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(54) **ORGANIC ELECTROLUMINESCENCE DEVICE AND HETEROCYCLIC COMPOUND FOR ORGANIC ELECTROLUMINESCENCE DEVICE**

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(57) **ABSTRACT**

An organic electroluminescence device and a heterocyclic compound, the device including a first electrode; a hole transport region on the first electrode; an emission layer on the hole transport region; an electron transport region on the emission layer; and a second electrode on the electron transport region, wherein the emission layer includes a heterocyclic compound that includes a nitrogen-containing monocycle, at least one linker, and two or more carbazole moieties, the at least one linker is a substituted or unsubstituted dibenzofuran group or a substituted or unsubstituted dibenzothiophene group, and at least one of the carbazole moieties and the nitrogen-containing monocycle are bonded to the at least one linker in an ortho relationship.

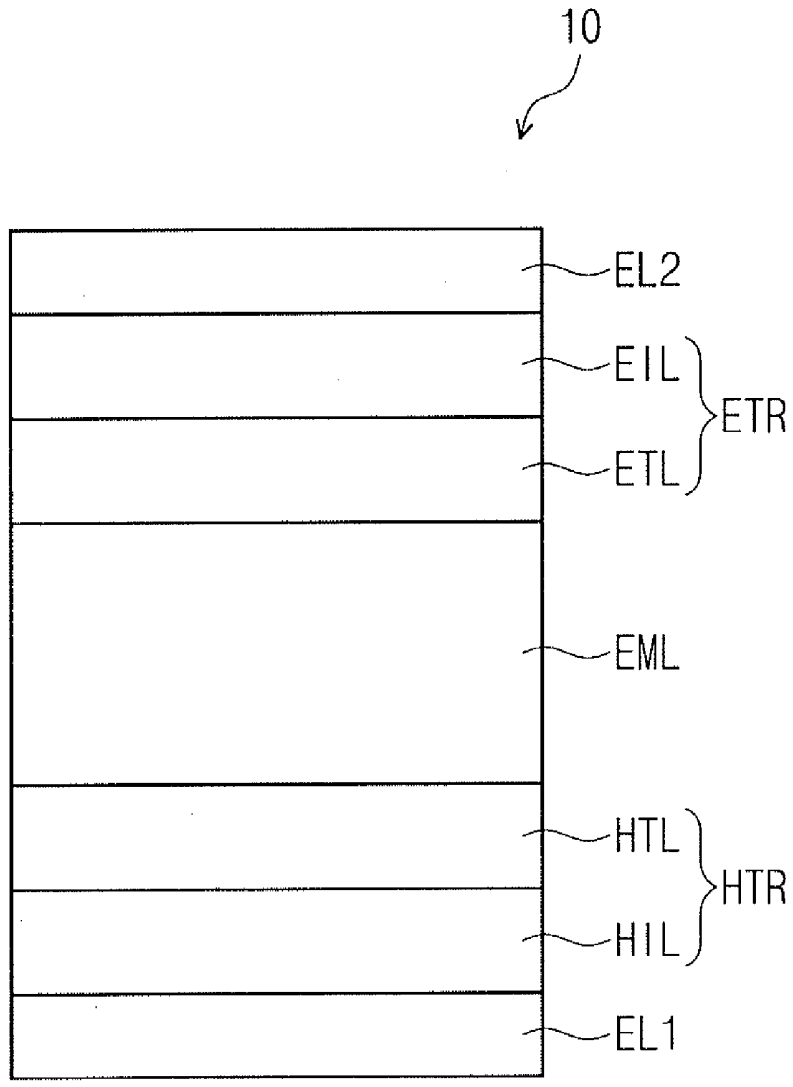


FIG. 1

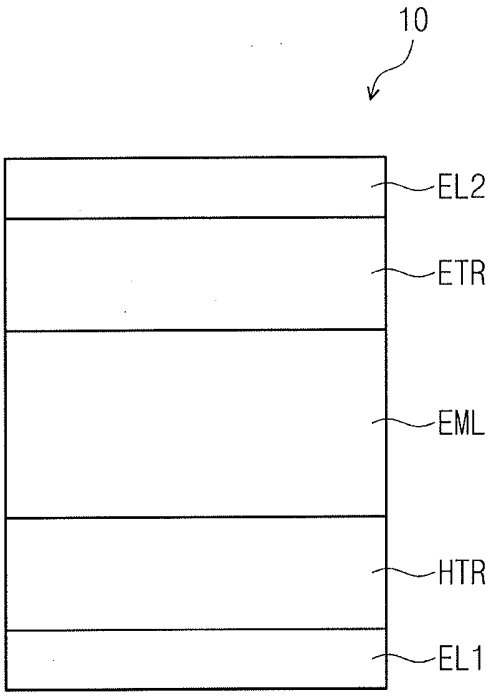



FIG. 2

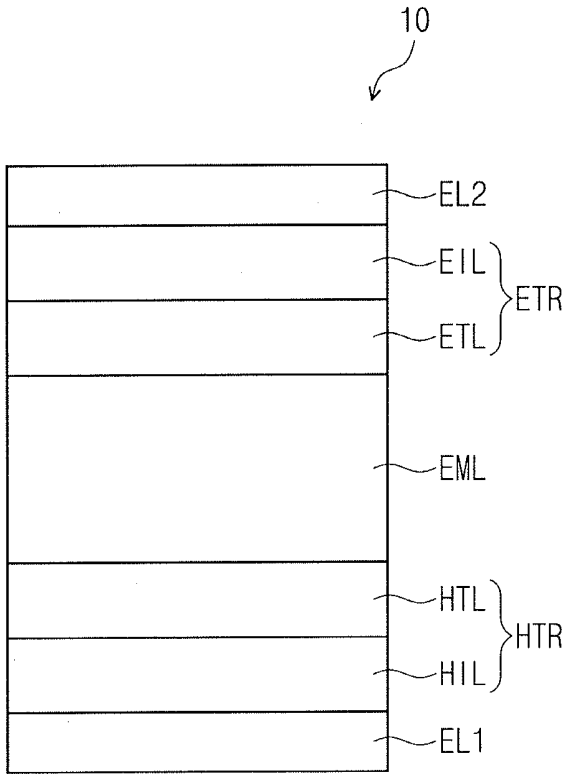
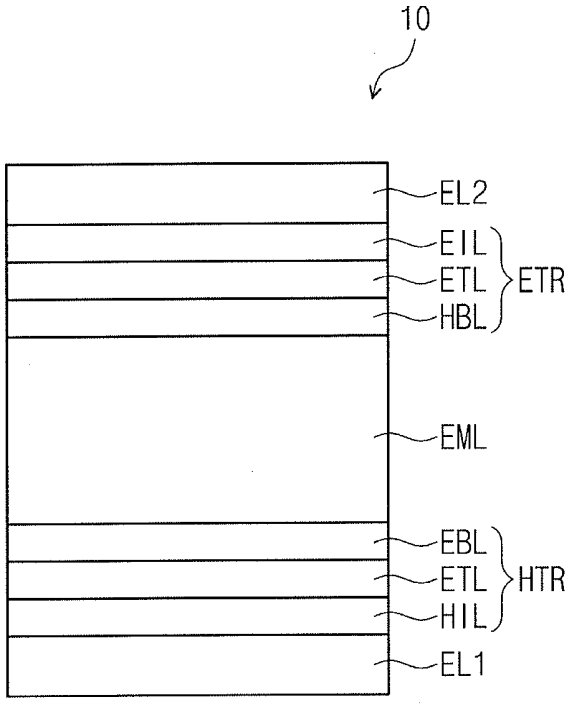


FIG. 3



# ORGANIC ELECTROLUMINESCENCE DEVICE AND HETEROCYCLIC COMPOUND FOR ORGANIC ELECTROLUMINESCENCE DEVICE

## CROSS-REFERENCE TO RELATED APPLICATION

**[0001]** Korean Patent Application No. 10-2018-0073189, filed on Jun. 26, 2018, in the Korean Intellectual Property Office, and entitled: "Organic Electroluminescence Device and Heterocyclic Compound for Organic Electroluminescence Device," is incorporated by reference herein in its entirety.

## BACKGROUND

### 1. Field

**[0002]** Embodiments relates to an organic electroluminescence device and a heterocyclic compound used for the organic electroluminescence device.

### 2. Description of the Related Art

**[0003]** The development of an organic electroluminescence display as an image display device is being actively conducted. Different from a liquid crystal display device, the organic electroluminescence display is a self-luminescent display in which holes and electrons injected from a first electrode and a second electrode recombine in an emission layer, and a light-emitting material which is an organic compound included in the emission layer emits light to attain display.

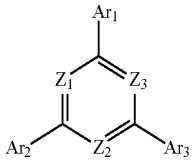
**[0004]** An organic electroluminescence device may include, e.g., an organic device including a first electrode, a hole transport layer on the first electrode, an emission layer on the hole transport layer, an electron transport layer on the emission layer, and a second electrode on the electron transport layer. Holes are injected from the first electrode, and the injected holes move via the hole transport layer and are injected into the emission layer. Meanwhile, electrons are injected from the second electrode, and the injected electrons move via the electron transport layer and are injected into the emission layer. The holes and electrons injected into the emission layer recombine to produce excitons in the emission layer. The organic electroluminescence device emits light using light generated by the transition of the excitons to a ground state.

## SUMMARY

**[0005]** The embodiments may be realized by providing an organic electroluminescence device including a first electrode; a hole transport region on the first electrode; an emission layer on the hole transport region; an electron transport region on the emission layer; and a second electrode on the electron transport region, wherein the emission layer includes a heterocyclic compound that includes a nitrogen-containing monocycle, at least one linker, and two or more carbazole moieties, the at least one linker is a substituted or unsubstituted dibenzofuran group or a substituted or unsubstituted dibenzothiophene group, and at least one of the carbazole moieties and the nitrogen-containing monocycle are bonded to the at least one linker in an ortho relationship.

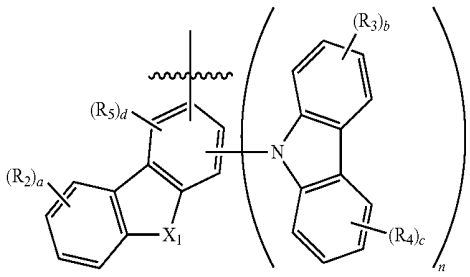
**[0006]** The embodiments may be realized by providing an organic electroluminescence device including a first electrode; a hole transport region on the first electrode; an emission layer on the hole transport region; an electron transport region on the emission layer; and a second electrode on the electron transport region, wherein the emission layer includes a heterocyclic compound represented by the following Formula 1:

[Formula 1]




**[0007]** in Formula 1, $Z_1$ to $Z_3$ are each independently $CR_1$ or N, at least one of $Z_1$ to $Z_3$ is N, $R_1$ is a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, $Ar_1$ to $Ar_3$ are each independently a group represented by the following Formula 2, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 carbon atoms for forming a ring, and at least one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2:

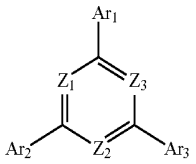
[Formula 2]




**[0008]** in Formula 2, $X_1$ is O or S, "n" is an integer of 1 to 3, "a" to "c" are each independently an integer of 0 to 4, "d" is an integer of 0 to 2, and $R_2$ to $R_5$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, when only one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2 above, "n" is 2 or 3, and at least one of the carbazole moieties in Formula 2 is bonded in an ortho relationship with respect to the nitrogen-containing monocycle of Formula 1.

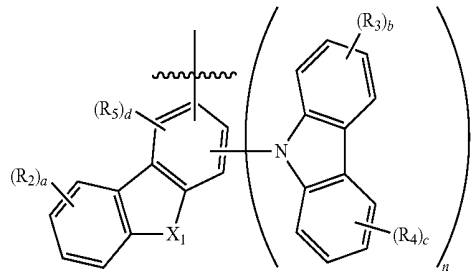
**[0009]** The embodiments may be realized by providing a heterocyclic compound represented by the following Formula 1:

[Formula 1]



**[0010]** wherein, in Formula 1, $Z_1$ to $Z_3$ are each independently $CR_1$ or N, at least one of $Z_1$ to $Z_3$ is N, $R_1$ is a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, $Ar_1$ to $Ar_3$ are each independently a group represented by the following Formula 2, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, and at least one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2:

[Formula 2]



**[0011]** in Formula 2, $X_1$ is O or S, "n" is an integer of 1 to 3, "a" to "c" are each independently an integer of 0 to 4, "d" is an integer of 0 to 2, and $R_2$ to $R_5$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, when only one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2 above, "n" is 2 or 3, and at least one of the carbazole moieties in Formula 2 is bonded in an ortho relationship with respect to the nitrogen-containing monocycle of Formula 1.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** Features will be apparent to those of skill in the art by describing in detail exemplary embodiments with reference to the attached drawings in which:

**[0013]** FIG. **1** illustrates a cross-sectional view of an organic electroluminescence device according to an embodiment;

**[0014]** FIG. **2** illustrates a cross-sectional view of an organic electroluminescence device according to an embodiment; and

**[0015]** FIG. **3** illustrates a cross-sectional view of an organic electroluminescence device according to an embodiment.

## DETAILED DESCRIPTION

**[0016]** Example embodiments will now be described more fully hereinafter with reference to the accompanying drawings; however, they may be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey exemplary implementations to those skilled in the art.

**[0017]** In the drawing figures, the dimensions of layers and regions may be exaggerated for clarity of illustration. Like reference numerals refer to like elements throughout.

**[0018]** It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element discussed below could be termed a second element, and similarly, a second element could be termed a first element. As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

**[0019]** It will be further understood that the terms "includes," "including," "comprises" or "comprising," when used in this specification, specify the presence of stated features, numerals, steps, operations, elements, parts, or a combination thereof, but do not preclude the presence or addition of one or more other features, numerals, steps, operations, elements, parts, or a combination thereof. It will also be understood that when a layer, a film, a region, a plate, etc. is referred to as being "on" another part, it can be "directly on" the other part, or intervening layers may also be present.

**[0020]** First, organic electroluminescence devices according to exemplary embodiments will be explained referring to FIG. **1** to FIG. **3**.

**[0021]** FIG. **1** illustrates a cross-sectional view of an organic electroluminescence device according to an embodiment. FIG. **2** illustrates a cross-sectional view of an organic electroluminescence device according to an embodiment. FIG. **3** illustrates a cross-sectional view of an organic electroluminescence device according to an embodiment.

**[0022]** Referring to FIG. **1** to FIG. **3**, an organic electroluminescence device **10** according to an embodiment may include a first electrode EL**1**, a hole transport region HTR, an emission layer EML, an electron transport region ETR, and a second electrode EL**2**.

**[0023]** The first electrode EL**1** has conductivity. The first electrode EL**1** may be a pixel electrode or an anode. The first electrode EL**1** may be a transmissive electrode, a transflective electrode, or a reflective electrode. If the first electrode EL**1** is the transmissive electrode, the first electrode EL**1** may include a transparent metal oxide such as indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium tin zinc oxide (ITZO). If the first electrode EL**1** is the transflective electrode or the reflective electrode, the first electrode EL**1** may include Ag, Mg, Cu, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, LiF/Ca, LiF/Al, Mo, Ti, a compound thereof, or a mixture thereof (for example, a mixture of Ag and Mg). Also, the first electrode EL**1** may include a plurality of layers including the reflective layer or transflective layer formed using the above materials, or a transparent layer formed using ITO, IZO, ZnO, or ITZO. For example, the first electrode EL**1** may have a three-layer structure of ITO/Ag/ITO.

**[0024]** The thickness of the first electrode EL**1** may be from about 1,000 Å to about 10,000 Å, for example, from about 1,000 Å to about 3,000 Å.

**[0025]** The hole transport region HTR is provided on the first electrode EL**1**. The hole transport region HTR may include at least one of a hole injection layer HIL, a hole transport layer HTL, a hole buffer layer, or an electron blocking layer EBL. The thickness of the hole transport region HTR may be, for example, from about 1,000 Å to about 1,500 Å

**[0026]** The hole transport region HTR may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure including a plurality of layers formed using a plurality of different materials.

**[0027]** For example, the hole transport region HTR may have the structure of a single layer such as a hole injection layer HIL and a hole transport layer HTL, and may have a structure of a single layer formed using a hole injection material and a hole transport material. In an implementation, the hole transport region HTR may have a structure of a single layer formed using a plurality of different materials, or a structure laminated from the first electrode EL**1** of hole injection layer HIL/hole transport layer HTL, hole injection layer HIL/hole transport layer HTL/hole buffer layer, hole injection layer HIL/hole buffer layer, hole transport layer HTL/hole buffer layer, or hole injection layer HIL/hole transport layer HTL/electron blocking layer EBL.

**[0028]** The hole transport region HTR may be formed using various methods such as a vacuum deposition method, a spin coating method, a cast method, a Langmuir-Blodgett (LB) method, an inkjet printing method, a laser printing method, and a laser induced thermal imaging (LITI) method.

**[0029]** The hole injection layer HIL may include, for example, a phthalocyanine compound such as copper phthalocyanine; N,N'-diphenyl-N,N'-bis-[4-(phenyl-m-tolyl-amino)-phenyl]-biphenyl-4,4'-diamine (DNTPD), 4,4',4"-tris(3-methylphenylphenylamino) triphenylamine (m-MTDATA), 4,4',4"-tris(N,N-diphenylamino)triphenylamine (TDATA), 4,4',4"-tris {N-(2-naphthyl)-N-phenylamino}-triphenylamine (2-TNATA), poly(3,4-ethylene-dioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), N,N'-dinaphthalene-1-yl)-N,N'-diphenyl-benzidine (NPB), triphenylamine-containing polyether ketone (TPAPEK), 4-isopropyl-4'-methyldiphenyliodonium tetrakis(pentafluorophenyl)borate, dipyrazino[2,3-f: 2',3'-h]quinoxaline-2,3,6,7,10,11-hexacarbonitrile (HAT-CN), etc.

**[0030]** The hole transport layer HTL may include, for example, carbazole derivatives such as N-phenyl carbazole and polyvinyl carbazole, fluorine-based derivatives, N,N'-bis(3-methylphenyl)-N,N'-diphenyl-[1,1-biphenyl]-4,4'-diamine (TPD), triphenylamine-based derivatives such as 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), N,N'-di(1-naphthalene-1-yl)-N,N'-diphenyl-benzidine (NPB), 4,4'-cyclohexylidene bis[N,N-bis(4-methylphenyl) benzenamine] (TAPC), 4,4'-bis[N,N'-(3-tolyl)amino]-3,3'-dimethylbiphenyl (HMTPD), 1,3-bis(N-carbazolyl)benzene (mCP), etc.

**[0031]** The thickness of the hole transport region HTR may be from about 100 Å to about 10,000 Å, for example, from about 100 Å to about 1,000 Å. If the hole transport region HTR includes both the hole injection layer HIL and the hole transport layer HTL, the thickness of the hole injection layer HIL may be from about 100 Å to about 10,000 Å, for example, from about 100 Å to about 1,000 Å, and the thickness of the hole transport layer HTL may be from about 30 Å to about 1,000 Å. If the thicknesses of the hole transport region HTR, the hole injection layer HIL, and the hole transport layer HTL satisfy the above-described ranges, satisfactory hole transport properties may be obtained without substantial increase of a driving voltage.

**[0032]** The hole transport region HTR may further include a charge generating material in addition to the above-described materials to increase conductivity. The charge generating material may be dispersed uniformly or non-uniformly in the hole transport region HTR. The charge generating material may be, for example, a p-dopant. In an implementation, the p-dopant may be one of quinone derivatives, metal oxides, or cyano group-containing compounds. Examples of the p-dopant may include quinone derivatives such as tetracyanoquinodimethane (TCNQ) and 2,3,5,6-tetrafluoro-tetracyanoquinodimethane (F4-TCNQ), metal oxides such as tungsten oxide, and molybdenum oxide.

**[0033]** As described above, the hole transport region HTR may further include at least one of a hole buffer layer or an electron blocking layer in addition to the hole injection layer HIL and the hole transport layer HTL. The hole buffer layer may compensate a resonance distance according to the wavelength of light emitted from the emission layer EML and increase light emission efficiency. Materials included in the hole transport region HTR may be used as materials included in the hole buffer layer. The electron blocking layer is a layer preventing electron injection from the electron transport region ETR to the hole transport region HTR.

**[0034]** The emission layer EML may be provided on the hole transport region HTR. In an implementation, the emission layer EML may have a thickness of about 100 Å to about 1,000 Å, e.g., about 100 Å to about 300 Å. In an implementation, the emission layer EML may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure having a plurality of layers formed using a plurality of different materials.

**[0035]** The emission layer EML may include, e.g., a heterocyclic compound including a nitrogen-containing monocycle, a (e.g., at least one) linker, and two or more carbazole moieties. In an implementation, the linker may be, e.g., a substituted or unsubstituted dibenzofuran group or a substituted or unsubstituted dibenzothiophene.

**[0036]** At least one of the carbazole moieties and the nitrogen-containing monocycle may be bonded the linker in an ortho relationship. For example, the nitrogen-containing monocycle and the carbazole moieties may be connected via the linker, and at least one of the carbazole moieties and the nitrogen-containing monocycle are bonded to the linker in ortho relationship. For example, the nitrogen-containing monocycle may be bound to one ring atom of the linker, and one of the carbazole moieties may be bound to another ring atom of the linker, which other ring atom of the linker is directly adjacent to the one ring atom of the linker on the ring (e.g., the one ring atom of the linker may be at a 3-position of the linker and the other ring atom of the linker may be at a 4-position of the linker).

**[0037]** In an implementation, if two carbazole moieties are included, only one of the two may be bonded in the ortho

relationship with respect to the nitrogen-containing monocycle, and the other carbazole moiety may be bonded in meta or para relationship with respect to the nitrogen-containing monocycle. In an implementation, each (e.g., both) of the two carbazole moieties may be bonded to the linker in the ortho relationship with respect to the nitrogen-containing monocycle. In an implementation, the heterocyclic compound may include two linkers.

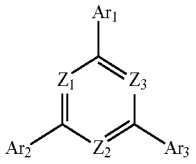
**[0038]** In an implementation, the heterocyclic compound may include one or two linkers. If the heterocyclic compound includes one linker, each of two or more carbazole moieties may be bonded to the linker. If the heterocyclic compound includes two linkers, at least one carbazole moiety may be bonded each of the linkers.

**[0039]** In an implementation, the nitrogen-containing monocycle may be, e.g., a substituted or unsubstituted pyridine group, a substituted or unsubstituted pyrimidine group, or a substituted or unsubstituted triazine group. In an implementation, the nitrogen-containing monocycle may be, e.g., a substituted or unsubstituted triazine group.

**[0040]** In an implementation, the nitrogen-containing monocycle may be substituted with at least one substituted or unsubstituted phenyl group. In an implementation, if the heterocyclic compound includes one linker, the nitrogen-containing monocycle may be unsubstituted or may be di-substituted with two substituted or unsubstituted phenyl groups. In an implementation, if the heterocyclic compound includes two linkers, the nitrogen-containing monocycle may be substituted with one substituted or unsubstituted phenyl group. In an implementation, the nitrogen-containing monocycle may be, e.g., substituted with one or two unsubstituted phenyl groups.

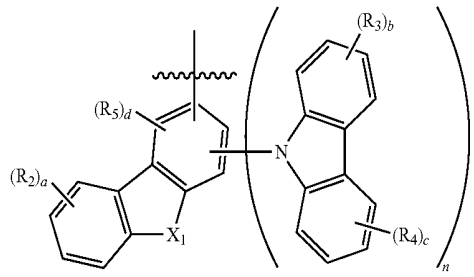
**[0041]** In an implementation, the heterocyclic compound may be, e.g., represented by the following Formula 1.

[Formula 1]




**[0042]** In Formula 1, $Z_1$ to $Z_3$ may each independently be, e.g., $CR_1$ or N, at least one of $Z_1$ to $Z_3$ is N. $R_1$ may be, e.g., a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. $Ar_1$ to $Ar_3$ may each independently be, e.g., a group represented by Formula 2, below, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. In an implementation, at least one of $Ar_1$ to $Ar_3$ may be a group represented by Formula 2. It may be understood that the substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms and the substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms are different from the group represented by Formula 2.

[Formula 2]




**[0043]** In Formula 2, $X_1$ may be, e.g., O or S. "n" may be, e.g., an integer of 1 to 3, "a" to "c" may each independently be, e.g., an integer of 0 to 4, and "d" may be, e.g., an integer of 0 to 2. $R_2$ to $R_5$ may each independently be, e.g., a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. In an implementation, $R_2$ to $R_5$ may each independently be, e.g., a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. In an implementation, when n of Formula 2 is 1, the compound represented by Formula 1 may include another carbazole moiety thereon.

**[0044]** In the description,  means a part to be connected or a bonding location (e.g., at a location of $Ar_1$ to $Ar_3$ of Formula 1).

**[0045]** In the description, "substituted or unsubstituted" may mean substituted with at least one substituent selected from a deuterium atom, a halogen atom, a cyano group, a nitro group, an amino group, a silyl group, a boron group, a phosphine group, an alkyl group, an alkenyl group, an aryl group, and a heterocycle, or unsubstituted. In addition, each of the substituent illustrated above may be substituted or unsubstituted. For example, a biphenyl group may be interpreted as an aryl group, or a phenyl group substituted with a phenyl group.

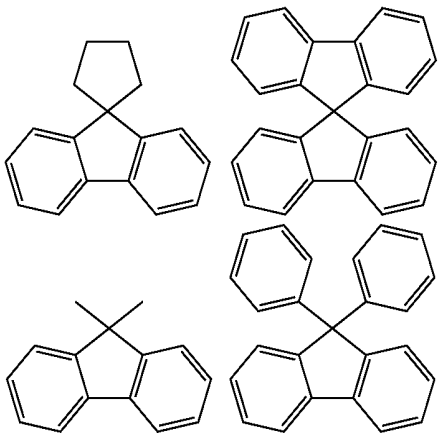
**[0046]** In the description, the halogen atom may include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

**[0047]** In the description, the alkyl may be a linear, branched or cyclic type. The carbon number of the alkyl may be from 1 to 30, from 1 to 20, 1 to 10, or from 1 to 4. The alkyl may include methyl, ethyl, n-propyl, isopropyl, n-butyl, s-butyl, t-butyl, i-butyl, 2-ethylbutyl, 3,3-dimethylbutyl, n-pentyl, i-pentyl, neopentyl, t-pentyl, cyclopentyl, I-methylpentyl, 3-methylpentyl, 2-ethylpentyl, 4-methyl-2-pentyl, n-hexyl, 1-methylhexyl, 2-ethylhexyl, 2-butylhexyl, cyclohexyl, 4-methylcyclohexyl, 4-t-butylcyclohexyl, n-heptyl, 1-methylheptyl, 2,2-dimethylheptyl, 2-ethylheptyl, 2-butylheptyl, n-octyl, t-octyl, 2-ethyloctyl, 2-butyloctyl, 2-hexyloctyl, 3,7-dimethyloctyl, cyclooctyl, n-nonyl, n-decyl, adamantyl, 2-ethyldecyl, 2-butyldecyl, 2-hexyldecyl, 2-octyldecyl, n-undecyl, n-dodecyl, 2-ethyldodecyl, 2-butyldodecyl, 2-hexyldocecyl, 2-octyldodecyl, n-tridecyl, n-tetradecyl, c-pentadecyl, n-hexadecyl, 2-ethylhexadecyl,

2-butylhexadecyl, 2-hexylhexadecyl, 2-octylhexadecyl, n-heptadecyl, n-octadecyl, n-nonadecyl, n-eicosyl, 2-ethyleicosyl, 2-butyleicosyl, 2-hexyleicosyl, 2-octyleicosyl, n-henicosyl, n-docosyl, n-tricosyl, n-tetracosyl, n-pentacosyl, n-hexacosyl, n-heptacosyl, n-octacosyl, n-nonacosyl, n-triacontyl, etc.

**[0048]** In the description, the aryl group means an optional functional group or substituent derived from an aromatic hydrocarbon ring. The aryl group may be a monocyclic aryl group or a heterocyclic aryl group. The carbon number for forming a ring in the aryl group may be, 6 to 30, 6 to 20, or 6 to 15. Examples of the aryl group may include phenyl, naphthyl, fluorenyl, anthracenyl, phenanthryl, biphenyl, terphenyl, quaterphenyl, quinqphenyl, sexiphenyl, biphenylene, triphenylene, pyrenyl, benzofluoranthenyl, chrysenyl, etc.

**[0049]** In the description, the fluorenyl group may be substituted, and two substituents may be combined with each other to form a spiro structure. If the fluorenyl group is substituted, examples are shown below.



**[0050]** In the description, the heteroaryl group may be a heteroaryl group including at least one of O, N, P, Si or S as a heteroatom. If the heteroaryl group includes two heteroatoms, two heteroatoms may be the same or different. The carbon number for forming a ring of the heteroaryl group may be 2 to 30 or 2 to 20. The heteroaryl group may be a monocyclic heteroaryl group or a polycyclic heteroaryl group. The polycyclic heteroaryl group may have, for example, a two-ring or a three-ring structure. Examples of the heteroaryl group may include thiophene, furan, pyrrole, imidazole, thiazole, oxazole, oxadiazole, triazole, pyridine, bipyridine, pyrimidine, triazine, triazole, acridyl, pyridazine, pyrazinyl, quinoline, quinazoline, quinoxaline, phenoxazine, phthalazine, pyrido pyrimidine, pyrido pyrazine, pyrazino pyrazine, isoquinoline, indole, carbazole, N-arylcarbazole, N-heteroarylcarbazole, N-alkylcarbazole, benzoxazole, benzoimidazole, benzothiazole, benzocarbazole, benzothiophene, dibenzothiophene, thienothiophene, benzofuran, phenanthroline, thiazole, isooxazole, oxadiazole, thiadiazole, phenothiazine, dibenzosilole, dibenzofuran, etc.

**[0051]** In the description, the silyl group includes an alkyl silyl group and an aryl silyl group. Examples of the silyl group may include trimethylsilyl, triethylsilyl, t-butyldimethylsilyl, vinyldimethylsilyl, propyldimethylsilyl, triphenylsilyl, diphenylsilyl, phenylsilyl, etc.

**[0052]** In the description, the boron group includes an alkyl boron group and an aryl boron group. Examples of the boron group may include trimethylboron, triethylboron, t-butyldimethylboron, triphenylboron, diphenylboron, phenylboron, etc.

**[0053]** In the description, the alkenyl group may be a linear chain or a branched chain. The carbon number is not specifically limited, but may be from 2 to 30, 2 to 20, or 2 to 10. Examples of the alkenyl group may include vinyl, I-butenyl, 1-pentenyl, 1,3-butadienyl aryl, styrenyl, styrylvinyl, etc.

**[0054]** In the description, the carbon number of the amino group is not specifically limited, but may be 1 to 30. The amino group may include an alkyl amino group and an aryl amino group. Examples of the amino group include a methylamino group, a dimethylamino group, a phenylamino group, a diphenylamino group, a naphthylamino group, a 9-methyl-anthracenylamino group, a triphenylamino group, etc.

**[0055]** In an implementation, $R_1$ may be, e.g., a hydrogen atom. For example, $Z_1$ to $Z_3$ may be each independently CH or N.

**[0056]** In an implementation, each (e.g., all) of $Z_1$ to $Z_3$ may be N.

**[0057]** In an implementation, at least one among $Ar_1$ to $Ar_3$ that is not represented by Formula 2 may be, e.g., a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms. In an implementation, at least one among $Ar_1$ to $Ar_3$ that is not represented by Formula 2 may be, e.g., 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 anthracene group, or a substituted or unsubstituted phenanthrene group.

**[0058]** In an implementation, if only one of $Ar_1$ to $Ar_3$ is represented by Formula 2, "n" of Formula 2 is 2 or 3.

**[0059]** In an implementation, at least one of the carbazole moieties in Formula 2 may be bonded in the ortho relationship with respect to the nitrogen-containing monocycle of Formula 1.

**[0060]** In an implementation, $X_1$ may be O. In an implementation, $X_1$ may be S.

**[0061]** If "a" is 2, 3, or 4, the 2, 3, or 4 $R_2$ groups may be the same or different, if "b" is 2, 3, or 4, the 2, 3, or 4 $R_3$ groups may be the same or different, if "c" is 2, 3, or 4, the 2, 3, or 4 $R_4$ groups may be the same or different, and if "d" is 2, the 2 $R_5$ groups may be the same or different.

**[0062]** In an implementation, if "a" is 1, $R_2$ may not be a hydrogen atom, if "b" is 1, $R_3$ may not be a hydrogen atom, if "c" is 1, $R_4$ may not be a hydrogen atom, and/or if "d" is 1, $R_5$ may not be a hydrogen atom.

**[0063]** In an implementation, if "a" is 1, 2, 3, or 4, $R_2$ may be, e.g., a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 5 carbon atoms, a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted naphthyl group, or a substituted or unsubstituted heteroaryl group having 2 to 15 ring carbon atoms.

**[0064]** In an implementation, if "b" is 1, 2, 3, or 4, $R_3$ may be a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 5 carbon atoms, a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted

naphthyl group, or a substituted or unsubstituted heteroaryl group having 2 to 15 ring carbon atoms.

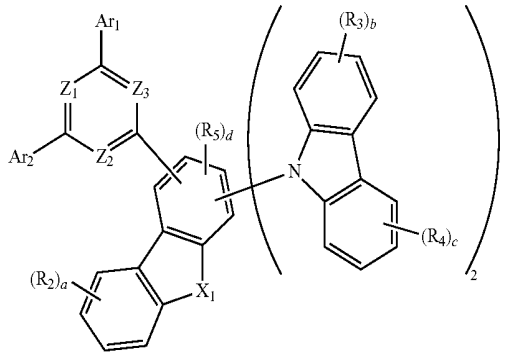
**[0065]** In an implementation, if "c" is 1, 2, 3, or 4, $R_4$ may be a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 5 carbon atoms, a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted naphthyl group, or a substituted or unsubstituted heteroaryl group having 2 to 15 ring carbon atoms.

**[0066]** In an implementation, if "d" is 1 or 2, $R_5$ may be a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 5 carbon atoms, a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted naphthyl group, or a substituted or unsubstituted heteroaryl group having 2 to 15 ring carbon atoms.

**[0067]** In an implementation, each (e.g., all) of "a" to "d" may be 0.

**[0068]** In an implementation, the compound represented by Formula 1 may be represented by the following Formula 1-1.

[Formula 1-1]



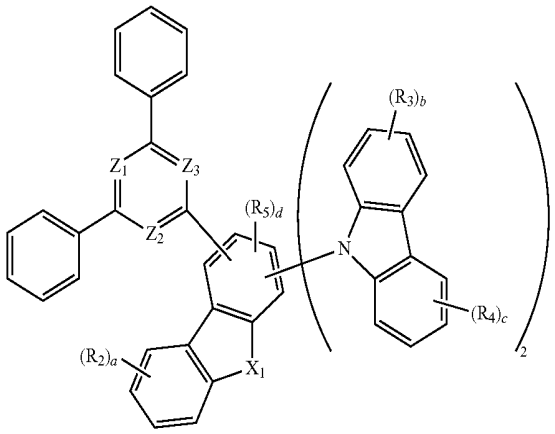
**[0069]** In Formula 1-1, $Z_1$ to $Z_3$, $Ar_1$, $Ar_2$, $R_2$ to $R_5$, "a" to "d" and $X_1$ may be defined the same as those of Formulae 1 and 2. In an implementation, "d" may be 0 or 1.

**[0070]** In an implementation, in Formula 1-1, $Ar_1$ and $Ar_2$ may each independently be, e.g., a substituted or unsubstituted aryl group having 6 to 18 ring carbon atoms or a substituted or unsubstituted heteroaryl group having 2 to 15 ring carbon atoms. For example, $Ar_1$ and $Ar_2$ may be each independently 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 anthracene group, a substituted or unsubstituted phenanthrene group, a substituted or unsubstituted dibenzofuran group, or a substituted or unsubstituted dibenzothiophene group.

**[0071]** At least one of the two carbazole moieties of Formula 1-1 may be bonded in an ortho relationship with respect to the nitrogen-containing monocycle (e.g., including $Z_1$ to $Z_3$).

**[0072]** In an implementation, the compound represented by Formula 1 may be represented by the following Formula 1-2.

[Formula 1-2]



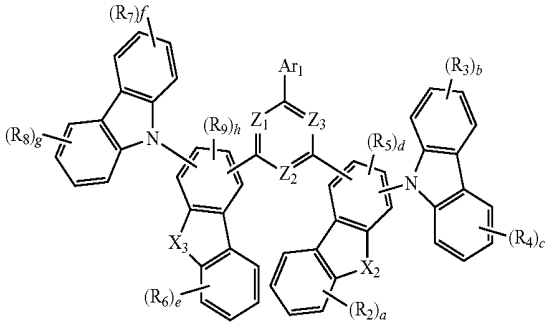
**[0073]** In Formula 1-2, $Z_1$ to $Z_3$, $R_2$ to $R_5$, "a" to "d" and $X_1$ may be defined the same as those of Formulae 1 and 2. In an implementation, "d" may be 0 or 1.

**[0074]** In an implementation, in Formula 1-2, each of "a" to "d" may be 0.

**[0075]** At least one of two carbazole moieties in Formula 1-2 may be bonded in an ortho relationship with respect to the nitrogen-containing monocycle (e.g., including $Z_1$ to $Z_3$).

**[0076]** In an implementation, the compound represented by Formula 1 may be represented by the following Formula 1-3.

[Formula 1-3]



**[0077]** In Formula 1-3, $X_2$ and $X_3$ may each independently be, e.g., O or S. $R_2$ to $R_9$ may each independently be, a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. "a" to "c" and "e" to "g" may each independently be, e.g., an integer of 0 to 4, "d" and "h" may each independently be, e.g., an integer of 0 to 2. $Z_1$ to $Z_3$, and $Ar_1$ may be defined the same as those of Formula 1.

**[0078]** In an implementation, in Formula 1-3, $X_2$ and $X_3$ may be the same.

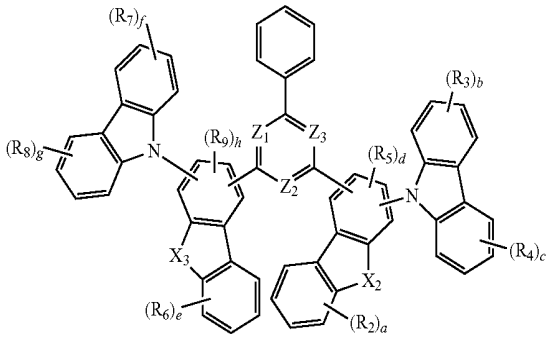
**[0079]** In an implementation, in Formula 1-3, $Ar_1$ may be, e.g., a substituted or unsubstituted aryl group having 6 to 18 ring carbon atoms. In an implementation, $Ar_1$ may be, e.g.,

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 anthracene group, or a substituted or unsubstituted phenanthrene group.

**[0080]** At least one of two carbazole moieties in Formula 1-3 may be bonded in an ortho relationship with respect to the nitrogen-containing monocycle (e.g., including $Z_1$ to $Z_3$).

**[0081]** In an implementation, the compound represented by Formula 1-3 may be represented by the following Formula 1-4.

[Formula 1-4]



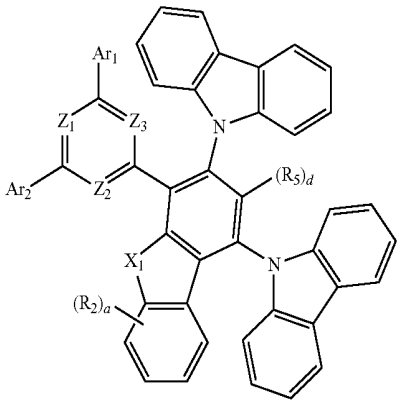
**[0082]** In Formula 1-4, $X_2$ and $X_3$ may each independently be, e.g., O or S. $R_2$ to $R_9$ may each independently be, e.g., a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, "a" to "c" and "e" to "g" may each independently be, e.g., an integer of 0 to 4, "d" and "h" may each independently be, e.g., an integer of 0 to 2. $Z_1$ to $Z_3$ may be defined the same as those Formula 1.

**[0083]** In an implementation, in Formula 1-4, $X_2$ and $X_3$ may be the same.

**[0084]** At least one of two carbazole moieties in Formula 1-4 is substituted in ortho relationship with respect to a ring including $Z_1$ to $Z_3$.

**[0085]** In an implementation, the compound represented by Formula 1 may be represented by the following Formula 1-5 or Formula 1-6.

[Formula 1-5]



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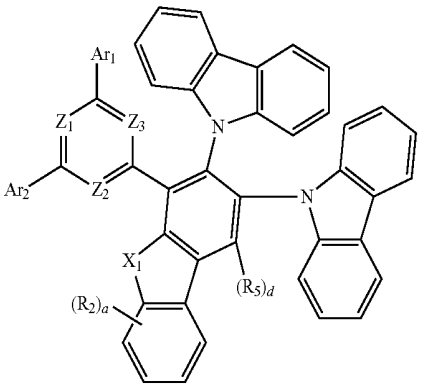
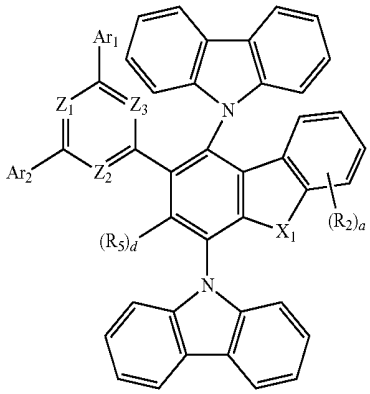
[Formula 1-6]



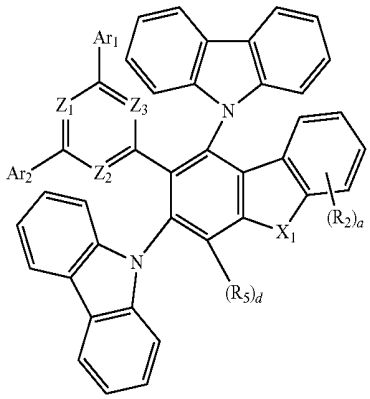
**[0086]** In Formulae 1-5 and 1-6, $Z_1$ to $Z_3$, $Ar_1$, $Ar_2$, $R_2$, $R_5$, "a", "d" and $X_1$ may be defined the same as those of Formulae 1 and 2. In an implementation, "d" may be 0 or 1.

**[0087]** In an implementation, the compound represented by Formula 1 may be represented by one of the following Formulae 1-7 to 1-9.

[Formula 1-7]



[Formula 1-8]



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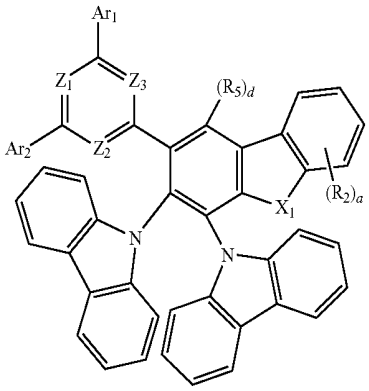
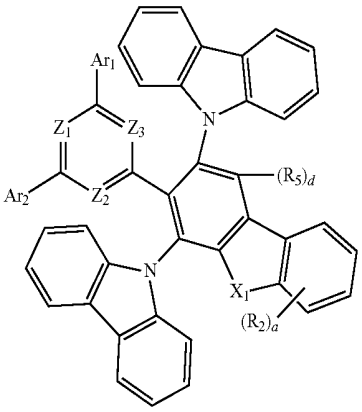
[Formula 1-9]



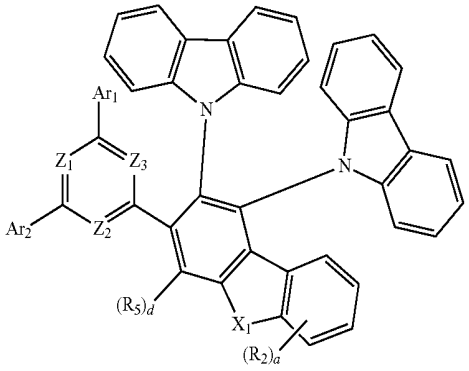
**[0088]** In Formulae 1-7 to 1-9, $Z_1$ to $Z_3$, Art, $Ar_2$, $R_2$, $R_5$, "a", "d" and $X_1$ may be defined the same as those of Formulae 1 and 2.

**[0089]** In an implementation, the compound represented by Formula 1 may be represented by one of the following Formulae 1-10 to 1-12.

[Formula 1-10]



[Formula 1-11]



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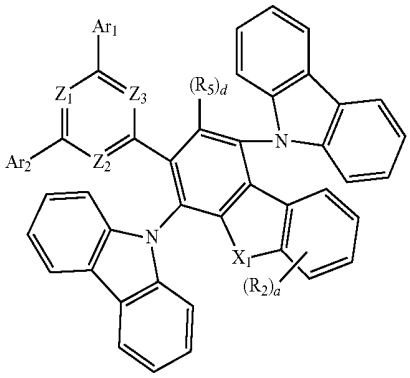
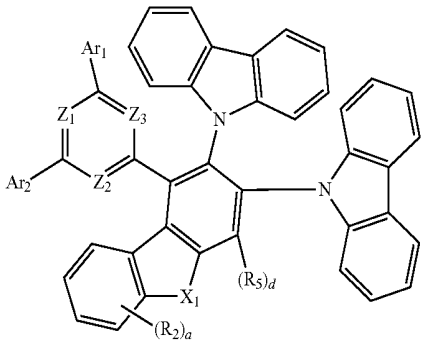
[Formula 1-12]



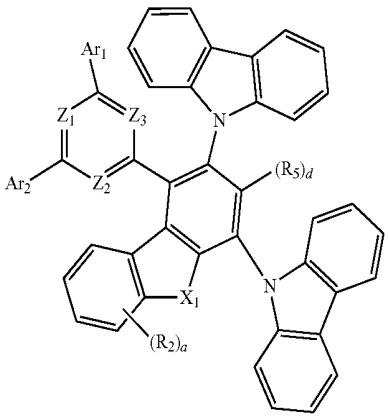
**[0090]** In Formulae 1-10 to 1-12, $Z_1$ to $Z_3$, $Ar_1$, $Ar_2$, $R_2$, $R_5$, "a", "d" and $X_1$ may be defined the same as those of Formulae 1 and 2.

**[0091]** In an implementation, the compound represented by Formula 1 may be represented by the following Formula 1-13 or Formula 1-14.

[Formula 1-13]



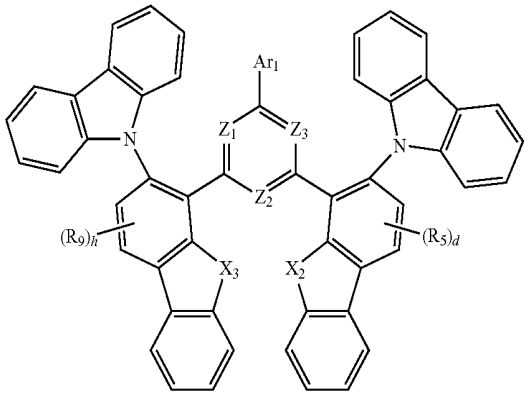
[Formula 1-14]



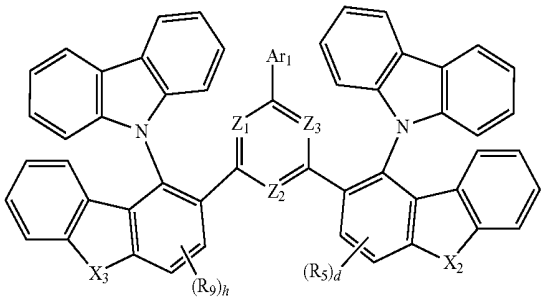
**[0092]** In Formulae 1-13 and 1-14, $Z_1$ to $Z_3$, $Ar_1$, $Ar_2$, $R_2$, $R_5$, "a", "d" and $X_1$ may be defined the same as those of Formulae 1 and 2.

**[0093]** In an implementation, the compound represented by Formula 1 may be represented by one of the following Formulae 1-15 to 1-17.

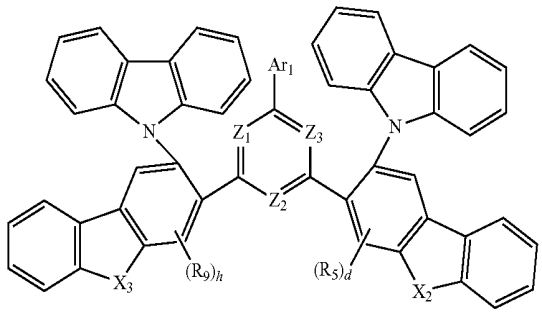
[Formula 1-15]



[Formula 1-16]



[Formula 1-17]

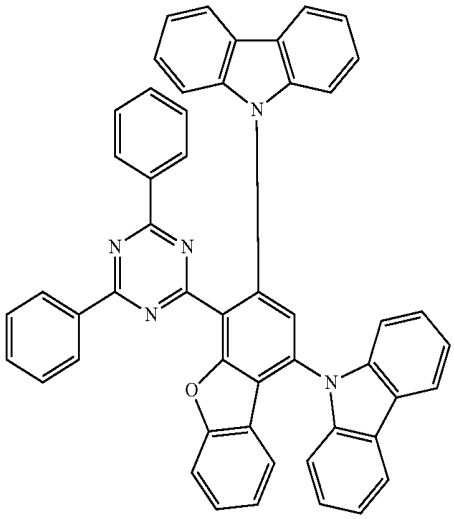


**[0094]** In Formulae 1-15 to 1-17, $Z_1$ to $Z_3$, An, $Ar_2$, $R_2$, $R_5$, "a", and "d" may be defined the same as those of Formula 1, and $X_2$ and $X_3$ may be O or S.

**[0095]** In an implementation, the heterocyclic compound may be, e.g., a compound of the following Compound Group 1.

[Compound Group 1]

1



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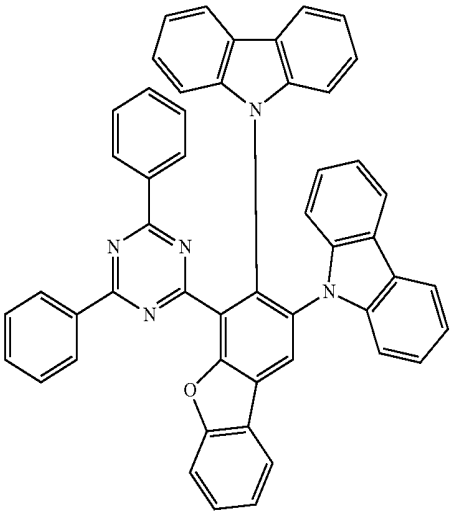

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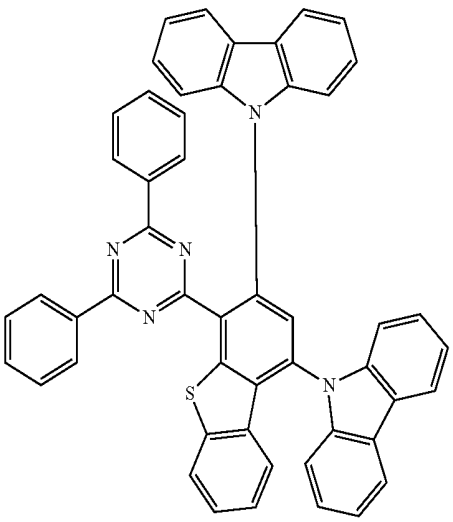

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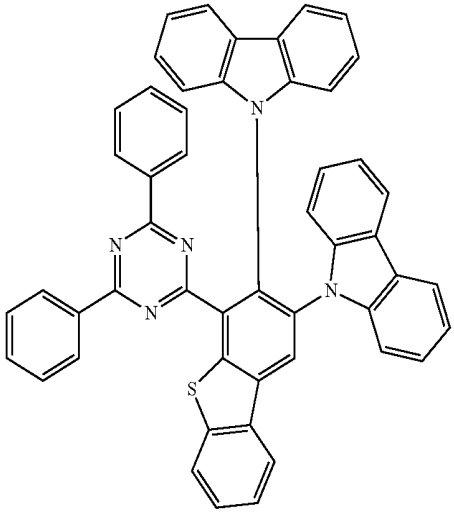

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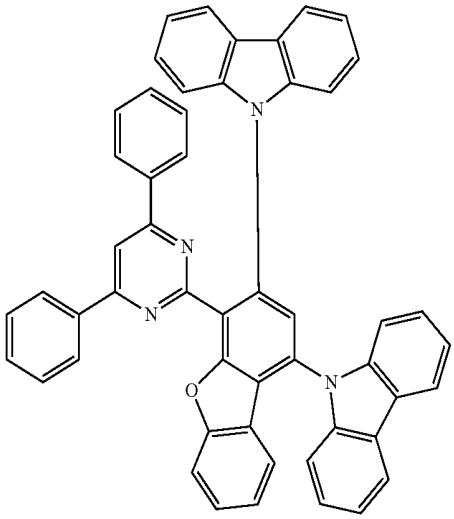

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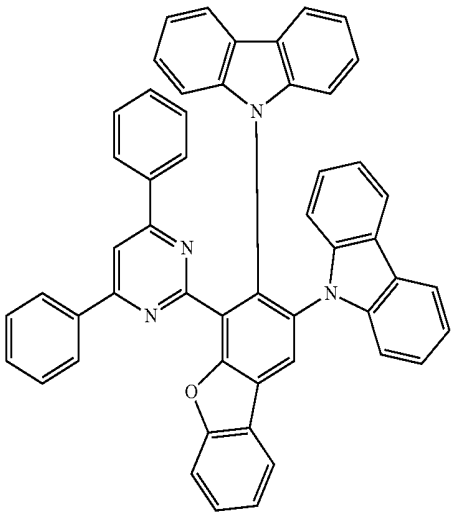

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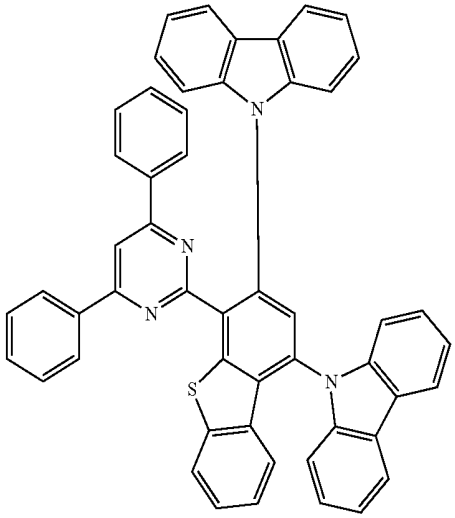

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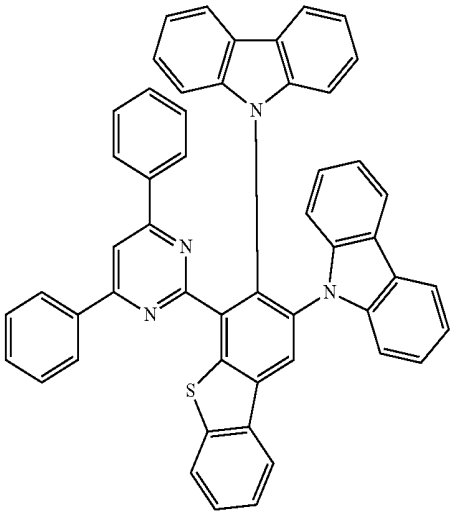

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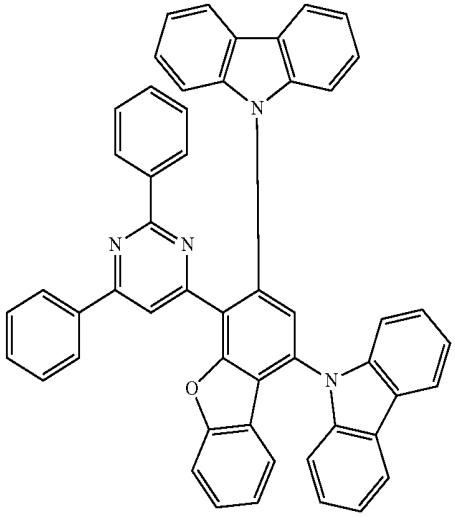

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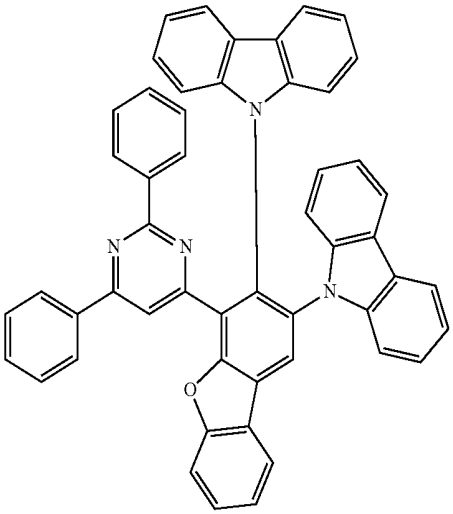

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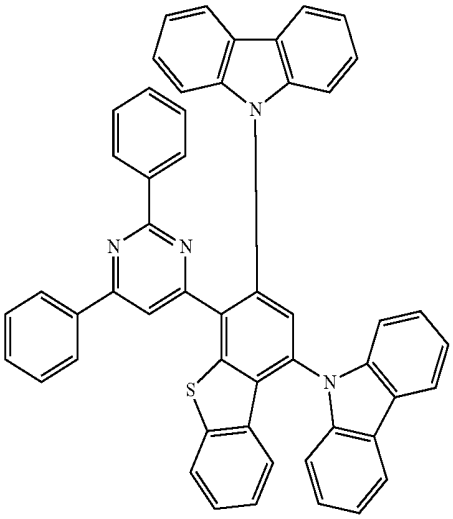

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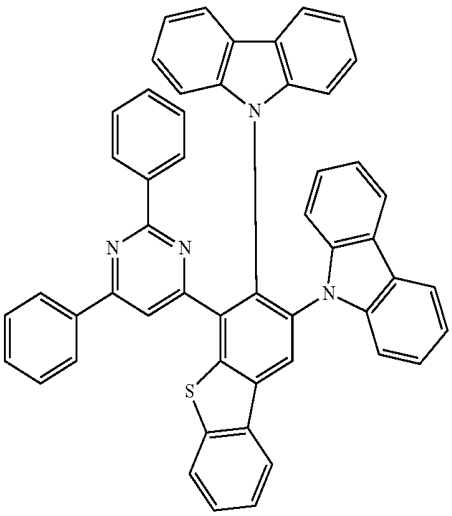

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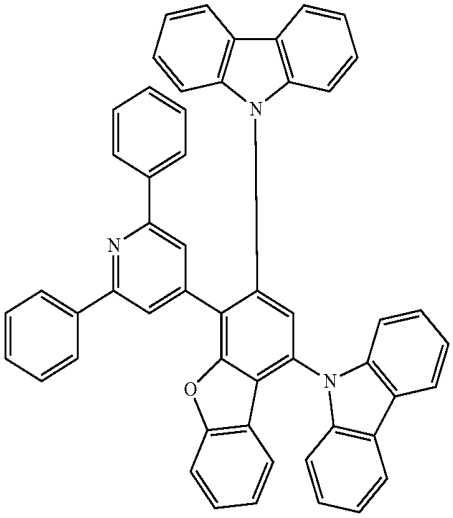

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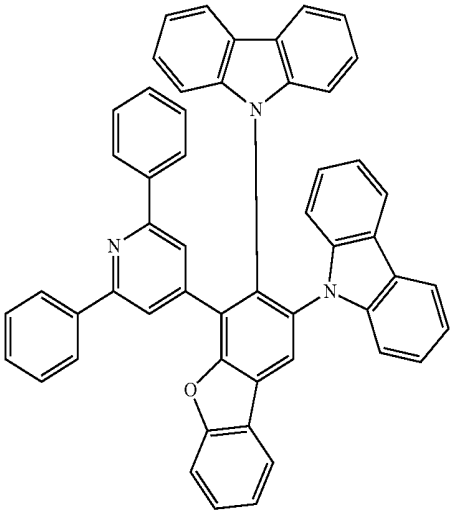

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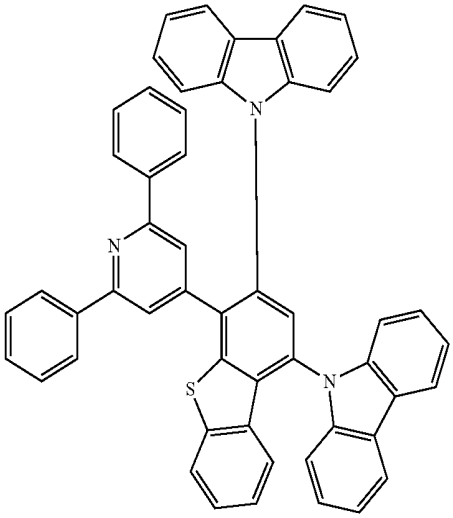

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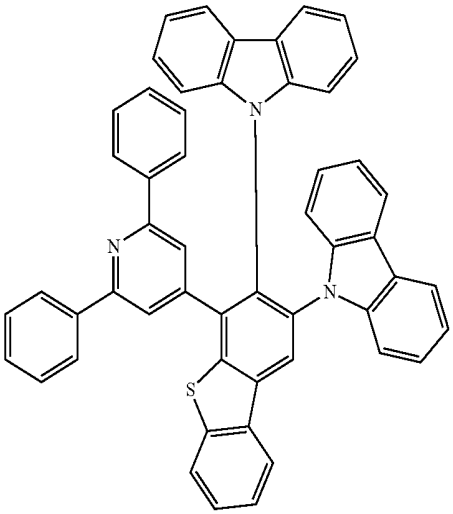

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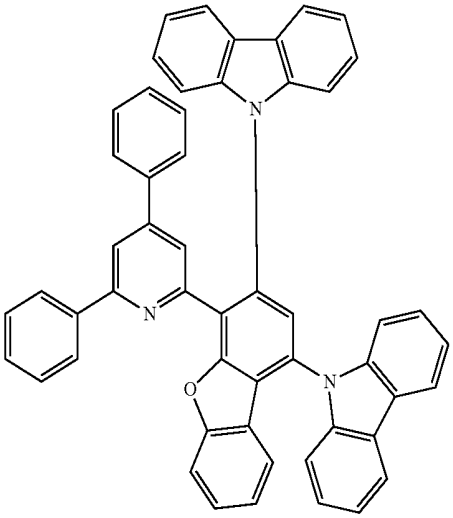

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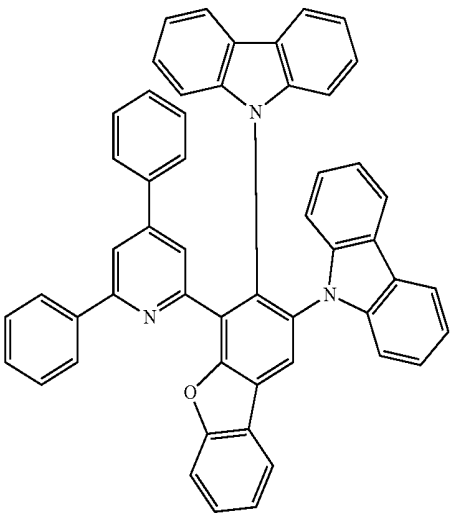

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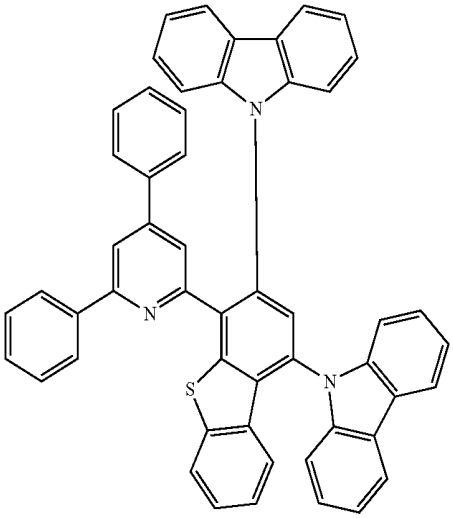

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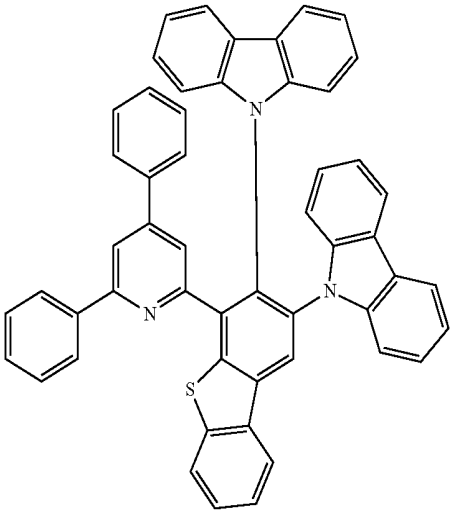

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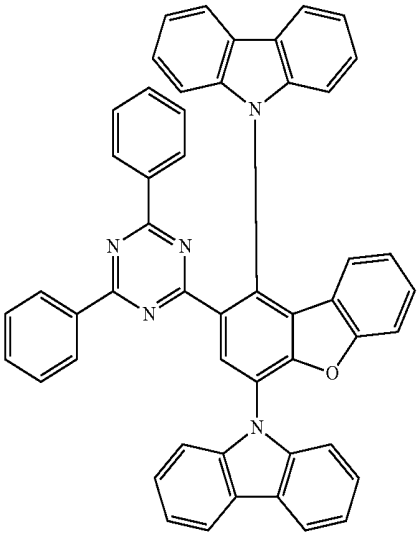

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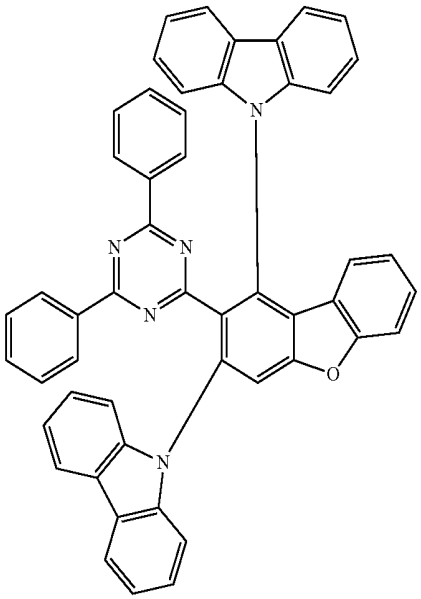

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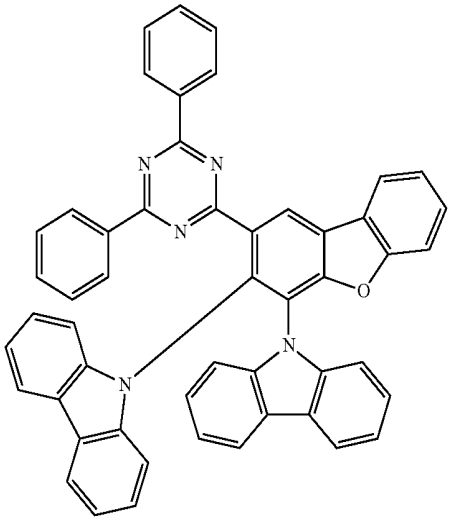

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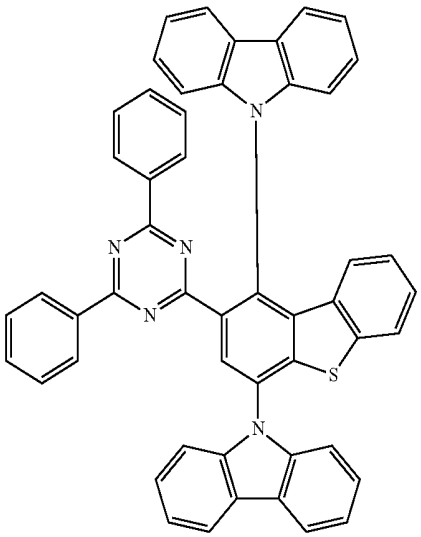

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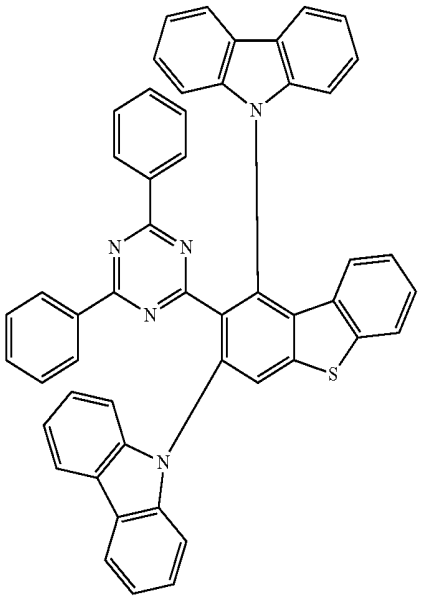

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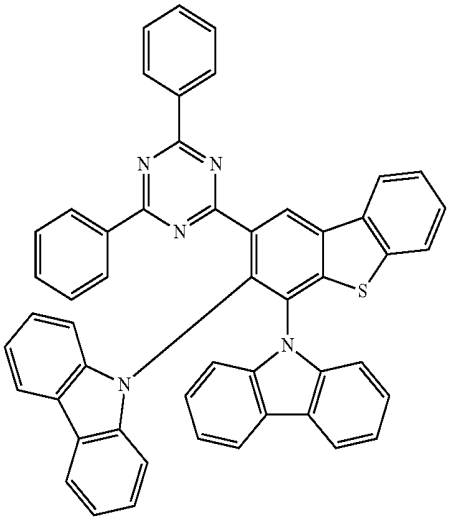

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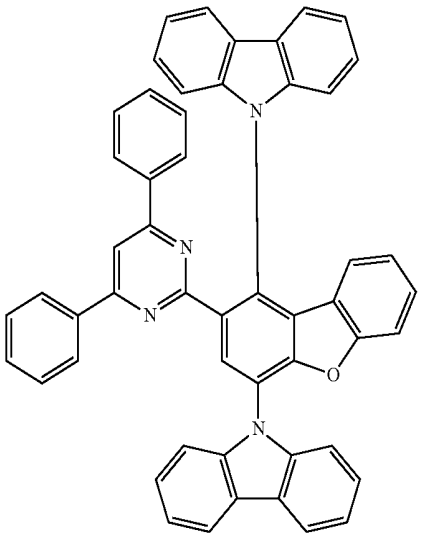

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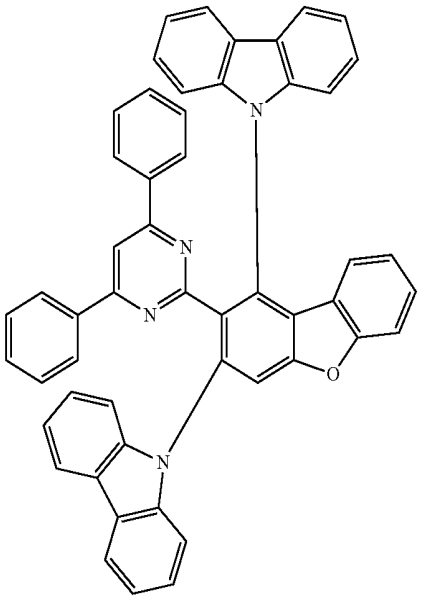

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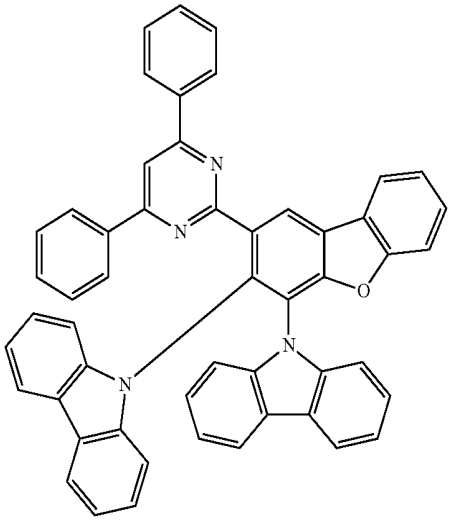

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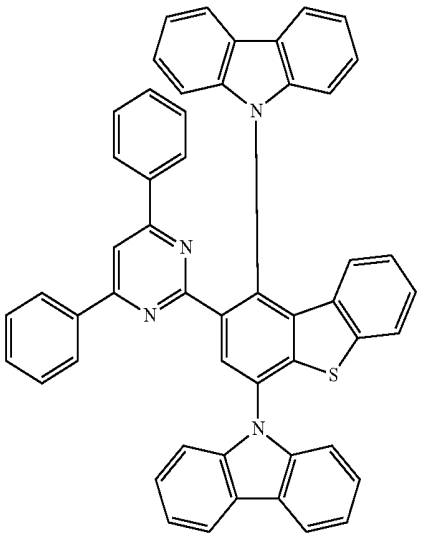

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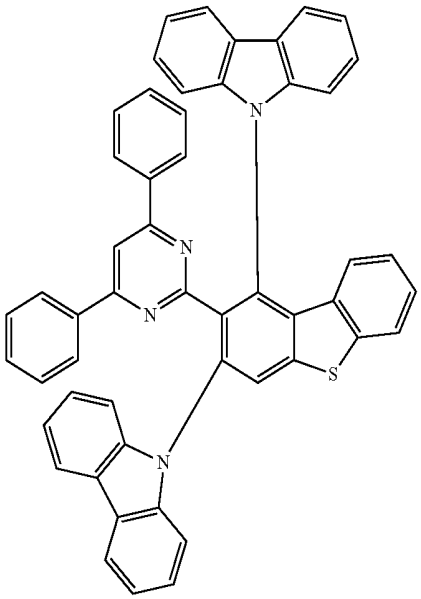

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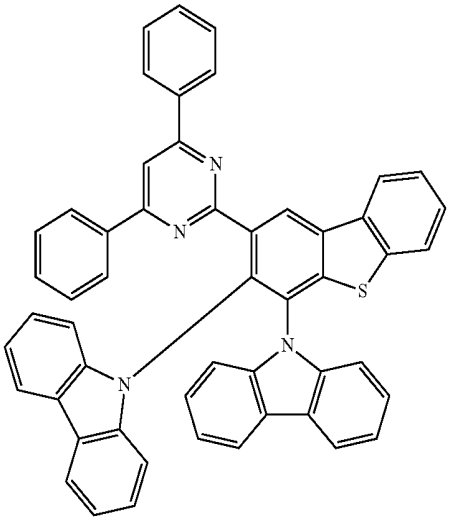

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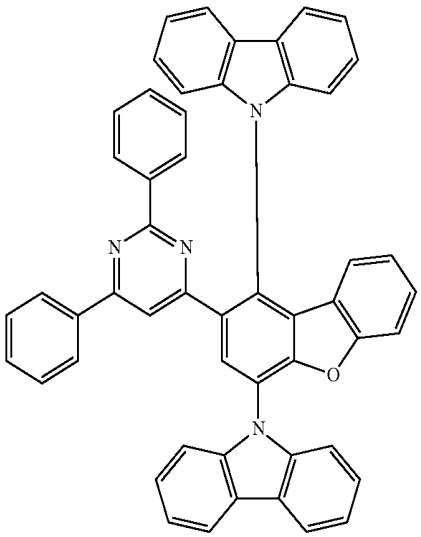

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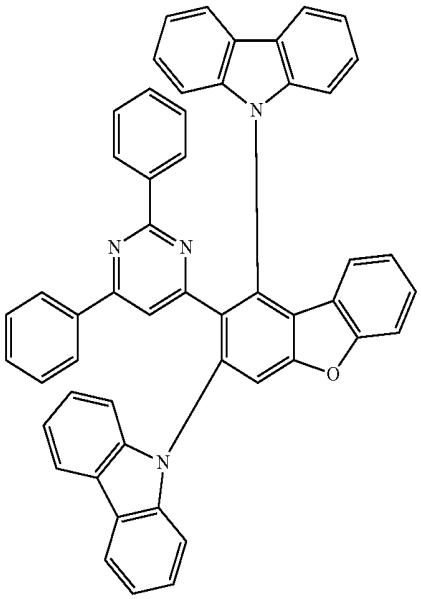

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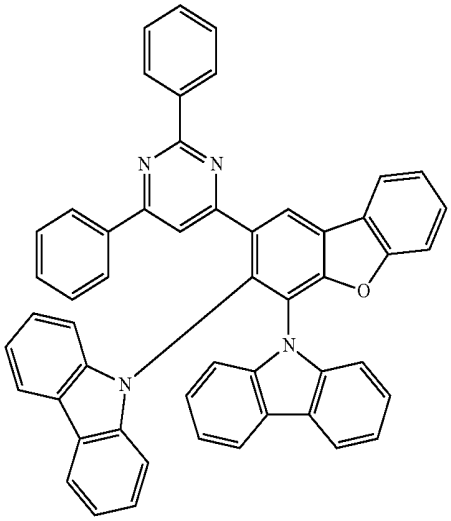

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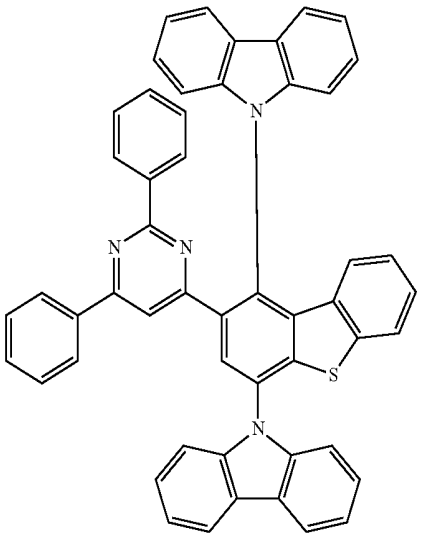

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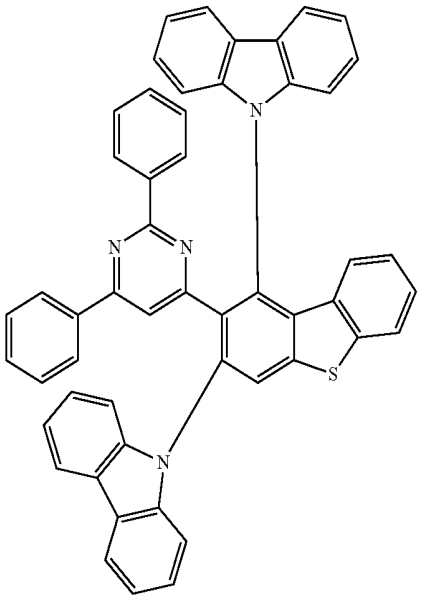

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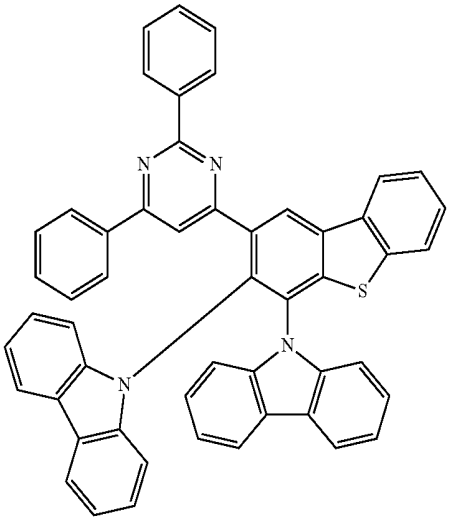

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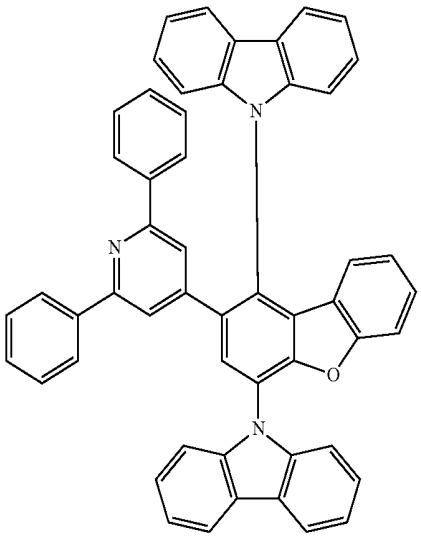

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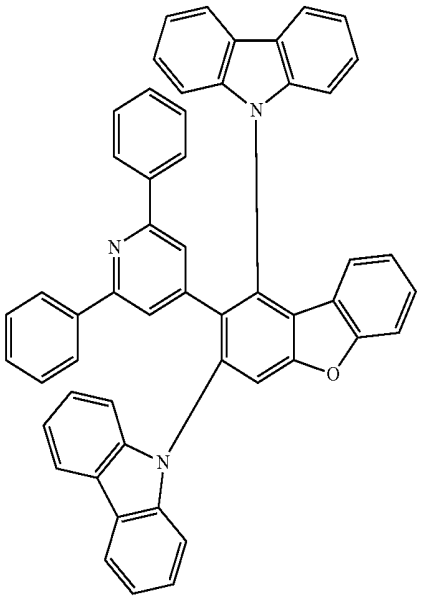

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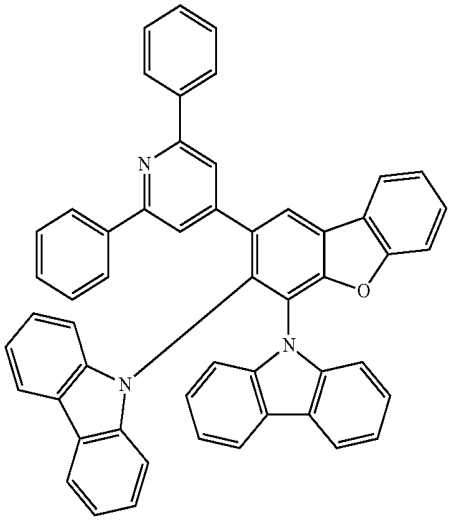

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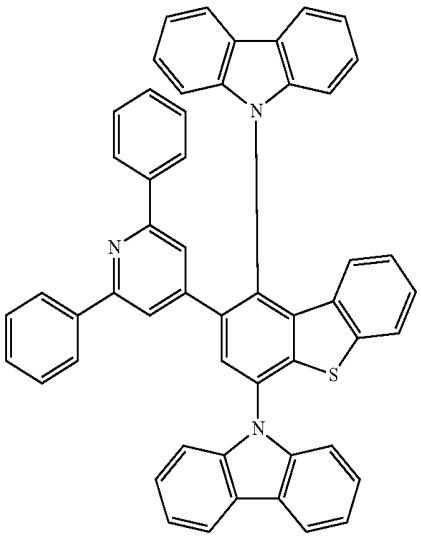

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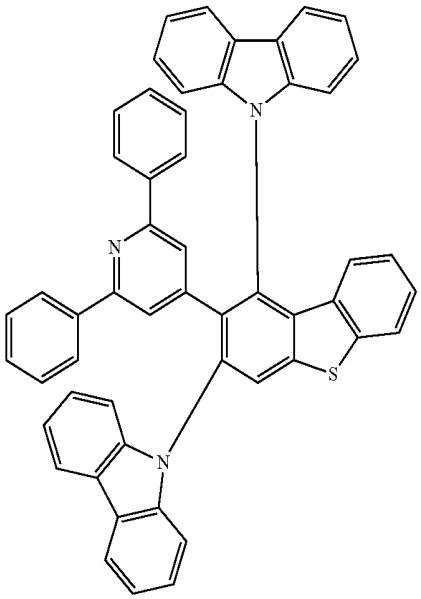

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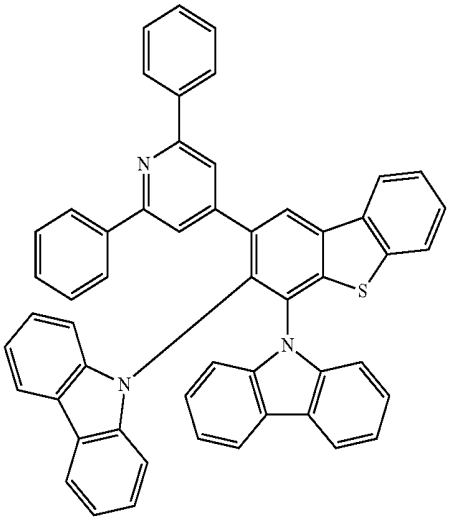

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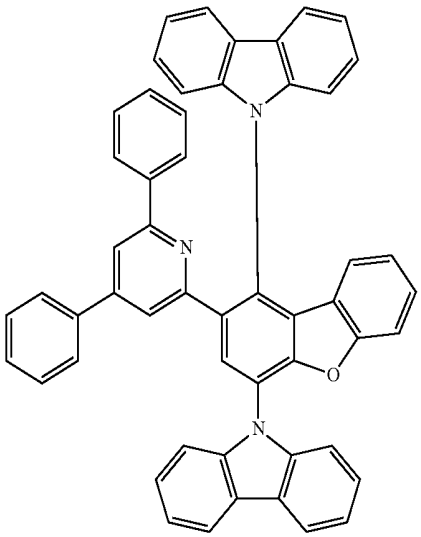

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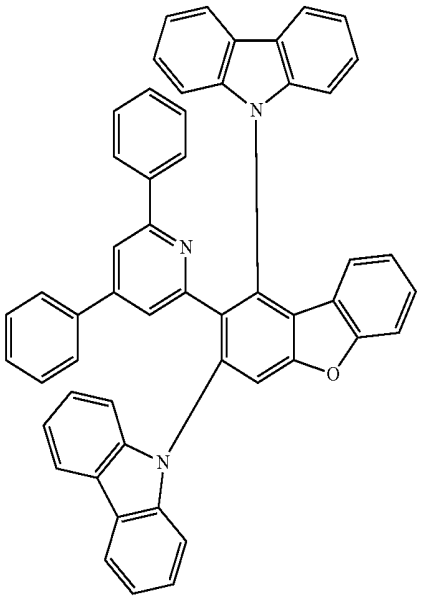

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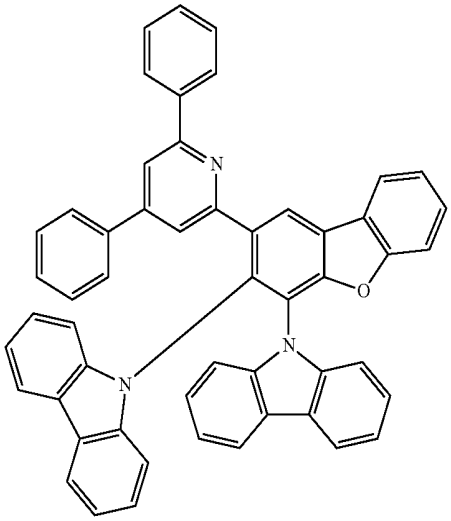

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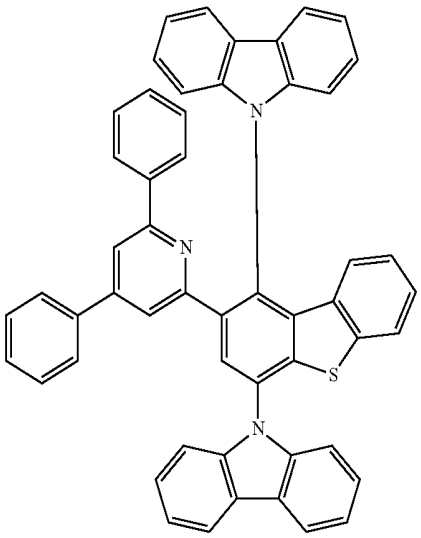

