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## (54) Organic electroluminscent element and display and illuminator

Organisches Elektrolumineszenzelement und Anzeige- und Beleuchtungsvorrichtung

Elément organique électroluminescent et dispositif d'affichage et d'éclairage

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## Description

## FIELD OF THE INVENTION

**[0001]** This invention relates to an organic electro-luminescent element (hereinafter also referred to as organic EL element), a display and an illuminator.

## BACKGROUND OF THE INVENTION

**[0002]** As an emission type electronic displaying device, there is an electroluminescence device (ELD). As elements constituting the ELD, there is an inorganic electro-luminescence element or an organic electroluminescent element (hereinafter referred to also as organic EL element). The inorganic electroluminescent element has been used for a plane-shaped light source, but a high voltage alternating current has been required to drive the element.

**[0003]** An organic electro-luminescent element has a structure in which a light emission layer containing a light emission compound is arranged between a cathode and an anode, and an electron and a hole were injected into the light emission layer and recombined to form an exciton. The element emits light, utilizing light (fluorescent light or phosphorescent light) generated by inactivation of the exciton, and the element can emit light by applying a relatively low voltage of from several volts to several decade volts. The element has a wide viewing angle and a high visuality since the element is of self light emission type. Further, the element is a thin, complete solid element, and therefore, the element is noted from the viewpoint of space saving and portability.

**[0004]** An organic EL element for practical use is required which efficiently emits light with high luminance at a lower power. For example, there are disclosed an element with long lifetime emitting light with high luminance in which stilbene derivatives, distyrylarylene derivatives or tristyrylarylene derivatives are doped with a slight amount of a fluorescent compound (Japanese Patent No. 3093796), an element which comprises an organic light emission layer containing an 8-hydroxyquinoline aluminum complex as a host compound doped with a slight amount of a fluorescent compound (Japanese Patent O.P.I. Publication No. 63-264692), and an element which comprises an organic light emission layer containing an 8-hydroxyquinoline aluminum complex as a host compound doped with a quinacridone type dye (Japanese Patent O.P.I. Publication No. 3-255190).

**[0005]** When light emitted through excited singlet state is used in the element disclosed in the above Patent documents, the upper limit of the external quantum efficiency ($\eta$ext) is considered to be at most 5%, as the generation ratio of singlet excited species to triplet excited species is 1:3, that is, the generation probability of excited species capable of emitting light is 25%, and further, external light emission efficiency is 20%.

**[0006]** Since an organic EL element, employing phosphorescence through the excited triplet, was reported by Prinston University (for example, see M. A. Baldo et al., Nature, 395, p. 151-154 (1998)), study on materials emitting phosphorescence at room temperature has been actively made (for example, see M. A. Baldo et al., Nature, 403, 17, p. 750-753 (2000) or US Patent No. 6,097,147).

**[0007]** As the upper limit of the internal quantum efficiency of the excited triplet is 100%, the light emission efficiency of the exited triplet is theoretically four times that of the excited singlet. Accordingly, light emission employing the excited triplet exhibits the same performance as a cold cathode tube, and can be applied to an illuminator.

**[0008]** For example, many kinds of heavy metal complexes such as iridium complexes has been synthesized and studied (for example, see (for example, see S. Lamansky et al., J. Am. Chem. Soc., 123, 4304 (2001)).

**[0009]** An example employing tris(2-phenylpyridine)iridium as a dopant has been studied (for example, M. A. Baldo et al., Nature, 395, p. 151-154 (1998)).

**[0010]** Further, an example employing as a dopant $L_2$Ir (acac) (in which L represents a bidentate ligand, and "acac represents acetyl acetone) such as $(ppy)_2$Ir (acac) (for example, see M. E. Tompson et. al., The 10th International Workshop on Inorganic and Organic Electroluminescence (EL' 00, Hamamatsu)), or employing as a dopant tris(2-p-tolylpyridine)iridium {Ir$(ptpy)_3$}, tris(benzo-[h]-quinoline)iridium {Ir$(bzq)_3$}, or Ir$(bzq)_2$ClP $(Bu)_3$ has been studied (for example, see Moon-Jae Youn. Og, Tetsuo Tsutsui et. al., The 10th International Workshop on Inorganic and Organic Electroluminescence (EL' 00, Hamamatsu)).

**[0011]** A hole transporting material is used as a host of a phosphorescent compound in order to increase emission efficiency (for example, see Ikai et. al., The 10th International Workshop on Inorganic and Organic Electroluminescence (EL' 00, Hamamatsu)).

**[0012]** Various kinds of electron transporting materials are used as a host of a phosphorescent compound, and further doped with a new iridium complex (for example, M. E. Tompson et. al., The 10th International Workshop on Inorganic and Organic Electroluminescence (EL' 00, Hamamatsu)). High emission efficiency is obtained by incorporation of a hole blocking layer (for example, see Moon-Jae Youn. Og, Tetsuo Tsutsui et. al., The 10th International Workshop on Inorganic and Organic Electroluminescence (EL' 00, Hamamatsu)).

**[0013]** An external qauntum efficiency of around 20%, which is theoretically a threshold value, is attained in green light emission, but there is a problem that emission efficiency greatly lowers at high luminance emission, and further, a sufficient emission efficiency is not attained in another color light, where there is room to be improved. An organic electroluminescent element with high emission efficiency is disclosed in for example, Japanese Patent O.P.I. Publication No. 2002-100476. An organic EL element for practical use is required which efficiently emits light with high luminance at a lower power.

**[0014]** Further, an organic electroluminescent element is strongly required which has durability or emission life enough to be applied to a display or an illuminator. Particularly in a display employing many organic electroluminescent elements, an element continuously emitting light and an element intermittently emitting light differ in deterioration degree. For example, when a first still image is displayed for long time, and then a second still image is displayed, the elements deteriorate at portions corresponding to the first still image, resulting in lowering of luminance of the first image, and the first still image is observed as a dark image with luminance lowered as compared with the second still image. That is, such a display has problem called burn-in. In the display displaying 256 gradations, a luminance lowering of 0.4% corresponds to one gradation lowering. This is a serious problem to be solved to meet requirement for a display providing an image with high precision.

**[0015]** In order to overcome the above problem, various proposals have been made. For example, a method is disclosed in for example, Japanese Patent O.P.I. Publication Nos. 2002-313559, 08-236271, and 2002-367771 in which an organic electroluminescent element is subjected to sealing treatment, a method is disclosed in for example, Japanese Patent O.P.I. Publication No. 07-065958 in which a dopant having an appropriate energy level is incorporated in an organic electroluminescent element to enhance durability, and a method is disclosed in for example, Japanese Patent O.P.I. Publication Nos. 2002-198170 in which a desiccant is incorporated in a space enclosed with a substrate, an organic electroluminescent element and a sealing agent. Further, an attempt has been made which employs an electron transporting material or a material used in a light emission layer each having higher durability in an organic electroluminescent element. This attempt is disclosed in many literatures, for example, in Japanese Patent O.P.I. Publication Nos. 2002-363227, 2002-352961, 2002-356462, 2002-36350, 2002-8860 and 2002-203683).

**[0016]** Generally, when continuous light emission from an organic electroluminescent element is carried out, a decaying speed of its luminance is not constant, but is high particularly at initial emission stage. Accordingly, in a display or an illuminator employing such an organic electroluminescent element, display image quality or illumination ability rapidly lowers at initial stage of operation and after that, it slowly lowers at a relatively small speed. With respect to the "burn-in" described above, this phenomenon implies the fact that images shown earlier on the display is more likely to deteriorate. In a display in which a still image have continued to be displayed at the beginning of operation or in a display for displaying mainly a still image, the "burn-in" phenomenon occurs immediately after the beginning of operation and after that, a viewer watches an image with lowered quality. It is needless to say that this greatly lowers quality as a display.

**[0017]** In order to minimize such a rapid luminance lowering after the beginning of operation and to obtain a reduced and relatively stable luminance lowering speed, an attempt has been made in Japanese Patent O.P.I. Publication Nos. 2002-198172 and 2002-203672 in which an organic electroluminescent element has been subjected to aging treatment until a reduced and relatively stable luminance lowering speed is obtained, as disclosed in Japanese Patent O.P.I. Publication Nos.. However, this incorporates a period immediately after the manufacture of the organic electroluminescent element in the form of aging treatment, in other words, a newly manufactured organic electroluminescent element is made fatigue to some extent in advance. However, this method shortens some of life, which the organic electroluminescent element inherently has, in the manufacture, and life of the organic electroluminescent element is considered to be shortened in proportion to degree of the aging treatment. If an organic electroluminescent element can be manufactured which does not greatly lower luminance, the aging treatment being eliminated or if any, being minimized, it can provide an organic electroluminescent element with life which the element inherently has, and an organic electroluminescent element solving or restraining burn-in described above.

**[0018]** In order to improve luminance and emission lifetime of the organic EL element, proposal has been made in which a hole blocking layer, inhibiting migration of holes from the light emission layer, is provided between the light emission layer and the cathode. This hole blocking layer can efficiently accumulate holes in the light emission layer and improve a recombination probability of electrons and holes therein, resulting in light emission with high efficiency. It is reported (see, for example, Japanese Patent O.P.I. Publication Nos. 8-109373 and 10-233284) that a phenanthroline derivative and a triazole derivative are effectively used alone as a hole blocking compound of the hole blocking layer. Further, disclosed is an organic El element with long lifetime in which a specific aluminum complex is used in the hole blocking layer (see Japanese Patent O.P.I. Publication No. 2001-284056).

**[0019]** It has been reported (for example, in Sixty second OyobutsuriGakkai Gakujutsukoen Kai Yokoshu 12-a-M7, Pioneer Gijutsu Johoshi, Vol. 11, No. 1) that a green light emission organic EL element employing a phosphorescent compound, when a hole blocking layer is incorporated in it, exhibits an inner quantum efficiency of approximately 100% and a lifetime of twenty thousand hours. However, there is room to be improved as for emission luminance.

**[0020]** There is an example in which a phosphorescent compound emitting a blue to blue-green color light is used as a dopant compound and a carbazole derivative such as CBP is used as a host compound, but the external qauntum efficiency of this example is around 6%, which provides unsatisfactory results, (see Sixty second OyobutsuriGakkai Gakujutsukoen Kai Yokoshu 12-a-M8), and there is room to be improved. Although emission from a fluorescent compound is employed, an organic EL element emitting blue light with excellent color purity and long life is prepared which employs a carbazole derivative compound in which a linkage group is incorporated in the biaryl position of the center of the molecule (see, for example, Japanese Patent O.P.I. Publication No. 2000-21572). An organic EL element emitting light with further longer life is obtained in which the above compound is employed, a specific metal complex having five ligands is incorporated in the hole blocking layer and a phosphorescent compound is used as a dopant (see, for example, Japanese Patent O.P.I. Publication No. 2002-8860).

**[0021]** However, the carbazole derivative as described in the above patent document in which the linkage group is incorporated as described above does not provide emission efficiency and heat resistance sufficient to be put into practical use. An organic EL element for practical use is desired which efficiently emits light with high luminance at a lower power.

## SUMMARY OF THE INVENTION

**[0022]** The present invention has been made in view of the above. An object of the invention is to provide an organic electroluminescent element with high luminance, high quantum yield, high durability, which minimizes luminance lowering at initial light emission.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0023]** Fig. 1 is a schematic drawing of an organic electroluminescent element having a sealing structure.

## DETAILED DESCRIPTION OF THE INVENTION

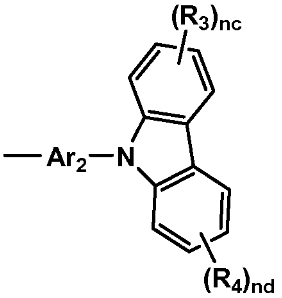
**[0024]** The above object of the invention can be attained by the following constitution:

1. An organic electroluminescent element comprising an anode, a cathode and a component layer including a light emission layer, the component layer being provided between the anode and the cathode, wherein the component layer contains a compound represented by formula 3,

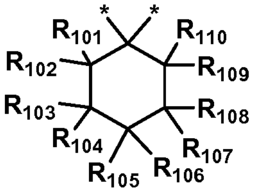
Formula 3 $X_2\text{-}(A_2)_m$

wherein $A_2$ represents a group represented by formula 4, and may be the same or different,

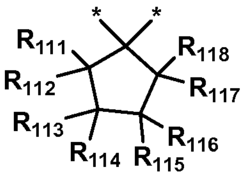
Formula 4



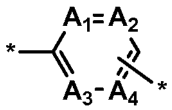
wherein $Ar_2$ represents a divalent aromatic hydrocarbon or aromatic heterocyclic group; $R_3$ and $R_4$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; nc and nd independently represent an integer of from 1 to 4; m represents an integer of 2; and $X_2$ represents a group represented by formula (l), (m), (n), or (o), Formula (l)



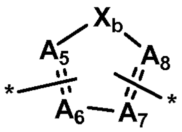
Formula (m)



Formula (n)



Formula (o)



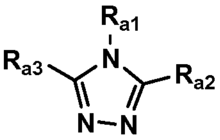
wherein $R_{101}$ through $R_{110}$ independently represent a hydrogen atom, an alkyl group, or an alkoxy group, provided that $R_{101}$ through $R_{110}$ are not simultaneously hydrogen atoms; and any two of $R_{101}$ through $R_{110}$ do not combine with each other to form a ring; $R_{111}$ through $R_{118}$ independently represent a hydrogen atom, an alkyl group, or an alkoxy group; $A_1$, $A_2$, $A_3$, and $A_4$ independently represent -C($R_{k1}$)= or -N=, in which $R_{k1}$ represents a hydrogen atom or an alkyl group, provided that at least one of $A_1$, $A_2$, $A_3$, and $A_4$ is -N=; $A_5$, $A_6$, $A_7$, and $A_8$ independently represent -C($R_{k2}$)= or -N=; $X_b$ represents -N($R_{k3}$)= or -Si($R_{k4}$) ($R_{k5}$)-, which $R_{k2}$, $R_{k3}$, $R_{k4}$, and $R_{k5}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; and "*" represents a linkage site.

2. The organic electroluminescent element of item 1 above, wherein a hole blocking layer is provided between the light emission layer and the cathode.

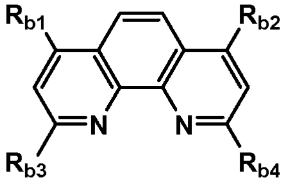
3. The organic electroluminescent element of item 2 above, wherein the hole blocking layer is comprised of at least one selected from the group consisting of a styryl compound, a triazole derivative, a phenanthroline derivative, an oxadiazole derivative and a boron derivative.

4. The organic electroluminescent element of item 3 above, wherein the hole blocking layer is comprised of at least one selected from the group consisting of compounds represented by formula 5, 6, 7 or 8 above.

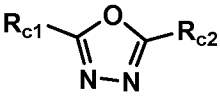
Formula 5



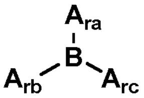
Formula 6



Formula 7



Formula 8



wherein $R_{a1}$ through $R_{a3}$, $R_{b1}$ through $R_{b4}$, and $R_{c1}$ and $R_{c2}$ independently represent an alkyl group, an aryl group or a heterocyclic group; and $A_{ra}$ through Arc independently represent an aryl group or a heterocyclic group.

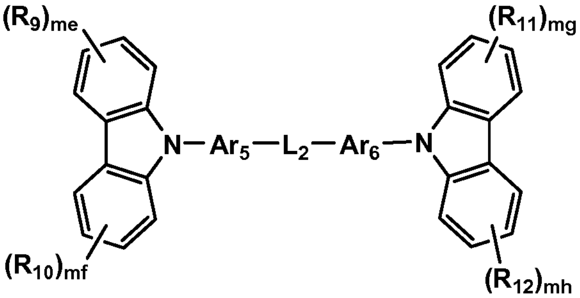
5. The organic electroluminescent element of item 1 above, wherein the light emission layer contains the compound represented by formula 3 above and H2, H3, H4, 11, 12, 13, J1 or J2 below.

6. The organic electroluminescent element of item 1 above, wherein the organic electroluminescent element contains a phosphorescent compound.

7. The organic electroluminescent element of item 6 above, wherein the phosphorescent compound is an osmium complex, an iridium complex or a platinum complex.

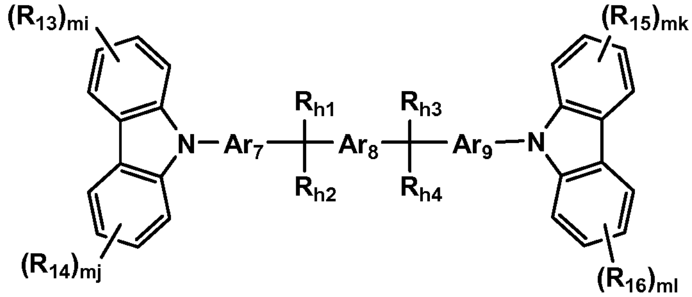
8. An organic electroluminescent element comprising an anode, a cathode and a component layer including a light emission layer, the component layer being provided between the anode and the cathode, wherein the component layer contains a compound represented by formula H2, H3 or H4,

Formula H2



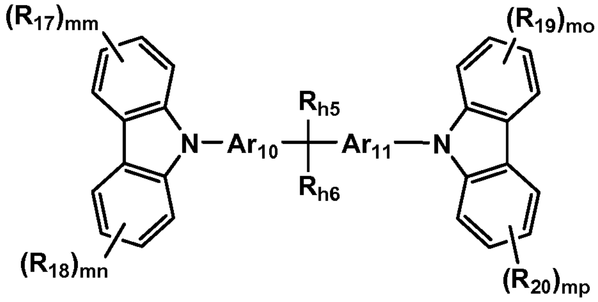
wherein $L_2$ represents an alkylene group having at least one fluorine atom; $Ar_5$ and $Ar_6$ independently represent a divalent aromatic hydrocarbon group or a divalent aromatic heterocyclic group; $R_9$, $R_{10}$, $R_{11}$ and $R_{12}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; and me, mf, mg, and mh independently represent an integer of from 1 to 4.

Formula H3



wherein $Ar_7$, $Ar_8$ and $Ar_9$ independently represent a divalent aromatic hydrocarbon group or a divalent aromatic heterocyclic group; $R_{h1}$, $R_{h2}$, $R_{h3}$, and $R_{h4}$ independently represent an alkyl group, a cycloalkyl group, an aralkyl group, an alkoxy group or a halogen atom; $R_{13}$, $R_{14}$, $R_{15}$, and $R_{16}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; and mi, mj, mk, and ml independently represent an integer of from 1 to 4,

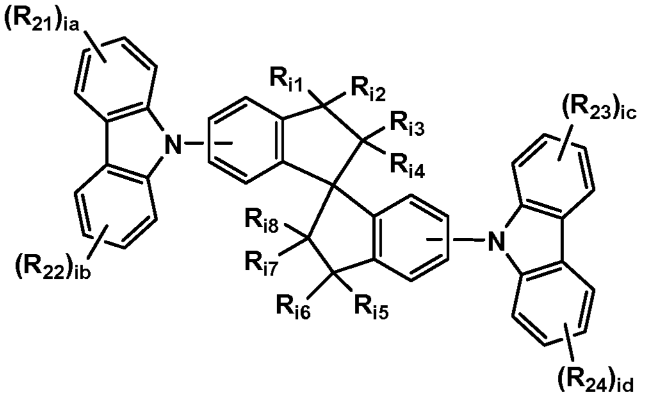
Formula H4



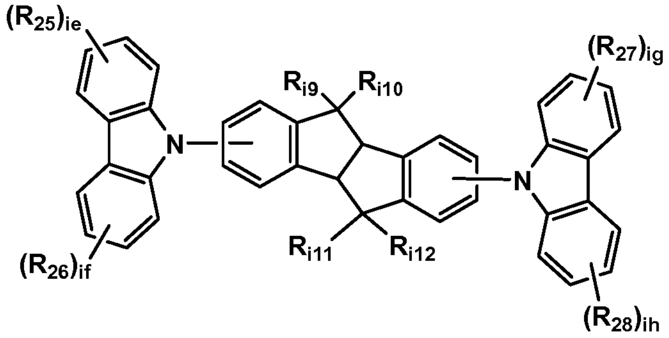
wherein $Ar_{10}$ and $Ar_{11}$ independently represent a divalent aromatic hydrocarbon group or a divalent aromatic heterocyclic group; $R_{h5}$ and $R_{h6}$ independently represent a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, a halogen atom, or $-\{C(R_{01})(R_{02})\}_pCF_3$, in which $R_{01}$ and $R_{02}$ independently represent a hydrogen atom or a fluorine atom, and p represents an integer of not less than 0, provided that at least one of $R_{h5}$ and $R_{h6}$ is $-\{C(R_{01})(R_{02})\}_pCF_3$; $R_{17}$, $R_{18}$, $R_{19}$, and $R_{20}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; and mm, mn, mo, and mp independently represent an integer of from 1 to 4.

