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(54) **Title**: ORGANIC ELECTROLUMINESCENT DEVICE

(57) **Abstract**: The present invention relates to an organic electroluminescent device. The organic electroluminescent device of the present invention shows high luminous efficiency and good lifespan by comprising a specific combination of the plural kinds of host compounds and a specific hole transport compound.

Description

Title of Invention: ORGANIC ELECTROLUMINESCENT DEVICE

Technical Field

[1] The present invention relates to an organic electroluminescent device.

Background Art

[2] An electroluminescent (EL) device is a self-light-emitting device which has advantages in that it provides a wider viewing angle, a greater contrast ratio, and a faster response time. An organic EL device was first developed by Eastman Kodak, by using small aromatic diamine molecules and aluminum complexes as materials to form a light-emitting layer [Appl. Phys. Lett. 51, 913, 1987].

[3] The organic EL device converts electric energy into light when electricity is applied to an organic light-emitting material(s). Generally, the organic EL device has a structure comprising an anode, a cathode, and an organic layer disposed between the anode and the cathode. The organic layer of the organic EL device comprises a hole injection layer, a hole transport layer, an electron blocking layer, a light-emitting layer, an electron buffering layer, a hole blocking layer, an electron transport layer, an electron injection layer, etc. Depending on its function, materials for forming the organic layer can be classified as a hole injection material, a hole transport material, an electron blocking material, a light-emitting material, an electron buffering material, a hole blocking material, an electron transport material, an electron injection material, etc. When a voltage is applied to the organic EL device, holes and electrons are injected from an anode and a cathode, respectively, to the light-emitting layer. Excitons having high energy are formed by recombinations between the holes and the electrons. The energy of excitons puts the light-emitting organic compound in an excited state, and the decay of the excited state results in a relaxation of the energy level into a ground state, accompanied by light-emission.

[4] The most important factor determining luminous efficiency in the organic EL device is light-emitting materials. The light-emitting material needs to have high quantum efficiency, high electron mobility, and high hole mobility. Furthermore, the light-emitting layer formed by the light-emitting material needs to be uniform and stable. Depending on colors visualized by light-emission, the light-emitting materials can be classified as a blue-, green-, or red-emitting material, and a yellow- or orange-emitting material can be additionally included therein. Depending on its function, the light-emitting materials can be classified as a host material and a dopant material. Recently, the development of an organic EL device providing high efficiency and long lifespan is

an urgent issue. Particularly, considering EL characteristic requirements for a middle or large-sized panel of OLED, materials showing better characteristics than conventional ones must be urgently developed. The host material acts as a solvent in a solid state and transfers energy, and thus needs to have high purity and a molecular weight appropriate for vacuum deposition. Furthermore, the host material needs to have high glass transition temperature and high thermal degradation temperature to achieve thermal stability; high electro-chemical stability to achieve long lifespan; easiness of forming amorphous thin film; good adhesion to materials of adjacent layers; and non-migration to other layers.

[5] In order to enhance color purity, luminous efficiency and stability, the light-emitting material may be used as a mixture of a host and a dopant. Generally, devices showing good electroluminescent characteristics have a structure comprising a light-emitting layer in which a dopant is doped into a host. In the dopant/host material system, efficiency and lifespan of the device are highly affected by the host material, and thus selection of the host material is important.

[6] Many prior art references such as WO 2013/168688 A1, WO 2009/060757 A1, and Japanese Patent Application Laying-Open No. 2013-183036 A disclose an organic electroluminescent device employing a biscarbazole derivative as a host material. However, they fail to specifically disclose an organic electroluminescent device employing, as a plurality of host materials, a biscarbazole derivative in which the nitrogen atoms of the carbazoles are linked to aryls, respectively, and a carbazole derivative in which the nitrogen atom of the carbazole is linked to a nitrogen-containing heteroaryl, and as a hole transport material, a biscarbazole derivative in which the nitrogen atoms of the carbazoles are linked to aryls, respectively.

[7]

Disclosure of Invention

Technical Problem

[8] The object of the present invention is to provide an organic electroluminescent device showing high efficiency and long lifespan.

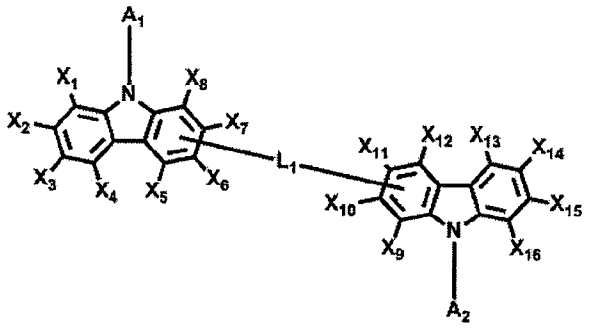
[9]

Solution to Problem

[10] The present inventors found that the above object can be achieved by an organic electroluminescent device comprising an anode, a cathode, and an organic layer between the anode and the cathode, wherein the organic layer comprises one or more light-emitting layers and one or more hole transport layers; at least one of the one or more light-emitting layers comprises one or more dopant compounds and two or more host compounds; a first host compound of the host compounds is represented by the

following formula 1; a second host compound is represented by the following formula 2; and at least one of the one or more hole transport layers comprises the compound represented by the following formula 3:

[11]



(1)

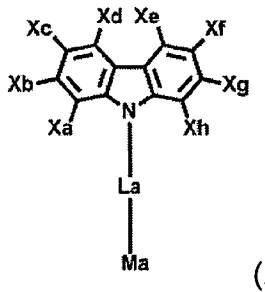
[12] wherein

[13] A_1 and A_2, each independently, represent a substituted or unsubstituted (C6-C30)aryl, provided that a nitrogen-containing heteroaryl is excluded from the substituent of A_1 and A_2;

[14] L_1 represents a single bond or a substituted or unsubstituted (C6-C30)arylene;

[15] X_1 to X_{16}, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di-(C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;

[16]



(2)

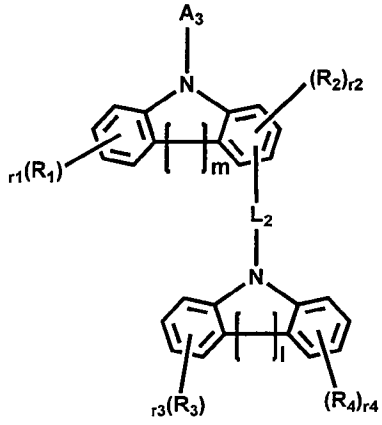
[17] wherein

[18] Ma represents a substituted or unsubstituted nitrogen-containing 5- to 11-membered heteroaryl;

[19] La represents a single bond, or a substituted or unsubstituted (C6-C30)arylene;

[20] Xa to Xh, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di-(C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;

[21]



----------(3)

[22] wherein

[23] A_3 represents a substituted or unsubstituted (C6-C30)aryl;

[24] L_2 represents a single bond, or a substituted or unsubstituted (C6-C30)arylene;

[25] l and m each independently, represent an integer of 0 or 1, l+m is 1 or 2;

[26] R_1 to R_4, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di-(C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring which may form a spiro structure, and the carbon atom(s) of the ring may be replaced

with at least one hetero atom selected from nitrogen, oxygen, and sulfur;

[27] r_1 to r_4, each independently, represent an integer of 1 to 4; and

[28] the heteroaryl contains at least one hetero atom selected from B, N, O, S, Si, and P.

[29]

Advantageous Effects of Invention

[30] According to the present invention, an organic electroluminescent device having high efficiency and long lifespan is provided. In addition, the organic electroluminescent device of the present invention can be used for the manufacture of a display system or a lighting system.

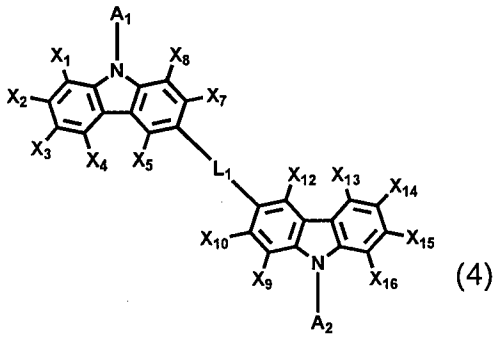
Mode for the Invention

[31] Hereinafter, the present invention will be described in detail. However, the following description is intended to explain the invention, and is not meant in any way to restrict the scope of the invention.

[32] The details of the organic electroluminescent device of the present invention are as follows.

[33] According to one embodiment of the organic electroluminescent device of the present invention, the compound of formula 1 may be represented by any one of the following formulae 4, 5, 6, and 7.

[34]



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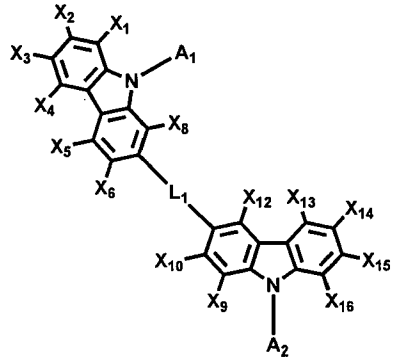

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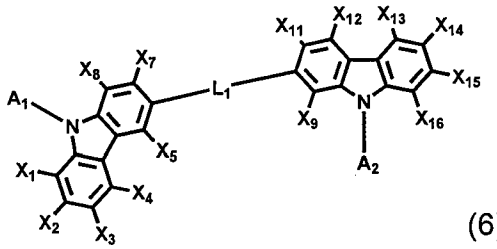

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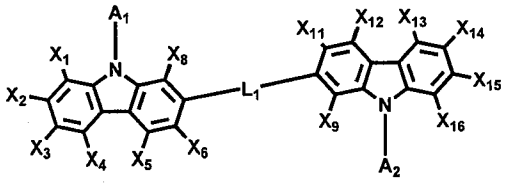


(7)

[35] wherein A_1, A_2, L_1 and X_1 to X_{16} are as defined in formula 1 above.

[36] In formula 1, A_1 and A_2, each independently, represent a substituted or unsubstituted (C6-C30)aryl. A_1 and A_2, each independently, may represent preferably, a substituted or unsubstituted (C6-C18)aryl; and more preferably, a (C6-C18)aryl unsubstituted or substituted with a cyano, a halogen, a (C1-C6)alkyl, a (C6-C12)aryl, or a tri(C6-C12)arylsilyl. Specifically, A_1 and A_2, each independently, may be selected

from the group consisting of a substituted or unsubstituted phenyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted naphthyl, a substituted or unsubstituted fluorenyl, a substituted or unsubstituted benzofluorenyl, a substituted or unsubstituted phenanthrenyl, a substituted or unsubstituted anthracenyl, a substituted or unsubstituted indenyl, a substituted or unsubstituted triphenylenyl, a substituted or unsubstituted pyrenyl, a substituted or unsubstituted tetracenyl, a substituted or unsubstituted perylenyl, a substituted or unsubstituted chrysenyl, a substituted or unsubstituted phenylnaphthyl, a substituted or unsubstituted naphthylphenyl, and a substituted or unsubstituted fluoranthenyl. Herein, the substituents of the substituted phenyl, etc., may be a cyano, a halogen, a (C1-C6)alkyl, a (C6-C12)aryl, or a tri(C6-C12)arylsilyl. In addition, A_1 and A_2 may be the same or different.

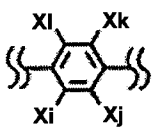
[37] In formula 1, X_1 to X_{16}, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino, or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur. Preferably, X_1 to X_{16}, each independently, may represent hydrogen, a cyano, a substituted or unsubstituted (C1-C10)alkyl, a substituted or unsubstituted (C6-C20)aryl, a substituted or unsubstituted 5- to 20-membered heteroaryl, or a substituted or unsubstituted tri(C6-C12)arylsilyl. More preferably, X_1 to X_{16}, each independently, may represent hydrogen; a cyano; a (C1-C10)alkyl; a (C6-C20)aryl unsubstituted or substituted with a cyano, a (C1-C10)alkyl, or a tri(C6-C12)arylsilyl; a 5- to 20-membered heteroaryl unsubstituted or substituted with a (C1-C10)alkyl, a (C6-C15)aryl or a tri(C6-C12)arylsilyl; or a tri(C6-C12)arylsilyl unsubstituted or substituted with a (C1-C10)alkyl. Specifically, X_1 to X_{16}, each independently, may represent hydrogen; a cyano; a (C1-C6)alkyl; phenyl, biphenyl, terphenyl, or naphthyl, unsubstituted or substituted with a cyano, a (C1-C6)alkyl or triphenylsilyl; dibenzothiophene or dibenzofuran, unsubstituted or substituted with a (C1-C6)alkyl, phenyl, biphenyl, naphthyl, or triphenylsilyl; or triphenylsilyl unsubstituted or substituted with a (C1-C6)alkyl.

[38] In formula 1, L_1 represents a single bond, or a substituted or unsubstituted

(C6-C30)arylene. Preferably, L_1 may represent a single bond, or a substituted or unsubstituted (C6-C15)arylene.

[39] L_1 may represent one selected from the following formulae 8 to 20.

[40]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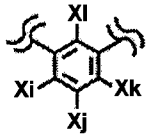
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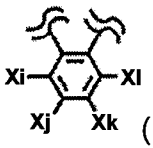
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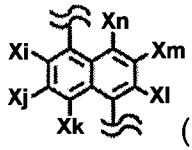
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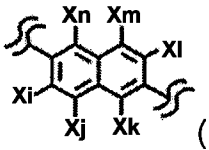
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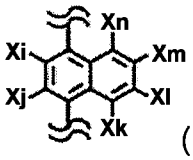
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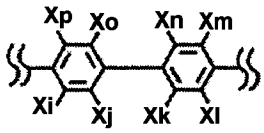
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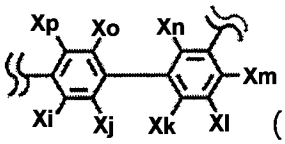
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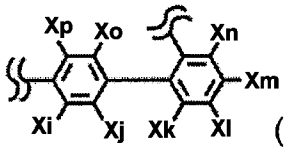
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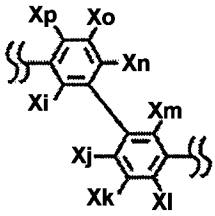
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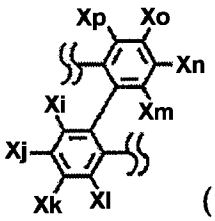
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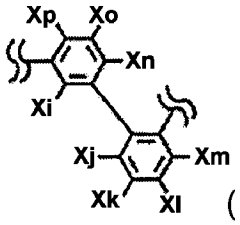
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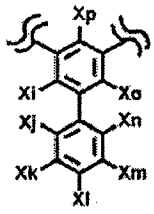

(20)

[44] wherein

[45] Xi to Xp, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di-(C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur; and  represents a bonding site to a mother nucleus.

[46] Xi to Xp, each independently, may represent preferably, hydrogen, a halogen, a cyano, a (C1-C10)alkyl, a (C3-C20)cycloalkyl, a (C6-C12)aryl, a

(C1-C6)alkyldi(C6-C12)arylsilyl, or a tri(C6-C12)arylsilyl; and more preferably, hydrogen, a cyano, a (C1-C6)alkyl, or a tri(C6-C12)arylsilyl.

[47] In formula 2, Ma represents a substituted or unsubstituted nitrogen-containing 5- to 11-membered heteroaryl. Ma may represent preferably, a substituted or unsubstituted nitrogen-containing 6- to 10-membered heteroaryl; and more preferably, a nitrogen-containing 6- to 10-membered heteroaryl substituted with an unsubstituted (C6-C18)aryl, a (C6-C12)aryl substituted with a cyano, a (C6-C12)aryl substituted with a (C1-C6)alkyl, a (C6-C12)aryl substituted with a tri(C6-C12)arylsilyl, or a 6- to 15-membered heteroaryl.

[48] Specifically, Ma may represent a substituted or unsubstituted monocyclic ring-type heteroaryl selected from the group consisting of a substituted or unsubstituted pyrrolyl, a substituted or unsubstituted imidazolyl, a substituted or unsubstituted pyrazolyl, a substituted or unsubstituted triazinyl, a substituted or unsubstituted tetrazinyl, a substituted or unsubstituted triazolyl, a substituted or unsubstituted tetrazolyl, a substituted or unsubstituted pyridyl, a substituted or unsubstituted pyrazinyl, a substituted or unsubstituted pyrimidinyl, and a substituted or unsubstituted pyridazinyl, or a substituted or unsubstituted fused ring-type heteroaryl selected from the group consisting of a substituted or unsubstituted benzimidazolyl, a substituted or unsubstituted isoindolyl, a substituted or unsubstituted indolyl, a substituted or unsubstituted indazolyl, a substituted or unsubstituted benzothiadiazolyl, a substituted or unsubstituted quinolyl, a substituted or unsubstituted isoquinolyl, a substituted or unsubstituted cinnolinyl, a substituted or unsubstituted quinazolinyl, a substituted or unsubstituted naphthyridinyl, and a substituted or unsubstituted quinoxalinyl. Preferably, Ma may represent a substituted or unsubstituted triazinyl, a substituted or unsubstituted pyrimidinyl, a substituted or unsubstituted pyridyl, a substituted or unsubstituted quinolyl, a substituted or unsubstituted isoquinolyl, a substituted or unsubstituted quinazolinyl, a substituted or unsubstituted naphthyridinyl, or a substituted or unsubstituted quinoxalinyl. The substituents for the substituted pyrrolyl, etc., of Ma may be a (C6-C18)aryl, a (C6-C12)aryl substituted with a cyano, a (C6-C12)aryl substituted with a (C1-C6)alkyl, a (C6-C12)aryl substituted with a tri(C6-C12)arylsilyl, a cyano, a (C1-C6)alkyl, a tri(C6-C12)arylsilyl, or a 6- to 15-membered heteroaryl; and specifically, phenyl, biphenyl, terphenyl, naphthyl, phenylnaphthyl, naphthylphenyl, phenanthrenyl, anthracenyl, dibenzothiophenyl, or dibenzofuranyl, unsubstituted or substituted with a cyano, a (C1-C6)alkyl, or triphenylsilyl.

[49] In formula 2, La represents a single bond, or a substituted or unsubstituted (C6-C30)arylene; and preferably, a single bond, or a substituted or unsubstituted (C6-C12)arylene.

[50] Specifically, La may represent a single bond, or any one of formulae 8 to 20.

[51] In formula 2, Xa to Xh, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino, or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur. Preferably, Xa to Xh, each independently, may represent hydrogen, a cyano, a substituted or unsubstituted (C6-C15)aryl, a substituted or unsubstituted 10- to 20-membered heteroaryl, or a substituted or unsubstituted tri(C6-C10)arylsilyl, or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C6-C20) , mono- or polycyclic, aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur. More preferably, Xa to Xh, each independently, may represent hydrogen, a cyano, a (C6-C15)aryl unsubstituted or substituted with a tri(C6-C10)arylsily, or a 10- to 20-membered heteroaryl unsubstituted or substituted with a (C6-C12)aryl, or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted benzene, a substituted or unsubstituted indole, a substituted or unsubstituted benzindole, a substituted or unsubstituted indene, a substituted or unsubstituted benzofuran, or a substituted or unsubstituted benzothiophene.

[52] In formula 3, A_3 represents a substituted or unsubstituted (C6-C30)aryl; preferably, a substituted or unsubstituted (C6-C18)aryl; and more preferably, a (C6-C18)aryl unsubstituted or substituted with a cyano, a (C6-C12)aryl, a 5- to 15-membered heteroaryl, or a tri(C6-C12)arylsilyl. Specifically, A_3 may be selected from the group consisting of a substituted or unsubstituted phenyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted naphthyl, and a substituted or unsubstituted triphenylenyl. Herein, the substituent of the substituted phenyl etc., may be a cyano, a (C6-C12)aryl, a 5- to 15-membered heteroaryl, or a tri(C6-C12)arylsilyl.

[53] In formula 3, L_2 represents a single bond, or a substituted or unsubstituted (C6-C30)arylene; and preferably, a single bond, or a substituted or unsubstituted (C6-C12)arylene.

[54] In formula 3, R_1 to R_4, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsub-

stituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring which may form a spiro structure, and the carbon atom(s) of the ring may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur. Preferably, R_1 to R_4, each independently, may represent hydrogen, a cyano, a substituted or unsubstituted (C6-C18)aryl, a substituted or unsubstituted 10- to 20-membered heteroaryl, or a substituted or unsubstituted tri(C6-C10)arylsilyl; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C6-C21), mono- or polycyclic, aromatic ring which may form a spiro structure, and the carbon atom(s) of the ring may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur. More preferably, R_1 to R_4, each independently, may represent hydrogen, a cyano, a (C6-C18)aryl unsubstituted or substituted with a (C1-C6)alkyl, or an unsubstituted 10- to 20-membered heteroaryl; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted benzene, a substituted or unsubstituted indole, a substituted or unsubstituted indene, a substituted or unsubstituted benzindene, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted spiro[cyclopentane-indene], a substituted or unsubstituted spiro[cyclohexane-indene], or a substituted or unsubstituted spiro[fluorene-indene].

[55] Herein, "(C1-C30)alkyl" indicates a linear or branched alkyl chain having 1 to 30, preferably 1 to 20, and more preferably 1 to 10 carbon atoms consistuting the chain, and includes methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl, etc. "(C2-C30) alkenyl" indicates a linear or branched alkenyl chain having 2 to 30, preferably 2 to 20, and more preferably 2 to 10 carbon atoms consistuting the chain and includes vinyl, 1-propenyl, 2-propenyl, 1-butenyl, 2-butenyl, 3-butenyl, 2-methylbut-2-enyl, etc. "(C2-C30)alkynyl" indicates a linear or branched alkynyl chain having 2 to 30, preferably 2 to 20, and more preferably 2 to 10 carbon atoms consistuting the chain and includes ethynyl, 1-propynyl, 2-propynyl, 1-butynyl, 2-butynyl, 3-butynyl, 1-methylpent-2-ynyl, etc. "(C3-C30)cycloalkyl" indicates a mono- or polycyclic hydrocarbon having 3 to 30, preferably 3 to 20, and more preferably 3 to 7 ring backbone carbon atoms and includes cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, etc. "3- to 7-membered heterocycloalkyl" indicates a cycloalkyl having 3 to 7, preferably 5 to 7 ring backbone atoms including at least one hetero atom

selected from B, N, O, S, Si, and P, preferably O, S, and N, and includes tetrahydrofuran, pyrrolidine, thiolan, tetrahydropyran, Furthermore, "(C6-C30)aryl(ene)" indicates a monocyclic or fused ring-based radical derived from an aromatic hydrocarbon and having 6 to 30, preferably 6 to 20, and more preferably 6 to 15 ring backbone carbon atoms, and includes phenyl, biphenyl, terphenyl, naphthyl, binaphthyl, phenylnaphthyl, naphthylphenyl, fluorenyl, phenylfluorenyl, benzofluorenyl, dibenzofluorenyl, phenanthrenyl, phenylphenanthrenyl, anthracenyl, indenyl, triphenylenyl, pyrenyl, tetracenyl, perylenyl, chrysenyl, naphthacenyl, fluoranthenyl, etc. "3- to 30-membered heteroaryl" indicates an aryl group having 3 to 30 ring backbone atoms including at least one, preferably 1 to 4, hetero atom selected from the group consisting of B, N, O, S, Si, and P; may be a monocyclic ring, or a fused ring condensed with at least one benzene ring; may be partially saturated; may be one formed by linking at least one heteroaryl or aryl group to a heteroaryl group via a single bond(s); and includes a monocyclic ring-type heteroaryl such as furyl, thiophenyl, pyrrolyl, imidazolyl, pyrazolyl, thiazolyl, thiadiazolyl, isothiazolyl, isoxazolyl, oxazolyl, oxadiazolyl, triazinyl, tetrazinyl, triazolyl, tetrazolyl, furazanyl, pyridyl, pyrazinyl, pyrimidinyl, pyridazinyl, etc., and a fused ring-type heteroaryl such as benzofuranyl, benzothiophenyl, isobenzofuranyl, dibenzofuranyl, dibenzothiophenyl, benzoimidazolyl, benzothiazolyl, benzoisothiazolyl, benzoisoxazolyl, benzoxazolyl, isoindolyl, indolyl, benzindolyl, indazolyl, benzothiadiazolyl, quinolyl, isoquinolyl, cinnolinyl, quinazolinyl, quinoxalinyl, carbazolyl, phenoxazinyl, phenanthridinyl, benzodioxolyl, etc. The "nitrogen-containing 5- to 30-membered heteroaryl" indicates a heteroaryl group having 5 to 30, preferably 5 to 20, and more preferably 5 to 15 ring backbone atoms including at least one, preferably 1 to 4, nitrogen as the hetero atom; may be a monocyclic ring, or a fused ring condensed with at least one benzene ring; may be partially saturated; may be one formed by linking at least one heteroaryl or aryl group to a heteroaryl group via a single bond(s); and includes a monocyclic ring-type heteroaryl such as pyrrolyl, imidazolyl, pyrazolyl, triazinyl, tetrazinyl, triazolyl, tetrazolyl, pyridyl, pyrazinyl, pyrimidinyl, pyridazinyl, etc., and a fused ring-type heteroaryl such as benzoimidazolyl, isoindolyl, indolyl, indazolyl, benzothiadiazolyl, quinolyl, isoquinolyl, cinnolinyl, quinazolinyl, quinoxalinyl, carbazolyl, phenanthridinyl, etc. Furthermore, "halogen" includes F, Cl, Br, and I.

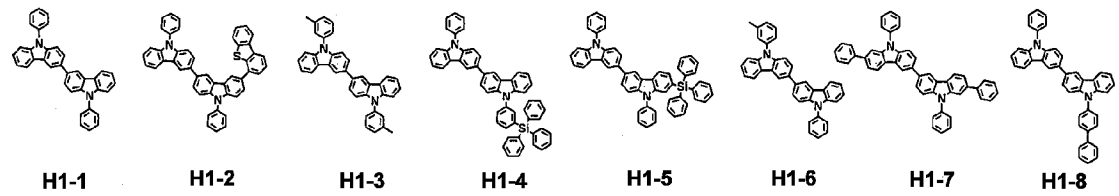
[56] Herein, "substituted" in the expression, "substituted or unsubstituted," means that a hydrogen atom in a certain functional group is replaced with another atom or group, i.e. a substituent. In the present invention, the substituents of the substituted alkyl, the substituted alkenyl, the substituted alkynyl, the substituted cycloalkyl, the substituted aryl(ene), the substituted heteroaryl, the substituted trialkylsilyl, the substituted triarylsilyl, the substituted dialkylarylsilyl, the substituted alkyldiarylsilyl, the substituted

mono- or di- arylamino, the substituted nitrogen-containing heteroaryl, and the substituted mono- or polycyclic, alicyclic or aromatic ring of A_1, A_2, L_1, X_1 to X_{16}, Ma, La, Xa to Xh, A_3, L_2, and R_1 to R_4 in formulae 1 to 3, each independently, are at least one selected from the group consisting of deuterium; a halogen; a cyano; a carboxyl; a nitro; a hydroxyl; a (C1-C30)alkyl; a halo(C1-C30)alkyl; a (C2-C30)alkenyl; a (C2-C30)alkynyl; a (C1-C30)alkoxy; a (C1-C30)alkylthio; a (C3-C30)cycloalkyl; a (C3-C30)cycloalkenyl; a 3- to 7-membered heterocycloalkyl; a (C6-C30)aryloxy; a (C6-C30)arylthio; a 3- to 30-membered heteroaryl unsubstituted or substituted with a (C6-C30)aryl; a (C6-C30)aryl unsubstituted or substituted with a cyano, a 3- to 30-membered heteroaryl, or a tri(C6-C30)arylsilyl; a tri(C1-C30)alkylsilyl; a tri(C6-C30)arylsilyl; a di(C1-C30)alkyl(C6-C30)arylsilyl; a (C1-C30)alkyldi(C6-C30)arylsilyl; an amino; a mono- or di- (C1-C30)alkylamino; a mono- or di- (C6-C30)arylamino; a (C1-C30)alkyl(C6-C30)arylamino; a (C1-C30)alkylcarbonyl; a (C1-C30)alkoxycarbonyl; a (C6-C30)arylcarbonyl; a di(C6-C30)arylboronyl; a di(C1-C30)alkylboronyl; a (C1-C30)alkyl(C6-C30)arylboronyl; a (C6-C30)aryl(C1-C30)alkyl; and a (C1-C30)alkyl(C6-C30)aryl, and preferably a halogen; a cyano; a (C1-C6)alkyl; a 5- to 15-membered heteroaryl; a (C6-C18)aryl unsubstituted or substituted with a cyano or a tri(C6-C12)arylsilyl; a tri(C6-C12)arylsilyl; and a (C1-C6)alkyl(C6-C12)aryl.

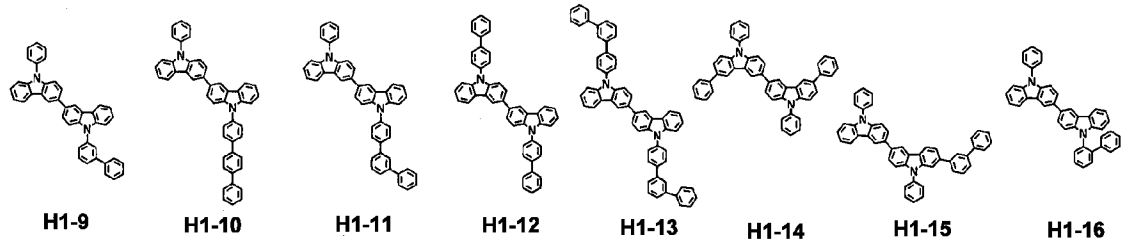
[57] In formula 1, triarylsilyl of X_1 to X_{16} in formula 1 is preferably triphenylsilyl.

[58] The first host compound represented by formula 1 includes the following, but is not limited thereto.