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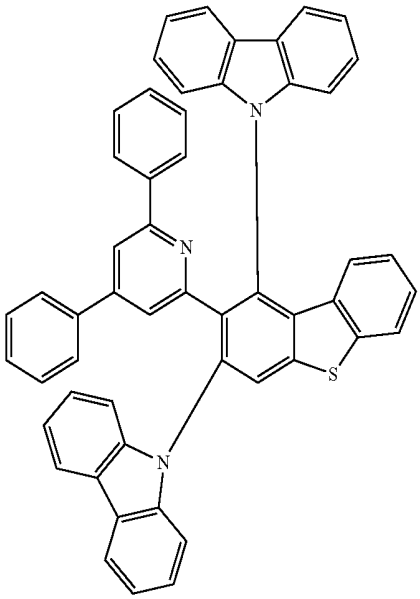

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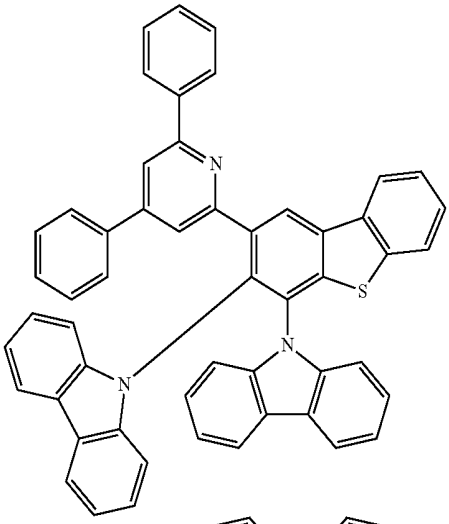

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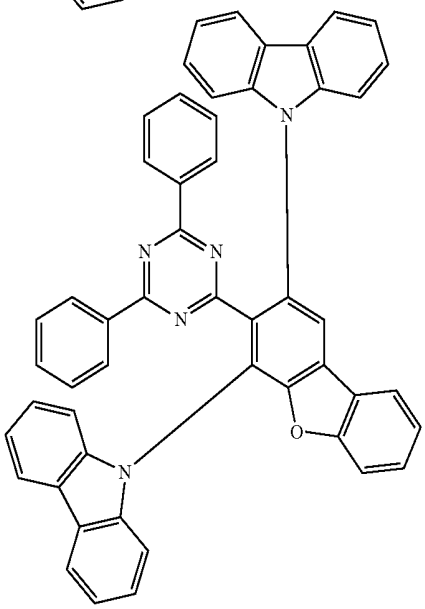

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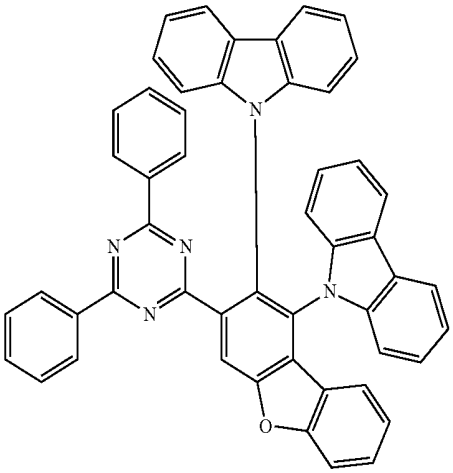

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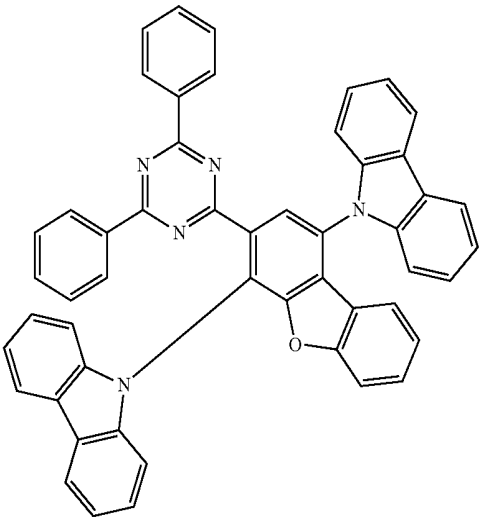

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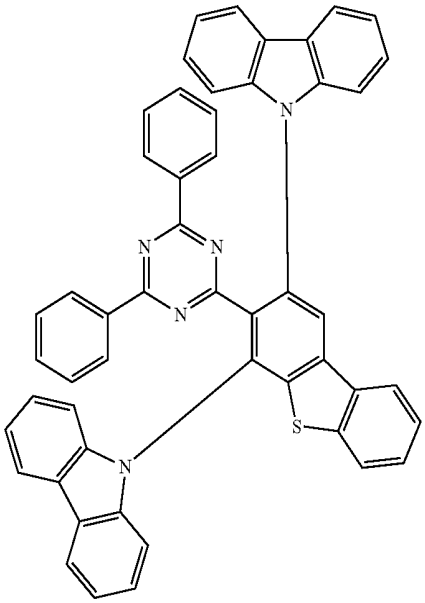

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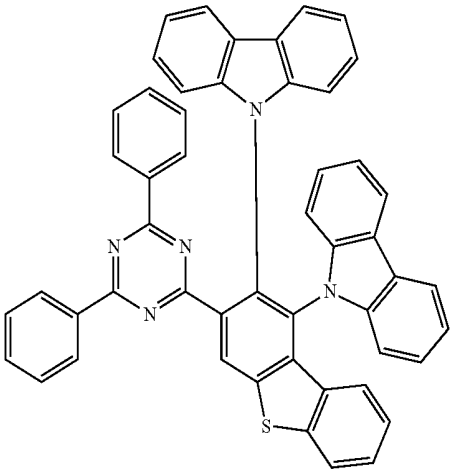

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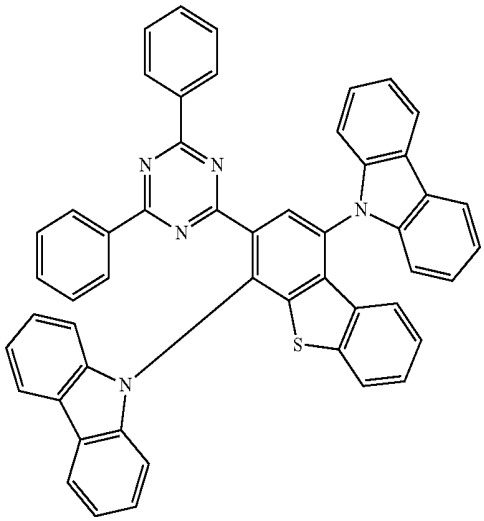

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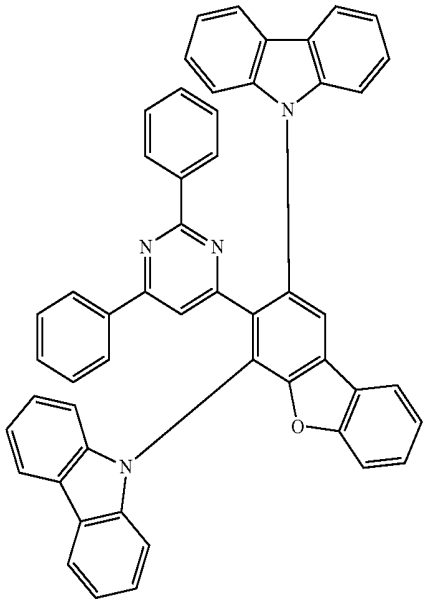

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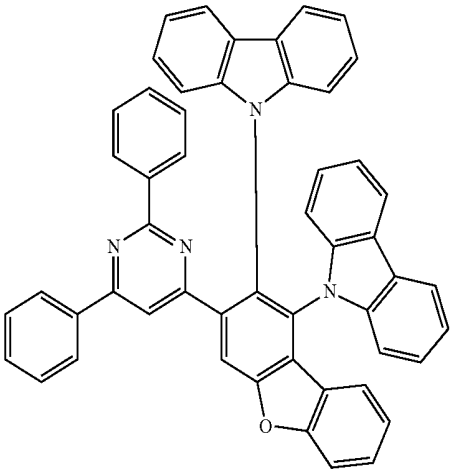

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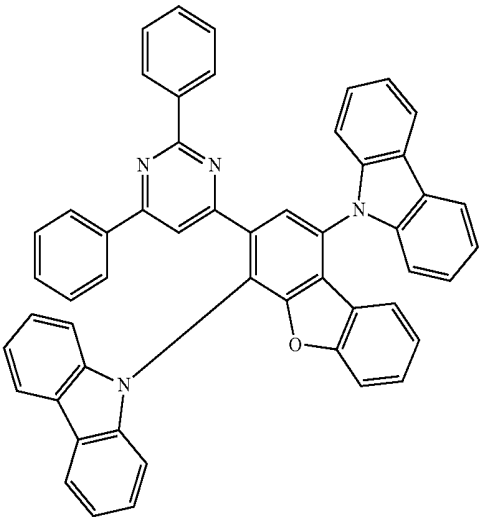

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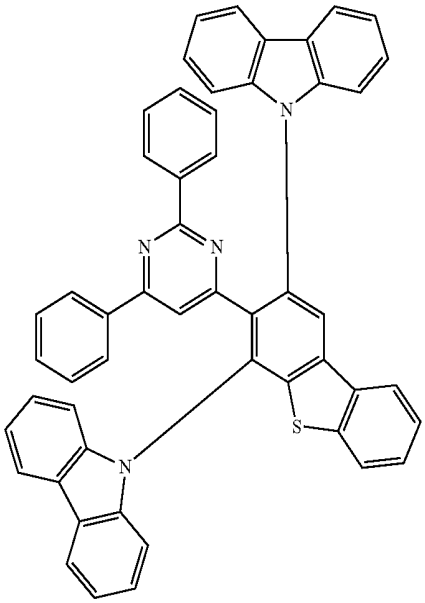

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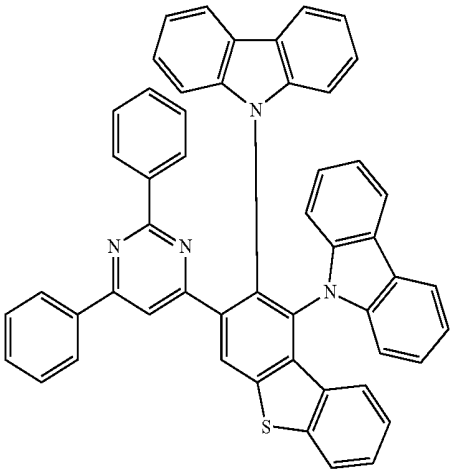

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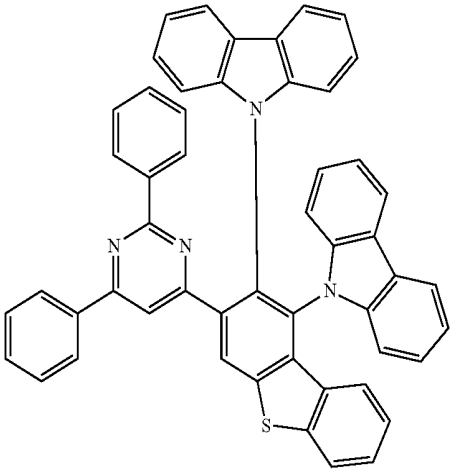

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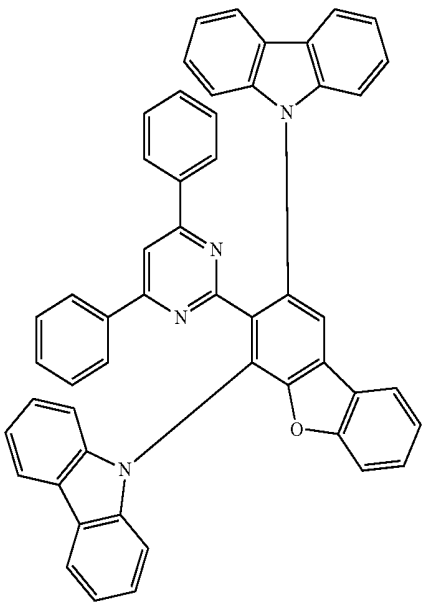

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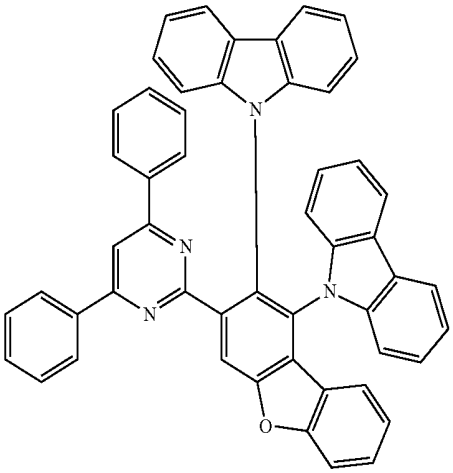

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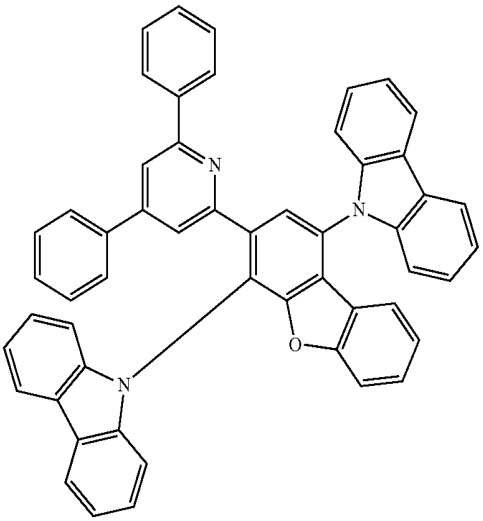

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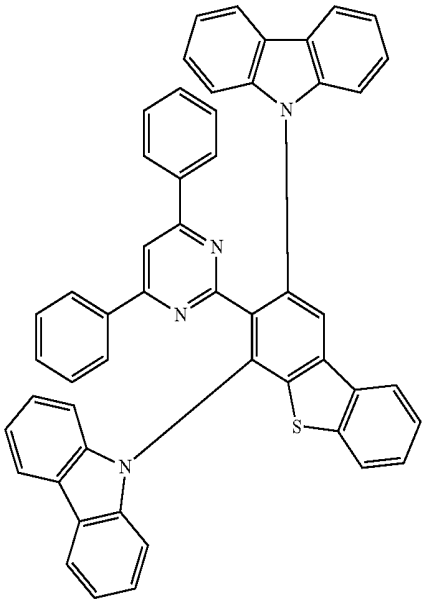

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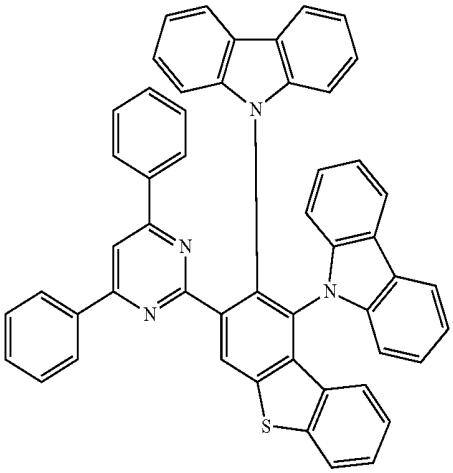

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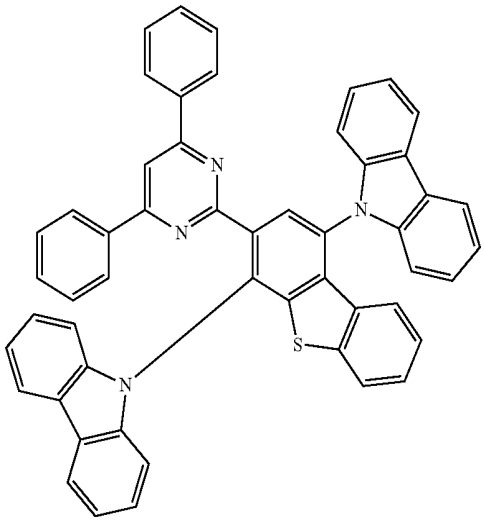

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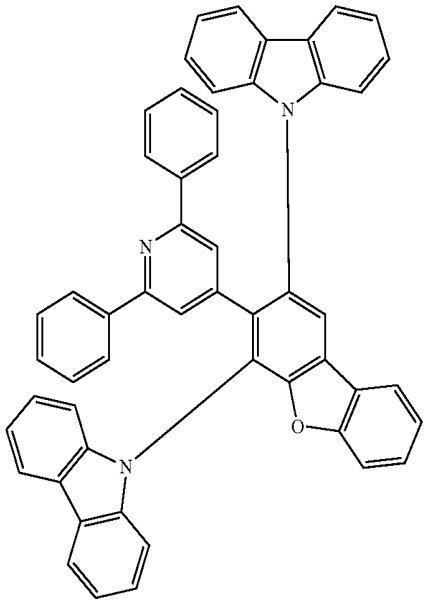

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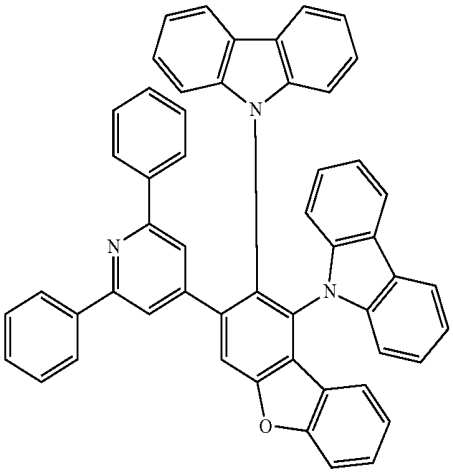

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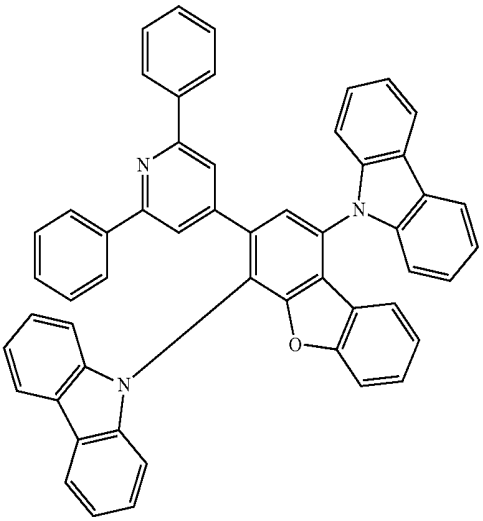

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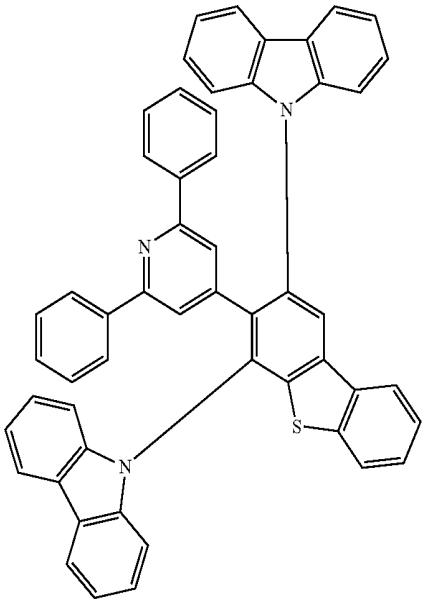

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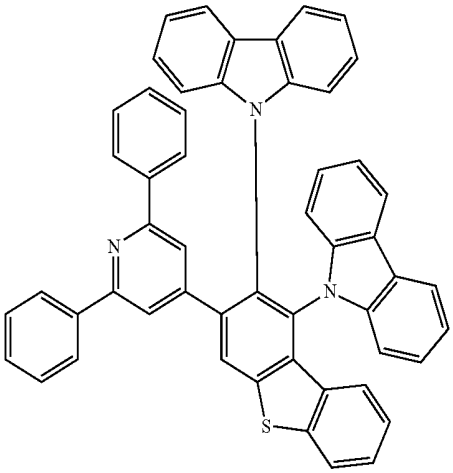

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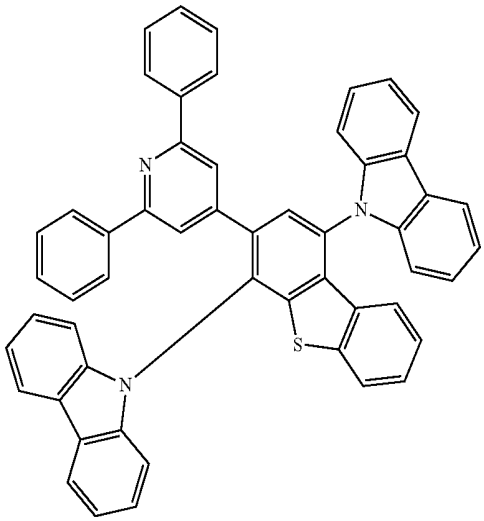

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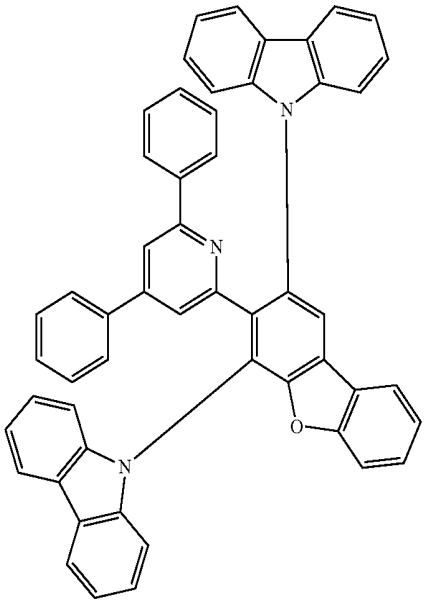

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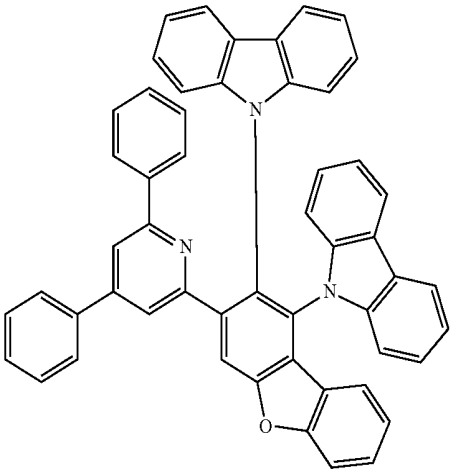

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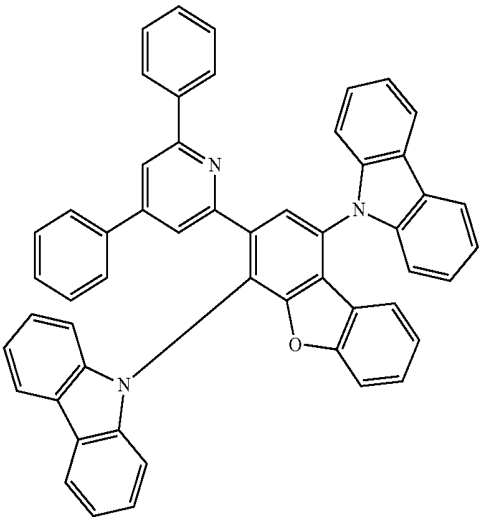

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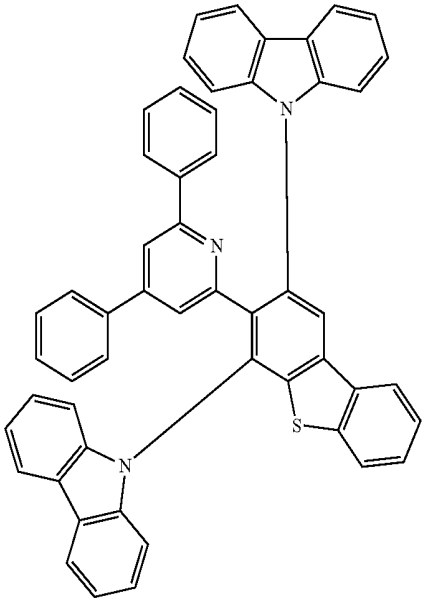

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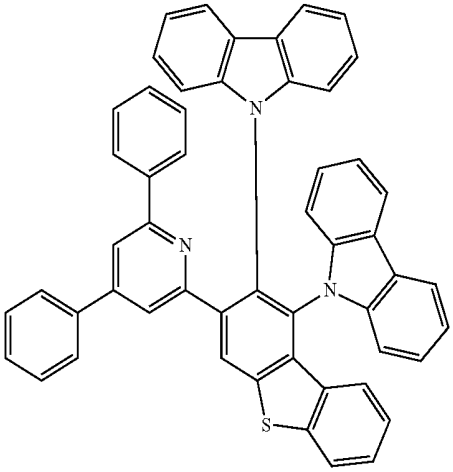

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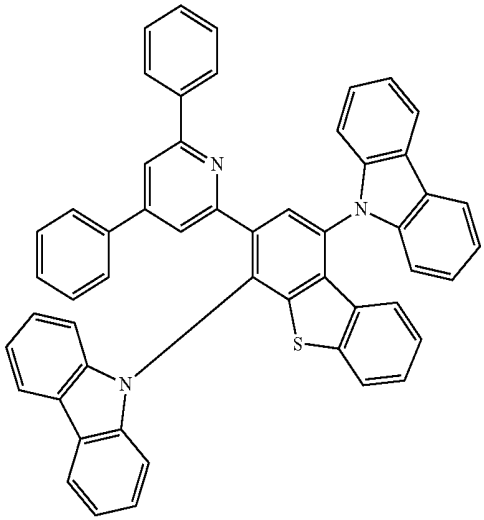

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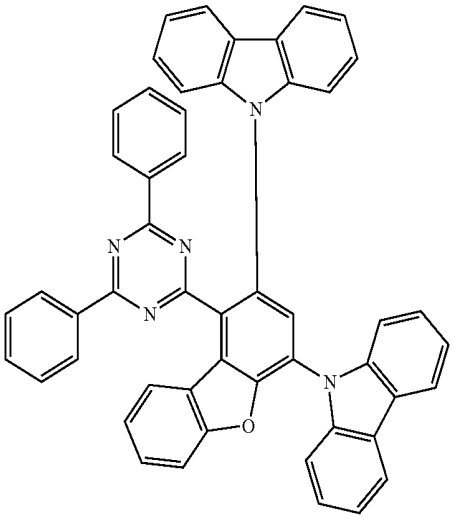

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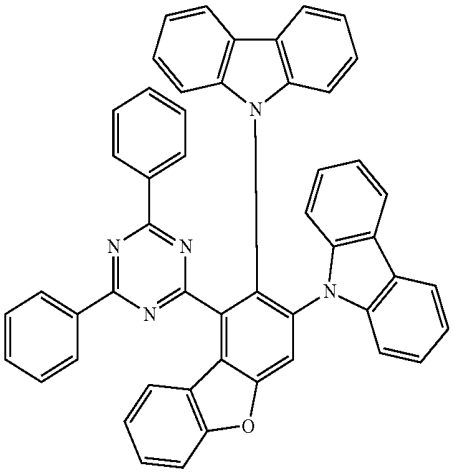

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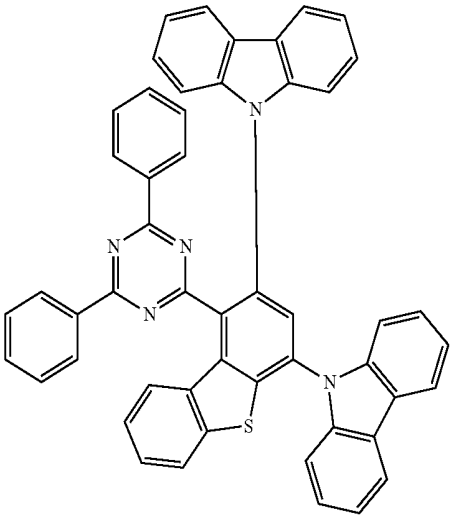

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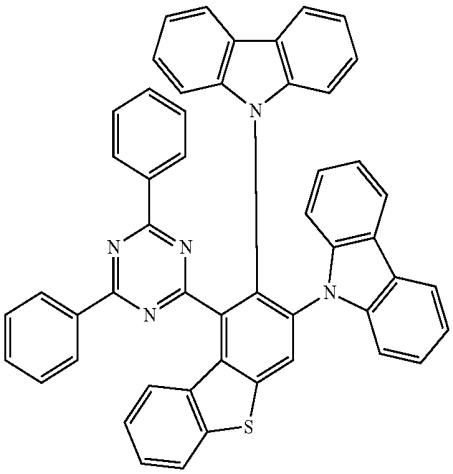

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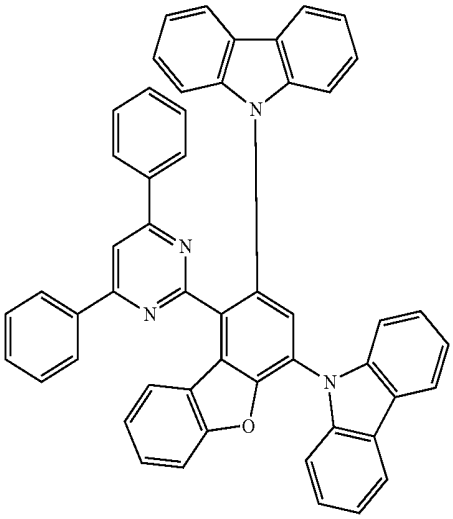

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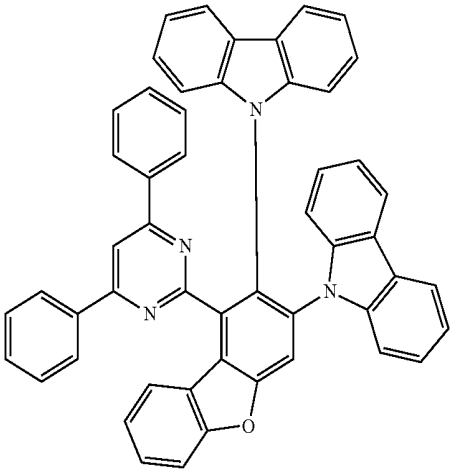

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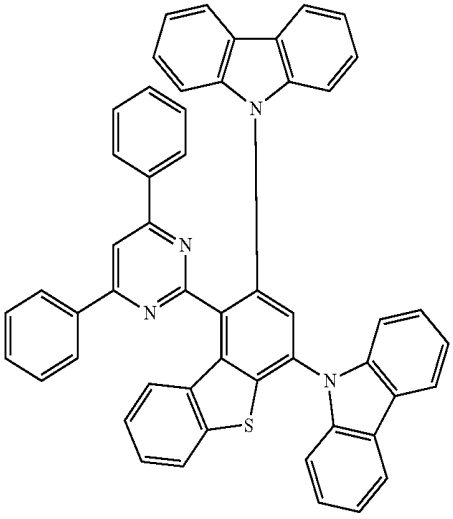

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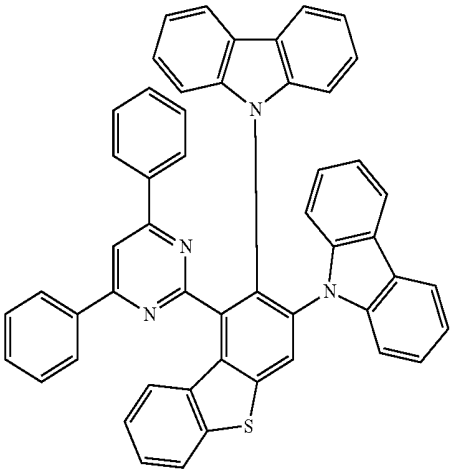

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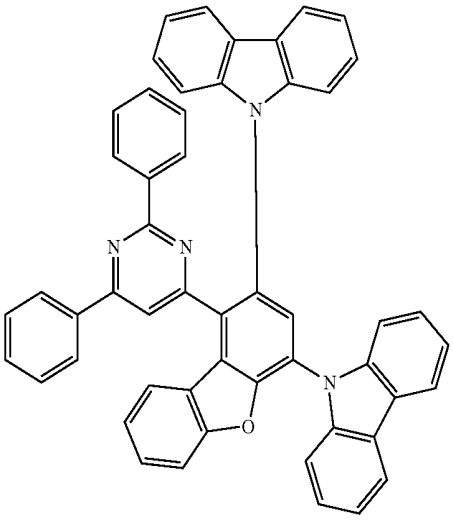

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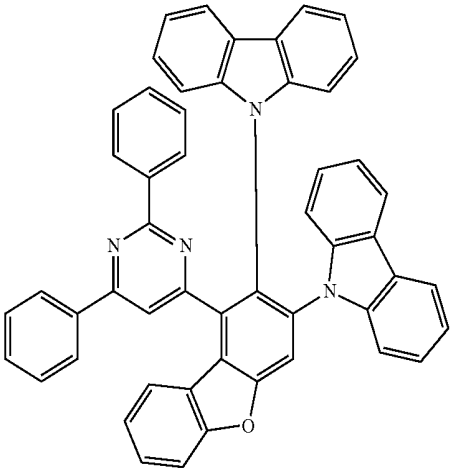

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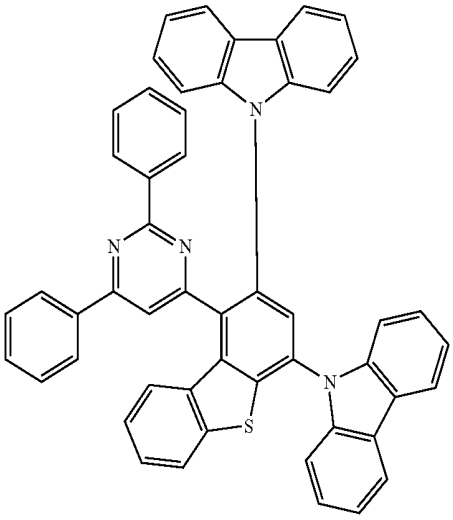

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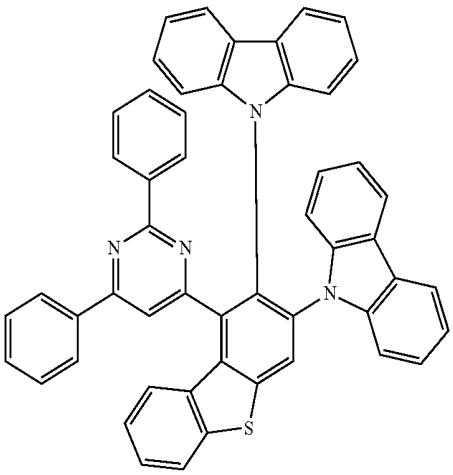

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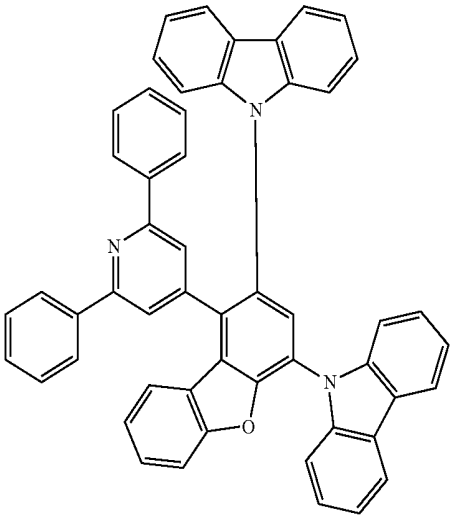

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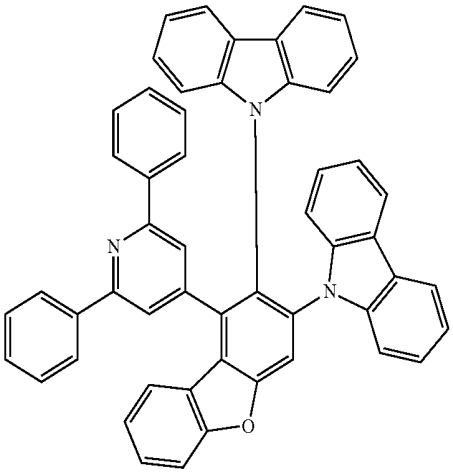

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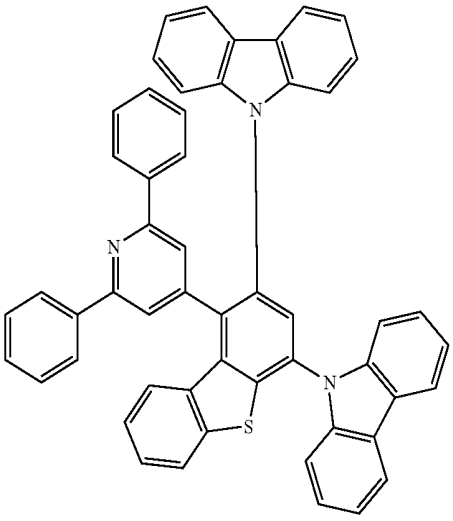

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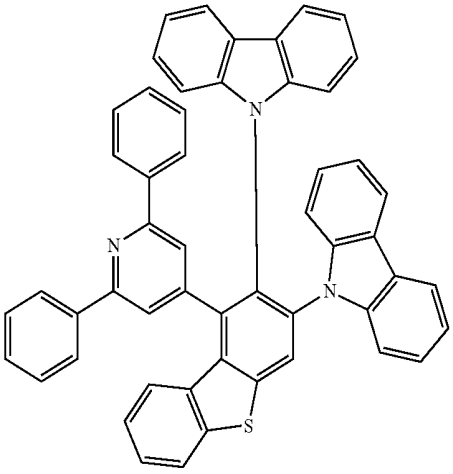

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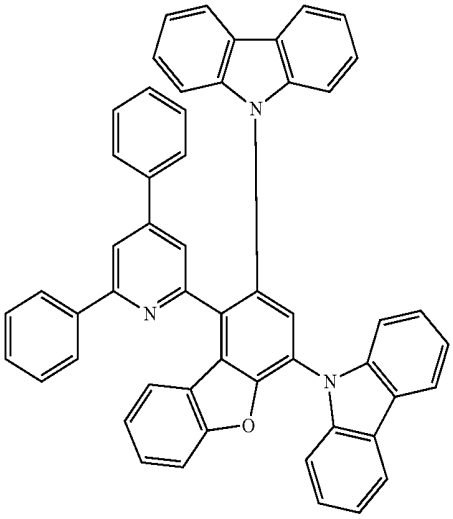

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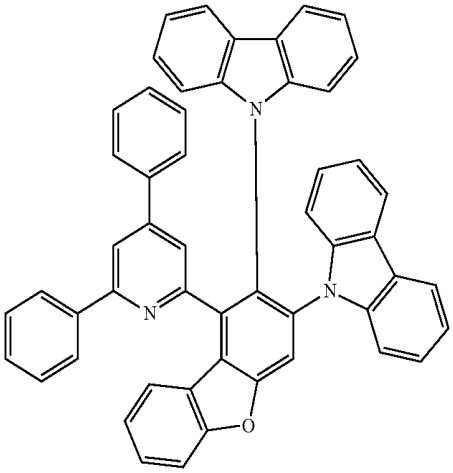

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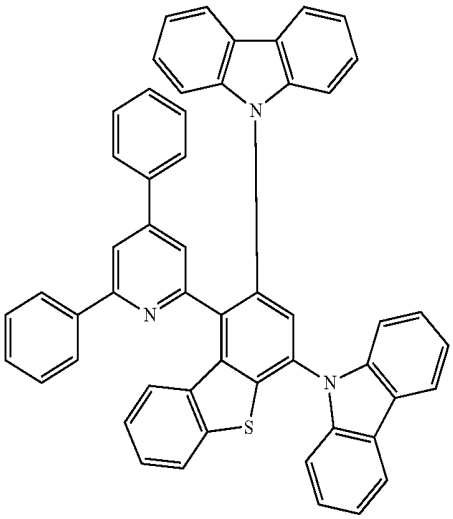

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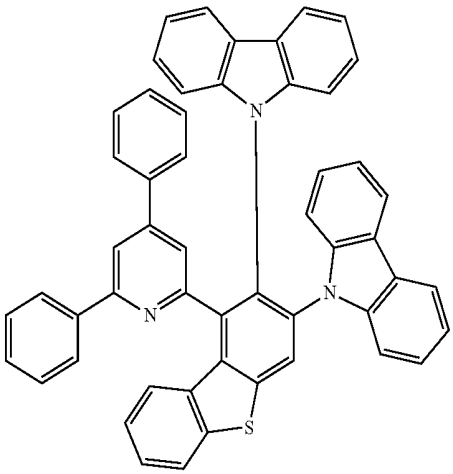

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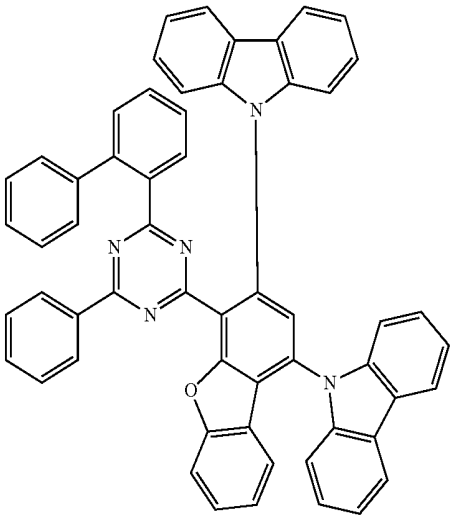

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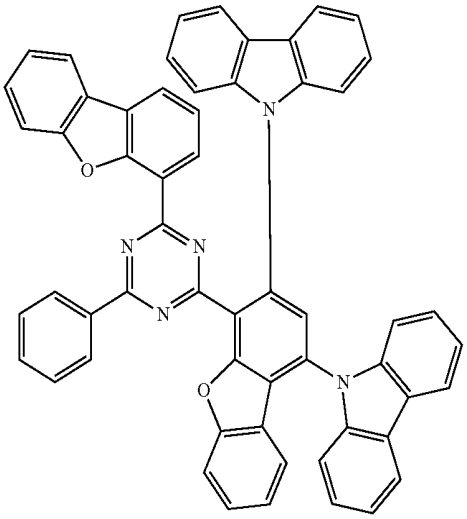

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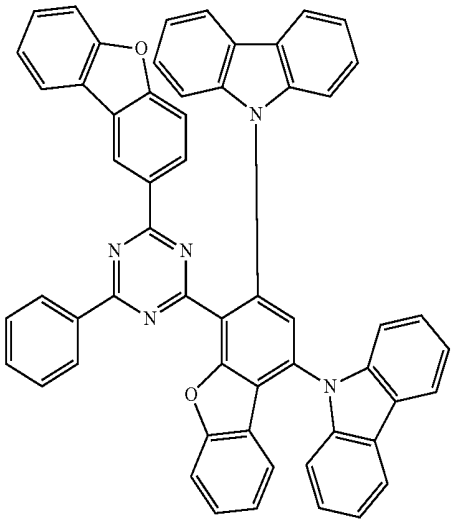

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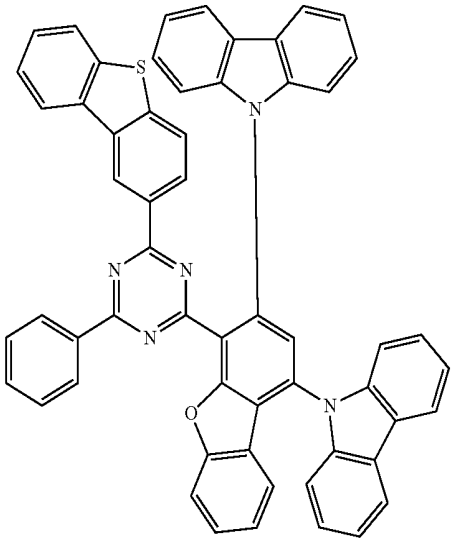

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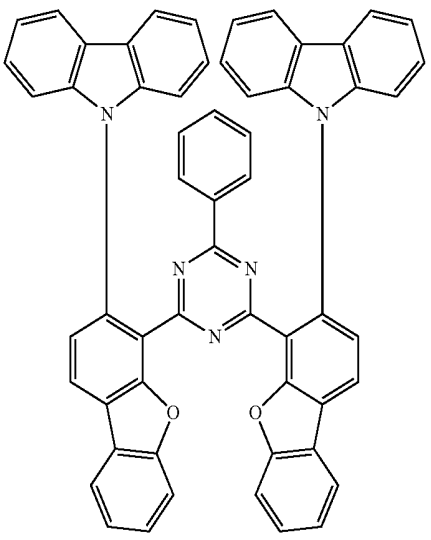

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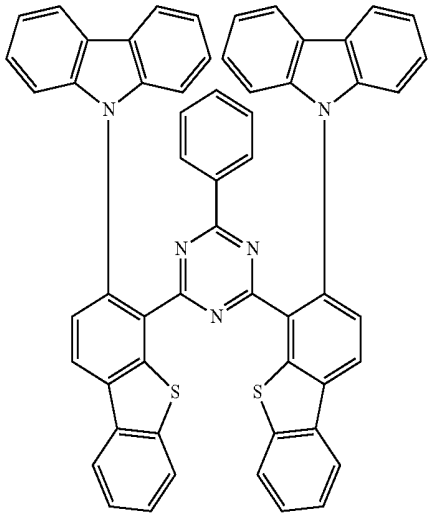

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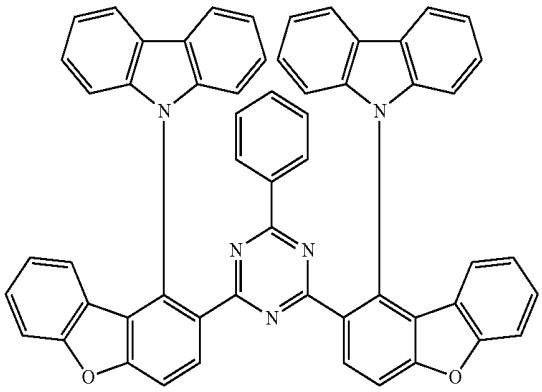

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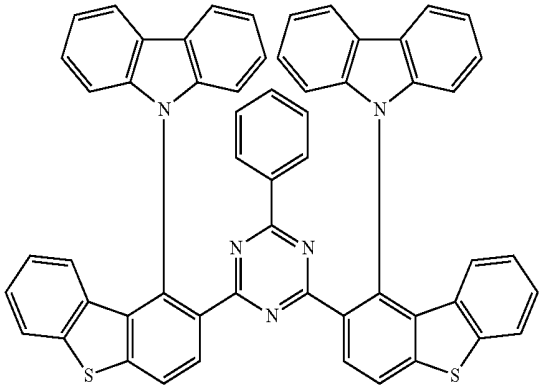

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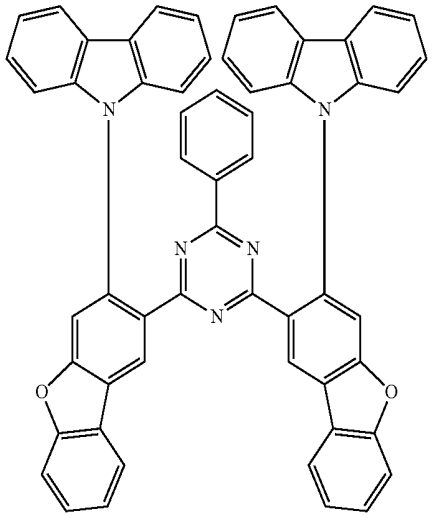

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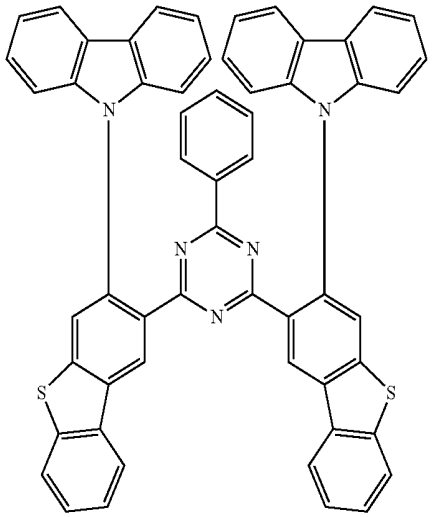

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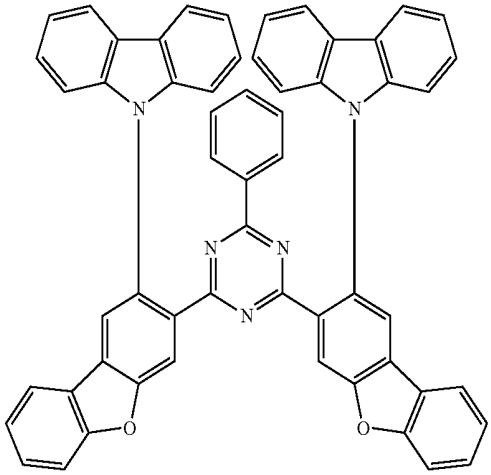

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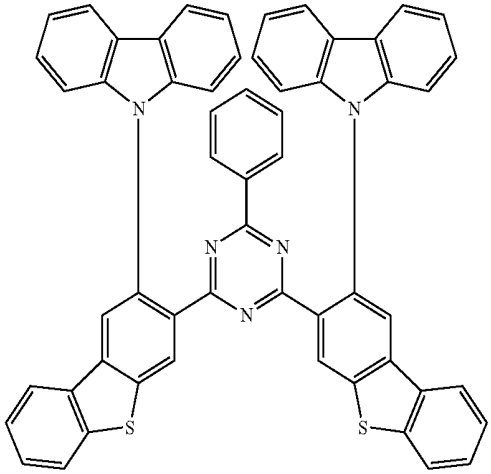

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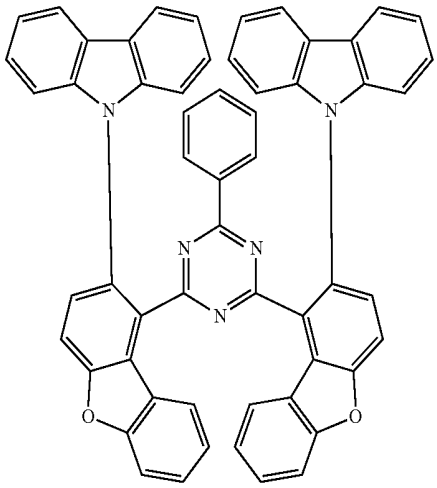

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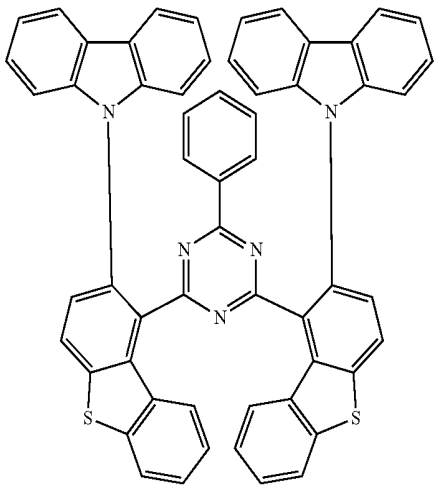

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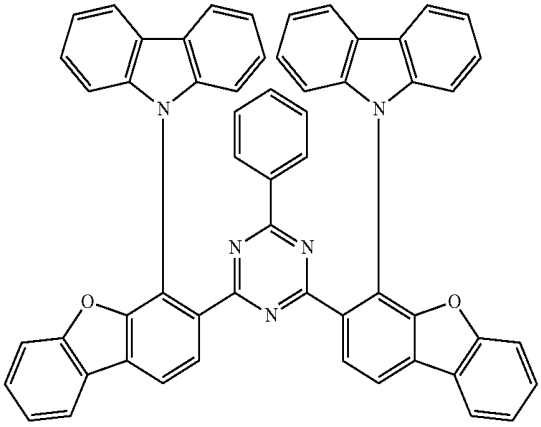

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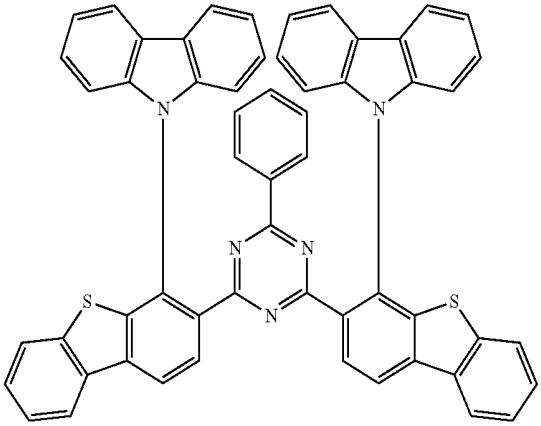

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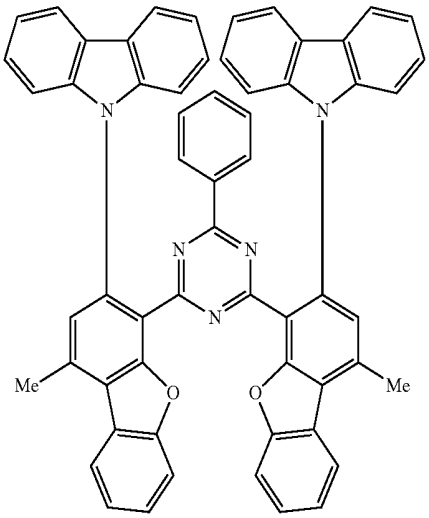

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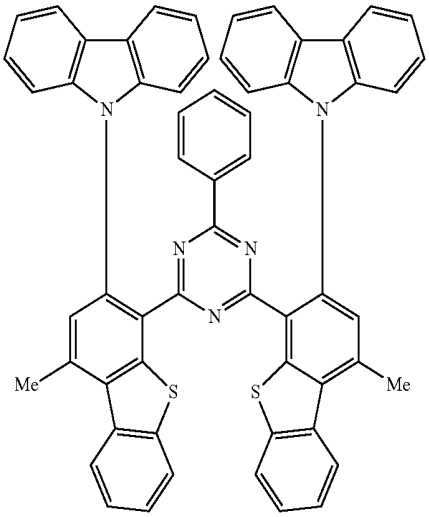

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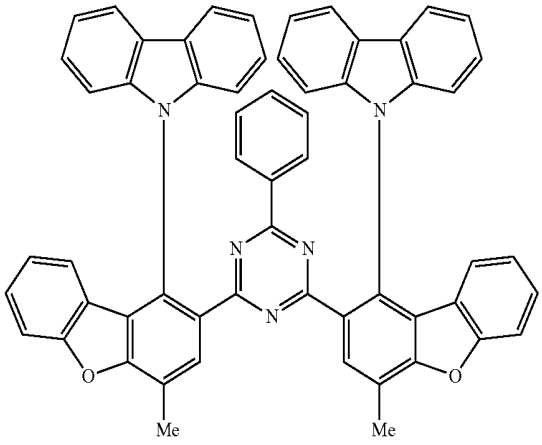

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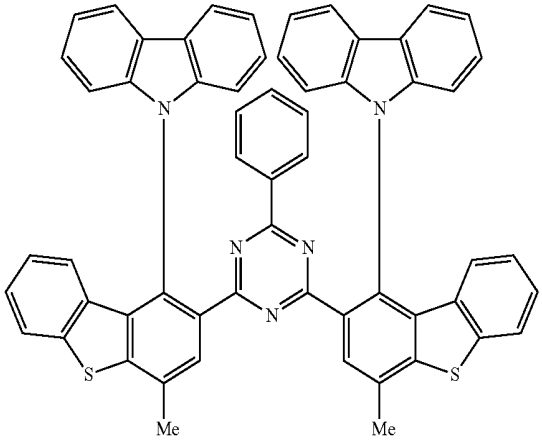

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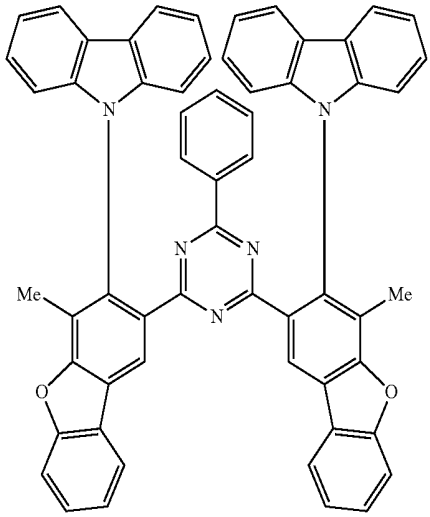

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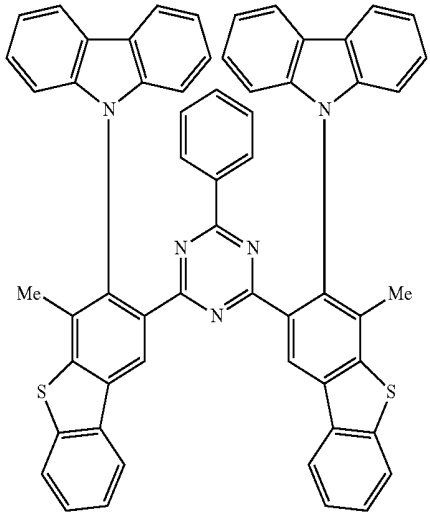

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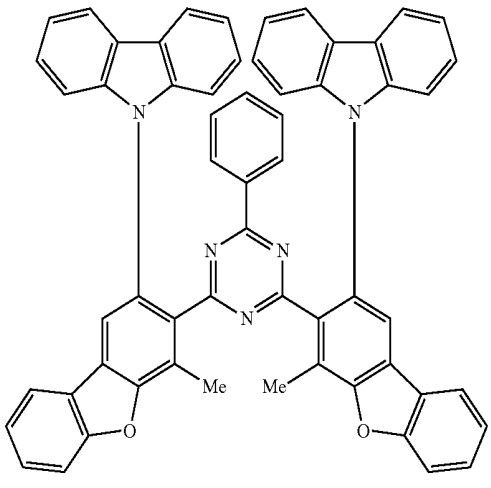

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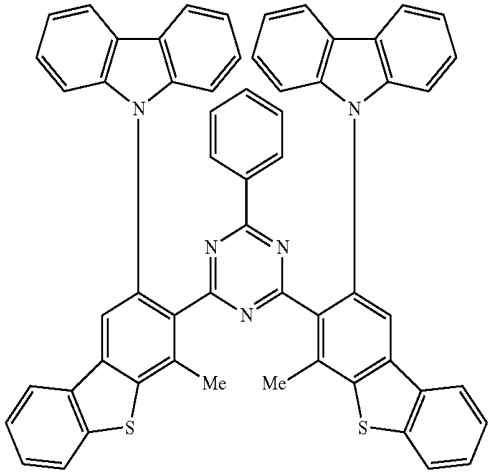

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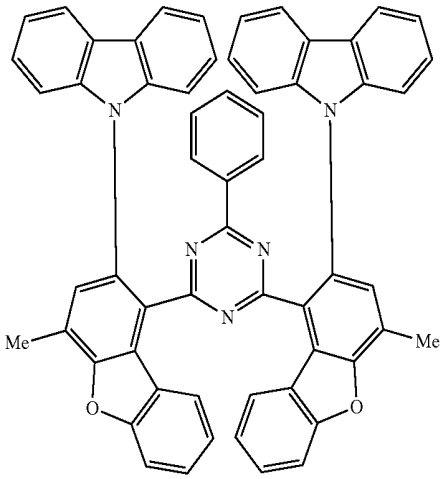

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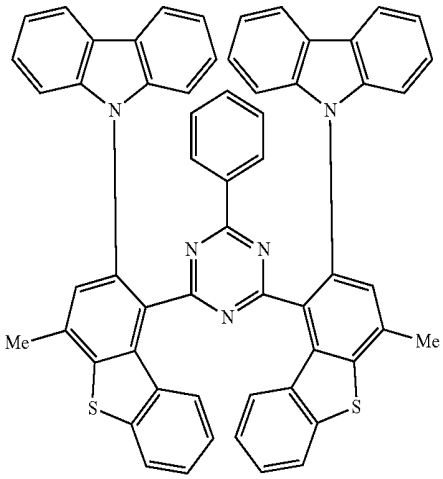

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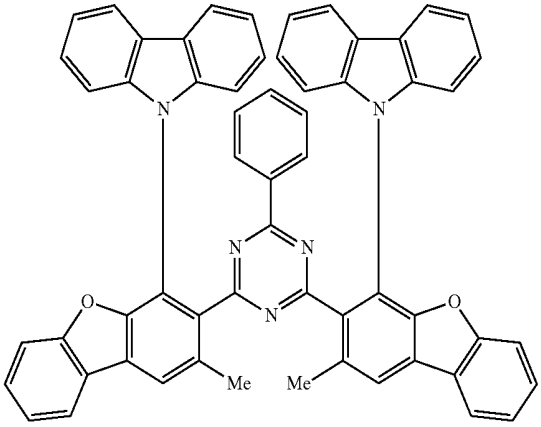

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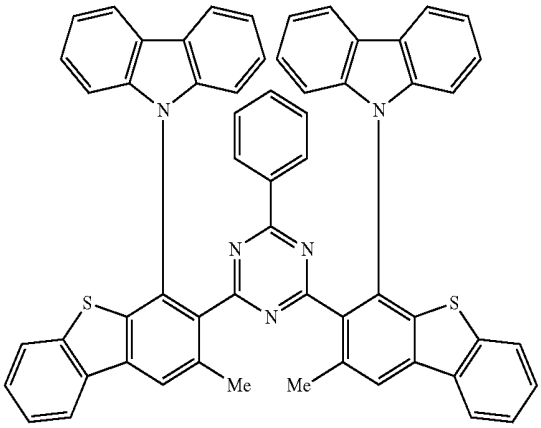

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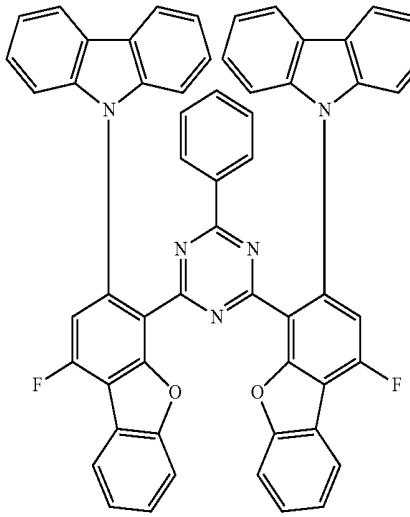

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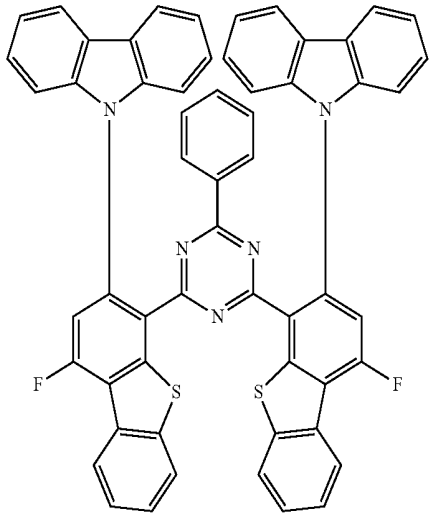

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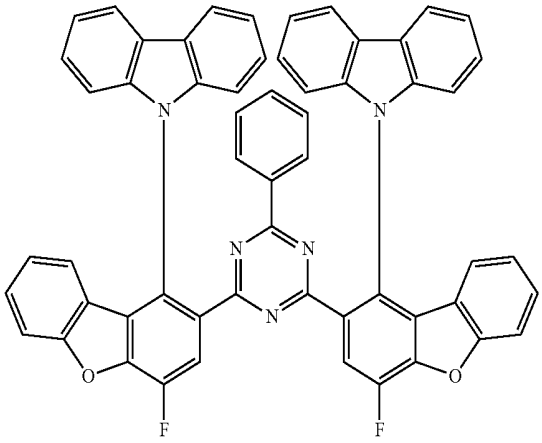

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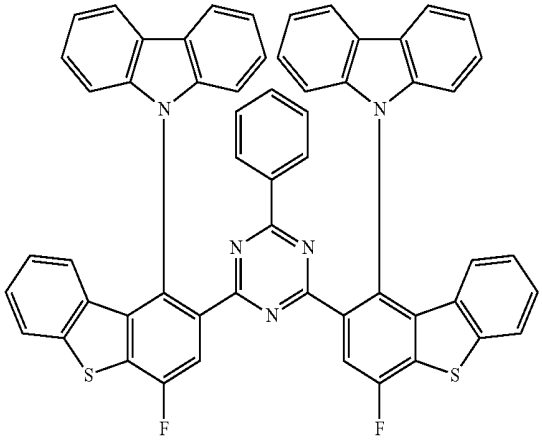

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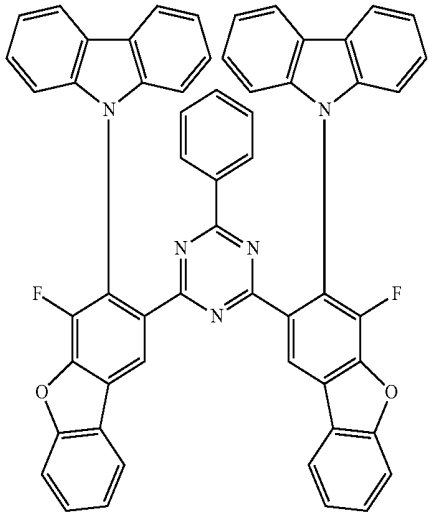

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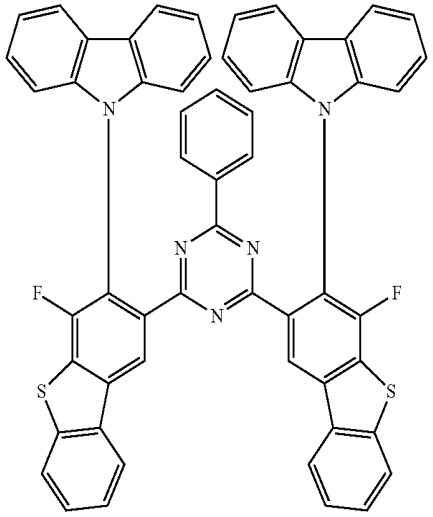

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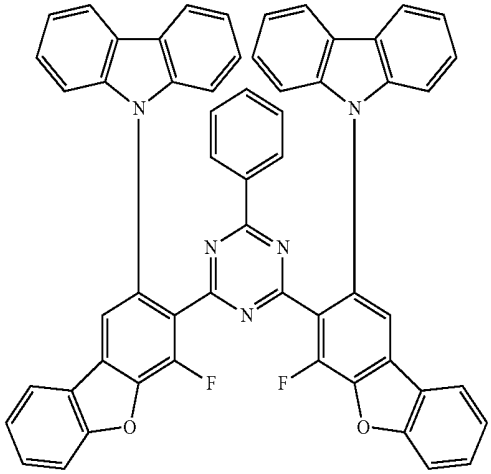

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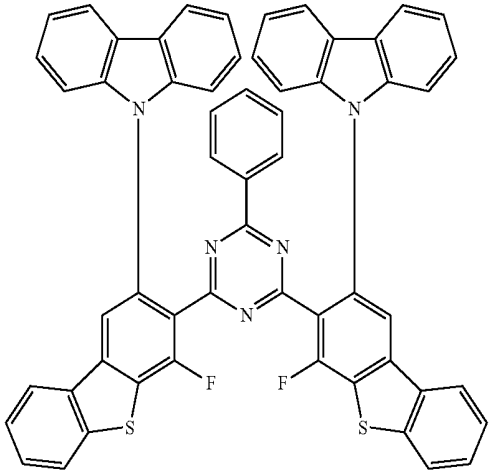

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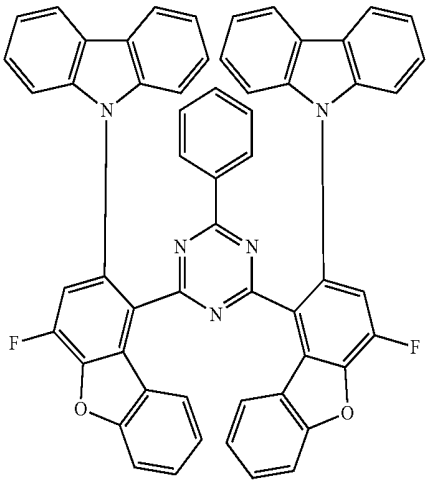

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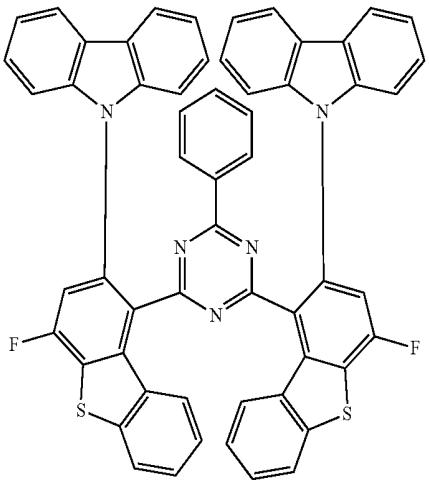

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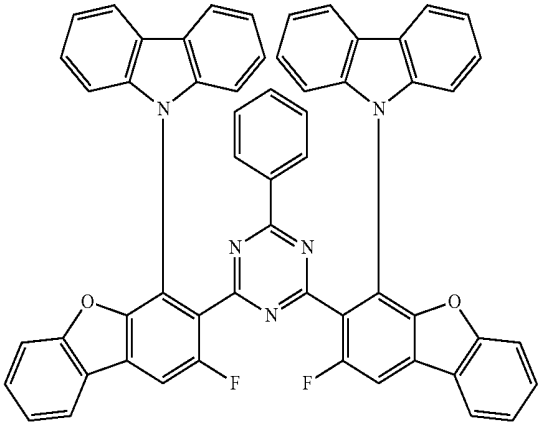

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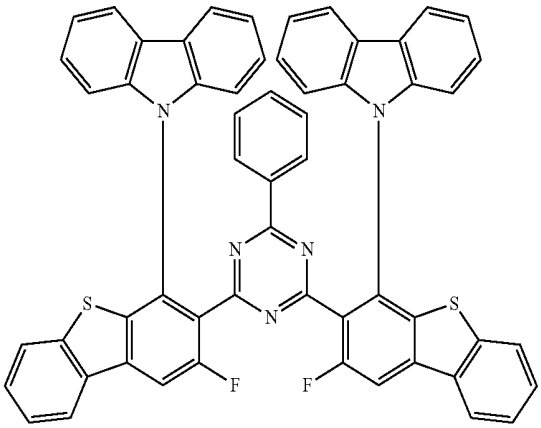

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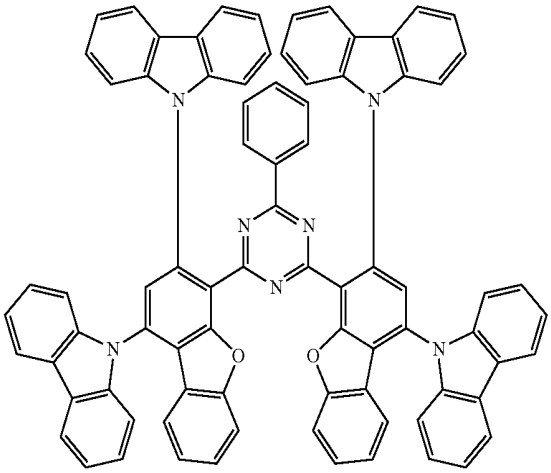

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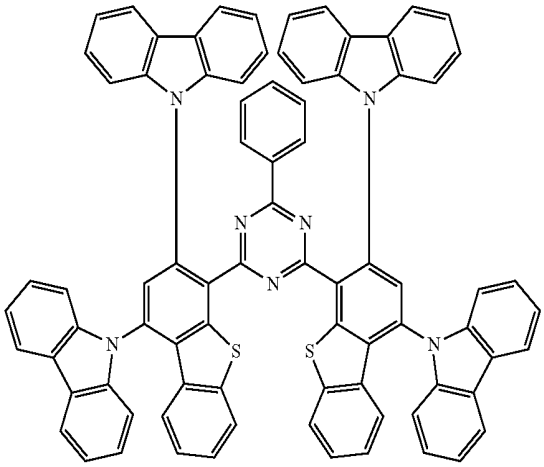

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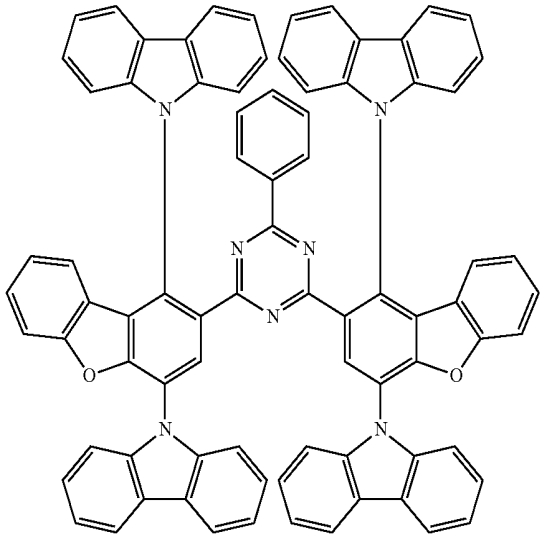

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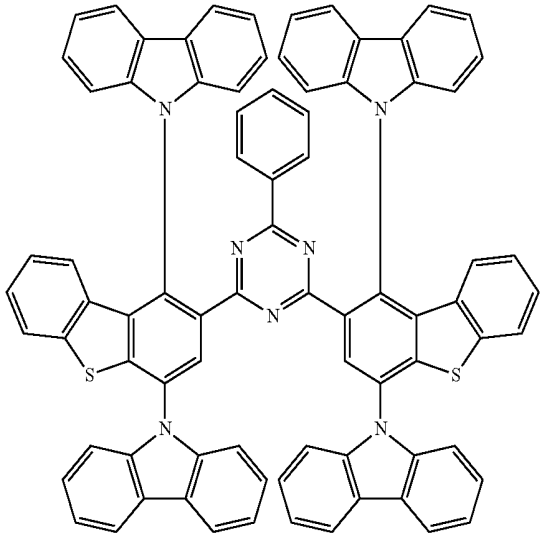

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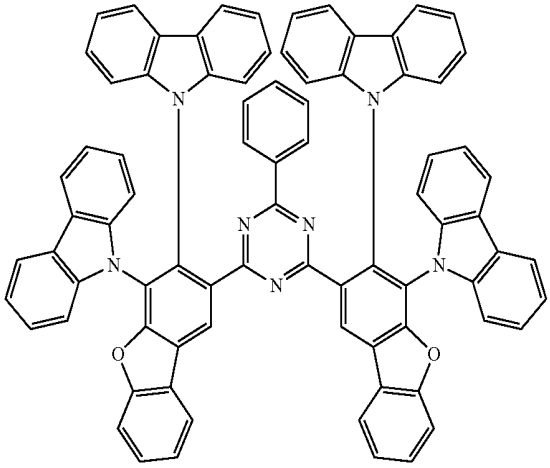

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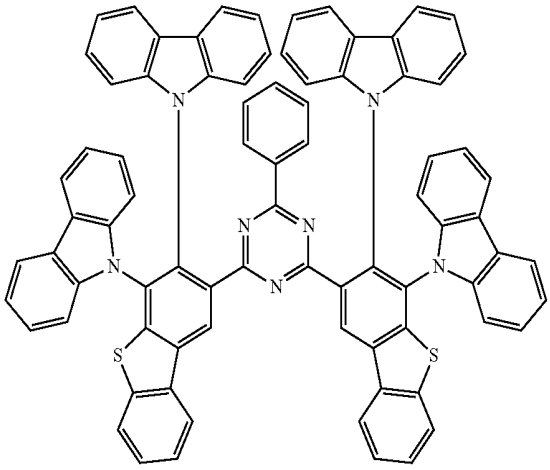

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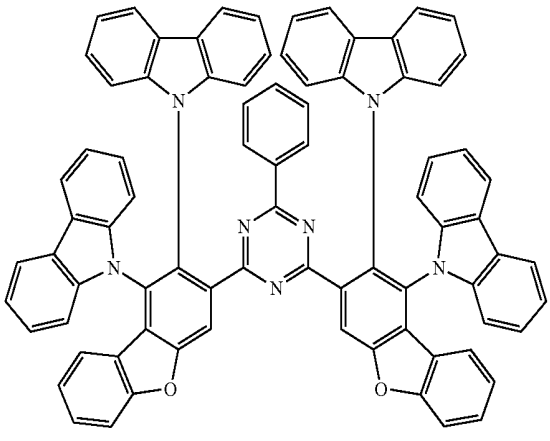

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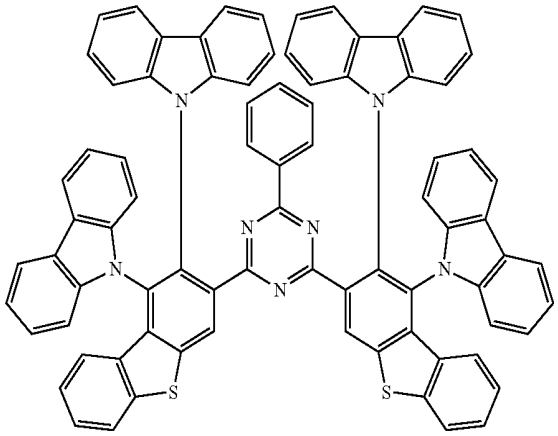

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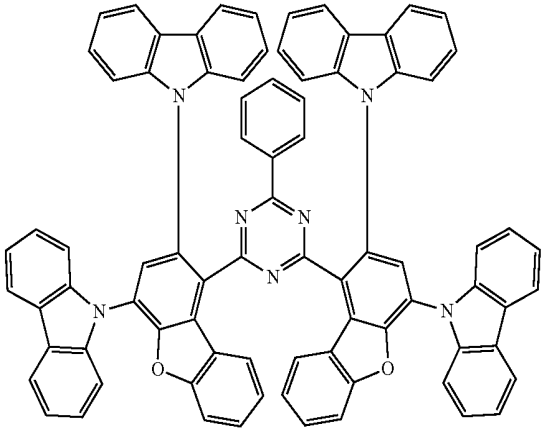

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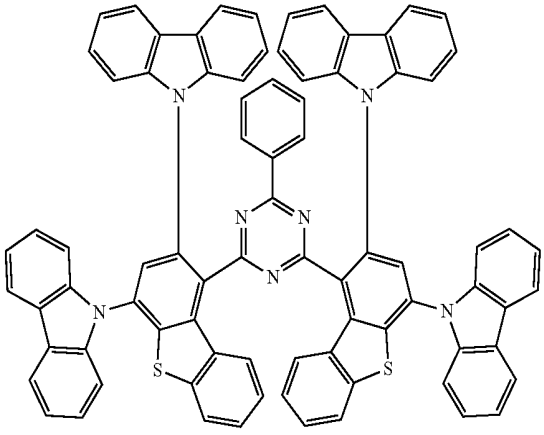

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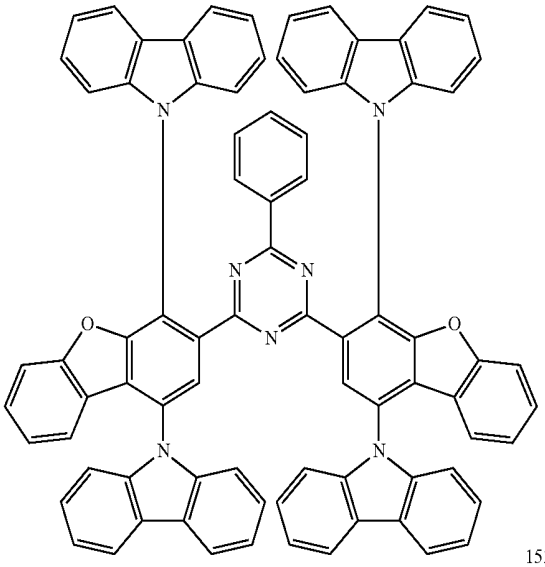

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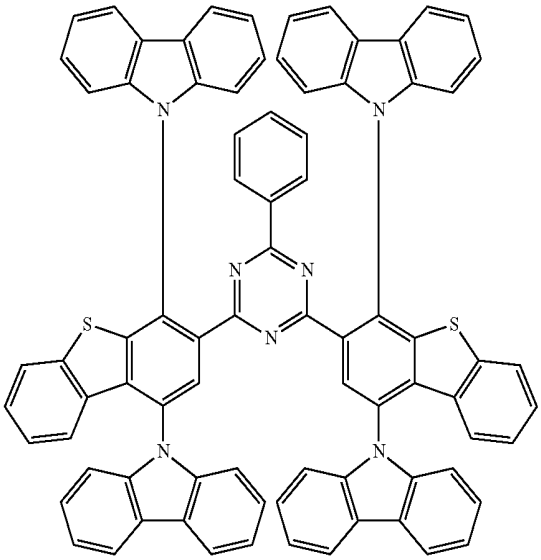

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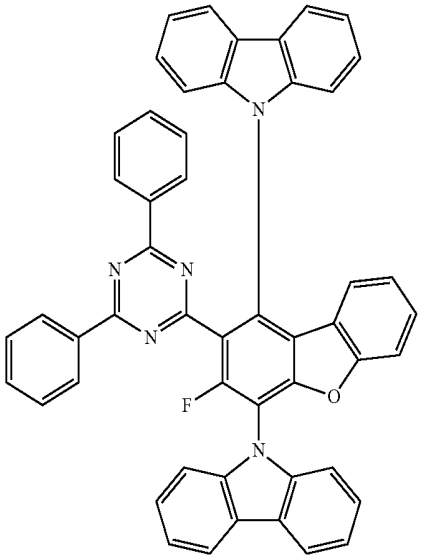

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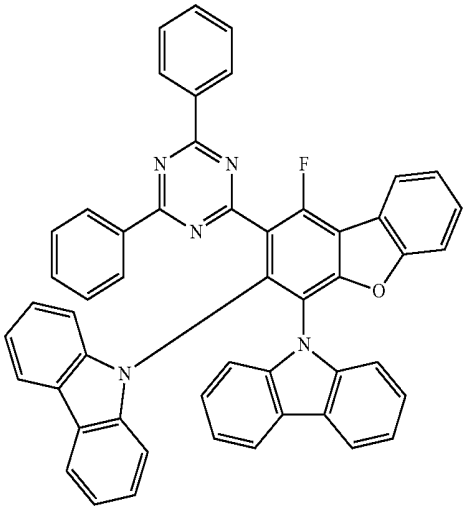

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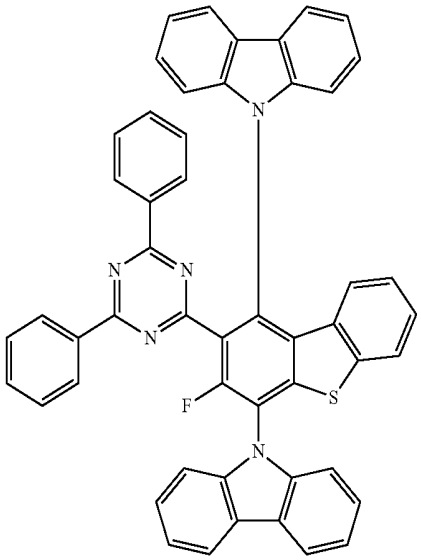

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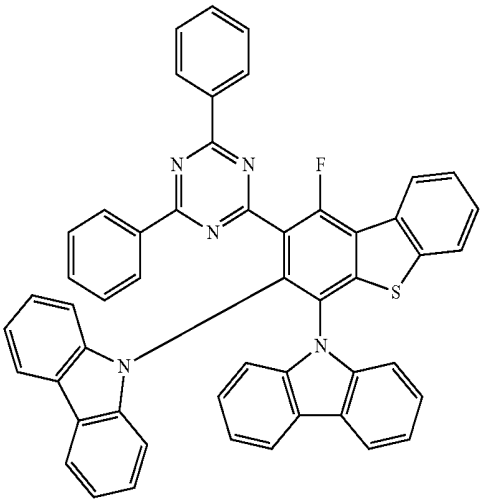

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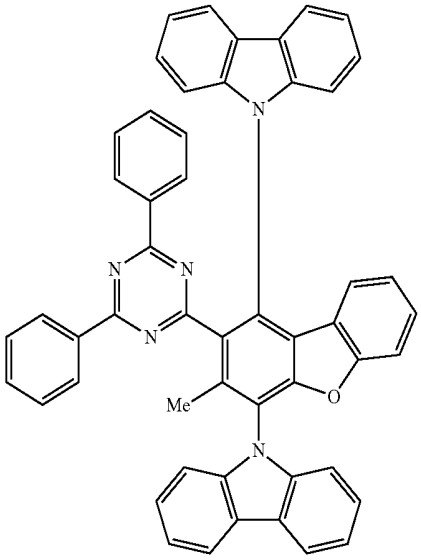

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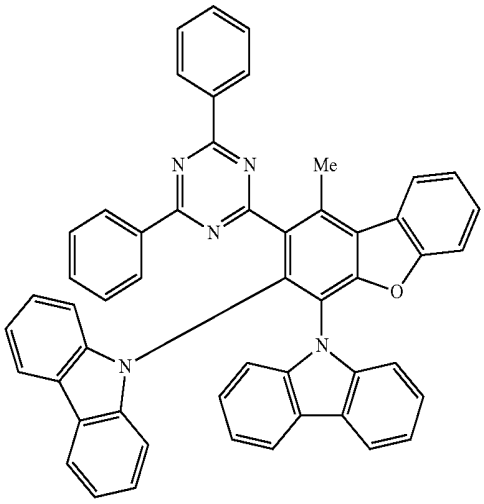

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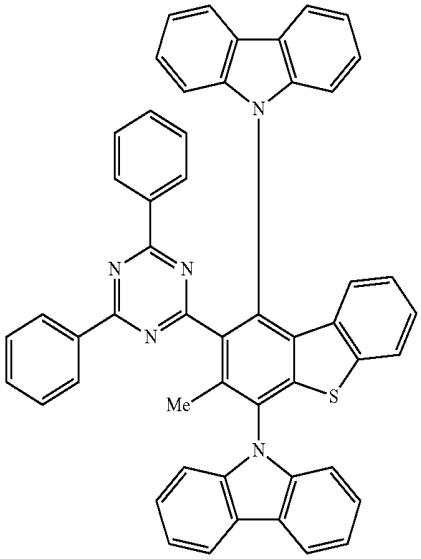

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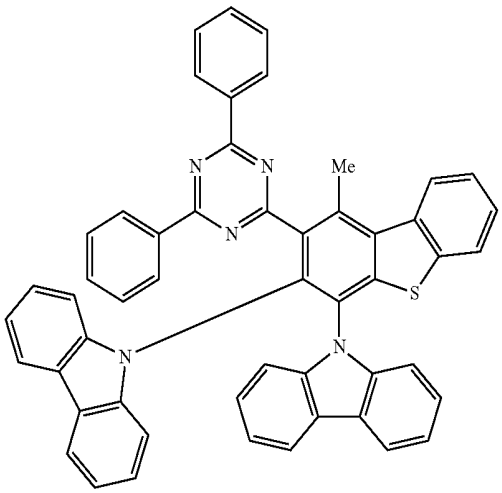