9. An organic electroluminescent comprising an anode, a cathode and a component layer including a light emission layer, the component layer being provided between the anode and the cathode, wherein the component layer contains a compound represented by formula I1, 12 or 13,

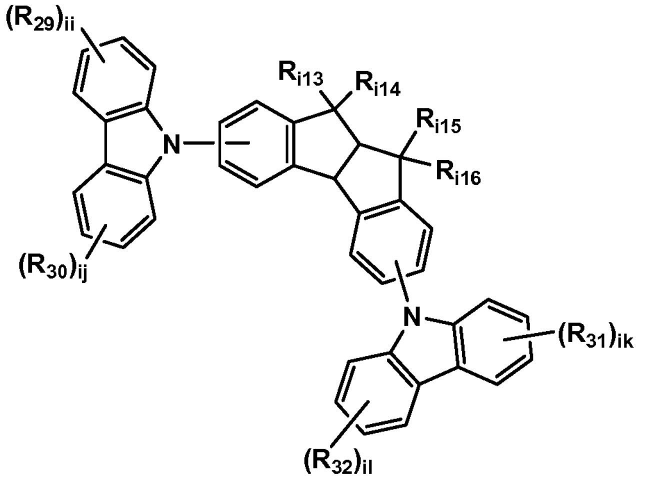
Formula I1



Formula I2



Formula I3

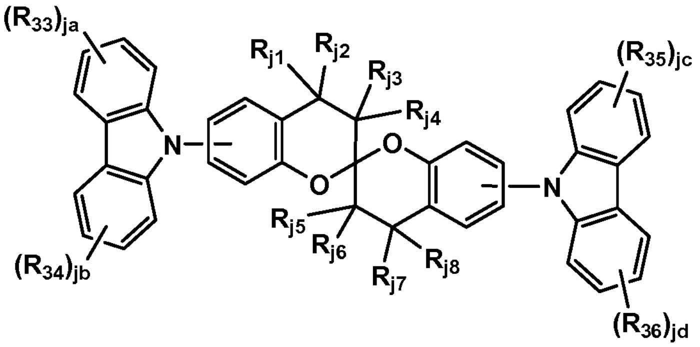


wherein $R_{i1}$, $R_{i2}$, $R_{i3}$, $R_{i4}$, $R_{i5}$, $R_{i6}$, $R_{i7}$, $R_{i8}$, $R_{i9}$, $R_{i10}$, $R_{i11}$, $R_{i12}$, $R_{i13}$, $R_{i14}$, $R_{i15}$, and $R_{i16}$ independently represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkoxy group or a halogen atom; $R_{21}$, $R_{22}$, $R_{23}$, $R_{24}$, $R_{25}$, $R_{26}$, $R_{27}$, $R_{28}$, $R_{29}$, $R_{30}$, $R_{31}$, and $R_{32}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; and ia, ib, ic, id, ie, if, ig, ih, ii, ij, ik, and io independently represent an integer of from 1 to 4.

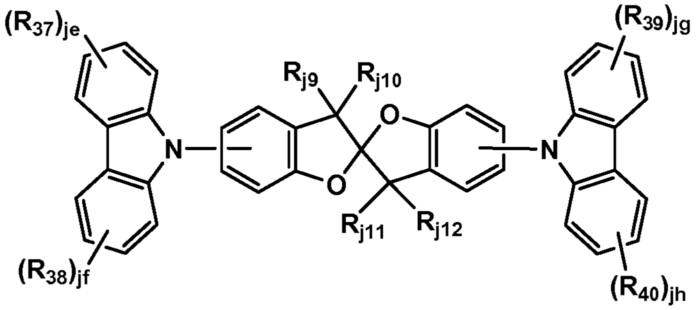
10. An organic electroluminescent comprising an anode, a cathode and a component layer including a light emission layer, the component layer being provided between the anode and the cathode, wherein the component layer

contains a compound represented by formula J1 or J2,

Formula J1



Formula J2



wherein $R_{j1}$, $R_{j2}$, $R_{j3}$, $R_{j4}$, $R_{j5}$, $R_{j6}$, $R_{j7}$, $R_{j8}$, $R_{j9}$, $R_{j10}$, $R_{j11}$, and $R_{j12}$ independently represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkoxy group or a halogen atom; $R_{33}$, $R_{34}$, $R_{35}$, $R_{36}$, $R_{37}$, $R_{38}$, $R_{39}$, and $R_{40}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; and ja, jb, jc, jd, ie, jf, jg, and jh independently represent an integer of from 1 to 4.

**[0025]** The present invention will be explained in detail below.

**[0026]** A first embodiment of the organic electroluminescent element of the invention comprises a component layer comprising an light emission layer, the component layer containing at least one selected from a compound (hereinafter also referred to as the compound in the invention) represented by formula 3, , H2, H3, H4, I1, 12, 13, J1, J2, or K above. It is preferred that the compound described above is contained in the light emission layer.

**[0027]** Japanese Patent O.P.I. Publication Nos. 2000-21572 and 2002-8860 disclose a method which incorporates a linkage group in the center of the biaryl position of a carbazole derivative molecule. Most of the linkage groups disclosed in these patent documents, particularly when they are cyclic, do not have a substituent. However, it has been found that incorporation of a substituent in the linkage group, particularly in the cyclic linkage group exhibits markedly improved characteristics as material for an organic EL element in some instances.

**[0028]** Most linkage groups disclosed in these patent documents have a structure of small steric hindrance, and therefore, the carbazole derivatives disclosed therein is likely to maintain planarity of the molecule. It has been found that incorporation of a linkage group inhibiting such molecular planarity, i.e., incorporation of a linkage group twisting the aryl groups in the biaryl portion, further improves characteristics of the derivative.

**[0029]** Examples of the linkage group are groups represented by formula (l), (m), (n), or (o). The linkage group linking the two aryl groups in the compounds represented by formulae H2 through H4, I1 through I3, and J1 and J2 above exhibits the same effects as above. It has been proved that an organic EL element, employing such carbazole derivatives, provides improved emission efficiency and emission life. This is considered to be due to the reason that the incorporation in carbazole derivatives of a linkage group with a substituent, i.e., a sterically bulky linkage group, improves characteristics of the carbazole derivatives, resulting in increase of stabilization effect.

**[0030]** Next, the compound in the invention will be explained in detail.

**[0031]** To begin with, a compound represented by formula 3 will be explained.

**[0032]** In formula 3, $A_2$ represents a group represented by formula 4 above, and may be the same or different.

**[0033]** In formula 3, $X_2$ represents a group represented by formula (l), (m), (n), or (o) above. "*" represents a linkage site, and n and m independently represent an integer of from 2 to 4.

**[0034]** In formula 4, $Ar_2$ represents a divalent aromatic hydrocarbon or aromatic heterocyclic group. $Ar_2$ represents preferably substituted or unsubstituted phenylene, substituted or unsubstituted biphenylene, substituted or unsubstituted naphthylene, substituted or unsubstituted anthrylene, substituted or unsubstituted phenanthrylene, substituted or unsubstituted pyrenylene, substituted or unsubstituted pyridylene, substituted or unsubstituted triazylene, substituted or unsubstituted pyrazylene, substituted or unsubstituted quinoxalylene, or substituted or unsubstituted thyenylene, and more preferably substituted or unsubstituted phenylene.

**[0035]** The substituents include a halogen atom, an alkyl group (for example, a methyl group, an ethyl group, an isopropyl group, a hydroxyethyl group, a methoxymethyl group, a trifluoromethyl group, or a t-butyl group), an alkenyl group (for example, a vinyl group), an aryl group (for example, a phenyl group or a naphtyl group), an alkoxycarbonyl group (for example, a methoxycarbonyl group or an ethoxycarbonyl group), an alkoxy group (for example, a methoxy group or an ethoxy group), an aryloxy group (for example, a phenoxy group or a benzyloxy group), and a dialkylamino group (for example, a diethylamino group or a diisopropylamino group), and the substituent is preferably a methyl group, a phenyl group, or a methoxy group.

**[0036]** In formula 4, $R_3$ and $R_4$ independently represent a hydrogen atom, or a substituent.

**[0037]** Examples of the substituent represented by R3 and $R_4$ include a substituted or unsubstituted alkyl group (for example, a methyl group, an ethyl group, an isopropyl group, a hydroxyethyl group, a methoxymethyl group, a trifluoromethyl group, or a t-butyl group), a substituted or unsubstituted cycloalkyl group (for example, a cyclopentyl group or a cyclohexyl group), a substituted or unsubstituted aralkyl group (for example, a benzyl group or a 2-phenetyl group), a substituted or unsubstituted aryl group (for example, a phenyl group, a naphthyl group, p-tolyl group, p-chlorophenyl group or a mesityl group), a substituted or unsubstituted alkoxy group (for example, an ethoxy group, a isopropoxy group or a butoxy group), a substituted or unsubstituted aryloxy group (for example, a phenoxy group), a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group (for example, a vinyl group), a substituted or unsubstituted styryl group, and a halogen atom (for example, a fluorine atom). These groups may further have a substituent. The substituent represented by $R_1$ through $R_4$ is preferably an alkyl group, an alkoxy group, or an aryl group.

**[0038]** In formula 4, nc, and nd independently represent an integer of from 1 to 4.

**[0039]** Next, a linkage group represented by formulae (1) through (o) will be explained.

**[0040]** In formulae (l) through (o), $R_{101}$ through $R_{110}$ independently represent a hydrogen atom or a substituent, provided that at least one of $R_{101}$ through $R_{110}$ is the substituent, and any two of $R_{101}$ through $R_{110}$ do not combine with each other to form a ring. $R_{111}$ through $R_{118}$ independently represent a hydrogen atom or a substituent. $A_1$, $A_2$, $A_3$, and $A_4$ independently represent $-C(R_{k1})=$ or -N=, provided that at least one of $A_1$, $A_2$, $A_3$, and $A_4$ is -N=. $R_{k1}$ represents a hydrogen atom or an alkyl group. $A_5$, $A_6$, $A_7$, and $A_8$ independently represent $-C(R_{k2})=$ or -N=, and $X_b$ represents $-N(R_{k3})=$ or $-Si(R_{k4})(R_{k5})-$. $R_{k2}$, $R_{k3}$, $R_{k4}$, and $R_{k5}$ independently represent a hydrogen atom, or a substituent.

**[0041]** Examples of the substituent of $R_{101}$ through $R_{110}$, $R_{111}$ through $R_{118}$ include an alkyl group (for example, a methyl group, an ethyl group, or an isopropyl group) and an alkoxy group (for example, a methoxy group or an ethoxy group).

**[0042]** The substituents represented by $R_{k2}$, $R_{k3}$, $R_{k4}$, and $R_{k5}$ are the same as those denoted in $R_1$ through $R_4$ above. The substituent is preferably an alkyl group, or an aryl group.

**[0043]** Of formulae (1) through (o), formula (1) or (m) is preferred.

**[0044]** Next, formulae (H2) through (H4) will be explained.

**[0045]** In formula (H2), $L_2$ represents an alkylene group having at least one fluorine atom, for example, di(trifluoromethyl)-methylene, or di(1,1,1-trifluoroethyl)methylene.

**[0046]** In formula (H3), $R_{h1}$, $R_{h2}$, $R_{h3}$, and $R_{h4}$ independently represent a substituent. Examples of the substituent include an alkyl group (for example, a methyl group, an ethyl group, an isopropyl group, a t-butyl group or a trifluoromethyl group), a cycloalkyl group (for example, a cyclopentyl group or a cyclohexyl group), an aralkyl group (for example, a benzyl group or a 2-phenetyl group), an alkoxy group (for example, an ethoxy group, a isopropoxy group or a butoxy group), and a halogen atom (for example, a fluorine atom), and of these, a methyl group or a trifluoromethyl group is preferred.

**[0047]** In formula (H4), $R_{h5}$ and $R_{h6}$ represent a substituent, provided that at least one of $R_{h5}$ and $R_{h6}$ is $-\{C(R_{01})(R_{02})\}_pCF_3$, in which $R_{01}$ and $R_{02}$ independently represent a hydrogen atom or a fluorine atom, and p represents an integer of not less than 0. The substituents represented by $R_{h5}$ and $R_{h6}$ are the same as those denoted in $R_1$ through $R_4$ above.

**[0048]** In formulae (H2) through (H4), $Ar_5$ through $Ar_{11}$ represent a divalent aromatic hydrocarbon group or a divalent aromatic heterocyclic group. Examples thereof are the same as those denoted in $Ar_2$ of formula (4) above.

**[0049]** In formulae (H2) through (H4), $R_9$ through $R_{20}$ independently represent a hydrogen atom or a substituent, and me, mf, mi, mj, mk, ml, mm, mn, mo, and mp independently represent an integer of from 0 to 4. Examples of the substituent of $R_9$ through $R_{20}$ are the same as those denoted in $R_3$ and $R_4$ of formula (4) above.

**[0050]** Next, a compound represented by formula (II), (I2), (I3), (J1) or (J2) will be explained.

**[0051]** In formula (I1), (I2), (I3), (J1) or (J2), $R_{i1}$ through $R_{i16}$, and $R_{j1}$ through $R_{j12}$ independently represent a hydrogen atom or a substituent. Examples of the substituent include an alkyl group (for example, a methyl group, an ethyl group, an isopropyl group, a t-butyl group or a trifluoromethyl group), a cycloalkyl group (for example, a cyclopentyl group or a cyclohexyl group), an aralkyl group (for example, a benzyl group or a 2-phenetyl group), an alkoxy group (for example, an ethoxy group, a isopropoxy group or a butoxy group), and a halogen atom (for example, a fluorine atom).

**[0052]** In the above, a hydrogen atom or an alkyl group is preferred, and in the alkyl group, a methyl group is most preferred.

**[0053]** In formula (I1), (I2), (I3), (J1) or (J2), $R_{21}$ through $R_{40}$ independently represent a hydrogen atom or a substituent. Examples thereof are the same as those denoted in R3 and $R_4$ in (4) above. ia, ib, ic, id, ie, if, ig, ih, ii, ij, ik, il, ja, jb, jc, jd, ie, jf, jg, and jh independently represent an integer of from 0 to 4.

**[0054]** Exemplified compounds of the compound in the invention will be listed below, but the compounds are not limited thereto.

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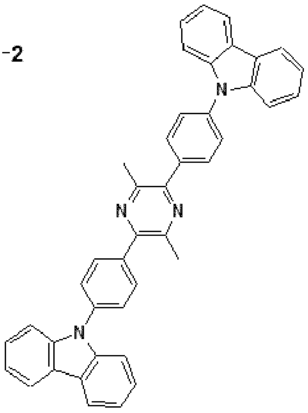

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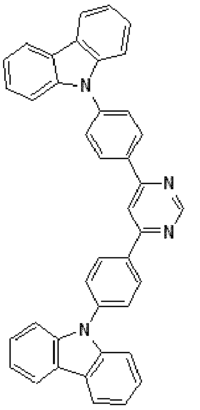

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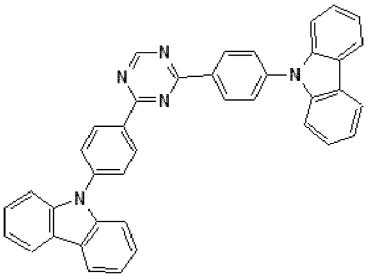

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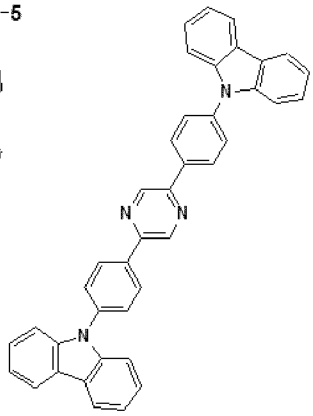

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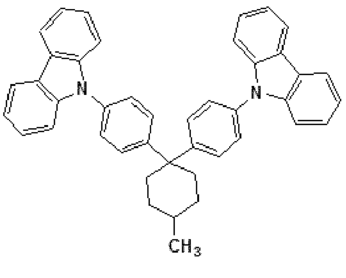

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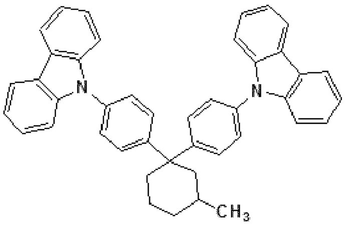

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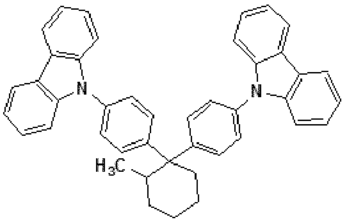

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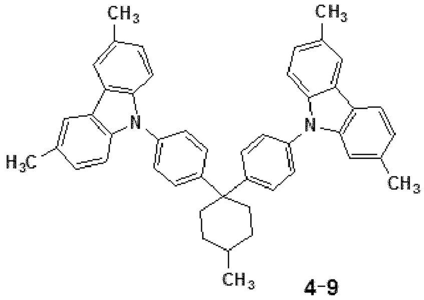

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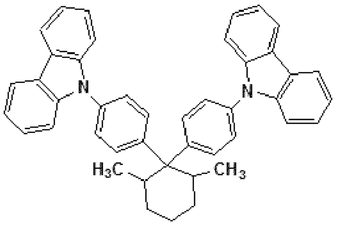

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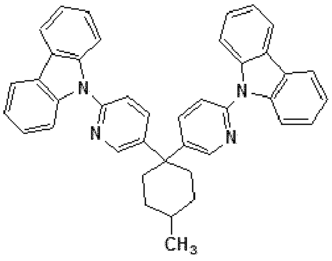

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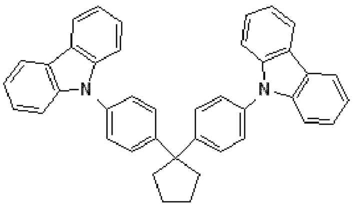

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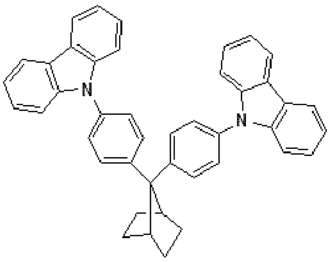

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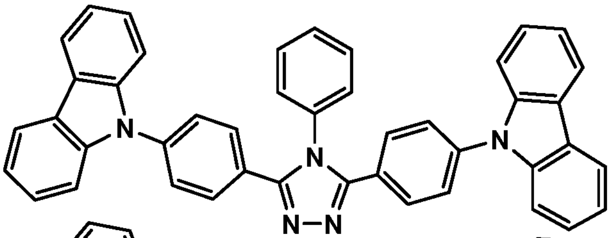

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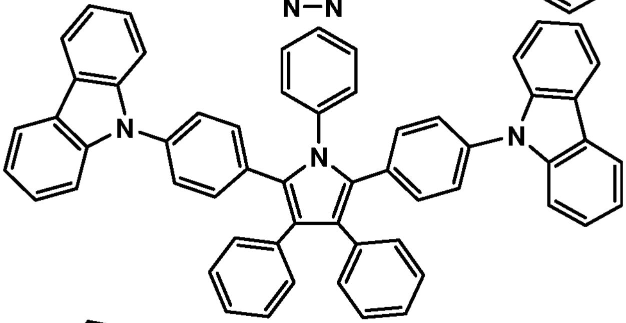

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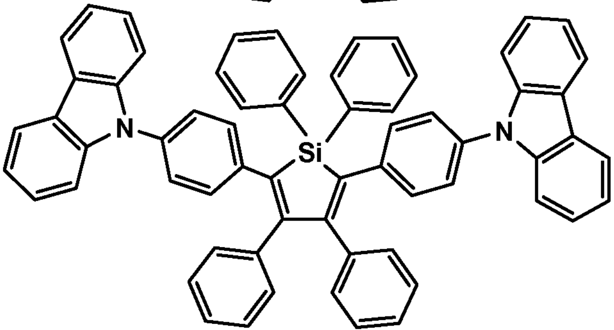

