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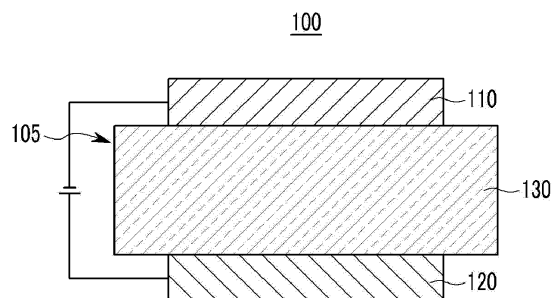
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(54) **ORGANIC OPTOELECTRONIC ELEMENT AND DISPLAY DEVICE**

(57) Disclosed are an organic optoelectronic device includes an anode and a cathode facing each other, and an organic layer disposed between the anode and the cathode. The organic layer includes one of a hole injection layer, a hole transport layer, a light emitting layer, and an electron transport layer. The light emitting layer includes a first host represented by Chemical Formula 1, a second host represented by Chemical Formula 2, and a phosphorescent dopant represented by Chemical Formula 3. A display device including the same.

【Figure 1】



Description**[Technical Field]**

5 **[0001]** An organic optoelectronic device and a display device are disclosed.

[Background Art]

10 **[0002]** An organic optoelectronic device (organic optoelectronic diode) is a device that converts electrical energy into photoenergy, and vice versa.

[0003] An organic optoelectronic device may be classified as follows in accordance with its driving principles. One is a photoelectric device where excitons are generated by photoenergy, separated into electrons and holes, and are transferred to different electrodes to generate electrical energy, and the other is a light emitting device where a voltage or a current is supplied to an electrode to generate photoenergy from electrical energy.

15 **[0004]** Examples of the organic optoelectronic diode may be an organic photoelectric device, an organic light emitting diode, an organic solar cell, and an organic photo conductor drum.

[0005] Of these, an organic light emitting diode (OLED) has recently drawn attention due to an increase in demand for flat panel displays. The organic light emitting diode is a device converting electrical energy into light by applying current to an organic light emitting material, and has a structure in which an organic layer is disposed between an anode and a cathode. Herein, the organic layer may include a light emitting layer and optionally an auxiliary layer, and the auxiliary layer may be, for example at least one layer selected from a hole injection layer, a hole transport layer, an electron blocking layer, an electron transport layer, an electron injection layer, and a hole blocking layer.

[0006] Performance of an organic light emitting diode may be affected by characteristics of the organic layer, and among them, may be mainly affected by characteristics of an organic material of the organic layer.

25 **[0007]** Particularly, development for an organic material being capable of increasing hole and electron mobility and simultaneously increasing electrochemical stability is needed so that the organic light emitting diode may be applied to a large-size flat panel display.

[Disclosure]

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[Technical Problem]

[0008] An embodiment provides an organic optoelectronic device having high efficiency and long life-span.

[0009] Another embodiment provides a display device including the organic optoelectronic device.

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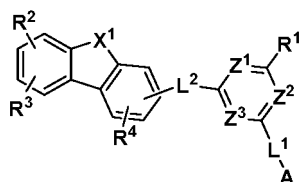
[Technical Solution]

[0010] According to an embodiment, an organic optoelectronic device includes an anode and a cathode facing each other and an organic layer disposed between the anode and the cathode, wherein the organic layer includes one of a hole injection layer, a hole transport layer, a light emitting layer, and an electron transport layer, and the light emitting layer includes a first host represented by Chemical Formula 1, a second host represented by Chemical Formula 2, and a phosphorescent dopant represented by Chemical Formula 3:

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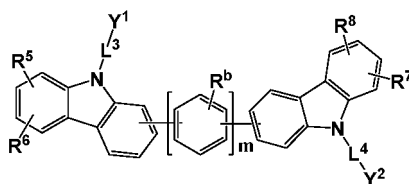
[Chemical Formula 1]

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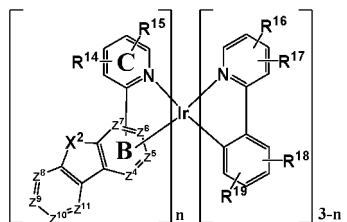


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[Chemical Formula 2]



[Chemical Formula 3]



[0011] In Chemical Formula 1,

X¹ is O or S,

Z¹ to Z³ are independently N or CR^a,

at least two of Z¹ to Z³ are N,

L¹ and L² are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

A is a substituted or unsubstituted carbazolyl group,

R¹ is a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

R^a and R² to R⁴ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group;

wherein, in Chemical Formula 2,

Y¹ and Y² are independently a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group,

L³ and L⁴ are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

R^b and R⁵ to R⁸ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group, m is an integer ranging from 0 to 2;

wherein, in Chemical Formula 3,

Z⁴ to Z¹¹ are independently N, C, or CR^c,

the ring C is bound to the ring B through a C-C bond,

iridium is bound to the ring B through an Ir-C bond,

X² is O or S,

R^c and R¹⁴ to R¹⁹ are independently hydrogen, deuterium, a halogen, germanium group, a cyano group, a substituted or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C3 to C20 cycloalkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group, and

n is an integer ranging from 1 to 3.

[0012] According to another embodiment, a display device including the organic optoelectronic device is provided.

[Advantageous Effects]

[0013] An organic optoelectronic device having high efficiency and a long life-span may be realized.

[Description of the Drawings]

[0014] FIGS. 1 and 2 are cross-sectional views showing organic light emitting diodes according to embodiments.

<Description of Symbols>

[0015]

5 100, 200: organic light emitting diode
 105: organic layer
 110: cathode
 120: anode
 130: light emitting layer
 10 140: hole auxiliary layer

[Best Mode]

15 **[0016]** Hereinafter, embodiments of the present invention are described in detail. However, these embodiments are exemplary, the present invention is not limited thereto and the present invention is defined by the scope of claims.

[0017] In the present specification when a definition is not otherwise provided, "substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a halogen, a hydroxyl group, an amino group, a substituted or unsubstituted C1 to C30 amine group, a nitro group, a substituted or unsubstituted C1 to C40 silyl group, a C1 to C30 alkyl group, a C1 to C10 alkylsilyl group, a C6 to C30 arylsilyl group, a C3 to C30 cycloalkyl group, a C3 to C30 heterocycloalkyl group, a C6 to C30 aryl group, a C2 to C30 heteroaryl group, a C1 to C20 alkoxy group, a C1 to C10 trifluoroalkyl group, a cyano group, or a combination thereof.

20 **[0018]** In one example of the present invention, "substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a C1 to C10 alkyl group, a C6 to C20 aryl group, or a C2 to C20 heterocyclic group. In addition, in specific examples of the present invention, "substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a C1 to C4 alkyl group, a C6 to C12 aryl group, or a C2 to C12 heterocyclic group. More specifically, "substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a C1 to C5 alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, or a carbazolyl group. In addition, in most specific examples of the present invention, "substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a methyl group, an ethyl group, a propyl group, a butyl group, a phenyl group, a para-biphenyl group, a meta-biphenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, or a carbazolyl group.

30 **[0019]** In the present specification, when a definition is not otherwise provided, "hetero" refers to one including one to three heteroatoms selected from N, O, S, P, and Si, and remaining carbons in one functional group.

35 **[0020]** In the present specification, when a definition is not otherwise provided, "alkyl group" refers to an aliphatic hydrocarbon group. The alkyl group may be "a saturated alkyl group" without any double bond or triple bond.

[0021] The alkyl group may be a C1 to C30 alkyl group. More specifically, the alkyl group may be a C1 to C20 alkyl group or a C1 to C10 alkyl group. For example, a C1 to C4 alkyl group may have one to four carbon atoms in the alkyl chain, and may be selected from methyl, ethyl, propyl, iso-propyl, n-butyl, isobutyl, sec-butyl, and t-butyl.

40 **[0022]** Specific examples of the alkyl group may be a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a t-butyl group, a pentyl group, a hexyl group, a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and the like.

[0023] In the present specification, "an aryl group" refers to a group including at least one hydrocarbon aromatic moiety, and

45 all elements of the hydrocarbon aromatic moiety have p-orbitals which form conjugation, for example a phenyl group, a naphthyl group, and the like,

 two or more hydrocarbon aromatic moieties may be linked by a sigma bond and may be, for example a biphenyl group, a terphenyl group, a quarterphenyl group, and the like, and

50 two or more hydrocarbon aromatic moieties are fused directly or indirectly to provide a non-aromatic fused ring. For example, it may be a fluorenyl group.

[0024] The aryl group may include a monocyclic, polycyclic, or fused ring polycyclic (i.e., rings sharing adjacent pairs of carbon atoms) functional group.

[0025] In the present specification, "a heterocyclic group" is a generic concept of a heteroaryl group, and may include at least one heteroatom selected from N, O, S, P, and Si instead of carbon (C) in a cyclic compound such as an aryl group, a cycloalkyl group, a fused ring thereof, or a combination thereof. When the heterocyclic group is a fused ring, the entire ring or each ring of the heterocyclic group may include one or more heteroatoms.

55 **[0026]** For example, "heteroaryl group" may refer to an aryl group including at least one heteroatom selected from N, O, S, P, and Si. Two or more heteroaryl groups are linked by a sigma bond directly, or when the heteroaryl group includes

two or more rings, the two or more rings may be fused. When the heteroaryl group is a fused ring, each ring may include one to three heteroatoms.

[0027] Specific examples of the heterocyclic group may include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, and the like.

[0028] More specifically, the substituted or unsubstituted C6 to C30 aryl group and/or the substituted or unsubstituted C2 to C30 heterocyclic group may be a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthrenyl group, a substituted or unsubstituted naphthacenyl group, a substituted or unsubstituted pyrenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted p-terphenyl group, a substituted or unsubstituted m-terphenyl group, a substituted or unsubstituted o-terphenyl group, a substituted or unsubstituted chrysenyl group, a substituted or unsubstituted triphenylene group, a substituted or unsubstituted perylenyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted indenyl group, a substituted or unsubstituted furanyl group, a substituted or unsubstituted thiophenyl group, a substituted or unsubstituted pyrrolyl group, a substituted or unsubstituted pyrazolyl group, a substituted or unsubstituted imidazolyl group, a substituted or unsubstituted triazolyl group, a substituted or unsubstituted oxazolyl group, a substituted or unsubstituted thiazolyl group, a substituted or unsubstituted oxadiazolyl group, a substituted or unsubstituted thiadiazolyl group, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted pyrimidinyl group, a substituted or unsubstituted pyrazinyl group, a substituted or unsubstituted triazinyl group, a substituted or unsubstituted benzofuranyl group, a substituted or unsubstituted benzothiophenyl group, a substituted or unsubstituted benzimidazolyl group, a substituted or unsubstituted indolyl group, a substituted or unsubstituted quinolinyl group, a substituted or unsubstituted isoquinolinyl group, a substituted or unsubstituted quinazolinyl group, a substituted or unsubstituted quinoxalinyl group, a substituted or unsubstituted naphthyridinyl group, a substituted or unsubstituted benzoxazinyl group, a substituted or unsubstituted benzthiazinyl group, a substituted or unsubstituted acridinyl group, a substituted or unsubstituted phenazinyl group, a substituted or unsubstituted phenothiazinyl group, a substituted or unsubstituted phenoxazinyl group, a substituted or unsubstituted carbazolyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, or combination thereof, but are not limited thereto.

[0029] In the present specification, hole characteristics refer to an ability to donate an electron to form a hole when an electric field is applied and that a hole formed in the anode may be easily injected into the light emitting layer, a hole formed in the light emitting layer may be easily transported into the anode, and a hole may be easily transported in the light emitting layer due to conductive characteristics according to a highest occupied molecular orbital (HOMO) level.

[0030] In addition, electron characteristics refer to an ability to accept an electron when an electric field is applied and that an electron formed in the cathode may be easily injected into the light emitting layer, an electron formed in the light emitting layer may be easily transported into the cathode, and an electron may be easily transported in the light emitting layer due to conductive characteristics according to a lowest unoccupied molecular orbital (LUMO) level.

[0031] Hereinafter, an organic optoelectronic device according to an embodiment is described.

[0032] The organic optoelectronic device may be any device to convert electrical energy into photoenergy and vice versa without particular limitation, and may be for example an organic photoelectric device, an organic light emitting diode, an organic solar cell, and an organic photo conductor drum, and the like.

[0033] Herein, an organic light emitting diode as one example of an organic optoelectronic device is described referring to drawings.

[0034] FIGS. 1 and 2 are cross-sectional views showing organic light emitting diodes according to embodiments.

[0035] Referring to FIG. 1, an organic light emitting diode 100 according to an embodiment includes an anode 120 and a cathode 110 facing each other and an organic layer 105 interposed between the anode 120 and cathode 110.

[0036] The anode 120 may be made of a conductor having a large work function to help hole injection, and may be for example metal, metal oxide and/or a conductive polymer. The anode 120 may be, for example a metal such as nickel, platinum, vanadium, chromium, copper, zinc, gold and the like or an alloy thereof; metal oxide such as zinc oxide, indium oxide, indium tin oxide (ITO), indium zinc oxide (IZO), and the like; a combination of a metal and an oxide such as ZnO and Al or SnO₂ and Sb; a conductive polymer such as poly(3-methylthiophene), poly(3,4-(ethylene-1,2-dioxy)thiophene) (PEDOT), polypyrrole, and polyaniline, but is not limited thereto.

[0037] The cathode 110 may be made of a conductor having a small work function to help electron injection, and may be for example metal, metal oxide and/or a conductive polymer. The cathode 110 may be for example a metal such as magnesium, calcium, sodium, potassium, titanium, indium, yttrium, lithium, gadolinium, aluminum silver, tin, lead, cesium, barium, and the like or an alloy thereof; a multi-layer structure material such as LiF/Al, LiO₂/Al, LiF/Ca, LiF/Al and BaF₂/Ca, but is not limited thereto.

[0038] The organic layer 105 includes a light emitting layer 130.

[0039] FIG. 2 is a cross-sectional view showing an organic light emitting diode according to another embodiment.

[0040] Referring to FIG. 2, an organic light emitting diode 200 further includes a hole auxiliary layer 140 in addition to the light emitting layer 130. The hole auxiliary layer 140 may further increase hole injection and/or hole mobility and

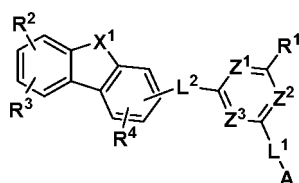
block electrons between the anode 120 and the light emitting layer 130. The hole auxiliary layer 140 may be, for example a hole transport layer, a hole injection layer, and/or an electron blocking layer and may include at least one layer.

[0041] The organic layer 105 of FIG. 1 or 2 may further include an electron injection layer, an electron transport layer, an electron transport auxiliary layer, a hole transport layer, a hole transport auxiliary layer, a hole injection layer, or a combination thereof even if they are not shown.

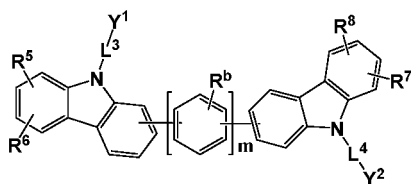
[0042] The organic light emitting diodes 100 and 200 may be manufactured by forming an anode or a cathode on a substrate, forming an organic layer using a dry film formation method such as a vacuum deposition method (evaporation), sputtering, plasma plating, and ion plating or a wet coating method such as spin coating, dipping, and flow coating, and forming a cathode or an anode thereon.

[0043] An organic optoelectronic device according to an embodiment includes an anode and a cathode facing each other, and an organic layer disposed between the anode and the cathode, wherein the organic layer includes at least one of a hole injection layer, a hole transport layer, a light emitting layer, and an electron transport layer and the light emitting layer includes a first host represented by Chemical Formula 1, a second host represented by Chemical Formula 2, and a phosphorescent dopant:

[Chemical Formula 1]



[Chemical Formula 2]



[0044] In Chemical Formula 1,

X¹ is O or S,

Z¹ to Z³ are independently N or CR^a,

at least two of Z¹ to Z³ are N,

L¹ and L² are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

A is a substituted or unsubstituted carbazolyl group,

R¹ is a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

R^a and R² to R⁴ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group;

wherein, in Chemical Formula 2,

Y¹ and Y² are independently a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group,

L³ and L⁴ are independently a single bond or a substituted or unsubstituted C6 to C20 arylene group,

R^b and R⁵ to R⁸ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group, and

m is an integer ranging from 0 to 2.

[0045] The organic optoelectronic device according to the present invention increases material stability by introducing a triazine or pyrimidine moiety linked with dibenzofuran (or dibenzothiophene) and simultaneously introducing a carbazole moiety to obtain additional stability due to bipolar characteristics as the first host. A glass transition temperature relative to a molecular weight due to the carbazole moiety may be improved and thus heat resistance may be ensured.

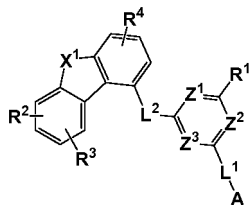
[0046] Particularly, biscarbazole is combined as the second host and thereby holes and electrons are balanced to

realize long life-span, low driving voltage characteristics.

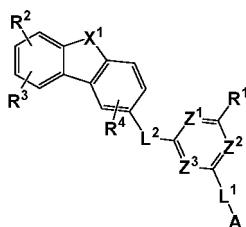
[0047] Simultaneously, a phosphorescent dopant is additionally combined and thereby combination matching such as packing of host and dopant materials, energy transfer, and the like may be ensured.

[0048] The first host represented by Chemical Formula 1 may be for example represented by one of Chemical Formula 1-1 to Chemical Formula 1-4 according to a specific linking position of dibenzofuran (or dibenzothiophene) with the nitrogen-containing hexagonal ring through L².

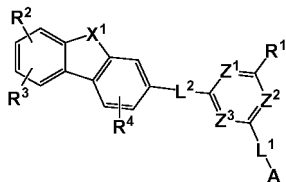
[Chemical Formula 1-1]



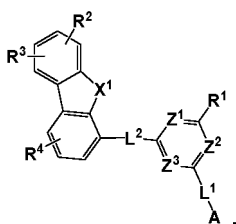
[Chemical Formula 1-2]



[Chemical Formula 1-3]



[Chemical Formula 1-4]

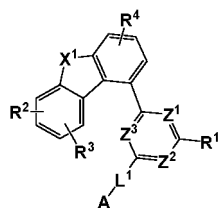


[0049] In Chemical Formula 1-1 to Chemical Formula 1-4, X¹, Z¹ to Z³, L¹, L², A, and R¹ to R⁴ are the same as described above.

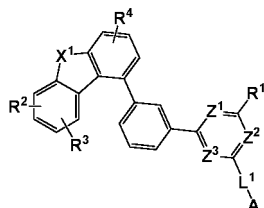
[0050] In an example embodiment of the present invention, the first host may be represented by Chemical Formula 1-1, Chemical Formula 1-3, or Chemical Formula 1-4, and preferably Chemical Formula 1-3 or Chemical Formula 1-4.

[0051] In a specific example embodiment of the present invention, Chemical Formula 1-1 may be for example represented by one of Chemical Formula 1-1 a, Chemical Formula 1-1b, and Chemical Formula 1-1c according to L².

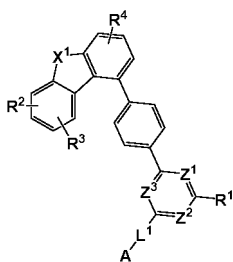
[Chemical Formula 1-1a]



[Chemical Formula 1-1b]

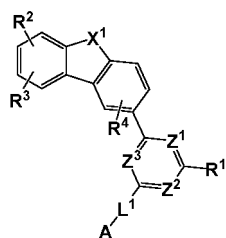


[Chemical Formula 1-1c]

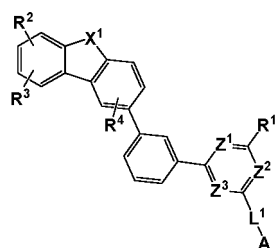


[0052] In a specific example embodiment of the present invention, Chemical Formula 1-2 may be for example represented by one of Chemical Formula 1-2a, Chemical Formula 1-2b and Chemical Formula 1-2c according to L².

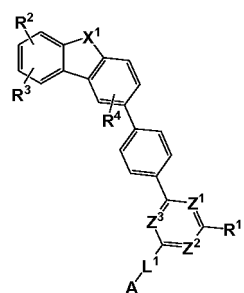
[Chemical Formula 1-2a]



[Chemical Formula 1-2b]

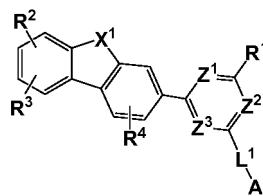


[Chemical Formula 1-2c]

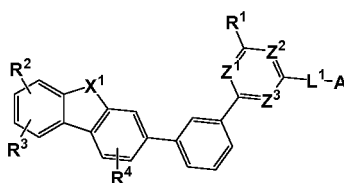


[0053] In a specific example embodiment of the present invention, Chemical Formula 1-3 may be for example represented by one of Chemical Formula 1-3a, Chemical Formula 1-3b, and Chemical Formula 1-3c according to L².

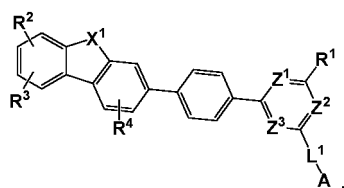
[Chemical Formula 1-3a]



[Chemical Formula 1-3b]

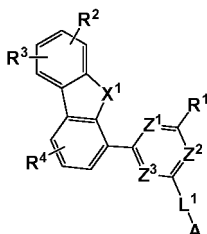


[Chemical Formula 1-3c]

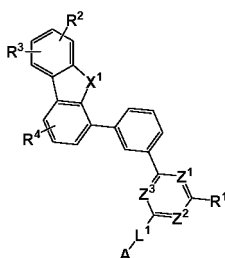


[0054] In a specific example embodiment of the present invention, Chemical Formula 1-4 may be for example represented by one of Chemical Formula 1-4a, Chemical Formula 1-4b, and Chemical Formula 1-4c according to L².

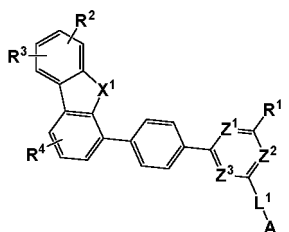
[Chemical Formula 1-4a]



[Chemical Formula 1-4b]



[Chemical Formula 1-4c]



[0055] In Chemical Formula 1-1 a to Chemical Formula 1-1c, Chemical Formula 1-2a to Chemical Formula 1-2c, Chemical Formula 1-3a to Chemical Formula 1-3c, and Chemical Formula 1-4a to Chemical Formula 1-4c, X¹, Z¹ to Z³, L¹, A, and R¹ to R⁴ are the same as described above.