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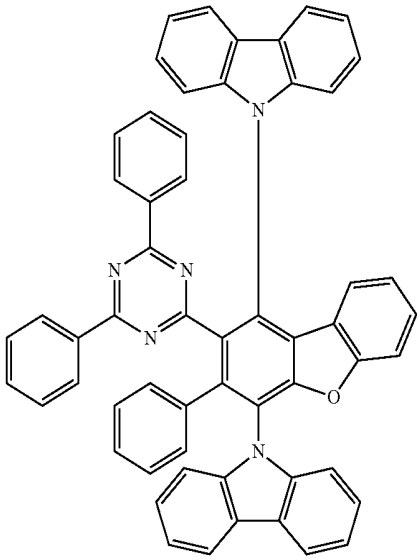

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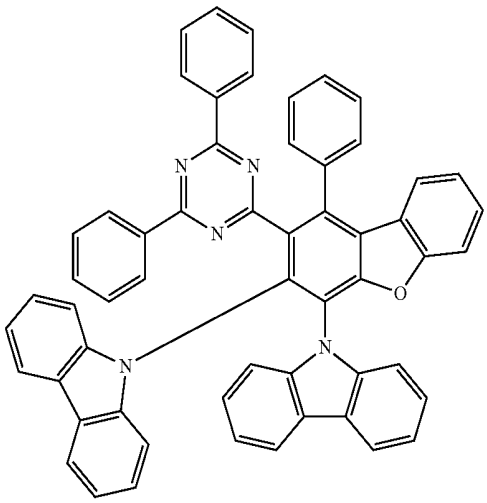

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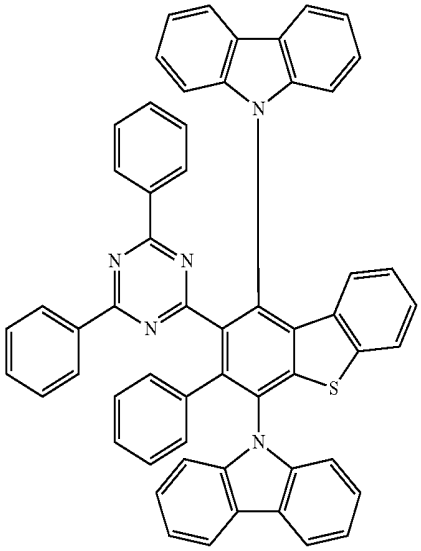

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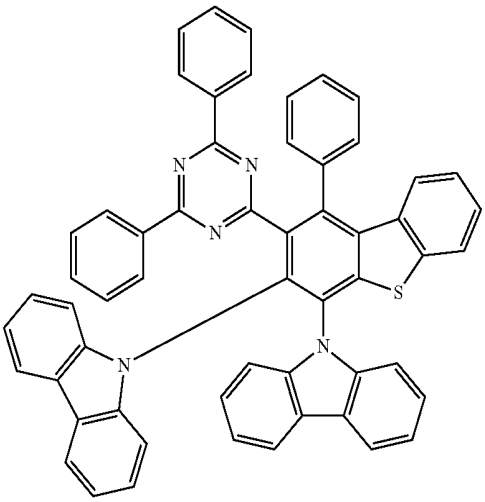

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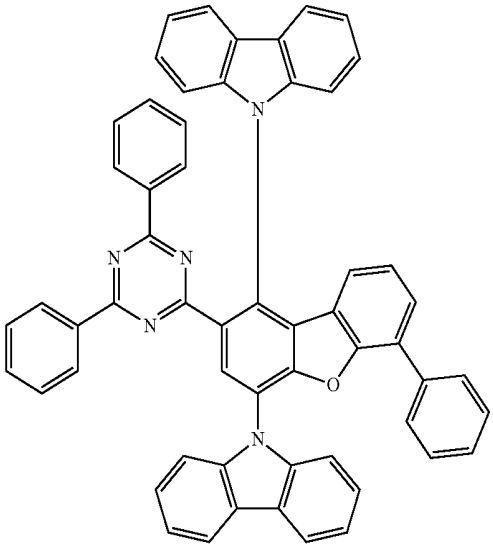

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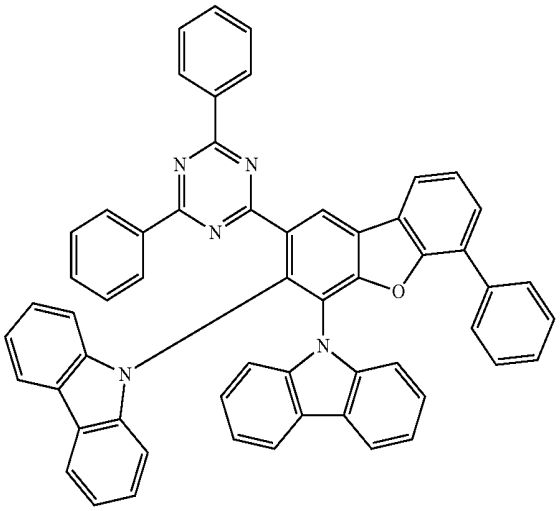

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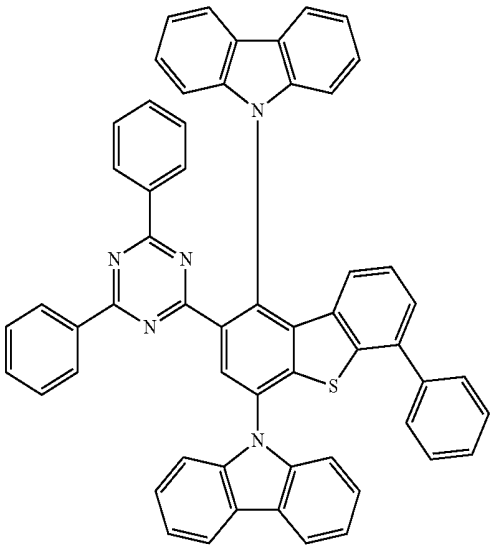

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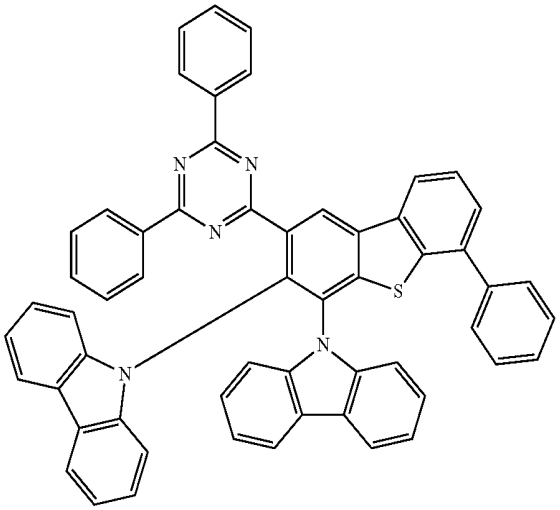

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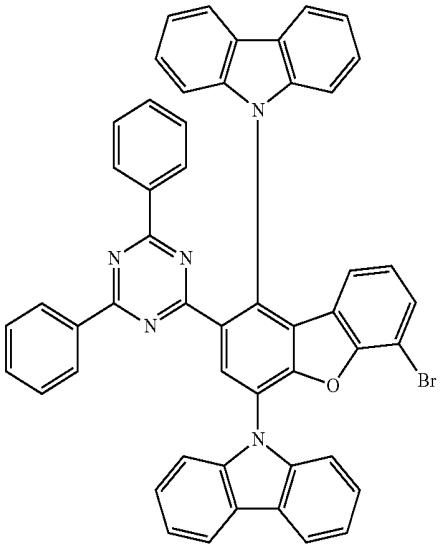

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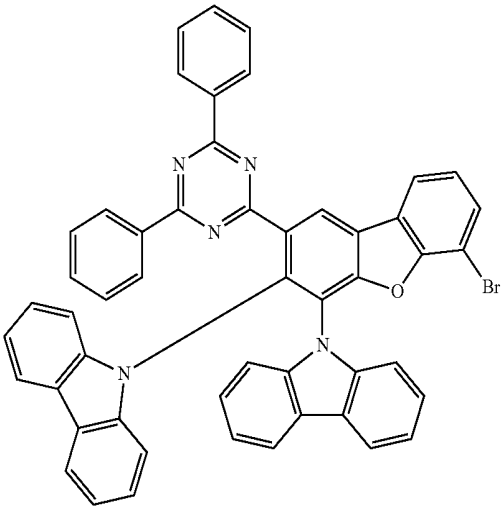

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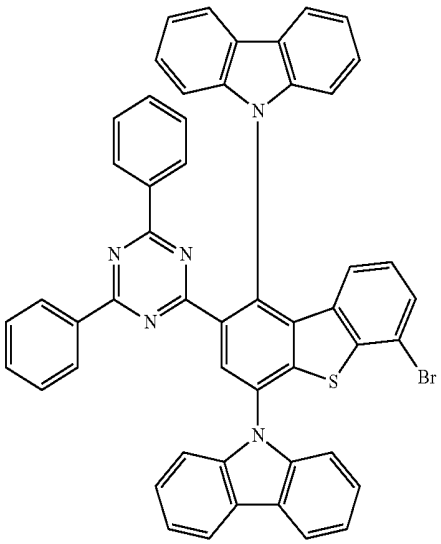

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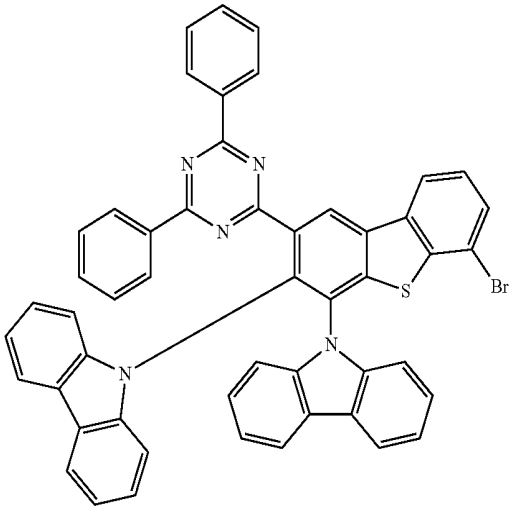

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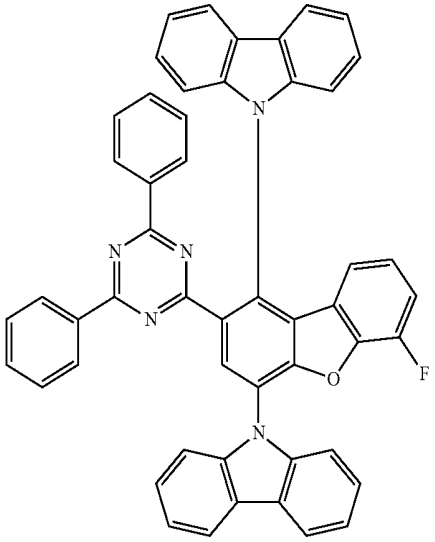

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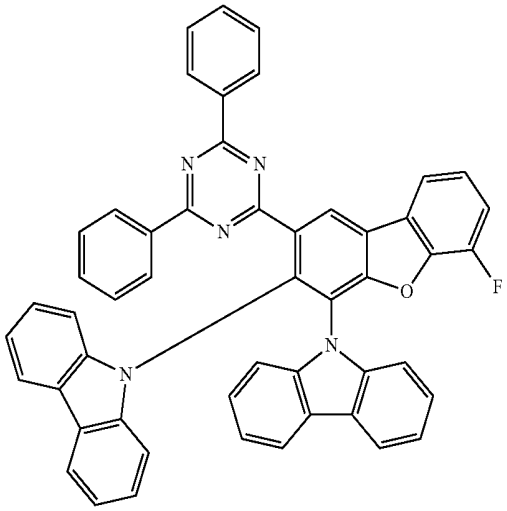

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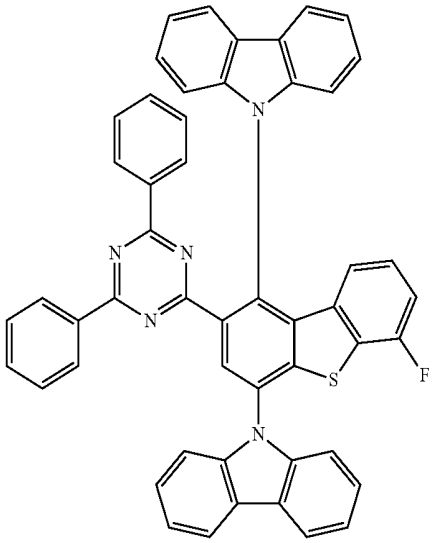

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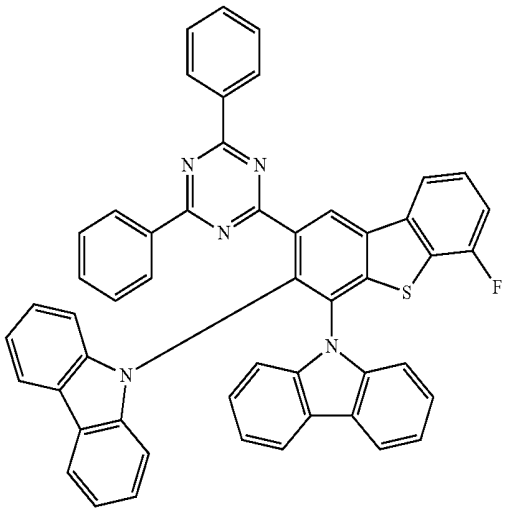

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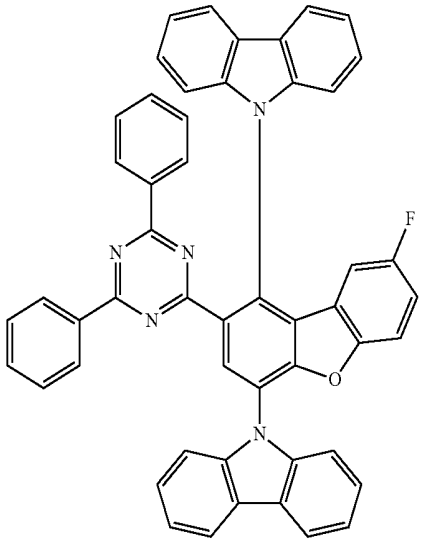

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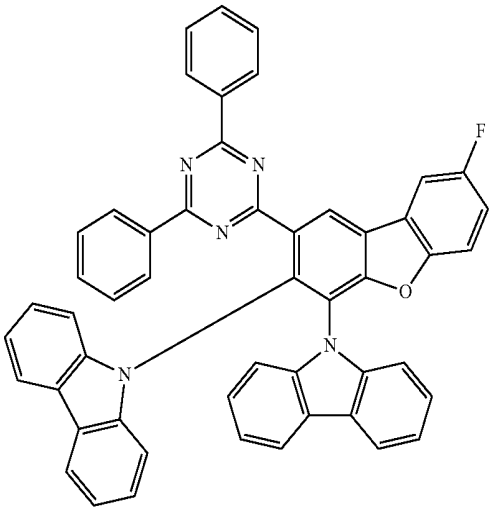

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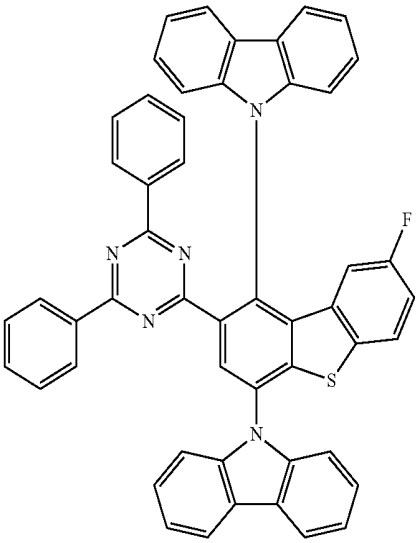

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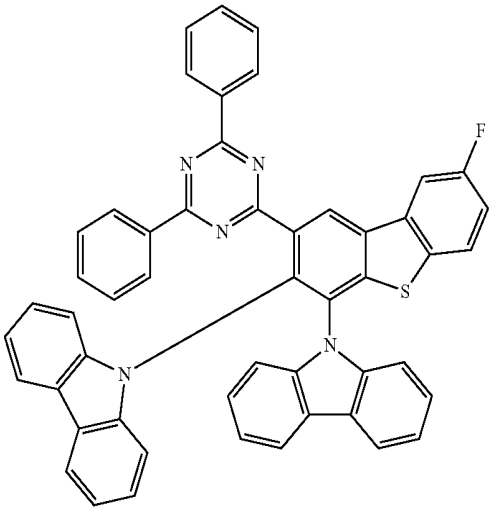

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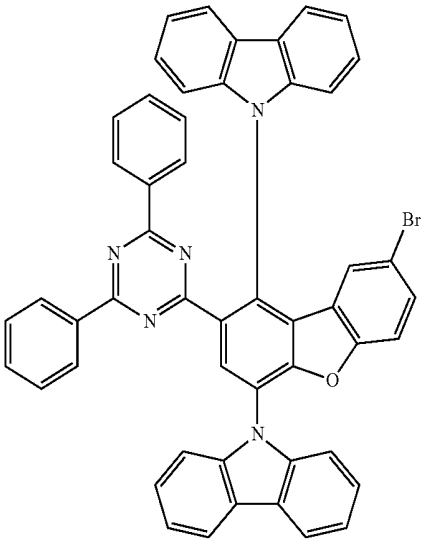

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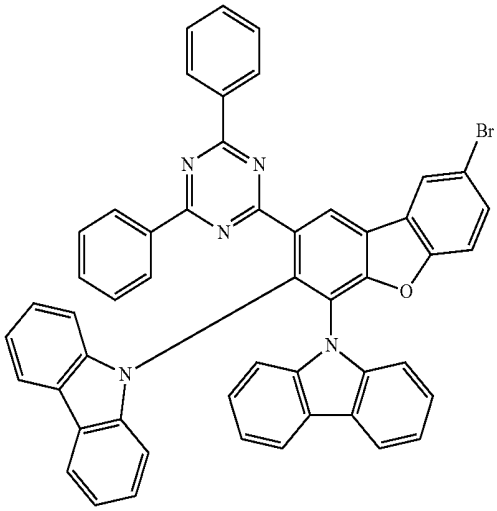

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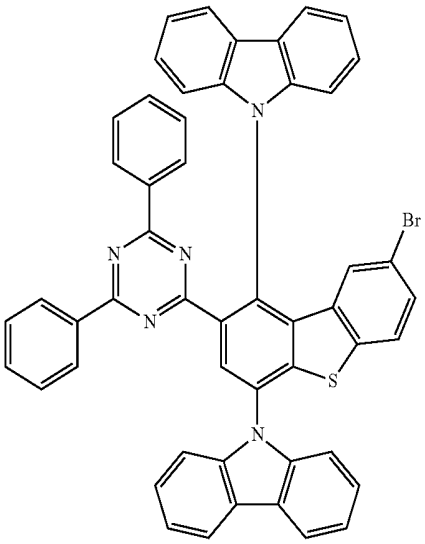

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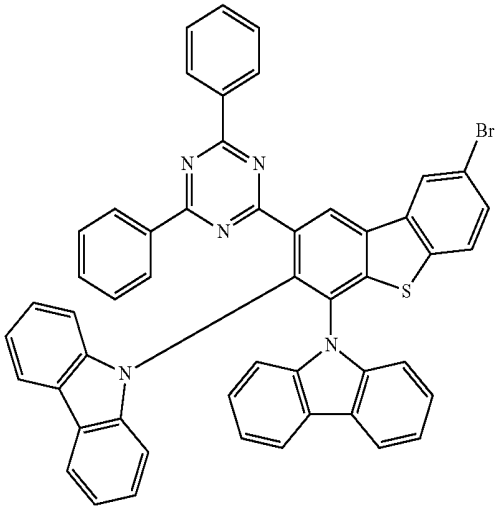


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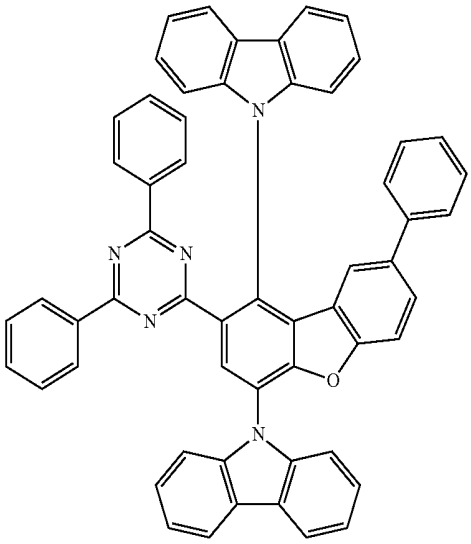


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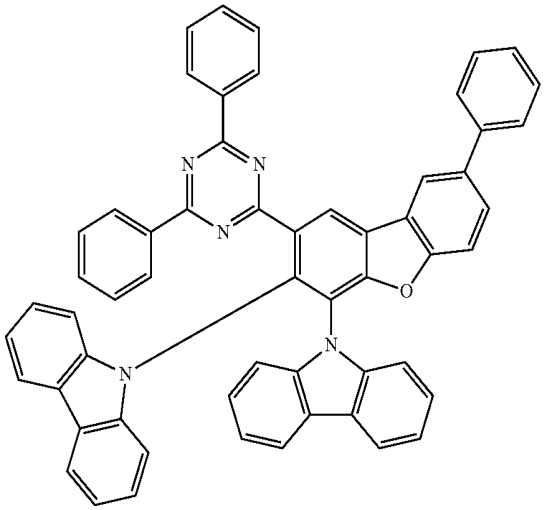


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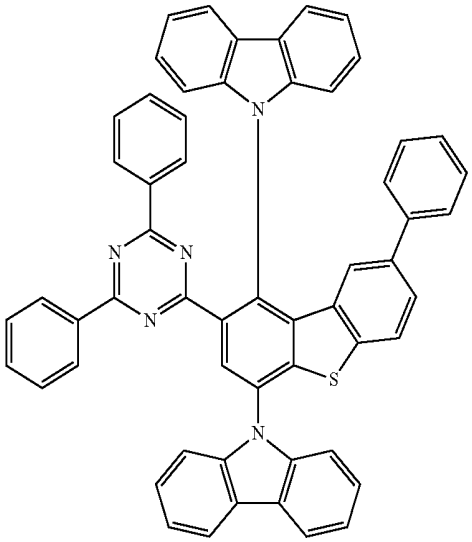


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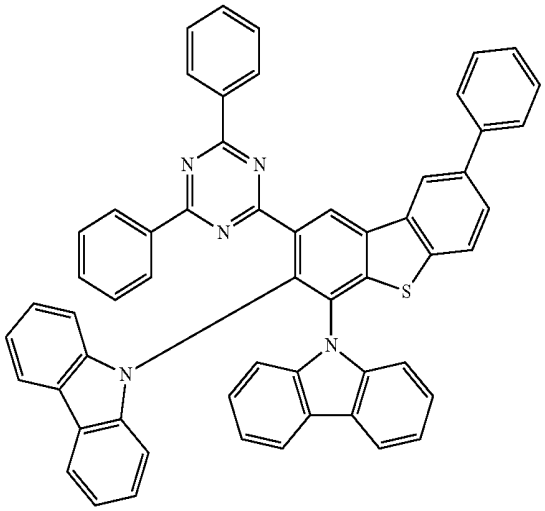



**[0096]** In an implementation, the emission layer EML may include one kind or two or more kinds of the heterocyclic compound. In an implementation, the emission layer EML may further include other suitable materials in addition to the heterocyclic compound.

**[0097]** In an implementation, the emission layer EML may include a host and a dopant, and the dopant may include the heterocyclic compound. In an implementation, the heterocyclic compound represented by Formula 1 may be included in the emission layer EML as a dopant. In an implementation, the heterocyclic compound represented by Formula 1 may be included in the emission layer EML as a dopant for thermally activated delayed fluorescence. The emission layer EML includes the heterocyclic compound and may be a blue emission layer emitting blue light having a wavelength region of less than about 470 nm. For example, the heterocyclic compound may be included in the emission layer EML as a dopant emitting deep blue light having a wavelength region of about 440 nm to about 470 nm, or about 450 nm to about 470 nm.

**[0098]** In an implementation, the host material may include suitable materials. For example, at least one of bis[2-(diphenylphosphino)phenyl] ether oxide (DPEPO), 4,4'-bis(carbazol-9-yl)biphenyl (CBP), 1,3-bis(carbazol-9-yl)benzene (mCP), 2,8-bis(diphenylphosphoryl)dibenzo[b,d]furan (PPF), 4,4',4"-tris(carbazol-9-yl)-triphenylamine (TcTa) or 1,3,5-tris(N-phenylbenzimidazole-2-yl)benzene (TPBi) may be included. For example, tris(8-hydroxyquinolino)aluminum ($Alq_3$), 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP), poly(N-vinylcarbazole) (PVK), 9,10-di(naphthalene-2-yl)anthracene (ADN), 4,4',4"-tris(carbazol-9-yl)-triphenylamine (TCTA), 1,3,5-tris(N-phenylbenzimidazole-2-yl)benzene (TPBi), 3-tert-butyl-9,10-di(naphth-2-yl) anthracene (TBADN), distyrylarylene (DSA), 4,4'-bis(9-carbazolyl)-2,2'-dimethyl-biphenyl (CDBP), 2-methyl-9,10-bis(naphthalen-2-yl)anthracene (MADN), bis[2-(diphenylphosphino)phenyl]ether oxide (DPEPO), hexaphenyl cyclotriphosphazene (CP1), 1,4-bis(triphenylsilyl)benzene (UGH2), hexaphenylcyclotrisiloxane ($DPSiO_3$), octaphenylcyclotetra siloxane ($DPSiO_4$), 2,8-bis(diphenylphosphoryl)dibenzofuran (PPF), etc., may be used as the host material.

**[0099]** In an implementation, in addition to the heterocyclic compound, the emission layer EML may further include as a dopant, at least one of N,N,N',N'-tetraphenyl-pyrene-1,6-diamine (TPD), 4,4'-bis(2-(9-ethyl-9H-carbazol-3-yl)vinyl)-1,1'-biphenyl (BCzVBi); 4,4'-bis(9-ethyl-3-carbazovinylene)-1,1'-biphenyl, 10-phenyl-10H,10'H-spiro[acridine-9,9'-anthracene]-10'-one (ACRSA), 3,4,5,6-tetra-9H-carbazol-9-yl-1,2-benzenedicarbonitrile (4CzPN), 2,4,5,6-tetra-9H-carbazol-9-yl-isophthalonitrile (4CzIPN), bis[4-9,9-dimethyl-9,10-dihydroacridine]phenyl]sulfone (DMAC-DPS), and 2-phenoxazine-4,6-diphenyl-1,3,5-triazine (PSZ-TRZ). In addition, the emission layer EML may further include, as known dopant materials, styryl derivatives (for example, 1,4-bis[2-(3-N-ethylcarbazoryl)vinyl]benzene (BCzVB), 4-(di-p-tolylamino)-4'-[(di-p-tolylamino)styryl] stilbene (DPAVB), and N-(4-((E)-2-(6-((E)-4-(diphenylamino)styryl)naphthalen-2-yl)vinyl)phenyl)-N-phenylbenzenamine (N-BDAVBi)), perylene and the derivatives thereof (for example, 2,5,8,11-tetra-t-butylperylene (TBP)), pyrene and the derivatives thereof (for example, 1,1-dipyrene, 1,4-dipyrenylbenzene, 1,4-bis(N,N-diphenylamino)pyrene), etc.

**[0100]** The emission layer EML may be a blue emission layer that emits blue light. The emission layer EML may be a fluorescence emission layer radiating fluorescence. The emission layer EML may be a delayed fluorescence emission layer radiating delayed fluorescence.

**[0101]** The electron transport region ETR is provided on the emission layer EML. The electron transport region ETR may include at least one of a hole blocking layer HBL, an electron transport layer ETL, or an electron injection layer EIL.

**[0102]** The electron transport region ETR may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure having a plurality of layers formed using a plurality of different materials.

**[0103]** For example, the electron transport region ETR may have a single layer structure of an electron injection layer EIL or an electron transport layer ETL, or a single layer structure formed using an electron injection material and an electron transport material. Further, the electron transport region ETR may have a single layer structure having a plurality of different materials, or a structure laminated from the emission layer EML of electron transport layer ETL/electron injection layer EIL, or hole blocking layer HBL/electron transport layer ETL/electron injection layer EIL. The thickness of the electron transport region ETR may be, for example, from about 1,000 Å to about 1,500 Å.

**[0104]** The electron transport region ETR may be formed using various methods such as a vacuum deposition method, a spin coating method, a cast method, a Langmuir-Blodgett (LB) method, an inkjet printing method, a laser printing method, and a laser induced thermal imaging (LITI) method.

**[0105]** If the electron transport region ETR includes an electron transport layer ETL, the electron transport region ETR may include tris(8-hydroxyquinolinato)aluminum ($Alq_3$), 1,3,5-tri[(3-pyridyl)-phen-3-yl]benzene, 2,4,6-tris(3'-(pyridin-3-yl)biphenyl-3-yl)-1,3,5-triazine, 2-(4-(N-phenylbenzoimidazolyl-1-ylphenyl)-9,10-dinaphthylanthracene, 1,3,5-tri(1-phenyl-1H-benzo[d]imidazol-2-yl)phenyl (TPBi), 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), 3-(4-biphenylyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (TAZ), 4-(naphthalen-1-yl)-3,5-diphenyl-4H-1,2,4-triazole (NTAZ), 2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (tBu-PBD), bis(2-methyl-8-quinolinolato-N1,O8)-(1,1'-biphenyl-4-olato)aluminum (BAlq), berylliumbis(benzoquinolin-10-olate ($Bebq_2$), 9,10-di(naphthalene-2-yl) anthracene (ADN), and a mixture thereof. The thickness of the electron transport layers ETL may be from about 100 Å to about 1,000 Å, for example, from about 150 Å to about 500 Å. If the thickness of the electron transport layers ETL satisfies the above-described range, satisfactory electron transport properties may be obtained without substantial increase of a driving voltage.

**[0106]** If the electron transport region ETR includes an electron injection layer EIL, the electron transport layer ETL may use LiF, lithium quinolate (LiQ), $Li_2O$, BaO, NaCl, CsF, a metal in lanthanides such as Yb, or a metal halide such as RbCl, and RbI. The electron injection layer EIL may also be formed using a mixture material of an electron transport material and an insulating organo metal salt. The organo metal salt may be a material having an energy band gap of about 4 eV or more. Particularly, the organo metal salt may include, for example, metal acetates, metal benzoates, metal acetoacetates, metal acetylacetonates, or metal stearates. The thickness of the electron injection layer EIL may be from about 1 Å to about 100 Å, from about 3 Å to about 90 Å. If the thickness of the electron injection layer EIL satisfies the above-described range, satisfactory electron injection properties may be obtained without substantial increase of a driving voltage.

**[0107]** The electron transport region ETR may include a hole blocking layer as described above. The hole blocking layer may include, for example, 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), or bis[2-(diphenylphosphino)phenyl]ether oxide (DPEPO).

**[0108]** The second electrode EL**2** is provided on the electron transport region ETR. The second electrode EL**2** may be a common electrode or a cathode. The second electrode EL**2** may be a transmissive electrode, a transflective electrode or a reflective electrode. If the second elec-

trode EL**2** is the transmissive electrode, the second electrode EL**2** may include a transparent metal oxide, for example, ITO, IZO, ZnO, ITZO, etc.

**[0109]** If the second electrode EL**2** is the transflective electrode or the reflective electrode, the second electrode EL**2** may include Ag, Mg, Cu, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, LiF/Ca, LiF/Al, Mo, Ti, a compound including thereof, or a mixture thereof (for example, a mixture of Ag and Mg). The second electrode EL**2** may have a multilayered structure including a reflective layer or a transflective layer formed using the above-described materials and a transparent conductive layer formed using ITO, IZO, ZnO, ITZO, etc.

**[0110]** In an implementation, the second electrode EL**2** may be connected with an auxiliary electrode. If the second electrode EL**2** is connected with the auxiliary electrode, the resistance of the second electrode EL**2** may decrease.

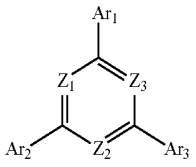
**[0111]** In the organic electroluminescence device **10**, according to the application of a voltage to each of the first electrode EL**1** and second electrode EL**2**, holes injected from the first electrode EL**1** may move via the hole transport region HTR to the emission layer EML, and electrons injected from the second electrode EL**2** may move via the electron transport region ETR to the emission layer EML. The electrons and the holes are recombined in the emission layer EML to produce excitons, and the excitons may emit light via transition from an excited state to a ground state.

**[0112]** If the organic electroluminescence device **10** is a top emission type, the first electrode EL**1** may be a reflective electrode and the second electrode EL**2** may be a transmissive electrode or a transflective electrode. If the organic electroluminescence device **10** is a bottom emission type, the first electrode EL**1** may be a transmissive electrode or a transflective electrode and the second electrode EL**2** may be a reflective electrode.

**[0113]** The organic electroluminescence device **10** according to an embodiment may include the heterocyclic compound represented by Formula 1, and thus, high efficiency and blue emission (e.g., deep blue emission) may be achieved at the same time.

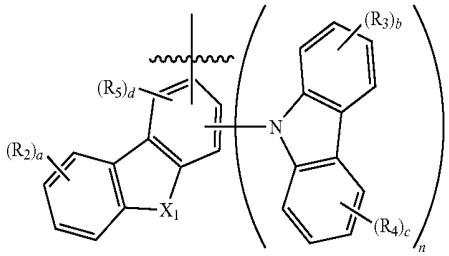
**[0114]** An embodiment provides a heterocyclic compound represented by Formula 1. The above-described explanation on Formula 1 will be applied unless otherwise explained. For example, the heterocyclic compound according to an embodiment may be represented by the following Formula 1.

[Formula 1]




**[0115]** In Formula 1, $Z_1$ to $Z_3$ may each independently be, e.g., $CR_1$ or N. In an implementation, at least one of $Z_1$ to $Z_3$ may be N. In an implementation, $R_1$ may be, e.g., a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. In an implementation, $Ar_1$ to $Ar_3$ may each independently be, e.g., a group represented by Formula 2, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. In an implementation, at least one of $Ar_1$ to $Ar_3$ may be a group represented by Formula 2.

[Formula 2]




**[0116]** In Formula 2, $X_1$ may be, e.g., O or S "n" may be, e.g., an integer of 1 to 3, "a" to "c" may each independently be, e.g., an integer of 0 to 4, and "d" may be, e.g., an integer of 0 to 2. $R_2$ to $R_5$ may each independently be, e.g., a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms. In an implementation, if only one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2, "n" may be 2 or 3. In an implementation, at least one of the carbazole moieties in Formula 2 may be bonded in ortho relationship with respect to the nitrogen-containing monocycle of Formula 1.

**[0117]** In an implementation, the heterocyclic compound according to an embodiment may be a compound of Compound Group 1, above.

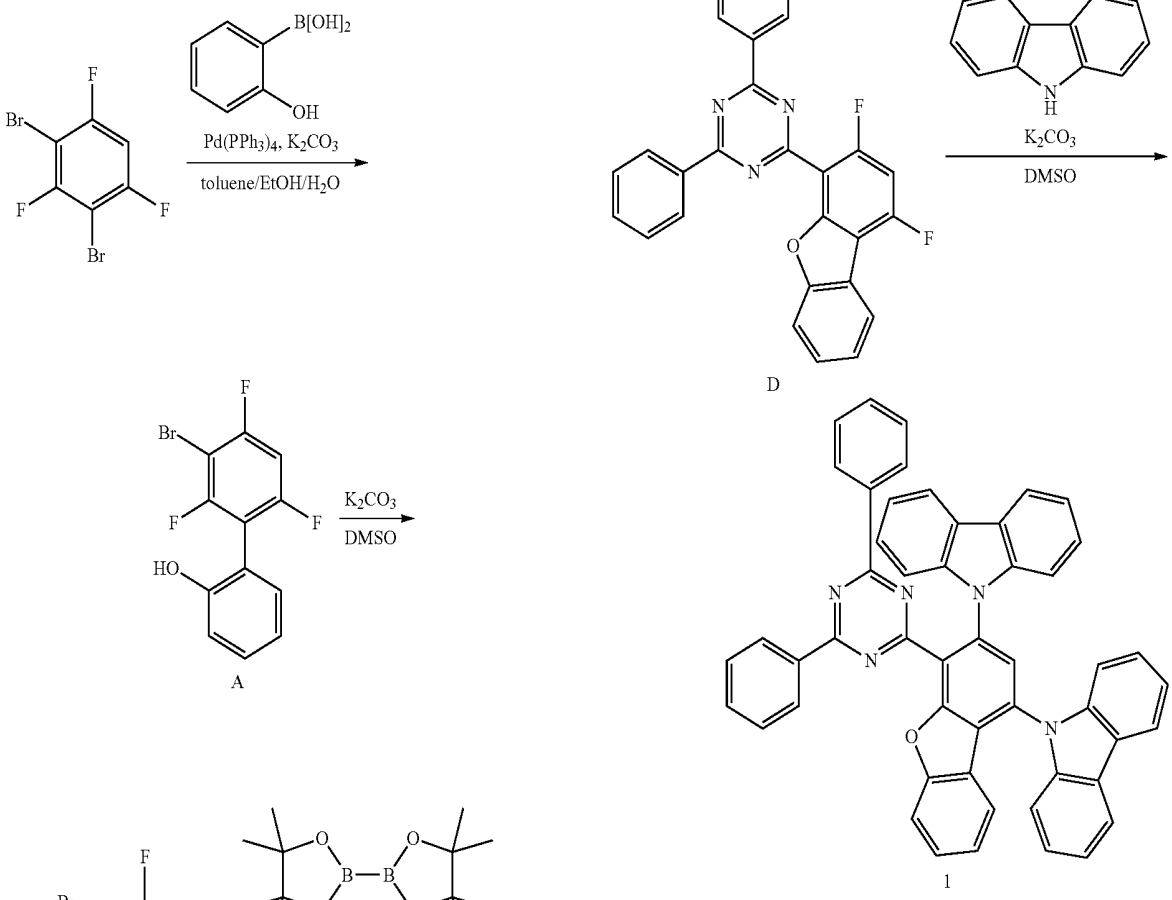
**[0118]** The heterocyclic compound according to an embodiment may have a difference between a singlet energy level and a triplet energy level of about 0.2 eV or less, and as a result, may be used as a material for thermally activated delayed fluorescence. The heterocyclic compound according to an embodiment may be applied as a material for an organic electroluminescence device and may contribute to the increase of efficiency.

**[0119]** The following Examples and Comparative Examples are provided in order to highlight characteristics of one or more embodiments, but it will be understood that the Examples and Comparative Examples are not to be construed as limiting the scope of the embodiments, nor are the Comparative Examples to be construed as being outside the scope of the embodiments. Further, it will be understood that the embodiments are not limited to the particular details described in the Examples and Comparative Examples.

## Synthetic Examples

**[0120]** Heterocyclic compounds according to embodiments may be synthesized, e.g., as follows.

**[0121]** 1. Synthesis of Compound 1




**[0122]** (Synthesis of Intermediate A)

**[0123]** Under an argon (Ar) atmosphere, in a 500 ml, three-neck flask, 2,4-dibromo-1,3,5-trifluorobenzene (10.00 g), (2-hydroxyphenyl)boronic acid (4.76 g), tetrakis(triphenylphosphine)palladium(0) ($Pd(PPh_3)_4$, 1.99 g), and potassium carbonate ($K_2CO_3$, 9.54 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 180 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 8.57 g (yield 82%) of Intermediate A. The molecular weight of Intermediate A measured by FAB-MS was 303.

**[0124]** (Synthesis of Intermediate B)

**[0125]** Under an argon (Ar) atmosphere, in a 300 ml, three-neck flask, Intermediate A (8.50 g) and $K_2CO_3$ (7.75 g) were dissolved in dehydrated DMSO (100 ml), followed by stirring at about 110° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 1,000 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (300 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography and recrystallization to

obtain 3.57 g (yield 45%) of Intermediate B. The molecular weight of Intermediate B measured by FAB-MS was 283.

**[0126]** (Synthesis of Intermediate C)

**[0127]** Under an argon (Ar) atmosphere, in a 200 ml, three neck flask, Intermediate B (3.50 g), bis(pinacolato)diboron (3.14 g), [1,1'-bis(diphenylphosphino)ferrocene]dichloropalladium(II) dichloromethane adduct ($PdCl_2$(dppf), 1.01 g), and potassium acetate (KOAc, 2.43 g) were dissolved in dehydrated 1,4-dioxane (70 ml), followed by stirring at about 90° C. for about 8 hours. After cooling in air, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 3.18 g (yield 78%) of Intermediate C. The molecular weight of Intermediate C measured by FAB-MS was 330.

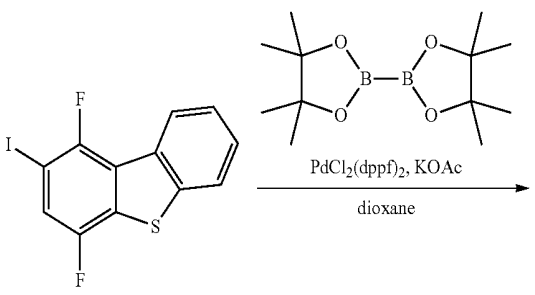
**[0128]** (Synthesis of Intermediate D)

**[0129]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate C (3.00 g), 2-chloro-4,6-diphenyl-1,3,5-triazine (2.43 g), $Pd(PPh_3)_4$ (0.53 g), and tripotassium phosphate ($K_3PO_4$, 3.86 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 60 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 2.85 g (yield 72%) of Intermediate D. The molecular weight of Intermediate D measured by FAB-MS was 435.

**[0130]** (Synthesis of Compound 1)

**[0131]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate D (2.80 g), carbazole (2.15 g), and $K_2CO_3$ (4.45 g) were dissolved in dehydrated DMSO (30 ml), followed by stirring at about 150° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (150 ml), and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 3.75 g (yield 80%) of Compound 1. The molecular weight of Compound 1 measured by FAB-MS was 729.

**[0132]** 2. Synthesis of Compound 24

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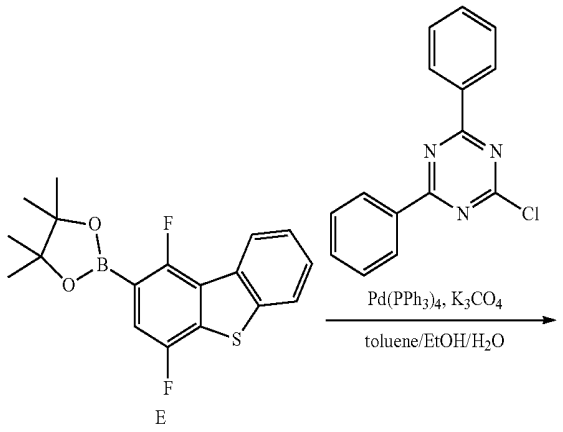
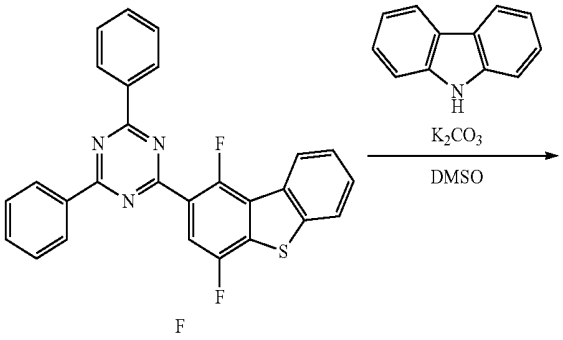
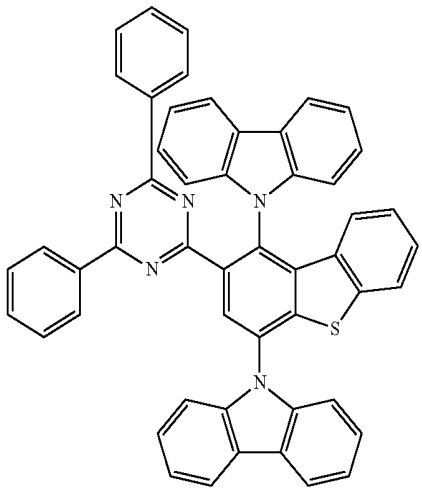



E




F




24

**[0133]** (Synthesis of Intermediate E)

**[0134]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, 1,4-difluoro-2-iododibenzo[b,d]thiophene (5.00 g), bis(pinacolato)diboron (3.66 g), $PdCl_2$(dppf) (1.18 g), and KOAc (2.84 g) were dissolved in dehydrated 1,4-dioxane (80 ml), followed by stirring at about 90° C. for about 8 hours. After cooling in the air, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Then, solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 3.10 g (yield 62%) of Intermediate E. The molecular weight of Intermediate E measured by FAB-MS was 346.

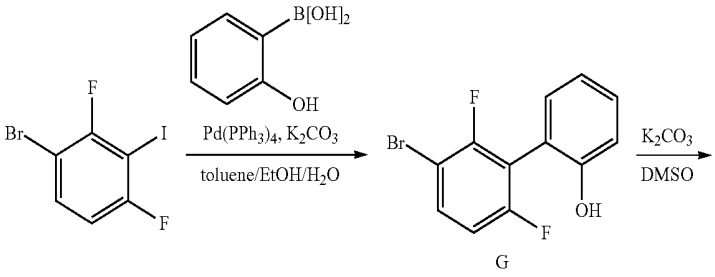
**[0135]** (Synthesis of Intermediate F)

**[0136]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate E (3.00 g), 2-chloro-4,6-diphenyl-1,3,5-triazine (2.32 g), $Pd(PPh_3)_4$ (0.50 g), and $K_3PO_4$ (3.68 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 50 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 2.74 g (yield 70%) of Intermediate F. The molecular weight of Intermediate F measured by FAB-MS was 451.

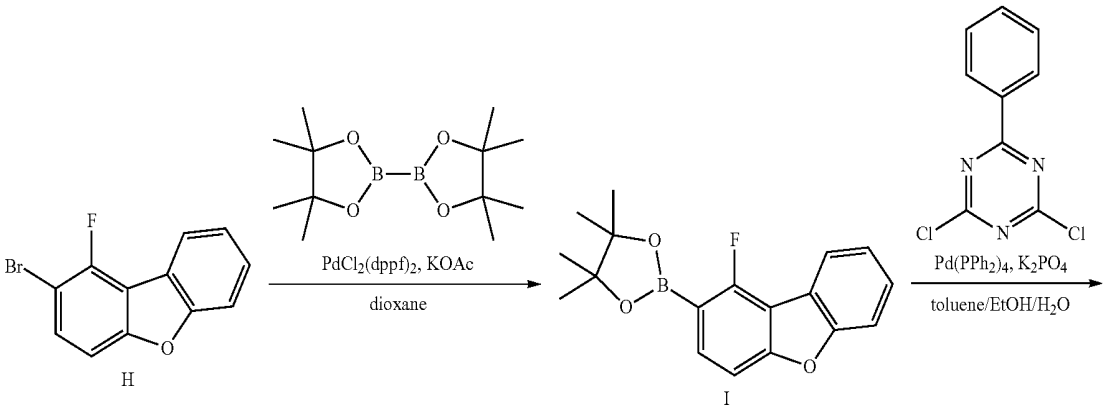
**[0137]** (Synthesis of Compound 24)

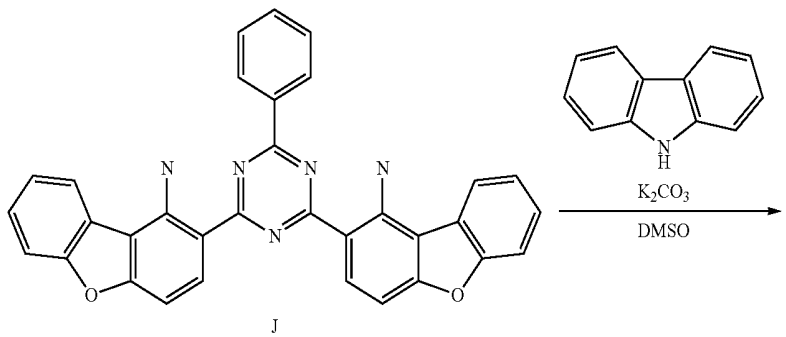
**[0138]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate F (2.70 g), carbazole (2.61 g), and $K_2CO_3$ (5.39 g) were dissolved in dehydrated DMSO (30 ml), followed by stirring at about 150° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (150 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 4.94 g (yield 85%) of Compound 24. The molecular weight of Compound 24 measured by FAB-MS was 745.

**[0139]** 3. Synthesis of Compound 107




G




J

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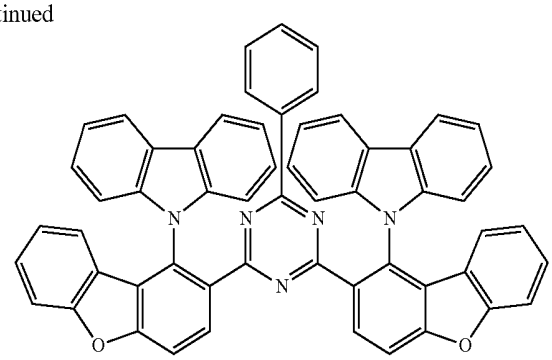


107

**[0140]** (Synthesis of Intermediate G)

**[0141]** Under an argon (Ar) atmosphere, in a 500 ml, three-neck flask, 1-bromo-2,4-difluoro-3-iodobenzene (10.00 g), (2-hydroxyphenyl)boronic acid (4.33 g), $Pd(PPh_3)_4$ (1.81 g), and $K_2CO_3$ (8.69 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 160 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 7.69 g (yield 86%) of Intermediate G. The molecular weight of Intermediate G measured by FAB-MS was 285.

**[0142]** (Synthesis of Intermediate H)

**[0143]** Under an argon (Ar) atmosphere, in a 300 ml, three-neck flask, Intermediate G (7.60 g) and $K_2CO_3$ (7.37 g) were dissolved in dehydrated DMSO (100 ml), followed by stirring at about 110° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 1,000 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (300 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography and recrystallization to obtain 2.69 g (yield 38%) of Intermediate H. The molecular weight of Intermediate H measured by FAB-MS was 265.

**[0144]** (Synthesis of Intermediate 1)

**[0145]** Under an argon (Ar) atmosphere, in a 200 ml, three neck flask, Intermediate H (2.60 g), bis(pinacolato)diboron (2.49 g), $PdCl_2(dppf)$ (0.80 g), and KOAc (1.93 g) were dissolved in dehydrated 1,4-dioxane (50 ml), followed by stirring at about 90° C. for about 8 hours. After cooling in air, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 1.84 g (yield 60%) of Intermediate I. The molecular weight of Intermediate I measured by FAB-MS was 312.

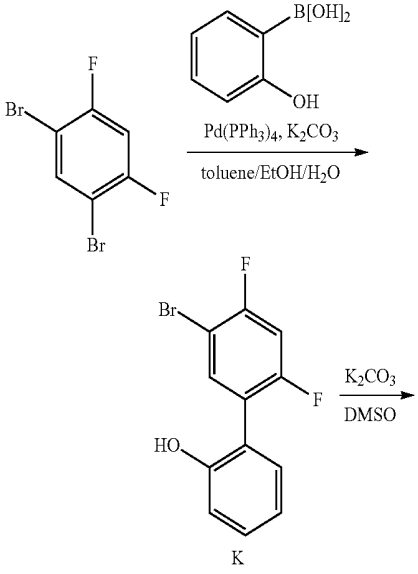
**[0146]** (Synthesis of Intermediate J)

**[0147]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate I (3.00 g), 2,4-dichloro-6-phenyl-1,3,5-triazine (0.65 g), $Pd(PPh_3)_4$ (0.33 g), and $K_3PO_4$ (2.45 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 50 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 2.27 g (yield 75%) of Intermediate J. The molecular weight of Intermediate J measured by FAB-MS was 525.

**[0148]** (Synthesis of Compound 107)

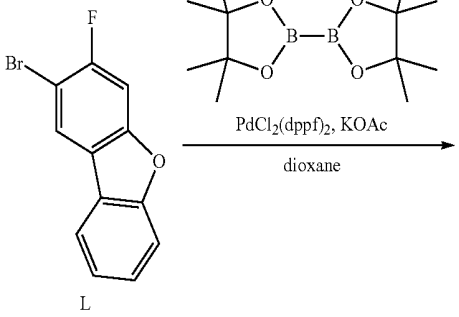
**[0149]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate J (2.20 g), carbazole (1.40 g), and $K_2CO_3$ (2.89 g) were dissolved in dehydrated DMSO (30 ml), followed by stirring at about 150° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (150 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 2.75 g (yield 80%) of Compound 107. The molecular weight of Compound 107 measured by FAB-MS was 819.

**[0150]** 4. Synthesis of Compound 109

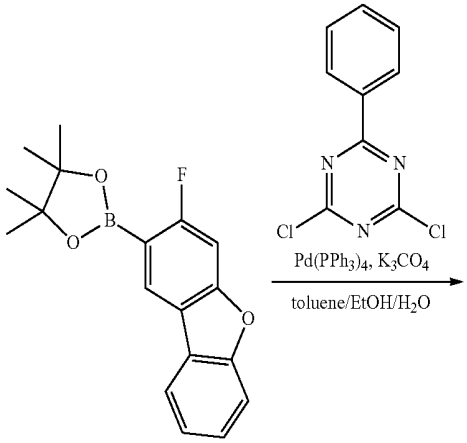



K

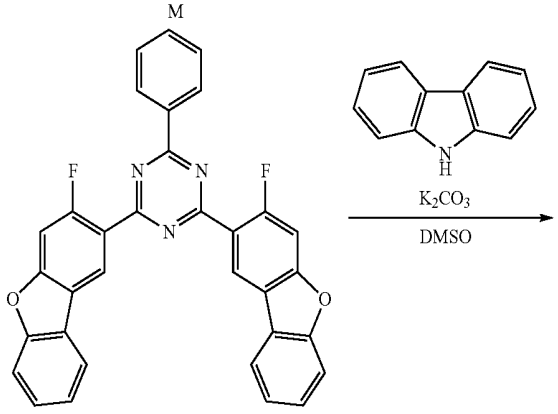
-continued



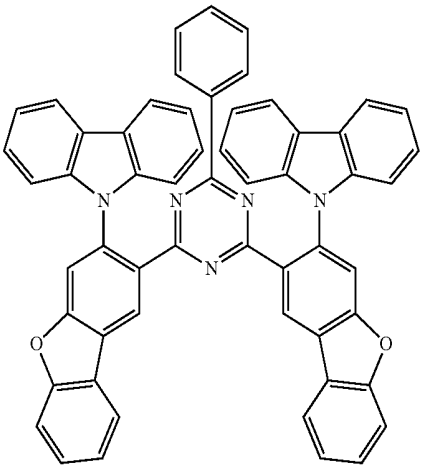

L




M




N




109

**[0151]** (Synthesis of Intermediate K)

**[0152]** Under an argon (Ar) atmosphere, in a 500 ml, three-neck flask, 1,5-dibromo-2,4-difluorobenzene (10.00 g), (2-hydroxyphenyl)boronic acid (5.07 g), $Pd(PPh_3)_4$ (2.13 g), and $K_2CO_3$ (10.17 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 180 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 8.91 g (yield 85%) of Intermediate K. The molecular weight of Intermediate K measured by FAB-MS was 285.

**[0153]** (Synthesis of Intermediate L)

**[0154]** Under an argon (Ar) atmosphere, in a 300 ml, three-neck flask, Intermediate K (8.90 g) and $K_2CO_3$ (8.63 g) were dissolved in dehydrated DMSO (100 ml), followed by stirring at about 110° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 1,000 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (300 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography and recrystallization to obtain 7.20 g (yield 87%) of Intermediate L. The molecular weight of Intermediate L measured by FAB-MS was 265.

**[0155]** (Synthesis of Intermediate M)

**[0156]** Under an argon (Ar) atmosphere, in a 500 ml, three neck flask, Intermediate L (7.20 g), bis(pinacolato)diboron (6.89 g), $PdCl_2(dppf)$ (2.22 g), and KOAc (5.33 g) were dissolved in dehydrated 1,4-dioxane (140 ml), followed by stirring at about 90° C. for about 8 hours. After cooling in air, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 4.41 g (yield 52%) of Intermediate M. The molecular weight of Intermediate M measured by FAB-MS was 312.

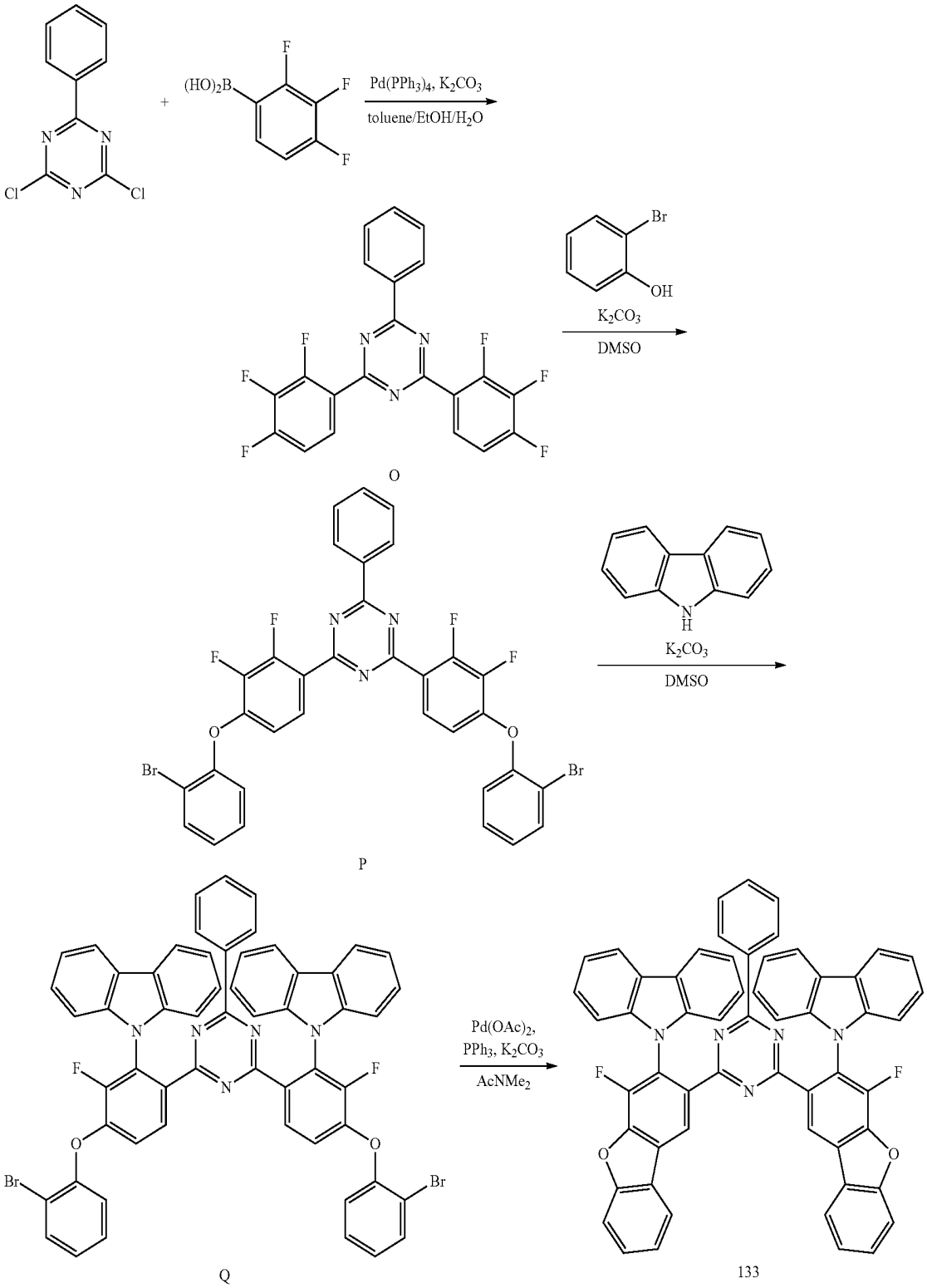
**[0157]** (Synthesis of Intermediate N)

**[0158]** Under an argon (Ar) atmosphere, in a 300 ml, three-neck flask, Intermediate M (4.40 g), 2,4-dichloro-6-phenyl-1,3,5-triazine (1.59 g), $Pd(PPh_3)_4$, (0.81 g), and $K_3PO_4$ (5.98 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 70 ml), followed by stirring at about 80° C. for about 10 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by silica gel column chromatography to obtain 5.04 g (yield 68%) of Intermediate N. The molecular weight of Intermediate N measured by FAB-MS was 525.

**[0159]** (Synthesis of Compound 109)

**[0160]** Under an argon (Ar) atmosphere, in a 200 ml, three-neck flask, Intermediate N (2.50 g), carbazole (1.59 g), and $K_2CO_3$ (3.28 g) were dissolved in dehydrated DMSO (30 ml), followed by stirring at about 150° C. for about 6 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (150 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 3.08 g (yield 79%) of Compound 109. The molecular weight of Compound 109 measured by FAB-MS was 819.

**[0161]** 5. Synthesis of Compound 133




**[0162]** (Synthesis of Intermediate O)

**[0163]** Under an argon (Ar) atmosphere, in a 500 ml, three-neck flask, 2,4-dichloro-6-phenyl-1,3,5-triazine (5.00 g), 2,3,4-trifluorophenylboronic acid (7.78 g), $Pd(PPh_3)_4$ (2.55 g), and $K_2CO_3$ (12.2 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 200 ml), followed by stirring at about 80° C. for about 8 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pres-

sure. The crude product thus obtained was separated by recrystallization to obtain 4.24 g (yield 46%) of Intermediate O. The molecular weight of Intermediate O measured by FAB-MS was 417.

**[0164]** (Synthesis of Intermediate P)

**[0165]** Under an argon (Ar) atmosphere, in a 500 ml, three-neck flask, Intermediate O (4.00 g), 2-bromophenol (3.32 g), and $K_2CO_3$ (5.30 g) were dissolved in dehydrated DMSO (150 ml), followed by stirring at about 60° C. for about 3 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 1,000 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (300 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 4.15 g (yield 60%) of Intermediate P. The molecular weight of Intermediate P measured by FAB-MS was 723.

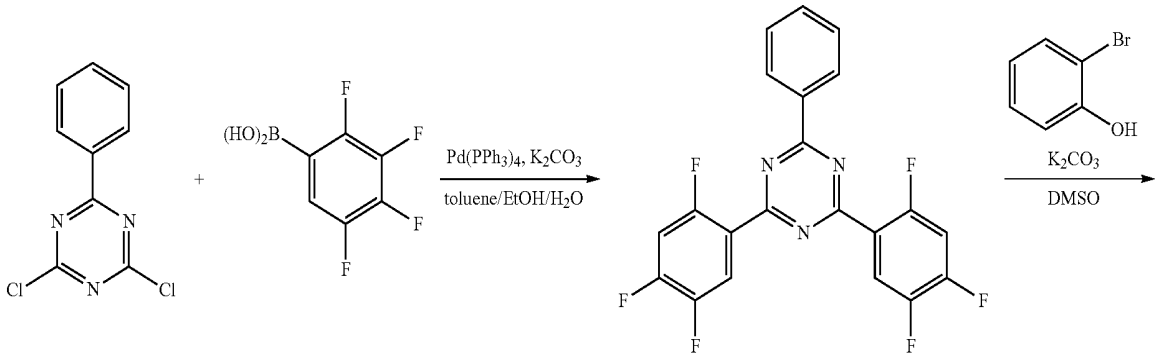
**[0166]** (Synthesis of Intermediate Q)

**[0167]** Under an Ar atmosphere, in a 300 ml, three-neck flask, Intermediate P (4.00 g), carbazole (1.85 g), and $K_2CO_3$ (3.06 g) were dissolved in dehydrated DMSO (50 ml), followed by stirring at about 100° C. for about 3 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 5.34 g (yield 95%) of Intermediate Q. The molecular weight of Intermediate Q measured by FAB-MS was 1,017.

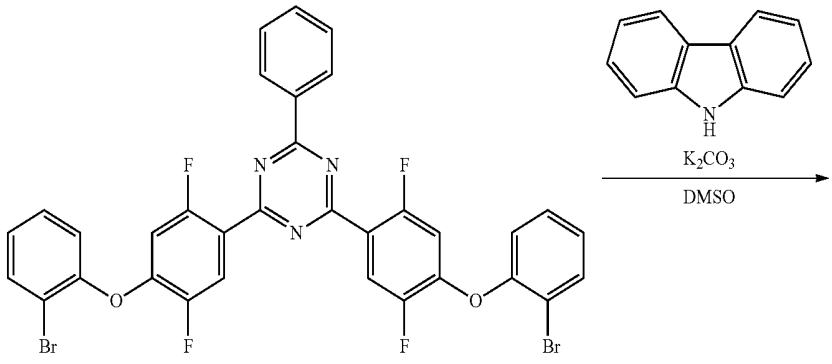
**[0168]** (Synthesis of Compound 133)

**[0169]** Under an Ar atmosphere, in a 500 ml, three-neck flask, Intermediate Q (5.00 g), $Pd(OAc)_2$ (0.11 g), $K_2CO_3$ (2.04 g), and $PPh_3$ (0.26 g) were dissolved in dehydrated dimethylacetamide (50 ml), followed by stirring at about 140° C. for about 1 hour. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 3.36 g (yield 80%) of Compound 133. The molecular weight of Compound 133 measured by FAB-MS was 855.

**[0170]** 6. Synthesis of Compound 131




R




S

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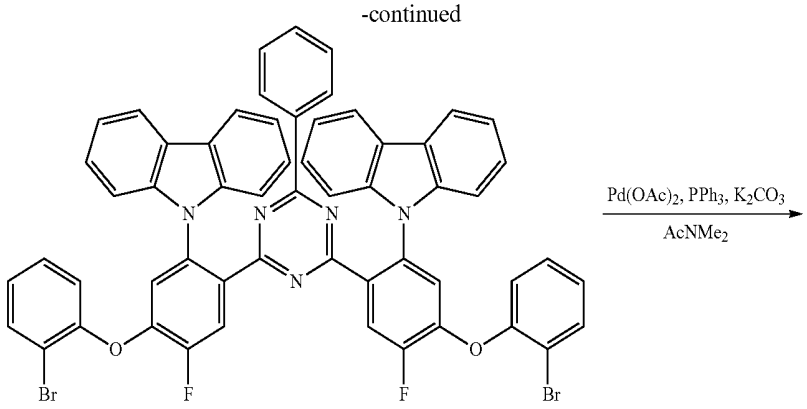
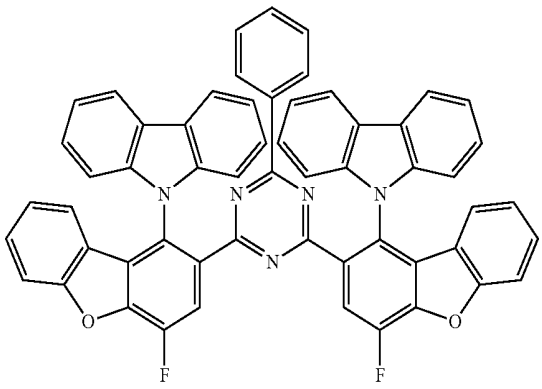



T




131

**[0171]** (Synthesis of Intermediate R)

**[0172]** Under an Ar atmosphere, in a 500 ml, three-neck flask, 2,4-dichloro-6-phenyl-1,3,5-triazine (5.00 g), 2,4,5-trifluorophenylboronic acid (7.78 g), $Pd(PPh_3)_4$ (2.55 g), and $K_2CO_3$ (12.2 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 200 ml), followed by stirring at about 80° C. for about 8 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 4.80 g (yield 52%) of Intermediate R. The molecular weight of Intermediate R measured by FAB-MS was 417.

**[0173]** (Synthesis of Intermediate S)

**[0174]** Under an Ar atmosphere, in a 500 ml, three-neck flask, Intermediate R (4.00 g), 2-bromophenol (3.32 g), and $K_2CO_3$ (5.30 g) were dissolved in dehydrated DMSO (150 ml), followed by stirring at about 60° C. for about 3 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 1,000 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (300 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 4.51 g (yield 65%) of Intermediate S. The molecular weight of Intermediate S measured by FAB-MS was 723.

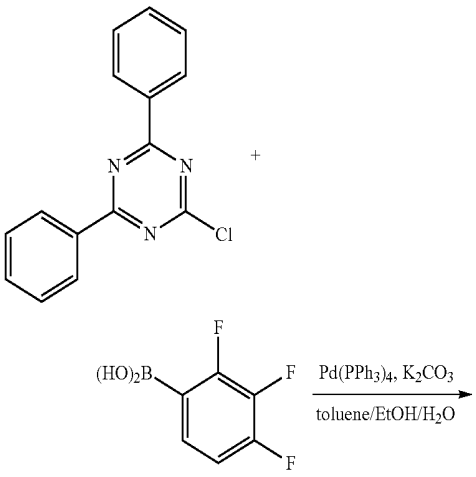
**[0175]** (Synthesis of Intermediate T)

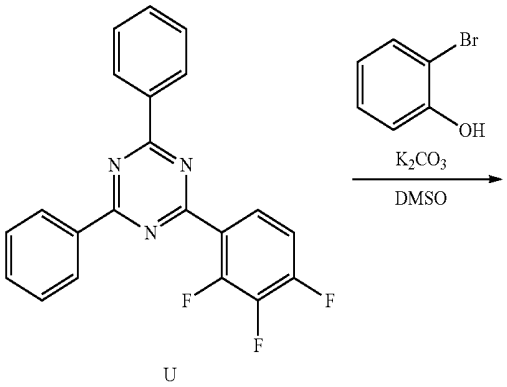
**[0176]** Under an Ar atmosphere, in a 300 ml, three-neck flask, Intermediate S (4.00 g), carbazole (1.85 g), and $K_2CO_3$ (3.06 g) were dissolved in dehydrated DMSO (50 ml), followed by stirring at about 100° C. for about 3 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 5.06 g (yield 90%) of Intermediate T. The molecular weight of Intermediate T measured by FAB-MS was 1,017.

**[0177]** (Synthesis of Compound 131)

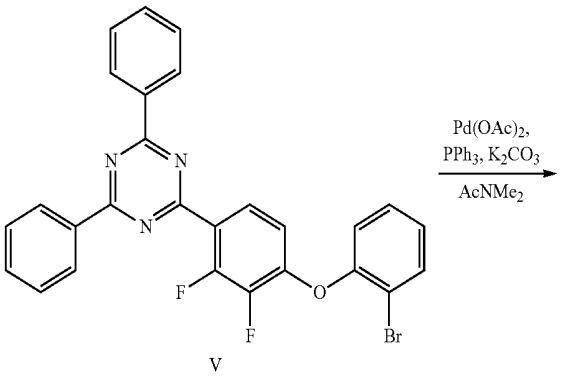
**[0178]** Under an Ar atmosphere, in a 500 ml, three-neck flask, Intermediate T (5.00 g), $Pd(OAc)_2$ (0.11 g), $K_2CO_3$ (2.04 g), and $PPh_3$ (0.26 g) were dissolved in dehydrated dimethylacetamide (50 ml), followed by stirring at about 140° C. for about 1 hour. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was isolated by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 3.45 g (yield 82%) of Compound 131. The molecular weight of Compound 131 measured by FAB-MS was 855.

**[0179]** 7. Synthesis of Compound 23

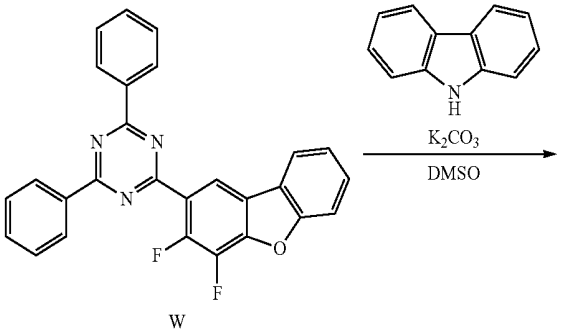



U




V




W

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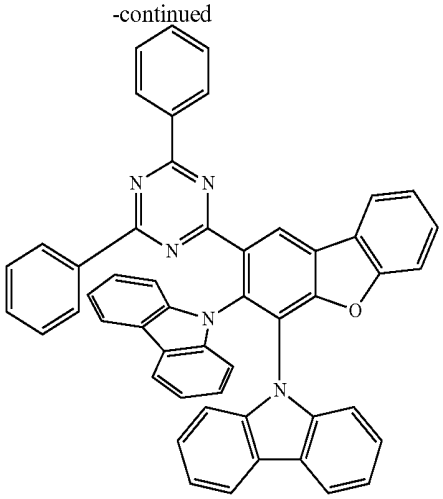


23

**[0180]** (Synthesis of Intermediate U)

**[0181]** Under an Ar atmosphere, in a 300 ml, three-neck flask, 2-chloro-4,6-diphenyl-1,3,5-triazine (5.00 g), 2,3,4-trifluorophenylboronic acid (3.29 g), $Pd(PPh_3)_4$ (1.08 g), and $K_2CO_3$ (5.16 g) were dissolved in a mixed solvent of degassed toluene/ethanol/water (10:1:2, 100 ml), followed by stirring at about 80° C. for about 8 hours. After finishing the reaction, water was added, and organic layers extracted with $CH_2Cl_2$ were collected and dried with $MgSO_4$. Solvents were distilled off under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 4.07 g (yield 60%) of Intermediate U. The molecular weight of Intermediate U measured by FAB-MS was 363.

**[0182]** (Synthesis of Intermediate V)

**[0183]** Under an Ar atmosphere, in a 500 ml, three-neck flask, Intermediate U (4.00 g), 2-bromophenol (1.90 g), and $K_2CO_3$ (3.80 g) were dissolved in dehydrated DMSO (50 ml), followed by stirring at about 60° C. for about 3 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 4.09 g (yield 72%) of Intermediate V. The molecular weight of Intermediate V measured by FAB-MS was 516.

**[0184]** (Synthesis of Intermediate W)

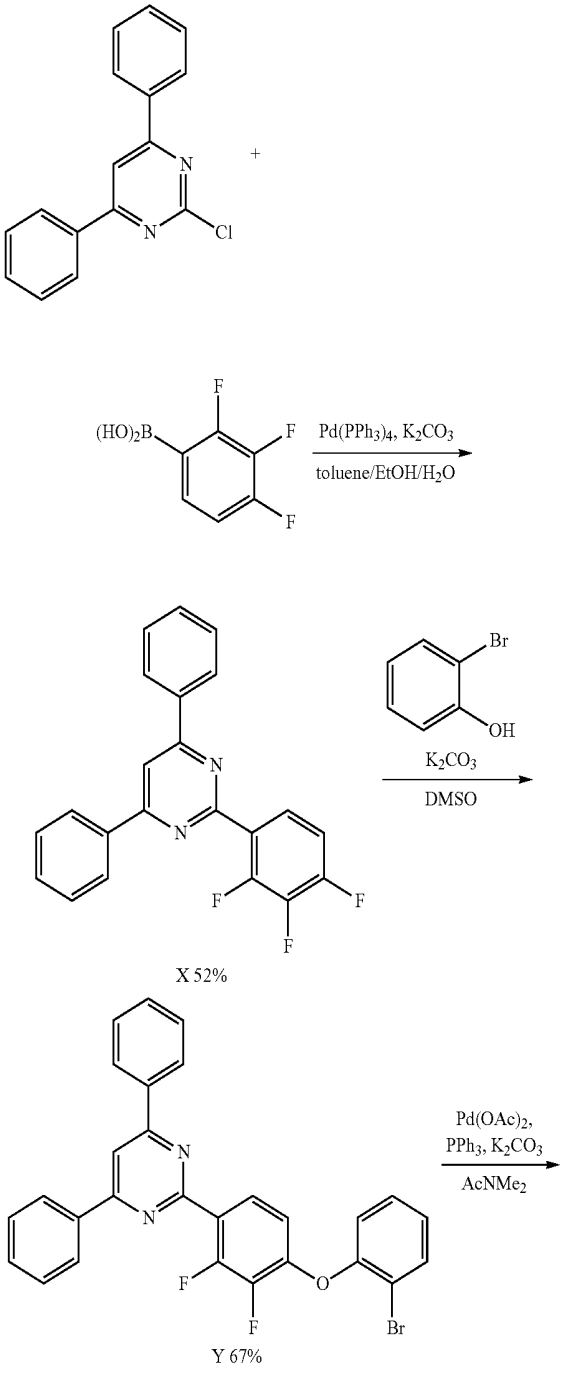
**[0185]** Under an Ar atmosphere, in a 500 ml, three-neck flask, Intermediate V (4.00 g), $Pd(OAc)_2$ (0.08 g), $K_2CO_3$ (1.61 g), and $PPh_3$ (0.20 g) were dissolved in dehydrated dimethylacetamide (40 ml), followed by stirring at about 140° C. for about 1 hour. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 2.36 g (yield 70%) of Intermediate W. The molecular weight of Intermediate W measured by FAB-MS was 435.

**[0186]** (Synthesis of Compound 23)

**[0187]** Under an Ar atmosphere, in a 300 ml, three-neck flask, Intermediate W (2.00 g), carbazole (1.54 g), and

$K_2CO_3$ (3.17 g) were dissolved in dehydrated DMSO (30 ml), followed by stirring at about 180° C. for about 8 hours. After decreasing the temperature to ambient temperature, the reaction solution was poured into 300 ml of water and stirred. The precipitate thus produced was recovered by suction filtration, dissolved in $CH_2Cl_2$ (200 ml) and dried with $MgSO_4$, and solvents were removed by distillation under a reduced pressure. The crude product thus obtained was separated by recrystallization to obtain 1.94 g (yield 58%) of Compound 23. The molecular weight of Compound 23 measured by FAB-MS was 729.

**[0188]** 8. Synthesis of Compound 29

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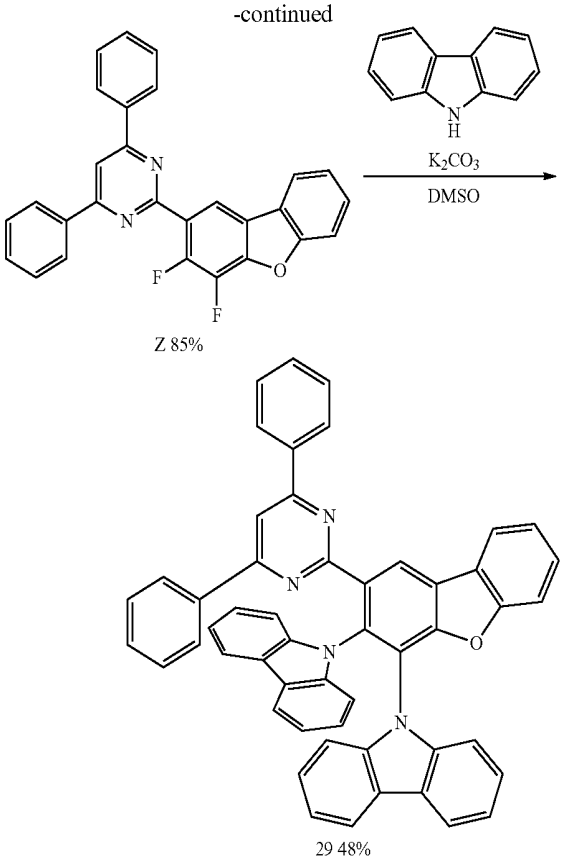



**[0189]** Compound 29 was synthesized by conducting the same procedure for synthesizing Compound 23 except for using 2-chloro-4,6-diphenylpyrimidine instead of 2-chloro-4,6-diphenyl-1,3,5-triazine.

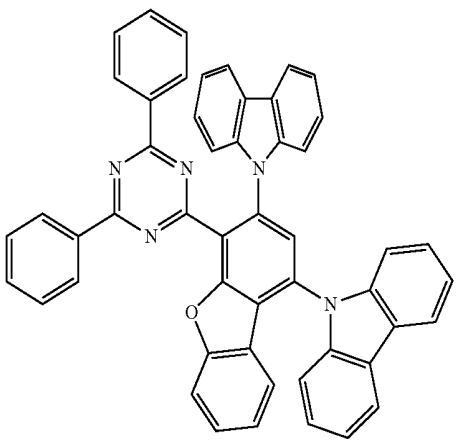
Device Manufacturing Examples

**[0190]** Organic electroluminescence devices of Examples 1 to 4 were manufactured using Compounds 1, 24, 107 and 109 as dopant materials for an emission layer.

Example Compounds

**[0191]**

1



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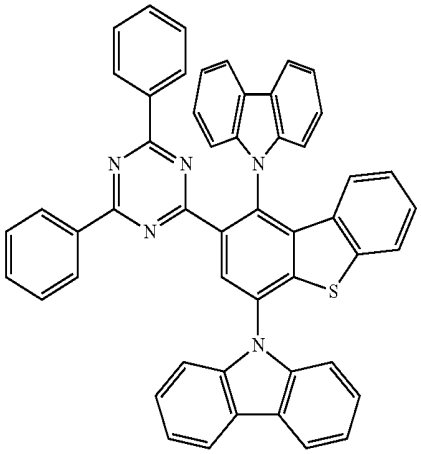
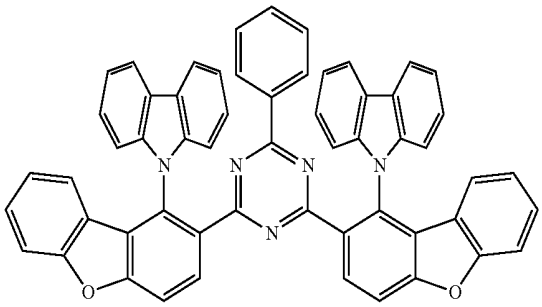
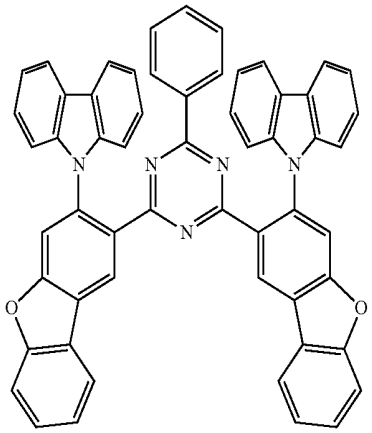
24



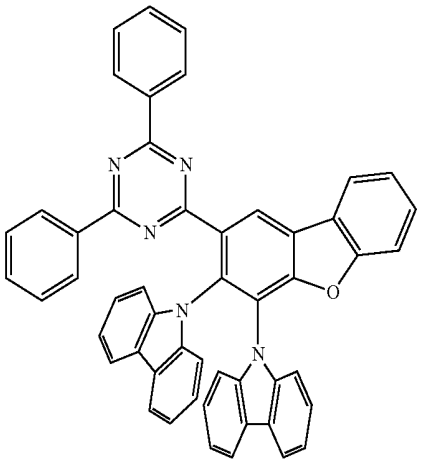
107



109



23



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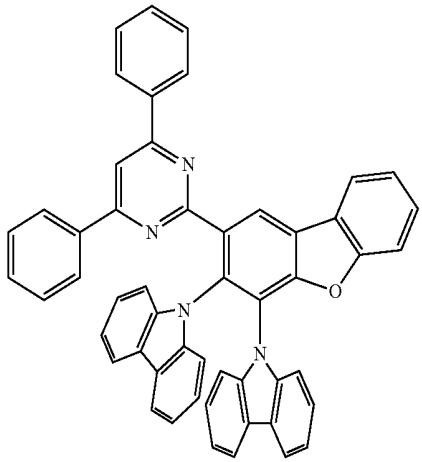
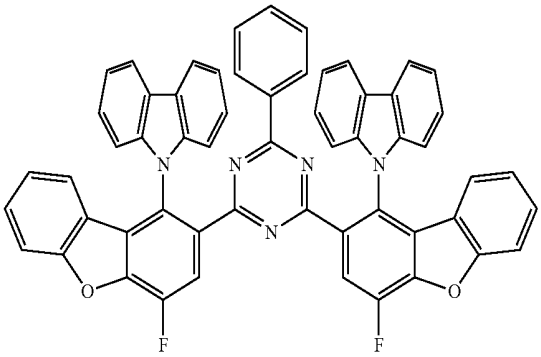
29



131



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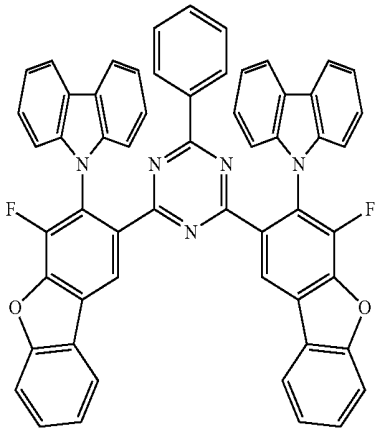
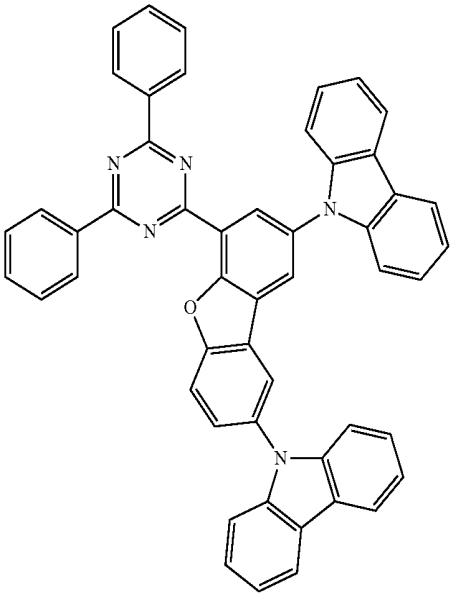


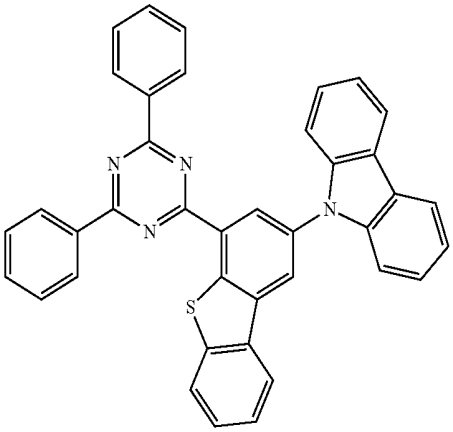
**[0192]** Using Compounds X-1 to X-3 below as dopant materials for an emission layer, organic electroluminescence devices of Comparative Examples 1 to 3 were manufactured.