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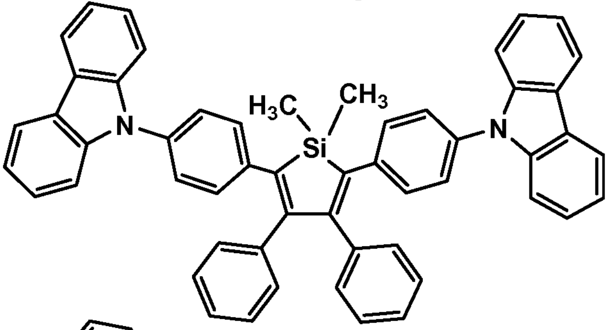

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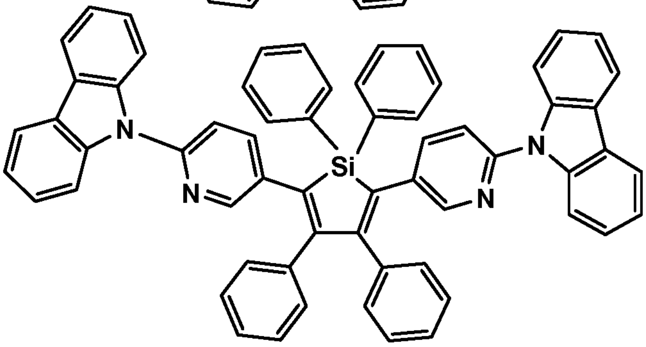

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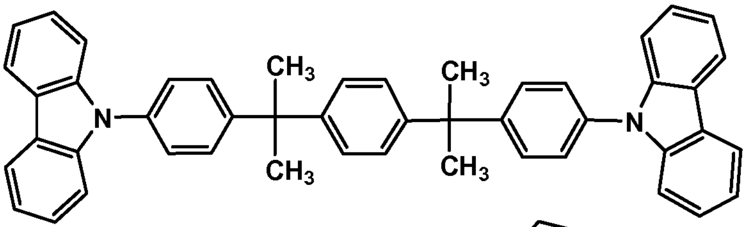

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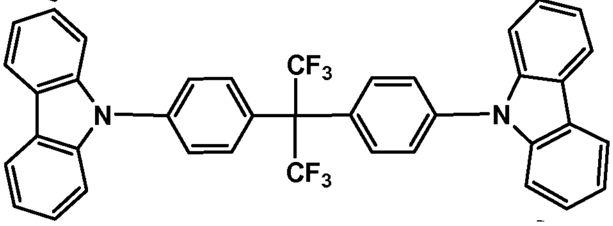

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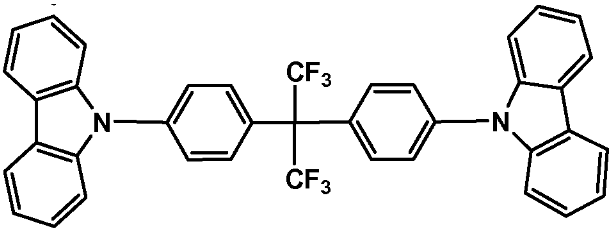

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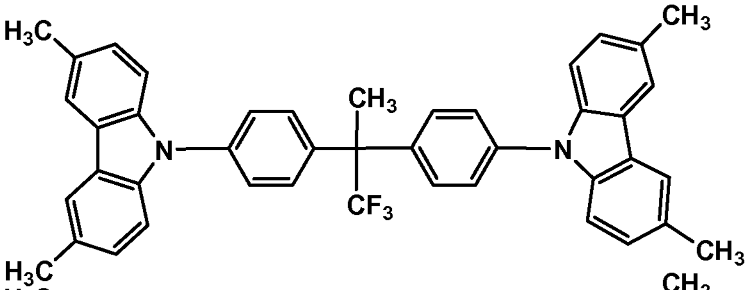

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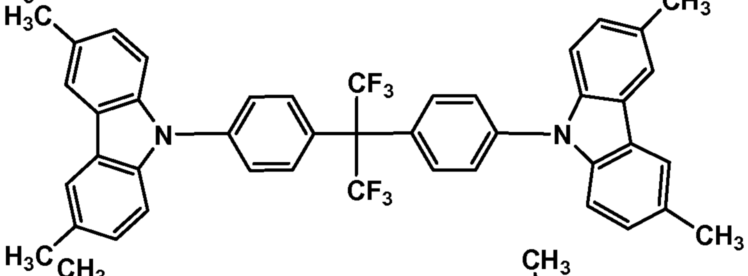

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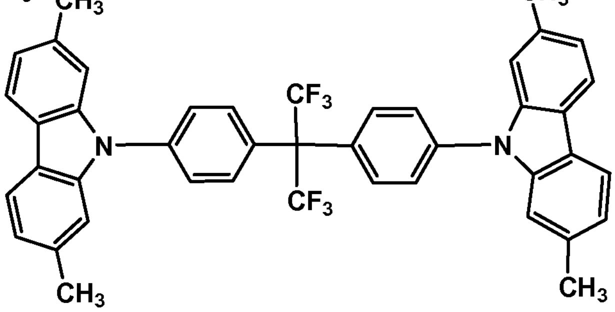

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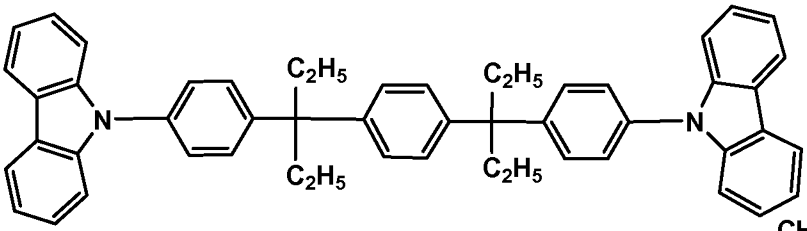

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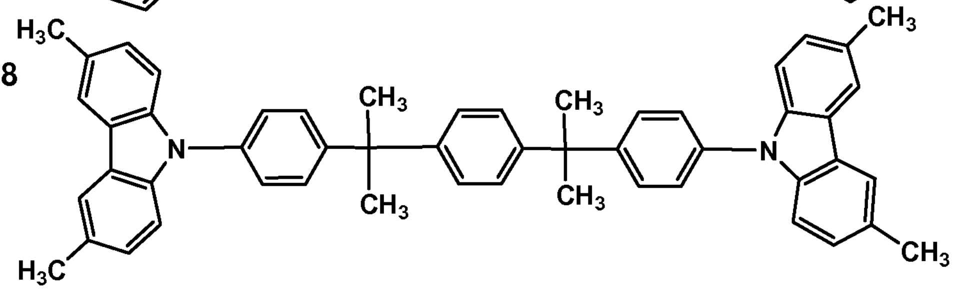

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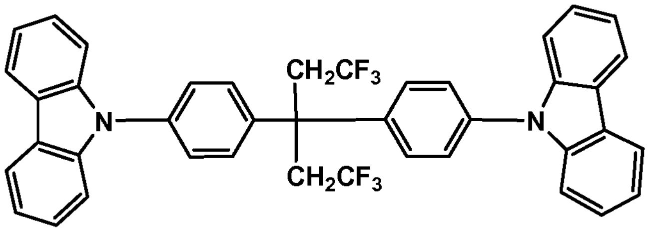

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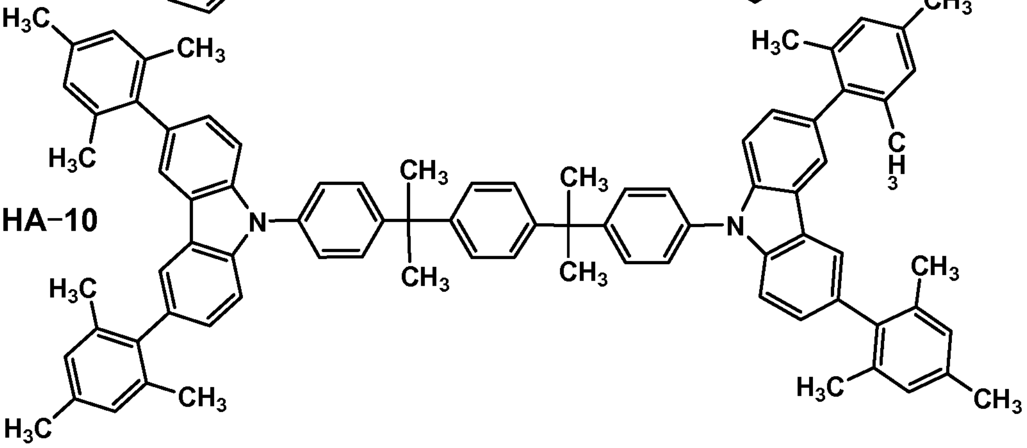

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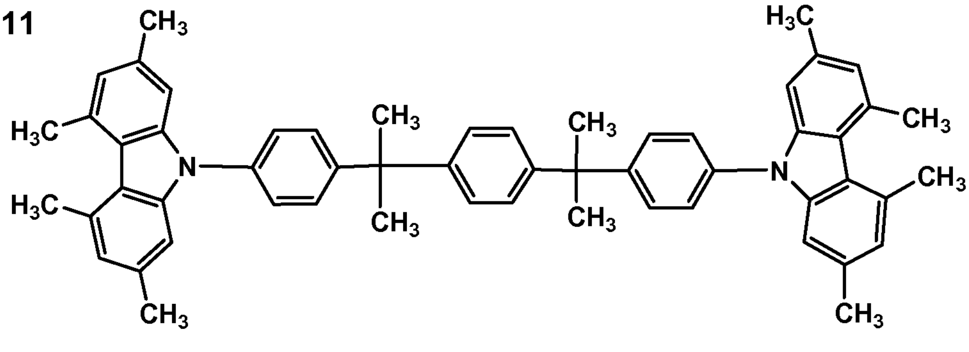

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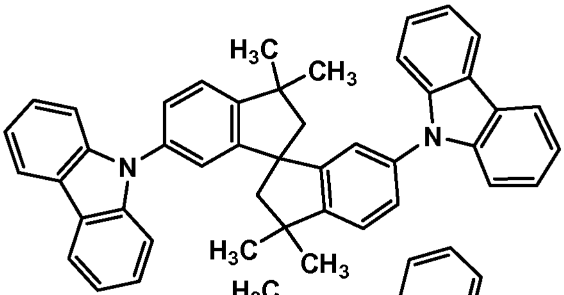

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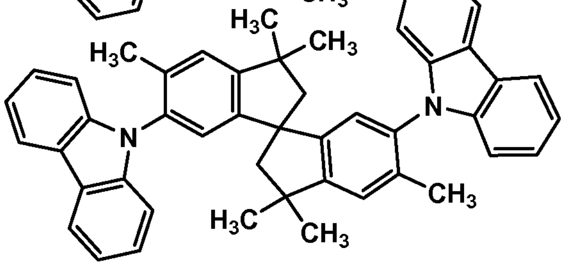

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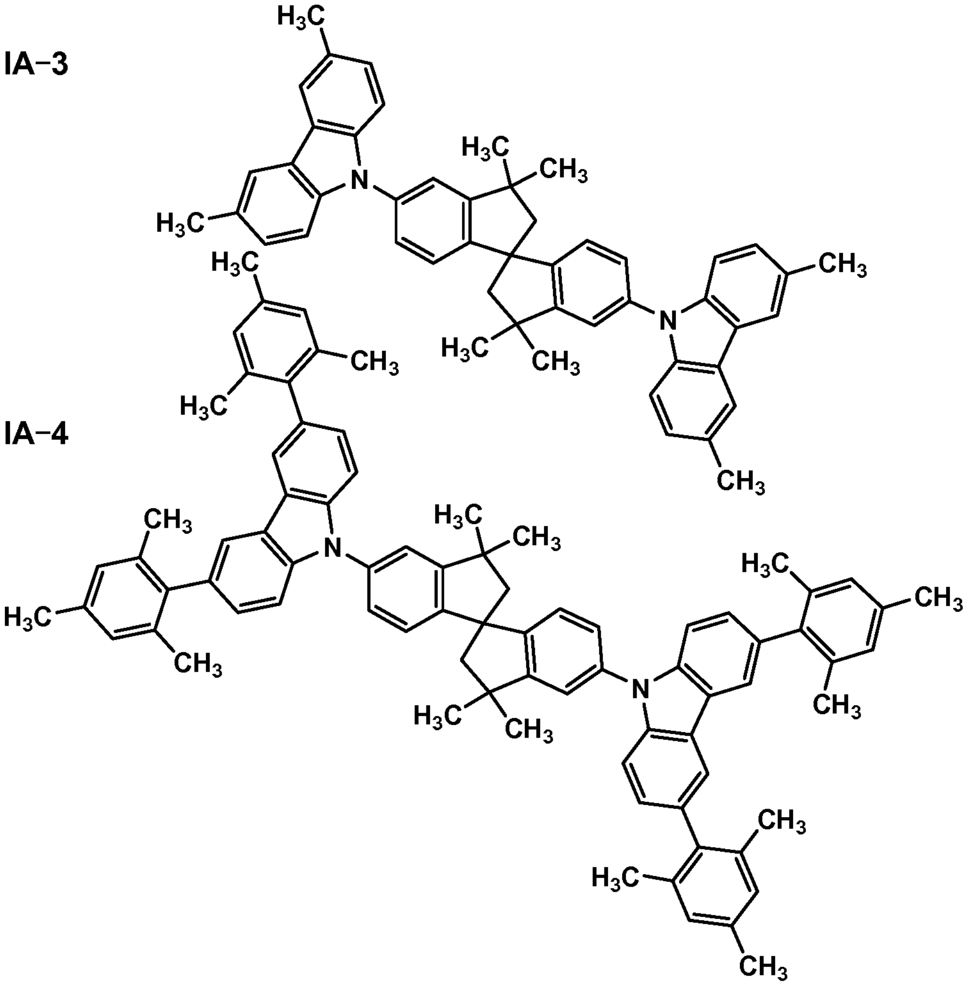

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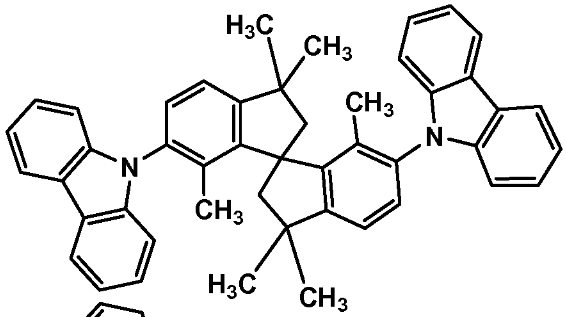

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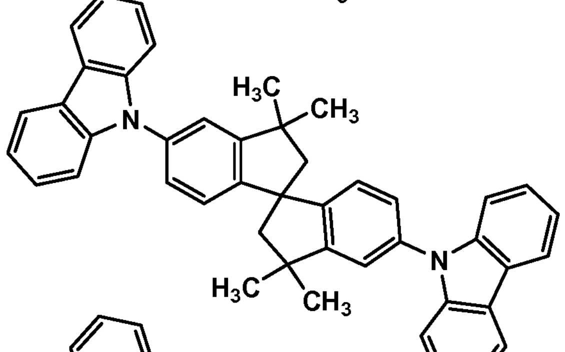

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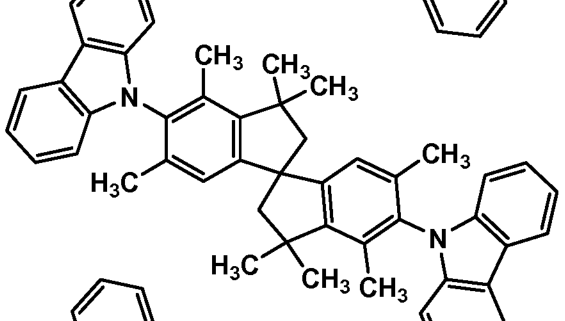

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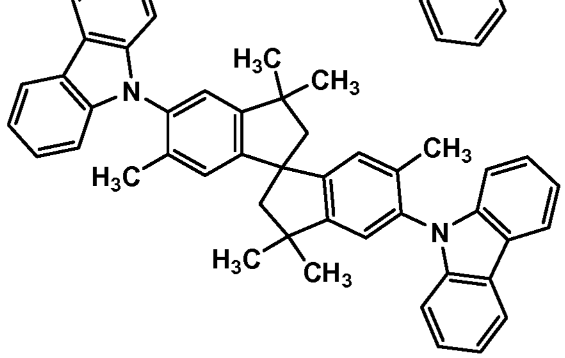

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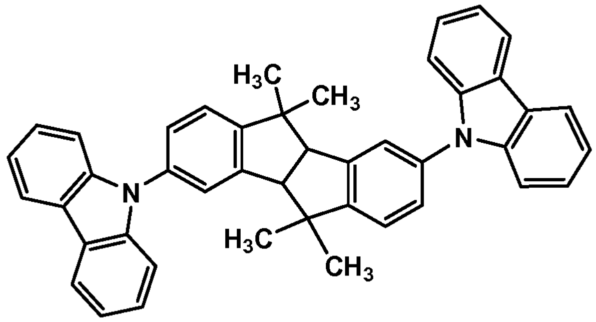

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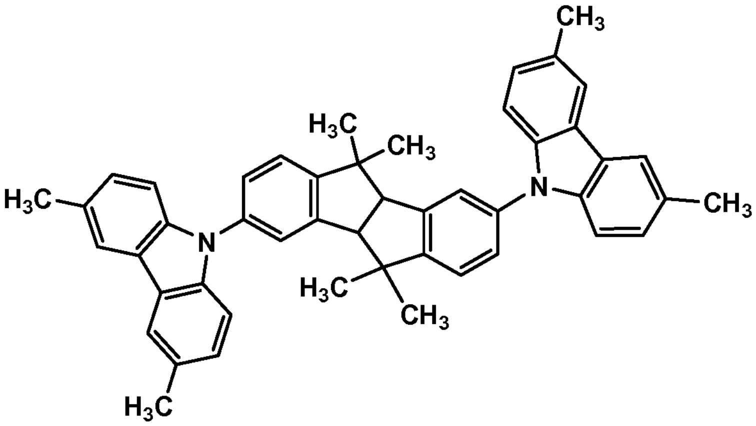
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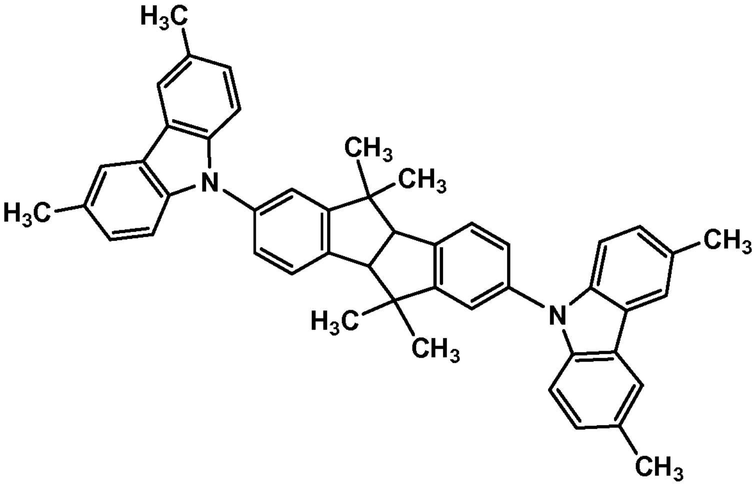
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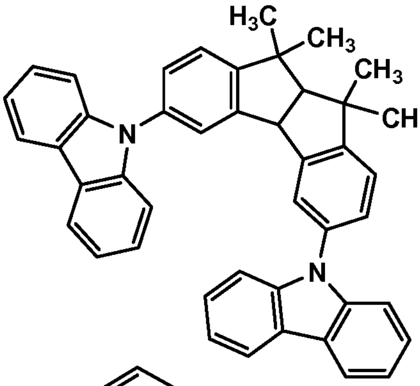

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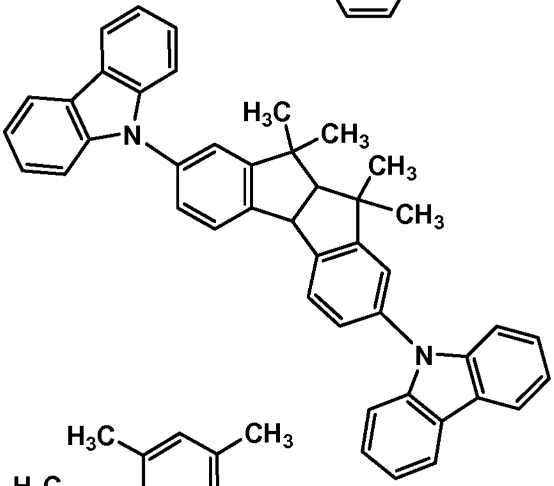

