



(11) **EP 1 412 450 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
29.02.2012 Bulletin 2012/09

(21) Application number: **02745913.0**

(22) Date of filing: **10.07.2002**

(51) Int Cl.:
C09K 11/06 (2006.01) H05B 33/14 (2006.01)

(86) International application number:
PCT/JP2002/006998

(87) International publication number:
WO 2003/007658 (23.01.2003 Gazette 2003/04)

(54) **LIGHT-EMITTING DEVICE AND AROMATIC COMPOUND**

LICHT-EMITTIERENDE VORRICHTUNG UND AROMATISCHE VERBINDUNG

DISPOSITIF ELECTROLUMINESCENT ET COMPOSE AROMATIQUE

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
IE IT LI LU MC NL PT SE SK TR**

(30) Priority: **11.07.2001 JP 2001211269**
26.10.2001 JP 2001329676

(43) Date of publication of application:
28.04.2004 Bulletin 2004/18

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EP-A- 1 009 041 EP-A2- 1 475 361
US-A- 5 077 142 US-A- 5 989 737

- **POPOVIC Z D ET AL: "Life extension of organic LED's by doping of a hole transport layer" THIN SOLID FILMS, ELSEVIER-SEQUOIA S.A. LAUSANNE, CH, vol. 363, no. 1-2, March 2000 (2000-03), pages 6-8, XP004189254 ISSN: 0040-6090**
- **PATENT ABSTRACTS OF JAPAN vol. 016, no. 273 (C-0953), 18 June 1992 (1992-06-18) & JP 04 068076 A (RICOH CO LTD), 3 March 1992 (1992-03-03)**

EP 1 412 450 B1

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Description

FIELD OF THE INVENTION

5 **[0001]** The present invention relates to a light-emitting device that converts electric energy to light, particularly to a light-emitting device suitable for indicating elements, displays, backlights, electrophotography, illumination light sources, recording light sources, exposing light sources, reading light sources, signs and marks, signboards, interiors, optical communications devices, and a novel aromatic compound usable for such a light-emitting device.

10 BACKGROUND OF THE INVENTION

[0002] Various display devices have been actively researched and, developed in recent years. In particular, organic electroluminescence (EL) devices attract much attention because they can emit light at a high luminance with low voltage applied. For example, a light-emitting device comprising organic thin layers provided by vapor-depositing organic compounds is disclosed in Applied Physics Letters, Vol. 51, page 913 (1987). This light-emitting device has a structure where an electron-transporting material of tris(8-hydroxyquinolinato) aluminum complex (Alq) and a hole-transporting material of an amine compound are disposed between electrodes as a laminate, thereby exhibiting more excellent light-emitting properties than those of conventional light-emitting devices having a single-layer structure.

20 **[0003]** Active research and development have been made to apply organic EL devices to full-color displays in recent years. To provide high-performance, full-color displays, light-emitting properties should be improved for each of blue, green and red colors. For instance, blue-color, light-emitting devices are disadvantageous in color purity, durability, light-emitting luminance and light-emitting efficiency, and thus their improvement is desired. To solve these problems, devices comprising aromatic condensed-ring compounds were investigated (JP 11-12205 A, etc.), but there is still a problem that such light-emitting devices are low in light-emitting efficiency, failing to emit blue light with high color purity.

25 **[0004]** In addition, improvement is desired in organic EL devices, too.

[0005] US 5,077,142 is directed to organic electroluminescence devices comprising as a luminescent layer at least one layer of an organic compound sandwiched between an anode and a cathode.

30 **[0006]** EP 1 475 361 was published after the priority date of the present invention, but has an earlier filing date. Said document relates to an aromatic condensed-ring compound, a material used for light-emitting devices capable of luminescing through conversion of electric energy into light, and a light-emitting device using such a material.

OBJECT OF THE INVENTION

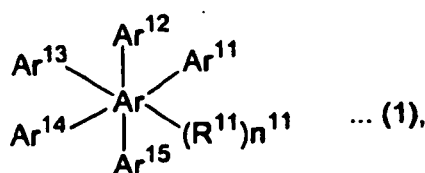
35 **[0007]** An object of the present invention is to provide a light-emitting device excellent in light-emitting properties and durability.

[0008] Another object of the present invention is to provide an aromatic compound excellent in color purity and durability, and usable for such light-emitting devices.

DISCLOSURE OF THE INVENTION

40 **[0009]** As a result of intense research in view of the above objects, the inventors have found that a light-emitting device comprising an aromatic compound having a particular structure is excellent in light-emitting properties and durability. The present invention has been completed based on this finding. The object of the present invention was solved on the basis of claims 1 to 27.

45 **[0010]** Thus, the light-emitting device of the present invention comprises a pair of electrodes and a light-emitting layer or a plurality of organic layers comprising a light-emitting layer disposed between the electrodes, either of the light-emitting layer or at least one of a plurality of organic layers comprising a light-emitting layer comprising at least one compound represented by the general formula (1):



wherein each of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ represents an aryl group or a heteroaryl group; Ar represents a benzene

ring; at least one of Ar, Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a condensed aryl group, a condensed or uncondensed heteroaryl group or a group comprising a condensed aryl group or a Ar¹⁵ condensed or uncondensed heteroaryl group: at least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a pyrenyl group; Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ are not bonded to each other to form a ring; R¹¹ represents a substituent; and n¹¹ represents an integer of 0 or more. Ar¹², Ar¹³, Ar¹⁴

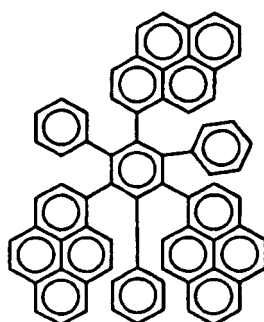
[0011] In the general formula (1), at least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a pyrenyl group.

[0012] In the above general formula (1), at least four of R¹¹, Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ are preferably a condensed aryl group or a condensed or uncondensed heteroaryl group, more preferably a condensed aryl group, most preferably a phenanthryl group or a pyrenyl group.

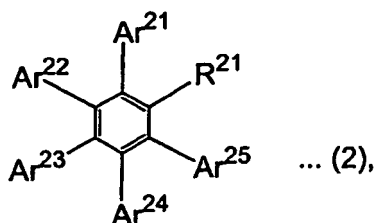
[0013] In the above general formula (1), at least one of R¹¹, Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is selected from the group consisting of a naphthyl group, a phenanthryl group, an anthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group, more preferably a naphthyl group or a phenanthryl group.

[0014] The compound represented by the general formula (1) preferably emits light from a singlet excited state.

[0015] The compound of general formula (1) is not:



[0016] The first preferred example of the general formula (1) is the following general formula (2):



wherein each of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ represents an aryl group or a heteroaryl group; at least one of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ is a condensed aryl group, a condensed or uncondensed heteroaryl group or a group comprising a condensed aryl group or a condensed or uncondensed heteroaryl group: at least one of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ is a pyrenyl group Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ are not bonded to each other to form a ring; R²¹ represents a hydrogen atom or a substituent.

[0017] In the general formula (2), it is preferable that each of Ar²¹, Ar²², Ar²³ and Ar²⁴ is selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group and a fluoranthenyl group; Ar²⁵ is selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group; R²¹ is selected from the group consisting of a hydrogen atom, an alkyl group and an aryl group; at least one of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ is a condensed aryl group; Ar²¹, Ar²², Ar²⁴ and Ar²⁵ are not bonded to each other to form a ring.

[0018] In the general formula (2), each of Ar²¹, Ar²², Ar²³ and Ar²⁴ is more preferably selected from the group consisting of a phenyl group, a naphthyl group and a phenanthryl group, most preferably a phenyl group.

[0019] In the general formula (2), Ar²⁵ is more preferably selected from the group consisting of an anthryl group, a phenanthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group.

[0020] In the general formula (2), R²¹ is more preferably selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group.

[0021] In the above general formula (2), at least four of R²¹, Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ are preferably a condensed aryl group or a condensed or uncondensed heteroaryl group, more preferably a condensed aryl group, most preferably

a phenanthryl group or a pyrenyl group.

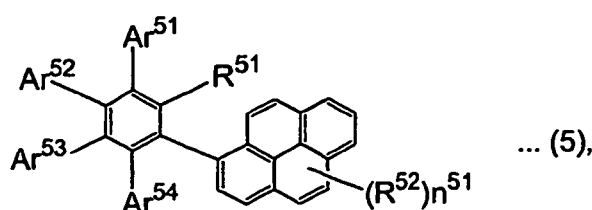
[0022] In the above general formula (2), each of Ar²¹ and Ar²² is a condensed aryl group or a condensed or uncondensed heteroaryl group, more preferably a condensed aryl group, most preferably a phenanthryl group or a pyrenyl group.

[0023] In the above general formula (2), each of Ar²¹ and Ar²⁴ is preferably a condensed aryl group or a condensed or uncondensed heteroaryl group, more preferably a condensed aryl group, most preferably a phenanthryl group or a pyrenyl group.

[0024] In the above general formula (2), at least one of R¹¹, Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is selected from the group consisting of a naphthyl group, a phenanthryl group, an anthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group, more preferably a naphthyl group or a phenanthryl group.

[0025] In the above general formula (2), it is preferable that each of Ar²¹ and Ar²³ is a condensed aryl group, and that each of R²¹, Ar²², Ar²⁴ and Ar²⁵ is selected from the group consisting of a phenyl group, a naphthyl group, a phenanthryl group, an anthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group; and it is more preferable that each of Ar²¹ and Ar²³ is a pyrenyl group, and that each of R²¹, Ar²², Ar²⁴ and Ar²⁵ is selected from the group consisting of a phenyl group, a naphthyl group and a phenanthryl group.

[0026] The first preferred example of the general formula (2) is the following general formula (5):

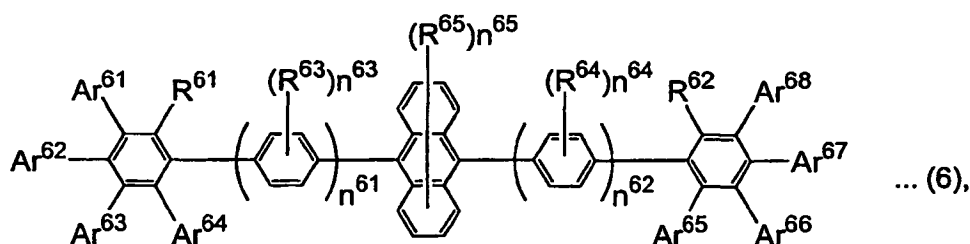


wherein each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ represents an aryl group, R⁵¹ represents a hydrogen atom or a substituent, R⁵² represents a substituent, and n⁵¹ is an integer of 0 to 9.

[0027] In the general formula (5), each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ is preferably selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group and a fluoranthenyl group, more preferably a phenyl group.

[0028] In the general formula (5), R⁵¹ is preferably selected from the group consisting of a hydrogen atom, an alkyl group and an aryl group, more preferably selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group, most preferably a phenyl group or a pyrenyl group.

[0029] The second preferred example of the general formula (2) is the following general formula (6):



wherein each of Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷, and Ar⁶⁸ represents an aryl group or a heteroaryl group; each of R⁶¹ and R⁶² represents a hydrogen atom or a substituent; each of R⁶³, R⁶⁴ and R⁶⁵ represents a substituent; each of n⁶¹ and n⁶² is an integer of 0 to 5; each of n⁶³ and n⁶⁴ is an integer of 0 to 4; and n⁶⁵ is an integer of 0 to 8.

[0030] In the general formula (6), each of Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷ and Ar⁶⁸ is preferably selected from the group consisting of a phenyl group, a naphthyl group and a phenanthryl group. In particular, each of R⁶¹ and R⁶² is preferably selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group. Each of n⁶¹ and n⁶² is preferably 0 or 1.

[0031] The compound of the general formula (1) is preferably represented by the general formula (2).

[0032] The content of the compound represented by the general formula (1) in the light-emitting layer is preferably 0.1 to 100% by mass as a light-emitting material.

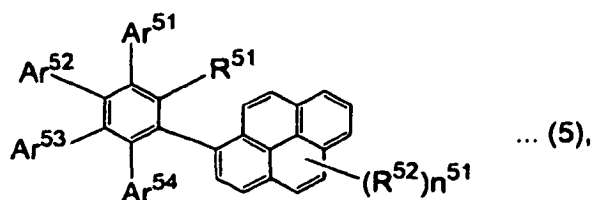
[0033] The content of the compound represented by the general formula (1) in the light-emitting layer or at least one of a plurality of organic layers comprising the light-emitting layer is preferably 10 to 99.9% by mass as a host material.

[0034] At least one of the above light-emitting layer and a plurality of organic layers comprising the above light-emitting layer is preferably a light-emitting layer.

[0035] At least one of the above light-emitting layer and a plurality of organic layers comprising the above light-emitting layer is preferably a hole-transporting layer.

[0036] The above light-emitting layer preferably comprises at least one fluorescent compound.

[0037] The aromatic compound of the present invention is represented by the general formula (5):



wherein each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ represents an aryl group; R⁵¹ represents a hydrogen atom or a substituent; R⁵² represents a substituent; and n⁵¹ is an integer of 0 to 9.

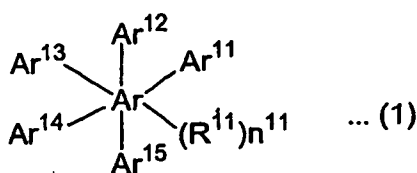
[0038] In the general formula (5), each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ is preferably selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group and a fluoranthenyl group, more preferably a phenyl group.

[0039] In the general formula (5), R⁵¹ is preferably selected from the group consisting of a hydrogen atom, an alkyl group and an aryl group, more preferably selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group, most preferably a phenyl group or a pyrenyl group.

[0040] The aromatic compound represented by the general formula (5) is a preferred example of the compound represented by the general formula (2), which can preferably be used as the compound represented by the general formula (1).

BEST MODE FOR CARRYING OUT THE INVENTION

[0041] The light-emitting device of the present invention comprises a pair of electrodes and a light-emitting layer and a plurality of organic layers comprising a light-emitting layer disposed therebetween. The light-emitting layer or at least one layer in a plurality of organic layers comprising the light-emitting layer comprises at least one compound represented by the following general formula (1). The compound represented by any one of the general formulae (1), (2), (5) and (6) may be referred to as "compound (1)" or "compound of the present invention" hereinafter.



[0042] In the general formula (1), each of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ represents an aryl group or a heteroaryl group. Examples of the aryl groups include a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a fluoranthenyl group, a pyrenyl group, a perylenyl group, a chrysenyl group, a triphenylenyl group, a benzoanthryl group, a benzophenanthryl group, etc. Preferable among them are a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a pyrenyl group and a perylenyl group. Examples of the condensed or uncondensed heteroaryl groups include a pyridyl group, a quinolyl group, a quinoxalyl group, a quinazolyl group, an acridyl group, a phenanthridyl group, a phthalazyl group, a phenanthrolyl group, a triazolyl group, etc. Preferable among them are a pyridyl group, a quinolyl group and a triazolyl group. Each of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ may have a substituent, whose examples may be the same as those of R¹¹ described later. Each of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴, and Ar¹⁵ is preferably an aryl group. Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ are not bonded to each other to form a ring.

[0043] In the general formula (1), Ar represents a benzene ring.

[0044] At least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a condensed aryl group or a group comprising a condensed

aryl group, such as a naphthyl group, a phenanthryl group, an anthryl group, a pyrenyl group, a perylenyl group, a fluoranthenyl group; or a condensed or uncondensed heteroaryl group or a group comprising a condensed or uncondensed heteroaryl group, such as a pyridyl group, a quinolyl group, a quinoxalyl group, a quinazolyl group, an acridyl group, a phenanthridyl group, a phthalazyl group, a phenanthrolyl group, a triazolyl group. least one of Ar, Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is preferably a condensed aryl group or a group comprising a condensed aryl group, more preferably a pyrenyl group. The number of pyrenyl groups in the compound (1) is preferably two or less. The above group comprising a condensed aryl group or a condensed or uncondensed heteroaryl group may be composed of a condensed aryl group or a condensed or uncondensed heteroaryl group, and an alkylene group, an arylene group, etc., though it is preferably composed of only a condensed aryl group or a condensed or uncondensed heteroaryl group. At least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a pyrenyl group.

