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(54) ORGANIC EL DEVICE AND DISPLAY

ORGANISCHES EL-BAUELEMENT UND -DISPLAY

DISPOSITIF ÉLECTROLUMINESCENT ORGANIQUE ET DISPOSITIF D'AFFICHAGE

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Description

TECHNICAL FIELD

[0001] The present invention relates to an organic electroluminescence device (organic EL device) that uses a naphthacene derivative and a compound having a pyrromethene skeleton or a metal complex of the compound together.

BACKGROUND ART

[0002] Organic EL (Electro-Luminescence) devices have been known. Organic EL devices formed from organic materials have been vigorously studied since a report on a low voltage-driven organic EL device formed by laminating layers was made by C. W. Tang et al. of Eastman Kodak Company (see Non-Patent Document 1:).

[0003] Known examples of an emitting material used for an organic EL device are a chelate complex such as a tris(8-quinolinol)aluminum (Alq) complex, a coumarin complex, a tetraphenylbutadiene derivative, a bisstyrylarylene derivative, an oxadiazole derivative or the like. These emitting materials, which have been reported to emit blue to red light in a visible region, are expected to be applied to color-display devices (e.g., Patent Documents 1-3 and the like). However, luminous efficiency and lifetime of such a device has been so insufficient that the device has not been practically applicable. While a full color display requires three primary colors of blue, green and red, among them, a red-emitting device with high efficiency has been demanded.

[0004] For instance, Patent Document 4 has recently disclosed a red-emitting device whose emitting layer is added with a naphthacene derivative or a pentacene derivative. However, although the red-emitting device is excellent in purity of red color, the red-emitting device requires voltage of 11V to be applied, and time lapsed until the luminescent intensity decreases to half is approximately 150 hours, i.e., the performance of the device is insufficient. Patent Document 5 discloses a device whose emitting layer is added with a dicyanomethylene (DCM)-based compound. However, the device exhibits insufficient purity of red color. Patent Document 6 discloses a red-emitting device whose emitting layer is added with an amine-based aromatic compound. However, although the emitting device exhibits excellent CIE (Commission Internationale d'Eclairage) chromaticity (0.64, 0.33) and chromatic purity, the device requires high voltage for driving. Patent Document 7 and 8 disclose devices in which an amine-based aromatic compound and an Alq compound are used for the emitting layer. However, although emitting red light, the device exhibits low efficiency and short lifetime.

[0005] Patent Document 9 discloses devices in which an amine-based aromatic compound and DPVDPAN are used for the emitting layer. However, high-efficient one of the devices emits orange light while red-emitting one of the devices exhibits low efficiency.

[0006] Patent Document 10 discloses a device in which a dicyanoanthracene derivative and an indenoperylene derivative are used for the emitting layer while a metal complex is used for the electron transporting layer. However, the device emits light of red orange color.

[0007] Patent Document 11 discloses a device in which a fluoranthene derivative and an indenoperylene derivative are used for the emitting layer while a fluoranthene derivative is used for the electron transporting layer. However, the device does not exhibit practically-applicable efficiency.

[0008]

Patent Document 1: JP-A-08-239655
Patent Document 2: JP-A-07-138561
Patent Document 3: JP-A-03-200889
Patent Document 4: JP-A-08-311442
Patent Document 5: JP-A-03-162481
Patent Document 6: JP-A-2001-81451
Patent Document 7: WO/01/23497
Patent Document 8: JP-A-2003-40845
Patent Document 9: JP-A-2003-81924
Patent Document 10: JP-A-2001-307885
Patent Document 11: JP-A-2003-338377
Non-Patent Document 1: Applied Physics Letters, vol. 51, page 913, by C.W. Tang and S. A. Vanslyke, 1987

[0009] JP 2006-245172, JP 2005-154534 and JP 2004-311030 each disclose that a compound having a pyrromethene skeleton or a metal complex thereof is used as a dopant material contained in a light-emitting layer. Further, JP 2006-245172 mentions that a known host material may be used by mixing into an anthracene compound, and discloses the optional use of a benzimidazole derivative for the electron-transporting layer in a list of suitable compounds, but does not disclose a naphthacene compound as a host. JP 2005-154534 describes that a condensed-ring derivative such as anthracene and pyrene conventionally known as light-emitting substance is used, but does not disclose the specific benzimidazoles for the electron-transporting layer, and naphthacene derivatives as a host. The same applies for JP 2004-311030, which discloses the use of conventionally known host materials for light-emitting layers.

[0010] JP 2003-338377 discloses a naphthacene derivative as host material in a light-emitting layer. It does not mention the use of such naphthacene derivatives as a host and the presence of compounds having a pyrromethene skeleton as a dopant. The document mentions a naphthacene compound in the electron-transporting layer, but no benzimidazole derivative having in its structure a fused aromatic hydrocarbon group with three or more rings.

[0011] WO 2005/075600 discloses an OLED comprising a electroluminescent layer comprising a host/dopant system. The host is an anthracene derivative and the dopant is a boron complex wherein the boron is bonded to a N of a 6 membered ring and to the N of a five-membered ring.

[0012] US 2006/008672 discloses an OLED comprising a electroluminescent layer comprising a host/dopant system. The host is a naphthacene derivative and the dopant system is a boron complex wherein the boron is bonded to two N of a 6 membered ring. The OLEDs described in this document emit green, green-yellow and yellow light, but no red light. US 2003/082406 discloses an OLED comprising a electroluminescent layer comprising a host/dopant system. The host is diketopyrrolopyrrole derivative and the dopant is a boron complex wherein the boron is bonded to a N of a 6 membered ring and to two N of a five-membered ring. The use of pyrromethene metal complexes as a dopant is disclosed, but the presence of a naphthacene derivative as a host is not mentioned.

[0013] WO 2008/047744 is a prior art document under Art. 54(3) EPC. Disclosed are OLEDs which are similar to those of the present invention. The document discloses the optional presence of benzimidazole compounds. The compound (E-3) mentioned in Example 8 of D8 does not enjoy the priority, and thus is no prior art for the present invention. D8 does not disclose a compound in the electron transporting layer which has in its structure at least one fused aromatic hydrocarbon group with three or more rings.

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

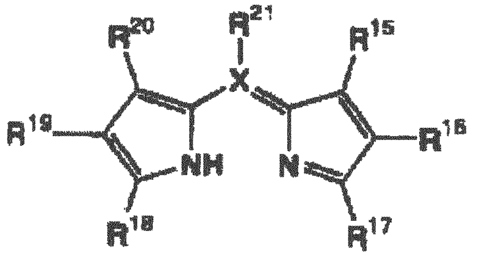
[0014] An object of the present invention is to provide an practically-applicable organic EL device excellent in efficiency, lifetime and chromatic purity.

MEANS FOR SOLVING THE PROBLEMS

[0015] After conducting concentrated studies in order to achieve such an object, the inventors have found that an organic EL device exhibits longer lifetime and higher efficiency by using a naphthacene derivative and a compound having a pyrromethene skeleton or a metal complex of the compound in at least one layer of organic compound layers of the organic EL device, and reached the present invention.

[0016] An organic electroluminescence device according to an aspect of the present invention includes: a cathode; an anode; an emitting layer provided between the cathode and the anode, and an electron transporting layer provided between the cathode and the emitting layer, in which the emitting layer comprises a host and a dopant, the host is a naphthacene derivative represented by a formula (3) as defined in claim 1, the dopant is a compound having a pyrromethene skeleton represented by a formula (2) as follows or a metal complex of the compound and the electron transporting layer comprises a compound represented by formula (4) as follows.

[Chemical Formula 2]



(2)

[0017] In the formula (2), at least one of R^{15} to R^{21} is a substituent having an aromatic ring or forms a fused ring together with an adjacent substituent while the rest of R^{15} to R^{21} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, a haloalkane, a haloalkene, a haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. The rest of R^{15} to R^{21} each may form a fused ring or an aliphatic ring with an adjacent substituent (the groups listed above each havs 1 to 20 carbon atoms). R^{15} to R^{21} may be mutually the same or different and may be substituted or unsubstituted. X represents a carbon atom or a nitrogen atom on a condition that R^{21} above does not exist when X represents a nitrogen atom. A metal in the metal complex is at least one metal selected from a group consisting of boron, beryllium, magnesium, chrome, iron, cobalt, nickel, copper, zinc and platinum.

[0018] The metal in the metal complex is particularly preferably boron.

[0019] The substituted or unsubstituted alkyl group is preferably an alkyl group having 1 to 20 carbon atoms, more preferably an alkyl group having 1 to 10 carbon atoms, further preferably an alkyl group having 1 to 5 carbon atoms. The alkyl group may be linear or branched. The alkyl group may be a primary alkyl group, a secondary alkyl group or a tertiary alkyl group.

[0020] Preferable examples of the alkyl group are a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-nonyl group and an n-decyl group.

[0021] The substituted or unsubstituted aryl group is preferably an aryl group having 6 to 30 carbon atoms, more preferably an aryl group having 6 to 20 carbon atoms. Examples of the aryl group are a phenyl group, a phenylphenyl group (4-phenylphenyl group, 3-phenylphenyl group, 2-phenylphenyl group), a naphthylphenyl group (4-(1-naphthyl)phenyl group, 4-(2-naphthyl)phenyl group), a naphthyl group (1-naphthyl group, 2-naphthyl group), a phenylnaphthyl group (6-phenyl-2-naphthyl group, 4-phenyl-1-naphthyl group), a naphthylnaphthyl group (6-naphthyl-2-naphthyl group, 4-naphthyl-1-naphthyl group), an anthranil group, a phenantyl group, a pyrenyl group and a chrysenyl group.

[0022] The animo group may be an amino group, a substituted or unsubstituted monoalkyl-aryl group having 1 to 20 carbon atoms, a substituted or unsubstituted dialkyl-aryl group having 1 to 20 carbon atoms, a substituted or unsubstituted monoaryl-aryl group having 6 to 30 carbon atoms, or a substituted or unsubstituted bisaryl-aryl group having 6 to 30 carbon atoms. Examples of the amino group are a dimethylamino group, a diethylamino group, a diphenylamino group, a ditolylamino group and a dixylylamino group.

[0023] The substituted or unsubstituted alkoxy group is preferably an alkoxy group having 1 to 20 carbon atoms, examples of which are a methoxy group, an ethoxy group and a propoxy group.

[0024] The substituted or unsubstituted alkylthio group is preferably an alkylthio group having 1 to 20 carbon atoms, examples of which are a methylthio group and an ethylthio group.

[0025] The substituted or unsubstituted aryloxy group is preferably an aryloxy group having 6 to 30 carbon atoms, an example of which is a phenoxy group.

[0026] The substituted or unsubstituted aryloxythio group is preferably an aryloxythio group having 6 to 30 carbon atoms, an example of which is a phenylthio group.

[0027] The substituted or unsubstituted alkenyl group is preferably an alkenyl group having 1 to 20 carbon atoms, examples of which are a vinyl group and a propenyl group.

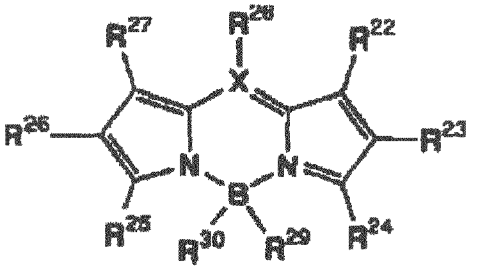
[0028] The substituted or unsubstituted aralkyl group is preferably an aralkyl group having 7 to 30 carbon atoms, an example of which is a benzyl group.

[0029] The substituted or unsubstituted heterocyclic group is preferably a heterocyclic group having 5 to 30 carbon atoms, examples of which are a pyridyl group, a furyl group, a thienyl group, a pyrazyl group, a pyrimidyl group and a quinolyl group.

[0030] According to the aspect of the present invention, since the emitting layer contains the host formed of a naphthacene derivative and the dopant formed of a compound having a pyrromethene skeleton or a metal complex of the compound, the organic EL device having practically-applicable efficiency and lifetime can be realized.

[0031] According to the aspect of the present invention, it is preferable that the compound having the pyrromethene skeleton represented by the formula (2) or the metal complex of the compound is a metal complex having a pyrromethene skeleton represented by a formula (2-1) as follows.

[Chemical Formula 3]



(2-1)

[0032] In the formula (2-1), at least one of R^{22} to R^{28} is a substituent having an aromatic ring or forms a fused aromatic ring together with an adjacent substituent while the rest of R^{22} to R^{28} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. The rest of R^{22} to R^{28} each may form a fused ring or an aliphatic ring with an adjacent substituent. R^{22} to R^{28} may be mutually the same or different and may be substituted or unsubstituted. R^{29} and R^{30} may be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, substituted or unsubstituted alkyl, substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group. X represents a carbon atom or a nitrogen atom on a condition that R^{28} above does not exist when X represents a nitrogen atom.

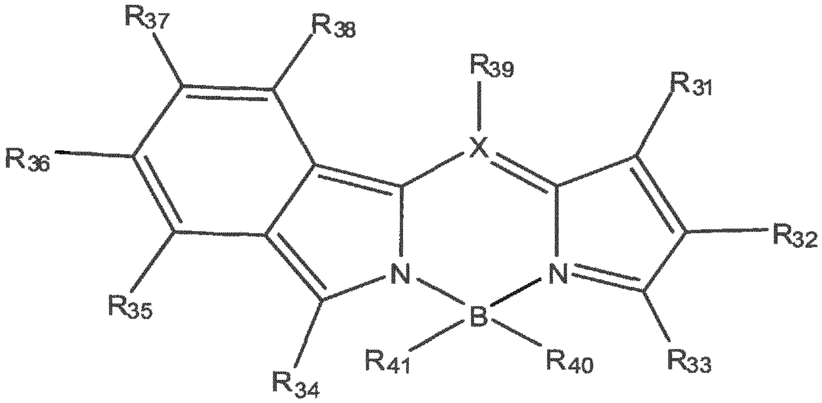
[0033] According to the aspect of the present invention, it is preferable that at least one of R^{22} to R^{28} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) is a substituent having an aromatic ring.

[0034] According to the aspect of the present invention, it is preferable that at least one of R^{22} to R^{28} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) forms a fused aromatic ring together with an adjacent substituent.

[0035] According to the aspect of the present invention, it is preferable that at least one of R^{22} to R^{24} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) forms a substituted or unsubstituted fused aromatic ring together with an adjacent substituent and/or at least one of R^{25} to R^{27} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) forms a substituted or unsubstituted fused aromatic ring together with an adjacent substituent.

[0036] According to the aspect of the present invention, it is preferable that the metal complex having the pyrromethene skeleton represented by the formula (2-1) is a metal complex having a pyrromethene skeleton represented by a formula (2-2) as follows.

[Chemical Formula 4]

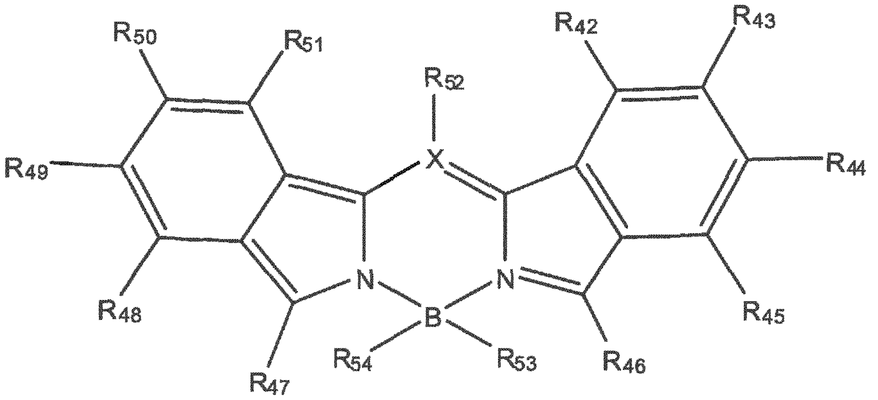


(2-2)

[0037] In the formula (2-2), R_{31} to R_{39} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. R_{31} to R_{39} may be mutually the same or different and may be substituted or unsubstituted. R_{40} and R_{41} maybe mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, substituted or unsubstituted alkyl, substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group. X represents a carbon atom or a nitrogen atom on a condition that R_{39} above does not exist when X represents a nitrogen atom.

[0038] According to the aspect of the present invention, it is preferable that the metal complex having the pyrromethene skeleton represented by the formula (2-1) is a metal complex having a pyrromethene skeleton represented by a formula (2-3) as follows.

[Chemical Formula 5]

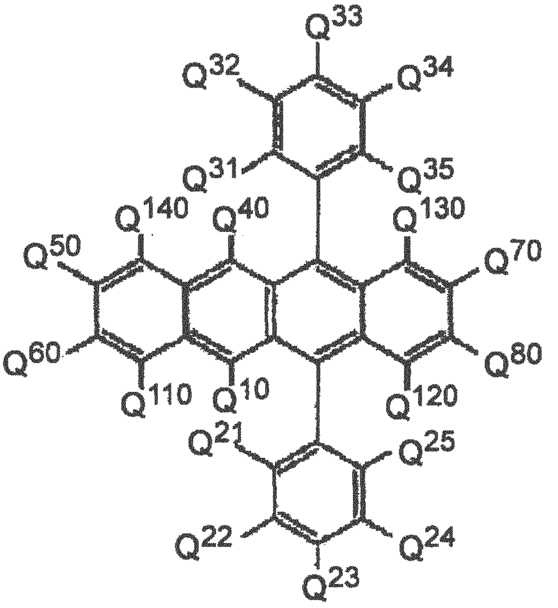


(2-3)

[0039] In the formula (2-3), R_{42} to R_{52} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. R_{42} to R_{52} may be mutually the same or different and may be substituted or unsubstituted. R_{53} and R_{54} may be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, a substituted or unsubstituted alkyl, a substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group. X represents a carbon atom or a nitrogen atom on a condition that R_{52} above does not exist when X represents a nitrogen atom.

[0040] According to the aspect of the present invention, the naphthacene derivative represented by a formula (3) as follows is used.

[Chemical Formula 6]



(3)

[0041] In the formula (3), Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40} to Q^{80} and Q^{110} to Q^{140} each represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted amino group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted alkylthio group, a substituted or unsubstituted aryloxy group, a substituted or unsubstituted arylthio group, a substituted or unsubstituted alkenyl group, a substituted or unsubstituted aralkyl group, or a substituted or unsubstituted heterocyclic group. Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40} to Q^{80} and Q^{110} to Q^{140} may be mutually the same or different.

[0042] Adjacent two or more of Q^{21} to Q^{25} and Q^{31} to Q^{35} may be mutually bonded to form a cyclic structure.

[0043] According to the aspect of the present invention, at least one of Q^{21}, Q^{25}, Q^{31} and Q^{35} in the naphthacene derivative represented by the formula (3) represents a substituted or unsubstituted aryl group.

[0044] According to the above structure, the naphthacene derivative represented by the formula (3) has a substituent in at least one ortho position of two benzene rings bonded to naphthacene.

[0045] By introducing substituent(s) to ortho position(s) of the two benzene rings bonded to naphthacene, a steric hindrance is caused between the introduced substituent(s) and the naphthacene skeleton. The steric hindrance directs the introduced substituent(s) to face in an out-of-plane direction of the naphthacene skeleton. Then, the substituent(s) directed in the out-of-plane direction prevents association of naphthacene derivatives with each other.

[0046] When two or more of Q^{21}, Q^{25}, Q^{31} and Q^{35} are substituents, the substituents may be mutually the same or different. In addition, adjacent two or more of Q^{21} to Q^{25} and Q^{31} to Q^{35} may be mutually bonded to form a cyclic structure.

[0047] An example of the substituent is a substituted or unsubstituted phenyl group.

[0048] Two or more of the ortho positions of the two benzene rings bonded to naphthacene are preferably substituted.

[0049] According to the aspect of the present invention, at least one of Q^{21} and Q^{25} in the naphthacene derivative represented by the formula (3) represents a substituted or unsubstituted aryl group while at least one of Q^{31} and Q^{35} in the naphthacene derivative represents a substituted or unsubstituted aryl group.

[0050] According to the aspect of the present invention, it is preferable that the dopant is contained in the emitting layer at a doping concentration of 0.1 to 10 mass%. It is more preferable that the dopant is contained in the emitting layer at a doping concentration of 0.5 to 2.0 mass%.