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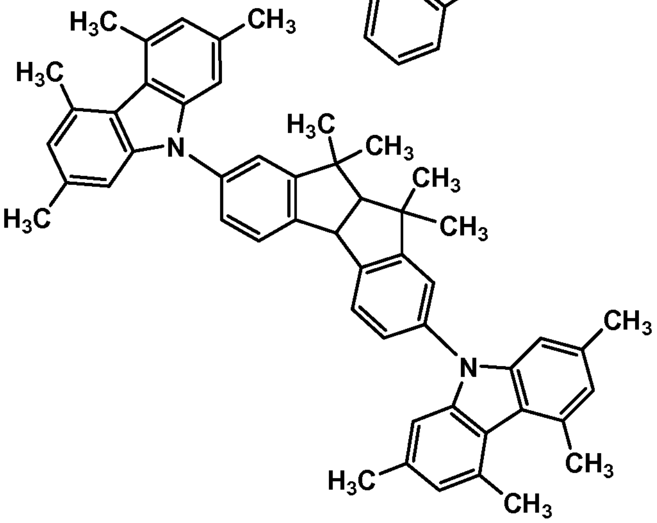

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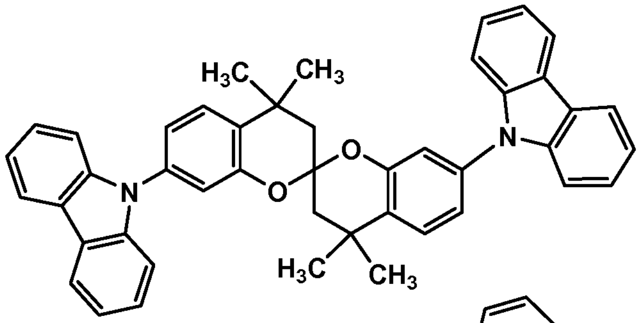

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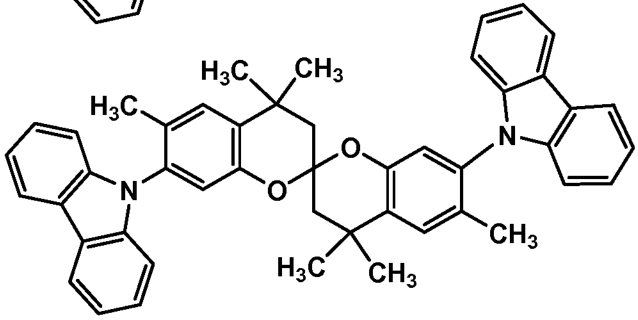

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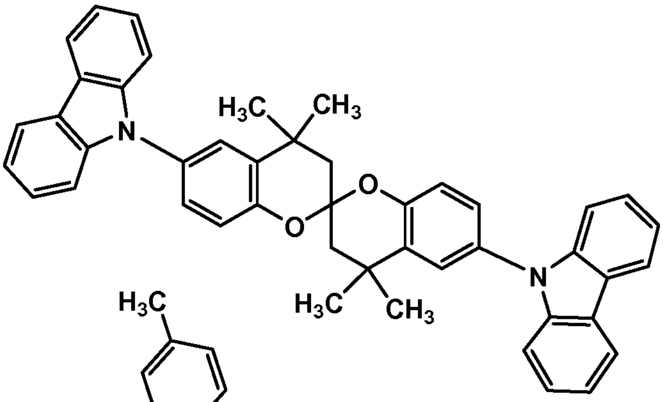

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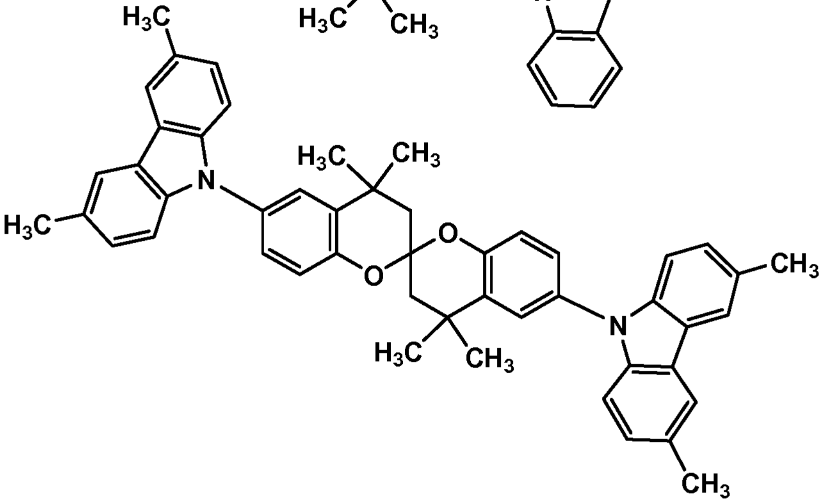

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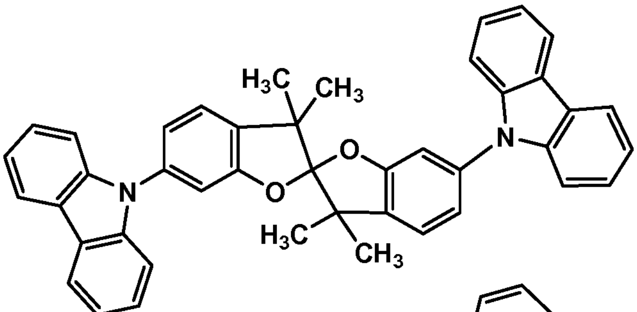

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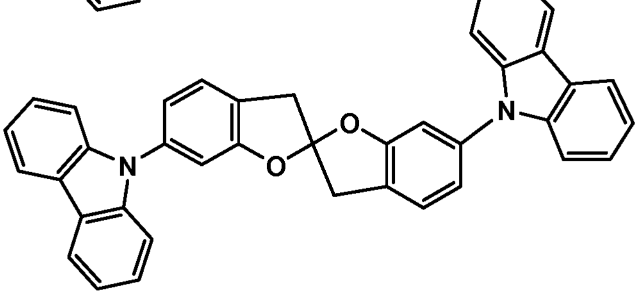

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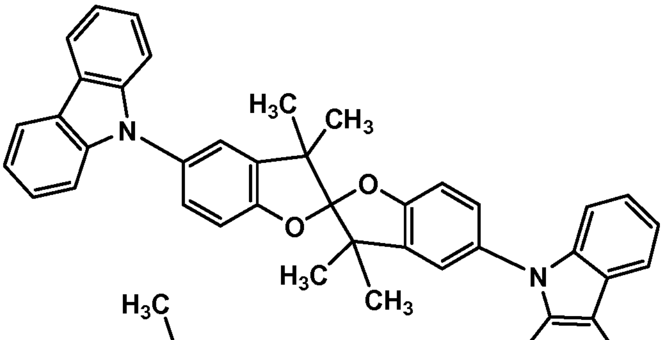

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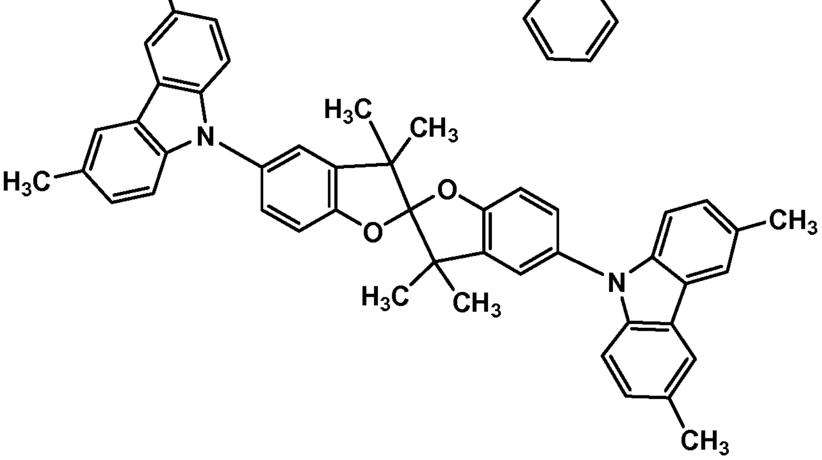


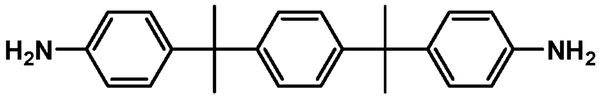
**[0055]** Typical synthetic examples of the compound in the invention will be shown below. Other compounds can be also synthesized in the same manner as in the examples.

**[0056]** (Synthetic example 2: Synthesis of Exemplified compound 4-4) Twenty g of 4-methylcyclohexanone and 38 g of aniline was added to concentrated hydrochloric acid and heated under reflux for 40 hours. The resulting reaction solution was neutralized, and mixed with water and ethyl acetate. Subsequently, the organic solution phase of the mixture was separated, and dried over magnesium sulfate. The solvent of the dried organic solution was distilled off under reduced pressure, and the residue was purified according to column chromatography to obtain 31 g of an amine compound. The resulting amine compound was brominated according to Sandmeyer reaction to obtain a brominated compound. Then, carbazol and 1.1 g of the brominated compound were incorporated in a xylene solvent, and reacted while heating with agitation for 8 hours while stirring in the presence of palladium acetate and tri-tert-butylphosphine as catalysts and of potassium carbonate as a base. After reaction was completed, the resulting reaction solution was mixed with ethyl acetate, tetrahydrofuran and water, and the organic solution phase of the mixture was separated, and dried over magnesium sulfate. The solvent of the dried solution was distilled off under reduced pressure, and the residue was purified according to column chromatography. The purified product was recrystallized from toluene to obtain 1.2 g of Exemplified compound 4-4 (Yield 75%). The recrystallized product was confirmed to be Exemplified compound 4-4 according to NMR spectra or mass spectra.

(Synthetic example 3: Synthesis of Exemplified compound HA-1)

**[0057]** The diamine compound described below of 2.6 g, 5.1 g of 2,2'-dibromophenyl, 0.45 g of bis(dibenzilydeneacetone)-palladium, 0.85 g of tri-tert-butylphospine, and sodium tert-butoxide were mixed in 60 ml of toluene, and reacted with agitation for 8 hours at refluxing temperature under a nitrogen atmosphere. The resulting mixture was added with toluene and water, and the organic solution phase of the mixture was separated, and purified according to silica gel column chromatography. The purified product was recrystallized from toluene to obtain 1.7 g of light brown crystal, Exemplified compound HA-1 (Yield 32%).

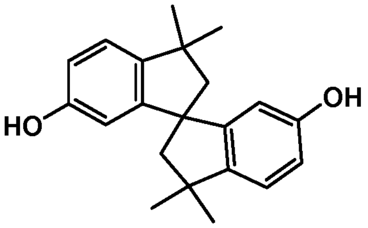
Diamine compound



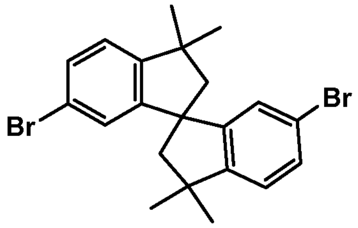
(Synthetic example 4: Synthesis of Exemplified compound IA-1)

**[0058]** The bisphenol compound described below of 2.0 g and 5.0 g of dibromotriphophoryl were heated at 320 °C for 5 hours in a nitrogen atmosphere. The resulting reaction mixture was added with ethyl acetate and water, and the organic solution phase of the mixture was separated, and purified according to silica gel column chromatography to obtain 1.4 g of the dibromo compound described below. Palladium acetate and tri-tert-butylphospine as a catalyst, sodium tert-butoxide as a base, 1.4 g of the dibromo compound, and 1.0 g of carbazole were mixed in 50 ml of Xylene, and the mixture was reacted with agitation for 9 hours at refluxing temperature in a nitrogen atmosphere. The resulting reaction mixture was added with toluene and water, and the organic solution phase of the mixture was separated, and purified according to silica gel column chromatography. The purified product was recrystallized from toluene to obtain 0.8 g of light brown crystal, Exemplified compound IA-1 (Yield 42%).

Bisphenol compound



Dibromo compound



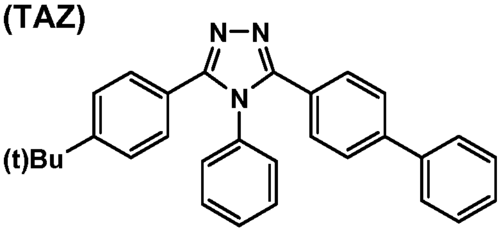
**[0059]** In the invention, it is effective that a hole blocking layer, which is comprised of at least one selected from the group consisting of a styryl compound, a triazole derivative, a phenanthroline derivative, an oxadiazole derivative and a boron derivative, is provided between the light emission layer and the cathode.

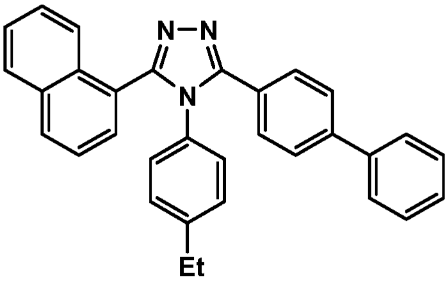
**[0060]** The hole blocking layer is formed from a compound which prevents holes injected from the hole transporting layer from flowing into the cathode and effectively transports electrons injected from the cathode to the light emission layer. Physical properties required for compounds constituting the hole blocking layer are high electron mobility, low hole mobility, and inonization potential higher than that of the light emission layer or band gap wider than that of the light emission layer. The hole blocking layer has a function which encloses electrons and holes within the light emission layer and increases emission efficiency. As a hole blocking compound meeting the above-described conditions, a compound represented by formula 5, 6, 7, or 8 is preferred.

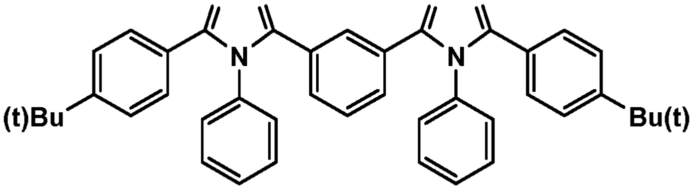
**[0061]** In formula 5, 6, 7 or 8, $R_{a1}$ through $R_{a3}$, $R_{b1}$ through $R_{b4}$, and $R_{c1}$ and $R_{c2}$ independently represent an alkyl group, an aryl group or a heterocyclic group, provided that they may have a substituent; and $A_{ra}$ and $A_{rb}$ independently represent an aryl group or a heterocyclic group. Examples of the alkyl group and the aryl group are the same as those denoted in $R_1$ through $R_4$ above. Examples of the heterocyclic group include a pyrrolyl group, a pyridyl group, a furyl group or a thienyl group.

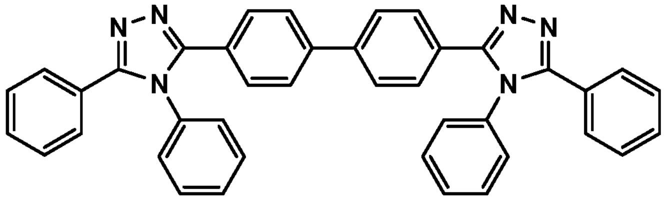
**[0062]** Exemplified compounds represented by formula 5, 6, 7 or 8 will be shown below, but the present invention is not limited thereto.

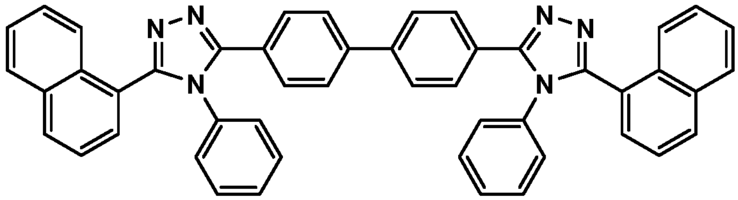
**(TAZ)**

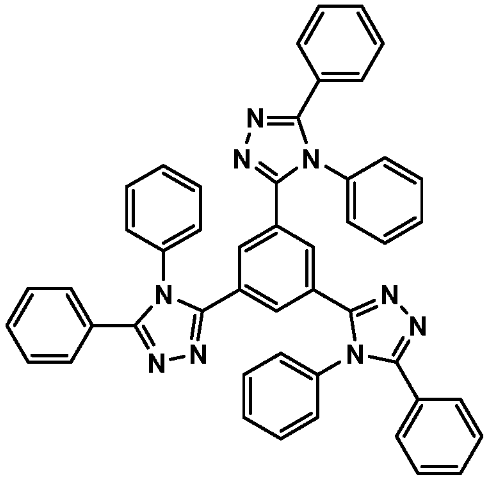












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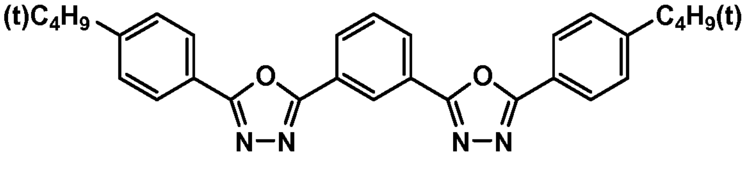

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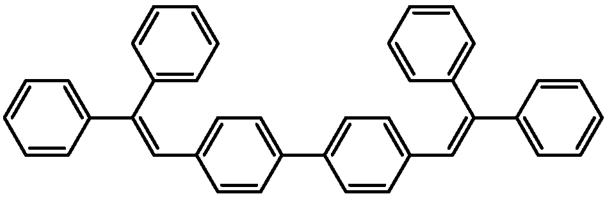

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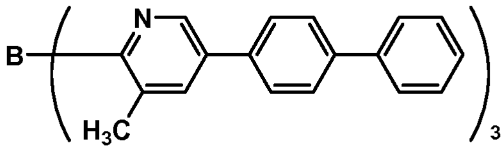

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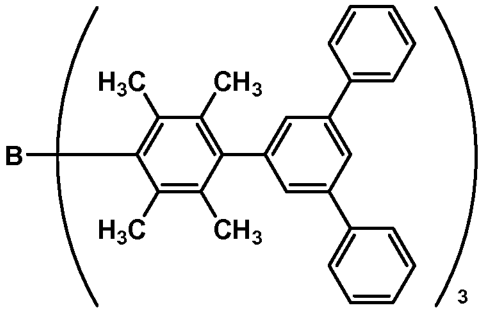
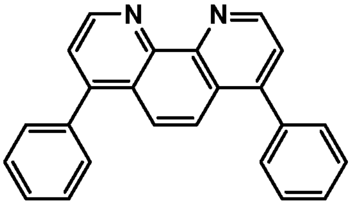
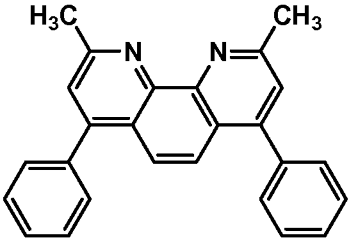
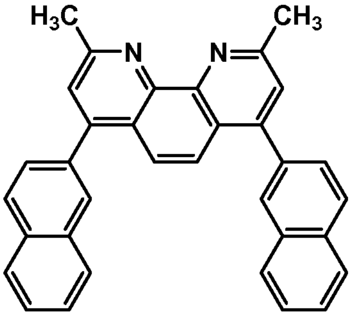
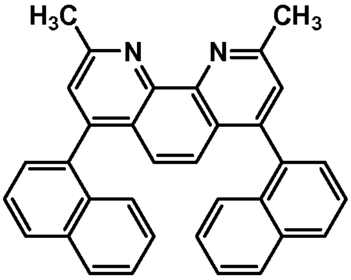
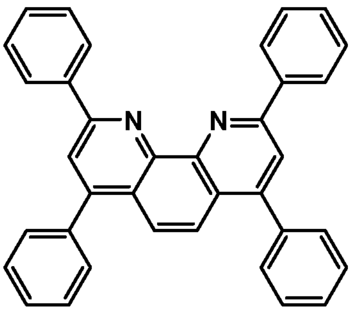


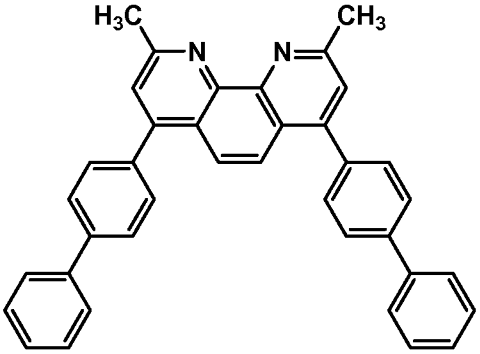












**[0063]** Other exemplified compounds include exemplified compounds disclosed in Japanese Patent O.P.I. Publication Nos. 2003-31367, 2003-31368, and Japanese Patent Publication No. 2721441.