[0056] In a specific example embodiment of the present invention, the first host may be represented by one of Chemical Formulae 1-1a, 1-3a, and 1-4b, for example, one of Chemical Formulae 1-3a, 1-4a, and 1-4b, and for example, Chemical Formula 1-3a wherein a position No. 3 of dibenzofuran (or dibenzothiophene) is directly linked to a nitrogen-containing hexagonal ring.

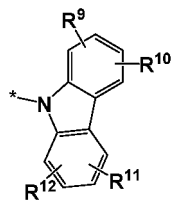
[0057] The first host increases a hole and electron injection rate through a LUMO expansion and a planarity expansion of an ET moiety such as triazine, pyrimidine, and the like by including a structure where 3-dibenzofuran (or 3-dibenzothiophene) is directly linked with the triazine or pyrimidine moiety as shown in Chemical Formula 1-3a and secures additional stability and improves a glass transition temperature relative to a molecular weight and thus secures heat resistance by introducing a carbazole moiety to apply bipolar characteristics.

[0058] In addition, biscarbazole as a second host may be combined with the first host material to balance the first host material having fast and stable electron transport characteristics and the second host material having fast and stable hole transport characteristics and thus to secure a low driving voltage /long life-span host set having a high glass transition temperature relative to a molecular weight.

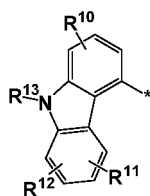
[0059] Simultaneously, the host set may be combined with a phosphorescent dopant to secure a combination/matching advantage of packing of the host and dopant materials, an energy transport, and the like and thereby obtain characteristics of a low driving voltage, a long life-span, and high efficiency.

[0060] In an example embodiment of the present invention, the substituent A is a substituted or unsubstituted carbazoly group, and may be represented by one of Chemical Formula A-1 to Chemical Formula A-5 according to specific substitution points.

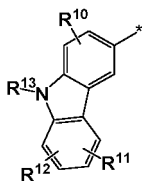
[Chemical Formula A-1]



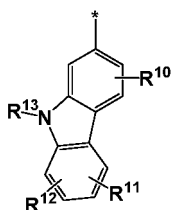
[Chemical Formula A-2]



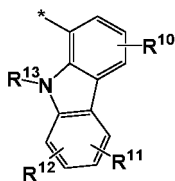
[Chemical Formula A-3]



[Chemical Formula A-4]



[Chemical Formula A-5]



[0061] In Chemical Formula A-1 to Chemical Formula A-5, R⁹ to R¹³ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group, and

* is a linking point with L¹.

[0062] In a specific example embodiment, R⁹ to R¹³ may independently be hydrogen, or a substituted or unsubstituted C6 to C20 aryl group, and more specifically R⁹ to R¹³ may independently be hydrogen or a phenyl group, for example when A is represented by Chemical Formula A-1, R⁹ to R¹² may be all hydrogen or one or two of R⁹ to R¹² may be a phenyl group.

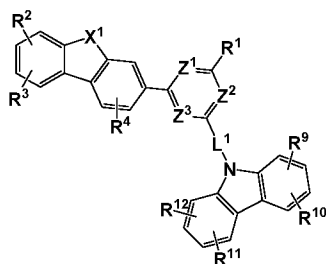
[0063] In addition, when A is represented by one of Chemical Formula A-2 to Chemical Formula A-5, R¹³ may be a phenyl group and R¹⁰ to R¹² are all hydrogen or at least one of R¹¹ and R¹² may be a phenyl group.

[0064] Particularly, Chemical Formula 1-3a may be for example represented by one of Chemical Formula 1-3a-I, Chemical Formula 1-3a-II, Chemical Formula 1-3a-III, Chemical Formula 1-3a-IV, and Chemical Formula 1-3a-V according to specific structure of the substituent A,

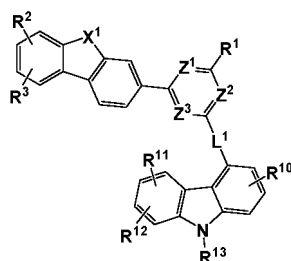
[0065] Chemical Formula 1-4a may be for example represented by one of Chemical Formula 1-4a-I, Chemical Formula 1-4a-II, Chemical Formula 1-4a-III, Chemical Formula 1-4a-IV and Chemical Formula 1-4a-V according to specific structure of the substituent A, and

[0066] Chemical Formula 1-4b may be for example represented by one of Chemical Formula 1-4b-I, Chemical Formula 1-4b-II, Chemical Formula 1-4b-III, Chemical Formula 1-4b-IV and Chemical Formula 1-4b-V according to specific structure of the substituent A.

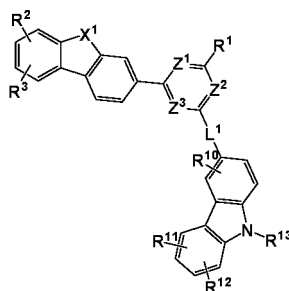
[Chemical Formula 1-3a-I]



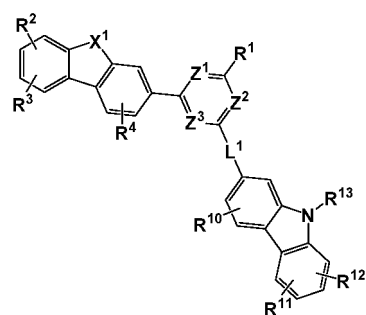
[Chemical Formula 1-3a-II]



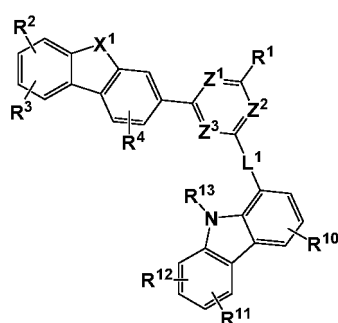
[Chemical Formula 1-3a-III]



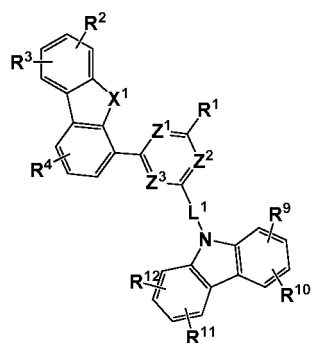
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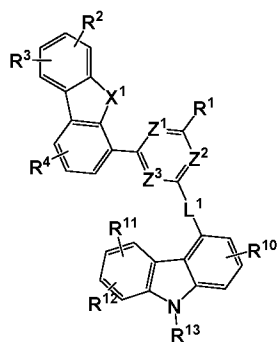
[Chemical Formula 1-3a-V]



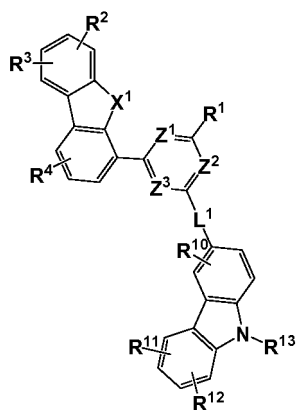
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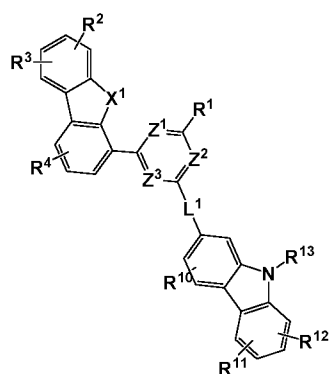
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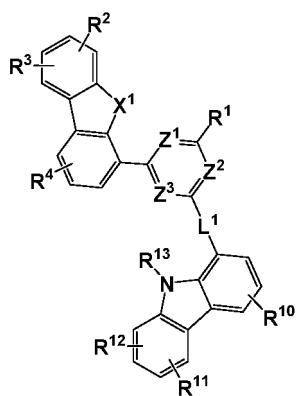
[Chemical Formula 1-4a-III]



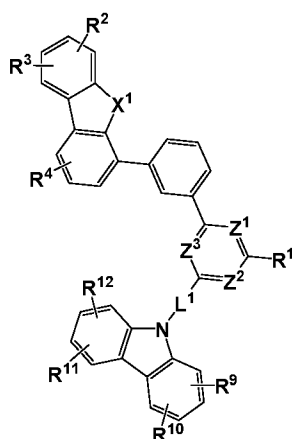
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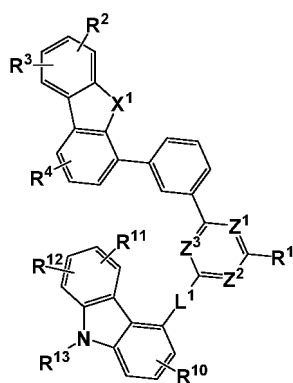
[Chemical Formula 1-4a-V]



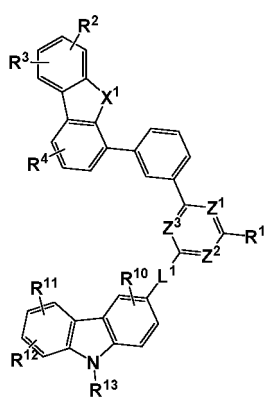
[Chemical Formula 1-4b-I]



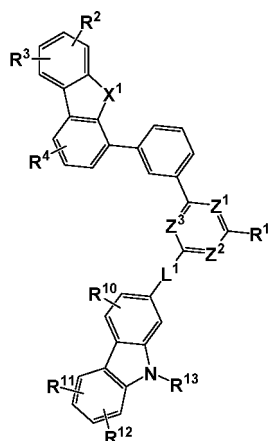
[Chemical Formula 1-4b-II]



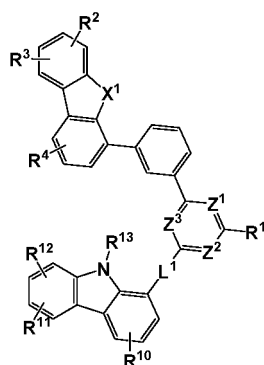
[Chemical Formula 1-4b-III]



[Chemical Formula 1-4b-IV]



[Chemical Formula 1-4b-V]



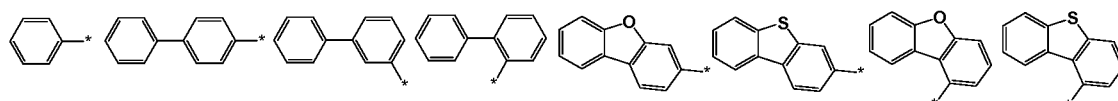
[0067] In Chemical Formula 1-3a-I to Chemical Formula 1-3a-V, Chemical Formula 1-4a-I to Chemical Formula 1-4a-V, and Chemical Formula 1-4b-I to Chemical Formula 1-4b-V, X^1 , Z^1 to Z^3 , L^1 , R^1 to R^4 and R^9 to R^{13} are the same as described above.

[0068] The first host may be preferably represented by one of Chemical Formula 1-3a-I, Chemical Formula 1-3a-II, Chemical Formula 1-3a-III, Chemical Formula 1-4a-I, Chemical Formula 1-4b-I and Chemical Formula 1-4b-II, and may be more preferably represented by one of Chemical Formula 1-3a-I, Chemical Formula 1-3a-II, and Chemical Formula 1-3a-III.

[0069] On the other hand, in an example embodiment of the present invention, the hexagonal ring consisting of Z^1 to Z^3 may be pyrimidine or triazine, in a specific example embodiment, pyrimidine where Z^1 and Z^2 are N, pyrimidine where Z^1 and Z^3 are N, pyrimidine where Z^2 and Z^3 are N, or triazine where Z^1 to Z^3 are N, and preferably triazine where Z^1 to Z^3 are N.

[0070] In an example embodiment of the present invention, R^1 may be a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and more specifically R^1 may be a substituted or unsubstituted phenyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and may be for example selected from substituents of Group I.

[Group I]



[0071] In Group I, * is a linking point with a nitrogen-containing hexagonal ring.

[0072] R¹ may be preferably a phenyl group, a dibenzofuranyl group, or a dibenzothiophenyl group.

[0073] In an example embodiment of the present invention, R^a and R² to R⁴ may independently be hydrogen, deuterium, a cyano group, or a substituted or unsubstituted C6 to C12 aryl group, more specifically R^a and R² to R⁴ may independently be hydrogen, deuterium, or a cyano group, and preferably R^a and R² to R⁴ may be all hydrogen.

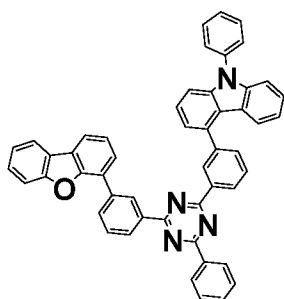
[0074] In addition, in an example embodiment of the present invention, L¹ and L² may independently be a single bond, or a substituted or unsubstituted C6 to C12 arylene group, and more specifically L¹ and L² may independently be a single bond, a meta-phenylene group, or a para-phenylene group.

[0075] In addition, in an example embodiment of the present invention, R⁹ to R¹¹ may independently be hydrogen, deuterium, a cyano group, or a substituted or unsubstituted C6 to C12 aryl group, more specifically R⁹ to R¹¹ may independently be hydrogen, deuterium, a cyano group or a phenyl group, and preferably R⁹ to R¹¹ are all hydrogen or at least one of R⁹ to R¹¹ may be a phenyl group. More preferably, R⁹ to R¹¹ may be all hydrogen or one of R⁹ to R¹¹ may be a phenyl group.

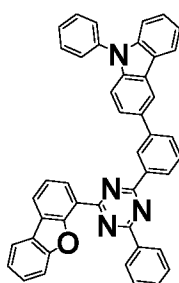
[0076] The first host may be for example selected from compounds of Group 1, but is not limited thereto.

[Group 1]

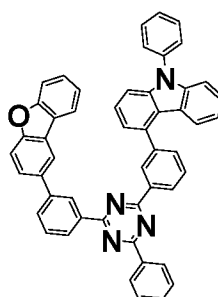
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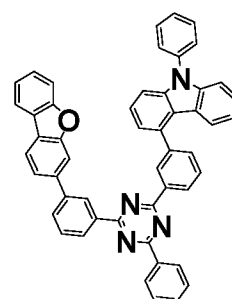
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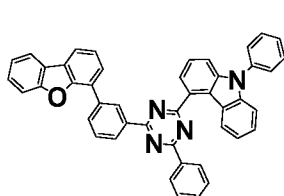
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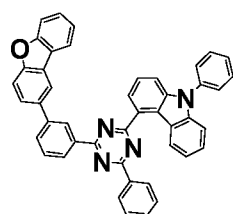
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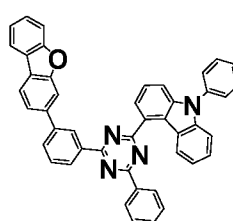
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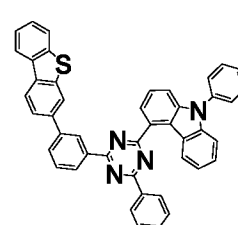
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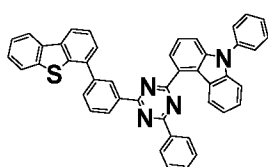
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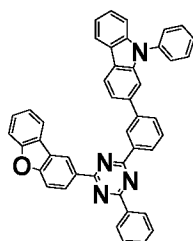
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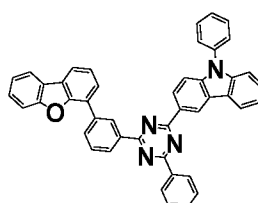
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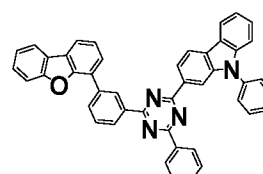
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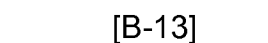
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[B-12]



[B-13]



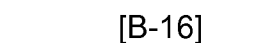
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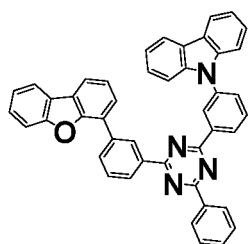


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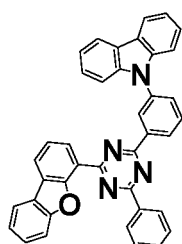


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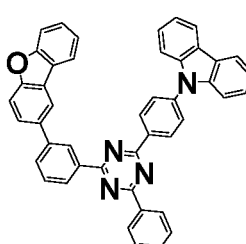




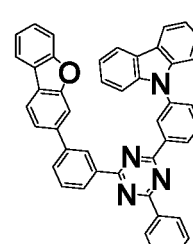
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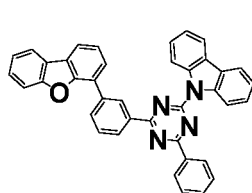
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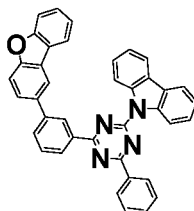
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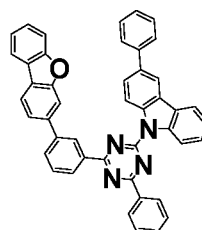
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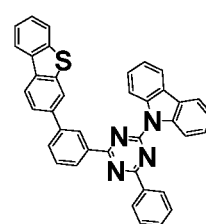
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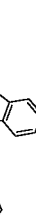
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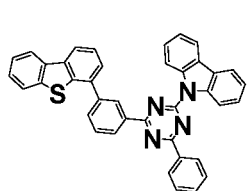
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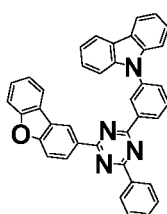
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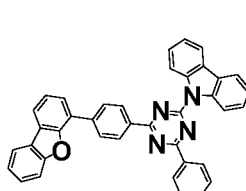
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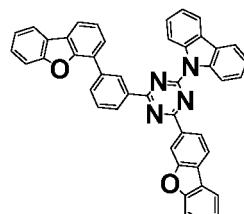
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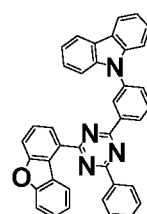
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[C-4]



