

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
6 January 2005 (06.01.2005)

PCT

(10) International Publication Number  
**WO 2005/000787 A1**

(51) International Patent Classification<sup>7</sup>: **C07C 211/61**,  
C09K 11/06, H05B 33/14

(21) International Application Number:  
PCT/JP2004/009372

(22) International Filing Date: 25 June 2004 (25.06.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
2003-184263 27 June 2003 (27.06.2003) JP

(71) Applicant (for all designated States except US): **CANON KABUSHIKI KAISHA** [JP/JP]; 3-30-2, Shimomaruko, Ohta-ku, Tokyo 146-8501 (JP).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **SAITOH, Akihito** [JP/JP]; c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko, Ohta-ku, Tokyo 146-8501 (JP). **SENOO,**

**Akihiro** [JP/JP]; c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko, Ohta-ku, Tokyo 146-8501 (JP). **UENO, Kazunori** [JP/JP]; c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko, Ohta-ku, Tokyo 146-8501 (JP). **OKI-NAKA, Keiji** [JP/JP]; c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko, Ohta-ku, Tokyo 146-8501 (JP). **SUZUKI, Koichi** [JP/JP]; c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko, Ohta-ku, Tokyo 146-8501 (JP).

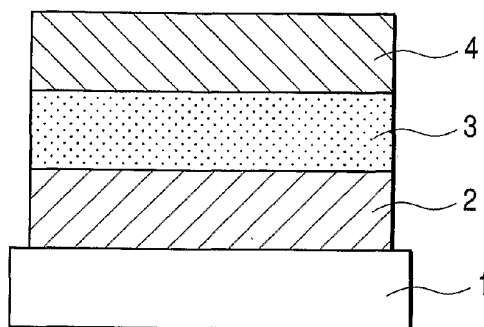
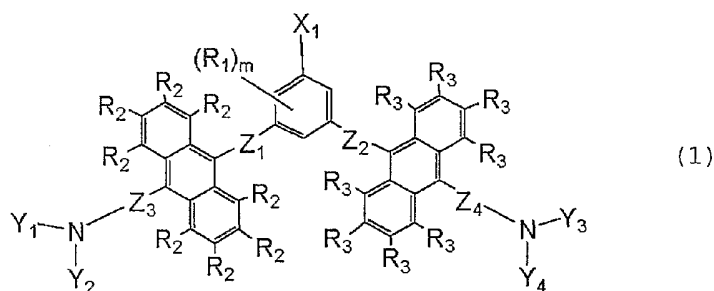
(74) Agents: **OKABE, Masao** et al.; No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo 100-0005 (JP).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH,

[Continued on next page]

(54) Title: AMINOANTHRYL DERIVATIVE SUBSTITUTION COMPOUND AND ORGANIC ELECTROLUMINESCENCE DEVICE USING THE SAME



(57) Abstract: There is provided an aminoanthryl derivative substitution compound represented by the following general formula (1). The compound according to the present invention can provide an organic electroluminescence device showing an extremely pure luminescence hue, and an optical output with high efficiency, high luminance, and long life.

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GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— with international search report

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## DESCRIPTION

AMINOANTHRYL DERIVATIVE SUBSTITUTION COMPOUND AND  
ORGANIC ELECTROLUMINESCENCE DEVICE USING THE SAME

5

## TECHNICAL FIELD

The present invention relates to an organic  
electroluminescence device, and more particularly, to  
a device from which light is emitted by applying an  
electric field on a thin film made of an organic  
compound.

10

## BACKGROUND ART

An organic electroluminescence device is a  
device that includes a thin film made of a  
fluorescent organic compound between an anode and a  
cathode, generates an exciton from the fluorescent  
compound by injection of an electron and an electron  
hole (hereinafter, also simply referred to as a hole)  
from each electrode, and uses light to be radiated  
when the exciton returns to the ground state.

20

The study conducted by Eastman Kodak Company in  
1987 (Appl. Phys. Lett., 51, p. 913, (1987)) reported  
light emission at about 1,000 cd/m<sup>2</sup> by an applied  
voltage of about 10 V from a device including a  
function-separated two-layer structure having an  
anode made of ITO and a cathode made of magnesium-

25

silver alloy where an aluminum quinolinol complex is used as each of an electron-transporting material and a light-emitting material and a triphenylamine derivative is used as a hole-transporting material.

5 In this case, related patent documents include U.S. Patent Nos.: 4,539,507, 4,720,432, and 4,885,211.

In addition, light emission at spectra ranging from ultraviolet through infrared is possible by changing the type of a fluorescent organic material.

10 Recently, various compounds have been studied actively and described in many publications such as U.S. Patent Nos. 5,151,629, 5,409,783, and 5,382,477, Japanese Patent Application Laid-Open Nos. H02-247278, H03-255190, H05-202356, H09-202878, and H09-2275756.

15 Furthermore, in addition to the organic electroluminescence devices using low molecular weight materials as described above, an organic electroluminescence device using a conjugated polymer has been reported from the group of Cambridge  
20 University (Nature, 347, 539 (1990)). This report has confirmed light emission from a monolayer by film formation with polyphenylene vinylene (PPV) in a coating system. Patents related to an organic electroluminescence device using a conjugated polymer  
25 include U.S. Patent Nos. 5,247,190, 5,514,878, and 5,672,678, Japanese Patent Application Laid-Open Nos. H04-145192, and H05-247460.

Recently, furthermore, an organic phosphorescence device using an iridium complex such as Ir (ppy)<sub>3</sub> (Appl. Phys. Lett., 75, 4 (1999)) has been attracting attention and high luminous efficiency thereof has been reported.

Recent advances in organic electroluminescence devices are remarkable and the characteristics thereof allow the formation of light-emitting devices having high luminance with a low applied voltage, the variety of emission wavelengths, high-speed responsiveness, low profile, and lightweight, suggesting the possibility for extensive uses. However, organic electroluminescence devices still involve many problems in durability, such as chronological changes by prolonged use, and degradation with atmospheric gases containing oxygen, humidity, or the like. When applications of organic electroluminescence devices to full-color displays and so on are taken into consideration, under the present circumstances, blue-, green-, and red light-emissions with extended-life, high conversion rate, and high color purity have been demanded.

Examples of the materials and organic electroluminescence devices containing anthracene rings include a phenyl anthracene derivative disclosed in Japanese Patent Application Laid-Open No. H08-012600. In particular, when a phenyl anthracene

derivative was used as a blue light-emitting material or an electron-injection transporting material, the phenyl anthracene derivative supposedly allows the formation of a good organic film because of its low crystallinity. However, the luminous efficiency and durable life of the phenyl anthracene ring were insufficient in practical application.

An aminoanthracene derivative and a diaminoanthracene derivative have been disclosed as other examples in Japanese Patent Application Laid-Open Nos. H09-157643 and H10-072579, respectively. In the documents, those materials supposedly generate green light-emission when they were used as light-emitting materials. However, devices prepared from those materials showed insufficient luminous efficiencies, and their durable lives were still insufficient in practical application.

Japanese Patent No. 3008897 discloses as another example a device using a particular bianthryl compound as a light-emitting material, which supposedly generates light emission with high luminance. However, the patent describes nothing about luminous efficiency and durable life.

Japanese Patent Application Laid-Open No. H11-008068 discloses as still another example a device using a particular anthracene compound having an olefin site as a light-emitting material, which

supposedly generates light emission from yellow to red. However, the device showed insufficient luminous efficiency in practical application.

Furthermore, Japanese Patent Application Laid-  
5 Open No. 2001-284050 discloses as another example a device that contains an anthracene derivative having a particular structure, an electron-transporting compound, and another fluorescent compound in a light-emitting medium layer. This device supposedly  
10 provides a red light-emitting device with improved reliability. However, the device showed insufficient luminous efficiency in practical application. In addition, it was difficult to obtain blue light emission because of its device configuration.