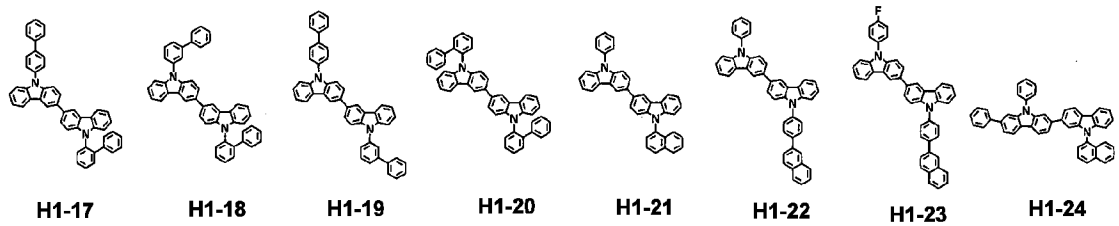
[59]



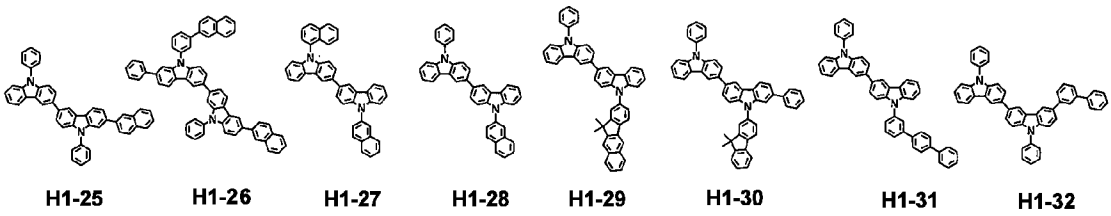
[60]



[61]



[62]



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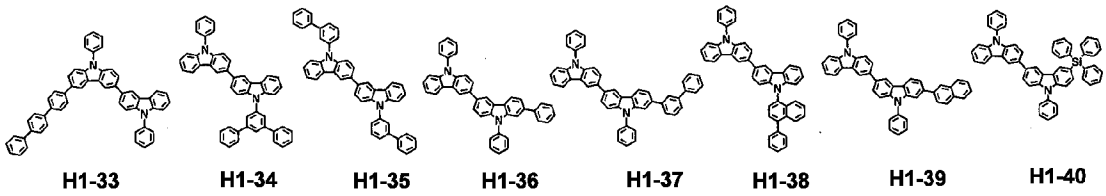
[63]



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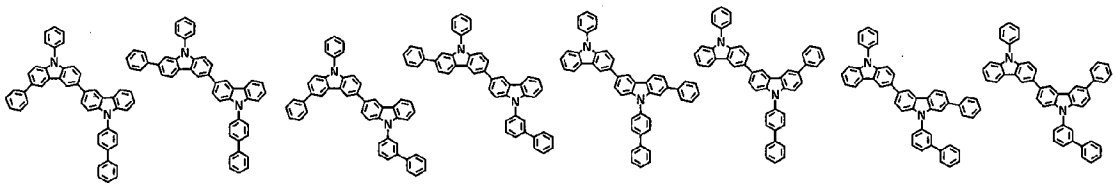
[64]



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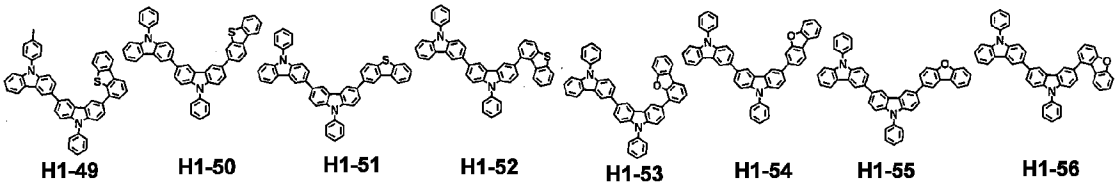
[65]



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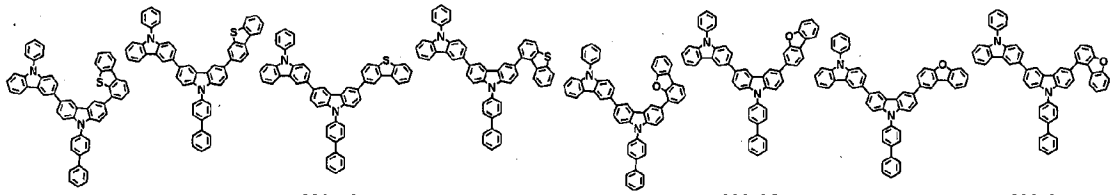
[66]



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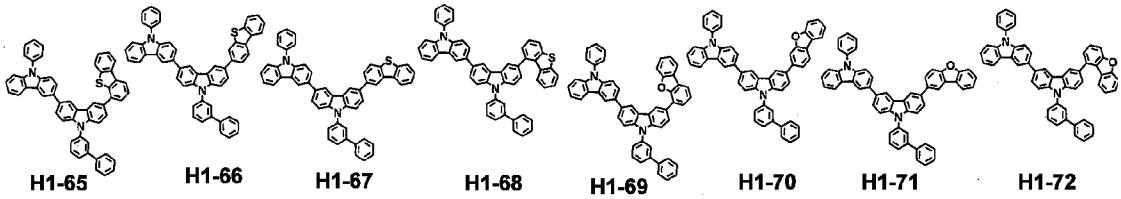
[67]



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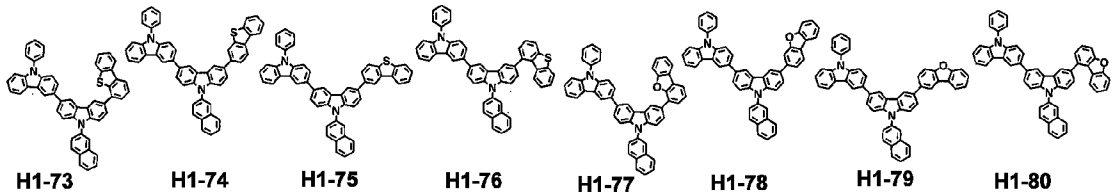
[68]



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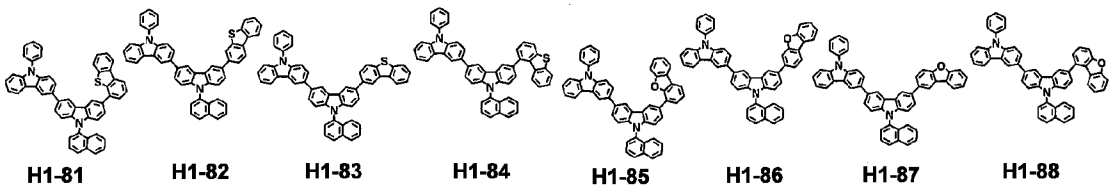
[69]



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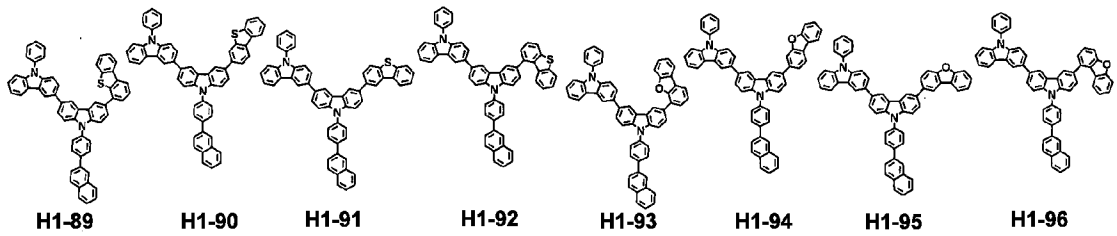
[70]



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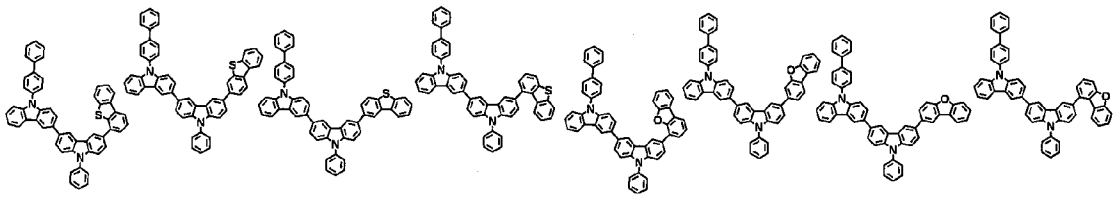
[71]



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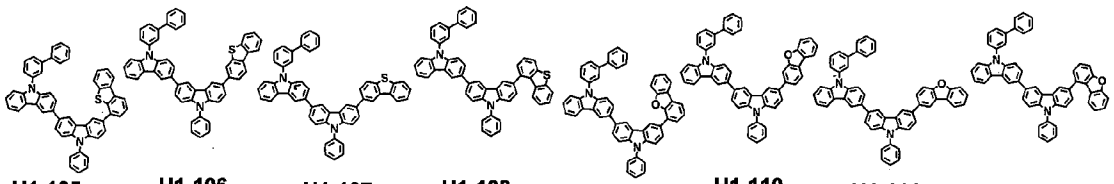
[72]



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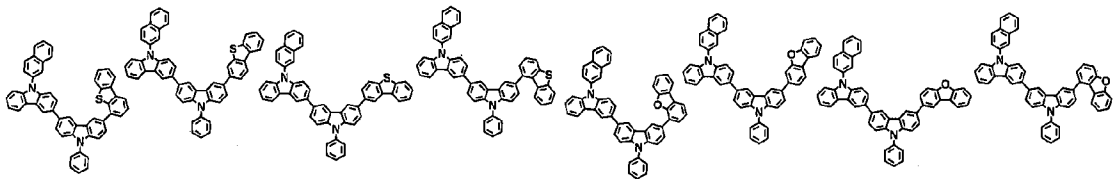
[73]



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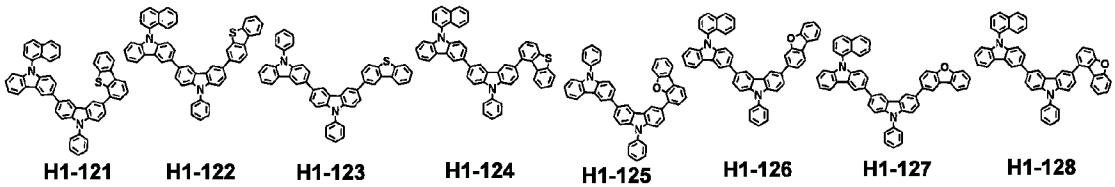
[74]



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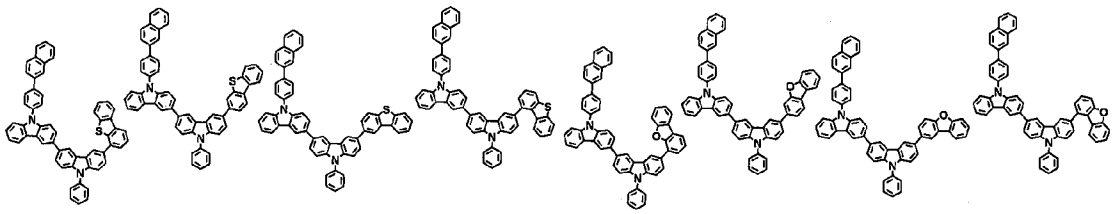
[75]



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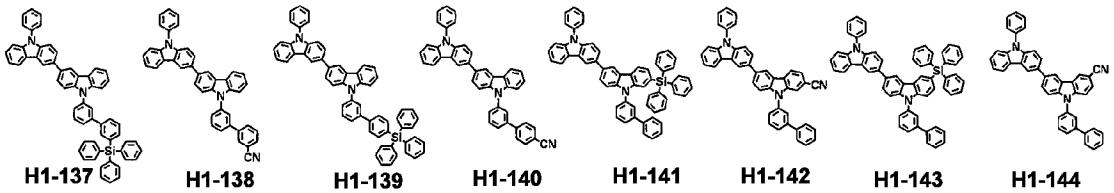
[76]



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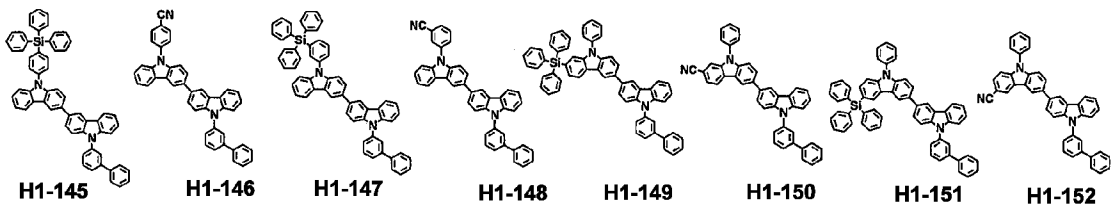
[77]



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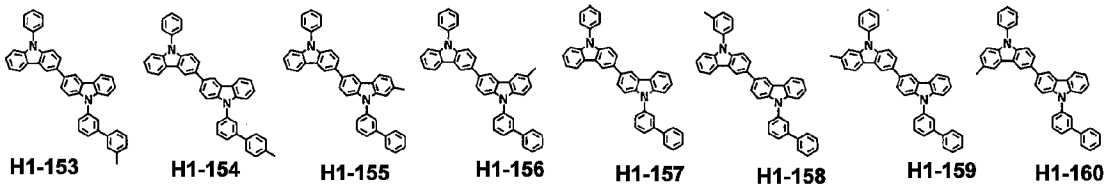
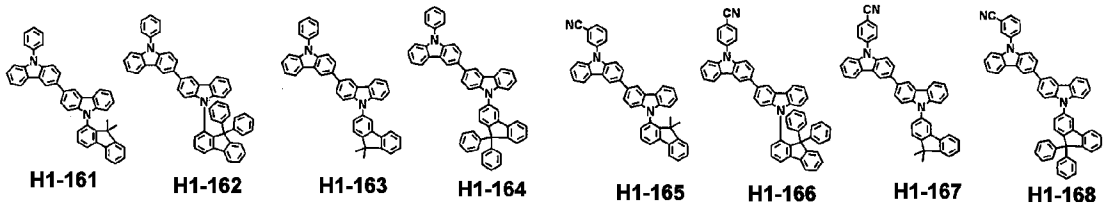
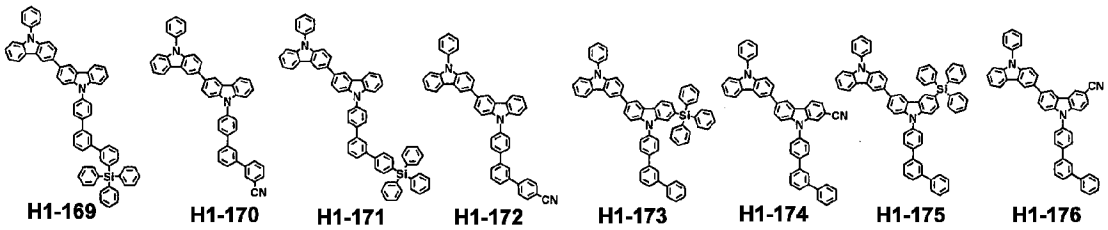
[78]



[79]



[80]



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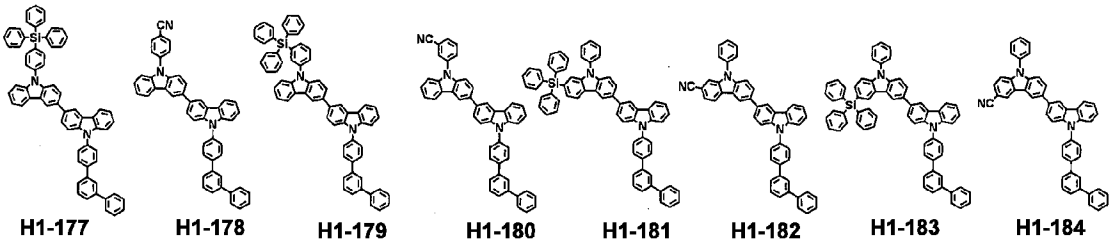

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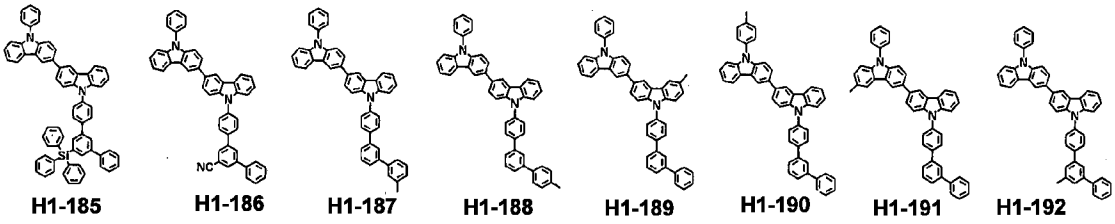
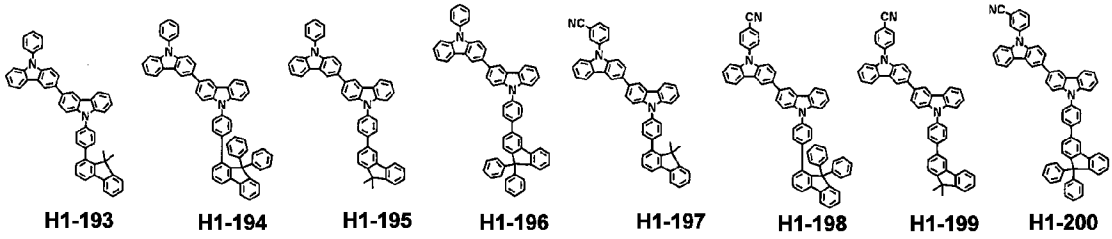


[83]



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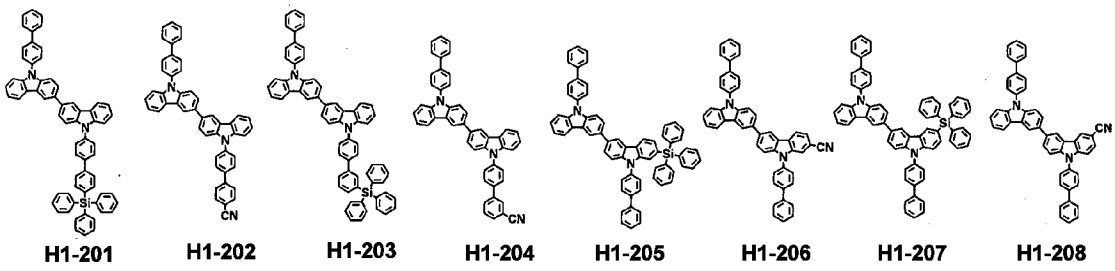

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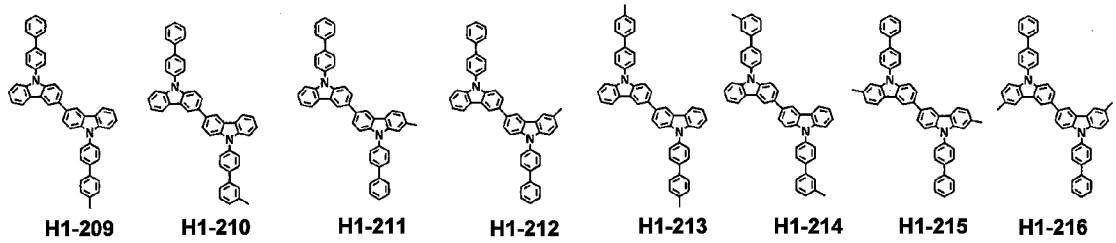

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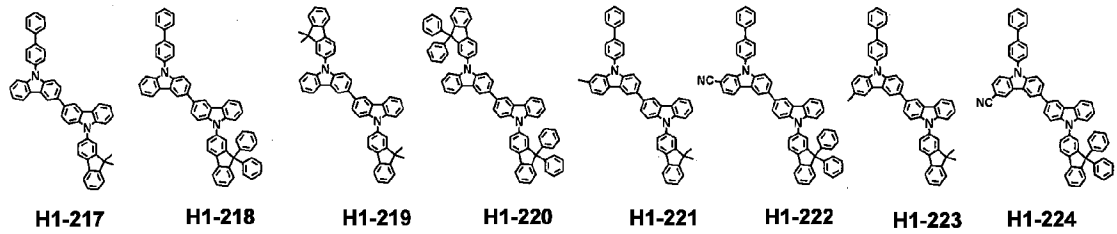

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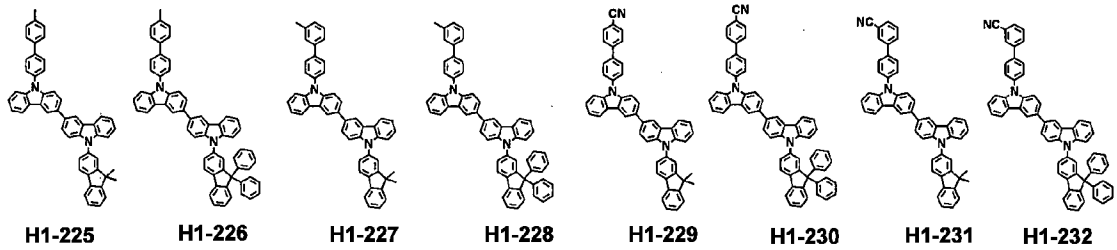

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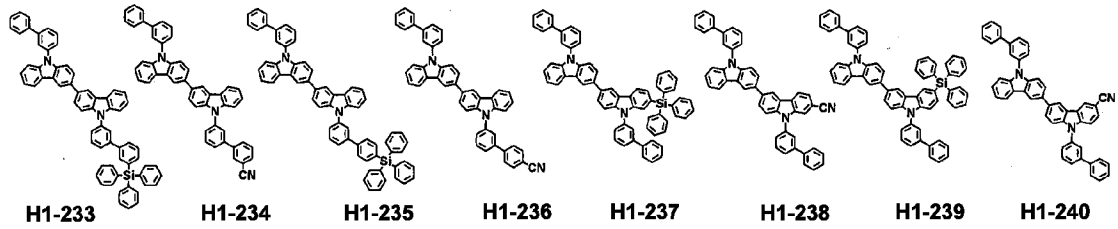

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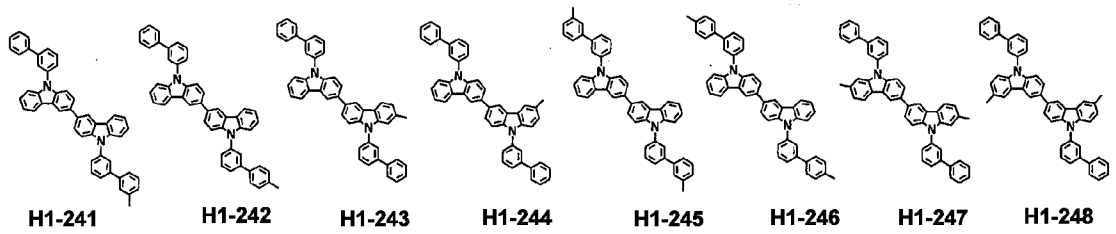

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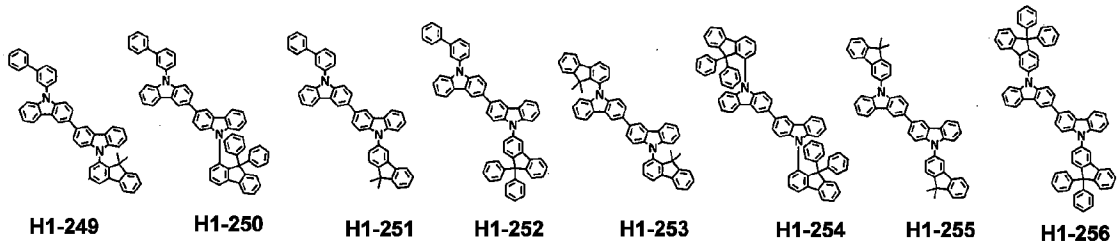
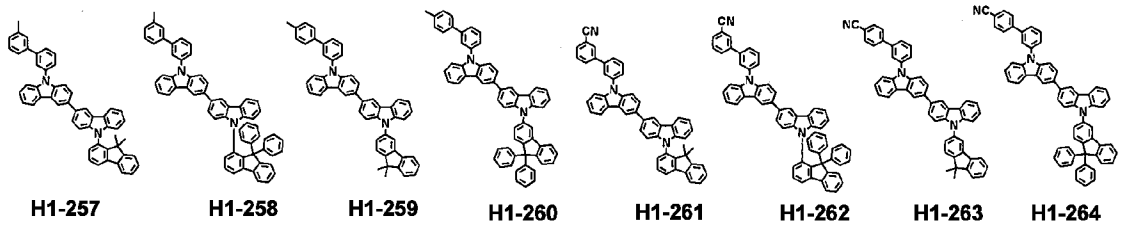


[91]



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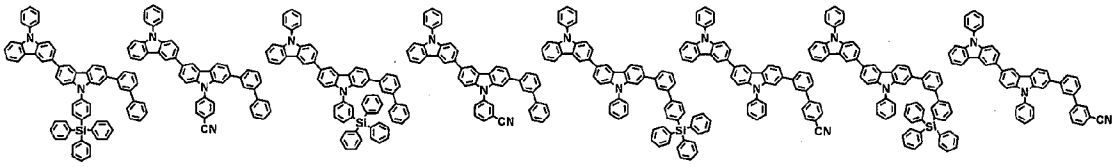
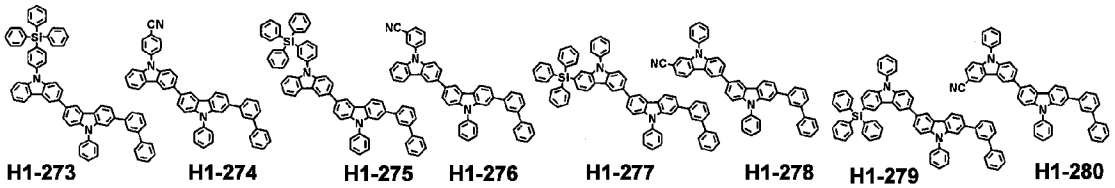


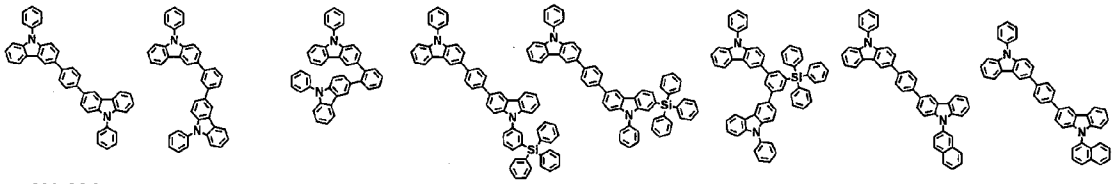
H1-265 H1-266 H1-267 H1-268 H1-269 H1-270 H1-271 H1-272

[93]



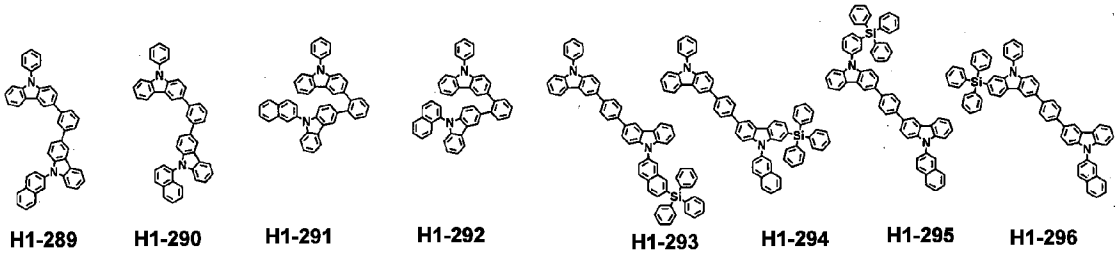
H1-273 H1-274 H1-275 H1-276 H1-277 H1-278 H1-279 H1-280

[94]



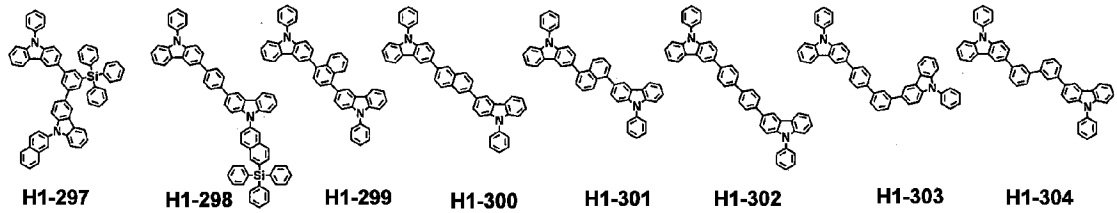
H1-281 H1-282 H1-283 H1-284 H1-285 H1-286 H1-287 H1-288

[95]



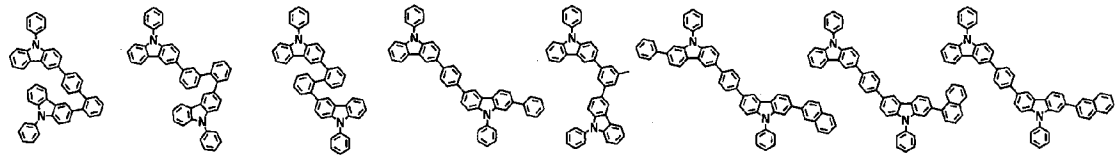
H1-289 H1-290 H1-291 H1-292 H1-293 H1-294 H1-295 H1-296

[96]



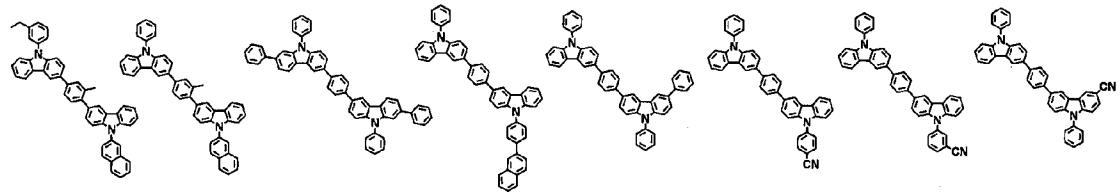
H1-297 H1-298 H1-299 H1-300 H1-301 H1-302 H1-303 H1-304

[97]



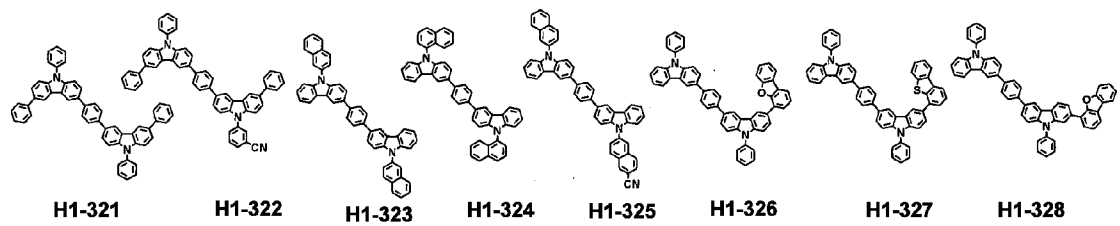
H1-305 H1-306 H1-307 H1-308 H1-309 H1-310 H1-311 H1-312