**[0064]** Next, constitution of the organic electroluminescent element of the invention will be explained in detail.

**[0065]** The organic EL element of the invention comprises a component layer including a light emission layer provided between an anode and a cathode. Examples of a layer other than the light emission layer include a hole injecting layer, a hole transporting layer, a hole blocking layer, an electron transporting layer, an electron injecting layer. In the invention, preferred examples of the organic EL element will be shown below, but the present invention is not limited thereto.

I: Anode/Hole transporting layer/Light emission layer/Cathode
II: Anode/Light emission layer/Electron transporting layer/Cathode
III: Anode/Hole transporting layer/Light emission layer/Electron transporting layer/Cathode
IV: Anode/Hole transporting layer/Light emission layer/ Hole blocking layer/Electron transporting layer/Cathode
V: Anode/Hole transporting layer/Light emission layer/ Hole blocking layer/Electron transporting layer/Cathode buffering layer/Cathode
VI: Anode/Anode buffering layer/Hole transporting layer/Light emission layer/Hole blocking layer/Electron transporting layer/Cathode buffering layer/Cathode

<<Anode>>

**[0066]** For the anode of the organic EL element, a metal, an alloy, or an electroconductive compound each having a high working function (not less than 4 eV), and mixture thereof are preferably used as the electrode material. Concrete examples of such an electrode material include a metal such as Au, and a transparent electroconductive material such as CuI, indium tin oxide (ITO), $SnO_2$, or ZnO, and a material capable of forming an amorphous and transparent conductive layer such as IDIXO ($In_2O_3$-ZnO). The anode may be prepared by forming a thin layer of the electrode material according to a depositing or spattering method, and by forming the layer into a desired pattern according to a photolithographic method. When required precision of the pattern is not so high (not less than 100 μm), the pattern may be formed by depositing or spattering of the electrode material through a mask having a desired form. When light is emitted through the anode, the transmittance of the anode is preferably 10% or more, and the sheet resistance of the anode is preferably not more than several hundred Ω/□. The thickness of the layer is ordinarily within the range of from 10 nm to 1 μm, and preferably from 10 to 200 nm, although it may vary due to kinds of materials used.

<<Cathode>>

**[0067]** On the other hand, for the cathode, a metal (also referred to as an electron injecting metal), an alloy, and an electroconductive compound each having a low working function (not more than 4 eV), and a mixture thereof is used as the electrode material. Concrete examples of such an electrode material include sodium, sodium-potassium alloy, magnesium, lithium, a magnesium/copper mixture, a magnesium/silver mixture, a magnesium/aluminum mixture, magnesium/indium mixture, an aluminum/aluminum oxide ($Al_2O_3$) mixture, indium, a lithium/aluminum mixture, and a rare-earth metal. Among them, a mixture of an electron injecting metal and a metal higher in the working function than that of the electron injecting metal, such as the magnesium/silver mixture, magnesium/aluminum mixture, magnesium/indium mixture, aluminum/aluminum oxide ($Al_2O_3$) mixture, lithium/aluminum mixture, or aluminum is suitable from the view point of the electron injecting ability and resistance to oxidation. The cathode can be prepared forming a thin layer of such an electrode material by a method such as a deposition or spattering method. The sheet resistance as the cathode is preferably not more than several hundred Ω/□, and the thickness of the layer is ordinarily from 10 nm to 1 μm, and preferably from 50 to 200 nm. It is preferable in increasing the light emission efficiency that either the anode or the cathode of the organic EL element is transparent or semitransparent.

**[0068]** Next, a light emission layer, an injecting layer, a hole transporting layer, and an electron transporting layer used in the component layer of the organic EL element of the invention will be explained.

<<Injecting layer: electron injecting layer, hole injecting layer>>

**[0069]** The injecting layer is optionally provided, for example, an electron injecting layer or a hole injecting layer, and may be provided between the anode and the light emission layer or hole transporting layer, and between the cathode and the light emission layer or electron transporting layer as described above.

**[0070]** The injecting layer herein referred to is a layer provided between the electrode and an organic layer in order to reduce the driving voltage or to improve of light emission efficiency. As the buffer layer there are a hole injecting layer (an anode buffer layer) and an electron injecting layer (a cathode buffer layer), which are described in "Electrode Material" page 123, Div. 2 Chapter 2 of "Organic EL element and its frontier of industrialization" (published by NTS Corporation, November 30, 1998) in detail.

**[0071]** The anode buffer layer (hole injecting layer) is described in Japanese Patent O.P.I. Publication Nos. 9-45479, 9-260062, and 8-288069 etc., and its examples include a phthalocyanine buffer layer represented by a copper phthalocyanine layer, an oxide buffer layer represented by a vanadium oxide layer, an amorphous carbon buffer layer, a polymer buffer layer employing an electroconductive polymer such as polyaniline (emeraldine), and polythiophene, etc.

**[0072]** The cathode buffer layer (electron injecting layer) is described in Japanese Patent O.P.I. Publication Nos. 6-325871, 9-17574, and 9-74586, etc. in detail, and its examples include a metal buffer layer represented by a strontium or aluminum layer, an alkali metal compound buffer layer represented by a lithium fluoride layer, an alkali earth metal compound buffer layer represented by a magnesium fluoride layer, and an oxide buffer layer represented by an aluminum oxide.

**[0073]** The buffer layer (injecting layer) is preferably very thin and has a thickness of preferably from 0.1 to 100 nm depending on kinds of the material used.

**[0074]** The blocking layer is a layer provided if necessary in addition to the fundamental configuration layers as described above, and is for example a hole blocking layer as described in Japanese Patent O.P.I. Publication Nos. 11-204258, and 11-204359, and on page 237 of "Organic EL element and its frontier of industrialization" (published by NTS Corporation, November 30, 1998).

**[0075]** The hole blocking layer is an electron transporting layer in a broad sense, and is comprised of material having an ability of transporting electrons but an extremely poor ability of holes, which can increase a recombination probability of electrons and holes by transporting electrons and blocking holes.

**[0076]** On the other hand, the electron blocking layer is an hole transporting layer in a broad sense, and is comprised of material having an ability of transporting holes but an extremely poor ability of electrons, which can increase a recombination probability of electrons and holes by transporting holes and blocking electrons.

**[0077]** The hole transporting layer is comprised of material having an ability of transporting holes, and a hole injecting layer and an electron blocking layer are included in the hole transporting layer in a broad sense. The hole transporting layer or electron transporting layer may be a single layer or plural layers.

**[0078]** In the organic EL element of the invention, it is preferred that all of a host contained in the light emission layer, a hole transporting material contained in the hole transporting layer adjacent to the light emission layer, and an electron transporting material contained in the electron transporting layer adjacent to the light emission layer be compounds having a maximum fluorescence wavelength of not longer than 415 nm.

<<Light emission layer>>

**[0079]** The light emission layer in the invention is a layer where electrons and holes, injected from electrodes, an electron transporting layer or a hole transporting layer, are recombined to emit light. The portions where light emits may be portions in the light emission layer or portions at the interface between the light emission layer and the layer adjacent thereto.

**[0080]** The light emission layer can be formed employing a known method such as a vacuum deposition method, a spin coat method, a casting method and an LB method. The thickness of the light emission layer is not specifically limited, but is ordinarily from 5 nm to 5 μm. The light emission layer may be composed of a single layer comprising one or two or more kinds of light emission materials, or of plural layers comprising the same composition or different composition. It is preferred in the invention that the light emission layer be composed of two or more kinds of light emission materials, and one of the light emission materials is the compound in the invention.

**[0081]** The light emission layer can be formed by the method such as that described in Japanese Patent O.P.I. Publication No. 57-51781, in which a light emission material is dissolved in a solvent together with a binder such as a resin, and the thus obtained solution is formed into a thin layer by a method such as a spin-coat method. Thickness of the emission layer thus formed is not specially restricted. Although the thickness of the layer thus formed is optionally selected, the thickness is ordinarily from 5 nm to 5 μm.

**[0082]** When the light emission layer contains two or more compounds, the main compound is called a host, and another a dopant. The compound represented by formulae 3, H2 through H4, I1 through 13, J1, J2, is preferably used as a host. In this case, the dopant content is from 0.1% to less than 15% by weight based on the host content.

<Host compound>

**[0083]** In the light emission layer comprised of a mixture of two or more kinds of compounds, the compound having the highest content (by weight) in the mixture is a host compound (also referred to as simply a host) and the compound other than the host compound is a dopant compound (also referred to as simply a dopant). For example, when a compound A to a compound B ratio (by weight) in the light emission layer is 10:90, the compound A is a dopant compound, and the compound B is a host compound.

**[0084]** Further, when the content ratio, compound A:compound B:compound C in the light emission layer is 5:10:85, compounds A and B are dopant compounds, and compound C is a host compound.

**[0085]** The host compound in the light emission layer is preferably an organic compound or a complex. In the invention, the host compound has a wavelength providing phosphorescence maximum of preferably no longer than 460 nm, which enables a visible light emission, particularly a BGR light emission. The host compound, having a phosphorescence maximum wavelength of no longer than 450 nm, has a wide energy gap (ionization potential-electron affinity), and advantageously works in the carrier trap type.

**[0086]** The host compound is preferably a compound with high Tg (glass transition temperature

<Dopant>

**[0087]** Next, the dopant compound will be explained.

**[0088]** The dopant is divided in two types in principle, one is an energy transfer type in which recombination of a carrier occurs on the host to which the carrier is transported to excite the host, the resulting energy is transferred to the dopant, and light is emitted from the dopant, and the other is a carrier trap type in which recombination of a carrier occurs on the dopant, a carrier trap material, and light is emitted from the dopant. However, in each type of the dopant, energy level of the dopant in excited state is lower than that of the host in excited state.

**[0089]** In the invention, a phosphorescent compound is preferably used as a dopant.

**[0090]** The phosphorescent compound in the invention is a compound which can emit light from the excited triplet, and has a phosphorescent quantum yield at 25 °C of not less than 0.001. The phosphorescent quantum yield at 25 °C is preferably not less than 0.01, and more preferably not less than 0.1. The phosphorescent quantum yield can be measured according to a method described in the fourth edition "Jikken Kagaku Koza 7", Bunko II, page 398 (1992) published by Maruzen. The phosphorescent quantum yield can be measured in a solution employing various kinds of solvents. The phosphorescent compound used in the invention may be any as long as it is a compound, in which the phosphorescent quantum yield measured employing any one of the solvents falls within the above-described range.

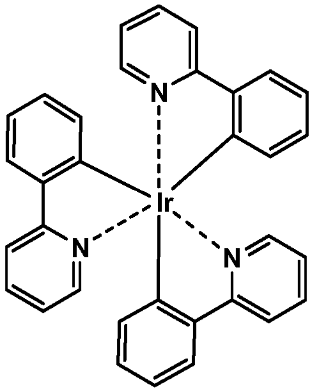
**[0091]** The phosphorescent compound in the invention herein referred to a phosphorescent compound which can emit phosphorescence at room temperature.

**[0092]** The phosphorescent compound used as the dopant in the invention is preferably a metal complex compound containing a metal belonging to a group VIII of the periodic table as a center metal, and is more preferably an iridium compound, an osmium compound, a rhodium compound, a palladium compound or a platinum compound (a platinum complex), still more preferably an iridium compound, a rhodium compound, or a platinum compound, and most preferably an iridium compound.

**[0093]** Examples of the phosphorescent compound include compounds disclosed in the following patent documents: WO00/70655, Japanese Patent O.P.I. Publication Nos. 2002-280178, 2001-181616, 2002-280179, 2001-181617, 2002-280180, 2001-247859, 2002-299060, 2001-313178, 2002-302671, 2001-345183, and 2002-324679, WO02/15645, Japanese Patent O.P.I. Publication Nos. 2002-332291, 2002-50484, 2002-332292, 2002-83684, Japanese Patent Publication No. 2002-540572, 2002-117978, 2002-338588, 2002-170684, 2002-352960, WO 01/93642, Japanese Patent O.P.I. Publication Nos. 2002-50483 2002-100476, 2002-173674, 2002-359082, 2002-175884, 2002-363552, 2002-184582, and 2003-7469, Japanese Patent Publication No. 2002-525808, Japanese Patent O.P.I. Publication No. 2003-7471, Japanese Patent Publication No. 2002-525833, Japanese Patent O.P.I. Publication Nos. 2003-31366, 2002-226495, 2002-234894, 2002-235076, 2002-241751, 2001-319779, 2001-319780, 2002-62824, 2002-100474, 2002-203679, 2002-343572, and 2002-203678.

**[0094]** Examples of the phosphorescent compound used in the invention will be listed below, but the invention is not limited thereto. These compounds can be synthesized according to a method described in Inorg. Chem., 40, 1704-1711.

Ir-1



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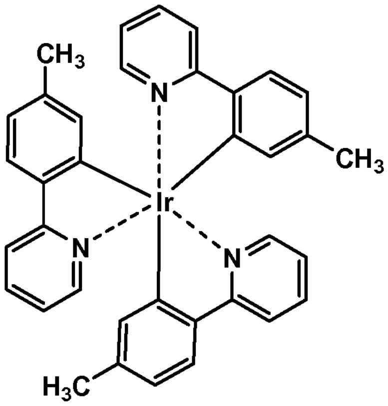

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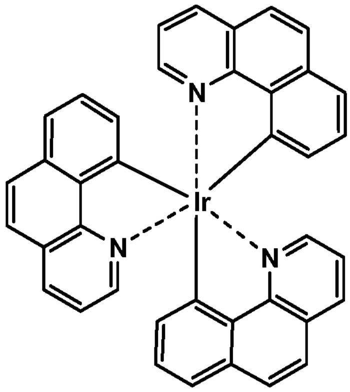

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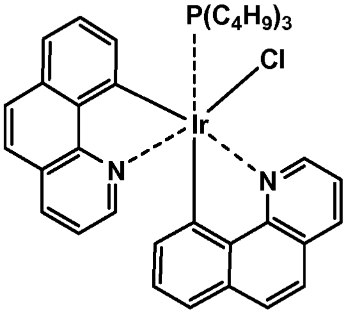

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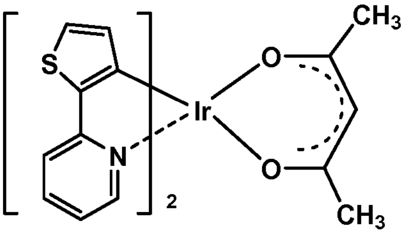
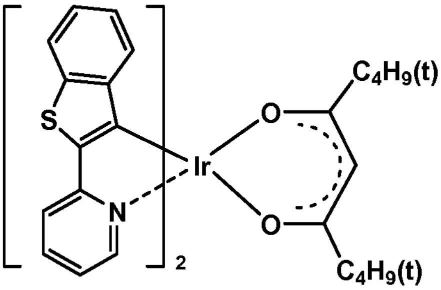
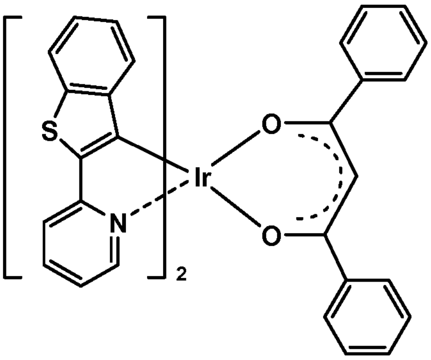


Ir-6



Ir-7



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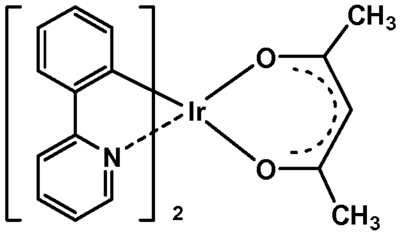

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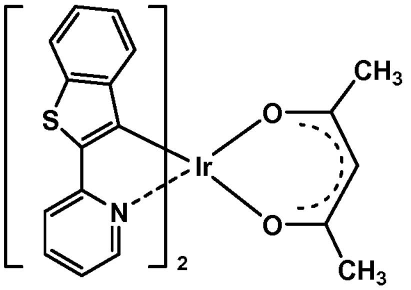

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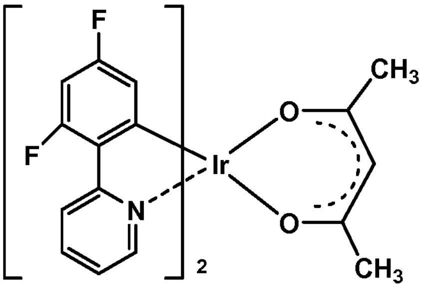

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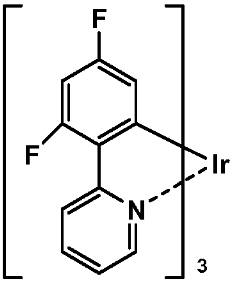

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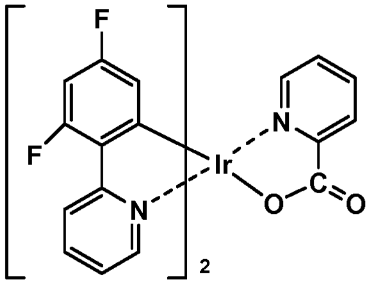

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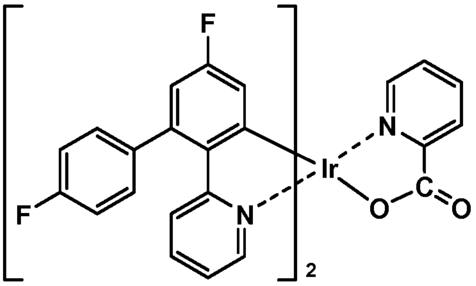

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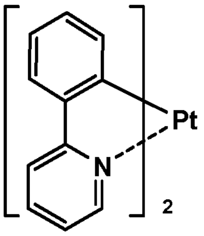

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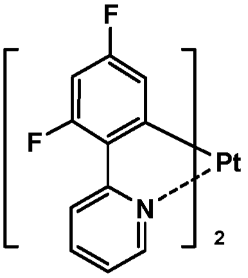

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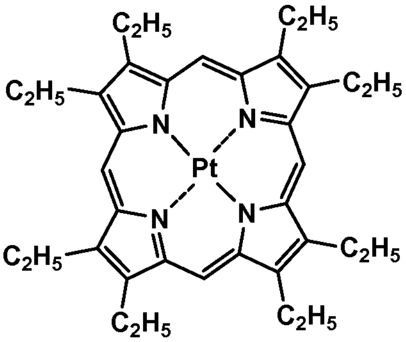

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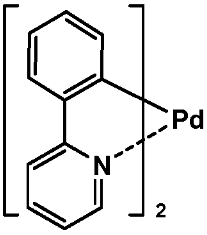

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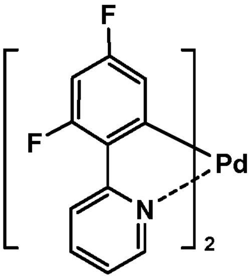

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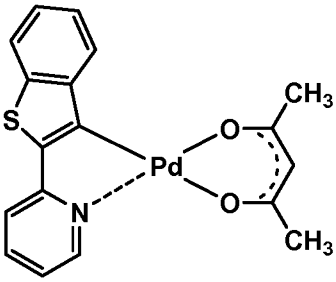

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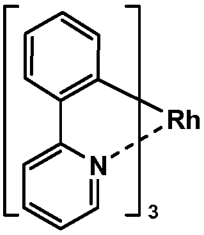

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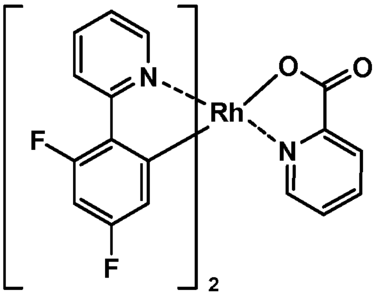