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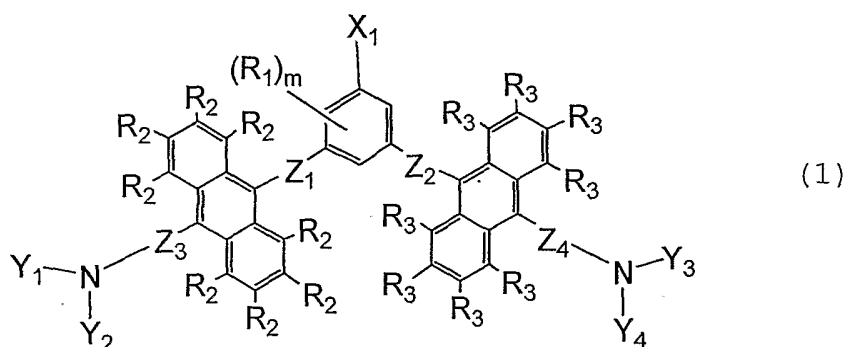
#### DISCLOSURE OF THE INVENTION

The present invention has been made to solve the problems inherent in the conventional technology and it is an object of the present invention to provide  
20 an organic electroluminescence device exhibiting an extremely pure luminescence hue, and an optional output with high efficiency, high luminance, and long life. Another object of the present invention is to provide an organic electroluminescence device which  
25 can be manufactured with ease at a relatively low cost.

The inventors of the present invention have made

extensive study to attain the above objects, thereby completing the present invention.

That is, the present invention provides an aminoanthryl derivative substitution compound represented by the following general formula (1):



(wherein,

each of  $Y_1$  to  $Y_4$  is one selected from the group consisting of a substituted or unsubstituted alkyl group, aralkyl group, aryl group, and heterocyclic group,  $Y_1$  to  $Y_4$  may be the same or different, and  $Y_1$  and  $Y_2$ , and  $Y_3$  and  $Y_4$  may bind to each other to form a ring;

each of  $Z_1$  and  $Z_2$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_1$  and  $Z_2$  may be the same or different;

each of  $Z_3$  and  $Z_4$  is one selected from the group

consisting of a direct bond, a substituted or unsubstituted arylene group and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_3$  and  $Z_4$  may be the same or different;

5            $X_1$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aralkyl group, alkenyl group, alkynyl group, alkoxy group, sulfide group, aryl group, and heterocyclic  
10           group, and  $X_1$  may be the same or different;

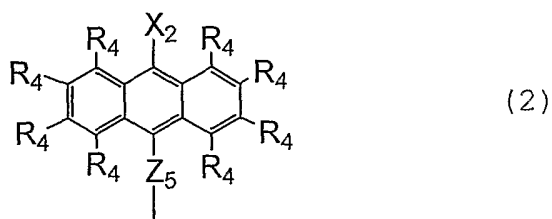
$R_1$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group and alkoxy group, and  $R_1$  may be the same or different;

15           each of  $R_2$  and  $R_3$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_2$  and  $R_3$  may be the same or different; and

20            $m$  is an integer of 0 to 3).

Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in which  $X_1$  is represented by the following general formula (2):

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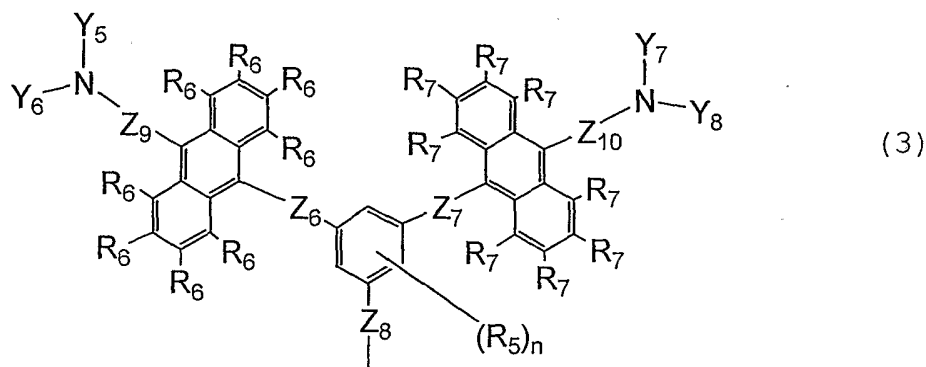
(wherein,

$Z_5$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_5$  may be the same or different;

$X_2$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group, aralkyl group, alkenyl group, alkynyl group, alkoxy group, sulfide group, amino group, aryl group, and heterocyclic group, and  $X_2$  may be the same or different; and

$R_4$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_4$  may be the same or different).

Furthermore, the present invention provide an aminoanthryl derivative substitution compound, in which  $X_1$  is represented by the following general formula (3):



(wherein,

each of  $Y_5$  to  $Y_8$  is one selected from the group consisting of a substituted or unsubstituted alkyl group, aralkyl group, aryl group, and heterocyclic group,  $Y_5$  to  $Y_8$  may be the same or different, and  $Y_5$  and  $Y_6$ , and  $Y_7$  and  $Y_8$  may bind to each other to form a ring;

each of  $Z_6$  to  $Z_8$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_6$  to  $Z_8$  may be the same or different;

each of  $Z_9$  and  $Z_{10}$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted arylene group and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_9$  and  $Z_{10}$  may be the same or different;

$R_5$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group and alkoxy group, and  $R_5$  may be the same or different;

5        each of  $R_6$  and  $R_7$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_6$  and  $R_7$  may be the same or different; and

10         $n$  is an integer of 0 to 3).

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross sectional diagram illustrating an embodiment of an organic electroluminescence  
15        device of the present invention;

Fig. 2 is a cross sectional diagram illustrating another embodiment of the organic electroluminescence device of the present invention;

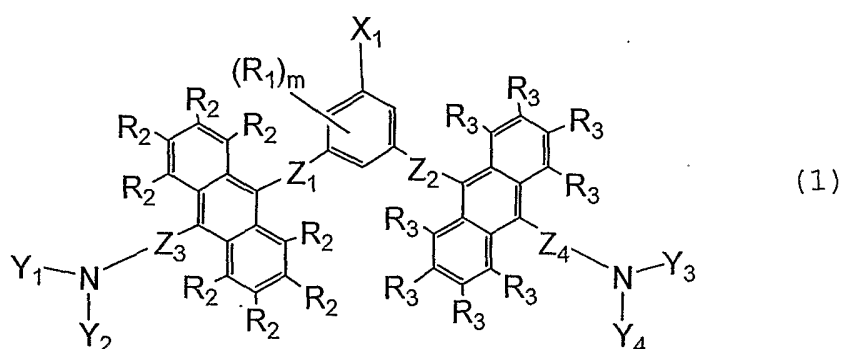
Fig. 3 is a cross sectional diagram illustrating  
20        another embodiment of the organic electroluminescence device of the present invention;

Fig. 4 is a cross sectional diagram illustrating another embodiment of the organic electroluminescence device of the present invention; and

25        Fig. 5 is a cross sectional diagram illustrating another embodiment of the organic electroluminescence device of the present invention.