**[0193]** [Comparative Compounds]

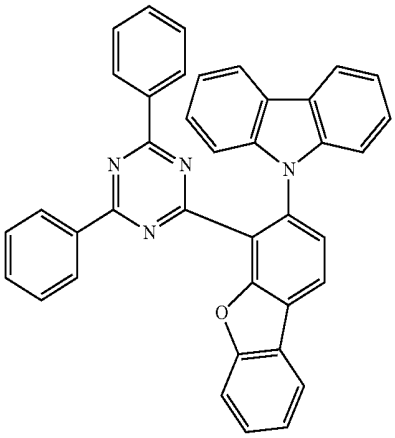
X-1



X-2



X-3



**[0194]** S1 level and T1 level of the Example Compounds and the Comparative Compounds were calculated by a non-empirical molecular orbital method. Particularly, the calculation was conducted using B3LYP as a functional, and 6-31G(d) as a basis function by using Gaussian09 of Gaussian Co. The results are shown in Table 1 below. $\Delta E_{ST}$ represents the difference between a singlet energy level and a triplet energy level.

TABLE 1

| | S1 energy level (eV) | T1 energy level (eV) | $\Delta E_{ST}$ |
|---|---|---|---|
| Example Compound 1 | 2.84 | 2.75 | 0.11 |
| Example Compound 24 | 2.97 | 2.87 | 0.10 |
| Example Compound 107 | 2.97 | 2.90 | 0.07 |
| Example Compound 109 | 2.96 | 2.87 | 0.09 |
| Example Compound 23 | 2.91 | 2.81 | 0.10 |
| Example Compound 29 | 3.01 | 2.90 | 0.11 |
| Example Compound 131 | 2.92 | 2.85 | 0.07 |
| Example Compound 133 | 2.89 | 2.81 | 0.08 |
| Comparative Compound X-1 | 2.76 | 2.58 | 0.18 |
| Comparative Compound X-2 | 2.75 | 2.56 | 0.19 |
| Comparative Compound X-3 | 2.89 | 2.74 | 0.15 |

**[0195]** Referring to the results of Table 1, all Example Compounds exhibited low $\Delta E_{ST}$ values and are thought to be appropriately used as materials for thermally activated delayed fluorescence. The Comparative Compounds exhibited relatively high $\Delta E_{ST}$ values, and are not thought to be appropriately used as materials for thermally activated delayed fluorescence.

**[0196]** Each of the organic electroluminescence devices of Examples 1 to 8 and Comparative Examples 1 to 3 was manufactured by forming a first electrode using ITO to a thickness of about 150 nm, a hole injection layer using HAT-CN to a thickness of about 10 nm, a hole transport layer using NPB to a thickness of about 80 nm, an electron blocking layer using mCP to a thickness of about 5 nm, an emission layer using DPEPO doped with 18% of the Example Compound or the Comparative Compound to a thickness of about 20 nm, a hole blocking layer using DPEPO to a thickness of about 10 nm, an electron transport layer using TPBi to a thickness of about 30 nm, an electron injection layer using LiF to a thickness of about 0.5 nm, and a second electrode using Al to a thickness of about 100 nm. Each layer was formed by a deposition method in vacuum.

**[0197]** The maximum emission wavelength (e.g., wavelength of maximum emission) and external quantum efficiency of each of the organic electroluminescence devices according to Examples 1 to 8 and Comparative Examples 1 to 3 were measured and are shown in Table 2 below. EQE in Table 2 means values at about 10 mA/cm$^2$. For the evaluation of the emission properties of the organic electroluminescence devices thus manufactured, a luminous brightness measurement apparatus, C9920-11 of HAMAMATSU Photonics Co. was used.

TABLE 2

| | Emission layer dopant material | $\lambda_{max}$ (nm) | EQE (%) |
|---|---|---|---|
| Example 1 | Example Compound 1 | 470 | 9 |
| Example 2 | Example Compound 24 | 463 | 11 |
| Example 3 | Example Compound 107 | 459 | 14 |
| Example 4 | Example Compound 109 | 461 | 13 |
| Example 5 | Example Compound 23 | 460 | 13 |
| Example 6 | Example Compound 29 | 452 | 10 |
| Example 7 | Example Compound 131 | 464 | 15 |
| Example 8 | Example Compound 133 | 462 | 14 |

TABLE 2-continued

| | Emission layer dopant material | $\lambda_{max}$ (nm) | EQE (%) |
|---|---|---|---|
| Comparative Example 1 | Comparative Compound X-1 | 474 | 5 |
| Comparative Example 2 | Comparative Compound X-2 | 472 | 2 |
| Comparative Example 3 | Comparative Compound X-3 | 466 | 3 |

**[0198]** Referring to the results of Table 2, Examples 1 to 8 exhibited increased efficiency when compared with Comparative Examples 1 to 3. These results were thought to be obtained because an azine group functioned an electron acceptor and a carbazole group functioned an electron donor in the example compounds, and the Example Compounds showed the properties of a material for thermally activated delayed fluorescence. Further, the azine group and the carbazole group were bonded in an ortho relationship, and the electron acceptor and the electron donor were twisted, HOMO and LUMO were efficiently separated, and the properties of a material for thermally activated delayed fluorescence were shown.

**[0199]** Meanwhile, in Comparative Example 1, since an azine group and a carbazolyl group were not bonded in ortho relationship, the donor and the acceptor were insufficiently twisted, and TADF was not shown. In Comparative Examples 2 and 3, $\Delta E_{ST}$ values were relatively large and only one carbazole group was included. Thus, the function of an electron donor was weak, reverse intersystem crossing was insufficiently arisen, and the properties as a material for thermally activated delayed fluorescence were now exhibited.

**[0200]** The heterocyclic compound according to an embodiment may be utilized as a dopant of thermally activated delayed fluorescence for emitting deep blue color.

**[0201]** The organic electroluminescence device including the heterocyclic compound according to an embodiment may facilitate emission of deep blue color and may have excellent efficiency at the same time.

**[0202]** The organic electroluminescence device according to an embodiment may have excellent efficiency.

**[0203]** The heterocyclic compound according to an embodiment may be applied to an organic electroluminescence device and may contribute to high efficiency.

**[0204]** Example embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. In some instances, as would be apparent to one of ordinary skill in the art as of the filing of the present application, features, characteristics, and/or elements described in connection with a particular embodiment may be used singly or in combination with features, characteristics, and/or elements described in connection with other embodiments unless otherwise specifically indicated. Accordingly, it will be understood by those of skill in the art that various changes in form and details may be made without departing from the spirit and scope of the present invention as set forth in the following claims.

What is claimed is:

**1**. An organic electroluminescence device, comprising:

a first electrode;

a hole transport region on the first electrode;

an emission layer on the hole transport region;

an electron transport region on the emission layer; and

a second electrode on the electron transport region,

wherein:

the emission layer includes a heterocyclic compound that includes a nitrogen-containing monocycle, at least one linker, and two or more carbazole moieties,

the at least one linker is a substituted or unsubstituted dibenzofuran group or a substituted or unsubstituted dibenzothiophene group, and

at least one of the carbazole moieties and the nitrogen-containing monocycle are bonded to the at least one linker in an ortho relationship.

**2**. The organic electroluminescence device as claimed in claim **1**, wherein the nitrogen-containing monocycle is a substituted or unsubstituted pyridine group, a substituted or unsubstituted pyrimidine group, or a substituted or unsubstituted triazine group.

**3**. The organic electroluminescence device as claimed in claim **1**, wherein the heterocyclic compound includes one or two linkers.

**4**. The organic electroluminescence device as claimed in claim **1**, wherein the nitrogen-containing monocycle is substituted with at least one substituted or unsubstituted phenyl group.

**5**. The organic electroluminescence device as claimed in claim **1**, wherein:

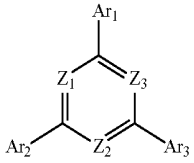
the emission layer includes a host and a dopant, and

the dopant includes the heterocyclic compound.

**6**. The organic electroluminescence device as claimed in claim **5**, wherein the dopant is a thermally activated delayed fluorescence dopant.

**7**. The organic electroluminescence device as claimed in claim **1**, wherein the heterocyclic compound is represented by the following Formula 1:

[Formula 1]




in Formula 1,

$Z_1$ to $Z_3$ are each independently $CR_1$ or N,

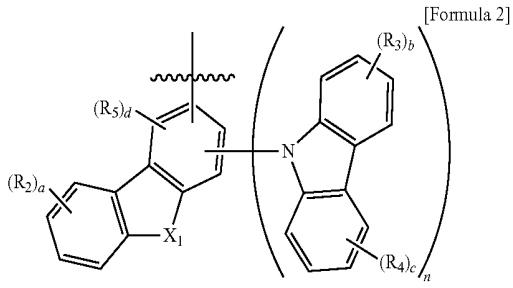
at least one of $Z_1$ to $Z_3$ is N,

$R_1$ is a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

$Ar_1$ to $Ar_3$ are each independently a group represented by the following Formula 2, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, and

at least one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2:

[Formula 2]



in Formula 2,

$X_1$ is O or S,

"n" is an integer of 1 to 3,

"a" to "c" are each independently an integer of 0 to 4,

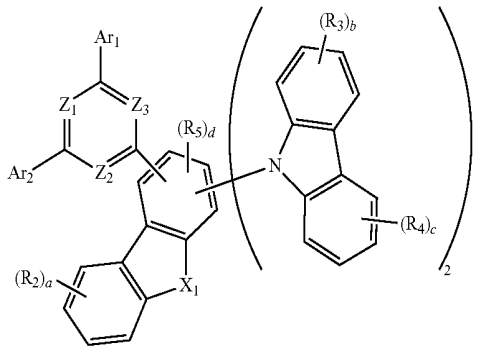
"d" is an integer of 0 to 2, and

$R_2$ to $R_5$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms.

**8**. The organic electroluminescence device as claimed in claim **7**, wherein each of $Z_1$ to $Z_3$ is N.

**9**. The organic electroluminescence device as claimed in claim **7**, wherein the compound represented by Formula 1 is represented by the following Formula 1-1:

[Formula 1-1]



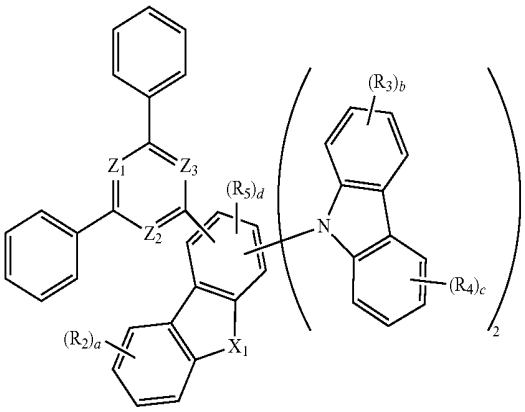
in Formula 1-1,

$Z_1$ to $Z_3$, Art, $Ar_2$, $R_2$ to $R_5$, "a" to "c" and $X_1$ are defined the same as those of Formula 1 and Formula 2, and

"d" is 0 or 1.

**10**. The organic electroluminescence device as claimed in claim **7**, wherein the compound represented by Formula 1 is represented by the following Formula 1-2:

[Formula 1-2]



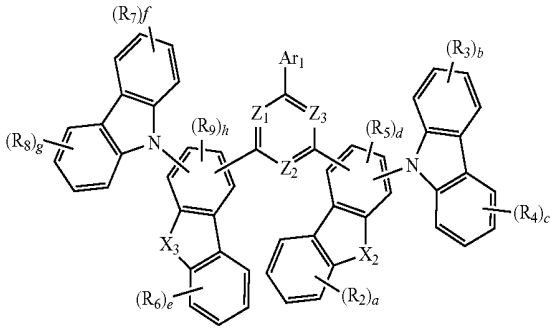
in Formula 1-2,

$Z_1$ to $Z_3$, $R_2$ to $R_5$, "a" to "c" and $X_1$ are defined the same as those of Formula 1 and Formula 2 Formula 2, and

"d" is 0 or 1.

**11**. The organic electroluminescence device as claimed in claim **7**, wherein the compound represented by Formula 1 is represented by the following Formula 1-3:

[Formula 1-3]



in Formula 1-3,

$X_2$ and $X_3$ are each independently 0 or S,

$R_2$ to $R_9$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

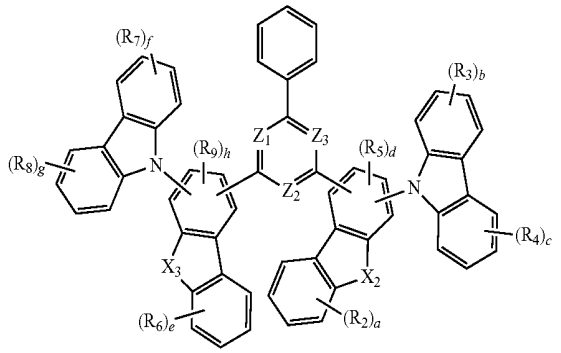
"a" to "c" and "e" to "g" are each independently an integer of 0 to 4,

"d" and "h" are each independently an integer of 0 to 2, and

$Z_1$ to $Z_3$, and $Ar_1$ are defined the same as those of Formula 1.

**12**. The organic electroluminescence device as claimed in claim **7**, wherein the compound represented by Formula 1 is represented by the following Formula 1-4:

[Formula 1-4]



in Formula 1-4,

$X_2$ and $X_3$ are each independently O or S,

$R_2$ to $R_9$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

"a" to "c" and "e" to "g" are each independently an integer of 0 to 4,

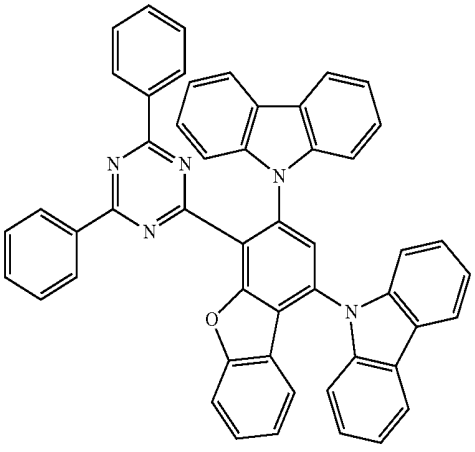
"d" and "h" are each independently an integer of 0 to 2, and

$Z_1$ to $Z_3$ are defined the same as those of Formula 1.

**13**. The organic electroluminescence device as claimed in claim **1**, wherein the heterocyclic compound is a compound of the following Compound Group 1:

[Compound Group 1]

1



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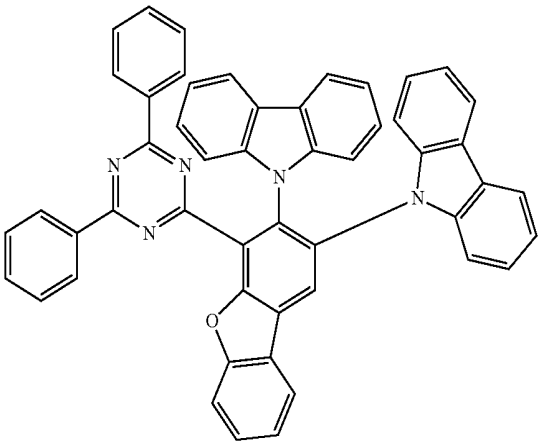

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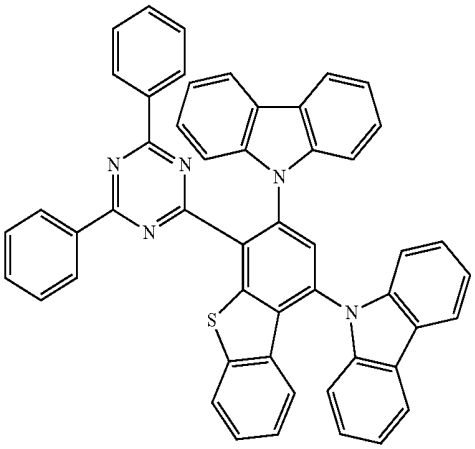

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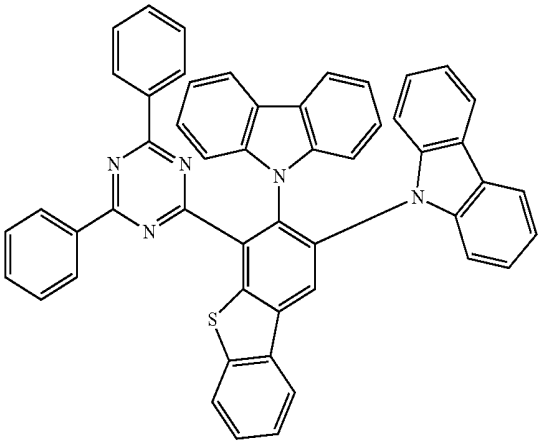

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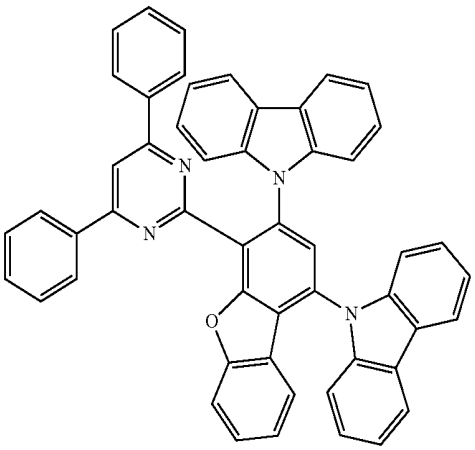

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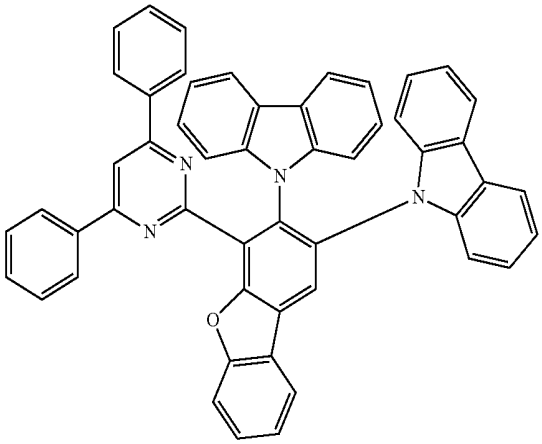

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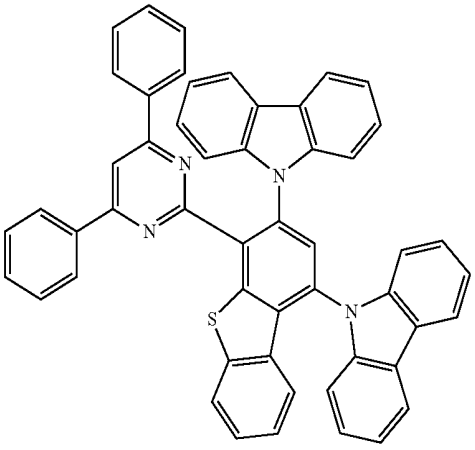

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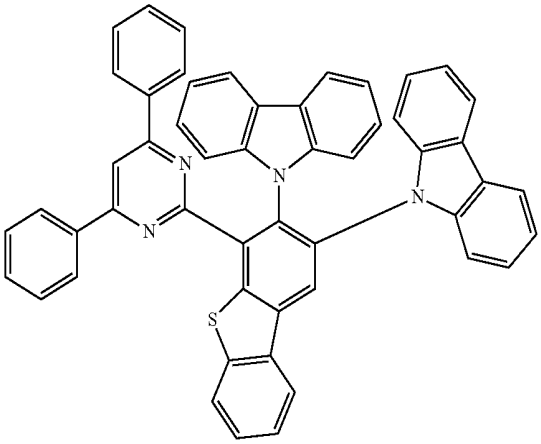

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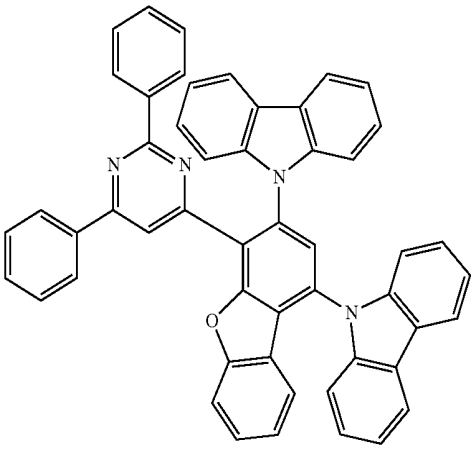

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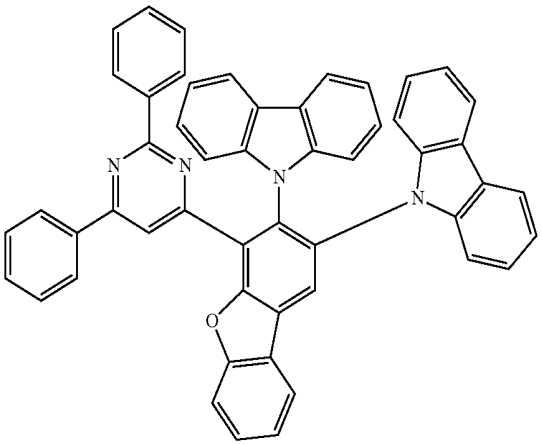

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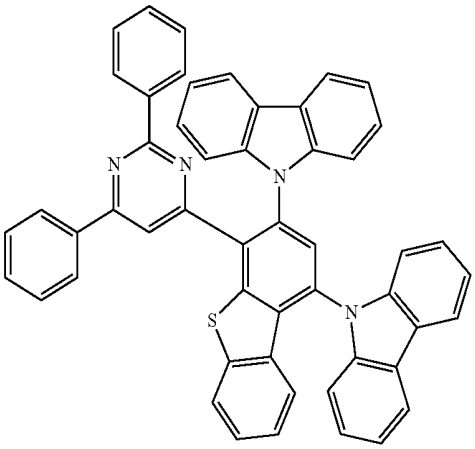

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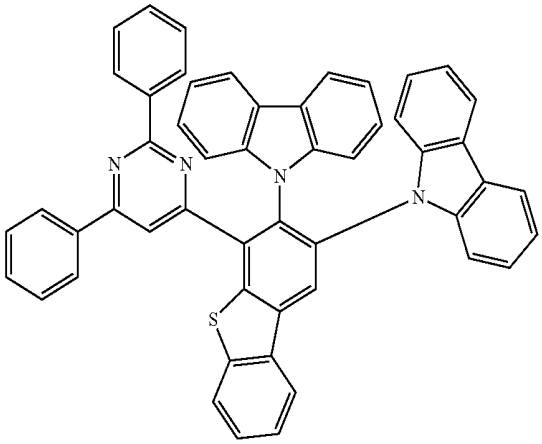

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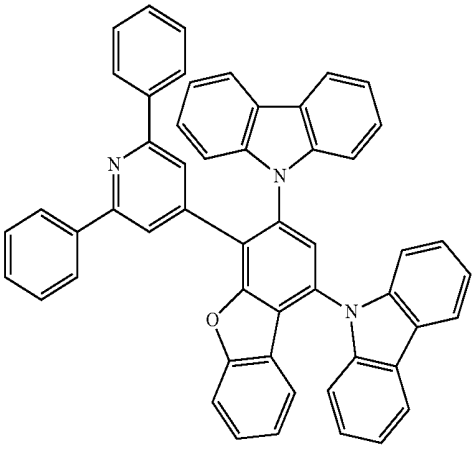

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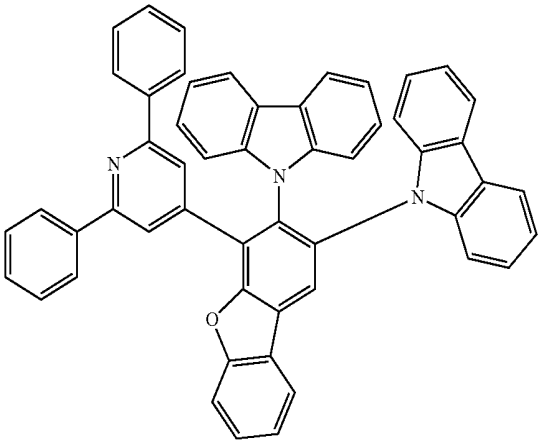

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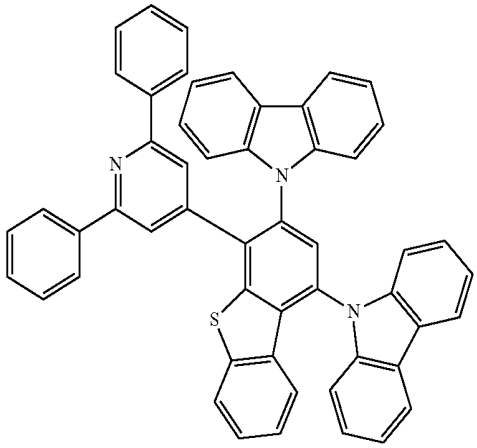

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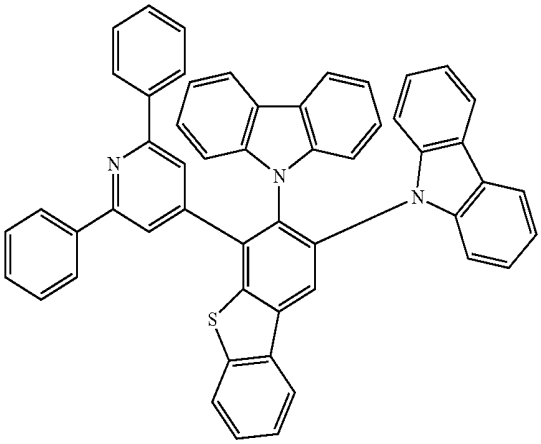

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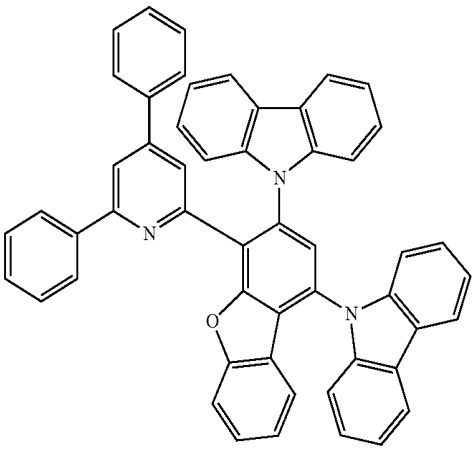

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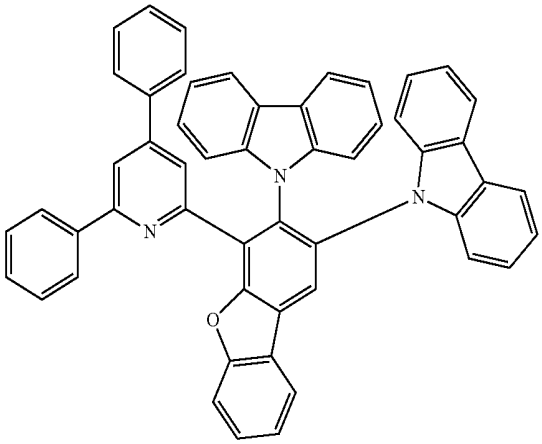

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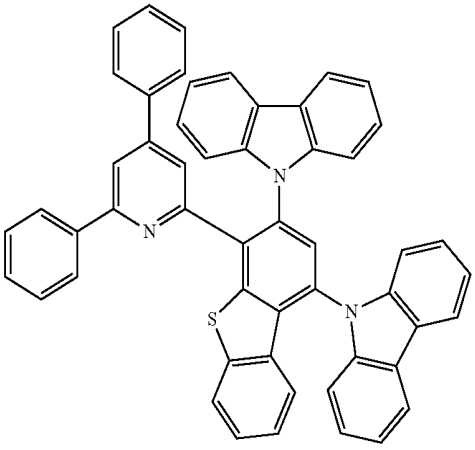

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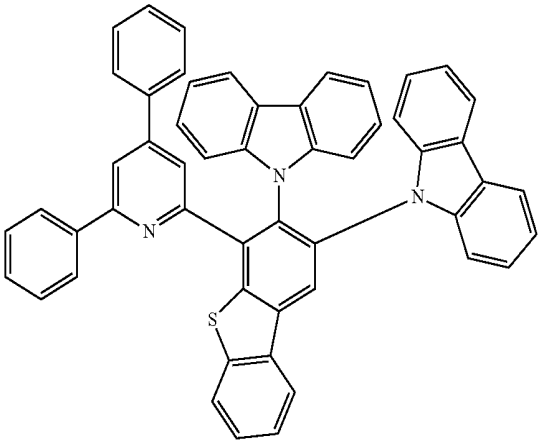

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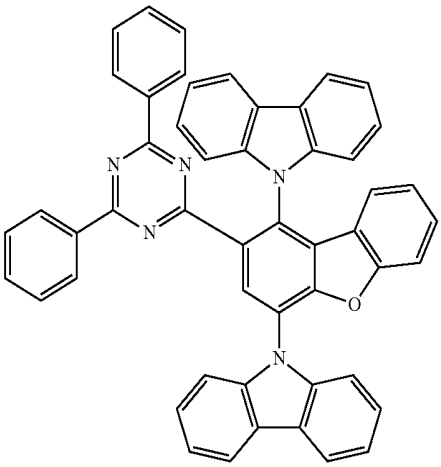

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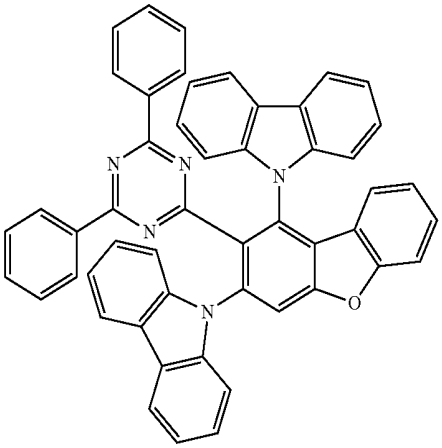

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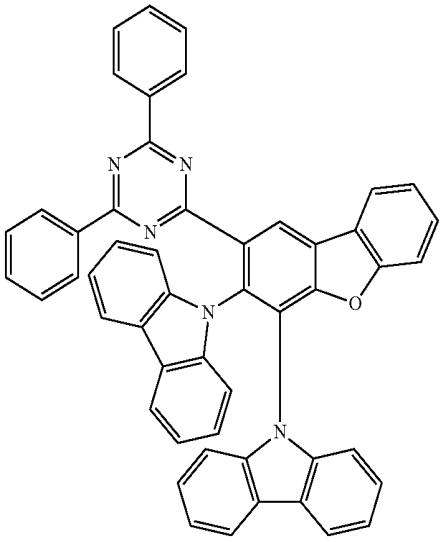

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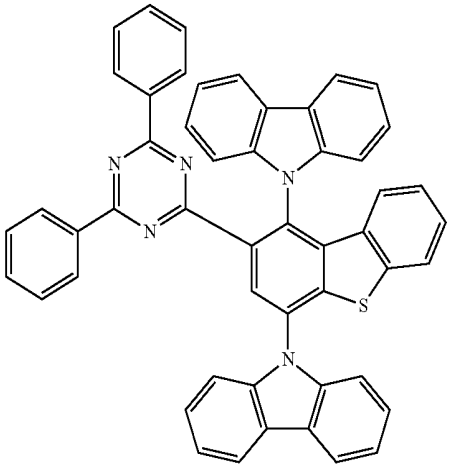

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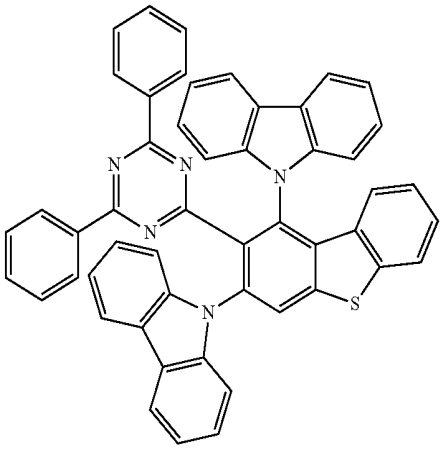

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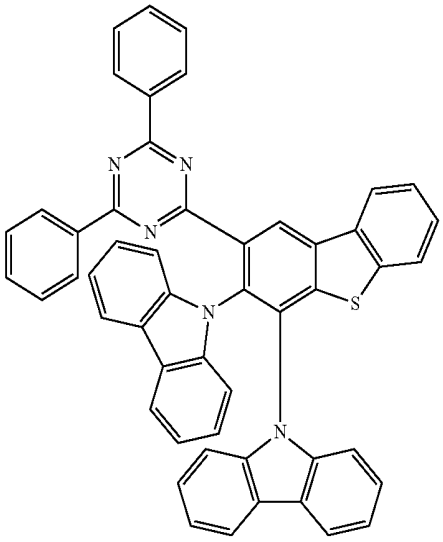

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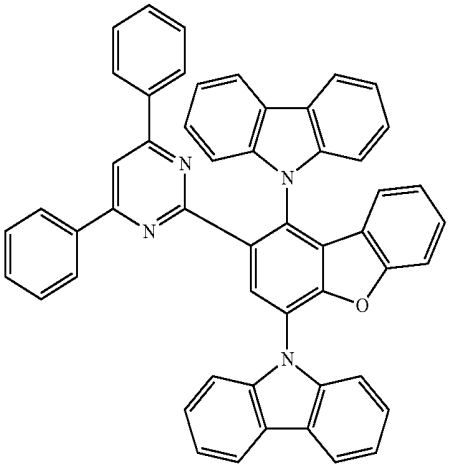

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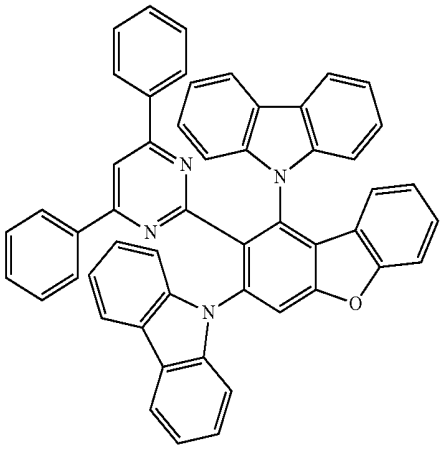

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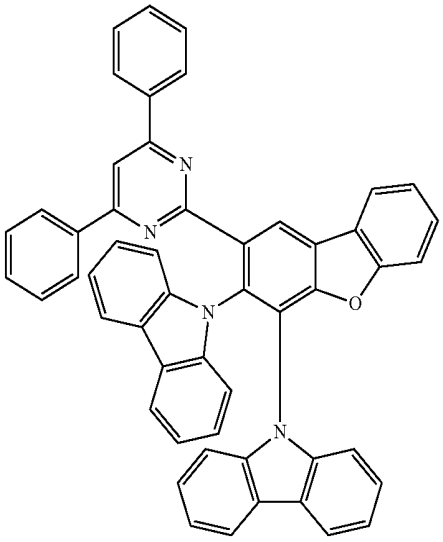

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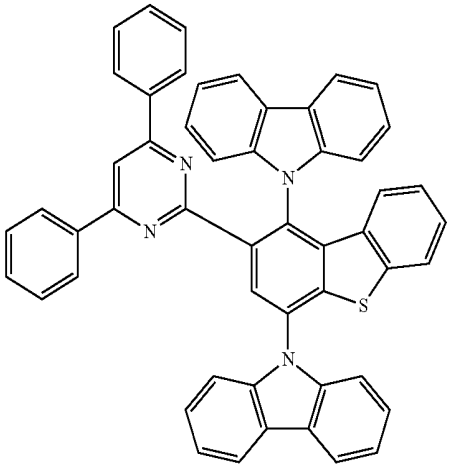

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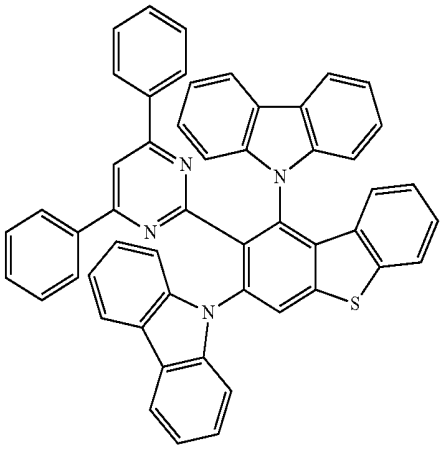

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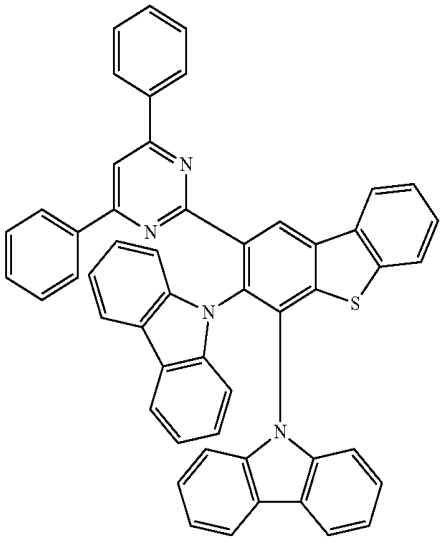

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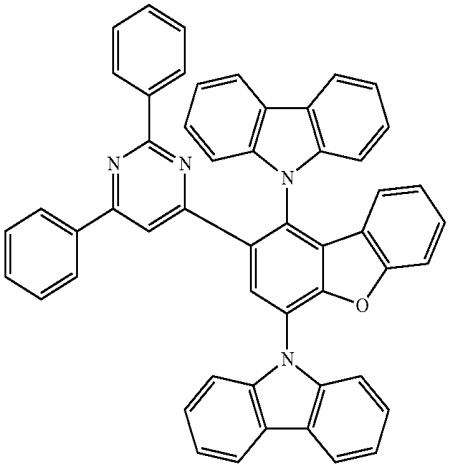

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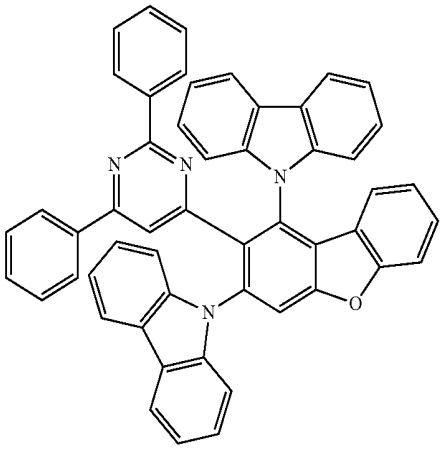

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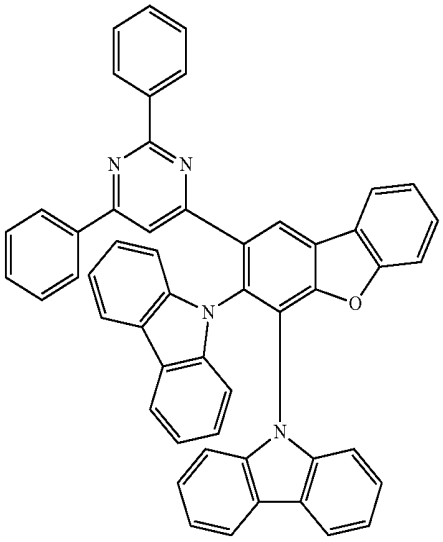

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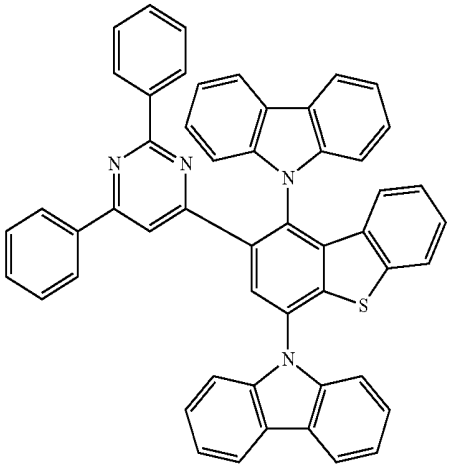

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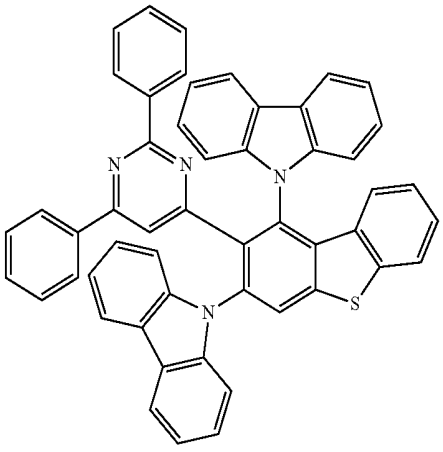

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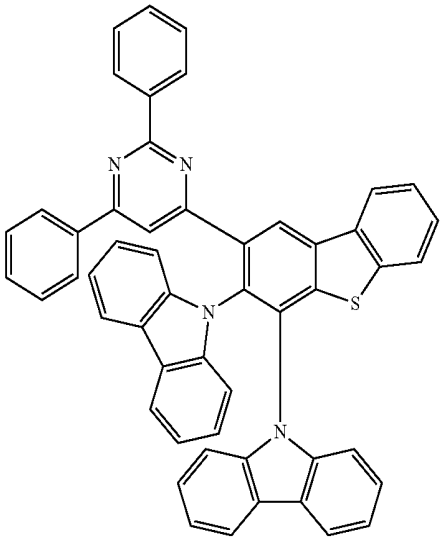

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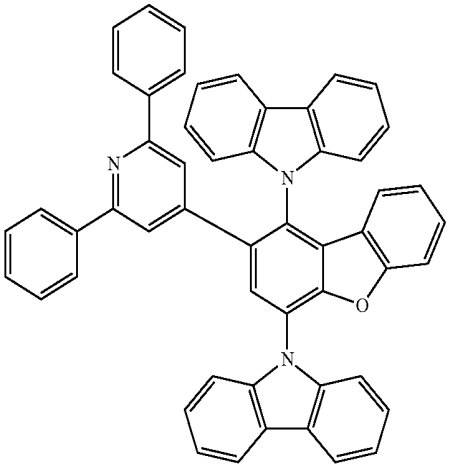

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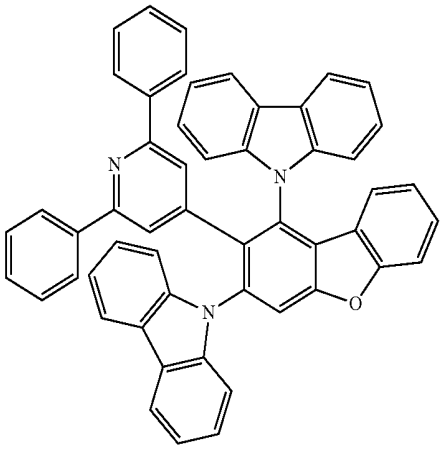

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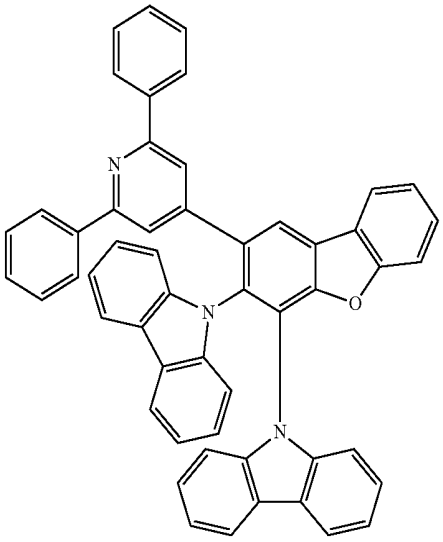

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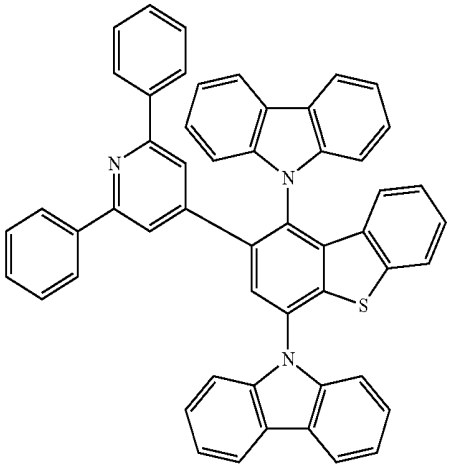

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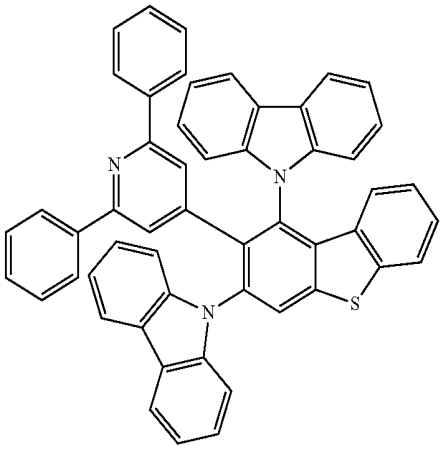

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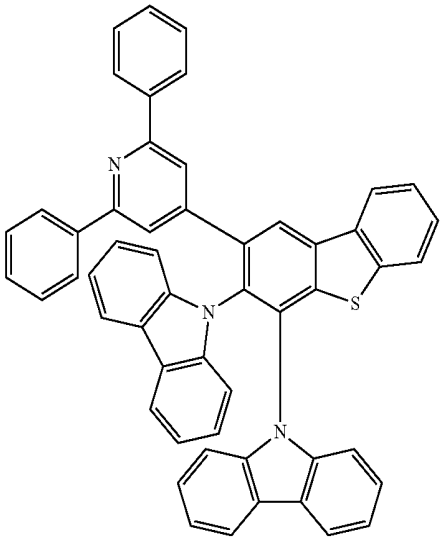

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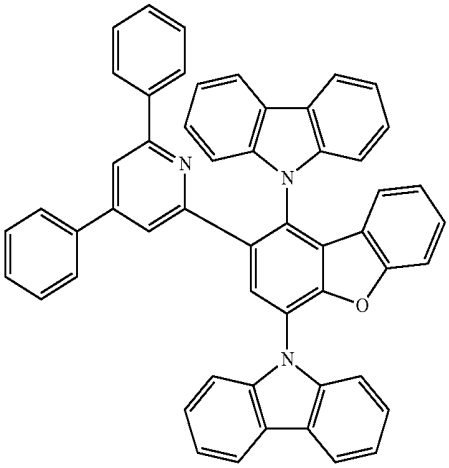

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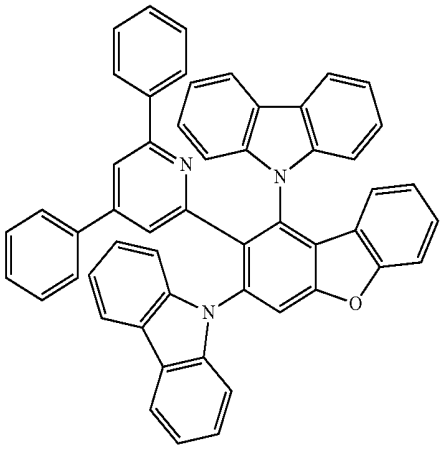

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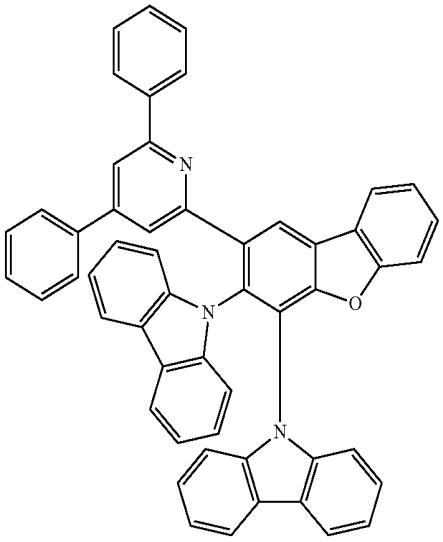

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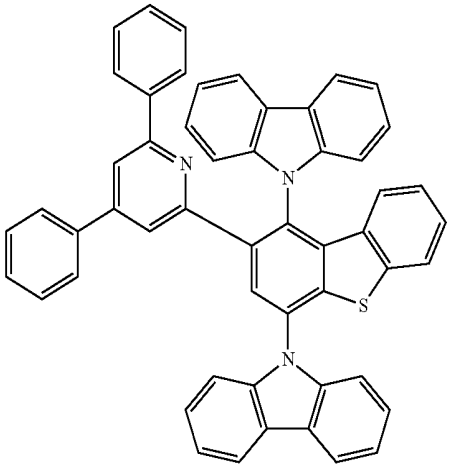

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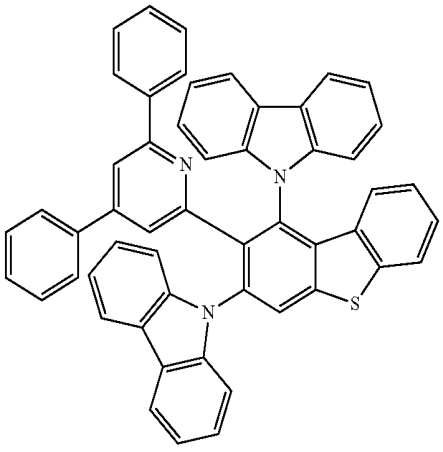

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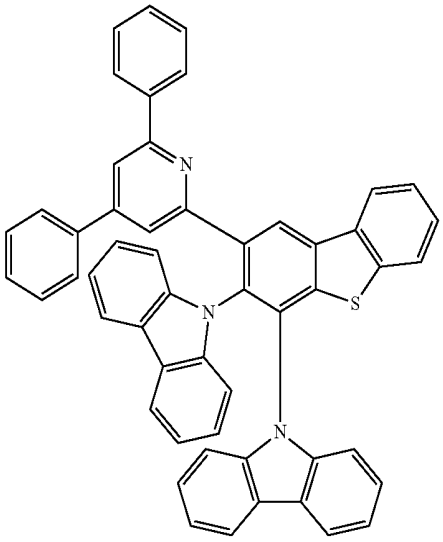

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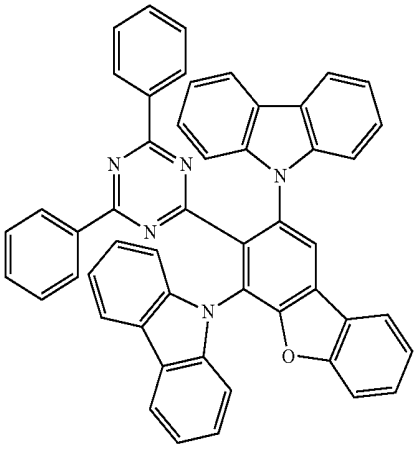

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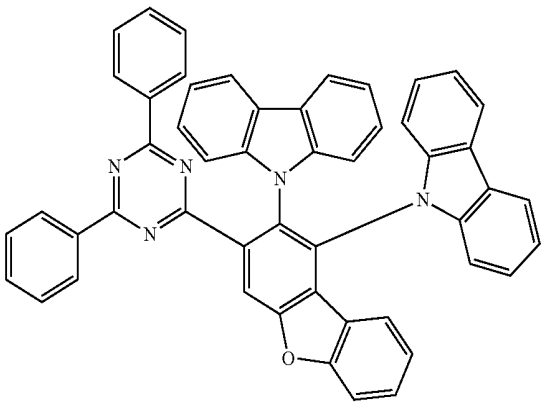

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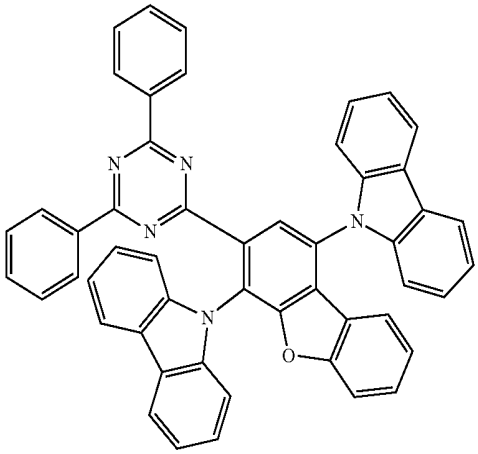

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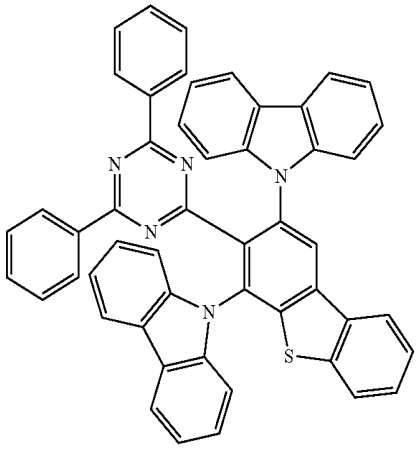

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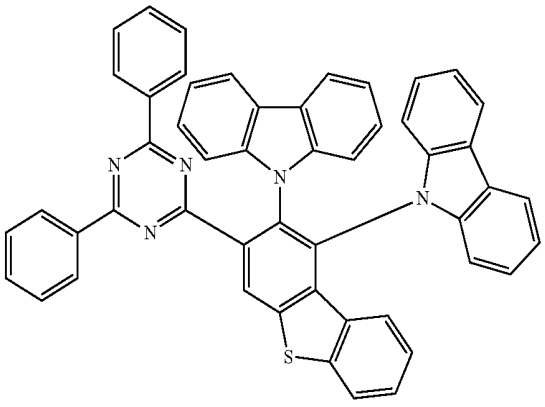

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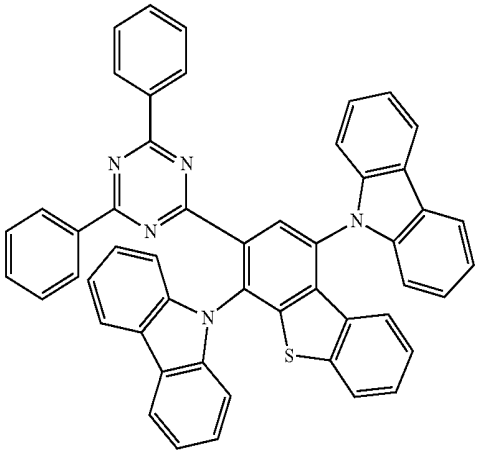

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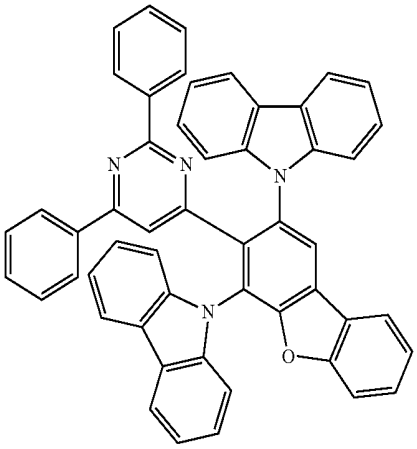

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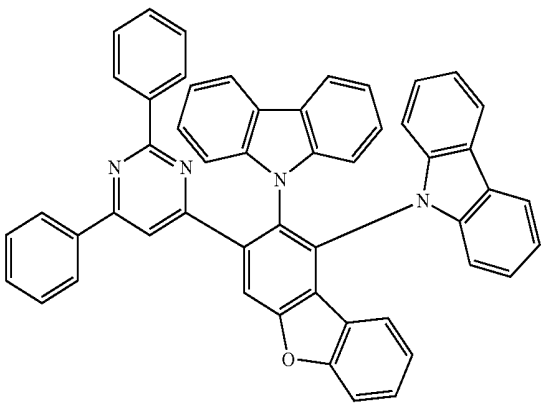

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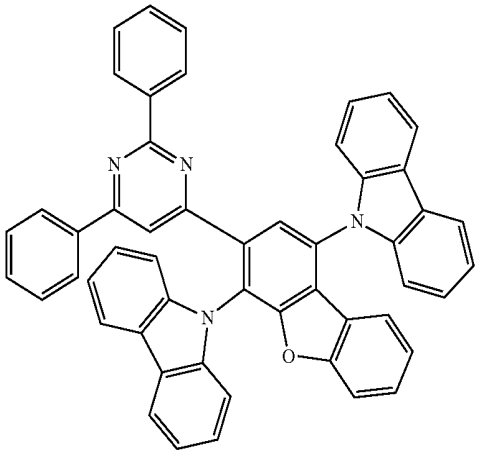

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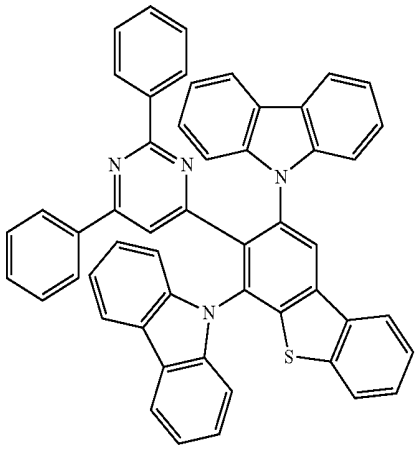

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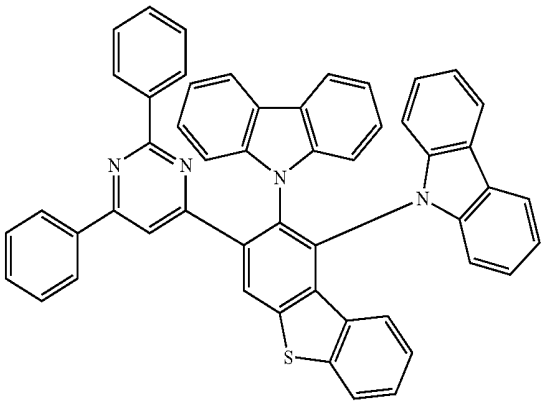

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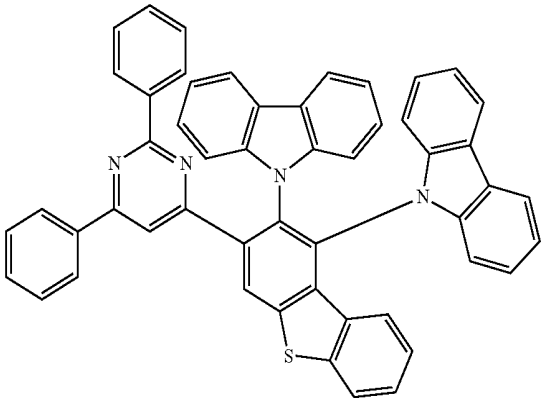

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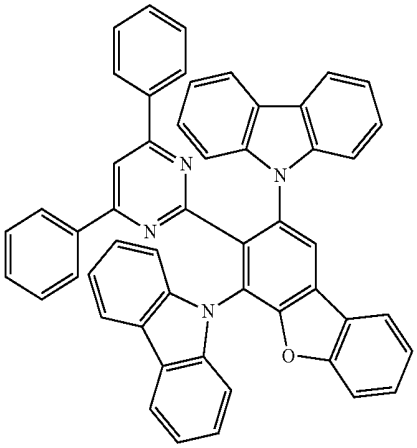

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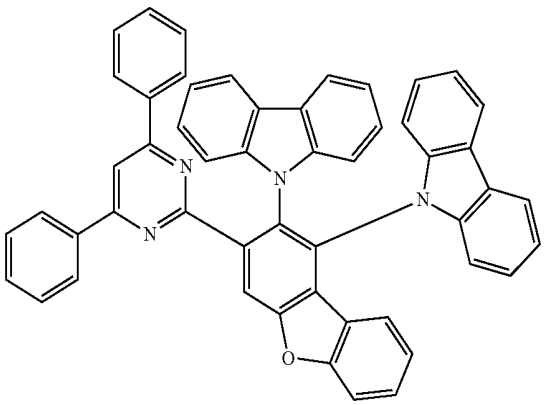

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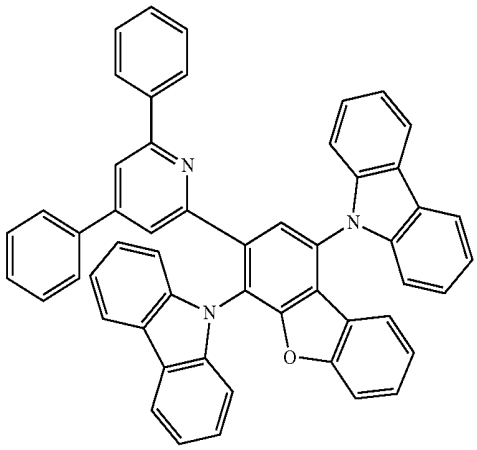

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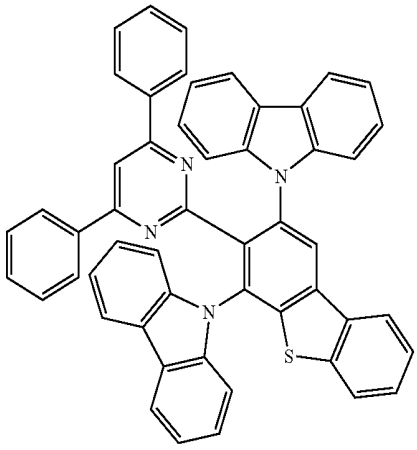

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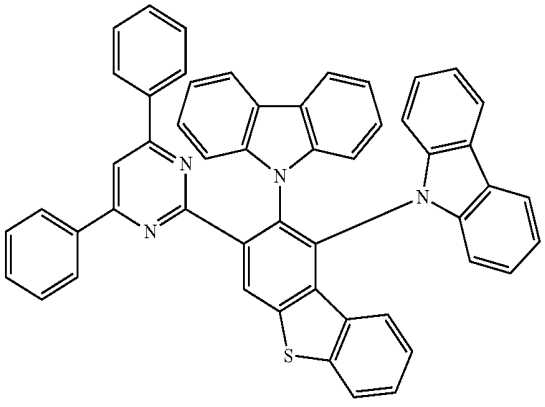

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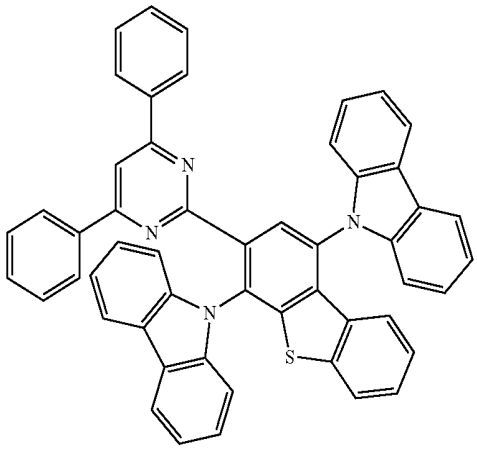

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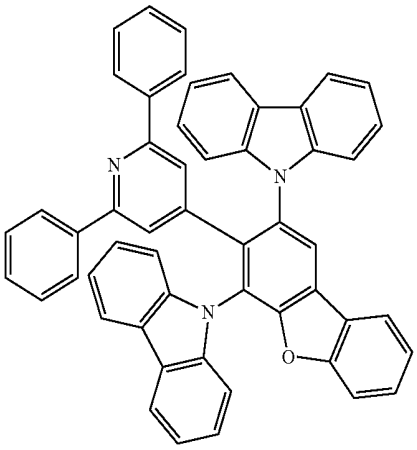

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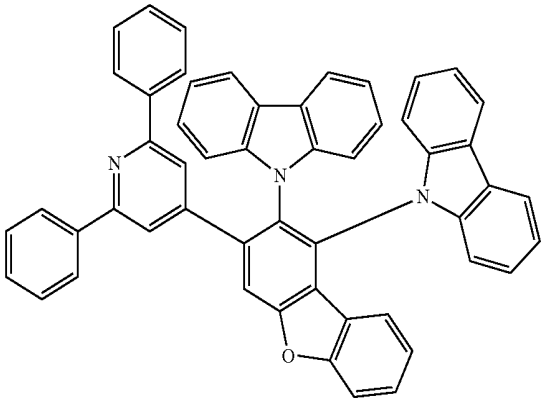

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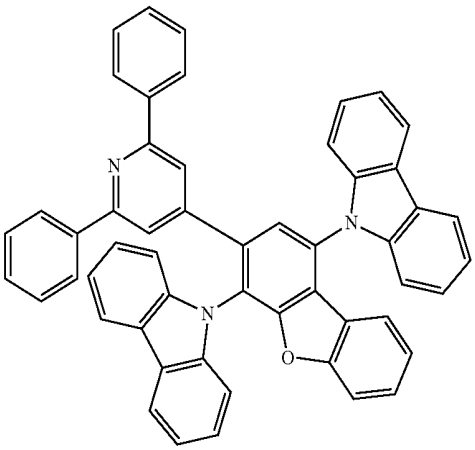

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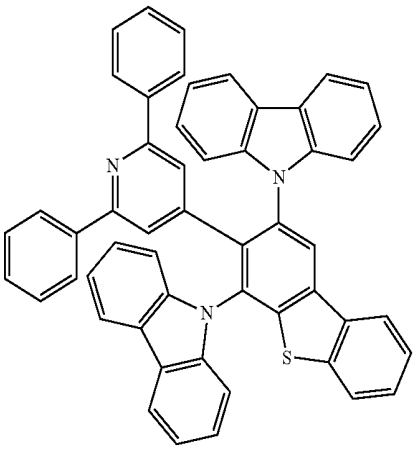

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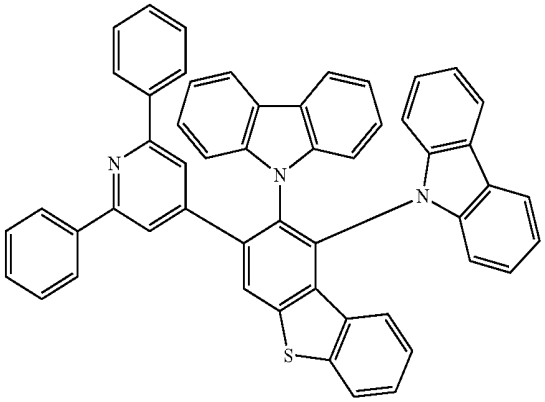

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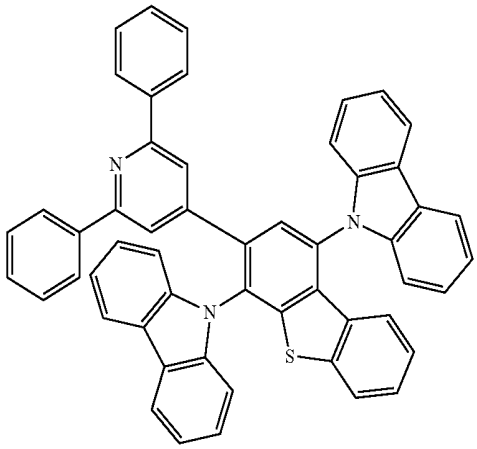

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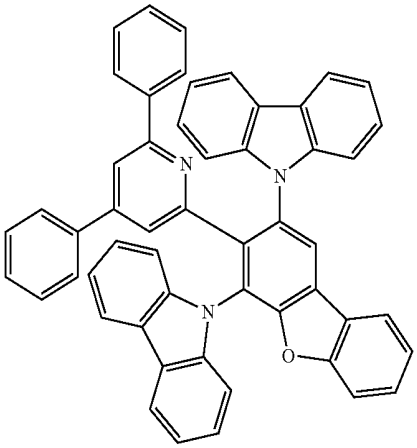

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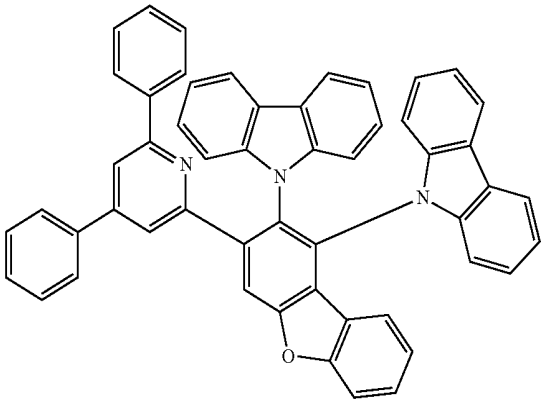

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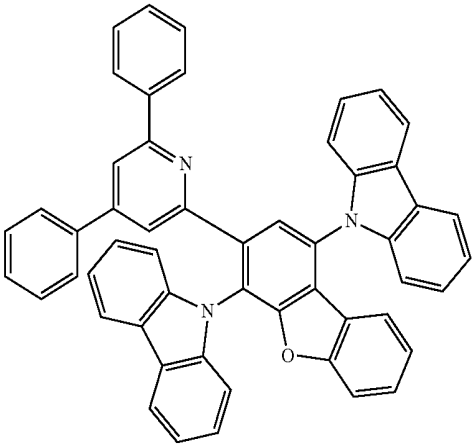

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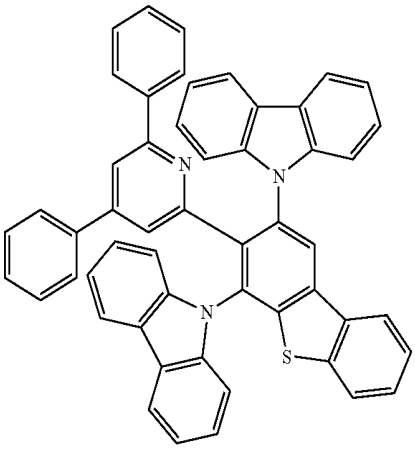

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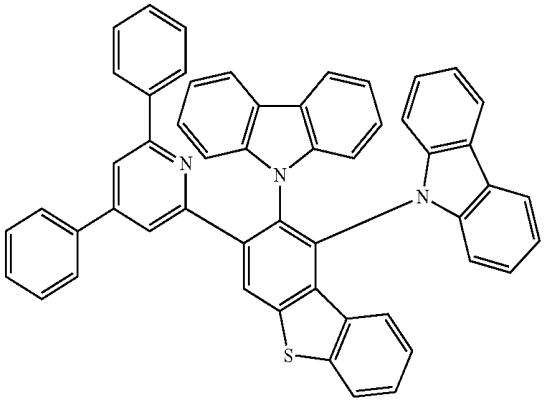

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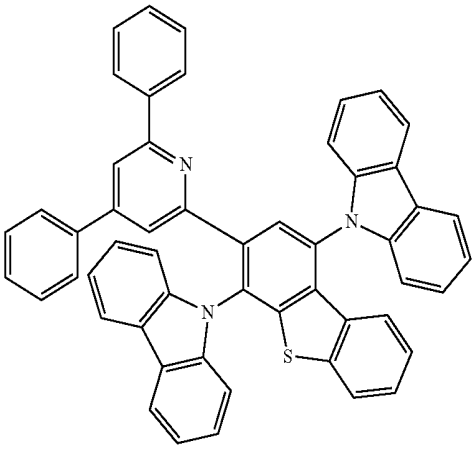

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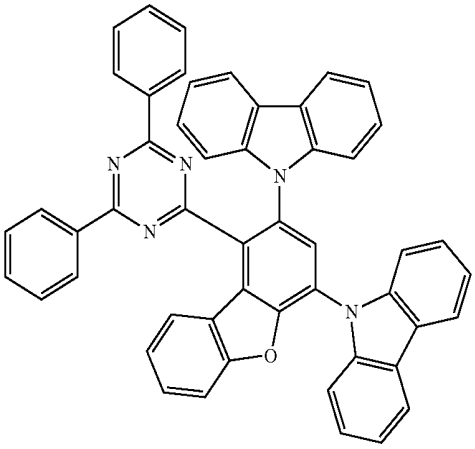

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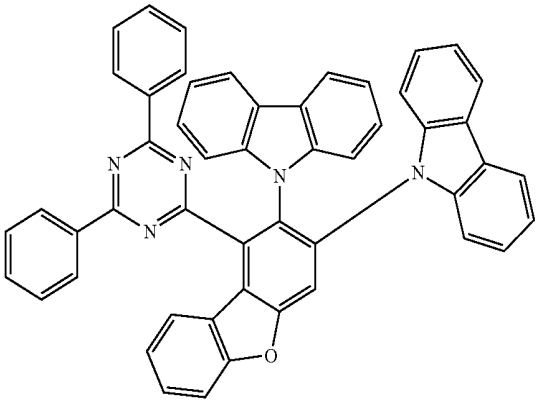

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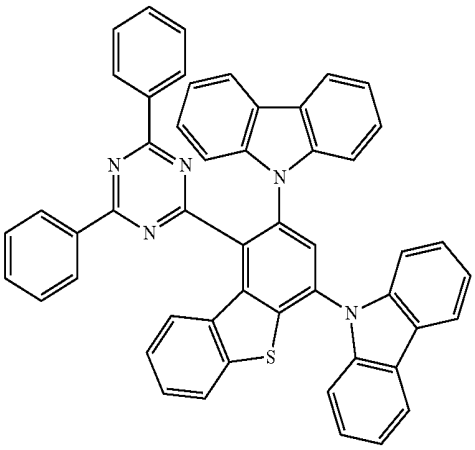

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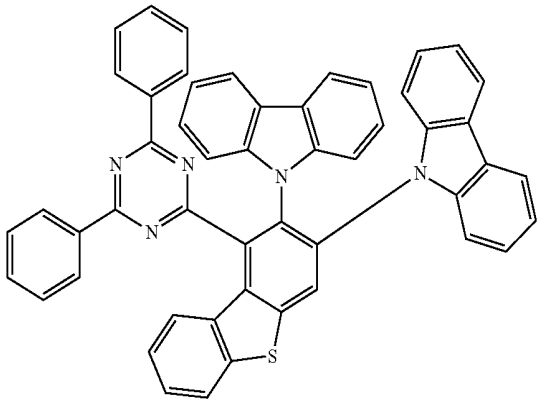

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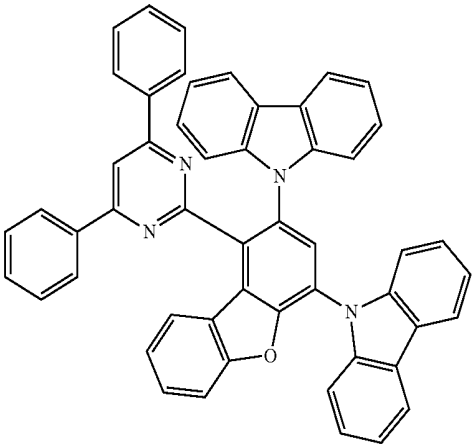

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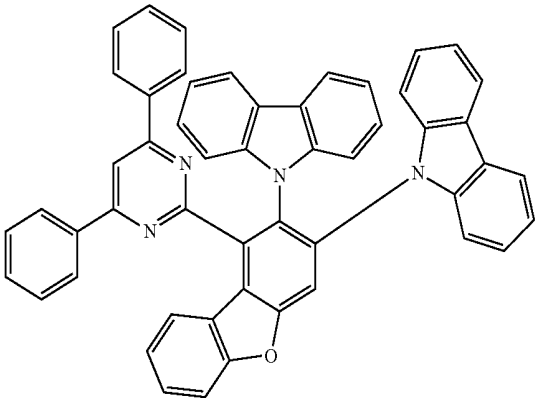

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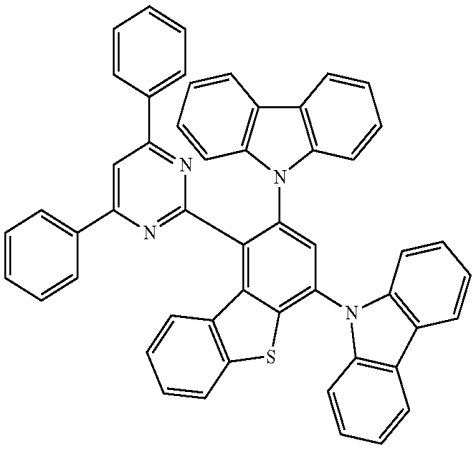

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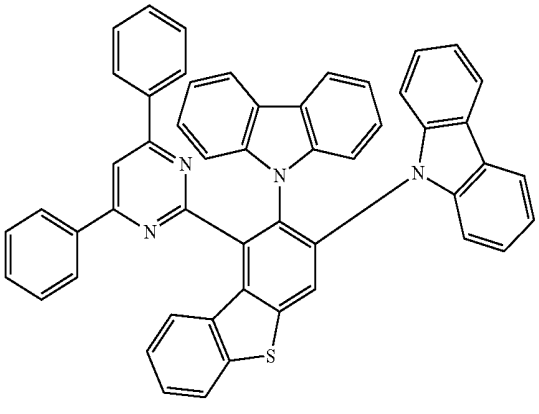

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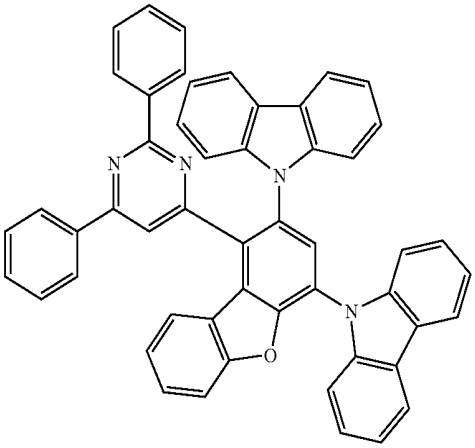

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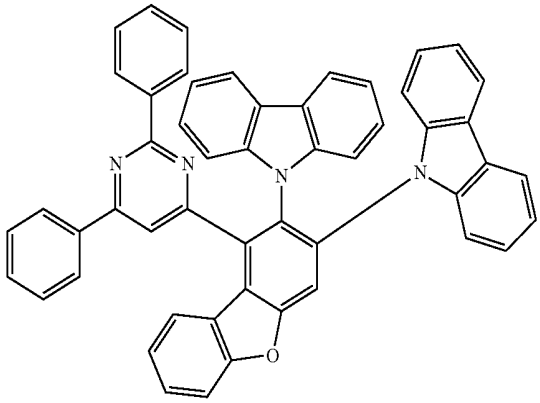

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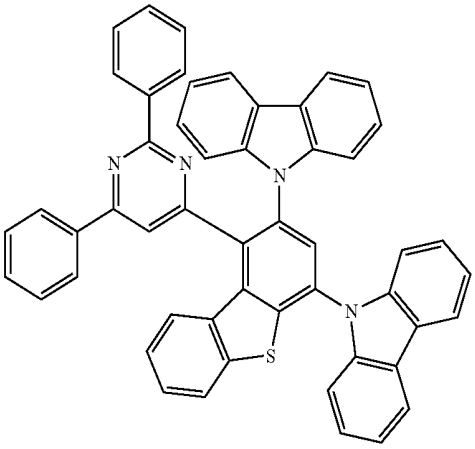

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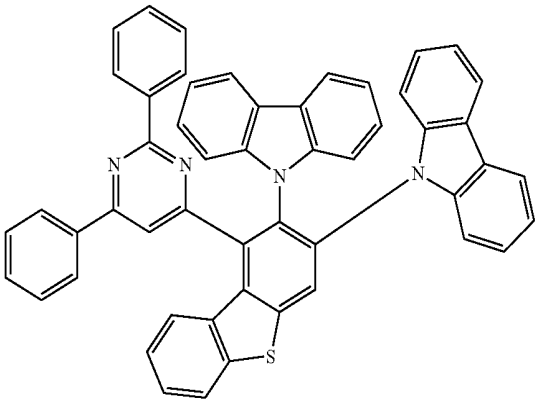

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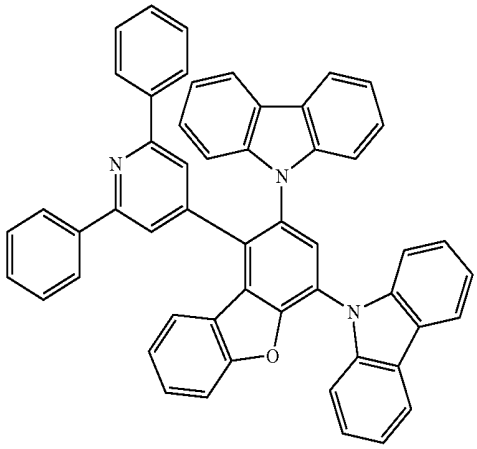

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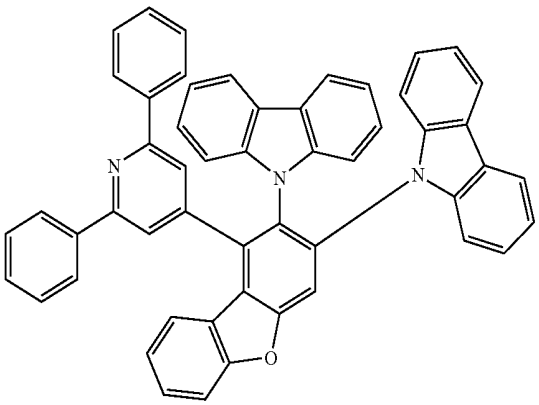

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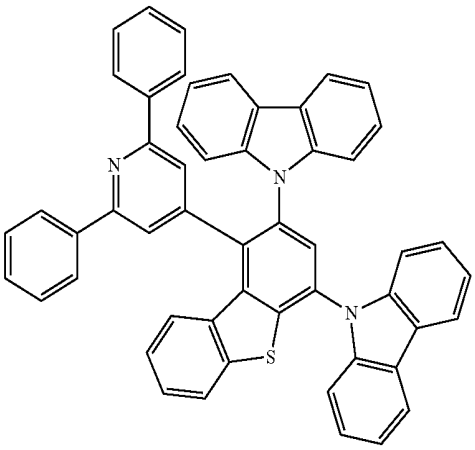

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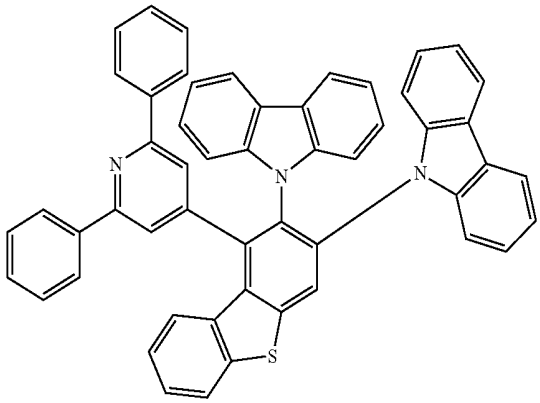

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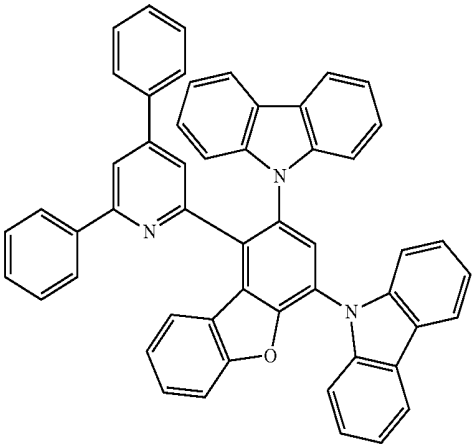

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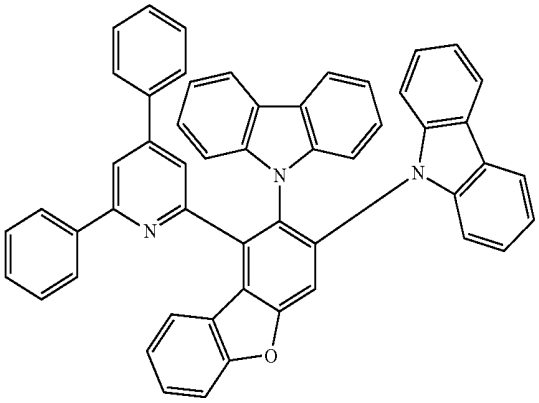

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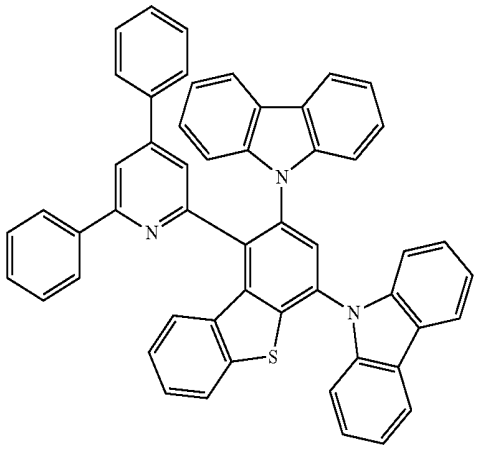

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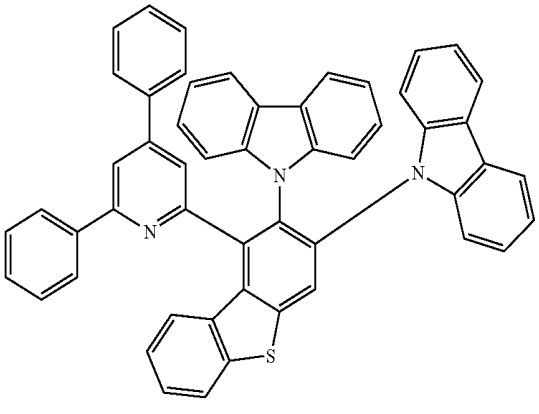

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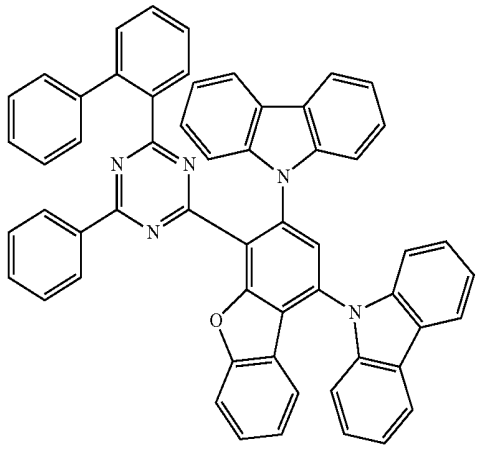

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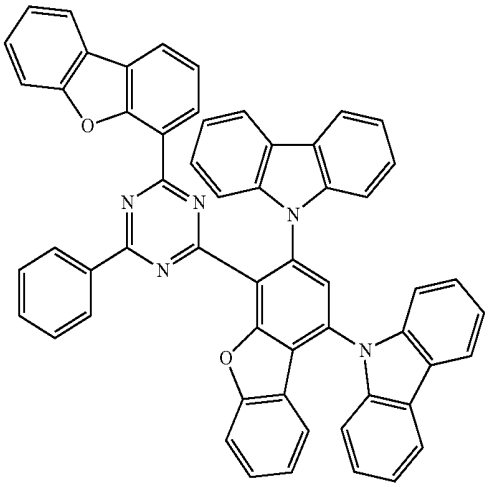

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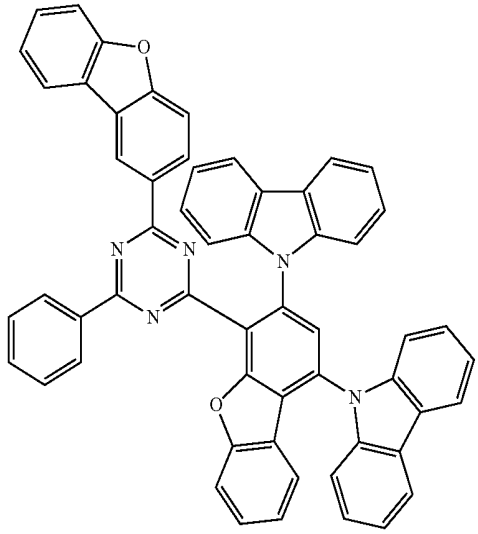

