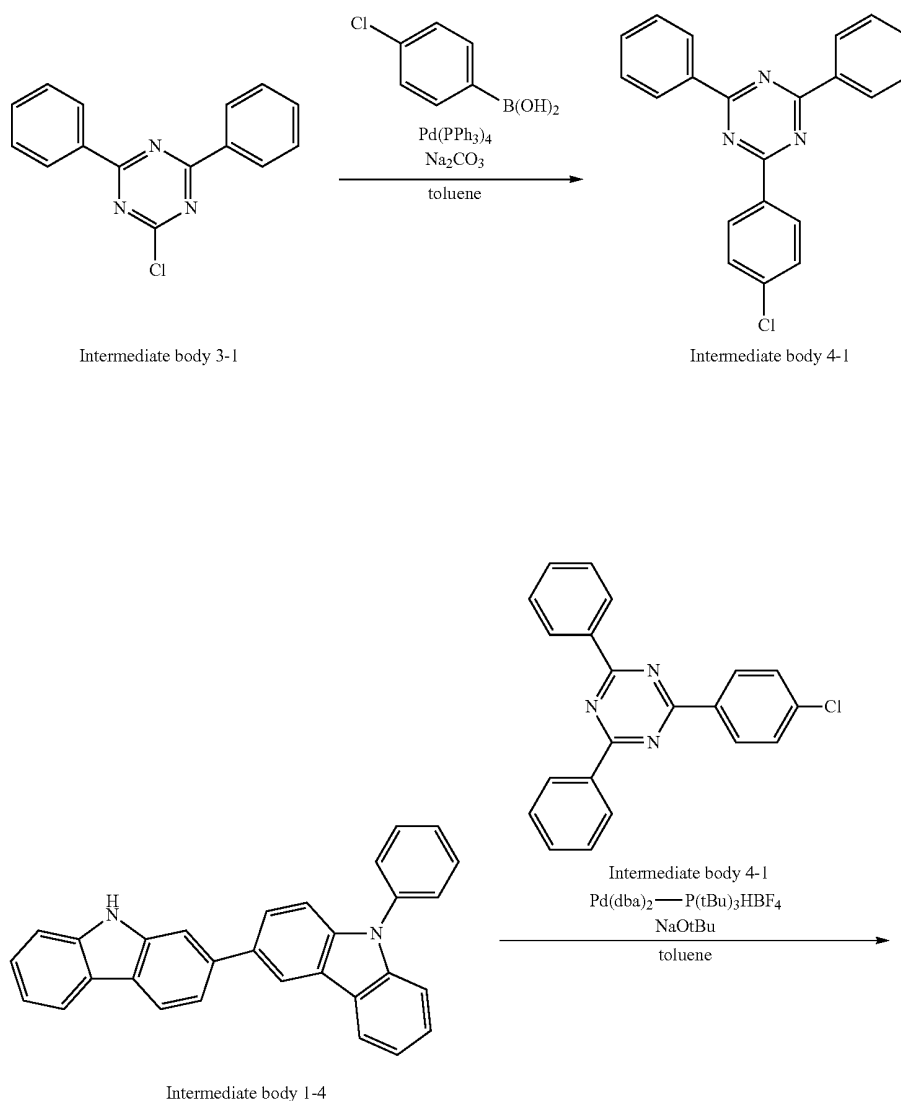
[0450] Under an argon gas atmosphere, the intermediate body 1-4 (1.6 g, 3.9 mmol), the intermediate body 4-1 (1.3 g,

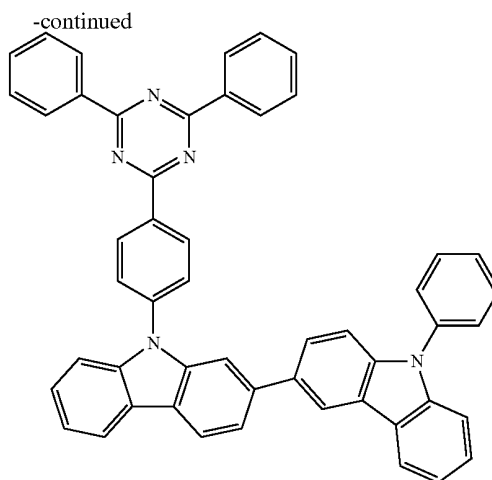
3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-*t*-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium *t*-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours.

[0451] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 4 (2.3 g, a yield of 82%) was obtained.

[0452] FD-MS analysis consequently showed that *m/e* was equal to 715 while a calculated molecular weight was 715.

[0453] A synthesis scheme of the compound 4 is shown below.





Compound 4

Synthesis Example 5

Synthesis of Compound 5

[0454] 3-bromobenzaldehyde (100 g, 54 mmol) and aniline (50 g, 54 mmol) were added to toluene (1 L) and heated to reflux for 8 hours. After the reaction solution was cooled down, a solvent was concentrated under reduced pressure to obtain an intermediate body 5-1 (130 g, a yield of 93%).

[0455] Subsequently, under an argon gas atmosphere, the intermediate body 5-1 (130 g, 50 mmol), benzamidine hydrochloride (152 g, 100 mmol), anhydrous ethanol (1 L), and sodium hydroxide (42 g) were added together in sequential order, and stirred at 80 degrees C. for 16 hours. Subsequently, sodium-t-butoxide (20 g, 208 mmol) were further added and heated at 80 degrees C. for 16 hours with stirring. After the reaction solution was cooled down, a solid was separated by

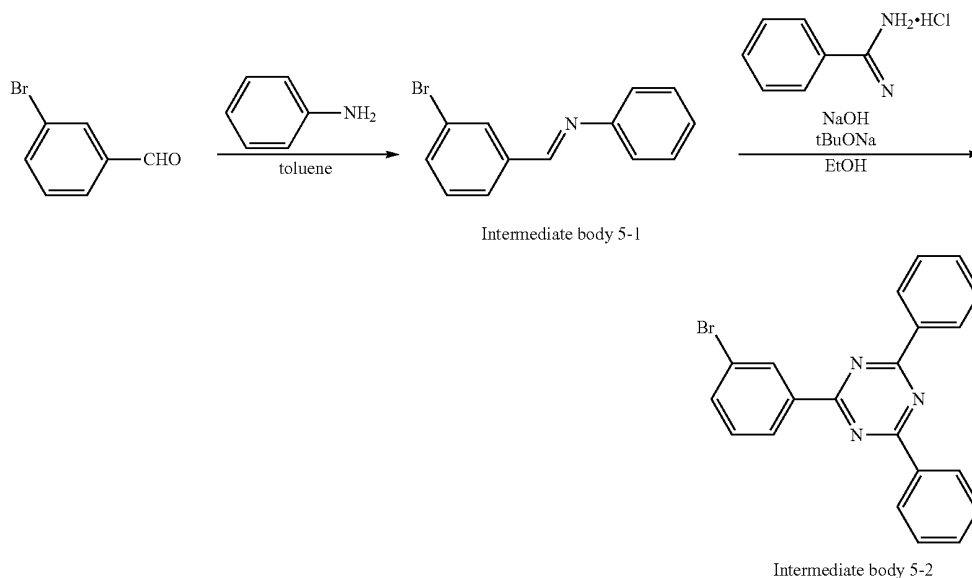
filtration and washed with methanol to obtain an intermediate body 5-2 (67 g, a yield of 37%).

[0456] Under an argon gas atmosphere, the intermediate body 1-4 (1.6 g, 3.9 mmol), the intermediate body 5-2 (1.5 g, 3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-t-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium t-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours.