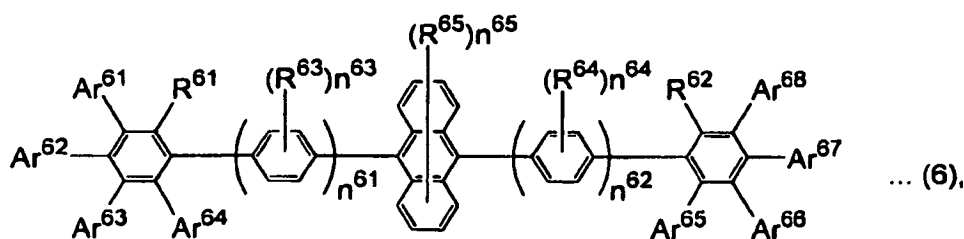
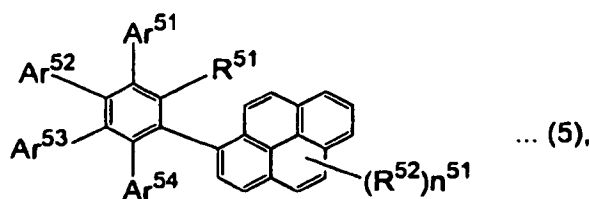
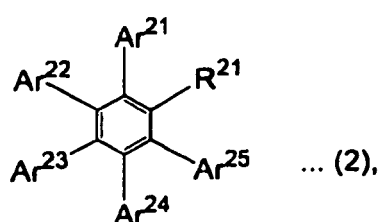
[0045] In the general formula (1), R¹¹ represents a substituent. Examples of the substituents R¹¹ include alkyl groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 10, such as a methyl group, an ethyl group, an isopropyl group, a t-butyl group, a n-octyl group, a n-decyl group, a n-hexadecyl group, a cyclopropyl group, a cyclopentyl group and a cyclohexyl group; alkenyl groups, the number of carbon atoms thereof being preferably 2 to 30, more preferably 2 to 20, most preferably 2 to 10, such as a vinyl group, an allyl group, a 2-butenyl group and a 3-pentenyl group; alkynyl groups, the number of carbon atoms thereof being preferably 2 to 30, more preferably 2 to 20, most preferably 2 to 10, such as a propargyl group and a 3-pentynyl group; aryl groups, the number of carbon atoms thereof being preferably 6 to 30, more preferably 6 to 20, most preferably 6 to 12, such as a phenyl group, a p-methylphenyl group, a naphthyl group and an anthranil group; amino groups, the number of carbon atoms thereof being preferably 0 to 30, more preferably 0 to 20, most preferably 0 to 10, such as an amino group, a methylamino group, a dimethylamino group, a diethylamino group, a dibenzylamino group, a diphenylamino group and a ditolylamino group; alkoxy groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 10, such as a methoxy group, an ethoxy group, a butoxy group and a 2-ethylhexyloxy group; aryloxy groups, the number of carbon atoms thereof being preferably 6 to 30, more preferably 6 to 20, most preferably 6 to 12, such as a phenyloxy group, a 1-naphthyloxy group and a 2-naphthyloxy group; heterocyclic oxy groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a pyridyloxy group, a pyrazolyloxy group, a pyrimidyloxy group and a quinolyloxy group; acyl groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as an acetyl group, a benzoyl group, a formyl group and a pivaloyl group; alkoxy-carbonyl groups, the number of carbon atoms thereof being preferably 2 to 30, more preferably 2 to 20, most preferably 2 to 12, such as a methoxycarbonyl group and an ethoxy-carbonyl group; aryloxy-carbonyl groups, the number of carbon atoms thereof being preferably 7 to 30, more preferably 7 to 20, most preferably 7 to 12, such as a phenyloxy-carbonyl group; acyloxy groups, the number of carbon atoms thereof being preferably 2 to 30, more preferably 2 to 20, most preferably 2 to 10, such as an acetoxyl group and a benzoyloxy group; acylamino groups, the number of carbon atoms thereof being preferably 2 to 30, more preferably 2 to 20, most preferably 2 to 10, such as an acetylamino group and a benzoylamino group; alkoxy-carbonylamino groups, the number of carbon atoms thereof being preferably 2 to 30, more preferably 2 to 20, most preferably 2 to 12, such as a methoxycarbonylamino group; aryloxy-carbonylamino groups, the number of carbon atoms thereof being preferably 7 to 30, more preferably 7 to 20, most preferably 7 to 12, such as a phenyloxy-carbonylamino group; sulfonylamino groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a methanesulfonylamino group and a benzenesulfonylamino group; sulfamoyl groups, the number of carbon atoms thereof being preferably 0 to 30, more preferably 0 to 20, most preferably 0 to 12, such as a sulfamoyl group, a methylsulfamoyl group, a dimethylsulfamoyl group and a phenylsulfamoyl group; carbamoyl groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a carbamoyl group, a methylcarbamoyl group, a diethylcarbamoyl group, a phenylcarbamoyl group; alkylthio groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a methylthio group and an ethylthio group; arylthio groups, the number of carbon atoms thereof being preferably 6 to 30, more preferably 6 to 20, most preferably 6 to 12, such as a phenylthio group; heterocyclic thio groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a pyridylthio group, a 2-benzimidazolylthio group, a 2-benzoxazolylthio group and a 2-benzthiazolylthio group; sulfonyl groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a mesyl group and a tosyl group; sulfinyl groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a methane sulfinyl group and a benzene sulfinyl group; ureide groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a ureide group, a methylureide group and a phenylureide group; phosphoric amide groups, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 20, most preferably 1 to 12, such as a diethylphosphoric amide group and a phenylphosphoric amide group; a hydroxyl group; mercapto groups; halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom and an iodine atom; cyano groups; sulfo groups; carboxyl groups; nitro groups; a hydroxamic acid group; a sulfinio group; a hydrazino group; an imino group; heterocyclic groups that may have a nitrogen atom, a

oxygen atom, a sulfur atom, as a hetero atom, the number of carbon atoms thereof being preferably 1 to 30, more preferably 1 to 12, such as an imidazolyl group, a pyridyl group, a quinolyl group, a furyl group, a thienyl group, a piperidyl group, a morpholino group, a benzoxazolyl group, a benzimidazolyl group, a benzthiazolyl group, a carbazolyl group, an azepinyl group and a triazolyl group; silyl groups, the number of carbon atoms thereof being preferably 3 to 40, more preferably 3 to 30, most preferably 3 to 24, such as a trimethylsilyl group and a triphenylsilyl group; siloxy groups, the number of carbon atoms thereof being preferably 3 to 30, more preferably 6 to 30, such as a triphenylsilyloxy group, a t-butyldimethylsilyloxy group. These substituents may be further substituted. R¹¹ is preferably an alkyl group or an aryl group.

[0046] In the general formula (1), n¹¹ represents an integer of 0 or more, preferably 0 to 5, more preferably 0 to 2, most preferably 1.

[0047] From the viewpoint of vapor depositability during the production of the light-emitting device, the number of benzene rings in the compound (1) is preferably 15 or less. Also, when the compound (1) comprises a condensed group having four or more rings, such as a pyrene group, a triphenylene group, the number of the condensed group having four or more rings is preferably 2 or less.

[0048] The compound (1) is represented preferably by the general formula (2), further preferably by the following general formula (5) or (6), most preferably by the general formula (5).



[0049] In the general formula (2), each of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ represents an aryl group or a heteroaryl group, preferably an aryl group. Each of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ may have a substituent. Examples of the substituents may be the same as those of R¹¹ described above. At least one of Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ is a condensed aryl group, a condensed or uncondensed heteroaryl group or a group comprising a condensed aryl group or a condensed or uncondensed heteroaryl group. Each of Ar²¹, Ar²², Ar²³ and Ar²⁴ is preferably a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group or a fluoranthenyl group, more preferably a phenyl group, a naphthyl group, an anthryl group or a phenanthryl group, further preferably a phenyl group, a naphthyl group or a phenanthryl group, most preferably a phenyl group. Ar²⁵ is preferably a phenyl group, a naphthyl group, a phenanthryl group, an anthryl group, a pyrenyl group, a perylenyl group or a fluoranthenyl group, more preferably a phenanthryl group, an anthryl group or a pyrenyl group, most preferably a pyrenyl group. Ar²¹, Ar²², Ar²³, Ar²⁴ and Ar²⁵ are not bonded to each other to form a ring.

[0050] In the general formula (2), R²¹ represents a hydrogen atom or a substituent. Examples of the substituents may be the same as those of R¹¹ described above. R²¹ is preferably a hydrogen atom, an alkyl group or an aryl group, more

preferably a hydrogen atom, a phenyl group or a pyrenyl group, most preferably a pyrenyl group.

[0051] In the general formula (5), each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ represents an aryl group, preferably a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group or a fluoranthenyl group, more preferably a phenyl group, a naphthyl group, an anthryl group or a phenanthryl group, further preferably a phenyl group, a naphthyl group or a phenanthryl group, most preferably a phenyl group. Each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ may have a substituent, whose examples may be the same as those of R¹¹ described above.

[0052] In the general formula (5), R⁵¹ represents a hydrogen atom or a substituent. Examples of the substituents may be the same as those of R¹¹ described above. R⁵¹ is preferably a hydrogen atom, an alkyl group or an aryl group, more preferably a hydrogen atom, a phenyl group or a pyrenyl group, most preferably a pyrenyl group.

[0053] In the general formula (5), R⁵² represents a substituent, whose examples may be the same as those of R¹¹ described above. R⁵² is preferably an alkyl group or an aryl group. n⁵¹ represents the number of R⁵², which is an integer of 0 to 9, preferably 0 to 2, more preferably 0.

The number of pyrenyl groups in the compound represented by the general formula (5) is preferably two or less.

[0054] In the general formula (6), Ar⁶¹ and Ar⁶⁸ are the same as the above Ar²¹; Ar⁶² and Ar⁶⁷ are the same as the above Ar²²; Ar⁶³ and Ar⁶⁶ are the same as the above Ar²³; and Ar⁶⁴ and Ar⁶⁵ are the same as the above Ar²⁴, in their definitions and preferred examples. Each of Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷ and Ar⁶⁸ may have a substituent, whose examples may be the same as those of R¹¹ described above. Each of n⁶¹ and n⁶² represents an integer of 0 to 5, preferably 0 to 3, more preferably 0 or 1.

[0055] In the general formula (6), R⁶¹ and R⁶² are the same as the above R²¹ in their definitions and preferred examples. R⁶³, R⁶⁴ and R⁶⁵ are the same as the above R⁵² in their definitions and preferred examples. Each of n⁶³ and n⁶⁴ represents an integer of 0 to 4, preferably 0 or 1, more preferably 0. n⁶⁵ represents an integer of 0 to 8, preferably 0 to 2, more preferably 0.

[0056] The compound (1) is preferably a low-molecular-weight compound and it may be an oligomer or a polymer. In a case where the compound (1) is a polymer or an oligomer, its weight-average molecular weight determined with polystyrene as a standard is preferably 1,000 to 5,000,000, more preferably 2,000 to 1,000,000, most preferably 3,000 to 100,000. The polymer may contain a moiety represented by the formula (1) in its main or side chain. The polymer may be a homopolymer or a copolymer.

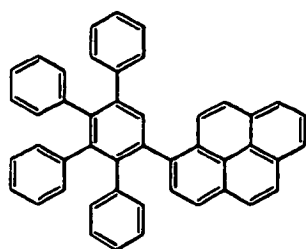
[0057] The compound (1) preferably has the maximum emitting wavelength λ_{\max} of 370 to 500 nm in a fluorescence spectrum of its single layer or powder. λ_{\max} is more preferably 390 to 480 nm, further preferably 400 to 460 nm, and most preferably 400 to 440 nm.

[0058] Each of the compounds represented by the general formula (1), compounds used in the electron-transporting layer and compounds used in the hole-transporting layer has a glass transition temperature T_g of preferably 100°C or higher, more preferably 120°C or higher, further preferably 140°C or higher, particularly preferably 160°C or higher.

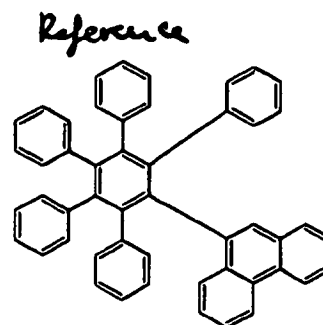
[0059] The light-emitting device of the present invention preferably further contains at least one fluorescent compound in its light-emitting layer. Within the preferred range of the fluorescent compounds are compounds described herein as materials for the light-emitting layer and their derivatives.

[0060] Specific examples of the compounds (1) are illustrated below.

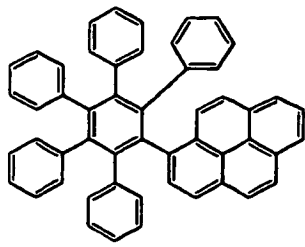
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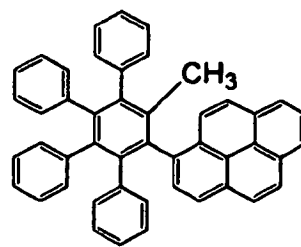
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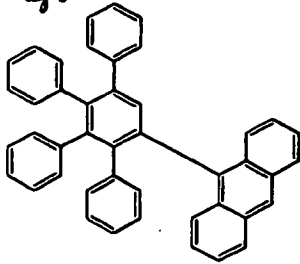
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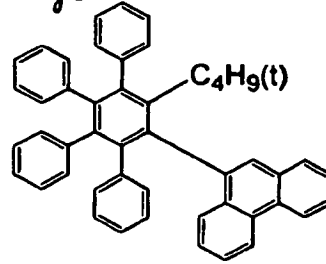
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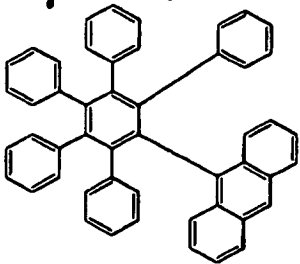
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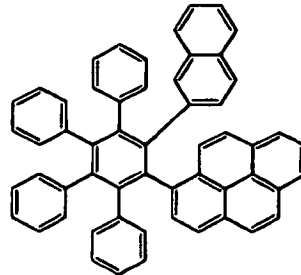
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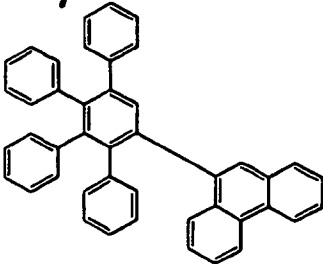
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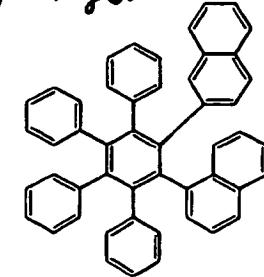
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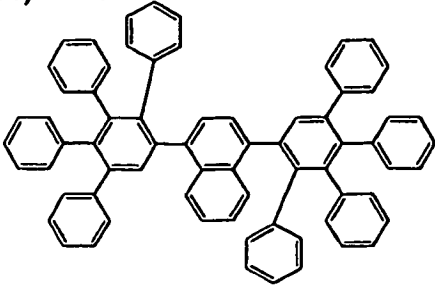
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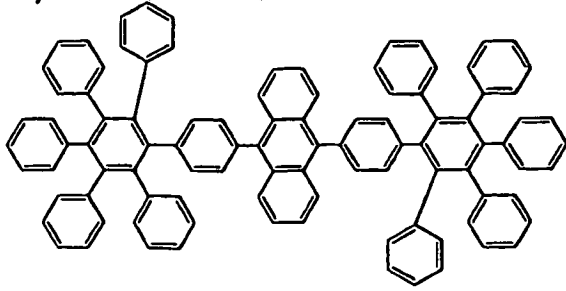
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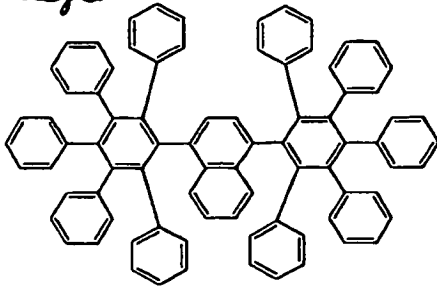
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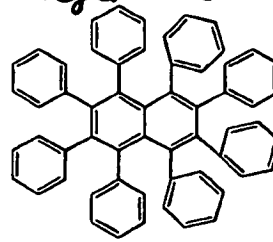
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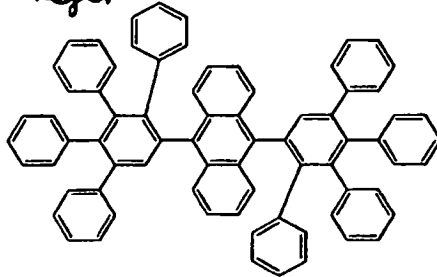
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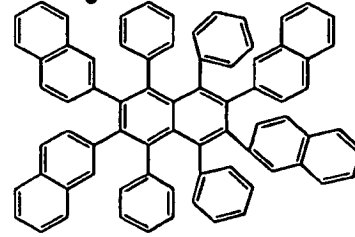
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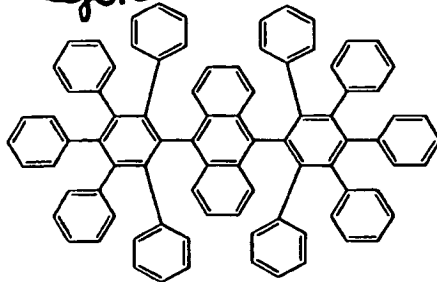
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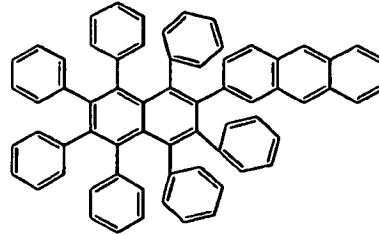
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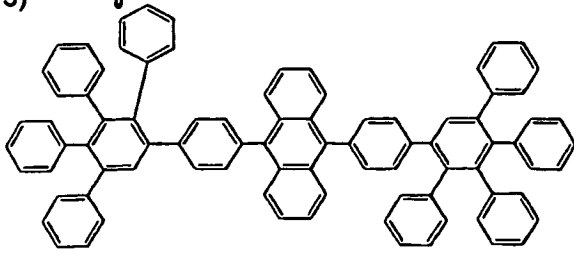


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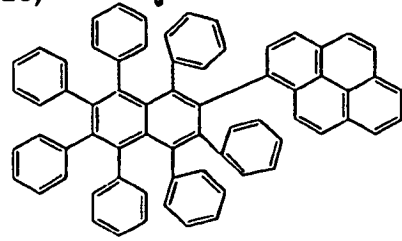