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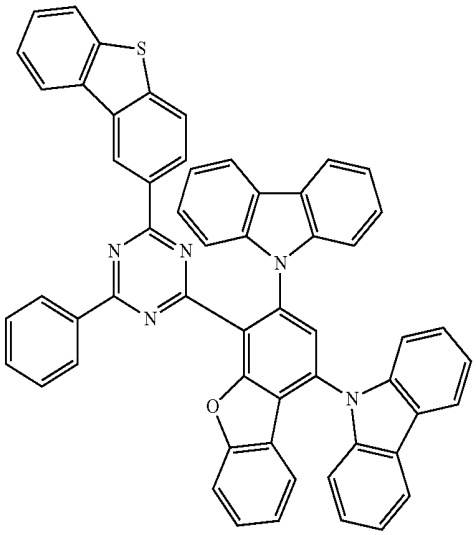

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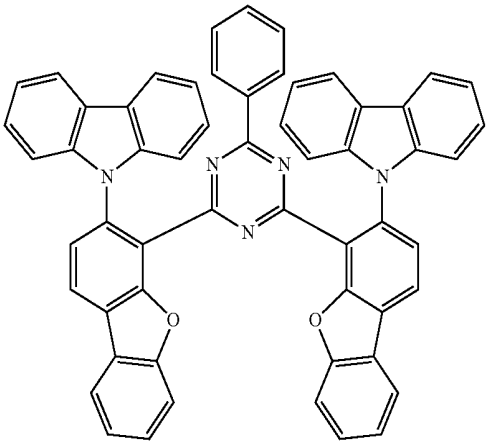

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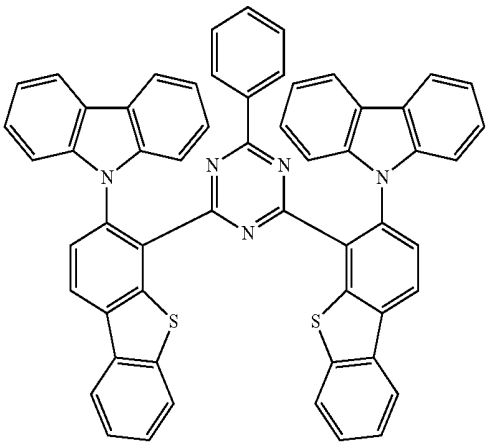

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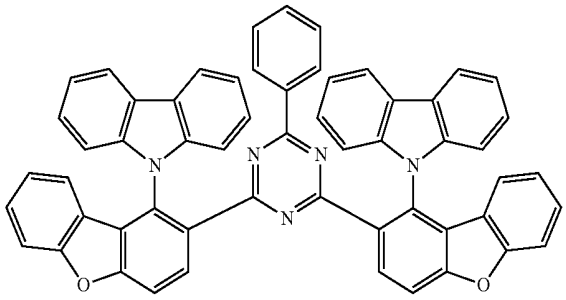

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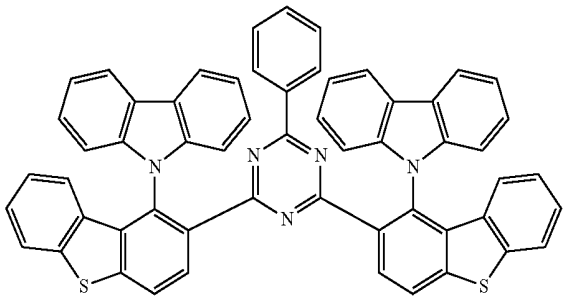

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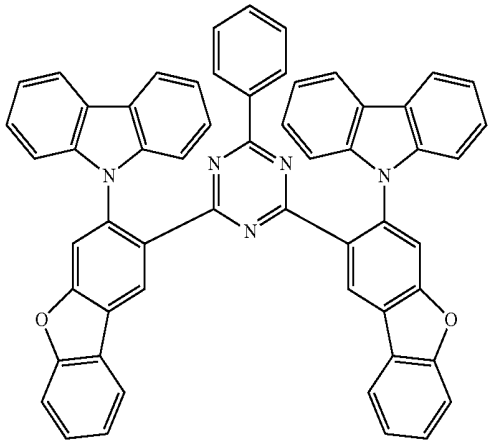

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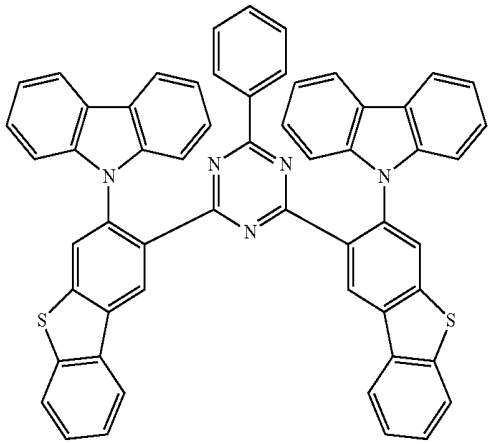

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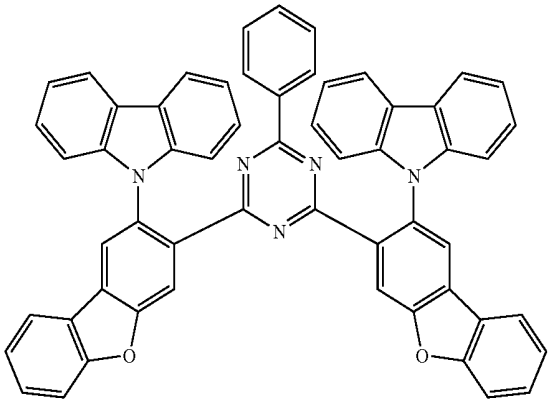

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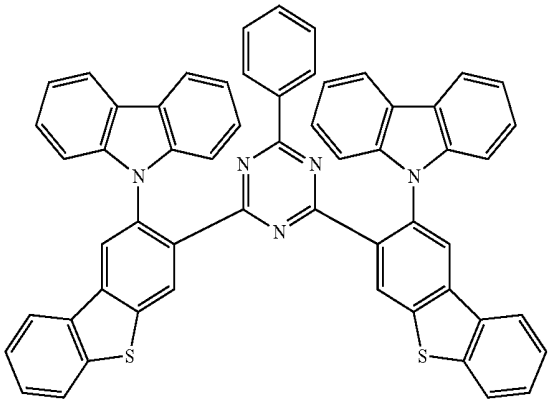

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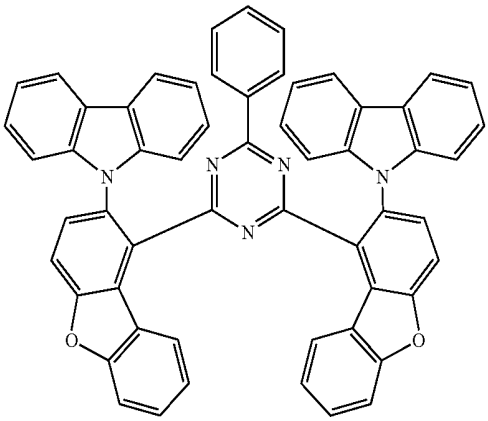

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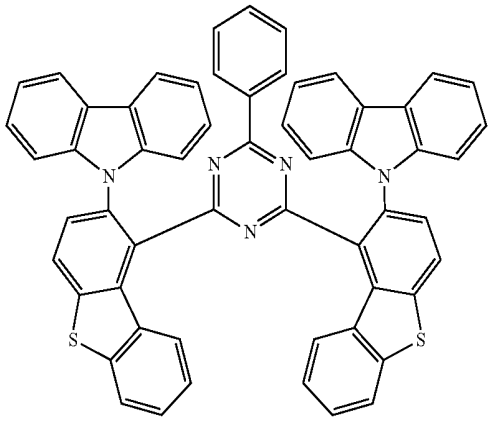

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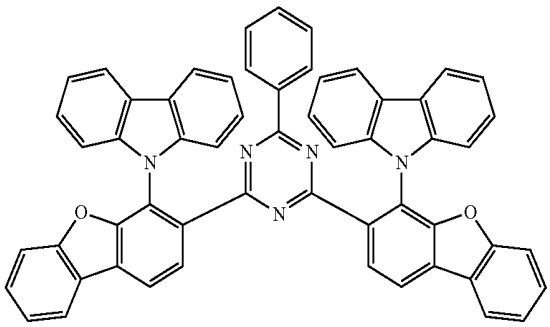

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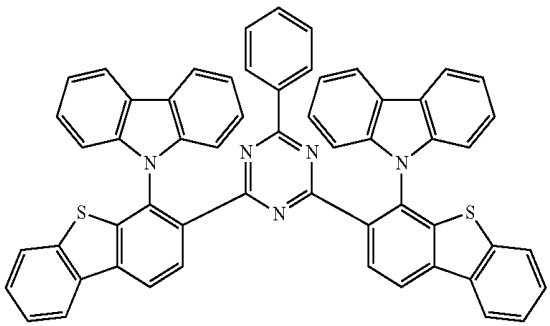

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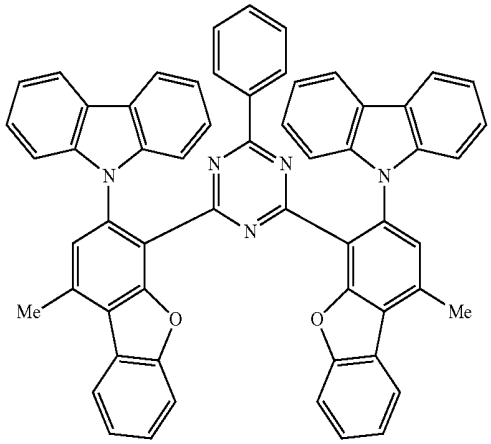

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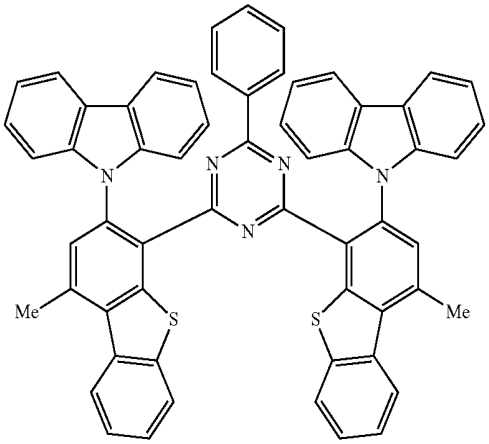

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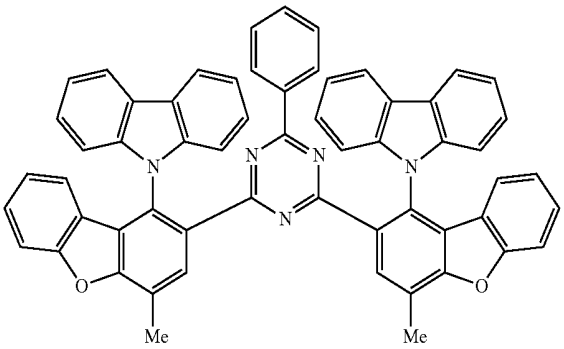

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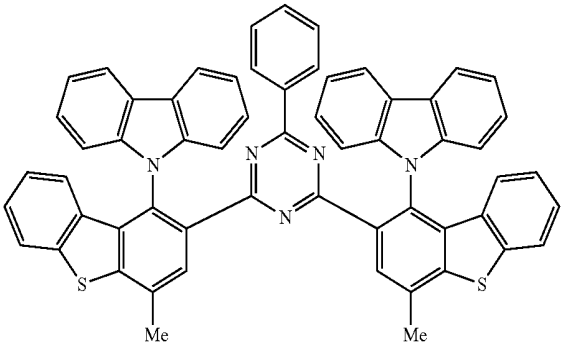

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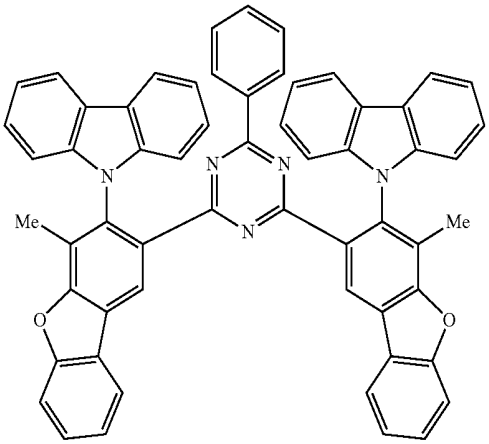

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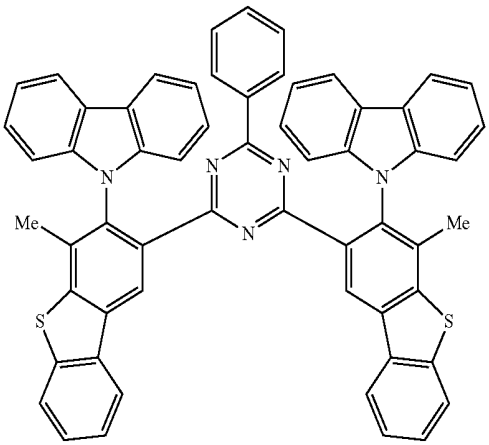

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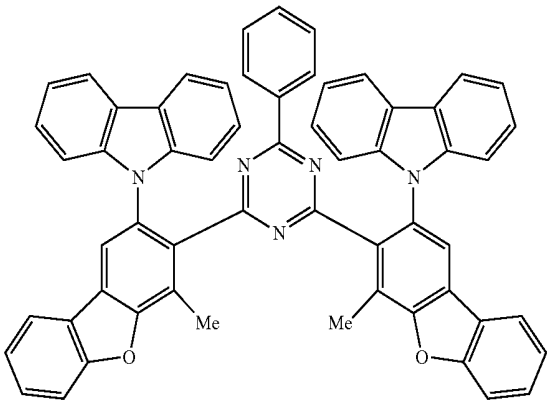

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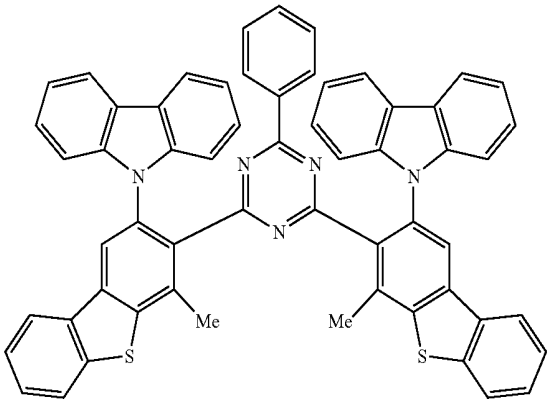

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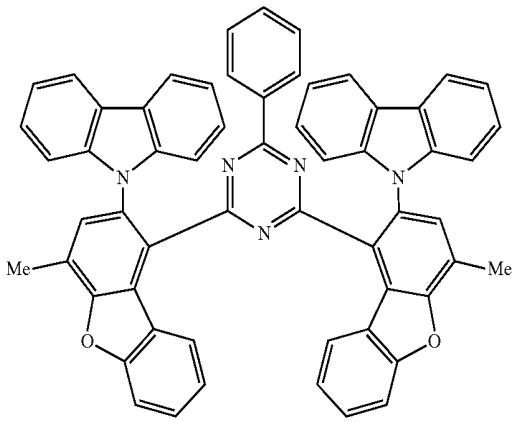

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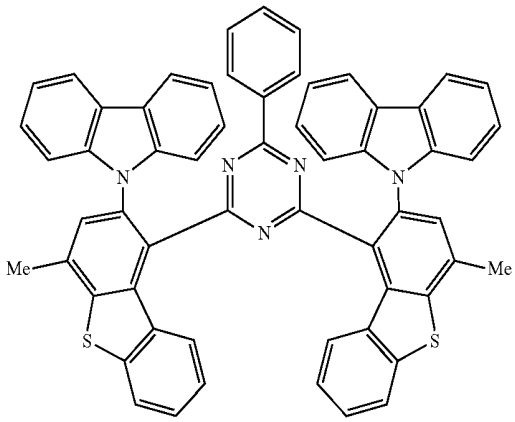

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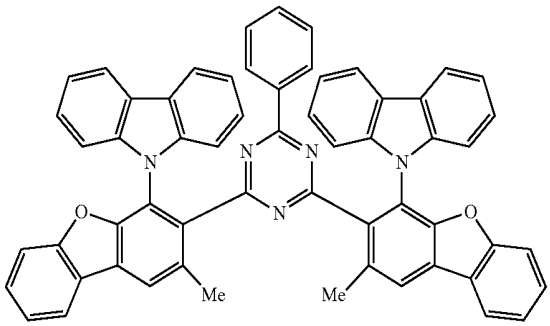

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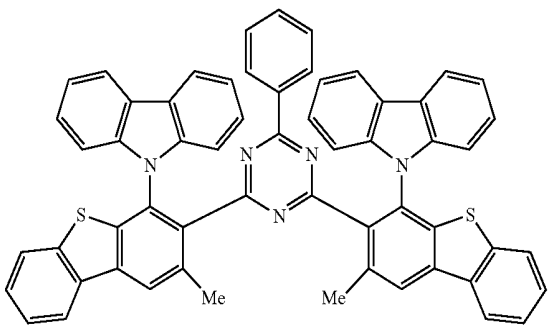

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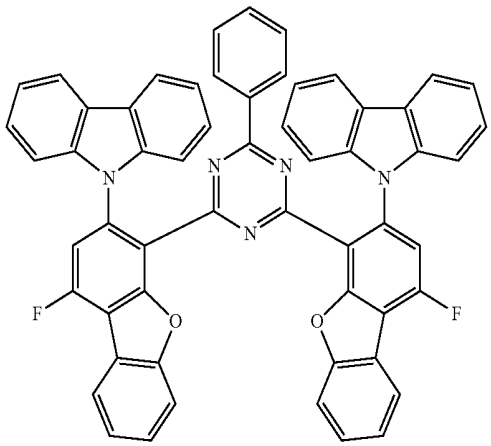

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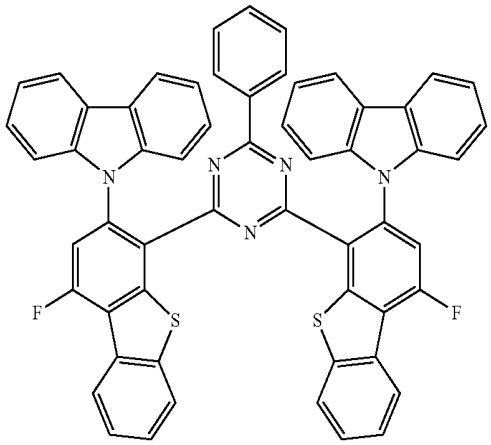

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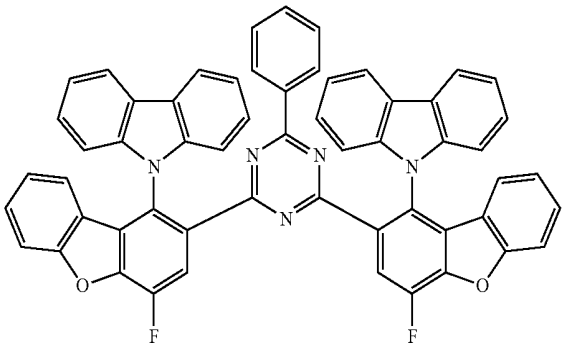

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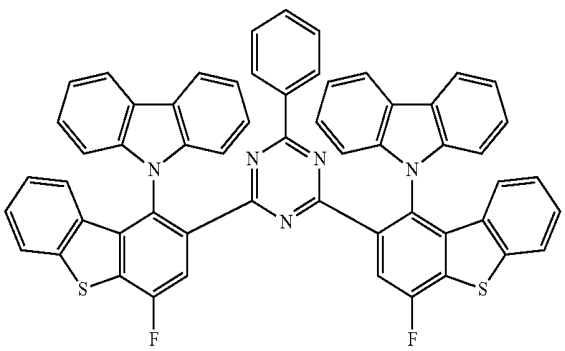

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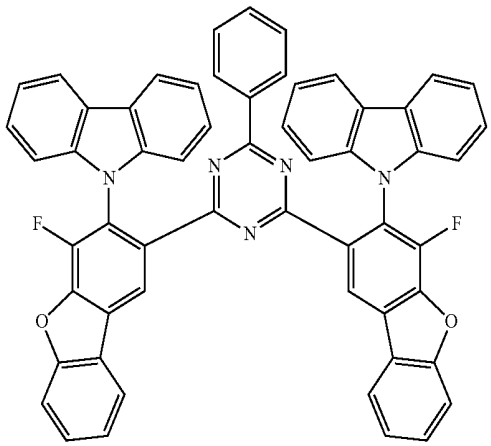

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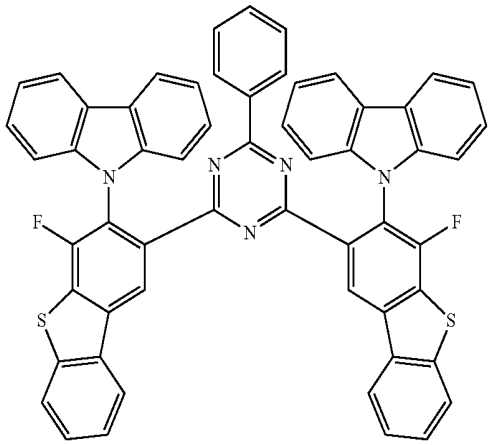

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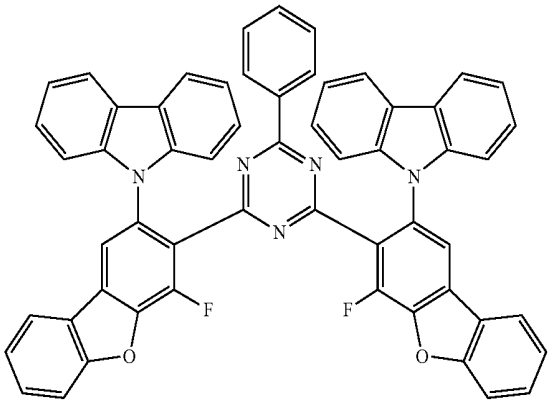

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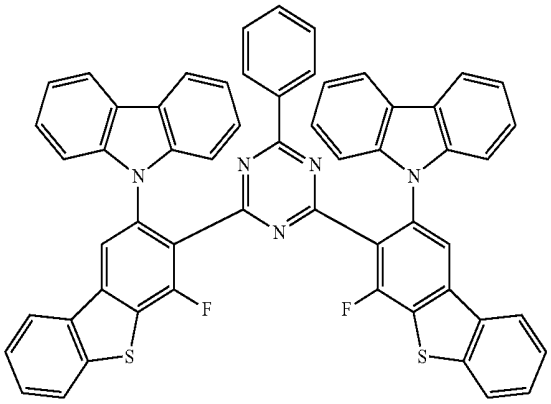

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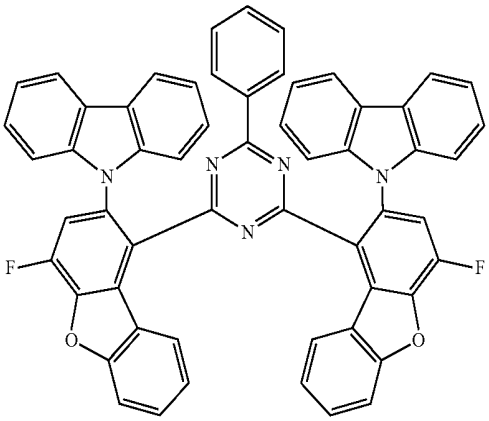

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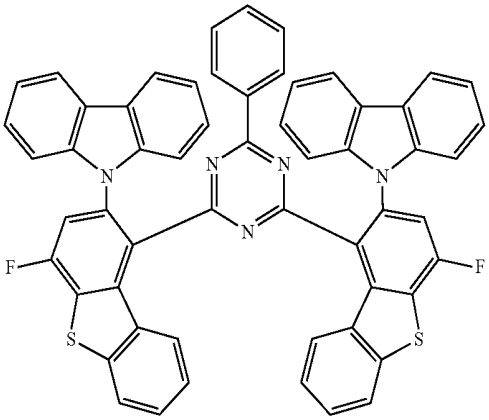

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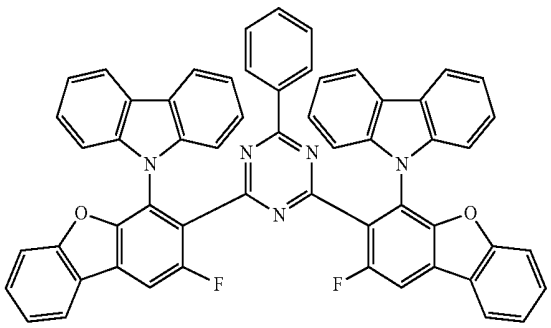

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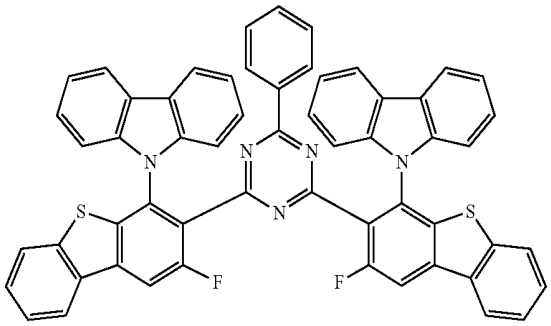

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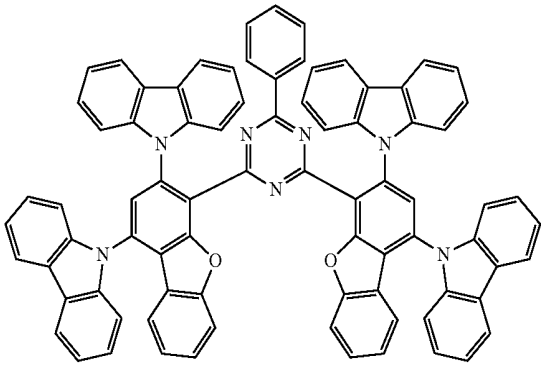

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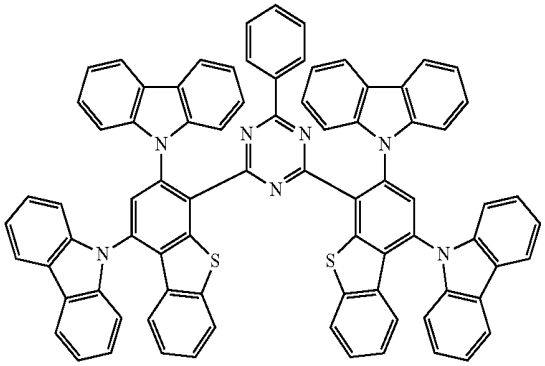

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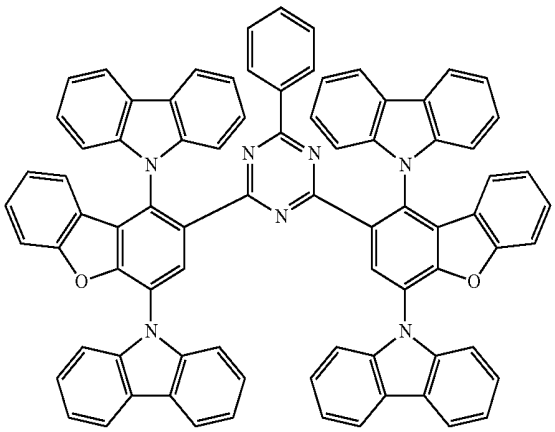

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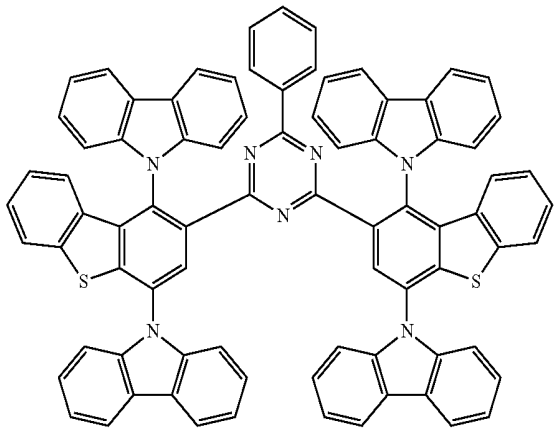

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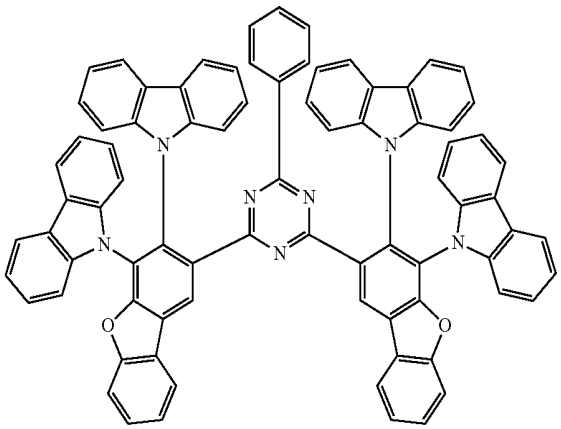

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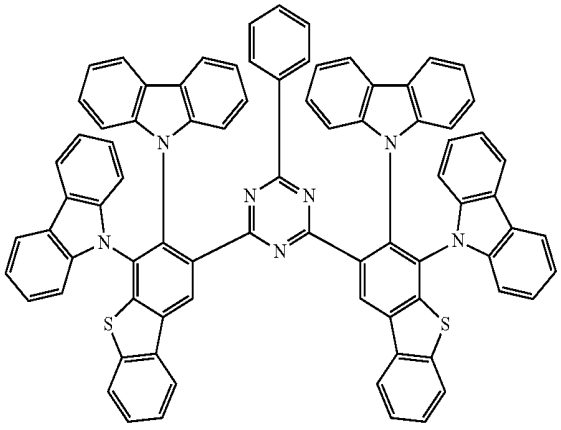

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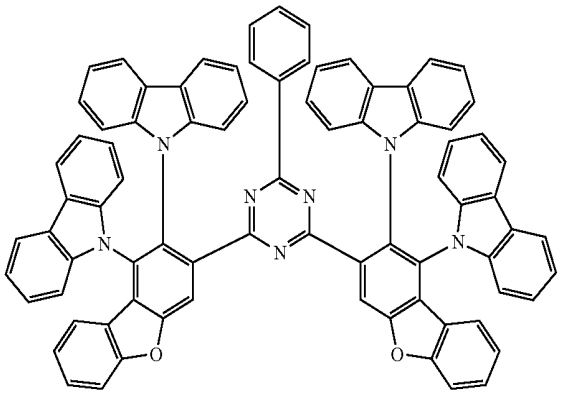

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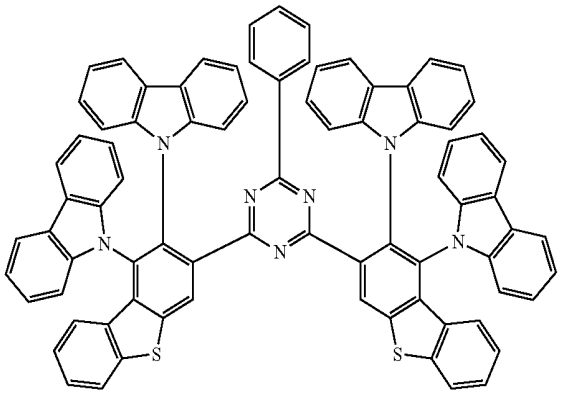

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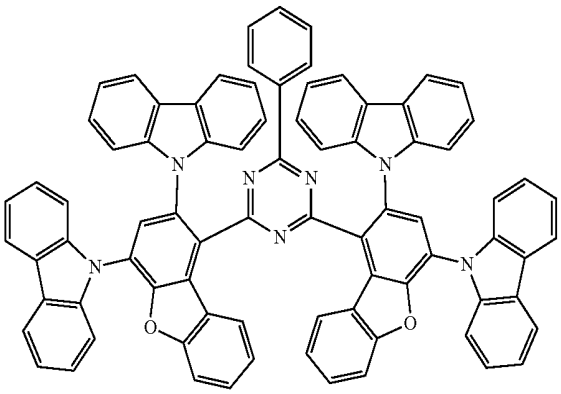

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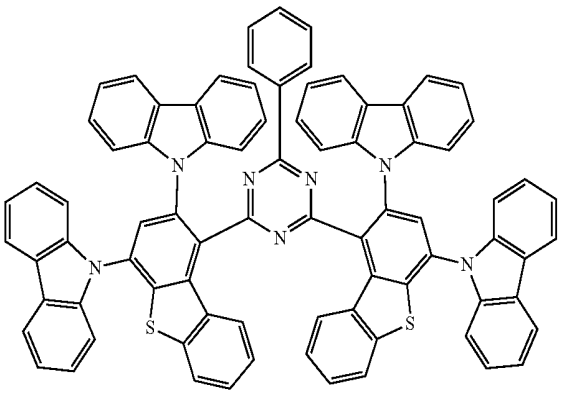

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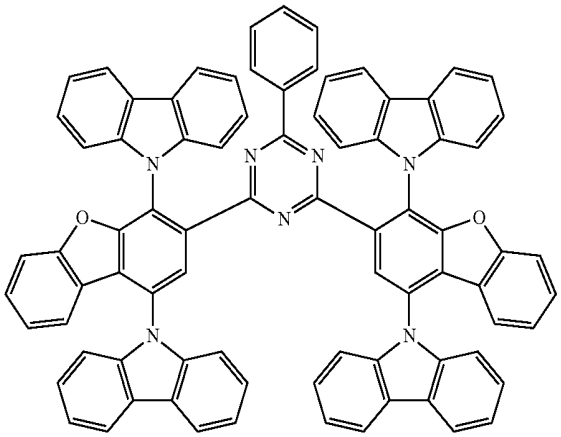

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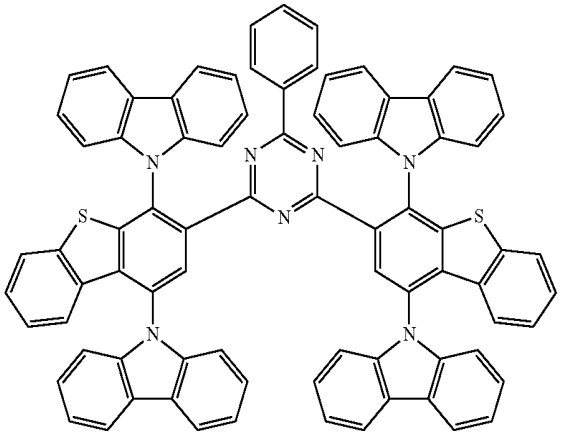

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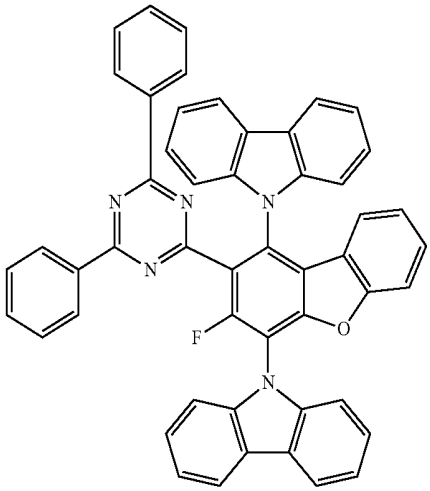

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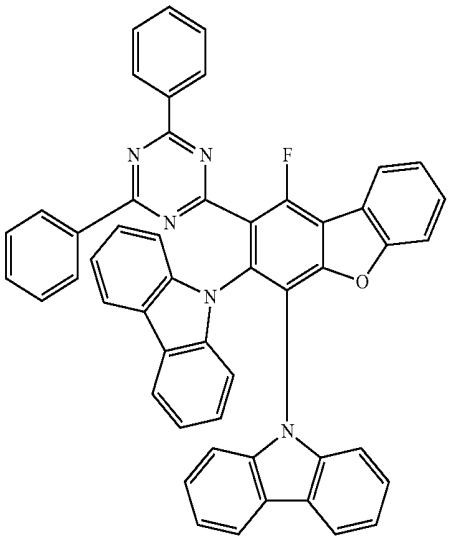

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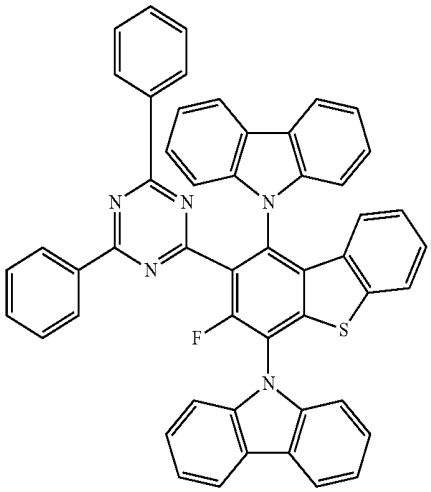

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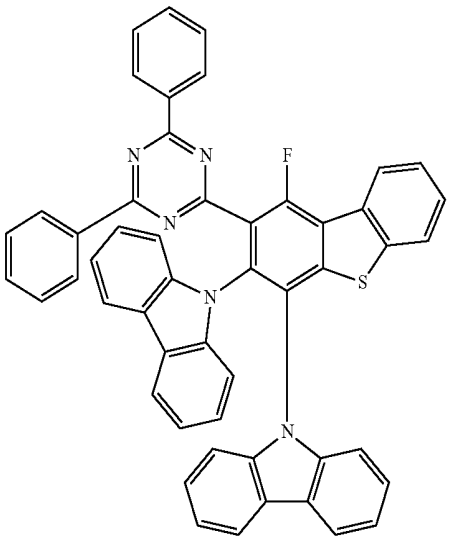

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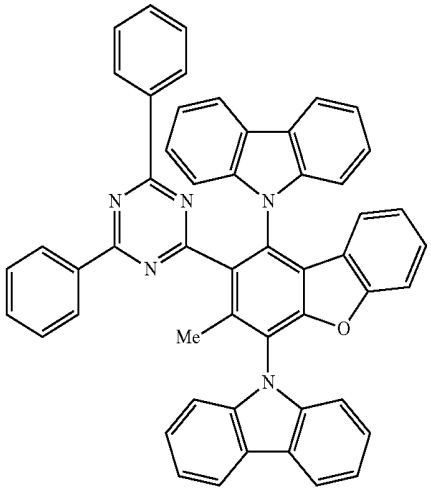

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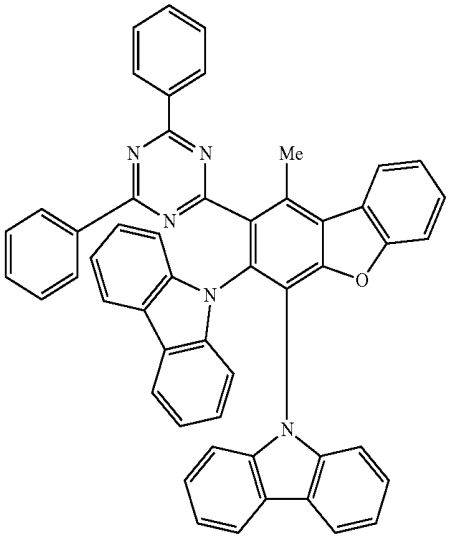

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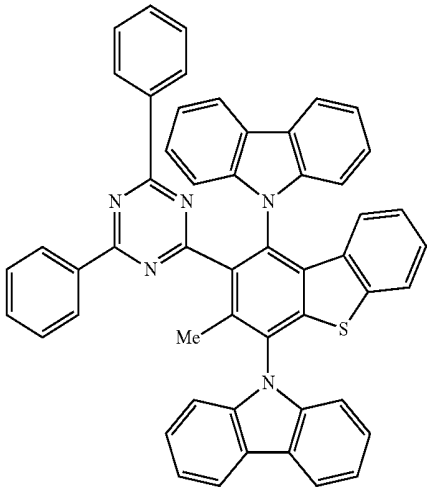

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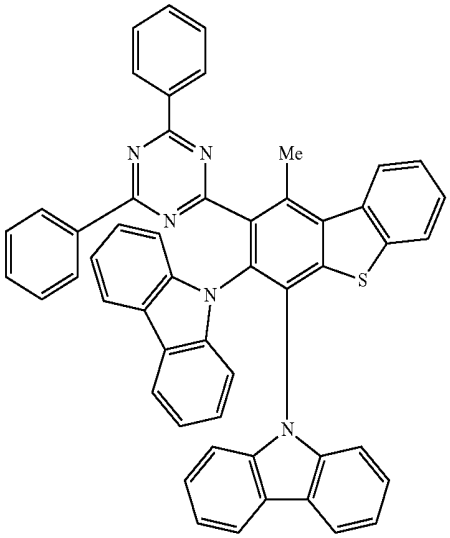

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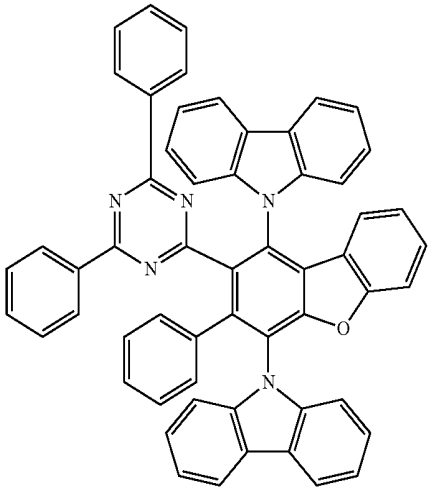

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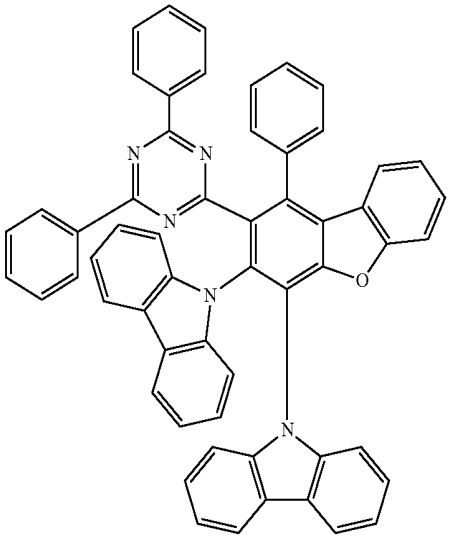

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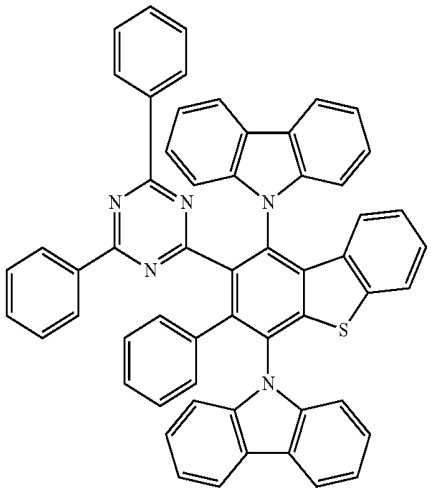

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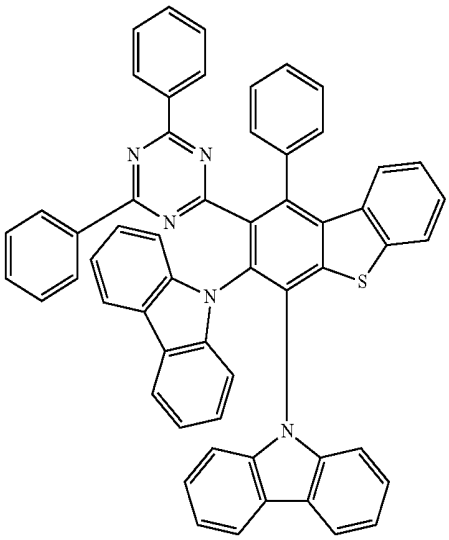

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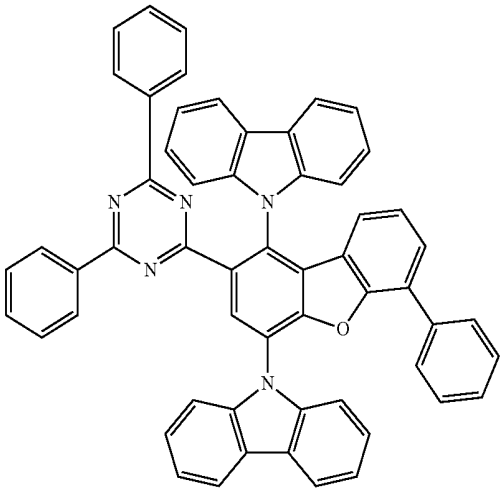

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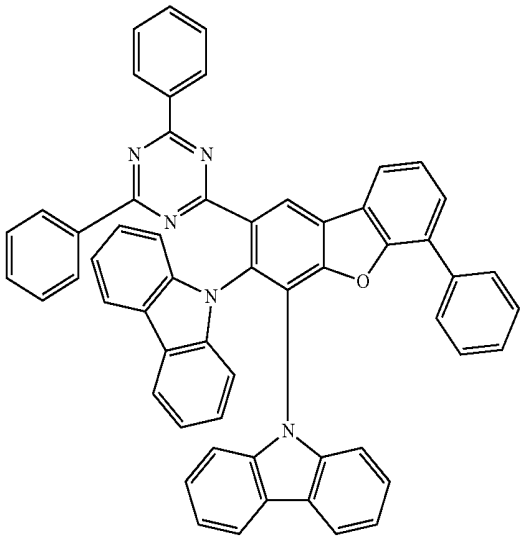

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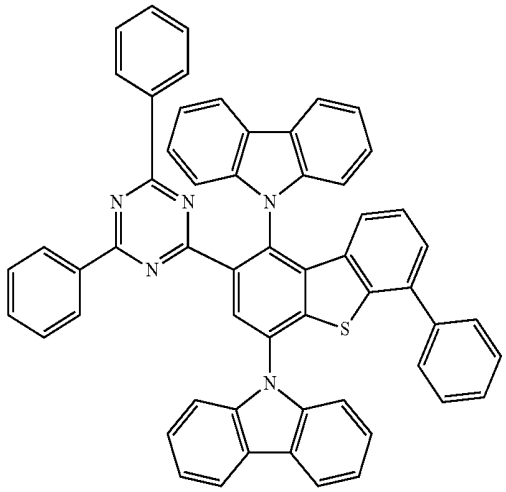

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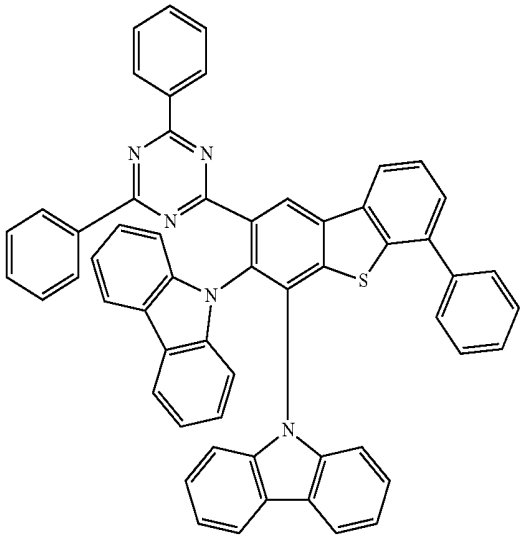

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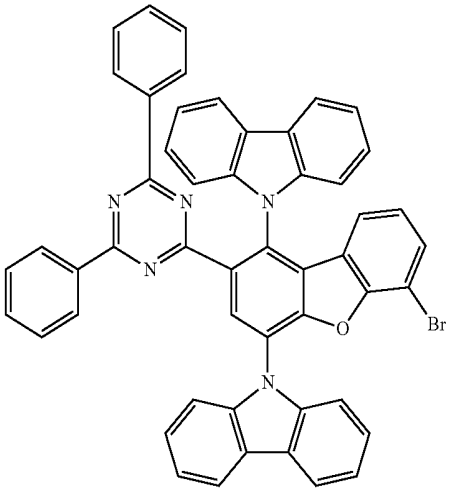

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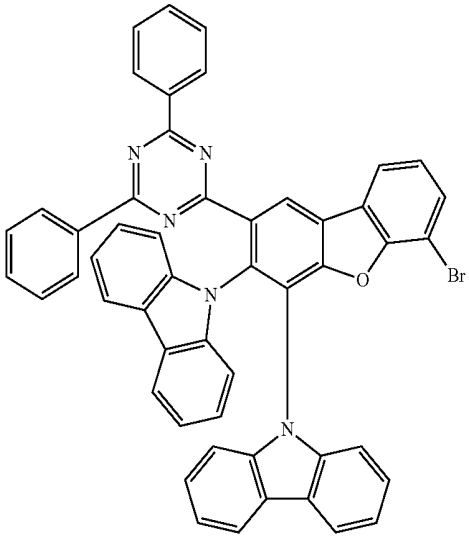

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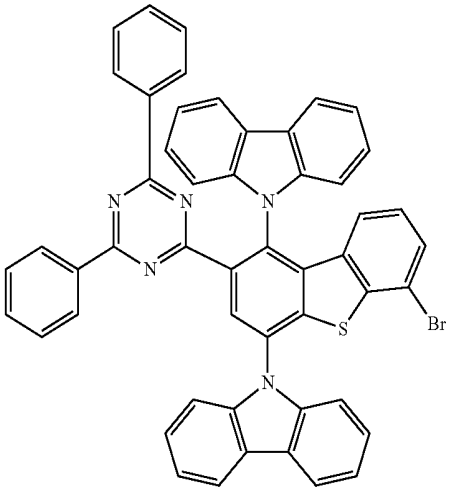

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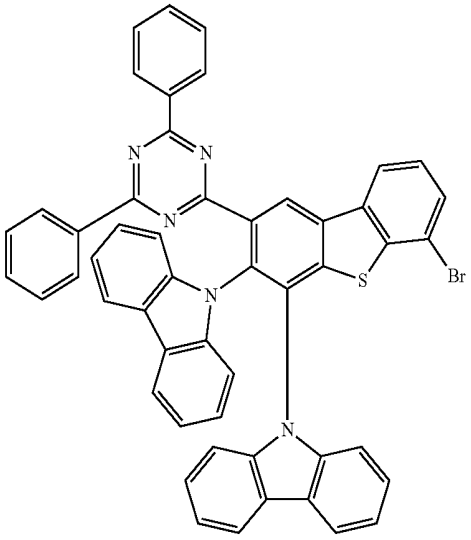

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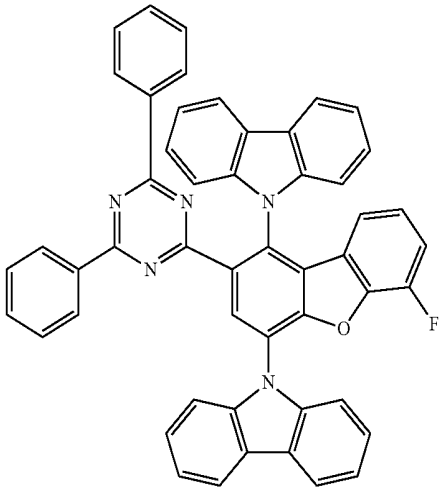

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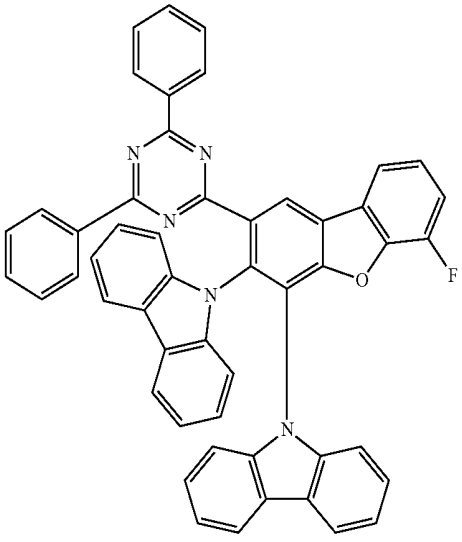

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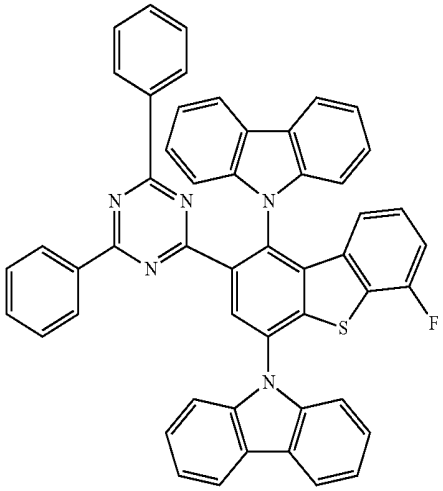

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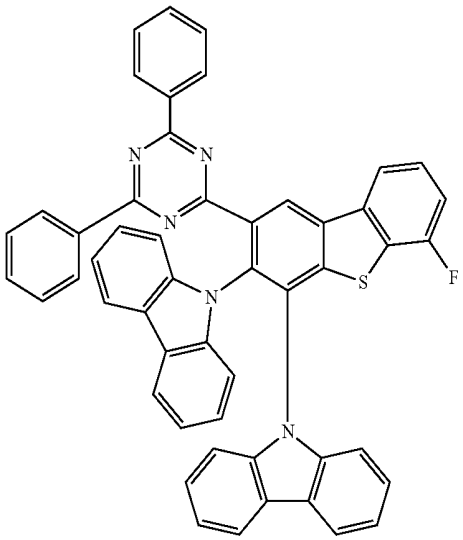

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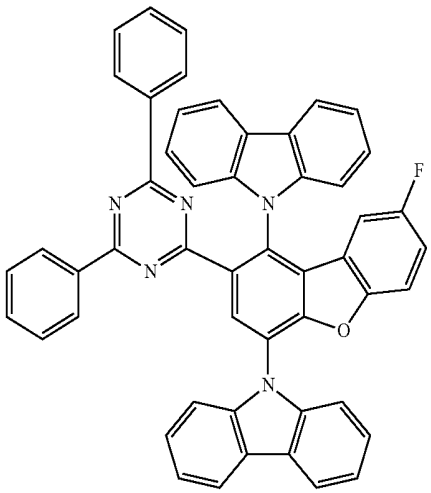

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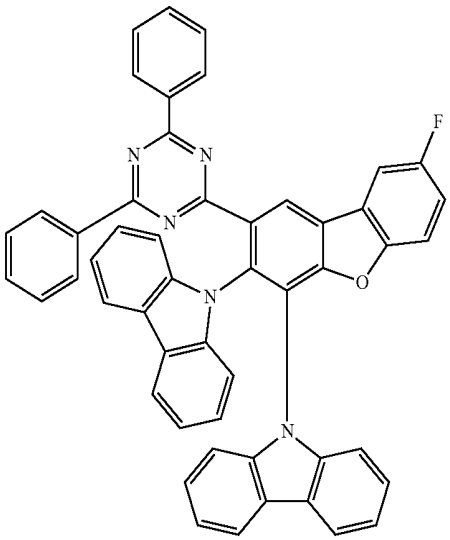

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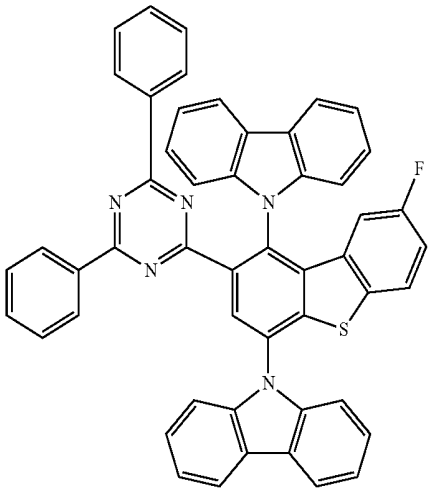

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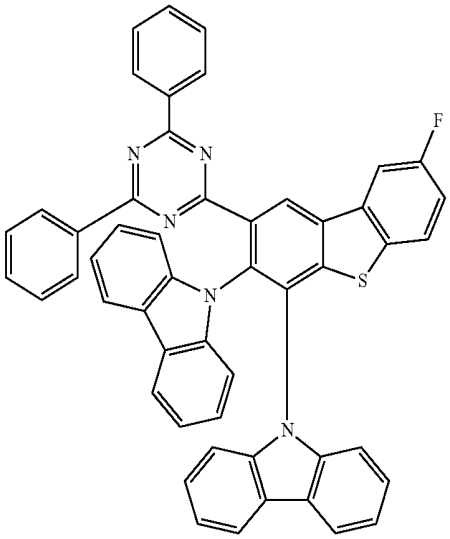

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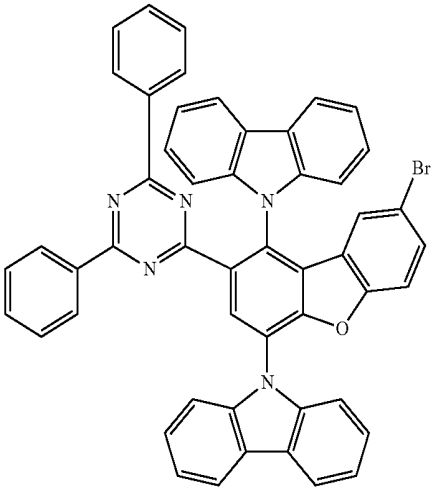

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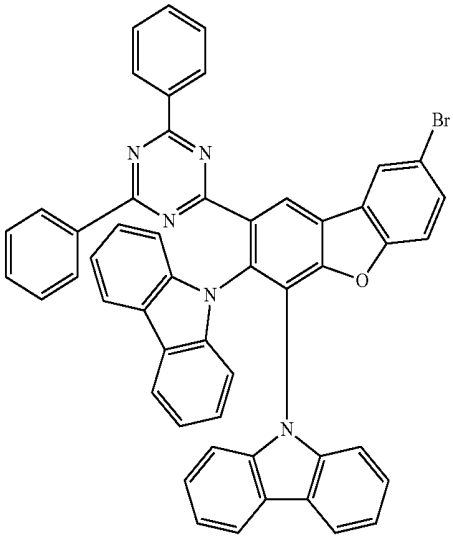

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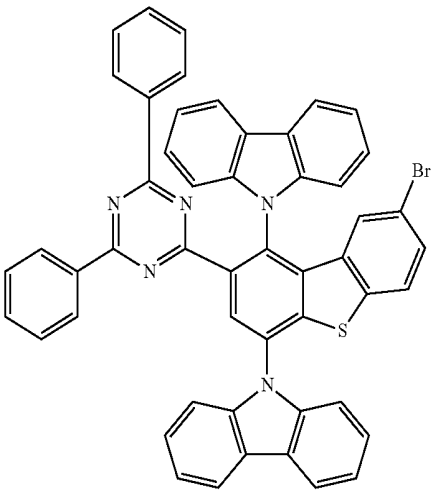

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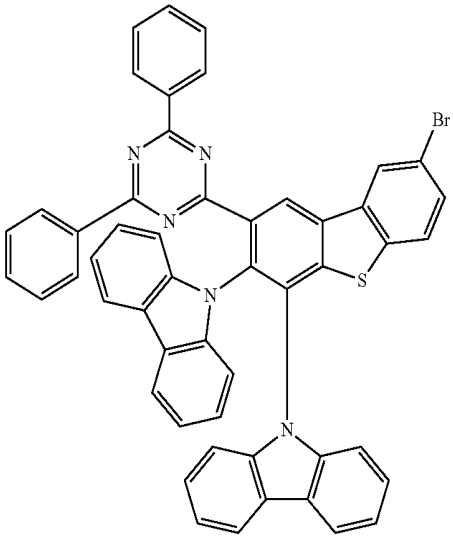

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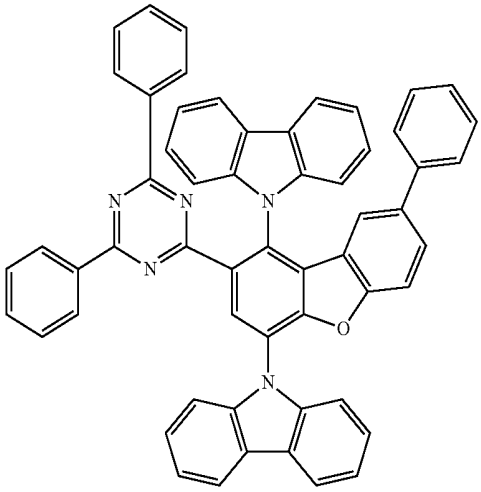

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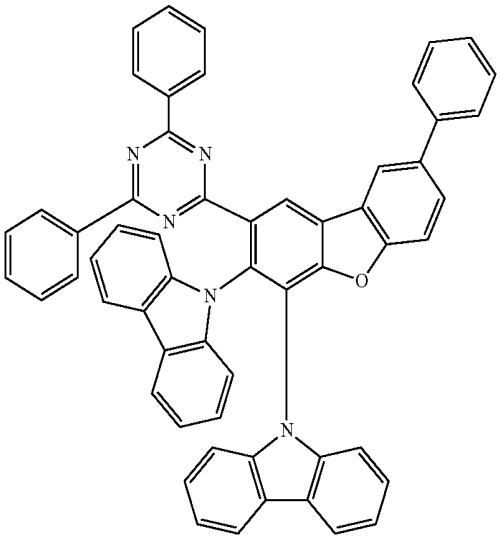

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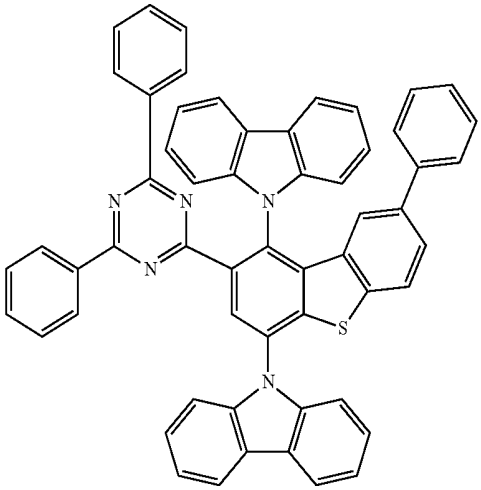

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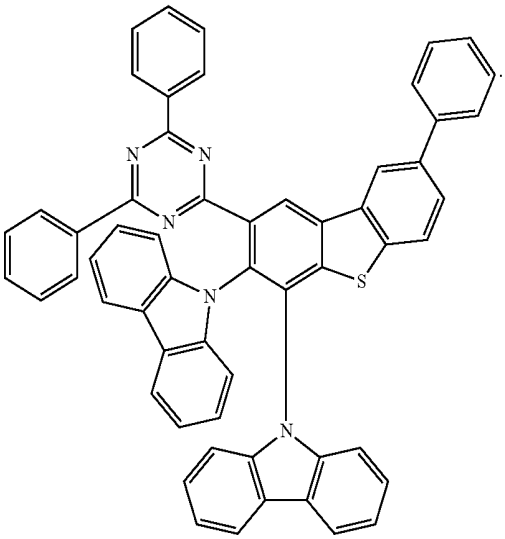


**14**. An organic electroluminescence device, comprising:

a first electrode;

a hole transport region on the first electrode;

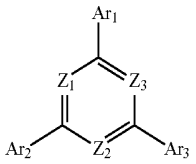
an emission layer on the hole transport region;

an electron transport region on the emission layer; and

a second electrode on the electron transport region,

wherein the emission layer includes a heterocyclic compound represented by the following Formula 1:

[Formula 1]



in Formula 1,

$Z_1$ to $Z_3$ are each independently $CR_1$ or N,

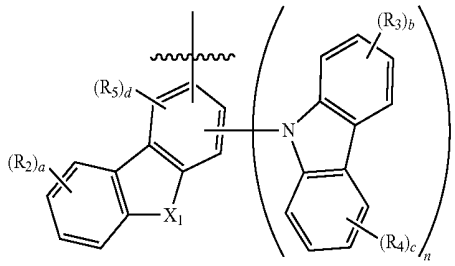
at least one of $Z_1$ to $Z_3$ is N,

$R_1$ is a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

$Ar_1$ to $Ar_3$ are each independently a group represented by the following Formula 2, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 carbon atoms for forming a ring, and

at least one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2:

[Formula 2]



in Formula 2,

$X_1$ is O or S,

"n" is an integer of 1 to 3,

"a" to "c" are each independently an integer of 0 to 4,

"d" is an integer of 0 to 2, and

$R_2$ to $R_5$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

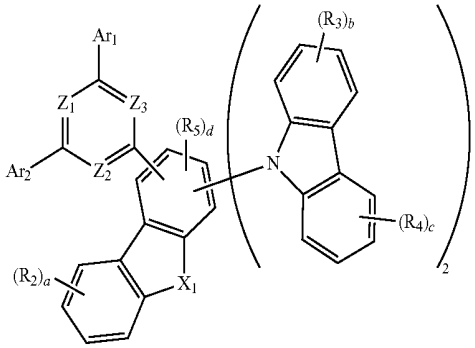
when only one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2 above, "n" is 2 or 3, and

at least one of the carbazole moieties in Formula 2 is bonded in an ortho relationship with respect to the nitrogen-containing monocycle of Formula 1.

**15**. The organic electroluminescence device as claimed in claim **14**, wherein each of $Z_1$ to $Z_3$ is N.

**16**. The organic electroluminescence device as claimed in claim **14**, wherein the compound represented by Formula 1 is represented by Formula 1-1 or Formula 1-3:

[Formula 1-1]



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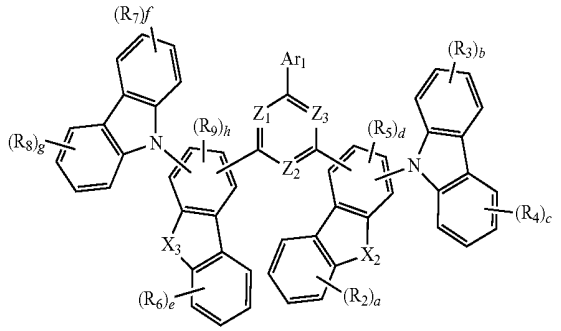
[Formula 1-3]



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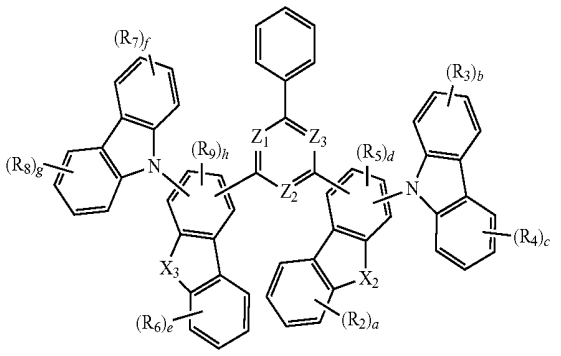
[Formula 1-4]



in Formulae 1-1 and 1-3,

$Z_1$ to $Z_3$, Art, $Ar_2$, $R_2$ to $R_5$, "a" to "d" and $X_1$ are defined the same as those of Formula 1 and Formula 2, and

in Formula 1-3,

$X_2$ and $X_3$ are each independently O or S,

$R_6$ to $R_9$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

"e" to "g" are each independently an integer of 0 to 4, and

"h" is an integer of 0 to 2.

**17**. The organic electroluminescence device as claimed in claim **14**, wherein the compound represented by Formula 1 is represented by the following Formula 1-2 or Formula 1-4:

in Formulae 1-2 and 1-4,

$Z_1$ to $Z_3$, $R_2$ to $R_5$, "a" to "d" and $X_1$ are defined the same as those of Formulae 1 and 2, and

in Formula 1-4,

$X_2$ and $X_3$ are each independently O or S,

$R_6$ to $R_9$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

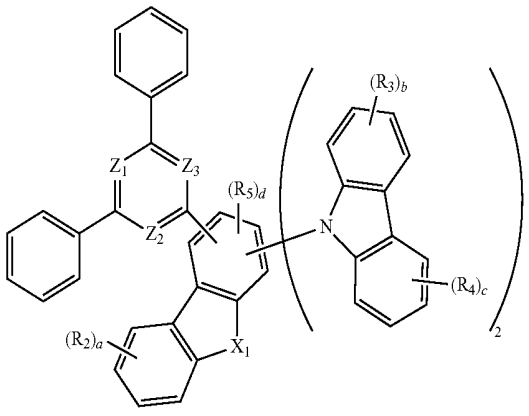
"e" to "g" are each independently an integer of 0 to 4, and

"h" is an integer of 0 to 2.

**18**. The organic electroluminescence device as claimed in claim **14**, wherein the heterocyclic compound is a compound of the following Compound Group 1:

[Compound Group 1]

[Formula 1-2]



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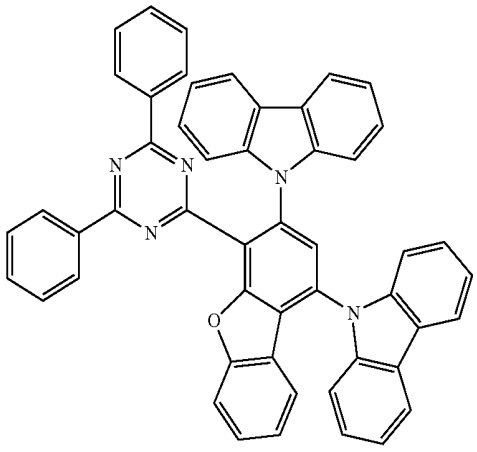

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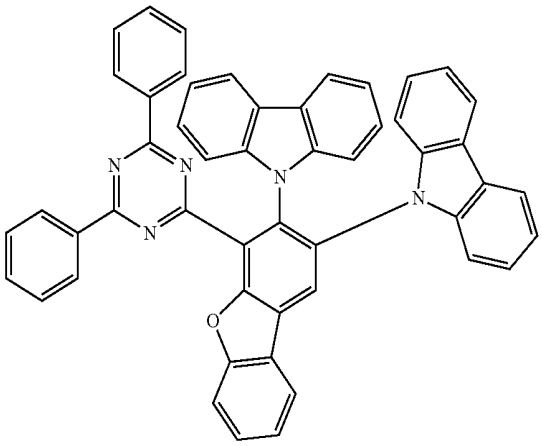

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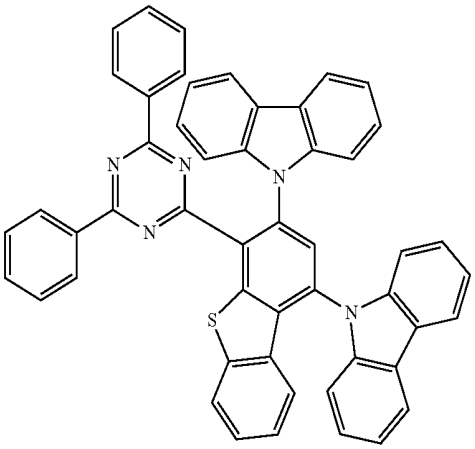

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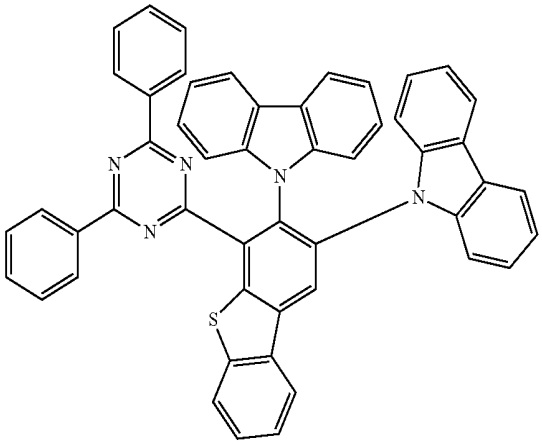

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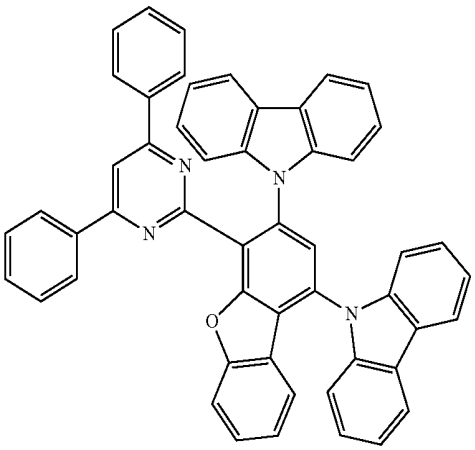

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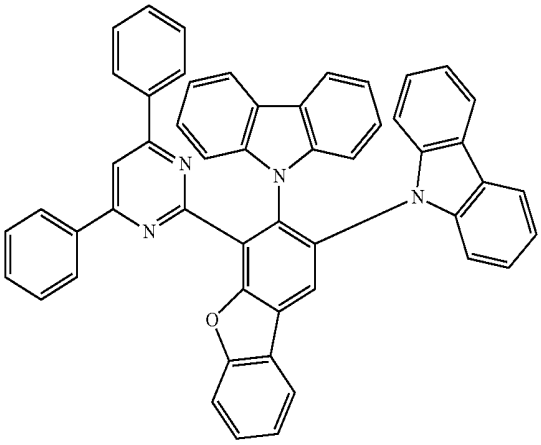

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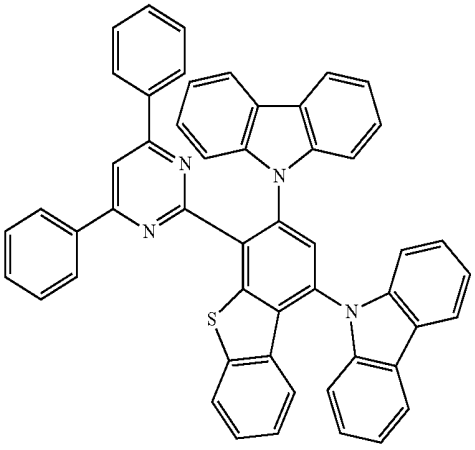

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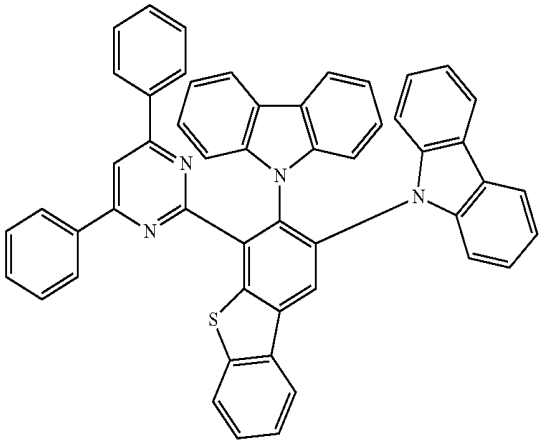

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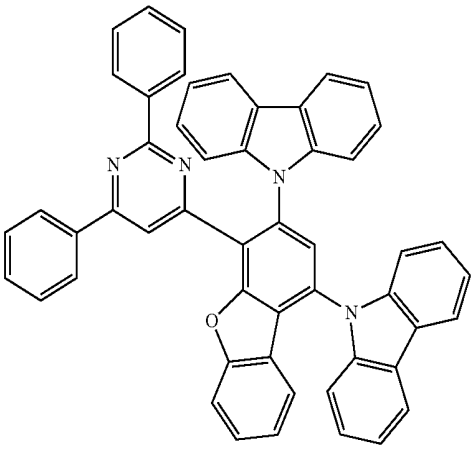

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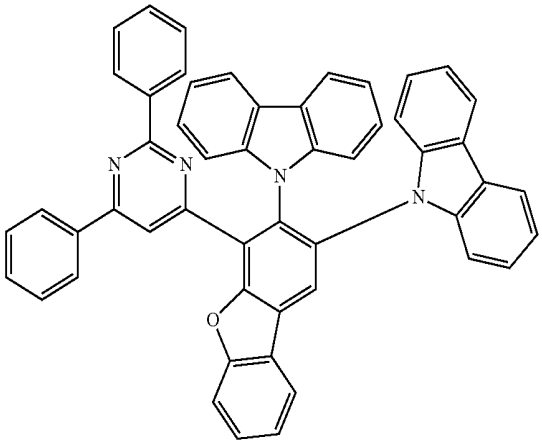

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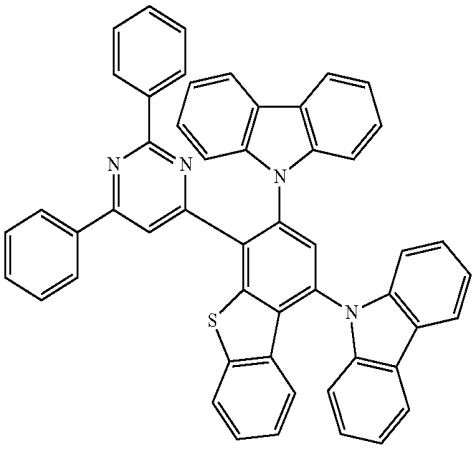

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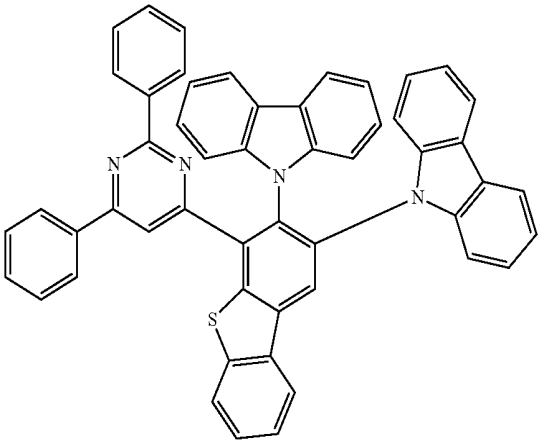

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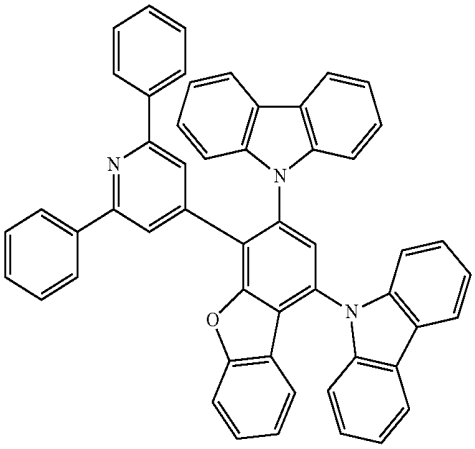

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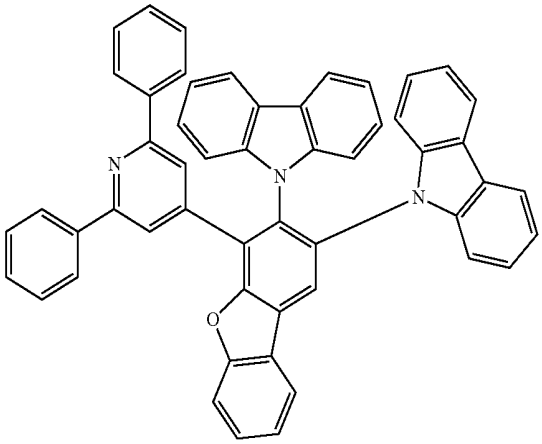

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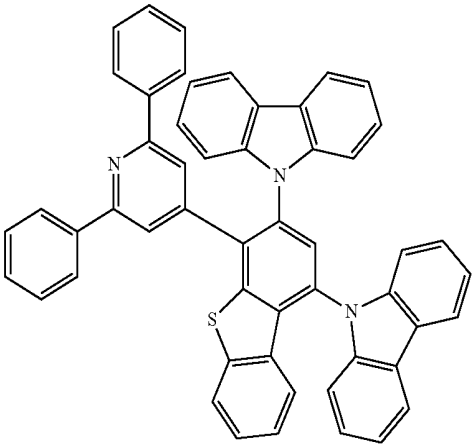

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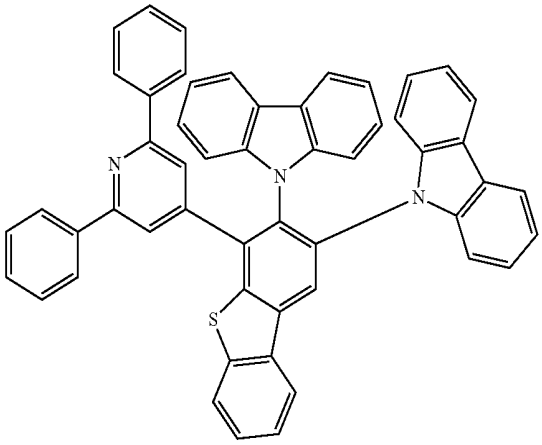

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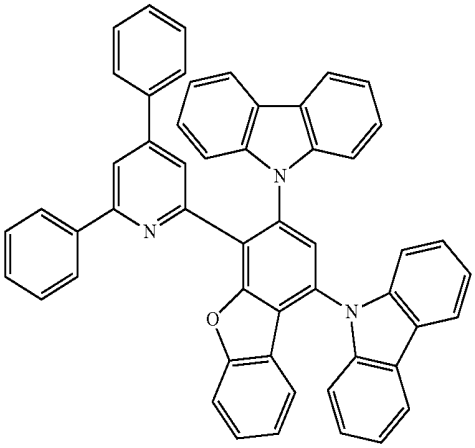

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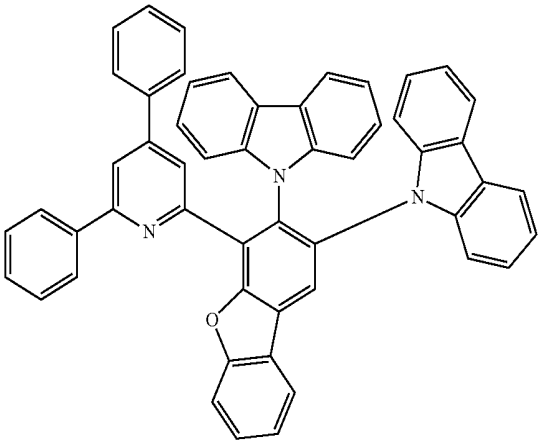

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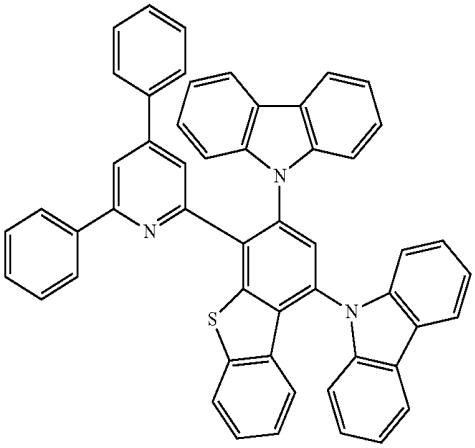

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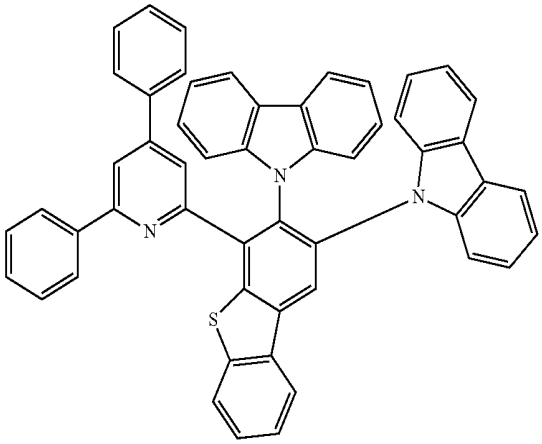

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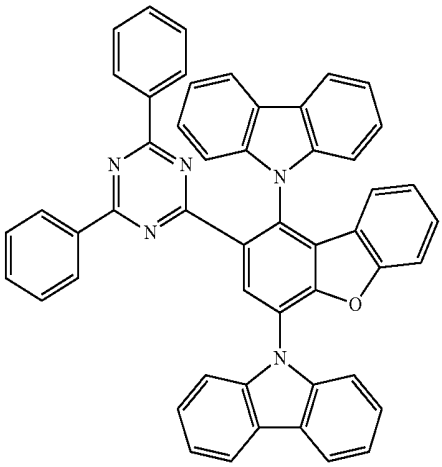

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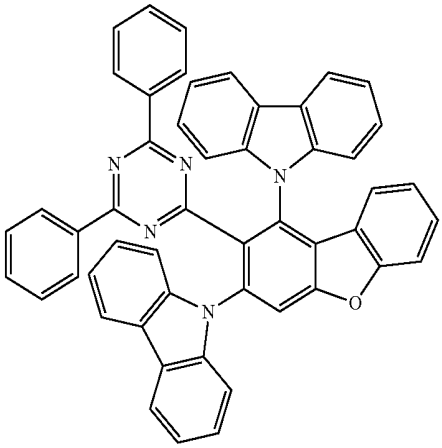

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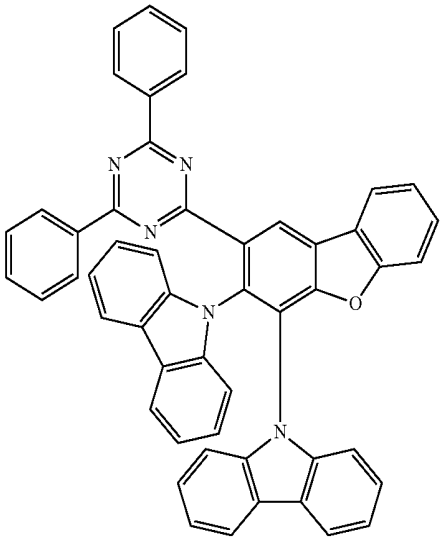

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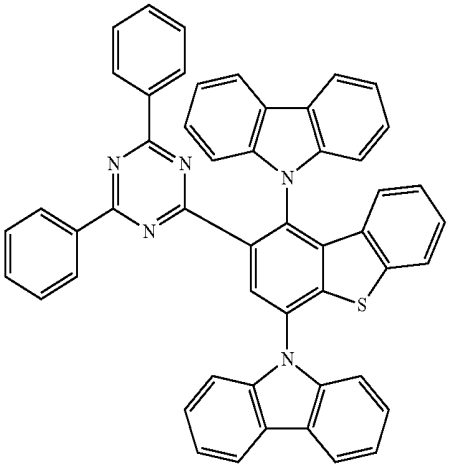

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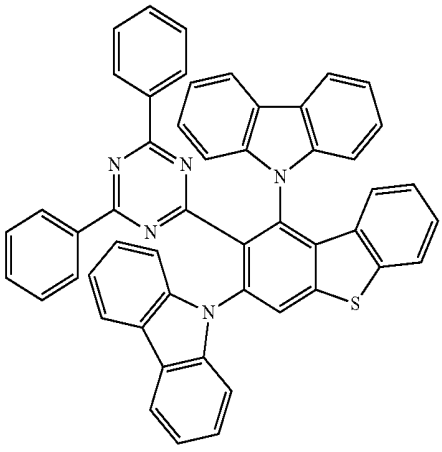

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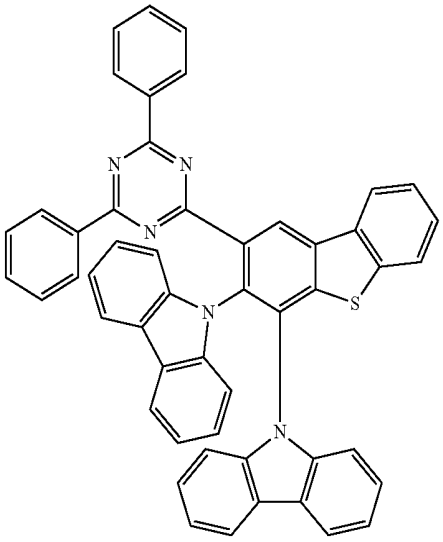