[0051] According to the aspect of the present invention, the organic EL device further includes an electron transporting layer provided between the cathode and the anode, in which the electron transporting layer comprises a compound represented by a formula (4) as follows.

[0052] [Chemical Formula 7]

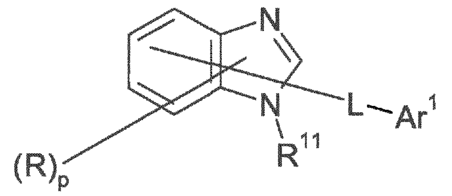
$$(A)_m\text{-}(B)_n \qquad (4)$$

[0053] In the formula, A represents a substituted or unsubstituted fused aromatic hydrocarbon group having three or more rings, and B represents a substituted or unsubstituted heterocyclic group. In addition, m and n each represent an integer in a range of 1 to 6.

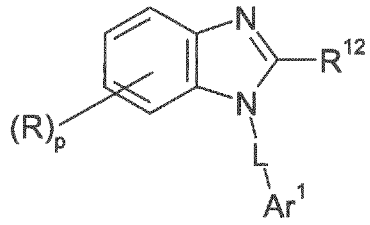
[0054] According to the aspect of the present invention, it is preferable that A in the compound represented by the formula (4) has a skeleton in its molecule, the skeleton selected from a group consisting of anthracene, phenanthrene, naphthacene, pyrene, chrysene, benzoanthracene, pentacene, dibenzoanthracene, benzopyrene, fluorene, benzofluorene, fluoranthene, benzofluoranthene, naphthofluoranthene, dibenzofluorene, dibenzopyrene and dibenzofluoranthene.

[0055] According to the aspect of the present invention, the compound represented by the formula (4) is a benzimidazole derivative represented by a formula (5) or a formula (6) as follows.

[Chemical Formula 8]



(5)



(6)

[0056] In the formulae: R represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms; p represents an integer in a range of 1 to 4; R^{11} represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or an alkoxy group having 1 to 20 carbon atoms; R^{12} represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms; L represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridinylene group, a substituted or unsubstituted quinolinylene group or a substituted or unsubstituted fluorenylene group; and Ar^1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group or a substituted or unsubstituted quinolyl group.

[0057] At least one of R, R^{11}, R^{12}, L and Ar^1 corresponds to A in the compound represented by the formula (4) and is a fused aromatic hydrocarbon group having three or more rings.

[0058] According to the aspect of the present invention, it is preferable that the emitting layer emits light of orange to red.

[0059] The present invention can provide a practically-applicable organic EL device that exhibits high efficiency, long life and excellent chromatic purity.

[0060] In addition, according to the present invention, by selecting a suitable compound for the materials of the electron transporting layer and the emitting layer, the organic EL device can exhibit higher efficiency. Specifically, with the arrangement according to the present invention, generation of exciters in the electron transporting layer can be prevented, thereby providing a highly chromatically-pure organic EL device whose micro emission from the electron transporting layer is further reduced In addition, for the same reason(s), the lifetime of the device can be prolonged.

BRIEF DESCRIPTION OF DRAWINGS

[0061] Fig. 1 shows a first embodiment of an organic EL device according to the present invention.

EXPLANATION OF CODES

[0062] 1: organic EL device, 10: substrate, 20: anode, 30: hole injecting layer, 40: hole transporting layer, 50: emitting layer, 60: electron transporting layer, 70: electron injecting layer, 80: cathode,

BEST MODE FOR CARRYING OUT THE INVENTION

[Arrangement of Organic EL Device]

[0063] Representative exemplary arrangements of an organic EL device usable in the present invention will be described below.

(1) anode / emitting layer / electron transporting layer / cathode
(2) anode / hole transporting layer / emitting layer / electron transporting layer / cathode
(3) anode / hole injecting layer / hole transporting layer / emitting layer / electron transporting layer / cathode
(4) anode / hole transporting layer / emitting layer / electron transporting layer / electron injecting layer / cathode
(5) anode / hole injecting layer / hole transporting layer / emitting layer / electron transporting layer / electron injecting layer / cathode (Fig. 1)
(6) anode / insulating layer / hole transporting layer / emitting layer / electron transporting layer / cathode
(7) anode / hole transporting layer / emitting layer / electron transporting layer / insulating layer / cathode
(8) anode / insulating layer / hole transporting layer / emitting layer / electron transporting layer / insulating layer / cathode
(9) anode / hole injecting layer / hole transporting layer / emitting layer / electron transporting layer / insulating layer / cathode
(10) anode / insulating layer / hole injecting layer / hole transporting layer / emitting layer / electron transporting layer / electron injecting layer / cathode
(11) anode / insulating layer / hole injecting layer / hole transporting layer / emitting layer / electron transporting layer / electron injecting layer / insulating layer / cathode

[0064] Among the above, the arrangement (2), (3), (4), (5), (8), (9) or (11) is typically preferable.

[0065] The organic EL device according to the present invention includes an anode, a cathode, a single-layered or plural-layered organic layer including an emitting layer and an electron transporting layer provided between the cathode and the emitting layer. At least one layer of the organic layer contains a host formed of a naphthacene derivative and a dopant formed of a compound having a pyrromethene skeleton or a metal complex of the compound.

[0066] An exemplary arrangement of the organic EL device according to the present invention is shown in Fig. 1. In Fig. 1, the organic EL device 1 includes an anode 20, a hole injecting layer 30, a hole transporting layer 40, an emitting layer 50, an electron transporting layer 60, an electron injecting layer 70 and a cathode 80, which are all laminated on a substrate 10 in this order. The hole injecting layer 30, the hole transporting layer 40, the emitting layer 50, the electron transporting layer 60 and the electron injecting layer 70 correspond to the organic layer interposed between the cathode 80 and the anode 20. At least one of the above layers contains a host material formed of a naphthacene derivative and a dopant material formed of a compound having a pyrromethene skeleton or a metal complex of the compound. Preferably, the emitting layer contains a naphthacene derivative and a compound having a pyrromethene skeleton or a metal complex of the compound.

[0067] Functions or the like of the layers of the organic EL device will be described below.

[Light-Transmissive Substrate]

[0068] When the organic EL device is to emit light through the substrate (i.e., when the organic EL device is bottom-emission type), the organic EL device according to the present invention is manufactured on a light-transmissive substrate. The light-transmissive plate, which supports the organic EL device, is preferably a smoothly-shaped substrate that transmits 50% or more of light in a visible region of 400nm to 700nm.

[0069] The light-transmissive plate is exemplarily a glass plate, a polymer plate or the like. For the glass plate, such materials as soda-lime glass, barium/strontium-containing glass, lead glass, aluminosilicate glass, borosilicate glass, barium borosilicate glass, quartz and the like can be used. For the polymer plate, such materials as polycarbonate, acryl, polyethylene terephthalate, polyether sulfide, polysulfone and the like can be used. In addition, the light-transmissive plate may be a TFT substrate on which a TFT (thin film transistor) for driving is formed.

[0070] On the other hand, when the organic EL device is to emit light from its top portion (i.e., when the organic EL device is top-emission type), the light-transmissive plate is required to be provided with a light reflector, an exemplary material of which is a metal such as aluminum.

[Anode]

[0071] The anode of the organic EL device is used for injecting holes into the hole transporting layer or the emitting layer. It is effective that the anode includes a work function of 4.5 eV or more. Exemplary materials for the anode are indium-tin oxide (ITO), tin oxide (NESA), indium zinc oxide alloy (IZO), gold, silver, platinum and copper.

[0072] One of the above materials may be singularly used, or alloys formed by mixing the above materials and materials formed by adding other element(s) to the above material(s) may be suitably selected as the material of the anode.

[0073] The anode may be made by forming a thin film from the above electrode materials through methods such as vapor deposition and sputtering.

[0074] When the organic EL device is bottom-emission type, the anode preferably transmits more than 10% of light emitted by the emitting layer. Sheet resistance of the anode is preferably several hundreds Ω/ square or lower. Although depending on the material of the anode, thickness of the anode is typically in a range of 10 nm to 1 μm, and preferably in a range of 10 to 200 nm.

[Emitting Layer]

[0075] The emitting layer of the organic EL device has functions described below. Specifically, the emitting layer has:

(i) injecting function: a function for accepting, when an electrical field is applied, the holes injected by the anode or the hole injecting/transporting layer, or the electrons injected by the cathode or the electron injecting/transporting layer;
(ii) transporting function: a function for transporting injected electric charges (the electrons and the holes) by the force of the electrical field; and
(iii) emitting function; a function for providing a condition for recombination of the electrons and the holes to emit light.

[0076] Although injectability of the holes may differ from that of the electrons and transporting capabilities represented by nobilities of the holes and the electrons may differ from each other, the emitting layer preferably transports at least either one of the electric charges.

[0077] As a method to form the emitting layer, known methods such as vapor deposition, spin coating and an LB (Langmuir Blodgett) method may be employed. The emitting layer is preferably a molecular deposit film.

[0078] The molecular deposit film means a thin film formed by depositing a material compound in gas phase or a film formed by solidifying a material compound in a solution state or in liquid phase. The molecular deposit film is generally distinguished from a thin film formed by the LB method (molecular accumulation film) by differences in aggregation structures, higher order structures and functional differences arising therefrom.

[0079] As disclosed in JP-A-57-51781, the emitting layer can be formed from a thin film formed by spin coating or the like, the thin film being formed from a solution prepared by dissolving a binder (e.g. a resin) and a material compound in a solvent.

[0080] The emitting layer of the present invention contains a host and a dopant.

[0081] The emitting layer is preferably doped with a dopant material at a doping concentration of 0.1 to 10 mass%, more preferably 0.5 to 2.0 mass%.

[0082] The emitting layer preferably emits light of orange to red.

[0083] The host is a naphthacene derivative represented by the formula (3).

[0084] In the formula (3), Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40}, Q^{50}, Q^{60}, Q^{70}, Q^{80}, Q^{110}, Q^{120}, Q^{130} and Q^{140} each represent a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms, a substituted or unsubstituted amino group, a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms, a substituted or unsubstituted alkylthio group having 1 to 20 carbon atoms, a substituted or unsubstituted aryloxy group having 6 to 30 carbon atoms, a substituted or unsubstituted arylthio group having 6 to 30 carbon atoms, a substituted or unsubstituted alkenyl group, a substituted or unsubstituted aralkyl group having 7 to 30 carbon atoms or a substituted or unsubstituted heterocyclic group. Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40}, Q^{50}, Q^{60}, Q^{70}, Q^{80}, Q^{110}, Q^{120}, Q^{130} and Q^{140} may be mutually the same or different.

[0085] In the above formula (3), Q^{10} and Q^{40} are each preferably selected from a group consisting of a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms, a substituted or unsubstituted amino group, a substituted or unsubstituted heterocyclic group and a substituted or unsubstituted alkenyl group having 1 to 20 carbon atoms. More preferably, Q^{10} and Q^{40} are aryl groups. Particularly, a structure where Q^{10} and Q^{40} are hydrogen atoms is also preferable. In addition, although Q^{10} and Q^{40} are preferably the same, they may be mutually different.

[0086] In the above formula, Q^{50}, Q^{60}, Q^{70} and Q^{80} (collectively referred to as Q^{50} to Q^{80}) are each preferably selected from a group consisting of a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms, a substituted or unsubstituted amino group, a substituted or unsubstituted alkenyl group having 1 to 20 carbon atoms and a substituted or unsubstituted heterocyclic group. More preferably, Q^{50} to Q^{80} are each a hydrogen atom or a substituted or unsubstituted aryl group having 6 to 30 carbon atoms. In addition, although a structure where Q^{50} and Q^{60} are the same while Q^{70} and Q^{80} are the same is preferable, Q^{50} to Q^{80} may be mutually different. Q^{110}, Q^{120}, Q^{130} and Q^{140} (collectively referred to as Q^{110} to Q^{140}) are each preferably a hydrogen atom.

[0087] The alkyl group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted, or may be linear or branched. Preferable examples of the alkyl group are a methyl group, an ethyl group, a (n, i)-propyl group, a (n, i, sec, tert)-butyl group, and (n, i, neo, tert)-pentyl group.

[0088] The aryl group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may monocyclic or polycyclic, or may be of a fused-ring structure or of a ring-assembly structure. The aryl group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted. The aryl group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{40} and Q^{110} to Q^{140} is preferably a phenyl group, an (o-, m-, p-) tolyl group, a pyrenyl group, a perylenyl group, a coronenyl group, a (1-, and 2-) naphthyl group, an anthryl group, a (o-, m-, p-) biphenyl group, a taphenyl group and a phenanthryl group.

[0089] Although the amino group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted, the amino group(s) is preferably substituted and may be an alkylamino group, an arylamino group, an aralkylamino group or the like. The above amino groups each preferably contain fatty series having 1 to 6 carbon atoms in total and/or an aromatic carbon ring having 1 to 4 rings. Examples of such an amino group are a dimethylamino group, a diethylamino group, an abutyl-amino group, a diphenylamino group, a ditolylamino group, a bis-diphenylamino group and a bis-naphtylamino group.

[0090] The heterocyclic group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted. Examples of the heterocyclic group(s) are a five- or six-membered aromatic heterocyclic group containing O, N and S as heteroatoms and a fused polycyclic aromatic group having 2 to 20 carbon atoms. Examples of the aromatic heterocyclic group and the fused polycyclic aromatic heterocyclic group are a thienyl group, a furyl group, a pyronyl group, a pyridyl group, a quinolyl group and a quinoxalyl group.

[0091] Preferable Examples of the substituted or unsubstituted alkenyl group(s) having 1 to 20 carbon atoms represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} are a (1- and 2-) phenylalkenyl group, a (1,2- and 2,2-) diphenylalkenyl group and a (1,2,2-)triphenylalkenyl group that are each substituted by at least one phenyl group. Each of the above examples may be unsubstituted.

[0092] The alkoxy group(s) or the alkylthio group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted. The alkoxy group(s) or the alkylthio group(s) preferably contains the above-described alkyl group.

[0093] The aryloxy group(s) or the arylthio group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted. The aryloxy group(s) or the arylthio group(s) preferably has an aryl group. An example of the aryloxy group(s) is an (o-, m-, p-) phenoxy group while an example of the arylthio group(s) is an (o-, m-, p-) phenylthio group.

[0094] The aralkyl group(s) represented by Q^{10}, Q^{40}, Q^{50} to Q^{80} and Q^{110} to Q^{140} may be substituted or unsubstituted, examples of which are a benzyl group and a phenethyl group.

[0095] When Q^{10}, Q^{40}, Q^{50} to Q^{80}, and Q^{110} to Q^{140} are substituted, at least two of the substituents contained, particularly, in Q^{10} and Q^{40} are each preferably an aryl group, an amino group, a heterocyclic group, an alkenyl group or an aryloxy group, more preferably an aryl group. The same as described in relation to Q^{10} and Q^{40} applies to the aryl group, the amino group, the heterocyclic group and the alkenyl group.

[0096] Two or more of the above substituents may form a fused ring. The above substituents may be further substituted, preferable substituents for which are the same as in the above description.

[0097] When Q^{10}, Q^{40}, Q^{50} to Q^{80}, and Q^{10} to Q^{140} are substituted, at least two, particularly, of Q^{10} and Q^{40} each preferably contain the above substituent. The substitution positions are not subject to any specific limitations. When Q^{10} and/or Q^{40} contains phenyl, the substitution positions may be any one of meta, para and ortho positions.

[0098] In the above formula (3), at least one of Q^{10} to Q^{80} is preferably a substituted or unsubstituted aryl group. More preferably, at least one of Q^{10} and Q^{40} is a substituted or unsubstituted aryl group.

[0099] Specifically, the naphthacene derivative is represented by the above formula (3).

[0100] In the formula (3), Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40} to Q^{80} and Q^{110} to Q^{140} each represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted amino group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted alkylthio group, a substituted or unsubstituted aryloxy group, a substituted or unsubstituted arylthio group, a substituted or unsubstituted alkenyl group, a substituted or unsubstituted aralkyl group, or a substituted or unsubstituted heterocyclic group. Q^{10}, Q^{21} to Q^{25} Q^{31} to Q^{35}, Q^{40} to Q^{80} and Q^{110} to Q^{140} may be mutually the same or different. Adjacent two or more of Q^{21} to Q^{25} and Q^{31}

to Q^{35} may be mutually bonded to form a cyclic structure. At least one of Q^{21}, Q^{25}, Q^{31} and Q^{35} represents a substituted or unsubstituted aryl group.

[0101] In the formula (3), Q^{21} to Q^{25} and Q^{31} to Q^{35} are each preferably selected from a group consisting of a hydrogen group, an aryl group, an amino group, a heterocyclic group, an aryloxy group and an alkenyl group, more preferably an aryl group. In addition, at least one of Q^{21} to Q^{25} and Q^{31} to Q^{35} is substituted by an aryl group. Adjacent two or more of the above may form a fused ring. The same as described in relation to Q^{10} and Q^{40} applies to preferable examples of the aryl group, the amino group, the heterocyclic group and the alkenyl group.

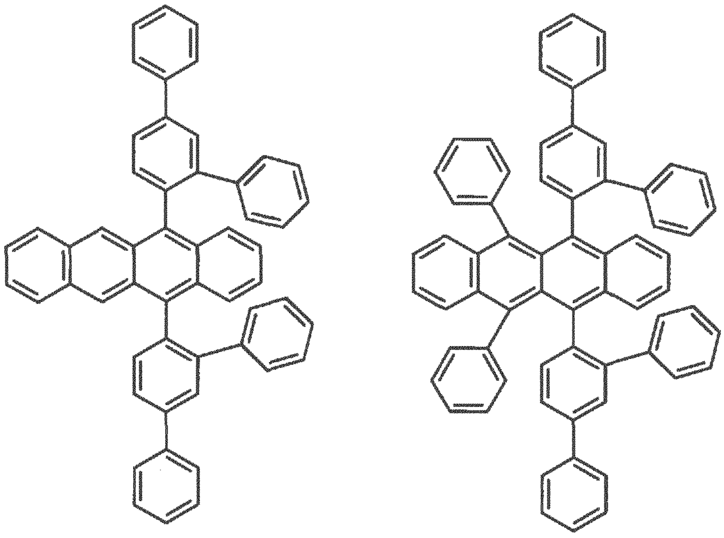
[0102] In addition, although a structure where Q^{21} to Q^{25} and Q^{31} to Q^{35} are the same is preferable, Q^{21} to Q^{25} may be different from Q^{31} to Q^{35}. Examples of the amino group for substituting Q^{21} to Q^{25} and Q^{31} to Q^{35} are an alkylamino group, an arylamino group and an aralkylamino group. The above amino groups each preferably contain fatty series having 1 to 6 carbon atoms in total and/or an aromatic carbon ring having 1 to 4 rings. Examples of such an amino group are a dimethylamino group, a diethylamino group, an abutyl-amino group, a diphenylamino group, a ditolylamino group, a bis-diphenylamino group and a bis-naphtylamino group.

[0103] Examples of the fused ring formed as above are indene, naphthalene, anthracene, phenanthrene, quinoline, isoquinoline, quinoxaline, phenazine, acridine, indole, carbazole, phenoxazine, phenothiazine, benzothiazole, benzothiophene, benzofuran, acridone, benzoimidazole, coumarin and flavone.

[0104] Q^{10}, Q^{40} and Q^{110} to Q^{140} are each particularly preferably a hydrogen atom.

[0105] Examples of the aromatic compound represented by the general formula (3) according to the present invention will be shown below.

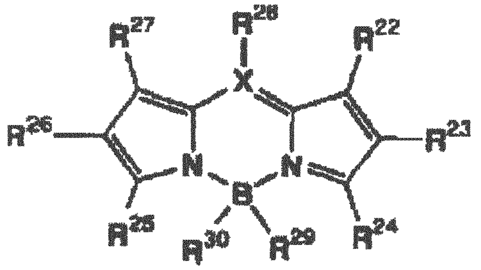
[Chemical Formula 9]



[0106] The dopant is a compound having the pyrromethene skeleton represented by the formula (2) or a metal complex of the compound.

[0107] The compound having the pyrromethene skeleton represented by the formula (2) or the metal complex of the compound is preferably a compound having a pyrromethene skeleton represented by the following formula (2-1) or a metal complex of the compound.