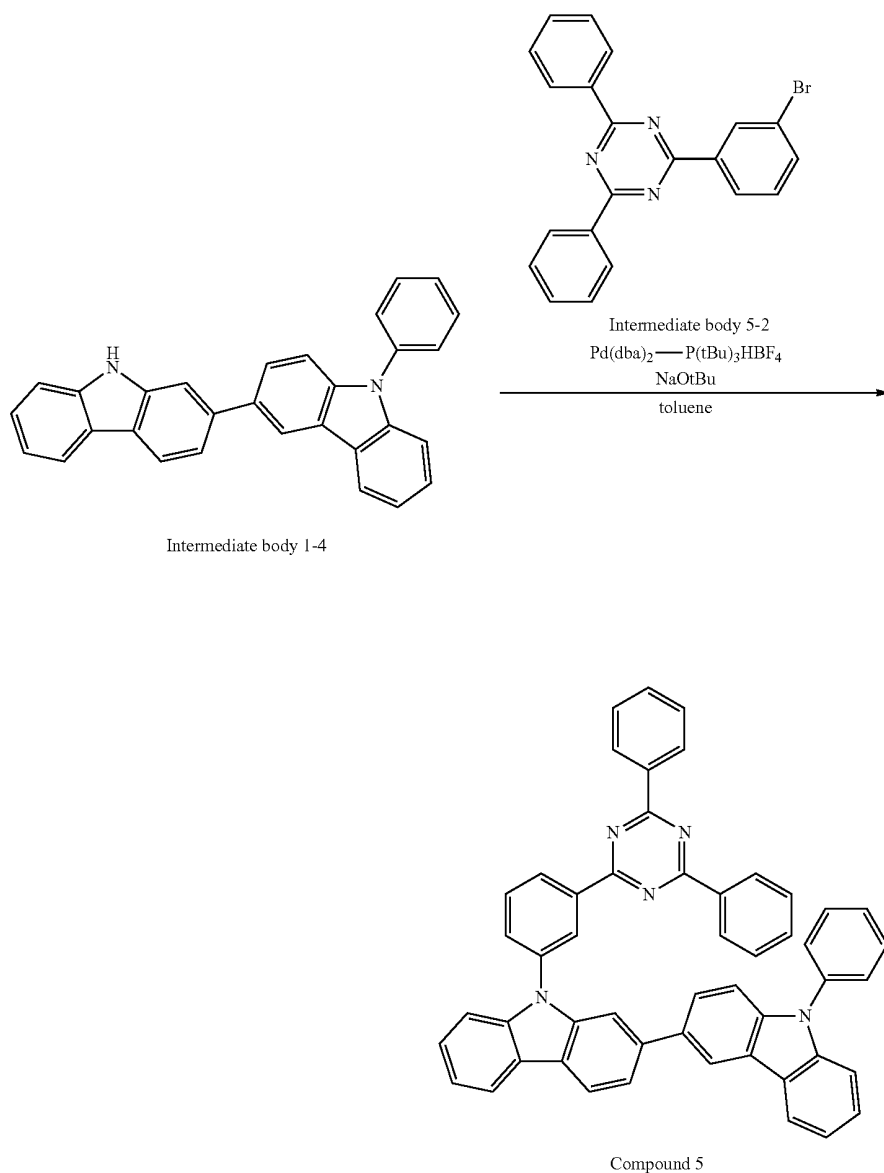
[0457] After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 5 (2.3 g, a yield of 82%) was obtained.

[0458] FD-MS analysis consequently showed that m/e was equal to 715 while a calculated molecular weight was 715.

[0459] A synthesis scheme of the compound 11 is shown below.



-continued



Synthesis Example 6 Synthesis of Compound 6

[0460] Under a nitrogen atmosphere, the intermediate body 3-1 (15.5 g, 58 mmol), 3-bromocarbazole (14.2 g, 58 mmol), and potassium carbonate (16 g, 116 mmol) were added to dimethylformamide (100 mL), and heated at 100 degrees C. for 16 hours with stirring. A precipitated solid was separated by filtration. Then, the obtained solid was washed with methanol to obtain an intermediate body 6-1 (25 g, a yield of 90%).

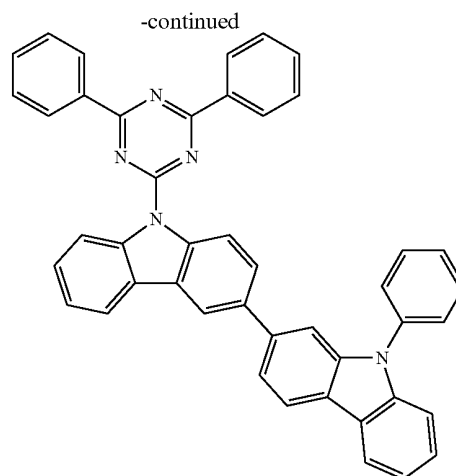
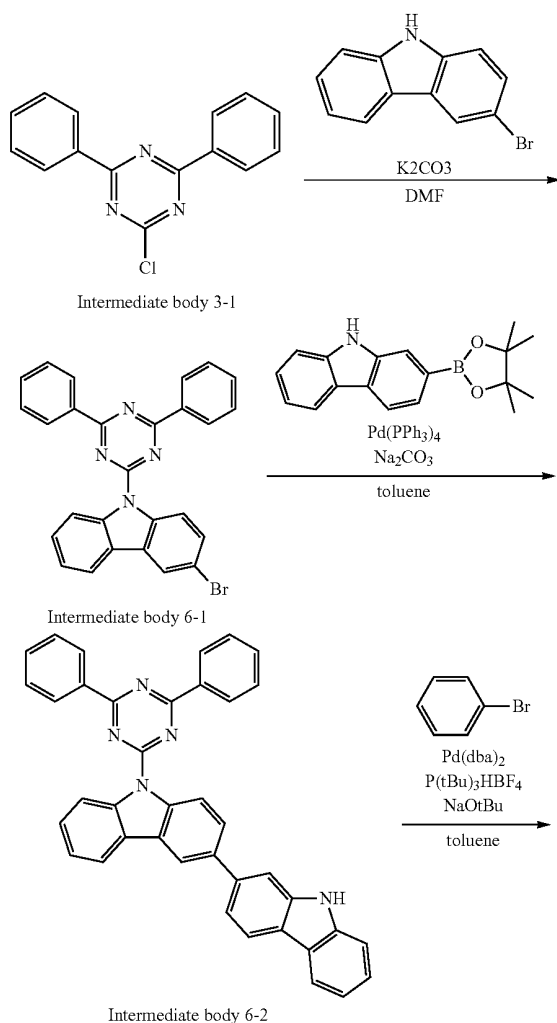
[0461] Subsequently, under a nitrogen atmosphere, the intermediate body 6-1 (8.1 g, 17 mmol), 9H-carbazole-2-boronic acid pinacol ester (5 g, 17 mmol), tetrakis(triphenylphosphine)palladium (0.39 g, 0.34 mmol), toluene (50 mL) and an aqueous solution of 2M sodium carbonate (26 mL) were added together, and stirred at 80 degrees C. for 8 hours. After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was concentrated under reduced pressure.

The obtained residue was refined by silica-gel column chromatography, whereby an intermediate body 6-2 (6.2 g, a yield of 65%) was obtained.

[0462] Under a nitrogen atmosphere, the intermediate body 6-2 (2.2 g, 3.9 mmol), bromobenzene (0.61 g, 3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-*t*-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium *t*-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours. After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 6 (1.8 g, a yield of 72%) was obtained.

[0463] FD-MS analysis consequently showed that *m/e* was equal to 639 while a calculated molecular weight was 639.

[0464] A synthesis scheme of the compound 6 is shown below.