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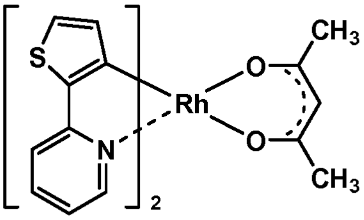

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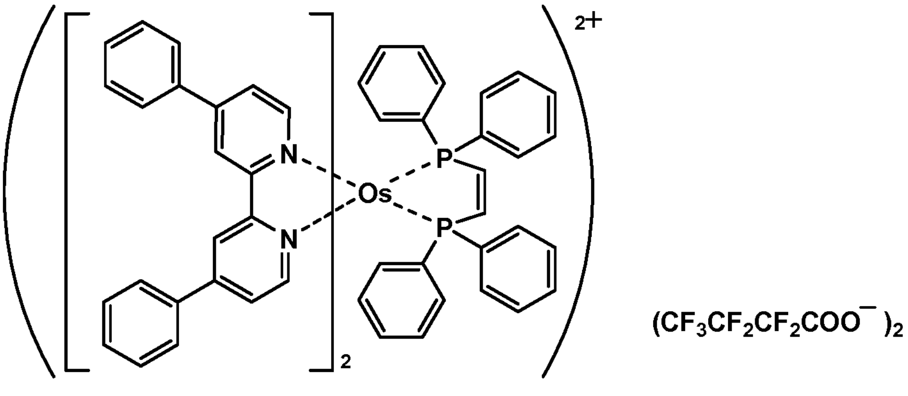

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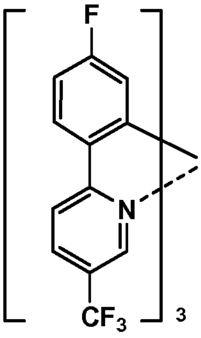

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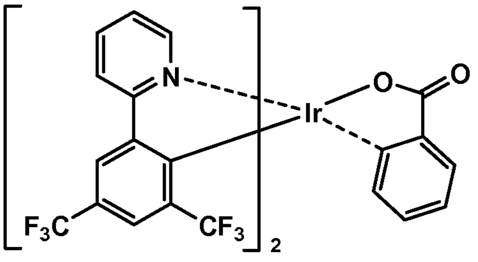

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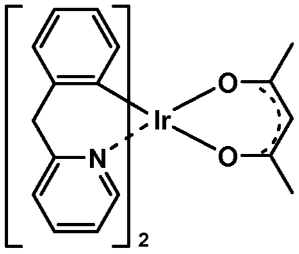
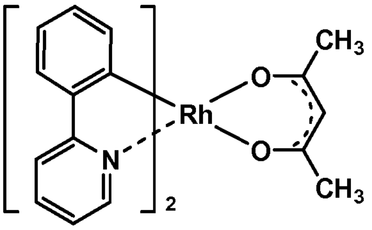
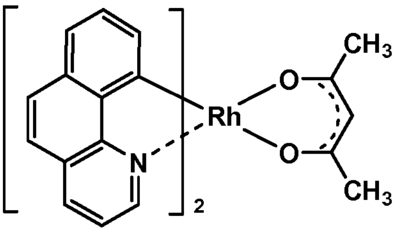


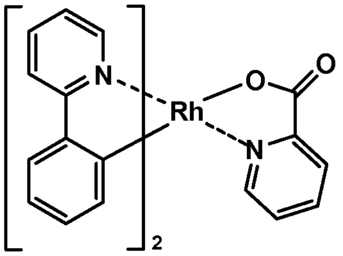
D-4



D-5



D-6



**[0095]** A fluorescent dopant may be added to the light emission layer besides the phosphorescent compound. Examples of the fluorescent compound include a coumarine dye, a pyrane die, a cyanine dye, a chloconium dye, a squalenium dye, an oxobenzanthracene dye, a fluorescene dye, a rhodamine dye, a pyrylium dye, a perylene dye, a stilbene dye, and a polythiophene dye, a rare earth element complex phosphorescent compound, and other known phosphorescent compounds.

<<Hole transporting layer>>

**[0096]** The hole transporting layer is comprised of material having an ability of transporting holes, and a hole injecting layer and an electron blocking layer are included in the hole transporting layer in a broad sense. The hole transporting layer or electron transporting layer may be a single layer or plural layers.

**[0097]** The hole transporting materials are not specifically limited, and can be optionally selected from those employed for hole transporting materials in conventional photoconductive elements or known materials used in the hole injecting layer or hole transporting layer of conventional EL elements.

**[0098]** The hole transporting material described above may be either an organic substance or an inorganic substance as long as it has a hole injecting ability, a hole transporting ability or an ability to form a barrier to electrons. Examples of the hole injecting material or the hole transporting material include a triazole derivative, an oxadiazole derivative, an imidazole derivative, a polyarylalkane derivative, a pyrazoline derivative and a pyrazolone derivative, a phenylenediamine derivative, an arylamine derivative, an amino substituted chalcone derivative, an oxazole derivative, a styryl anthracene derivative, a fluorenone derivative, a hydrazone derivative, a stilbene derivative, a silazane derivative, an aniline copolymer, and an electroconductive oligomer, particularly a thiophene oligomer. As the hole transporting material, those described above are used, but a porphyrin compound, an aromatic tertiary amine compound, or a styrylamine compound is preferably used, and an aromatic tertiary amine compound is more preferably used.

**[0099]** Typical examples of the aromatic tertiary amine compound and styrylamine compound include N,N,N',N'-tetraphenyl-4,4'-diaminophenyl, N,N'-diphenyl-N,N'-bis(3-methylphenyl)-[1,1'-biphenyl]-4,4'-diamine (TPD), 2,2'-bis(4-di-p-tolylaminophenyl)propane, 1,1'-bis(4-di-p-tolylaminophenyl)cyclohexane, N,N,N',N'-tetra-p-tolyl-4,4'-diaminobiphenyl, 1,1'-bis(4-di-p-tolylaminophenyl)-4-phenylcyclohexane, bis(4-dimethylamino-2-methylphenyl)-phenylmethane, bis(4-di-p-tolylaminophenyl)-phenylmethane, N,N'-diphenyl-N,N'-di(4-methoxyphenyl)-4,4'-diaminobiphenyl, N,N,N',N'-tetraphenyl-4,4'-diaminodiphenylether, 4,4'-bis(diphenylamino)quardriphenyl, N,N,N-tri(p-tolyl)amine, 4-(di-p-tolylamino)-4'-[4-(di-p-tolylamino)styryl]stilbene, 4-N,N-diphenylamino-(2-diphenylvinyl)benzene, 3-methoxy-4'-N,N-diphenylaminostylbenzene, N-phenylcarbazole, compounds described in US Patent No. 5,061,569 which have two condensed aromatic rings in the molecule thereof such as 4,4'-bis[N-(1-naphthyl)-N-phenylamino]biphenyl (NPD), and compounds described in Japanese Patent O.P.I. Publication No. 4-308688 such as 4,4',4''-tris[N-(3-methylphenyl)-N-phenylamino]-triphenylamine (MTDATA) in which three triphenylamine units are bonded in a starburst form.

**[0100]** A polymer in which the material mentioned above is introduced in the polymer chain or a polymer having the material as the polymer main chain can be also used.

**[0101]** As the hole injecting material or the hole transporting material, inorganic compounds such as p-Si and p-SiC are usable.

**[0102]** In the invention, the hole transporting material contained in the hole transporting layer is preferably a compound having a maximum fluorescence wavelength of not longer than 415 nm. That is, the hole transporting material is preferably a material with high Tg, which has a hole transporting ability, and prevents the emission wavelength from shifting to longer wavelength.

**[0103]** The hole transporting layer can be formed by layering the hole transporting material by a known method such as a vacuum deposition method, a spin coat method, a casting method, an ink jet method, and an LB method. The thickness of the hole transporting layer is not specifically limited, but is ordinarily from 5 to 5000 nm. The hole transporting layer may be composed of a single layer structure comprising one or two or more of the materials mentioned above.

### <<Electron transporting layer>>

**[0104]** The electron transporting layer comprises a material (an electron transporting material) having an electron transporting ability, and in a broad sense refers to an electron injecting layer or a hole blocking layer. The electron transporting layer can be provided as a single layer or plural layers.

**[0105]** As an electron transporting material (which serves also as a hole blocking material) used in a single electron transporting layer or in the electron transporting layer closest to the cathode of plural electron transporting layers, compounds to be described below are known.

**[0106]** The electron transporting layer may be any layer, as long as it has a function of incorporating electrons injected from a cathode to a light emission layer, and a material used in the electron transporting layer can be optionally selected from known compounds used as electron transporting materials.

**[0107]** Examples of the material used in the electron transporting layer (hereinafter also referred to as electron transporting material) include a nitro-substituted fluorene derivative, a diphenylquinone derivative, a thiopyran dioxide derivative, a carbodiimide, a fluolenylidenemethane derivative, an anthraquinodimethane, an anthrone derivative, and an oxadiazole derivative. Moreover, a thiadiazole derivative which is formed by substituting the oxygen atom in the oxadiazole ring of the foregoing oxadiazole derivative with a sulfur atom, and a quinoxaline derivative having a quinoxaline ring known as an electron withdrawing group are usable as the electron transporting material.

**[0108]** A polymer in which the material mentioned above is introduced in the polymer side chain or a polymer having the material as the polymer main chain can be also used.

**[0109]** A metal complex of an 8-quinolynol derivative such as aluminum tris-(8-quinolynol) ($Alq_3$), aluminum tris-(5,7-dichloro-8-quinolynol), aluminum tris-(5,7-dibromo-8-quinolynol), aluminum tris-(2-methyl-8-quinolynol), aluminum tris-(5-methyl-8-quinolynol), or zinc bis-(8-quinolynol) ($Znq_2$), and a metal complex formed by replacing the central metal of the foregoing complexes with another metal atom such as In, Mg, Cu, Ca, Sn, Ga or Pb, can be used as the electron transporting material. Furthermore, a metal free or metal-containing phthalocyanine, and a derivative thereof, in which the molecular terminal is replaced by a substituent such as an alkyl group or a sulfonic acid group, are also preferably used as the electron transporting material. The distyrylpyrazine derivative exemplified as a material for the light emission layer may preferably be employed as the electron transporting material. An inorganic semiconductor such as n-Si and n-SiC may also be used as the electron transporting material in a similar way as in the hole transporting layer.

**[0110]** A material used in the electron transporting layer is preferably a compound having a maximum fluorescence wavelength of not longer than 415 nm. That is, the material used in the electron transporting layer is preferably a material with high Tg, which has an electron transporting ability, and prevents the emission wavelength from shifting to longer wavelength.

**[0111]** The electron transporting layer can be formed by layering the electron transporting material by a known method such as a vacuum deposition method, a spin coat method, a casting method, an ink jet method, an LB method, a transfer method, or a printing method. The thickness of the electron transporting layer is not specifically limited, but is ordinarily from 5 to 5000 nm. The electron transporting layer may be composed of a single layer structure comprising one or two or more of the materials mentioned above.

<<Substrate (referred to as also base plate, base or support)>>

**[0112]** Examples of a substrate preferably employed for the organic electroluminescence element in the invention include glass, quartz and plastic. Especially preferred one is a resin film capable of providing flexibility to the organic EL element. When light is taken out from the substrate side, the substrate is transparent or translucent.

**[0113]** The resin film is not specifically limited, and examples of the resin film include films of polyesters such as polyethylene terephthalate and polyethylene naphthalate; polyethylene; polypropylene; cellophane; cellulose esters such as cellulose diacetate, cellulose triacetate, cellulose acetate butyrate, cellulose acetate propionate, cellulose acetate phthalate, and cellulose nitrate or their derivatives; polyvinylidene chloride; polyvinyl alcohol; polyethylene vinyl alcohol; syndiotactic polystyrene; polycarbonate; norbornene resin; polymethylpentene; polyether ketone; polyimide; polyether sulfone; polysulfone; polyether ketone imide; polyamide; fluorine-contained resin; nylon; polymethyl methacrylate; polyacrylate or polyarylate; norbornene resin (or cyclolefin resin) such as ARTON (produced by JSR Co., Ltd.) or APER (produced by Mitsui Chemical Co., Ltd.); and an organic and inorganic hybrid resin. As the organic and inorganic hybrid resin, there is a resin obtained from a combination of an organic resin and an inorganic resin (silica, alumina, titania, or zirconia) obtained according to a sol-gel reaction.

**[0114]** The surface of the resin film may be covered with a cover layer of an inorganic or organic compound or a hybrid cover layer comprised of both compounds. Examples of the cover layer include a silica layer according to a sol-gel method, organic layers formed according to coating of polymers (including layers obtained by subjecting a layer containing a polymerizable organic compound to post-treatment such as UV irradiation or heating), a DLC layer, and a metal oxide or metal nitride layer. Examples of the metal oxide or metal nitride constituting the metal oxide or metal nitride layer include a metal oxide such as silicon oxide, titanium oxide, or aluminum oxide, a metal nitride such as silicon nitride, and a metal nitride oxide such as silicon nitride oxide or titanium nitride oxide.

**[0115]** The resin film, whose surface is covered with a cover layer of an inorganic or organic compound or a hybrid cover layer comprised of both compounds, is preferably a film with high barrier having a water vapor transmittance of not more than 0.01 g/m$^2$·day·atmospheric pressure plasma discharge treatment apparatus.

<<Preparation of organic EL element>>

**[0116]** For one example, the preparation of the organic EL element, which has the constitution, Anode/Hole injecting layer/Hole transporting layer/Light emission layer/Electron transporting layer/Electron injecting layer/Cathode, will be described. A thin layer of a desired material for an electrode such as a material of the anode is formed on a suitable substrate by a deposition or sputtering method to prepare the anode, so that the thickness of the layer is not more than 1 $\mu$m, and preferably within the range of from 10 to 200 nm. Then the hole injecting layer, the hole transporting layer, the light emission layer, the electron transporting layer and the electron injecting layer, which constitute the element, are formed on the resulting anode in that order as organic compound thin layers.

**[0117]** As methods for formation of the thin layers, there are a spin coating method, a casting method, an ink jet method, a vacuum deposition method, and a printing method, however, a spin coating method and a vacuum deposition method are preferably used, since a uniform layer can be formed and a pinhole is formed with difficulty. Different methods may be used for formation of different layers. When the vacuum deposition method is used for the thin layer formation method, although conditions of the vacuum deposition differs due to kinds of materials used, vacuum deposition is preferably carried out at a boat temperature of from 50° C to 450° C, at a degree of vacuum of from $10^{-6}$ to $10^{-2}$ Pa, at a deposition speed of from 0.01 to 50 nm/second, and at a substrate temperature of from -50 to 300° C to form a layer with a thickness of from 0.1 nm to 5 $\mu$m.

**[0118]** After these layers has been formed, a thin layer comprised of a material for a cathode is formed thereon to prepare a cathode, employing, for example, a deposition method or sputtering method to give a thickness of not more than 1 $\mu$m, and preferably from 50 to 200 nm. Thus, a desired organic EL element is obtained. It is preferred that the layers from the hole injecting layer to the cathode are continuously formed under one time of vacuuming to obtain an organic EL element. However, on the way of the layer formation under vacuum a different layer formation method may be inserted. When the different method is used, its process is required to be carried out under a dry inert gas atmosphere.

**[0119]** When the light emission layer only is formed by patterning, the layer formation method, although not specifically limited, is carried out preferably according to a deposition method, an ink jet method or a printing method. When a deposition method is used as the layer formation method, patterning of the layer is preferably carried out employing a shadow mask.

**[0120]** Further, the organic EL element can be prepared in the reverse order, in which the cathode, the electron injecting layer, the electron transporting layer, the light emission layer, the hole transporting layer, the hole injecting layer, and the anode are formed in that order.

**[0121]** Examples of the light emission sources include a home lamp, a room lamp in a car, a backlight for a watch or a liquid crystal, a light source for boarding advertisement, a signal device, a light source for a photo memory medium, a light source for an electrophotographic copier, a light source for an optical communication instrument, and a light source for an optical sensor, but are not limited thereto.

**[0122]** The organic EL element of the invention may be an organic EL element having a resonator structure.

**[0123]** The organic EL element having a resonator structure is applied to a light source for a photo-memory medium, a light source for an electrophotographic copier, a light source for an optical communication instrument, or a light source for a photo-sensor, but its application is not limited thereto. In the above application, a laser oscillation may be carried out.

## EXAMPLES

**[0124]** The present invention will be explained in the following examples, but is not limited thereto.

### Example 1

<<Preparation of organic EL element sample OLED 1-1; Comparative>>

**[0125]** A pattern was formed on a substrate (NA-45, manufactured by NH Technoglass Co., Ltd.) composed of a glass plate and a 150 nm ITO (indium tin oxide) layer as an anode. Then the resulting transparent substrate having the ITO transparent electrode was subjected to ultrasonic washing in i-propyl alcohol and dried by a dry nitrogen gas and subjected to UV-ozone cleaning for 5 minutes.

**[0126]** The thus obtained transparent substrate was fixed on a substrate holder of a vacuum deposition apparatus available on the market. Further, $\alpha$-NPD, CBP, Ir-12, BCP and $Alq_3$ were put in each of five resistive heating molybdenum boats, and set in the vacuum deposition apparatus.

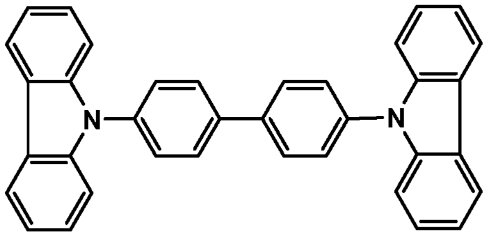
**[0127]** Thereafter, pressure in the vacuum tank was reduced to $4 \times 10^{-4}$ Pa, and $\alpha$-NPD was deposited onto the transparent substrate to form a hole injecting/transporting layer with a thickness of 50 nm. After that, supplying electric current to the boat carrying CBP and the boat carrying Ir-12, individually, in which the depositing speed rate of CBP to Ir-12 was adjusted to be 100:7, CBP to Ir-12 were codeposited onto the resulting hole transporting layer to form a light emission layer with a thickness of 30 nm. Subsequently, BCP was deposited onto the resulting light emission layer to form a hole blocking layer with a thickness of 10 nm, and then, $Alq_3$ was deposited onto the resulting layer to form an electron transporting layer with a thickness of 40 nm.

**[0128]** Next, the vacuum tank was opened, and a stainless steel mask having a rectangular hole was placed on the electron injecting layer. Further, 3 g of magnesium were put in a resistive heating molybdenum boat and 0.5 g of silver were put in a tungsten basket for deposition. The resulting boat and basket were set in the vacuum tank. Pressure in the vacuum tank was reduced to $2 \times 10^{-4}$ Pa. Then, the boat carrying magnesium was heated by supplying an electric current so as to deposit magnesium at a deposition speed of from 1.5 to 2.0 nm/sec, and at this time, the basket carrying silver was simultaneously heated so as to deposit silver at a deposition speed of 0.1 nm/sec to form a cathode electrode (200 nm) composed of a mixture of magnesium and silver. Thus, a comparative organic EL element sample OLED 1-1 was prepared.

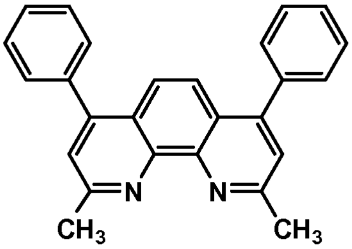
<<Preparation of organic EL element samples OLED 1-2 through 1-33>>

**[0129]** Organic EL element samples OLED 1-2 through 1-33 were prepared in the same manner as comparative organic EL element sample OLED 1-1, except that CBP used in the light emission layer was replaced with those (comparative compounds 1 through 10 or Exemplified compounds in the invention) as shown in Table 1.