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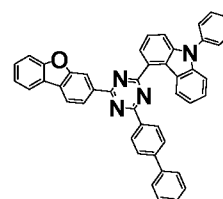
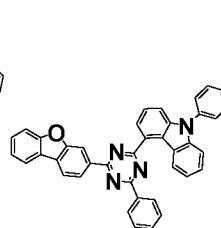
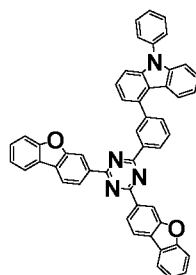
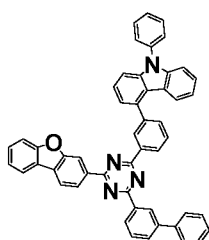
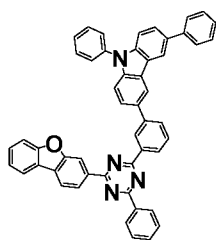
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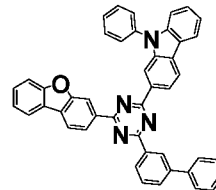
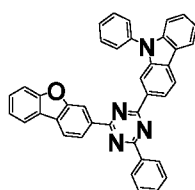
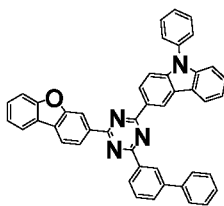
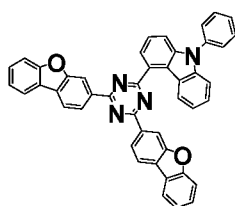
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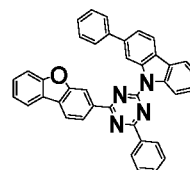
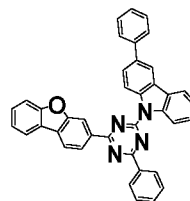
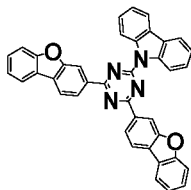
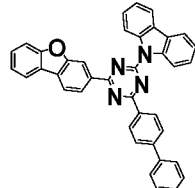
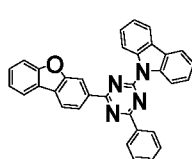
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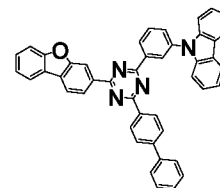
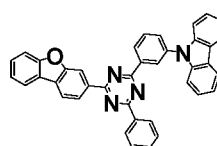
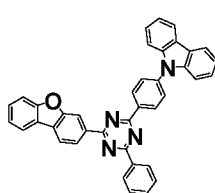
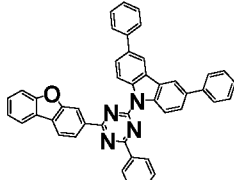
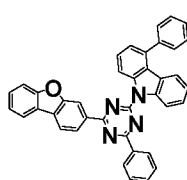
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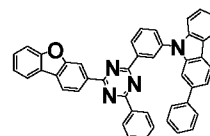
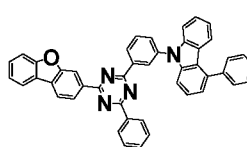
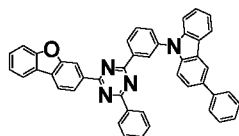
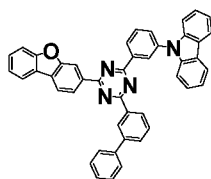
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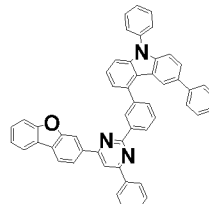
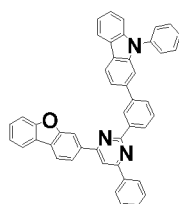
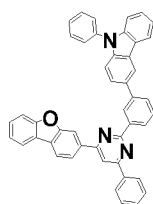
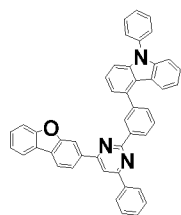
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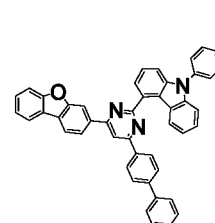
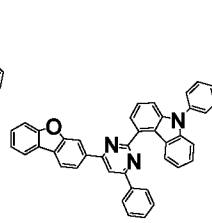
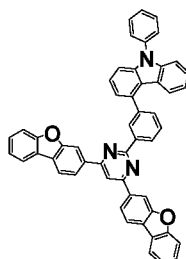
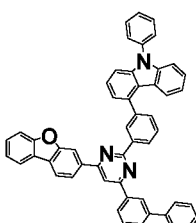
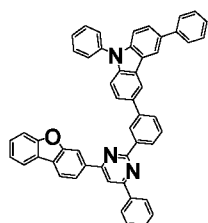
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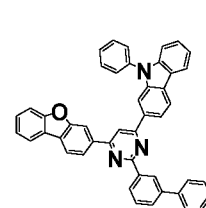
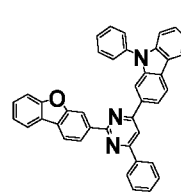
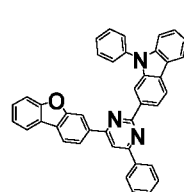
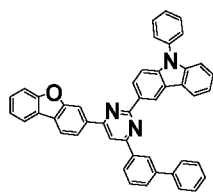
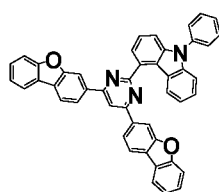
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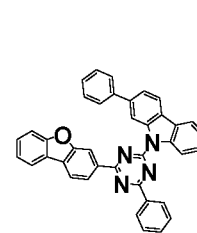
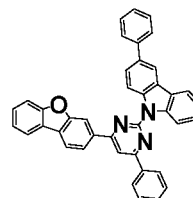
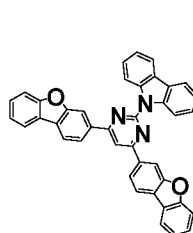
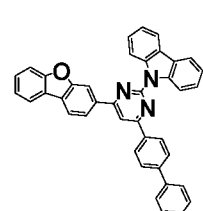
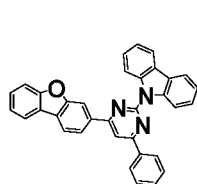
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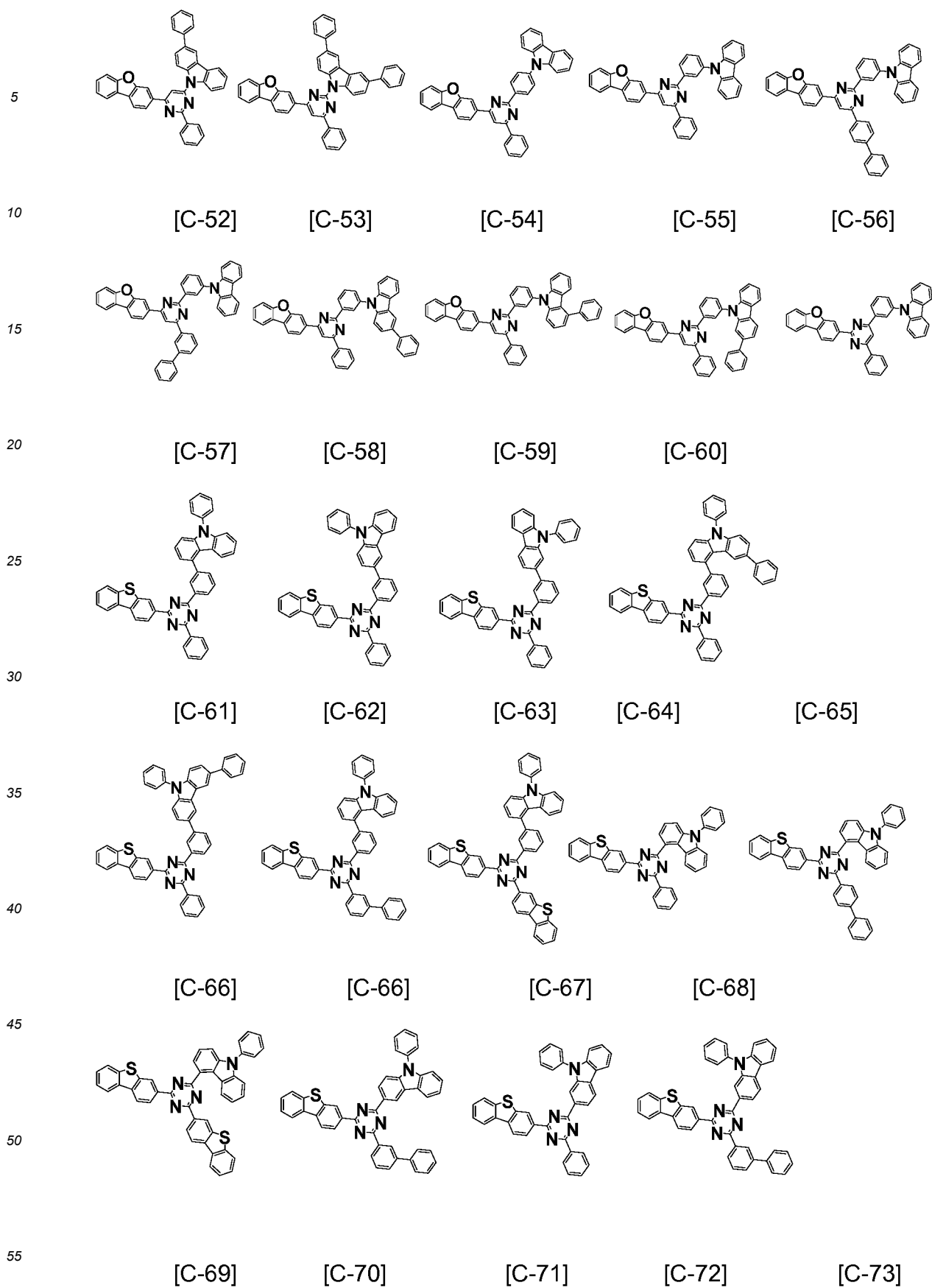
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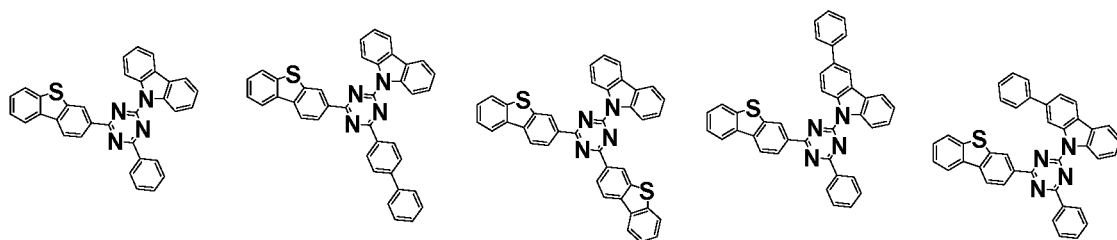
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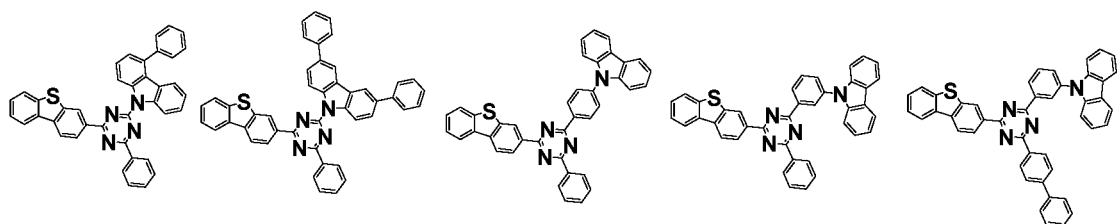
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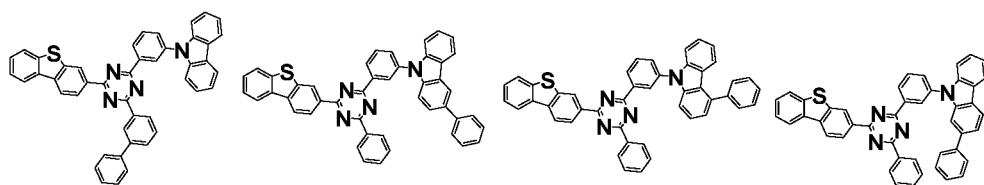


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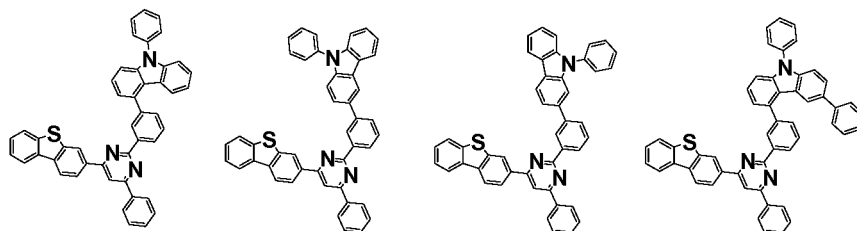


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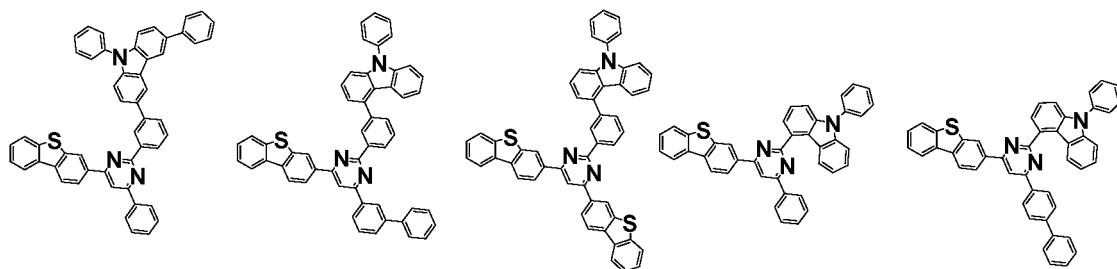
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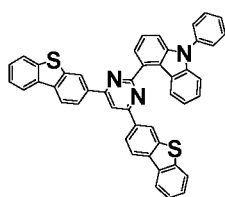
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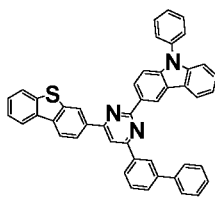
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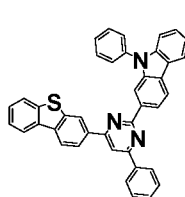
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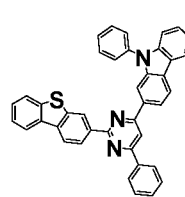
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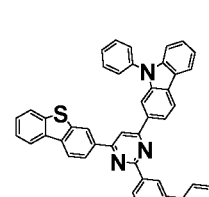
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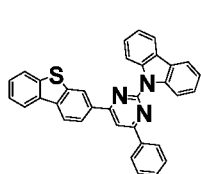
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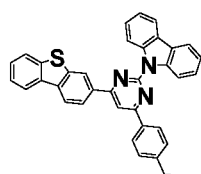
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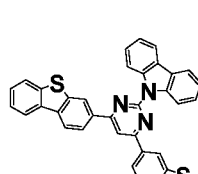
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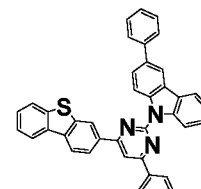
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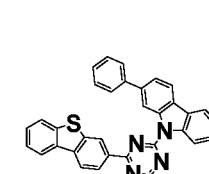
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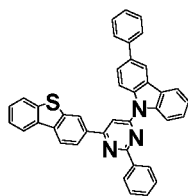
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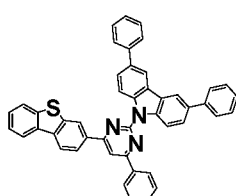
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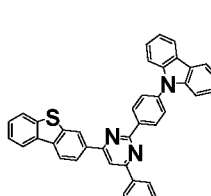
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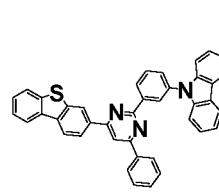
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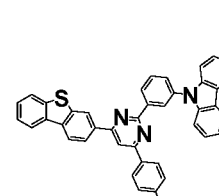
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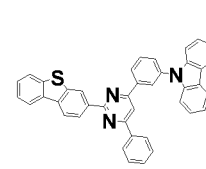
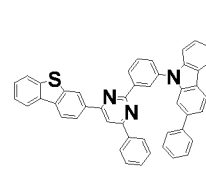
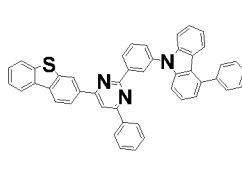
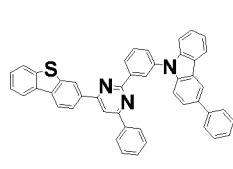
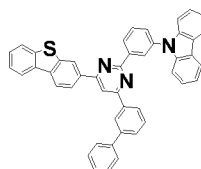
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[C-110]



[C-111]

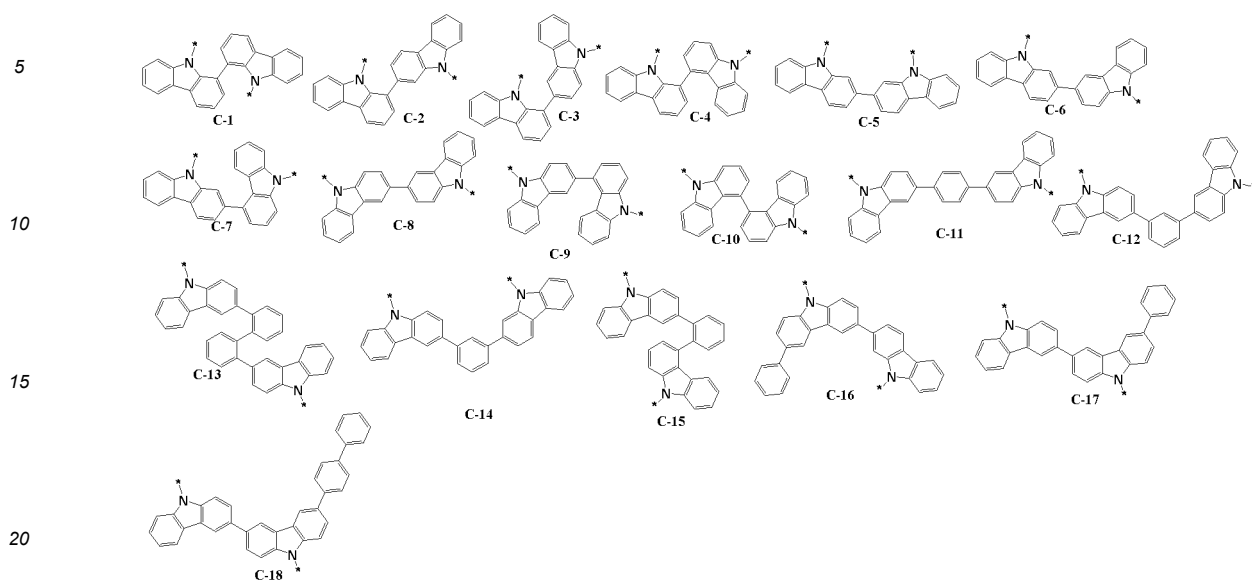


[0077] In an example embodiment of the present invention, regarding the second host, Y¹ and Y² of Chemical Formula 2 may independently be a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted triphenylenyl group, a substituted or unsubstituted carbazolyl group, a substituted or unsubstituted dibenzothiophenyl group, a substituted or unsubstituted dibenzofuranyl group, a substituted or unsubstituted fluorenyl group, or a substituted or unsubstituted pyridinyl group, L³ and L⁴ are independently a single bond, a substituted or unsubstituted phenylene group, or a substituted or unsubstituted biphenylene group, R⁵ to R⁸ are independently hydrogen, deuterium, or a substituted or unsubstituted C6 to C12 aryl group, and m may be 0 or 1.

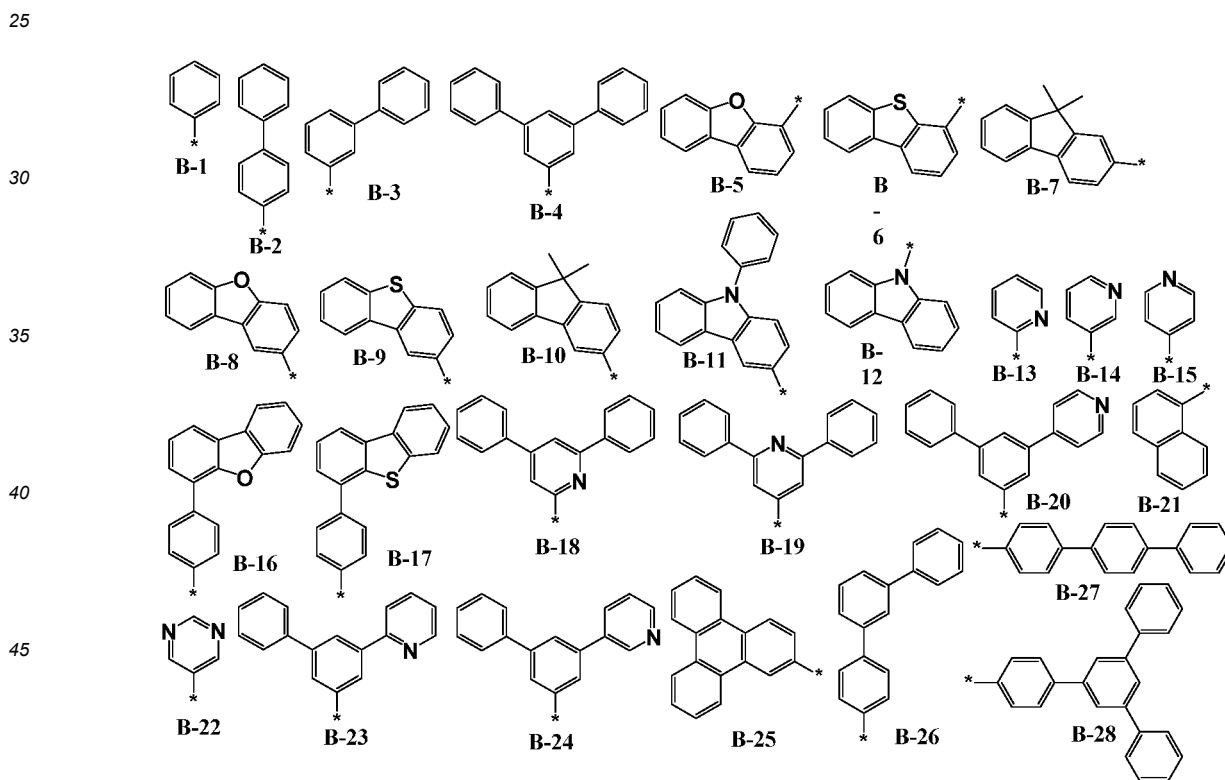
[0078] "Substituted" of Chemical Formula 2 refers to replacement of at least one hydrogen by deuterium, a C1 to C4 alkyl group, a C6 to C18 aryl group, or a C2 to C30 heteroaryl group.

[0079] In a specific example embodiment of the present invention, Chemical Formula 2 may be one of structures of Group II, and *-L³-Y¹ and *-L⁴-Y² may be one of substituents of Group III.

[Group II]



[Group III]



[0080] In Group II and Group III, * is a linking point.

[0081] In a specific example embodiment of the present invention, Chemical Formula 2 may be represented by Chemical Formula c-8 or Chemical Formula c-17 of Group II and *-L³-Y¹ and *-L⁴-Y² may be selected from Group III.

[0082] Preferably, Y¹ and Y² of Chemical Formula 2 may independently be a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted carbazolyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and more preferably *-L³-Y¹ and *-L⁴-Y² may be selected from B-1, B-2, B-3, B-11, B-16, and B-17 of Group III.

[0083] The second host may be for example selected from compounds of Group 2, but is not limited thereto.

[Group 2]

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[D-1]

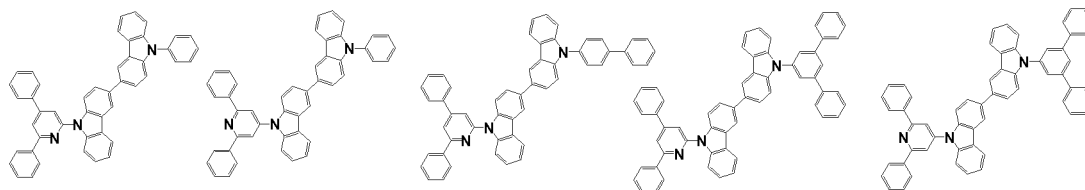
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[D-5]

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[D-6]