[Chemical Formula 10]



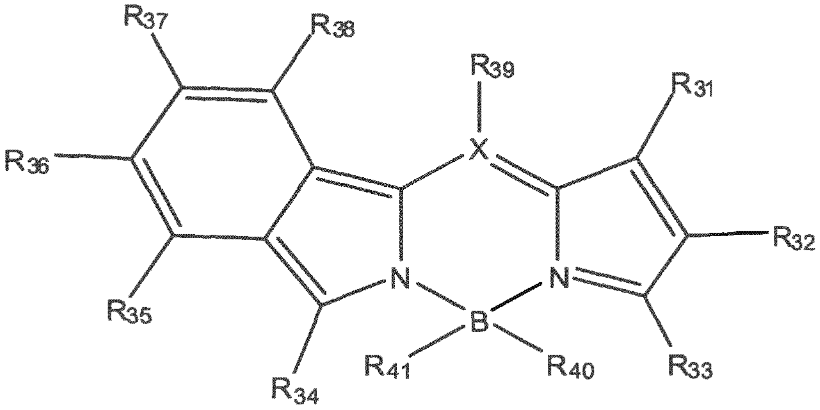
(2 − 1)

[0108] In the formula (2-1), at least one of R^{22} to R^{28} is a substituent having an aromatic ring or forms a fused aromatic ring together with an adjacent substituent while the rest of R^{22} to R^{28} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. The rest of R^{22} to R^{28} each may form a fused ring or an aliphatic ring with an adjacent substituent. R^{22} to R^{28} may be mutually the same or different and may be substituted or unsubstituted. R^{29} and R^{30} may be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, substituted or unsubstituted alkyl, substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group. X represents a carbon atom or a nitrogen atom on a condition that R^{28} above does not exist when X represents a nitrogen atom.

[0109] When one or more of R^{22} to R^{28} forms a fused aromatic ring(s) together with adjacent substituent(s), the fused aromatic ring(s) is preferably formed by a pair of R^{22} and R^{23}, a pair of R^{23} and R^{24}, a pair of R^{25} and R^{26} and/or a pair of R^{26} and R^{27}. The fused aromatic ring(s) is particularly preferably formed by the pair of R^{22} and R^{23} and/or the pair of R^{26} and R^{27}. Examples of the fused aromatic ring(s) are a benzo ring and a naphtho ring.

[0110] The compound having the pyrromethene skeleton represented by the formula (2) or the metal complex of the compound is preferably a compound having a pyrromethene skeleton represented by the following formula (2-2) or a metal complex of the compound.

[Chemical Formula 11]



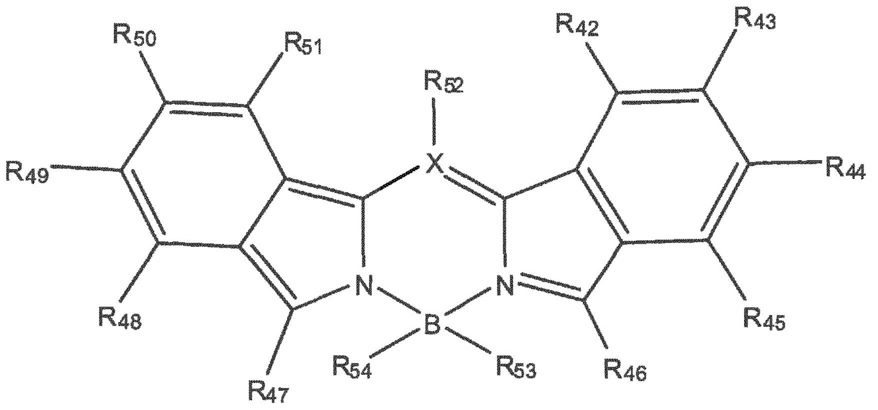
(2−2)

[0111] In the formula (2-2), R_{31} to R_{39} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. R_{31} to R_{39} may be mutually the same or different and may be substituted or unsubstituted. R_{40} and R_{41} may be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, substituted or unsubstituted alkyl, substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group. X represents a carbon atom or a nitrogen atom on a condition that R_{39} above does not exist when X represents a nitrogen atom.

[0112] According to the present invention, the compound having the pyrromethene skeleton represented by the formula

(2-1) or the metal complex of the compound is preferably a metal complex having a pyrromethene skeleton represented by the following formula (2-3).

[Chemical Formula 12]

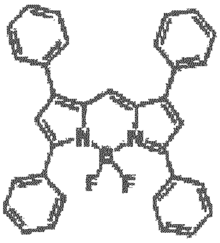


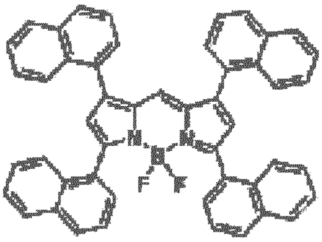
(2-3)

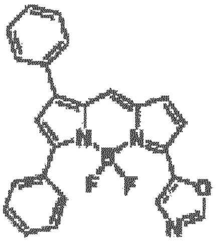
[0113] In the formula (2-3), R_{42} to R_{52} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group. R_{42} to R_{52} may be mutually the same or different and may be substituted or unsubstituted. R_{53} and R_{54} may be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, a substituted or unsubstituted alkyl, a substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group. X represents a carbon atom or a nitrogen atom on a condition that R_{52} above does not exist when X represents a nitrogen atom.

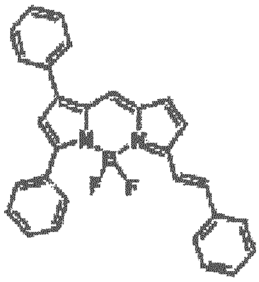
[0114] Examples of the aromatic compound represented by the general formula (2) according to the present invention will be shown below.

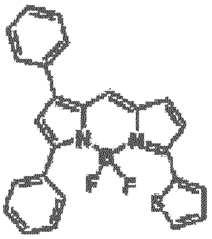
[Chemical Formula 13]

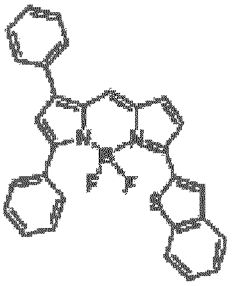


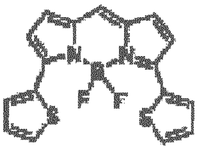


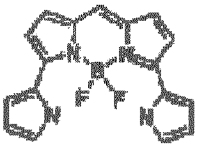


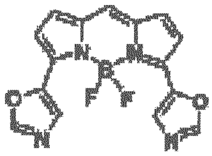


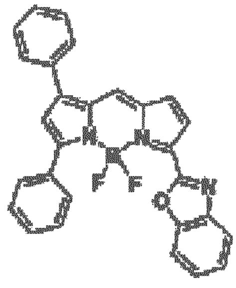


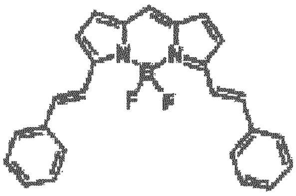


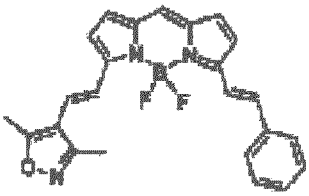


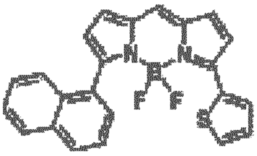


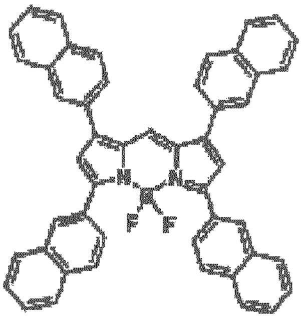


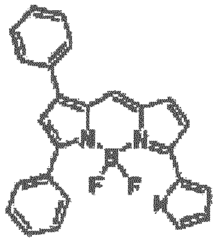


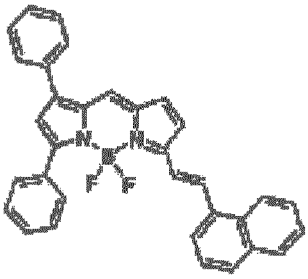


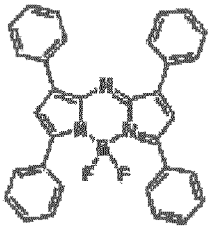








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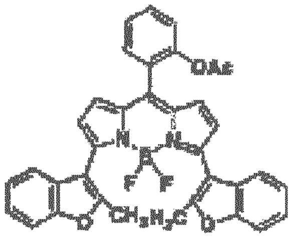
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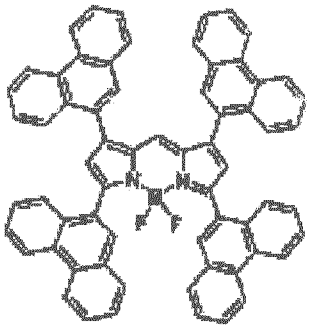
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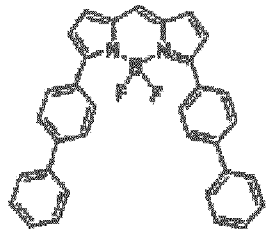
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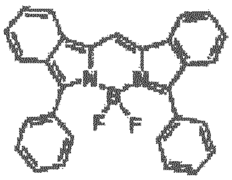
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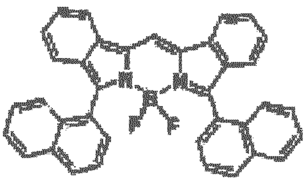
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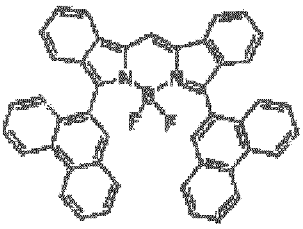
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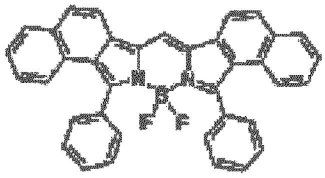
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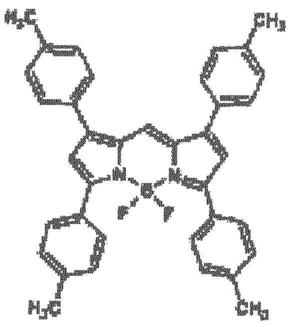
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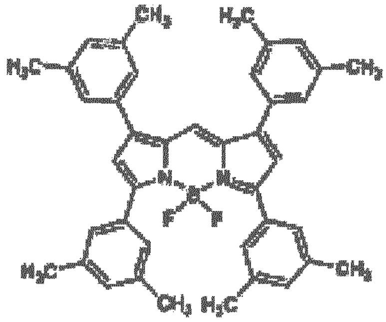
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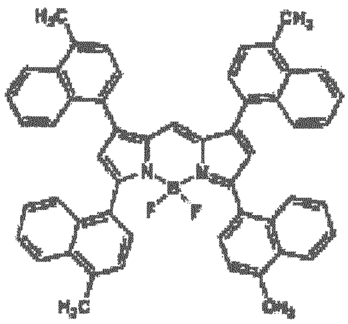
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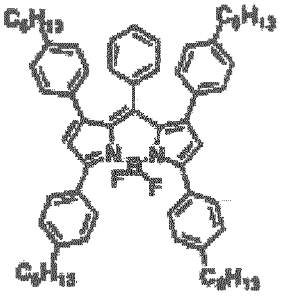
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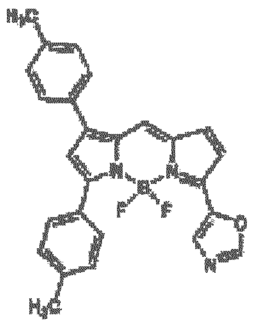
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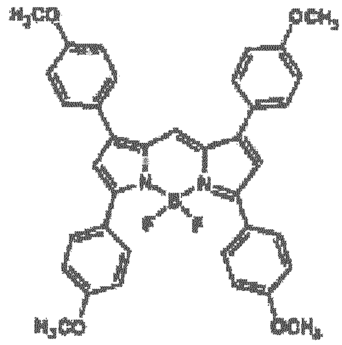
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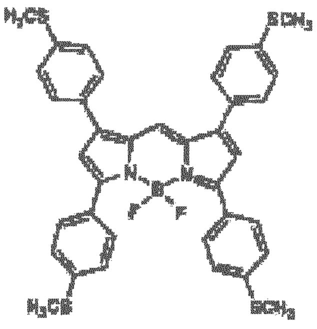
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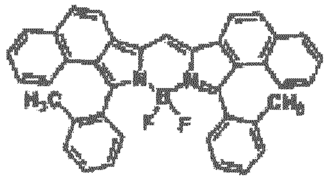
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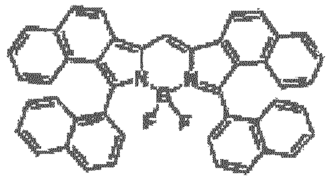
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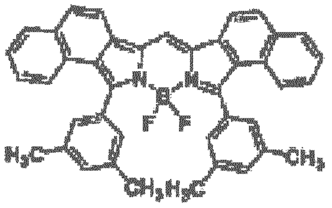
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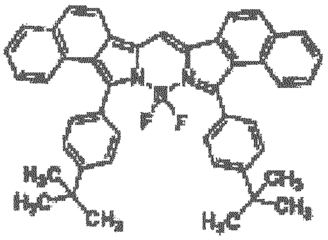
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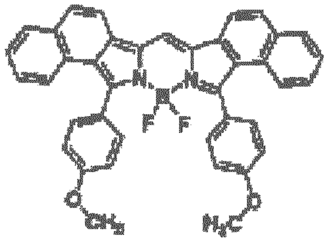
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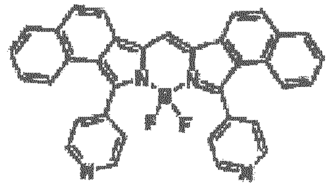
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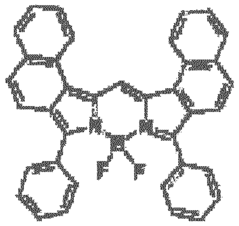
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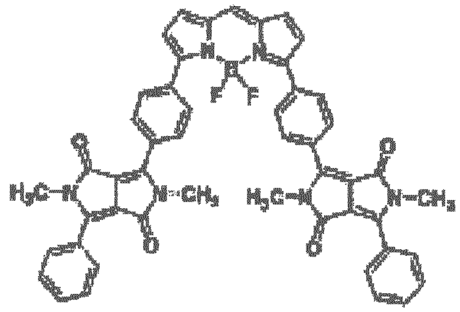
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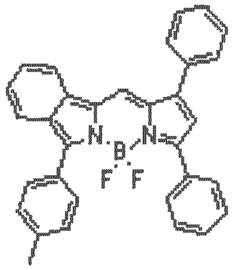
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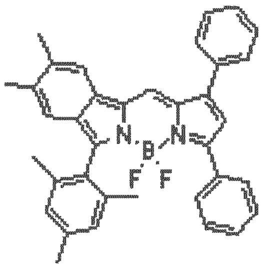
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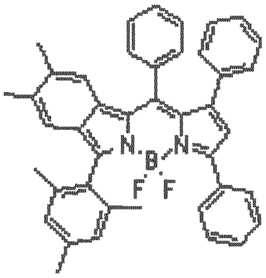
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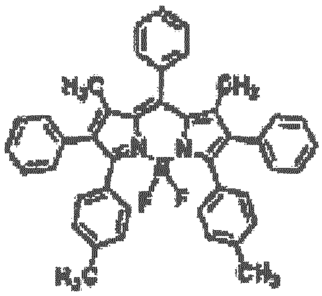
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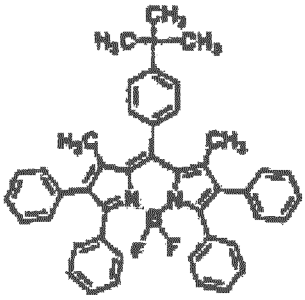
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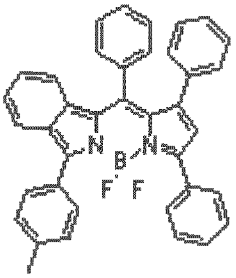
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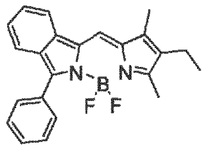
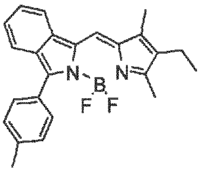
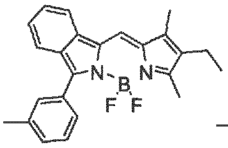
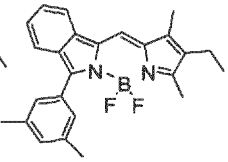
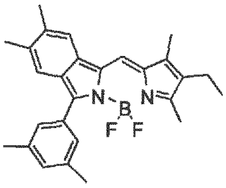
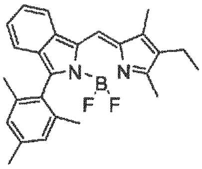
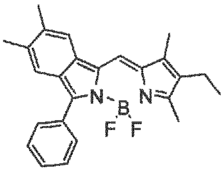
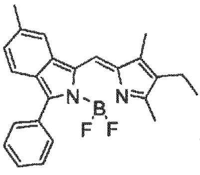
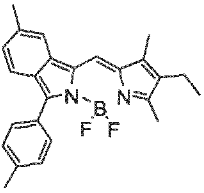
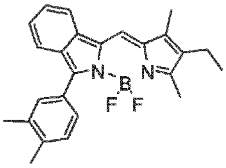
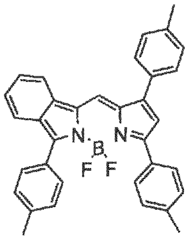
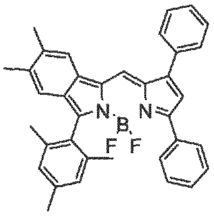
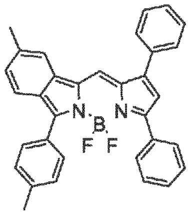
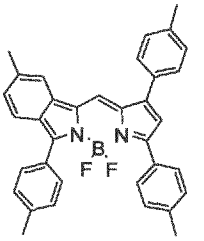
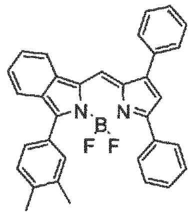
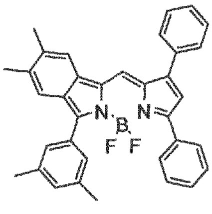
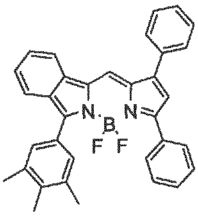
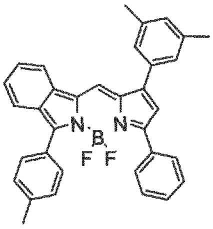
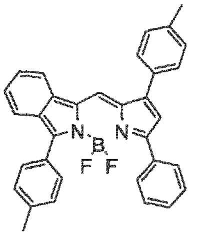
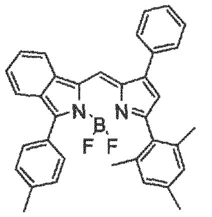
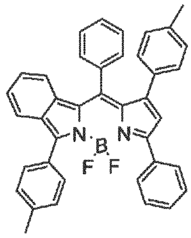
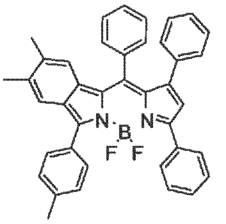
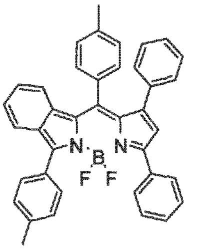
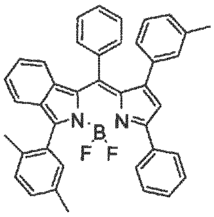
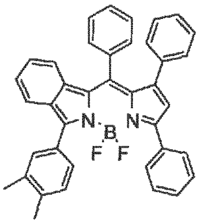
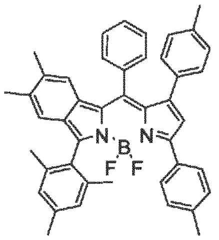
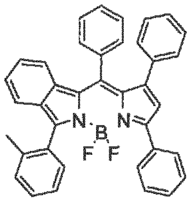
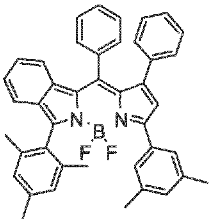
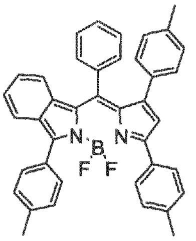
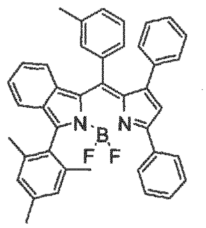