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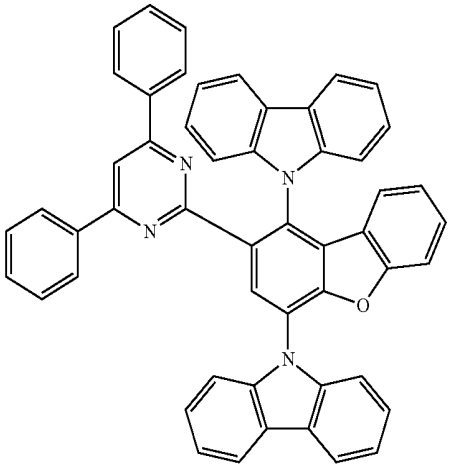

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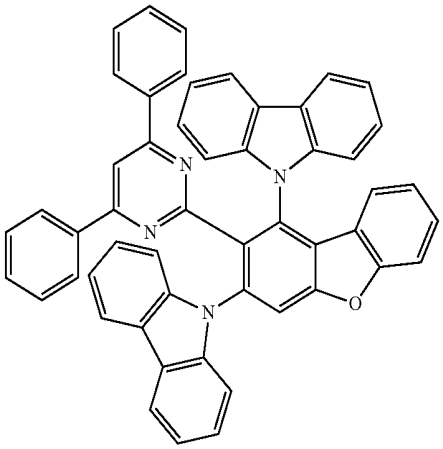

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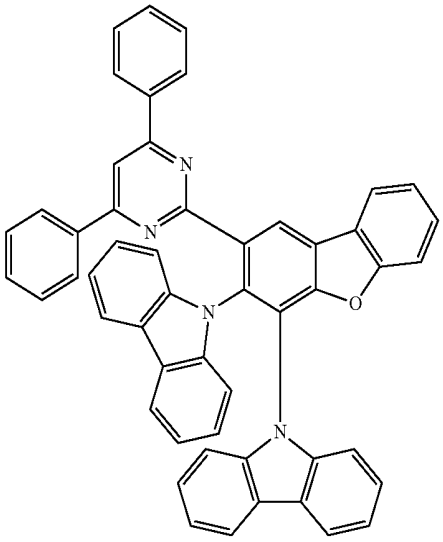

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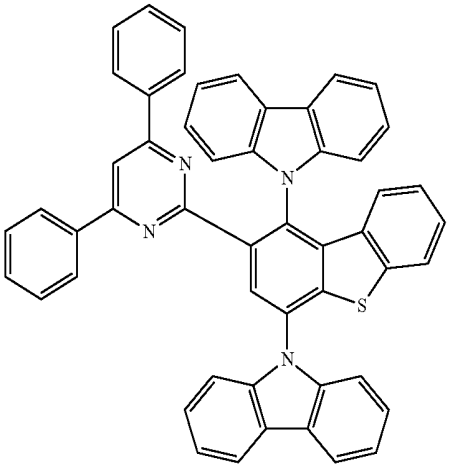

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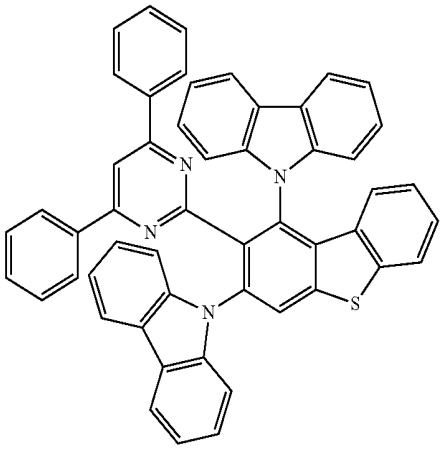

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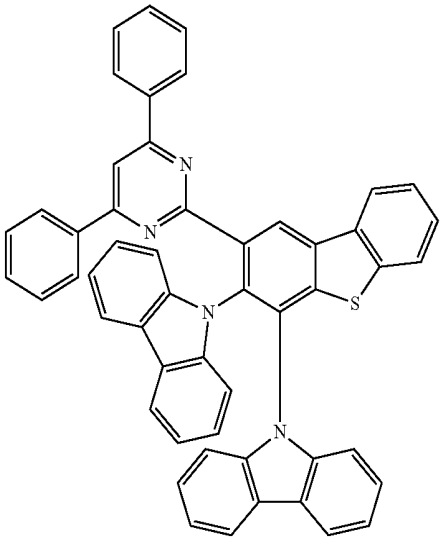

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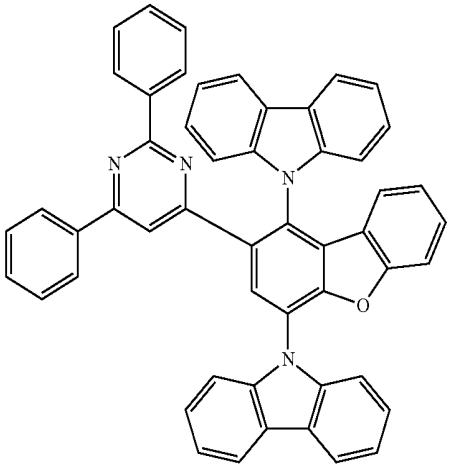

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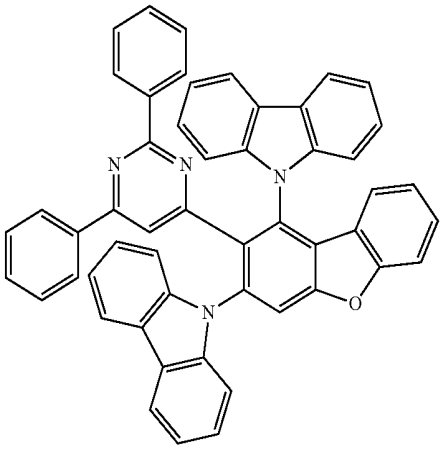

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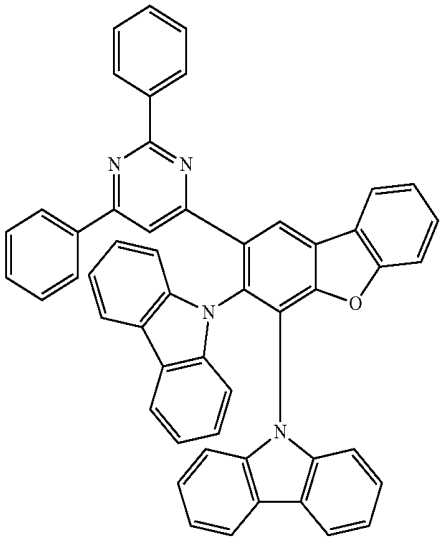

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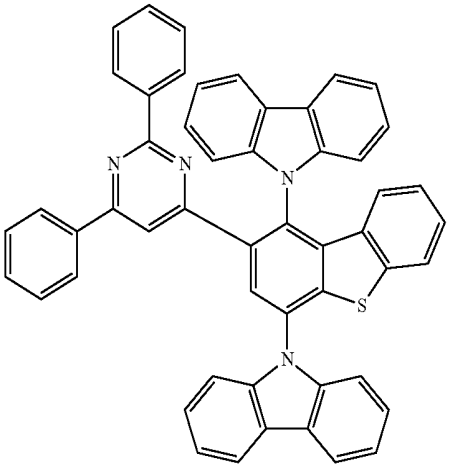

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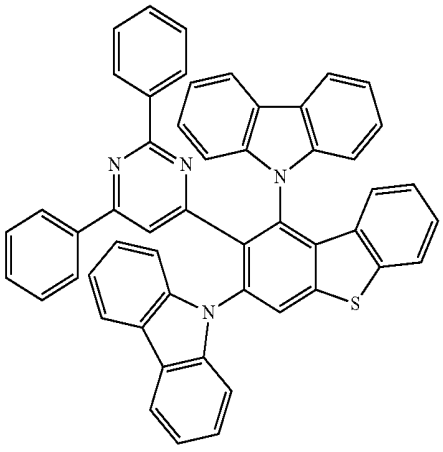

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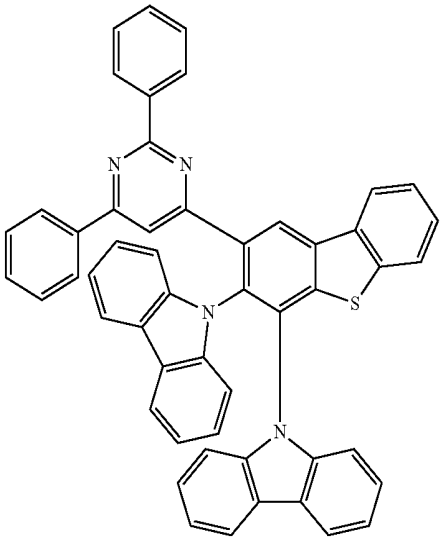

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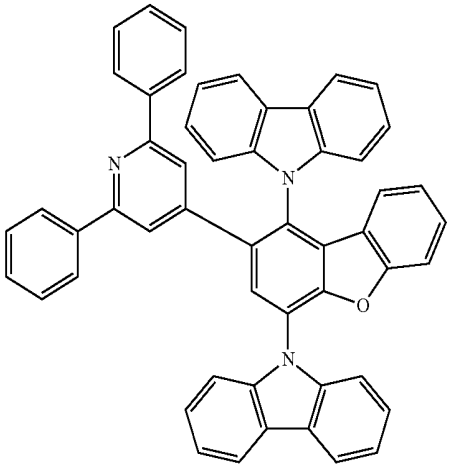

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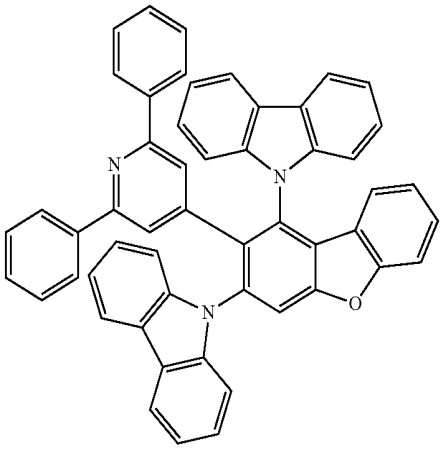

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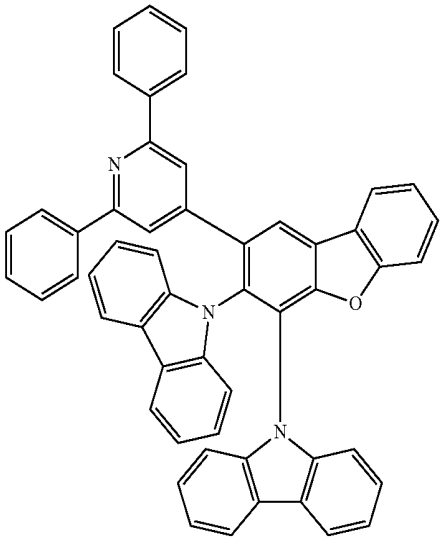

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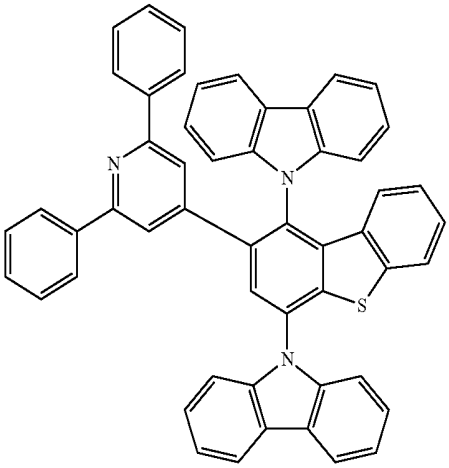

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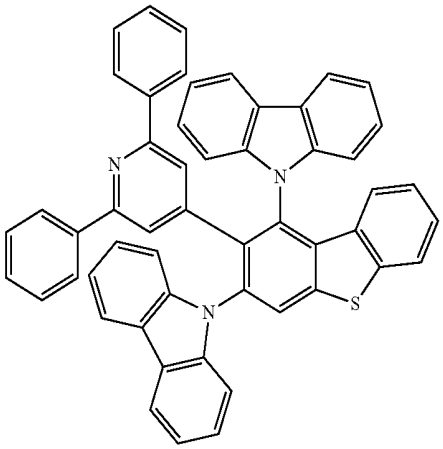

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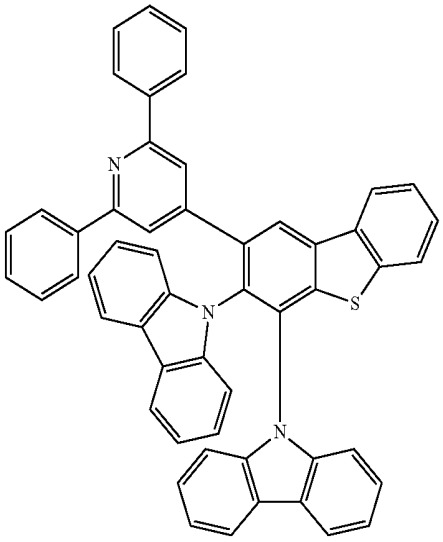

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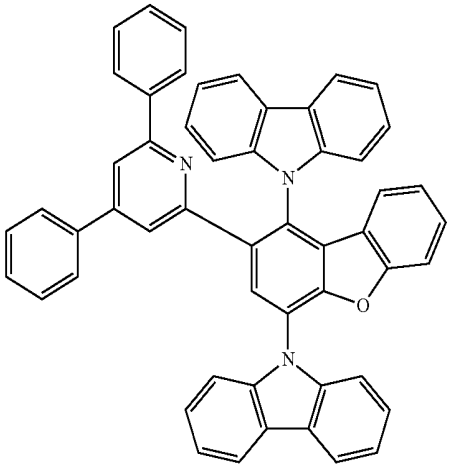

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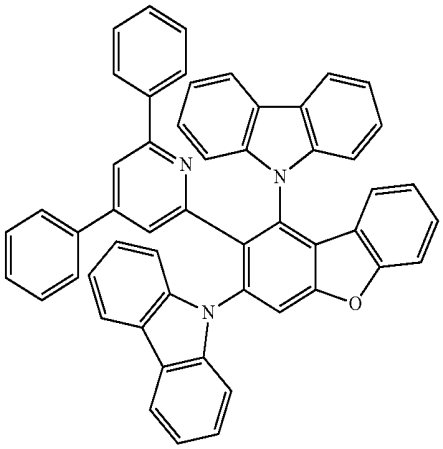

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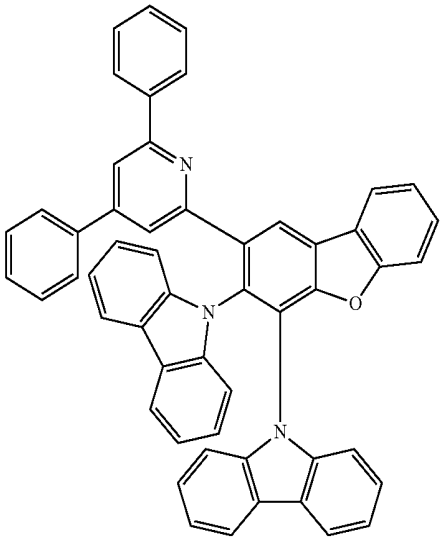

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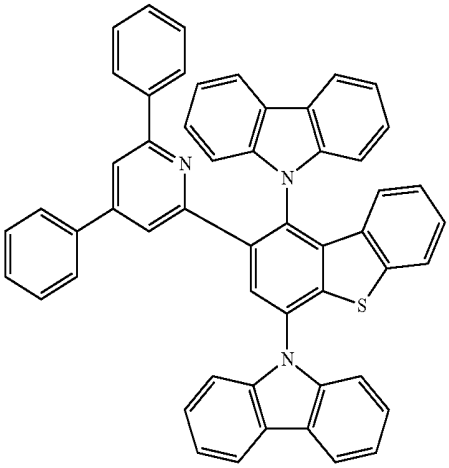

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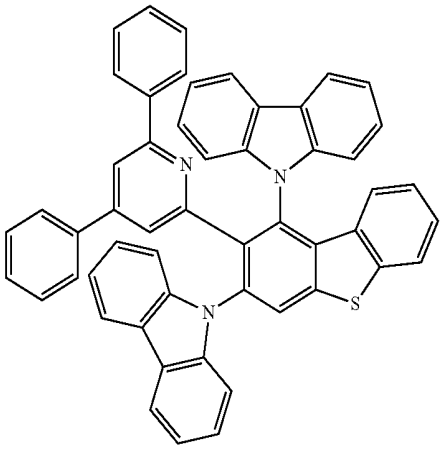

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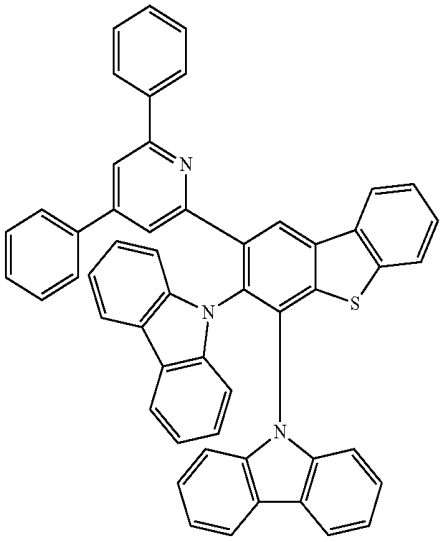

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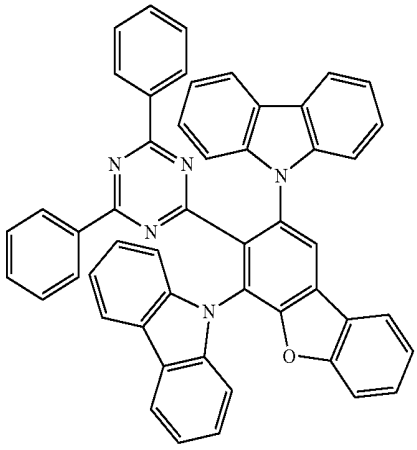

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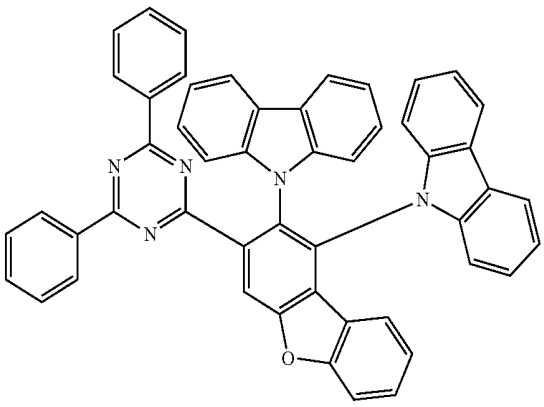

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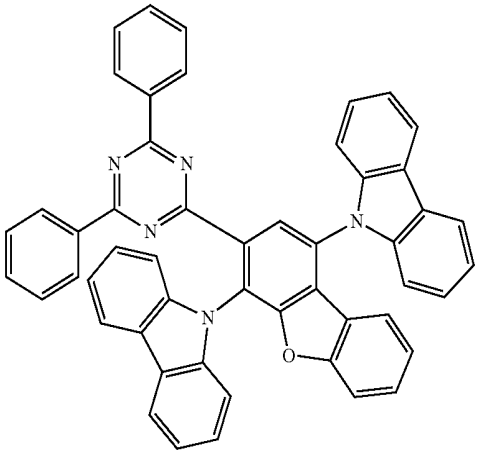

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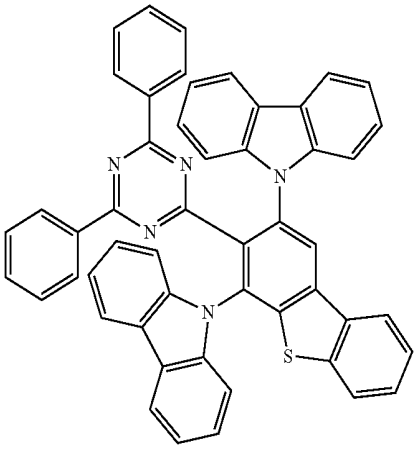

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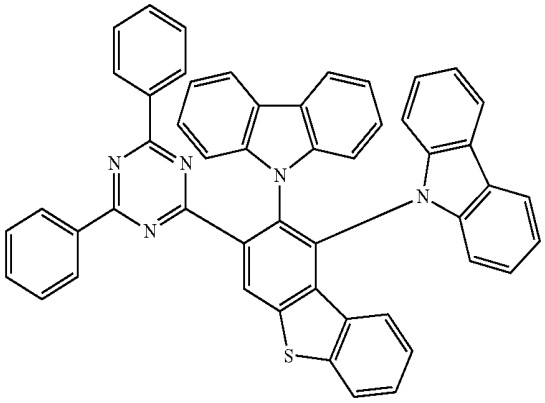

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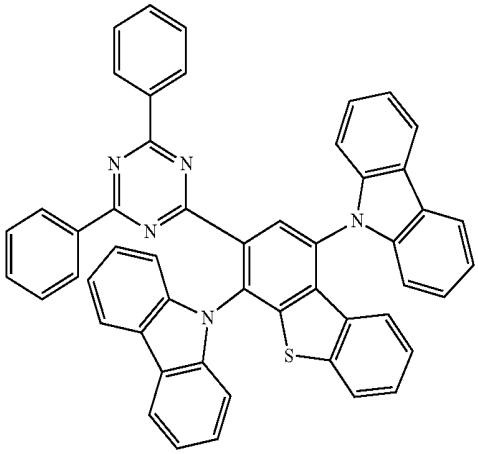

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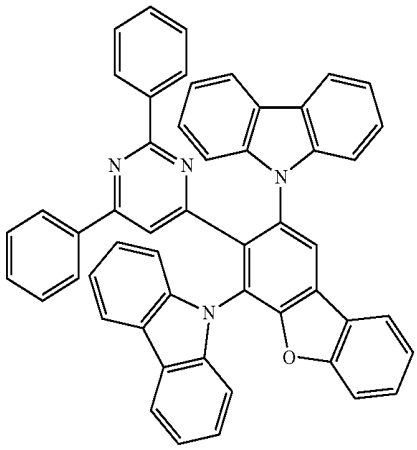

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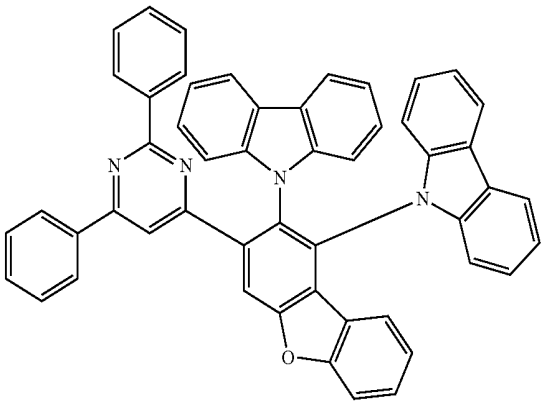

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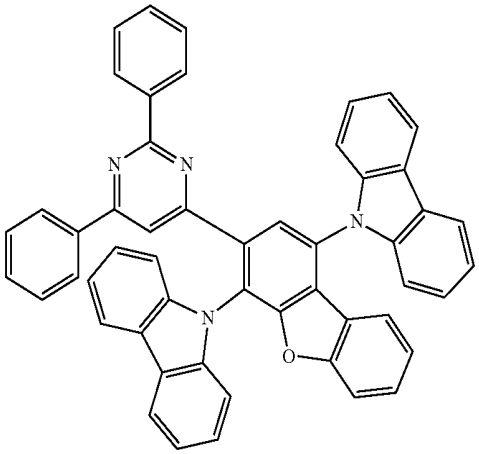

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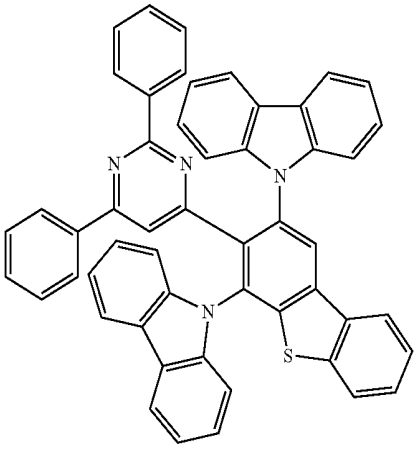

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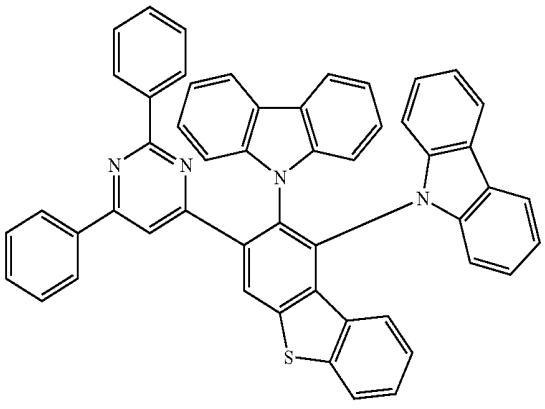

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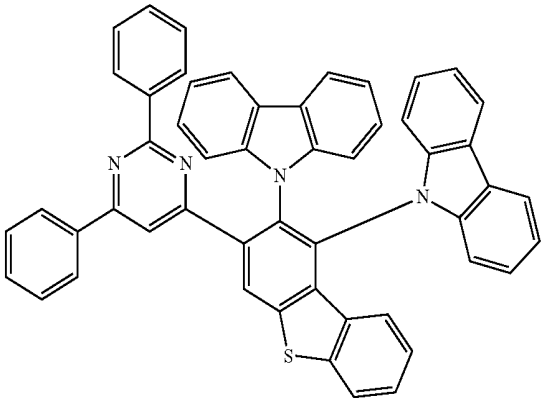

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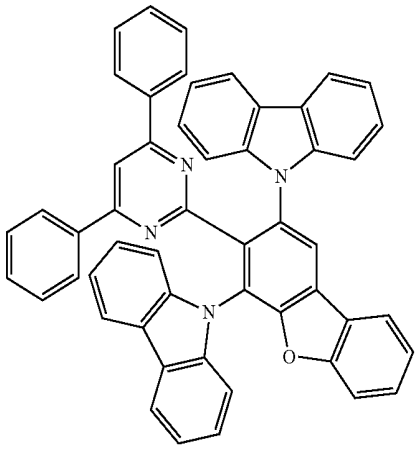

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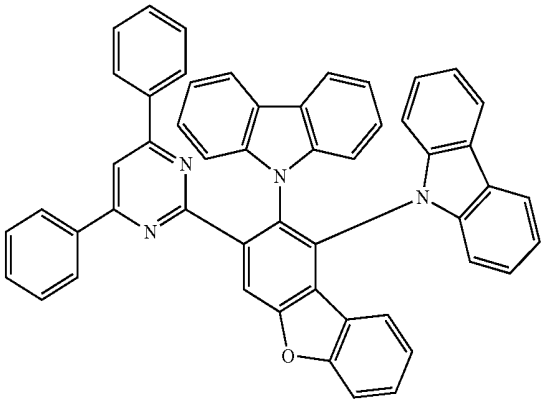

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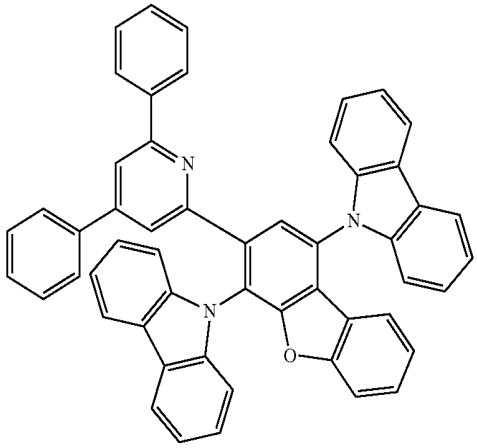

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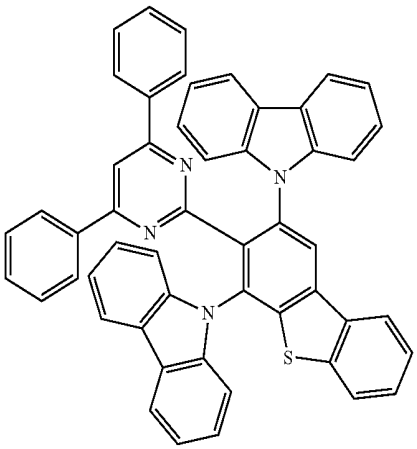

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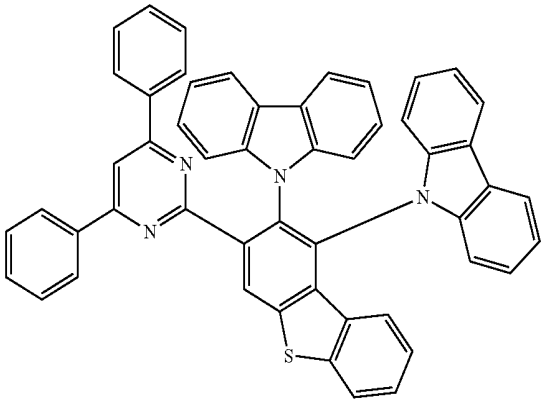

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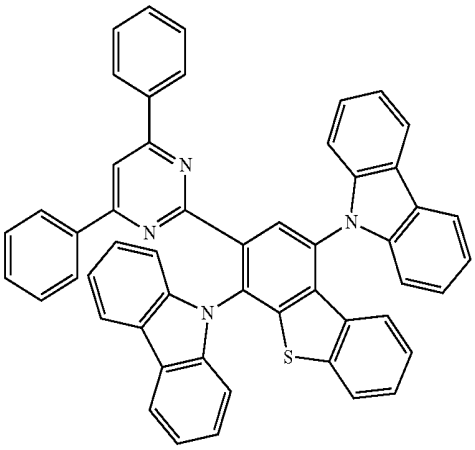

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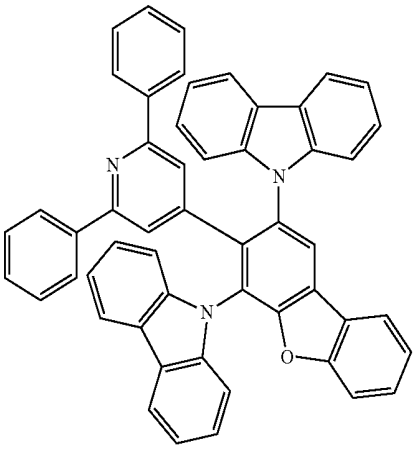

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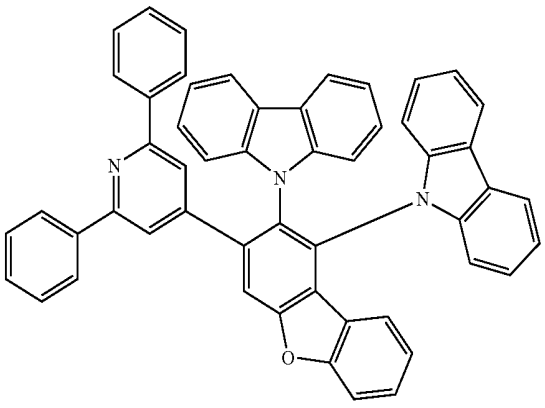

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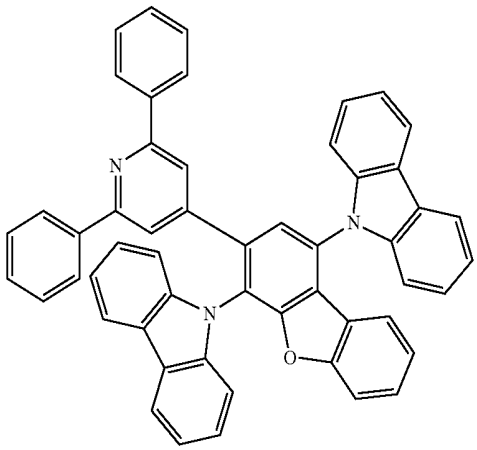

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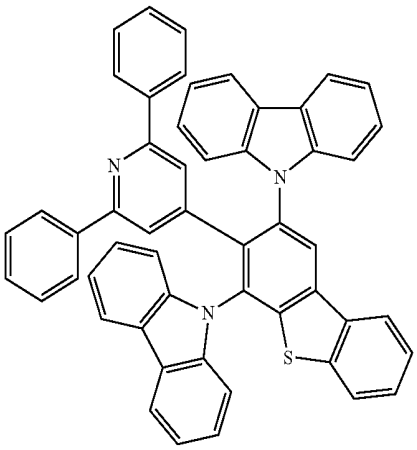

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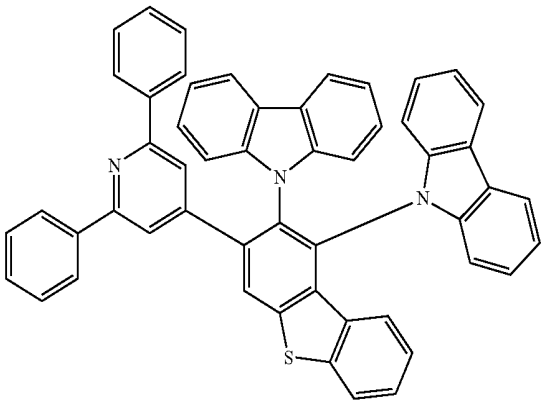

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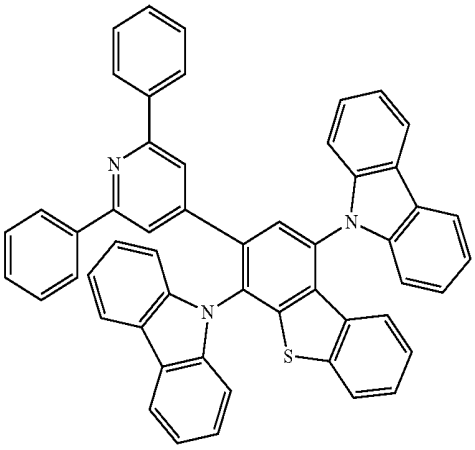

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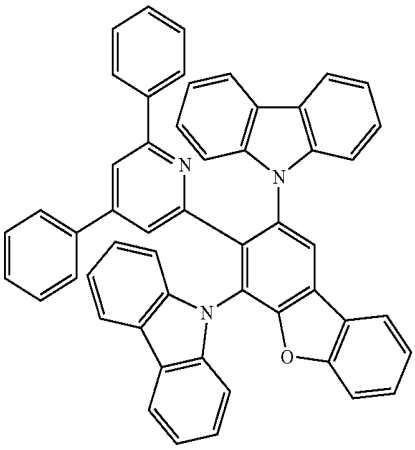

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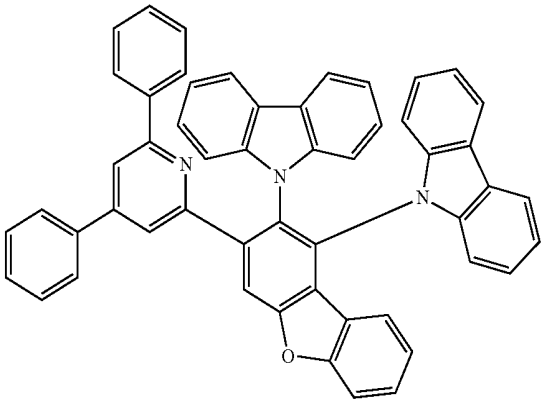

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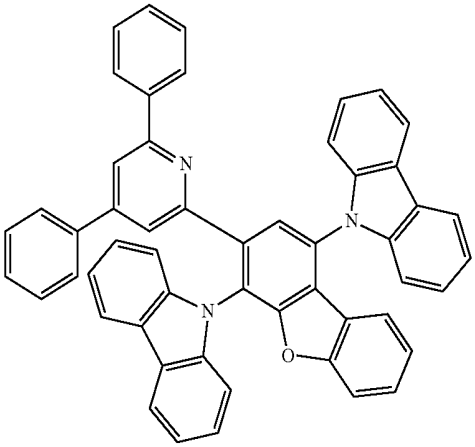

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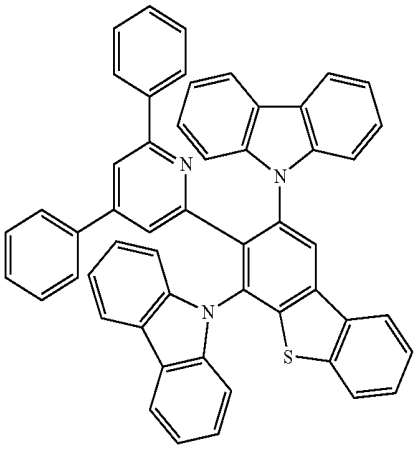

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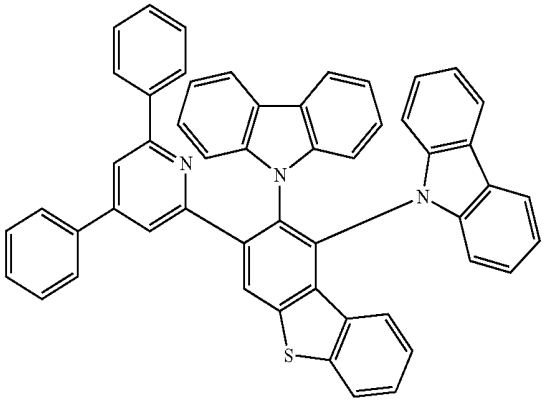

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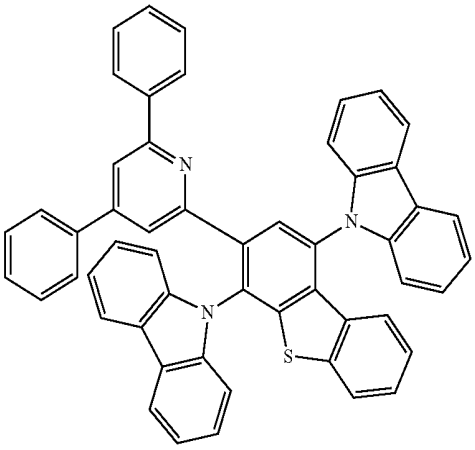

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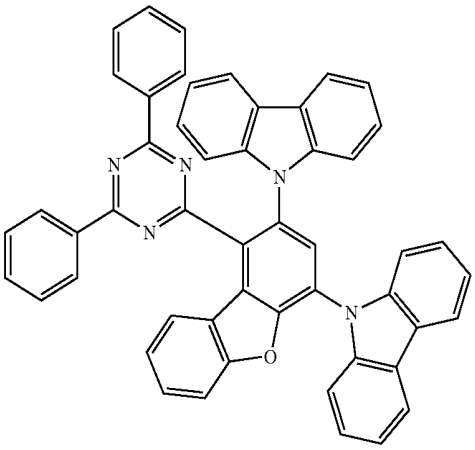

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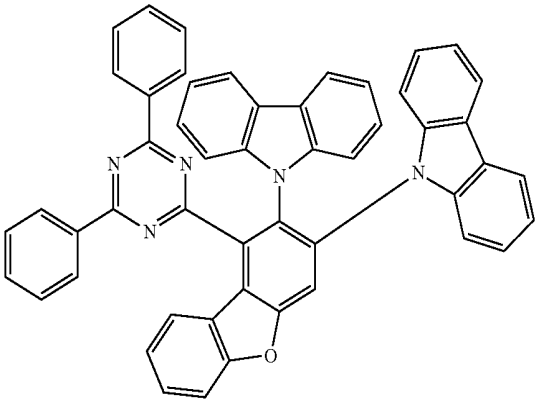

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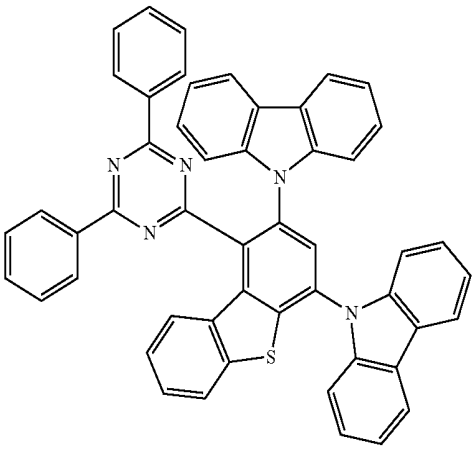

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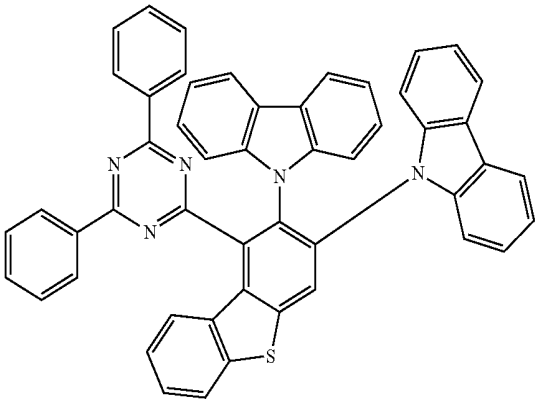

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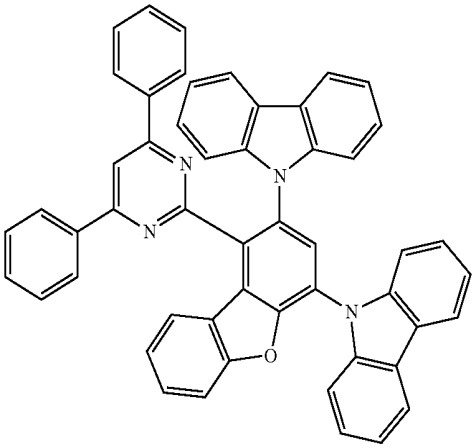

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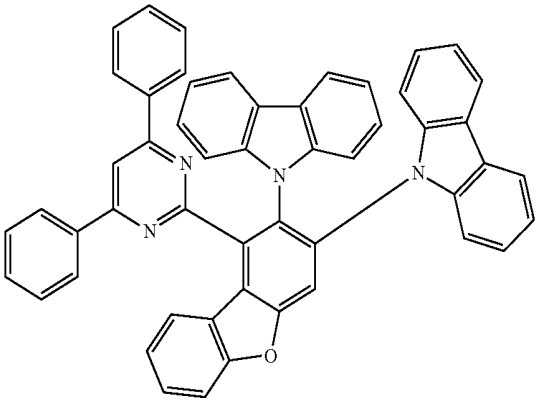

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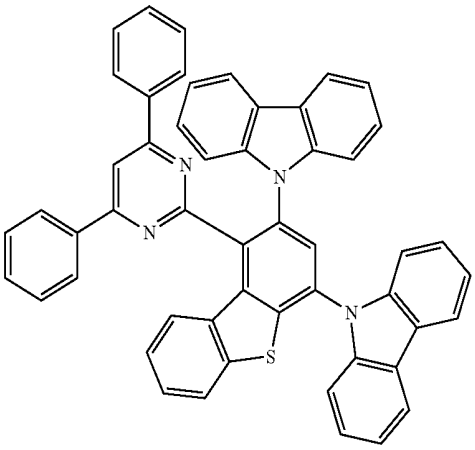

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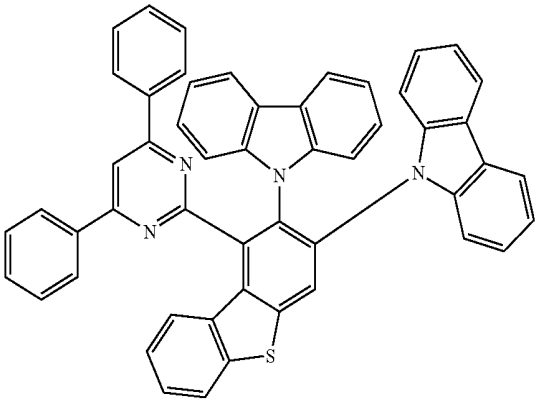

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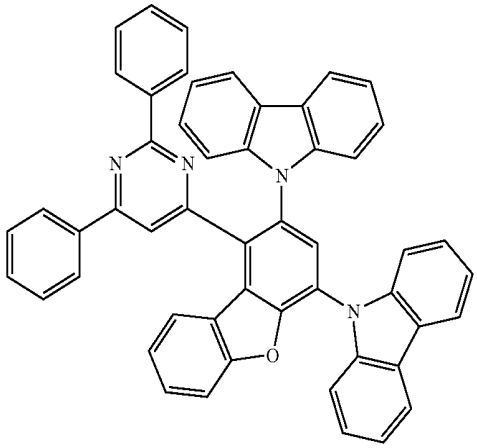

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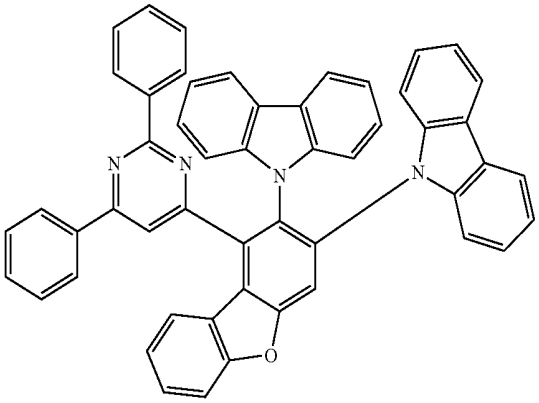

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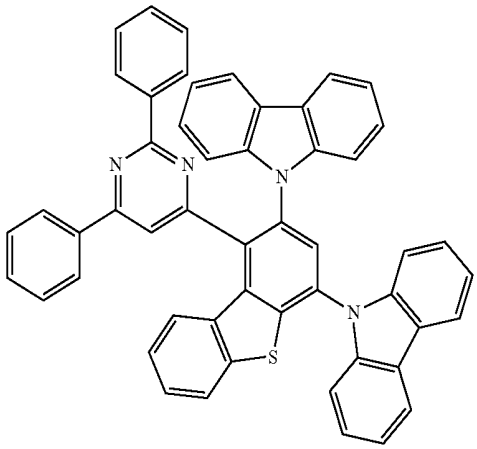

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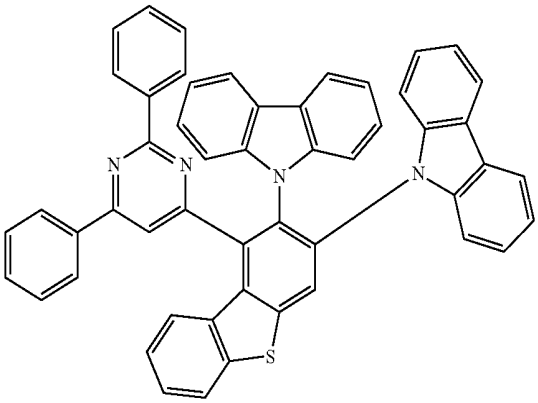

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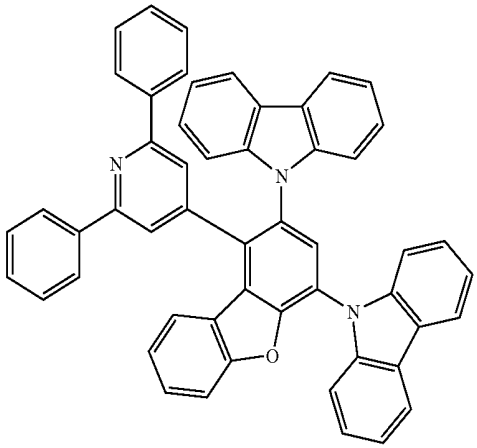

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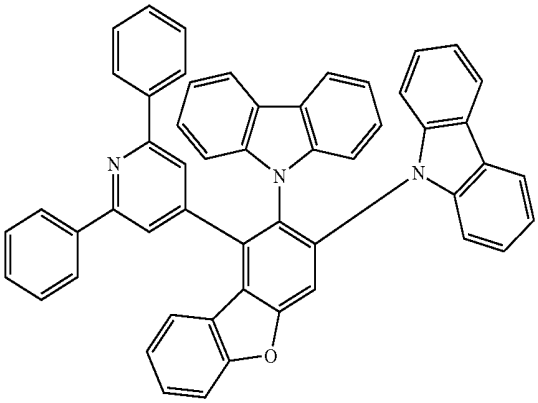

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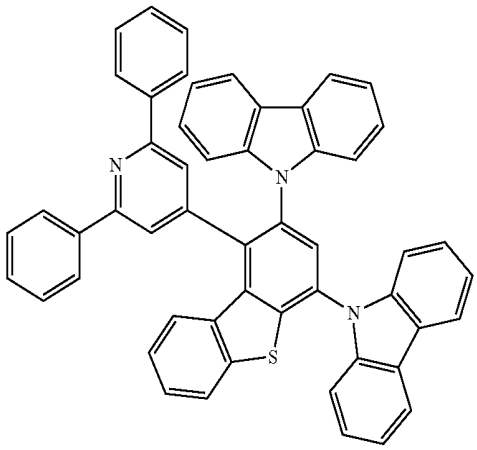

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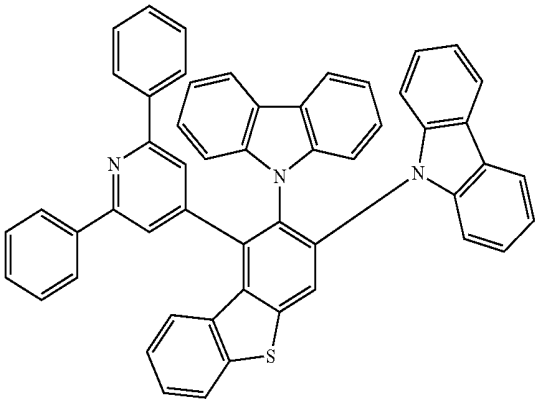

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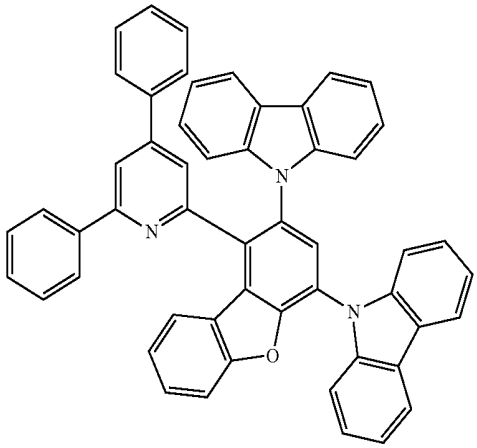

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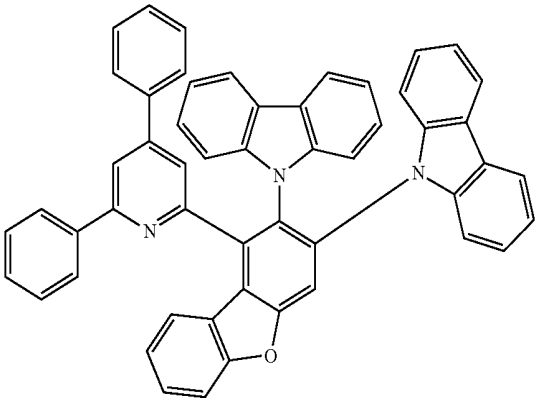

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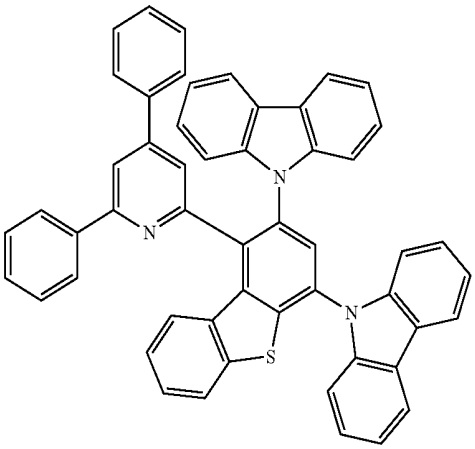

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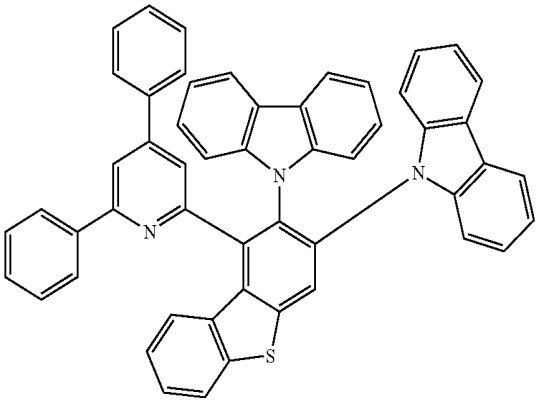

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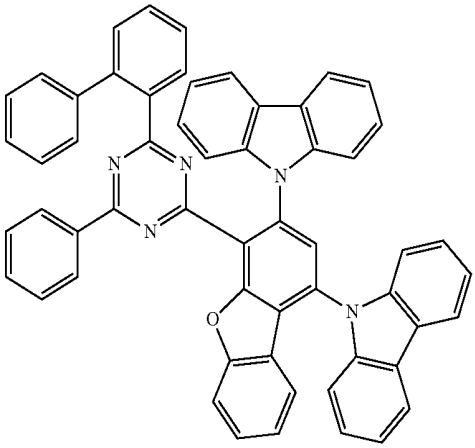

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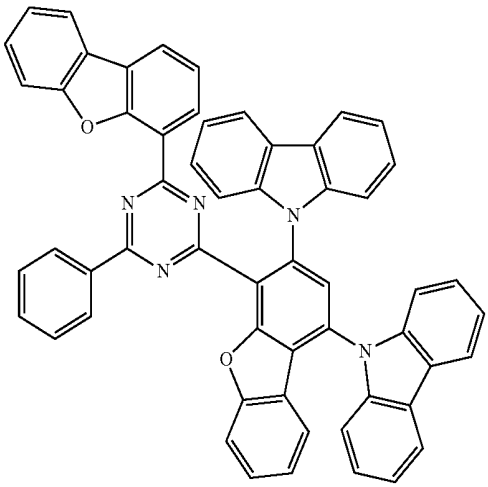

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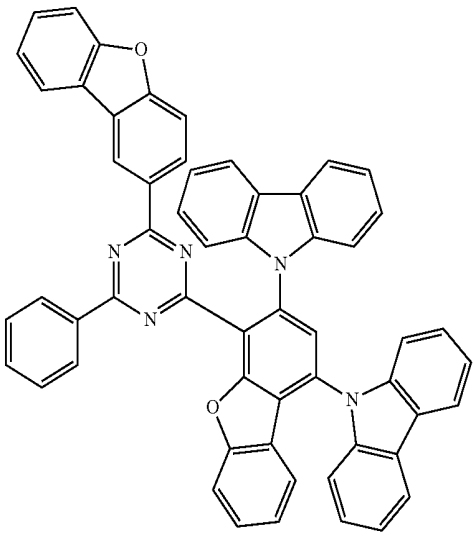

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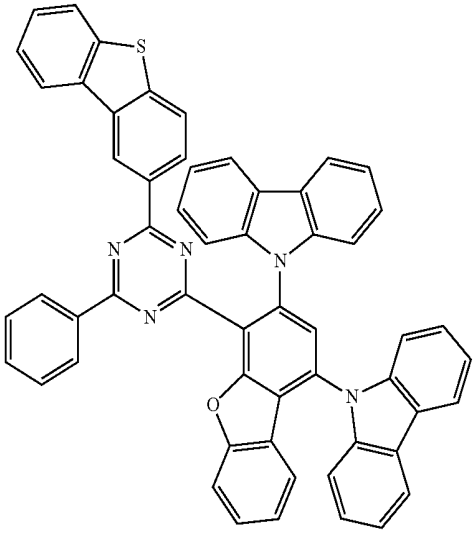

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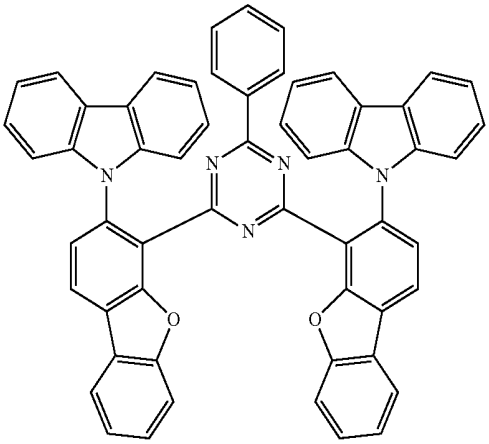

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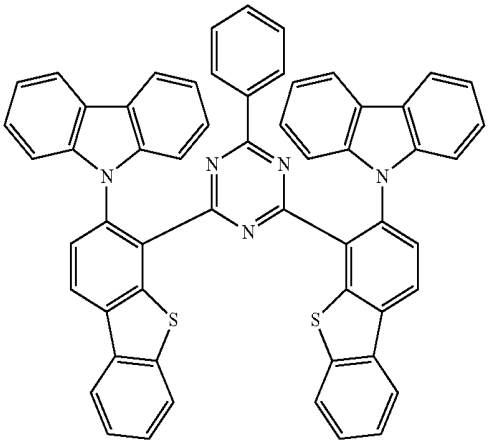

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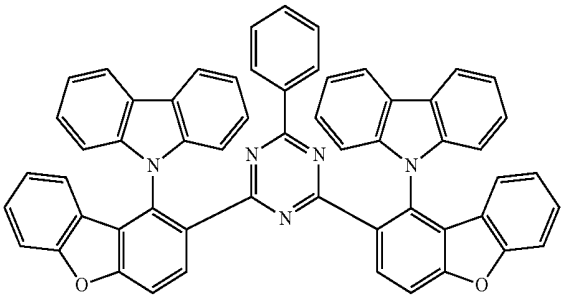

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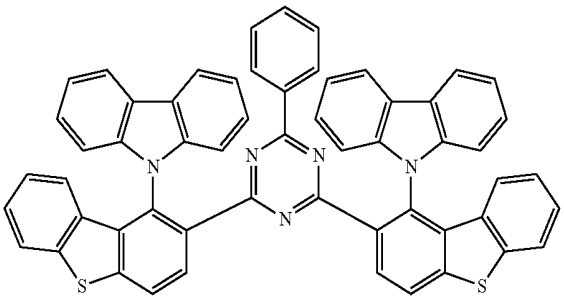

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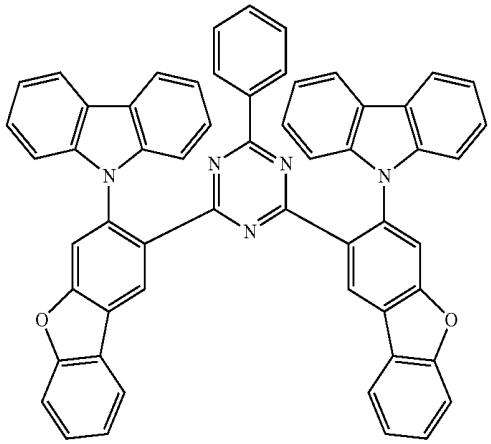

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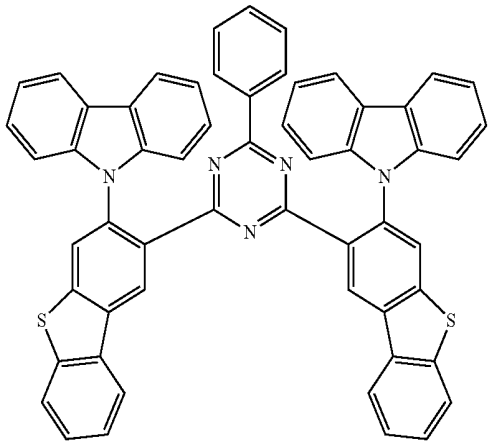

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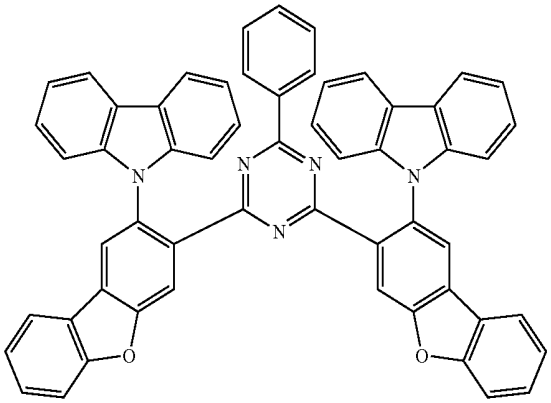

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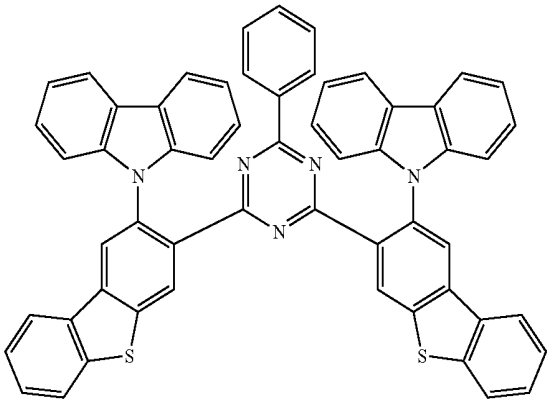

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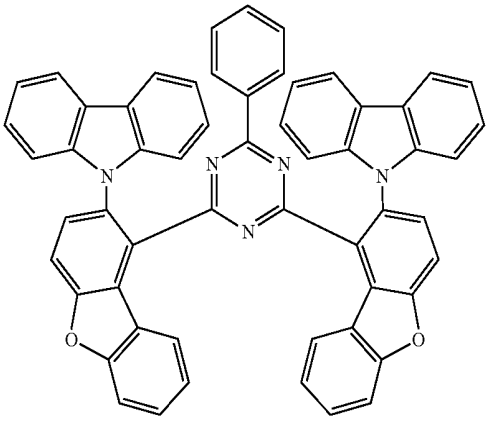

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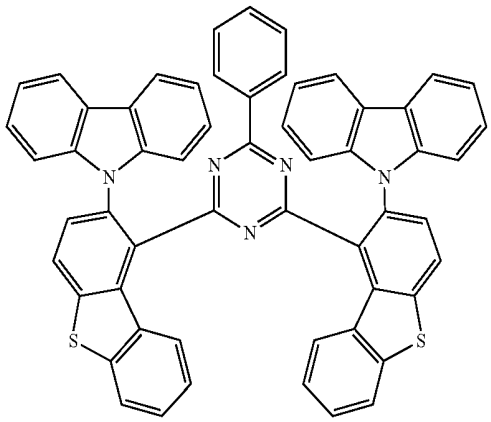

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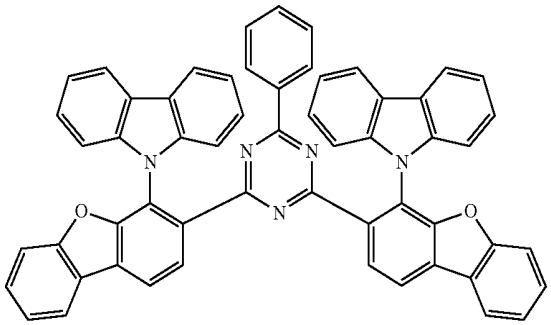

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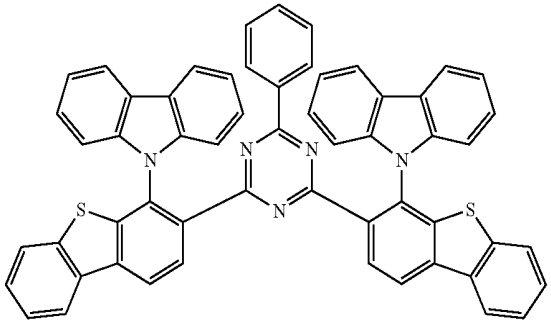

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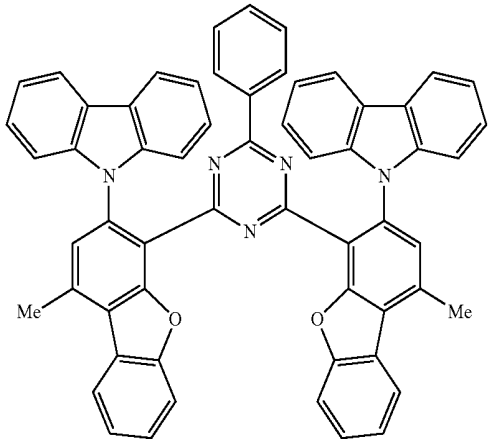

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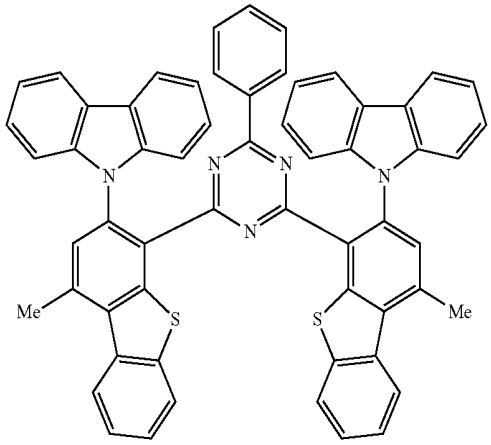

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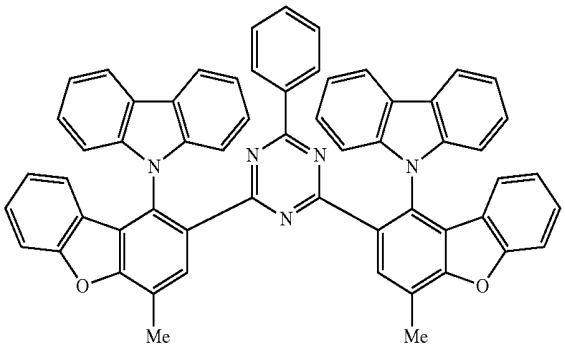

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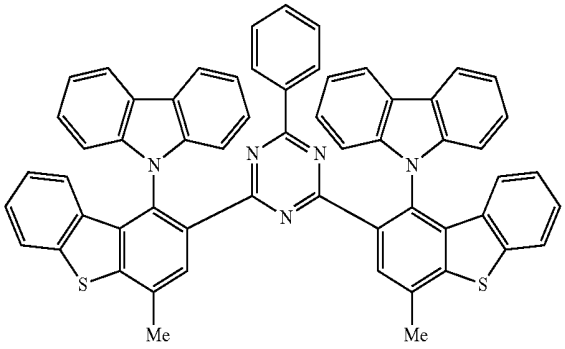

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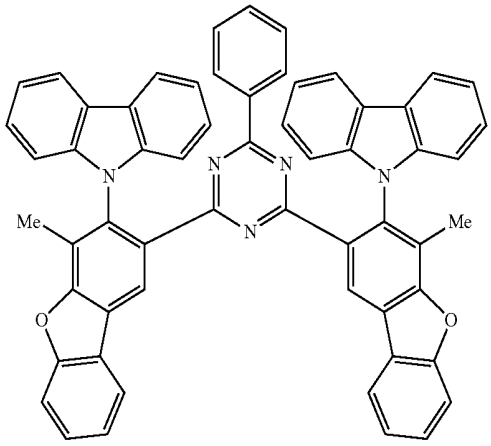

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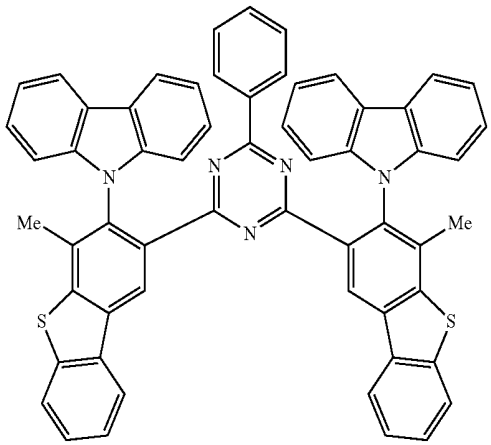

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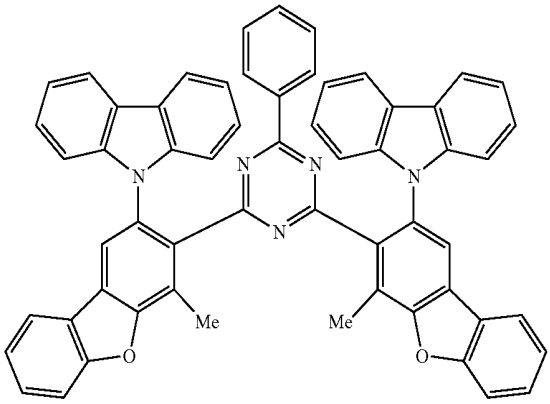

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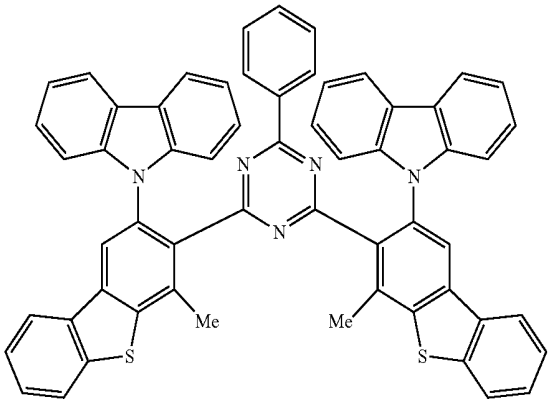

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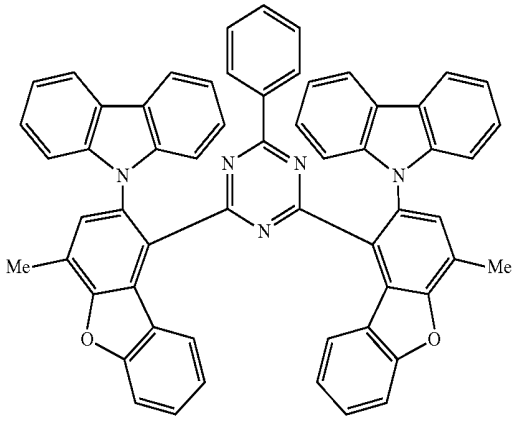

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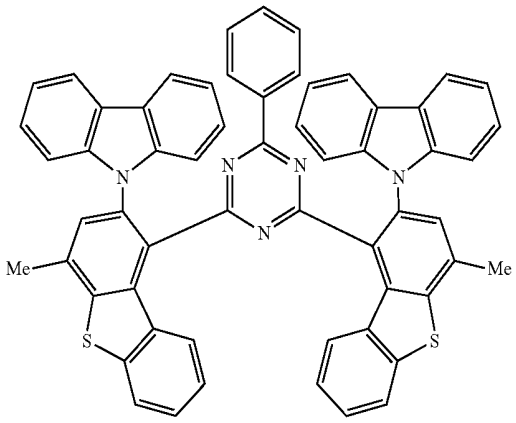

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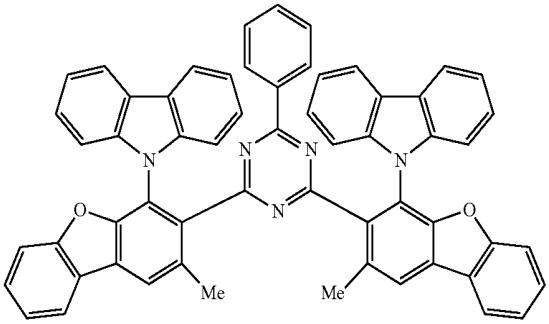

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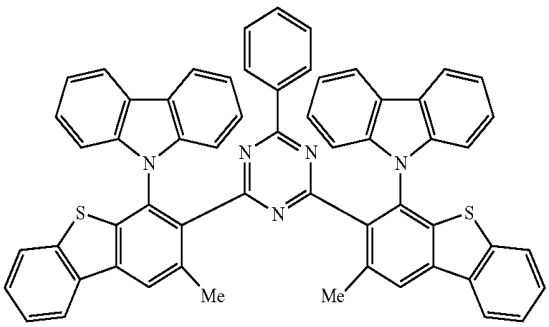

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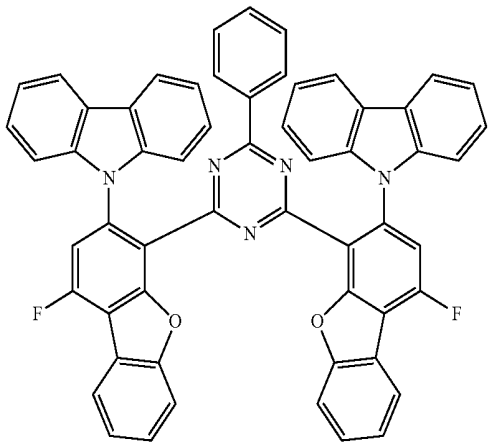

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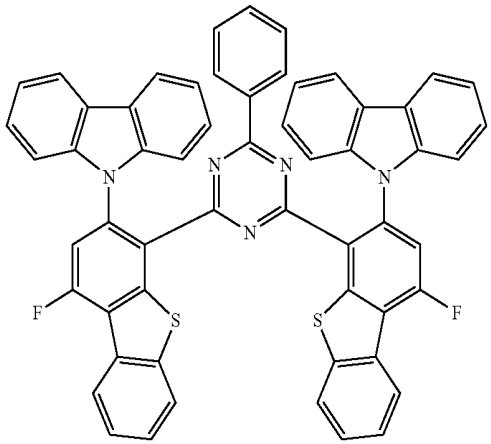

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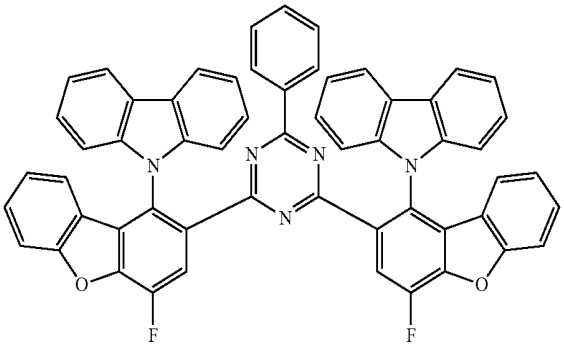

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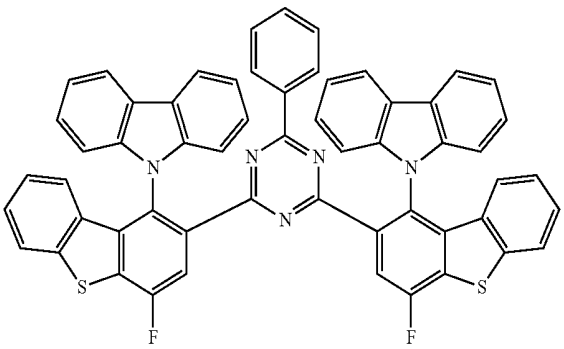

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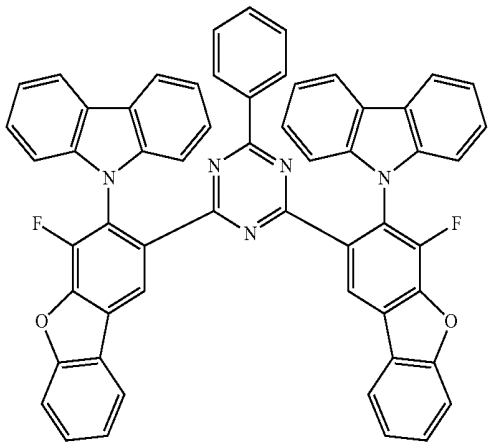

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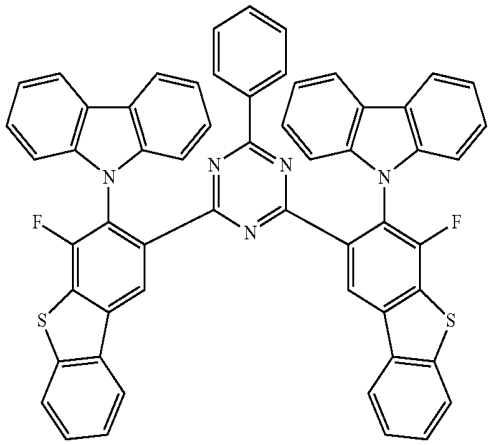

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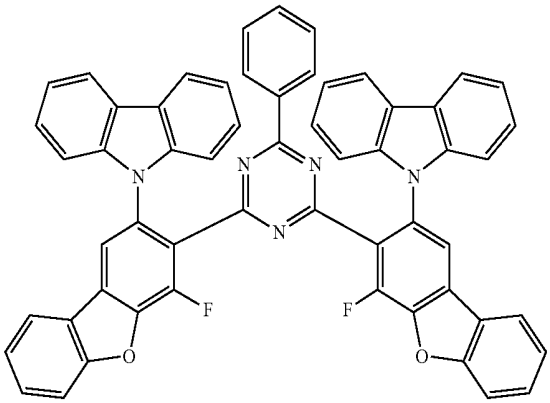

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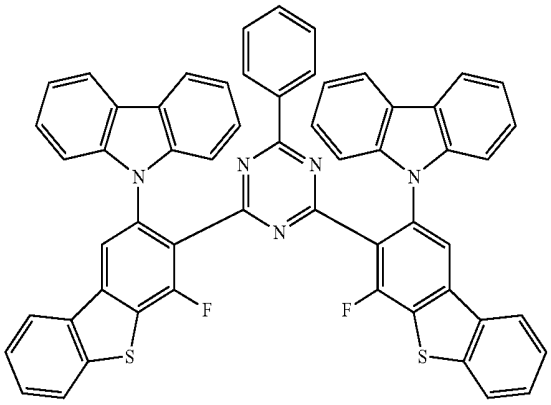

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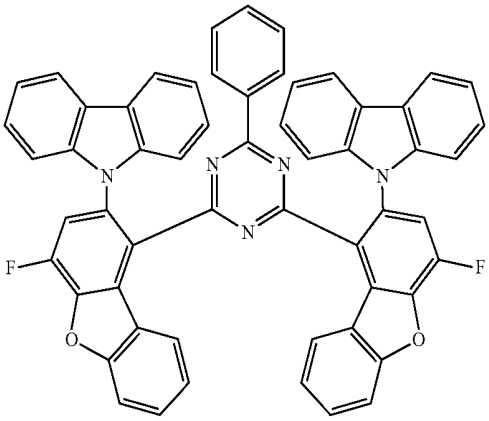

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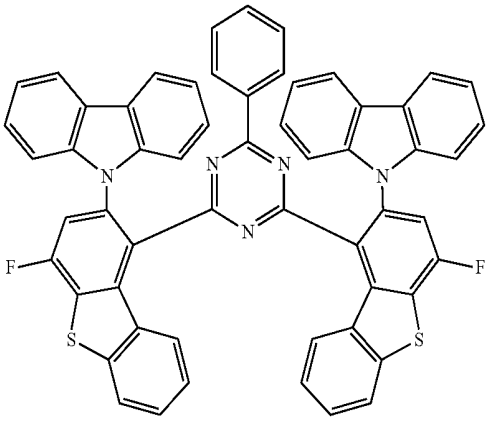

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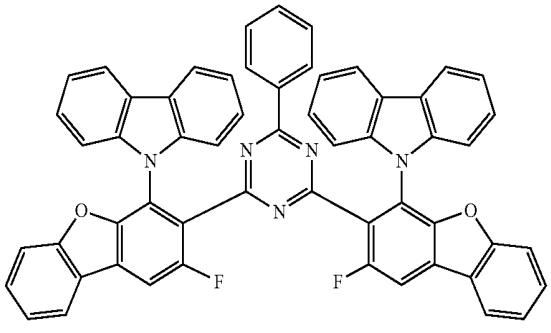

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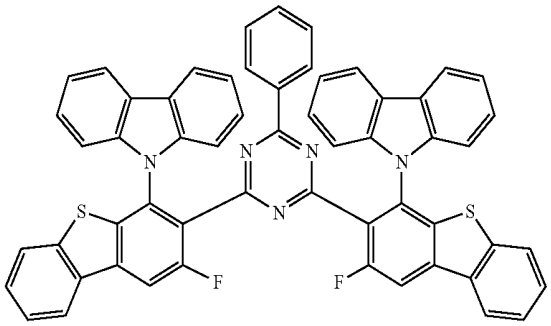

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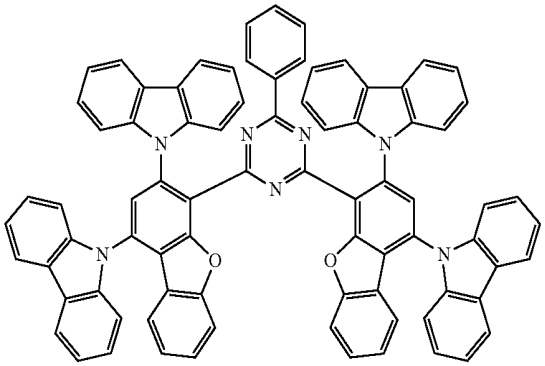

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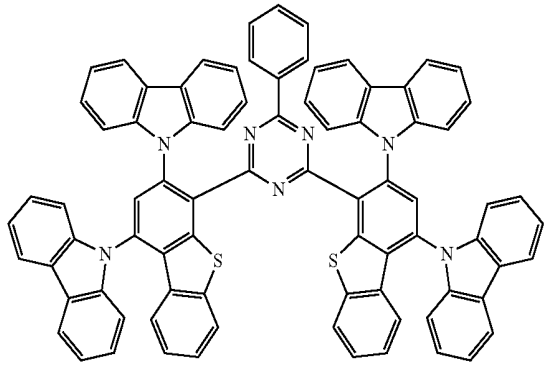

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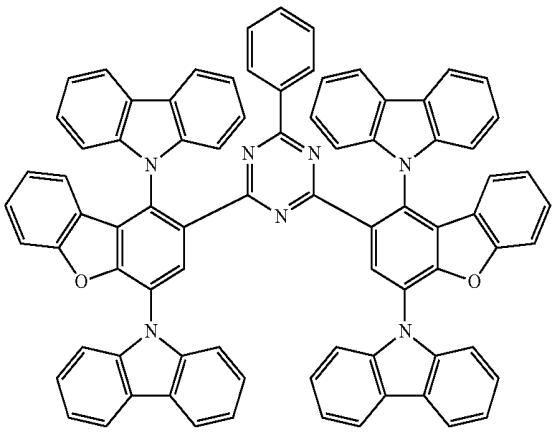

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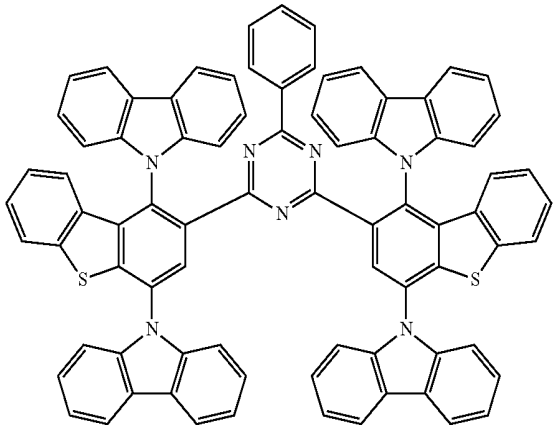

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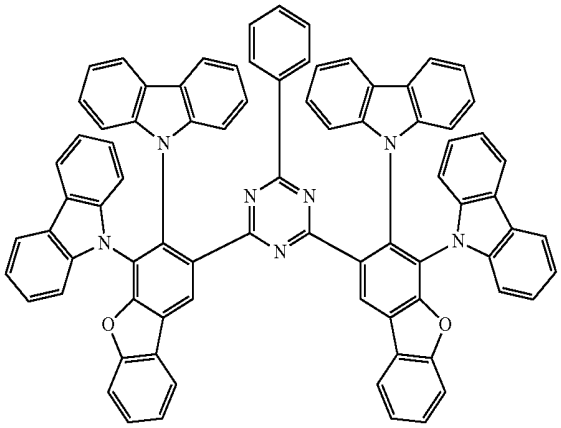

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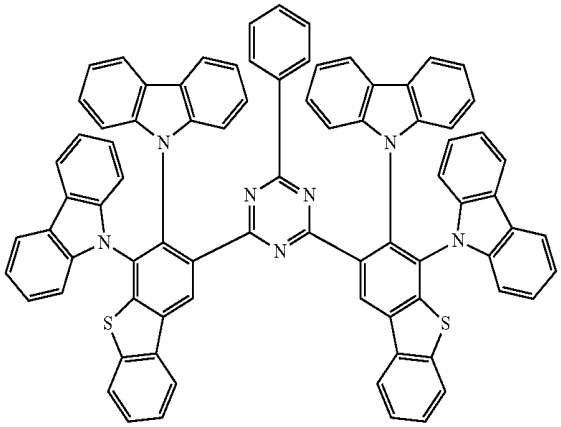

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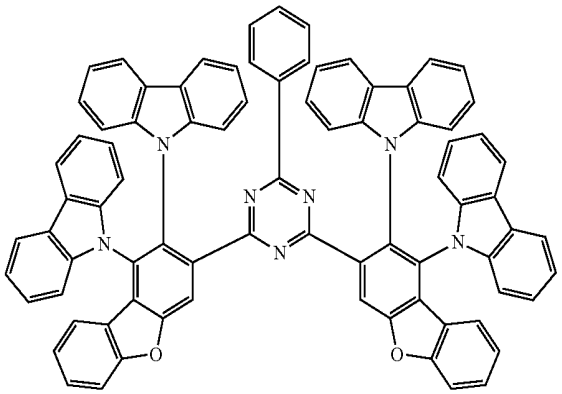

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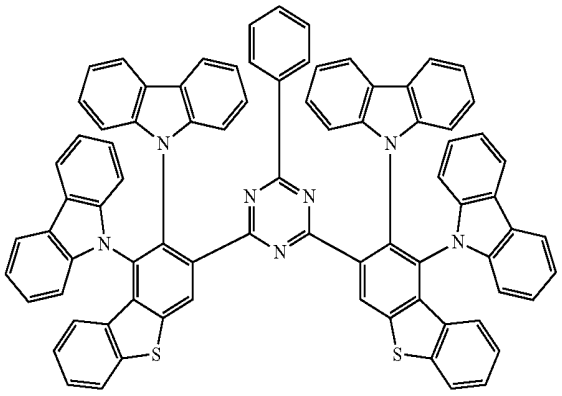

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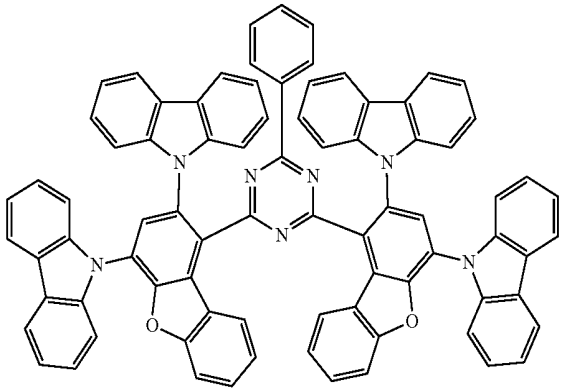