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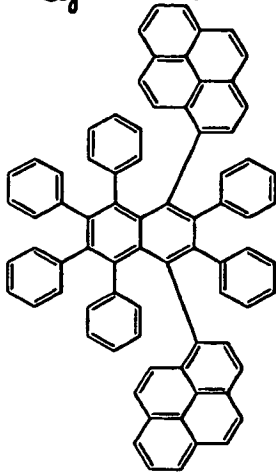
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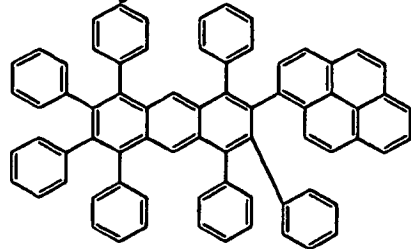
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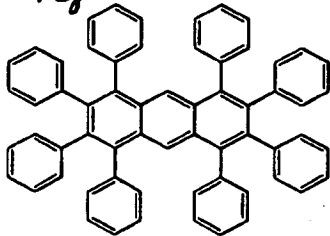
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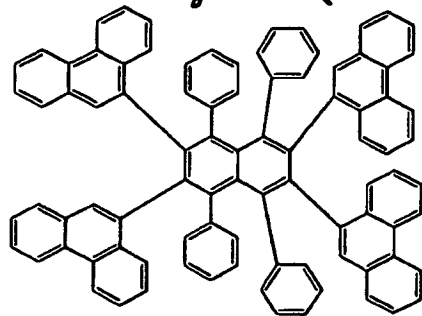
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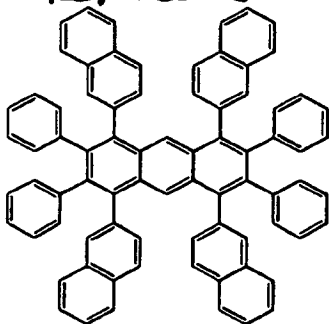
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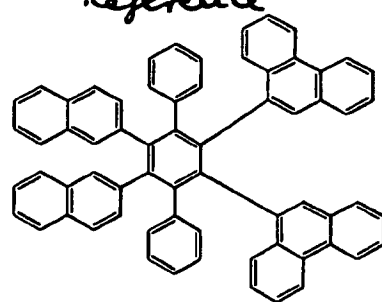
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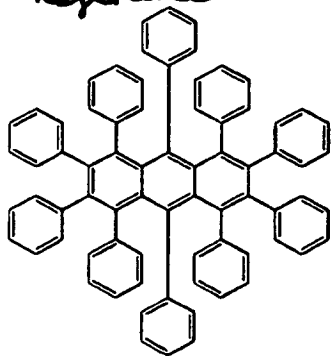
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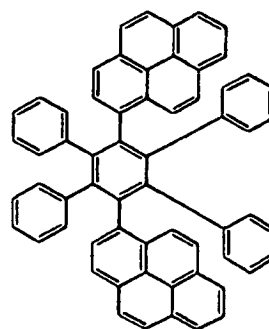
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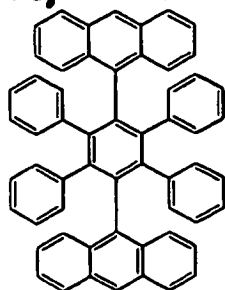
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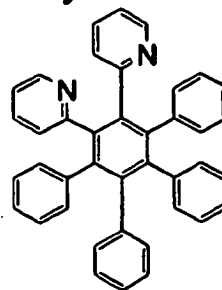
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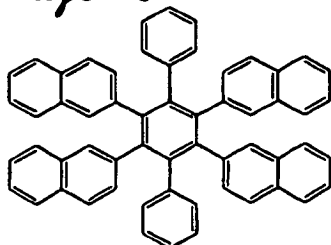
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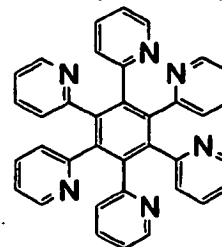
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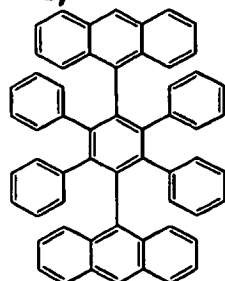
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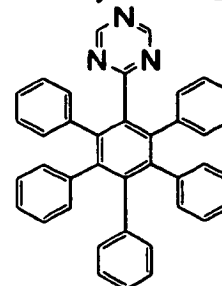
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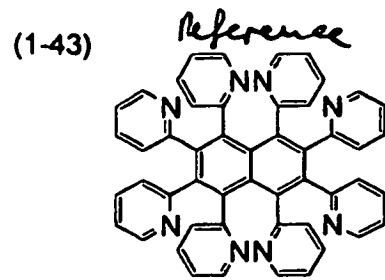
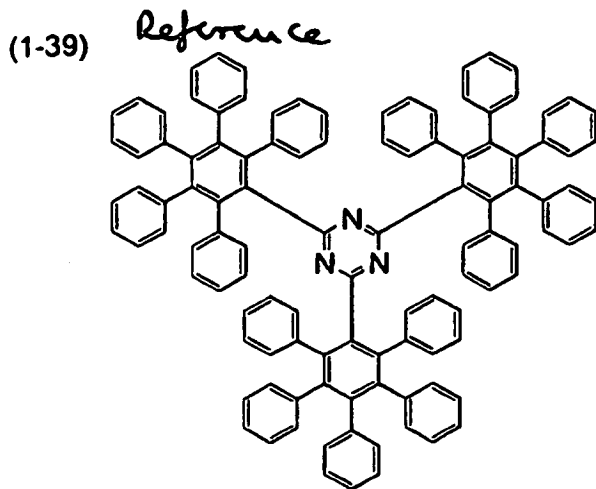
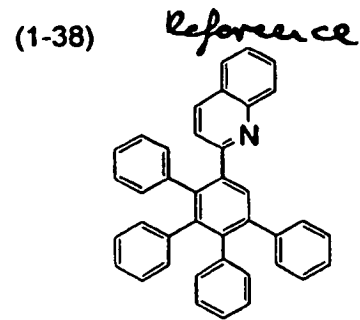
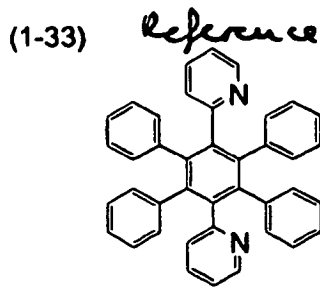
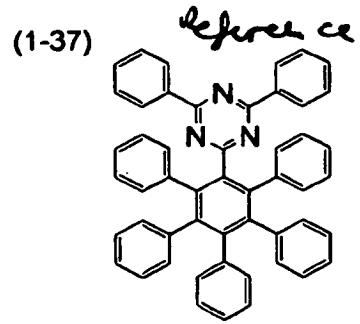
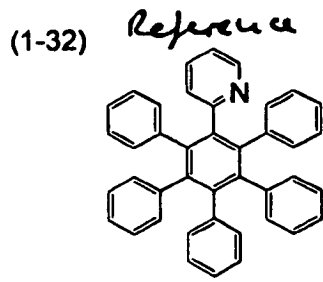


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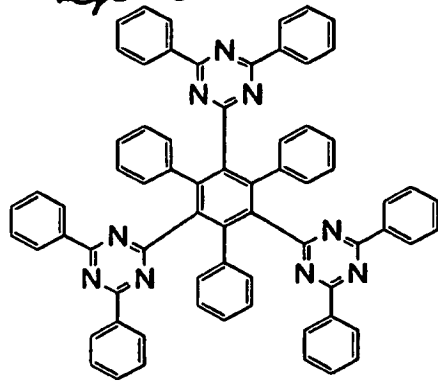




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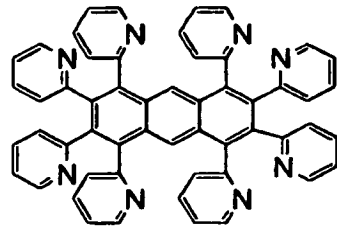
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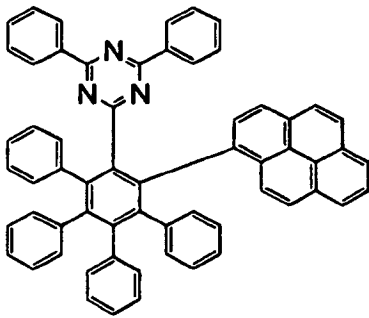


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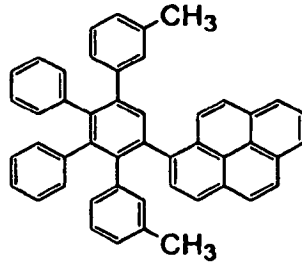
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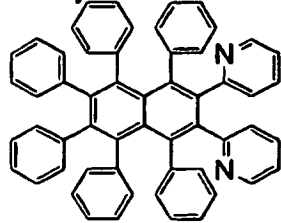


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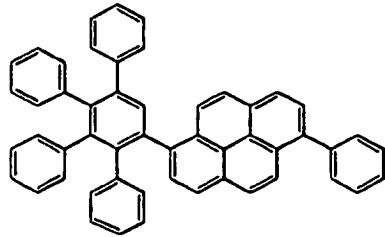


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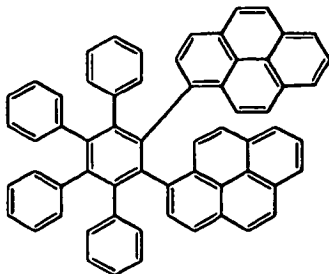
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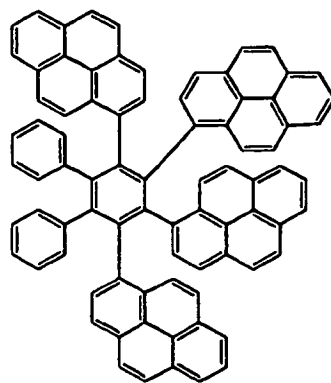
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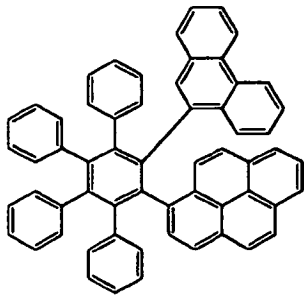
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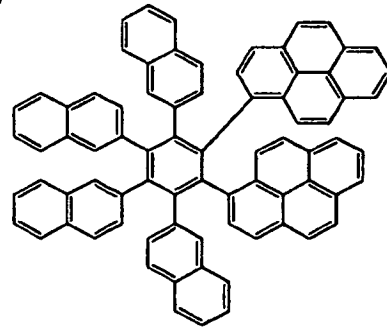
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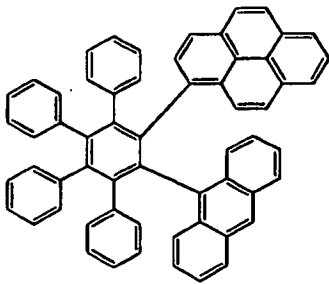
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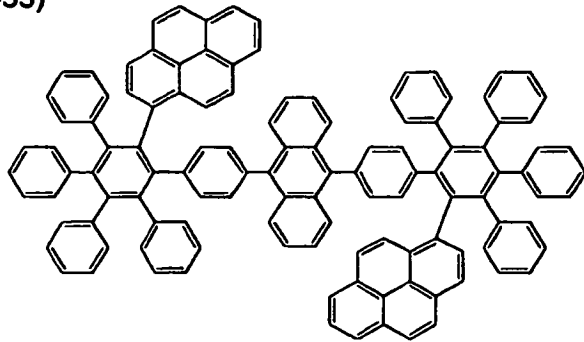
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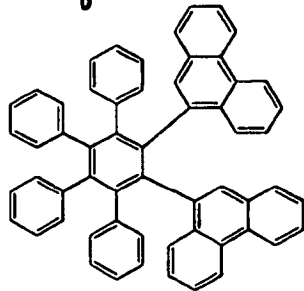
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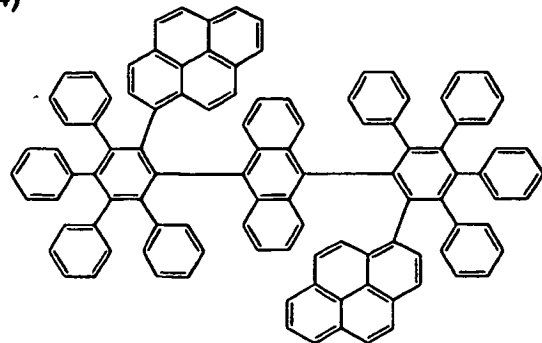
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(1-50) *Reference*



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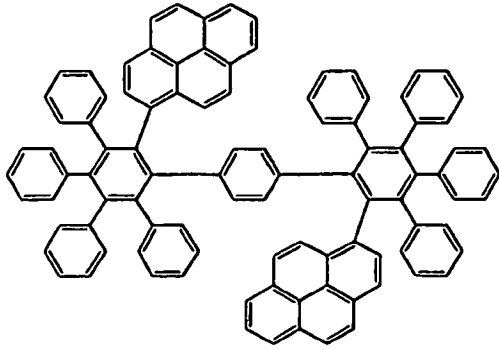
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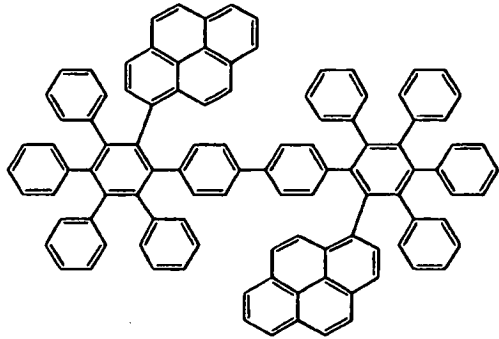
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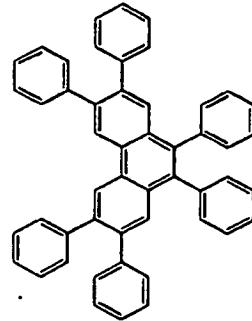
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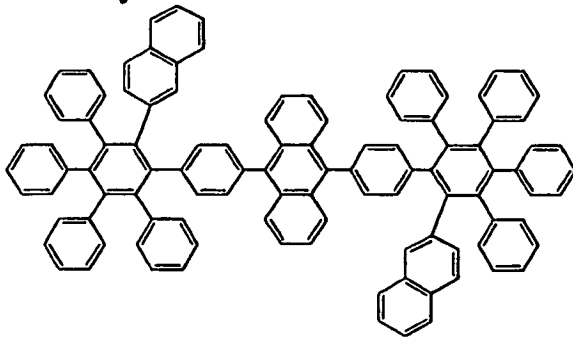


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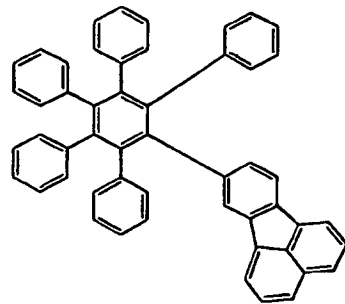
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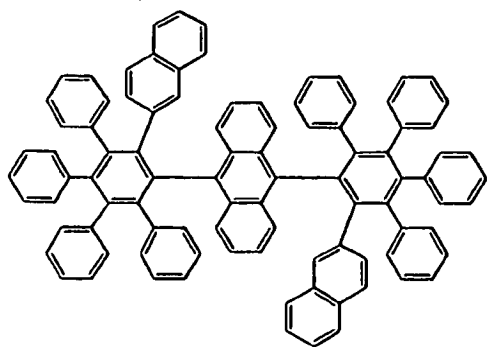


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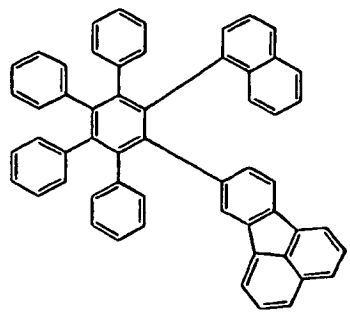
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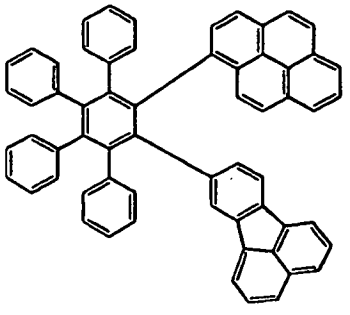
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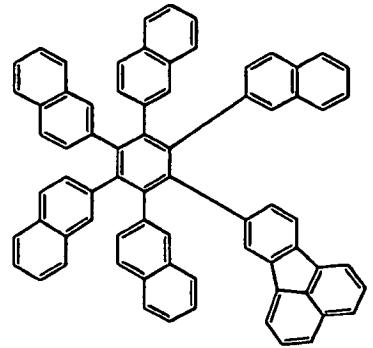
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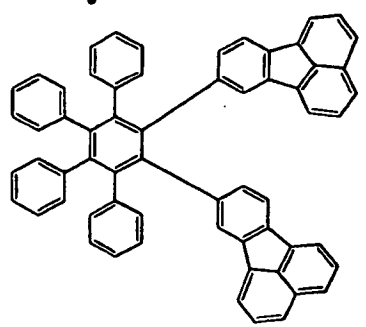
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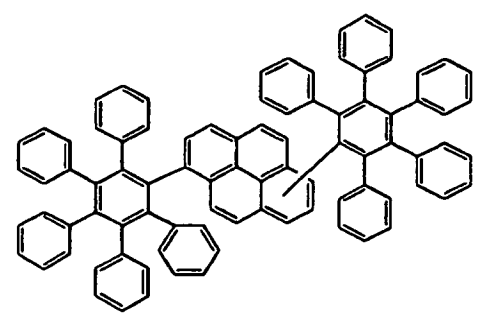
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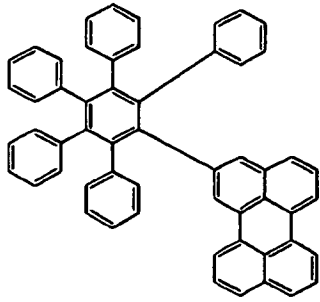


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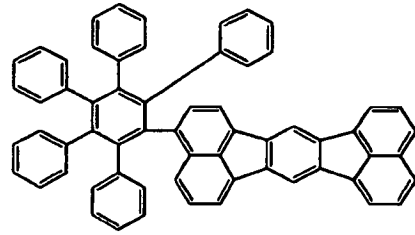
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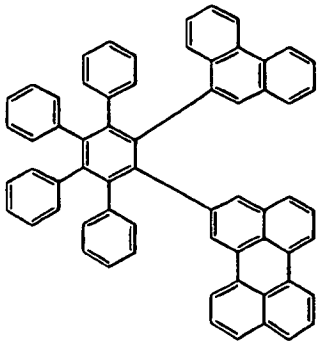
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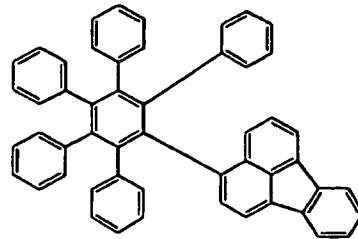
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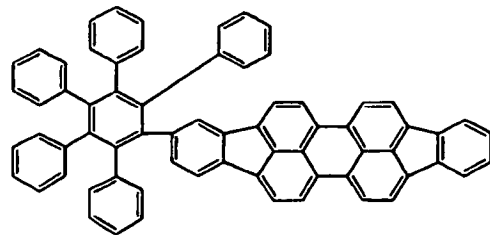
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(1-71) Reference