## BEST MODE FOR CARRYING OUT THE INVENTION

The present invention provides an aminoanthryl derivative substitution compound represented by the following general formula (1):



5 (wherein,

each of  $Y_1$  to  $Y_4$  is one selected from the group consisting of a substituted or unsubstituted alkyl group, aralkyl group, aryl group, and heterocyclic group,  $Y_1$  to  $Y_4$  may be the same or different, and  $Y_1$  and  $Y_2$ , and  $Y_3$  and  $Y_4$  may bind to each other to form a ring;

10

each of  $Z_1$  and  $Z_2$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_1$  and  $Z_2$  may be the same or different;

15

each of  $Z_3$  and  $Z_4$  is one selected from the group consisting of a direct bond, a substituted or

20

unsubstituted arylene group and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_3$  and  $Z_4$  may be the same or different;

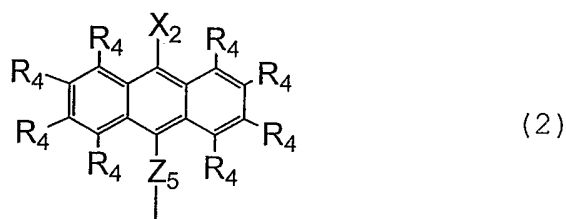
5  $X_1$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aralkyl group, alkenyl group, alkynyl group, alkoxy group, sulfide group, aryl group, and heterocyclic group, and  $X_1$  may be the same or different;

10  $R_1$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group and alkoxy group, and  $R_1$  may be the same or different;

15 each of  $R_2$  and  $R_3$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_2$  and  $R_3$  may be the same or different; and

$m$  is an integer of 0 to 3).

20 Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in which  $X_1$  is represented by the following general formula (2):



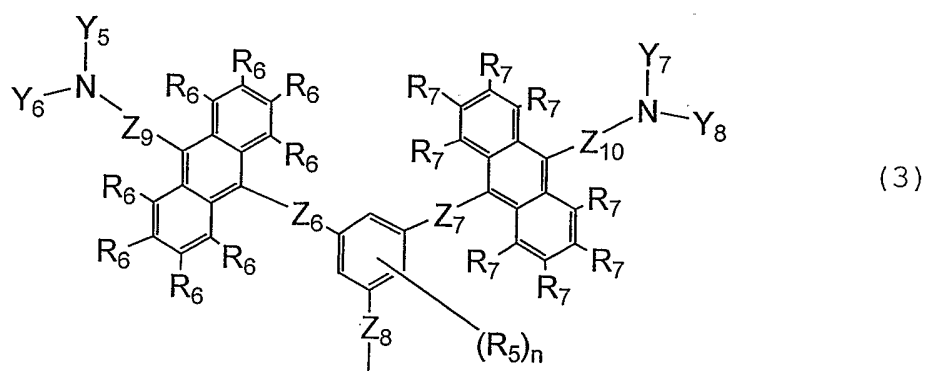
(wherein,

$Z_5$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_5$  may be the same or different;

$X_2$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group, aralkyl group, alkenyl group, alkynyl group, alkoxy group, sulfide group, amino group, aryl group, and heterocyclic group, and  $X_2$  may be the same or different; and

$R_4$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_4$  may be the same or different).

Furthermore, the present invention provide an aminoanthryl derivative substitution compound, in which  $X_1$  is represented by the following general formula (3):



(wherein,

each of  $Y_5$  to  $Y_8$  is one selected from the group consisting of a substituted or unsubstituted alkyl group, aralkyl group, aryl group, and heterocyclic group,  $Y_5$  to  $Y_8$  may be the same or different, and  $Y_5$  and  $Y_6$ , and  $Y_7$  and  $Y_8$  may bind to each other to form a ring;

each of  $Z_6$  to  $Z_8$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_6$  to  $Z_8$  may be the same or different;

each of  $Z_9$  and  $Z_{10}$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted arylene group and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_9$  and  $Z_{10}$  may be the same or different;

$R_5$  is one selected from the group consisting of

a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group and alkoxy group, and  $R_5$  may be the same or different;

each of  $R_6$  and  $R_7$  is one selected from the group  
5 consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_6$  and  $R_7$  may be the same or different; and  
 $n$  is an integer of 0 to 3).

10 Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in which the  $X_1$  is an alkyl group.

Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in  
15 which each of the  $Z_1$  to  $Z_4$  is a direct bond.

Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in which at least one of the  $Y_1$  to  $Y_4$ ,  $Z_1$  to  $Z_4$ ,  $X_1$ , and  $R_1$  to  $R_3$  is a group containing a heavy hydrogen atom  
20 or a heavy hydrogen atom.

Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in which at least one of the  $Y_1$  to  $Y_4$ ,  $Z_1$  to  $Z_5$ ,  $X_2$ , and  $R_1$  to  $R_4$  is a group containing a heavy hydrogen atom  
25 or a heavy hydrogen atom.

Furthermore, the present invention provides an aminoanthryl derivative substitution compound, in

which at least one of the  $Y_1$  to  $Y_8$ ,  $Z_1$  to  $Z_4$ ,  $Z_6$  to  $Z_{10}$ ,  $R_1$  to  $R_3$ , and  $R_5$  to  $R_7$  is a group containing a heavy hydrogen atom or a heavy hydrogen atom.

Furthermore, the present invention provides an  
5 aminoanthryl derivative substitution compound, in which at least one of the  $Y_1$  to  $Y_4$ ,  $Z_1$  to  $Z_4$ ,  $X_1$ , and  $R_1$  to  $R_3$  is a group containing a heavy hydrogen atom or a heavy hydrogen atom.

Furthermore, the present invention provides an  
10 aminoanthryl derivative substitution compound, in which at least one of the  $Y_1$  to  $Y_4$ ,  $X_1$ , and  $R_1$  to  $R_3$  is a group containing a heavy hydrogen atom or a heavy hydrogen atom.

Furthermore, the present invention provides an  
15 organic electroluminescence device including a pair of electrodes composed of an anode and a cathode at least one of which is transparent or translucent, and one or more organic compound layers sandwiched between the pair of electrodes, in which at least one  
20 of the organic compound layers contains at least one kind of the aminoanthryl derivative substitution compounds.

Furthermore, the present invention provides an  
organic electroluminescence device including a light-  
25 emitting layer, a pair of electrodes composed of an anode and a cathode at least one of which is transparent or translucent, and one or more organic

compound layers sandwiched between the pair of electrodes, in which the light-emitting layer contains at least one kind of the aminoanthryl derivative substitution compounds.

5           The compounds each represented by the general formula (1) and the compounds each represented by the general formula (1) in which  $X_1$  is represented by the general formula (2) or (3) can be predominantly used as materials for an organic electroluminescence  
10       device, respectively. Each of the compounds may be solely used in a light-emitting layer for a light-emitting purpose or may be used for a dopant (guest) or host material to produce a device having high color purity, high luminous efficiency, and long life.

15           The compounds each represented by the general formula (1) and the compounds each represented by the general formula (1) in which  $X_1$  is represented by the general formula (2) or (3) contain at least two anthryl groups as a luminescent unit with high  
20       luminous efficiency in a benzene ring core and the two anthryl groups are substituted by an amino group or an amino group with a coupling group. In introducing a substituted amino group, luminescence colors of blue, green, and other colors at longer  
25       wavelengths can be easily obtained by adjusting the HOMO/LUMO level of the material by the change of the substituent on the amino group (e.g., the HOMO/LUMO

levels of Exemplified Compounds 27 and 33 calculated with B3LYP/3-21G are -5.030/-1.877 and -4.805/-1.696, respectively). When the above compound is used as a dopant material, the desired material can be easily designed and synthesized on the basis of the HOMO/LUMO level of the host material by making a prediction as to the HOMO/LUMO level of the material by calculation with respect to the change of the substituent on the anthryl group. In addition, the same is applied when the above compound is used as a host material. Furthermore, the above compounds permit easy molecular design in consideration of difference in energy level with respect to the hole-transporting layer and the electron-transporting layer. An improvement in hole-transporting ability can be expected from the substitution of an amino group. In addition, the amino group on the anthryl group can increase T<sub>g</sub> (for example, Exemplified Compound 28 has a T<sub>g</sub> of 215°C). As to the thermal characteristics of the device, a material having good film-forming ability and thermal stability can be obtained when the compound adopts the form of a star-burst type dendritic molecule. The cohesion between molecules can be prevented by introducing a steric hindrance group or a fluorine atom having a large electronegativity which tends to cause an electrostatic repulsion to a proximal molecule into

the substituent on the benzene ring core, the anthryl group, and the amino group, and such introduction can be particularly expected to extend the life of the device. In addition to the above consideration, the material of the present invention has considered the introduction of a molecule unit substituted with heavy hydrogen by an isotope effect in consideration of inhibition of molecular vibration and thermal inactivation. The present invention has been achieved by performing molecular design on the basis of the above consideration.