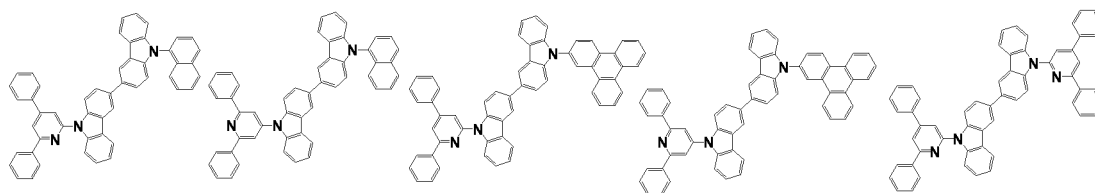
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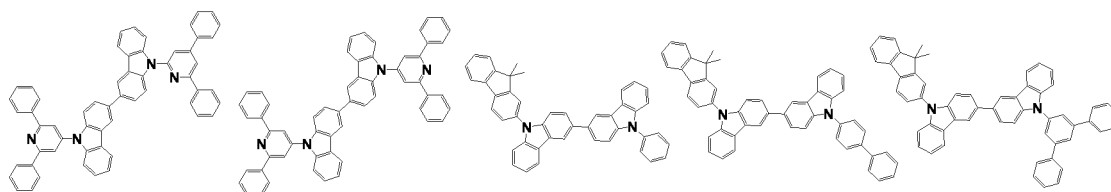
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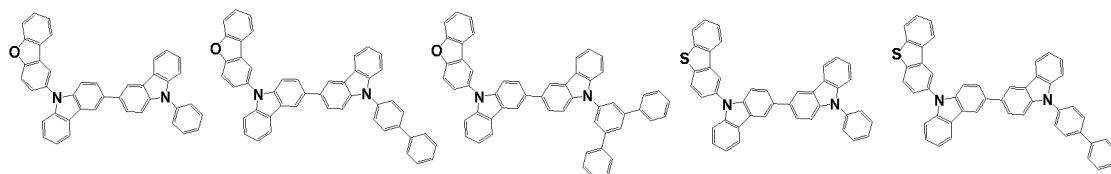
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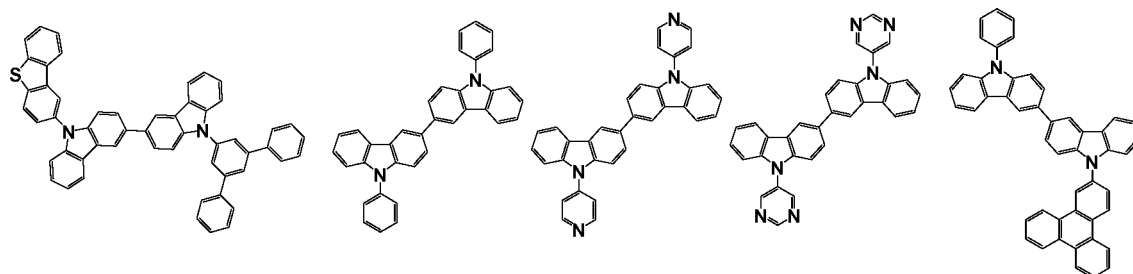
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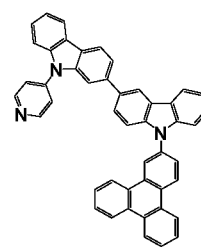
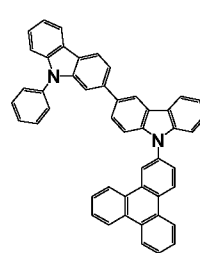
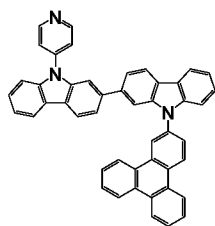
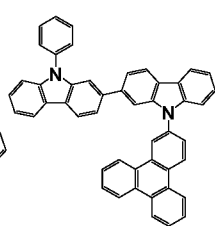
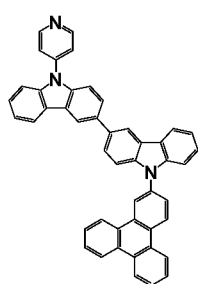
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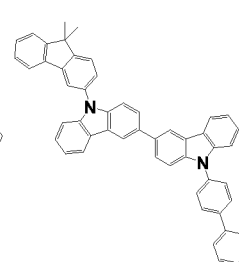
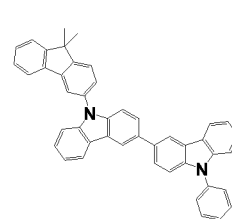
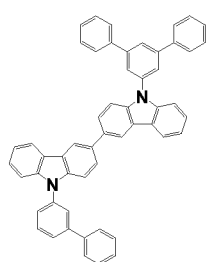
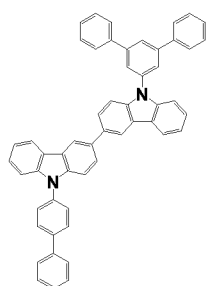
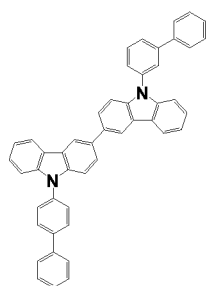
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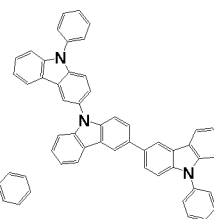
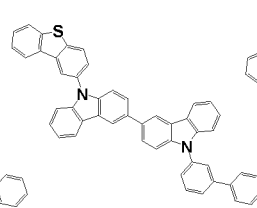
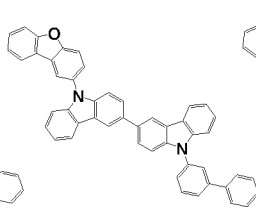
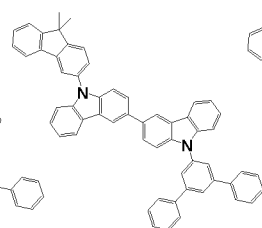
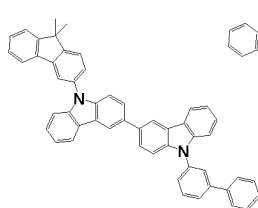
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[D-44]

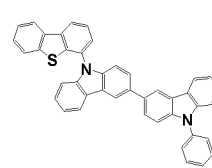
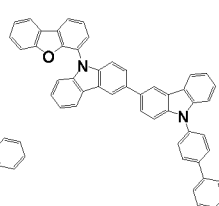
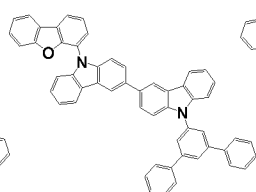
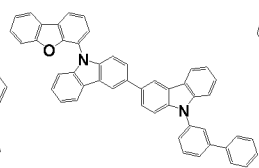
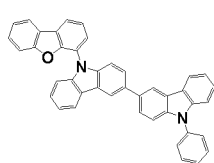
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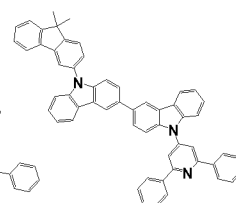
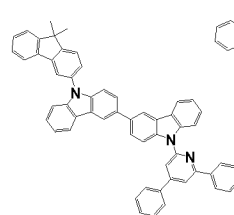
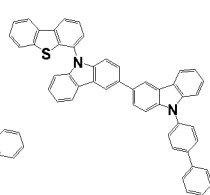
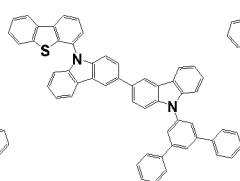
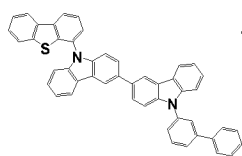
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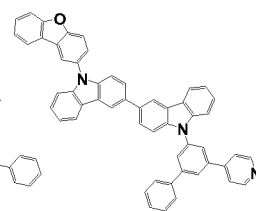
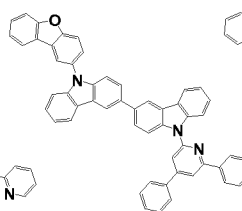
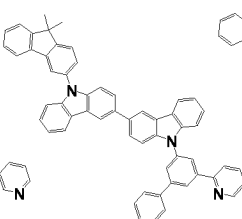
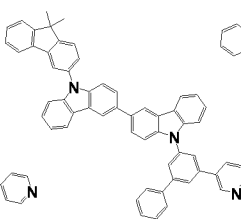
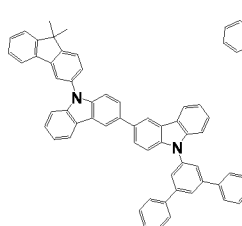
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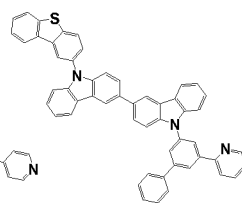
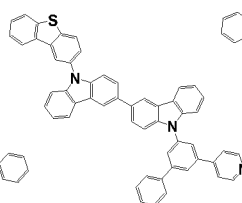
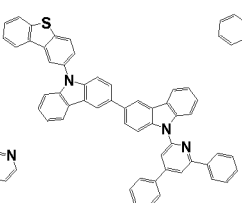
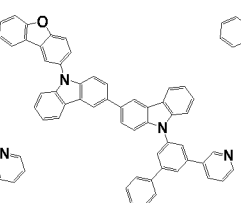
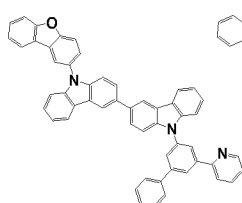
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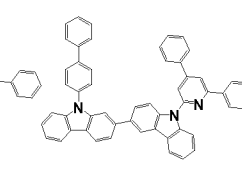
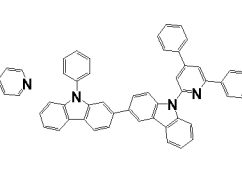
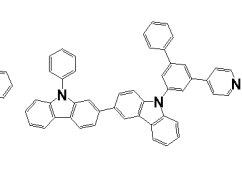
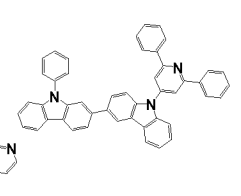
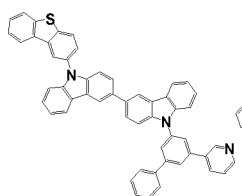
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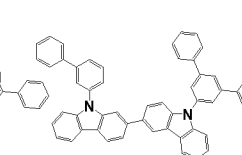
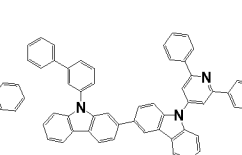
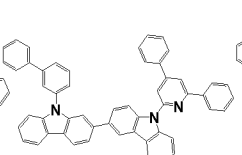
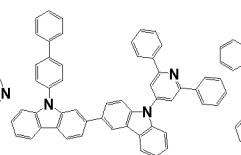
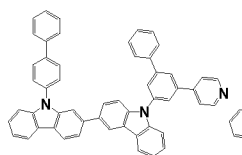
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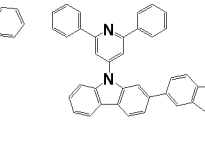
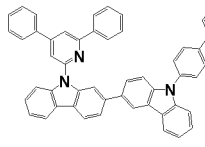
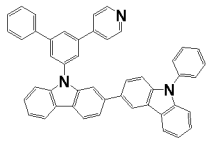
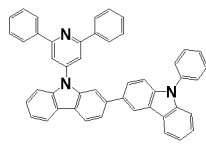
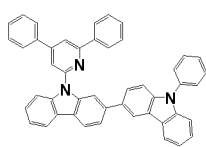
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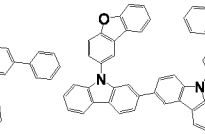
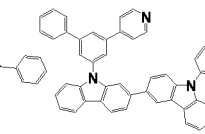
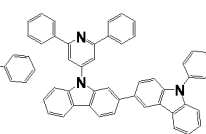
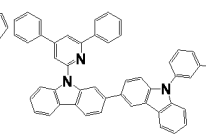
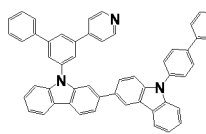
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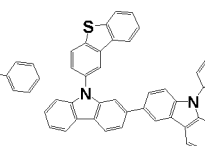
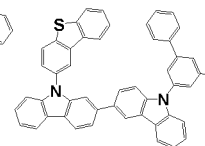
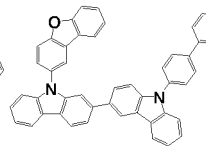
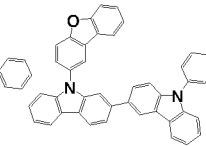
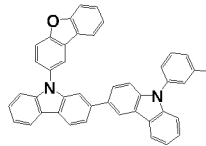
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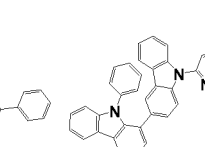
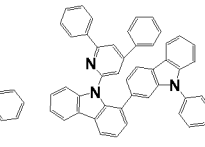
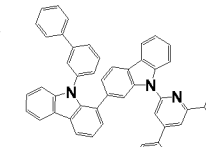
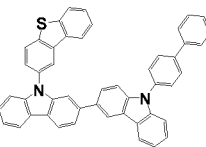
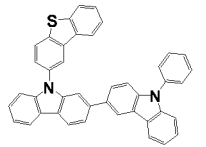
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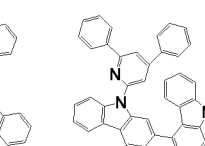
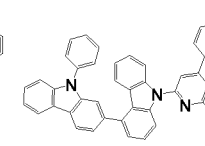
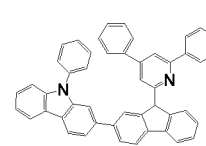
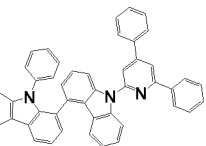
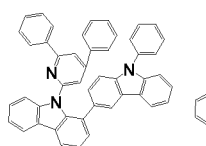
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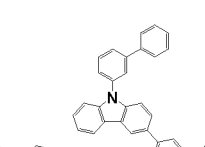
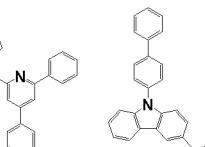
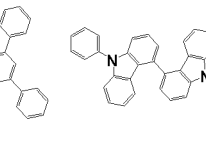
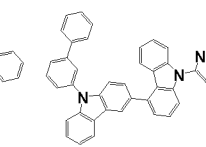
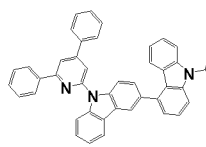
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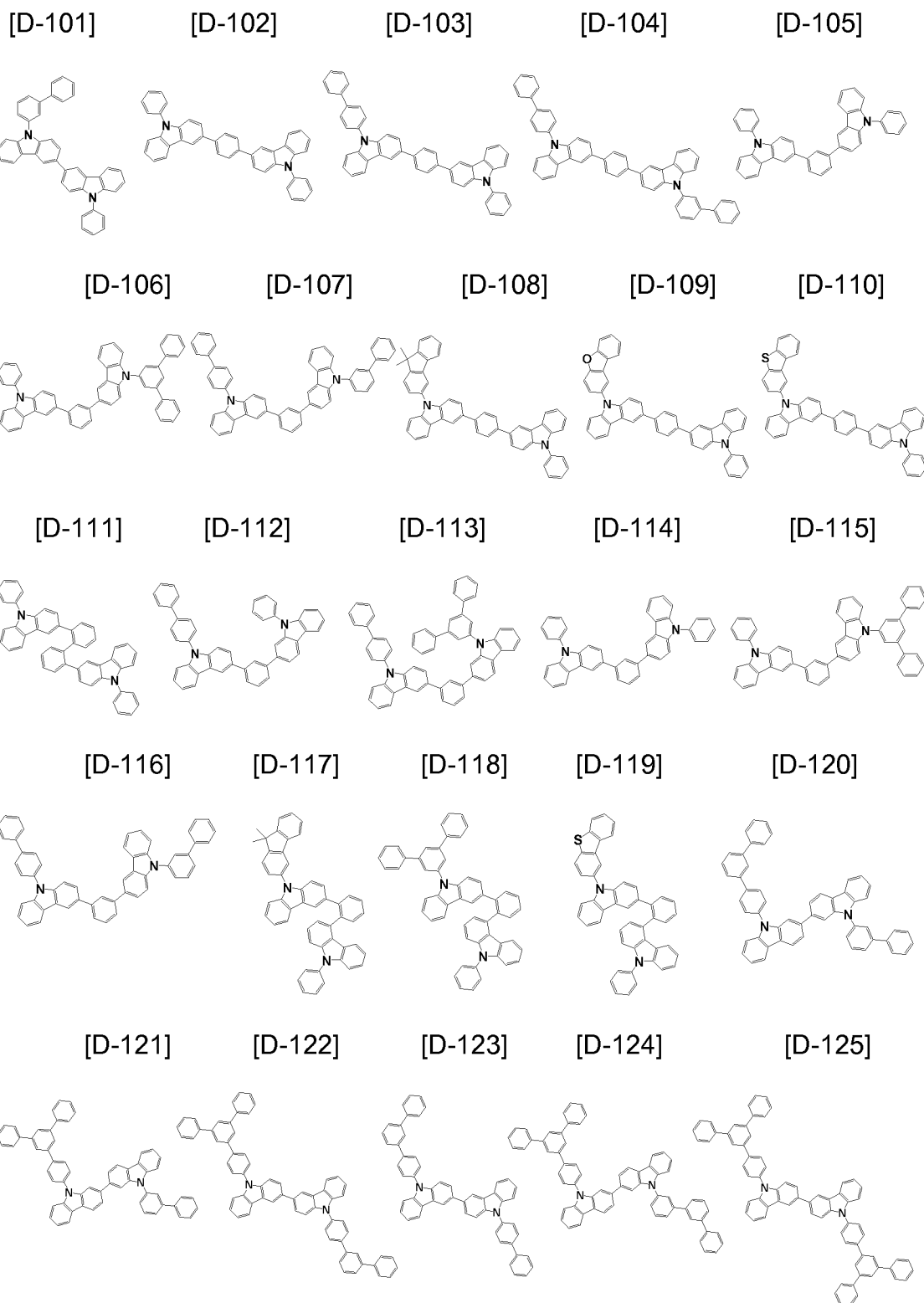
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[D-100]





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[D-129]

[D-130]

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[D-137]

[D-138]

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[0084] The first host and the second host may be applied as a form of a composition.

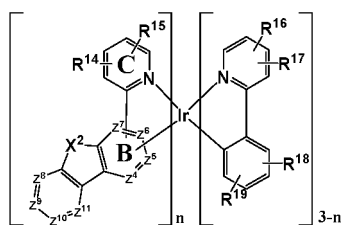
[0085] The phosphorescent dopant may be a red or green phosphorescent dopant, and in an example embodiment of the present invention, the phosphorescent dopant may be an organ metal compound represented by Chemical Formula 3:

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[Chemical Formula 3]

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[0086] In Chemical Formula 3,

Z⁴ to Z¹¹ are independently N, C or CR^c,

the ring C is bound to the ring B through a C-C bond,

iridium is bound to the ring B through a Ir-C bond,

X² is O or S,

R^c and R¹⁴ to R¹⁹ are independently hydrogen, deuterium, a halogen, germanium group, a cyano group, a substituted

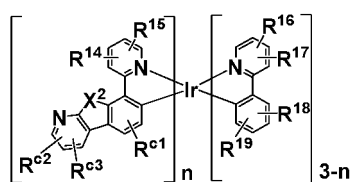
or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C3 to C20 cycloalkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group, and n is an integer ranging from 1 to 3.

[0087] The composition including the first and second hosts may be combined with the phosphorescent dopant including a dibenzofuranyl group, a dibenzothiophenyl group, or a derivative of the dibenzofuranyl group and the dibenzothiophenyl group including at least one N in a hexagonal ring of the dibenzofuranyl group and the dibenzothiophenyl group to secure a combination/matching advantage of packing of host and dopant materials, an energy transport, and the like and thus obtain characteristics of a low driving voltage, a long life-span, and high efficiency.

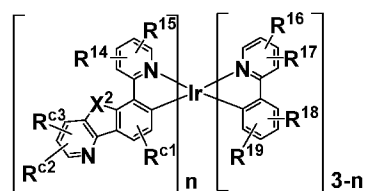
[0088] In an example embodiment of the present invention, one of Z⁴ to Z¹¹ of Chemical Formula 3 may be preferably N, and two, three, or four may be N.

[0089] The phosphorescent dopant may be for example represented by one of Chemical Formula 3-1 to Chemical Formula 3-6.

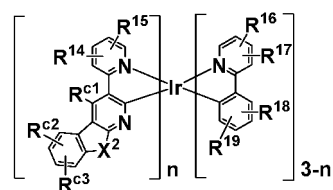
[Chemical Formula 3-1]



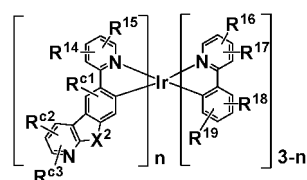
[Chemical Formula 3-2]



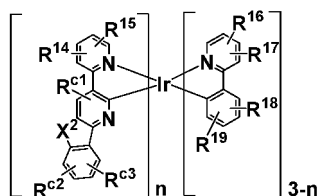
[Chemical Formula 3-3]



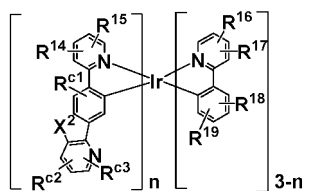
[Chemical Formula 3-4]



[Chemical Formula 3-5]



[Chemical Formula 3-6]



[0090] In Chemical Formula 3-1 to Chemical Formula 3-6, X^2 , R^{14} to R^{19} and n are the same as described above, and R^c , R^{c1} , R^{c2} , and R^{c3} are the same as R^c .

[0091] In a specific example embodiment of the present invention, R^c , R^{c1} , R^{c2} , R^{c3} , and R^{14} to R^{19} may independently be hydrogen, deuterium, a halogen, a substituted or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, or a substituted or unsubstituted C6 to C20 aryl group, for example R^c , R^{c1} , R^{c2} , R^{c3} , and R^{14} to R^{19} may independently be hydrogen, deuterium, a halogen, a substituted or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, or a substituted or unsubstituted C6 to C12 aryl group, preferably R^c , R^{c1} , R^{c2} , R^{c3} , and R^{14} to R^{19} may independently be hydrogen, deuterium, a halogen, a silyl group that is substituted or unsubstituted with deuterium or a halogen, a methyl group that is substituted or unsubstituted with deuterium or a halogen, an isopropyl group that is substituted or unsubstituted with deuterium or a halogen, a tert-butyl group that is substituted or unsubstituted with deuterium or a halogen, or a silyl group that is substituted or unsubstituted with a C1 to C4 alkyl group.

[0092] The phosphorescent dopant may be for example selected from compounds of Group 3, but is not limited thereto.