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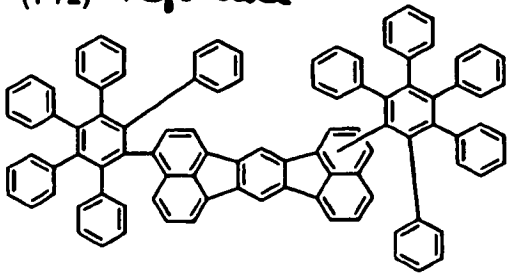
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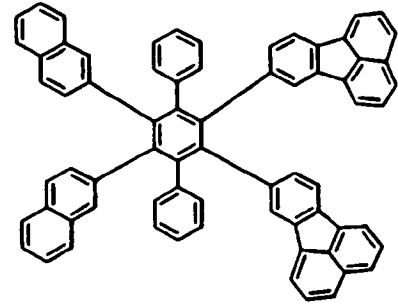
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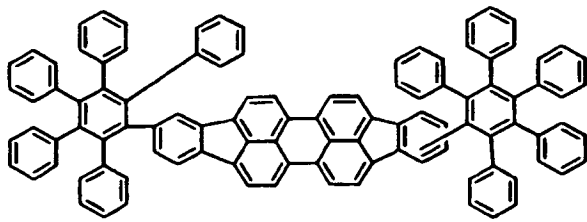
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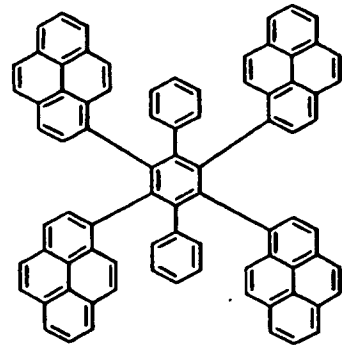
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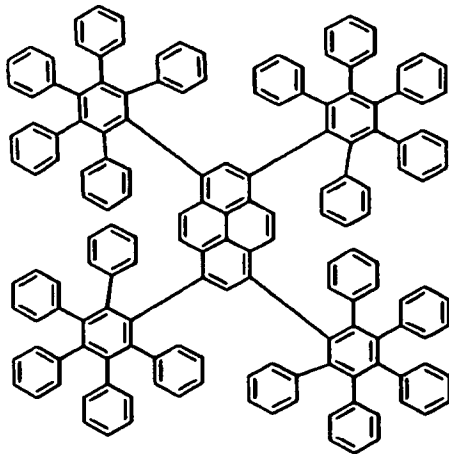
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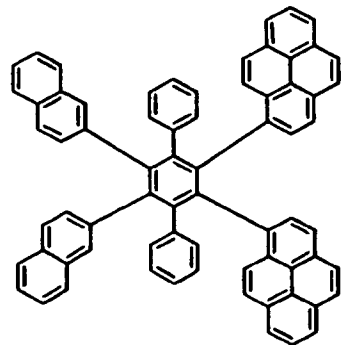
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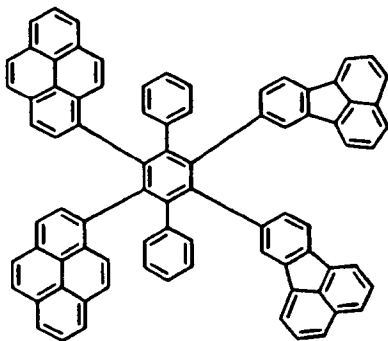
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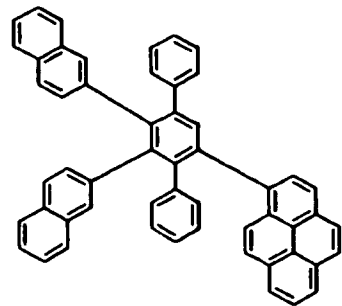


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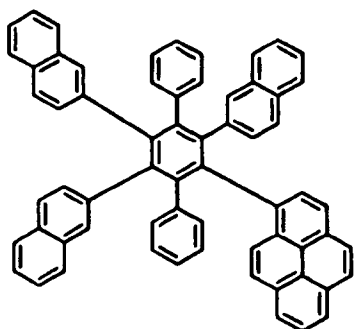
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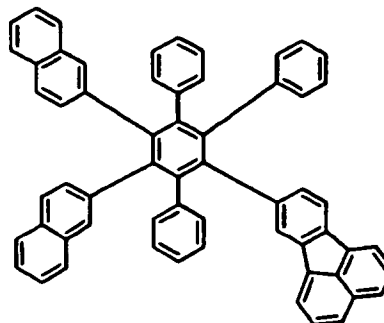
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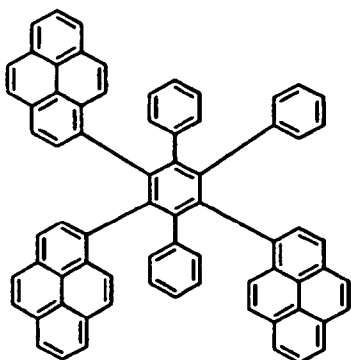
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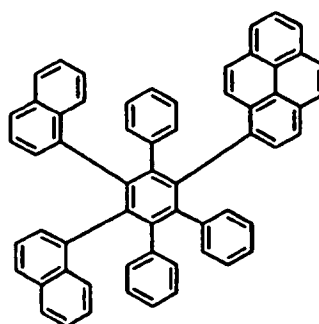
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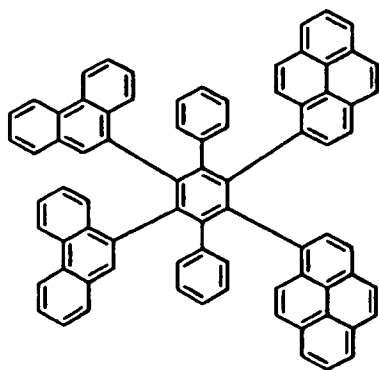
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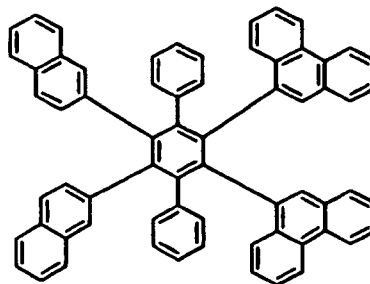
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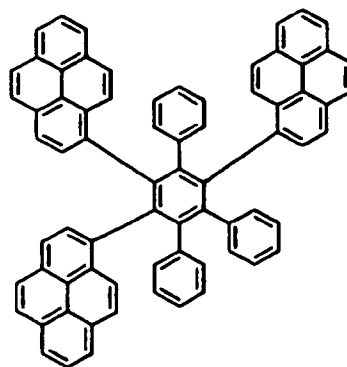
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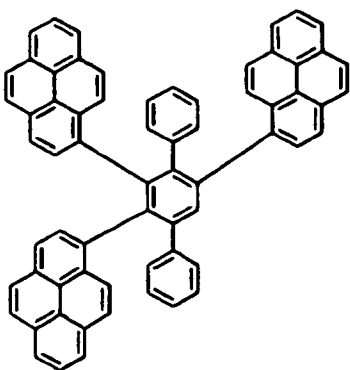
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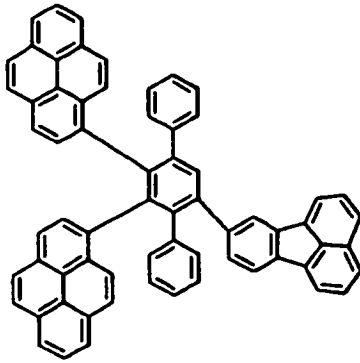
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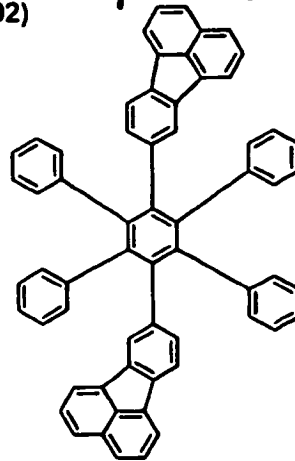


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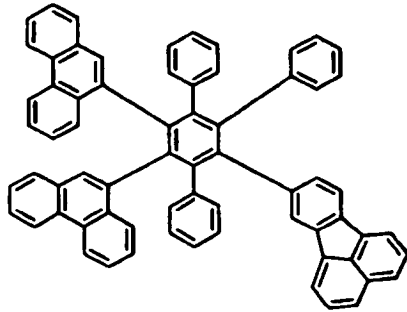


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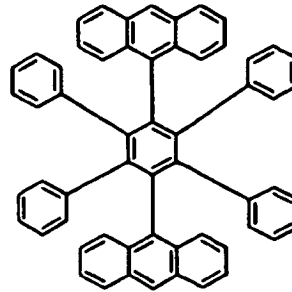
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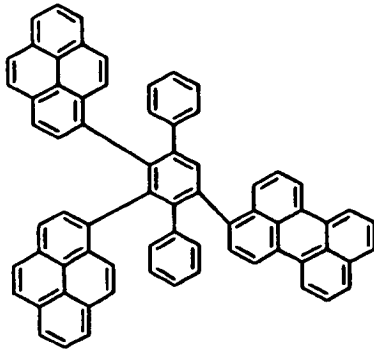
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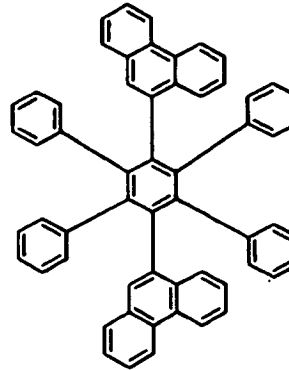
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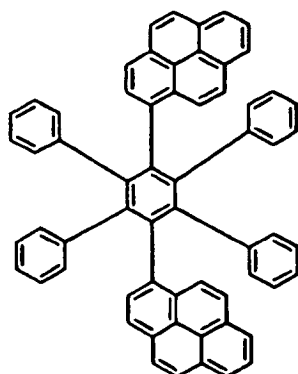


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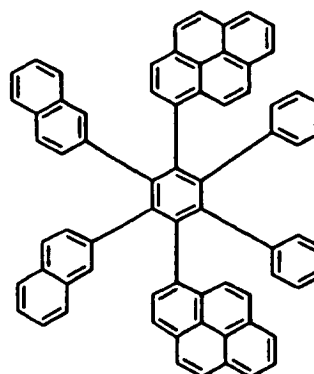


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[0061] The compounds represented by the general formulae (1)-(6) may be purified. Purification methods are not particularly limited but may be a recrystallization method, a column chromatography method, a sublimation purification method.

[0062] The sublimation purification methods are known, and may be a method described, for instance, in "Lecture One on Experimental Chemistry, Basic Operations [I]" issued by Maruzen Co., Ltd. pp. 425 to 430, methods described in JP 5-269371 A, JP 6-263438 A, JP 7-24205 A, JP 7-204402 A, JP 11-171801 A, JP 2000-93701 A, JP 2000-48955 A, JP 62-22960 B, JP 2583306 B, JP 2706936 B, etc. The sublimation purification may be carried out in vacuum or in a flow of an inert gas such as nitrogen, argon, etc. A vacuum pump for carrying out the sublimation purification in vacuum is not particularly restrictive, but may be a rotary pump, a turbo molecular pump, a diffusion pump.

[0063] The compound (1) may be synthesized by known methods described in Tetrahedron, 1997, 53, No. 45, p. 15349; J. Am. Chem. Soc., 1996, 118, p. 741; J. Org. Chem. Soc., 1986, 51, p. 979; Angew. Chem. Int. Ed. Engl., 1997, 36, p. 631; Indian J. Chem. Sect. B, 2000, 39, p. 173; Org. Synth. Coll. Vol. 5, 1973, p. 604; Chem. Ber., 1960, 93, p. 1769.

[0064] Although the light-emitting device of the present invention is not particularly limited with respect to a system and a driving method therefor, use thereof, etc., the light-emitting device preferably has a structure that uses the compound (1) as a light-emitting material, or as a host material, an electron-injecting material, an electron-transporting material, a hole-injecting material and/or a hole-transporting material. Typically known as the light-emitting devices are organic electroluminescence (EL) devices.

[0065] The light-emitting device of the present invention comprises a light-emitting layer and a plurality of organic layers comprising a light-emitting layer between a pair of electrodes (a positive electrode and a negative electrode). The light-emitting layer or at least one of the organic layers comprises the compound (1). When the compound of the present invention is used as a light-emitting material, the amount of the compound (1) in the layer comprising the compound (1) is preferably 0.1 to 100% by mass, more preferably 0.5 to 100% by mass. When the compound (1) is used as a host material, the amount of the compound (1) is preferably 10 to 99.9% by mass, more preferably 20 to 99.5% by mass.

[0066] The formation of a layer comprising the compound (1) is not particularly limited, and the layer may be formed by a resistance-heating vapor deposition method, an electron beam method, a sputtering method, a molecular-stacking method, a coating method, an inkjet-printing method, a printing method, a transferring method, an electrophotography method. Preferable among them are a resistance-heating vapor deposition method, a coating method and a printing method from the viewpoints of properties and production cost of the light-emitting device.

[0067] The light-emitting device of the present invention may comprise functional layers such as a hole-injecting layer, a hole-transporting layer, an electron-injecting layer, an electron-transporting layer, a protective layer, in addition to the light-emitting layer. The functional layers may have other functions. The compound (1) may be contained in any of these layers. Each component of the light-emitting device of the present invention is described in detail below.

(A) Positive electrode

[0068] The positive electrode acts to supply holes to the hole-injecting layer; the hole-transporting layer, the light-emitting layer. The positive electrode is generally made of a pure metal, an alloy, a metal oxide, an electrically conductive compound, a mixture thereof, preferably made of a material having a work function of 4 eV or more. Examples of materials for the positive electrode include metals such as gold, silver, chromium, nickel and these alloys; electrically conductive metal oxides such as tin oxide, zinc oxide, indium oxide and indium tin oxide (ITO); mixtures and laminations of the

metals and the electrically conductive metal oxides; electrically conductive inorganic compounds such as copper iodide and copper sulfide; electrically conductive organic compounds such as polyaniline, polythiophene and polypyrrole; laminates of the electrically conductive organic compounds and ITO. The positive electrode is preferably made of electrically conductive metal oxides, particularly ITO, from the viewpoints of productivity, electron conductivity, transparency.

[0069] A method for forming the positive electrode may be selected depending on the material used therefor. For example, the positive electrode made of ITO may be formed by an electron beam method, a sputtering method, a resistance-heating vapor deposition method, a chemical reaction method such as a sol-gel method, a coating method using a dispersion containing indium tin oxide. The positive electrode may be subjected to a washing treatment, to lower the driving voltage, or to increase the light-emitting efficiency of the light-emitting device. For example, in the case of the positive electrode of ITO, a UV-ozone treatment and a plasma treatment are effective. The positive electrode preferably has sheet resistance of a few hundred Ω /square or less. Although the thickness of the positive electrode may be appropriately determined depending on the material used therefor, it is in general preferably 10 nm to 5 μ m, more preferably 50 nm to 1 μ m, most preferable 100 to 500 nm.

[0070] The positive electrode is generally disposed on a substrate made of soda lime glass, non-alkali glass, transparent resins, etc. The glass substrate is preferably made of non-alkali glass to reduce ion elution. In the case of using the soda lime glass, a barrier coating of silica is preferably formed thereon beforehand. The thickness of the substrate is not particularly limited as long as it has sufficient strength. In the case of the glass substrate, the thickness of the substrate is generally 0.2 mm or more, preferably 0.7 mm or more.

(B) Negative electrode

[0071] The negative electrode acts to supply electrons to the electron-injecting layer, the electron-transporting layer, the light-emitting layer. Materials for the negative electrode may be selected from pure metals, alloys, metal halides, metal oxides, electrically conductive compounds, mixtures thereof, depending on ionization potential, stability, adhesion to a layer adjacent to the negative electrode such as the light-emitting layer. Examples of materials for the negative electrode include alkali metals such as Li, Na and K, and fluorides and oxides thereof; alkaline earth metals such as Mg and Ca and fluorides and oxides thereof; gold; silver; lead; aluminum; alloys and mixtures of sodium and potassium; alloys and mixtures of lithium and aluminum; alloys and mixtures of magnesium and silver; rare earth metals such as indium and ytterbium; mixtures thereof. The negative electrode is preferably made of a material having a work function of 4 eV or less, more preferably made of aluminum, an alloy or a mixture of lithium and aluminum, or an alloy and a mixture of magnesium and silver.

[0072] The negative electrode may have a single-layer structure or a multi-layer structure. A preferred multi-layer structure is aluminum/lithium fluoride, aluminum/lithium oxides. The negative electrode may be formed by an electron beam method, a sputtering method, a resistance-heating vapor deposition method, a coating method. A plurality of materials may be simultaneously deposited by the vapor deposition method. The negative electrode of an alloy may be formed by simultaneously depositing a plurality of metals, or by depositing their alloy. The negative electrode preferably has a sheet resistance of a few hundred Ω /square or less. Although the thickness of the negative electrode may be appropriately determined depending on the material used therefor, it is in general preferably 10 nm to 5 μ m, more preferably 50 nm to 1 μ m, most preferably 100 nm to 1 μ m.