[98]



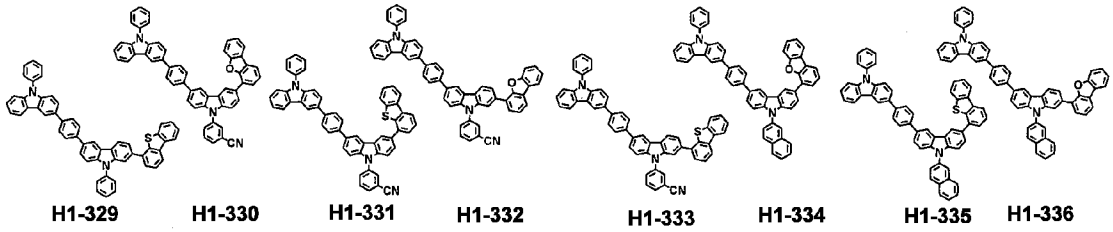
H1-313 H1-314 H1-315 H1-316 H1-317 H1-318 H1-319 H1-320

[99]



H1-321 H1-322 H1-323 H1-324 H1-325 H1-326 H1-327 H1-328

[100]



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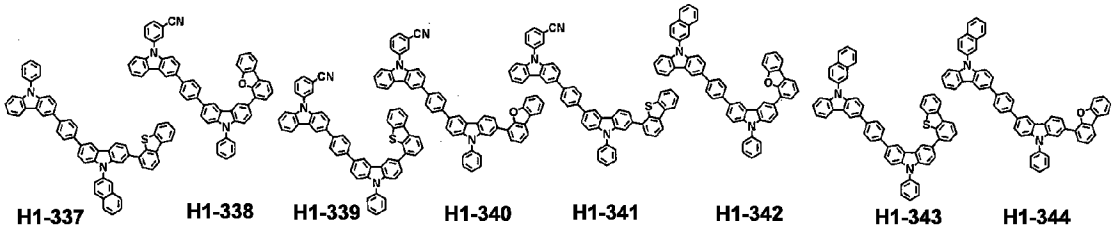

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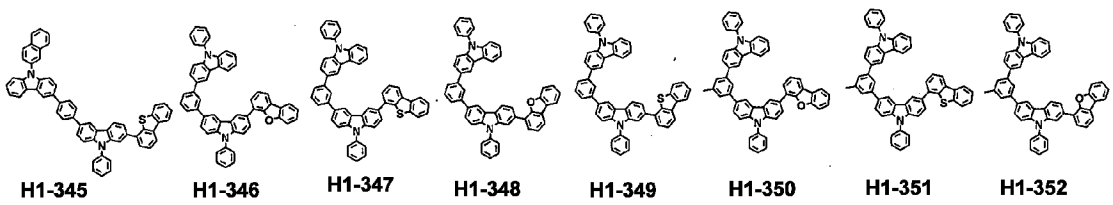

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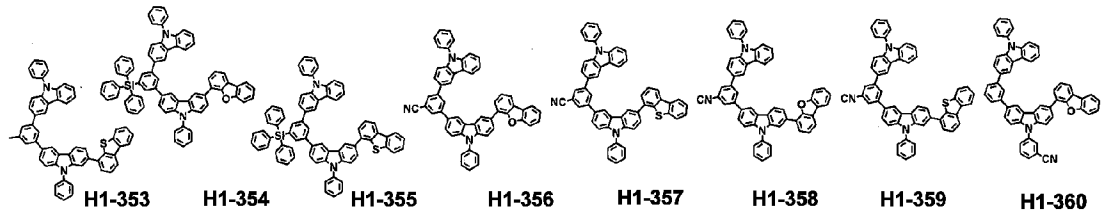
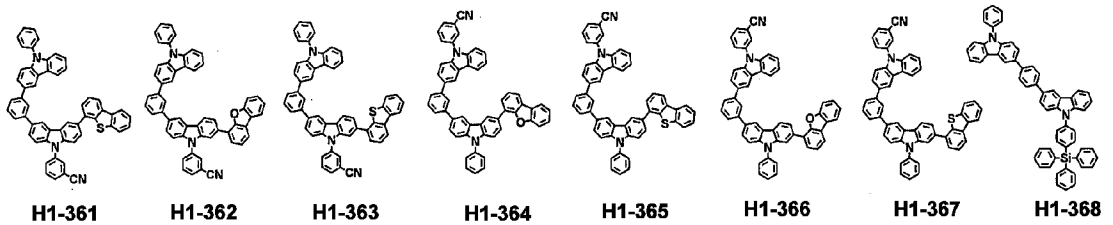


[104]



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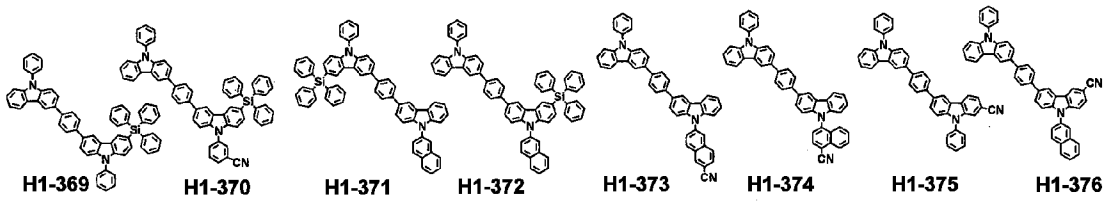

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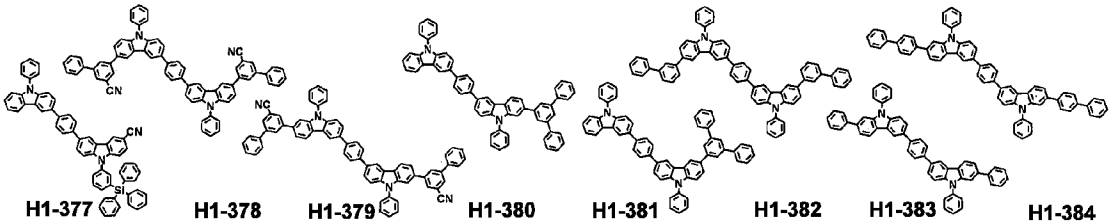
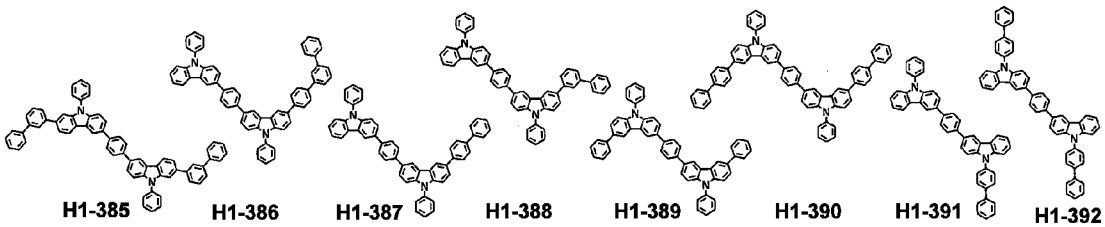
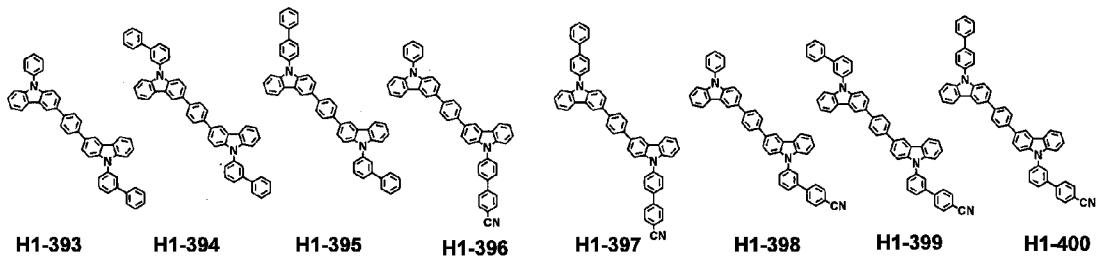


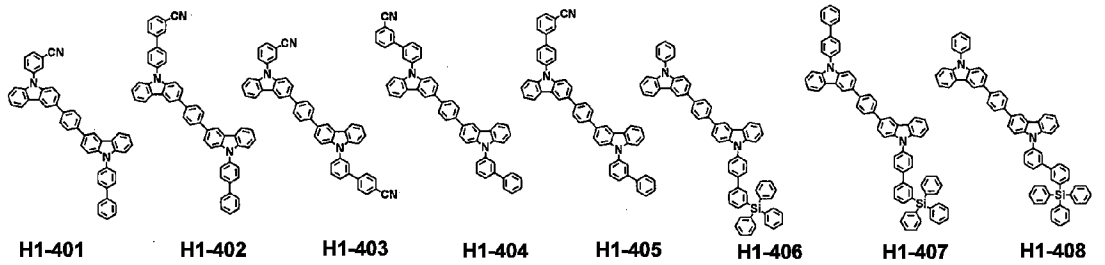
[107]



[108]



[109]



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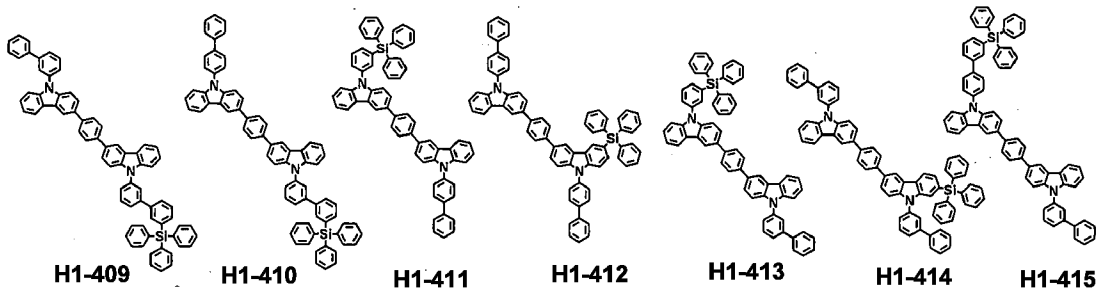

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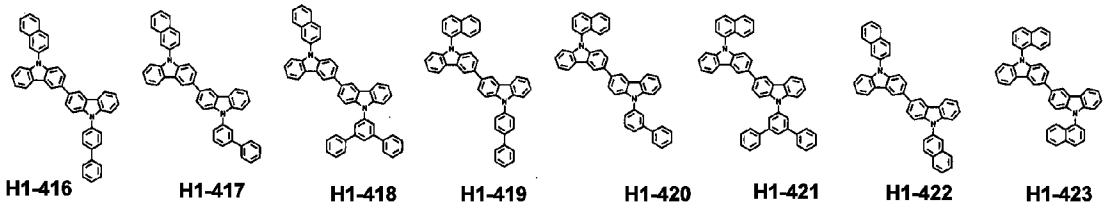
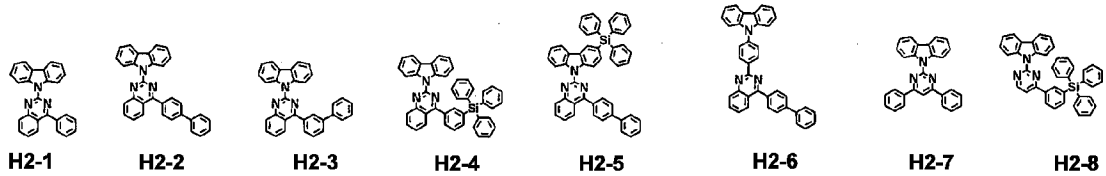
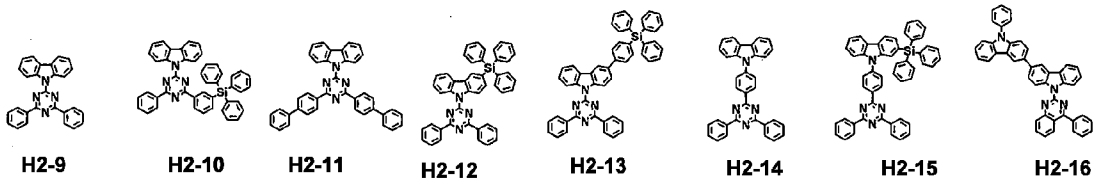


[112] The second host compound represented by formula 2 includes the following, but is not limited thereto:

[113]

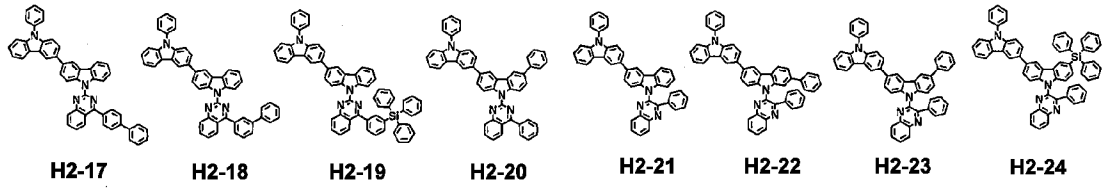


[114]



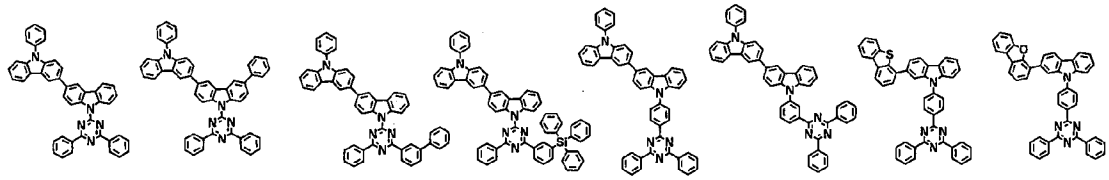
H2-9 H2-10 H2-11 H2-12 H2-13 H2-14 H2-15 H2-16

[115]



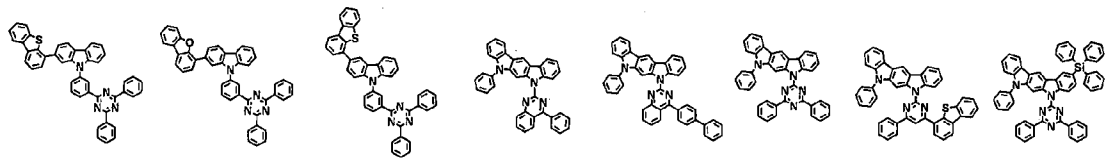
H2-17 H2-18 H2-19 H2-20 H2-21 H2-22 H2-23 H2-24

[116]



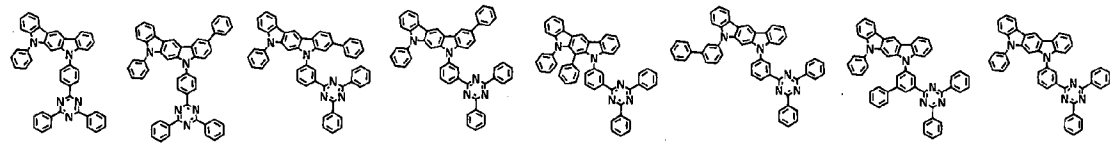
H2-25 H2-26 H2-27 H2-28 H2-29 H2-30 H2-31 H2-32

[117]



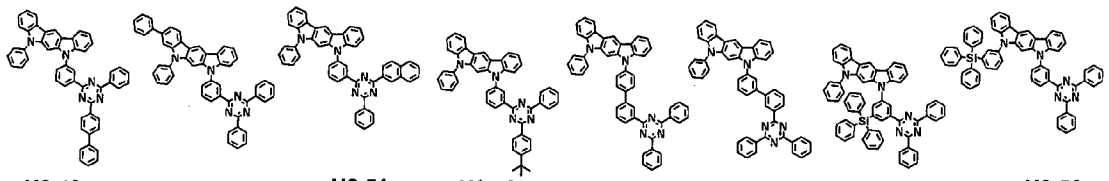
H2-33 H2-34 H2-35 H2-36 H2-37 H2-38 H2-39 H2-40

[118]



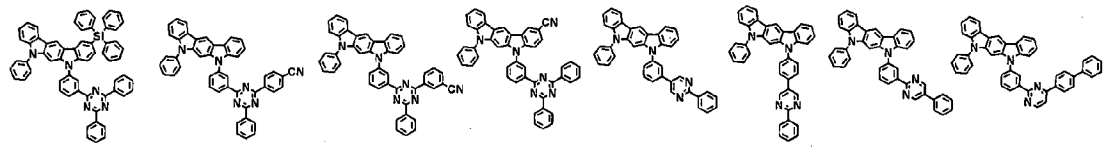
H2-41 H2-42 H2-43 H2-44 H2-45 H2-46 H2-47 H2-48

[119]



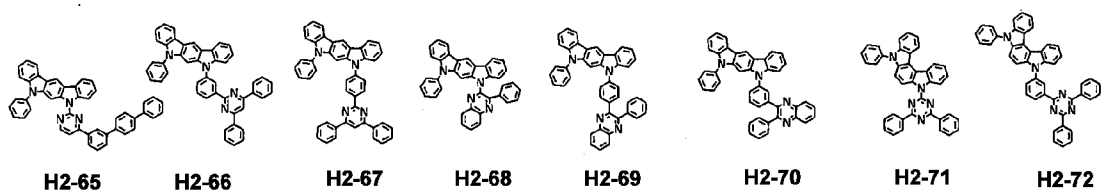
H2-49 H2-50 H2-51 H2-52 H2-53 H2-54 H2-55 H2-56

[120]



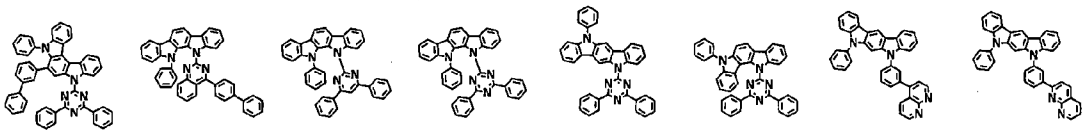
H2-57 H2-58 H2-59 H2-60 H2-61 H2-62 H2-63 H2-64

[121]



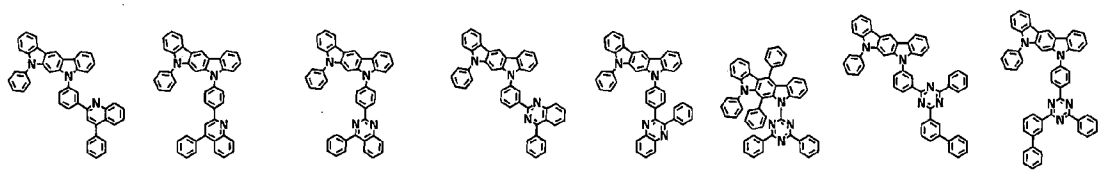
H2-65 H2-66 H2-67 H2-68 H2-69 H2-70 H2-71 H2-72

[122]



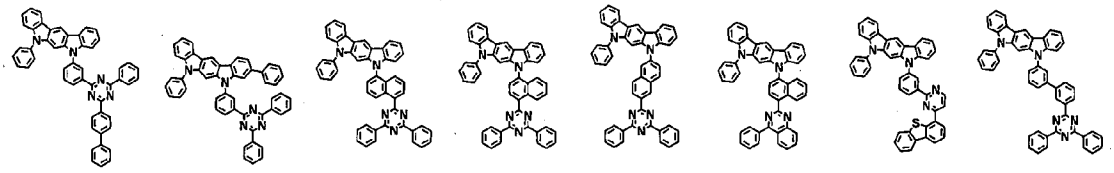
H2-73 H2-74 H2-75 H2-76 H2-77 H2-78 H2-79 H2-80

[123]



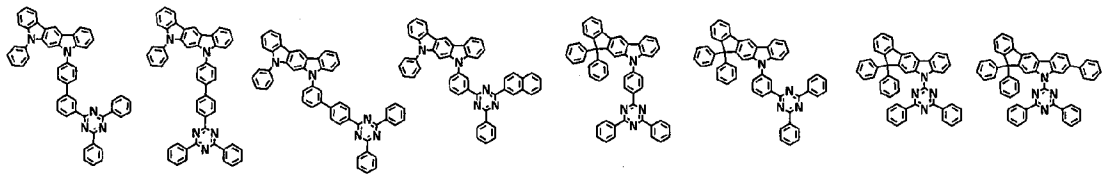
H2-81 H2-82 H2-83 H2-84 H2-85 H2-86 H2-87 H2-88

[124]



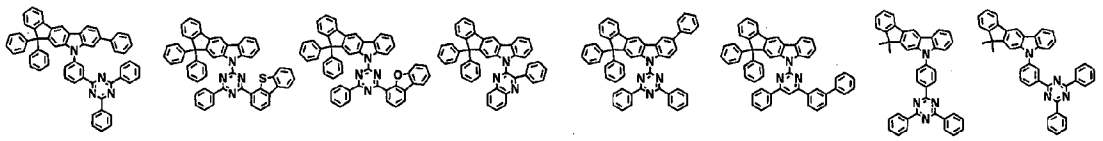
H2-89 H2-90 H2-91 H2-92 H2-93 H2-94 H2-95 H2-96

[125]



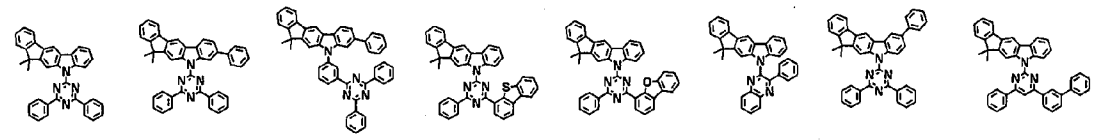
H2-97 H2-98 H2-99 H2-100 H2-101 H2-102 H2-103 H2-104

[126]



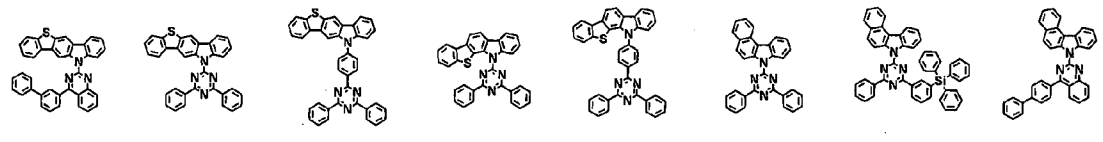
H2-105 H2-106 H2-107 H2-108 H2-109 H2-110 H2-111 H2-112

[127]



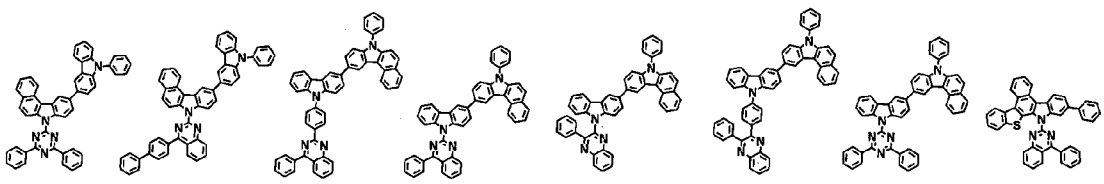
H2-113 H2-114 H2-115 H2-116 H2-117 H2-118 H2-119 H2-120

[128]



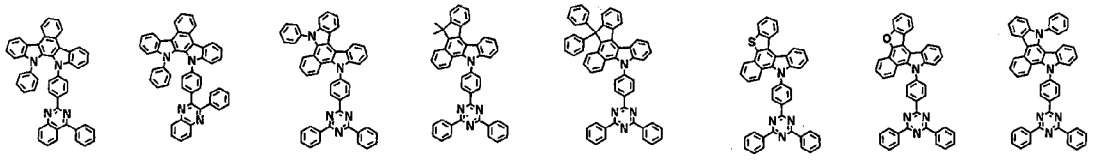
H2-121 H2-122 H2-123 H2-124 H2-125 H2-126 H2-127 H2-128

[129]



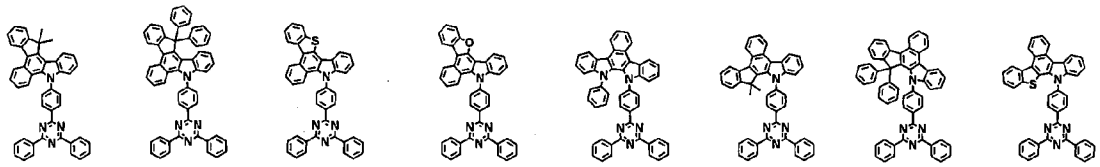
H2-129 H2-130 H2-131 H2-132 H2-133 H2-134 H2-135 H2-136

[130]



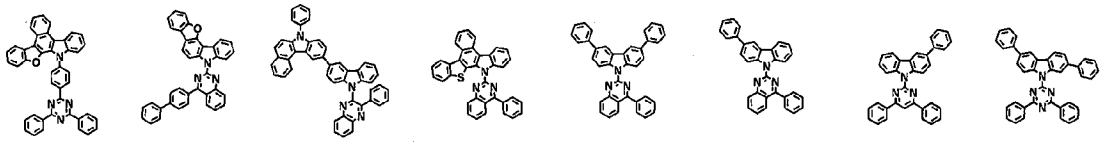
H2-137 H2-138 H2-139 H2-140 H2-141 H2-142 H2-143 H2-144

[131]



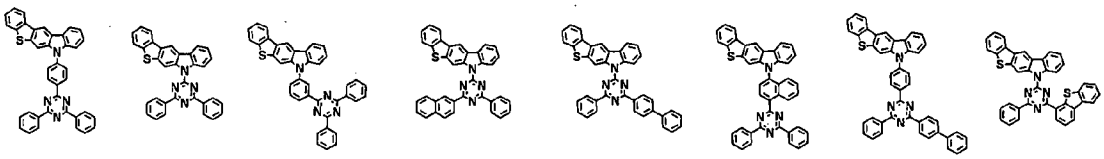
H2-145 H2-146 H2-147 H2-148 H2-149 H2-150 H2-151 H2-152

[132]



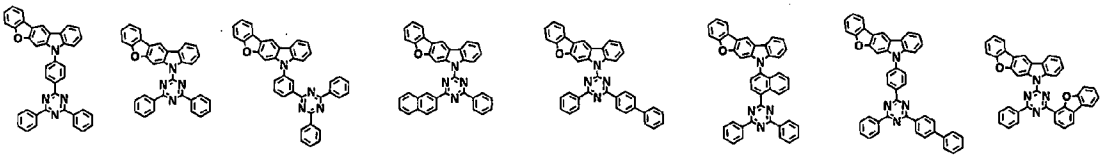
H2-153 H2-154 H2-155 H2-156 H2-157 H2-158 H2-159 H2-160

[133]



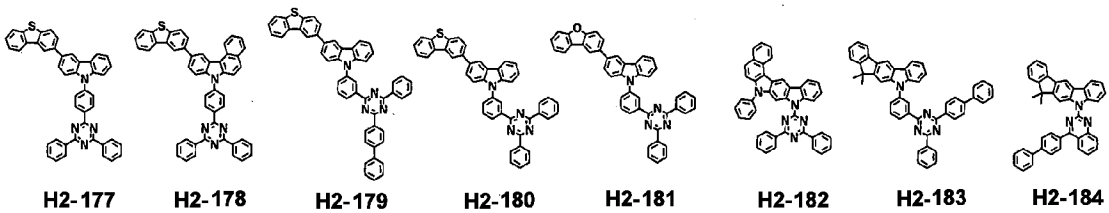
H2-161 H2-162 H2-163 H2-164 H2-165 H2-166 H2-167 H2-168

[134]



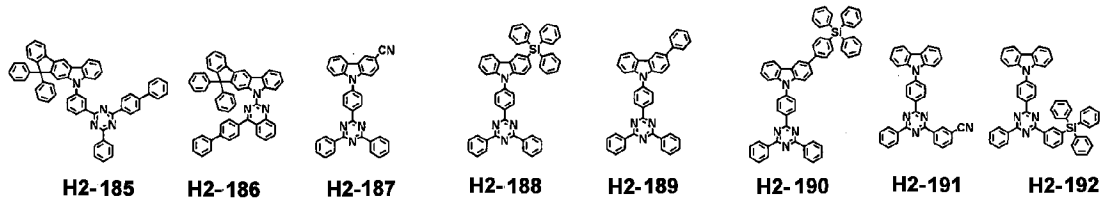
H2-169 H2-170 H2-171 H2-172 H2-173 H2-174 H2-175 H2-176

[135]



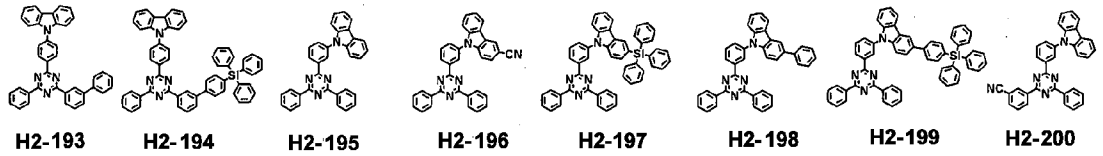
H2-177 H2-178 H2-179 H2-180 H2-181 H2-182 H2-183 H2-184

[136]



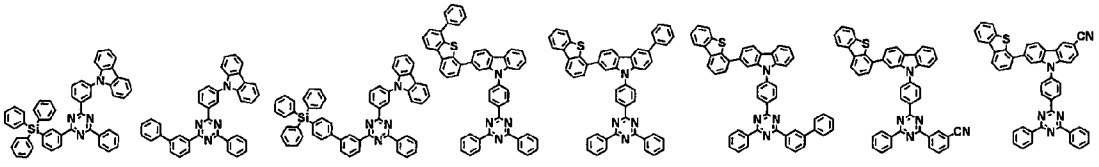
H2-185 H2-186 H2-187 H2-188 H2-189 H2-190 H2-191 H2-192

[137]



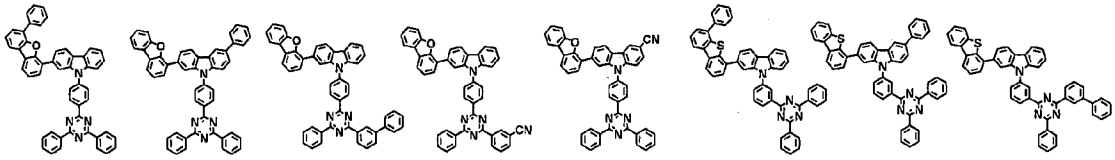
H2-193 H2-194 H2-195 H2-196 H2-197 H2-198 H2-199 H2-200