Furthermore, when the compound is used as a dopant material, the concentration of the dopant against the host material is 0.01% to 80%, preferably 1% to 40%. The dopant material may be distributed in a layer made of the host material uniformly or with a concentration gradient, or may be partially distributed in a certain region of the host material layer to allow the layer to have a region containing no dopant material.

Hereinafter, the present invention will be described in detail.

Specific examples of the coupling group and the substituent in the general formulae (1) to (3) described above are as follows:

Examples of a coupling group in each of the above general formulae (1) to (3) include, but not

limited to, a substituted or unsubstituted arylene group and divalent heterocyclic group.

Examples of a divalent substituent having a coupling group in each of the above general formulae (1) to (3) include, but not limited to, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, and amino group, and a substituted silyl group, ether group, thioether group, and carbonyl group.

Examples of a substituted or unsubstituted alkyl group include, but not limited to, a methyl group, a methyl-d1 group, a methyl-d3 group, an ethyl group, an ethyl-d5 group, an n-propyl group, an n-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-decyl group, an iso-propyl group, an iso-propyl-d7 group, an iso-butyl group, a sec-butyl group, a tert-butyl group, a tert-butyl-d9 group, an iso-pentyl group, a neopentyl group, a tert-octyl group, a fluoromethyl group, a difluoromethyl group, a trifluoromethyl group, a 2-fluoroethyl group, a 2,2,2-trifluoroethyl group, a perfluoroethyl group, a 3-fluoropropyl group, a perfluoropropyl group, a 4-fluorobutyl group, a perfluorobutyl group, a 5-fluoropentyl group, a 6-fluorohexyl group, a chloromethyl group, a trichloromethyl group, 2-chloroethyl group, a 2,2,2-trichloroethyl group, a 4-chlorobutyl group, a 5-

chloropentyl group, a 6-chlorohexyl group, a  
bromomethyl group, a 2-bromoethyl group, an  
iodomethyl group, a 2-iodoethyl group, a  
hydroxymethyl group, a hydroxyethyl group, a  
5 cyclopropyl group, a cyclobutyl group, a cyclopentyl  
group, a cyclohexyl group, a cyclopentylmethyl group,  
a cyclohexylmethyl group, a cyclohexylethyl group, a  
4-fluorocyclohexyl group, a norbornyl group, and an  
adamantyl group.

10 Examples of a substituted or unsubstituted  
aralkyl group include, but not limited to, a benzyl  
group, a 2-phenylethyl group, a 2-phenylisopropyl  
group, a 1-naphthylmethyl group, a 2-naphthylmethyl  
group, a 2-(1-naphthyl)ethyl group, a 2-(2-  
15 naphthyl)ethyl group, a 9-anthrylmethyl group, a 2-(9-  
anthryl)ethyl group, a 2-fluorobenzyl group, a 3-  
fluorobenzyl group, a 4-fluorobenzyl group, a 2-  
chlorobenzyl group, a 3-chlorobenzyl group, a 4-  
chlorobenzyl group, a 2-bromobenzyl group, a 3-  
20 bromobenzyl group, and a 4-bromobenzyl group.

Examples of a substituted or unsubstituted  
alkenyl group include, but not limited to, a vinyl  
group, an allyl group (2-propenyl group), a 1-  
propenyl group, an iso-propenyl group, a 1-butenyl  
25 group, a 2-butenyl group, a 3-butenyl group, and a  
styryl group.

Examples of a substituted or unsubstituted

alkynyl group include, but not limited to, an acetylenyl group, a phenylacetylenyl group, and a 1-propynyl group.

Examples of a substituted or unsubstituted aryl group include, but not limited to, a phenyl group, a phenyl-d5 group, a 4-methylphenyl group, a 4-methoxyphenyl group, a 4-ethylphenyl group, a 4-fluorophenyl group, a 4-trifluorophenyl group, a 3,5-dimethylphenyl group, a 2,6-diethylphenyl group, a mesityl group, a 4-tert-butylphenyl group, a ditolylaminophenyl group, a biphenyl group, a terphenyl group, a 1-naphthyl group, a 2-naphthyl group, a 1-naphthyl-d7 group, a 2-naphthyl-d7 group, a 1-anthryl group, a 2-anthryl group, a 9-anthryl group, a 9-anthryl-d9 group, a 2-phenanthryl group, a 3-phenanthryl group, a 4-phenanthryl group, a 9-phenanthryl group, a 9-phenanthryl-d9 group, a 1-pyrenyl group, a 1-pyrenyl-d9 group, a 2-pyrenyl group, a 4-pyrenyl group, a tetracenyl group, a pentacenyl group, a fluorenyl group, a triphenylenyl group, and a perylenyl group.

Examples of a substituted or unsubstituted heterocyclic group include, but not limited to, a pyrrolyl group, a pyridyl group, a pyridyl-d5 group, a bipyridyl group, a methylpyridyl group, a terpyrrolyl group, a thienyl group, a thienyl-d4 group, a terthienyl group, a propylthienyl group, a

furyl group, a furyl-d4 group, an indolyl group, a  
1,10-phenanthroline group, a phenaziny group, a  
quinolyl group, a carbazolyl group, an oxazolyl group,  
an oxadiazolyl group, a thiazolyl group, and a  
5 thiadiazolyl group.

Examples of a substituted or unsubstituted  
alkylene group include, but not limited to, a  
methylene group, a methylene-d2 group, a  
difluoromethylene group, an ethylene group, an  
10 ethylene-d4 group, a perfluoroethylene group, a  
propylene group, an iso-propylene group, a butylene  
group, and a 2,2-dimethylpropylene group.

Examples of a substituted or unsubstituted  
aralkylene group include, but not limited to, a  
15 benzylene group, a 2-phenylethylene group, a 2-  
phenylisopropylene group, a 1-naphthylmethylene group,  
a 2-naphthylmethylene group, a 9-anthrylmethylene  
group, a 2-fluorobenzylene group, a 3-fluorobenzylene  
group, a 4-fluorobenzylene group, a 4-chlorobenzyl  
20 group, and a 4-bromobenzylene group.

Examples of a substituted or unsubstituted  
alkenyl group include, but not limited to, a vinylene  
group, an iso-propenylene group, a styrylene group,  
and a 1,2-diphenylvinylene group.

25 Examples of a substituted or unsubstituted  
alkynyl group include, but not limited to, an  
acetylenylene group and a phenyl acetylenylene group.

Examples of a substituted or unsubstituted arylene group include, but not limited to, a phenylene group, a biphenylene group, a tetrafluorophenylene group, a dimethylphenylene group, a naphthylene group, an anthrylene group, a phenanthrylene group, a pyrenylene group, a tetracenylenylene group, a pentacenylenylene group, and a perylenylene group.

Examples of a substituted or unsubstituted divalent heterocyclic group include, but not limited to, a furylene group, a pyrrolylene group, a pyridilene group, a terpyridilene group, a thienylene group, a terthienylene group, an oxazolylenylene group, a thiazolylenylene group, and a carbazolylenylene group.