Compound 6

Synthesis Example 7

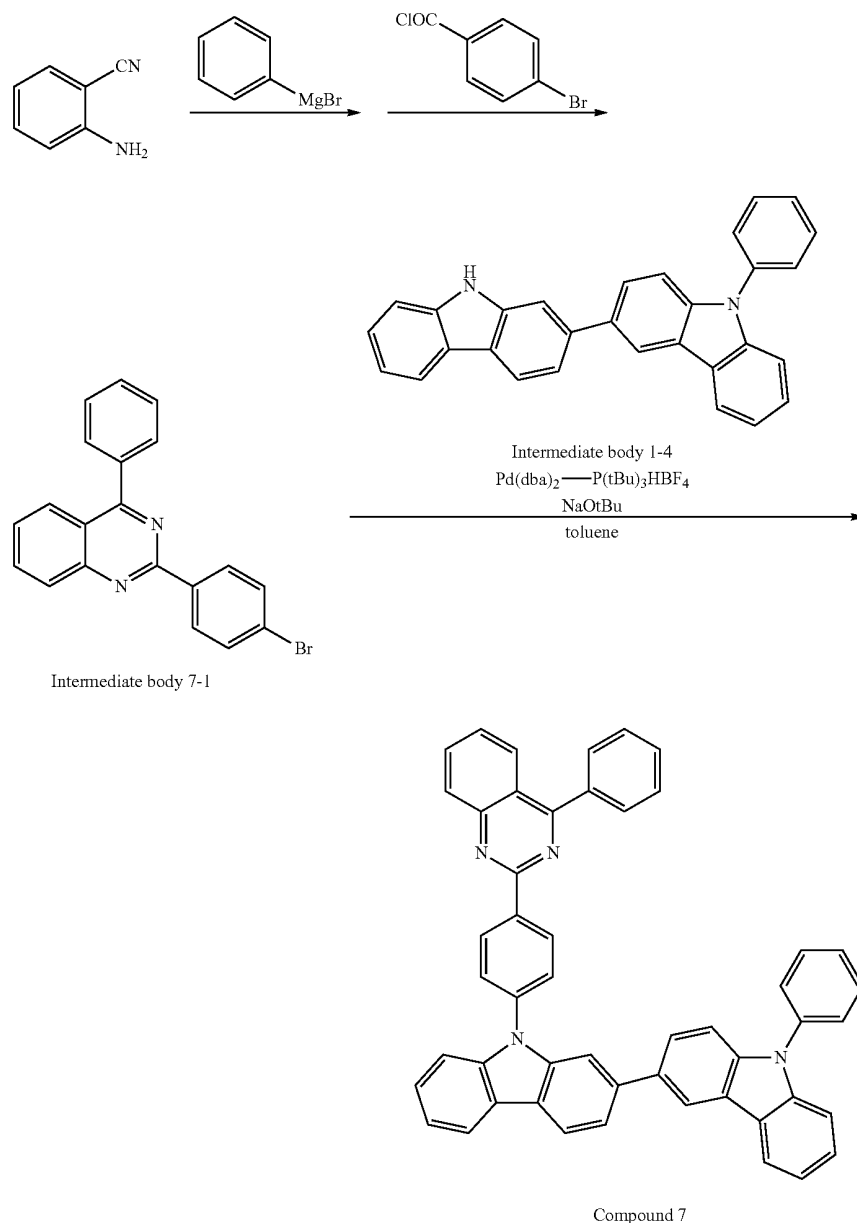
Synthesis of Compound 7

[0465] An intermediate body 7-1 was synthesized by applying a method described in a document (J. Bergman, A. Brynolf, B. Elman and E. Vuorinen, *Tetrahedron*, 42, 3697-3706 (1986)). Specifically, to a three-necked flask (500 ml), a 1M tetrahydrofuran solution of phenylmagnesium bromide (100 ml, 100 mmol) was added. Dry ether (100 ml) was further added and heated to reflux in a 45-degree-C. oil bath. A dry ether solution (50 ml) of 2-cyanoaniline (5.91 g, 50 mmol) was dropped in the reaction solution for 30 minutes. After refluxed for another 1.5 hours, the reaction solution was cooled down to 0 degree C. in an ice water bath. Subsequently, a dry ether solution (100 ml) of 4-bromobenzoate chloride (13.2 g, 60 mmol) was dropped in the reaction solution for 10 minutes and heated to reflux for 2 hours in a 45-degree-C. oil bath. After the reaction, the reaction solution was cooled down to 0 degree C. in an ice water bath and a saturated ammonium chloride aqueous solution was added. A precipitated solid was separated by filtration. Then, the obtained solid was washed with a small amount of methanol and vacuum-dried to obtain an intermediate body 7-1 (10.8 g, a yield of 60%).

[0466] Subsequently, under a nitrogen atmosphere, the intermediate body 7-1 (1.4 g, 3.9 mmol), the intermediate body 1-4 (1.6 g, 3.9 mmol), tris(dibenzylideneacetone)dipalladium (0.071 g, 0.078 mmol), tri-*t*-butylphosphonium tetrafluoroborate (0.091 g, 0.31 mmol), sodium *t*-butoxide (0.53 g, 5.5 mmol), and anhydrous toluene (20 mL) were sequentially mixed, and heated to reflux for 8 hours. After the reaction solution was cooled down to the room temperature, an organic layer was removed and an organic solvent was distilled away under reduced pressure. The obtained residue was refined by silica-gel column chromatography, whereby a compound 7 (2.2 g, a yield of 82%) was obtained.

[0467] FD-MS analysis consequently showed that *m/e* was equal to 688 while a calculated molecular weight was 688.

[0468] A synthesis scheme of the compound 13 is shown below.



Example 1

Manufacture of Organic EL Device

[0469] A glass substrate (size: 25 mm×75 mm×1.1 mm) having an ITO transparent electrode (manufactured by GEO-MATEC Co., Ltd.) was ultrasonic-cleaned in isopropyl alcohol for five minutes, and then UV (Ultraviolet)/ozone-cleaned for 30 minutes.

[0470] After the glass substrate having the transparent electrode was cleaned, the glass substrate was mounted on a substrate holder of a vacuum deposition apparatus, and a hole injecting layer was initially formed by depositing a com-

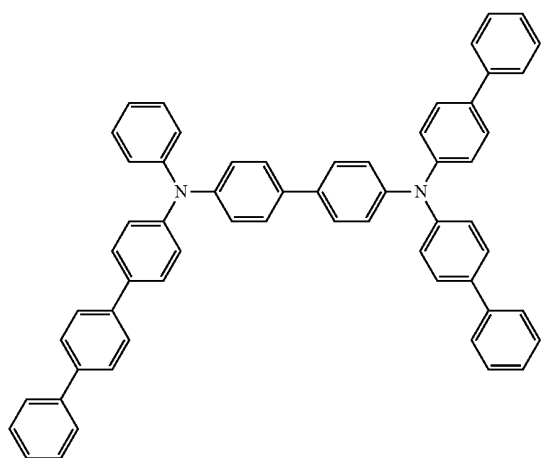
pound A onto the substrate to be 40 nm thick to cover a surface of the glass substrate where a transparent electrode line was provided. Next, a compound B was deposited onto the hole injecting layer to be 20 nm thick to obtain a hole transporting layer.

[0471] A phosphorescent-emitting layer was obtained by co-depositing the compound 1 used as a phosphorescent host material and Ir(Ph-ppy)_3 used as a phosphorescent dopant material onto the hole transporting layer to be 40 nm thick. The concentration of Ir(Ph-ppy)_3 was 20 mass %.