[138]



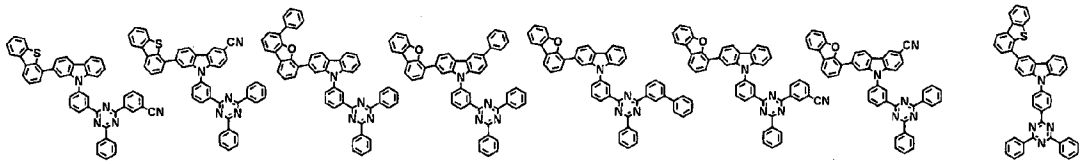
H2-201 H2-202 H2-203 H2-204 H2-205 H2-206 H2-207 H2-208

[139]



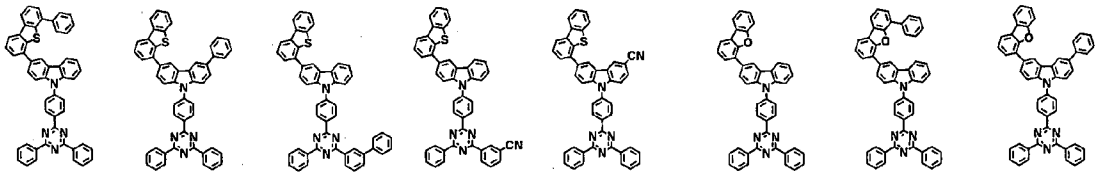
H2-209 H2-210 H2-211 H2-212 H2-213 H2-214 H2-215 H2-216

[140]



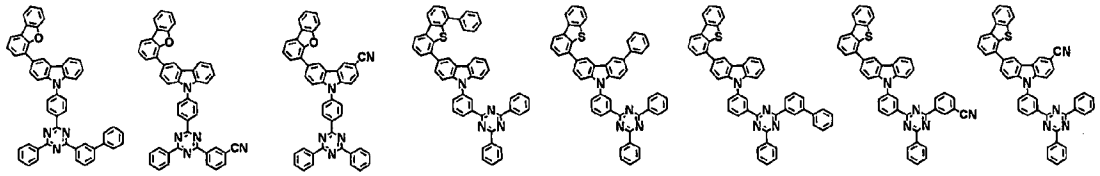
H2-217 H2-218 H2-219 H2-220 H2-221 H2-222 H2-223 H2-224

[141]



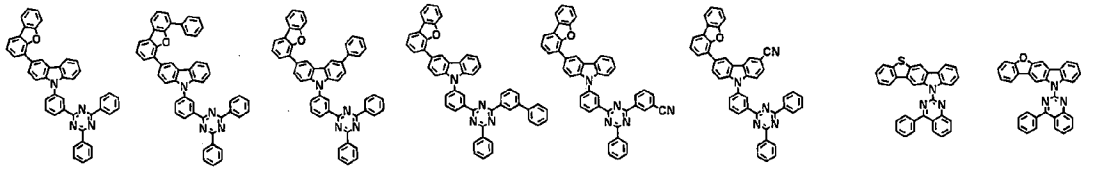
H2-225 H2-226 H2-227 H2-228 H2-229 H2-230 H2-231 H2-232

[142]



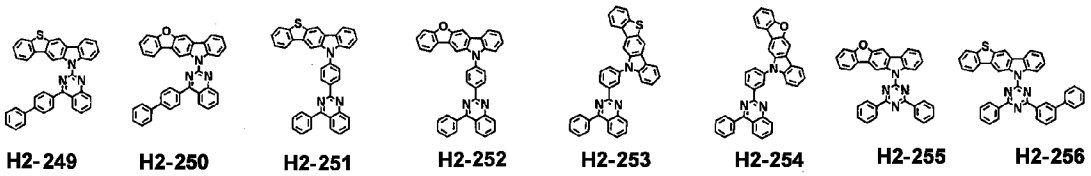
H2-233 H2-234 H2-235 H2-236 H2-237 H2-238 H2-239 H2-240

[143]



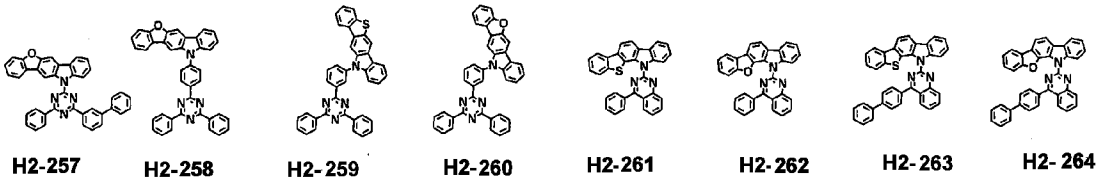
H2-241 H2-242 H2-243 H2-244 H2-245 H2-246 H2-247 H2-248

[144]



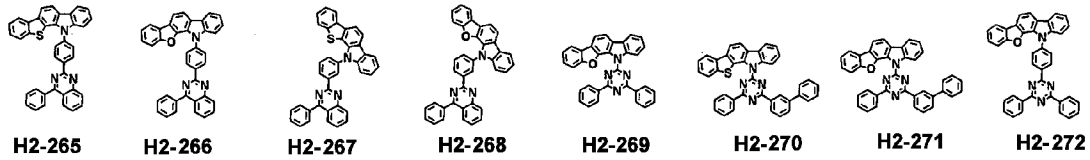
H2-249 H2-250 H2-251 H2-252 H2-253 H2-254 H2-255 H2-256

[145]



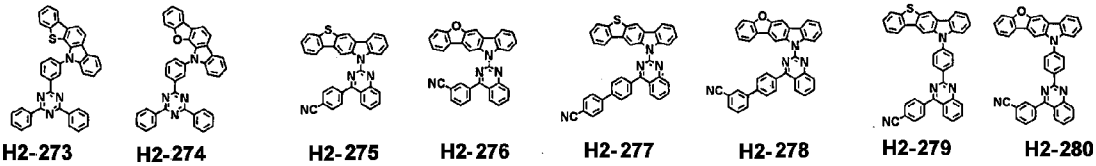
H2-257 H2-258 H2-259 H2-260 H2-261 H2-262 H2-263 H2-264

[146]



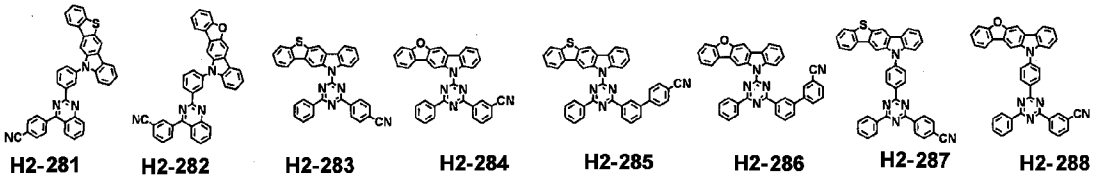
H2-265 H2-266 H2-267 H2-268 H2-269 H2-270 H2-271 H2-272

[147]



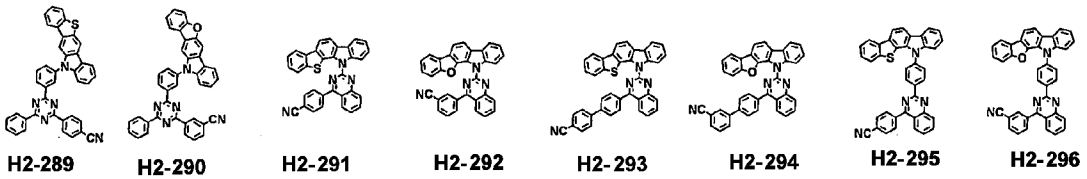
H2-273 H2-274 H2-275 H2-276 H2-277 H2-278 H2-279 H2-280

[148]



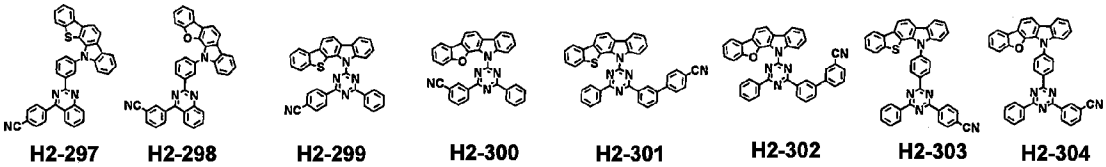
H2-281 H2-282 H2-283 H2-284 H2-285 H2-286 H2-287 H2-288

[149]



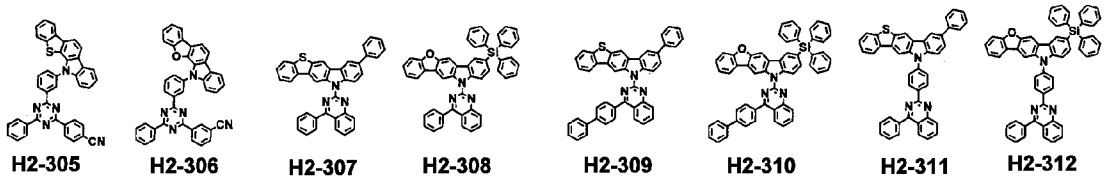
H2-289 H2-290 H2-291 H2-292 H2-293 H2-294 H2-295 H2-296

[150]



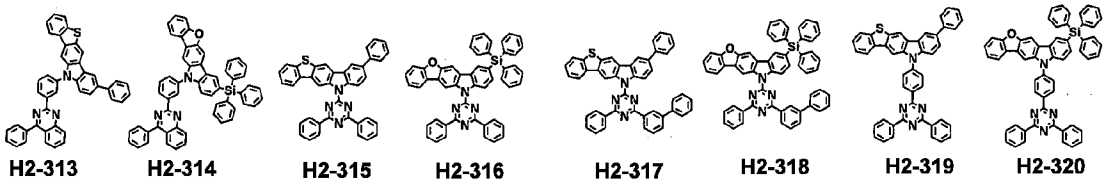
H2-297 H2-298 H2-299 H2-300 H2-301 H2-302 H2-303 H2-304

[151]



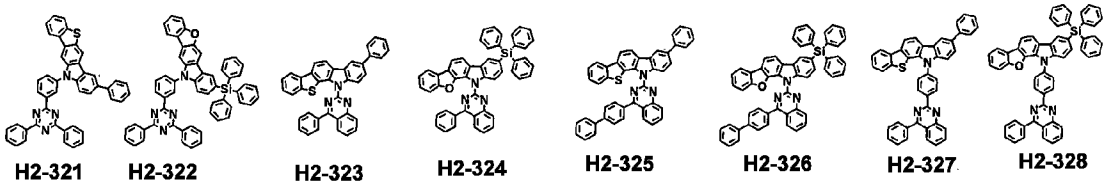
H2-305 H2-306 H2-307 H2-308 H2-309 H2-310 H2-311 H2-312

[152]



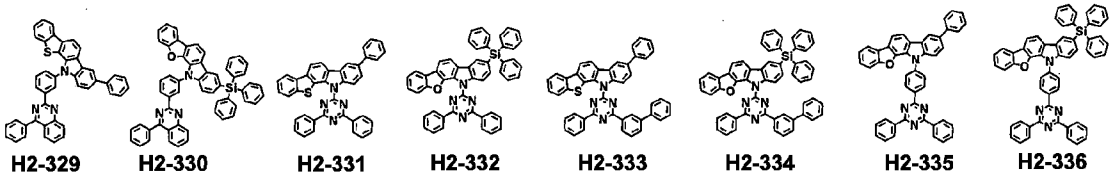
H2-313 H2-314 H2-315 H2-316 H2-317 H2-318 H2-319 H2-320

[153]



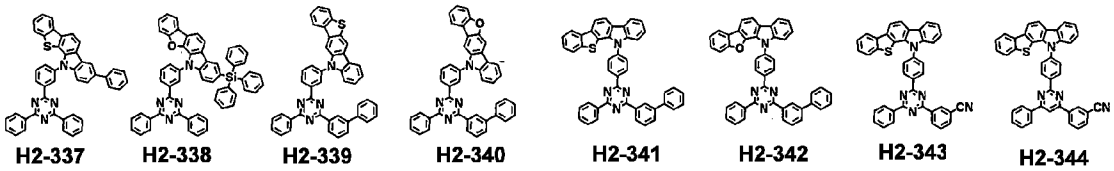
H2-321 H2-322 H2-323 H2-324 H2-325 H2-326 H2-327 H2-328

[154]



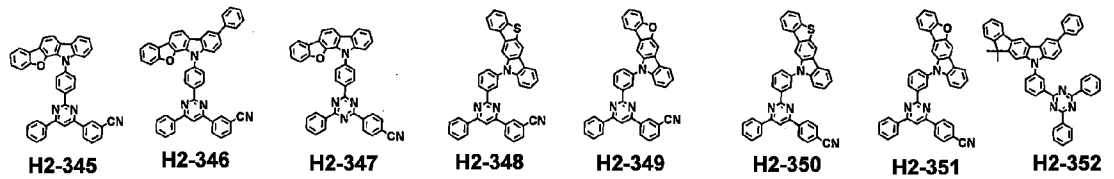
H2-329 H2-330 H2-331 H2-332 H2-333 H2-334 H2-335 H2-336

[155]



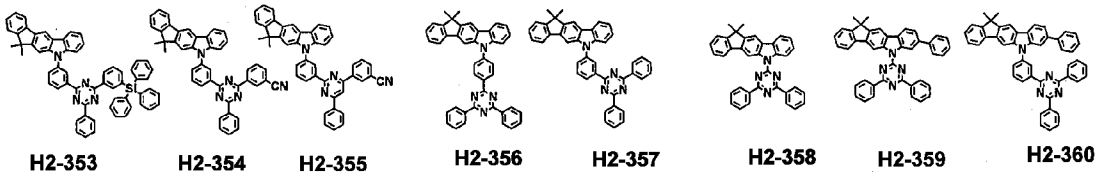
H2-337 H2-338 H2-339 H2-340 H2-341 H2-342 H2-343 H2-344

[156]



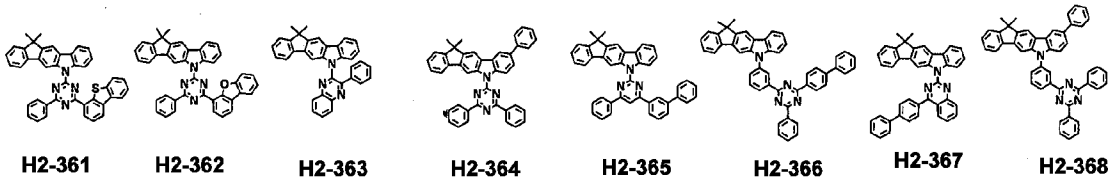
H2-345 H2-346 H2-347 H2-348 H2-349 H2-350 H2-351 H2-352

[157]



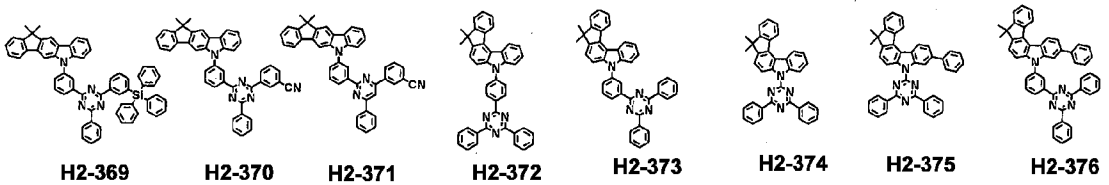
H2-353 H2-354 H2-355 H2-356 H2-357 H2-358 H2-359 H2-360

[158]



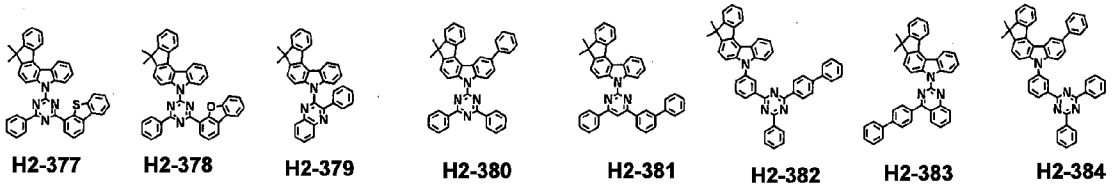
H2-361 H2-362 H2-363 H2-364 H2-365 H2-366 H2-367 H2-368

[159]



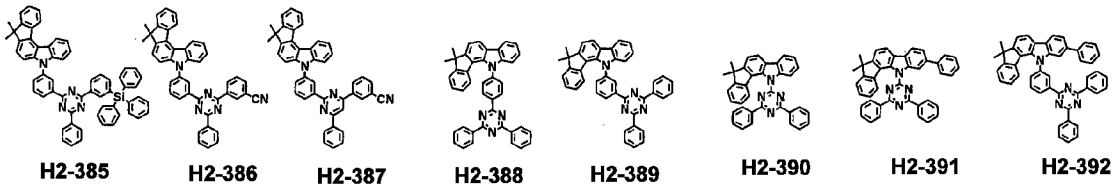
H2-369 H2-370 H2-371 H2-372 H2-373 H2-374 H2-375 H2-376

[160]



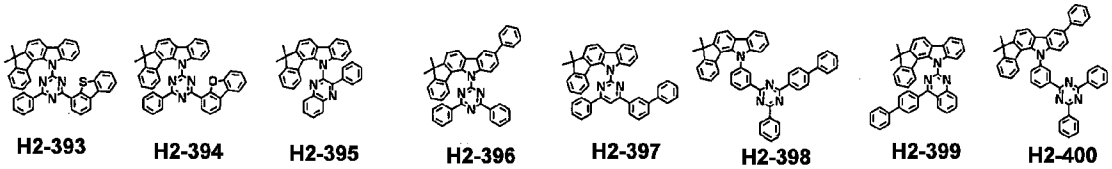
H2-377 H2-378 H2-379 H2-380 H2-381 H2-382 H2-383 H2-384

[161]



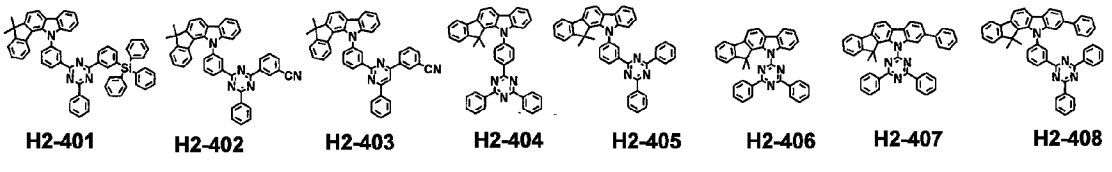
H2-385 H2-386 H2-387 H2-388 H2-389 H2-390 H2-391 H2-392

[162]



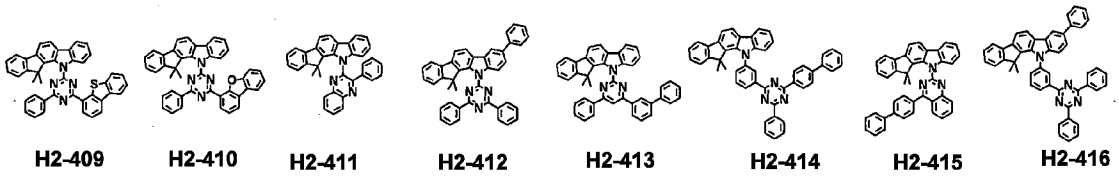
H2-393 H2-394 H2-395 H2-396 H2-397 H2-398 H2-399 H2-400

[163]



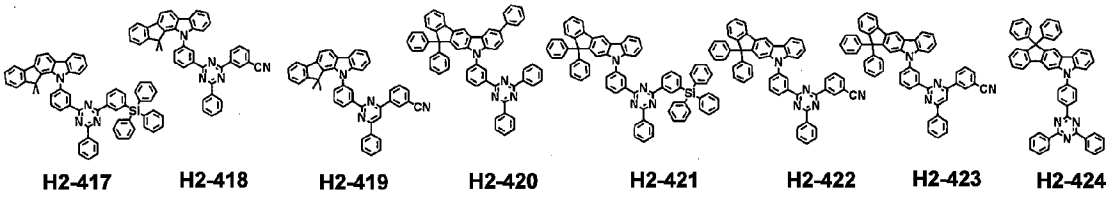
H2-401 H2-402 H2-403 H2-404 H2-405 H2-406 H2-407 H2-408

[164]



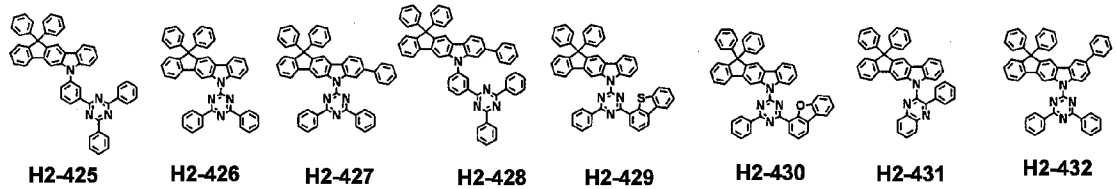
H2-409 H2-410 H2-411 H2-412 H2-413 H2-414 H2-415 H2-416

[165]



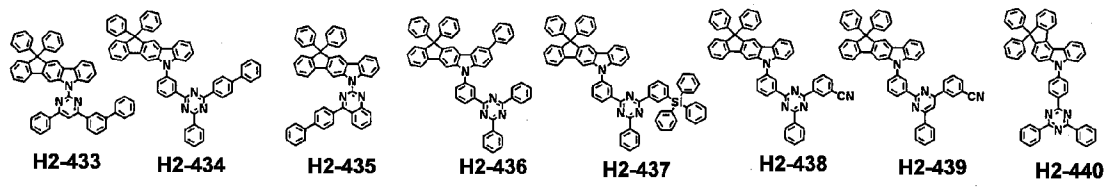
H2-417 H2-418 H2-419 H2-420 H2-421 H2-422 H2-423 H2-424

[166]



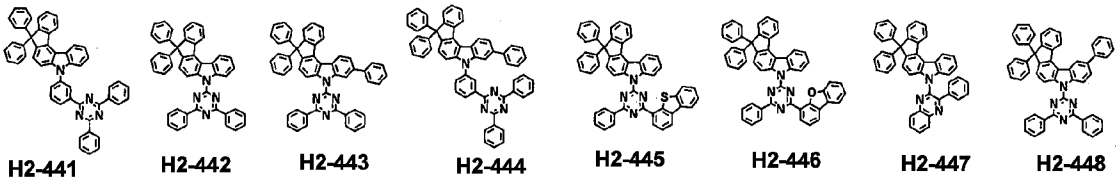
H2-425 H2-426 H2-427 H2-428 H2-429 H2-430 H2-431 H2-432

[167]



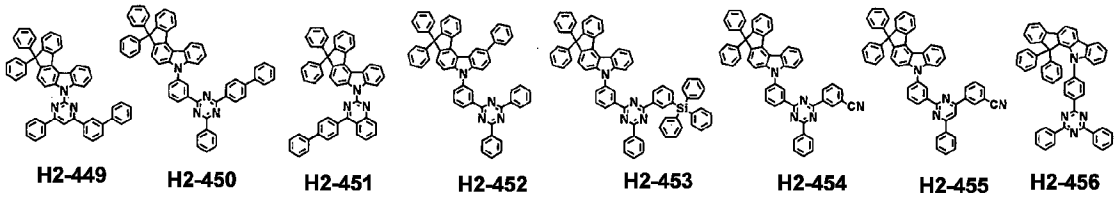
H2-433 H2-434 H2-435 H2-436 H2-437 H2-438 H2-439 H2-440

[168]



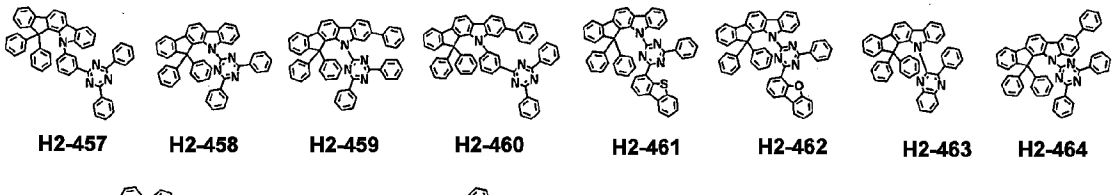
H2-441 H2-442 H2-443 H2-444 H2-445 H2-446 H2-447 H2-448

[169]



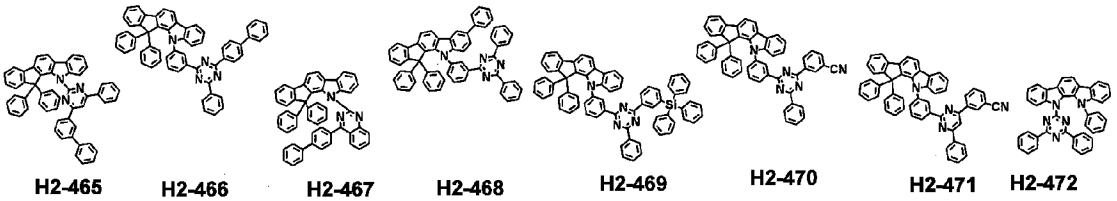
H2-449 H2-450 H2-451 H2-452 H2-453 H2-454 H2-455 H2-456

[170]



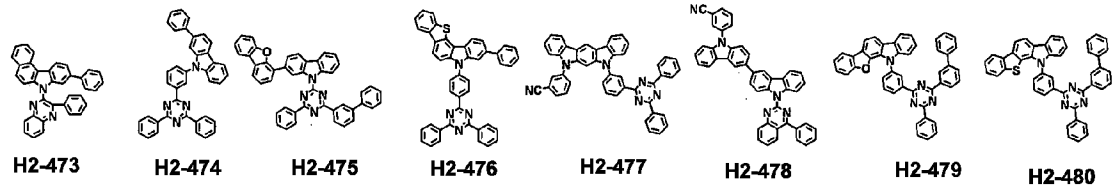
H2-457 H2-458 H2-459 H2-460 H2-461 H2-462 H2-463 H2-464

[171]



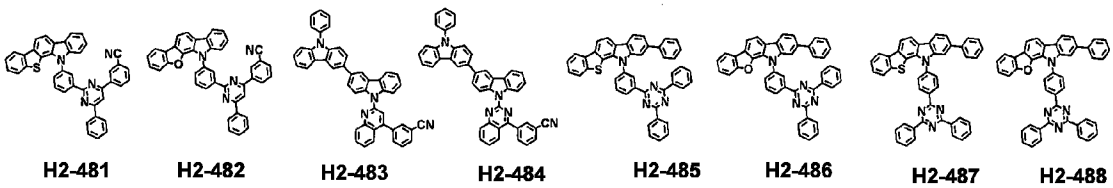
H2-465 H2-466 H2-467 H2-468 H2-469 H2-470 H2-471 H2-472

[172]



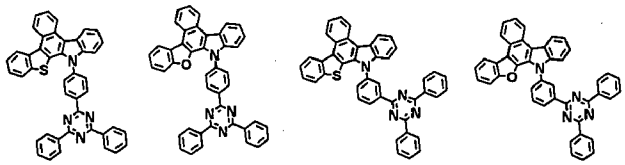
H2-473 H2-474 H2-475 H2-476 H2-477 H2-478 H2-479 H2-480

[173]



H2-481 H2-482 H2-483 H2-484 H2-485 H2-486 H2-487 H2-488

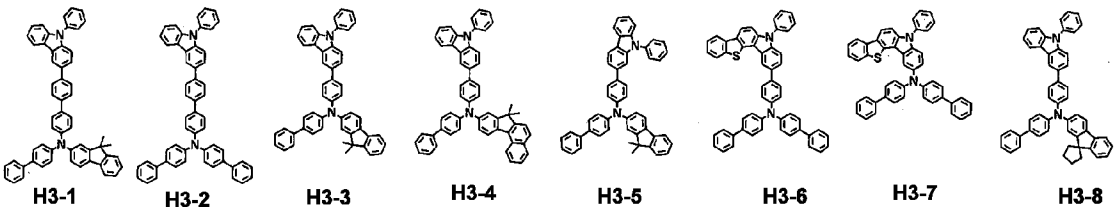
[174]



H2-489 H2-490 H2-491 H2-492

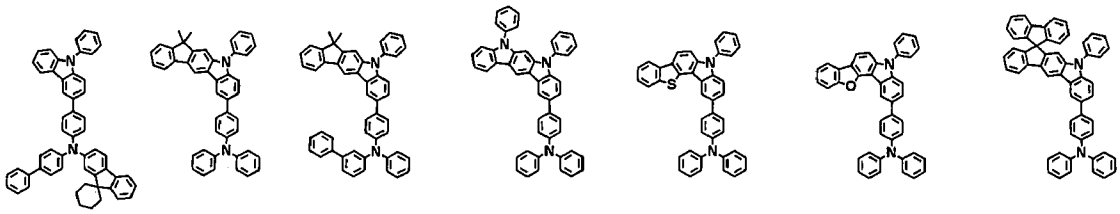
[175] The hole transport compound represented by formula 3 includes the following, but is not limited thereto:

[176]



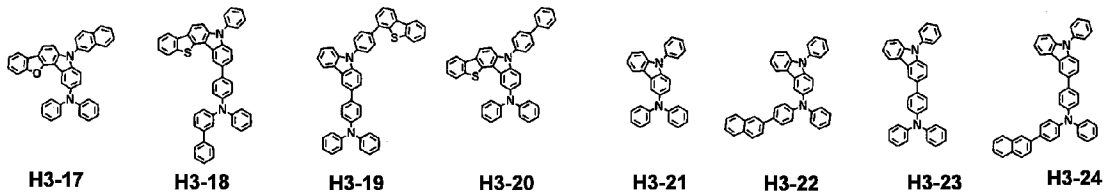
H3-1 H3-2 H3-3 H3-4 H3-5 H3-6 H3-7 H3-8

[177]



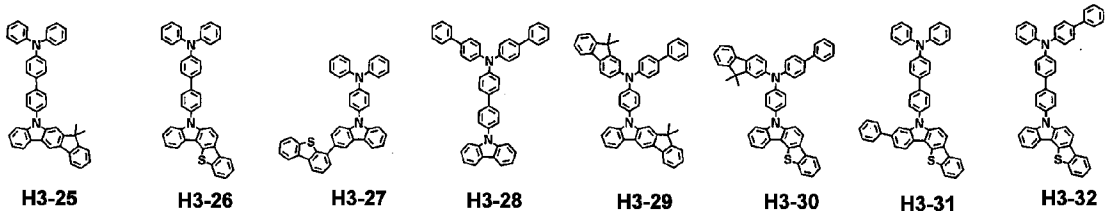
H3-9 H3-10 H3-11 H3-12 H3-13 H3-14 H3-15