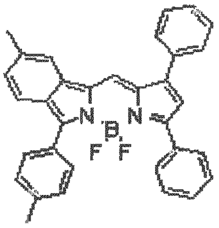
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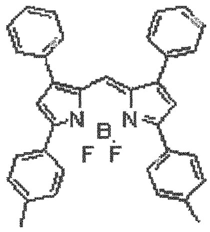
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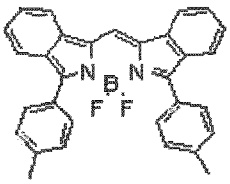
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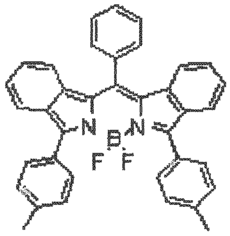
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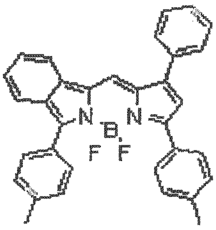
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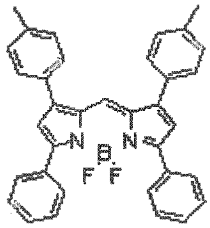
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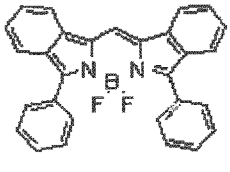
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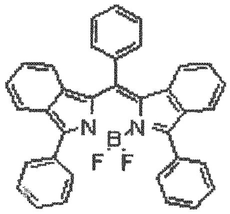
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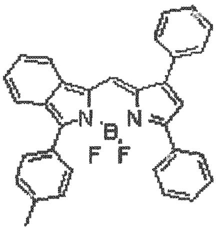
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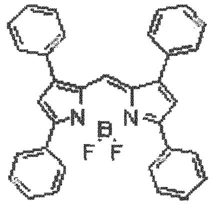
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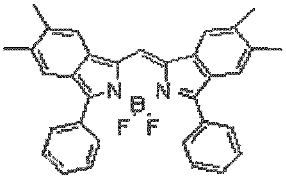
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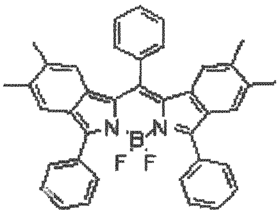
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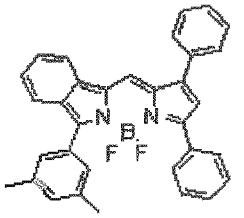
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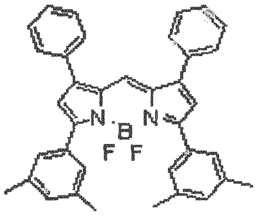
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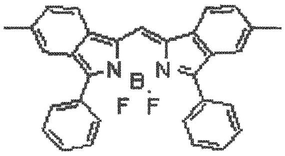
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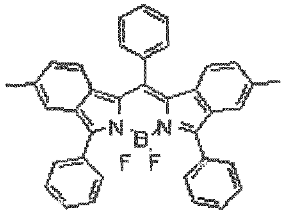
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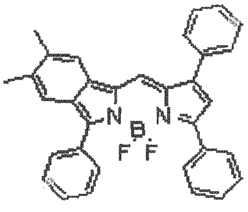
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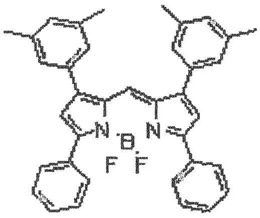
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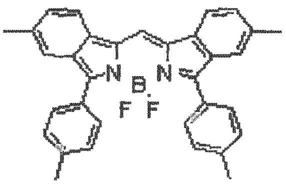
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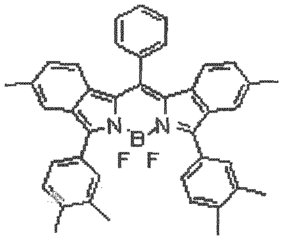
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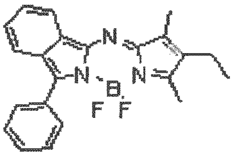
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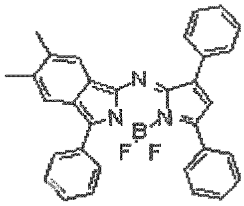
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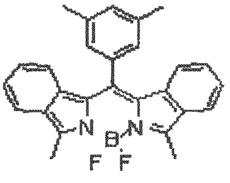
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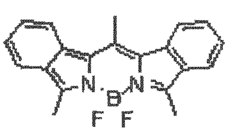
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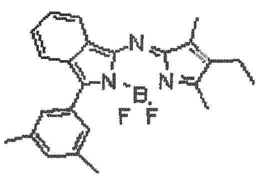
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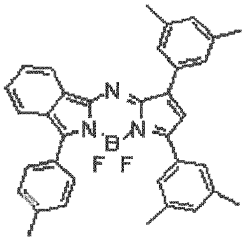
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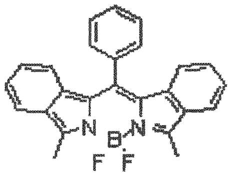
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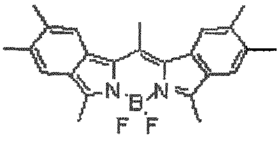
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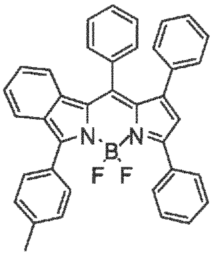
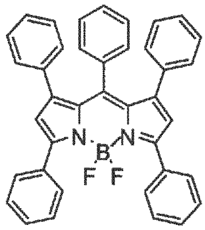
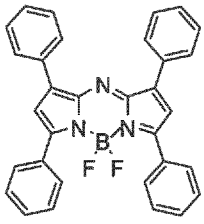
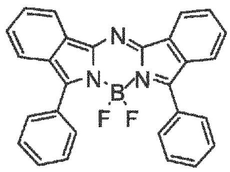
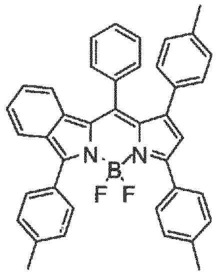
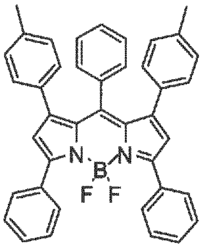
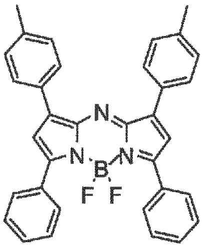
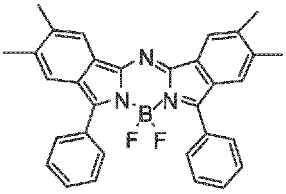
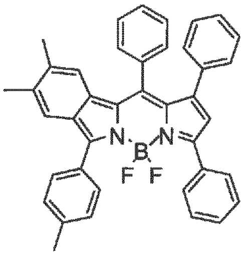
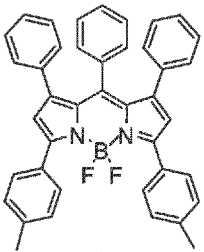
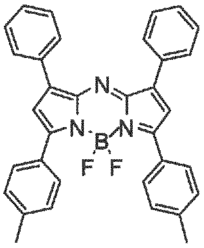
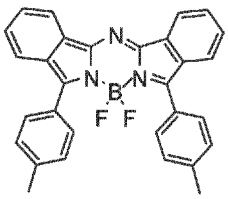
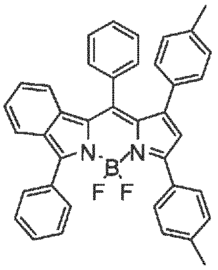
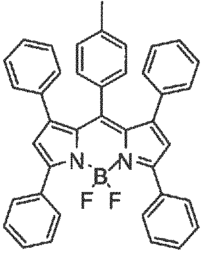
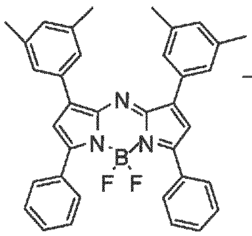
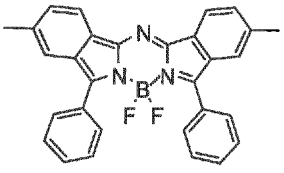
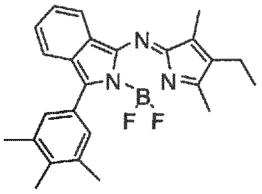
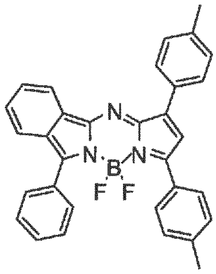
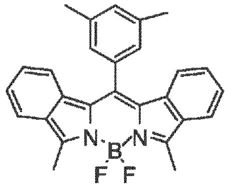
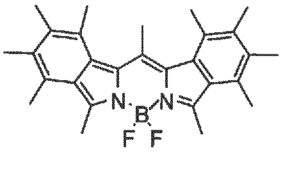
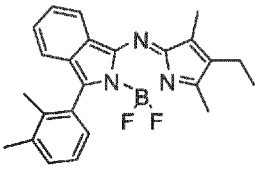
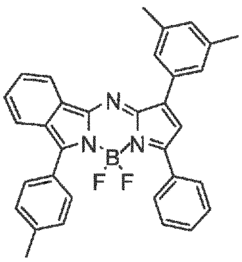
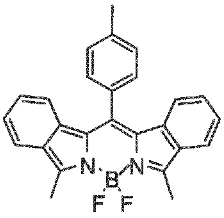
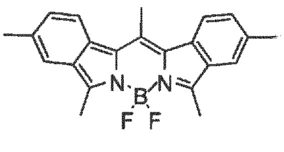





[0115] In the above formulae, Q^{10} to Q^{140} and R^{15} to R^{54} may be substituted or unsubstituted as specified above, a substituent for each of which is preferably an alkyl group, an aryl group or an alkoxy group.

[0116] The alkyl group is preferably an alkyl group having 1 to 20 carbon atoms, more preferably an alkyl group having 1 to 10 carbon atoms, further preferably an alkyl group having 1 to 5 carbon atoms. The alkyl group may be linear or branched. The alkyl group may be a primary alkyl group, a secondary alkyl group or a tertiary alkyl group.

[0117] Preferable examples of the alkyl group are a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-nonyl group and an n-decyl group.

[0118] The aryl group is preferably an aryl group having 6 to 30 carbon atoms, more preferably an aryl group having 6 to 20 carbon atoms. Examples of the aryl group are a phenyl group, a tolyl group, a xylyl group, a phenylphenyl group (4-phenylphenyl group, 3-phenylphenyl group, 2-phenylphenyl group), a naphthylphenyl group, a naphthyl group (1-naphthyl group, 2-naphthyl group), a phenylnaphthyl group, a naphthylnaphthyl group, a taphenyl group, an anthranil group, a phenantryl group, a pyrenyl group and a chrysenyl group.

[Hole Transporting Layer and Hole Injecting Layer]

[0119] The hole transporting layer helps injection of the holes into the emitting layer and transports the holes to an emitting region, in which the hole mobility is large and the energy of ionization is typically small (5.5 eV or smaller). A material of the hole transporting layer is preferably such a material that transports the holes to the emitting layer with a low field intensity, and more preferably such a material that transports the holes with the hole mobility of at least 10^{-4} $cm^2/V*sec$ when the exemplary electrical field of 10^4 to 10^6 V/cm is applied.

[0120] A material for the hole transporting layer is not specifically limited as long as the material has the above preferable characteristics. Any materials conventionally used for transporting charges of the holes in photoconducting materials or any materials publicly known to be applicable to the hole transporting layers of the EL devices may be used.

[0121] Examples of the material are a triazole derivative (see, for instance, the specification of US Patent No. 3,112,197), an oxadiazole derivative (see, for instance, the specification of US Patent No. 3,189,447), an imidazole derivative (see, for instance, the publication of JP-B-37-16096), a polyarylalkane derivative (see, for instance, the specifications of US Patent No. 3,615,402, No.3,820,989 and No. 3,542,544 and the publications of JP-B-45-555, JP-B-51-10983, JP-A-51-93224, JP-A-55-17105, JP-A-56-4148, JP-A-55-108667, JP-A-55-156953, and JP-A-56-36656), a pyrazoline derivative and a pyrazolone derivative (see, for instance, the specifications of US Patent No. 3,180,729 and No. 4,278,746 and the publications of JP-A-55-88064, JP-A-55-88065, JP-49-105537, JP-A-55-51086, JP-A-56-80051, JP-A-56-88141, JP-A-57-45545, JP-A-54-112637 and JP-A-55-74546, a phenylenediamine derivative (see, for instance, the specification of US Patent No. 3,615,404 and the publications of JP-B-51-10105, JP-B-46-3712, JP-B-47-25336 and JP-A-54-119925), an arylamine derivative (see, for instance, the specifications of US Patent No. 3,567,450, No. 3,240,597, No. 3,658,520, No. 4,232,103, No. 4,175,961 and No. 4,012,376 and the publications of JP-B-49-35702, JP-B-39-27577, JP-A-55-144250, JP-A-56-119132 and JP-A-56-22437 and the specification of West Germany Patent No. 1,110,518), an amino-substituted chalcone derivative (see, for instance, the specification of US Patent No. 3,526,501), an oxazole derivative (disclosed in, for instance, the specification of US Patent No. 3, 257,203), a styrylanthracene derivative (see, for instance, the publication of JP-A-56-46234), a fluorenone derivative (see, for instance, the publication of JP-A-54-110837), a hydrazone derivative (see, for instance, the specification of US Patent No. 3,717,462 and the publications of JP-A-54-59143, JP-A-55-52063, JP-A-55-52064, JP-A-55-46760, JP-A-57-11350, JP-A-57-148749 and JP-A-2-311591), a stilbene derivative (see, for instance, the publications of JP-A-61-210363, JP-A-61-228451, JP-A-61-14642, JP-A-61-72255, JP-A-62-47646, JP-A-62-36674, JP-A-62-10652, JP-A-62-30255, JP-A-60-93455, JP-A-60-94462, JP-A-60-174749 and JP-A-60-175052), a silazane derivative (see the specification of US Patent No. 4,950,950), a polysilane type (see the publication of JP-A-2-204996), an aniline-based copolymer (see the publication of JP-A-02-282263), and a conductive high-molecular oligomer (particularly, thiophene oligomer).

[0122] Preferably, a material represented by the following formula (7) may be used.

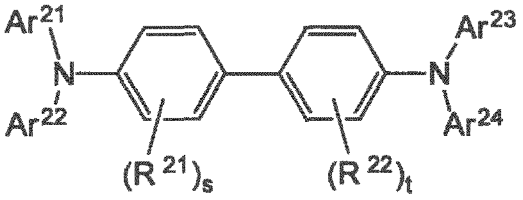
[0123] [Chemical Formula 14]

$$Q^1\text{-}G\text{-}Q^2 \qquad (7)$$

[0124] In the formula (7), Q^1 and Q^2 each represent a portion having at least one tertiary amine while G represents a linking group.

[0125] More preferable material is an amine derivative represented by the following formula (8).

[Chemical Formula 15]



(8)

[0126] In the above formula (8), Ar^{21} to Ar^{24} each represent a substituted or unsubstituted aromatic ring having 6 to 50 carbon atoms forming the ring or a substituted or unsubstituted heteroaromatic ring having 5 to 50 atoms forming the ring. R^{21} and R^{22} each represent a substituent while s and t each represent an integer in a range of 0 to 4. Ar^{21} and Ar^{22} may be bonded together to form a cyclic structure while Ar^{23} and Ar^{24} may also be bonded together to form a cyclic structure. R^{21} and R^{22} may also be bonded together to form a cyclic structure.

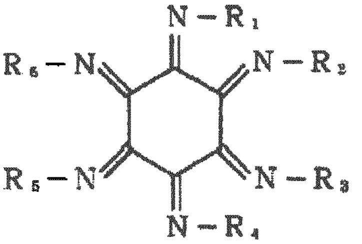
[0127] The substituent for Ar^{21} to Ar^{24} each, and R^{21} and R^{22} are selected from a group consisting of a substituted or unsubstituted aromatic ring having 6 to 50 carbon atoms forming the ring, a substituted or unsubstituted heteroaromatic ring having 5 to 50 atoms forming the ring, an alkyl group having 1 to 50 carbon atoms, an alkoxy group having 1 to 50 carbon atoms, an alkylaryl group having 1 to 50 carbon atoms, an aralkyl group having 1 to 50 carbon atoms, a styryl group, an amino group substituted by an aromatic ring having 6 to 50 carbon atoms forming the ring or by a heteroaromatic ring having 5 to 50 atoms forming the ring, an aromatic ring having 6 to 50 carbon atoms forming the ring substituted by an amino group substituted by an aromatic ring having 6 to 50 carbon atoms forming the ring or by a heteroaromatic ring having 5 to 50 atoms forming the ring, and a heteroaromatic ring having 5 to 50 atoms forming the ring substituted by an amino group substituted by an aromatic ring having 6 to 50 carbon atoms forming the ring or by a heteroaromatic ring having 5 to 50 atoms forming the ring.

[0128] In order to aid the injection of the holes, a hole injecting layer may be provided in addition to the hole transporting layer. The above materials for the hole transporting layer can be used as the materials of the hole injecting layer, preferable examples of which are a porphyrin compound (disclosed in JP-A-63-295695), an aromatic tertiary amine compound and a styrylamine compound (see, for instance, the specification of US Patent No. 4,127,412, JP-A-53-27033, JP-A-54-58445, JP-A-55-79450, JP-A-55-144250, JP-A-56-119132, JP-A-61-29558, JP-A-61-98353 and JP-A-63-295695). Among these, use of an aromatic tertiary amine compound is particularly preferable.

[0129] In addition, 4,4'-bis(N-(1-naphthyl)-N-phenylamino)biphenyl (hereinafter, abbreviated as NPD) having in the molecule two fused aromatic rings disclosed in US Patent No. 5,061,569, 4,4',4"-tris(N-3-methylphenyl-N-phenylamino)triphenylamine (hereinafter, abbreviated as MTDATA) in which three triphenylamine units disclosed in JP-A-04-30868 are bonded in a starbust form and the like may also be used.

[0130] As another example, a nitrogen-containing heterocyclic derivative represented by the following formula (9), which is disclosed in Japanese Patent No. 03571977, may be used.

[Chemical Formula 16]

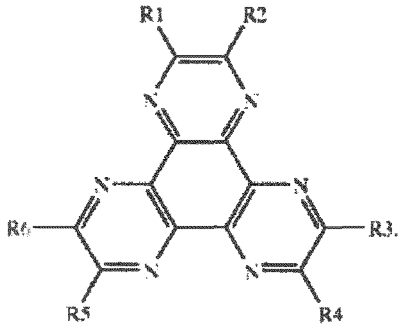


(9)

[0131] In the formula (9), R_1 to R_6 each represent a substituted or unsubstituted alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted aralkyl group, or a substituted or unsubstituted heterocyclic group. R_1 to R_6 may be mutually the same or different. A pair of R_1 and R_2, a pair of R_3 and R_4 or a pair of R_5 and R_6 may form a fused ring(s). Alternatively, a pair of R_1 and R_6, a pair of R_2 and R_3 or a pair of R_4 and R_5 may form a fused ring(s).

[0132] As another example, a compound represented by the following formula (10), which is disclosed in US 2004/113547A1, may be used.

[Chemical Formula 17]



(10)

[0133] In the formula (10), R1 to R6 each represent a substituent, a preferable example of which is an electron-attracting group such as a cyano group, a nitro group, a sulfonyl group, a carbonyl group, a trifluoromethyl group and halogen.

[0134] In addition to aromatic dimethylidyne-based compounds, inorganic compounds such as p-type Si and p-type SiC can be used as the material of the hole injecting layer.

[0135] The hole injecting layer and the hole transporting layer can be formed by forming thin films from the compounds listed above by known methods such as vacuum deposition, spin coating, casting and the LB method. Although the thickness of the hole injecting layer and the hole transporting layer is not particularly limited, the thickness is typically in the range from 5 nm to 5 μm. The hole injecting layer and the hole transporting layer may be formed by a single layer formed of at least one of the above materials as long as the hole injecting layer and the hole transporting layer contains the above compound(s) in the hole transporting region. Alternatively, the hole injecting layer and the hole transporting layer may be formed by laminating layers respectively formed of a different material.