(C) Hole-injecting layer and hole-transporting layer

[0073] Materials used for the hole-injecting layer and the hole-transporting layer are not particularly limited as long as they have any functions of injecting holes provided from the positive electrode into the light-emitting layer; transporting holes to the light-emitting layer; and blocking electrons provided from the negative electrode. Their examples include carbazole, triazole, oxazole, oxadiazole, imidazole, polyarylanthracenes, pyrazoline, pyrazolone, phenylenediamine, arylamines, amino-substituted chalcone, styrylanthracene, fluorenone, hydrazone, stilbene, silazane, aromatic tertiary amine compounds, styrylamine compounds, aromatic dimethyldiyne compounds, porphyrin compounds, polysilane compounds, poly(N-vinylcarbazole), aniline copolymers, electrically conductive polymers and oligomers such as oligothiophenes and polythiophenes, organic silane compounds, the compound (1), derivatives thereof, carbon.

[0074] Each of the hole-injecting layer and the hole-transporting layer may be a single layer made of one or more materials, or a multi-layer made of the same or different materials. The hole-injecting layer and the hole-transporting layer may be formed by a vacuum deposition method, an LB method, a coating method using a solution or a dispersion containing the above material such as a spin-coating method, a casting method and a dip-coating method, an inkjet-printing method, a printing method, a transferring method, an electrophotography method. A solution and a dispersion used in the coating method may contain a resin. Examples of such resins include poly(vinyl chloride), polycarbonates, polystyrene, poly(methyl methacrylate), poly(butyl methacrylate), polyesters, polysulfones, poly(phenylene oxide), polybutadiene, poly(N-vinylcarbazole), hydrocarbon resins, ketone resins, phenoxy resins, polyamides, ethyl cellulose, poly

(vinyl acetate), ABS resins, polyurethanes, melamine resins, unsaturated polyester resins, alkyd resins, epoxy resins, silicone resins. Although the thickness of each of the hole-injecting layer and the hole-transporting layer is not particularly limited, it is in general preferably 1 nm to 5 μm , more preferably 5 nm to 1 μm , particularly 10 to 500 nm.

5 (D) Light-emitting layer

[0075] In the light-emitting layer, holes injected from the positive electrode, the hole-injecting layer or the hole-transporting layer and electrons injected from the negative electrode, the electron-injecting layer or the electron-transporting layer are recombined to emit light when an electric field is applied to the light-emitting device. Light-emitting materials and fluorescent compounds for the light-emitting layer are not particularly limited as long as they have functions of receiving holes provided from the positive electrode; receiving electrons provided from the negative electrode; transporting charges; and recombining holes and electrons to emit light when an electric field is applied to the light-emitting device. Examples of the light-emitting materials include benzoxazole; benzimidazole; benzothiazole; styrylbenzene; polyphenyl; diphenylbutadiene; tetraphenylbutadiene; naphthalimido; coumarin; perynone; oxadiazole; aldazine; pyralidine; cyclopentadiene; bis(styryl)anthracene; quinacridon; pyrrolopyridine; thiadiazolopyridine; cyclopentadiene; styrylamine; aromatic dimethylidene compounds; pyrromethene; condensed aromatic compounds such as anthracene, pyrene, fluoranthene, perylene; metal complexes such as 8-quinolinol derivative metal complexes; high-molecular-weight, light-emitting materials such as polythiophene, polyphenylene and polyphenylenevinylene; organic silane compounds; the compound (1); derivatives thereof.

[0076] The light-emitting layer may be made of one or more materials. The light-emitting device of the present invention may comprise one or more light-emitting layers. In a case where the light-emitting device comprises a plurality of light-emitting layers, each of the light-emitting layers may be made of one or more materials, and may emit light with a different color to provide white light. The single light-emitting layer may provide white light.

[0077] The light-emitting layer may be formed by a resistance-heating vapor deposition method; an electron beam method; a sputtering method; a molecular-stacking method; a coating method such as a spin-coating method, a casting method and a dip-coating method; an inkjet-printing method; a printing method; an LB method; a transferring method; an electrophotography method. Preferable among them are the resistance-heating vapor deposition method and the coating method. Although the thickness of the light-emitting layer is not particularly limited, it is in general preferably 1 nm to 5 μm , more preferably 5 nm to 1 μm , particularly 10 to 500 nm.

30 (E) Electron-injecting layer and electron-transporting layer

[0078] Materials used for the electron-injecting layer and the electron-transporting layer are not particularly limited as long as they have any functions of injecting electrons provided from the negative electrode into the light-emitting layer; transporting electrons to the light-emitting layer; and blocking holes provided from the positive electrode. Examples of such materials include triazole; oxazole; oxadiazole; imidazole; fluorenone; anthraquinodimethane; anthrone; diphenylquinone; thiopyran dioxide; carbodiimide; fluorenylidene methane; distyrylpyrazine; tetracarboxylic anhydrides having such aromatic rings as a naphthalene ring and a perylene ring; phthalocyanine; metal complexes such as 8-quinolinol derivative metal complexes, metallophthalocyanines and metal complexes containing benzoxazole or benzothiazole as a ligand; metals such as aluminum, zinc, gallium, beryllium, magnesium; organic silane compounds; the compound (1); derivatives thereof.

[0079] Each of the electron-injecting layer and the electron-transporting layer may have a structure of single-layer made of one or more materials, or multi-layers made of the same or different materials. The electron-injecting layer and the electron-transporting layer may be formed by a vacuum deposition method; an LB method; a coating method using a solution or a dispersion containing the above material, such as a spin-coating method, a casting method and a dip-coating method; an inkjet-printing method; a printing method; a transferring method; an electrophotography method. The solution and the dispersion used in the coating method may contain a resin. Examples of such resins may be the same as those for the hole-injecting layer and the hole-transporting layer. Although the thickness of each of the electron-injecting layer and the electron-transporting layer is not particularly limited, it is in general preferably 1 nm to 5 μm , more preferably 5 nm to 1 μm , particularly 10 to 500 nm.

(F) Protective layer

[0080] The protective layer acts to shield the light-emitting device from the penetration of moisture, oxygen, etc. that deteriorates the device. Examples of materials for the protective layer include metals such as In, Sn, Pb, Au, Cu, Ag, Al, Ti and Ni; metal oxides such as MgO, SiO, SiO₂, Al₂O₃, GeO, NiO, CaO, BaO, Fe₂O₃, Y₂O₃ and TiO₂; metal fluorides such as MgF₂, LiF, AlF₃ and CaF₂; nitrides such as SiN_x and SiO_xN_y; polyethylene; polypropylene; polymethyl methacrylate; polyimides; polyureas; polytetrafluoroethylene; polychlorotrifluoroethylene; polydichlorodifluoroethylene; co-

polymers of chlorotrifluoroethylene and dichlorodifluoroethylene; copolymers of tetrafluoroethylene and at least one comonomer; fluorine-containing copolymers having main chains with cyclic structures; moisture-absorbing materials having a water absorption of 1% or more; moisture-resistant materials having a water absorption of 0.1% or less.

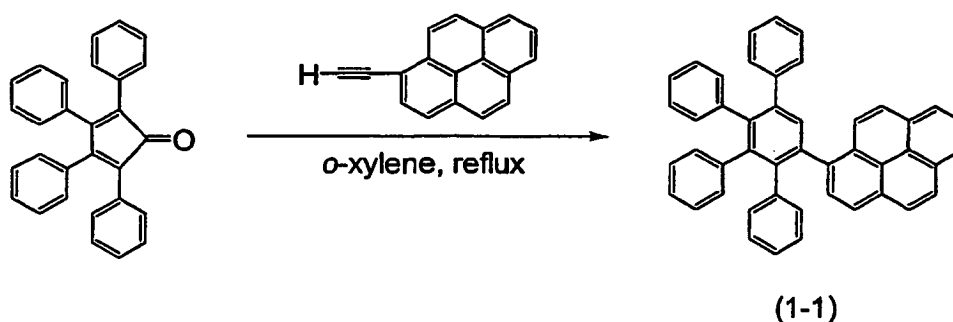
[0081] A method for forming the protective layer is not particularly limited. The protective layer may be formed by a vacuum deposition method, a sputtering method, a reactive sputtering method, a molecular beam epitaxy (MBE) method, a cluster ion beam method, an ion-plating method, a high-frequency excitation ion-plating method, a plasma polymerization method, a plasma CVD method, a laser CVD method, a thermal CVD method, a gas source CVD method, a coating method, a printing method, a transferring method.

[0082] The present invention will be specifically described below with reference to Examples without intention of restricting the scope of the present invention.

Synthesis Example 1

Synthesis of Compound (1-1)

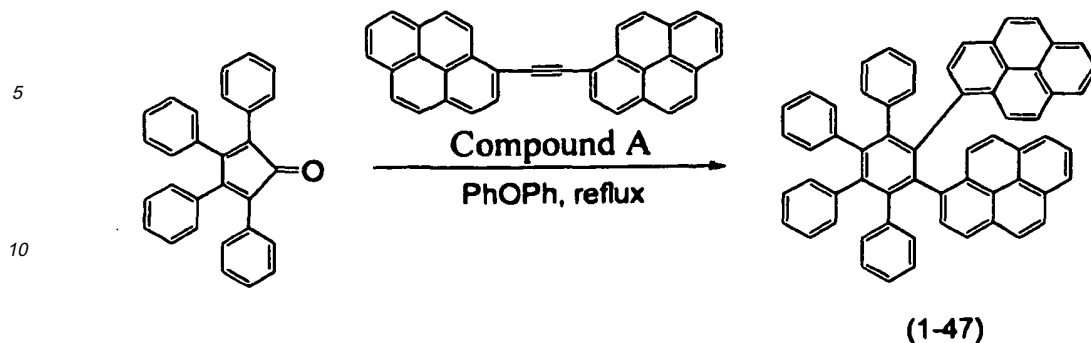
[0083] 10 ml of *o*-xylene was added to 0.5 g of 1-ethynylpyrene and 0.85 g of tetraphenylcyclopentadienone and stirred under reflux for 3 hours. The resultant reaction product solution was cooled to room temperature, and 50 ml of methanol was added thereto to precipitate a solid. The solid was separated by filtration, and purified by a silica gel column chromatography (hexane/chloroform = 5/1), to obtain 1.1 g of a white solid. Mass spectrum measurement confirmed that the white solid was Compound (1-1). This result suggested that Compound (1-1) was obtained by the following reaction.



Synthesis Example 2

Synthesis of Compound (1-47)

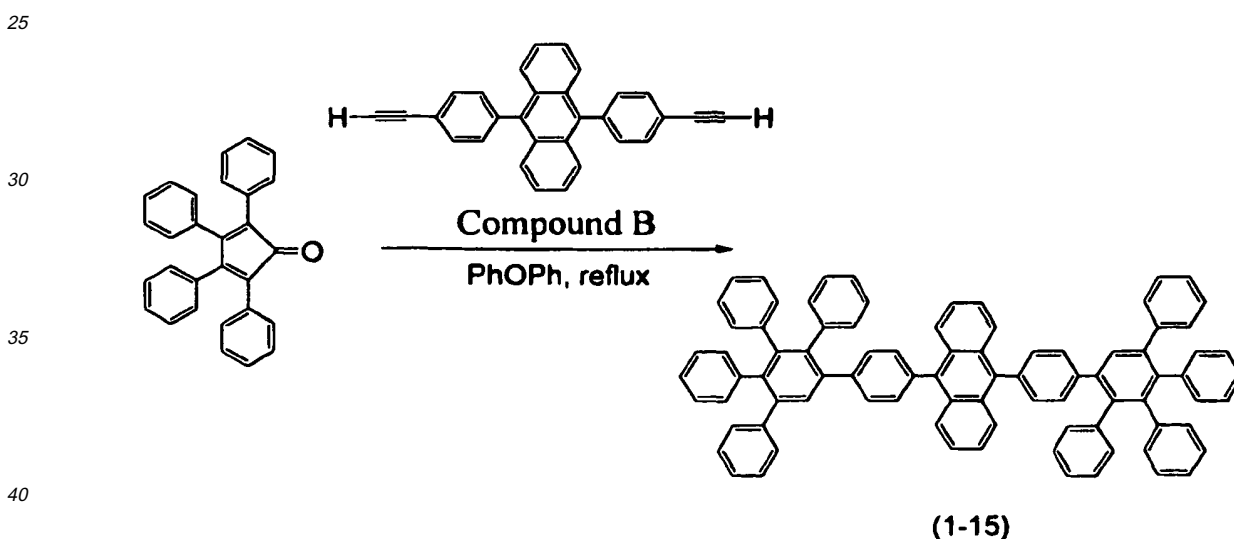
[0084] 50 ml of diphenyl ether was added to 1 g of the following Compound A and 1.35 g of tetraphenylcyclopentadienone and stirred under reflux for 30 hours. The resultant reaction product solution was cooled to room temperature, and 100 ml of methanol was added thereto to precipitate a solid. The solid was separated by filtration, and purified by a silica gel column chromatography (chloroform), to obtain 1.3 g of a white solid. Mass spectrum measurement confirmed that the white solid was Compound (1-47). This result suggested that Compound (1-47) was obtained by the following reaction.



15 Synthesis Example 3

Synthesis of Reference Compound (1-15)

20 **[0085]** 50 ml of diphenyl ether was added to 1 g of the following Compound B and 3 g of tetraphenylcyclopentadienone and stirred under reflux for 10 hours. The resultant reaction product solution was cooled to room temperature, and 100 ml of methanol was added thereto to precipitate a solid. The solid was separated by filtration, and purified by a silica gel column chromatography (chloroform), to obtain 2.0 g of a white solid. Mass spectrum measurement confirmed that the white solid was Compound (1-15). This result suggested that Compound (1-15) was obtained by the following reaction.

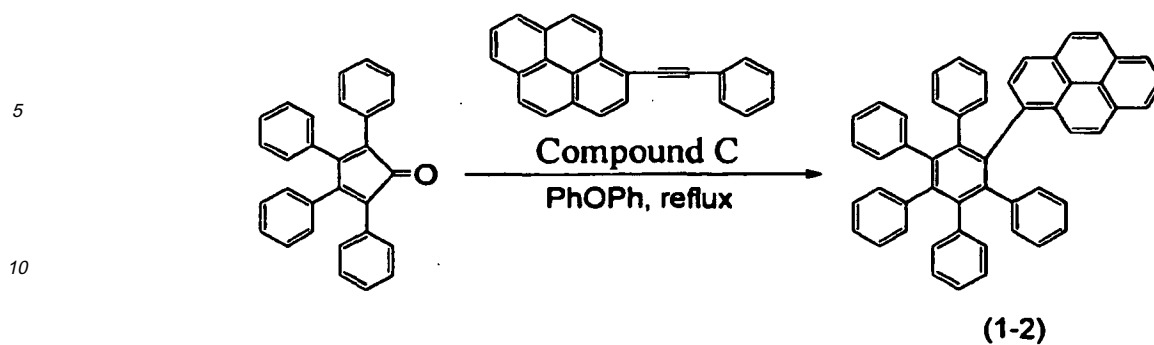


45 Synthesis Example 4

Synthesis of Compound (1-2)

50 **[0086]** 10 ml of diphenyl ether was added to 0.5 g of the following Compound C and 0.85 g of tetraphenylcyclopentadienone and the resultant reaction mixture was stirred under reflux for 3 hours. The resultant reaction product solution was cooled to room temperature, and 50 ml of methanol was added thereto to precipitate a solid. The solid was separated by filtration, and purified by a silica gel column chromatography (hexane/chloroform = 5/1), to obtain 1.0 g of a white solid. Mass spectrum measurement confirmed that the white solid was Compound (1-2). This result suggested that Compound (1-2) was obtained by the following reaction.

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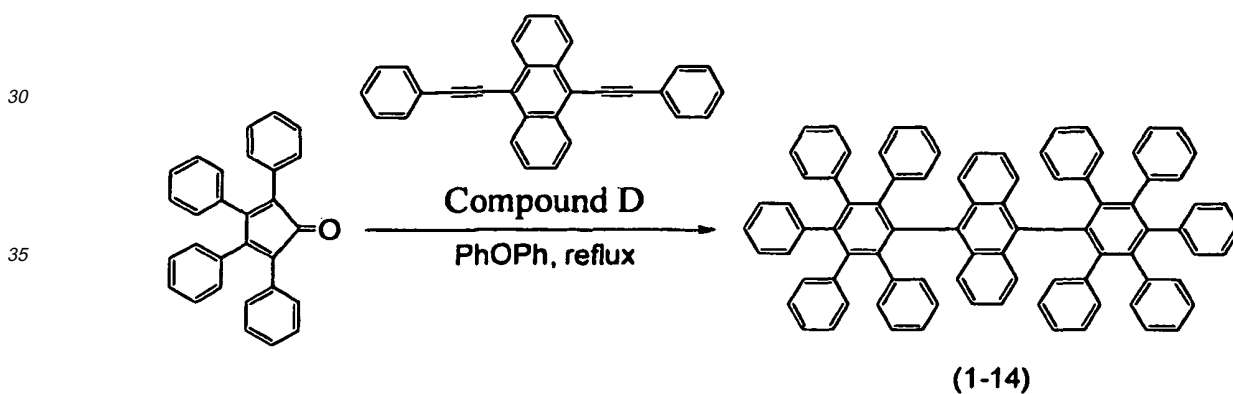
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Synthesis Example 5

Synthesis of Reference Compound (1-14)

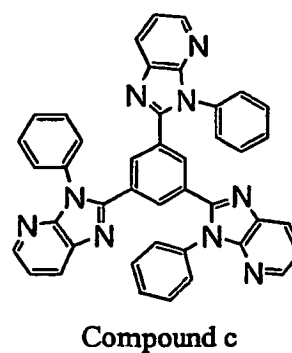
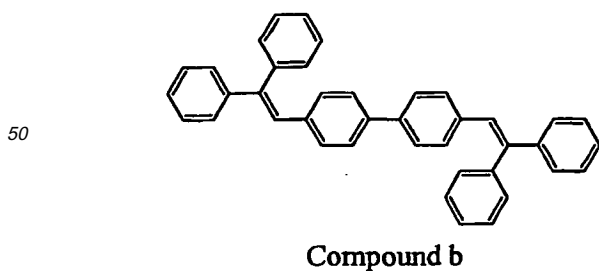
20 **[0087]** 50 ml of diphenyl ether was added to 0.5 g of the following Compound D and 3 g of tetraphenylcyclopentadienone and stirred under reflux for 10 hours. The resultant reaction product solution was cooled to room temperature, and 100 ml of methanol was added thereto to precipitate a solid. The solid was separated by filtration, and purified by a silica gel column chromatography (chloroform), to obtain 0.9 g of pale yellow solid. Mass spectrum measurement confirmed that the pale yellow solid was Compound (1-14). This result suggested that Compound (1-14) was obtained by the following

25 reaction.