[178]



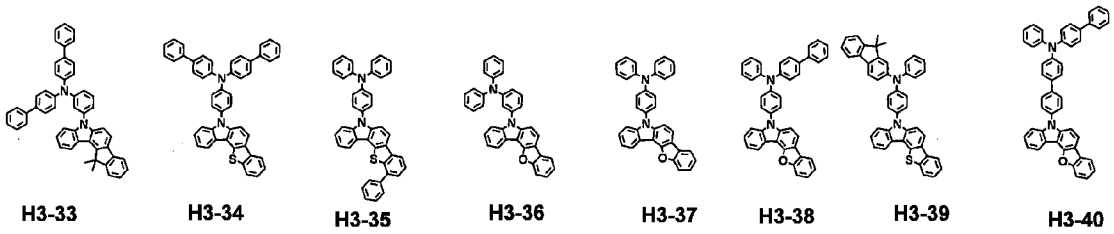
H3-17 H3-18 H3-19 H3-20 H3-21 H3-22 H3-23 H3-24

[179]

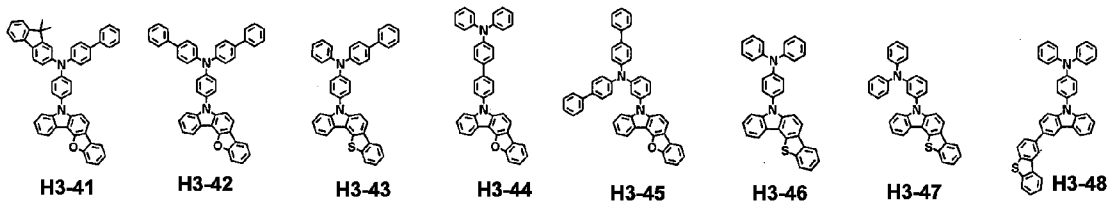


H3-25 H3-26 H3-27 H3-28 H3-29 H3-30 H3-31 H3-32

[180]



[181]



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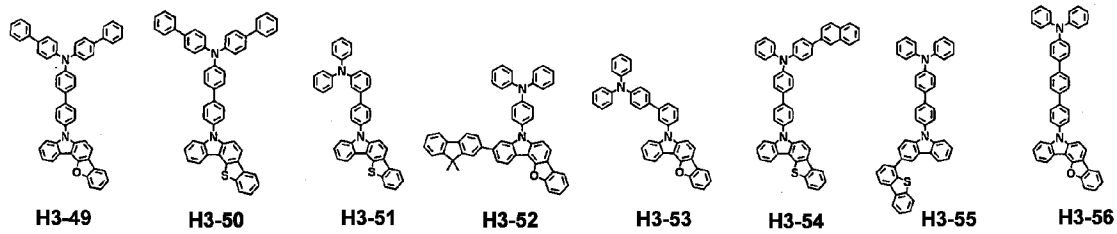

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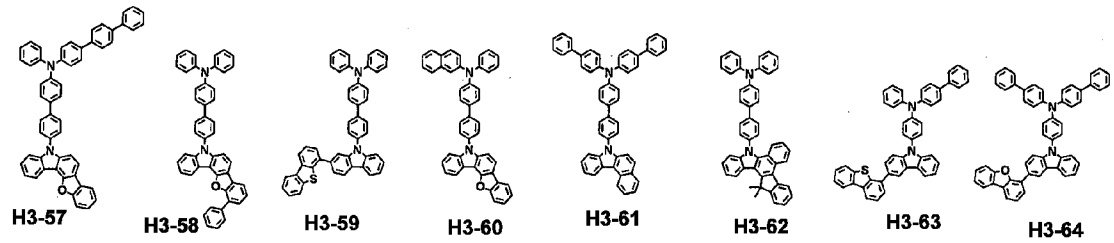

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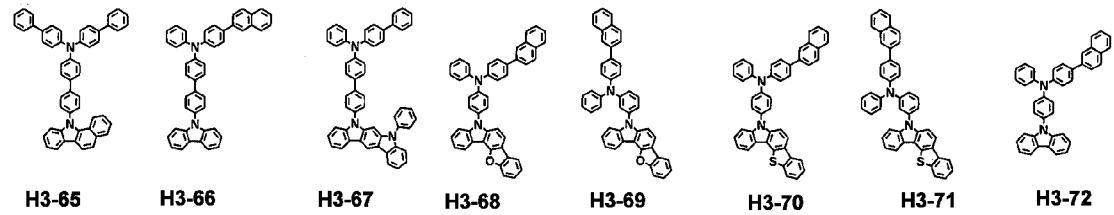

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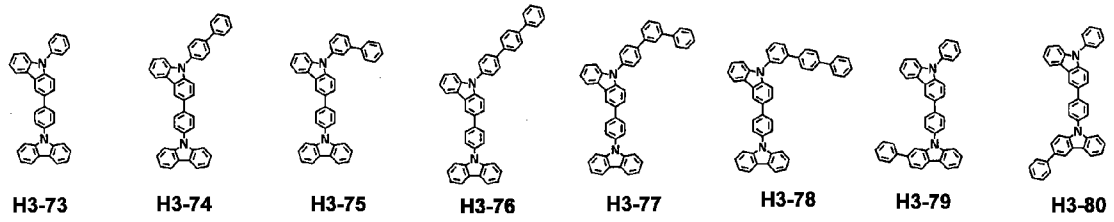

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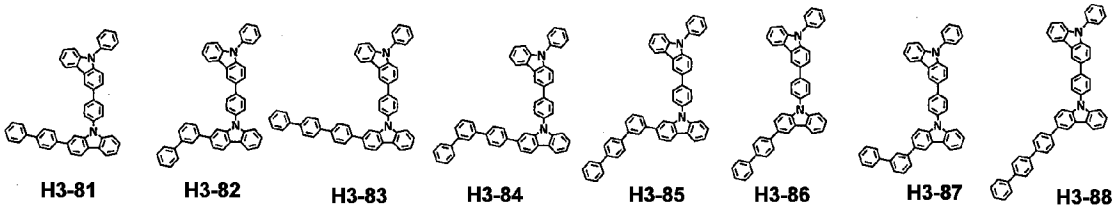

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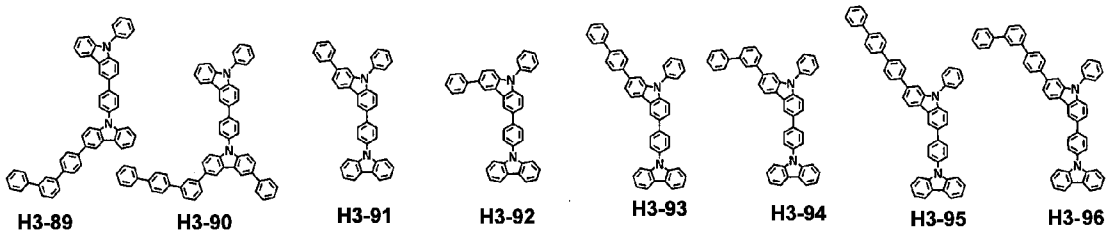
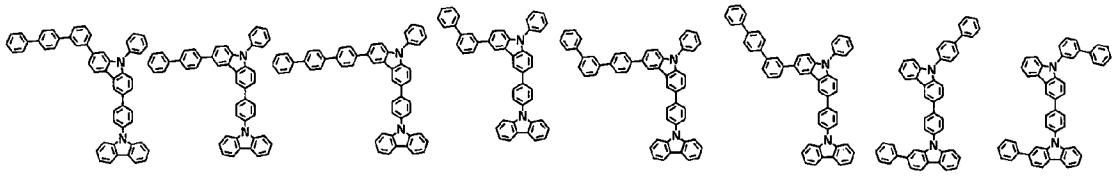


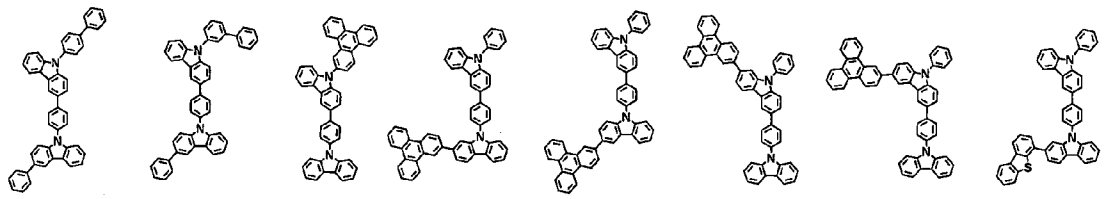
H3-89 H3-90 H3-91 H3-92 H3-93 H3-94 H3-95 H3-96

[188]



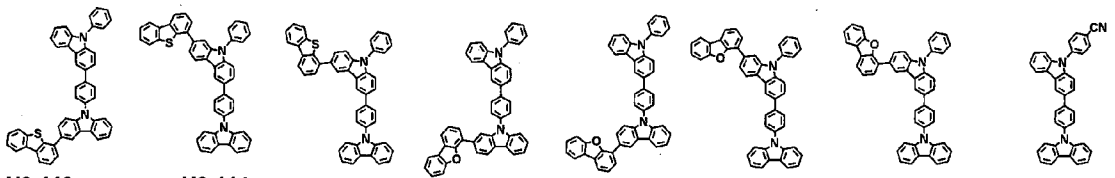
H3-97 H3-98 H3-99 H3-100 H3-101 H3-102 H3-103 H3-104

[189]



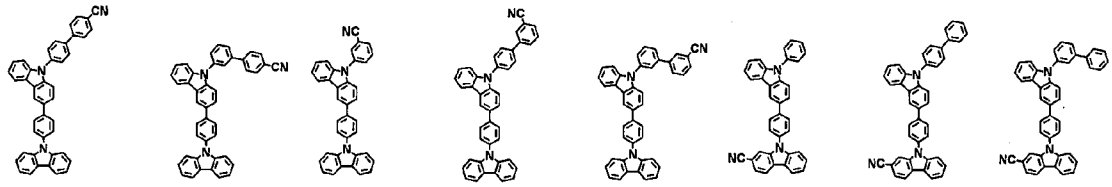
H3-105 H3-106 H3-107 H3-108 H3-109 H3-110 H3-111 H3-112

[190]



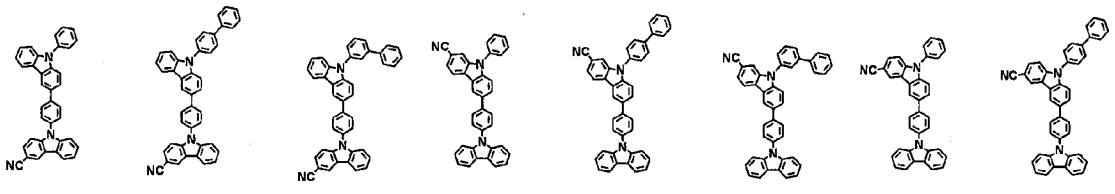
H3-113 H3-114 H3-115 H3-116 H3-117 H3-118 H3-119 H3-120

[191]



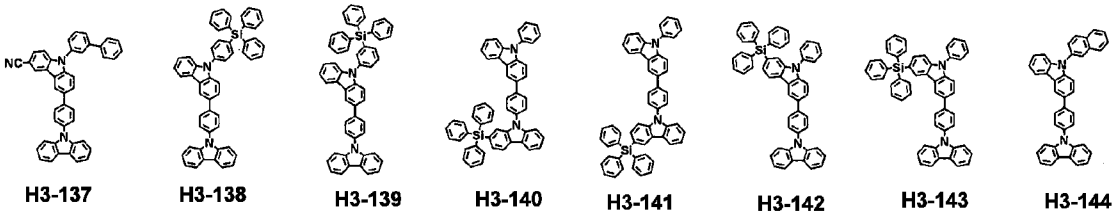
H3-121 H3-122 H3-123 H3-124 H3-125 H3-126 H3-127 H3-128

[192]



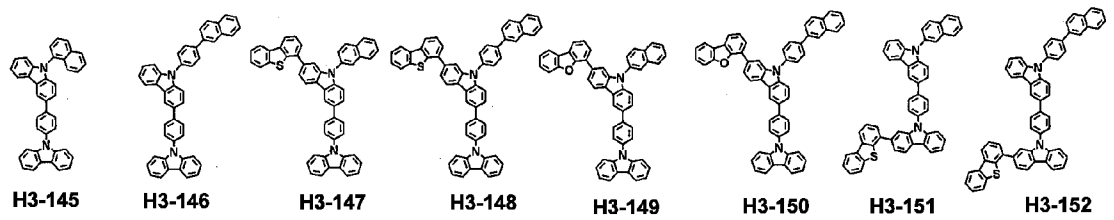
H3-129 H3-130 H3-131 H3-132 H3-133 H3-134 H3-135 H3-136

[193]



H3-137 H3-138 H3-139 H3-140 H3-141 H3-142 H3-143 H3-144

[194]



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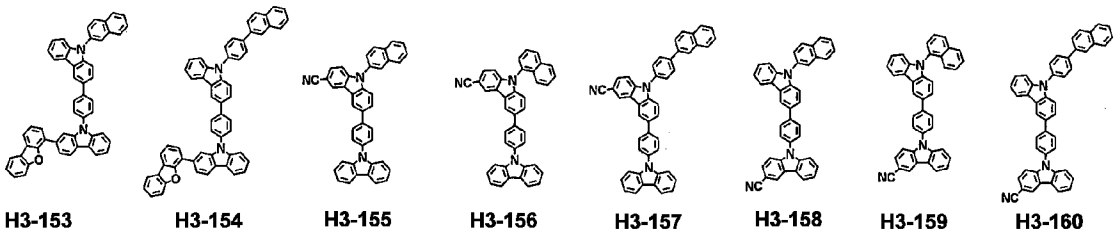

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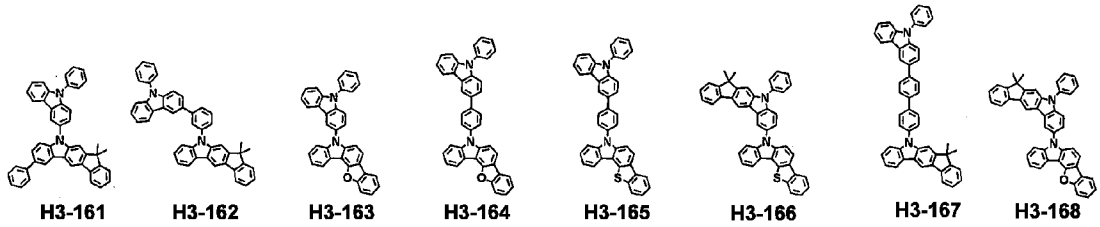

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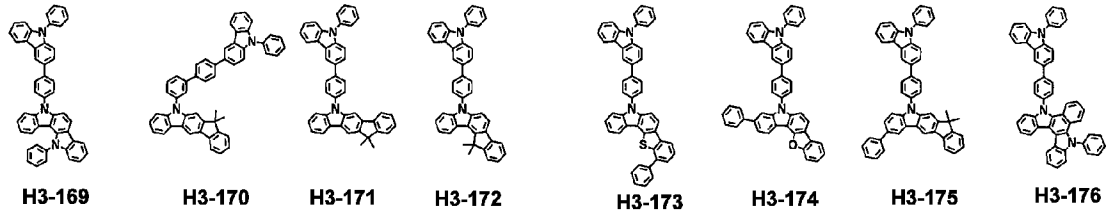

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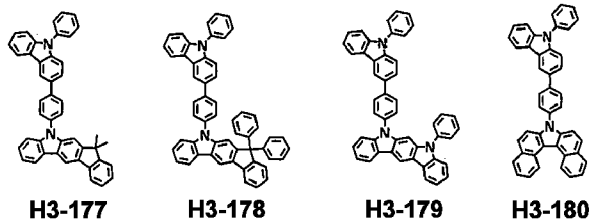


[199] The organic electroluminescent device of the present invention comprises an anode, a cathode, and an organic layer between the anode and the cathode, wherein the organic layer comprises one or more light-emitting layers and one or more hole transport layers; at least one of the one or more light-emitting layers comprises one or more dopant compounds and two or more host compounds; a first host compound of the host compounds is represented by formula 1; a second host compound is represented by formula 2; and at least one of the one or more hole transport layers comprises the compound represented by formula 3.

[200] The light-emitting layer indicates a layer from which light is emitted. It is preferable that a doping amount of the dopant compound is less than 20 wt% based on the total amount of the host compound and the dopant compound in a light-emitting layer. In the organic electroluminescent device of the present invention, the weight ratio in the

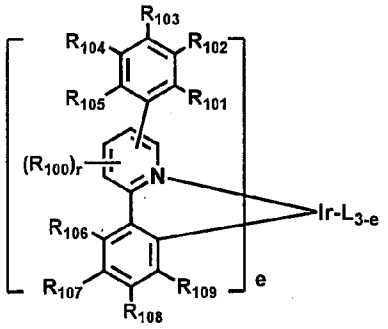
light-emitting layer between the first host material and the second host material may be in the range of 1:99 to 99:1.

[201] In addition to the light-emitting layer and the hole transport layer, the organic layer may comprise at least one layer selected from a hole injection layer, an electron transport layer, an electron injection layer, an electron buffering layer, an interlayer, a hole blocking layer, and an electron blocking layer.

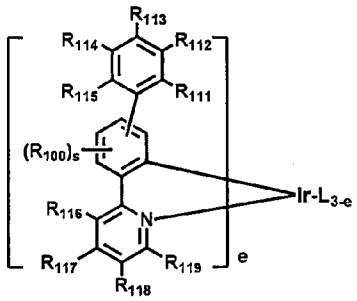
[202] The dopant to be comprised in the organic electroluminescent device of the present invention is preferably at least one phosphorescent dopant. The phosphorescent dopant material for the organic electroluminescent device of the present invention is not limited, but may be preferably selected from metallated complex compounds of iridium (Ir), osmium (Os), copper (Cu) or platinum (Pt), more preferably selected from ortho-metallated complex compounds of iridium (Ir), osmium (Os), copper (Cu) or platinum (Pt), and even more preferably ortho-metallated iridium complex compounds.

[203] Preferably, the phosphorescent dopant may be selected from the group consisting of compounds represented by the following formulae 101 to 103.

[204]

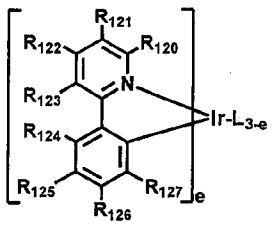


(101)



(102)

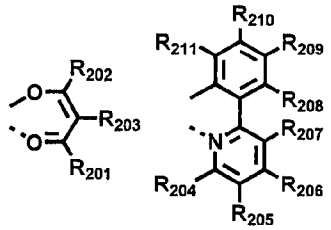
[205]



(103)

[206] wherein L is selected from the following structures:

[207]



[208] R_{100} represents hydrogen, a substituted or unsubstituted (C1-C30)alkyl, or a substituted or unsubstituted (C3-C30)cycloalkyl;

[209] R_{101} to R_{109}, and R_{111} to R_{123}, each independently, represent hydrogen, deuterium, a

halogen, a (C1-C30)alkyl unsubstituted or substituted with deuterium or a halogen(s), a substituted or unsubstituted (C6-C30)aryl, a cyano, a substituted or unsubstituted (C1-C30)alkoxy, or a substituted or unsubstituted (C3-C30)cycloalkyl; adjacent substituents of R_{106} to R_{109} may be linked to each other to form a substituted or unsubstituted fused ring, e.g., fluorene unsubstituted or substituted with alkyl, dibenzothiophene unsubstituted or substituted with alkyl, or dibenzofuran unsubstituted or substituted with alkyl; adjacent substituents of R_{120} to R_{123} may be linked to each other to form a substituted or unsubstituted fused ring, e.g., quinoline unsubstituted or substituted with halogen, alkyl, or aryl;

[210] R_{124} to R_{127}, each independently, represent hydrogen, deuterium, a halogen, a substituted or unsubstituted (C1-C30)alkyl, or a substituted or unsubstituted (C6-C30)aryl; and adjacent substituents of R_{124} to R_{127} may be linked to each other to form a substituted or unsubstituted fused ring, e.g., fluorene unsubstituted or substituted with alkyl, dibenzothiophene unsubstituted or substituted with alkyl, or dibenzofuran unsubstituted or substituted with alkyl;

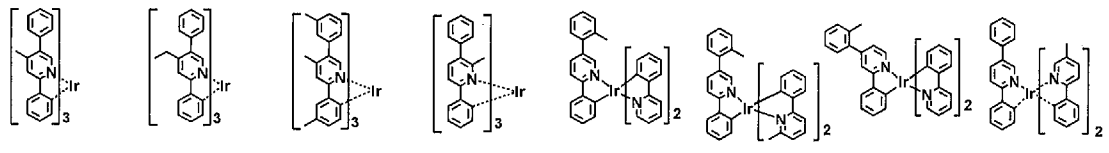
[211] R_{201} to R_{211}, each independently, represent hydrogen, deuterium, a halogen, a (C1-C30)alkyl unsubstituted or substituted with deuterium or a halogen(s), a substituted or unsubstituted (C3-C30)cycloalkyl, or a substituted or unsubstituted (C6-C30)aryl; and adjacent substituents of R_{208} to R_{211} may be linked to each other to form a substituted or unsubstituted fused ring, e.g., fluorene unsubstituted or substituted with alkyl, dibenzothiophene unsubstituted or substituted with alkyl, or dibenzofuran unsubstituted or substituted with alkyl;

[212] r and s, each independently, represent an integer of 1 to 3; when r or s is an integer of 2 or more, each of R_{100} may be the same or different; and

[213] e represents an integer of 1 to 3.

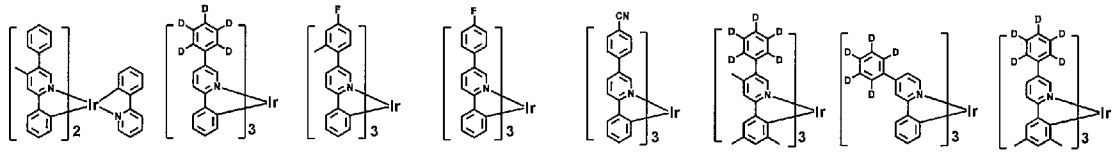
[214] Specifically, the phosphorescent dopant material includes the following:

[215]



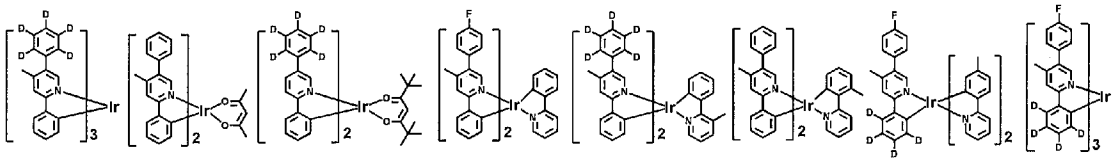
D-1 D-2 D-3 D-4 D-5 D-6 D-7 D-8

[216]



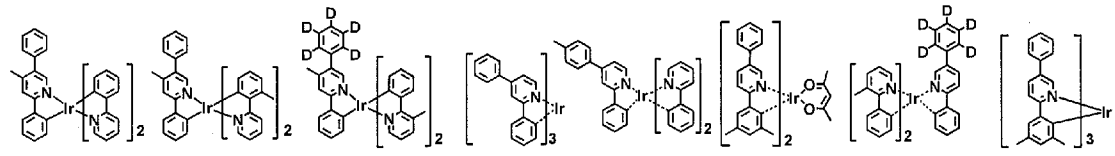
D-9 D-10 D-11 D-12 D-13 D-14 D-15 D-16

[217]



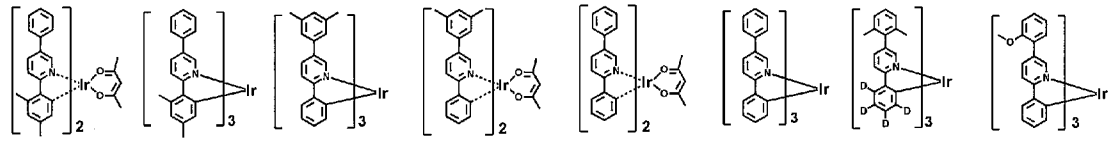
D-17 D-18 D-19 D-20 D-21 D-22 D-23 D-24

[218]



D-25 D-26 D-27 D-28 D-29 D-30 D-31 D-32

[219]



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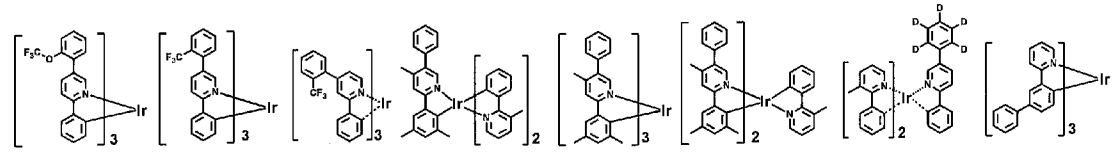
[220]



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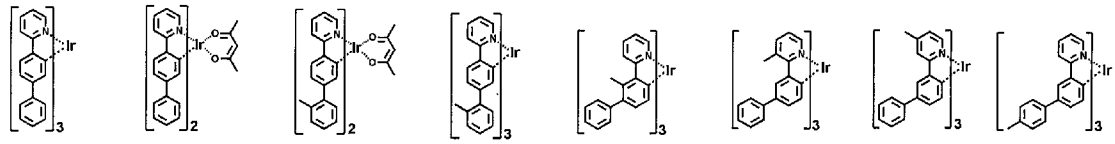
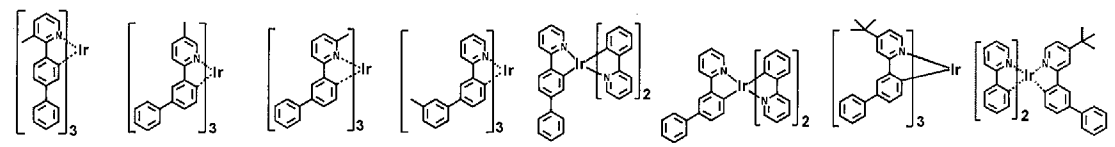
[221]



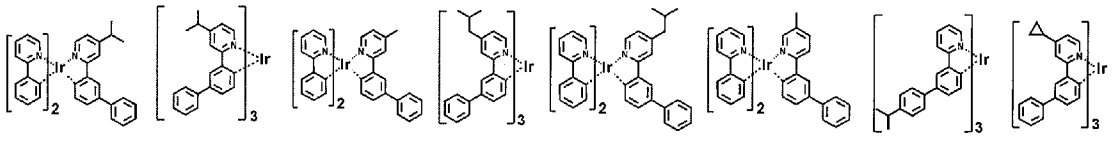
D-49 D-50 D-51 D-52 D-53 D-54 D-55 D-56

[222]



D-57 D-58 D-59 D-60 D-61 D-62 D-63 D-64

[223]



D-65 D-66 D-67 D-68 D-69 D-70 D-71 D-72

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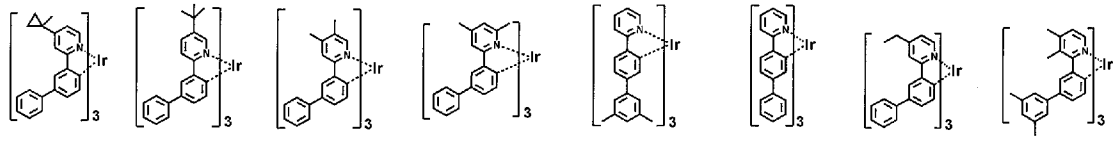

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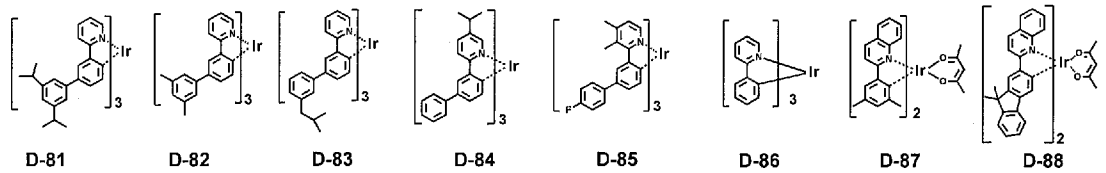

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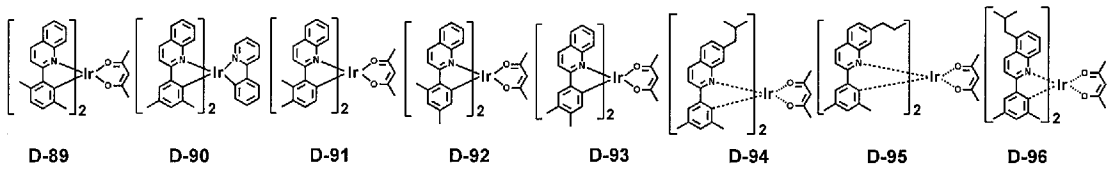
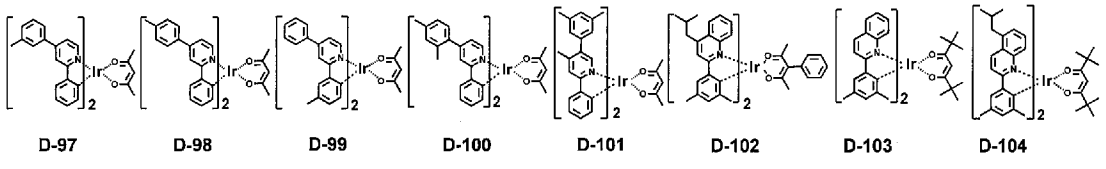


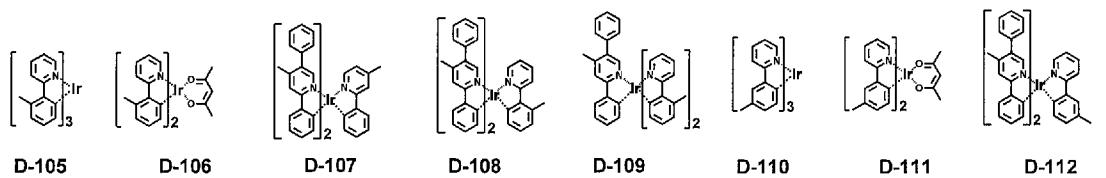
D-89 D-90 D-91 D-92 D-93 D-94 D-95 D-96

[227]