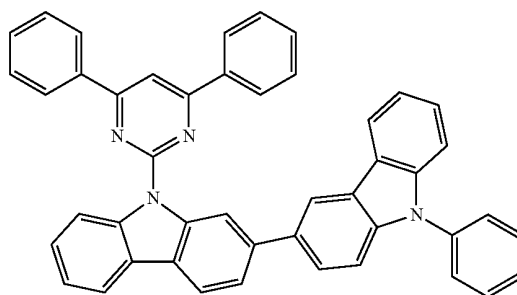
[0472] Subsequently, a 30-nm-thick compound C, 1-nm-thick LiF and 80-nm-thick metal Al are sequentially layered to obtain a cathode. LiF, which is an electron injectable electrode, was formed at a speed of 1 Å/min.

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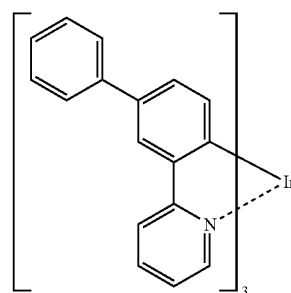
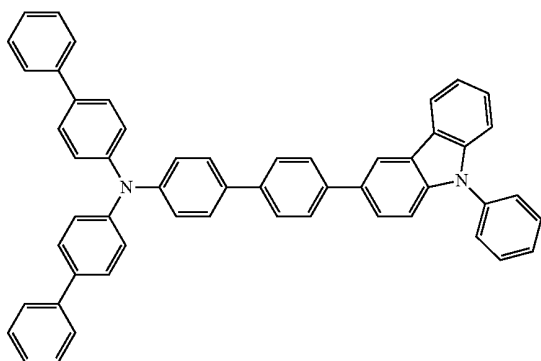
Compound A



Compound 1



Compound B

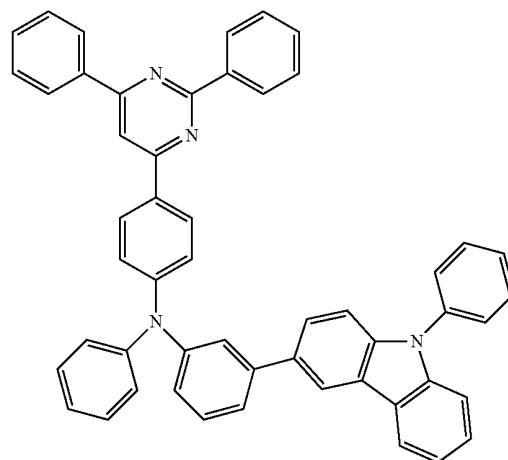
Ir(Ph-ppy)₃ (facial body)

Examples 2 to 5

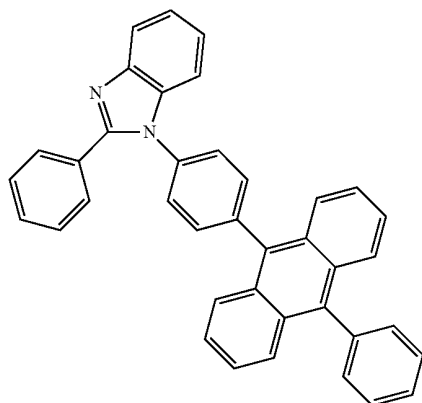
Manufacture of Organic EL Devices 2 to 5

[0473] In Example 1, the compounds 2 to 5 below were used in place of the compound 1 to manufacture organic EL devices 2 to 5.

Compound 2

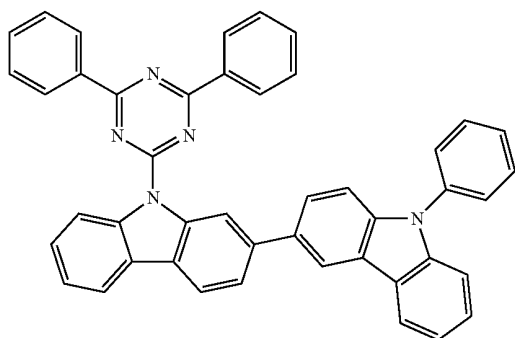


Compound C

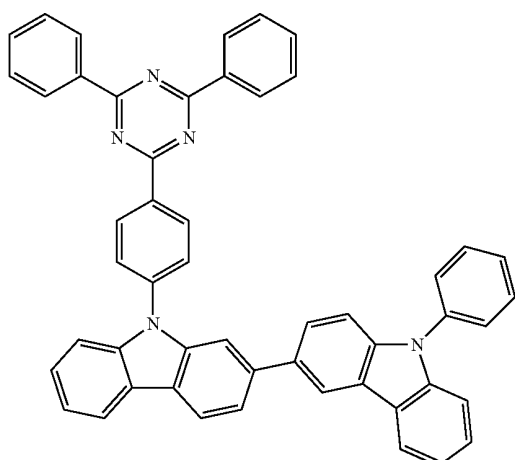


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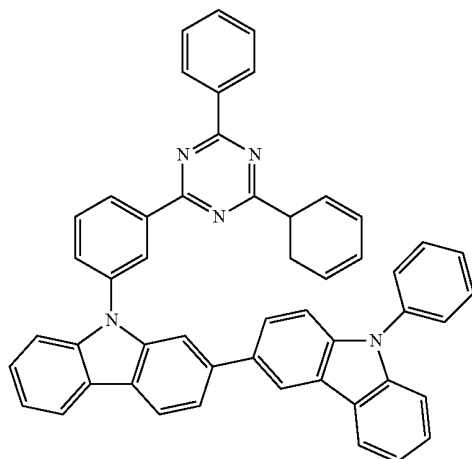
Compound 3



Compound 4



Compound 5



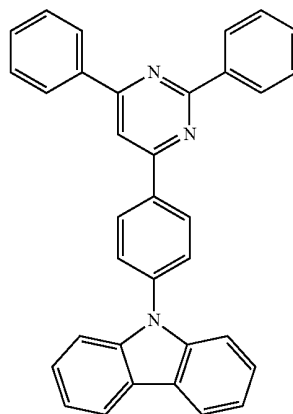
Comparisons 1 to 4

[0474] The organic EL devices according respectively to Comparisons 1 to 4 were formed in the same manner as in Example 1 except that the following comparative compounds D to G were respectively used as a host material in place of the compound 1 in Example 1.

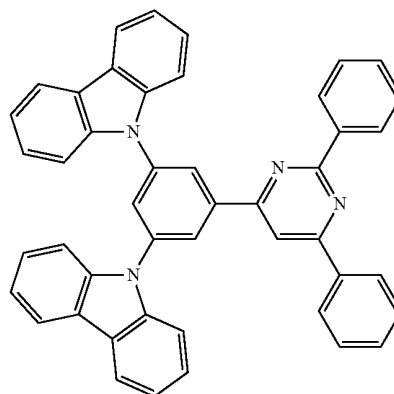
Evaluation of Organic EL Device

[0475] The organic EL devices manufactured in Examples 1 to 5 and Comparisons 1 to 4 were driven by direct-current electricity to emit light, where luminescent performance was evaluated and time elapsed until an initial luminescence intensity of 20,000 cd/m² was reduced to the half was measured. The results are shown in Table 4.