[0136] In addition, an organic semiconductor layer, which is a part of the hole transporting layer, aids the injection of the holes or the electrons into the emitting layer. The organic semiconductor layer preferably has electric conductivity of 10^{-10}S/cm or more. Examples of a material for the organic semiconductor layer are a conductive oligomer such as a thiophene-containing oligomer or an arylamine-containing oligomer (disclosed in JP-A-08-193191), and a conductive dendrimer such as an arylamine-containing dendrimer.

[Electron Injecting/Transporting Layers (Electron Transport Zone)]

[0137] The electron transporting layer, which aids injection of the electrons into the emitting layer, has a high electron mobility. The thickness of the electron transporting layer is suitably selected from the range of several nanometers to several micrometers. However, especially when the thickness of the electron transporting layer is large, the electron mobility, in order to prevent voltage from rising, is preferably at least 10^{-5} cm^2/Vs or higher with the electrical field of 10^4 to 10^6 V/cm applied.

[0138] The electron transporting layer contains a compound represented by any one of the following formulae (5) and (6).

[0139] In the formulae (5) and (6), R represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms while p represents an integer in a range of 1 to 4.

[0140] Preferable examples of the aryl group having 6 to 60 carbon atoms are a phenyl group, 1-naphthyl group, 2-naphthyl group, 1-anthryl group, 2-anthryl group, 9-anthryl group, 1-phenanthryl group, 2-phenanthryl group, 3-phenanthryl group, 4-phenanthryl group, 9-phenanthryl group, 1-naphthacenyl group, 2-naphthacenyl group, 9-naphthacenyl group, 1-pyrenyl group, 2-pyrenyl group, 4-pyrenyl group, 2-biphenylyl group, 3-biphenylyl group, 4-biphenylyl group, p-ta-phenyl-4-yl group, p-ta-phenyl-3-yl group, p-ta-phenyl-2-yl group, m-ta-phenyl-4-yl group, m-ta-phenyl-3-yl group, m-ta-phenyl-2-yl group, o-tolyl group, m-tolyl group, p-tolyl group, p-t-butylphenyl group, p-(2-phenylpropyl)phenyl group, 3-methyl-2-naphthyl group, 4-methyl-1-naphthyl group, 4-methyl-1-anthryl group, 4'-methylbiphenylyl group, 4"-t-butyl-p-ta-phenyl-4-yl group, fluoranthenyl group and fluorenyl group. More preferable examples thereof are a phenyl group, naphthyl group, biphenyl group, anthracenyl group, phenanthryl group, pyrenyl group, crycenyl group, fluoranthenyl group and fluorenyl group.

[0141] Preferable examples of the alkyl group having 1 to 20 carbon atoms are a methyl group, ethyl group, propyl group, isopropyl group, n-butyl group, s-butyl group, isobutyl group, t-butyl group, n-pentyl group, n-hexyl group, n-heptyl group, n-octyl group, hydroxymethyl group, 1-hydroxyethyl group, 2-hydroxyethyl group, 2-hydroxyisobutyl group, 1,2-dihydoroxyethyl group, 1,3-dihydroxyisopropyl group, 2,3-dihydroxy-t-butyl group, 1,2,3-trihydroxypropyl group, chloromethyl group, 1-chloroethyl group, 2-chloroethyl group, 2-chloroisobutyl group, 1,2-dichloroethyl group, 1,3-dichloroisopropyl group, 2,3-dichloro-t-butyl group, 1,2,3-trichloropropyl group, bromomethyl group, 1-bromoethyl group, 2-bromoethyl group, 2-bromoisobuthyl group, 1,2-dibromoethyl group, 1,3-dibromoisopropyl group, 2,3-dibromo-t-butyl group, 1,2,3-tribromopropyl group, iodomethyl group, 1-iodoethyl group, 2-iodoethyl group, 2-iodoisobutyl group, 1,2-diiodoethyl group, 1,3-diiodoisopropyl group, 2,3-diiodo-t-butyl group, 1,2,3-triiodopropyl group, aminomethyl group, 1-aminoethyl group, 2-aminoethyl group, 2-aminoisobutyl group, 1,2-diaminoethyl group, 1,3-diaminoisopropyl group, 2,3-diamino-t-butyl group, 1,2,3-triaminopropyl group, cyanomethyl group, 1-cyanoethyl group, 2-cyanoethyl group, 2-cyanoisobutyl group, 1,2-dicyanoethyl group, 1,3-dicyanoisopropyl group, 2,3-dicyano-t-butyl group, 1,2,3-tricyanopropyl group, nitromethyl group, 1-nitroethyl group, 2-nitroethyl group, 2-nitroisobutyl group, 1,2-dinitroethyl group, 1,3-dinitroisopropyl group, 2,3-dinitro-t-butyl group, 1,2,3-trinitropropyl group, cyclopropyl group, cyclobutyl group, cyclopentyl group, cyclohexyl group, 4-methylcyclohexyl group, 1-adamantyl group, 2-adamantyl group, 1-norbornyl group and 2-norbornyl goup.

[0142] The alkoxy group having 1 to 20 carbon atoms is a group represented by -OY'". Examples of Y'" are the same as those of the above alkyl group.

[0143] Examples of the substituent for the aryl group, the pyridyl group, the quinolyl group, the alkyl group or the alkoxy group are a substituted or unsubstituted aryl group having 6 to 50 carbon atoms forming the ring, a substituted or unsubstituted aromatic heterocyclic group having 5 to 50 atoms forming the ring, a substituted or unsubstituted alkyl group having 1 to 50 carbon atoms, a substituted or unsubstituted alkoxy group having 1 to 50 carbon atoms, a substituted or unsubstituted aralkyl group having 1 to 50 carbon atoms, a substituted or unsubstituted aryloxy group having 5 to 50 atoms forming the ring, a substituted or unsubstituted arylthio group having 5 to 50 atoms forming the ring, a substituted or unsubstituted carboxyl group having 1 to 50 carbon atoms, a halogen group, a cyano group, a nitro group and a hydroxyl group.

[0144] p represents an integer in a range of 1 to 4. Preferably, p is any one of 1 to 3, more preferably 1 or 2.

[0145] R preferably represents a hydrogen atom.

[0146] R^{11} represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or an alkoxy group having 1 to 20 carbon atoms. Examples of each group and substituent are the same as R.

[0147] R^{12} represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms. Examples of each group and substituent are the same as R.

[0148] L represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridinylene group, a substituted or unsubstituted quinolinylene group, or a substituted or unsubstituted fluorenylene group.

[0149] Preferable examples of the arylene group having 6 to 60 carbon atoms are divalent substituents formed by further removing one hydrogen atom from the substituents listed in the description of the aryl group having 6 to 60 carbon atoms. More preferable examples thereof are a phenylene group, naphthylene group, biphenylene group, anthracenylene group, phenantolylene group, pyrenylene group, chrysenylene group, fluoranthenylene group and fluorenylene group.

[0150] Examples of the substituent for each of the arylene group, the pyridinylene group, the quinolinylene group or the fluorenylene group are the same as R.

[0151] Ar^1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms (preferably, 6 to 30 carbon atoms), a substituted or unsubstituted pyridyl group or a substituted or unsubstituted quinolyl group.

[0152] Examples of the substituent for each of the aryl group having 6 to 60 carbon atoms, the aryl group, the pyridyl group or the quinolyl group are the same as R.

[0153] Preferably in the benzoimidazole derivative represented by the formula (5): R represents a hydrogen atom; R^{11} represents an aryl group; L represents an arylene group having 6 to 30 carbon atoms (preferably, 6 to 20 carbon atoms); and Ar^1 represents an aryl group having 6 to 30 carbon atoms.

[0154] Preferably in the benzoimidazole derivative represented by the formula (6): R represents a hydrogen atom; R^{12} represents an aryl group; L represents an arylene group having 6 to 30 carbon atoms (preferably, 6 to 20 carbon atoms); and Ar^1 represents an aryl group having 6 to 30 carbon atoms.

[0155] The compound(s) represented by the formulae (5) and (6) are applied to the electron transporting layer.

[0156] As a preferred embodiment of the organic EL device according to the present invention, there is known a device containing a reductive dopant at a boundary between a region transporting the electrons or the cathode and an organic layer. The reductive dopant is defined as a substance capable of reducing an electron transporting compound. Thus, various substances having a certain level of reducibility can be used, preferable examples of which are at least one substance selected from a group consisting of: alkali metal, alkali earth metal, rare earth metal, an oxide of the alkali metal, a halogenide of the alkali metal, an oxide of the alkali earth metal, a halogenide of the alkali earth metal, an oxide of the rare earth metal, a halogenide of the rare earth metal, an organic complex of the alkali metal, an organic complex of the alkali earth metal and an organic complex of the rare earth metal.

[0157] Specifically, the reductive dopant is preferably a substance(s) having the work function of 2.9 eV or lower, which is exemplified by at least one alkali metal selected from a group consisting of Na (work function: 2.36 eV), K (work function: 2.28 eV), Rb (work function: 2.16 eV) and Cs (work function: 1.95 eV) or at least one alkali earth metal selected from a group consisting of Ca (work function: 2.9 eV), Sr (work function: 2.0 to 2.5 eV) and Ba (work function: 2.52 eV). Among these, the reductive dopant is more preferably at least one alkali metal selected from a group consisting of K, Rb and Cs, among which Rb and Cs are even more preferable and Cs is the most preferable. These alkali metals have particularly high reducibility, so that addition of a relatively small amount of these alkali metals to an electron injecting zone can enhance luminescence intensity and lifecycle of the organic electroluminescence device. In addition, as the reductive dopant having the work function of 2.9 eV or lower, a combination of two or more of these alkali metals is also preferable, and a combination including Cs is particularly preferable (e.g. combinations of Cs and Na, Cs and K, Cs and Rb or Cs, Na and K). The combinations including Cs can effectively exert the reducibility, so that the addition of such reductive dopant to the electron injecting zone can enhance the luminescence intensity and the lifecycle of the organic electroluminescence device.

[0158] According to the present invention, an electron injecting layer formed from an insulator or a semiconductor may be provided between the cathode and the organic layer. With the arrangement, leak of electric current can be effectively prevented and the electron injecting capability can be enhanced. As the insulator, it is preferable to use at least one metal compound selected from a group consisting of an alkali metal chalcogenide, an alkali earth metal chalcogenide, a halogenide of alkali metal and a halogenide of alkali earth metal. By forming the electron injecting layer from the alkali metal chalcogenide or the like, the electron injecting capability can preferably be further enhanced. Specifically, preferable examples of the alkali metal chalcogenide are Li_2O, LiO, Na_2S, Na_2Se and NaO, while preferable example of the alkali earth metal chalcogenide are CaO, BaO, SrO, BeO, BaS and CaSe. Preferable examples of the halogenide of the alkali metal are LiF, NaF, KF, LiCl, KCl and NaCl. Preferable examples of the halogenide of the alkali earth metal are fluorides such as CaF_2, BaF_2, SrF_2, MgF_2 and BeF_2, and halogenides other than the fluoride.

[0159] Examples of the semiconductor for forming the electron injecting layer are one of or a combination of two or more of an oxide, a nitride or an oxidized nitride containing at least one element selected from a group consisting of Ba, Ca, Sr, Yb, Al, Ga, In, Li, Na, Cd, Mg, Si, Ta, Sb and Zn. An inorganic compound for forming the electron injecting layer is preferably a microcrystalline or amorphous semiconductor film. When the electron injecting layer is formed of such semiconductor film, more uniform thin film can be formed, thereby reducing pixel defects such as a dark spot. Examples of such an inorganic compound are the above-described alkali metal chalcogenide, alkali earth metal chalcogenide, halogenide of the alkali metal and halogenide of the alkali earth metal.

[Cathode]

[0160] In order to inject the electrons into the electron injecting and transporting layers or the emitting layer, a material whose work function is small (4 eV or lower) is used as an electrode material for the cathode, examples of the material being metals, alloys, electrically conductive compounds and mixtures thereof. Examples of the electrode material are sodium, a sodium-potassium alloy, magnesium, lithium, a magnesium-silver alloy, aluminium/aluminium oxide, an aluminium-lithium alloy, indium, rare earth metal and the like.

[0161] The cathode is made by forming a thin film from the electrode material by vapor deposition and sputtering.

[0162] When the organic EL device is top-emission type, the cathode preferably transmits more than 10% of light emitted by the emitting layer.

[0163] The sheet resistance as the cathode is preferably several hundreds Ω/ square or lower, and the thickness of the film is typically in a range from 10 nm to 1 μm, preferably 50 to 200 nm.

[Insulating Layer]

[0164] Since the electrical field is applied to ultra thin films in the organic electroluminescence device, pixel defects resulted from leak or short circuit are likely to occur. In order to prevent such defects, it is preferable to interpose an insulating thin film layer between a pair of electrodes.

[0165] Examples of a material used for the insulating layer are aluminum oxide, lithium fluoride, lithium oxide, cesium fluoride, cesium oxide, magnesium oxide, magnesium fluoride, calcium oxide, calcium fluoride, cesium fluoride, cesium carbonate, aluminium nitride, titanium oxide, silicon oxide, germanium oxide, silicon nitride, boron nitride, molybdenum oxide, ruthenium oxide, vanadium oxide and the like.

[0166] Mixtures or laminates thereof may also be used.

[Manufacturing Example(s) of Organic EL Device]

[0167] The organic EL device can be manufactured by forming the anode, the emitting layer, the electron transporting layer and the cathode (in addition to the above, forming the hole injecting layer, the hole transporting layer and the electron injecting layer as necessary) from the materials listed above by the above-described formation methods. The organic EL device can also be manufactured by forming the above elements in the inverse order of the above, namely from the cathode to the anode.

[0168] The following is a manufacturing example of the organic EL device in which the anode, the hole transporting layer, the emitting layer, the electron transporting layer and the cathode are sequentially formed on the light-transmissive substrate.

[0169] A thin film is formed of the anode material on a suitable light-transmissive substrate by vapor deposition or sputtering such that the thickness of the thin film is 1 μm or smaller, preferably in a range from 10 nm to 200 nm, thereby forming the anode. Then, the hole transporting layer is formed on the formed anode. The hole transporting layer may be formed by a method such as vacuum deposition, spin coating, casting and the LB method as described above, among which vacuum deposition is preferable in forming the hole transporting layer because the method can easily form homogeneous films and can prevent generation of pin holes. When the hole transporting layer is formed by vacuum deposition, conditions for conducting vacuum deposition depend on the compounds to be used (i.e., the material of the hole transporting layer), a crystal structure of the targeted hole transporting layer, and a recombination structure of the targeted hole transporting layer. Generally, conditions are preferably set so as to satisfy deposition-source temperature of 50 to 450 degrees C, vacuum of $0.133 \cdot 10^{-4}$ to 0.133 Pa (10^{-7} to 10^{-3}torr), deposition speed of 0.01 to 50 nm/second, substrate temperature of -50 to 300 degrees C, film thickness of 5nm to 5μm.

[0170] Then, the emitting layer is formed on the hole transporting layer. The emitting layer may also be formed of a desirable material by a method such as vacuum deposition, sputtering, spin coating and casting, among which vacuum deposition is preferable in forming the emitting layer because the method can easily form homogeneous films and can prevent generation of pin holes. When the emitting layer is formed by vacuum deposition, deposition conditions for forming the emitting layer can be generally set in the same manner as the hole transporting layer although the deposition conditions may vary depending on compounds used for forming the emitting layer.

[0171] Next, the electron transporting layer is formed on the emitting layer. As with the hole transporting layer and the emitting layer, the electron transporting layer is also preferably formed by vacuum deposition so as to form a homogeneous film. Deposition conditions for forming the electron transporting layer can be set in the same manner as the hole transporting layer and the emitting layer.

[0172] Lastly, the cathode is laminated thereon.

[0173] The cathode can be formed from a metal by a method such as vapor deposition and sputtering. In order to protect the organic layers deposited under the cathode from being damaged, the vacuum deposition is preferable.

[0174] The above-described organic EL device is preferably manufactured such that all layers from the anode to the cathode are formed in one vacuuming.

[0175] The methods for forming each layer of the organic EL device are not particularly limited. Conventionally-known methods such as vacuum deposition, molecular-beam deposition, spin coating, dipping, casting, bar coating and roll coating are applicable to forming the layers.

[0176] Although the thickness of each organic layer of the organic EL device is not particularly limited, the thickness is generally preferably in a range of several nanometers to 1 μm because excessively-thinned film likely entails defects such as a pin hole while excessively-thickened film requires high voltage to be applied and deteriorates efficiency. When a voltage is applied to the organic EL device, the light-emission can be observed by applying a voltage of 3 to 40V with the anode having the positive polarity and the cathode having the negative polarity. When the voltage is applied with the inversed polarity, no current flows, so that no light is emitted. When an alternating voltage is applied, the uniform light-emission can be observed only when the anode has the positive polarity and the cathode has the negative polarity. A waveform of the alternating current to be applied may be suitably selected.

[Example 1]

[0177] Next, the present invention will be further described in detail by exemplifying Examples. However, the present invention is not limited to such Examples.

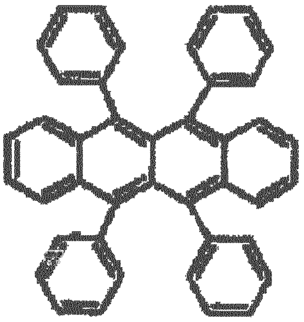
[Example 1] (not according to the invention)

[0178] A 130 nm-thick transparent electrode formed of indium tin oxide was formed on a glass substrate having a size of 25mm by 75mm by 0.7mm. After the transparent substrate was ultrasonically cleaned in isopropyl alcohol for five minutes, the substrate was further cleaned with UV (ultraviolet) ozone for thirty minutes, and then the substrate was mounted on a vapor deposition apparatus.

Initially,

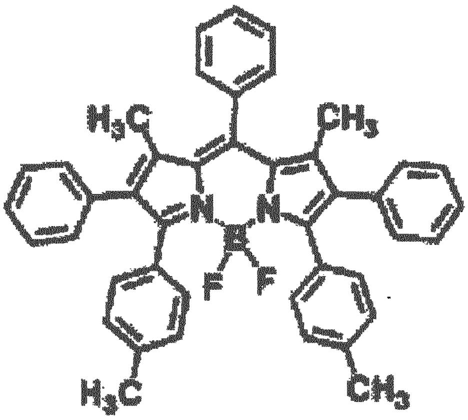
[0179] N,N'-bis[4-(N,N-diphenylamino)phenyl-1-yl]-N,N'-diphenyl-4,4'-benzidine was deposited on the substrate to form a 60 nm-thick hole injecting layer, and subsequently N,N'-bis[4'-{N-(naphthyl-1-yl)-N-phenyl}aminobiphenyl-4-yl]-N-phenylamine was deposited thereon to form a 10 nm-thick hole transporting layer. Then, the following compound (A-1), a naphthacene derivative, and the following compound (B-1), a compound having a pyrromethene skeleton, were simultaneously deposited thereon by weight ratio of 40 to 0.4 (= 0.99 wt%) to form a 40 nm-thick emitting layer.

[Chemical Formula 25]



Compound (A-1)

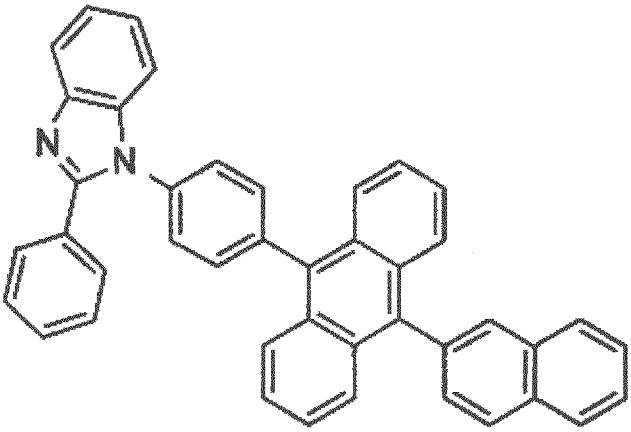
[Chemical Formula 26]



Compound (B-1)

[0180] Next, the following compound (C-1) was deposited thereon to form a 30 nm-thick electron transporting layer.