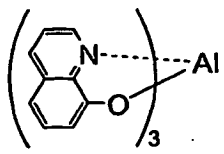


[0088] Compounds b-v used in the following Examples and Comparative Examples will be illustrated below.

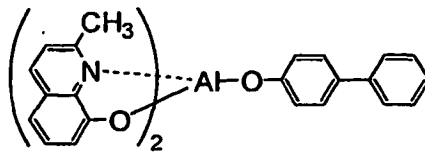
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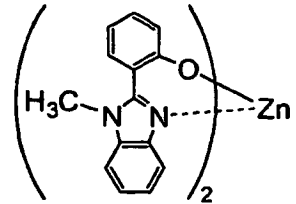
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Compound d



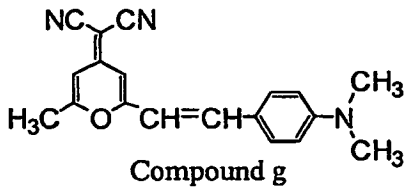
Compound e



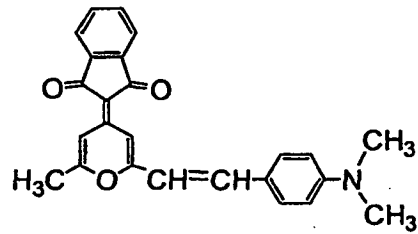
Compound f

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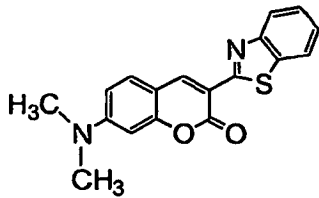
Compound g



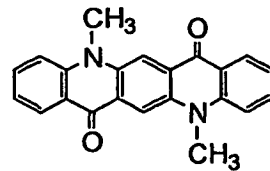
Compound h

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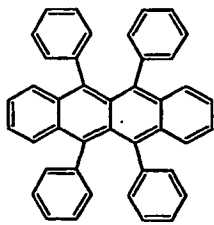
Compound i



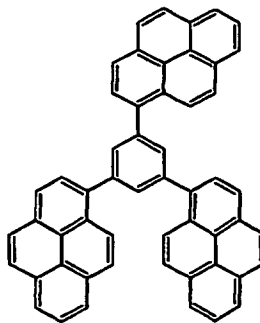
Compound j

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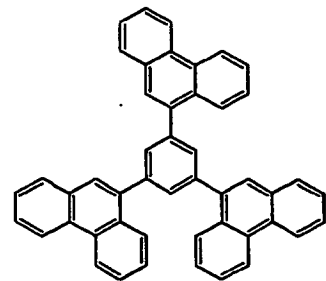
35



Compound k



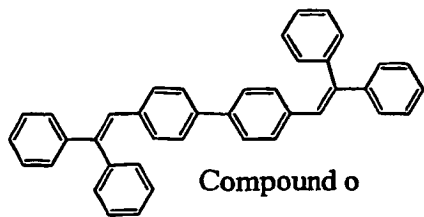
Compound m



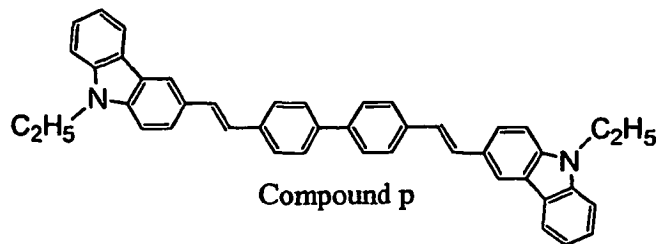
Compound n

45

50

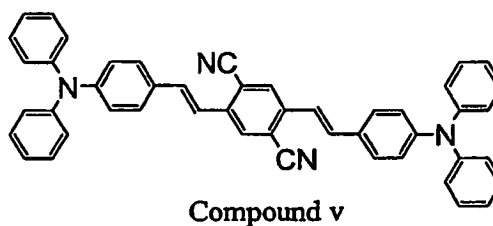
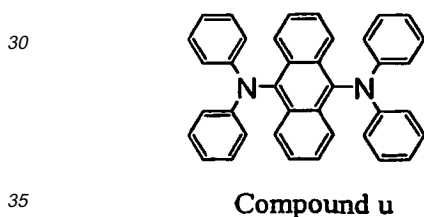
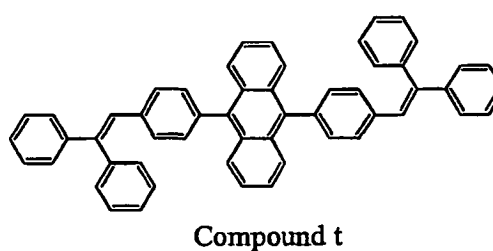
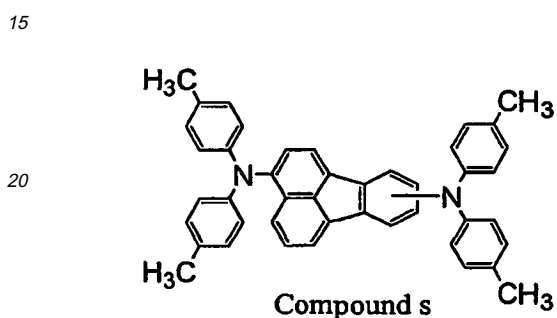
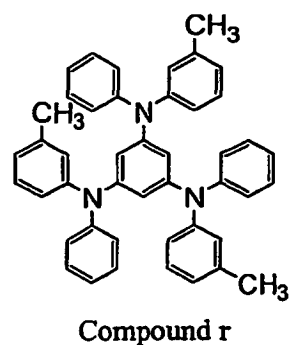
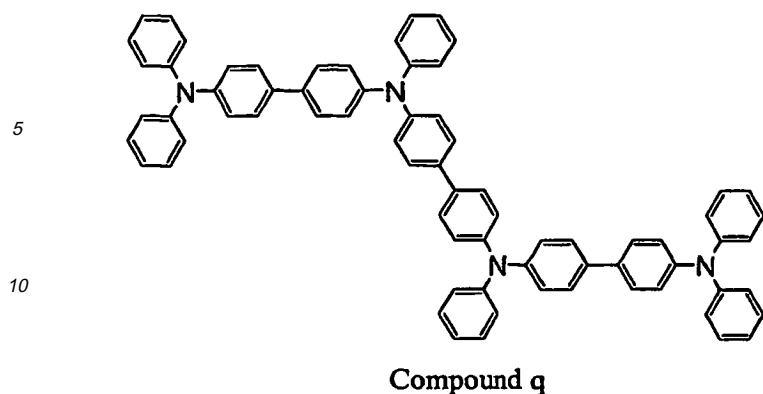


Compound o



Compound p

55



Comparative Example 1

40 [0089] *N,N*-diphenyl-*N,N*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. The above distyryl compound (Compound b) was vapor-deposited in a thickness of 20 nm thereon, and the above azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, and silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device.

45 [0090] DC voltage was applied to the light-emitting device of Comparative Example 1 by "Source-Measure Unit 2400" available from Toyo Corporation to make it emit light, and the emitted light was measured with respect to luminance by "Luminance Meter BM-8" available from Topcon Corporation, and emission wavelength by "Spectral Analyzer PMA-11" available from Hamamatsu Photonics K. K. As a result, it was found that the light-emitting device of Comparative Example 1 emitted bluish green light with a chromaticity of (0.15, 0.20) at the maximum luminance of 1,130 cd/m². After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked clouded.

Example 1

55 [0091] *N,N*-diphenyl-*N,N*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) was vapor-deposited in a thickness of 20 nm thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. With a mask patterned

for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10: 1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, and silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.15, 0.10) at the maximum luminance of 4,370 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 1.4\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Reference Example 2

[0092] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-17) was vapor-deposited in a thickness of 20 nm thereon, and the azole compound (Compound c) was vapor-deposited in a thickness of 40 nm thereon. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, and silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.15, 0.14) at the maximum luminance of 2,920 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 1.3\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Reference Example 3

[0093] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-24) was vapor-deposited in a thickness of 20 nm thereon, and the azole compound (Compound c) was vapor-deposited in a thickness of 40 nm thereon. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, and silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.15, 0.18) at the maximum luminance of 2,000 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 1.3\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 4

[0094] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and 7,4-(dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran (DCM) were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / DCM of 1000:5 thereon, and the azole compound (Compound c) was vapor-deposited in a thickness of 40 nm thereon. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, and silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted white light with a chromaticity of (0.30, 0.32) at the maximum luminance of 4,300 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 2.2\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 5

[0095] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Tris(8-hydroxyquinolino) aluminum (Alq) and DCM were co-deposited in a thickness of 5 nm at a mass ratio of Alq/DCM of 100:1 thereon, and Compound (1-1) was further vapor-deposited in a thickness of 15 nm thereon. The azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm

thereon. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted white light with a chromaticity of (0.31, 0.33) at the maximum luminance of 4,400 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 2.3\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 6

[0096] 40 mg of poly(*N*-vinylcarbazole), 12 mg of 2-(4-*t*-butylphenyl)-5-(4-biphenyl)-1,3,4-oxadiazole and 1 mg of Compound (1-1) were dissolved in 2.5 ml of dichloroethane. The resultant solution was spin-coated to a cleaned ITO substrate under the conditions of 1,500 rpm and 20 seconds, to form an organic layer having a thickness of 110 nm. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.15, 0.10) at the maximum luminance of 1,900 cd/m².

Reference Example 7

[0097] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-15) was vapor-deposited in a thickness of 20 nm thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. With a mask patterned for a desired light-emitting area of 4 mm x 5 mm disposed on the resultant organic thin film, magnesium and silver were co-deposited at a mass ratio of magnesium/silver of 10:1 in a thickness of 50 nm on the organic thin film in the deposition apparatus, and silver was further vapor-deposited in a thickness of 50 nm thereon, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.16, 0.08) at the maximum luminance of 3,200 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 1.2\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 8

[0098] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-2) was vapor-deposited in a thickness of 20 nm thereon, and the azole compound (Compound c) was vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.16, 0.08) at the maximum luminance of 1,400 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 1.5\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 9

[0099] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) was vapor-deposited in a thickness of 20 nm thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.17, 0.17) at the maximum luminance of 6,470 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 3.4\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Reference Example 10

5 [0100] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-14) was vapor-deposited in a thickness of 20 nm thereon, and theazole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.16, 0.17) at the maximum luminance of 2,500 cd/m².
10 The external quantum efficiency of this light-emitting device was $\phi_{EL} = 0.8\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 11

15 [0101] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) was vapor-deposited in a thickness of 20 nm thereon, and Compound d was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 1,100 cd/m².
20

Example 12

25 [0102] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) was vapor-deposited in a thickness of 20 nm thereon, and Compound e was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 9 V applied, the light-emitting device emitted blue light of 1,300 cd/m².

Example 13

30 [0103] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) was vapor-deposited in a thickness of 20 nm thereon, and Compound f was vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 9 V applied, the light-emitting device emitted blue light of 1,200 cd/m².
35

Example 14

40 [0104] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound g were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound g of 100:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted orange light of 2,500 cd/m².
45

Example 15

50 [0105] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound h were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound h of 100:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted red light of 1,800 cd/m².

Example 16

55 [0106] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound i were co-deposited in a thickness of

20 nm at a mass ratio of Compound (1-1) / Compound i of 100:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted green light of 6,300 cd/m².

5

Example 17

[0107] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-2) and Compound j were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-2) / Compound j of 100:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted yellow green light of 4,500 cd/m².

10

15

Example 18

[0108] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) and Compound k were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-47) / Compound k of 100:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted yellow light of 3,900 cd/m².

20

Example 19

[0109] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound m were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound m of 10:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 2,800 cd/m².

25

30

Example 20

[0110] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) and Compound m were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-47) / Compound m of 1:10 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted bluish green light of 3,400 cd/m².

35

40

Example 21

[0111] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound n were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound n of 1:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 1,100 cd/m².

45

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Example 22

[0112] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound o were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound o of 10:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 1,800 cd/m².

55

Example 23

5 [0113] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound p of 20:1 thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 3,800 cd/m².

10 Example 24

15 [0114] Compound q was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) was vapor-deposited in a thickness of 20 nm thereon, and Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 2,100 cd/m².

Example 25

20 [0115] Compound r was vapor-deposited in a thickness of 10 nm on a cleaned ITO substrate placed in a deposition apparatus. *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 30 nm thereon, and Compound (1-1) was then vapor-deposited in a thickness of 20 nm thereon. Compound c was further vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 6 V applied, the light-emitting device emitted blue light of 2,200 cd/m².

Example 26

30 [0116] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound (1-2) were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound (1-2) of 1:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 2,200 cd/m².

35 Example 27

40 [0117] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound d and Compound k were co-deposited in a thickness of 5 nm at a mass ratio of Compound d / Compound k of 100:1 thereon, and Compound (1-1) and Compound p were then co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound p of 20:1 thereon. Compound c was further vapor-deposited in a thickness of 20 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted white light of 4,100 cd/m².

45 Reference Example 28

50 [0118] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-14) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-14) / Compound p of 20:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 2,900 cd/m².

55 Reference Example 29

[0119] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-14) and Compound m were co-deposited in

a thickness of 20 nm at a mass ratio of Compound (1-14) / Compound m of 1:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 3,700 cd/m².

5

Example 30

[0120] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1), Compound p and Compound g were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound p / Compound g of 100:5:0.2 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted white light of 1,800 cd/m².

10

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Example 31

[0121] A cleaned ITO substrate was spin-coated with "Baytron P" (solution of PEDOT-PSS, poly(ethylenedioxythiophene) doped with polystyrene sulfonic acid, available from BAYER AG.) under the conditions of 1,000 rpm and 30 seconds, and vacuum-dried at 150°C for 1.5 hours, to form an organic layer having a thickness of 70 nm. An organic layer thus obtained was spin-coated with a mixture of 10 mg of polymethyl methacrylate and 30 mg of Compound (1-1) in 4 ml of dichloroethane under the conditions of 1,500 rpm and 20 seconds, to form an organic layer having a total thickness of 120 nm. Compound c was vapor-deposited in a thickness of 50 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 10 V applied, the light-emitting device emitted blue light of 800 cd/m².

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Example 32

[0122] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) was vapor-deposited in a thickness of 20 nm thereon, and Compound d was then vapor-deposited in a thickness of 40 nm thereon. LiF was vapor-deposited in a thickness of 3 nm on the resultant organic thin film, and aluminum was then vapor-deposited in a thickness of 100 nm, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting device emitted blue light of 1,300 cd/m².

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Example 33

[0123] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-2) and Compound s were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-2) / Compound s of 100:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted green light of 2,500 cd/m².

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Example 34

[0124] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-2) and Compound t were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-2) / Compound t of 1:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted blue light of 1,500 cd/m².

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Example 35

[0125] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) and Compound u were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-47) / Compound u of 100:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted blue light of 1,500 cd/m².

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device emitted green light of 2,700 cd/m²

Example 36

5 **[0126]** *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) and Compound v were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-47) / Compound v of 100:1 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 8 V applied, the light-emitting
10 device emitted reddish orange light of 2,200 cd/m².

Reference Example 37

15 **[0127]** *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference compound (1-61) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-61) / Compound p of 100:2 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted blue light of 1,000 cd/m².

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Reference Example 38

25 **[0128]** *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Reference Compound (1-65) and Compound s were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-65) / Compound s of 100:2 thereon, and Compound c was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With a voltage of 7 V applied, the light-emitting device emitted blue light of 1,100 cd/m².

Example 39

30 **[0129]** *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-2) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-2) / Compound p of 95:5 thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.16, 0.18) at the maximum luminance of 17,000 cd/m². The external quantum efficiency of this light-emitting device
35 was $\phi_{EL} = 4\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

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Example 40

45 **[0130]** *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-47) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-47) / Compound p of 95:5 thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.16, 0.20) at the maximum luminance of 10,000 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 3.5\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

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Example 41

55 **[0131]** *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned

ITO substrate placed in a deposition apparatus. Compound (1-47) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-47) / Compound p of 99:1 thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.16, 0.18) at the maximum luminance of 12,000 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 3.5\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

Example 42

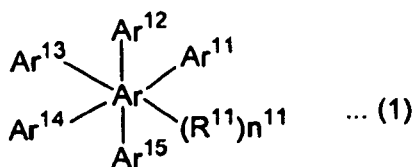
[0132] *N,N'*-diphenyl-*N,N'*-di(α -naphthyl)benzidine (α -NPD) was vapor-deposited in a thickness of 40 nm on a cleaned ITO substrate placed in a deposition apparatus. Compound (1-1) and Compound p were co-deposited in a thickness of 20 nm at a mass ratio of Compound (1-1) / Compound p of 95:5 thereon, and the azole compound (Compound c) was then vapor-deposited in a thickness of 40 nm thereon. A negative electrode was vapor-deposited on the resultant organic thin film in the same manner as in Comparative Example 1, to produce a light-emitting device. With respect to the light emitted from this light-emitting device, luminance and emission wavelength were measured in the same manner as in Comparative Example 1. As a result, it was found that the light-emitting device emitted blue light with a chromaticity of (0.15, 0.22) at the maximum luminance of 13,000 cd/m². The external quantum efficiency of this light-emitting device was $\phi_{EL} = 3.3\%$ in a calculated value. After leaving this light-emitting device in a nitrogen atmosphere for one day, the layer surface of the light-emitting device looked transparent.