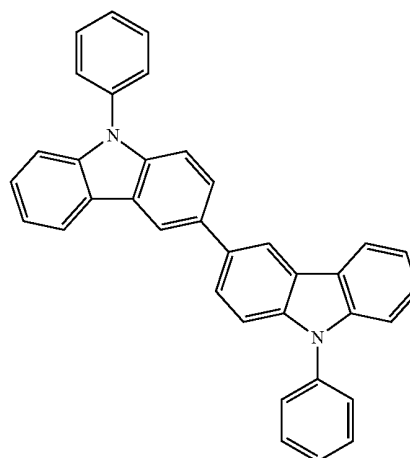
Compound D



Compound E



Compound F



-continued

Compound G

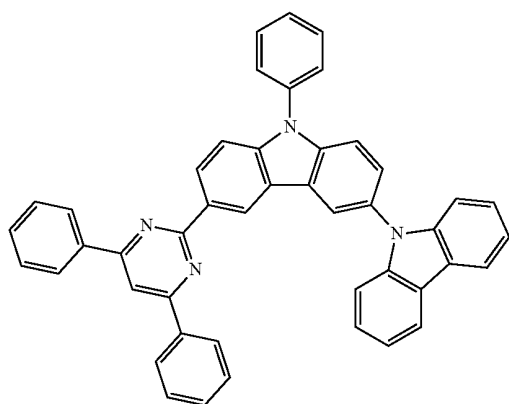


TABLE 4

	Host Material	Voltage (V) @1 mA/cm ²	Luminous Efficiency (cd/A) @ 1 mA/cm ²	Luminance half-life (hrs)
Example 1	Compound 1	4.2	60	600
Example 2	Compound 2	4.1	62	600
Example 3	Compound 3	4.3	61	700
Example 4	Compound 4	4.2	60	630
Example 5	Compound 5	4.2	61	800
Comparison 1	Compound D	4.2	38	310
Comparison 2	Compound E	4.5	54	450
Comparison 3	Compound F	5.1	50	210
Comparison 4	Compound G	4.6	48	350

[0476] Table 4 shows that the compounds of the invention used in Examples 1 to 5 have a significantly long luminance half-life and a high luminous efficiency while being capable of low-voltage drive, as compared with those of Comparisons 1 to 4.

[0477] In Comparison 1, since the compound D has a single carbazolyl group and is poor in hole transporting performance, luminance half-life is short. In Comparison 2, although having two carbazolyl groups, the compound E has a poor hole transporting performance and a short luminance half-life, presumably because of small overlapping margin between the molecules. In Comparison 3, since the compound F has a nitrogen-containing heterocyclic group only in a carbazolyl group, electrons are difficult to be injected, so that the compound F has a low luminous efficiency and a short luminance half-life. In Comparison 4, although having two carbazolyl groups, the compound G has a poor hole transporting capability and a short luminance half-life, presumably because of small overlapping margin between the molecules.

[0478] Table 5 shows physical properties of the host materials used in Examples 1 to 5.

[0479] A method for measuring each of the physical properties is as follows.

(1) Ionization Potential (Ip)

[0480] Ionization potential was measured in the atmosphere by using a photoelectron spectrometer (AC-1 manufactured by Riken Keiki Co., Ltd.). Specifically, ionization potential was measured by irradiating the materials with light and measuring the amount of electrons generated by charge separation at that time.

(2) Affinity (Af)

[0481] Affinity was calculated based on measurement values of ionization potential Ip and energy gap Eg. A calculation equation is as follows.

$$Af = Ip - Eg$$

[0482] The energy gap was measured from an absorption end of absorption spectrum of benzene. Specifically, the absorption spectrum is measured with a commercially available ultraviolet-visible spectrophotometer, and the energy gap is calculated from a wavelength at which the absorption spectrum appears.

(3) Singlet Energy (SI) and Triplet Energy (TI)

[0483] The optical energy gap SI (also referred to as singlet energy) is a difference between a conduction level and a valence level. The optical energy gap was obtained by converting into energy a wavelength value at an intersection of a long-wavelength-side tangent line in an absorbing spectrum of a toluene-diluted solution of each material and a base line in the absorbing spectrum (zero absorption).

[0484] The triplet energy gap TI of the material may be exemplarily defined based on the phosphorescence spectrum. The triplet energy gap TI was defined as follows in Examples.

[0485] Specifically, each material was dissolved in an EPA solvent (diethylether:isopentane:ethanol=5:5:2 in volume ratio) with a concentration of 10 mmol/L, thereby forming a sample for phosphorescence measurement.

[0486] Then, the sample for phosphorescence measurement was put into a quartz cell, cooled to 77K and irradiated with exciting light, so that a wavelength of phosphorescence radiated therefrom was measured.

[0487] A tangent line is drawn to be tangent to a rising section adjacent to short-wavelength of the obtained phosphorescence spectrum, a wavelength value at an intersection of the tangent line and a base line is converted into energy value, and the converted energy value is defined as the triplet energy gap TI.

[0488] For the measurement, a measurement machine F-4500 (manufactured by Hitachi) was used.

TABLE 5

	IP (eV)	Af (eV)	SI (eV)	TI (eV)
Compound 1	5.5	2.1	3.4	2.7
Compound 2	5.8	2.3	3.4	2.8
Compound 3	5.6	2.2	3.4	2.7
Compound 4	5.7	2.6	3.1	2.7
Compound 5	5.6	2.2	3.4	2.7

Example 6

Manufacture of Organic EL Device 6

[0489] A glass substrate (size: 25 mm×75 mm×1.1 mm thick) having an ITO transparent electrode (manufactured by GEOMATEC Co., Ltd.) was ultrasonic-cleaned in isopropyl alcohol for five minutes, and then UV/ozone-cleaned for 30 minutes.

[0490] After the glass substrate having the transparent electrode line was cleaned, the glass substrate was mounted on a substrate holder of a vacuum deposition apparatus, so that the following electron accepting compound (C-1) was deposited to form a 5-nm thick C-1 film on a surface of the glass substrate where the transparent electrode line was provided so as to cover the transparent electrode. On the C-1 film, the

following aromatic amine derivative (X1) was deposited as a first hole transporting material to form a 50-nm thick first hole transporting layer. After film formation of the first hole transporting layer, the following aromatic amine derivative (X2) was deposited as a second hole transporting material to form a 60-nm thick second hole transporting layer.

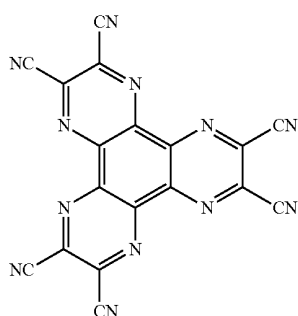
[0491] Further on the second hole transporting layer, the compound 1 obtained in Synthesis Example 1 was deposited to form a 45-nm thick emitting layer. Simultaneously, the following compound (D3) was co-deposited as a phosphorescent material. A concentration of the compound D3 was 8.0 mass %.

[0492] After the film formation of the emitting layer, a 30-nm thick film of the following compound (ET2) was

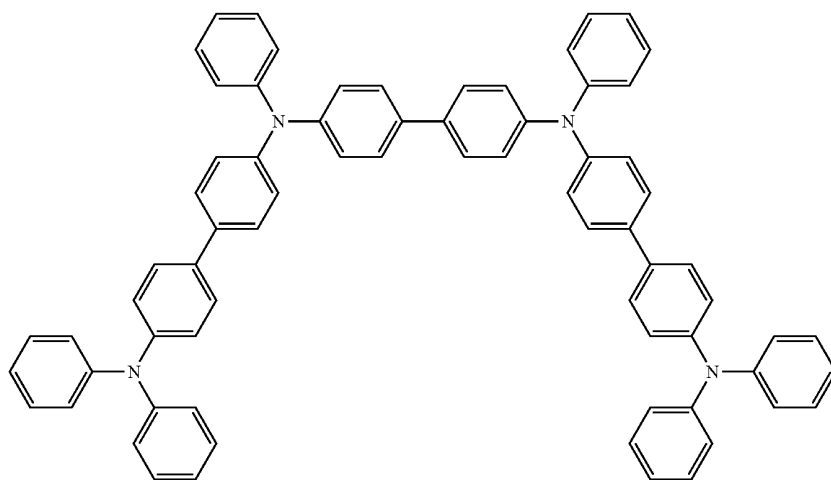
formed. The ET2 film serves as the electron transporting layer.