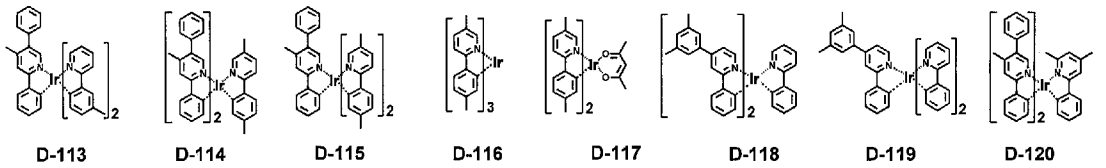
D-97 D-98 D-99 D-100 D-101 D-102 D-103 D-104

[228]



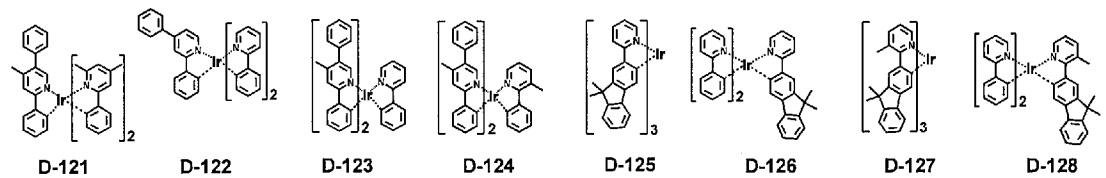
D-105 D-106 D-107 D-108 D-109 D-110 D-111 D-112

[229]



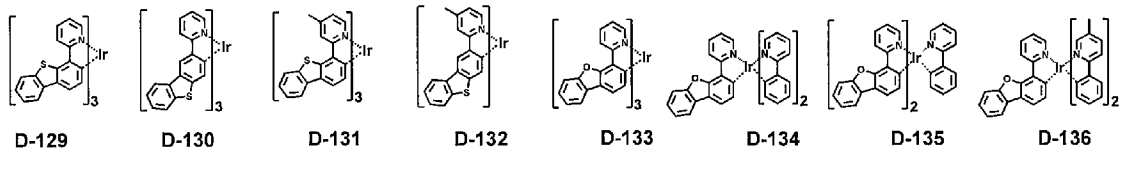
D-113 D-114 D-115 D-116 D-117 D-118 D-119 D-120

[230]



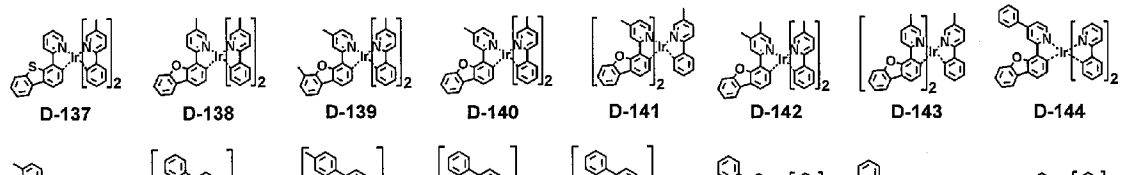
D-121 D-122 D-123 D-124 D-125 D-126 D-127 D-128

[231]



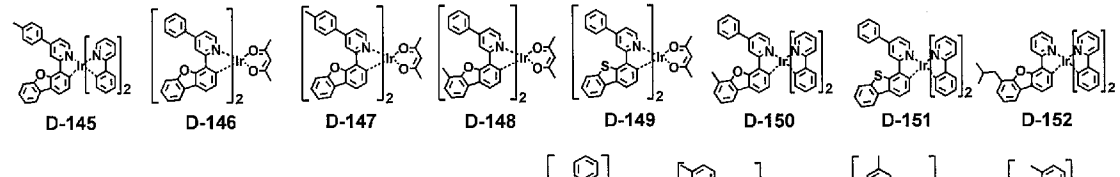
D-129 D-130 D-131 D-132 D-133 D-134 D-135 D-136

[232]



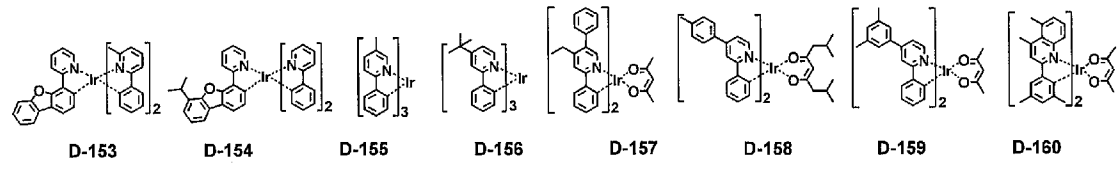
D-137 D-138 D-139 D-140 D-141 D-142 D-143 D-144

[233]



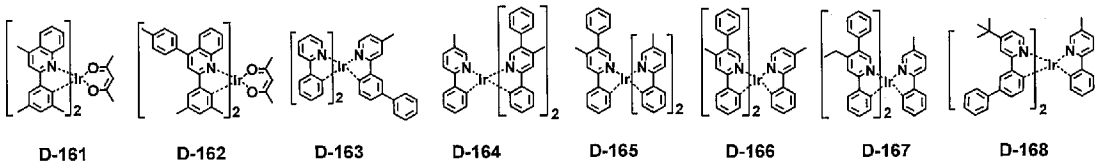
D-145 D-146 D-147 D-148 D-149 D-150 D-151 D-152

[234]



D-153 D-154 D-155 D-156 D-157 D-158 D-159 D-160

[235]



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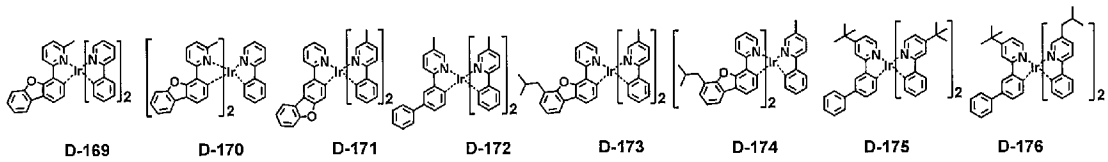
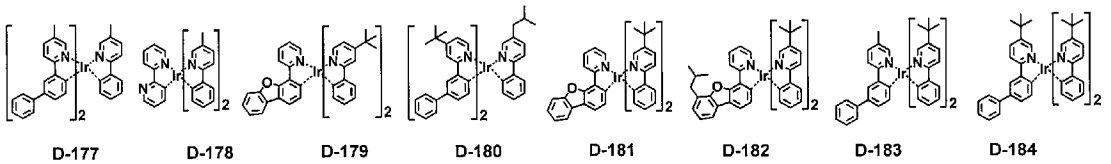


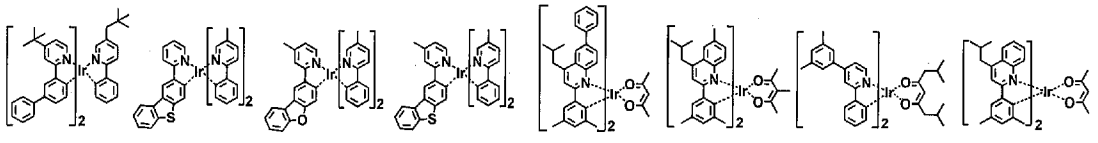
D-169 D-170 D-171 D-172 D-173 D-174 D-175 D-176

[237]



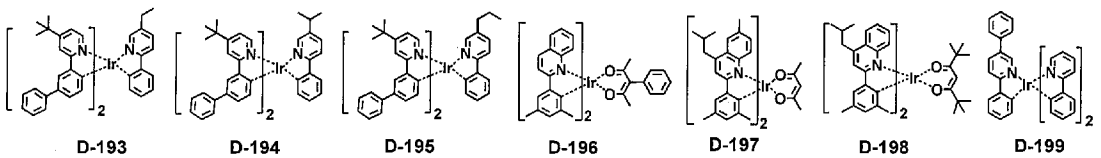
D-177 D-178 D-179 D-180 D-181 D-182 D-183 D-184

[238]



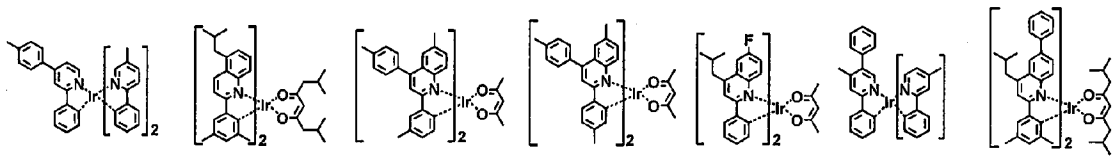
D-185 D-186 D-187 D-188 D-189 D-190 D-191 D-192

[239]



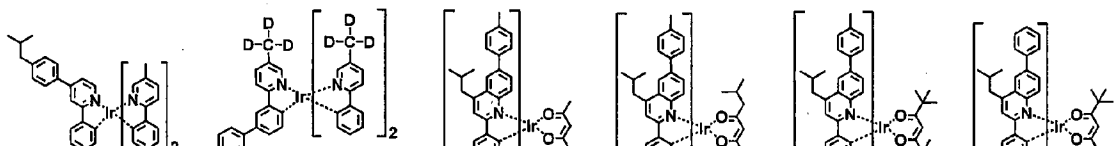
D-193 D-194 D-195 D-196 D-197 D-198 D-199

[240]



D-200 D-201 D-202 D-203 D-204 D-205 D-206

[241]



D-207 D-208 D-209 D-210 D-211 D-212

[242] In the organic electroluminescent device of the present invention, the organic layer may further comprise at least one compound selected from the group consisting of arylamine-based compounds and styrylarylamine-based compounds.

[243] In the organic electroluminescent device of the present invention, the organic layer may further comprise at least one metal selected from the group consisting of metals of Group 1, metals of Group 2, transition metals of the 4th period, transition metals of the 5th period, lanthanides and organic metals of the d-transition elements of the Periodic Table, or at least one complex compound comprising the metal.

[244] In the organic electroluminescent device of the present invention, preferably, at least

one layer (hereinafter, "a surface layer") may be placed on an inner surface(s) of one or both electrode(s), selected from a chalcogenide layer, a metal halide layer and a metal oxide layer. Specifically, a chalcogenide (includes oxides) layer of silicon or aluminum is preferably placed on an anode surface of an electroluminescent medium layer, and a metal halide layer or a metal oxide layer is preferably placed on a cathode surface of an electroluminescent medium layer. Such a surface layer provides operation stability for the organic electroluminescent device. Preferably, the chalcogenide includes SiO_X ($1 \leq X \leq 2$), AlO_X ($1 \leq X \leq 1.5$), SiON, SiAlON, etc.; the metal halide includes LiF, MgF_2, CaF_2, a rare earth metal fluoride, etc.; and the metal oxide includes Cs_2O, Li_2O, MgO, SrO, BaO, CaO, etc.

[245] In addition to the hole transport layer, a hole injection layer, an electron blocking layer, or a combination thereof may be disposed between the anode and the light-emitting layer. The hole injection layer may be composed of two or more layers in order to lower an energy barrier for injecting holes from the anode to a hole transport layer or an electron blocking layer (or a voltage for injecting a hole). Each of the layers may comprise two or more compounds. The electron blocking layer may be composed of two or more layers.

[246] An electron buffering layer, a hole blocking layer, an electron transport layer, an electron injection layer, or a combination thereof may be disposed between the light-emitting layer and the cathode. The electron buffering layer may be composed of two or more layers in order to control the electron injection and improve characteristics of interface between the light-emitting layer and the electron injection layer. Each of the layers may comprise two or more compounds. The hole blocking layer or electron transport layer may be composed of two or more layers, and each of the layers may comprise two or more compounds.

[247] In the organic electroluminescent device of the present invention, a mixed region of an electron transport compound and a reductive dopant, or a mixed region of a hole transport compound and an oxidative dopant may be placed on at least one surface of a pair of electrodes. In this case, the electron transport compound is reduced to an anion, and thus it becomes easier to inject and transport electrons from the mixed region to an electroluminescent medium. Furthermore, the hole transport compound is oxidized to a cation, and thus it becomes easier to inject and transport holes from the mixed region to the electroluminescent medium. Preferably, the oxidative dopant includes various Lewis acids and acceptor compounds, and the reductive dopant includes alkali metals, alkali metal compounds, alkaline earth metals, rare-earth metals, and mixtures thereof. A reductive dopant layer may be employed as a charge generating layer to prepare an electroluminescent device having two or more light-emitting layers and emitting white light.

[248] In order to form each layer of the organic electroluminescent device of the present invention, dry film-forming methods such as vacuum evaporation, sputtering, plasma and ion plating methods, or wet film-forming methods such as inkjet printing, nozzle printing, slot coating, spin coating, dip coating, and flow coating methods can be used. Where a layer is formed with the first host compound and the second host compound of the present invention, they may be co-evaporated or mixture-evaporated.

[249] When using a wet film-forming method, a thin film can be formed by dissolving or diffusing materials forming each layer into any suitable solvent such as ethanol, chloroform, tetrahydrofuran, dioxane, etc. The solvent can be any solvent where the materials forming each layer can be dissolved or diffused, and where there are no problems in film-formation capability.

[250] In the organic electroluminescent device of the present invention, two or more host compounds for a light-emitting layer may be co-evaporated or mixture-evaporated. Herein, a co-evaporation indicates a process for two or more materials to be deposited as a mixture, by introducing each of the two or more materials into respective crucible cells, and applying electric current to the cells for each of the materials to be evaporated. Herein, a mixture-evaporation indicates a process for two or more materials to be deposited as a mixture, by mixing the two or more materials in one crucible cell before the deposition, and applying electric current to the cell for the mixture to be evaporated.

[251] The organic electroluminescent device of the present invention can be used for the manufacture of a display system or a lighting system.

[252] Hereinafter, the preparation method of the device comprising the host compounds and the hole transport compound of the present invention, and its luminescent properties will be explained in detail with reference to the following examples.

[253]

[254] **[Device Examples 1-1 to 1-4] OLED produced by an evaporation of a hole**

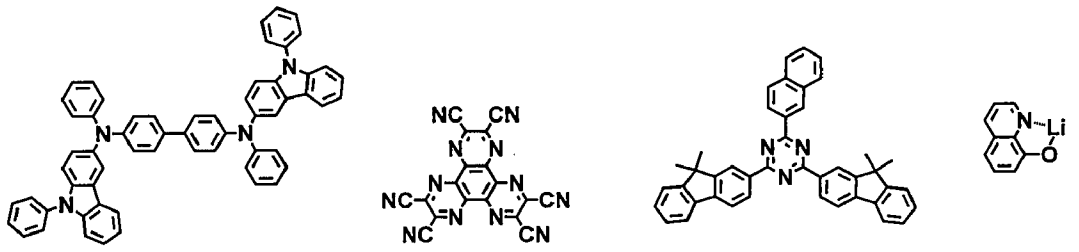
[255] **transport compound of the present invention, and a co-evaporation of a first host compound and a second host compound of the present invention**

[256] An organic electroluminescent device (OLED) was produced comprising the light-emitting material of the present invention as follows. A transparent electrode indium tin oxide (ITO) thin film (10 Ω/sq) on a glass substrate for OLED (Geomatec) was subjected to an ultrasonic washing with acetone, ethanol, and distilled water sequentially, and was then stored in isopropanol. The ITO substrate was then mounted on a substrate holder of a vacuum vapor depositing apparatus. $N^4,N^{4'}$-diphenyl-$N^4,N^{4'}$-bis(9-phenyl-9H-carbazol-3-yl)-[1,1'-biphenyl]-4,4'-diamine (compound HI-1) was introduced into a cell of the vacuum vapor depositing apparatus, and then the pressure in the chamber of the apparatus was controlled to 10^{-6} torr. Thereafter, an electric current

was applied to the cell to evaporate HI-1, thereby forming a first hole injection layer having a thickness of 80 nm on the ITO substrate.

1,4,5,8,9,12-hexaazatriphenylene-hexacarbonitrile (compound HI-2) was then introduced into another cell of the vacuum vapor depositing apparatus, and evaporated by applying electric current to the cell, thereby forming a second hole injection layer having a thickness of 3 nm on the first hole injection layer. N-([1,1'-biphenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine (compound H3-3) was introduced into one cell of the vacuum vapor depositing apparatus, and evaporated by applying electric current to the cell, thereby forming a first hole transport layer having a thickness of 10 nm on the second hole injection layer. A compound for a second hole transport layer shown in Table 1 below was then introduced into another cell of the vacuum vapor depositing apparatus, and evaporated by applying electric current to the cell, thereby forming a second hole transport layer having a thickness of 30 nm on the first hole transport layer. As a host material, compounds H1-34 and H2-31 were introduced into two cells of the vacuum vapor depositing apparatus, respectively. D-25 was introduced into another cell as a dopant. The two host compounds were evaporated at the same rate of 1:1, while the dopant was evaporated at a different rate from the host compounds, so that the dopant was deposited in a doping amount of 15 wt% based on the total amount of the host and dopant to form a light-emitting layer having a thickness of 40 nm on the hole transport layer. 2,4-bis(9,9-dimethyl-9H-fluoren-2-yl)-6-(naphthalen-2-yl)-1,3,5-triazine (compound ET-1) and lithium quinolate (compound EI-1) were introduced into two cells of the vacuum vapor depositing apparatus, respectively, and evaporated at the same rate of 4:6, thereby forming an electron transport layer having a thickness of 35 nm on the light-emitting layer. After depositing lithium quinolate (compound EI-1) as an electron injection layer having a thickness of 2 nm on the electron transport layer, an Al cathode having a thickness of 80 nm was then deposited by another vacuum vapor deposition apparatus on the electron injection layer.

[257]

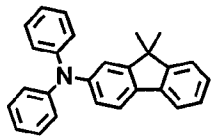


[258]

[259] **[Comparative Example 1-1] OLED produced by an evaporation of compound**

[260] **HTL-A as a compound for a second hole transport layer**

[261] OLEDs were produced in the same manner as in Device Examples 1-1 to 1-4, except that compound HTL-A shown below was used as a compound for a second hole transport layer.

[262] 

HTL-A

[263] A driving voltage at 1,000 nit, luminous efficiency, CIE color coordinate, and time taken to be reduced from 100% to 97% of the luminance at 15,000 nit and a constant current (T97 lifespan) of OLEDs were measured.

[264] The characteristics of the organic electroluminescent devices produced in device examples 1-1 to 1-4 and comparative example 1-1 are shown in Table 1 below.

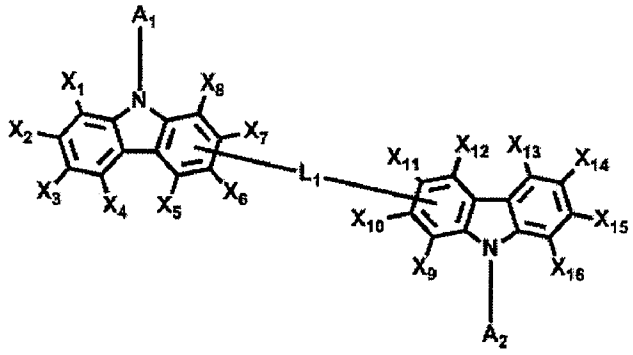
[265] [Table 1]

Device Example No.	The second hole transport layer	Voltage (V)	Efficiency (cd/A)	Color coordinate (x, y)	T97 Lifespan [hr]
Device Example 1-1	H3-3	2.9	52.1	0.299,0.657	28
Device Example 1-2	H3-164	3.4	60.1	0.298,0.658	11
Device Example 1-3	H3-177	3.5	58.7	0.298,0.657	14
Device Example 1-4	H3-28	3.1	57.7	0.298,0.657	15
Comparative Example 1-1	HTL-A	3.5	51.6	0.301,0.660	3

[266] As confirmed in the Device Examples above, the organic electroluminescent device of the present invention has better lifespan characteristics than conventional devices by comprising a specific hole transport compound and a plurality of hosts.

Claims

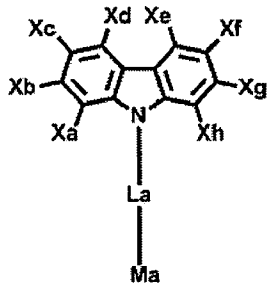
[Claim 1] An organic electroluminescent device comprising an anode, a cathode, and an organic layer between the anode and the cathode,
wherein the organic layer comprises one or more light-emitting layers and one or more hole transport layers; at least one light-emitting layer comprises one or more dopant compounds and two or more host compounds; a first host compound of the host compounds is represented by the following formula 1; a second host compound is represented by the following formula 2; and at least one hole transport layer comprises the compound represented by the following formula 3:



(1)

wherein
A_1 and A_2, each independently, represent a substituted or unsubstituted (C6-C30)aryl, provided that a nitrogen-containing heteroaryl is excluded from the substituent of A_1 and A_2;
L_1 represents a single bond or a substituted or unsubstituted (C6-C30)arylene;
X_1 to X_{16}, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be

replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;



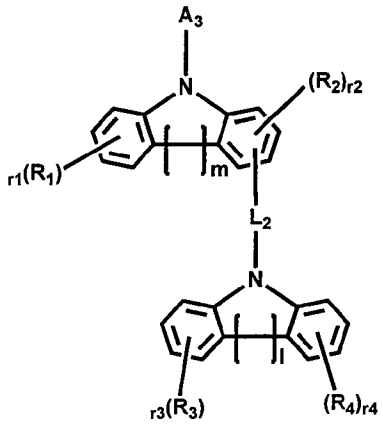
(2)

wherein

Ma represents a substituted or unsubstituted nitrogen-containing 5- to 11-membered heteroaryl;

La represents a single bond, or a substituted or unsubstituted (C6-C30)arylene;

Xa to Xh, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;



----------(3)

wherein

A_3 represents a substituted or unsubstituted (C6-C30)aryl;

L_2 represents a single bond, or a substituted or unsubstituted (C6-C30)arylene;

l and m each independently, represent an integer of 0 or 1, l+m is 1 or 2;

R_1 to R_4, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring which may form a spiro structure, and the carbon atom(s) of the ring may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur;

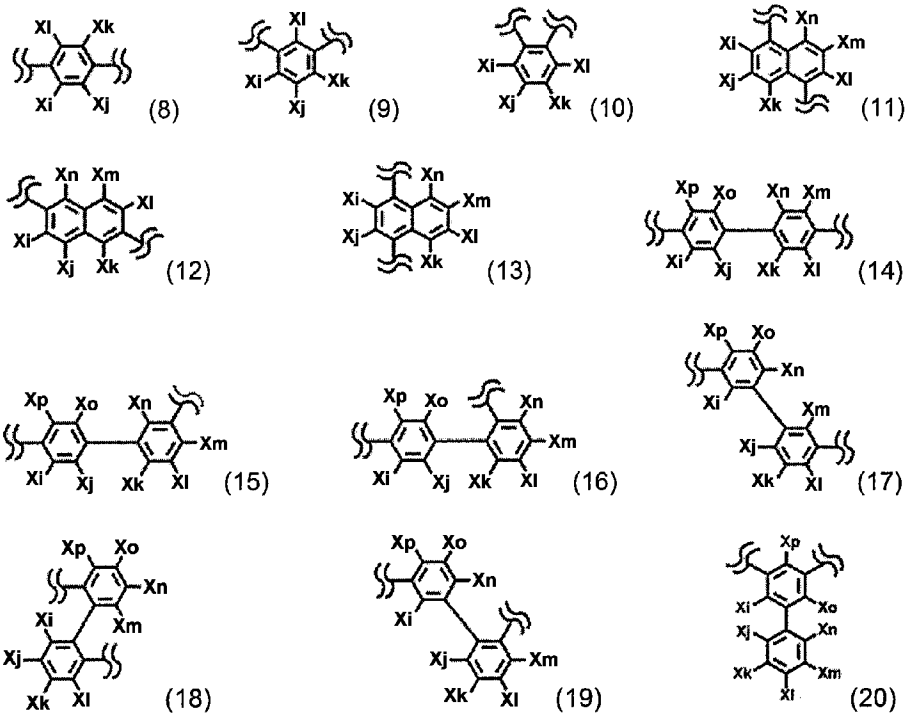
r_1 to r_4, each independently, represent an integer of 1 to 4; and

the heteroaryl contains at least one hetero atom selected from B, N, O, S, Si, and P.

[Claim 2] The organic electroluminescent device according to claim 1, wherein in formula 1, A_1 and A_2, each independently, are selected from the group consisting of a substituted or unsubstituted phenyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted naphthyl, a substituted or unsubstituted fluorenyl, a substituted or unsubstituted benzofluorenyl, a substituted or unsubstituted phenanthrenyl, a substituted or unsubstituted anthracenyl, a substituted or unsubstituted indenyl, a substituted or unsubstituted triphenylenyl, a substituted or unsubstituted pyrenyl, a substituted or unsubstituted tetracenyl, a substituted or unsubstituted perylenyl, a substituted or unsubstituted chrysenyl, a substituted or unsubstituted phenylnaphthyl, a substituted or unsubstituted naphthylphenyl, and a substituted or unsubstituted fluoranthenyl.

[Claim 3] The organic electroluminescent device according to claim 1, wherein in

formula 1, L_1 represents a single bond, or one selected from the following formulae 8 to 20.



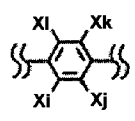
wherein

Xi to Xp, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsubstituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur; and  represents a bonding site to the mother nucleus.

[Claim 4] The organic electroluminescent device according to claim 1, wherein in formula 2, Ma represents a substituted or unsubstituted monocyclic ring-type heteroaryl selected from the group consisting of a substituted

or unsubstituted pyrrolyl, a substituted or unsubstituted imidazolyl, a substituted or unsubstituted pyrazolyl, a substituted or unsubstituted triazinyl, a substituted or unsubstituted tetrazinyl, a substituted or unsubstituted triazolyl, a substituted or unsubstituted tetrazolyl, a substituted or unsubstituted pyridyl, a substituted or unsubstituted pyrazinyl, a substituted or unsubstituted pyrimidinyl, and a substituted or unsubstituted pyridazinyl, or a substituted or unsubstituted fused ring-type heteroaryl selected from the group consisting of a substituted or unsubstituted benzimidazolyl, a substituted or unsubstituted isoindolyl, a substituted or unsubstituted indolyl, a substituted or unsubstituted indazolyl, a substituted or unsubstituted benzothiadiazolyl, a substituted or unsubstituted quinolyl, a substituted or unsubstituted isoquinolyl, a substituted or unsubstituted cinnolinyl, a substituted or unsubstituted quinazolinyl, a substituted or unsubstituted naphthyridinyl, and a substituted or unsubstituted quinoxalinyl.

[Claim 5] The organic electroluminescent device according to claim 1, wherein in formula 2, La represents a single bond, or one selected from the following formulae 8 to 20.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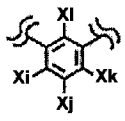
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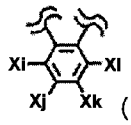
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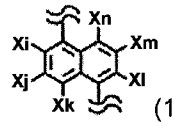
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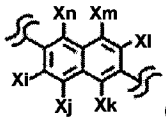
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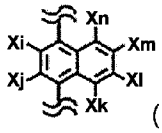
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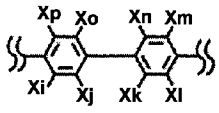
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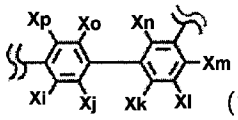
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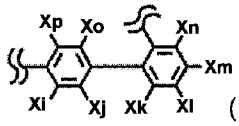
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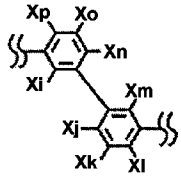
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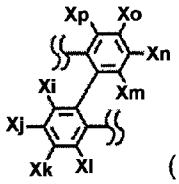
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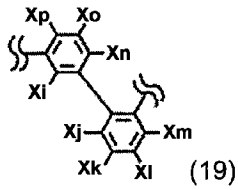
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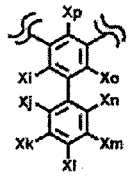

(20)

wherein

Xi to Xp, each independently, represent hydrogen, deuterium, a halogen, a cyano, a substituted or unsubstituted (C1-C30)alkyl, a substituted or unsubstituted (C2-C30)alkenyl, a substituted or unsub-

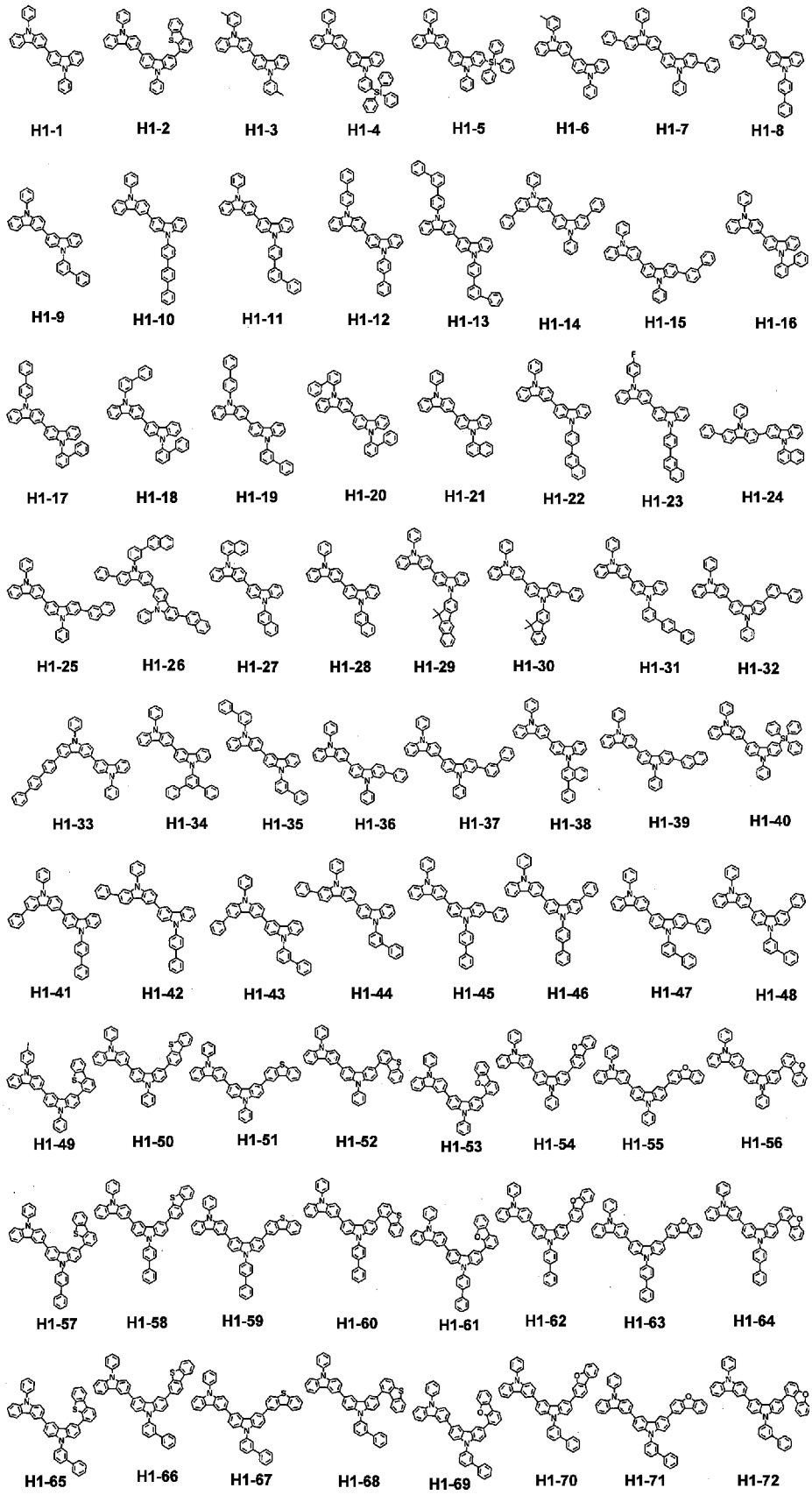
stituted (C2-C30)alkynyl, a substituted or unsubstituted (C3-C30)cycloalkyl, a substituted or unsubstituted (C6-C60)aryl, a substituted or unsubstituted 3- to 30-membered heteroaryl, a substituted or unsubstituted tri(C1-C30)alkylsilyl, a substituted or unsubstituted tri(C6-C30)arylsilyl, a substituted or unsubstituted di(C1-C30)alkyl(C6-C30)arylsilyl, a substituted or unsubstituted (C1-C30)alkyldi(C6-C30)arylsilyl, or a substituted or unsubstituted mono- or di- (C6-C30)arylamino; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted (C3-C30), mono- or polycyclic, alicyclic or aromatic ring, whose carbon atom(s) may be replaced with at least one hetero atom selected from nitrogen, oxygen, and sulfur; and (( )) represents a bonding site to the mother nucleus.