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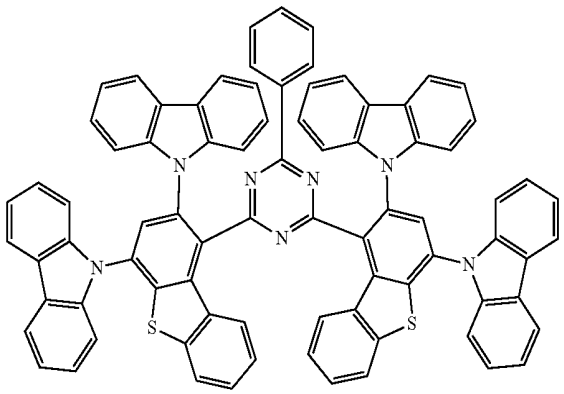

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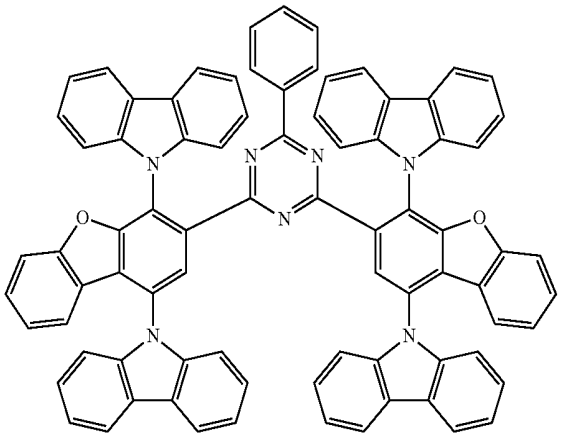

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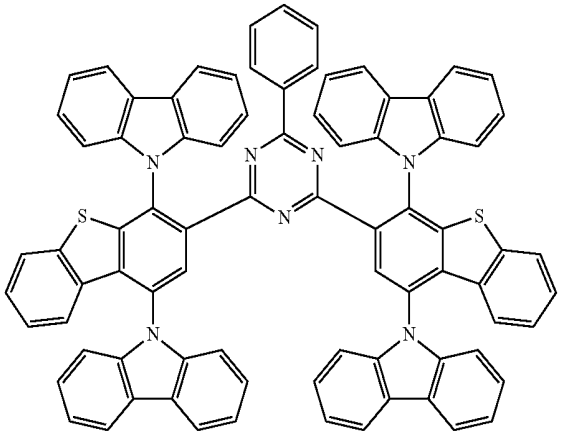

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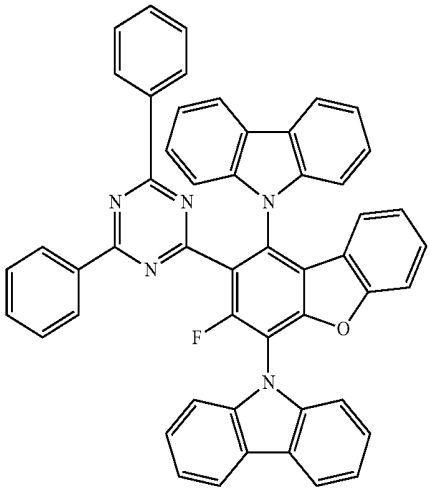

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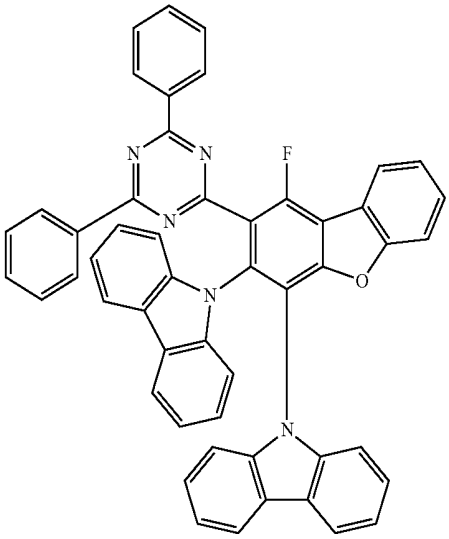

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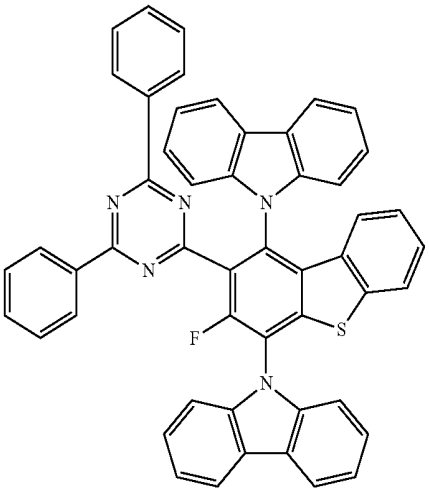

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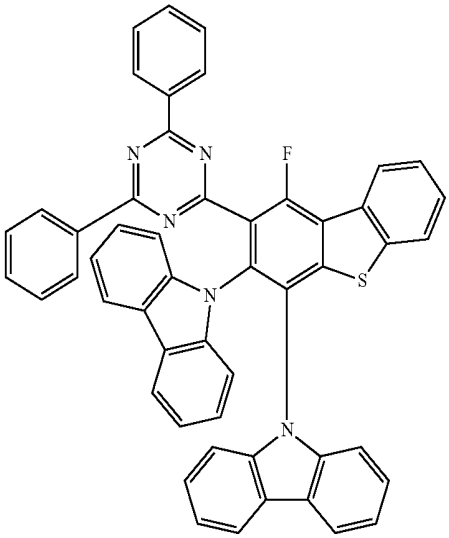

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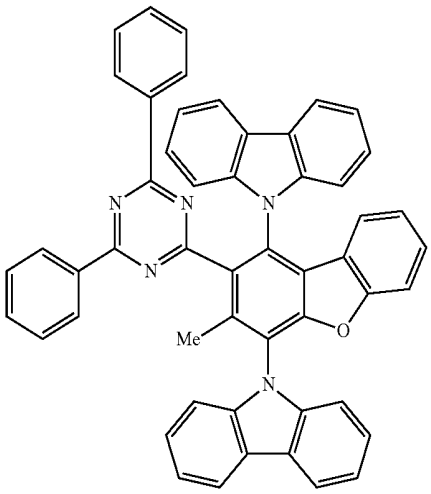

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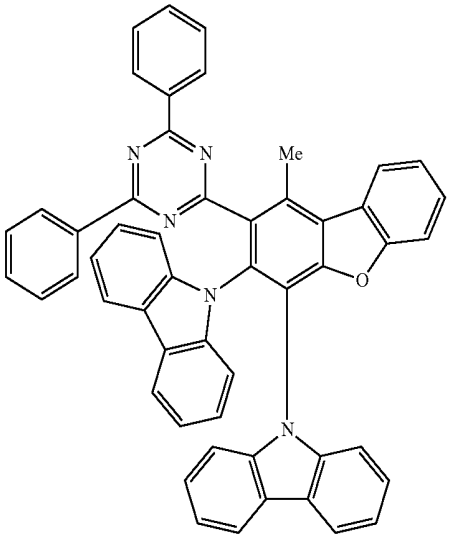

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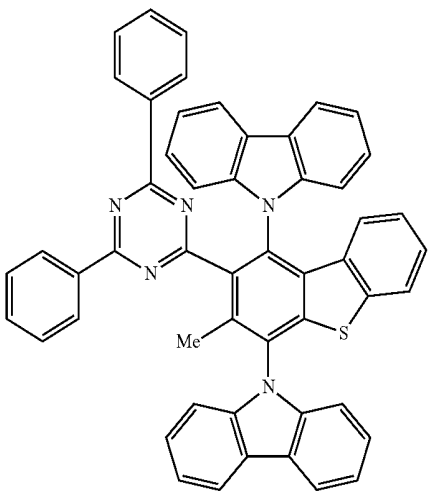

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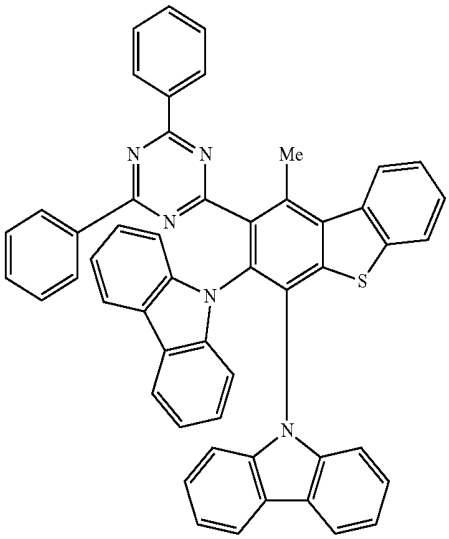


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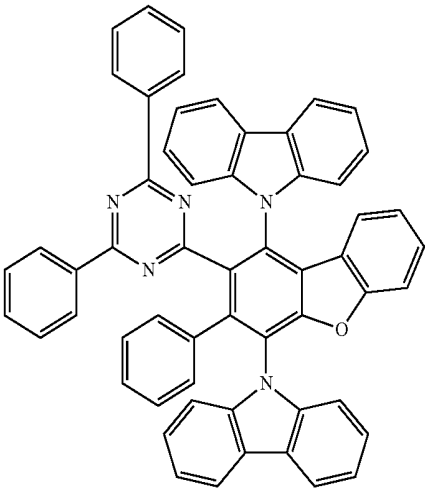


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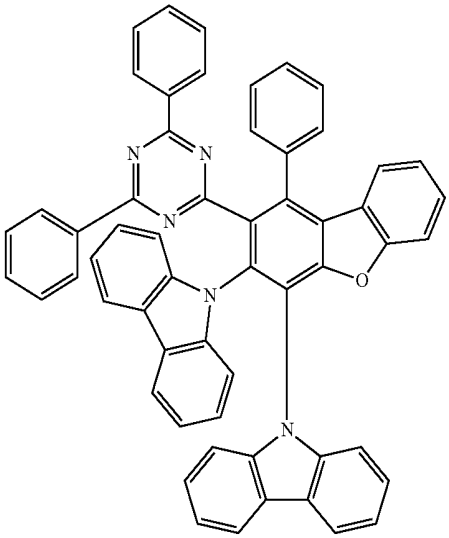


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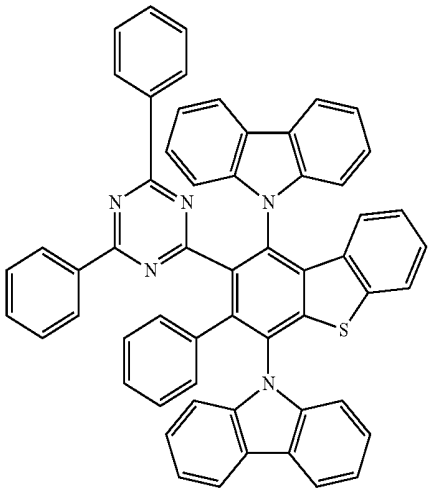


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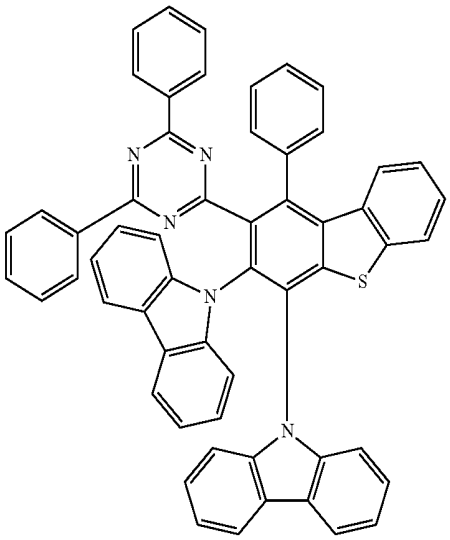


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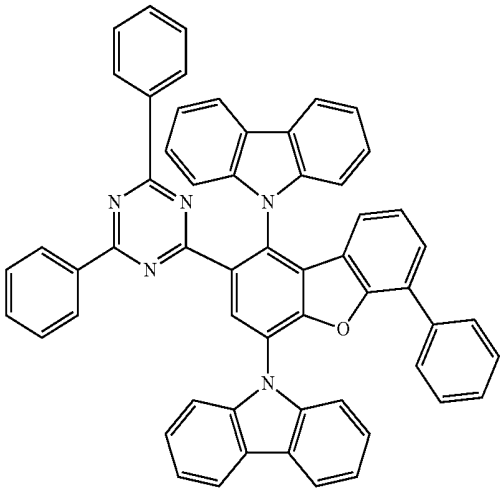

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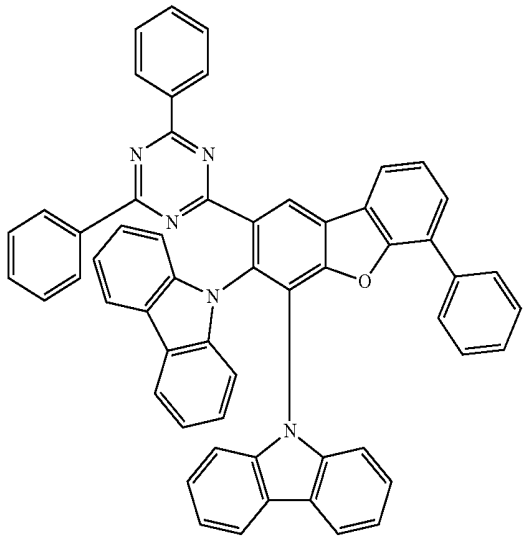

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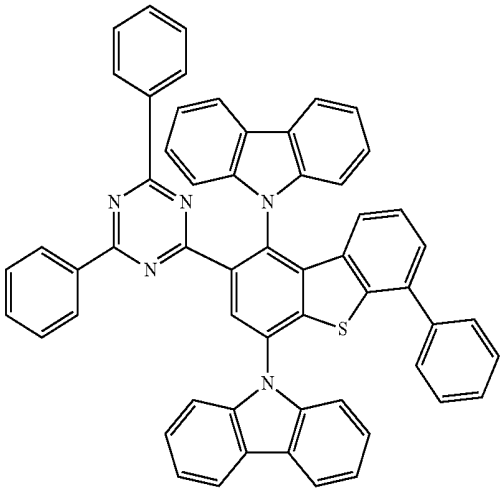

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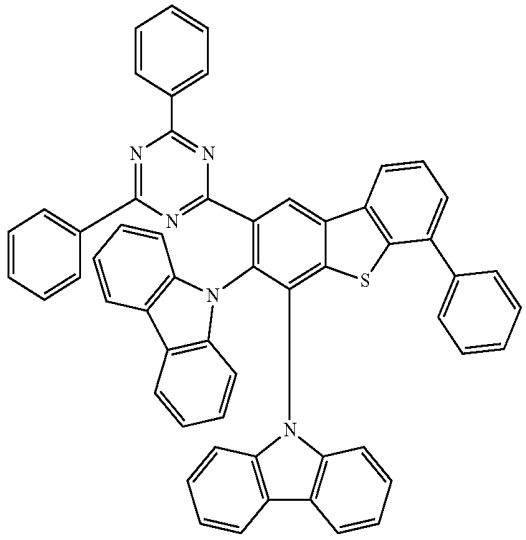

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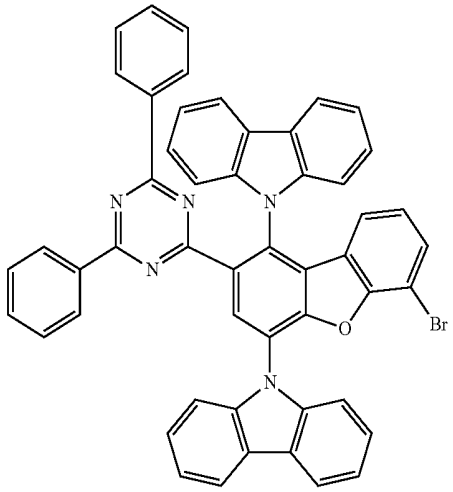

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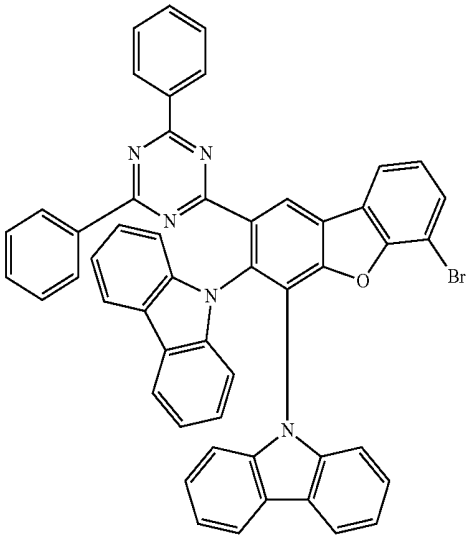

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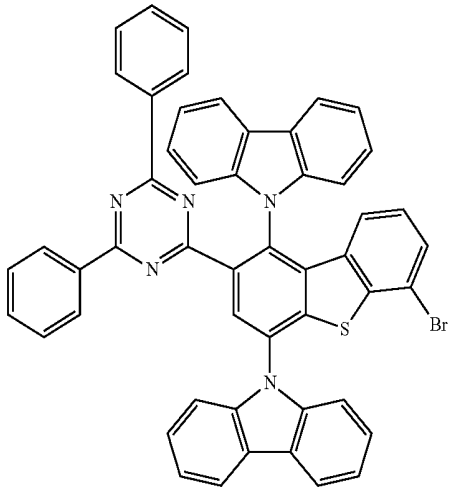

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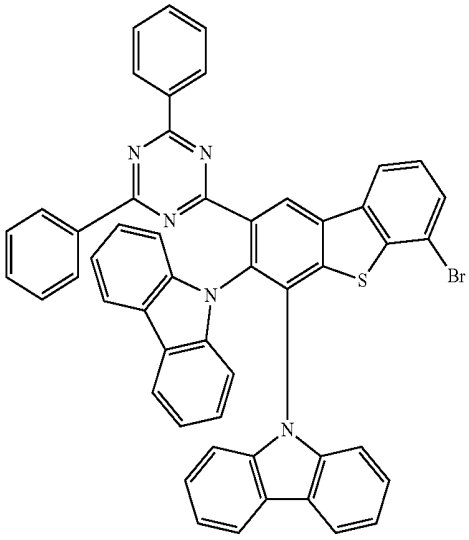

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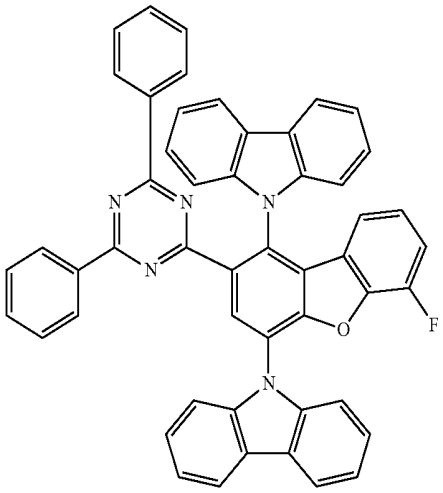

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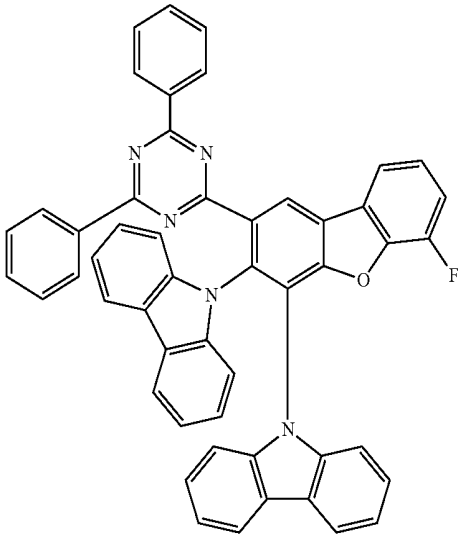

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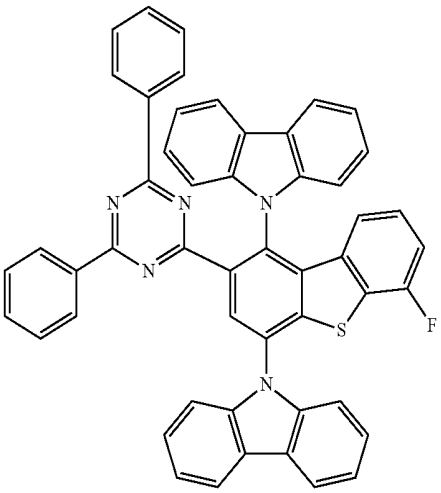

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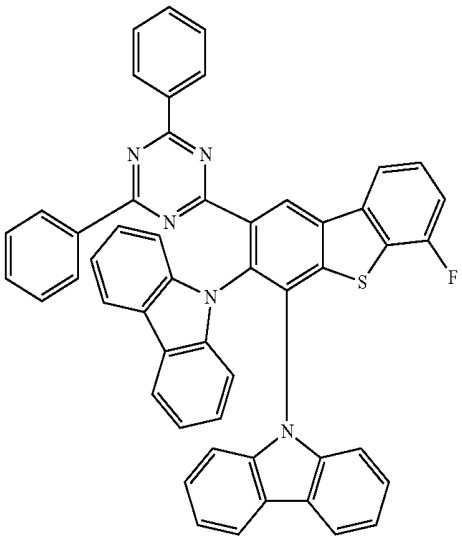

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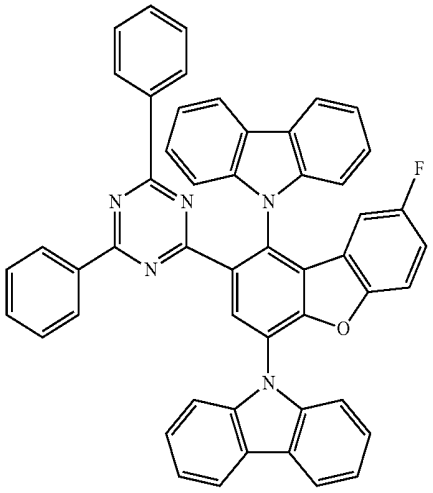

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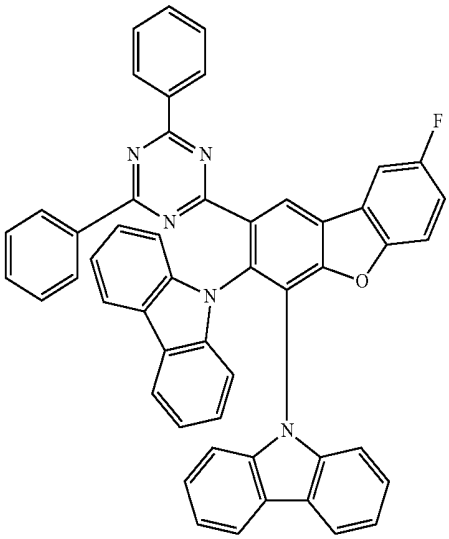

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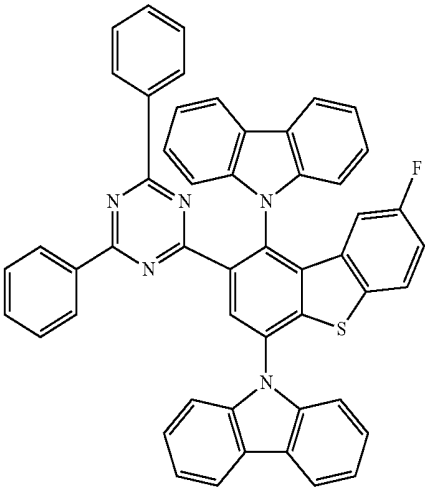

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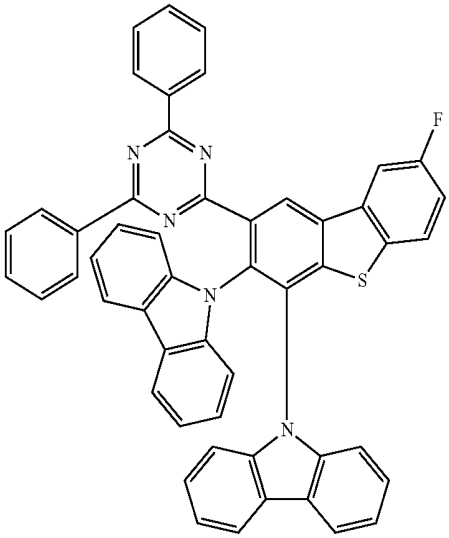

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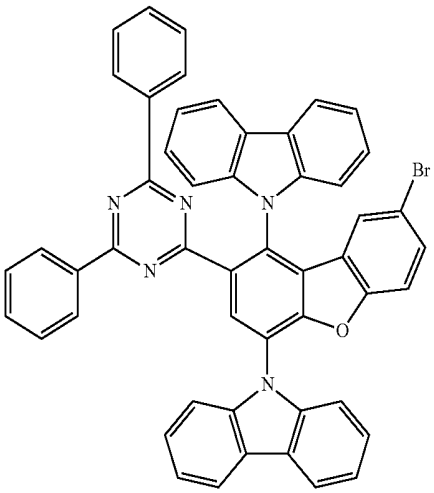

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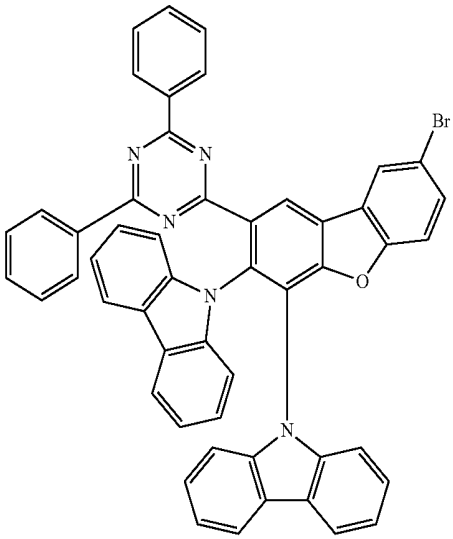

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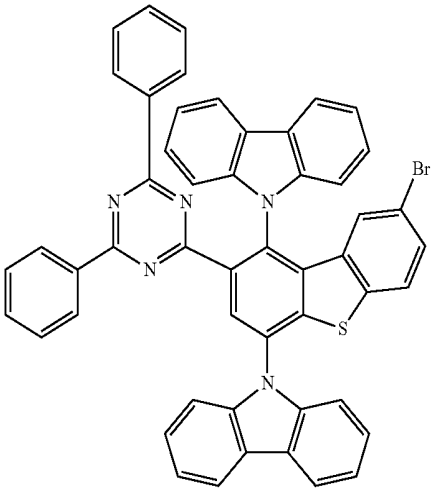

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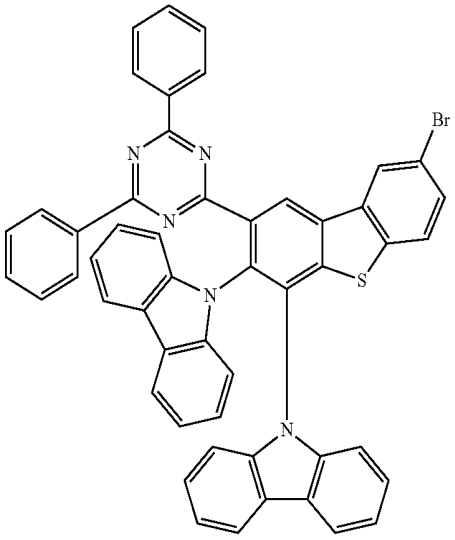

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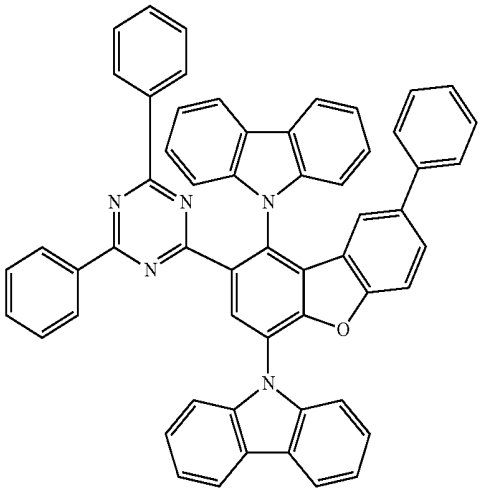

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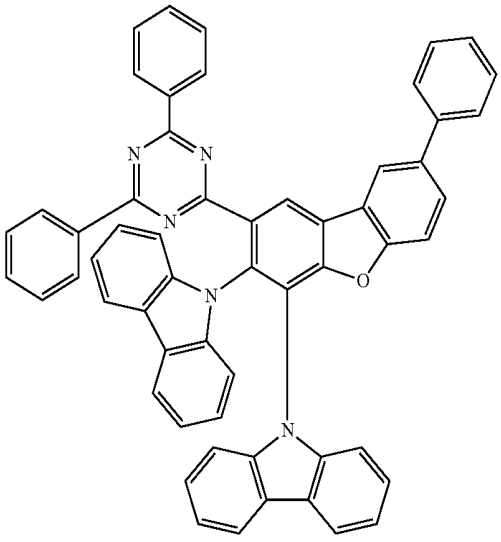

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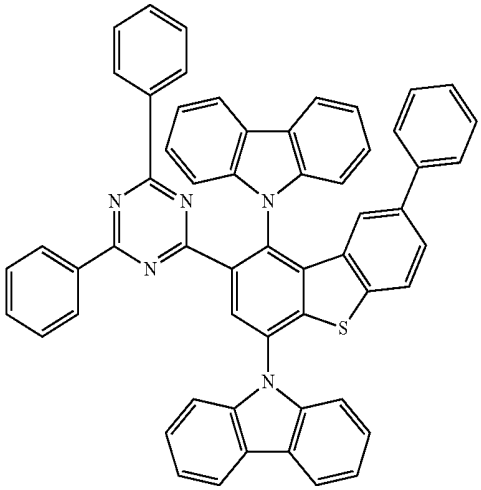

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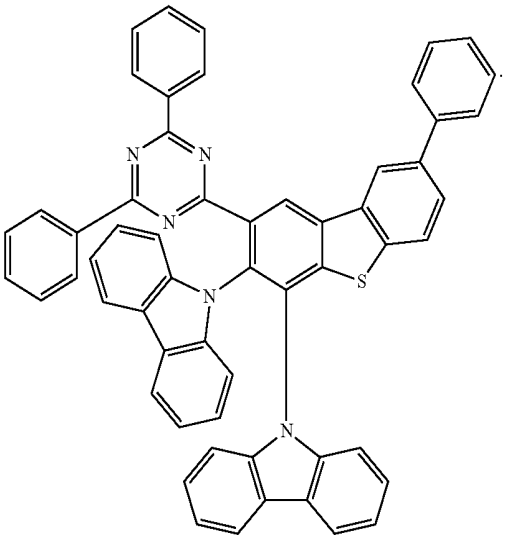
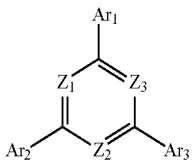


**19**. A heterocyclic compound represented by the following Formula 1:

[Formula 1]



wherein, in Formula 1,

$Z_1$ to $Z_3$ are each independently $CR_1$ or N,

at least one of $Z_1$ to $Z_3$ is N,

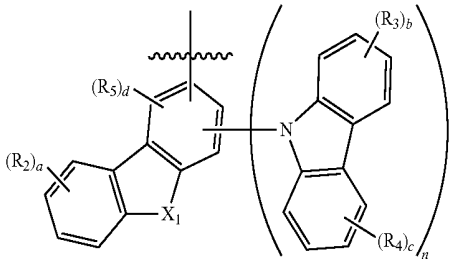
$R_1$ is a hydrogen atom, a deuterium atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

$Ar_1$ to $Ar_3$ are each independently a group represented by the following Formula 2, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a

substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms, and

at least one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2:

[Formula 2]



in Formula 2,

$X_1$ is O or S,

"n" is an integer of 1 to 3,

"a" to "c" are each independently an integer of 0 to 4,

"d" is an integer of 0 to 2, and

$R_2$ to $R_5$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

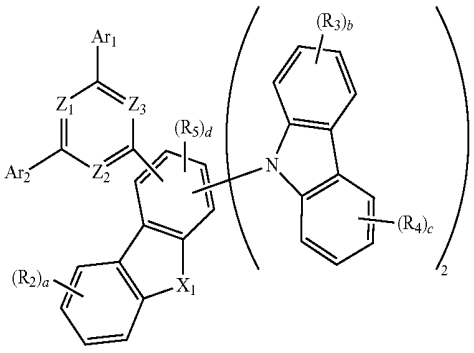
when only one of $Ar_1$ to $Ar_3$ is a group represented by Formula 2 above, "n" is 2 or 3, and

at least one of the carbazole moieties in Formula 2 is bonded in an ortho relationship with respect to the nitrogen-containing monocycle of Formula 1.

**20**. The heterocyclic compound as claimed in claim **19**, wherein each of $Z_1$ to $Z_3$ is N.

**21**. The heterocyclic compound as claimed in claim **19**, wherein the compound represented by Formula 1 is represented by the following Formula 1-1 or Formula 1-3:

[Formula 1-1]



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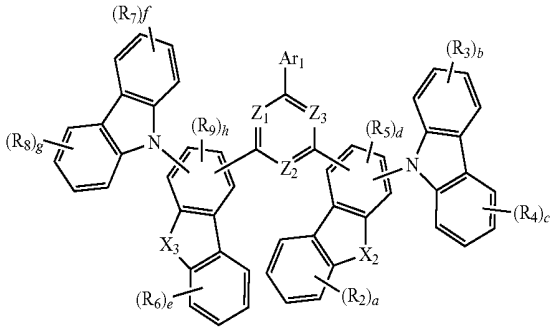
[Formula 1-3]



in Formulae 1-1 and 1-3,

$Z_1$ to $Z_3$, Art, $Ar_2$, $R_2$ to $R_5$, "a" to "d" and $X_1$ are defined the same as those of Formulae 1 and 2, and

in Formula 1-3,

$X_2$ and $X_3$ are each independently O or S,

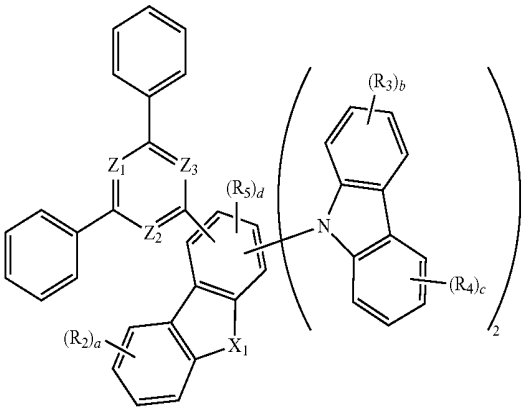
$R_6$ to $R_9$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

"e" to "g" are each independently an integer of 0 to 4, and

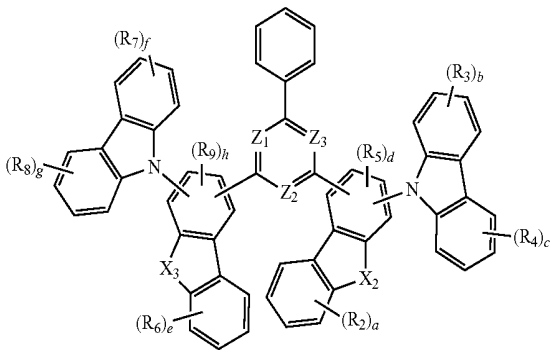
"h" is an integer of 0 to 2.

**22**. The heterocyclic compound as claimed in claim **19**, wherein the compound represented by Formula 1 is represented by the following Formula 1-2 or Formula 1-4:

[Formula 1-2]



[Formula 1-4]



in Formulae 1-2 and 1-4,

$Z_1$ to $Z_3$, $R_2$ to $R_5$, "a" to "d" and $X_1$ are defined the same as those of Formulae 1 and 2, and

in Formula 1-4,

$X_2$ and $X_3$ are each independently O or S,

$R_6$ to $R_9$ are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted alkyl group having 1 to 10 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 ring carbon atoms, or a substituted or unsubstituted heteroaryl group having 2 to 30 ring carbon atoms,

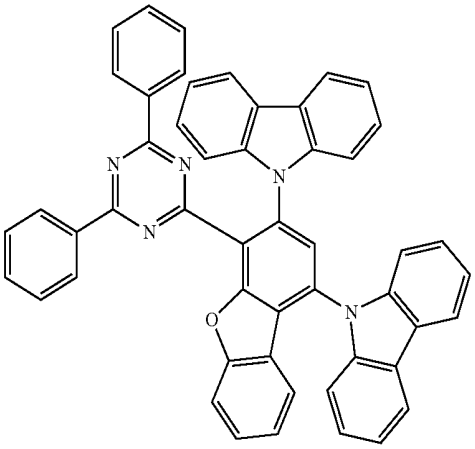
"e" to "g" are each independently an integer of 0 to 4, and

"h" is an integer of 0 to 2.

**23**. The heterocyclic compound as claimed in claim **19**, wherein the heterocyclic compound is a compound of the following Compound Group 1:

[Compound Group 1]

1



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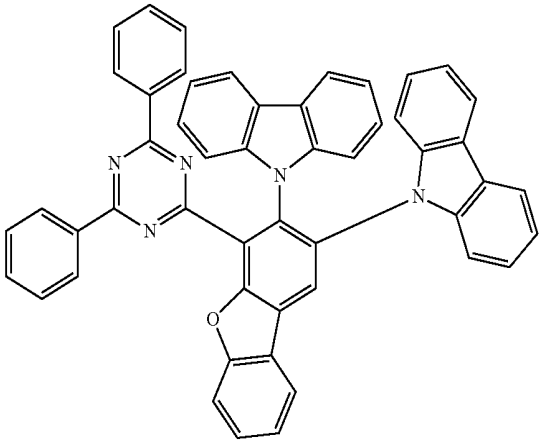

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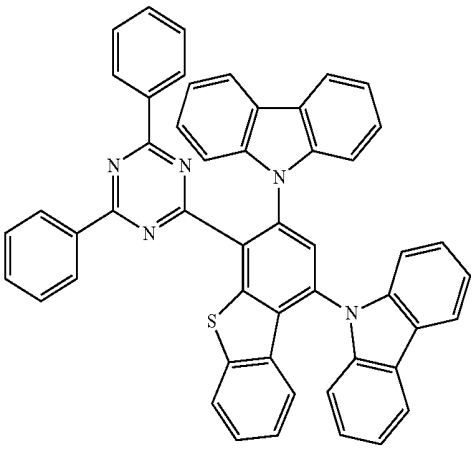

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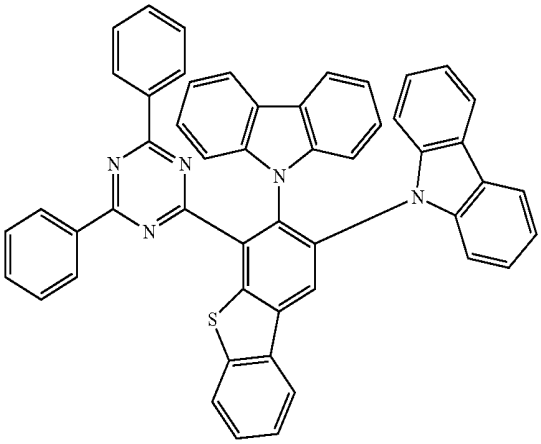

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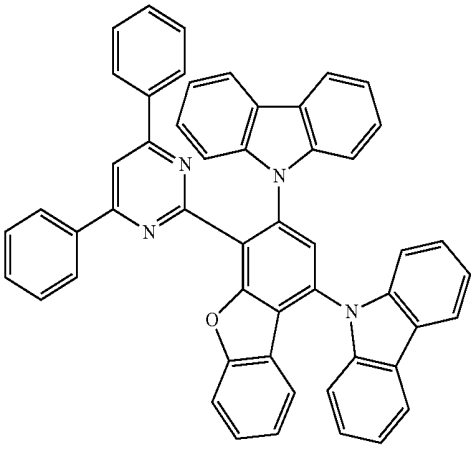

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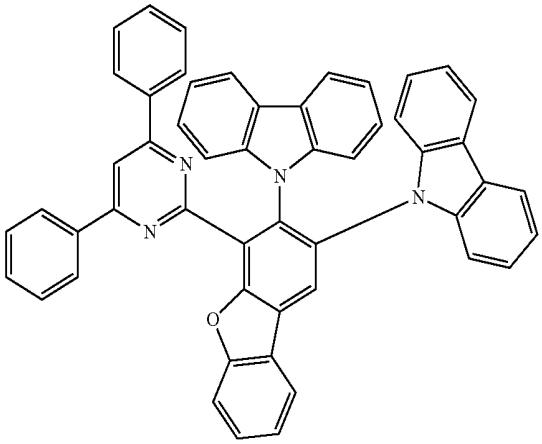

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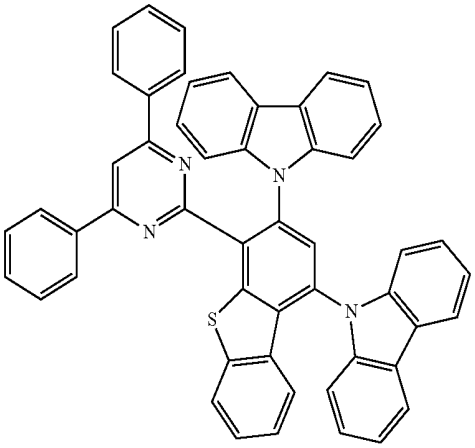

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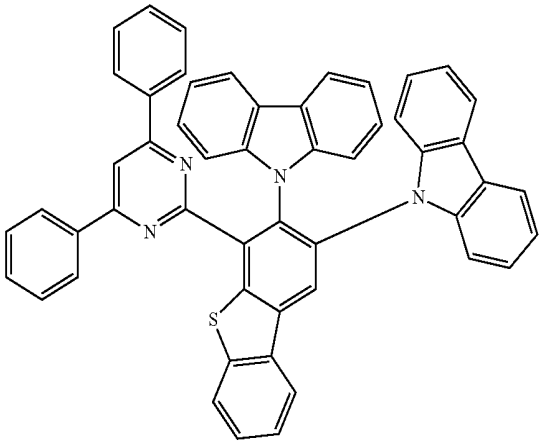

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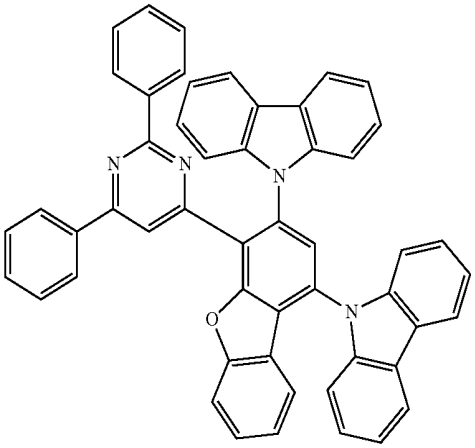

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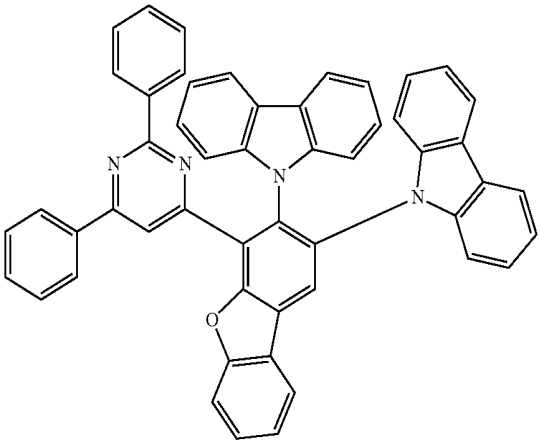

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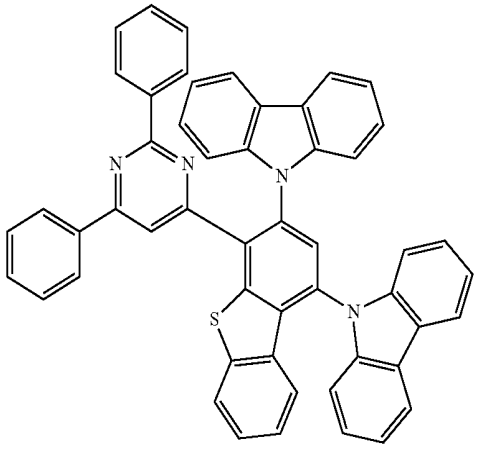

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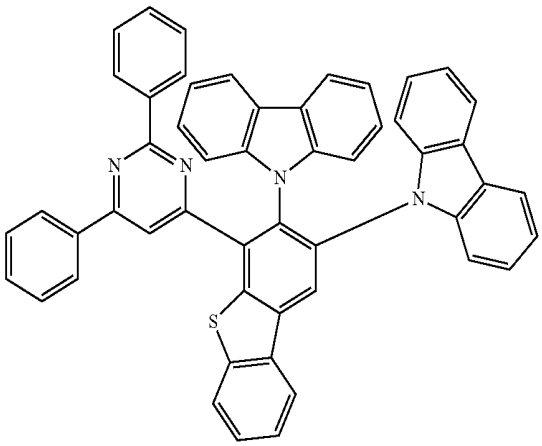

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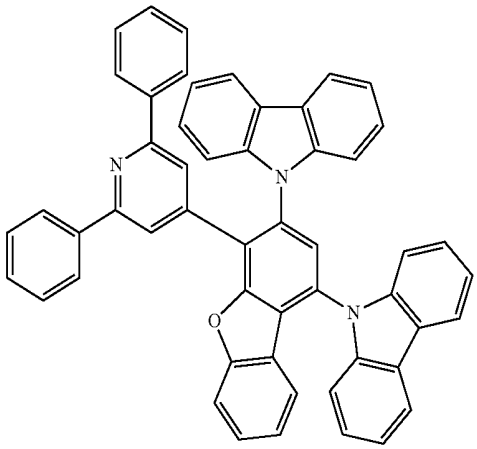

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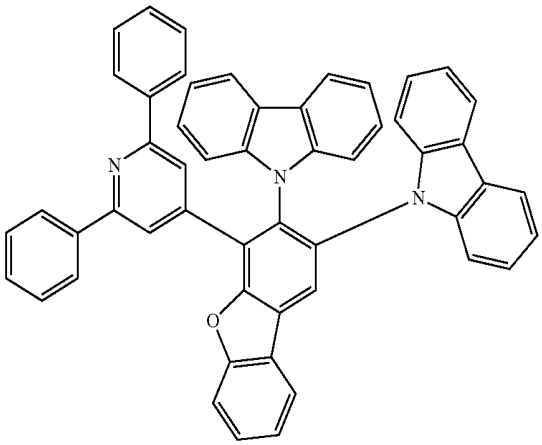

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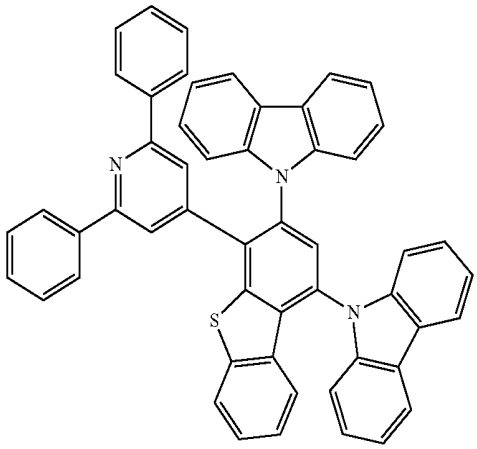

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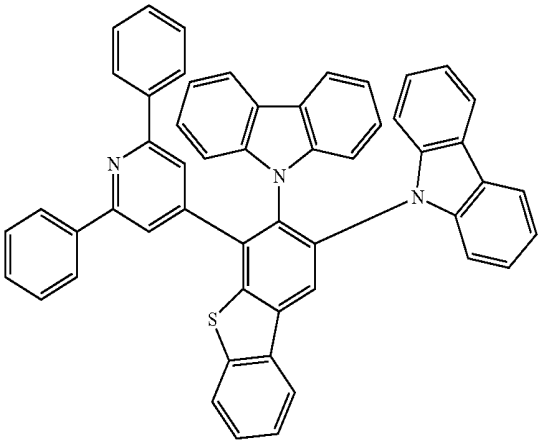

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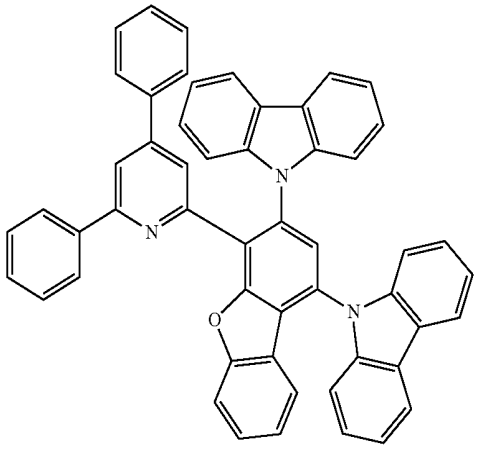

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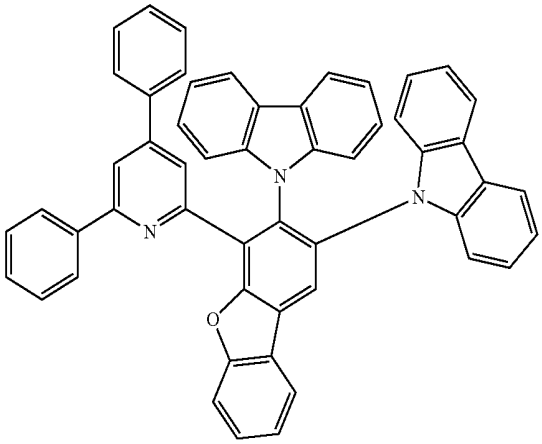

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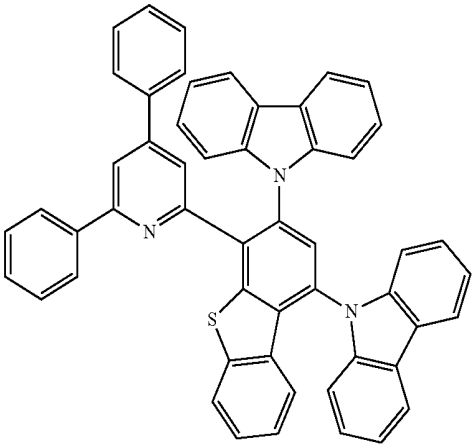

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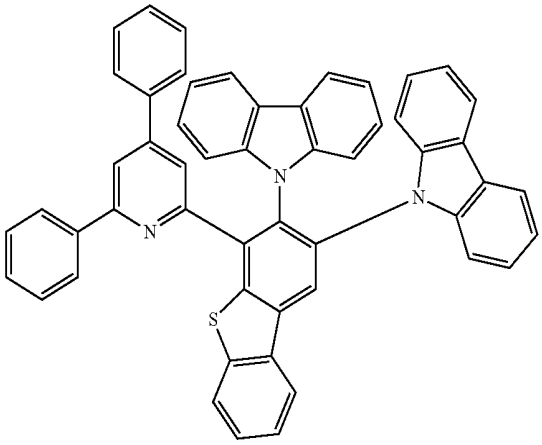

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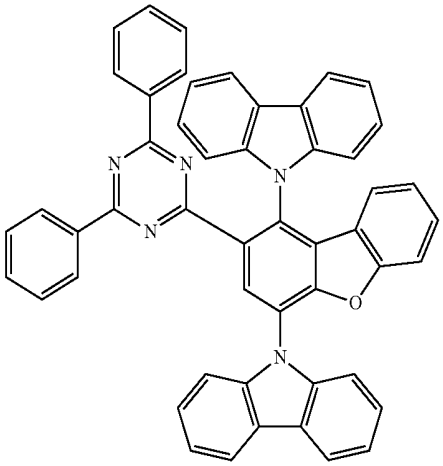

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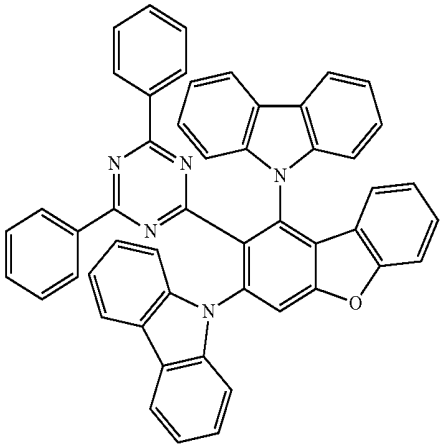

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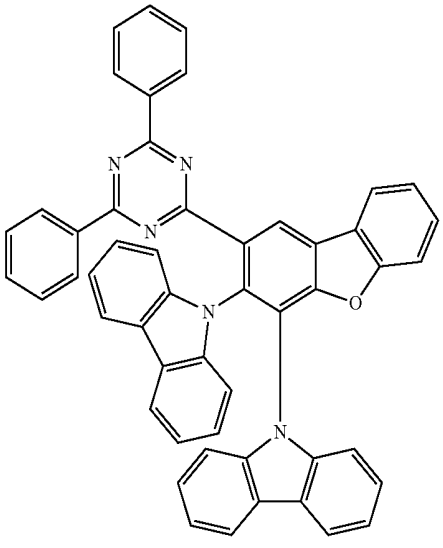

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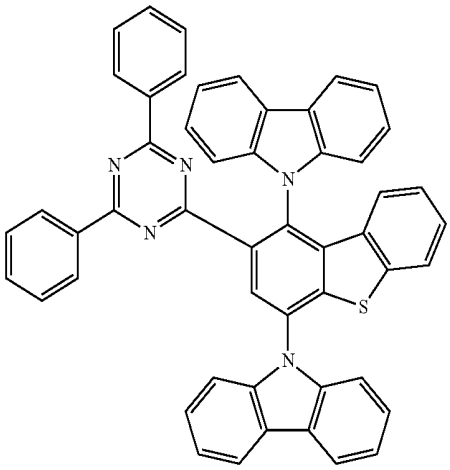

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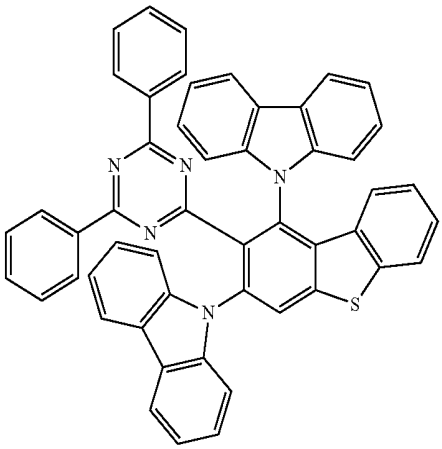

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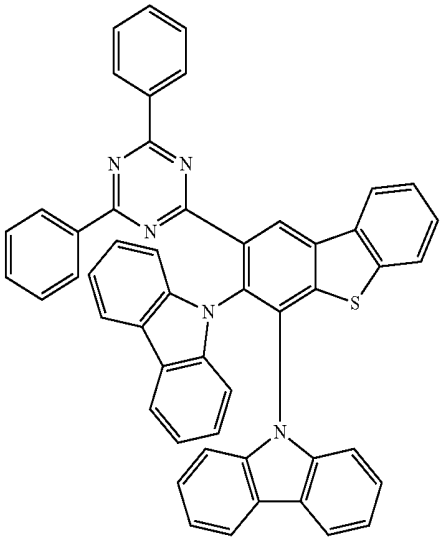

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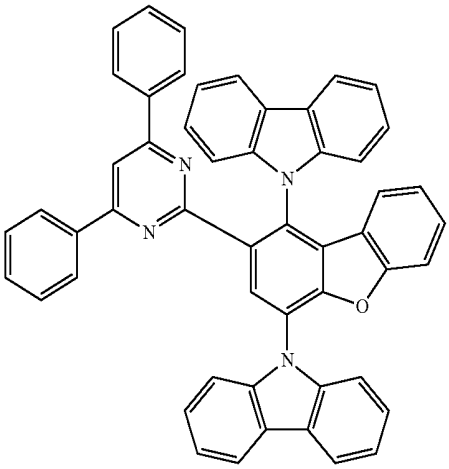

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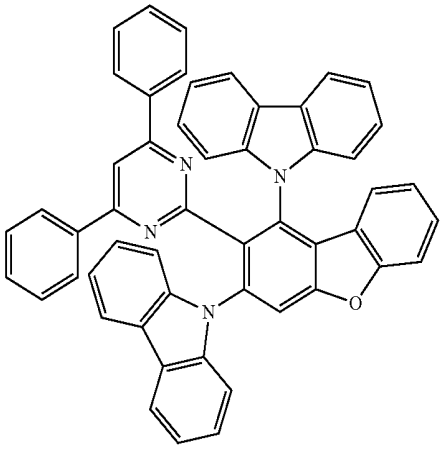

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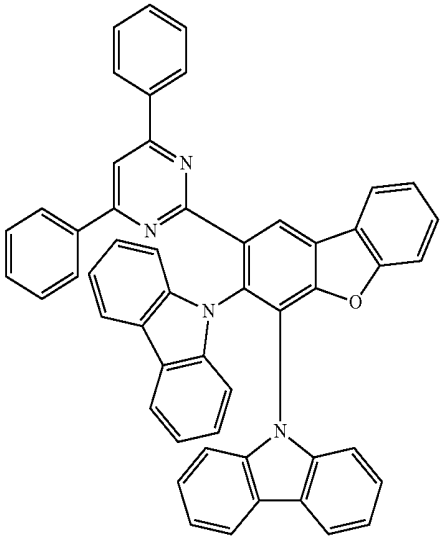

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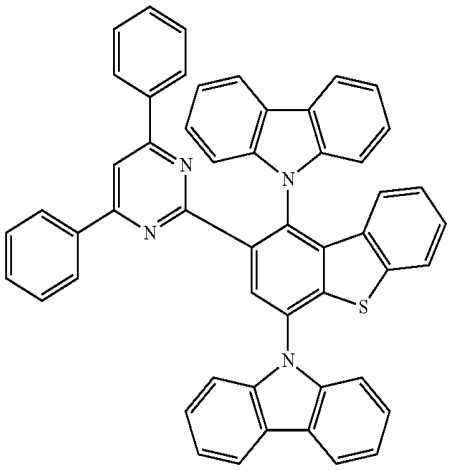

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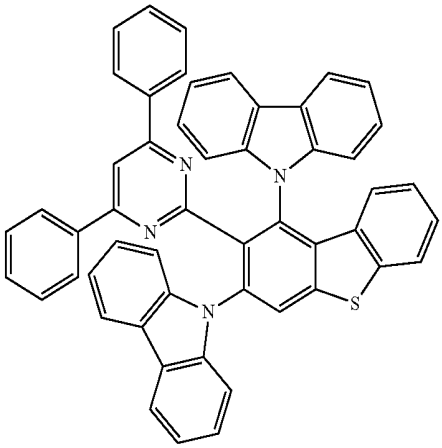

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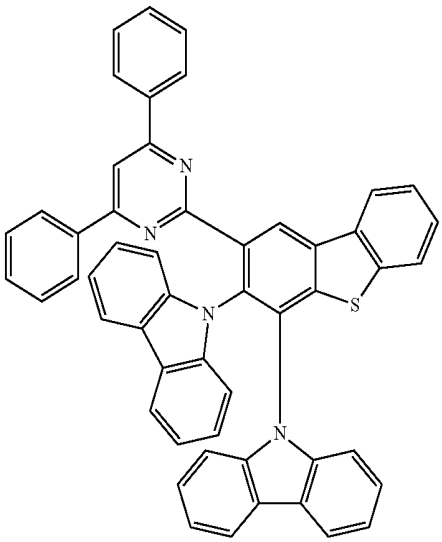

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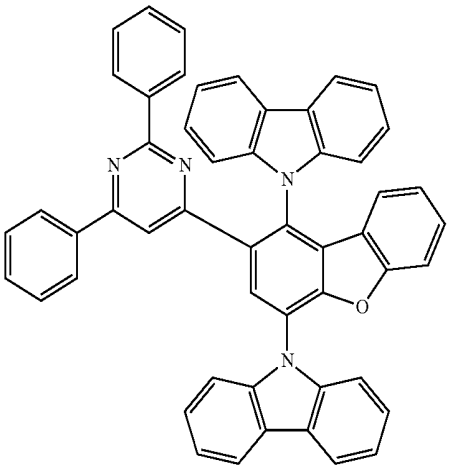

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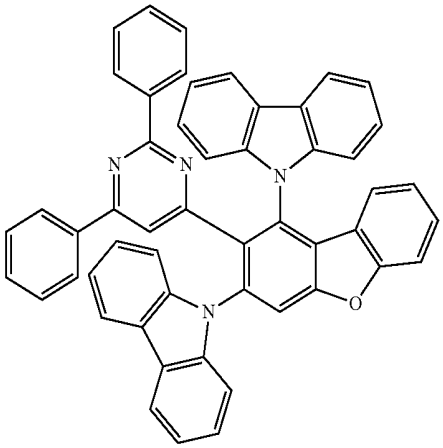

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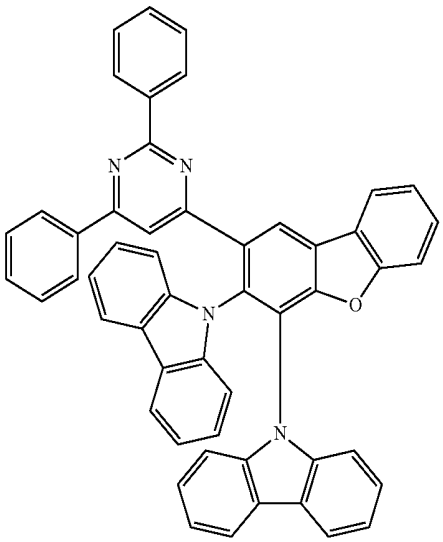

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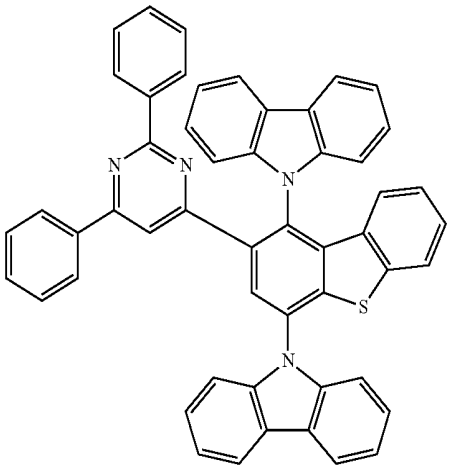

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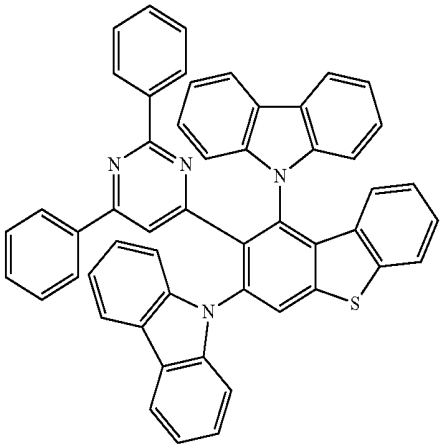

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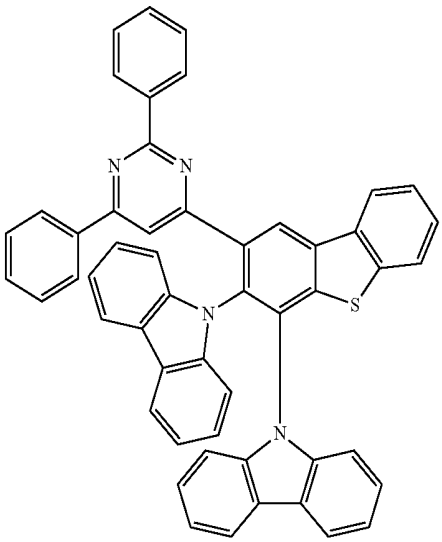

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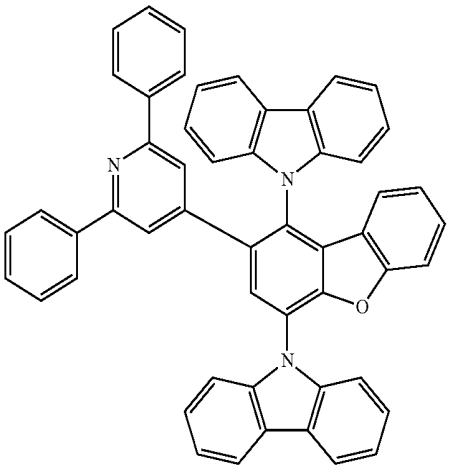

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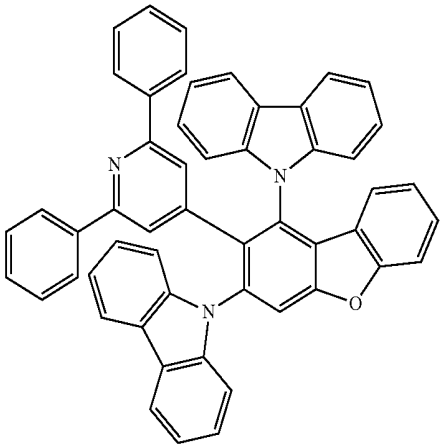

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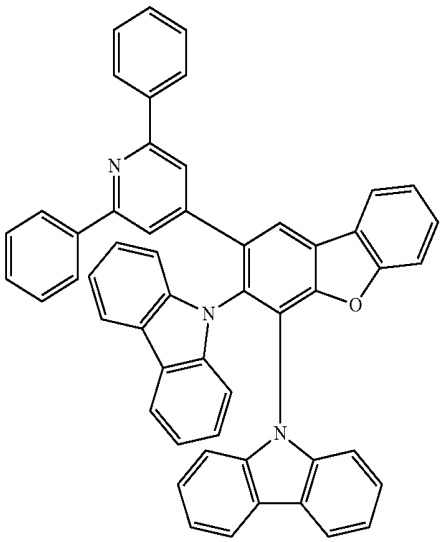

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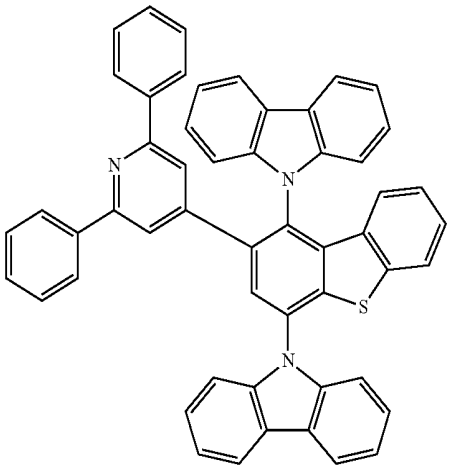

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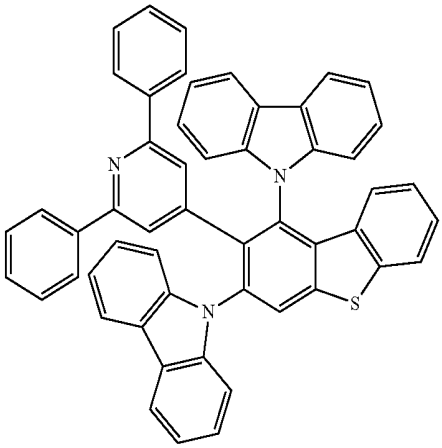

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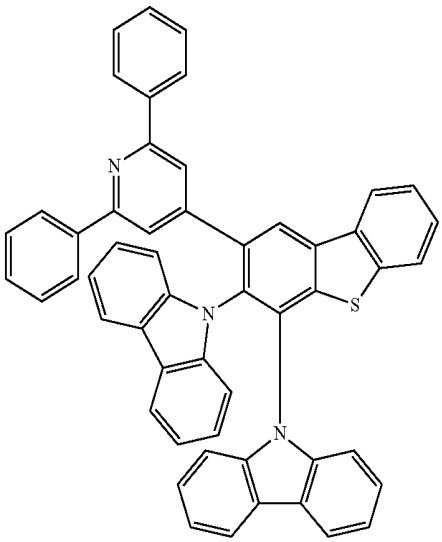

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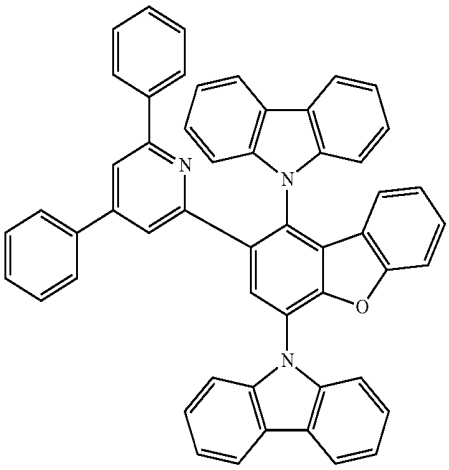

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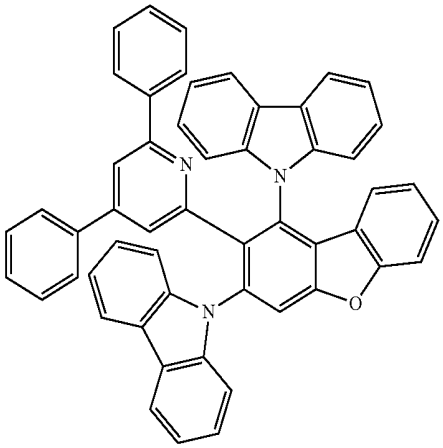

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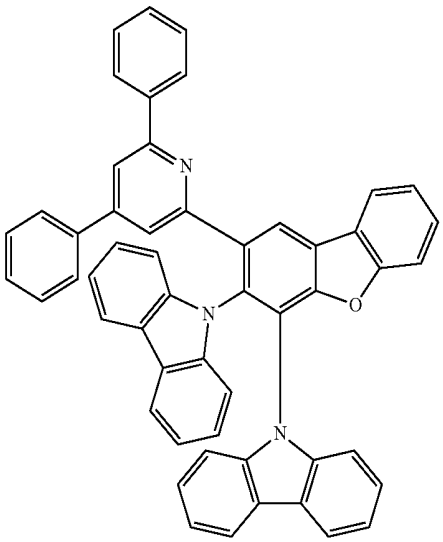

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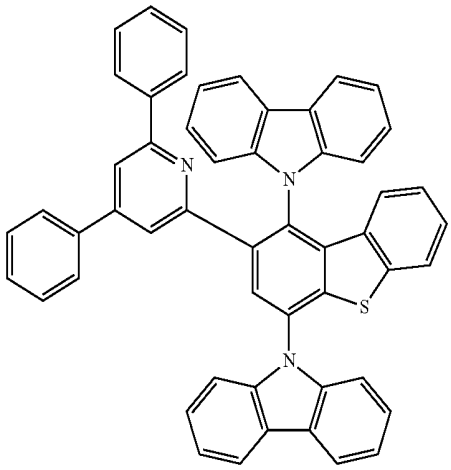

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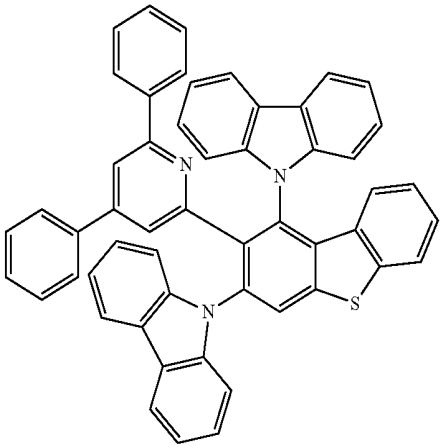

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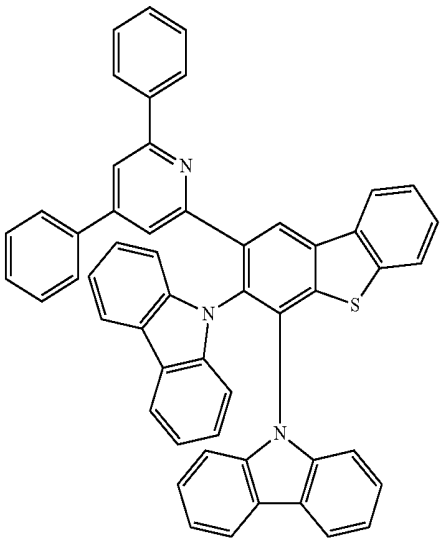

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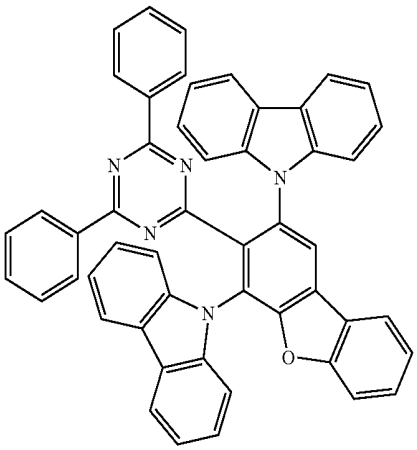

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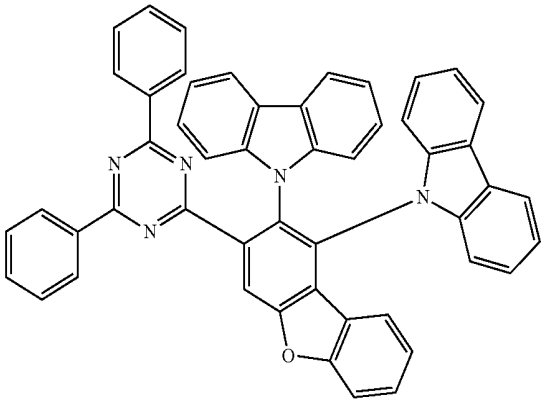

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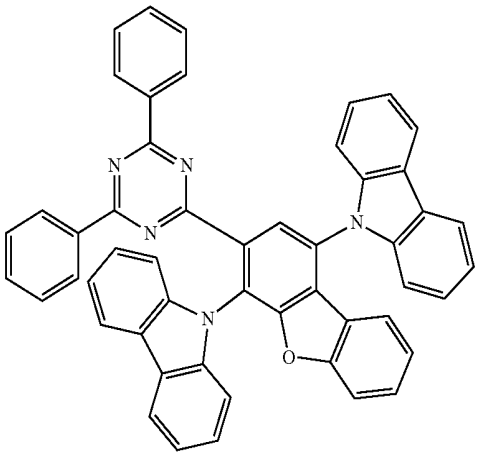

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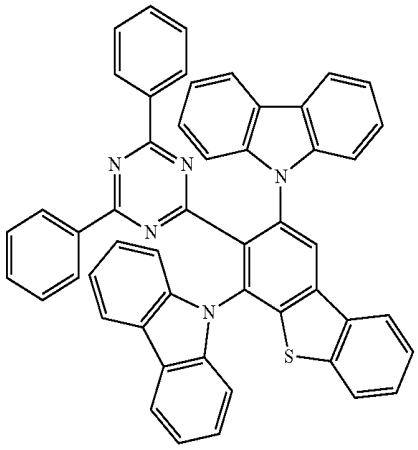

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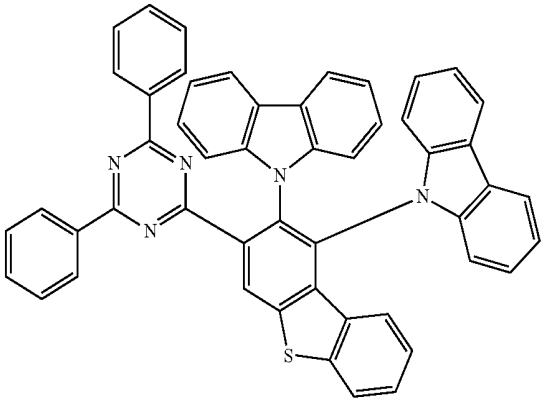

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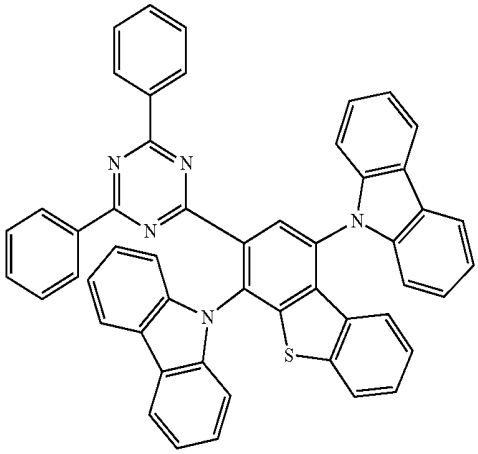

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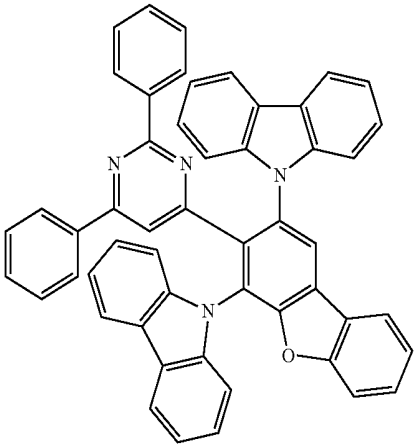

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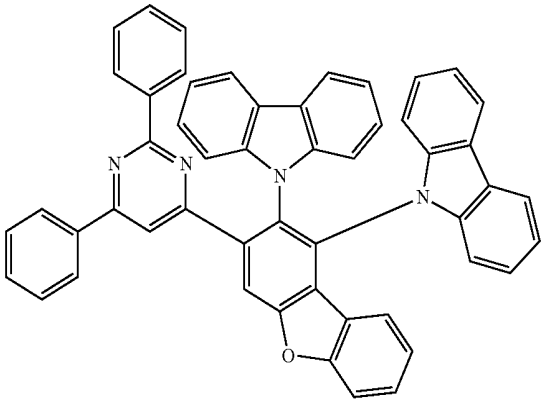

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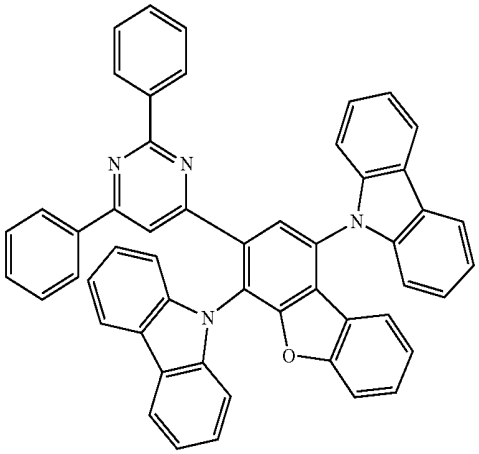

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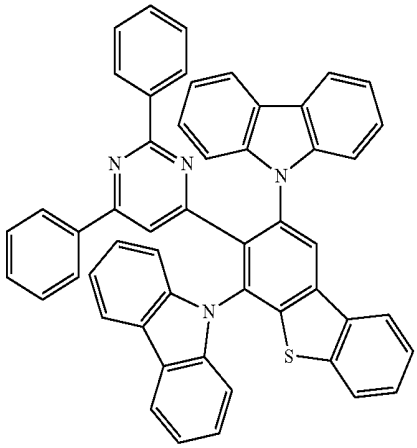

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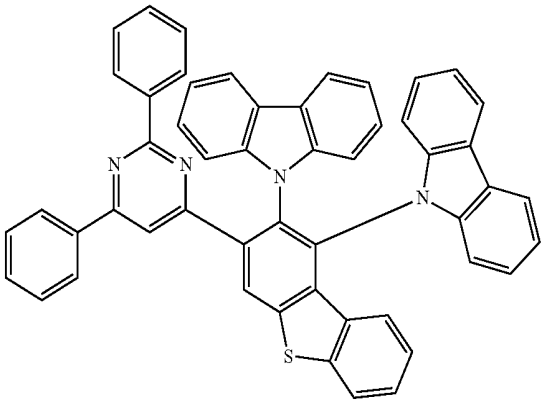

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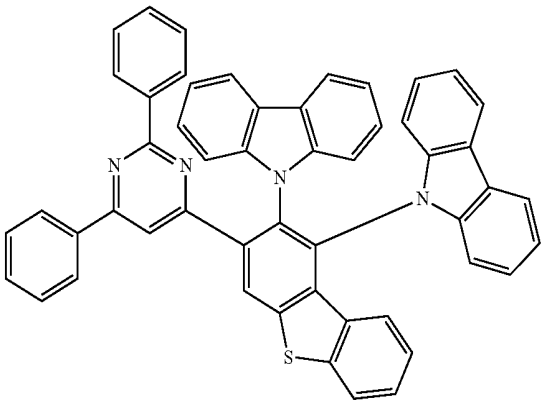

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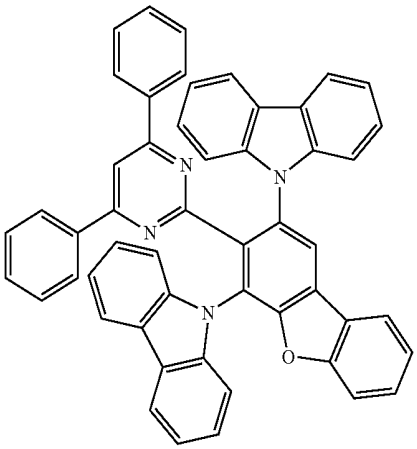

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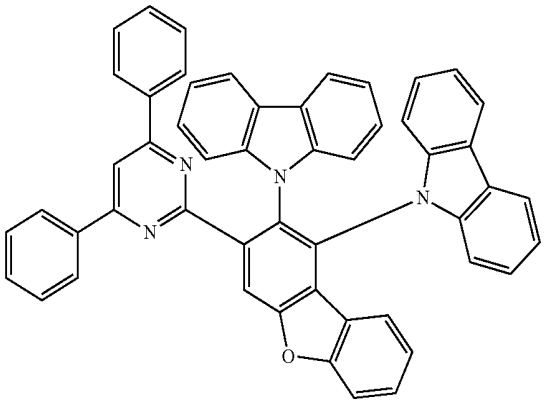

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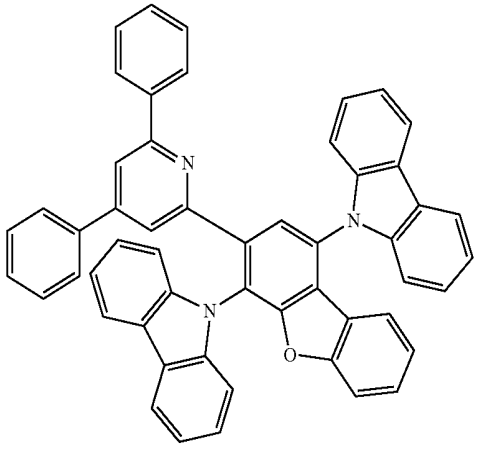

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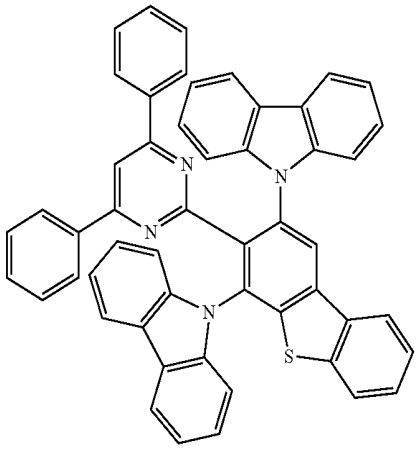

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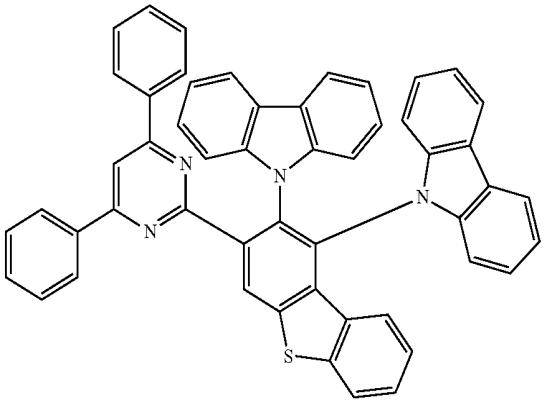

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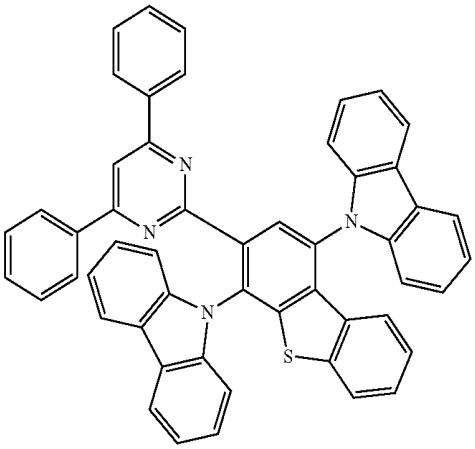

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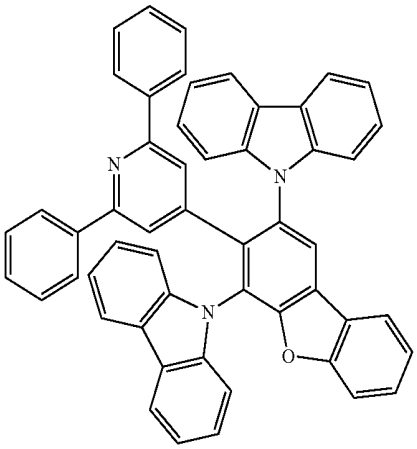

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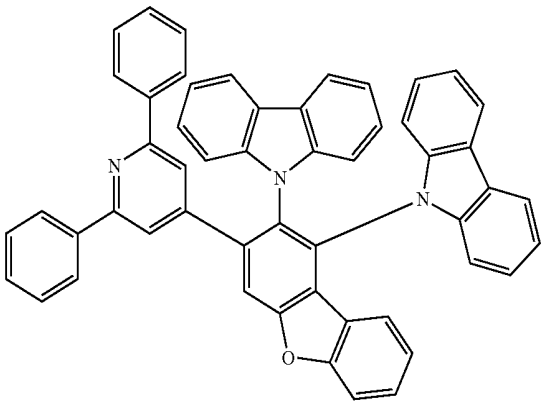

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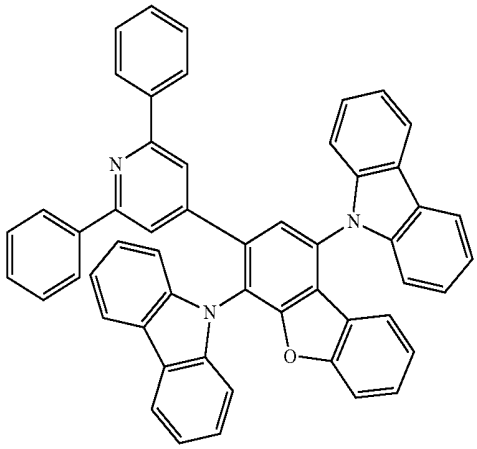

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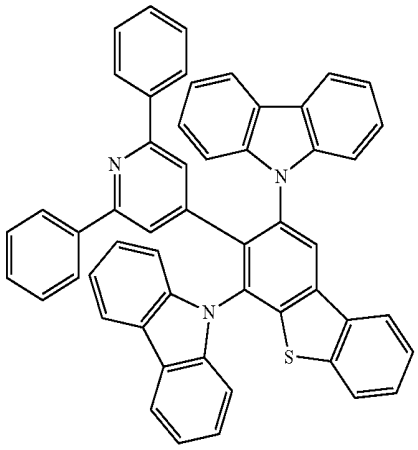