[0493] Next, a 1-nm thick film of LiF was formed as an electron-injecting electrode (cathode) at a film-forming speed of 0.1 Å/min. Metal (Al) was deposited on the LiF film to form an 80-nm thick metal cathode, thereby providing an organic electroluminescence device.

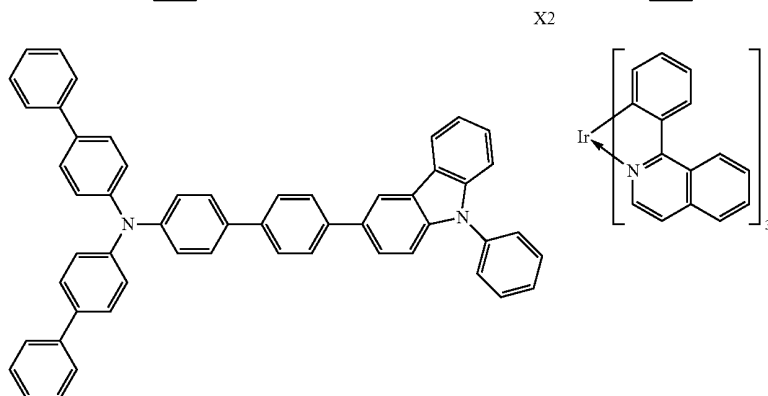
[0494] For each of the obtained organic EL devices, luminous efficiency was measured when the device was driven by DC constant current at the initial luminescence of 2000 cd/m² at the room temperature, and the time elapsed until a half-life of emission was measured when the device was driven by DC constant current at the initial luminescence of 5000 cd/m² at the room temperature. The results are shown in Table 6.



C-1



X1

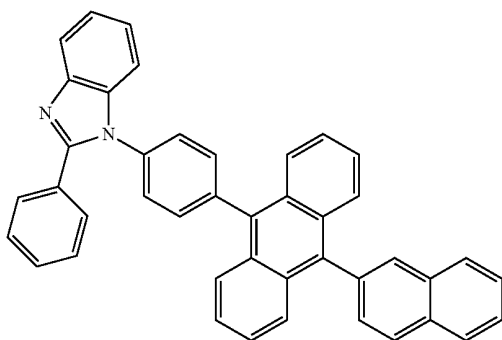


X2

D3

-continued

ET2



Examples 7 to 11

Manufacture of Organic EL Devices 7 to 11

[0495] The organic EL devices according to Examples 9 to 14 were manufactured in the same manner as that in Example 6 except that the compounds 2 to 5 and 7 were used in place of the compound 1 as materials for the emitting layer. For each of the obtained organic EL devices, luminous efficiency was measured when the device was driven by DC constant current at the initial luminescence of 2000 cd/m² at the room temperature, and the time elapsed until a half-life of emission was measured when the device was driven by DC constant current at the initial luminescence of 5000 cd/m² at the room temperature. The results are shown in Table 6.

Comparisons 5 and 6

[0496] The organic EL devices according to Comparisons 5 and 6 were manufactured in the same manner as that in Example 6 except that the comparative compounds D and F were used in place of the compound 1 as materials for the emitting layer. For each of the obtained organic EL devices, luminous efficiency was measured when the device was driven by DC constant current at the initial luminescence of 2000 cd/m² at the room temperature, and the time elapsed until a half-life of emission was measured when the device was driven by DC constant current at the initial luminescence of 5000 cd/m² at the room temperature.

[0497] The results are shown in Table 6.

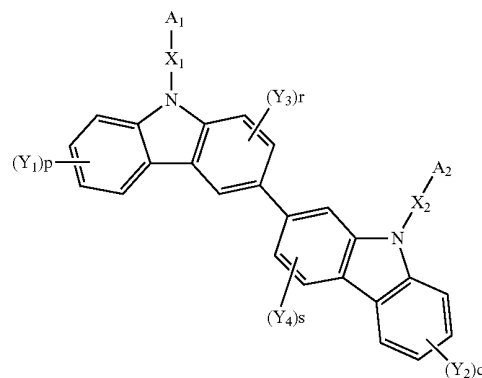
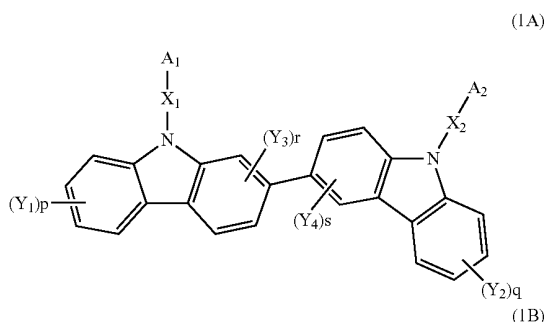
TABLE 6

	Host Material	Voltage (V)	Luminous Efficiency (cd/A)	Luminance half-life (hrs)
Example 6	Compound 1	4.1	9	400
Example 7	Compound 2	4.2	11	400
Example 8	Compound 3	4.1	10	350
Example 9	Compound 4	4.1	12	440
Example 10	Compound 5	4.4	12	350
Example 11	Compound 7	4.1	12	450
Comparison 5	Compound D	4.1	7	200
Comparison 6	Compound F	5.2	6.5	220

[0498] The table 6 shows that the compounds of the invention also function as a red phosphorescent host material.

What is claimed is:

1. A bis-carbazole derivative represented by a formula (1A) or (1B) below.



[where:

A₁ represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 carbon atoms forming a ring;

A₂ represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

X₁ and X₂ each are a linking group and independently represent a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic

hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

Y_1 to Y_4 independently represent a hydrogen atom, fluorine atom, cyano group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl having 6 to 30 carbon atoms, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

adjacent ones of Y_1 to Y_4 are allowed to be bonded to each other to form a ring structure;

p and q represent an integer of 1 to 4; r and s represent an integer of 1 to 3; and

when p and q are an integer of 2 to 4 and r and s are an integer of 2 to 3, a plurality of Y_1 to Y_4 are allowed to be the same or different.]

2. The biscarbazole derivative according to claim 1, wherein

A_1 is selected from the group consisting of a substituted or unsubstituted pyridine ring, substituted or unsubstituted pyrimidine ring and substituted or unsubstituted triazine ring.

3. The biscarbazole derivative according to claim 1, wherein

A_1 is selected from a substituted or unsubstituted pyrimidine ring or substituted or unsubstituted triazine ring.

4. The biscarbazole derivative according to claim 1, wherein A_1 is a substituted or unsubstituted pyrimidine ring.

5. The biscarbazole derivative according to claim 1, wherein A_1 is a substituted or unsubstituted quinazoline ring.

6. An organic-EL-device material comprising the biscarbazole derivative according to claim 1.

7. An organic electroluminescence device comprising: a cathode; an anode; and a plurality of organic thin-film layers provided between the cathode and the anode, the organic thin-film layers comprising an emitting layer, wherein

at least one of the organic thin-film layers comprises the organic-EL-device material according to claim 6.

8. The organic electroluminescence device according to claim 7, wherein

the emitting layer comprises the organic-EL-device material as a host material.

9. The organic electroluminescence device according to claim 7, wherein the emitting layer comprises a phosphorescent material.