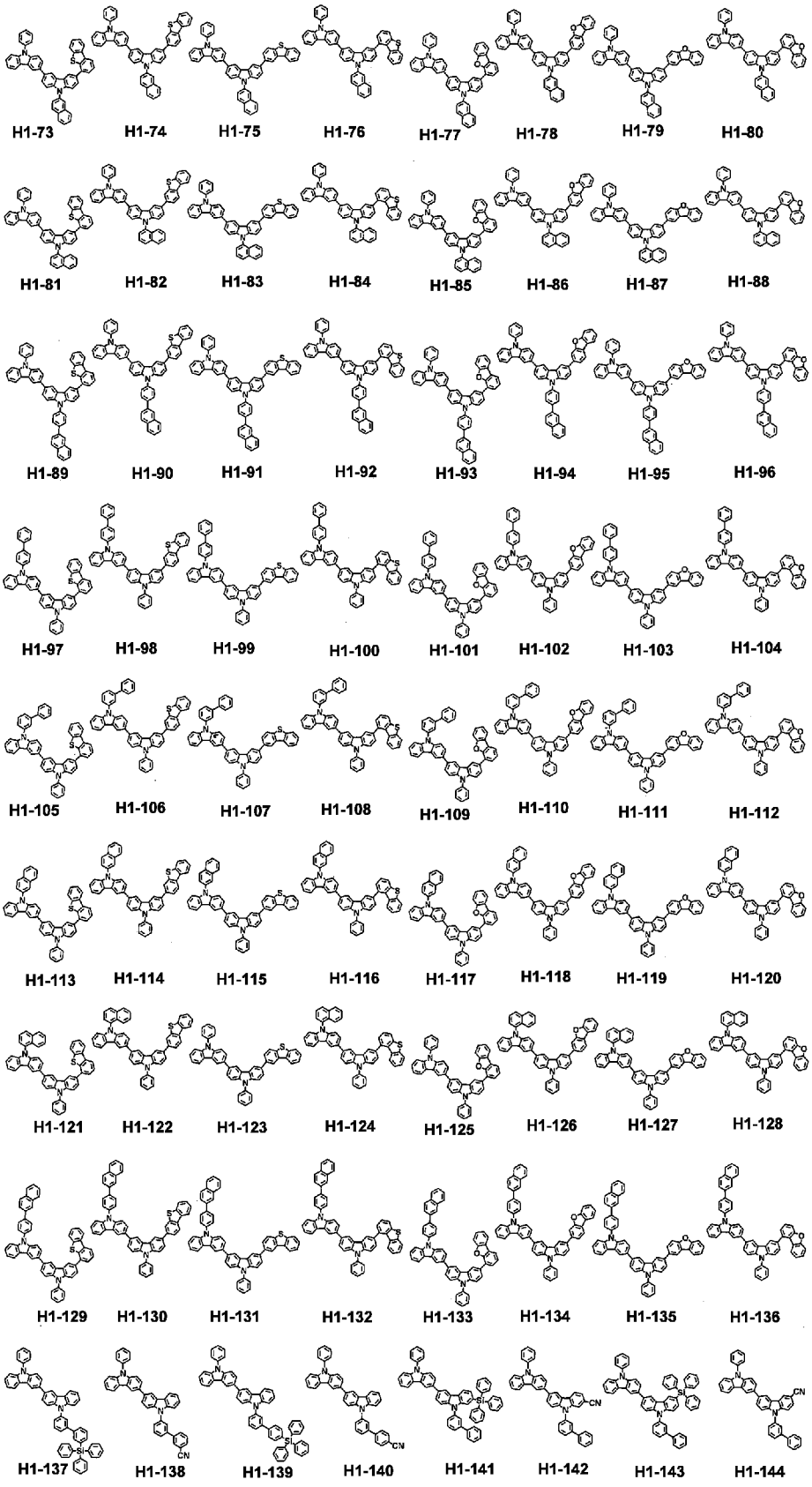
[Claim 6] The organic electroluminescent device according to claim 1, wherein in formula 2, Xa to Xh, each independently, represent hydrogen, a cyano, a (C6-C15)aryl unsubstituted or substituted with a tri(C6-C10)arylsilyl, or a 10- to 20-membered heteroaryl unsubstituted or substituted with a (C6-C12)aryl; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted benzene, a substituted or unsubstituted indole, a substituted or unsubstituted benzindole, a substituted or unsubstituted indene, a substituted or unsubstituted benzofuran, or a substituted or unsubstituted benzothiophene.

[Claim 7] The organic electroluminescent device according to claim 1, wherein in formula 3, A_3 is selected from the group consisting of a substituted or unsubstituted phenyl, a substituted or unsubstituted biphenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted naphthyl, and a substituted or unsubstituted triphenylenyl.

[Claim 8] The organic electroluminescent device according to claim 1, wherein in formula 3, R_1 to R_4, each independently, represent hydrogen, a cyano, a (C6-C18)aryl unsubstituted or substituted with a (C1-C6)alkyl, or an unsubstituted 10- to 20-membered heteroaryl; or may be linked to an adjacent substituent(s) to form a substituted or unsubstituted benzene, a substituted or unsubstituted indole, a substituted or unsubstituted indene, a substituted or unsubstituted benzindene, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted spiro[cyclopentane-indene], a substituted or unsubstituted spiro[cyclohexane-indene], or a substituted or unsubstituted spiro[fluorene-indene].

[Claim 9] The organic electroluminescent device according to claim 1, wherein the compound of formula 1 is selected from the group consisting of:

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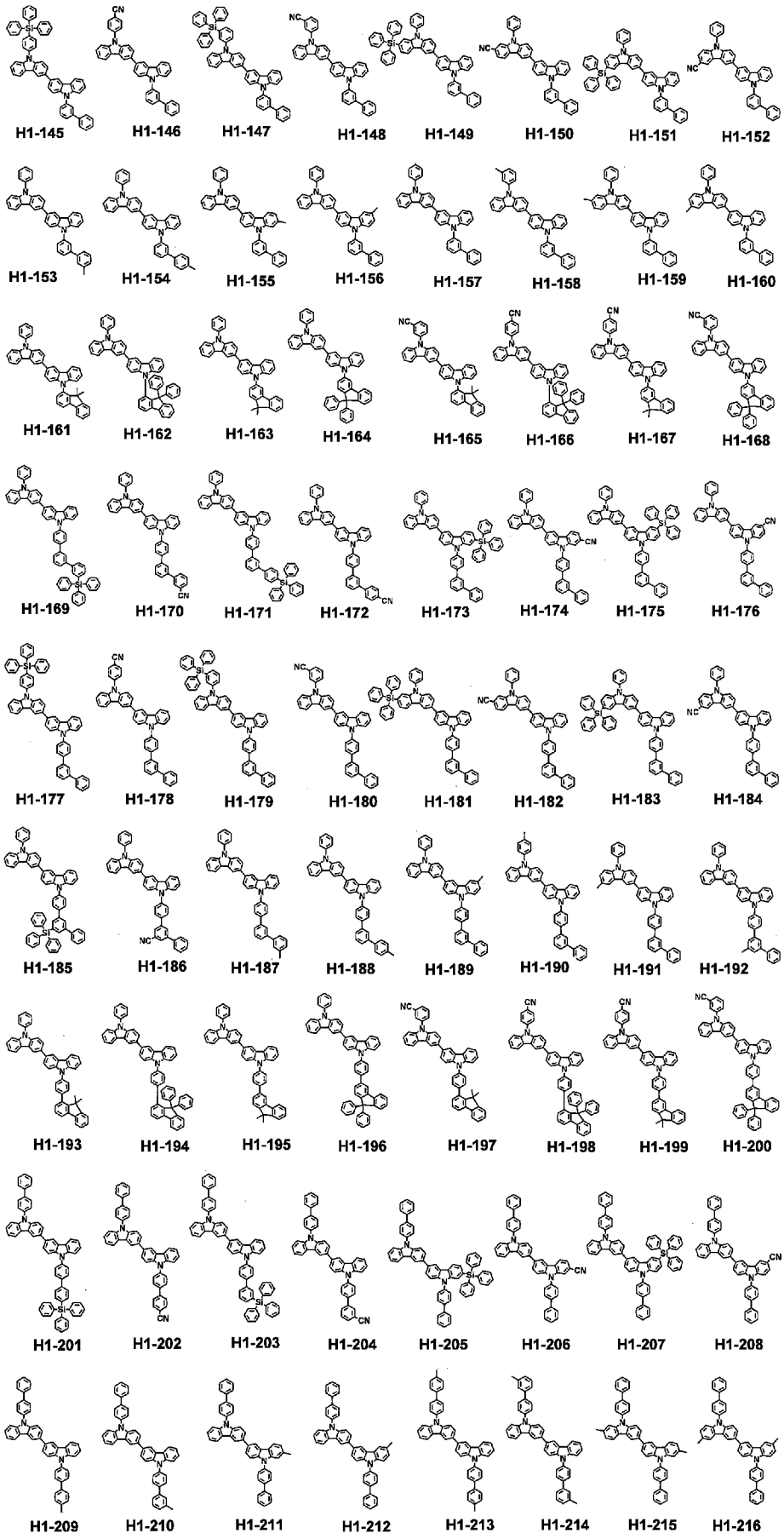
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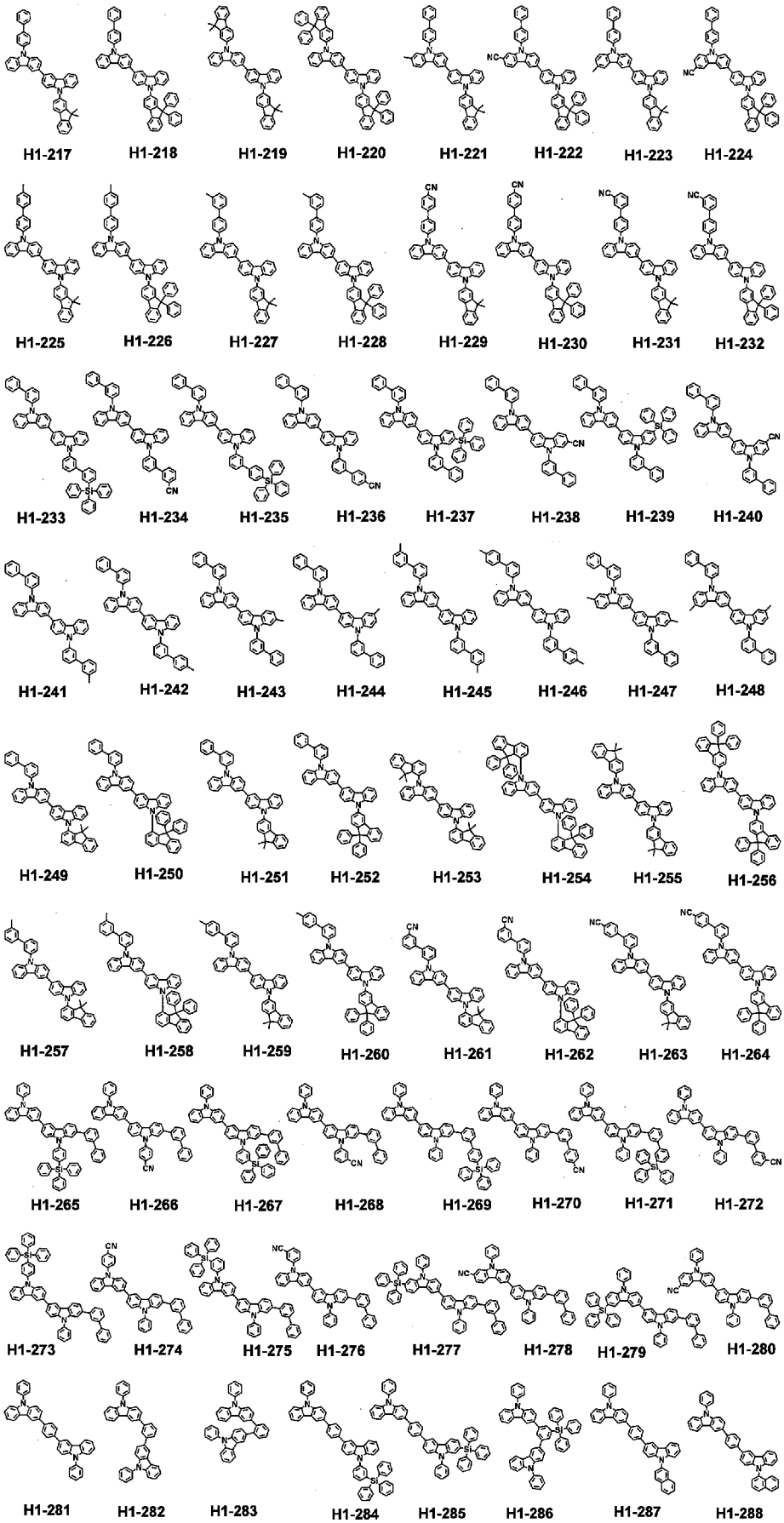
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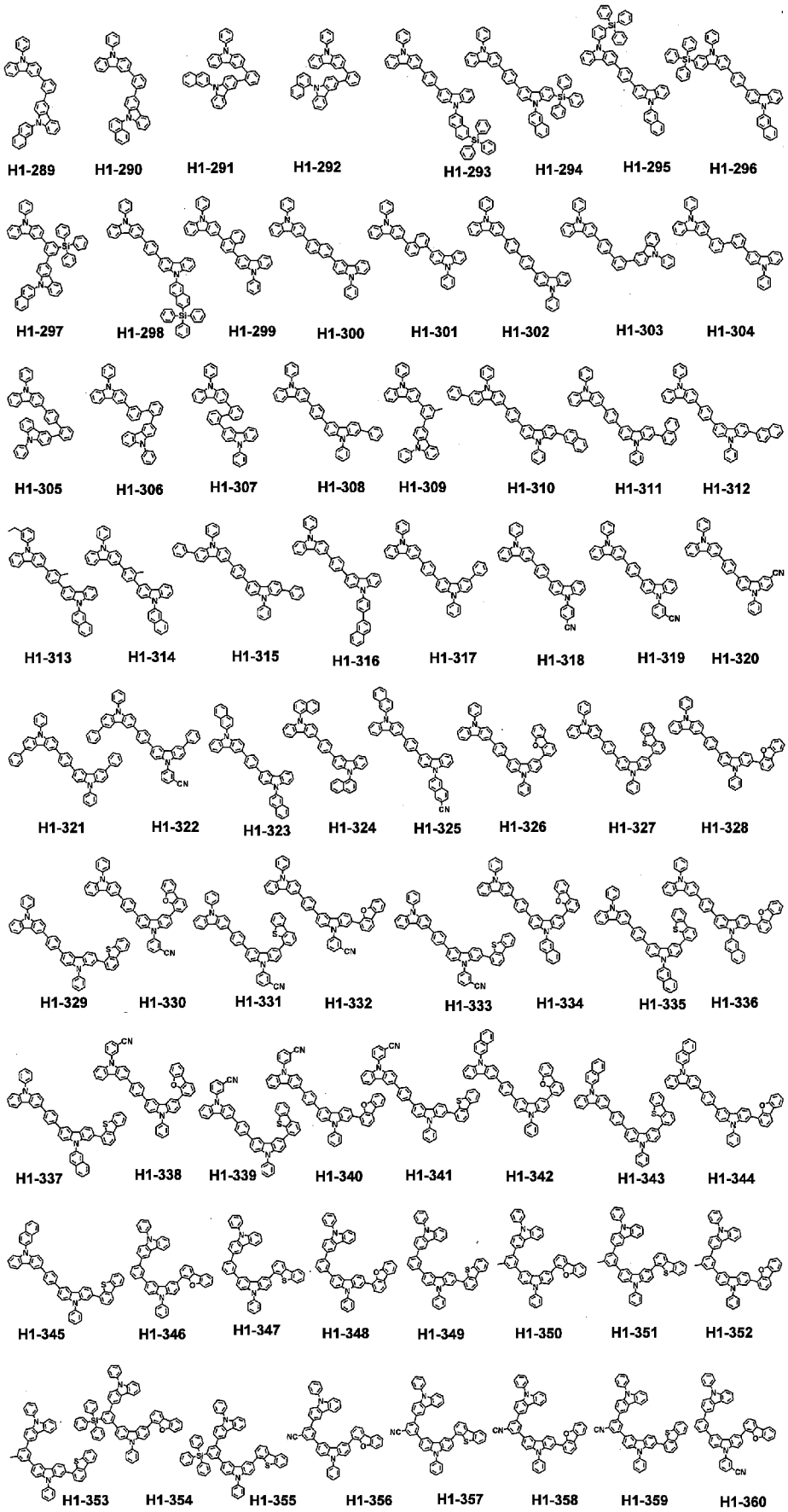
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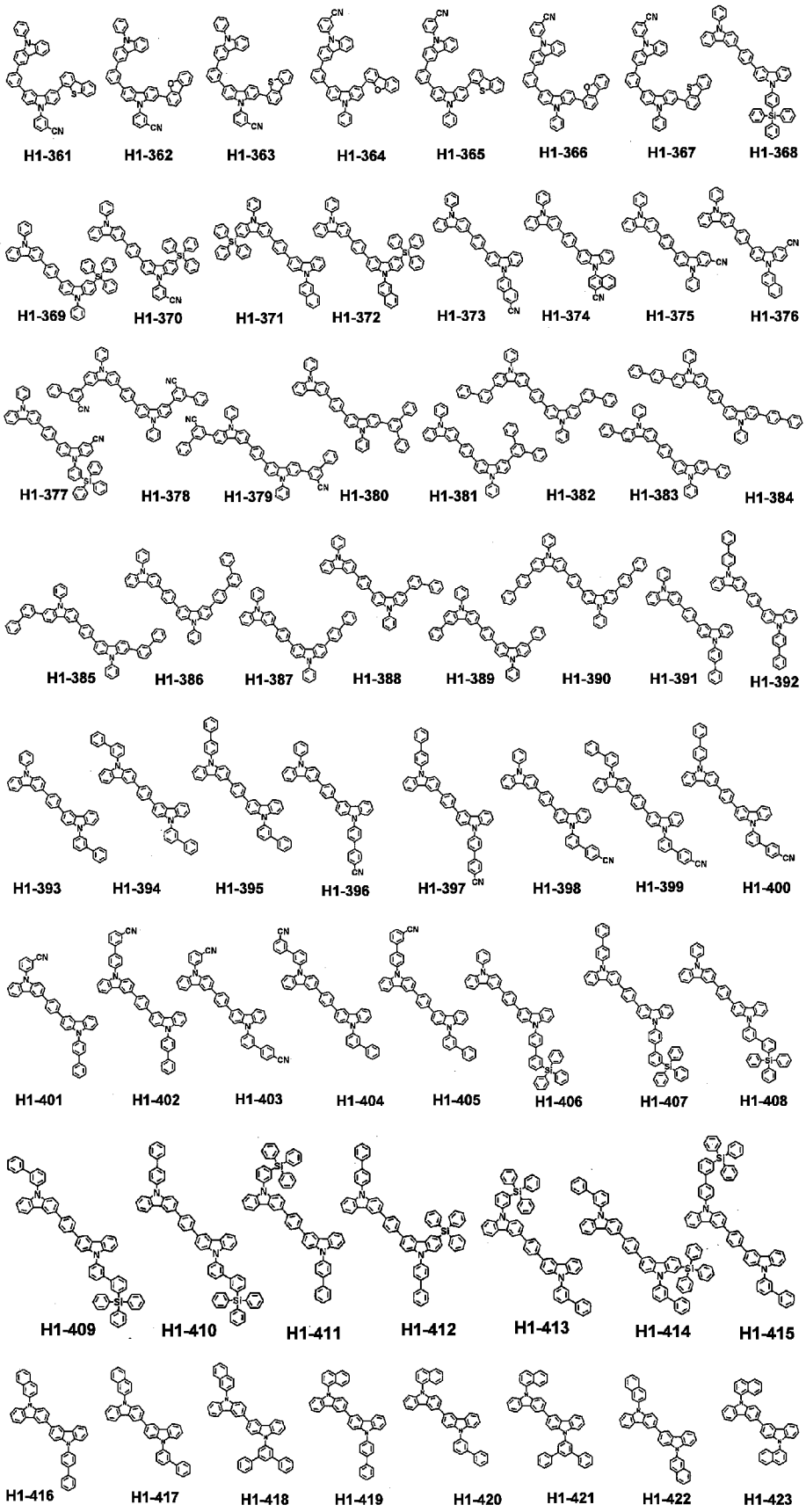
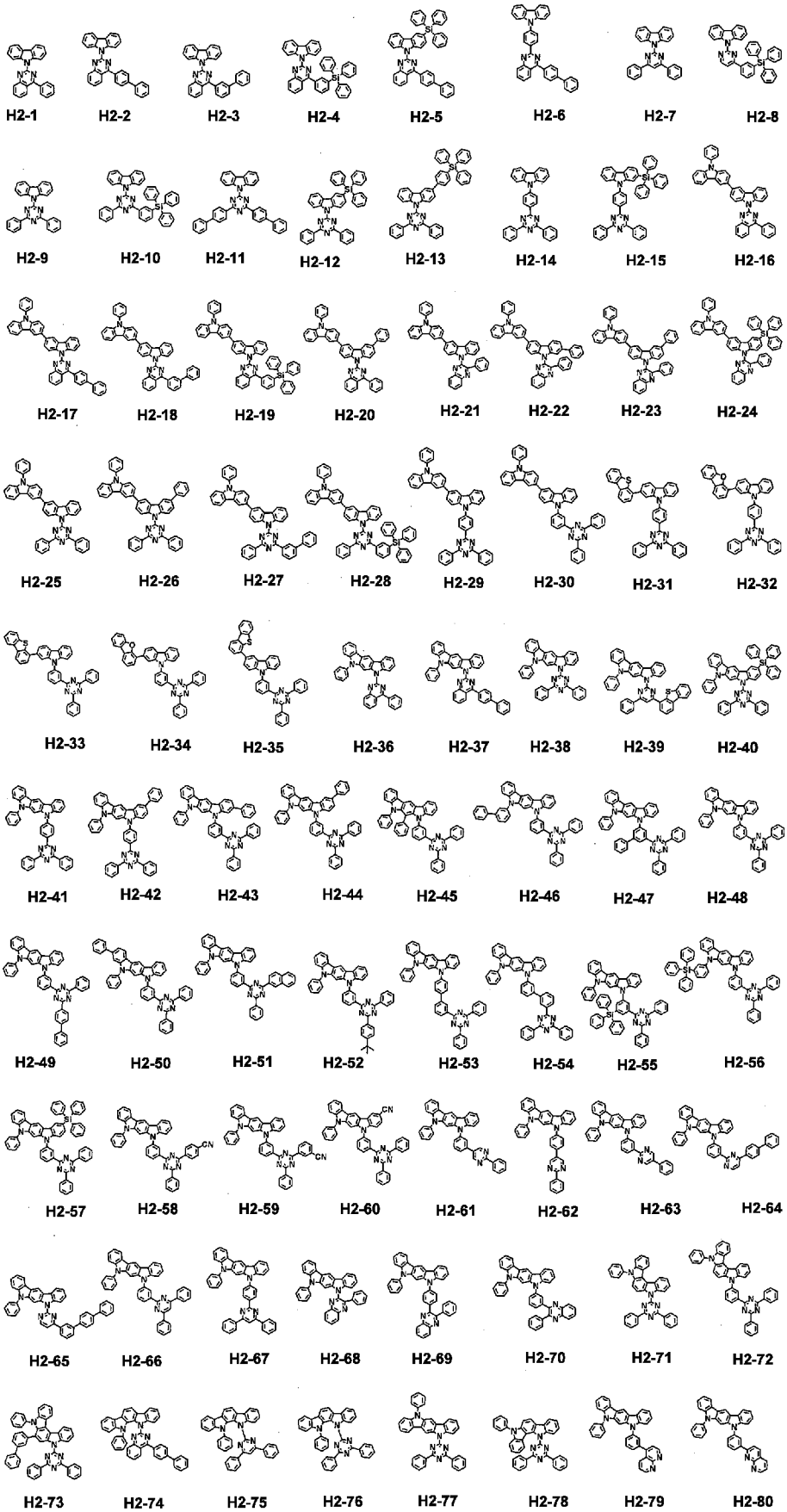
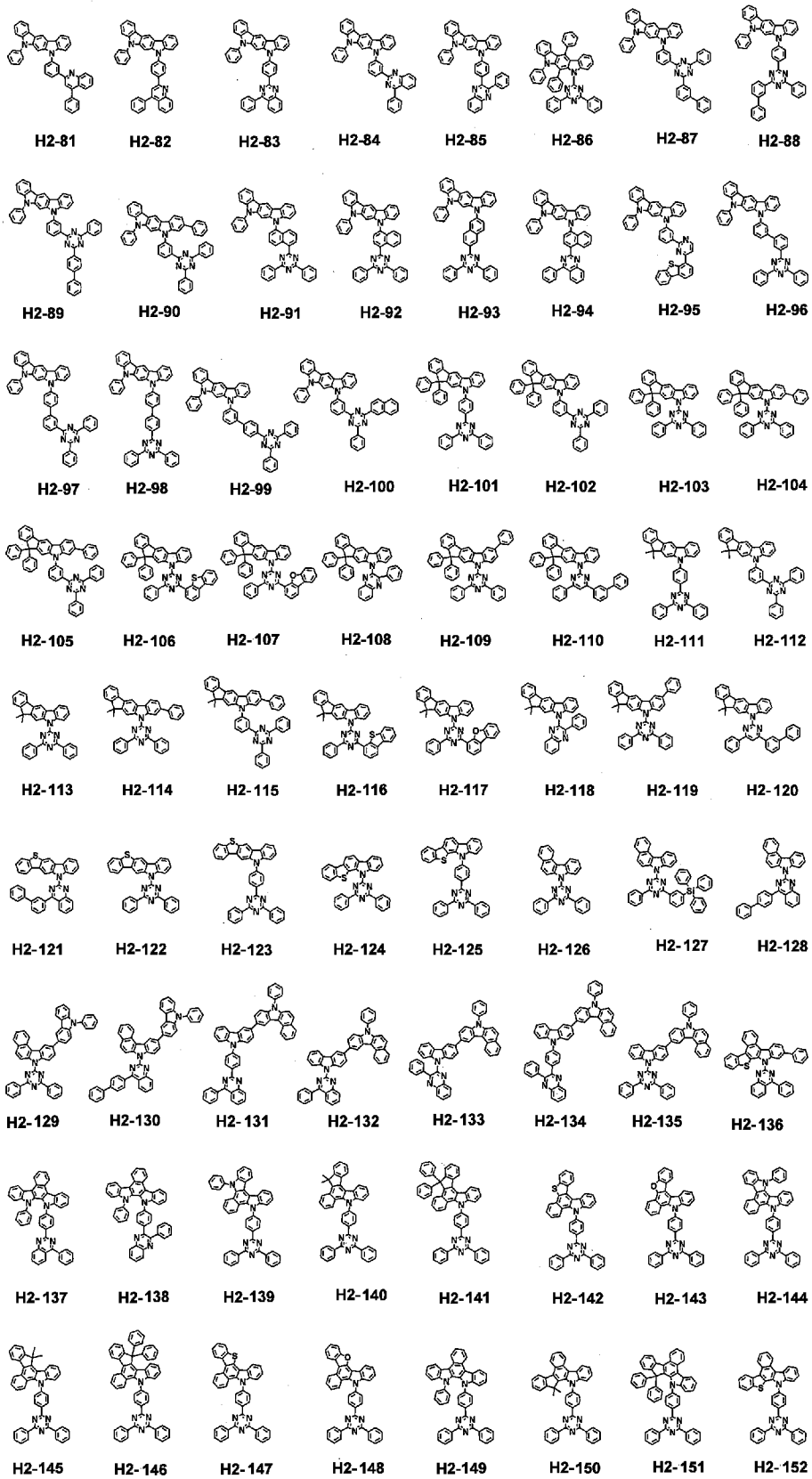