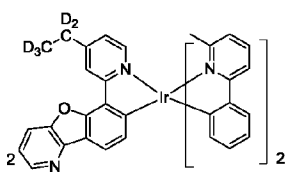
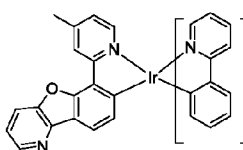
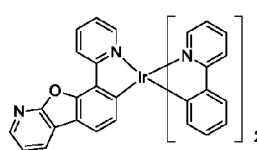
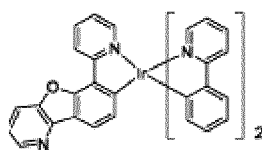
[Group 3]

[E-1]

[E-2]

[E-3]

[E-4]

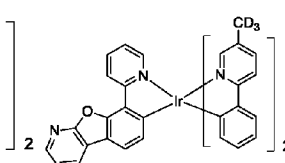
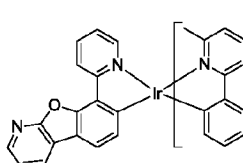
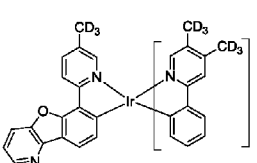
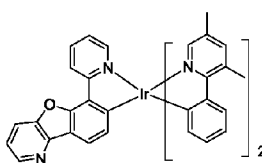


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[E-7]

[E-8]

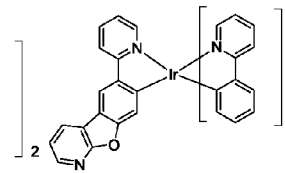
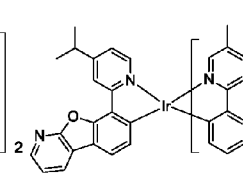
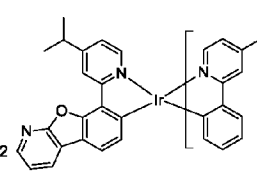
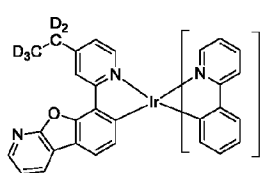


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[E-12]

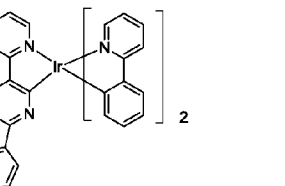
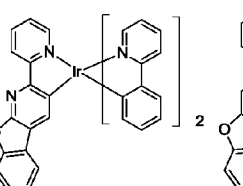
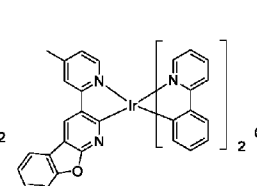
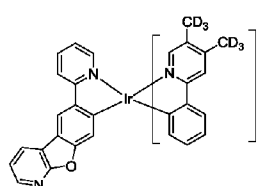


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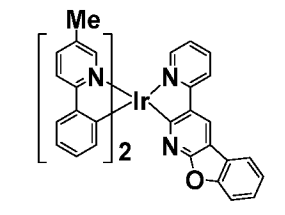
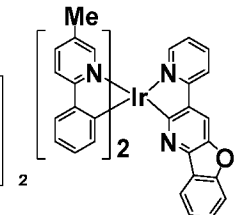
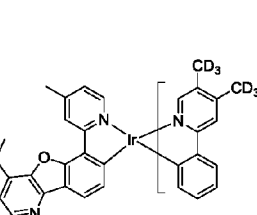
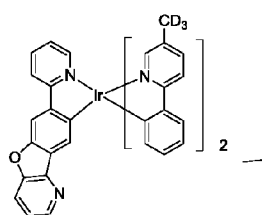


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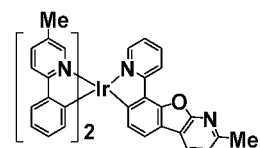
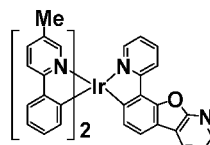
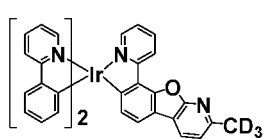
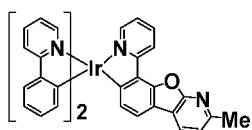


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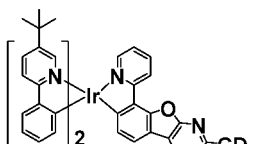
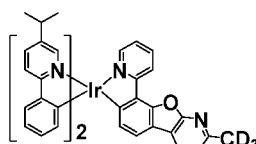
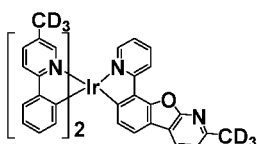
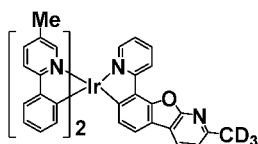


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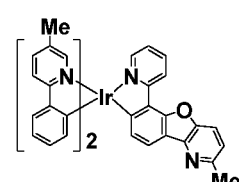
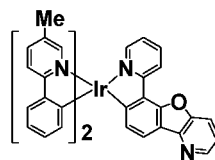
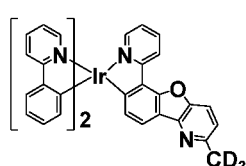
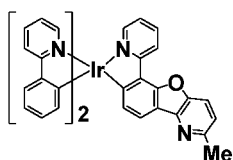


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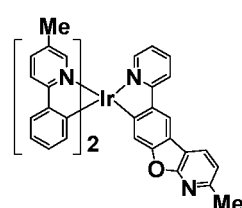
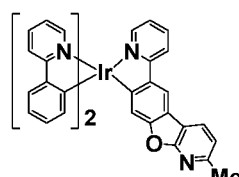
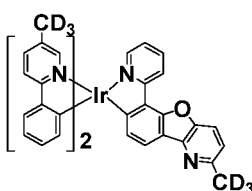
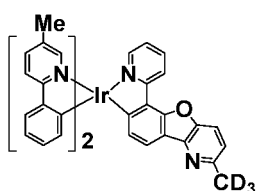


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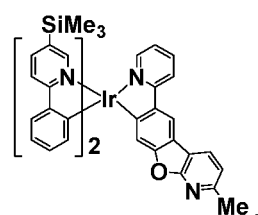
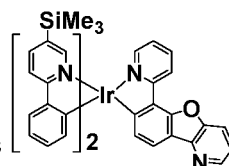
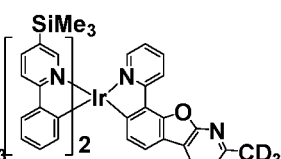
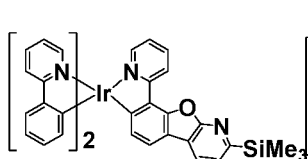


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[E-40]



[0093] In a more preferably example embodiment of the present invention, a composition including a first host represented by Chemical Formula 1-3, a second host represented by Chemical Formula 2A, and a phosphorescent dopant represented by Chemical Formula 3-1 may be applied to the light emitting layer, and

[0094] Chemical Formula 1-3 may be for example Chemical Formula 1-3a.

[0095] Z¹ to Z³ of Chemical Formula 1-3a may be all N, R¹ may be a substituted or unsubstituted C₆ to C₂₀ aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and L¹ may be a single bond or a meta-phenylene group,

Y¹ and Y² of Chemical Formula 2A may independently be a substituted or unsubstituted phenyl group, a substituted or unsubstituted meta-biphenyl group, a substituted or unsubstituted para-biphenyl group, a substituted or unsubstituted carbazolyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and L³ and L⁴ are independently a single bond or a substituted or unsubstituted C₆ to C₂₀ arylene group, and

R^{c1} , R^{c2} , R^{c3} and R^{14} to R^{19} of Chemical Formula 3-1 may independently be hydrogen, deuterium, a halogen, a substituted or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, or a substituted or unsubstituted C6 to C12 aryl group.

[0096] More specifically, the first host and the second host may be included in a weight ratio of 1:9 to 6:4, 2:8 to 6:4, 3:7 to 6:4, more preferably, the first host and the second host may be included in a weight ratio of 1:9 to 5:5, 2:8 to 5:5, 3:7 to 5:5, and the most preferably the first host and the second host may be included in a weight ratio of 3:7 to 5:5.

[0097] The phosphorescent dopant may be included in an amount of about 0.1 wt% to 15 wt%, preferably 1 wt% to 15 wt%, and more preferably 5 wt% to 15 wt% based on 100 wt% of the composition of the first host and second host. For example, the first host and the second host may be included in a weight ratio of 3:7 and the phosphorescent dopant may be included in an amount of 5 wt% to 15 wt% based on 100 wt% of the composition of the first host and second host.

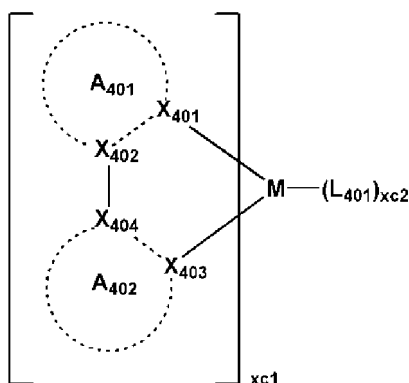
[0098] The composition of the first host and the second host according to the present invention may include a known phosphorescent dopant in addition to the phosphorescent dopant.

[0099] The known phosphorescent dopant may be mixed an organ metal compound including one of Ir, Pt, Os, Ti, Or, Hf, Eu, Tb, Tm, Fe, Co, Ni, Ru, Rh, Pd, or a combination thereof.

[0100] However, these are exemplified, and a dopant that exhibit excellent effect by combining the composition of the first host and the second host according to the present invention is a phosphorescent dopant represented by Chemical Formula 3.

[0101] Hereinafter, one example of the known phosphorescent dopant may be an organ metal compound represented by Chemical Formula 401.

<Chemical Formula 401>



[0102] In Chemical Formula 401, M is selected from Ir, Pt, Os, Ti, Or, Hf, Eu, Tb, and Tm; X_{401} to X_{404} are independently nitrogen or carbon; A_{401} and A_{402} rings are independently selected from a substituted or unsubstituted benzene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted fluorene, a substituted or unsubstituted spiro-fluorene, a substituted or unsubstituted indene, a substituted or unsubstituted pyrrole, a substituted or unsubstituted thiophene, a substituted or unsubstituted furan, a substituted or unsubstituted imidazole, a substituted or unsubstituted pyrazole, a substituted or unsubstituted thiazole, a substituted or unsubstituted isothiazole, a substituted or unsubstituted oxazole, a substituted or unsubstituted isoxazole, a substituted or unsubstituted pyridine, a substituted or unsubstituted pyrazine, a substituted or unsubstituted pyrimidine, a substituted or unsubstituted pyridazine, a substituted or unsubstituted quinoline, a substituted or unsubstituted isoquinoline, a substituted or unsubstituted benzoquinoline, a substituted or unsubstituted quinoxaline, a substituted or unsubstituted quinazoline, a substituted or unsubstituted carbazole, a substituted or unsubstituted benzimidazole, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted isobenzothiophene, a substituted or unsubstituted benzoxazole, a substituted or unsubstituted isobenzoxazole, a substituted or unsubstituted triazole, a substituted or unsubstituted oxadiazole, a substituted or unsubstituted triazine, a substituted or unsubstituted dibenzofuran, and a substituted or unsubstituted dibenzothiophene; wherein "substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a halogen, a hydroxyl group, a cyano group, an amino group, a substituted or unsubstituted C1 to C30 amine group, a nitro group, a substituted or unsubstituted C1 to C40 silyl group, a C1 to C30 alkyl group, a C1 to C10 alkylsilyl group, a C6 to C30 arylsilyl group, a C3 to C30 cycloalkyl group, a C3 to C30 heterocycloalkyl group, a C6 to C30 aryl group, a C2 to C30 heterocyclic group, a C1 to C20 alkoxy group, a C1 to C10 trifluoroalkyl group, or a combination thereof; L_{401} is an organic ligand; xc1 is 1, 2, or 3; and xc2 is 0, 1, 2, or 3.

[0103] L_{401} may be any monovalent, divalent, or trivalent organic ligand. For example, L_{401} may be selected from a

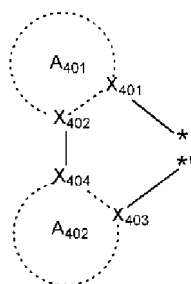
halogen ligand (for example, Cl, F), diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propanedionate, 2,2,6,6-tetramethyl-3,5-heptanedionate, or hexafluoroacetone), carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazolecarboxylate, benzoate), a carbon monoxide ligand, an isonitrile ligand, a cyano ligand, and a phosphorus ligand (for example, phosphine, phosphite), but is not limited thereto.

[0104] Q_{401} to Q_{407} , Q_{411} to Q_{417} , and Q_{421} to Q_{427} may independently be selected from hydrogen, a C1 to C60 alkyl group, a C2 to C60 alkenyl group, a C6 to C60 aryl group, and a C2 to C60 heteroaryl group.

[0105] When A_{401} of Chemical Formula 401 has two or more substituents, they may be combined with two or more substituents of A_{401} to form a saturated or unsaturated ring.

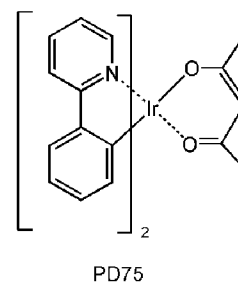
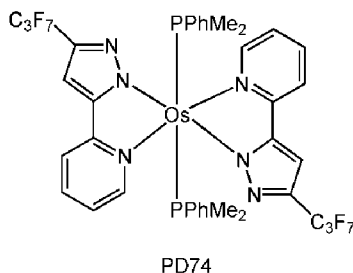
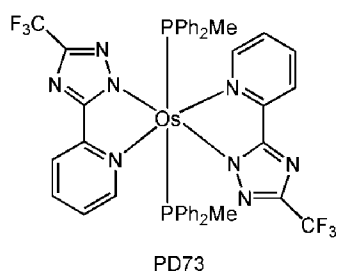
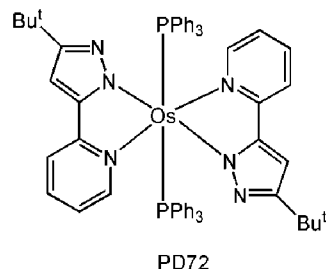
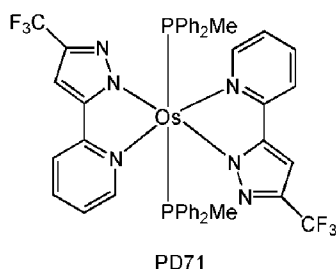
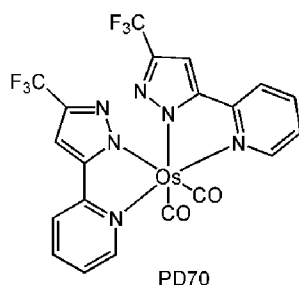
[0106] When A_{402} of Chemical Formula 401 has two or more substituents, they may be combined with two or more substituents of A_{402} to form a saturated or unsaturated ring.

[0107] When xc1 of Chemical Formula 401 is two or more, a plurality of ligands



of Chemical Formula 401 may be the same or different. When xc1 of Chemical Formula 401 is two or more, A_{401} and A_{402} may be independently linked with A_{401} and A_{402} of adjacent other ligand directly or by a linking group (for example, C1 to C5 alkylene group, $-N(R')$ (wherein, R' is a C1 to C10 alkyl group or a C6 to C20 aryl group), or $-C(=O)-$).

[0108] For example, the known phosphorescent dopant may be selected from Compounds PD1 to PD75, but is not limited thereto:



[0109] The organic light emitting diode may be applied to an organic light emitting diode (OLED) display.

[Mode for Invention]

[0110] Hereinafter, the embodiments are illustrated in more detail with reference to examples. These examples, however, are not in any sense to be interpreted as limiting the scope of the invention.

[0111] Hereinafter, starting materials and reactants used in Examples and Synthesis Examples were purchased from Sigma-Aldrich Co. Ltd. or TCI Inc. as far as there is no particular comment or were synthesized by known methods.

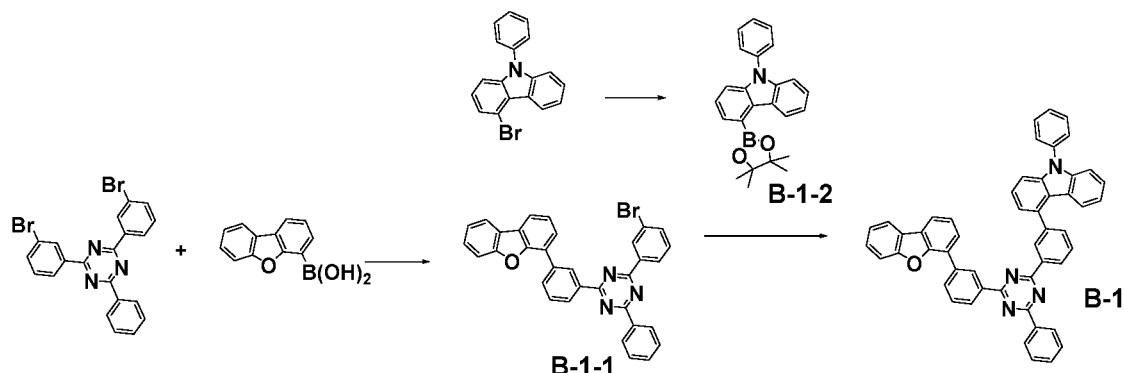
[0112] The compound as one specific examples of the present invention was synthesized through the following steps.

(Preparation of First Host)

Synthesis Example 1: Synthesis of Compound B-1

[0113]

[Reaction Scheme 1]



a) Synthesis of Intermediate B-1-1

[0114] 30.0 g (64.2 mmol) of 2,4-bis(3-bromophenyl)-6-phenyl-1,3,5-triazine were added to 100 mL of tetrahydrofuran, 100 mL of toluene, and 100 mL of distilled water in a 500 mL round-bottomed flask, 1.0 equivalent of dibenzofuran-4-boronic acid, 0.03 equivalent of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 6 hours, the reaction solution was cooled down, an aqueous layer was removed therefrom, and an organic layer therein was dried under a reduced pressure. The obtained solid was washed with water and hexane, the solid was recrystallized with 300 mL of toluene to obtain 21.4 g (a yield of 60 %) of Intermediate B-1-1.

b) Synthesis of Intermediate B-1-2

[0115] 15 g (46.55 mmol) of 4-bromo-9-phenylcarbazole (cas: 1097884-37-1) was added to 200 mL of toluene in a 500 mL round-bottomed flask, 0.05 equivalent of dichlorodiphenylphosphinoferrocene palladium, 1.2 equivalent of bis(pinacolato) diboron, and 2 equivalents of potassium acetate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere for 18 hours. The reaction solution was cooled down and added to 1 L of water in a dropwise fashion. A solid obtained therefrom was dissolved in boiling toluene to treat activated carbon and then, filtered with silica gel, and a filtrate therefrom was concentrated. The concentrated solid was stirred with a small amount of hexane and filtered to obtain Intermediate B-1-2 at a yield of 80 %.

c) Synthesis of Compound B-1

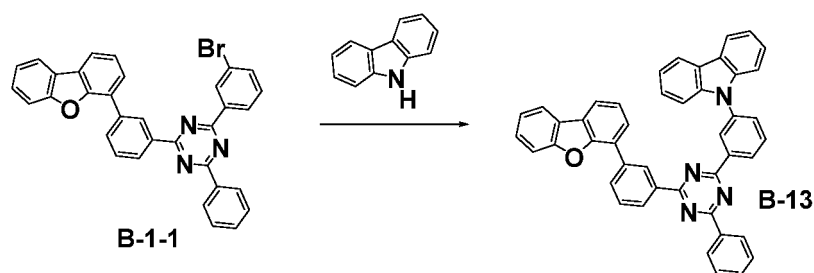
[0116] 20 g (36.1 mmol) of Intermediate B-1-1 was added to 100 mL of tetrahydrofuran and 50 mL of distilled water in a 500 mL round-bottomed flask, 1.1 equivalent of Intermediate B-1-2, 0.03 equivalent of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 18 hours, the reaction solution was cooled down, and a solid precipitated therein was filtered and washed with 500 mL of water. The solid was recrystallized with 500 mL of monochlorobenzene to obtain 24 g of Compound B-1.

LC/MS calculated for: $C_{51}H_{32}N_4O$ Exact Mass: 716.2576 found for: 717.26 [M+H]

Synthesis Example 2: Synthesis of Compound B-13

[0117]

[Reaction Scheme 2]

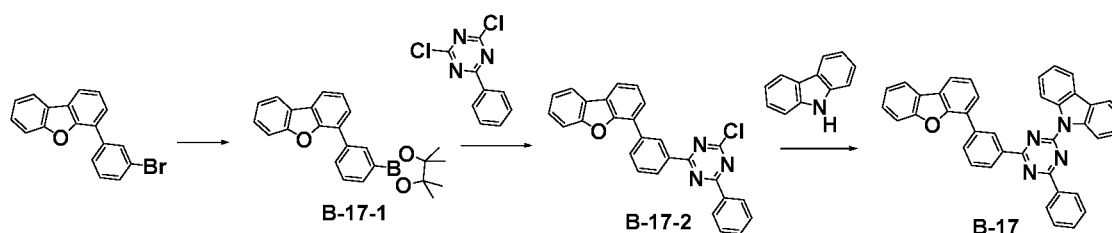


[0118] 1 equivalent of Intermediate B-1-1, 1 equivalent of carbazole, 2 eq of sodium t-butoxide, and 0.05 eq of $\text{Pd}_2(\text{dba})_3$ were suspended to be 0.2 M in xylene, 0.15 eq of tri-tertiarybutylphosphine was added thereto, and the mixture was refluxed and stirred for 18 hours. Methanol was added thereto in 1.5 times as much as the solvent, the mixture was stirred, and a solid obtained therefrom was filtered and washed with 300 mL of water. The solid was recrystallized by using monochlorobenzene to obtain Compound B-13 at a yield of 85 %.

LC/MS calculated for: $\text{C}_{45}\text{H}_{28}\text{N}_4\text{O}$ Exact Mass: 640.2263 found for: 641.23 [M+H]

Synthesis Example 3: Synthesis of Compound B-17**[0119]**

[Reaction Scheme 3]

**a) Synthesis of Intermediate B-17-1**

[0120] 15 g (46.4 mmol) of 4-(3-bromophenyl)-dibenzofuran (cas: 887944-90-3) was added to 200 mL of toluene in a 500 mL round-bottomed flask, 0.05 equivalent of dichlorodiphenylphosphinoferrocene palladium, 1.2 equivalent of bis(pinacolato) diboron, and 2 equivalents of potassium acetate were added thereto, and the mixture was heated and refluxed under an nitrogen atmosphere for 18 hours. The solution was washed with water through an extraction, an organic layer therefrom was treated with activated carbon and filtered in silica gel, and a filtrate was concentrated. The concentrated solid was stirred with an amount of hexane and filtered to obtain Intermediate B-17-1 at a yield of 85 %.

b) Synthesis of Intermediate B-17-2

[0121] 9.04 g (40 mmol) of 2,4-dichloro-6-phenyltriazine was added to 60 mL of tetrahydrofuran, 60 mL of toluene, and 60 mL of distilled water in a 500 mL round-bottomed flask, 0.9 equivalent of Intermediate B-17-1, 0.03 equivalent of tetrakis(triphenyl)phosphine palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 6 hours, the reaction solution was cooled down, and after removing an aqueous layer therefrom, an organic layer therein was dried under a reduced pressure. A solid therefrom was washed with water and hexane and then, recrystallized with 300 mL of toluene to obtain Intermediate B-17-2 at a yield of 40 %.

c) Synthesis of Compound B-17

[0122] 1 equivalent of Intermediate B-17-2, 1.1 equivalent of carbazole, 2 eq of sodium t-butoxide, and 0.05 eq of $\text{Pd}_2(\text{dba})_3$ were suspended to be 0.2 M in xylene, 0.15 eq of tri-tertiarybutylphosphine was added thereto, and the mixture was refluxed and stirred for 18 hours. Methanol was added thereto 1.5 times as much as the solvent, and a solid therein

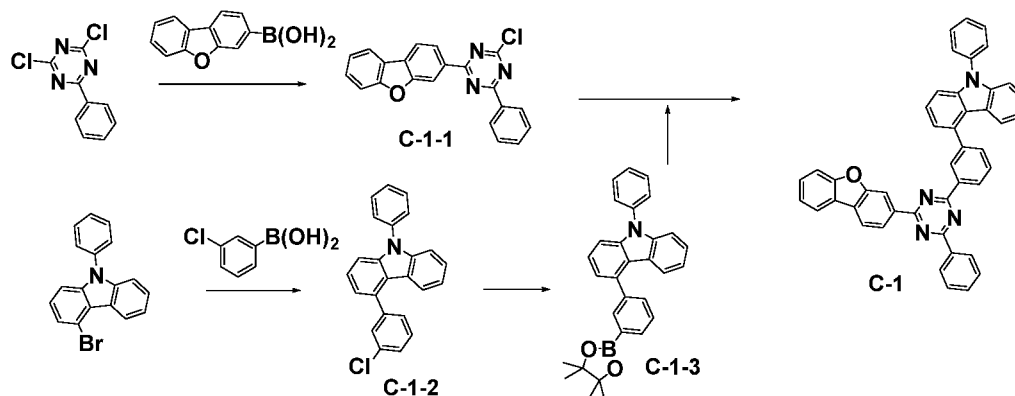
was filtered and washed with 300 mL of water. The solid was recrystallized by using monochlorobenzene to obtain Compound B-17 at a yield of 80 %.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.21 [M+H]