[Chemical Formula 27]



Compound (C-1)

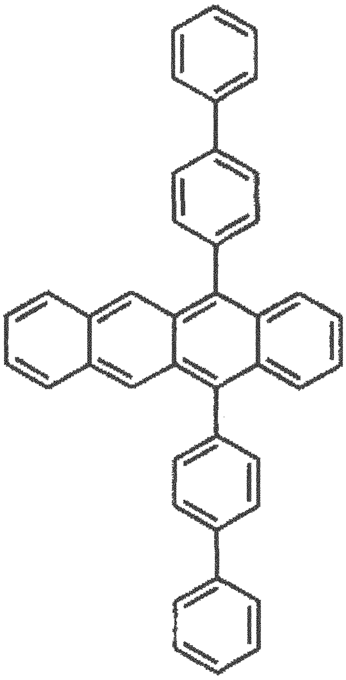
[0181] After 0.5 nm-thick lithium fluoride was subsequently deposited thereon, 150 nm-thick aluminum was deposited further thereon. The layer of aluminum/lithium fluoride served as the cathode. The organic EL device was manufactured by the above-described manner.

[0182] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.7 V to emit red light having a luminescence intensity of 711 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.66, 0.33), and efficiency of the device was 7.11 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half (i.e., time until half-life) was 1,800 hours.

[Example 2] (not according to the invention)

[0183] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (A-2) was used in place of the compound (A-1) for forming the emitting layer.

[Chemical Formula 28]



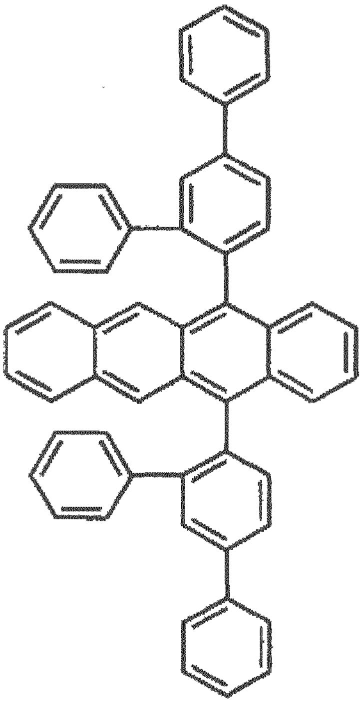
Compound (A-2)

[0184] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.8 V to emit red light having a luminescence intensity of 720 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.66, 0.33), and efficiency of the device was 7.20 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 2,000 hours..

[Example 3]

[0185] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (A-3) was used in place of the compound (A-1) for forming the emitting layer.

[Chemical Formula 29]



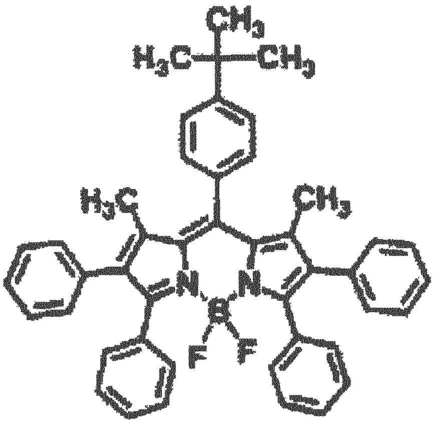
Compound (A-3)

[0186] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.8 V to emit red light having a luminescence intensity of 737 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.66, 0.33), and efficiency of the device was 7.37 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 3,200 hours.

[Example 4] (not according to the invention)

[0187] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (B-2) was used in place of the compound (B-1) for forming the emitting layer.

[Chemical Formula 30]



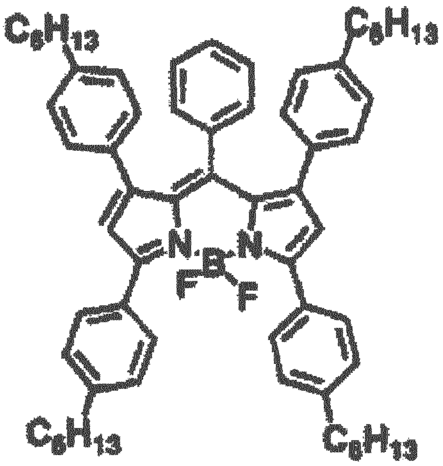
Compound (B-2)

[0188] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.8 V to emit red light having a luminescence intensity of 698 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.66, 0.33), and efficiency of the device was 6.98 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 1,900 hours..

[Example 5] (not according to the invention)

[0189] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (B-3) was used in place of the compound (B-1) for forming the emitting layer.

[Chemical Formula 31]



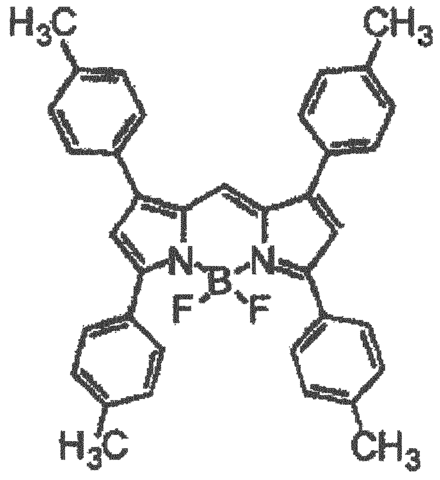
Compound (B-3)

[0190] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.8 V to emit red light having a luminescence intensity of 710 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.66, 0.33), and efficiency of the device was 7.10 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 1,500 hours..

[Example 6] (not according to the invention)

[0191] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (B-4) was used in place of the compound (B-1) for forming the emitting layer.

[Chemical Formula 32]



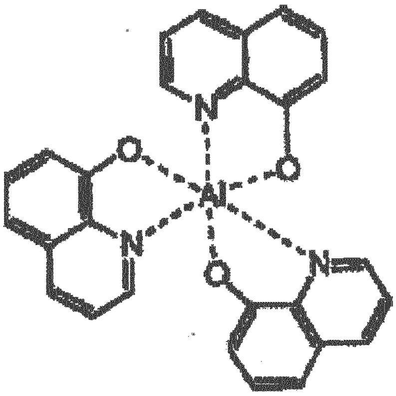
Compound (B-4)

[0192] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.7 V to emit red light having a luminescence intensity of 676 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.66, 0.33), and efficiency of the device was 6.76 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 1,600 hours..

[Example 7] (not according to the invention)

[0193] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (C-2) was used in place of the compound (C-1) for forming the electron transporting layer.

[Chemical Formula 33]



Compound (C-2)

[0194] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 5.6 V to emit red light having a luminescence intensity of 564 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.64, 0.34), and efficiency of the device was 5.64 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 1,000 hours..

[Comparative 1]

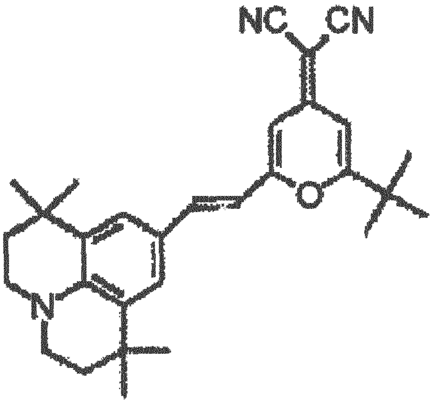
[0195] An organic EL device was manufactured in the same manner as in Example 7 except that the following compound (C-2) was used in place of the compound (A-1) for forming the emitting layer.

[0196] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 6.1 V to emit red light having a luminescence intensity of 434 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.63, 0.35), and efficiency of the device was 4.34 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 500 hours..

[Comparative 2]

[0197] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (B-5) was used in place of the compound (B-1) for forming the emitting layer.

[Chemical Formula 34]



Compound (B-5)

[0198] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.7 V to emit red light having a luminescence intensity of 385 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.64, 0.37), and efficiency of the device was 3.85 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 700 hours..

[Comparative 3]

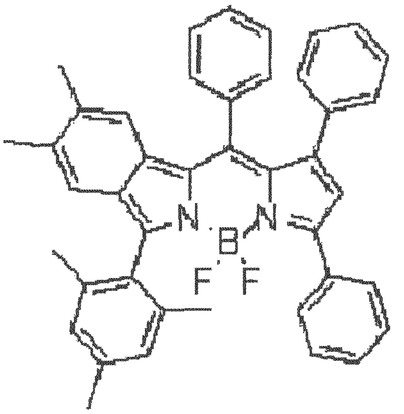
[0199] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (C-2) was used in place of the compound (A-1) for forming the emitting layer.

[0200] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 5.2 V to emit red light having a luminescence intensity of 451 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.65, 0.33), and efficiency of the device was 4.51 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 600 hours..

[Example 8] (not according to the invention)

[0201] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (B-6) was used in place of the compound (B-1) for forming the emitting layer.

[Chemical Formula 35]



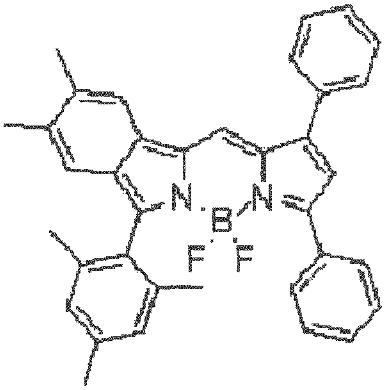
Compound (B-6)

[0202] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.4 V to emit red light having a luminescence intensity of 1,081 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.65, 0.34), and efficiency of the device was 10.81 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 3,500 hours..

[Example 9] (not according to the invention)

[0203] An organic EL device was manufactured in the same manner as in Example 1 except that the following compound (B-7) was used in place of the compound (B-1) for forming the emitting layer.

[Chemical Formula 36]



Compound (B-7)

[0204] When a current test was conducted on the obtained device, the organic EL device was driven by a voltage of 4.5 V to emit red light having a luminescence intensity of 852 cd/m^2 at a current density of 10 mA/cm^2, a trichromatic coordinate of the emitted light was (0.67, 0.33), and efficiency of the device was 8.52 cd/A. In addition, when a continuous direct-current test was conducted with the initial luminescence intensity set at 5,000 cd/m^2, time elapsed until the luminescence intensity was reduced by half was 3,300 hours..

[Table 1]

	Drive Voltage (V)	luminescence intensity (cd/m^2)	trichromatic coordinate	Luminous Efficiency (cd/A)	time until half-life (hr)
Example 1 *	4.7	711	(0.66, 0.33)	7.11	1,800

(continued)

	Drive Voltage (V)	luminescence intensity (cd/m^2)	trichromatic coordinate	Luminous Efficiency (cd/A)	time until half-life (hr)
Example 2 *	4.8	720	(0.66, 0.33)	7.20	2,000
Example 3	4.8	737	(0.66, 0.33)	7.37	3,200
Example 4 *	4.8	698	(0.66, 0.33)	6.98	1,900
Example 5 *	4.8	710	(0.66, 0.33)	7.10	1,500
Example 6 *	4.7	676	(0.66, 0.33)	6.76	1,600
Example 7 *	5.6	564	(0.64, 0.34)	5.64	1,000
Comparative 1	6.1	434	(0.63, 0.35)	4.34	500
Comparative 2	4.7	385	(0.64, 0.37)	3.85	700
Comparative 3	5.2	451	(0.65, 0.33)	4.51	600
Example 8 *	4.4	1,081	(0.65, 0.34)	10.81	3,500
Example 9 *	4.5	852	(0.67, 0.33)	8.52	3,300
*: not according to the invention					

[0205] In Example 3 and Comparatives 2 and 3, the compound (C-1) was used as the electron transporting layer. The compound (B-5) was used as the dopant in Comparative 2 while the compound (C-2) was used as the host in Comparative 3. In contrast, the combination of the host and the dopant according to the present invention was used in Example 3.

[0206] Consequently, the combination of the host and the dopant according to the present invention is excellent in terms of drive voltage, luminescence intensity, chromaticity, luminous efficiency and time until half-life.

[0207] In other words, irrespective of what compound is used for forming the electron transporting layer, the combination of the host material and the dopant material according to the present invention is excellent in terms of drive voltage, luminescence intensity, chromaticity, efficiency and time until half-life.

[0208] It is understood from Example 3 that, by using such a material as represented by the compound (C-1) according to the present invention for the electron transporting material, the device can exhibit excellent performance in terms of drive voltage, luminescence intensity, chromaticity, efficiency, time until half-time and the like.

[0209] The emitting region is typically preferably located within the emitting layer in the organic EL device.

[0210] On the other hand, an emitting material for emitting red light tends to cause electron traps because an energy gap of the dopant is small. Accordingly, the electrons injected into the emitting layer from the electron transporting layer tend to be trapped in the dopant located adjacent to the electron transporting layer, thereby moving the emitting region toward the electron transporting layer.

[0211] In Example 7 (not according to the invention), the chromaticity was shifted toward green, and the compound (C-2) emitted light. It can be deduced from the above with respect to Example 7 that the holes were more strongly injected into the emitting layer than the electrons, and that many of the holes penetrated the emitting layer to reach the electron transporting layer, thereby generating exciters in the compound (C-2) forming the electron transporting layer. In addition, since the compound (C-2) emitted light, the time elapsed until the lifetime of the organic EL device was reduced by half is short.

[0212] In this respect, the electron transporting material according to the present invention, a representative example of which is the compound (C-1), is excellent in transporting electrons. The electron transporting layer formed of such an electron transporting material can strongly inject the electrons into the emitting layer, thereby preventing the holes from penetrating the emitting layer to reach the electron transporting layer.

[0213] In other words, the organic EL device according to the present invention can emit light of high chromaticity with high efficiency while preventing generation of exciters in the electron transporting layer, and lifetime of the entire device is long.

[0214] In addition, when a naphthacene derivative and a compound having pyrromethene skeleton or the like are respectively used for the host and the dopant, the electron transporting material can exhibit above-described excellent effects and advantages.

[0215] Lifetime of Example 3 is much longer than those of Examples 1 (not according to the invention) and 2 (not according to the invention) because the compound A-3 was used for the host in Example 3. It has been revealed from the above that substituent(s) in ortho position(s) of benzene rings bonded to the naphthacene skeleton prevents molecular association, thereby contributing to longer lifetime.

[0216] The present invention is not limited to the above examples, but includes modifications and improvements made within a scope where an object of the present invention can be achieved.

[0217] For instance, rubrene, which is an example of the host material of Example 1 (not according to the invention), may be substituted or unsubstituted. In addition, the compounds used in the other Examples may be substituted or unsubstituted.

INDUSTRIAL APPLICABILITY

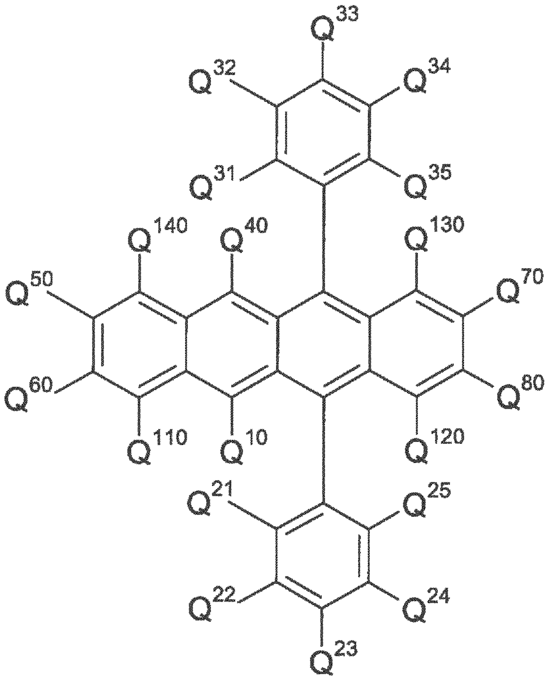
[0218] The organic EL device according to the present invention is applicable to the field of various types of display apparatuses, a display, a backlight, an illuminating source, an indicator, an advertising display, and an interior design, and the like, and especially applicable to a display device of a color display.

Claims

1. An organic electroluminescence device, comprising:

    a cathode;
    an anode;
    an emitting layer provided between the cathode and the anode; and an electron transporting layer provided between the cathode and the emitting layer;

   wherein
   the emitting layer comprises a host and a dopant,
   the host is a naphthacene derivative represented by formula (3) as follows, the dopant is a compound having a pyrromethene skeleton represented by formula (2) as follows or a metal complex of the compound, and
   the electron transporting layer comprises a compound represented by formula (4) as follows,



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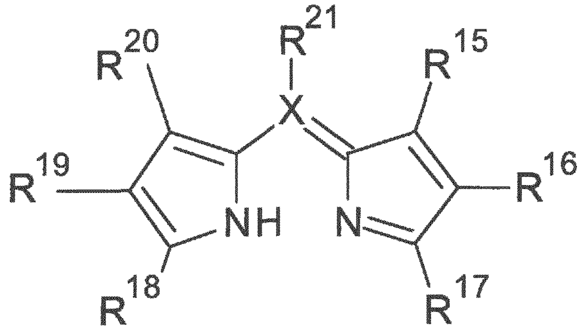


(2)

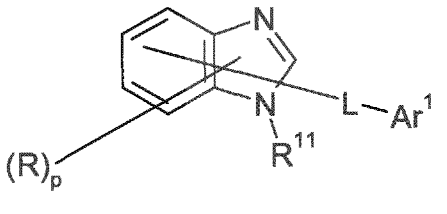
wherein in the formula (3) Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40} to Q^{80} and Q^{110} to Q^{140} each represent a hydrogen atom, a substituted or unsubstituted alkyl group, a substituted or unsubstituted aryl group, a substituted or unsubstituted amino group, a substituted or unsubstituted alkoxy group, a substituted or unsubstituted alkylthio group, a substituted or unsubstituted aryloxy group, a substituted or unsubstituted arylthio group, a substituted or unsubstituted alkenyl group, a substituted or unsubstituted aralkyl group, or a substituted or unsubstituted heterocyclic group, Q^{10}, Q^{21} to Q^{25}, Q^{31} to Q^{35}, Q^{40} to Q^{80} and Q^{110} to Q^{140} being allowed to be mutually the same or different, adjacent two or more of Q^{21} to Q^{25} and Q^{31} to Q^{35} being allowed to be mutually bonded to form a cyclic structure, and
at least one of Q^{21}, Q^{25}, Q^{31} and Q^{35} in the naphthacene derivative represented by the formula (3) represents a substituted or unsubstituted aryl group;
in the formula (2): at least one of R^{15} to R^{21} is a substituent having an aromatic ring or forming a fused ring together with an adjacent substituent, while the rest of R^{15} to R^{21} each represents a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, a haloalkane, a haloalkene, a haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group, the rest of R^{15} to R^{21} each being allowed to form a fused ring or an aliphatic ring with an adjacent substituent, the groups listed above each having 1 to 20 carbon atoms, R^{15} to R^{21} being allowed to be mutually the same or different and being allowed to be substituted or unsubstituted; X representing a carbon atom or a nitrogen atom on the condition that R^{21} above does not exist when X represents a nitrogen atom; and a metal in the metal complex being at least one metal selected from a group consisting of boron, beryllium, magnesium, chrome, iron, cobalt, nickel, copper, zinc and platinum;

$$(A)_m\text{-}(B)_n \qquad (4)$$

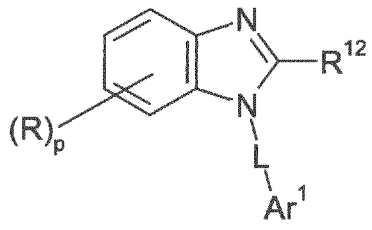
wherein

A represents a substituted or unsubstituted fused aromatic hydrocarbon group having three or more rings;
B represents a substituted or unsubstituted heterocyclic group; and
m and n each represent an integer in a range of 1 to 6,

the compound represented by the formula (4) is a benzimidazole derivative represented by formula (5) or formula (6) as follows,



(5)



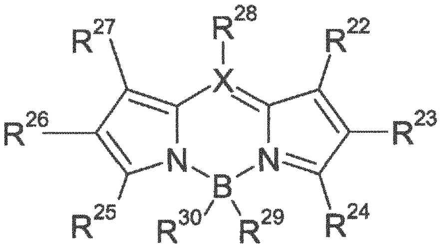
(6)

wherein:

R represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms; p represents an integer in a range of 1 to 4; R^{11} represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or an alkoxy group having 1 to 20 carbon atoms; R^{12} represents a hydrogen atom, a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group, a substituted or unsubstituted quinolyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms or a substituted or unsubstituted alkoxy group having 1 to 20 carbon atoms; L represents a substituted or unsubstituted arylene group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridinylene group, a substituted or unsubstituted quinolinylene group or a substituted or unsubstituted fluorenylene group; and Ar^1 represents a substituted or unsubstituted aryl group having 6 to 60 carbon atoms, a substituted or unsubstituted pyridyl group or a substituted or unsubstituted quinolyl group; and

at least one of R, R^{11}, R^{12}, L and Ar^1 corresponds to A in the compound represented by the formula (4) and is a fused aromatic hydrocarbon group having three or more rings.