In a substituted or unsubstituted amino ( $-NR'R''$ ) group, each of  $R'$  and  $R''$  is a hydrogen atom, a heavy hydrogen atom, the above substituted or unsubstituted alkyl group, aralkyl group, aryl group, or heterocyclic group, an alkylene group, alkenylene group, alkynylene group, aralkylene group, and amino group having a coupling group derived from a substituted or unsubstituted arylene group, or divalent heterocyclic group, a substituted silyl group, ether group, thioether group, and carbonyl group. Examples of the substituted or unsubstituted amino group include, but not limited to, an amino group, an N-methylamino group, an N-ethylamino group,

an N,N-dimethylamino group, an N,N-diethylamino group,  
an N-methyl-N-ethylamino group, an N-benzylamino  
group, an N-methyl-N-benzylamino group, an N,N-  
dibenzylamino group, an anilino group, an N,N-  
5 diphenylamino group, an N-phenyl-N-tolylamino group,  
an N,N-ditolylamino group, an N-methyl-N-phenylamino  
group, an N,N-dianisylamino group, an N-mesityl-N-  
phenylamino group, an N,N-dimesitylamino group, an N-  
phenyl-N-(4-tert-butylphenyl)amino group, and an N-  
10 phenyl-N-(4-trifluoromethylphenyl)amino group.

Examples of a substituted or unsubstituted  
alkoxy group include: an alkyloxy group and  
aralkyloxy group having the above substituted or  
unsubstituted alkyl group, or aralkyl group; and an  
15 aryloxy group having the above substituted or  
unsubstituted aryl group or heterocyclic group.  
Specific examples thereof include, but not limited to,  
a methoxy group, an ethoxy group, a propoxy group, a  
2-ethyl-octyloxy group, a phenoxy group, a 4-tert-  
20 butylphenoxy group, a benzyloxy group, and a  
thienyloxy group.

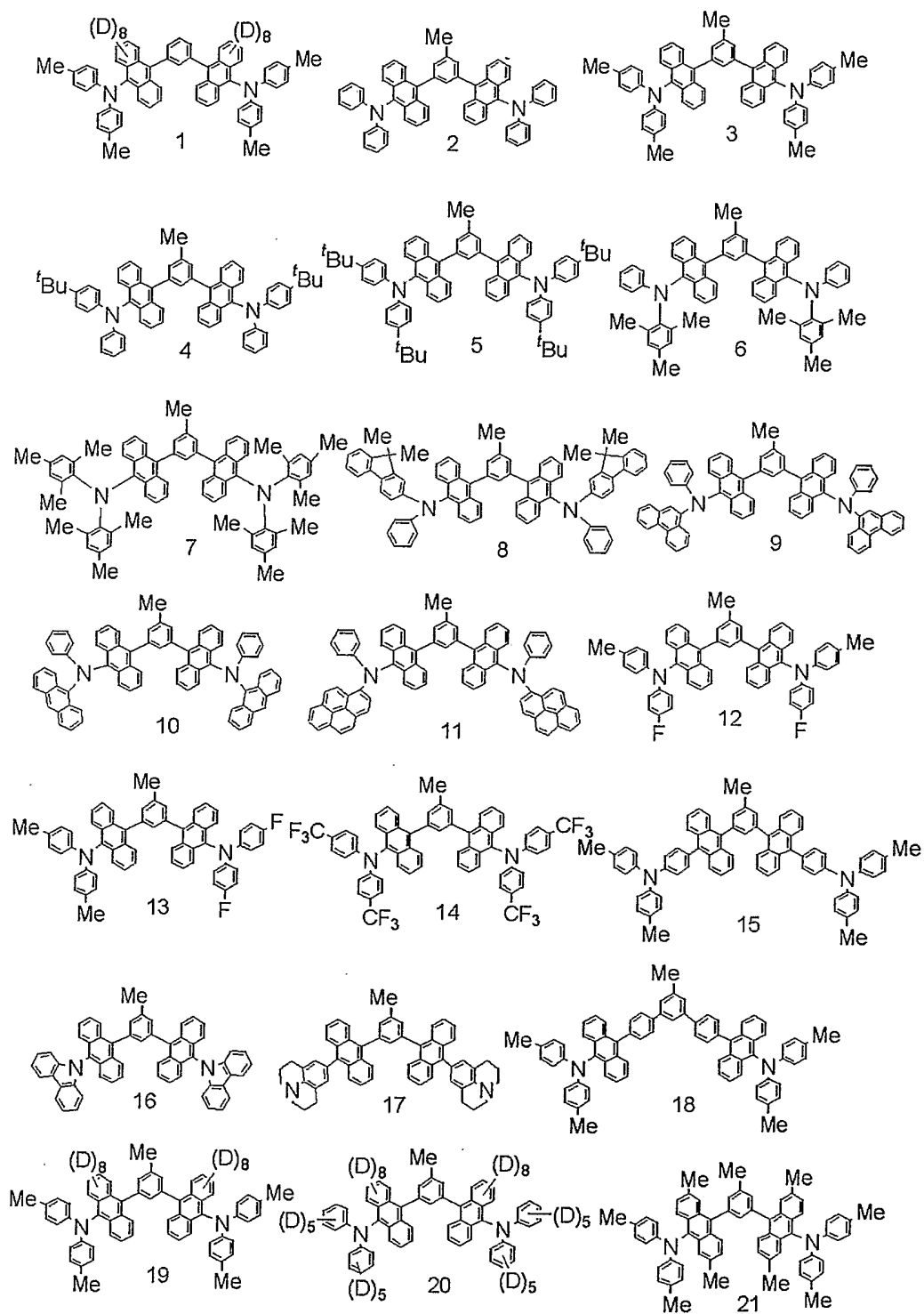
Examples of a substituted or unsubstituted  
sulfide group include: an alkylsulfide group or  
aralkylsulfide group having the above substituted or  
unsubstituted alkyl group, or aralkyl group; and an  
25 arylsulfide group having the above substituted or  
unsubstituted aryl group or heterocyclic group.

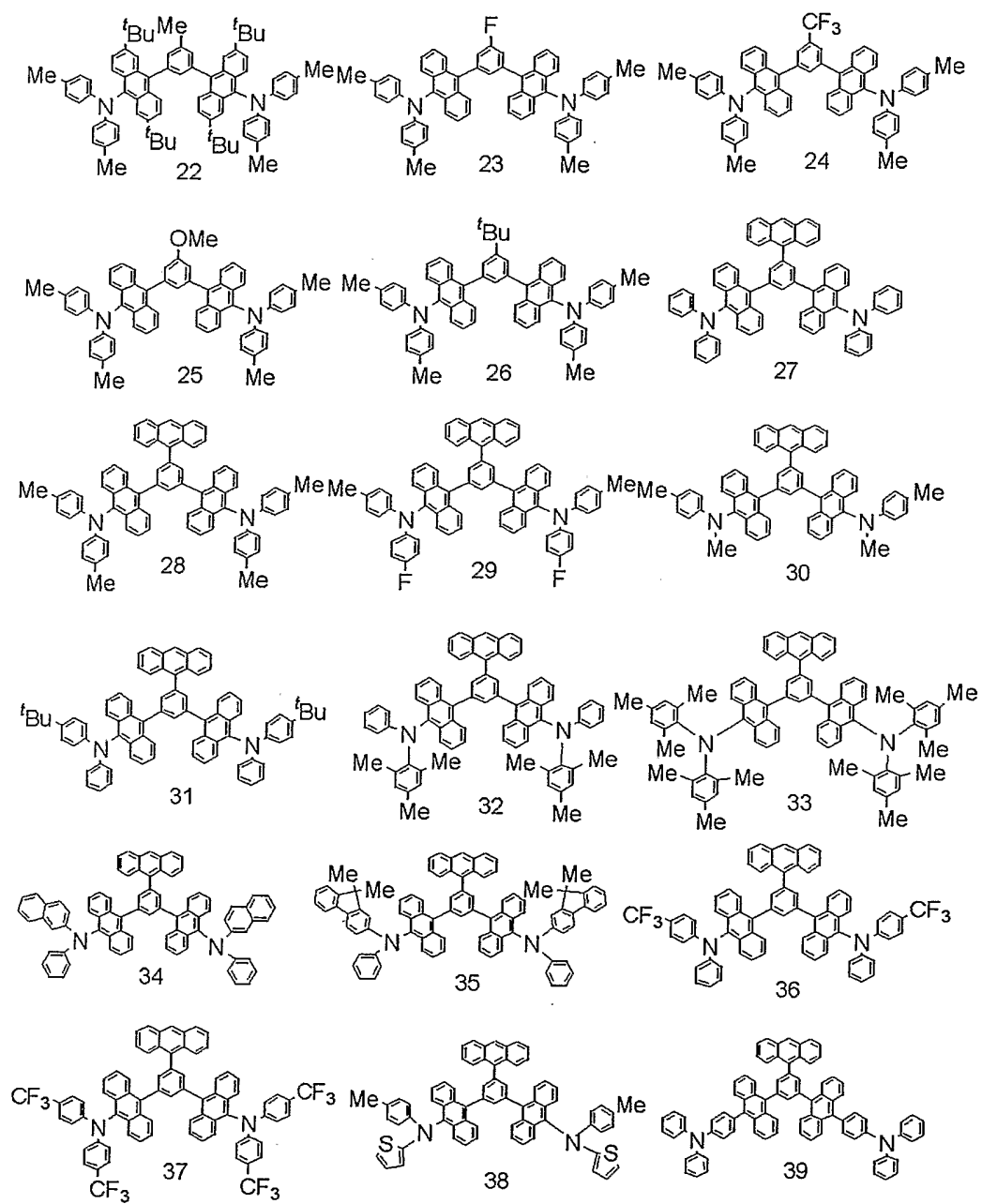
Specific examples thereof include, but not limited to, a methylsulfide group, an ethylsulfide group, a phenylsulfide group, and a 4-methylphenylsulfide group.