[Claim 10] The organic electroluminescent device according to claim 1, wherein

the compound of formula 2 is selected from the group consisting of:

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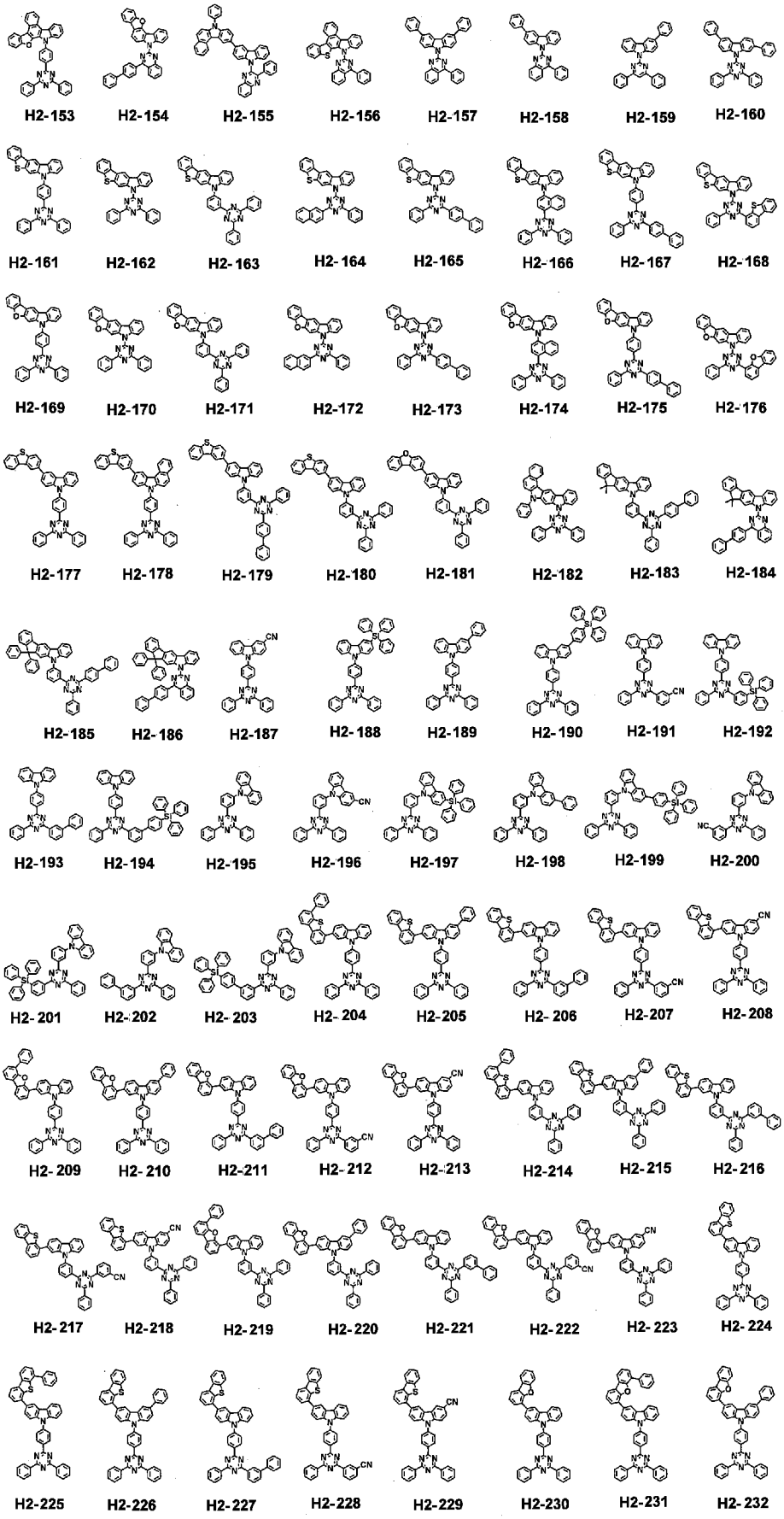
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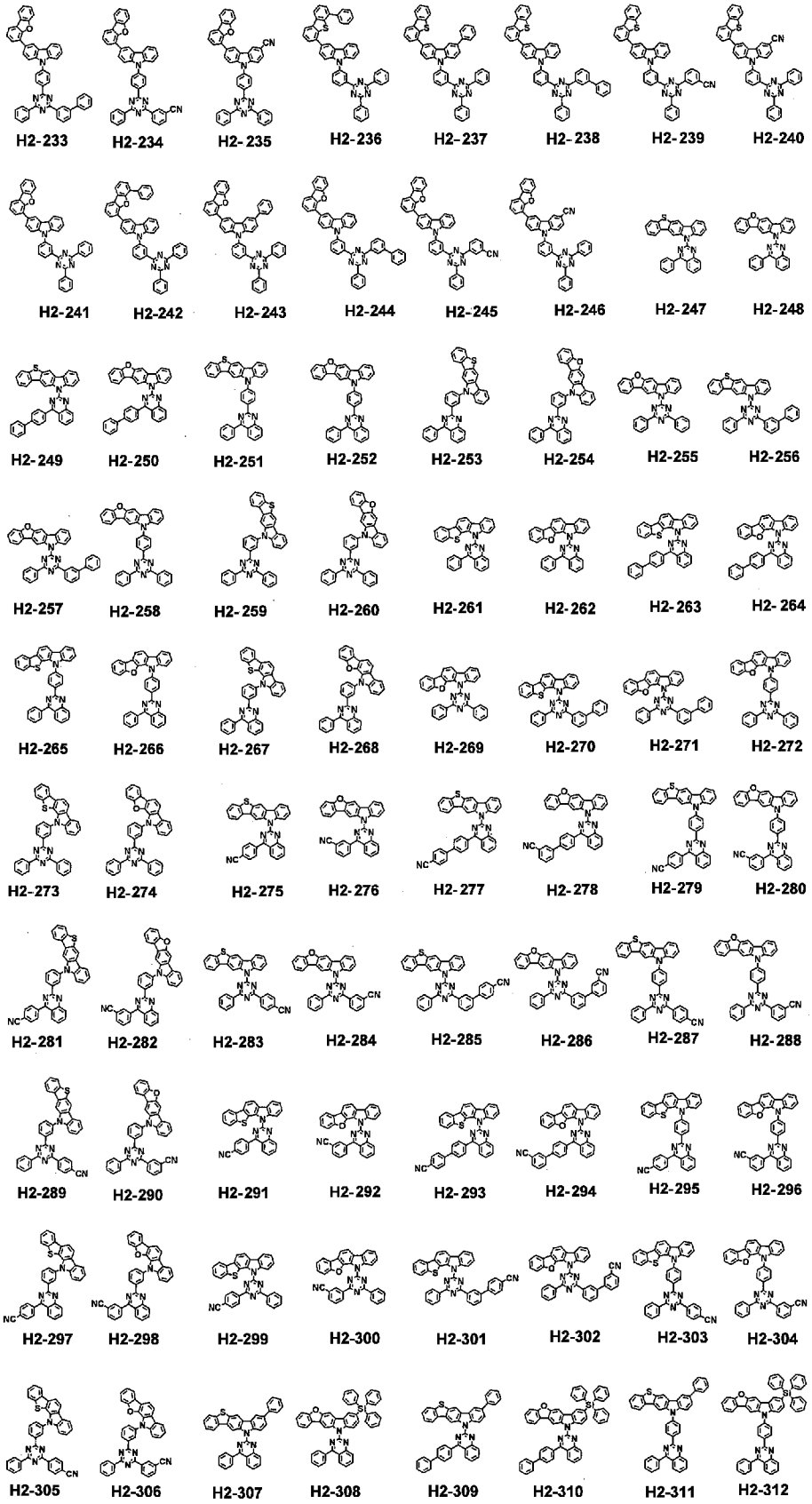
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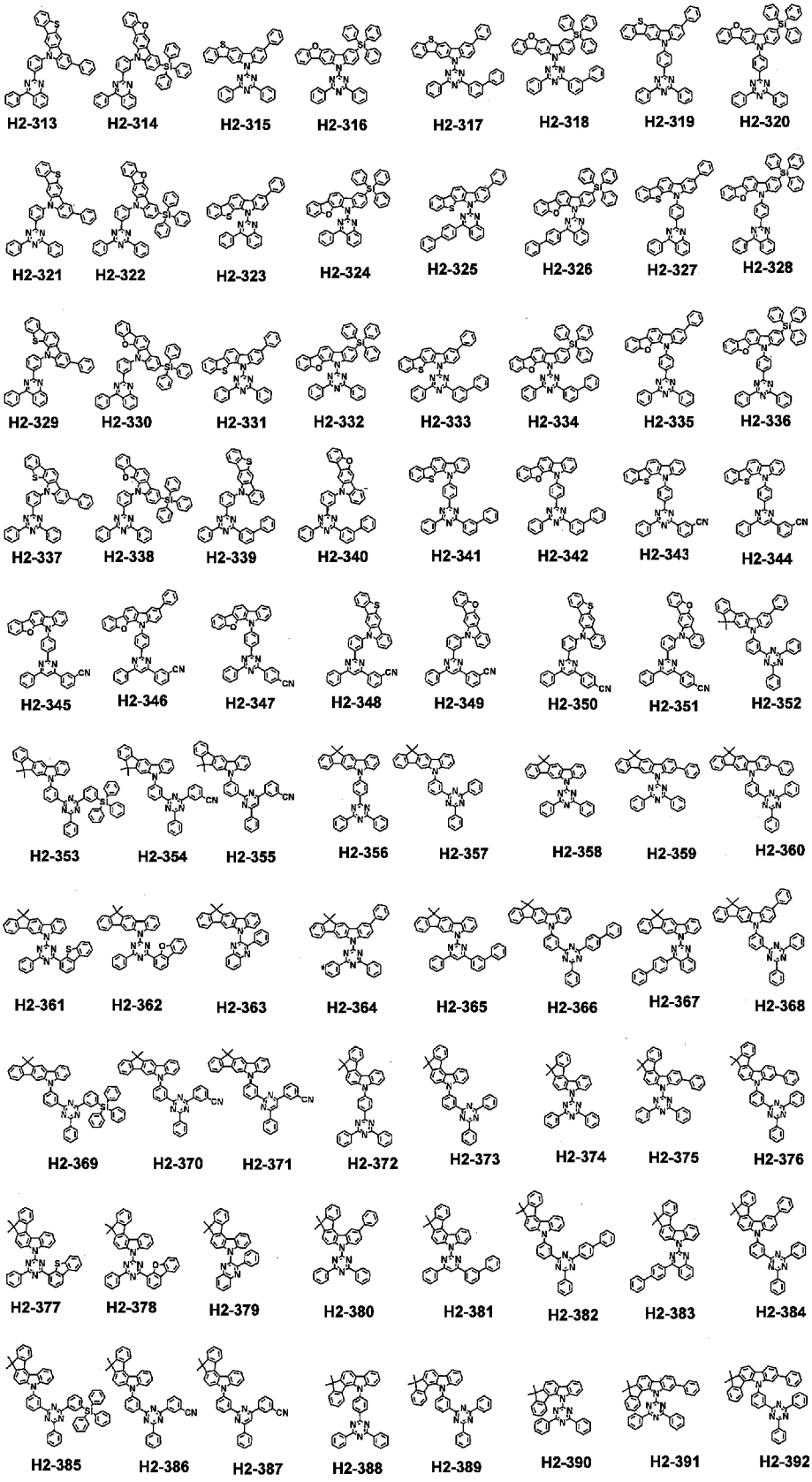
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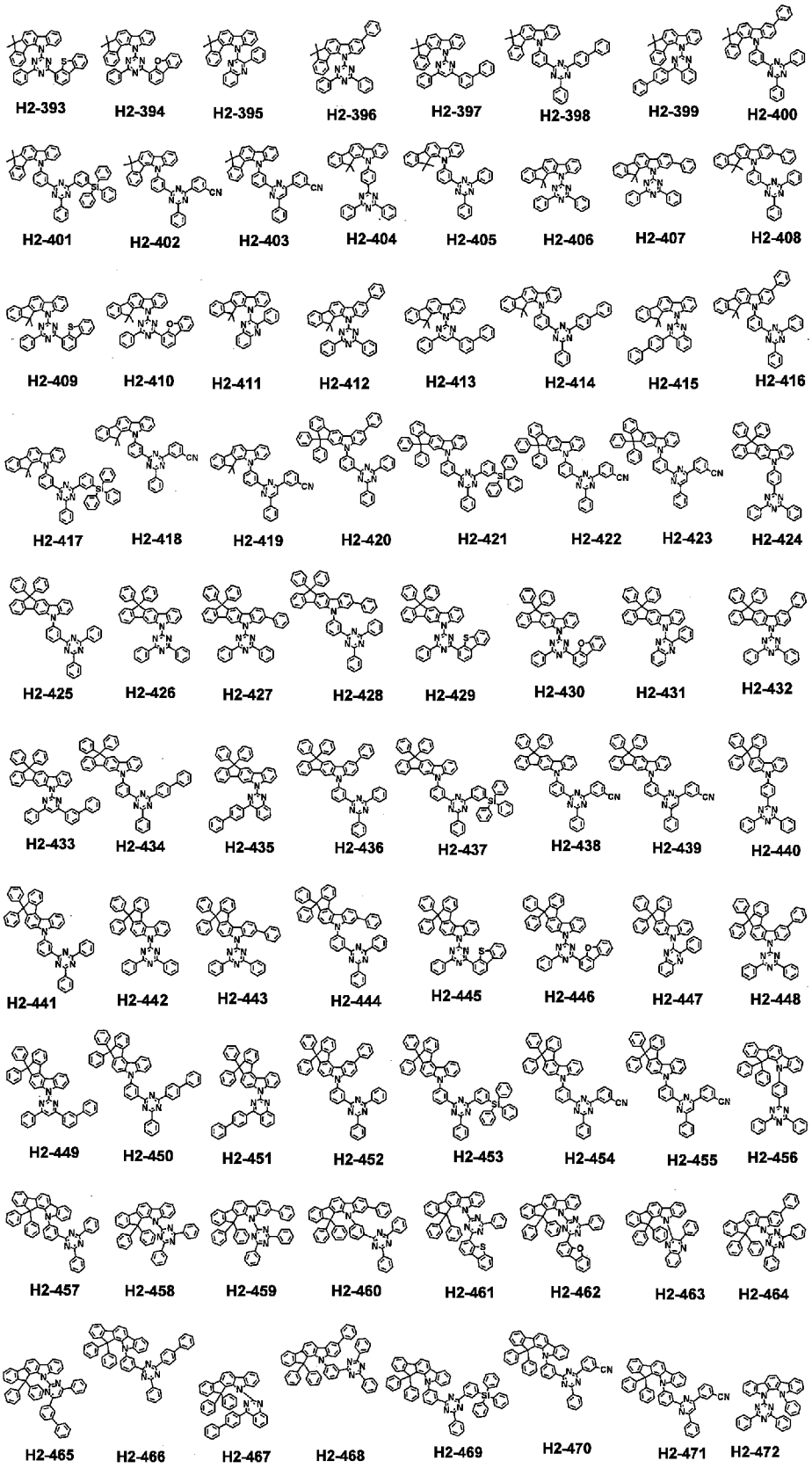
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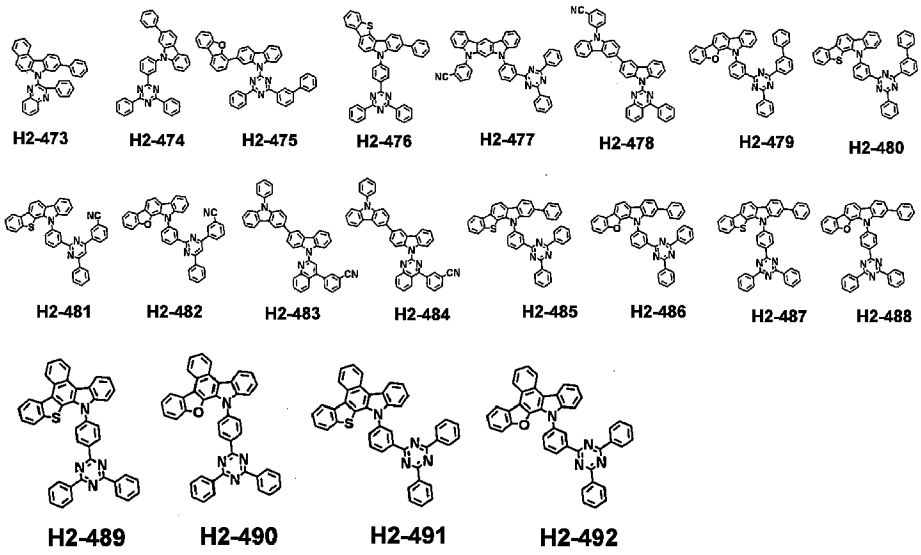
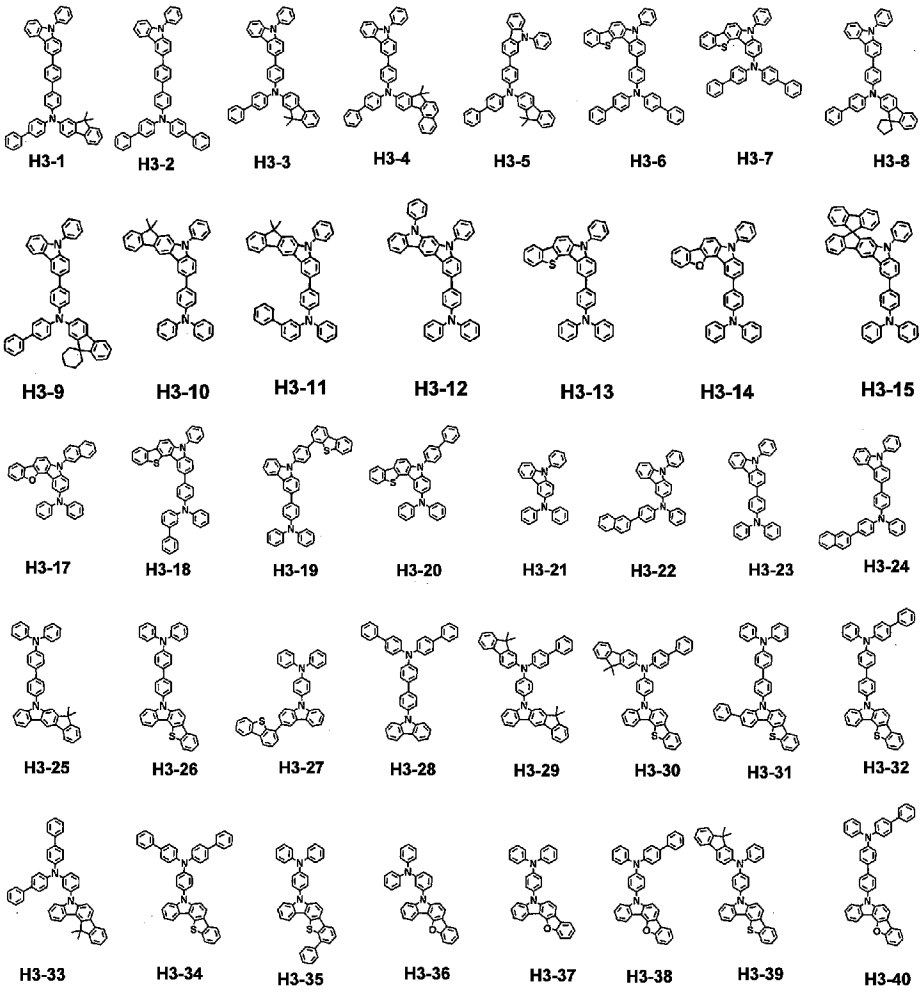
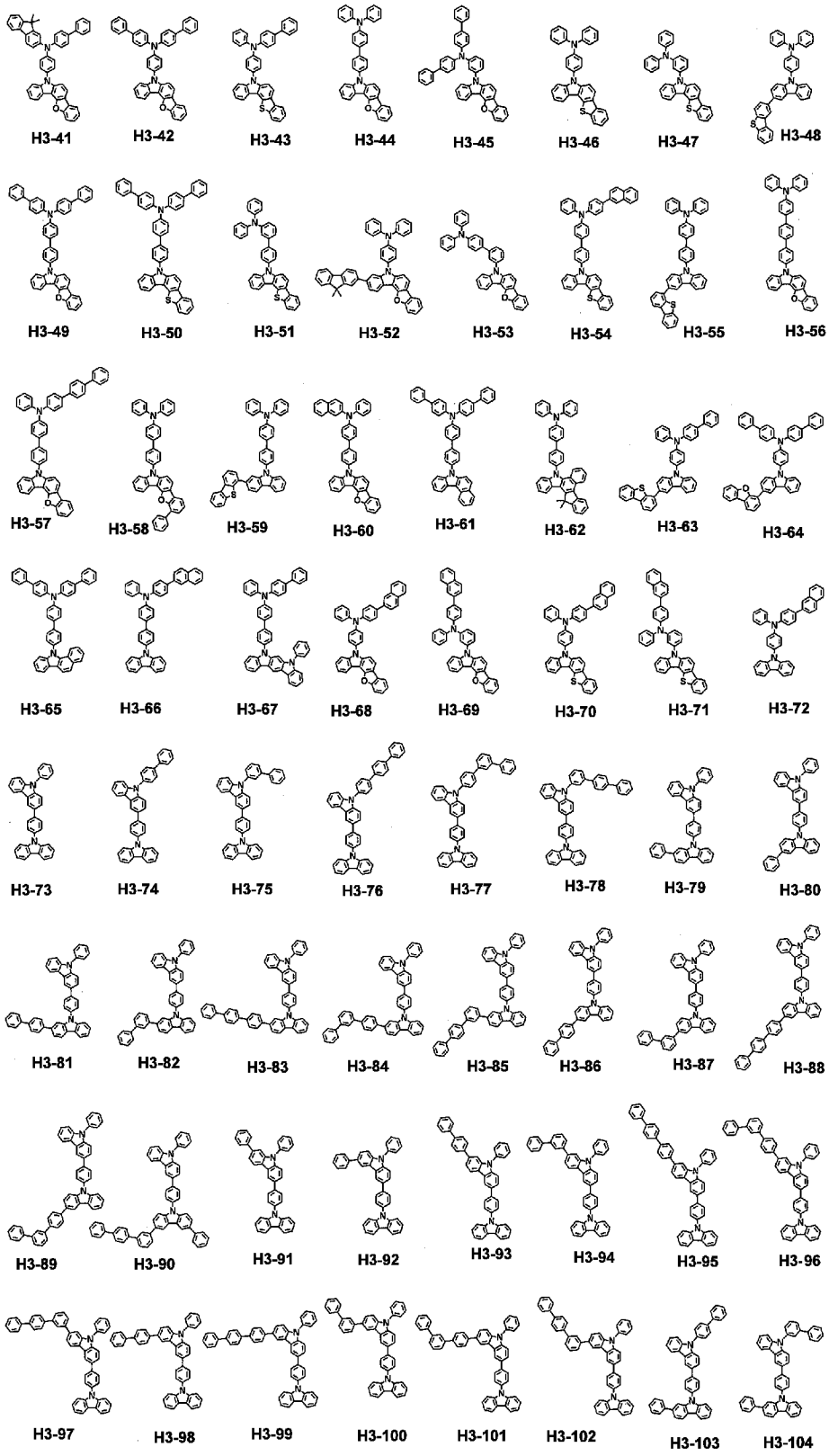


[Claim 11] The organic electroluminescent device according to claim 1, wherein the compound of formula 3 is selected from the group consisting of:

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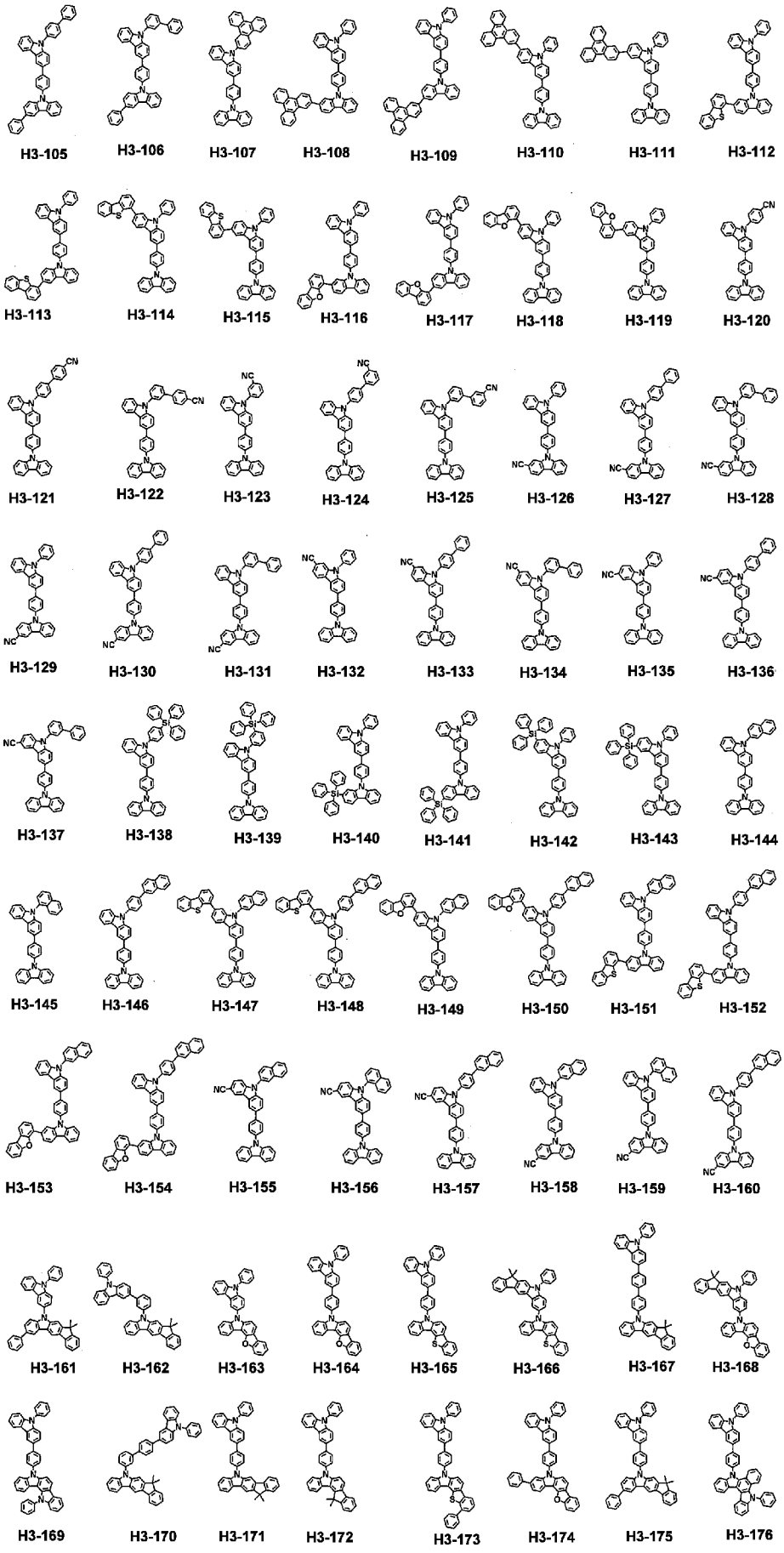
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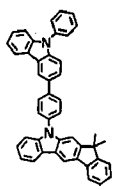

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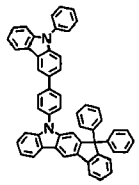
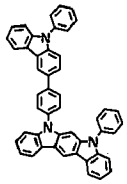
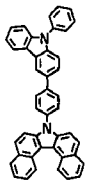


H3-178



H3-179



H3-180

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2015/007636

A. CLASSIFICATION OF SUBJECT MATTER

H01L 51/54 (2006.01) H01L 27/32 (2006.01) C09K 11/06 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

REGISTRY, CAPLUS - structure search based on formulae 1, 2, and 3, refined by keywords (co-host, multi-host, second host and the like) or CPC mark (H01L 2251/5384)

GOOGLE PATENTS - Rohm and Haas, Park Kyoung-Jin, Lee Tae-Jin, Shim Jae-Hoon, Doh Yoo-Jin, Ahn Hee-Choon, Kim Young-Kwang, Moon Doo-Hyeon, Yang Jeong-Eun, Lee Su-Hyun, Kim Chi-Sik, Jun Ji-Song, and H01L

Internal IP Australia databases

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 September 2015	29 September 2015

Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Cassandra Smith AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61 2 6222 3633

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/KR2015/007636**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/062075 A1 (NISHIMURA et al.) 02 May 2013 & US2014/0306207A1 used for English translation pages 25-34, 57-108, 125-132, 138; paragraph 077, 0152, 0314; formula 19, 84, 236; table 1, 2; abstract	1-11
X	US 2013/0234119 A1 (IDEMITSU KOSAN CO., LTD.,) 12 September 2013 pages 9-50, 53-154, 172-173; paragraph 0145, 0195, 0296; tables 1-4; abstract	1-8, 10-11
X	EP 2423209 A1 (IDEMITSU KOSAN CO., LTD.) 29 February 2012 & family member of WO2011/132683 pages 20-32, 51, 73; paragraph 0001-0005, 0235; figure 1; abstract	1-8, 10-11
X	EP 2415769 A1 (IDEMITSU KOSAN CO., LTD.) 08 February 2012 & family member of WO2011/132684 pages 18-28, 46, 59-66, 69; paragraph 0001-0005, 0228; figure 1; abstract	1-8, 11
X	US 2014/0042469 A1 (SEMICONDUCTOR ENERGY LABORATORY CO., LTD.,) 13 February 2014 page 26; table 5; abstract	1-9
P,X	US 2014/0340888 A1 (SEMICONDUCTOR ENERGY LABORATORY CO., LTD.,) 20 November 2014 pages 18-19; table 1; abstract	1-9
P,X	US 2015/0200373 A1 (SAMSUNG DISPLAY CO., LTD.,) 16 July 2015 pages 8-11, 65-85, 90-96, 99-106, 109-111, 113-114, 131; table 1; abstract	1-10
P,X	WO 2015/093878 A1 (ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.) 25 June 2015 pages 9-12, 17-20, 40-41; table 1, 3; abstract	1-8, 10-11

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/KR2015/007636**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/KR2015/007636**

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Patent Document/s Cited in Search Report		**Patent Family Member/s**	
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INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/KR2015/007636**

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INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/KR2015/007636**

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End of Annex

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