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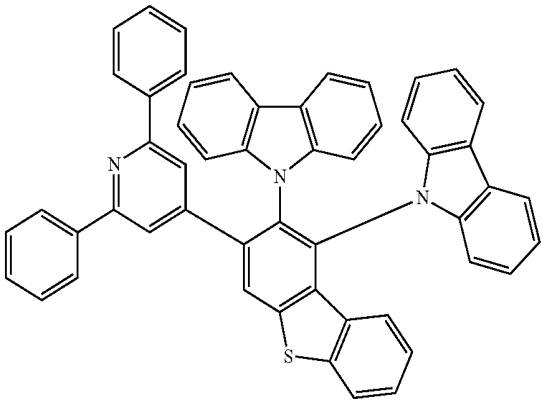

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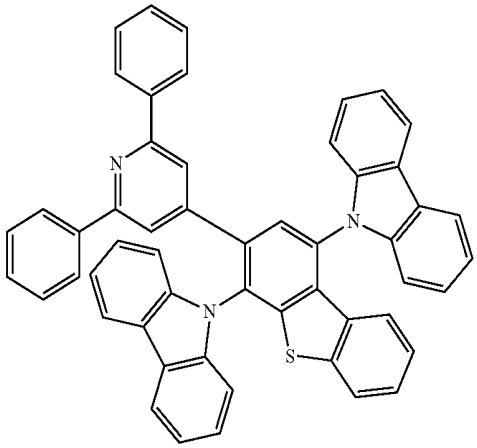

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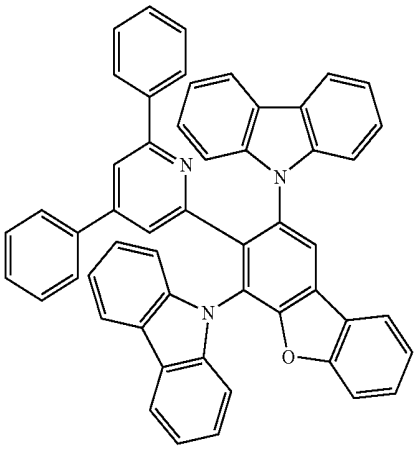

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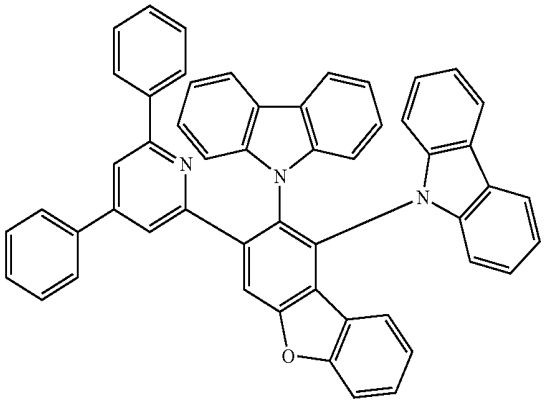

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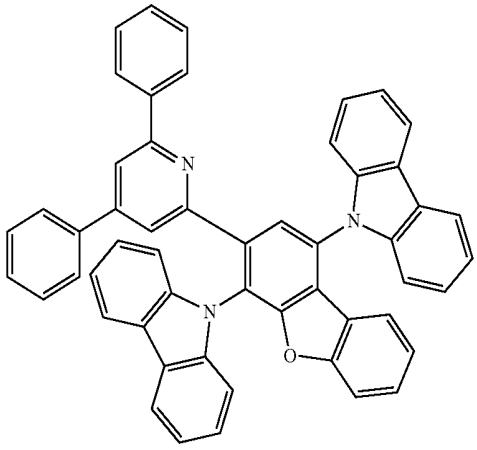

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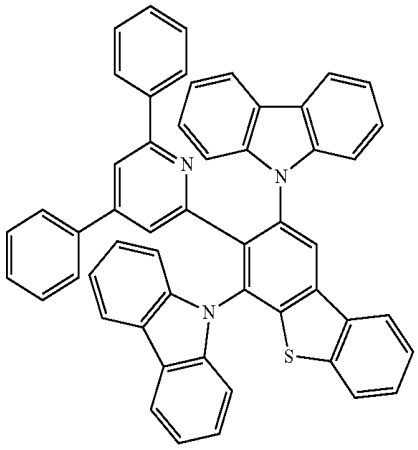

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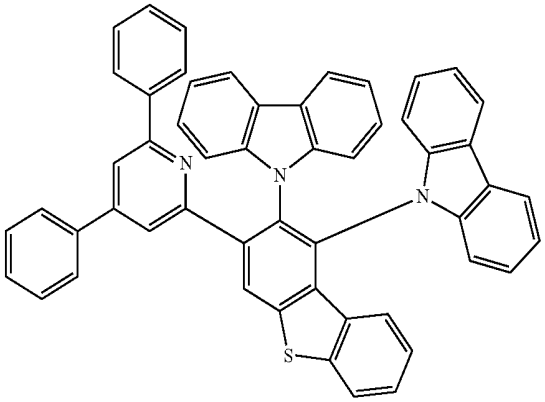

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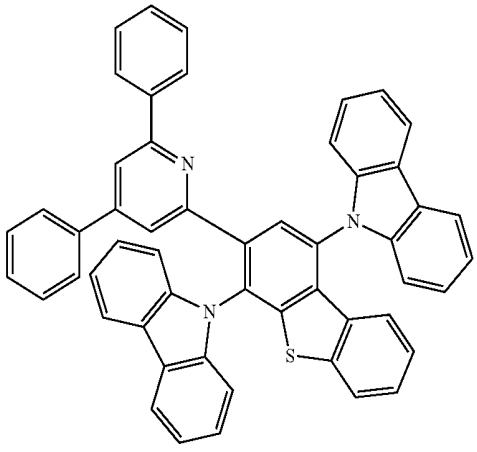

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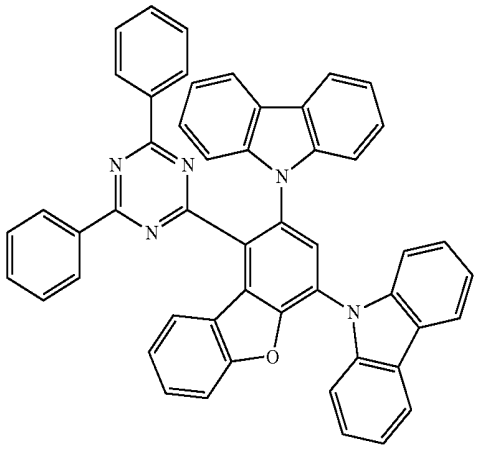

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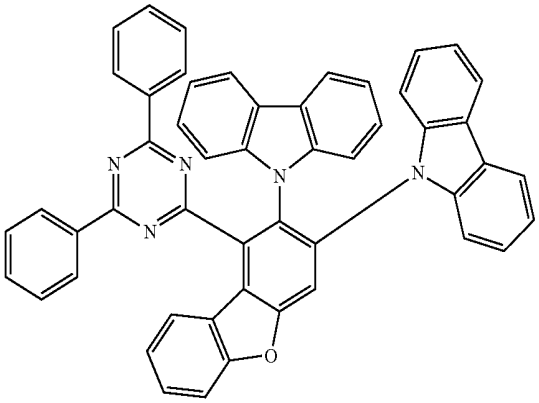

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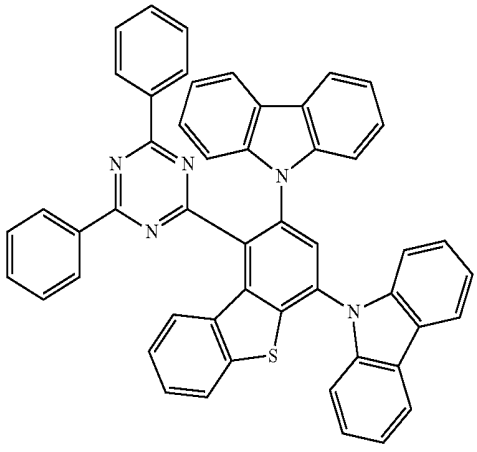

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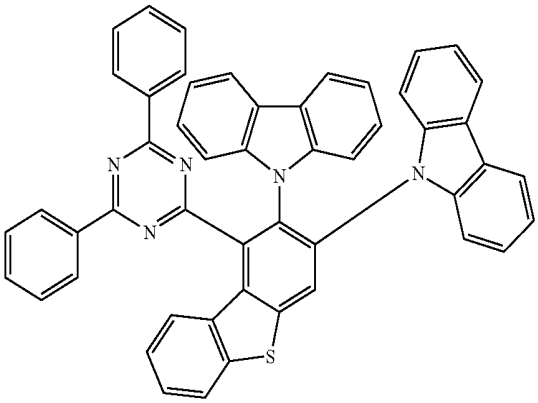

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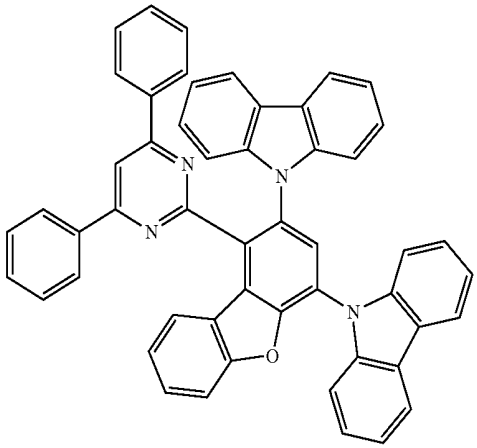

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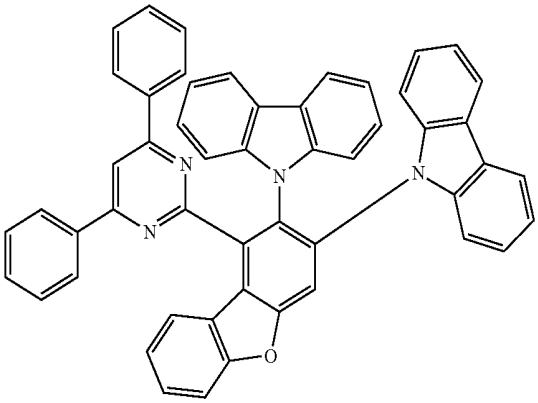

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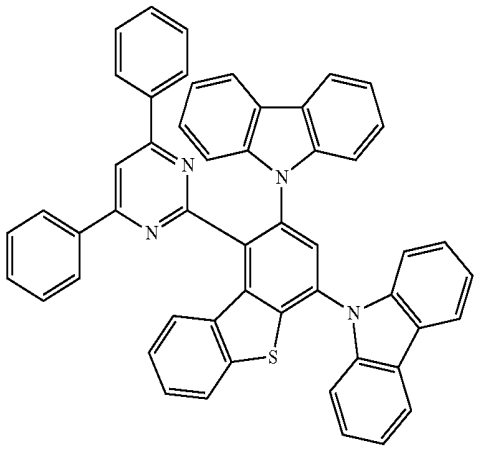

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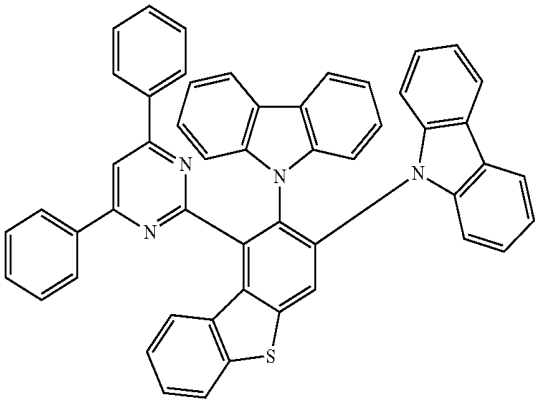

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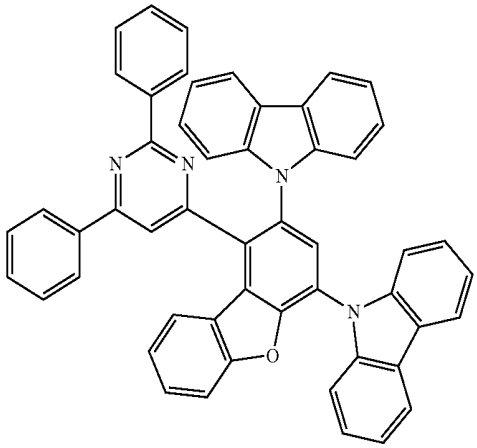

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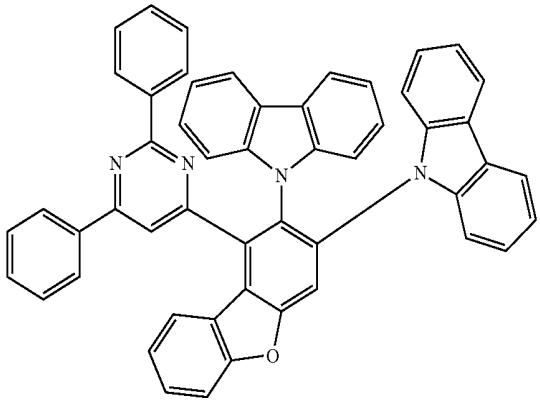

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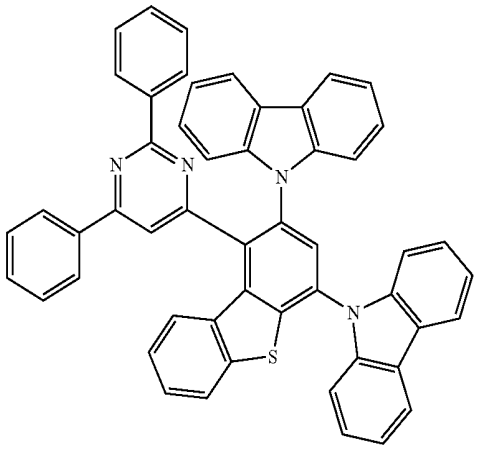

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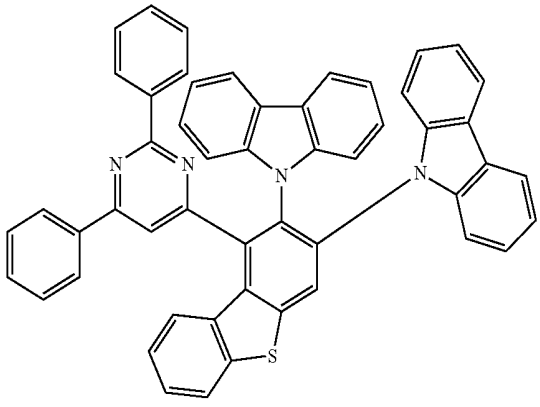

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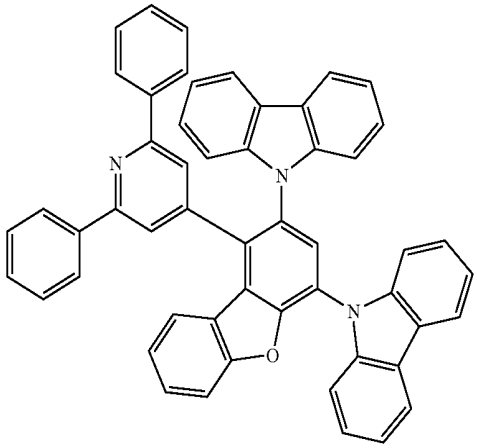

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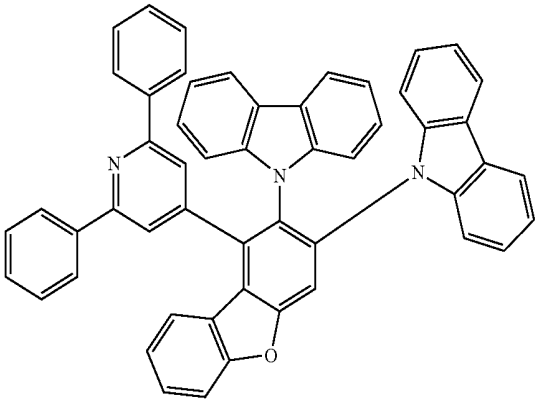

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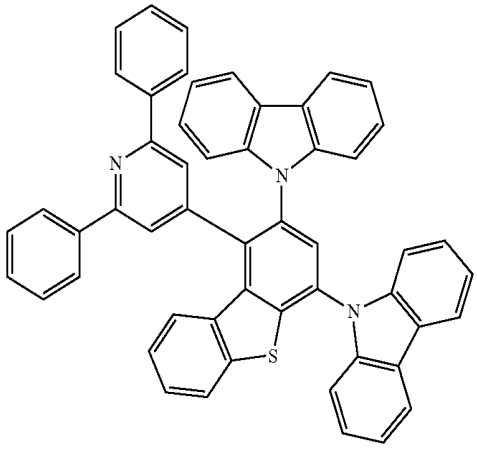

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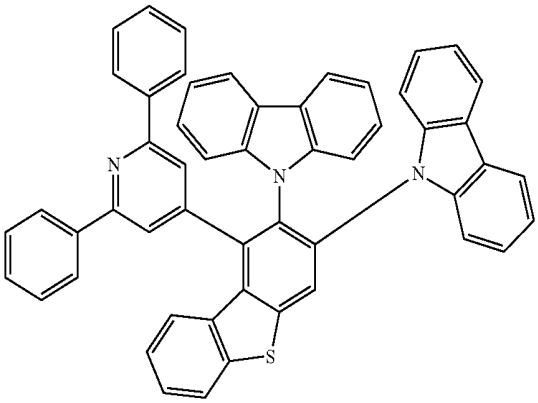

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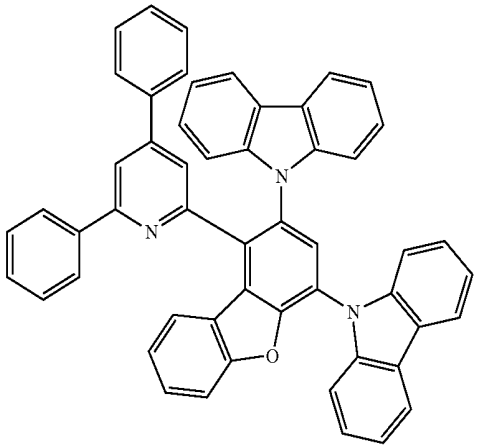

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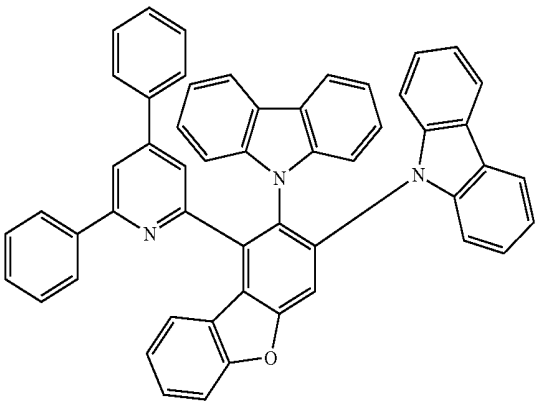

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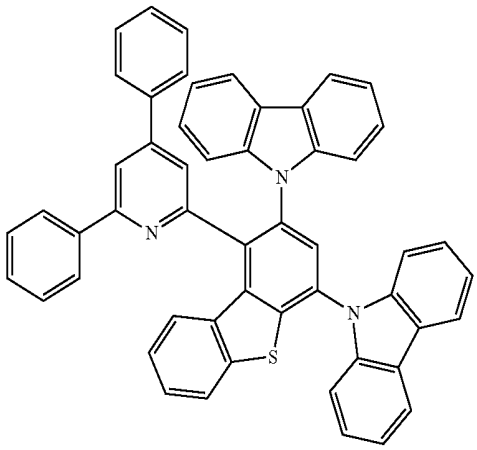

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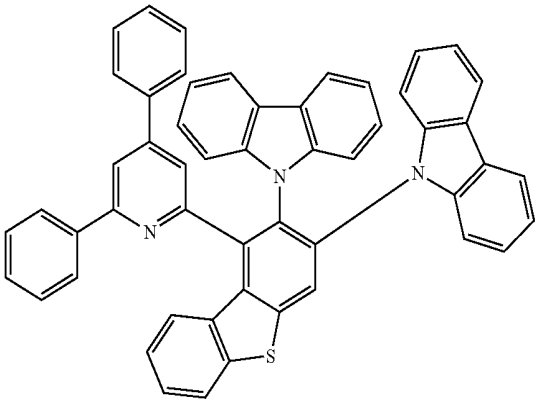

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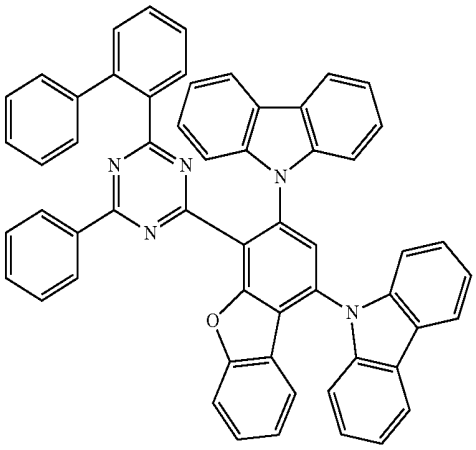

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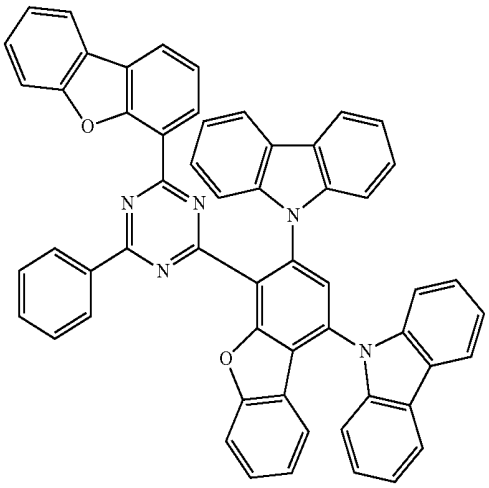

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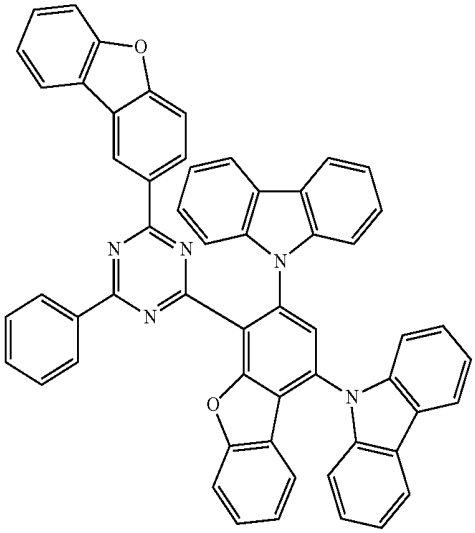

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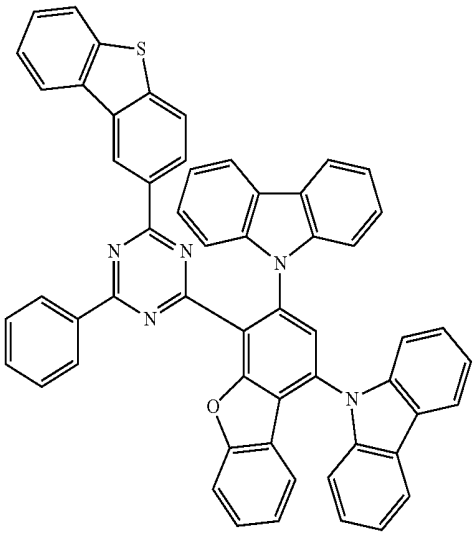

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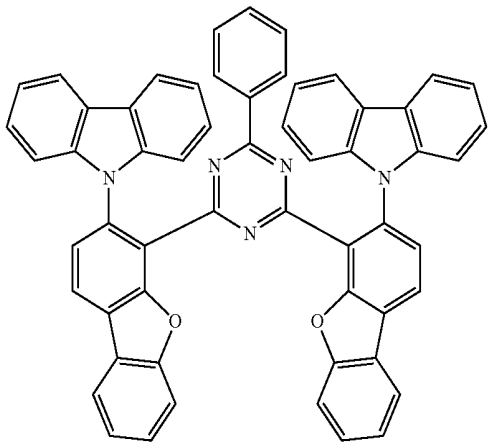

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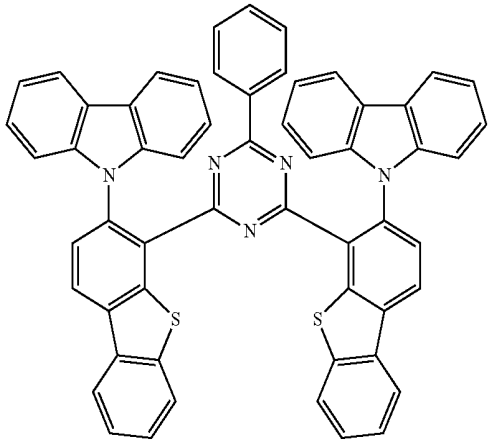

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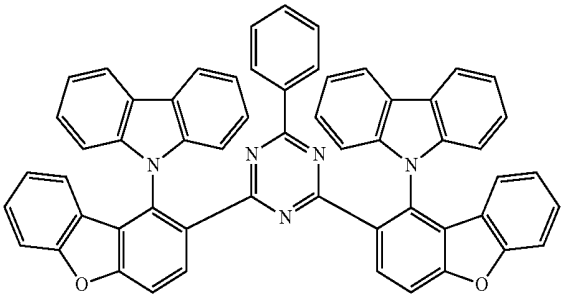

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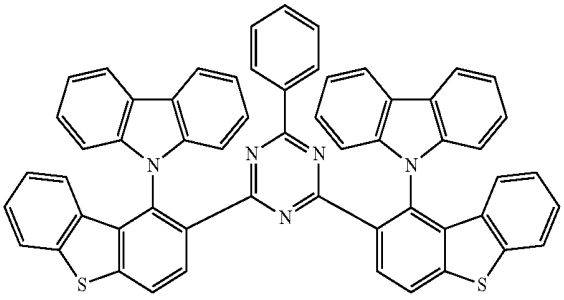

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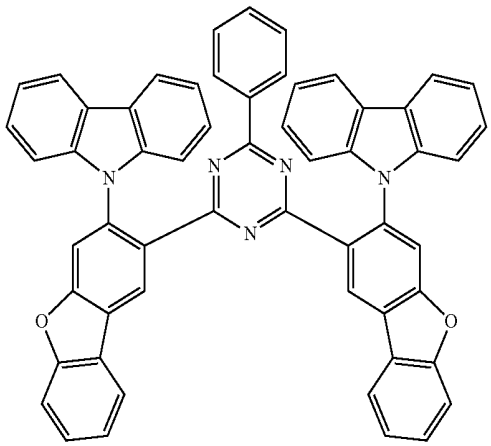

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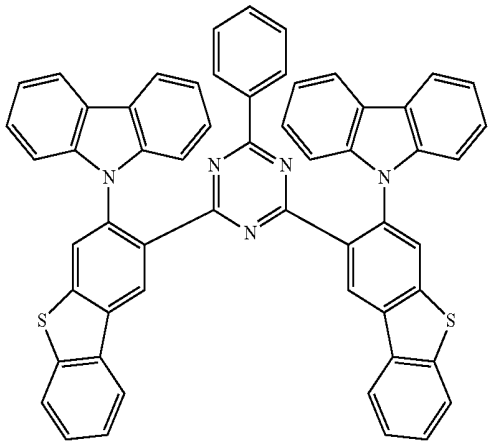

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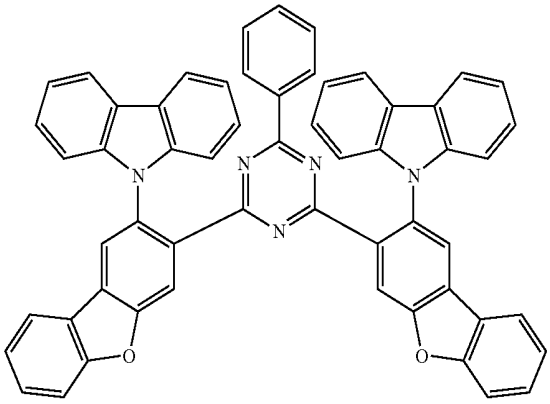

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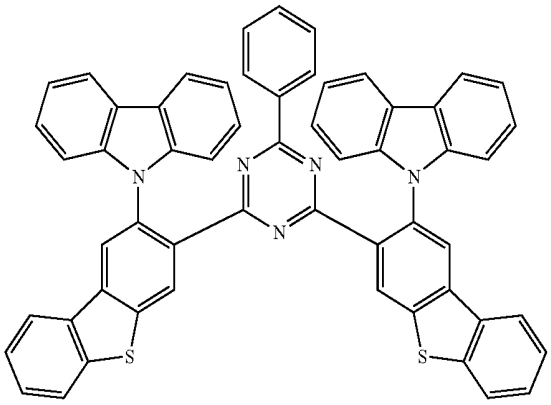

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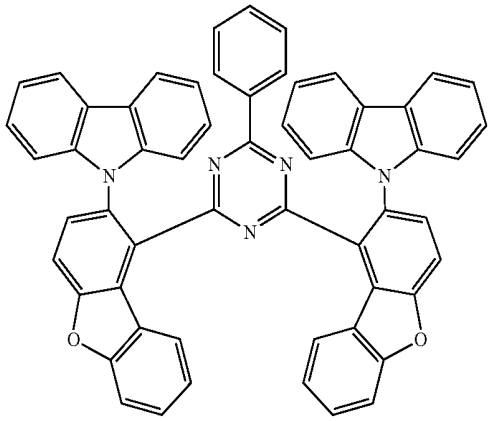

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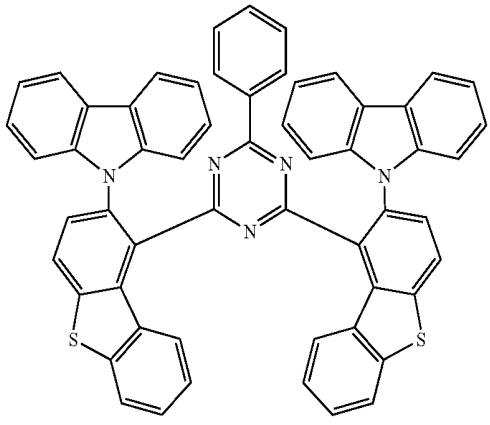

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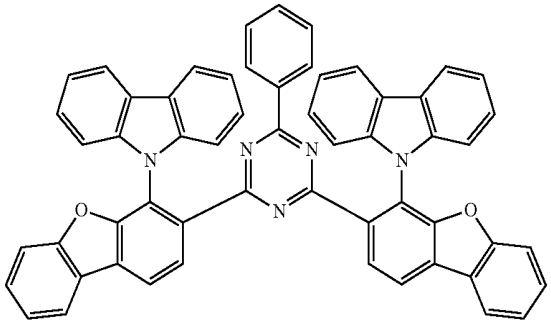

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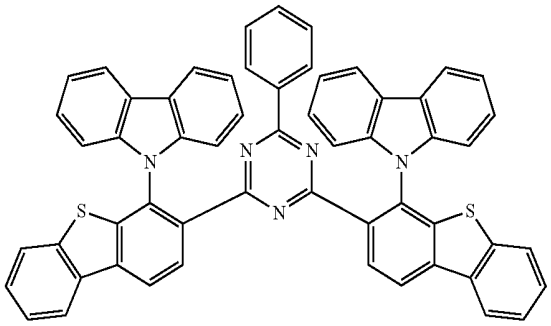

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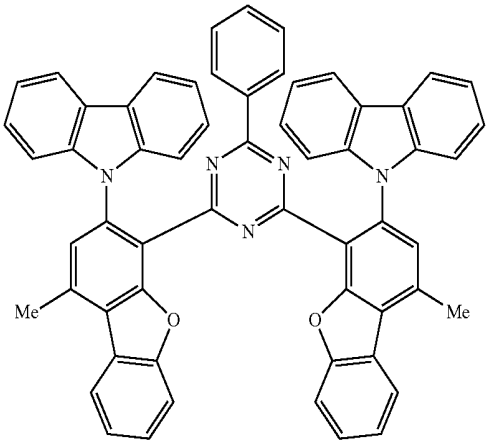

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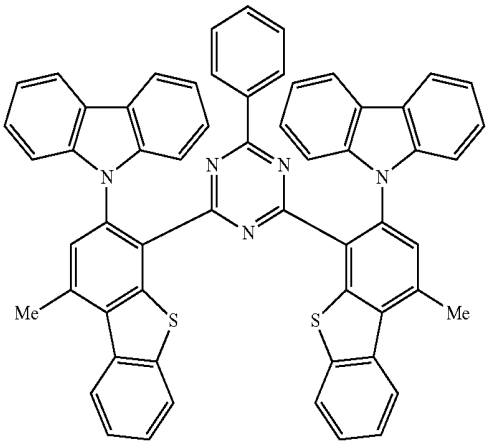

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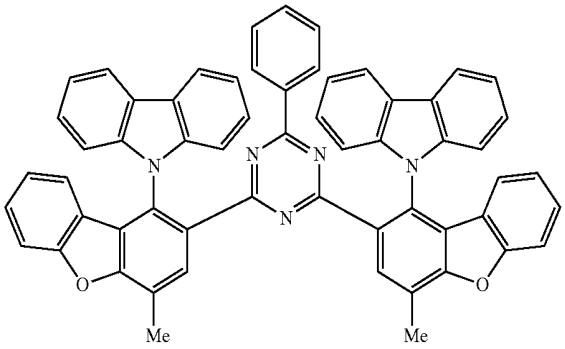

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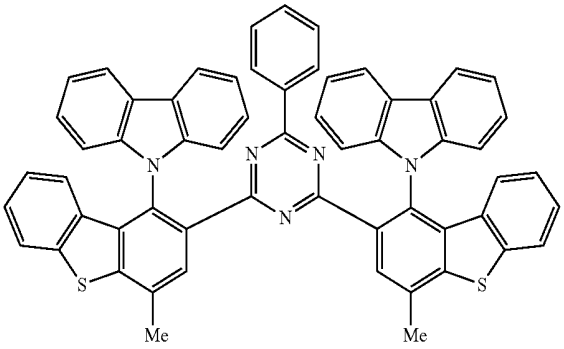

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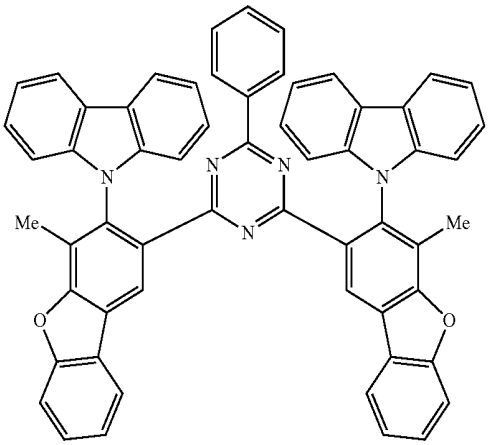

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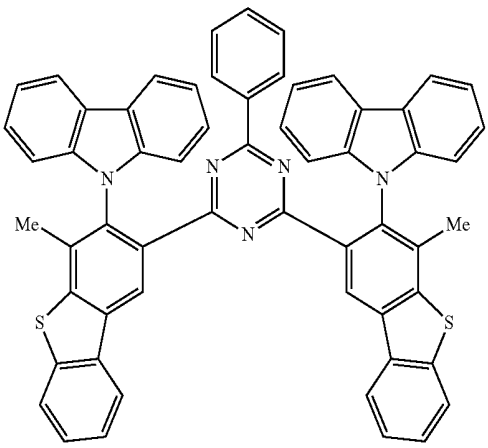

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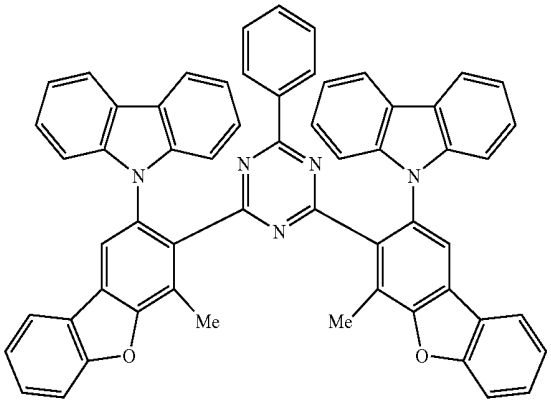

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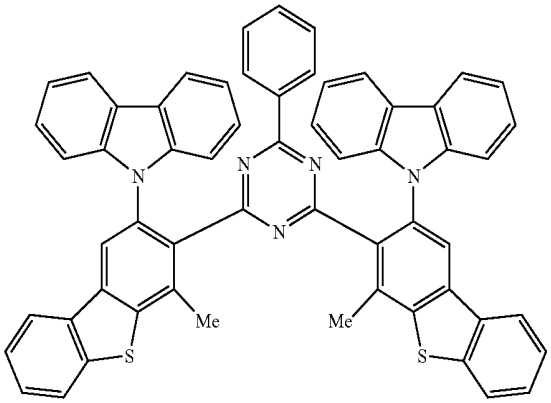

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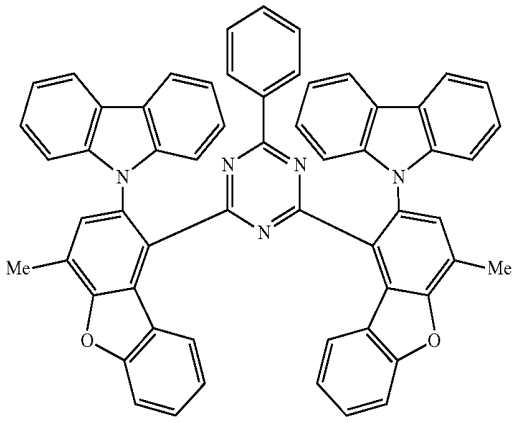

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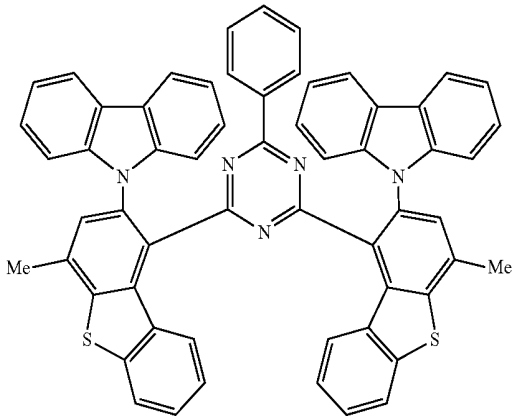

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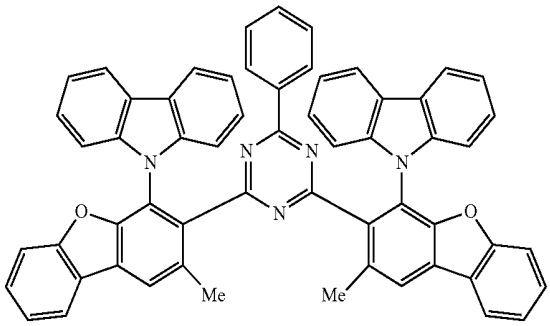

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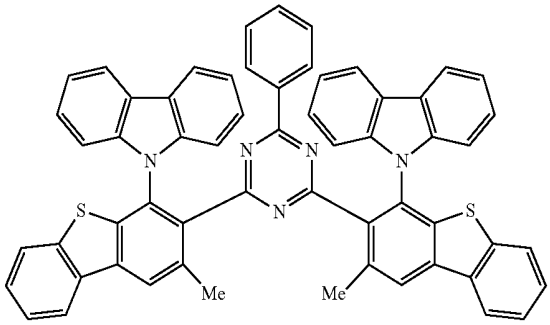

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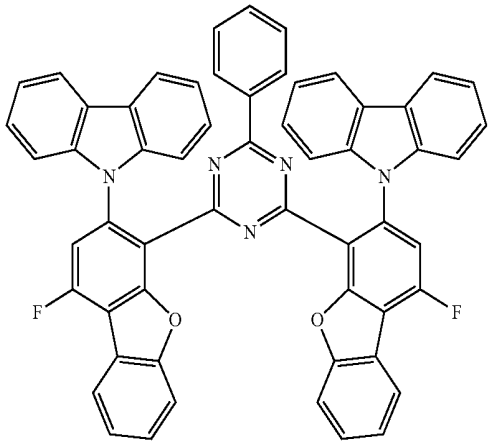

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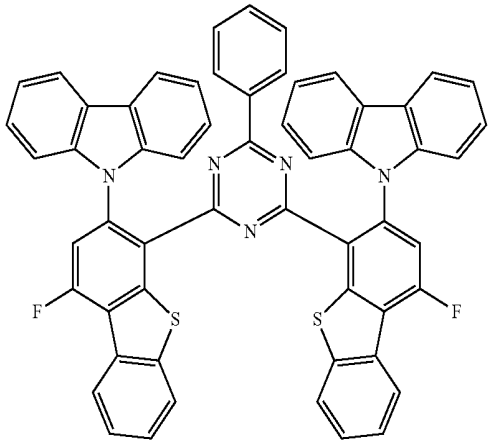

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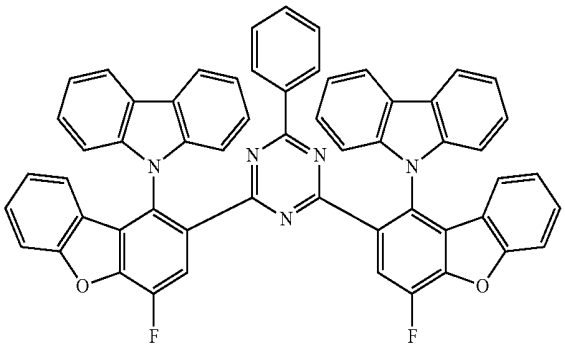

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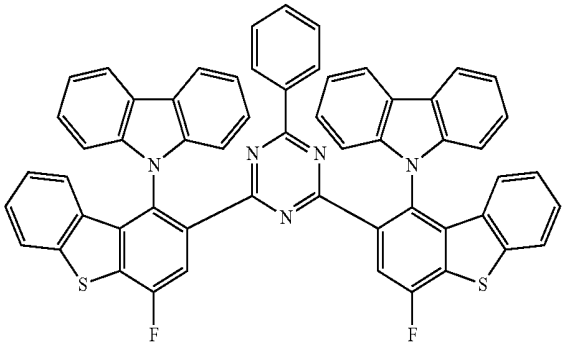

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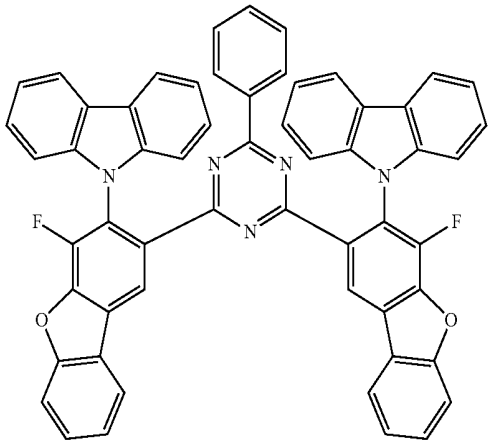

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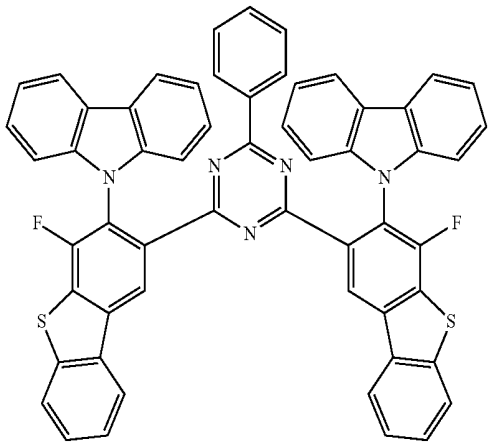

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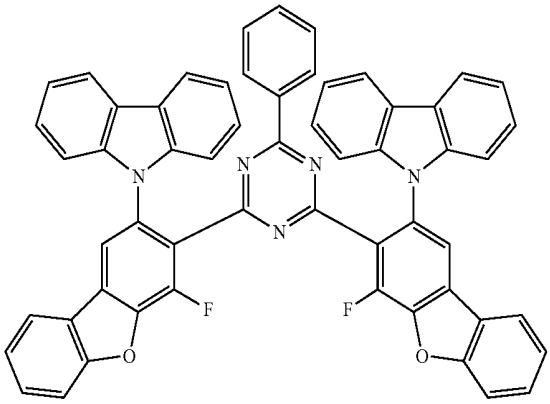

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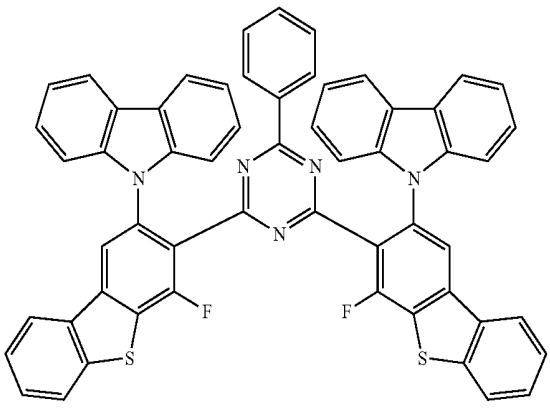

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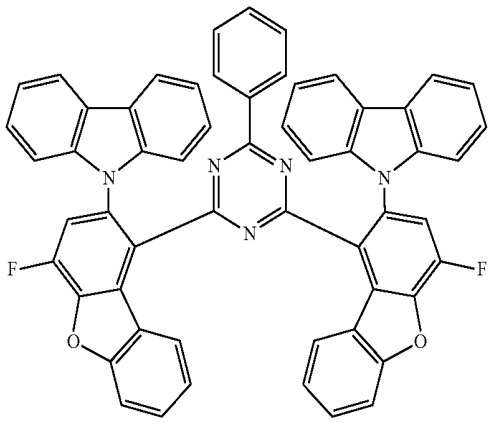

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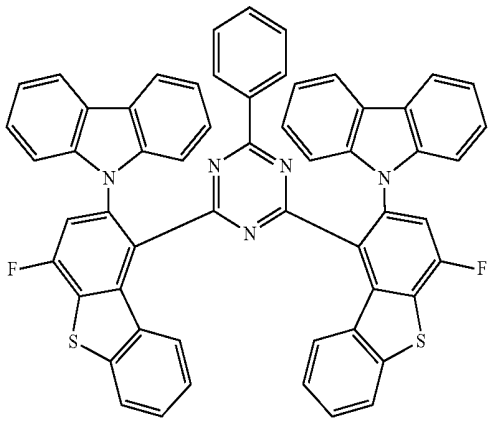

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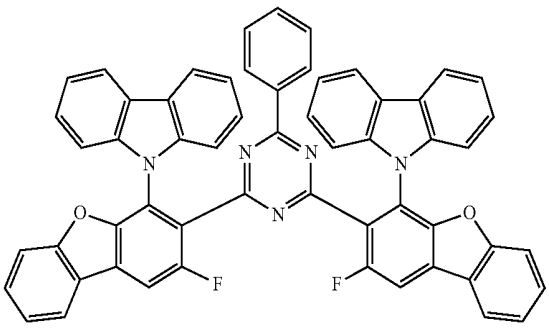

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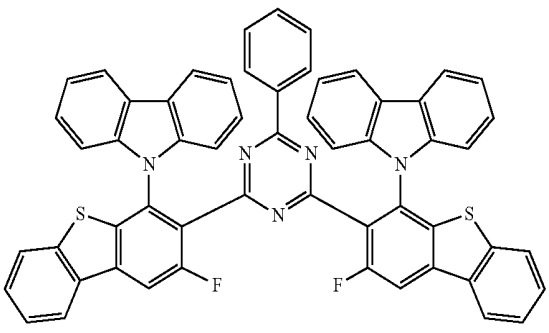

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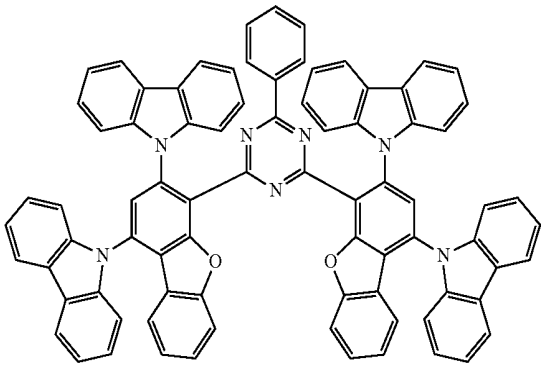

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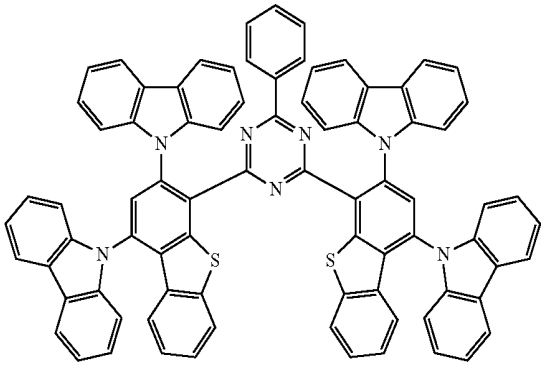

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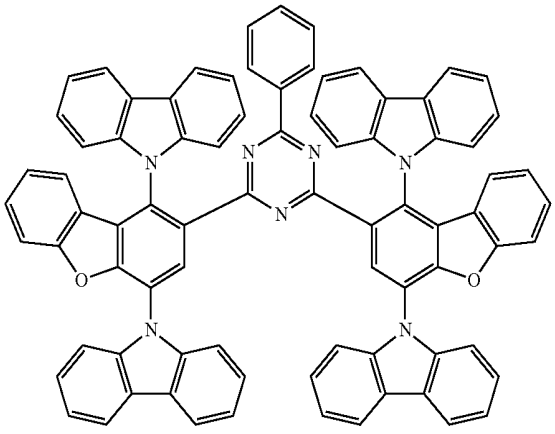

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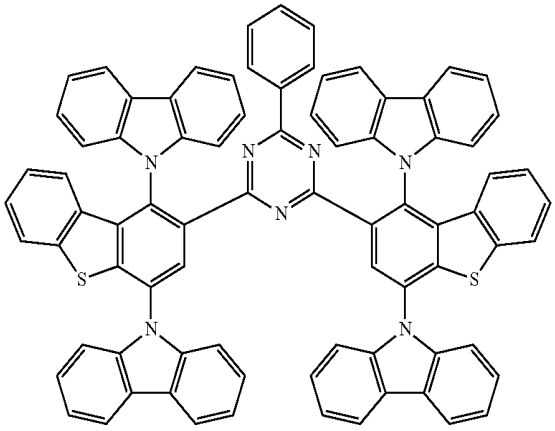

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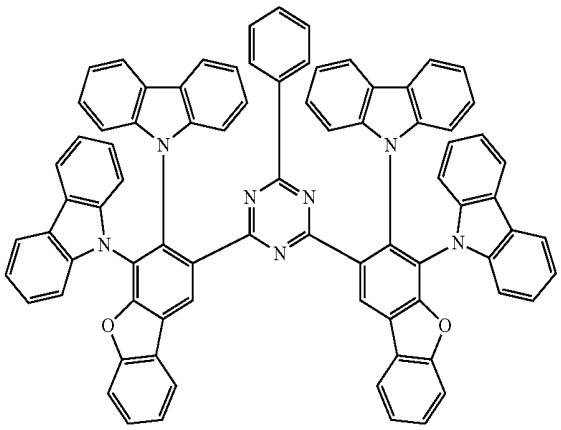

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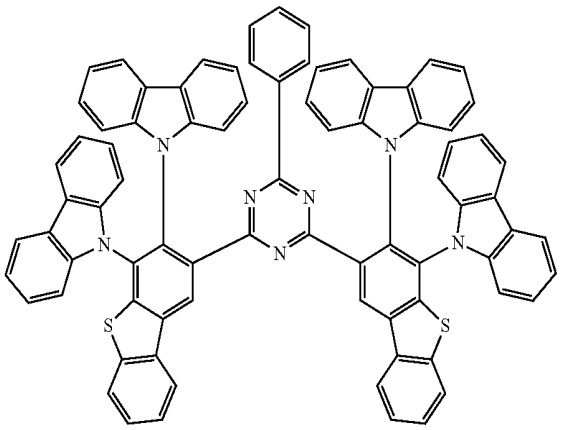

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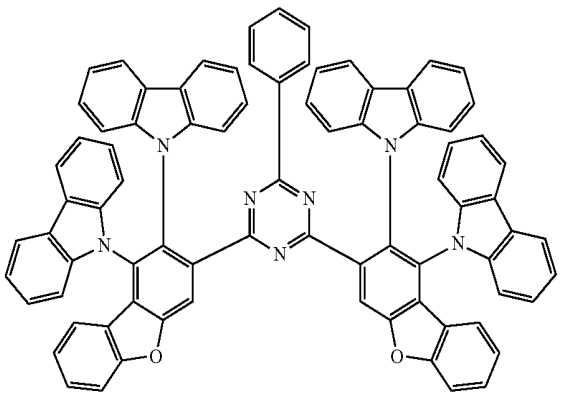

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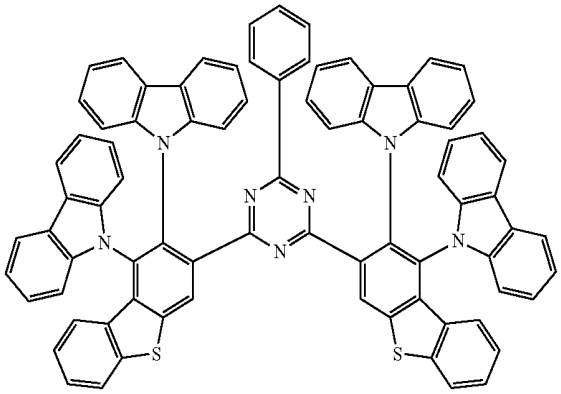

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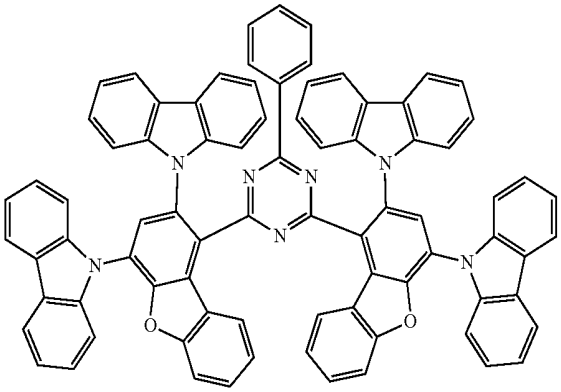

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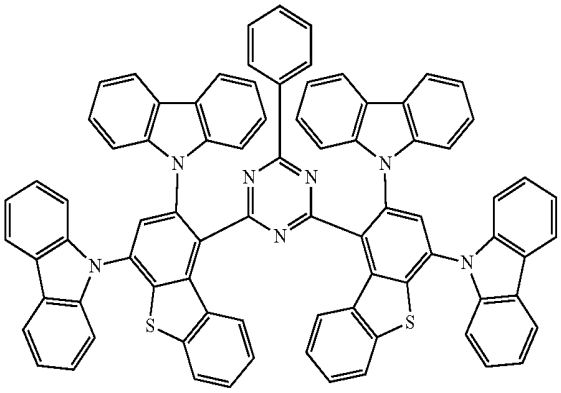

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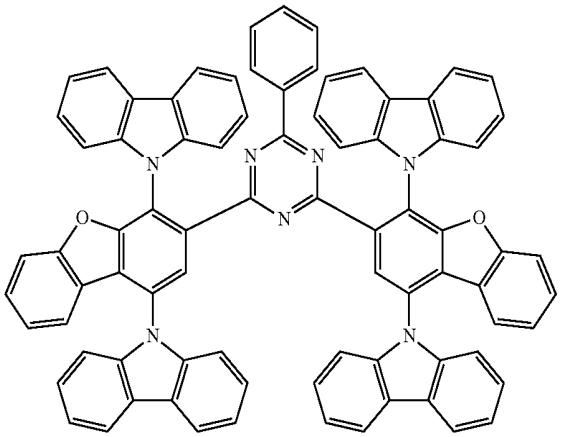

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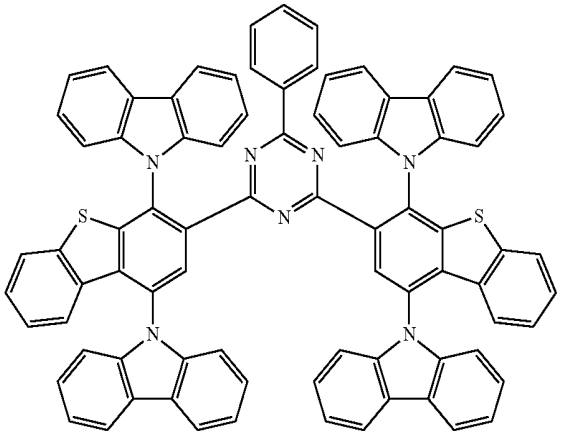

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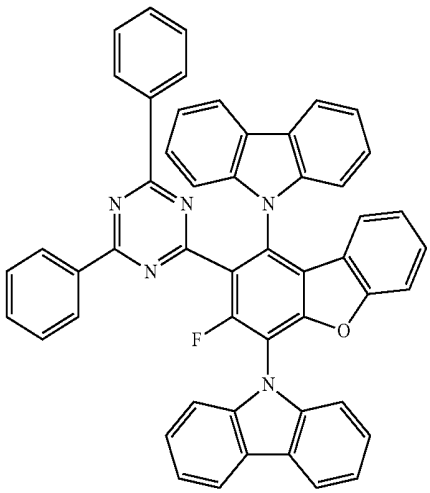

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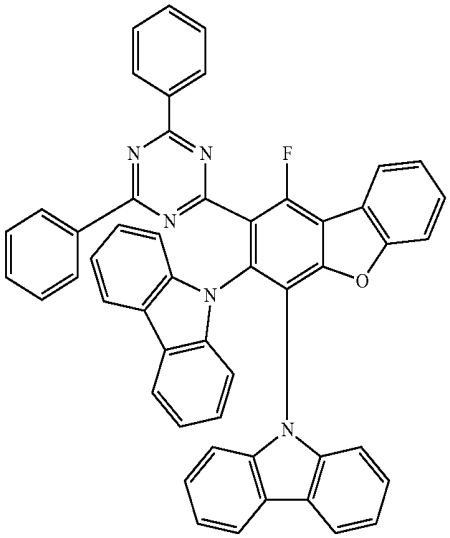

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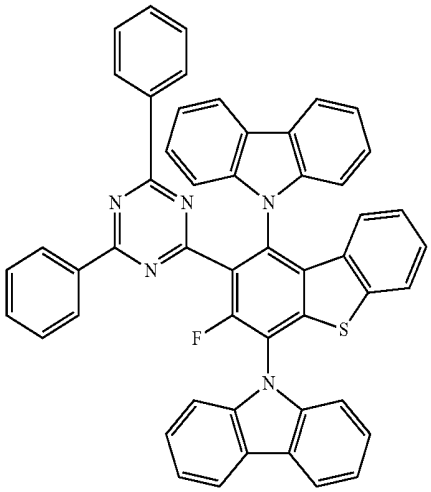

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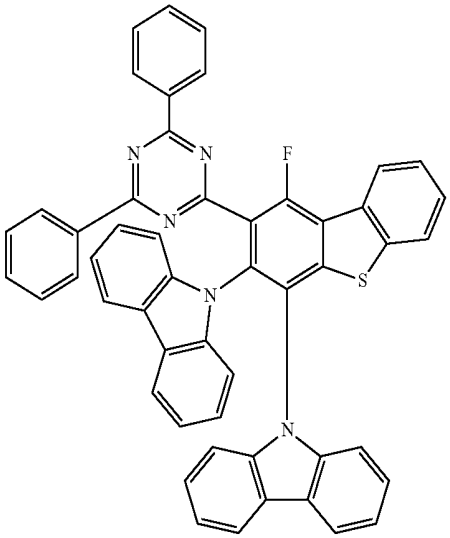

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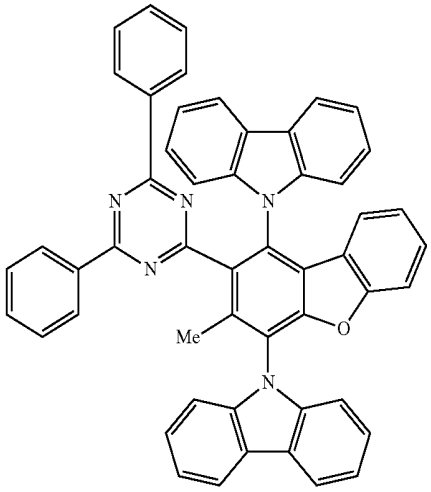


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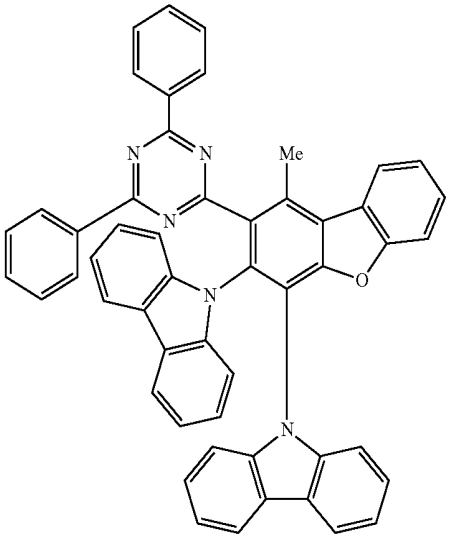


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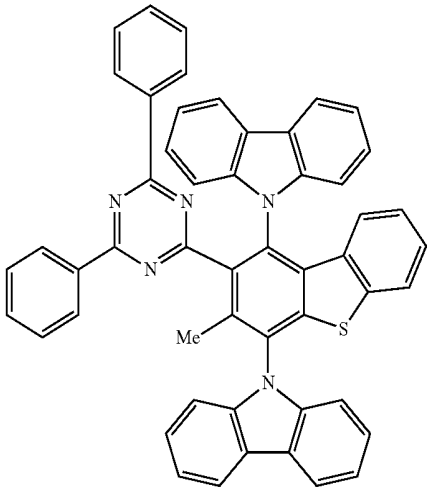


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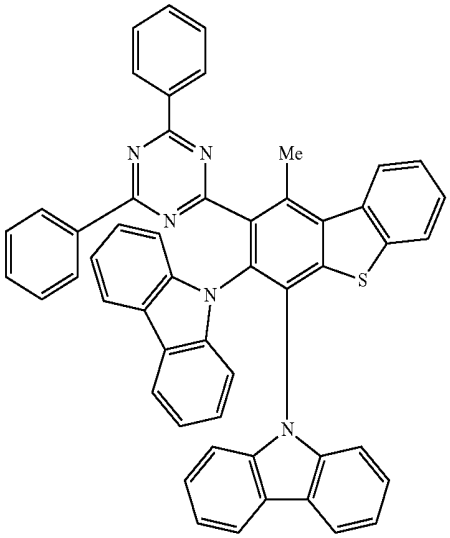


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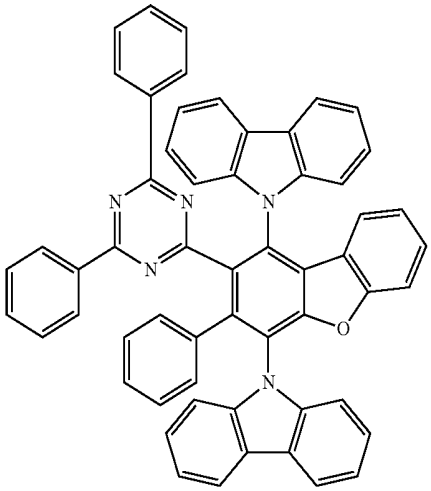


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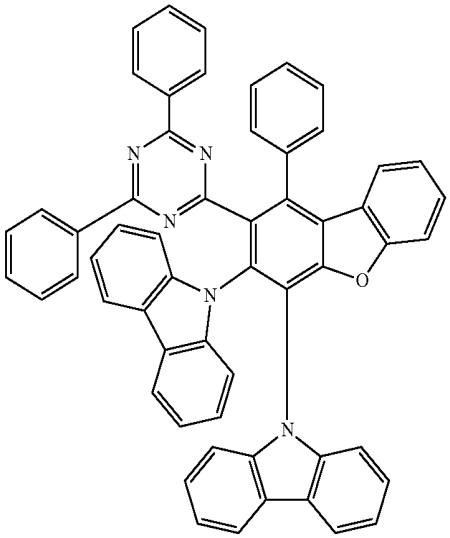

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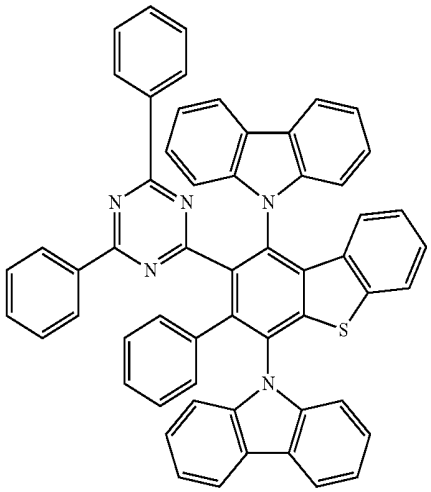

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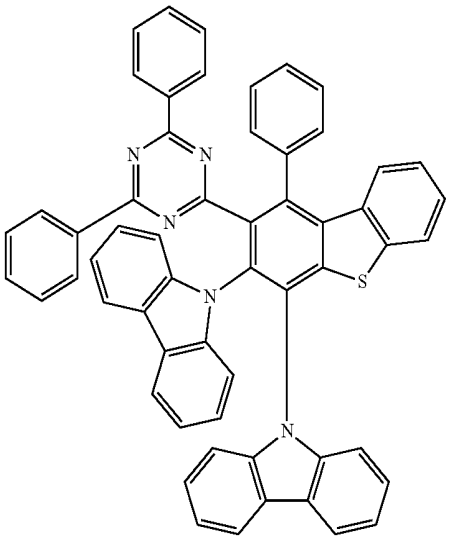

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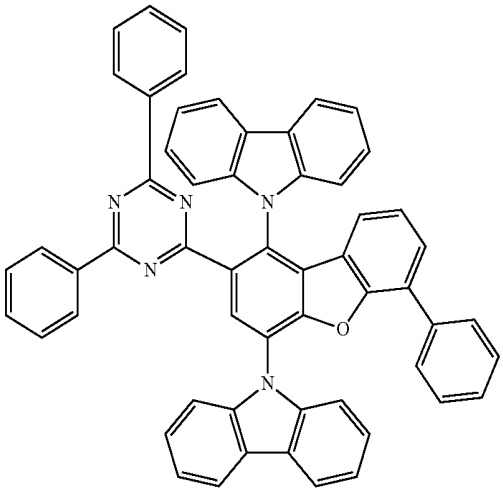

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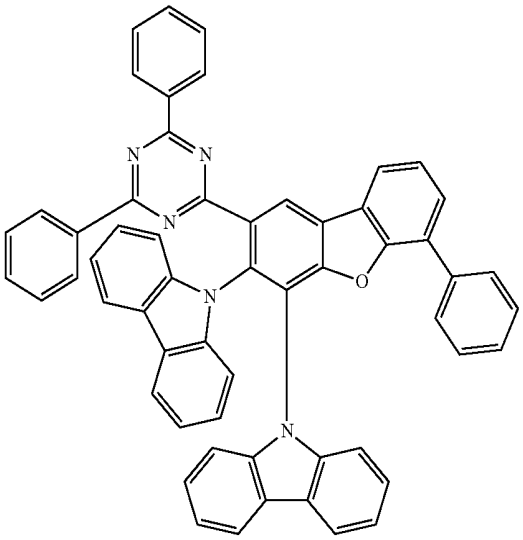

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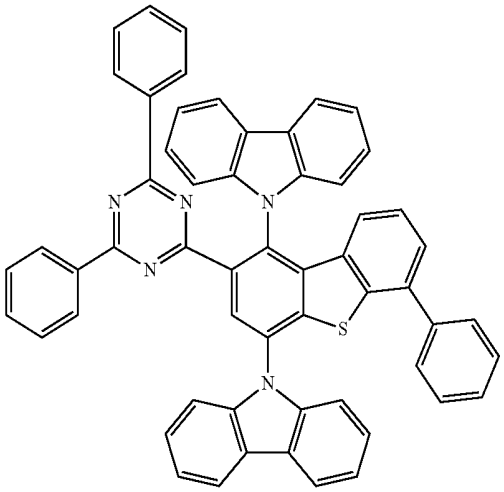

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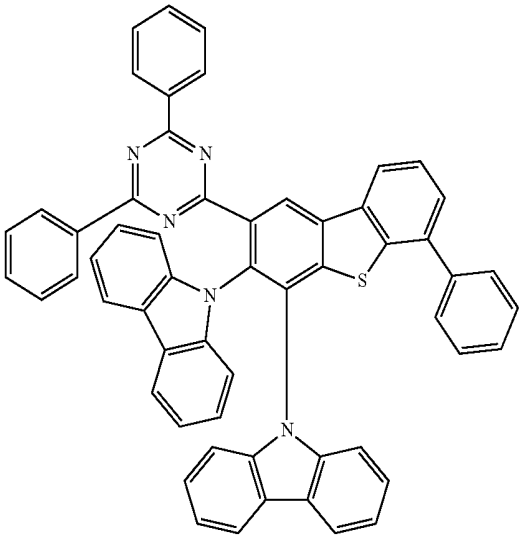

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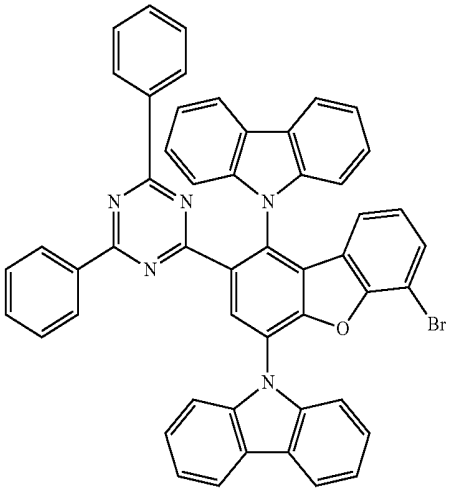

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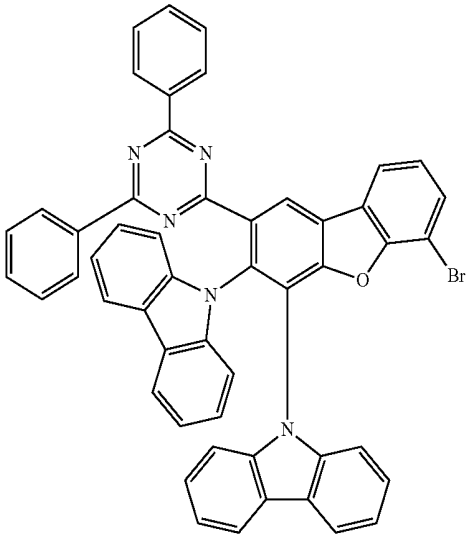

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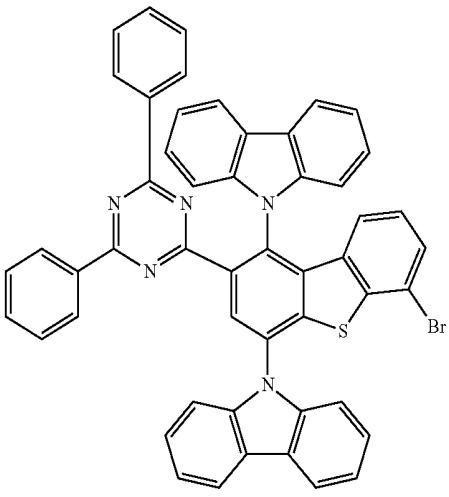

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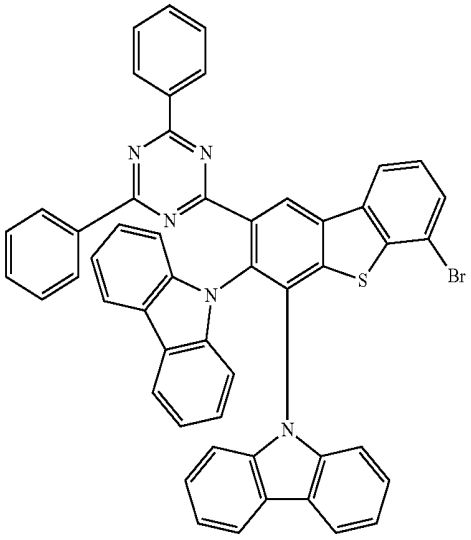

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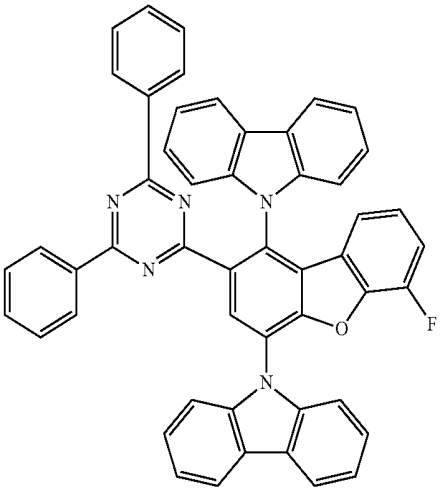

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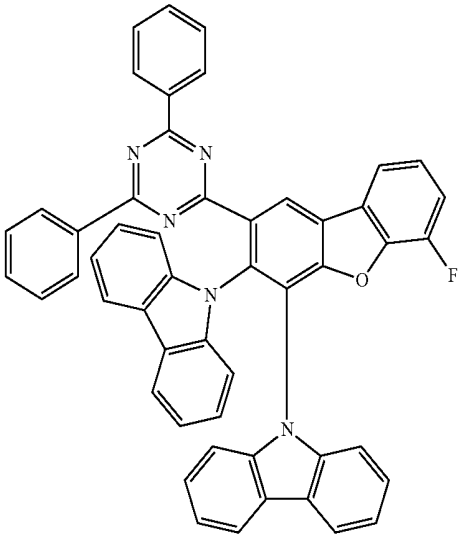

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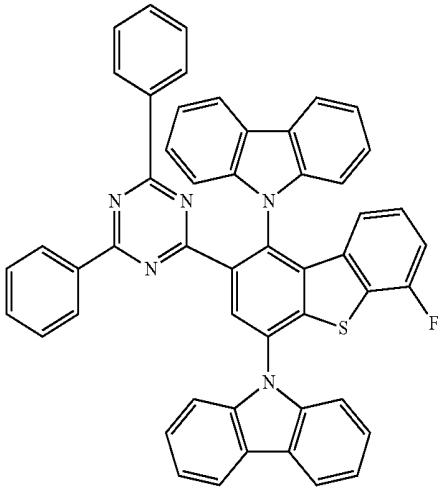

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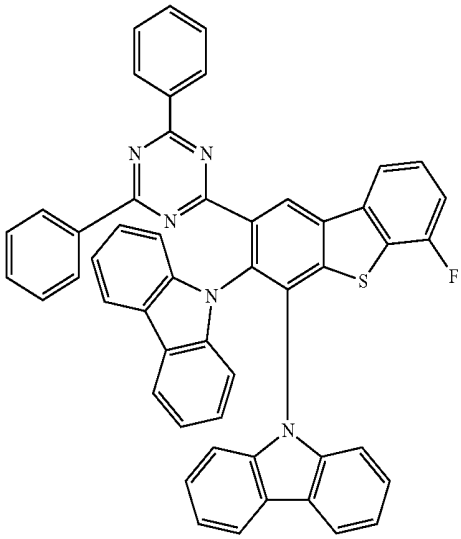

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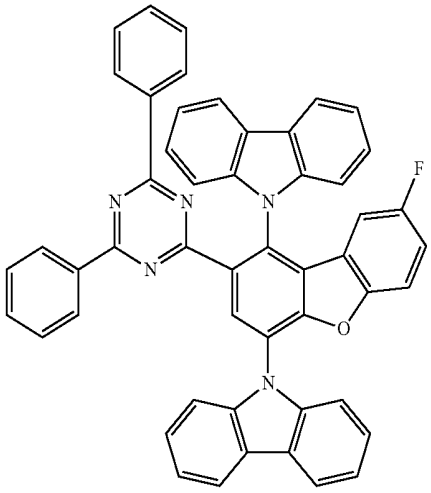

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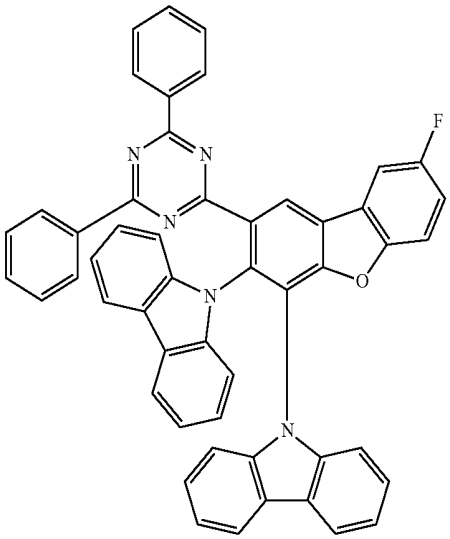

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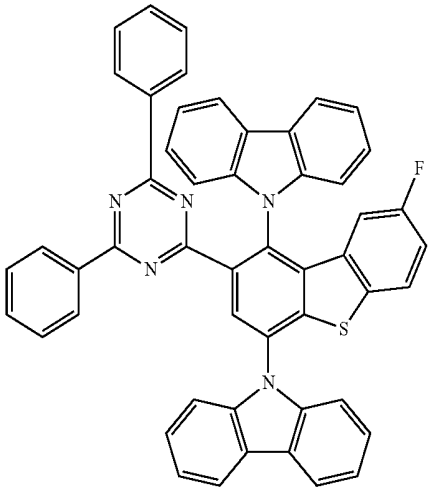

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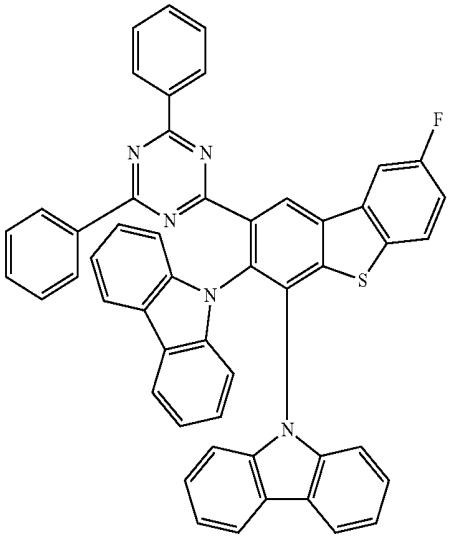

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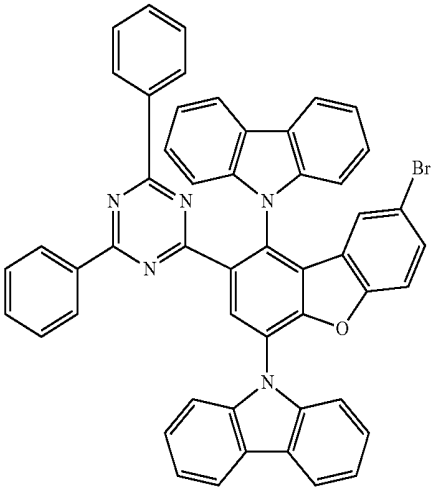

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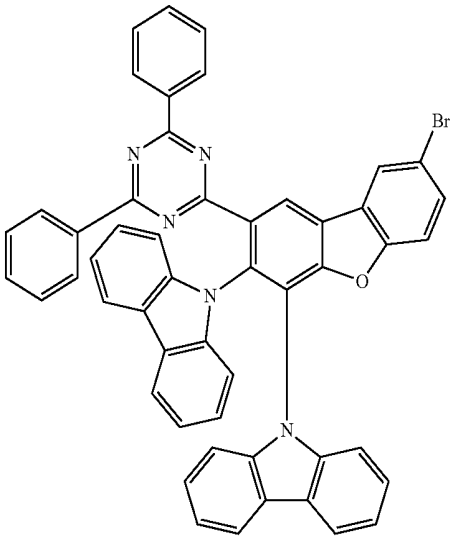

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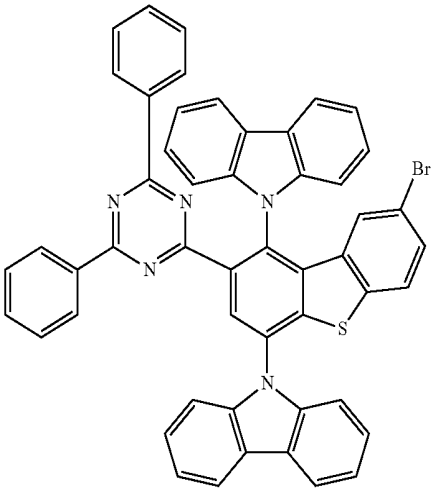

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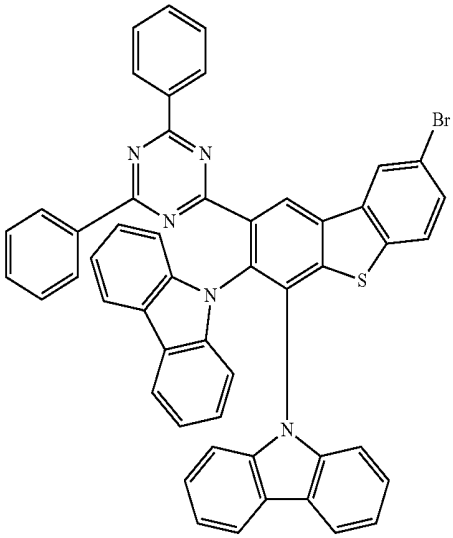

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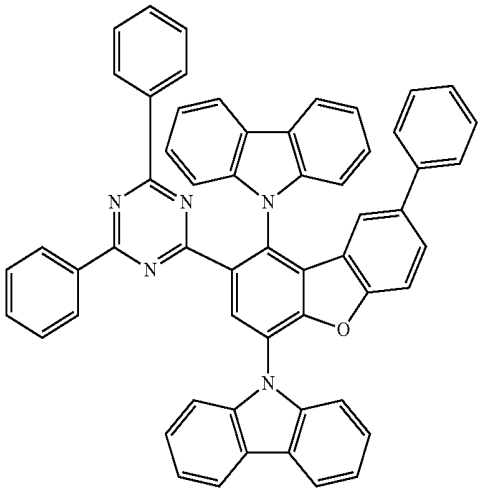

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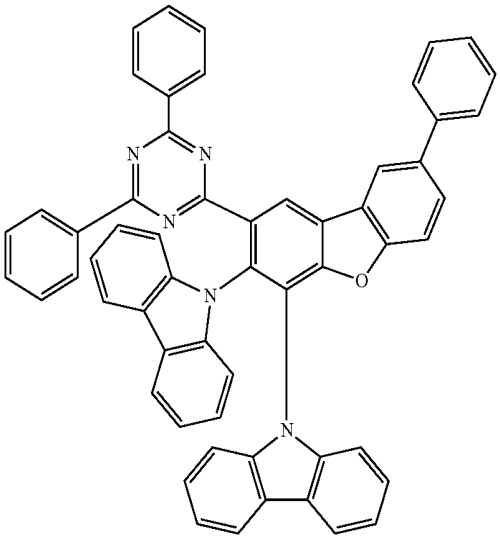

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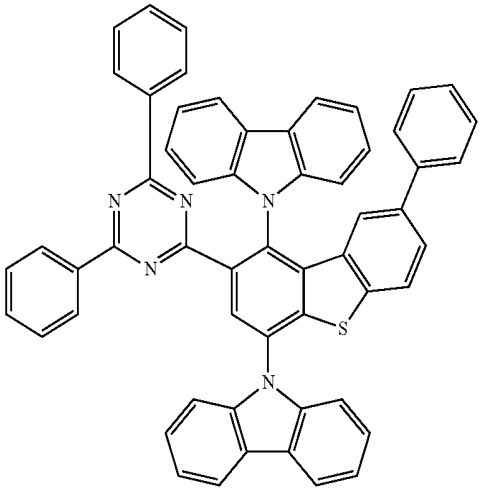

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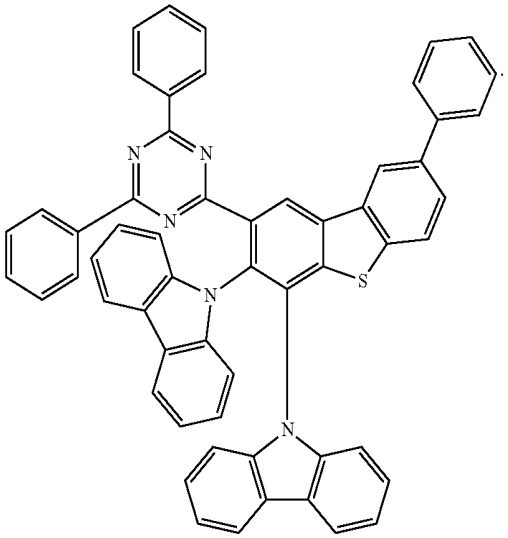

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|---|---|---|---|
| 专利名称(译) | 有机电致发光器件和用于有机电致发光器件的杂环化合物 | | |
| 公开(公告)号 | US20190393422A1 | 公开(公告)日 | 2019-12-26 |
| 申请号 | US16/382346 | 申请日 | 2019-04-12 |
| [标]申请(专利权)人(译) | 三星显示有限公司 | | |
| 申请(专利权)人(译) | 三星DISPLAY CO.，LTD. | | |
| 当前申请(专利权)人(译) | 三星DISPLAY CO.，LTD. | | |
| [标]发明人 | SAKAMOTO NAOYA | | |
| 发明人 | SAKAMOTO, NAOYA | | |
| IPC分类号 | H01L51/00 C07D405/14 C09K11/06 C07D409/14 | | |
| CPC分类号 | C09K11/06 C07D405/14 H01L51/0067 H01L51/5088 H01L51/5096 H01L51/5056 H01L51/0074 H01L51/5012 C07D409/14 C09K2211/1018 H01L51/0072 H01L51/0073 H01L51/5072 H01L51/5092 C09K2211/1007 C09K2211/1029 C09K2211/1044 C09K2211/1059 C09K2211/1088 C09K2211/1092 H01L51/5024 | | |
| 优先权 | 1020180073189 2018-06-26 KR | | |
| 外部链接 | Espacenet USPTO | | |


摘要(译)

有机电致发光器件和杂环化合物，该器件包括第一电极； 第一电极上的空穴传输区； 空穴传输区域上的发射层； 发射层上的电子传输区； 在电子传输区域上的第二电极，其中发射层包括杂环化合物，该杂环化合物包括含氮单环，至少一个连接基和两个或多个咔唑基团，该至少一个连接基是取代或未取代的二苯并呋喃基团 咔唑基团和含氮单环中的至少一个以邻位关系键合到至少一个连接基上。