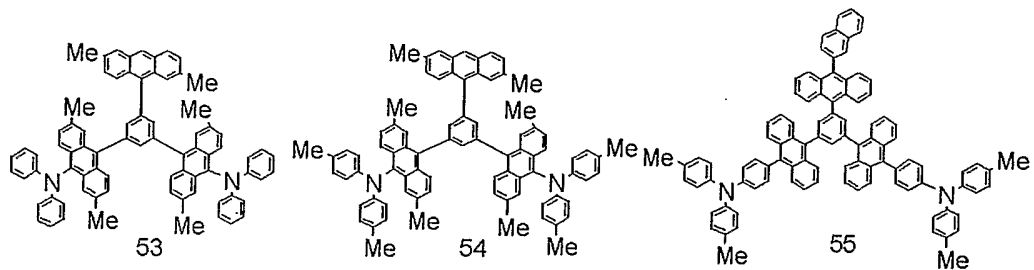
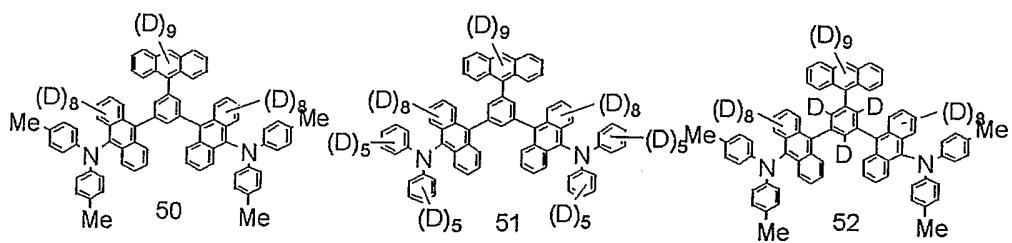
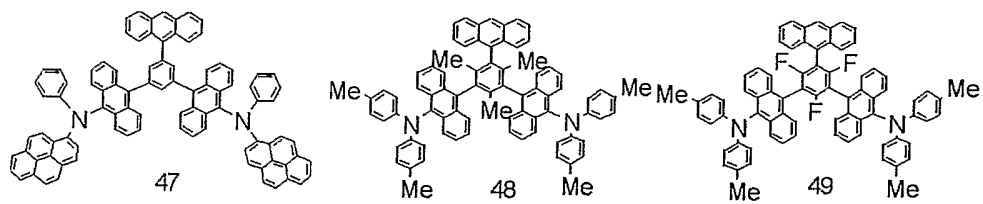
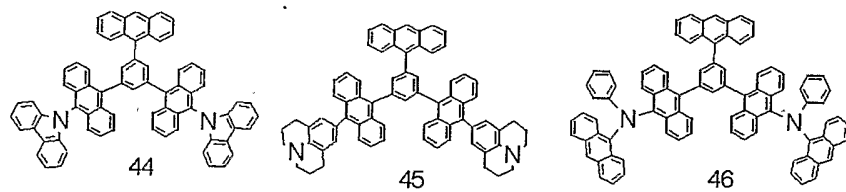
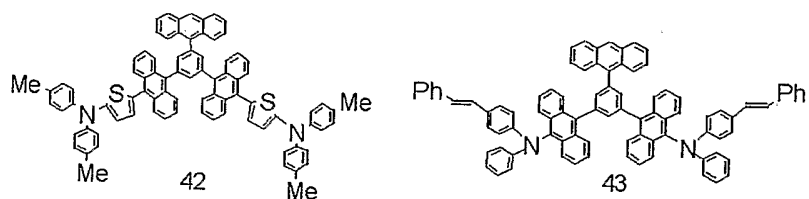
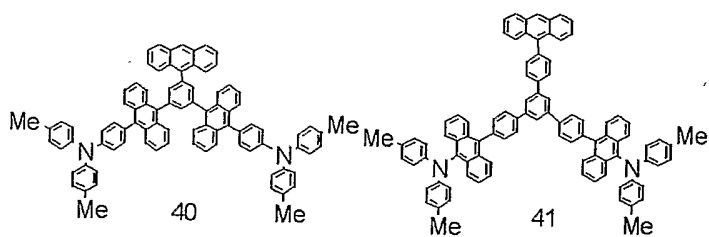
5           Examples of substituents which the above substituents and coupling groups may additionally have include, but not limited to: a heavy hydrogen atom; alkyl groups such as a methyl group, an ethyl group, an n-propyl group, an n-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an  
10           n-octyl group, an n-decyl group, an iso-propyl group, an iso-butyl group, a sec-butyl group, a tert-butyl group, an iso-pentyl group, a neopentyl group, a tert-octyl group, a benzyl group, and a 2-phenylethyl group; alkoxy groups such as an aralkyl group, a  
15           methoxy group, an ethoxy group, a propoxy group, a 2-ethyl-octyloxy group, a phenoxy group, a 4-tert-butylphenoxy group, and a benzyloxy group; aryl groups such as a phenyl group, a 4-methylphenyl group, a 4-ethylphenyl group, a 3-chlorophenyl group, a 3,5-dimethylphenyl group, a triphenylamino group, a  
20           biphenyl group, a terphenyl group, a naphthyl group, an anthryl group, a phenanthryl group, and a pyrenyl group; heterocyclic groups such as a pyridyl group, a  
25           bipyridyl group, a methylpyridyl group, a thienyl group, a terthienyl group, a propylthienyl group, a furyl group, a quinolyl group, a carbazolyl group,