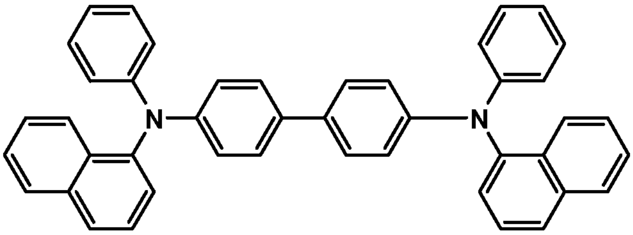
CBP



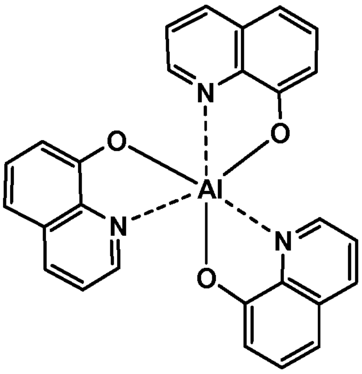
BCP



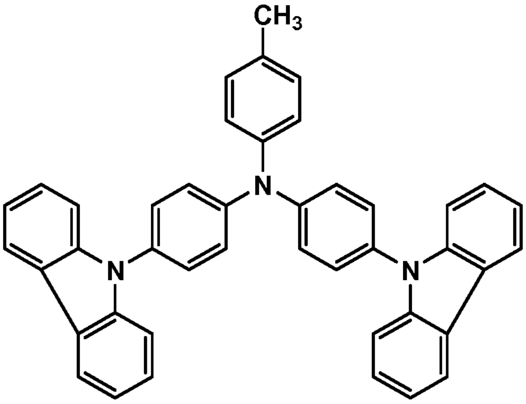
α-NPD



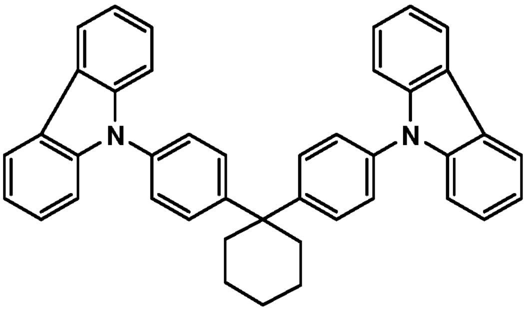
$Alq_3$



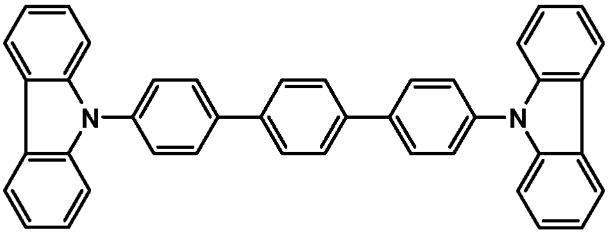
Comparative compound 1



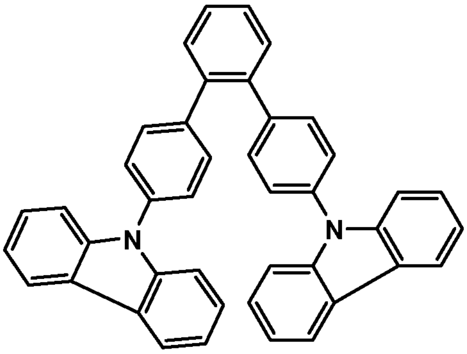
Comparative compound 2



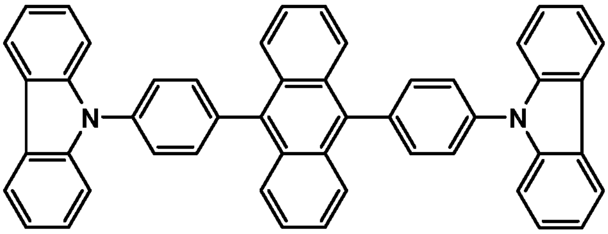
Comparative compound 3



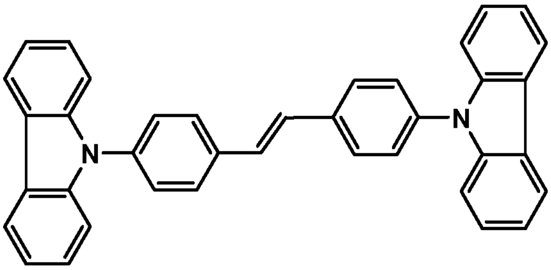
Comparative compound 4



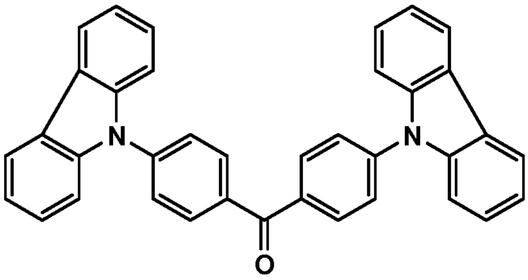
Comparative compound 5



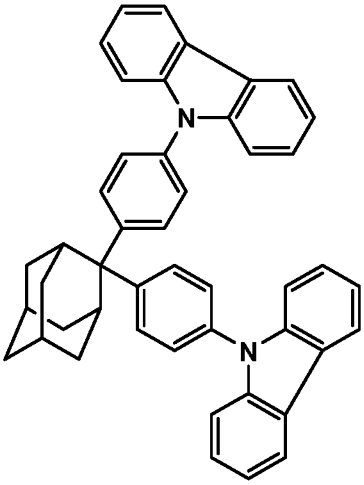
Comparative compound 6



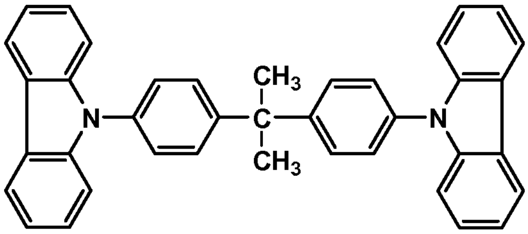
Comparative compound 7



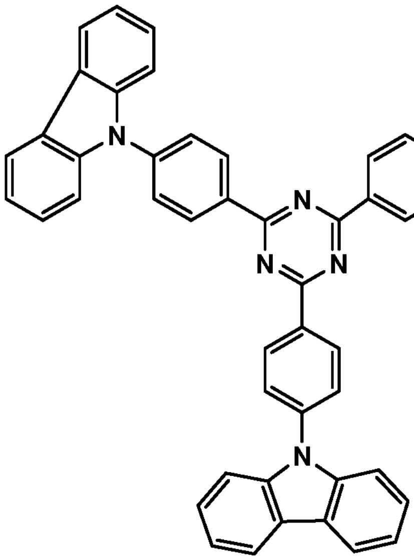
Comparative compound 8



Comparative compound 9



Comparative compound 10



<<Evaluation of organic EL element samples>>

**[0130]** The resulting organic EL element samples OLED 1-1 through 1-9, 1-16, 1-18 through 1-33 were evaluated as follows:

(Emission luminance, time when the initial emission luminance reduces by half)

**[0131]** When a current of 2.5 mA/cm$^2$ was supplied to each sample at 23° C in an atmosphere of a dry nitrogen gas, emission luminance L (cd/m$^2$) of light emitted and time ($\tau$) when the initial emission luminance after emission reduces by half (hereinafter also referred to as half life) were measured according to CS-1000 produced by Minolta Co., Ltd.

**[0132]** Emission luminance and half life of the organic EL element samples OLED 1-2 through 1-9, 1-16, 1-18 through 1-33 were expressed by a relative value when the emission luminance and half life of comparative organic EL element sample OLED 1-1 were set at 100, respectively. The results are shown in Table 1.

Table 1

| Sample OLED No. | Compound used in light emission layer | Emission luminance | Half life | Remarks |
|---|---|---|---|---|
| 1-1 | CBP | 100 | 100 | Comp. |
| 1-2 | Comparative compound 1 | 98 | 105 | Comp. |
| 1-3 | Comparative compound 2 | 90 | 113 | Comp. |
| 1-4 | Comparative compound 3 | 102 | 109 | Comp. |
| 1-5 | Comparative compound 4 | 110 | 60 | Comp. |
| 1-6 | Comparative compound 5 | 86 | 101 | Comp. |
| 1-7 | Comparative compound 6 | 82 | 93 | Comp. |
| 1-8 | Comparative compound 7 | 77 | 74 | Comp. |
| 1-9 | Comparative compound 8 | 106 | 110 | Comp. |
| 1-16 | 3-3 | 172 | 183 | Inv. |
| 1-18 | 4-4 | 195 | 215 | Inv. |
| 1-19 | 4-11 | 185 | 210 | Inv. |
| 1-20 | 5-2 | 170 | 172 | Inv. |

(continued)

| Sample OLED No. | Compound used in light emission layer | Emission luminance | Half life | Remarks |
|---|---|---|---|---|
| 1-21 | Comparative compound 9 | 105 | 96 | Comp. |
| 1-22 | Comparative compound 10 | 101 | 103 | Comp. |
| 1-23 | HA-1 | 185 | 231 | Inv. |
| 1-24 | HA-3 | 189 | 234 | Inv. |
| 1-25 | HA-5 | 180 | 245 | Inv. |
| 1-26 | IA-1 | 178 | 225 | Inv. |
| 1-27 | IA-11 | 172 | 202 | Inv. |
| 1-28 | IA-13 | 178 | 198 | Inv. |
| 1-29 | JA-2 | 188 | 210 | Inv. |
| 1-30 | JA-8 | 170 | 195 | Inv. |
| 1-31 | 2-2 | 170 | 230 | Inv. |
| 1-32 | 4-12 | 180 | 235 | Inv. |
| 1-33 | 4-13 | 178 | 222 | Inv. |
| Comp.: Comparative, Inv.: Inventive | | | | |

**[0133]** As is apparent from Table 1, inventive organic EL element samples OLED 1-16, 1-18 through 1-20, and 1-23 through 1-33 comprising the compound in the invention provide high emission luminance and long half life as compared with comparative organic EL element samples OLED 1-1 through 1-9, 1-21 and 1-22.

**[0134]** Organic EL element samples OLED1-16, 1-18 through 1-120, and 1-23 G through 1-33G were prepared in the same manner as in Organic EL element samples OLED1-16 and 1-18,through 1-20, and 1-23 through 1-33, respectively, except that Ir-1 was used instead of Ir-12, and the resulting samples exhibited the same results as above. Further, organic EL element samples OLED 1-16R, 1-18R through 1-20 and 1-23 R through 1-33 R were prepared in the same manner as in organic EL element samples OLED1-16, 1-18 through 1-20 and 1-23 through 1-33, respectively, except that Ir-9 was used instead of Ir-12, and the resulting samples exhibited the same results as above. Green light was emitted from organic EL elements employing Ir-1, and red light was emitted from organic EL elements employing Ir-9.

**[0135]** A voltage necessary to emit light with a luminance of 50 cd/cm$^2$ was measured with respect to organic EL element samples OLED 1-4

## Example 2

### <<Preparation of organic EL element samples OLED 2-1, 2-2, 2-11 and 2-12>>

**[0136]** Organic EL element samples OLED 2-1, 2-2, 2-11 and 2-12 were prepared in the same manner as comparative organic EL element sample OLED 1-1, except that the host compound used in the light emission layer and the compound used in the hole blocking layer were replaced with those as shown in Table 2, respectively.

**[0137]** The resulting samples were evaluated for emission luminance, and half life in the same manner as in Example 1. The results are shown in Table 2.

**[0138]** In Table 2, emission luminance and half life of the organic EL element samples OLED 2-2 2-2, 2-11 and 2-12 are expressed by a relative value when the emission luminance and half life of organic EL element sample OLED 2-1 were set at 100, respectively.

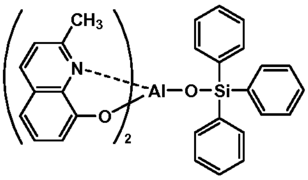
Table 2

| Sample OLED No. | Compound used in light emission layer | Compound used in hole blocking layer | Emission luminance (%) | Half life (%) | Remarks |
|---|---|---|---|---|---|
| 2-1 | CBP | BCP | 100 | 100 | Comp. |
| 2-2 | CBP | Compound A1 | 107 | 115 | Comp. |

(continued)

| Sample OLED No. | Compound used in light emission layer | Compound used in hole blocking layer | Emission luminance (%) | Half life (%) | Remarks |
|---|---|---|---|---|---|
| 2-11 | 4-4 | B2 | 162 | 230 | Inv. |
| 2-12 | 4-11 | B2 | 160 | 230 | Inv. |
| Comp.: Comparative, Inv.: Inventive | | | | | |

Compound A1



**[0139]** As is apparent from Table 2, inventive organic EL element samples OLED 2-11 and 2-12 employing the compound in the invention provide high emission luminance and long luminance half life as compared with comparative organic EL element samples OLED 2-1 and 2-2 employing the comparative compound.

**[0140]** Organic EL element samples employing the compound in the invention other than the above exhibited the same results as above. In these samples, samples employing TAZ, OXD7, DPVBi, B1 or B2 in the hole blocking layer exhibited higher emission luminance and longer life time as compared to those employing BCP or Compound A1 in the hole blocking layer.

Example 3

<<Preparation of organic EL element samples OLED 3-1 through 3-28>>

**[0141]** Organic EL element samples OLED 3-1 through 3-28 were prepared in the same manner as comparative organic EL element sample OLED 1-1, except that the host compound used in the light emission layer and the compound used in the hole blocking layer were replaced with those as shown in Table 3, respectively.

**[0142]** The resulting samples OLED 3-1 through 3-12, 3-15 and 3-16, 3-18 through 3-28 were evaluated for emission luminance, and half life in the same manner as in Example 1. The results are shown in Table 3.

**[0143]** In Table 3, emission luminance and half life are expressed by a relative value when the emission luminance and luminance half life of organic EL element sample OLED 3-1 were set at 100, respectively.

Table 3

| Sample OLED No. | Compound used in light emission layer | Compound used in hole blocking layer | Emission luminance (%) | Half life (%) | Remarks |
|---|---|---|---|---|---|
| 3-1 | Comparative compound 1 | Compound A1 | 100 | 100 | Comp. |
| 3-2 | Comparative compound 2 | Compound A1 | 94 | 112 | Comp. |
| 3-3 | Comparative compound 3 | Compound A1 | 104 | 111 | Comp. |
| 3-4 | Comparative compound 4 | Compound A1 | 108 | 75 | Comp. |
| 3-5 | Comparative compound 5 | Compound A1 | 92 | 105 | Comp. |
| 3-6 | Comparative compound 6 | Compound A1 | 88 | 105 | Comp. |

(continued)

| Sample OLED No. | Compound used in light emission layer | Compound used in hole blocking layer | Emission luminance (%) | Half life (%) | Remarks |
|---|---|---|---|---|---|
| 3-7 | Comparative compound 7 | Compound A1 | 83 | 90 | Comp. |
| 3-8 | Comparative compound 8 | Compound A1 | 105 | 110 | Comp. |
| 3-9 | Comparative compound 9 | Compound A1 | 110 | 109 | Comp. |
| 3-10 | Comparative compound 3 | B2 | 109 | 116 | Comp. |
| 3-11 | Comparative compound 8 | B2 | 108 | 115 | Comp. |
| 3-12 | Comparative compound 9 | B2 | 112 | 114 | Comp. |
| 3-15 | 3-3 | B2 | 166 | 192 | Inv. |
| 3-16 | 4-5 | B2 | 171 | 185 | Inv. |
| 3-18 | 4-13 | B2 | 165 | 204 | Inv. |
| 3-19 | 5-2 | B2 | 165 | 184 | Inv. |
| 3-20 | HA-1 | B2 | 174 | 220 | Inv. |
| 3-21 | HA-3 | B2 | 172 | 215 | Inv. |
| 3-22 | HA-5 | B2 | 170 | 225 | Inv. |
| 3-23 | IA-1 | B2 | 180 | 208 | Inv. |
| 3-24 | IA-11 | B2 | 175 | 195 | Inv. |
| 3-25 | IA-13 | B2 | 166 | 191 | Inv. |
| 3-26 | JA-1 | B2 | 162 | 195 | Inv. |
| 3-27 | JA-2 | B2 | 170 | 193 | Inv. |
| 3-28 | JA-8 | B2 | 169 | 187 | Inv. |
| Comp.: Comparative, Inv.: Inventive | | | | | |

**[0144]** As is apparent from Table 3, inventive organic EL element samples employing the compound in the invention in the light emission layer provide high emission luminance and long luminance half life as compared with comparative organic EL element samples employing the comparative compound in the light emission layer.

**[0145]** Further, inventive organic EL element samples employing BCP, Compound A1, OXD7, TAZ or B1 as a hole blocking material used in the hole blocking layer exhibited higher emission luminance and longer luminance life as compared to comparative organic EL element samples employing BCP, Compound A1, OXD7, TAZ or B1 as a hole blocking material in the hole blocking layer.

Example 4

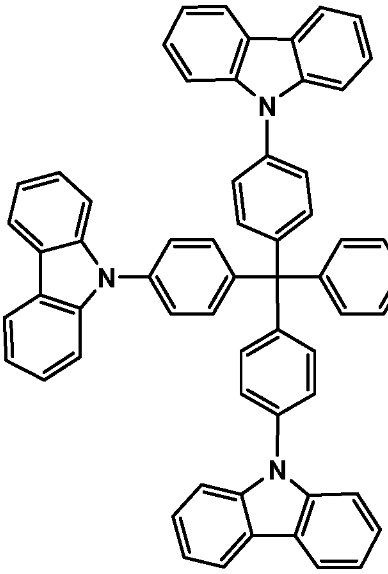
<<Preparation of organic EL element samples OLED 4-1 through 4-3, 4-5, 4-6>>

**[0146]** Organic EL element samples OLED 4-1 through 4-3, 4-5, 4-6 were prepared in the same manner as comparative organic EL element sample OLED 1-1, except that the host compound used in the light emission layer and the compound used in the hole blocking layer were replaced with those as shown in Table 4, respectively.

**[0147]** The resulting samples OLED 4-1 through 4-3, 4-5, 4-6 were evaluated for emission luminance, and luminance half life in the same manner as in Example 1. The results are shown in Table 4.

**[0148]** In Table 4, emission luminance and half life are expressed by a relative value when the emission luminance and half life of organic EL element sample OLED 4-1 were set at 100, respectively.

Comparative compound 11



Comparative compound 12

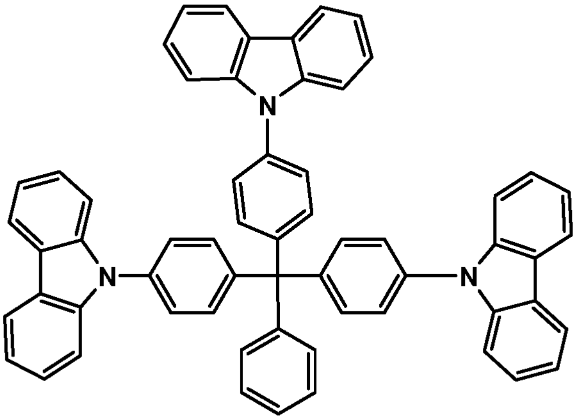


Table 4

| Sample OLED No. | Compound used in light emission layer | Compound used in hole blocking layer | Emission luminance (%) | Half life (%) | van der waals volume (Å$^3$) | Remarks |
|---|---|---|---|---|---|---|
| 4-1 | Comparative compound 9 | B2 | 100 | 100 | 49.4 | Comp. |
| 4-2 | Comparative compound 11 | B2 | 92 | 110 | 435.0 | Comp. |
| 4-3 | Comparative compound 12 | B2 | 95 | 107 | 294.4 | Comp. |
| 4-5 | HA-3 | B2 | 142 | 223 | 84.4 | Inv. |

(continued)

| Sample OLED No. | Compound used in light emission layer | Compound used in hole blocking layer | Emission luminance (%) | Half life (%) | van der waals volume (Å$^3$) | Remarks |
|---|---|---|---|---|---|---|
| 4-6 | HA-4 | B2 | 147 | 210 | 67.7 | Inv. |
| Comp.: Comparative, Inv.: Inventive | | | | | | |

**[0149]** As is apparent from Table 4, inventive organic EL element samples employing the compound in the invention in the light emission layer provide high emission luminance and long half life as compared with comparative organic EL element samples employing the comparative compound in the light emission layer.

**[0150]** Further, when BCP, Compound A1, OXD7, TAZ or B1 is used as a hole blocking material instead of B2, the compound in the invention exhibited higher emission luminance and longer life time as compared to the comparative compound.

[EFFECT OF THE INVENTION]

**[0151]** The present invention can provide an organic electroluminescent element with high luminance, high emission efficiency, high durability.