Synthesis Example 4: Synthesis of Compound C-1

[0123]

[Reaction Scheme 4]



a) Synthesis of Intermediate C-1-1

[0124] 22.6 g (100 mmol) of 2,4-dichloro-6-phenyltriazine was added to 100 mL of tetrahydrofuran, 100 mL of toluene, and 100 mL of distilled water in a 500 mL round-bottomed flask, 0.9 equivalent of dibenzofuran-3-boronic acid, 0.03 equivalent of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 6 hours, the reaction solution was cooled down, and after removing an aqueous layer therefrom, an organic layer therein was dried under a reduced pressure. The obtained solid was washed with water and hexane and recrystallized with 200 mL of toluene to obtain 21.4 g of Intermediate C-1-1 at a yield of 60 %.

b) Synthesis of Compound C-1-2

[0125] 15 g (46.55 mmol) of 4-bromo-9-phenylcarbazole (cas: 1097884-37-1) was added to 140 mL of tetrahydrofuran and 70 mL of distilled water in a 500 mL round-bottomed flask, 1.1 equivalent of 3-chlorophenyl boronic acid, 0.03 equivalents of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 12 hours, the reaction solution was cooled down, an organic layer was extracted to remove a solvent under a reduced pressure. A compound concentrated therefrom was treated through silica column chromatography to obtain Intermediate C-1-2 at a yield of 85 %.

c) Synthesis of Intermediate C-1-3

[0126] 12 g (33.9 mmol) of Intermediate C-1-2 was added to 150 mL of xylene in a 500 mL round-bottomed flask, 0.05 equivalent of dichlorodiphenylphosphinoferrocene palladium, 1.2 equivalent of bis(pinacolato) diboron, and 2 equivalents of potassium acetate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere for 18 hours. The reaction solution was cooled down and then, washed with water through an extraction, an organic layer therefrom was treated with activated carbon and filtered in silica gel, and a filtrate therefrom was concentrated. A solid concentrated therefrom was stirred with a small amount of hexane and filtered to obtain Intermediate C-1-3 at a yield of 75 %.

d) Synthesis of Compound C-1

[0127] 8 g (22.4 mmol) of Intermediate C-1-1 was added to 80 mL of tetrahydrofuran and 40 mL of distilled water in a 500 mL round-bottomed flask, 1.0 equivalent of Intermediate C-1-3, 0.03 equivalent of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed

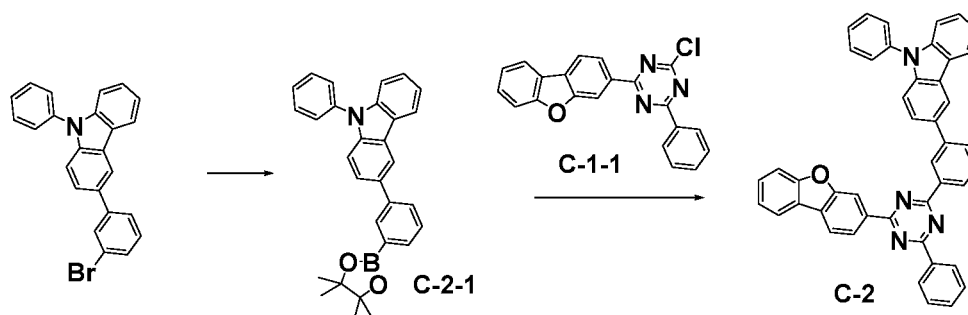
under a nitrogen atmosphere. After 18 hours, the reaction solution was cooled down, and a solid precipitated therein was filtered and washed with 500 mL of water. The solid was recrystallized with 500 mL of monochlorobenzene to obtain 12 g of Compound C-1.

LC/MS calculated for: $C_{45}H_{28}N_4O$ Exact Mass: 640.2263 found for: 641.24

Synthesis Example 5: Synthesis of Compound C-2

[0128]

[Reaction Scheme 5]



a) Synthesis of Intermediate C-2-1

[0129] 15 g (46.4 mmol) of 3-(3-bromophenyl)-9-phenylcarbazole (cas: 854952-59-3) was added to 200 mL of toluene in a 500 mL round-bottomed flask, 0.05 equivalent of dichlorodiphenylphosphinoferrocene palladium, 1.2 equivalent of bis(pinacolato) diboron, and 2 equivalents of potassium acetate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere for 18 hours. The reaction solution was cooled down and added to 1 L of water in a dropwise fashion to collect a solid. The solid was dissolved in boiling toluene to treat activated carbon and filtered in silica gel, and a filtrate therefrom was concentrated. The concentrated solid was stirred with a small amount of hexane and filtered to obtain Intermediate C-2-1 at a yield of 85 %.

b) Synthesis of Compound C-2

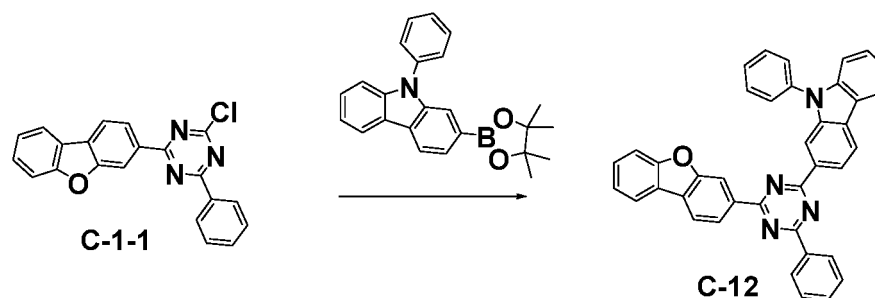
[0130] 8 g (22.4 mmol) of Intermediate C-1-1 according to Synthesis Example 4 was added to 80 mL of tetrahydrofuran and 40 mL of distilled water in a 500 mL round-bottomed flask, 1.0 equivalent of Intermediate C-2-1, 0.03 equivalent of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 18 hours, the reaction solution was cooled down, and a solid precipitated therein was washed with 500 mL of water. The solid was recrystallized by using 500 mL of monochlorobenzene to obtain 13 g of Compound C-2.

LC/MS calculated for: $C_{45}H_{28}N_4O$ Exact Mass: 640.2263 found for: 641.24

Synthesis Example 6: Synthesis of Compound C-12

[0131]

[Reaction Scheme 6]

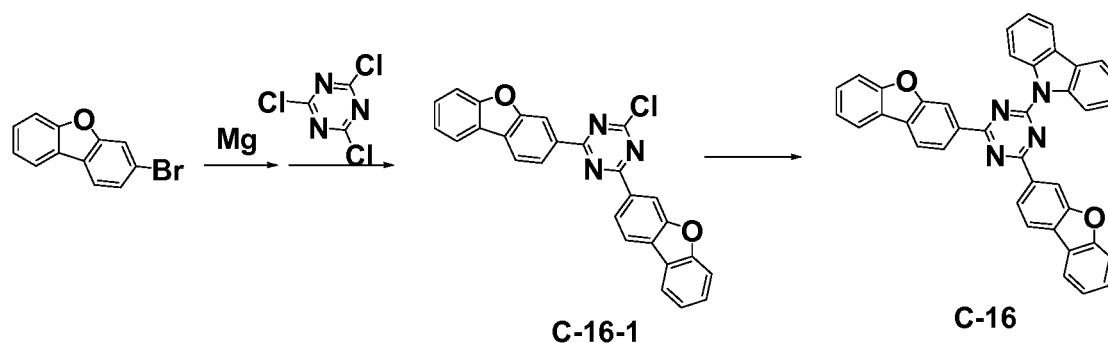


[0132] 8 g (22.4 mmol) of Intermediate C-1-1 according to Synthesis Example 4 was added to 80 mL of tetrahydrofuran and 40 mL of distilled water in a 500 mL round-bottomed flask, 1.0 equivalent of 9-phenyl-2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-carbazole (cas:1246669-45-3), 0.03 equivalent of tetrakis(triphenylphosphine) palladium, and 2 equivalents of potassium carbonate were added thereto, and the mixture was heated and refluxed under a nitrogen atmosphere. After 18 hours, the reaction solution was cooled down, and a solid precipitated therein was filtered and washed with 500 mL of water. The solid was recrystallized with 500 mL of monochlorobenzene to obtain 11 g of Compound C-12.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.20

Synthesis Example 7: Synthesis of Compound C-16**[0133]**

[Reaction Scheme 7]

**a) Synthesis of Intermediate C-16-1**

[0134] Magnesium (7.86 g, 323 mmol) and iodine (1.64 g, 6.46 mmol) were added to 0.1 L of tetrahydrofuran (THF) in a nitrogen environment, the mixture was stirred for 30 minutes, and 3-bromo dibenzofuran (80 g, 323 mmol) dissolved in 0.3 L of THF was slowly added thereto in a dropwise fashion at 0 °C over 30 minutes. The mixed solution was slowly added in a dropwise fashion to 29.5 g (160 mmol) of cyanuric chloride dissolved in 0.5 L of THF at 0 °C over 30 minutes. After heating a reaction up to room temperature, the mixture was stirred for 1 hour and additionally stirred for 12 hours under a reflux condition. After cooling down the reaction, water was slowly added thereto to finish the reaction, and an organic solvent therefrom was concentrated under a reduced pressure to obtain a solid. The solid was stirred with 200 mL of acetone and filtered to obtain Intermediate C-16-1 at a yield of 40 %.

b) Synthesis of Compound C-16

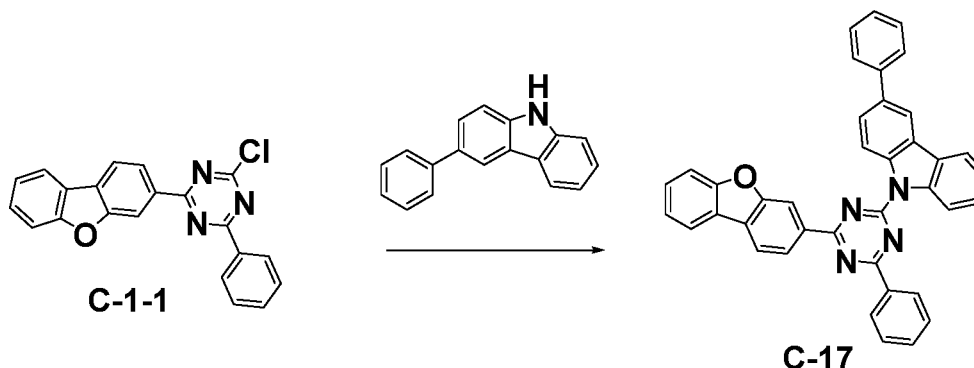
[0135] Compound C-16 was synthesized according to the same method as Synthesis Example 2 by using Intermediate C-16-1.

LC/MS calculated for: $C_{39}H_{22}N_4O_2$ Exact Mass: 578.1743 found for 579.20

Synthesis Example 8: Synthesis of Compound C-17

[0136]

[Reaction Scheme 8]



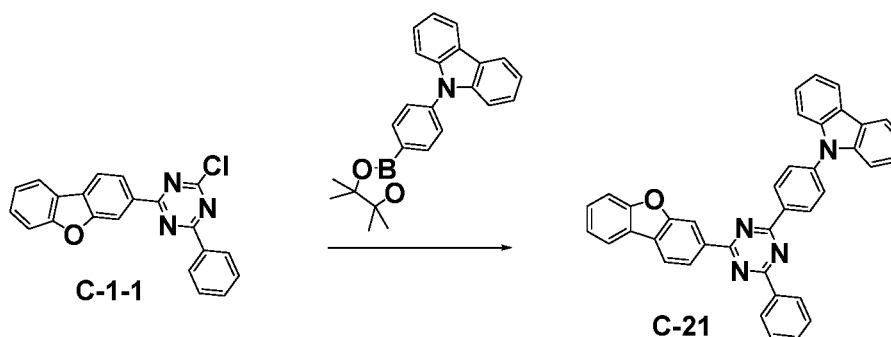
[0137] Compound C-17 was synthesized according to the same method as Synthesis Example 2 by using Intermediate C-1-1 and 3-phenyl-9H-carbazole respectively by 1 equivalent.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.20

Synthesis Example 9: Synthesis of Compound C-21

[0138]

[Reaction Scheme 9]



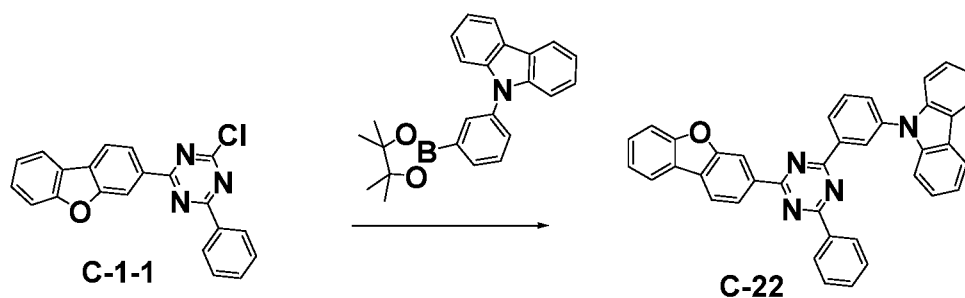
[0139] Compound C-21 was synthesized according to the same method as Synthesis Example 6 by using Intermediate C-1-1 and 9-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenyl)-carbazole (Cas:785051-54-9) respectively by 1.0 equivalent.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.20

Synthesis Example 10: Synthesis of Compound C-22

[0140]

[Reaction Scheme 10]

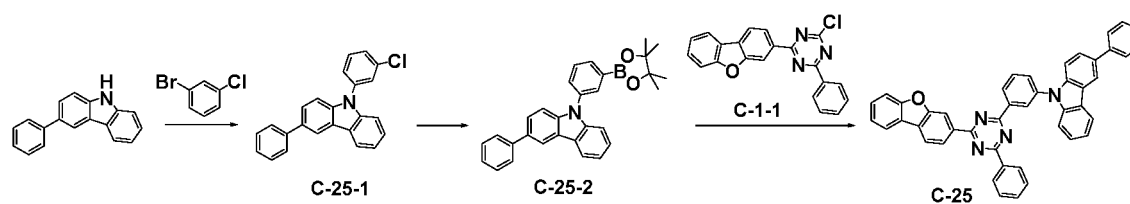


[0141] Compound C-22 was synthesized according to the same method as Synthesis Example 6 by using Intermediate C-1-1 and 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenyl)-carbazole (cas:870119-58-7) respectively by 1.0 equivalent.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.20

Synthesis Example 11: Synthesis of Compound C-25**[0142]**

[Reaction Scheme 11]

a) Synthesis of Intermediate C-25-1

[0143] Intermediate C-25-1 was synthesized according to the same method as Synthesis Example 2 by using 1 equivalent of 3-phenyl-9H-carbazole and 1.2 equivalents of 3-chloro-1-bromobenzene.

b) Synthesis of Intermediate C-25-2

[0144] Intermediate C-25-2 was synthesized according to the same method as a) of Synthesis Example 5 by using Intermediate C-25-1.

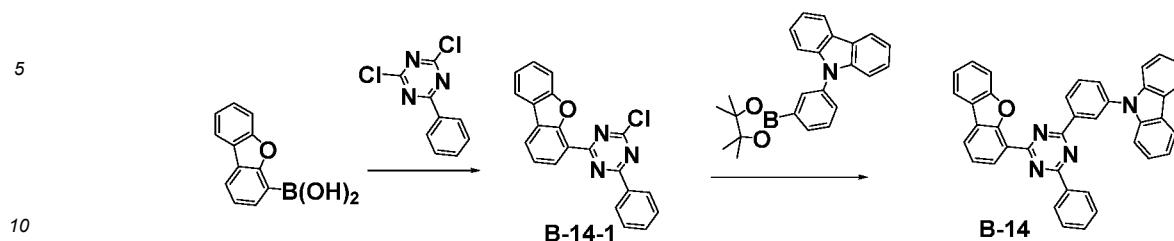
c) Synthesis of Compound C-25

[0145] Intermediate C-25 was synthesized according to the same method as a) of Synthesis Example 6 by using Intermediate C-25-2 and Intermediate C-1-1 respectively by 1.0 equivalent.

LC/MS calculated for: $C_{45}H_{28}N_4O$ Exact Mass: 640.2263 found for: 641.23

Synthesis Example 12: Synthesis of Compound B-14**[0146]**

[Reaction Scheme 12]



a) Synthesis of Intermediate B-14-1

[0147] Intermediate B-14-1 was synthesized according to the same method as a) of Synthesis Example 4 by using 1 equivalent of 2,4-dichloro-6-phenyltriazine and 0.9 equivalent of dibenzofuran-4-boronic acid.

b) Synthesis of Compound B-14

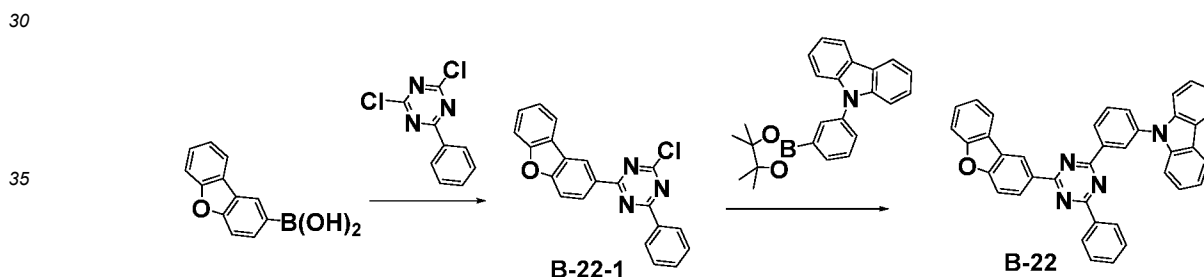
[0148] Intermediate B-14 was synthesized according to the same method as Synthesis Example 6 by using Intermediate B-14-1 and 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenyl)-carbazole (cas: 870119-58-7) by respectively 1.0 equivalent.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.20

Synthesis Example 13: Synthesis of Compound B-22

[0149]

[Reaction Scheme 13]



a) Synthesis of Intermediate B-22-1

[0150] Intermediate B-22-1 was synthesized according to the same method as a) of Synthesis Example 4 by using 1 equivalent of 2,4-dichloro-6-phenyltriazine and 0.9 equivalent of dibenzofuran-2-boronic acid.

b) Synthesis of Compound B-22

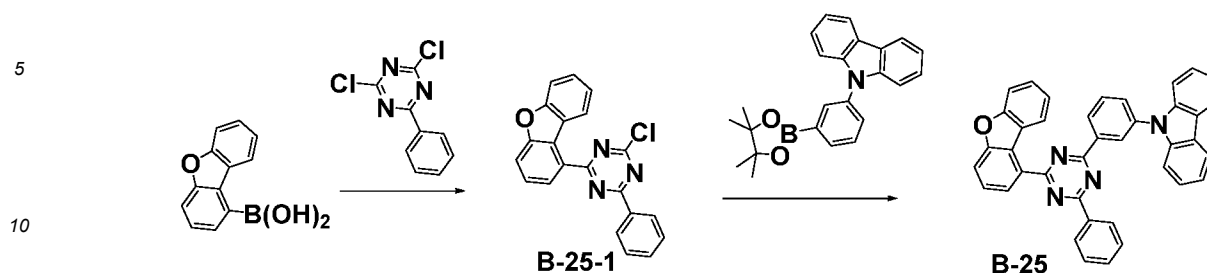
[0151] Compound B-22 was synthesized according to the same method as Synthesis Example 6 by using Intermediate B-22-1 and 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenyl)-carbazole (cas: 870119-58-7) respectively by 1.0 equivalent.

LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.21

Synthesis Example 14: Synthesis of Compound B-25

[0152]

[Reaction Scheme 14]



a) Synthesis of Intermediate B-25-1

[0153] Intermediate B-25-1 was synthesized according to the same method as a) of Synthesis Example 4 by using 1 equivalent of 2,4-dichloro-6-phenyl-1,3,5-triazine and 0.9 equivalent of dibenzofuran-1-boronic acid.

b) Synthesis of Compound B-25

[0154] Compound B-25 was synthesized according to the same method as Synthesis Example 6 by using Intermediate B-25-1 and 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-phenyl)-carbazole (cas: 870119-58-7) respectively by 1.0 equivalent.

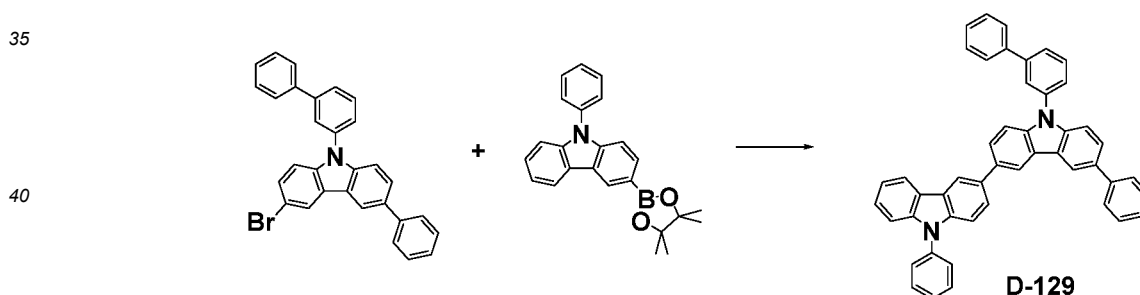
LC/MS calculated for: $C_{39}H_{24}N_4O$ Exact Mass: 564.1950 found for: 565.20

(Preparation of Second Host)

Synthesis Example 15: Synthesis of Compound D-129

[0155]

[Reaction Scheme 15]



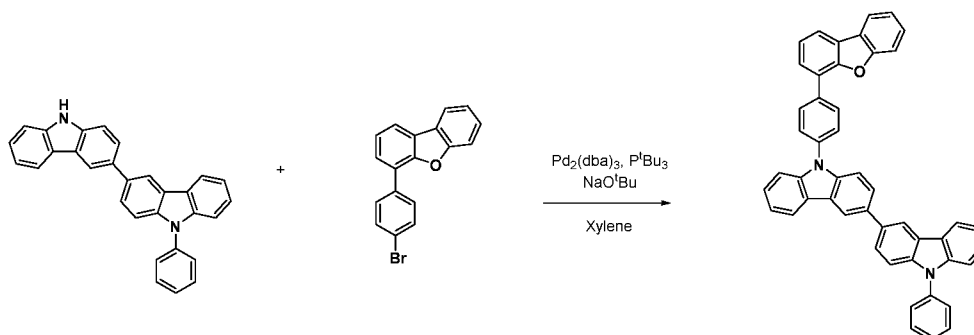
[0156] 20.00 g (42.16 mmol) of 3-bromo-6-phenyl-N-metabiphenylcarbazole, 17.12 g (46.38 mmol) of N-phenylcarbazole-3-boronic ester were added to 175 mL of tetrahydrofuran:toluene (1:1) and 75 mL of a 2 M-potassium carbonate aqueous solution under a nitrogen atmosphere in a 500 mL round-bottomed flask equipped with an agitator, 1.46 g (1.26 mmol) of tetrakis(triphenylphosphine)palladium (0) was added thereto, and the mixture was heated and refluxed under a nitrogen current for 12 hours. When a reaction was complete, the reactant was poured into methanol, a solid therein was filtered, sufficiently washed with water and methanol, and dried. A resulting material obtained therefrom was heated and dissolved in 700 mL of chlorobenzene, the solution was silica gel-filtered to completely remove the solvent, and a solid therefrom was heated and dissolved in 400 mL of chlorobenzene and recrystallized to obtain 18.52 g of Compound D-129 (a yield of 69 %).