APPLICABILITY IN INDUSTRY

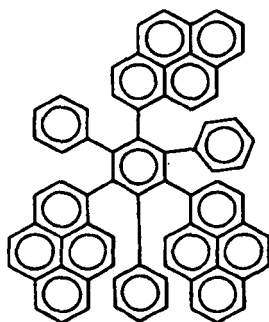
[0133] As described above in detail, the light-emitting device of the present invention exhibits excellent light-emitting efficiency, light-emitting properties, durability, heat resistance and amorphousness with less likelihood of being crystallized. The light-emitting device of the present invention having such characteristics can be used as a blue light-emitting device or a white light-emitting device with high color purity useful for indicating elements, displays, backlights, electrophotography, illumination light sources, recording light sources, exposing light sources, reading light sources, signs and marks, signboards, interiors, optical communications devices, etc. The compound (1) used in the light-emitting device of the present invention can be used as a material for organic EL devices, and be further applied to medical applications, fluorescent-whitening agents, materials for photography, UV-absorbing materials, laser dyes, dyes for color filters, color conversion filters, organic semiconductor materials, electrically conductive organic materials.

Claims

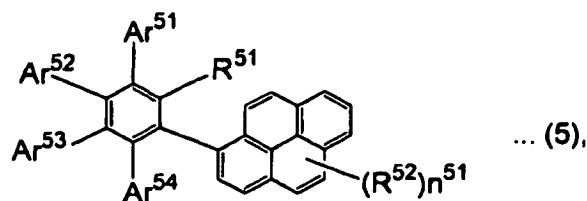
1. A light-emitting device comprising a pair of electrodes and a light-emitting layer or a plurality of organic layers comprising a light-emitting layer disposed between said electrodes, said light-emitting layer or at least one of a plurality of organic layers comprising said light-emitting layer comprising at least one compound represented by the following general formula (1):



wherein each of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ represents an aryl group or a heteroaryl group; Ar represents a benzene ring, at least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a condensed aryl group, a condensed or uncondensed heteroaryl group or a group comprising a condensed aryl group or a condensed or uncondensed heteroaryl group; at least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a pyrenyl group; Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ are not bonded to each other to form a ring; R¹¹ represents a substituent; and n¹¹ represents an integer of 0 or more, with the proviso that the compound is not



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2. The light-emitting device of claim 1, wherein in said general formula (1), at least four of R¹¹, Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ are a condensed aryl group or a condensed or uncondensed heteroaryl group.
 3. The light-emitting device of claim 1, wherein in said general formula (1), at least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is selected from the group consisting of a naphthyl group, a phenanthryl group, an anthryl group, a fluoranthenyl group and a perylenyl group, and R¹¹ is selected from the group consisting of a naphthyl group, a phenanthryl group, an anthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group.
 4. The light-emitting device of claim 1, wherein said compound represented by said general formula (1) emits light from a singlet excited state.
 5. The light-emitting device of claim 1, wherein in said general formula (1), R¹¹ represents a hydrogen atom or a substituent.
 6. The light-emitting device of claim 5, wherein in said general formula (1), each of Ar¹¹, Ar¹², Ar¹³ and Ar¹⁴ which is not a pyrenyl group is selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group and a fluoranthenyl group; Ar¹⁵ which is not a pyrenyl group is selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a fluoranthenyl group and a perylenyl group; R¹¹ is selected from the group consisting of a hydrogen atom, an alkyl group and an aryl group; and at least one of Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ and Ar¹⁵ is a condensed aryl group.
 7. The light-emitting device of claim 6, wherein in said general formula (1), each of Ar¹¹, Ar¹², Ar¹³ and Ar¹⁴ is selected from the group consisting of a phenyl group, a naphthyl group and a phenanthryl group.
 8. The light-emitting device of claim 6, wherein in said general formula (1), R¹¹ is selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group.
 9. The light-emitting device of claim 5, wherein in said general formula (1), Ar¹¹ and Ar¹² is a condensed aryl group or a condensed or uncondensed heteroaryl group.
 10. The light-emitting device of claim 5, wherein in said general formula (1), each of Ar¹¹ and Ar¹⁴ is a condensed aryl group or a condensed or uncondensed heteroaryl group.
 11. The light-emitting device of claim 5, wherein in said general formula (1), each of Ar¹¹ and Ar¹³ is a condensed aryl; each of R¹¹, Ar¹², Ar¹⁴ and Ar¹⁵ is selected from the group consisting of a phenyl group, a naphthyl group, a phenanthryl group, an anthryl group, a fluoranthenyl group, a pyrenyl group and a perylenyl group.
 12. The light-emitting device according to claim 1, wherein the compound of formula (1) is represented by the following general formula (5):



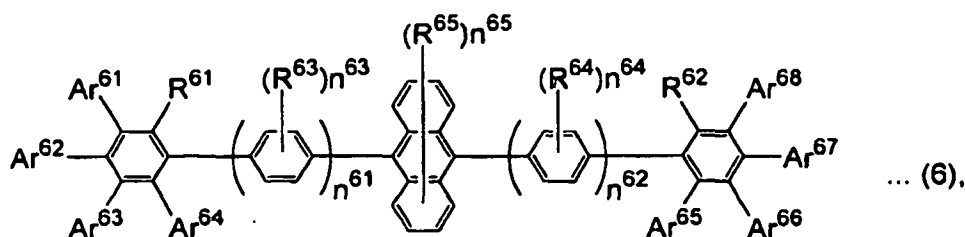
10 wherein each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ represents an aryl group; R⁵¹ represents a hydrogen atom or a substituent; R⁵² represents a substituent; and n⁵¹ represents an integer of 0 to 9.

15 13. The light-emitting device of claim 12, wherein in said general formula (5), each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ is selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group and a fluoranthenyl group.

14. The light-emitting device of claim 12, wherein in said general formula (5), R⁵¹ is selected from the group consisting of a hydrogen atom, an alkyl group and an aryl group.

20 15. The light-emitting device of claim 14, wherein in said general formula (5), R⁵¹ is selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group.

25 16. The light-emitting device according to claim 1, wherein the compound of formula (1) is represented by the following general formula (6):



35 wherein each of Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷ and Ar⁶⁸ represents an aryl group or a heteroaryl group; each of R⁶¹ and R⁶² represents a hydrogen atom or a substituent; each of R⁶³, R⁶⁴ and R⁶⁵ represents a substituent; each of n⁶¹ and n⁶² represents an integer of 0 to 5; each of n⁶³ and n⁶⁴ represents an integer of 0 to 4; and n⁶⁵ represents an integer of 0 to 8.

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45 17. The light-emitting device of claim 16, wherein in said general formula (6), each of Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷ and Ar⁶⁸ is selected from the group consisting of a phenyl group, a naphthyl group and a phenanthryl group.

18. The light-emitting device of claim 16, wherein in said general formula (6), each of R⁶¹ and R⁶² is selected from the group consisting of a hydrogen atom, a phenyl group and a pyrenyl group.

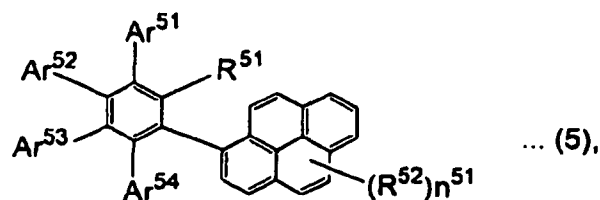
19. The light-emitting device of claim 16, wherein in said general formula (6), each of n⁶¹ and n⁶² represents 0 or 1.

50 20. The light-emitting device of claim 1, wherein the content of said compound of said general formula (1) in said light-emitting layer is 0.1 to 100% by mass as a light-emitting material.

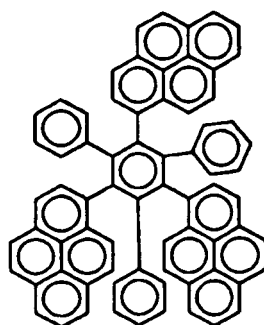
55 21. The light-emitting device of claim 1, wherein the content of said compound of said general formula (1) in said light-emitting layer or at least one of a plurality of organic layers comprising said light-emitting layer is 10 to 99.9% by mass as a host material.

22. The light-emitting device of claim 1, wherein at least one of said light-emitting layer and a plurality of organic layers comprising said light-emitting layer is a light-emitting layer.

23. The light-emitting device of claim 1, wherein at least one of said light-emitting layer and a plurality of organic layers comprising said light-emitting layer is a hole-transporting layer.
24. The light-emitting device of claim 1, wherein said light-emitting layer comprises at least one fluorescent compound.
25. A compound represented by the following general formula (5):



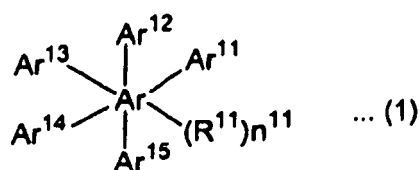
wherein each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ represents an aryl group; R⁵¹ represents a hydrogen atom or a substituent; R⁵² represents a substituent; and n⁵¹ represents an integer of 0 to 9, with the proviso that the compound is not



26. The compound of claim 25, wherein in said general formula (5), each of Ar⁵¹, Ar⁵², Ar⁵³ and Ar⁵⁴ is selected from the group consisting of a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group and a fluoranthryl group.
27. The compound of claim 25, wherein in said general formula (5), R⁵¹ is selected from the group consisting of a hydrogen atom, an alkyl group and an aryl group.

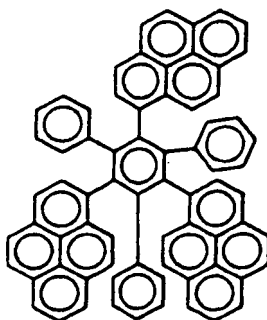
Patentansprüche

1. Lichtemittierende Vorrichtung, umfassend ein Elektrodenpaar und eine lichtemittierende Schicht oder eine Vielzahl von organischen Schichten, umfassend eine lichtemittierende Schicht, angeordnet zwischen den genannten Elektroden, wobei die lichtemittierende Schicht oder mindestens eine von der Vielzahl von organischen Schichten, umfassend die genannte lichtemittierende Schicht, mindestens eine Verbindung dargestellt durch die folgende allgemeine Formel (1) umfasst:



EP 1 412 450 B1

wobei jedes von Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ eine Arylgruppe oder eine Heteroarylgruppe darstellt; Ar einen Benzolring darstellt, mindestens eines von Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ eine kondensierte Arylgruppe, eine kondensierte oder unkondensierte Heteroarylgruppe oder eine Gruppe, umfassend eine kondensierte Arylgruppe oder eine kondensierte oder unkondensierte Heteroarylgruppe, ist; mindestens eines von Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ eine Pyrenylgruppe ist; Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ nicht miteinander verbunden sind, um einen Ring zu bilden; R¹¹ einen Substituenten darstellt; und n¹¹ eine ganze Zahl von 0 oder mehr darstellt, unter der Bedingung, dass die Verbindung nicht



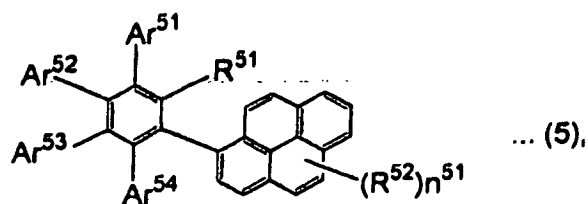
ist.

2. Lichtemittierende Vorrichtung nach Anspruch 1, wobei in der genannten allgemeinen Formel (1) mindestens vier von R¹¹ und Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ eine kondensierte Arylgruppe oder eine kondensierte oder unkondensierte Heteroarylgruppe sind.
3. Lichtemittierende Vorrichtung nach Anspruch 1, wobei in der genannten allgemeinen Formel (1) mindestens eines von Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ ausgewählt ist aus der Gruppe bestehend aus einer Naphthylgruppe, einer Phenanthrylgruppe, einer Anthrylgruppe, einer Fluoranthenylgruppe und einer Perylenylgruppe, und R¹¹ ist ausgewählt aus der Gruppe bestehend aus einer Naphthylgruppe, einer Phenanthrylgruppe, einer Anthrylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe und einer Perylenylgruppe.
4. Lichtemittierende Vorrichtung nach Anspruch 1, wobei die genannte Verbindung dargestellt durch die allgemeine Formel (1) Licht aus einem Singulett angeregten Zustand emittiert.
5. Lichtemittierende Vorrichtung nach Anspruch 1, wobei in der genannten allgemeinen Formel (1) R¹¹ ein Wasserstoffatom oder einen Substituenten darstellt.
6. Lichtemittierende Vorrichtung nach Anspruch 5, wobei in der genannten allgemeinen Formel (1) jedes von Ar¹¹, Ar¹², Ar¹³ und Ar¹⁴, das keine Pyrenylgruppe ist, ausgewählt ist aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe, einer Anthrylgruppe, einer Phenanthrylgruppe und einer Fluoranthenylgruppe; Ar¹⁵, das keine Pyrenylgruppe ist, ist ausgewählt aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe, einer Anthrylgruppe, einer Phenanthrylgruppe, einer Fluoranthenylgruppe und einer Perylenylgruppe; R¹¹ ist ausgewählt aus der Gruppe bestehend aus einem Wasserstoffatom, einer Alkylgruppe und einer Arylgruppe; und mindestens eines von Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ und Ar¹⁵ ist eine kondensierte Arylgruppe.
7. Lichtemittierende Vorrichtung nach Anspruch 6, wobei in der genannten allgemeinen Formel (1) jedes von Ar¹¹, Ar¹², Ar¹³ und Ar¹⁴ ausgewählt ist aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe und einer Phenanthrylgruppe.
8. Lichtemittierende Vorrichtung nach Anspruch 6 wobei in der genannten allgemeinen Formel (1) Ar¹¹ ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer Phenylgruppe und einer Pyrenylgruppe.
9. Lichtemittierende Vorrichtung nach Anspruch 5, wobei in der genannten allgemeinen Formel (1) Ar¹¹ und Ar¹² eine kondensierte Arylgruppe oder eine kondensierte oder unkondensierte Heteroarylgruppe ist.

10. Lichtemittierende Vorrichtung nach Anspruch 5, wobei in der genannten allgemeinen Formel (1) jedes von Ar¹¹ und Ar¹⁴ eine kondensierte Arylgruppe oder eine kondensierte oder unkondensierte Heteroarylgruppe ist.

11. Lichtemittierende Vorrichtung nach Anspruch 5, wobei in der genannten allgemeinen Formel (1) jedes von Ar¹¹ und Ar¹³ ein kondensiertes Aryl ist; jedes von R¹¹, Ar¹², Ar¹⁴ und Ar¹⁵ ausgewählt ist aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe, einer Phenanthrylgruppe, einer Anthrylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe und einer Perylenylgruppe.

12. Lichtemittierende Vorrichtung nach Anspruch 1, wobei die Verbindung der Formel (1) dargestellt ist durch die folgende allgemeine Formel (5):



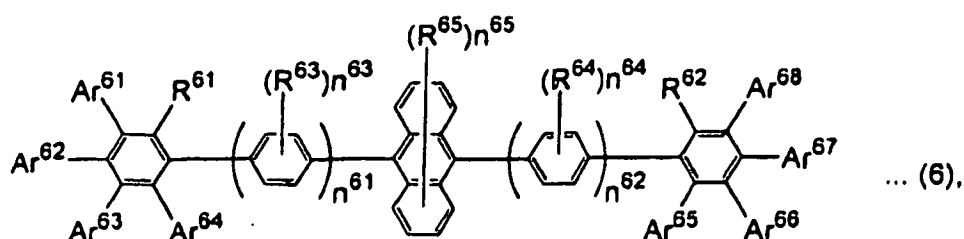
wobei jedes von Ar⁵¹, Ar⁵², Ar⁵³ und Ar⁵⁴ eine Arylgruppe darstellt; R⁵¹ ein Wasserstoffatom oder einen Substituenten darstellt; R⁵² einen Substituenten darstellt; und n⁵¹ eine ganze Zahl von 0 bis 9 darstellt.

13. Lichtemittierende Vorrichtung nach Anspruch 12, wobei in der genannten allgemeinen Formel (5) jedes von Ar⁵¹, Ar⁵², Ar⁵³ und Ar⁵⁴ ausgewählt ist aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe, einer Anthrylgruppe, einer Phenanthrylgruppe und einer Fluoranthenylgruppe.

14. Lichtemittierende Vorrichtung nach Anspruch 12, wobei in der genannten allgemeinen Formel (5), R⁵¹ ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer Alkylgruppe und einer Arylgruppe.

15. Lichtemittierende Vorrichtung nach Anspruch 14, wobei in der genannten allgemeinen Formel (5) R⁵¹ ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer Phenylgruppe und einer Pyrenylgruppe.

16. Lichtemittierende Vorrichtung nach Anspruch 1, wobei die Verbindung der Formel (1) dargestellt ist durch die folgende allgemeine Formel (6):



wobei jedes von Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷ und Ar⁶⁸ eine Arylgruppe oder eine Heteroarylgruppe darstellt; jedes von R⁶¹ und R⁶² ein Wasserstoffatom oder einen Substituenten darstellt; jedes von R⁶³, R⁶⁴ und R⁶⁵ einen Substituenten darstellt; jedes von n⁶¹ und n⁶² eine ganze Zahl von 0 bis 5 darstellt; jedes von n⁶³ und n⁶⁴ eine ganze Zahl von 0 bis 4 darstellt; und n⁶⁵ eine ganze Zahl von 0 bis 8 darstellt.

17. Lichtemittierende Vorrichtung nach Anspruch 16, wobei in der genannten allgemeinen Formel (6) jedes von Ar⁶¹, Ar⁶², Ar⁶³, Ar⁶⁴, Ar⁶⁵, Ar⁶⁶, Ar⁶⁷ und Ar⁶⁸ ausgewählt ist aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe und einer Phenanthrylgruppe.