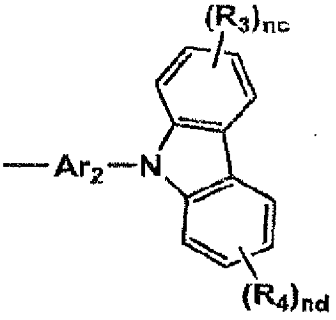
## Claims

1. An organic electroluminescent element comprising an anode, a cathode and a component layer including a light emission layer, the component layer being provided between the anode and the cathode, wherein the component layer contains a compound represented by the following formula 3:

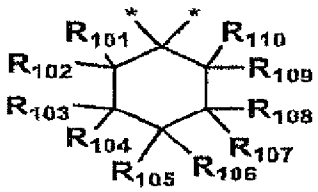
Formula 3 $X_2\text{-}(A_2)_m$

wherein $A_2$ represents a group represented by formula 4, and may be the same or different,

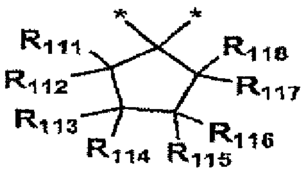
Formula 4



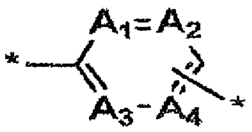
wherein $Ar_2$ represents a divalent aromatic hydrocarbon or aromatic heterocyclic group; $R_3$ and $R_4$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubstituted alkenyl group, or a halogen atom; nc and nd independently represent an integer of from 1 to 4; m represents an integer of 2; and $X_2$ represents a group represented by formula (l), (m), (n), or (o), Formula (1)



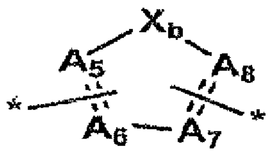
Formula (m)



Formula (n)



Formula (o)



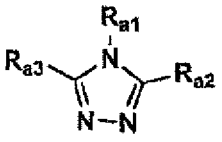
wherein $R_{101}$ through $R_{110}$ independently represent a hydrogen atom, an alkyl group, or an alkoxy group, provided that $R_{101}$ through $R_{110}$ are not simultaneously hydrogen atoms; and any two of $R_{101}$ through $R_{110}$ do not combine with each other to form a ring; $R_{111}$ through $R_{118}$ independently represent a hydrogen atom, an alkyl group, or an alkoxy group; $A_1$, $A_2$; $A_3$, and $A_4$ independently represent -C($R_{k1}$)- or -N=, in which $R_{k1}$ represents a hydrogen atom or an alkyl group, provided that at least one of $A_1$ $A_2$, $A_3$, and. $A_4$ is -N=; $A_5$, $A_6$, $A_7$, and $A_8$ independently represent -C($R_{k2}$)= or -N=; $X_b$ represents -N($R_{k3}$)= or -Si($R_{k4}$)($R_{k5}$)-, which $R_{k2}$, $R_{K3}$, $R_{k4}$, and $R_{k5}$ independently represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted cycloalkyl group, a substituted or unsubstituted aralkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted aryloxy group, a cyano group, a hydroxyl group, a substituted or unsubtituted alkenyl group, or a halogen atom; and "*"represents a linkage site.

2. The organic electroluminescent element of claim 1, wherein a hole, blocking layer is provided between the light emission layer and the cathode.

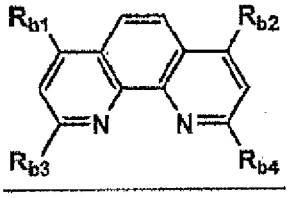
3. The organic electroluminescent element of claim 2, wherein the hole blocking layer is comprised of at least one selected from the group consisting of a styryl compound, a triazole derivative, a phenanthroline derivative, an oxadiazole derivative and a boron derivative.

4. The organic electroluminescent element of claim 2, wherein the hole blocking layer is comprised of at least one selected from the group consisting of compounds represented by the following formula 5, 6, 7 or 8:

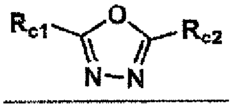
Formula 5



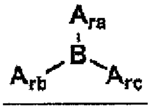
Formula 6



Formula 7



Formula 8



wherein $R_{a1}$ through $R_{a3}$, $R_{b1}$ through $R_{b4}$, and $R_{c1}$ and $R_{c2}$ independently represent an alkyl group, an aryl group or a heterocyclic group; and $A_{ra}$ through $A_{rc}$ independently represent an aryl group or a heterocyclic group.

5. The organic electroluminescent element of claim 1, wherein the light emission layer contains the compound represented by formula 3, H2, H3, H4, I1, I2, I3, J1 or J2 above,

6. The organic electroluminescent element of any of claims 1 to 5, wherein the organic electroluminescent element contains a phosphorescent compound.

7. The organic electroluminescent element of claim 6, wherein the phosphorescent compound is an osmium complex, an iridium complex or a platinum complex.

8. The organic electroluminescent element of claim 1, wherein the component layer contains the compound represented by formula 3 above.

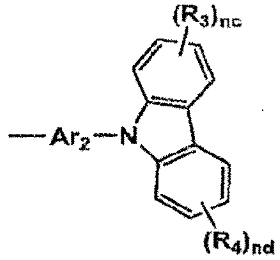
9. The organic electroluminescent element of claim 1, wherein the component layer contains the compound represented by formula I1, I2 or I3 above.

**Patentansprüche**

1. Organisches Elektrolumineszenzelement mit einer Anode, einer Kathode und einer Bestandteilschicht mit einer lichtemittierenden Schicht, wobei die Bestandteilschicht zwischen der Anode und der Kathode vorgesehen ist, wobei die Bestandteilschicht eine Verbindung enthält, die durch die folgende Formel 3 dargestellt wird:

Formel 3 $X_2\text{-}(A_2)_m$

in welcher $A_2$ für eine durch die Formel 4 dargestellte Gruppe steht, die gleich oder verschieden sein kann, Formel 4



in welcher $Ar_2$ für eine zweiwertige aromatische oder aromatische heterocyclische Kohlenwasserstoffgruppe stellt;

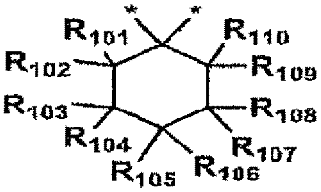
$R_3$ und $R_4$ stehen, unabhängig voneinander, für ein Wasserstoffatom, eine substituierte oder unsubstituierte Alkylgruppe, eine substituierte oder unsubstituierte Cycloalkylgruppe, eine substituierte oder unsubstituierte Aralkylgruppe, eine substituierte oder unsubstituierte Arylgruppe, eine substituierte oder unsubstituierte Alkoxygruppe eine substituierte oder unsubstituierte Aryloxygruppe, eine Cyanogruppe, eine Hydroxylgruppe, eine substituierte oder unsubstituierte Alkenylgruppe oder ein Halogenatom;

nc und nd stehen, unabhängig voneinander, für eine ganze Zahl von 1 bis 4;

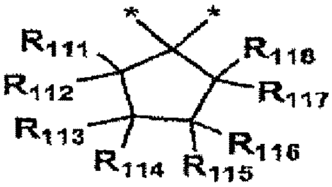
m bedeutet eine ganze Zahl gleich 2 ; und

$X_2$ steht für eine Gruppe der Formel (l), (m), (n) oder (o),

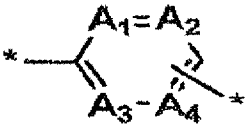
Formel (l)



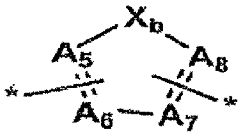
Formel (m)



Formel (n)



Formel (o)



in welcher

$R_{101}$ bis $R_{110}$, unabhängig voneinander, für ein Wasserstoffatom, eine Alkylgruppe oder eine Alkoxygruppe mit der Maßgabe stehen, dass $R_{101}$ bis $R_{110}$ nicht gleichzeitig Wasserstoffatome sind; und beliebig zwei Reste von $R_{101}$ bis $R_{110}$ nicht miteinander verbunden sind, um einen Ring zu bilden;

$R_{111}$ bis $R_{118}$, unabhänig voneinander, für ein Wasserstoffatom, eine Alkylgruppe oder eine Alkoxygruppe stehen;

$A_1$, $A_2$, $A_3$ und $A_4$, unabhängig voneinander, für -C($R_{k1}$)- oder -N= stehen, wobei $R_{k1}$ für ein Wasserstoffatom oder eine Alkylgruppe mit der Maßgabe stehen, dass mindestens ein Rest von $A_1$, $A_2$, $A_3$ und $A_4$ gleich -N = ist;

$A_5$, $A_6$, $A_7$ und $A_8$, unabhängig voneinander, für -C($R_{k2}$)= oder -N= stehen; und

$X_b$ für -N($R_{k3}$)= oder -Si($R_{k4}$)($R_{k5}$)- stehen, wobei $R_{k2}$, $R_{k3}$, $R_{k4}$ und $R_{k5}$, unabhängig voneinander, für ein Wasserstoffatom, eine substituierte oder unsubstituierte Alkylgruppe, eine substituierte oder unsubstituierte Cycloalkylgruppe, eine substituierte oder unsubstituierte Aralkylgruppe, eine substituierte oder unsubstituierte Arylgruppe, eine substituierte oder unsubstituierte Alkoxygruppe, eine substituierte oder unsubstituierte Aryloxygruppe, eine Cyanogruppe, eine Hydroxylgruppe, eine substituierte oder unsubstituierte Alkenylgruppe oder ein Halogenatom stehen; und

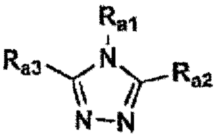
"*" für eine Verknüpfungsstelle steht.

2. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei eine Lochblockierschicht zwischen der lichtemittierenden Schicht und der Kathode vorgesehen ist.

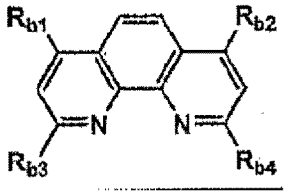
3. Organisches Elektrolumineszenzelement nach Anspruch 2, wobei die Lochblockierschicht aus mindestens einem Mitglied ausgewählt ist aus der Gruppe, bestehend aus einer Styrylverbindung, einem Triazolderivat, einem Phenanthrolinderivat, ein Oxadiazolderivat und ein Borderivat.

4. Organisches Elektrolumineszenzelement nach Anspruch 2, wobei die Lochblockierschicht aus mindestens einem Mitglied ausgewählt ist aus der Gruppe, bestehend aus Verbindungen der folgenden Formeln 5, 6, 7 oder 8:

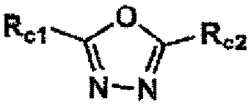
Formel 5



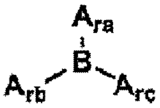
Formel 6



Formel 7



Formel 8



in welchen

$R_{a1}$ bis $R_{a3}$, $R_{b1}$ bis $R_{b4}$, und $R_{c1}$ und $R_{c2}$, unabhängig voneinander, für eine Alkylgruppe, eine Arylgruppe oder

eine heterocyclische Gruppe stehen; und
$A_{ra}$ bis $A_{rc}$, unabhängig voneinander, für eine Arylgruppe oder eine heterocyclische Gruppe stehen.

5. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei die lichtemittierende Schicht die Verbindung der obigen Formel 3, H2, H3, H4, I1, I2, I3, J1 oder J2 enthält.

6. Organisches Elektrolumineszenzelement nach einem der Ansprüche 1 bis 5, wobei das organische Elektrolumineszenzelement eine phosphoreszierende Verbindung enthält.

7. Organisches Elektrolumineszenzelement nach Anspruch 6, wobei die phosphoreszierende Verbindung ein Osmiumkomplex, ein Iridiumkomplex oder ein Platinkomplex ist.

8. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei die Bestandteilschicht die durch die obige Formel (3) dargestellte Verbindung enthält.

9. Organisches Elektrolumineszenzelement nach Anspruch 1, wobei die Bestandteilschicht die Verbindung enthält, die durch die obigen Formeln I1, I2 oder I3 dargestellt ist.

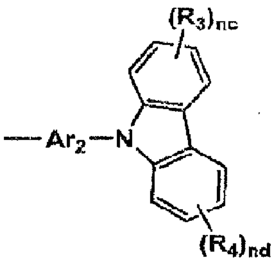
## Revendications

1. Élément électroluminescent organique comprenant une anode, une cathode et une couche constitutive comportant une couche d'émission de lumière, la couche constitutive étant prévue entre l'anode et la cathode, où la couche constitutive contient un composé représenté par la formule 3 suivante :

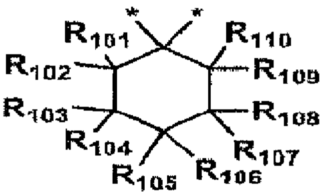
Formule 3 $X_2\text{-}(A_2)_m$

où $A_2$ représente un groupe représenté par la formule 4, et peut être identique ou différent,

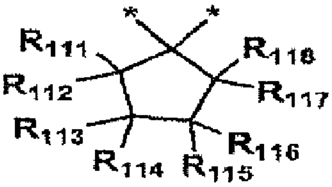
Formule 4



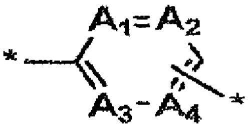
où $Ar_2$ représente un groupe hydrocarboné aromatique ou hétérocyclique aromatique divalent ; $R_3$ et $R_4$ représentent indépendamment un atome d'hydrogène, un groupe alkyle substitué ou non substitué, un groupe cycloalkyle substitué ou non substitué, un groupe aralkyle substitué ou non substitué, un groupe aryle substitué ou non substitué, un groupe alcoxy substitué ou non substitué, un groupe aryloxy substitué ou non substitué, un groupe cyano, un groupe hydroxyle, un groupe alcényle substitué ou non substitué, ou un atome d'halogène ; nc et nd représentent indépendamment un nombre entier allant de 1 à 4 ; m représente un nombre entier égal à 2 et $X_2$ représente un groupe représenté par la formule (l), (m), (n) ou (o), Formule (l)



Formule (m)



Formule (n)



Formule (o)

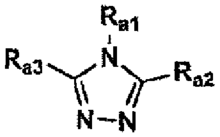
où, $R_{101}$ à $R_{110}$ représentent indépendamment un atome d'hydrogène, un groupe alkyle ou un groupe alcoxy, à condition que $R_{101}$ à $R_{110}$ ne soient pas simultanément des atomes d'hydrogène ; et deux quelconque parmi $R_{101}$ à $R_{110}$ ne se combinent pas pour former un noyau ; $R_{111}$ à $R_{118}$ représentent indépendamment un atome d'hydrogène, un groupe alkyle ou un groupe alcoxy ; $A_1$, $A_2$, $A_3$ et $A_4$ représentent indépendamment $-C(R_{k1})-$ ou -N=, où $R_{k1}$ représente un atome d'hydrogène ou un groupe alkyle, à condition qu'au moins l'un de $A_1$, $A_2$, $A_3$, et $A_4$ soit -N= ; $A_5$, $A_6$, $A_7$ et $A_8$ représentent indépendamment $-C(R_{k2})=$ ou -N= ; $X_b$ représente $-N(R_{k3})=$ ou $-Si(R_{k4})(R_{k5})-$, lesquels $R_{k2}$, $R_{k3}$, $R_{k4}$ et $R_{k5}$ représentent indépendamment un atome d'hydrogène, un groupe alkyle substitué ou non substitué, un groupe cycloalkyle substitué ou non substitué, un groupe aralkyle substitué ou non substitué, un groupe aryle substitué ou non substitué, un groupe alcoxy substitué ou non substitué, un groupe aryloxy substitué ou non substitué, un groupe cyano, un groupe hydroxyle, un groupe alcényle substitué ou non substitué ou un atome d'halogène ; et « * » représente un site de liaison.

2. Élément électroluminescent organique de la revendication 1, dans lequel une couche de blocage de trous est prévue entre la couche d'émission de lumière et la cathode.

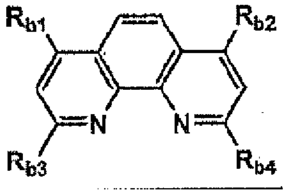
3. Élément électroluminescent organique de la revendication 2, dans lequel la couche de blocage de trous est constituée d'au moins un élément choisi dans le groupe constitué d'un composé de styryle, d'un dérivé de triazole, d'un dérivé de phénanthroline, d'un dérivé d'oxadiazole et d'un dérivé de bore.

4. Élément électroluminescent organique de la revendication 2, dans lequel la couche de blocage de trous est constituée d'au moins un élément choisi dans le groupe constitué de composés représentés par la formule 5, 6, 7 ou 8 suivante :

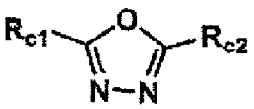
Formule 5



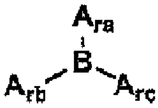
Formule 6



Formule 7



Formule 8



où $R_{a1}$ à $R_{a3}$, $R_{b1}$ à $R_{b4}$, et $R_{c1}$ et $R_{c2}$ représentent indépendamment un groupe alkyle, un groupe aryle ou un groupe hétérocyclique ; et $A_{ra}$ à $A_{rc}$ représentent indépendamment un groupe aryle ou un groupe hétérocyclique.

**5.** Élément électroluminescent organique de la revendication 1, dans lequel la couche d'émission de lumière contient le composé représenté par la formule 3, H2, H3, H4, I1, I2, I3, J1 ou J2 ci-dessus.

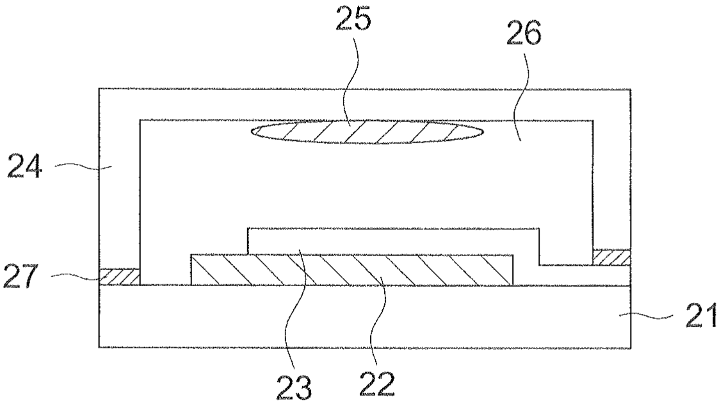
**6.** Élément électroluminescent organique de l'une des revendications 1 à 5, dans lequel l'élément électroluminescent organique contient un composé phosphorescent.

**7.** Élément électroluminescent organique de la revendication 6, dans lequel le composé phosphorescent est un complexe d'osmium, un complexe d'iridium ou un complexe de platine.

**8.** Élément électroluminescent organique de la revendication 1, dans lequel la couche constitutive contient le composé représenté par la formule 3 ci-dessus.

**9.** Élément électroluminescent organique de la revendication 1, dans lequel la couche constitutive contient le composé représenté par la formule I1, I2 ou I3 ci-dessus.

FIG. 1



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|---|---|---|---|
| 专利名称(译) | 有机电致发光元件和显示器和发光器 | | |
| 公开(公告)号 | EP2248870B1 | 公开(公告)日 | 2018-12-26 |
| 申请号 | EP2010174005 | 申请日 | 2003-11-20 |
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| 发明人 | OSHIYAMA, TOMOHIRO<br>KINOSHITA, MOTOI<br>YAMADA, TAKETOSHI<br>FUKUDA, MITSUHIRO<br>SUZURI, YOSHIYUKI<br>UEDA, NORIKO<br>KITA, HIROSHI | | |
| IPC分类号 | C09K11/06 H05B33/14 H01L51/00 H01L51/30 H01L51/50 | | |
| CPC分类号 | C09K11/06 C09K2211/1003 C09K2211/1007 C09K2211/1011 C09K2211/1014 C09K2211/1029 C09K2211/1044 C09K2211/1051 C09K2211/1059 C09K2211/1074 C09K2211/1088 C09K2211/1096 H01L51/0052 H01L51/0059 H01L51/0067 H01L51/0072 H01L51/0081 H01L51/0084 H01L51/0085 H01L51/0094 H01L51/5012 H01L51/5016 H01L51/5036 H01L51/5096 H01L2251/308 H05B33/14 Y10S428/917 | | |
| 优先权 | 2002342193 2002-11-26 JP<br>2003061201 2003-03-07 JP<br>2003084071 2003-03-26 JP<br>2003084073 2003-03-26 JP<br>2003084075 2003-03-26 JP<br>2003160609 2003-06-05 JP | | |
| 其他公开文献 | EP2248870A2<br>EP2248870A3 | | |
| 外部链接 | Espacenet | | |

**摘要(译)**

公开了一种有机电致发光元件，包括阳极，阴极和包括发光层的组件层，该组件层设置在阳极和阴极之间，其中组件层包含由式1，式1 X1-表示的化合物（A1）n其中A1表示由式2表示的基团;

Formula 4