LC/MS calculated for: $C_{42}H_{32}N_2$ Exact Mass: 636.2565 found for: 636.27

Synthesis Example 16: Synthesis of Compound D-137

[0157]

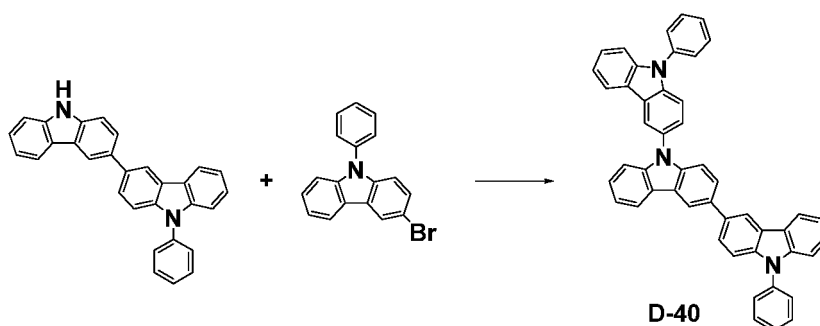
[Reaction Scheme 16]



[0158] 6.3 g (15.4 mmol) of N-phenyl-3,3'-bicarbazole, 5.0 g (15.4 mmol) of 4-(4-bromophenyl)dibenzo[b,d]furan, 3.0 g (30.7 mmol) of sodium t-butoxide, 0.9 g (1.5 mmol) of tris(dibenzylideneacetone)dipalladium, and 1.2 mL of tri t-butylphosphine (50 % in toluene) were mixed in 100 mL of xylene in a 250 mL round flask, and the mixture was heated and refluxed under a nitrogen flow for 15 hours. 300 mL of methanol was added to the obtained mixture to crystallize a solid, the solid was filtered, dissolved in dichlorobenzene, filtered with silica gel/ Celite, and after removing an appropriate amount of the organic solvent, recrystallized with methanol to obtain Intermediate D-137 (7.3 g, a yield of 73 %). LC/MS calculated for: $C_{48}H_{30}N_2O$ Exact Mass: 650.2358 found for: 650.24

Synthesis Example 17: Synthesis of Compound D-40**[0159]**

[Reaction Scheme 17]

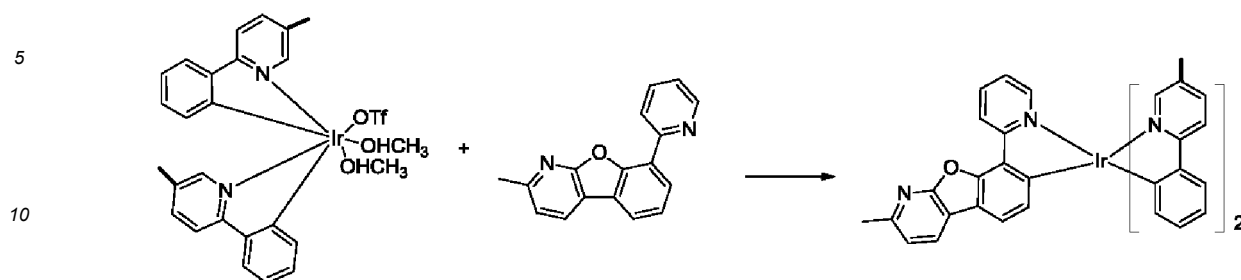


[0160] 1 equivalent of N-phenyl-3,3'-bicarbazole and 1 equivalent of 3-bromo-9-phenylcarbazole along with 1.5 equivalent of sodium t-butoxide, 0.03 equivalent of tris(dibenzylideneacetone)dipalladium, and 0.06 equivalent of tri t-butylphosphine were mixed with xylene (0.3 M) in a 250 mL round flask, and the mixture was heated and refluxed under a nitrogen flow for 15 hours. The obtained mixture was added to 300 mL of methanol to crystallize a solid, and the solid was filtered, dissolved in dichlorobenzene with silica gel/ Celite, and after removing an appropriate amount of the organic solvent, recrystallized with methanol to obtain Compound D-40 at a yield of 60 %. LC/MS calculated for: $C_{48}H_{31}N_3$ Exact Mass: 649.2518 found for: 649.25

(Preparation of Phosphorescent Dopant)**Synthesis Example 18: Synthesis of Compound E-24**

[0161] Dopant Compound E-24 was prepared through the same reaction as above except for using an iridium complex described Reaction Scheme 16 as a starting material in a method of preparing Compound 11-1 of US2014-0131676.

[Reaction Scheme 18]



(Manufacture of Organic Light Emitting Diode)

Example 1:

[0162] A glass substrate coated with ITO (indium tin oxide) as a 1500 Å-thick thin film was washed with distilled water. After washing with the distilled water, the glass substrate was ultrasonic wave-washed with a solvent such as isopropyl alcohol, acetone, methanol, and the like and dried and then, moved to a plasma cleaner, cleaned by using oxygen plasma for 10 minutes, and moved to a vacuum depositor. This obtained ITO transparent electrode was used as an anode, Compound A was vacuum-deposited on the ITO substrate to form a 700 Å-thick hole injection layer, Compound B was deposited to be 50 Å thick on the injection layer, and Compound C was deposited to be 1020 Å thick to form a hole transport layer. On the hole transport layer, a 400 Å-thick light emitting layer was formed by vacuum-depositing Compound C-1 as a first host and Compound D-99 as a second host and 10 wt% of Compound E-24 as a phosphorescent dopant. Herein Compound C-1 and Compound D-99 were used in a weight ratio of 3:7, but their ratio in the following Examples was separately provided. Subsequently, on the light emitting layer, a 300 Å-thick electron transport layer was formed by simultaneously vacuum-depositing the compound D and Liq in a ratio of 1:1, and on the electron transport layer, Liq and Al were sequentially vacuum-deposited to be 15 Å thick and 1200 Å thick, manufacturing an organic light emitting diode.

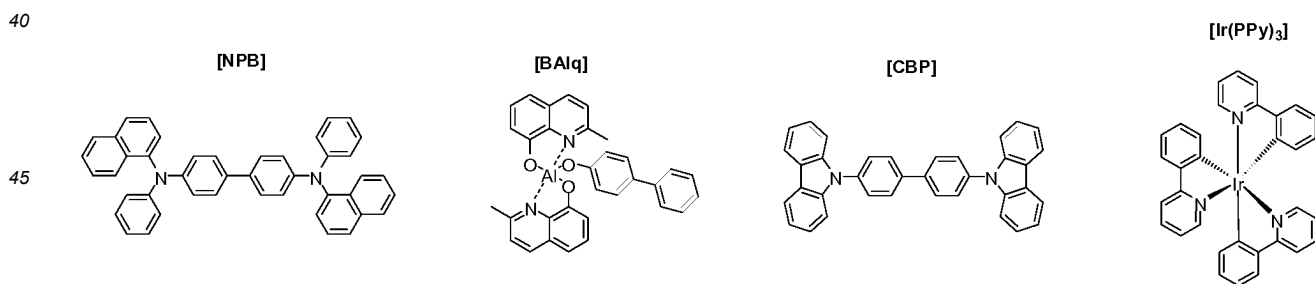
[0163] The organic light emitting diode had a five-layered organic thin layer, and specifically a structure of ITO/Compound A (700 Å)/Compound B (50 Å)/Compound C (1020 Å)/EML [Compound C-1 : Synthesis of Compound D-99 : Synthesis of Compound E-24 (10 wt%)] (400 Å) / Compound D : Liq (300 Å) / Liq (15 Å) / Al (1200 Å).

Compound A: N4,N4'-diphenyl-N4,N4'-bis(9-phenyl-9H-carbazol-3-yl)biphenyl-4,4'-diamine

Compound B: 1,4,5,8,9,11-hexaazatriphenylene-hexacarbonitrile (HAT-CN),

Compound C: N-(biphenyl-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluorene-2-amine

Compound D: 8-(4-(4,6-di(naphthalen-2-yl)-1,3,5-triazin-2-yl)phenyl)quinolone

**Examples 2 to 23 and Comparative Examples 1 to 6**

[0164] Each organic light emitting diode was manufactured according to the same method as Example 1 except for changing the composition of the first host, the second host, and the phosphorescent dopant into each composition shown in Table 1.

Evaluation 1: Luminous Efficiency and Life-span Increase Effect

[0165] Luminous efficiency and life-span characteristics of the organic light emitting diodes according to Examples 1

to 23 and Comparative Examples 1 to 6 were evaluated. The measurements were specifically performed in the following methods, and the results are shown in Table 1.

(1) Measurement of Current Density Change Depending on Voltage Change

[0166] The obtained organic light emitting diodes were measured regarding a current value flowing in the unit device, while increasing the voltage from 0 V to 10 V using a current-voltage meter (Keithley 2400), and, the measured current value was divided by area to provide the results.

(2) Measurement of Luminance Change Depending on Voltage Change

[0167] Luminance was measured by using a luminance meter (Minolta Cs-1000A), while the voltage of the organic light emitting diodes was increased from 0 V to 10 V.

(3) Measurement of Luminous Efficiency

[0168] Current efficiency (cd/A) at the same current density (10 mA/cm²) were calculated by using the luminance, current density, and voltages (V) from the items (1) and (2).

(4) Measurement of Life-span

[0169] T90 life-spans of the organic light emitting diodes according to Examples 1 to 24 and Comparative Examples 1 to 6 were measured as a time when their luminance decreased down to 90 % relative to the initial luminance (cd/m²) after emitting light with 5000 cd/m² as the initial luminance (cd/m²) and measuring their luminance decrease depending on a time with a Polaronix life-span measurement system.

(5) Measurement of Driving Voltage

[0170] A driving voltage of each diode was measured using a current-voltage meter (Keithley 2400) at 15 mA/cm².

[Table 1]

	First host	Second host	Ratio of first and second hosts	Dopant	Color	Efficiency Cd/A	Life-span T90	Driving voltage (Vd)
Comparative Example 1	C-1	-	alone	E-24	green	56	30	4.1
Comparative Example 2	C-1	CBP	3:7	E-24	green	61	60	4.8
Example 1	C-1	D-99	3:7	E-24	green	70	600	3.9
Comparative Example 3	C-1	D-99	3:7	Ir(ppy) ₃	green	49	220	4.2
Comparative Example 4	C-22	-	alone	E-24	green	53	40	4.0
Comparative Example 5	C-22	CBP	3:7	E-24	green	60	80	4.7
Example 2	C-22	D-99	3:7	E-24	green	71	640	3.9
Comparative Example 6	C-22	D-99	3:7	Ir(ppy) ₃	green	49	240	4.3
Example 3	C-1	D-40	3:7	E-24	green	69	380	3.7
Example 4	C-22	D-40	3:7	E-24	green	70	420	3.7
Example 5	C-1	D-137	3:7	E-24	green	68	580	4.2
Example 6	C-22	D-137	3:7	E-24	green	67	620	4.3

(continued)

	First host	Second host	Ratio of first and second hosts	Dopant	Color	Efficiency Cd/A	Life-span T90	Driving voltage (Vd)
Example 7	C-1	D-31	3:7	E-24	green	72	620	4.1
Example 8	C-22	D-31	3:7	E-24	green	72	700	4.2
Example 9	C-1	D-129	3:7	E-24	green	69	600	4.2
Example 10	C-22	D-129	3:7	E-24	green	67	610	4.4
Example 11	C-2	D-99	3:7	E-24	green	71	590	4.0
Example 12	C-12	D-99	3:7	E-24	green	67	580	3.8
Example 13	C-16	D-99	3:7	E-24	green	69	650	3.8
Example 14	C-17	D-99	3:7	E-24	green	69	570	3.9
Example 15	C-21	D-99	3:7	E-24	green	67	550	3.9
Example 16	C-22	D-99	3:7	E-24	green	69	620	4.0
Example 17	C-25	D-99	3:7	E-24	green	72	650	4.0
Example 18	B-1	D-99	3:7	E-24	green	68	410	4.2
Example 19	B-13	D-99	3:7	E-24	green	67	350	4.3
Example 20	B-17	D-99	3:7	E-24	green	67	370	4.1
Example 21	B-14	D-99	3:7	E-24	green	65	380	4.2
Example 22	B-14	D-31	3:7	E-24	green	66	440	4.3
Example 23	B-25	D-31	3:7	E-24	green	65	310	4.5

[0171] Referring to Table 1, when a material including DBX and carbazole was used as a first host, and biscarbazole was used as a second host, an advantage in terms of driving voltage and life-span was obtained, compared with when the first host was used alone or when CBP was used as the second host. In addition, when Ir(ppy)₃ as a phosphorescent dopant not including a DBX bone was used, a life-span and efficiency were largely increased, compared with when Compound E-24 as a phosphorescent dopant including a DBX bone was used. Particularly, when the structure of directly linking a position No. 3 of dibenzofuran with triazine as the first host was used, an effect of additionally decreasing a driving voltage but additionally increasing a life-span was obtained.

[0172] While this invention has been described in connection with what is presently considered to be practical example embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims. Therefore, the aforementioned embodiments should be understood to be exemplary but not limiting the present invention in any way.

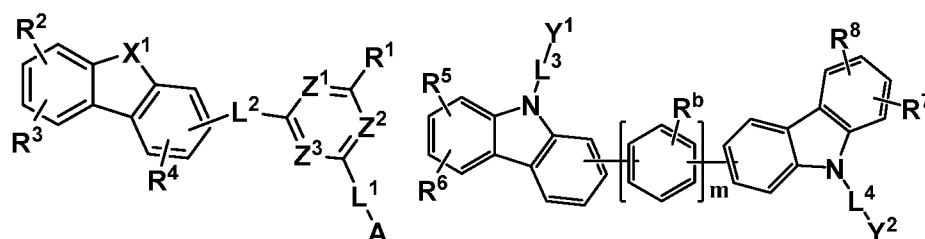
Claims

1. An organic optoelectronic device comprising:

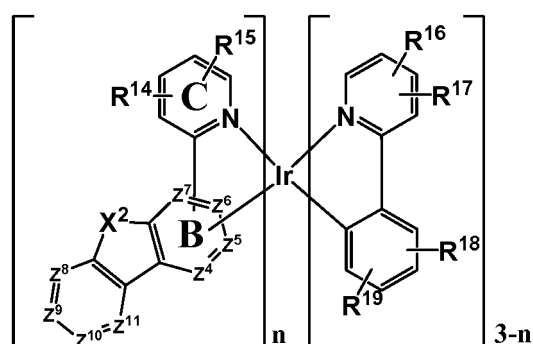
an anode and a cathode facing each other; and
 an organic layer disposed between the anode and the cathode,
 wherein the organic layer comprises one of a hole injection layer, a hole transport layer, a light emitting layer, and an electron transport layer, and
 the light emitting layer includes a first host represented by Chemical Formula 1, a second host represented by Chemical Formula 2, and a phosphorescent dopant represented by Chemical Formula 3:

[Chemical Formula 1]

[Chemical Formula 2]



[Chemical Formula 3]



wherein, in Chemical Formula 1,

X¹ is O or S,

Z¹ to Z³ are independently N or CR^a,

at least two of Z¹ to Z³ are N,

L¹ and L² are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

A is a substituted or unsubstituted carbazoyl group,

R¹ is a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

R^a and R² to R⁴ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group;

wherein, in Chemical Formula 2,

Y¹ and Y² are independently a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group,

L³ and L⁴ are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

R^b and R⁵ to R⁸ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group, and

m is an integer ranging from 0 to 2;

wherein, in Chemical Formula 3,

Z⁴ to Z¹¹ are independently N, C or CR^c,

the ring C is bound to the ring B through a C-C bond,

iridium is bound to the ring B through a Ir-C bond, and

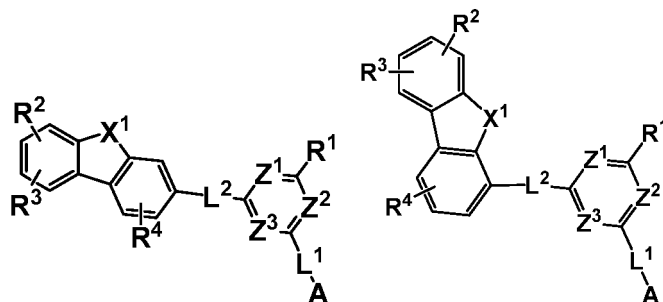
X² is O or S,

R^c and R¹⁴ to R¹⁹ are independently hydrogen, deuterium, a halogen, germanium group, a cyano group, a substituted or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C3 to C20 cycloalkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic

group, and
n is an integer ranging from 1 to 3.

2. The organic optoelectronic device of claim 1, wherein the first host is represented by Chemical Formula 1-3 or Chemical Formula 1-4:

[Chemical Formula 1-3] [Chemical Formula 1-4]



wherein, in Chemical Formula 1-3 and Chemical Formula 1-4,

X1 is O or S,

Z¹ to Z³ are independently N or CR^a,

at least two of Z¹ to Z³ are N,

L¹ and L² are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

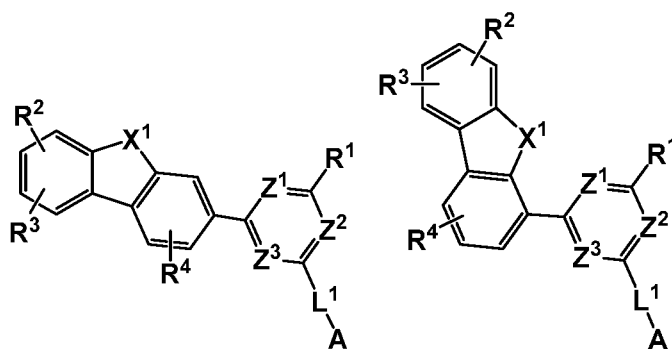
A is a substituted or unsubstituted carbazolyl group,

R¹ is a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

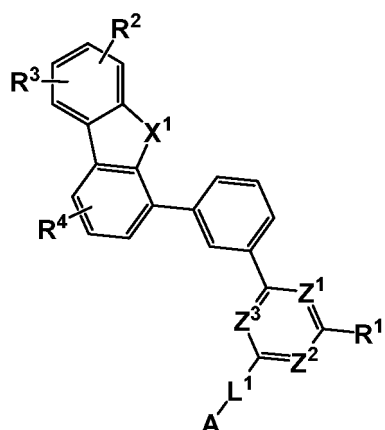
R^a and R² to R⁴ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group.

3. The organic optoelectronic device of claim 1, wherein the first host is represented by one of Chemical Formula 1-3a, Chemical Formula 1-4a, and Chemical Formula 1-4b:

[Chemical Formula 1-3a] [Chemical Formula 1-4a]



[Chemical Formula 1-4b]



wherein, in Chemical Formula 1-3a, Chemical Formula 1-4a, and Chemical Formula 1-4b,

X¹ is O or S,

Z¹ to Z³ are independently N or CR^a,

at least two of Z¹ to Z³ are N,

L¹ is a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

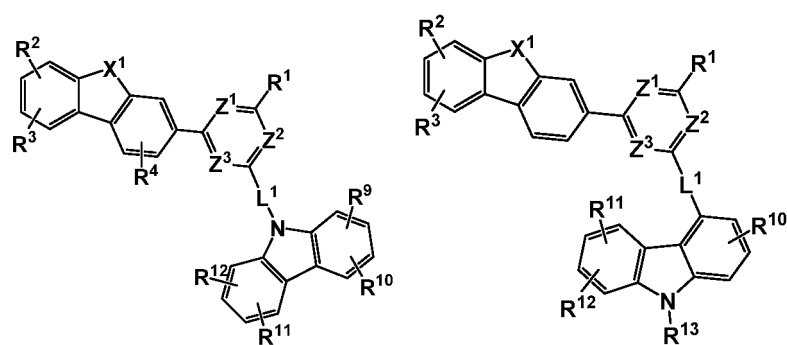
A is a substituted or unsubstituted carbazolyl group,

R¹ is a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

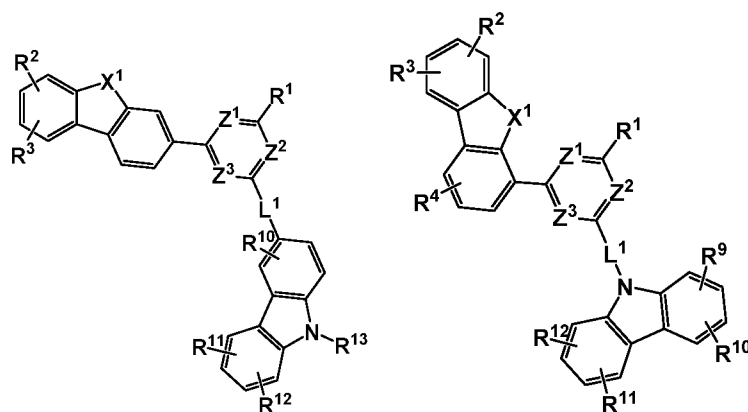
R^a, R² to R⁴ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group.