2. The organic electroluminescence device according to Claim 1, wherein the compound having the pyrromethene skeleton represented by the formula (2) or the metal complex of the compound is a metal complex having a pyrromethene skeleton represented by the formula (2-1) as follows,



(2-1)

wherein:

at least one of R^{22} to R^{28} is a substituent having an aromatic ring or forms a fused aromatic ring together with an adjacent substituent while the rest of R^{22} to R^{28} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group, the rest of R^{22} to R^{28} each being allowed to form a fused ring or an aliphatic ring with an adjacent substituent, R^{22} to R^{28} being allowed to be mutually the same or different and being allowed to be substituted or unsubstituted;

R^{29} and R^{30} are allowed to be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, substituted or unsubstituted alkyl, substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group; and

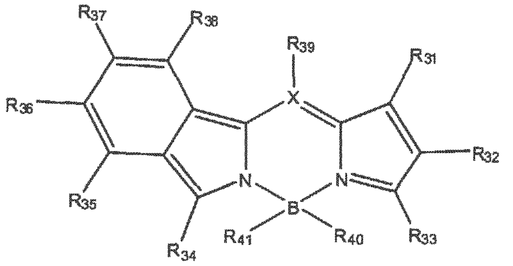
X represents a carbon atom or a nitrogen atom on the condition that R^{28} above does not exist when X represents a nitrogen atom.

3. The organic electroluminescence device according to Claim 2, wherein at least one of R^{22} to R^{28} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) is a substituent having an aromatic ring.

4. The organic electroluminescence device according to Claim 2, wherein at least one of R^{22} to R^{28} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) forms a fused aromatic ring together with an adjacent substituent.

5. The organic electroluminescence device according to Claim 4, wherein at least one of R^{22} to R^{24} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) forms a substituted or unsubstituted fused aromatic ring together with an adjacent substituent and/or at least one of R^{25} to R^{27} in the metal complex having the pyrromethene skeleton represented by the formula (2-1) forms a substituted or unsubstituted fused aromatic ring together with an adjacent substituent.

6. The organic electroluminescence device according to Claim 2, wherein the metal complex having the pyrromethene skeleton represented by the formula (2-1) is a metal complex having a pyrromethene skeleton represented by the formula (2-2) as follows,

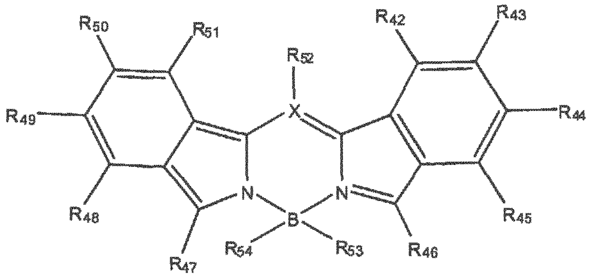


(2−2)

wherein:

R_{31} to R_{39} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group, R_{31} to R_{39} being allowed to be mutually the same or different and being allowed to be substituted or unsubstituted; R_{40} and R_{41} are allowed to be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, substituted or unsubstituted alkyl, substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group; and X represents a carbon atom or a nitrogen atom on a condition that R_{39} above does not exist when X represents a nitrogen atom.

7. The organic electroluminescence device according to Claim 4, wherein the metal complex having the pyrromethene skeleton represented by the formula (2-1) is a metal complex having a pyrromethene skeleton represented by the formula (2-3) as follows,



(2−3)

wherein:

R_{42} to R_{52} each represent a hydrogen atom, an alkyl group, a cycloalkyl group, an aralkyl group, an alkenyl group, a cycloalkenyl group, an alkynyl group, a hydroxyl group, a mercapto group, an alkoxy group, an alkylthio group, an arylether group, an arylthioether group, an aryl group, a heterocyclic group, halogen, haloalkane, haloalkene, haloalkyne, a cyano group, an aldehyde group, a carbonyl group, a carboxyl group, an ester group, a carbamoyl group, an amino group, a nitro group, a silyl group or a siloxanyl group, R_{42} to R_{52} being allowed to be mutually the same or different and being allowed to be substituted or unsubstituted; R_{53} and R_{54} are allowed to be mutually the same or different and each are selected from a group consisting of halogen, a hydrogen atom, a substituted or unsubstituted alkyl, a substituted or unsubstituted aryl and a substituted or unsubstituted heterocyclic group; and X represents a carbon atom or a nitrogen atom on a condition that R_{52} above does not exist when X represents a nitrogen atom.

8. The organic electroluminescence device according to any one of Claims 1 to 7, wherein the dopant is contained in the emitting layer at a doping concentration of 0.1 to 10 mass%.

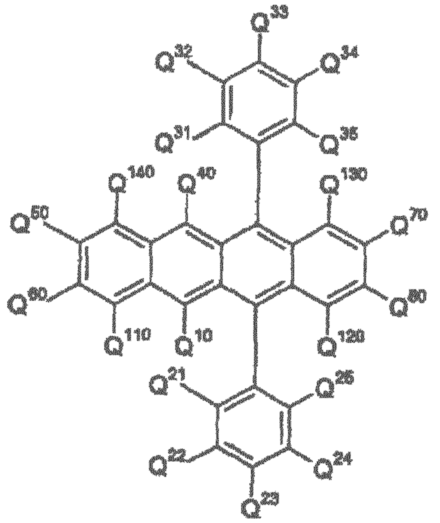
9. The organic electroluminescence device according to any of the claims 1 to 8, wherein A in the compound represented by the formula (4) has a skeleton in its molecule, the skeleton selected from a group consisting of anthracene, phenanthrene, naphthacene, pyrene, chrysene, benzoanthracene, pentacene, dibenzoanthracene, benzopyrene, fluorene, benzofluorene, fluoranthene, benzofluoranthene, naphthofluoranthene, dibenzofluorene, dibenzopyrene and dibenzofluoranthene.

Patentansprüche

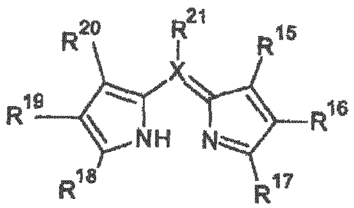
1. Organische Elektrolumineszenz-Vorrichtung, umfassend:

eine Kathode;
eine Anode;

eine Emissionsschicht, die zwischen der Kathode und der Anode vorgesehen ist; und
eine Elektronentransportschicht, die zwischen der Kathode und der Emissionsschicht vorgesehen ist;
wobei
die Emissionsschicht einen Wirt und ein Dotierungsmittel umfasst,
der Wirt ein Naphthacen-Derivat ist, das durch die folgende Formel (3) dargestellt ist,
das Dotierungsmittel eine Verbindung mit einem Pyrromethen-Skelett, das durch die folgende Formel (2) dargestellt ist, oder ein Metallkomplex der Verbindung ist, und
die Elektronentransportschicht eine durch die folgende Formel (4) dargestellte Verbindung umfasst,



(3)



(2)

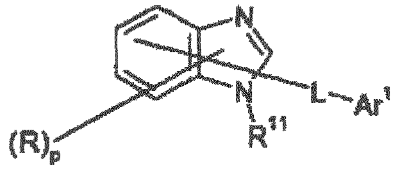
wobei in der Formel (3) Q^{10}, Q^{21} bis Q^{25}, Q^{31} bis Q^{35}, Q^{40} bis Q^{80} und Q^{110} bis Q^{140} jeweils folgendes darstellen: ein Wasserstoffatom, eine substituierte oder unsubstituierte Alkylgruppe, eine substituierte oder unsubstituierte Arylgruppe, eine substituierte oder unsubstituierte Aminogruppe, eine substituierte oder unsubstituierte Alkoxygruppe, eine substituierte oder unsubstituierte Alkylthiogruppe, eine substituierte oder unsubstituierte Aryloxygruppe, eine substituierte oder unsubstituierte Arylthiogruppe, eine substituierte oder unsubstituierte Alkenylgruppe, eine substituierte oder unsubstituierte Aralkylgruppe, oder eine substituierte oder unsubstituierte heterocyclische Gruppe, wobei Q^{10}, Q^{21} bis Q^{25}, Q^{31} bis Q^{35}, Q^{40} bis Q^{80} und Q^{110} bis Q^{140} einander gleich oder verschieden sein können, benachbarte zwei oder mehrere von Q^{21} bis Q^{25} und Q^{31} bis Q^{35} miteinander verbunden sein können, um eine cyclische Struktur zu bilden, und
mindestens eines von Q^{21}, Q^{25}, Q^{31} und Q^{35} in dem Naphthacen-Derivat, wie durch die Formel (3) dargestellt, eine substituierte oder unsubstituierte Arylgruppe darstellt;
in der Formel (2): mindestens eines von R^{15} bis R^{21} ein Substituent mit einem aromatischen Ring ist oder ein Substituent ist, der einen kondensierten Ring zusammen mit einem benachbarten Substituenten bildet, während der Rest von R^{15} bis R^{21} jeweils folgendes darstellt: ein Wasserstoffatom, eine Alkylgruppe, eine Cycloalkylgruppe, eine Aralkylgruppe, eine Alkenylgruppe, eine Cycloalkenylgruppe, eine Alkinylgruppe, eine Hydroxylgruppe, eine Mercaptogruppe, eine Alkoxygruppe, eine Alkylthiogruppe, eine Arylethergruppe, eine Arylthioethergruppe, eine Arylgruppe, eine heterocyclische Gruppe, Halogen, ein Halogenalkan, ein Halogenalken, ein Halogenalkin, eine Cyanogruppe, eine Aldehydgruppe, eine Carbonylgruppe, eine Carboxylgruppe, eine Estergruppe, eine Carbamoylgruppe, eine Aminogruppe, eine Nitrogruppe, eine Silylgruppe, oder eine Siloxanylgruppe, der Rest von R^{15} bis R^{21} jeweils einen kondensierten Ring oder einen aliphatischen Ring mit einem benachbarten Substituenten bilden kann, die oben aufgeführten Gruppen jeweils 1 bis 20 Kohlenstoffatome aufweisen, Erz bis R^{21} einander gleich oder verschieden und substituiert oder unsubstituiert sein können; X ein Kohlenstoffatom oder ein Stickstoffatom darstellt, mit der Maßgabe, dass obiges R^{21} nicht vorhanden ist, wenn X ein Stickstoffatom darstellt; und ein Metall in dem Metallkomplex mindestens ein Metall ist, das aus der Gruppe ausgewählt ist bestehend aus Bor, Beryllium, Magnesium, Chrom, Eisen, Kobalt, Nickel, Kupfer, Zink und Platin:

$$(A)_m\text{-}(B)_n \qquad (4)$$

wobei

A eine substituierte oder unsubstituierte kondensierte aromatische Kohlenwasserstoffgruppe mit drei oder mehr Ringen darstellt;
B eine substituierte oder unsubstituierte heterocyclische Gruppe darstellt; und
m und n jeweils eine ganze Zahl im Bereich von 1 bis 6 darstellen;

die Verbindung, die durch die Formel (4) dargestellt ist, ein Benzimidazol-Derivat ist, das durch die folgende Formel (5) oder Formel (6) dargestellt ist



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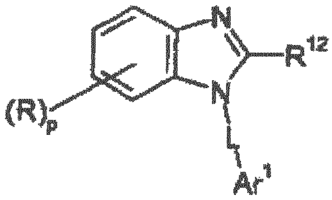
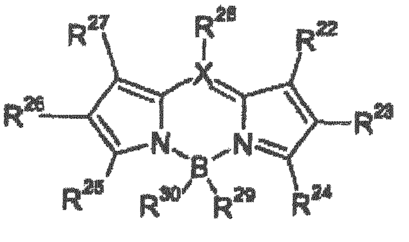


(6)

wobei:

R folgendes darstellt: ein Wasserstoffatom, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, eine substituierte oder unsubstituierte Pyridylgruppe, eine substituierte oder unsubstituierte Chinolylgruppe, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 20 Kohlenstoffatomen, oder eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 20 Kohlenstoffatomen; p eine ganze Zahl im Bereich von 1 bis 4 darstellt; R^{11} folgendes darstellt: eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, eine substituierte oder unsubstituierte Pyridylgruppe, eine substituierte oder unsubstituierte Chinolylgruppe, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 20 Kohlenstoffatomen, oder eine Alkoxygruppe mit 1 bis 20 Kohlenstoffatomen; R^{12} ein Wasserstoffatom, eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, eine substituierte oder unsubstituierte Pyridylgruppe, eine substituierte oder unsubstituierte Chinolylgruppe, eine substituierte oder unsubstituierte Alkylgruppe mit 1 bis 20 Kohlenstoffatomen darstellt, oder eine substituierte oder unsubstituierte Alkoxygruppe mit 1 bis 20 Kohlenstoffatomen; L folgendes darstellt: eine substituierte oder unsubstituierte Arylengruppe mit 6 bis 60 Kohlenstoffatomen, eine substituierte oder unsubstituierte Pyridinylengruppe, eine substituierte oder unsubstituierte Chinolinylengruppe oder eine substituierte oder unsubstituierte Fluorenylengruppe; und Ar^1 folgendes darstellt: eine substituierte oder unsubstituierte Arylgruppe mit 6 bis 60 Kohlenstoffatomen, eine substituierte oder unsubstituierte Pyridylgruppe oder eine substituierte oder unsubstituierte Chinolylgruppe; und
mindestens eines von R, R^{11}, R^{12}, L und AR^{1A} in der durch die Formel (4) dargestellten Verbindung entspricht und eine kondensierte aromatische Hydrocarbongruppe mit drei oder mehr Ringen ist.

2. Organische Elektrolumineszenz-Vorrichtung nach Anspruch 1, wobei die Verbindung mit dem Pyrromethen-Skelett, das durch die Formel (2) dargestellt ist, oder der Metallkomplex der Verbindung ein Metallkomplex mit einem Pyrromethen-Skelett ist, das durch die folgende Formel (2-1) dargestellt ist,



(2-1)

wobei:

mindestens eines von R^{22} bis R^{28} ein Substituent mit einem aromatischen Ring ist oder ein Substituent ist, der einen kondensierten aromatischen Ring zusammen mit einem benachbarten Substituenten bildet, während der Rest von R^{22} bis R^{28} jeweils folgendes darstellt: ein Wasserstoffatom, eine Alkylgruppe, eine Alkylgruppe, eine Cycloalkylgruppe, eine Aralkylgruppe, eine Alkenylgruppe, eine Cycloalkenylgruppe, eine Alkinylgruppe, eine Hydroxylgruppe, eine Mercaptogruppe, eine Alkoxygruppe, eine Alkylthiogruppe, eine Arylethergruppe, eine Arylthioethergruppe, eine Arylgruppe, eine heterocyclische Gruppe, Halogen, Halogenalkan, Halogenalken, Halogenalkin, eine Cyanogruppe, eine Aldehydgruppe, eine Carbonylgruppe, eine Carboxylgruppe, eine Estergruppe, eine Carbamoylgruppe, eine Aminogruppe, eine Nitrogruppe, eine Silylgruppe, oder eine Siloxanylgruppe, der Rest von R^{22} bis R^{28} jeweils einen kondensierten Ring oder einen aliphatischen Ring mit einem benachbarten Substituenten bilden kann, R^{22} bis R^{28} einander gleich oder verschieden und substituiert oder unsubstituiert sein können;
R^{29} und R^{30} einander gleich oder verschieden sein können und jeweils aus einer Gruppe ausgewählt sind bestehend aus Halogen, einem Wasserstoffatom, substituiertem oder unsubstituiertem Alkyl, substituiertem oder unsubstituiertem Aryl und einer substituierten oder unsubstituierten heterocyclischen Gruppe; und X ein

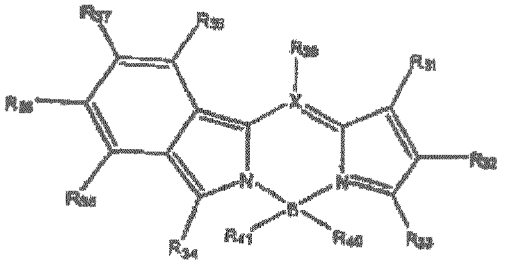
Kohlenstoffatom oder Stickstoffatom darstellt, mit der Maßgabe, dass obiges R^{28} nicht vorhanden ist, wenn X ein Stickstoffatom darstellt.

3. Organische Elektrolumineszenz-Vorrichtung nach Anspruch 2, wobei mindestens eines von R^{22} bis R^{28} in dem Metallkomplex mit dem Pyrromethen-Skelett, das durch die Formel (2-1) dargestellt ist, ein Substituent mit einem aromatischen Ring ist.

4. Organische Elektrolumineszenz-Vorrichtung nach Anspruch 2, wobei mindestens eines von R^{22} bis R^{28} in dem Metallkomplex mit dem Pyrromethen-Skelett, das durch die Formel (2-1) dargestellt ist, einen kondensierten aromatischen Ring zusammen mit einem benachbarten Substituenten bildet.

5. Organische Elektrolumineszenz-Vorrichtung nach Anspruch 4, wobei mindestens eines von R^{22} bis R^{24} in dem Metallkomplex mit dem Pyrromethen-Skelett, das durch die Formel (2-1) dargestellt ist, einen substituierten oder unsubstituierten kondensierten aromatischen Ring zusammen mit einem benachbarten Substituenten bildet, und/oder mindestens eines von R^{25} bis R^{27} in dem Metallkomplex mit dem Pyrromethen-Skelett, das durch die Formel (2-1) dargestellt ist, einen substituierten oder unsubstituierten kondensierten aromatischen Ring zusammen mit einem benachbarten Substituenten bildet.

6. Organische Elektrolumineszenz-Vorrichtung nach Anspruch 2, wobei der Metallkomplex mit dem Pyrromethen-Skelett, das durch die Formel (2-1) dargestellt ist, ein Metallkomplex mit einem Pyrromethen-Skelett ist, das durch die folgende Formel (2-2) dargestellt ist,

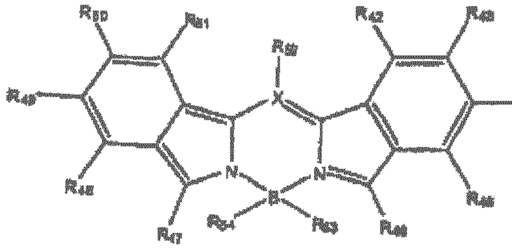


(2-2)

wobei:

R_{31} bis R_{39} jeweils folgendes darstellen: ein Wasserstoffatom, eine Alkylgruppe, eine Cycloalkylgruppe, eine Aralkylgruppe, eine Alkenylgruppe, eine Cycloalkenylgruppe, eine Alkinylgruppe, eine Hydroxylgruppe, eine Mercaptogruppe, eine Alkoxygruppe, eine Alkylthiogruppe, eine Arylethergruppe, eine Arylthioethergruppe, eine Arylgruppe, eine heterocyclische Gruppe, Halogen, Halogenalkan, Halogenalken, Halogenalkin, eine Cyanogruppe, eine Aldehydgruppe, eine Carbonylgruppe, eine Carboxylgruppe, eine Estergruppe, eine Carbamoylgruppe, eine Aminogruppe, eine Nitrogruppe, eine Silylgruppe, oder eine Siloxanylgruppe; R_{31} bis R_{39} einander gleich oder verschieden und substituiert oder unsubstituiert sein können; R_{40} und R_{41} einander gleich oder verschieden sein können und jeweils aus einer Gruppe ausgewählt sind bestehend aus Halogen, einem Wasserstoffatom, substituiertem oder unsubstituiertem Alkyl, substituiertem oder unsubstituiertem Aryl und einer substituierten oder unsubstituierten heterocyclischen Gruppe; und
X ein Kohlenstoffatom oder ein Stickstoffatom darstellt, mit der Maßgabe, dass obiges R_{39} nicht vorhanden ist, wenn X ein Stickstoffatom darstellt,

7. Organische Elektrolumineszenz-Vorrichtung nach Anspruch 4, wobei der Metallkomplex mit dem Pyrromethen-Skelett, das durch die Formel (2-1) dargestellt ist, ein Metallkomplex mit einem Pyrromethen-Skelett ist, das durch die folgende Formel (2-3) dargestellt ist,



(2-3)

wobei
R_{42} bis R_{52} jeweils folgendes darstellen: ein Wasserstoffatom, eine Alkylgruppe, eine Cycloalkylgruppe, eine Aralkylgruppe, eine Alkenylgruppe, eine Cycloalkenylgruppe, eine Alkinylgruppe, eine Hydroxylgruppe, eine Mercaptogruppe, eine Alkoxygruppe, eine Alkylthiogruppe, eine Arylethergruppe, eine Arylthioethergruppe, eine Arylgruppe, eine heterocyclische Gruppe, Halogen, Halogenalkan, Halogenalken, Halogenalkin, eine Cyanogruppe, eine Aldehydgruppe, eine Carbonylgruppe, eine Carboxylgruppe, eine Estergruppe, eine Carbamoylgruppe, eine Aminogruppe, eine Nitrogruppe, eine Silylgruppe, oder eine Siloxanylgruppe,
R_{42} bis R_{52} einander gleich oder verschieden und substituiert oder unsubstituiert sein können; R_{53} bis R_{54} einander gleich oder verschieden sein können und jeweils aus einer Gruppe ausgewählt sind bestehend aus Halogen, einem Wasserstoffatom, einem substituierten oder unsubstituierten Alkyl, einem substituierten oder unsubstituierten Aryl, und einer substituierten oder unsubstituierten heterocyclischen Gruppe; und X ein Wasserstoffatom oder ein Stickstoffatom darstellt, mit der Maßgabe, dass obiges R_{52} nicht vorhanden ist,
wenn X ein Stickstoffatom darstellt.