EP 1 412 450 B1

18. Lichtemittierende Vorrichtung nach Anspruch 16, wobei in der genannten allgemeinen Formel (6) jedes von R^{61} und R^{62} ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer Phenylgruppe und einer Pyrenylgruppe.

5 19. Lichtemittierende Vorrichtung nach Anspruch 16, wobei in der genannten allgemeinen Formel (6) jedes von n^{61} und n^{62} 0 oder 1 darstellt.

10 20. Lichtemittierende Vorrichtung nach Anspruch 1, wobei der Gehalt von der genannten Verbindung der genannten allgemeinen Formel (1) in der genannten lichtemittierenden Schicht 0,1 bis 100 Gew.-% als ein lichtemittierendes Material beträgt.

15 21. Lichtemittierende Vorrichtung von Anspruch 1, wobei der Gehalt der genannten Verbindung der genannten allgemeinen Formel (1) in der genannten lichtemittierenden Schicht oder mindestens einer von einer Vielzahl von organischen Schichten, umfassend die genannte lichtemittierende Schicht, 10 bis 99,9 Gew.-% als ein Trägermaterial beträgt.

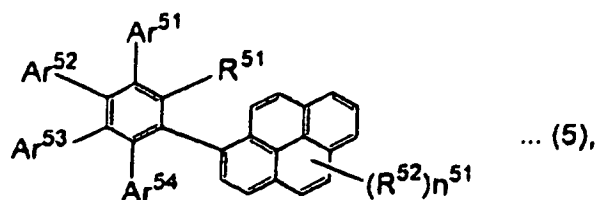
20 22. Lichtemittierende Vorrichtung von Anspruch 1, wobei mindestens eine der genannten lichtemittierenden Schicht und einer Vielzahl von organischen Schichten, umfassend die genannte lichtemittierende Schicht, eine lichtemittierende Schicht ist.

23. Lichtemittierende Vorrichtung nach Anspruch 1, wobei mindestens eine der genannten lichtemittierenden Schicht und einer Vielzahl von organischen Schichten, umfassend die genannte lichtemittierende Schicht, eine Lochtransportierende Schicht ist.

25 24. Lichtemittierende Vorrichtung von Anspruch 1, wobei die genannte lichtemittierende Schicht mindestens eine fluoreszierende Verbindung umfasst.

25. Verbindung dargestellt durch die folgende allgemeine Formel (5):

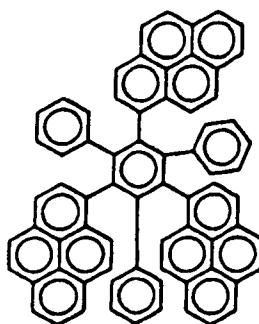
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40 wobei jedes von Ar^{51} , Ar^{52} , Ar^{53} und Ar^{54} eine Arylgruppe darstellt; R^{51} , ein Wasserstoffatom oder einen Substituenten darstellt; R^{52} einen Substituenten darstellt; und n^{51} eine ganze Zahl von 0 bis 9 darstellt, unter der Bedingung dass die Verbindung nicht

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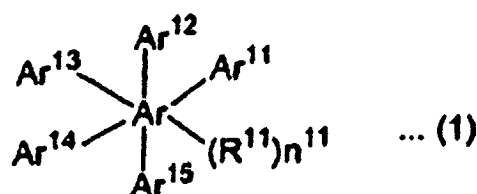
ist.

26. Verbindung nach Anspruch 25, wobei in der genannten allgemeinen Formel (5) jedes von Ar⁵¹, Ar⁵², Ar⁵³ und Ar⁵⁴ ausgewählt ist aus der Gruppe bestehend aus einer Phenylgruppe, einer Naphthylgruppe, einer Anthrylgruppe, einer Phenanthrylgruppe und einer Fluoranthenylgruppe.

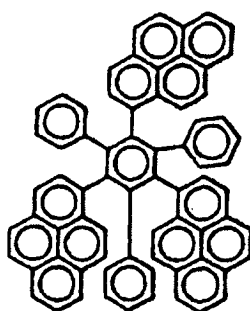
27. Verbindung nach Anspruch 25, wobei in der genannten allgemeinen Formel (5) R⁵¹ ausgewählt ist aus der Gruppe bestehend aus einem Wasserstoffatom, einer Alkylgruppe und einer Arylgruppe.

Revendications

1. Dispositif électroluminescent comprenant une paire d'électrodes et une couche électroluminescente ou une pluralité de couches organiques comprenant une couche électroluminescente disposée entre lesdites électrodes, ladite couche électroluminescente ou au moins l'une d'une pluralité de couches organiques comprenant ladite couche électroluminescente comprenant au moins un composé représenté par la formule générale (1) suivante :



dans laquelle chacun des radicaux Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ et Ar¹⁵, représente un groupe aryle ou un groupe hétéroaryle ; Ar représente un noyau benzène, au moins l'un des radicaux Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ et Ar¹⁵ représente un groupe aryle condensé, un groupe hétéroaryle condensé ou non condensé ou un groupe comprenant un groupe aryle condensé ou un groupe hétéroaryle condensé ou non condensé ; au moins l'un des radicaux Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ et Ar¹⁵ représente un groupe pyrényle ; Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ et Ar¹⁵ ne sont pas reliés les uns aux autres pour former un noyau ; R¹¹ représente un substituant ; et n¹¹ représente un nombre entier supérieur ou égal à 0, à condition que le composé ne représente pas un groupe



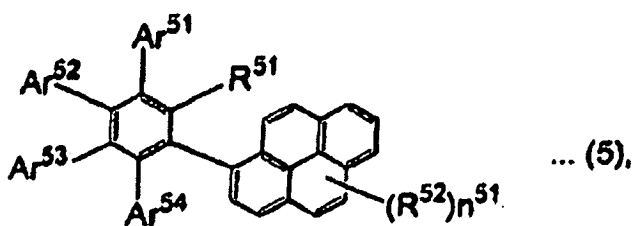
2. Dispositif électroluminescent selon la revendication 1, dans lequel dans ladite formule générale (1), au moins quatre des radicaux Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ et Ar¹⁵ représentent un groupe aryle condensé ou un groupe hétéroaryle condensé ou non condensé.

3. Dispositif électroluminescent selon la revendication 1, dans lequel dans ladite formule générale (1), au moins l'un des radicaux Ar¹¹, Ar¹², Ar¹³, Ar¹⁴ et Ar¹⁵ est choisi dans le groupe constitué d'un groupe naphthyle, d'un groupe phénanthryle, d'un groupe anthryle, d'un groupe fluoranthényle et d'un groupe pérylényle, et R¹¹ est choisi dans le groupe constitué d'un groupe naphthyle, d'un groupe phénanthryle, d'un groupe anthryle, d'un groupe fluoranthényle, d'un groupe pyrényle et d'un groupe pérylényle.

4. Dispositif électroluminescent selon la revendication 1, dans lequel ledit composé représenté par ladite formule

générale (1) émet de la lumière à partir d'un état excité singulet.

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6. Dispositif électroluminescent selon la revendication 5, dans lequel dans ladite formule générale (1), R^{11} représente un atome d'hydrogène ou un substituant.
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7. Dispositif électroluminescent selon la revendication 5, dans lequel dans ladite formule générale (1), chacun des radicaux Ar^{11} , Ar^{12} , Ar^{13} et Ar^{14} qui n'est pas un groupe pyrényle est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle, d'un groupe anthryle, d'un groupe phénanthryle et d'un groupe fluoranthényle ; Ar^{15} qui n'est pas un groupe pyrényle est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle, d'un groupe anthryle, d'un groupe phénanthryle, d'un groupe fluoranthényle et d'un groupe pérylényle ; R^{11} est choisi dans le groupe constitué d'un atome d'hydrogène, d'un groupe alkyle et d'un groupe aryle ; et au moins l'un des radicaux Ar^{11} , Ar^{12} , Ar^{13} , Ar^{14} et Ar^{15} représente un groupe aryle condensé.
- 15
8. Dispositif électroluminescent selon la revendication 6, dans lequel dans ladite formule générale (1), chacun des radicaux Ar^{11} , Ar^{12} , Ar^{13} et Ar^{14} est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle et d'un groupe phénanthryle.
- 20
9. Dispositif électroluminescent selon la revendication 6, dans lequel dans ladite formule générale (1), R^{11} est choisi dans le groupe constitué d'un atome d'hydrogène, d'un groupe phényle et d'un groupe pyrényle.
- 25
10. Dispositif électroluminescent selon la revendication 5, dans lequel dans ladite formule générale (1), Ar^{11} et Ar^{12} représentent un groupe aryle condensé ou un groupe hétéroaryle condensé ou non condensé.
- 30
11. Dispositif électroluminescent selon la revendication 5, dans lequel dans ladite formule générale (1), chacun des radicaux Ar^{11} et Ar^{13} représente un groupe aryle condensé ; chacun des radicaux Ar^{12} , Ar^{14} et Ar^{15} est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle, d'un groupe phénanthryle, d'un groupe anthryle, d'un groupe fluoranthényle, d'un groupe pyrényle et d'un groupe pérylényle.
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12. Dispositif électroluminescent selon la revendication 1, dans lequel le composé de formule (1) est représenté par la formule générale (5) suivante :

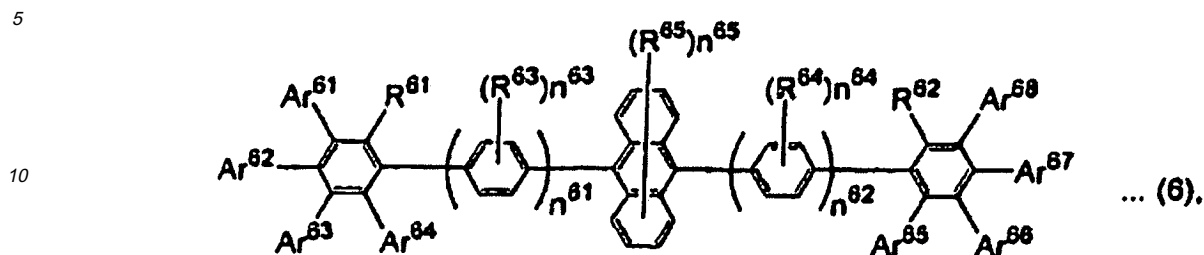


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dans laquelle chacun des radicaux Ar^{51} , Ar^{52} , Ar^{53} et Ar^{54} représente un groupe aryle ; R^{51} représente un atome d'hydrogène ou un substituant ; R^{52} représente un substituant ; et n^{51} représente un nombre entier de 0 à 9.

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13. Dispositif électroluminescent selon la revendication 12, dans lequel dans ladite formule générale (5), chacun des radicaux Ar^{51} , Ar^{52} , Ar^{53} et Ar^{54} est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle, d'un groupe anthryle, d'un groupe phénanthryle et d'un groupe fluoranthényle.
- 55
14. Dispositif électroluminescent selon la revendication 12, dans lequel dans ladite formule générale (5), R^{51} est choisi dans le groupe constitué d'un atome d'hydrogène, d'un groupe alkyle et d'un groupe aryle.
15. Dispositif électroluminescent selon la revendication 14, dans lequel dans ladite formule générale (5), R^{51} est choisi dans le groupe constitué d'un atome d'hydrogène, d'un groupe phényle et d'un groupe pyrényle.

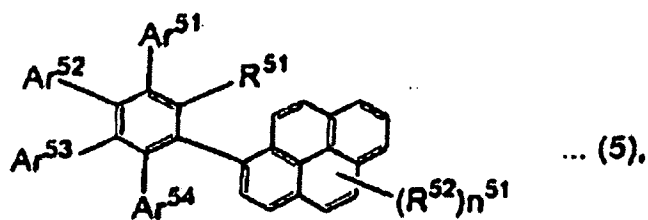
16. Dispositif électroluminescent selon la revendication 1, dans lequel le composé de formule (1) est représenté par la formule générale suivante (6) :



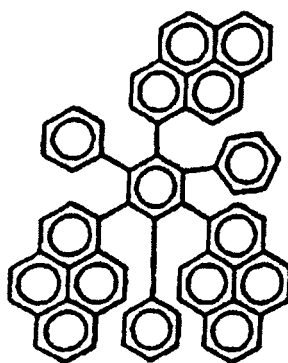
15 dans laquelle chacun des radicaux Ar^{61} , Ar^{62} , Ar^{63} , Ar^{64} , Ar^{65} , Ar^{66} , Ar^{67} et Ar^{68} représente un groupe aryle ou un groupe hétéroaryle ; chacun des radicaux R^{61} et R^{62} représente un atome d'hydrogène ou un substituant ; chacun des radicaux R^{63} , R^{64} et R^{65} représente un substituant ; chacun des nombres n^{61} et n^{62} représente un nombre entier de 0 à 5 ; chacun des nombres n^{63} et n^{64} représente un nombre entier de 0 à 4 ; et n^{65} représente un nombre entier de 0 à 8.

- 20
17. Dispositif électroluminescent selon la revendication 16, dans lequel dans ladite formule générale (6), chacun des radicaux Ar^{61} , Ar^{62} , Ar^{63} , Ar^{64} , Ar^{65} , Ar^{66} , Ar^{67} et Ar^{68} est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle et d'un groupe phénanthryle.
- 25
18. Dispositif électroluminescent selon la revendication 16, dans lequel dans ladite formule générale (6), chacun des radicaux R^{61} et R^{62} est choisi dans le groupe constitué d'un atome d'hydrogène, d'un groupe phényle et d'un groupe pyrényle.
- 30
19. Dispositif électroluminescent selon la revendication 16, dans lequel dans ladite formule générale (6), chacun des nombres n^{61} et n^{62} représente 0 ou 1.
20. Dispositif électroluminescent selon la revendication 1, dans lequel la teneur dudit composé de ladite formule générale (1) dans ladite couche électroluminescente est de 0,1 à 100 % en masse en tant que matériau électroluminescent.
- 35
21. Dispositif électroluminescent selon la revendication 1, dans lequel la teneur dudit composé de ladite formule générale (1) dans ladite couche électroluminescente ou au moins l'une d'une pluralité de couches organiques comprenant ladite couche électroluminescente est de 10 à 99,9 % en masse en tant que matériau hôte.
- 40
22. Dispositif électroluminescent selon la revendication 1, dans lequel au moins l'une de ladite couche électroluminescente et d'une pluralité de couches organiques comprenant ladite couche électroluminescente est une couche électroluminescente.
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23. Dispositif électroluminescent selon la revendication 1, dans lequel au moins l'une de ladite couche électroluminescente et d'une pluralité de couches organiques comprenant ladite couche électroluminescente est une couche de transport de trous.
24. Dispositif électroluminescent selon la revendication 1, dans lequel ladite couche électroluminescente comprend au moins un composé fluorescent.
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25. Composé représenté par la formule générale suivante (5) :

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10 dans laquelle chacun de Ar^{51} , Ar^{52} , Ar^{53} et Ar^{54} représente un groupe aryle ; R^{51} , représente un atome d'hydrogène ou un substituant ; R^{52} représente un substituant ; et n^{51} représente un nombre entier de 0 à 9, à condition que le composé ne représente pas un groupe



30 **26.** Composé selon la revendication 25, dans lequel dans ladite formule générale (5), chacun de Ar^{51} , Ar^{52} , Ar^{53} et Ar^{54} est choisi dans le groupe constitué d'un groupe phényle, d'un groupe naphthyle, d'un groupe anthryle, d'un groupe phénanthryle et d'un groupe fluoranthényle.

35 **27.** Composé selon la revendication 25, dans lequel dans ladite formule générale (5), R^{51} est choisi dans le groupe constitué d'un atome d'hydrogène, d'un groupe alkyle et d'un groupe aryle.

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REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	发光器件和芳香族化合物		
公开(公告)号	EP1412450B1	公开(公告)日	2012-02-29
申请号	EP2002745913	申请日	2002-07-10
[标]申请(专利权)人(译)	富士摄影胶片公司		
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当前申请(专利权)人(译)	UDC IRELAND LIMITED		
[标]发明人	IGARASHI TATSUYA C O FUJI PHOTO FILM CO LTD QIU XUEPENG		
发明人	IGARASHI, TATSUYA, C/O FUJI PHOTO FILM CO., LTD. QIU, XUEPENG		
IPC分类号	C09K11/06 H05B33/14 H01L51/50 C07C13/62 C07C13/66 C07C15/24 C07C15/28 C07C15/30 C07C15/38 C07C15/60 C07C15/62 C07D251/24 H01L51/00 H01L51/30		
CPC分类号	H01L51/0052 C07C13/62 C07C13/66 C07C15/24 C07C15/28 C07C15/30 C07C15/38 C07C2603/24 C07C2603/26 C07C2603/50 C07D251/24 H01L51/0037 H01L51/0042 H01L51/0054 H01L51/0056 H01L51/0058 H01L51/006 H01L51/0067 H01L51/007 H01L51/0071 H01L51/0081 H01L51/0083 H01L51/5012 H01L2251/308 Y10S428/917		
代理机构(译)	GRÜNECKER, KINKELDEY, STOCKMAIR & SCHWANHÄUSSER		
优先权	2001329676 2001-10-26 JP 2001211269 2001-07-11 JP		
其他公开文献	EP1412450A2		
外部链接	Espacenet		

摘要(译)

一种发光装置，包括一对电极和发光层或多个有机层，所述多个有机层包括设置在其间的发光层，所述发光层或包括所述发光层的多个有机层中的至少一个发光层，其包含至少一种由以下通式(1)表示的化合物：其中Ar¹¹，Ar¹²，Ar¹³，Ar¹⁴和Ar¹⁵各自表示芳基或a杂芳基；Ar表示苯环，萘环，菲环或蒽环；Ar，Ar¹¹，Ar¹²，Ar¹³，Ar¹⁴和Ar¹⁵中的至少一个是稠合芳基，缩合或未缩合的杂芳基或包含稠合芳基的基团或稠合或未稠合的杂芳基；Ar¹¹，Ar¹²，Ar¹³，Ar¹⁴和Ar¹⁵不相互键合而形成环。R¹¹表示取代基；n¹¹表示0以上的整数。