4. The organic optoelectronic device of claim 3, wherein the first host is represented by one of Chemical Formula 1-3a-I, Chemical Formula 1-3a-II, Chemical Formula 1-3a-III, Chemical Formula 1-4a-I, Chemical Formula 1-4b-I, and Chemical Formula 1-4b-II:

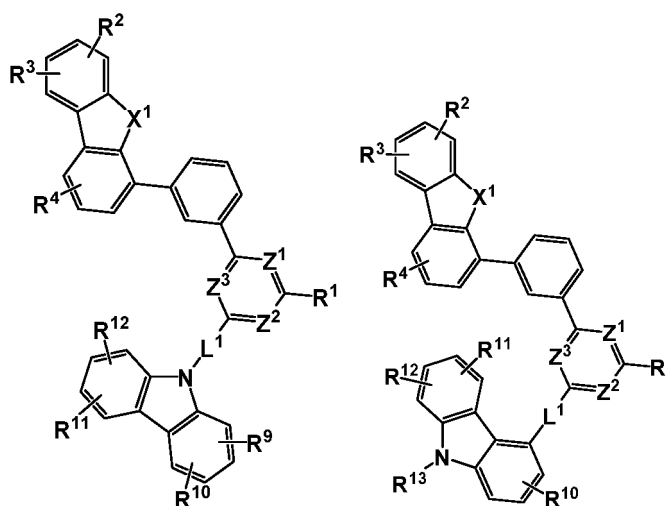
[Chemical Formula 1-3a-I] [Chemical Formula 1-3a-II]



[Chemical Formula 1-3a-III] [Chemical Formula 1-4a-I]



[Chemical Formula 1-4b-I] [Chemical Formula 1-4b-II]



wherein, in Chemical Formula 1-3a-I, Chemical Formula 1-3a-II, Chemical Formula 1-3a-III, Chemical Formula 1-4a-I, Chemical Formula 1-4b-I, and Chemical Formula 1-4b-II,

X¹ is O or S,

Z¹ to Z³ are independently N or CR^a,

at least two of Z¹ to Z³ are N,

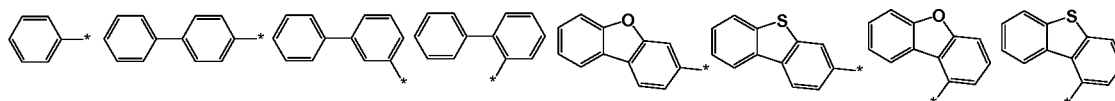
L¹ is a single bond, or a substituted or unsubstituted C₆ to C₂₀ arylene group,

R¹ is a substituted or unsubstituted C₆ to C₂₀ aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

R^a, R² to R⁴ and R⁹ to R¹³ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C₁ to C₁₀ alkyl group, or a substituted or unsubstituted C₆ to C₂₀ aryl group.

5. The organic optoelectronic device of claim 1, wherein Z¹ to Z³ of Chemical Formula 1 are N.
6. The organic optoelectronic device of claim 1, wherein R¹ of Chemical Formula 1 is selected from substituents of Group I:

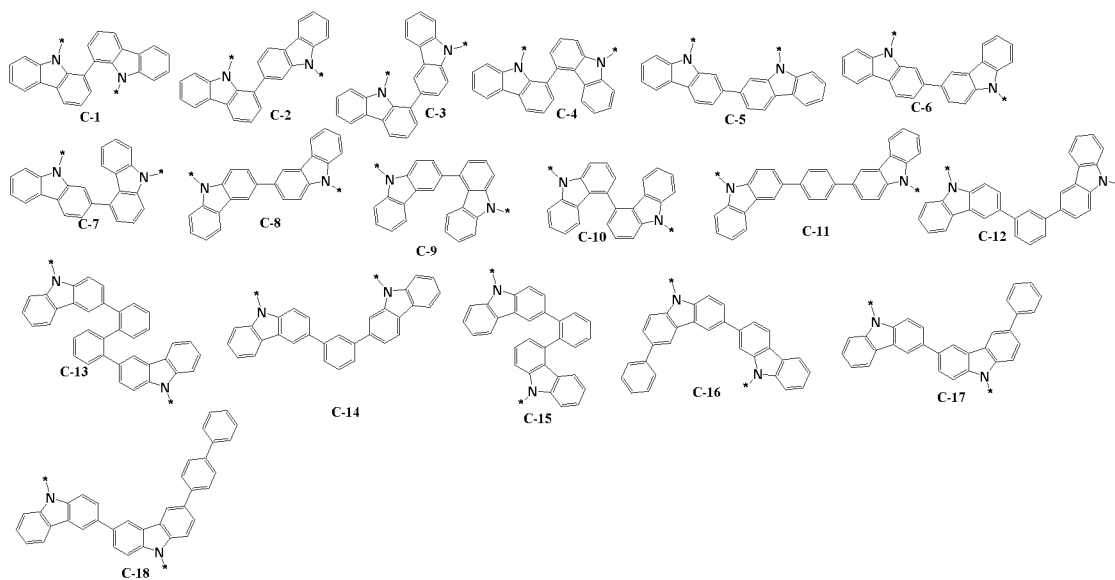
[Group I]



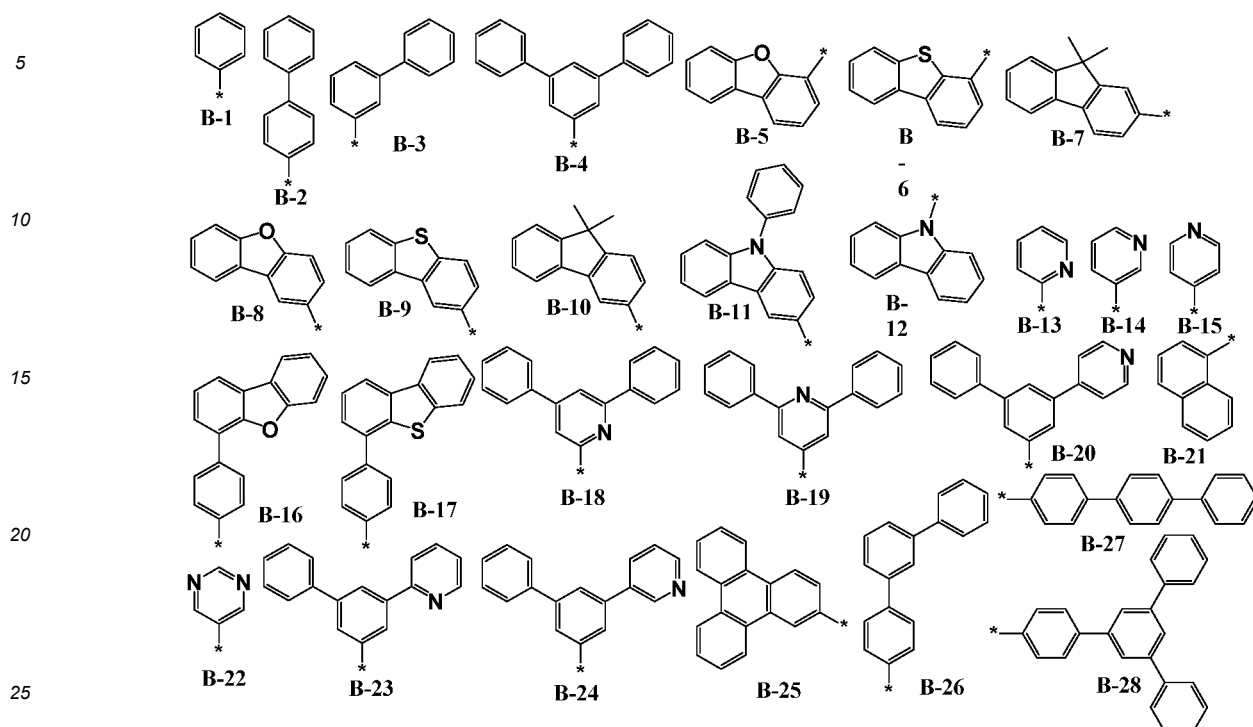
wherein, in Group I, * is a linking point.

7. The organic optoelectronic device of claim 1, wherein Chemical Formula 2 is one of structures of Group II, and *-L³-Y¹ and *-L⁴-Y² one of substituents of Group III:

[Group II]



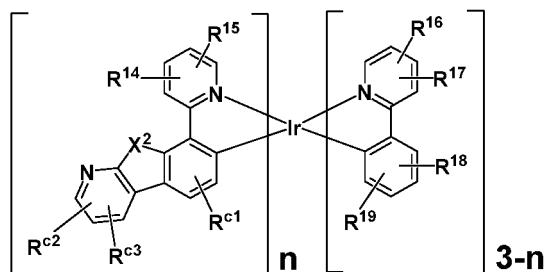
[Group II]



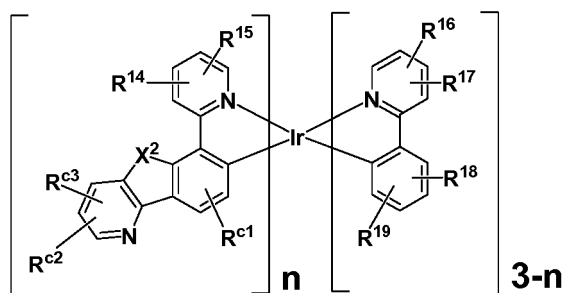
wherein, in Group II and Group III, * is a linking point.

8. The organic optoelectronic device of claim 7, wherein Chemical Formula 2 is represented by Chemical Formula c-8 or Chemical Formula c-17 of Group II, and * L_3 -Y¹ and * L_4 -Y² are selected from Group III.
9. The organic optoelectronic device of claim 7, wherein Chemical Formula 2 is represented by Chemical Formula c-8 or Chemical Formula c-17 of Group II, and * L_3 -Y¹ and * L_4 -Y² are B-1, B-2, B-3, B-11, B-16, and B-17 of Group III.
10. The organic optoelectronic device of claim 1, wherein Chemical Formula 3 is represented by one of Chemical Formula 3-1 to Chemical Formula 3-6:

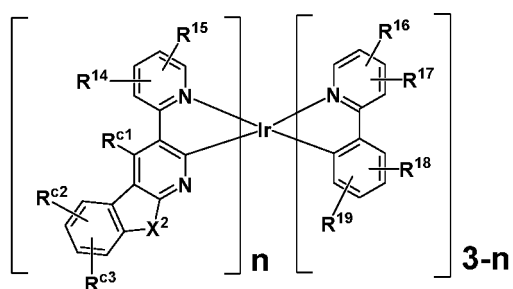
[Chemical Formula 3-1]



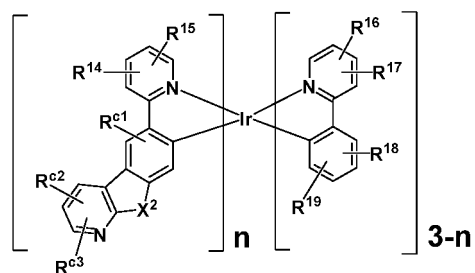
[Chemical Formula 3-2]



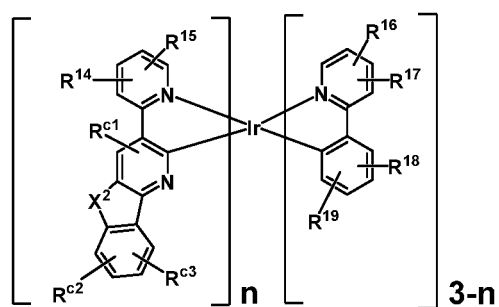
[Chemical Formula 3-3]



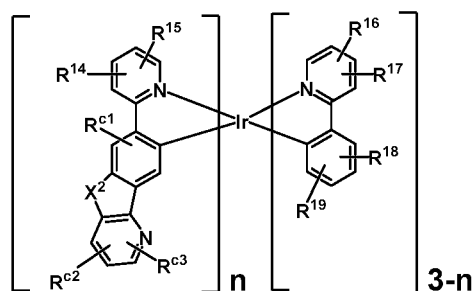
[Chemical Formula 3-4]



[Chemical Formula 3-5]



[Chemical Formula 3-6]



wherein, in Chemical Formula 3-1 to Chemical Formula 3-6,

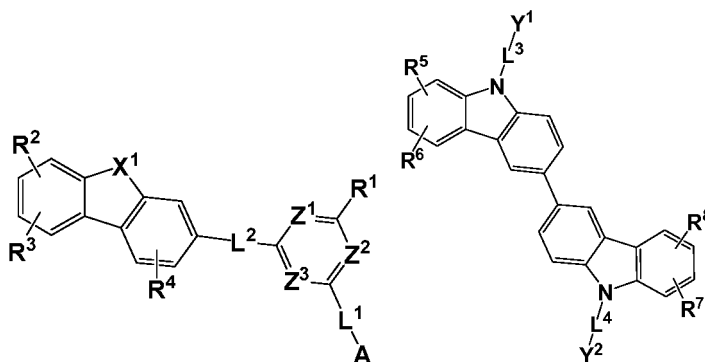
X^2 is O or S,

R^{c1} , R^{c2} , R^{c3} , and R^{14} to R^{19} are independently hydrogen, deuterium, a halogen, germanium group, a cyano group, a substituted or unsubstituted silyl group, a substituted or unsubstituted C1 to C10 alkyl group, a substituted or unsubstituted C3 to C20 cycloalkyl group, a substituted or unsubstituted C1 to C10 alkylsilyl group, a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group, and

n is an integer ranging from 1 to 3.

11. The organic optoelectronic device of claim 1, wherein the first host is represented by Chemical Formula 1-3, the second host is represented by Chemical Formula 2A:

[Chemical Formula 1-3] [Chemical Formula 2A]



wherein, in Chemical Formula 1-3 and Chemical Formula 2A,

X^1 is O or S,

Z^1 to Z^3 are independently N or CR^a ,

at least two of Z^1 to Z^3 are N,

A is a substituted or unsubstituted carbazolyl group,

R^1 is a substituted or unsubstituted C6 to C20 aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group,

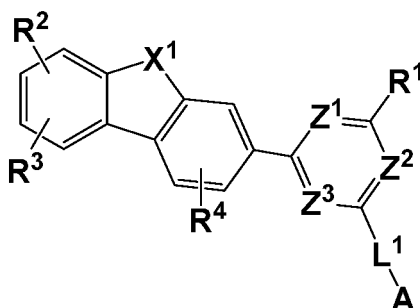
L^1 to L^4 are independently a single bond, or a substituted or unsubstituted C6 to C20 arylene group,

R^a and R^2 to R^8 are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C1 to C10 alkyl group, or a substituted or unsubstituted C6 to C20 aryl group, and

Y^1 and Y^2 are independently a substituted or unsubstituted C6 to C20 aryl group, or a substituted or unsubstituted C2 to C30 heterocyclic group.

12. The organic optoelectronic device of claim 11, wherein the first host is represented by Chemical Formula 1-3a:

[Chemical Formula 1-3a]



wherein, in Chemical Formula 1-3a,

X¹ is O or S,

Z¹ to Z³ are independently N,

L¹ is a single bond, or a meta-phenylene group,

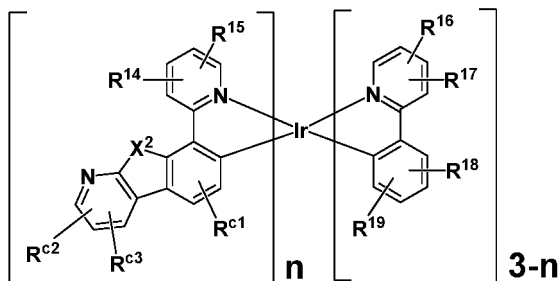
A is a substituted or unsubstituted carbazolyl group,

R¹ is a substituted or unsubstituted C₆ to C₂₀ aryl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted dibenzothiophenyl group, and

R² to R⁴ are independently hydrogen, deuterium, a cyano group, a substituted or unsubstituted C₁ to C₁₀ alkyl group, or a substituted or unsubstituted C₆ to C₂₀ aryl group.

13. The organic optoelectronic device of claim 11, wherein Chemical Formula 3 is represented by Chemical Formula 3-1:

[Chemical Formula 3-1]



wherein, in Chemical Formula 3-1,

X² is O or S,

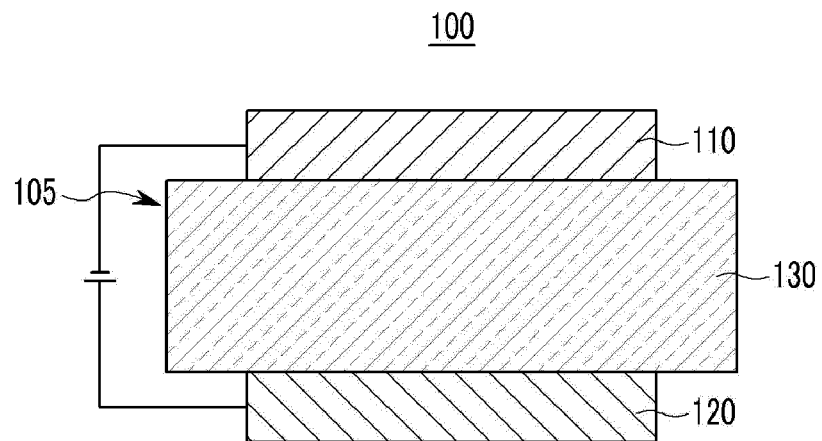
R^{c1}, R^{c2}, R^{c3}, and R¹⁴ to R¹⁹ are independently hydrogen, deuterium, a halogen, a substituted or unsubstituted silyl group, a substituted or unsubstituted C₁ to C₁₀ alkyl group, a substituted or unsubstituted C₁ to C₁₀ alkylsilyl group, or a substituted or unsubstituted C₆ to C₂₀ aryl group,

n is an integer ranging from 1 to 3, and

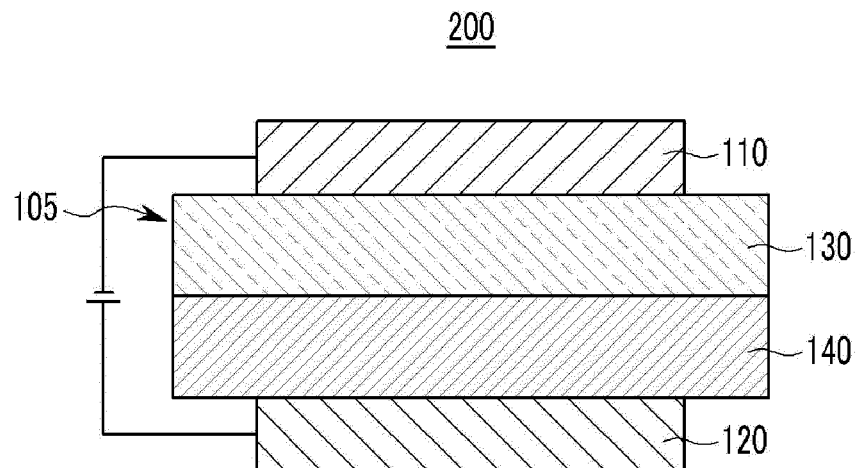
"substituted" refers to replacement of at least one hydrogen of a substituent or a compound by deuterium, a halogen, a C₁ to C₄ alkyl group, or a C₆ to C₁₂ aryl group.

14. A display device comprising the organic optoelectronic device of any one of claim 1 to claim 13.

【Figure 1】



【Figure 2】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2018/006794

A. CLASSIFICATION OF SUBJECT MATTER

C09K 11/06(2006.01)i, H01L 51/00(2006.01)i

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)

C09K 11/06; C07D 251/12; C07F 15/00; C07F 7/08; H01L 51/00; H01L 51/50

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

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal), STN (Registry, CAplus), Google & Keywords: organic optoelectronic element, display device, host, dopant

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2016-0010373 A (ROHM AND HAAS ELECTRONIC MATERIALS KOREA LTD.) 27 January 2016 See claims 1, 7, 8; paragraphs [0023], [0206].	1-14
X	US 2016-0093808 A1 (UNIVERSAL DISPLAY CORPORATION) 31 March 2016 See claims 1, 9(compound A1), 11(compound F1), 14(emitter 34); paragraph [0003].	1-14
Y	US 2014-0231769 A1 (IDEMITSU KOSAN CO., LTD.) 21 August 2014 See claim 1; paragraphs [0139](first compound), [0183](page 152, second compound of left column), [0186].	1-14
Y	KR 10-2016-0011036 A (SAMSUNG SDI CO., LTD.) 29 January 2016 See claims 1, 12(compound 23), 13(compound B-1), 17-20.	1-14
Y	KR 10-2016-0064955 A (SAMSUNG ELECTRONICS CO., LTD.) 08 June 2016 See claims 1, 17(compound 179)-20.	1-14

☐ Further documents are listed in the continuation of Box C.☒ 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

02 OCTOBER 2018 (02.10.2018)

Date of mailing of the international search report

02 OCTOBER 2018 (02.10.2018)

Name and mailing address of the ISA/KR



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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2018/006794

Patent document cited in search report	Publication date	Patent family member	Publication date
KR 10-2016-0010373 A	27/01/2016	CN 106575663 A EP 3170206 A1 EP 3170206 A4 JP 2017-527129 A US 2017-0170408 A1 WO 2016-010402 A1	19/04/2017 24/05/2017 14/03/2018 14/09/2017 15/06/2017 21/01/2016
US 2016-0093808 A1	31/03/2016	NONE	
US 2014-0231769 A1	21/08/2014	JP 2014-157947 A JP 6317544 B2 US 9397307 B2	28/08/2014 25/04/2018 19/07/2016
KR 10-2016-0011036 A	29/01/2016	CN 106471093 A KR 10-1835502 B1 US 2017-0104163 A1 WO 2016-013732 A1	01/03/2017 07/03/2018 13/04/2017 28/01/2016
KR 10-2016-0064955 A	08/06/2016	CN 105646590 A EP 3026056 A1 EP 3026056 B1 US 2016-0155962 A1	08/06/2016 01/06/2016 08/11/2017 02/06/2016

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20140131676 A [0161]

专利名称(译)	有机光电元件和显示装置		
公开(公告)号	EP3643762A1	公开(公告)日	2020-04-29
申请号	EP2018821423	申请日	2018-06-15
[标]申请(专利权)人(译)	三星斯笛爱股份有限公司		
申请(专利权)人(译)	三星SDI CO. , LTD		
当前申请(专利权)人(译)	三星SDI CO. , LTD		
[标]发明人	JANG KIPO KIM BYUNGKU KANG GIWOOK LEE HANILL JUNG SUNG HYUN JUNG HO KUK JO YOUNGKYOUNG YU EUN SUN		
发明人	JANG, KIPO KIM, BYUNGKU KANG, GIWOOK LEE, HANILL JUNG, SUNG-HYUN JUNG, HO KUK JO, YOUNGKYOUNG YU, EUN SUN		
IPC分类号	C09K11/06 H01L51/00		
CPC分类号	C09K11/06 H01L51/00 C07D405/14 C09K11/025 C09K2211/1029 C09K2211/1088 C09K2211/185 H01L51/0067 H01L51/0072 H01L51/0073 H01L51/0085 H01L51/5016 H01L51/5056 H01L51/5072 H01L51/5088 H01L2251/5384		
优先权	1020170079209 2017-06-22 KR		
外部链接	Espacenet		

摘要(译)

公开了一种有机光电器件，其包括彼此面对的阳极和阴极，以及设置在阳极和阴极之间的有机层。有机层包括空穴注入层，空穴传输层，发光层和电子传输层之一。发光层包括由化学式1表示的第一主体，由化学式2表示的第二主体和由化学式3表示的磷光掺杂剂。

【Figure 1】