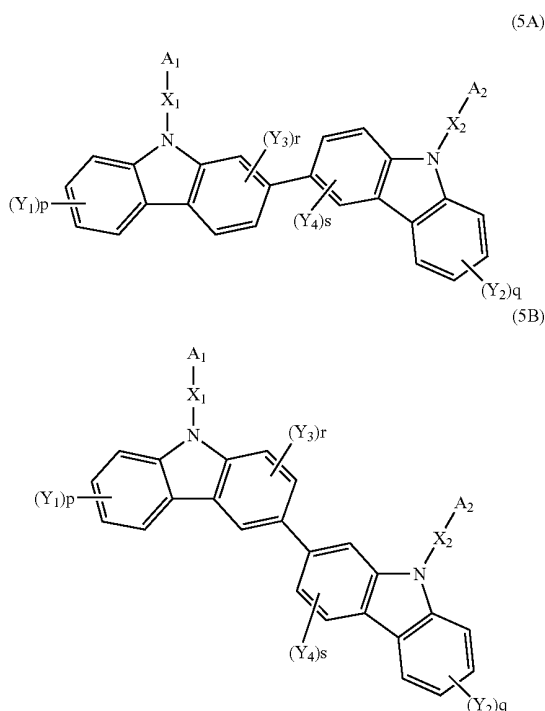
10. The organic electroluminescence device according to claim 9, wherein

the phosphorescent material is an ortho-metalated complex of a metal atom selected from iridium (Ir), osmium (Os) and platinum (Pt).

11. An organic electroluminescence device comprising: a cathode; an anode; and a plurality of organic thin-film layers provided between the cathode and the anode, the organic thin-film layers comprising an emitting layer, wherein

at least one of the organic thin-film layers is the emitting layer comprising a first host material, a second host material and a phosphorescent material providing phosphorescence,

the first host material being a compound represented by a formula (5A) or (5B) below.



[where:

A_1 represents a substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

A_2 represents a substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, or substituted or unsubstituted nitrogen-containing heterocyclic group having 1 to 30 ring carbon atoms;

X_1 and X_2 each are a linking group and independently represent a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

Y_1 to Y_4 independently represent a hydrogen atom, fluorine atom, cyano group, substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkyl group having 1 to 20 carbon atoms, substituted or unsubstituted haloalkoxy

group having 1 to 20 carbon atoms, substituted or unsubstituted alkylsilyl having 1 to 10 carbon atoms, substituted or unsubstituted arylsilyl having 6 to 30 carbon atoms, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 ring carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 ring carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 ring carbon atoms;

adjacent ones of Y_1 to Y_4 are allowed to be bonded to each other to form a ring structure;

p and q represent an integer of 1 to 4; r and s represent an integer of 1 to 3; and

when p and q are an integer of 2 to 4 and r and s are an integer of 2 to 3, a plurality of Y_1 to Y_4 are allowed to be the same or different.]

12. The organic electroluminescence device according to claim 11, wherein the second host material is represented by either one of a formula (6) or (7) below.



[where:

Cz represents a substituted or unsubstituted arylcarbazolyl group or carbazolylaryl group;

A^3 represents a group represented by a formula (8A) or (8B) below; and

a and b each represent an integer of 1 to 3.]



[where:

M^1 and M^2 each independently represent a substituted or unsubstituted nitrogen-containing aromatic heterocyclic ring or nitrogen-containing fused aromatic heterocyclic ring having 2 to 40 ring carbon atoms; M^1 and M^2 are allowed to be the same or different; L^5 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 30 carbon atoms, or substituted or unsubstituted fused aromatic heterocyclic group having 2 to 30 carbon atoms;

c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and c+e represents 1 or more.]



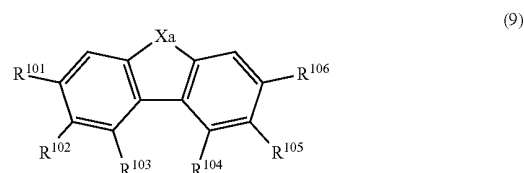
[where:

M^3 and M^4 each independently represent a substituted or unsubstituted aromatic hydrocarbon group having 6 to 40 ring carbon atoms; M^3 and M^4 are allowed to be the same or different;

L^6 represents a single bond, substituted or unsubstituted aromatic hydrocarbon group having 6 to 30 carbon atoms, substituted or unsubstituted fused aromatic hydrocarbon group having 6 to 30 carbon atoms, or substituted or unsubstituted cycloalkylene group having 5 to 30 carbon atoms;

c represents an integer of 0 to 2; d represents an integer of 1 to 2; e represents an integer of 0 to 2; and c+e represents 1 or more.]

13. The organic electroluminescence device according to claim 11, wherein the second host material is represented by a formula (9) below.



[where:

R^{101} to R^{106} each independently represent a hydrogen atom, halogen atom, substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted arylcarbonyl group having 7 to 40 carbon atoms, substituted or unsubstituted arylthio group having 6 to 20 carbon atoms, substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms or cyano group;

at least one of R^{101} to R^{106} is a substituted or unsubstituted 9-carbazolyl group, substituted or unsubstituted azacarbazolyl group having 2 to 5 nitrogen atoms, or -L-9-carbazolyl group;

L represents a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted cycloalkyl group having 3 to 15 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted alkoxy group having 1 to 40 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aryloxy group having 6 to 20 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted arylamino group having 6 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms, substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted arylcarbonyl group having 7 to 40 carbon atoms, substituted or unsubstituted arylthio group having 6 to 20 carbon atoms, or substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms;

Xa represents a sulfur atom, oxygen atom or $N-R^{108}$; and R^{108} represents the same as R^{101} to R^{106} .]

14. The organic electroluminescence device according to claim 11, wherein the second host material is a compound

selected from the group consisting of polycyclic aromatic compounds represented by formulae (10A), (10B) and (10C) below.



[where: Ar^{101} , Ar^{102} , Ar^{103} , Ra and Rb represent a polycyclic aromatic skeleton having 6 to 60 ring carbon atoms selected from a substituted or unsubstituted benzene ring, substituted or unsubstituted naphthalene ring, substituted or unsubstituted chrysene ring, substituted or unsubstituted fluoranthene ring, substituted or unsubstituted phenanthrene ring, substituted or unsubstituted benzophenanthrene ring, substituted or unsubstituted dibenzophenanthrene ring, substituted or unsubstituted triphenylene ring, substituted or unsubstituted benzo[a]triphenylene ring, substituted or unsubstituted benzo-chrysene ring, substituted or unsubstituted benzo[b]fluoranthene ring, substituted or unsubstituted fluorene ring and substituted or unsubstituted picene ring.

15. The organic electroluminescence device according to claim 14, wherein either one or both of Ra and Rb in the formulae (10A) to (10C) are selected from the group consisting of a substituted or unsubstituted phenanthrene ring, substituted or unsubstituted benzo[c]phenanthrene ring and substituted or unsubstituted fluoranthene ring.

16. The organic electroluminescence device according to claim 11, wherein the second host material is a monoamine derivative represented by any one of formulae (11) to (13) below.



[where:

Ar^{111} , Ar^{112} and Ar^{113} are a substituted or unsubstituted aryl group or heteroaryl group.]



[where:

Ar^{114} , Ar^{115} and Ar^{117} are a substituted or unsubstituted aryl group or heteroaryl group; and Ar^{116} is a substituted or unsubstituted arylene group or heteroarylene group.]



[where:

Ar^{118} , Ar^{119} and Ar^{121} are a substituted or unsubstituted aryl group or heteroaryl group; Ar^{120} is a substituted or unsubstituted arylene group or heteroarylene group; and

n is an integer of 2 to 5: when n is 2 or more, Ar^{120} are allowed to be the same or different.]

17. The organic electroluminescence device according to claim 11, wherein the second host material is represented by either one of a formula (14) or (15) below.