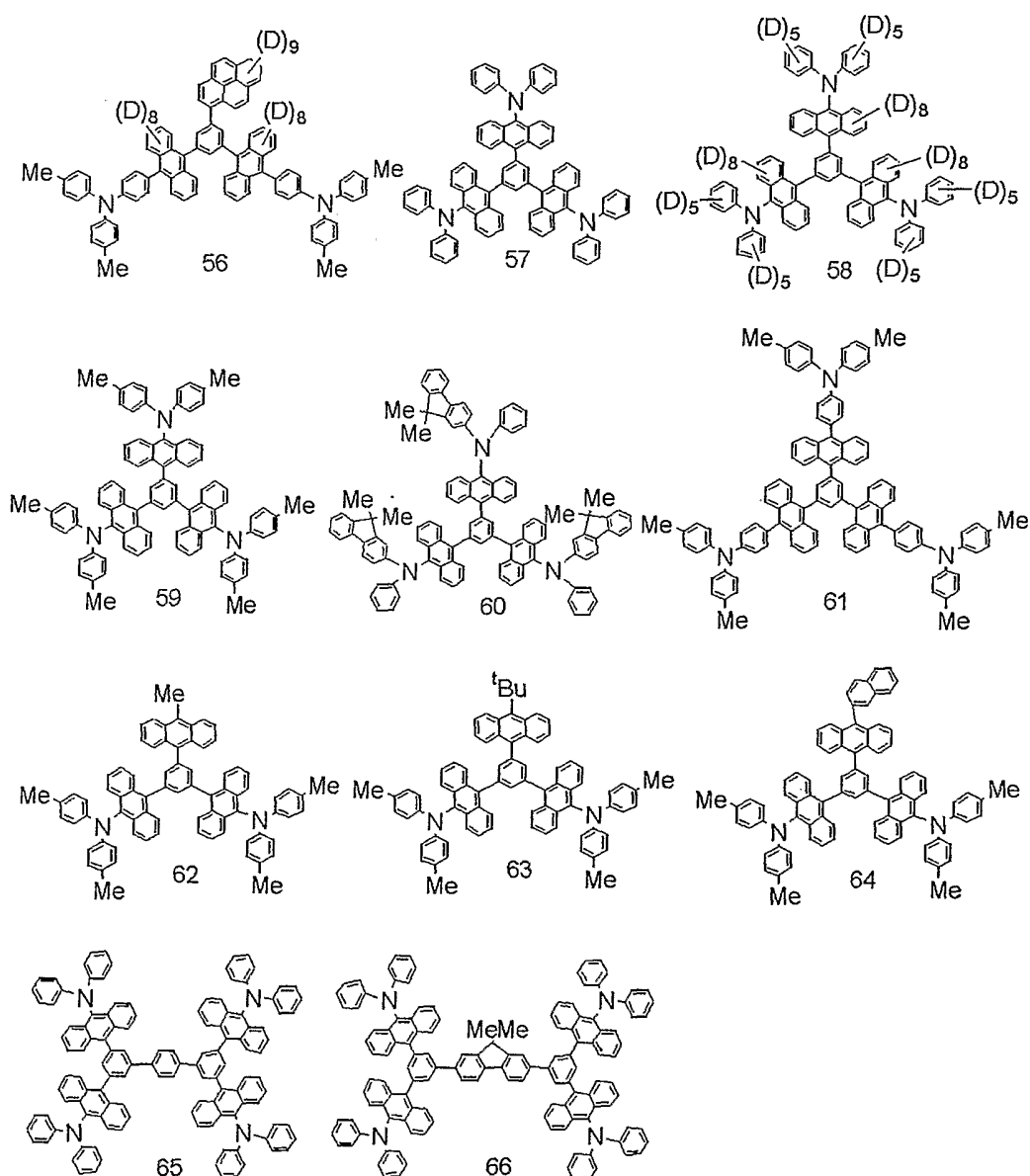
and an N-ethylcarbazolyl group; halogen groups; a hydroxyl group; a cyano group; and a nitro group.

Next, typical compounds represented by the general formulae (1) and (2) will be given. However,  
5 the present invention is not limited to those compounds.









Next, the organic electroluminescence device of the present invention will be described in detail.

5

The organic electroluminescence device of the present invention includes a pair of electrodes consisting of an anode and a cathode and one or more organic-compound-containing layers. At least one of

the organic-compound-containing layers contains at least one kind of the compounds represented by the general formula (1) or the general formula (1) in which  $X_1$  is a compound represented by the general  
5 formula (2) or (3).

Figs. 1 to 5 show preferable embodiments of the organic electroluminescence device of the present invention. In each figure, reference numeral 1 denotes a substrate; 2, an anode; 3, a light-emitting  
10 layer; 4, a cathode; 5, a hole-transporting layer; 6, an electron-transporting layer; 7, a hole-injection layer; and 8, a hole/exciton-blocking layer.

Fig. 1 is a cross sectional diagram that illustrates an organic electroluminescence device  
15 according to an embodiment of the present invention. As shown in Fig. 1, the device is constructed by mounting the anode 2, the light-emitting layer 3, and the cathode 4 on the substrate 1 in that order. The electroluminescence device used herein is useful in  
20 the case where the device has a hole-transporting ability, an electron-transporting ability, and a light-emitting ability by itself or where compounds having the respective properties are used in combination.

25 Fig. 2 is a cross sectional diagram that illustrates an organic electroluminescence device according to another embodiment of the present

invention. As shown in Fig. 2, the device is constructed by mounting the anode 2, the hole-transporting layer 5, the electron-transporting layer 6, and the cathode 4 on the substrate 1 in that order.

5 In this case, a light-emitting material is useful when it is used in combination with merely a non-illuminant hole-transporting or electron-transporting material using materials having hole-transporting ability or electron-transporting ability or both of  
10 them in the respective layers. In this case, furthermore, the light-emitting layer 3 is constructed of the hole-transporting layer 5 or the electron-transporting layer 6.

Fig. 3 is a cross sectional diagram that  
15 illustrates an organic electroluminescence device according to another embodiment of the present invention. As shown in Fig. 3, the device is constructed by mounting the anode 2, the hole-transporting layer 5, the light-emitting layer 3, the  
20 electron-transporting layer 6, and the cathode 4 on the substrate 1 in that order. In this case, the carrier-transporting function and the light-emitting function are separated from each other. The device is used in combination with compounds having hole-  
25 transporting ability, electron-transporting ability, and light-emitting ability as appropriate, allowing a substantial increase in flexibility for material

choice. Simultaneously, various kinds of compounds having different emission wavelengths can be used, allowing an increase in variety of luminescence hue. Furthermore, an increase in luminous efficiency may  
5 be ensured by effectively closing each carrier or exciton in the middle light-emitting layer 3.

Fig. 4 is a cross sectional diagram that illustrates an organic electroluminescence device according to another embodiment of the present  
10 invention. In Fig. 4, comparing with the device shown in Fig. 3, the device is constructed such that the hole-injection layer 7 is inserted in the layer structure on the anode 2 side (i.e., between the hole-transporting layer 5 and the anode 2). Therefore  
15 it is effective in improving the close contact between the anode 2 and the hole-transporting layer 5 or improving the hole-injecting ability, so that such a configuration of the device will be advantageous in lowering the voltage of the device.

20 Fig. 5 is a cross sectional diagram that illustrates an organic electroluminescence device according to another embodiment of the present invention. In Fig. 5, comparing with the device shown in Fig. 3, a layer for blocking the travel of a hole  
25 or exciton to the cathode 4 (the hole/exciton-blocking layer 8) is inserted between the light-emitting layer 3 and the electron-transporting layer

6. Using a compound having an extremely high ionization potential as the hole/exciton-blocking layer 8 allows the configuration of the device to be effective in improving luminous efficiency.

5           However, all of the devices shown in Figs. 1 to 5 are substantially fundamental device structures, so that the configuration of the organic electroluminescence device using the compound of the present invention is not limited to these examples.  
10   For instance, various kinds of layer structures may be configured, such as the formation of an insulating layer on the boundary surface between an electrode and an organic layer, the formation of an adhesive or interference layer, or the formation of a hole-  
15   transporting layer composed of two layers with different ionization potentials.