8. Organische Elektrolumineszenz-Vorrichtung nach einem der Ansprüche 1 bis 7, wobei das Dotierungsmittel in der Emissionsschicht in einer Dotierungskonzentration von 0,1 bis 10 Masse-% enthalten ist.

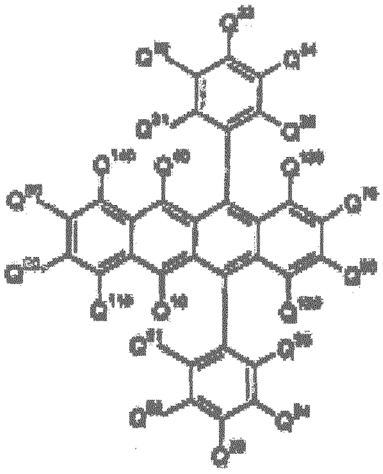
9. Organische Elektrolumineszenz-Vorrichtung nach einem der Ansprüche 1 bis 8, wobei A in der Verbindung, die durch Formel (4) dargestellt ist, ein Skelett in seinem Molekül aufweist, wobei das Skelett aus einer Gruppe ausgewählt ist bestehend aus Anthracen, Phenanthren, Naphthacen, Pyren, Chrysen, Benzoanthracen, Pentacen, Dibenzoanthracen, Benzopyren, Fluoren, Benzofluoren, Fluoranthen, Benzofluoranthen, Naphthofluoranthen, Dibenzofluoren, Dibenzopyren und Dibenzofluoranthen.

Revendications

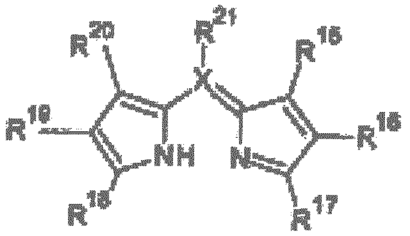
1. Dispositif électroluminescent organique, comprenant :

une cathode ;
une anode;
une couche émettrice fournie entre la cathode et l'anode ; et
une couche transporteuse d'électrons fournie entre la cathode et la couche émettrice ;

dans lequel
la couche émettrice comprend un hôte et un dopant,
l'hôte est un dérivé du naphtacène représenté par la formule (3) comme suit, le dopant est un composé ayant un squelette pyrrométhène représenté par la formule (2) comme suit ou un complexe métallique du composé, et
la couche transporteuse d'électrons comprend un composé représenté par la formule (4) comme suit,



(3)



(2)

où dans la formule (3) Q^{10}, Q^{21} à Q^{25}, Q^{31} à Q^{35}, Q^{40} à Q^{80} et Q^{110} à Q^{140} représentent chacun un atome d'hydrogène, un groupe alkyle substitué ou non substitué, un groupe aryle substitué ou non substitué, un groupe amino substitué ou non substitué, un groupe alkoxy substitué ou non substitué, un groupe alkylthio substitué ou non substitué, un groupe aryloxy substitué ou non substitué, un groupe arylthio substitué ou non substitué, un groupe alkényle substitué ou non substitué, un groupe aralkyle substitué ou non substitué ou un groupe hétérocyclique substitué ou non substitué, Q^{10}, Q^{21} à Q^{25}, Q^{31} à Q^{35}, Q^{40} à Q^{80} et Q^{110} à Q^{140} étant laissés être mutuellement identiques ou différents, adjacents deux ou plus de Q^{21} à Q^{25} et Q^{31} à Q^{35} étant laissés être mutuellement liés pour former une structure cyclique, et

au moins un de Q^{21}, Q^{25}, Q^{31} et Q^{35} dans le dérivé naphtacène représenté par la formule (3) représente un groupe aryle substitué ou non substitué ;

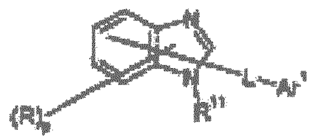
dans la formule (2) : au moins un de R^{15} à R^{21} est un substituant ayant un cycle aromatique ou formant un cycle condensé ensemble avec un substituant adjacent, alors que le reste de R^{15} à R^{21} représente chacun un atome d'hydrogène, un groupe alkyle, un groupe cycloalkyle, un groupe aralkyle, un groupe alkényle, un groupe cycloalkényle, un groupe alkynyle, un groupe hydroxyle, un groupe mercapto, un groupe alkoxy, un groupe alkylthio, un groupe aryléther, un groupe arylthioéther, un groupe aryle, un groupe hétérocyclique, un halogène, un halogénoalkane, un halogénoalkène, un halogénoalkyne, un groupe cyano, un groupe aldéhyde, un groupe carbonyle, un groupe carboxyle, un groupe ester, un groupe carbamoyle, un groupe amino, un groupe nitro, un groupe silyle ou un groupe siloxanyle, le reste de R^{15} à R^{21} étant chacun laissé former un cycle condensé ou un cycle aliphatique avec un substituant adjacent, les groupes listés ci-dessus ayant chacun de 1 à 20 atomes de carbone, R^{15} à R^{21} étant laissés mutuellement être identiques ou différents et étant laissés être substitués ou non substitués ; X représentant un atome de carbone ou un atome d'azote à la condition que R21 ci-dessus n'existe pas quand X représente un atome d'azote ; et un métal dans le complexe métallique étant au moins un métal choisi dans un groupe constitué par le bore, le béryllium, le magnésium, le chrome, le fer, le cobalt, le nickel, le cuivre, le zinc et la platine ;

$$(A)_m - (B)_n \qquad (4)$$

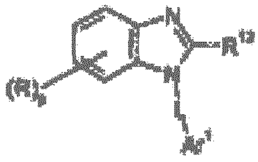
dans laquelle

A représente un groupe hydrocarbure aromatique condensé substitué ou non substitué ayant trois cycles ou plus ;
B représente un groupe hétérocyclique substitué ou non substitué ; et
m et n représentent chacun un nombre entier dans une plage de 1 à 6,

le composé représenté par la formule (4) est u dérivé de benzimidazole représenté par la formule (5) ou la formule (6) comme suit,



(5)

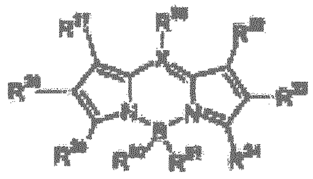


(6)

dans lesquelles :

R représente un atome d'hydrogène, un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone, un groupe pyridyle substitué ou non substitué, un groupe quinolyle substitué ou non substitué, un groupe alkyle substitué ou non substitué ayant de 1 à 20 atomes de carbone ou un groupe alkoxy substitué ou non substitué ayant de 1 à 20 atomes de carbone ; p représente un nombre entier dans une plage de 1 à 4 ; R^{11} représente un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone, un groupe pyridyle substitué ou non substitué, un groupe quinolyle substitué ou non substitué, un groupe alkyle substitué ou non substitué ayant de 1 à 20 atomes de carbone ou un groupe alkoxy substitué ou non substitué ayant de 1 à 20 atomes de carbone ; R^{12} représente un atome d'hydrogène, un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone, un groupe pyridyle substitué ou non substitué, un groupe quinolyle substitué ou non substitué, un groupe alkyle substitué ou non substitué ayant de 1 à 20 atomes de carbone ou un groupe alkoxy substitué ou non substitué ayant de 1 à 20 atomes de carbone ; L représente un groupe arylène substitué ou non substitué ayant de 6 à 60 atomes de carbone, un groupe pyridinylène substitué ou non substitué, un groupe quinolinylène substitué ou non substitué ou un groupe fluorénylène substitué ou non substitué ; et Ar^1 représente un groupe aryle substitué ou non substitué ayant de 6 à 60 atomes de carbone, un groupe pyridyle substitué ou non substitué ou un groupe quinolyle substitué ou non substitué ; et
au moins un de R, R^{11}, R^{12}, L et Ar^1 correspond à A dans le composé représenté par la formule (4) et est un groupe hydrocarbure aromatique condensé ayant trois cycles ou plus.

2. Dispositif électroluminescent selon la revendication 1, dans lequel le composé ayant le squelette pyrrométhène représenté par la formule (2) ou le complexe métallique du composé est un complexe métallique ayant un squelette pyrrométhène représenté par la formule (2-1) comme suit,



(2-1)

dans laquelle :

au moins un de R^{22} à R^{28} est un substituant ayant un cycle aromatique ou forme un cycle aromatique condensé ensemble avec un substituant adjacent alors que le reste de R^{22} à R^{28} représentent chacun un atome d'hydrogène, un groupe alkyle, un groupe cycloalkyle, un groupe aralkyle, un groupe alkényle, un groupe cycloalkényle, un groupe alkynyle, un groupe hydroxyle, un groupe mercapto, un groupe alkoxy, un groupe alkylthio, un groupe aryléther, un groupe arylthioéther, un groupe aryle, un groupe hétérocyclique, un halogène, un halogénoalkane, un halogénoalkène, un halogénoalkyne, un groupe cyano, un groupe aldéhyde, un groupe carbonyle, un groupe carboxyle, un groupe ester, un groupe carbamoyle, un groupe amino, un groupe nitro, un groupe silyle ou un groupe siloxanyle, le reste de R^{22} à R^{28} étant chacun laissé former un cycle condensé ou un cycle aliphatique avec un substituant adjacent, R^{22} à R^{28} étant laissés être mutuellement identiques ou différents et étant laissés être substitués ou non substitués ;

R^{29} et R^{30} sont laissés être mutuellement identiques ou différents et sont chacun choisis dans un groupe constitué par un halogène, un atome d'hydrogène, un alkyle substitué ou non substitué, un aryle substitué ou non substitué et un groupe hétérocyclique substitué ou non substitué ; et

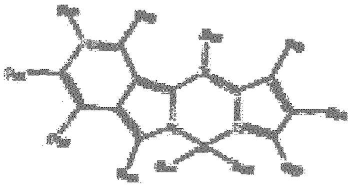
X représente un atome de carbone ou un atome d'azote à la condition que R^{28} ci-dessus n'existe pas quand X représente un atome d'azote.

3. Dispositif électroluminescent organique selon la revendication 2, dans lequel au moins un de R^{22} à R^{28} dans le complexe métallique ayant le squelette pyrrométhène représenté par la formule (2-1) est un substituant ayant un cycle aromatique.

4. Dispositif électroluminescent organique selon la revendication 2, dans lequel au moins un de R^{22} à R^{28} dans le complexe métallique ayant le squelette pyrrométhène représenté par la formule (2-1) forme un cycle aromatique condensé ensemble avec un substituant adjacent.

5. Dispositif électroluminescent organique selon la revendication 4, dans lequel au moins un de R^{22} à R^{24} dans le complexe métallique ayant le squelette pyrrométhène représenté par la formule (2-1) forme un cycle aromatique condensé substitué ou non substitué avec un substituant adjacent et/ou au moins un de R^{25} à R^{27} dans le complexe métallique ayant le squelette pyrrométhène représenté par la formule (2-1) forme un cycle aromatique condensé substitué ou non substitué ensemble avec un substituant adjacent.

6. Dispositif électroluminescent organique selon la revendication 2, dans lequel le complexe métallique ayant le squelette pyrrométhène représenté par la formule (2-1) est un complexe métallique ayant un squelette pyrrométhène représenté par la formule (2-2) comme suit,

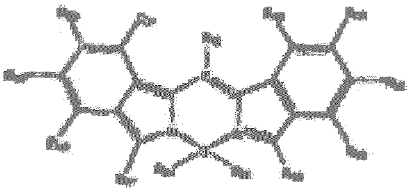


(2-2)

dans laquelle :

R_{31} à R_{39} représentent un atome d'hydrogène, un groupe alkyle, un groupe cycloalkyle, un groupe aralkyle, un groupe alkényle, un groupe cycloalkényle, un groupe alkynyle, un groupe hydroxyle, un groupe mercapto, un groupe alkoxy, un groupe alkylthio, un groupe aryléther, un groupe arylthioéther, un groupe aryle, un groupe hétérocyclique, un halogène, un halogénoalkane, un halogénoalkène, un halogénoalkyne, un groupe cyano, un groupe aldéhyde, un groupe carbonyle, un groupe carboxyle, un groupe ester, un groupe carbamoyle, un groupe amino, un groupe nitro, un groupe silyle ou un groupe siloxanyle, R_{31} à R_{39} étant laissés être mutuellement identiques ou différents et étant laissés être substitués ou non substitués ; R_{40} et R_{41} sont laissés mutuellement être identiques ou différents et chacun est choisi dans un groupe constitué par un halogène, un atome d'hydrogène, un alkyle substitué ou non substitué, un aryle substitué et non substitué et un groupe hétérocyclique substitué ou non substitué ; et X représente un atome de carbone ou un atome d'azote à la condition que R_{39} ci-dessus n'existe pas quand X représente un atome d'azote.

7. Dispositif électroluminescent organique selon la revendication 4, dans lequel le complexe métallique ayant le squelette pyrrométhène représenté par la formule (2-1) est un complexe métallique ayant un squelette pyrrométhène représenté



(2-3)

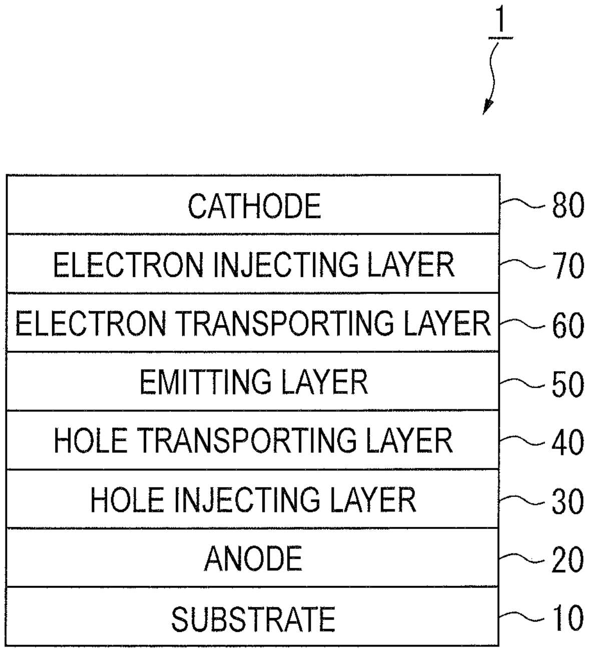
par la formule (2-3) comme suit,
dans laquelle :

> R_{42} à R_{52} représentent chacun un atome d'hydrogène, un groupe alkyle, un groupe cycloalkyle, un groupe aralkyle, un groupe alkényle, un groupe cycloalkényle, un groupe alkynyle, un groupe hydroxyle, un groupe mercapto, un groupe alkoxy, un groupe alkylthio, un groupe aryléther, un groupe arylthioéther, un groupe aryle, un groupe hétérocyclique, un halogène, un halogénoalkane, un halogénoalkène, un halogénoalkyne, un groupe cyano, un groupe aldéhyde, un groupe carbonyle, un groupe carboxyle, un groupe ester, un groupe carbamoyle, un groupe amino, un groupe nitro, un groupe silyle ou un groupe siloxanyle, R_{42} à R_{52} étant laissés être mutuellement identiques ou différents et étant laissés substitués ou non substitués ; R_{53} et R_{54} sont laissés être mutuellement identiques ou différents et chacun est choisi dans un groupe constitué par un halogène, un atome d'hydrogène, un alkyle substitué ou non substitué, un aryle substitué et non substitué et un groupe hétérocyclique substitué ou non substitué ; et X représente un atome de carbone ou un atome d'azote à une condition que R_{52} ci-dessus n'existe pas quand X représente un atome d'azote.

8. Dispositif électroluminescent organique selon l'une quelconque des revendications 1 à 7, dans lequel le dopant est contenu dans la couche émettrice à une concentration de dopage de 0,1 à 10 % en masse.

9. Dispositif électroluminescent organique selon l'une quelconque des revendications 1 à 8, dans lequel A dans le composé représenté par la formule (4) a un squelette dans sa molécule, le squelette choisi dans un groupe constitué par l'anthracène, le phénanthrène, le naphtacène, le pyrène, le chrysène, le benzoanthracène, le pentacène, le dibenzoathracène, le benzopyrène, le fluorène, le benzofluorène, le fluoranthène, le benzofluoranthène, le naphtofluoranthène, le dibenzofluorène, le dibenzopyrène et le dibenzofluoranthène.

FIG. 1


1
CATHODE
80
ELECTRON INJECTING LAYER
70
ELECTRON TRANSPORTING LAYER
60
EMITTING LAYER
50
HOLE TRANSPORTING LAYER
40
HOLE INJECTING LAYER
30
ANODE
20
SUBSTRATE
10

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专利名称(译)	有机el设备和显示器		
公开(公告)号	EP2128910B1	公开(公告)日	2016-03-09
申请号	EP2008721707	申请日	2008-03-10
[标]申请(专利权)人(译)	出光兴产株式会社		
申请(专利权)人(译)	出光兴产股份有限公司.		
当前申请(专利权)人(译)	出光兴产股份有限公司.		
[标]发明人	HOSOKAWA CHISHIO SADO TAKAYASU IKEDA KIYOSHI		
发明人	HOSOKAWA, CHISHIO SADO, TAKAYASU IKEDA, KIYOSHI		
IPC分类号	H01L51/56 H01L51/50 C07C15/38 C09K11/06 C07F5/02		
CPC分类号	H01L51/008 C07C15/38 C07C15/62 C07C2603/44 C09K11/06 C09K2211/1011 C09K2211/1055 H01L51/0054 H01L51/0065 H01L51/0072 H01L51/5012		
优先权	2007061091 2007-03-09 JP		
其他公开文献	EP2128910A1 EP2128910A4		
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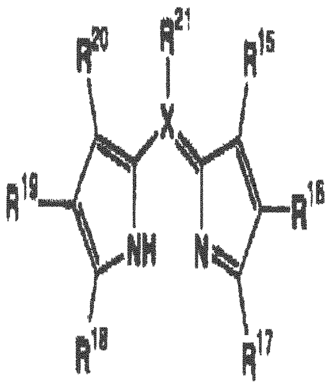
摘要(译)

在包括阴极和阳极的有机电致发光器件中，在阴极和阳极之间至少设置发光层和电子传输层。发光层含有由下式（1）表示的并四苯衍生物形成的主体材料和由具有下式（2）表示的亚甲基吡咯骨架的化合物或该化合物的金属络合物形成的掺杂剂材料。电子传输层优选为苯并咪唑衍生物。

[Chemical Formula 2]



(2)