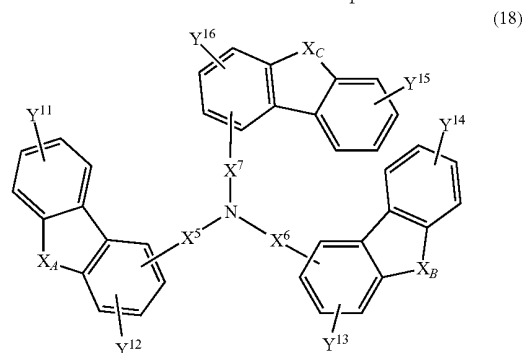
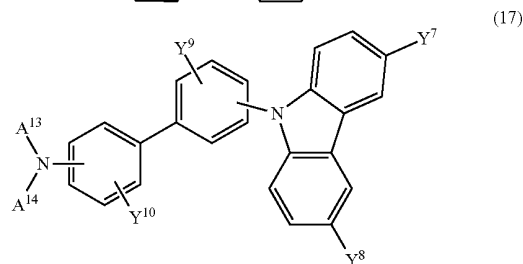
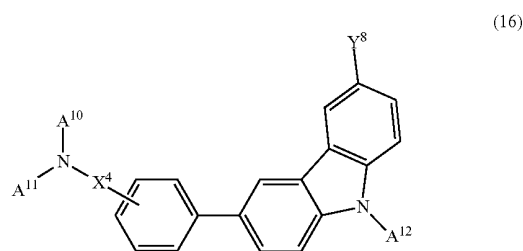


[where: X^3 represents a substituted or unsubstituted arylene group having 10 to 40 ring carbon atoms; and A^3 to A^6 represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms, or heteroaryl group having 6 to 60 ring atoms.]

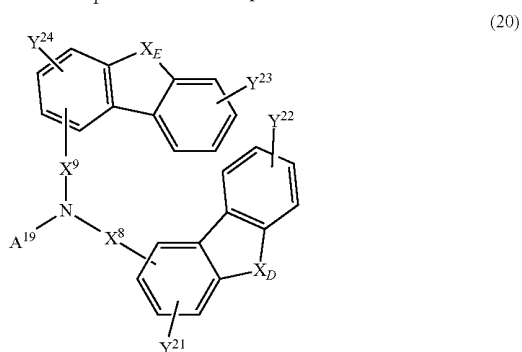
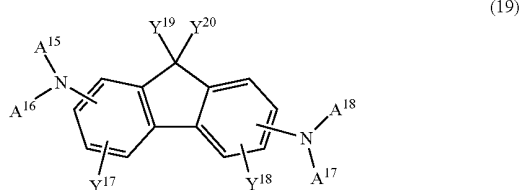


[where: A^7 to A^9 represent a substituted or unsubstituted aryl group having 6 to 60 ring carbon atoms, or heteroaryl group having 6 to 60 ring atoms.]

18. The organic electroluminescence device according to claim 17, wherein the second host material is represented by any one of formulae (16) to (20) below.



-continued



[where:

A¹⁰ to A¹⁹ each represent a substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aromatic heterocyclic group having 2 to 40 carbon atoms, substituted or unsubstituted aryl group having 8 to 40 carbon atoms bonded with an aromatic amino group, or substituted or unsubstituted aryl group having 8 to 40 carbon atoms bonded with an aromatic heterocyclic group;

A¹⁰, A¹³, A¹⁵ and A¹⁷ are adapted to be respectively bonded to A¹¹, A¹⁴, A¹⁶ and A¹⁸ to form a ring;

X⁴ to X⁹ represent a single bond or a linking group having 1 to 30 carbon atoms;

Y⁶ to Y²⁴ represent a hydrogen atom, halogen atom, substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, substituted or unsubstituted heterocyclic group having 3 to 20 carbon atoms, substituted or unsubstituted aryl group having 6 to 40 carbon atoms, substituted or unsubstituted aralkyl group having 7 to 20 carbon atoms, substituted or unsubstituted alkenyl group having 2 to 40 carbon atoms, substituted or unsubstituted alkylamino group having 1 to 40 carbon atoms,

substituted or unsubstituted aralkylamino group having 7 to 60 carbon atoms, substituted or unsubstituted alkylsilyl group having 3 to 20 carbon atoms, substituted or unsubstituted arylsilyl group having 8 to 40 carbon atoms, substituted or unsubstituted aralkylsilyl group having 8 to 40 carbon atoms, or substituted or unsubstituted halogenated alkyl group having 1 to 40 carbon atoms; and

X_A, X_B, X_C, X_D, X_E each represent a sulfur atom, an oxygen atom or a monoaryl-substituted nitrogen atom.]

19. The organic electroluminescence device according to claim 11, wherein

the emitting layer comprises a host material and a phosphorescent material, the phosphorescent material being an ortho-metalated complex of a metal atom selected from iridium (Ir), osmium (Os) and platinum (Pt).

20. The organic electroluminescence device according to claim 7, wherein

an electron injecting layer is provided between the cathode and the emitting layer, the electron injecting layer comprising a nitrogen-containing cyclic derivative.

21. The organic electroluminescence device according to claim 7, wherein

an electron transporting layer is provided between the cathode and the emitting layer, the electron transporting layer comprising the organic-EL-device material.

22. The organic electroluminescence device according to claim 7, wherein

a reduction-causing dopant is present at an interfacial region between the cathode and the organic thin-film layer.

23. The organic electroluminescence device according to claim 11, wherein

an electron injecting layer is provided between the cathode and the emitting layer, the electron injecting layer comprising a nitrogen-containing cyclic derivative.

24. The organic electroluminescence device according to claim 11, wherein

an electron transporting layer is provided between the cathode and the emitting layer, the electron transporting layer comprising the organic-EL-device material.

25. The organic electroluminescence device according to claim 11, wherein

a reduction-causing dopant is present at an interfacial region between the cathode and the organic thin-film layer.

* * * * *

专利名称(译)	双唑啉衍生物，用于有机电致发光器件的材料和使用其的有机电致发光器件		
公开(公告)号	US20110278555A1	公开(公告)日	2011-11-17
申请号	US13/091071	申请日	2011-04-20
申请(专利权)人(译)	出光兴产股份有限公司.		
当前申请(专利权)人(译)	出光兴产股份有限公司.		
[标]发明人	INOUE TETSUYA ITO MITSUNORI YOSHIDA KEI HIBINO KUMIKO NISHIMURA KAZUKI OGIWARA TOSHINARI IKEDA KIYOSHI		
发明人	INOUE, TETSUYA ITO, MITSUNORI YOSHIDA, KEI HIBINO, KUMIKO NISHIMURA, KAZUKI OGIWARA, TOSHINARI IKEDA, KIYOSHI		
IPC分类号	H01L51/54 C07D209/82		
CPC分类号	C07D209/82 H01L51/5012 C09K11/06 C09K2211/1007 C09K2211/1029 C09K2211/1044 C09K2211/1059 H01L51/0072 H01L51/5016 H05B33/20 H01L2251/5384 C09B57/00 Y10S428/917 H01L51/5076 H01L51/5092 H01L51/0067 C07D403/14 C07D401/14 H01L51/0085 H01L51/5072 H01L51/5024		
优先权	2010097317 2010-04-20 JP 2010291138 2010-12-27 JP 61/353047 2010-06-09 US 61/433084 2011-01-14 US		
其他公开文献	US8877352		
外部链接	Espacenet USPTO		

摘要(译)

本发明的双唑啉衍生物由下式 (1A) 或 (1B) 表示。在式 (1A) 或 (1B) 中：A1表示具有1至30个环碳原子的取代或未取代的含氮杂环基；A2表示取代或未取代的成环碳原子数6~30的芳香族烃基，或取代或未取代的成环碳原子数1~30的含氮杂环基。X1和X2各自为连接基团；Y1至Y4各自代表取代基；p和q表示1至4的整数；r和s代表1到3的整数。