          The compound used in the present invention, which is represented by the general formula (1) or by the general formula (1) in which  $X_1$  is represented by  
20   the general formula (2) or (3), can be used in each of the configurations of Figs. 1 to 5.

          In particular, an organic layer using the compound of the present invention is useful as a light-emitting layer, an electron-transporting layer,  
25   or a hole-transporting layer. In addition, a layer formed by a vacuum evaporation method, a solution coating method, or the like is hardly crystallized,

so that the layer will be excellent in stability over time.

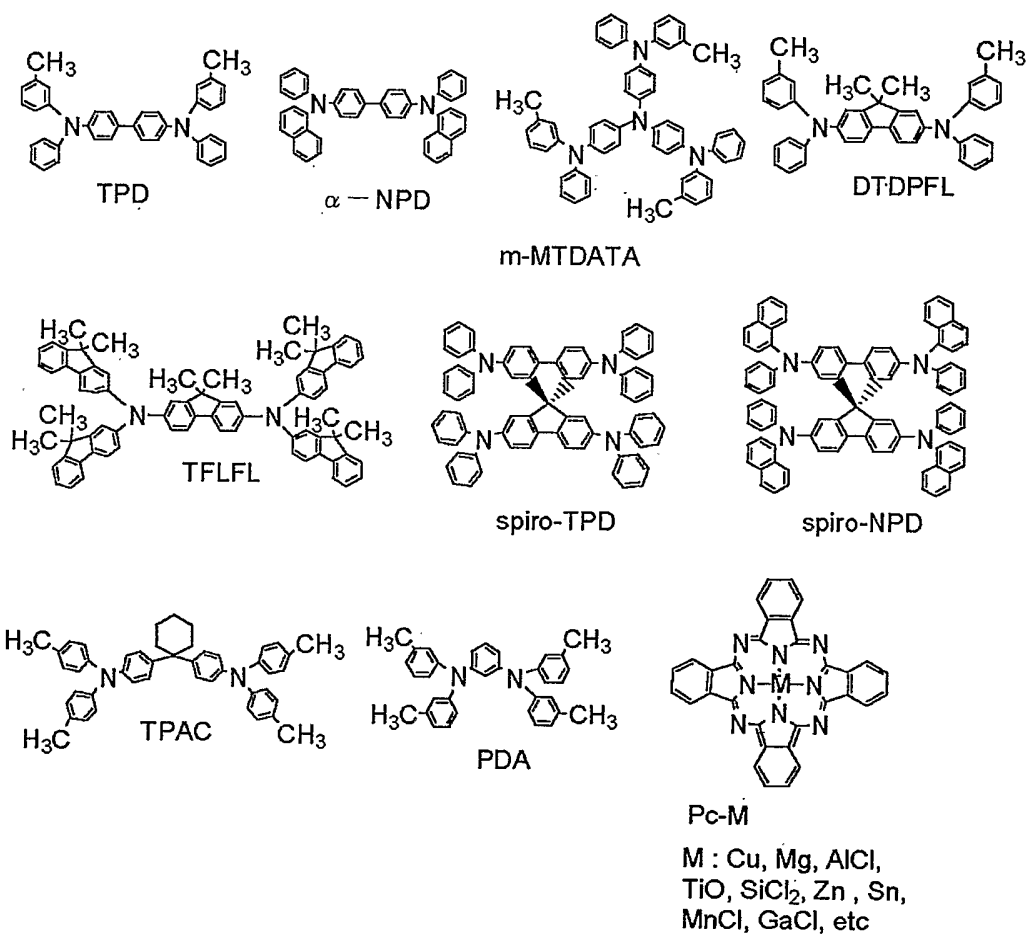
In the present invention, the compound represented by the general formula (1) or by the  
5 general formula (1) in which  $X_1$  is represented by the general formula (2) or (3) is particularly used as a component of the light-emitting layer and may be used in combination with a conventionally known low molecular or polymer hole-transporting compound,  
10 light-emitting compound, electron-transporting compound, or the like as required.

Those compounds will be exemplified below.

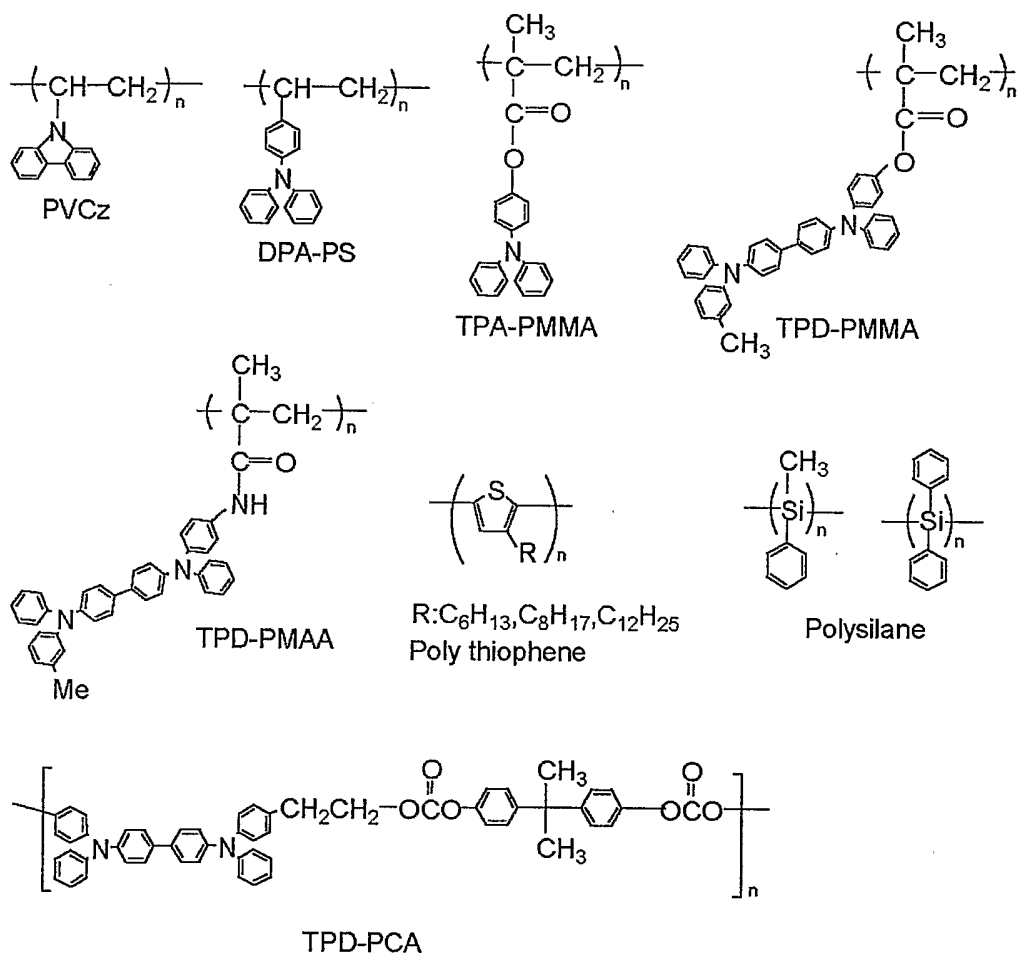
A preferable hole-injection transporting material has excellent mobility to make the injection  
15 of a hole from an anode easy and to transport the injected hole to a light-emitting layer. Low molecular and high molecular hole-injection transporting materials include a triarylamine derivative, a phenylene diamine derivative, a  
20 triazole derivative, an oxadiazole derivative, an imidazole derivative, a pyrazoline derivative, a pyrazolone derivative, an oxazole derivative, a fluorenone derivative, a hydrazone derivative, a stilbene derivative, a phthalocyanine derivative, a  
25 porphyrin derivative, and poly (vinylcarbazole), poly (silylene), poly (thiophene), and other conductive polymers. However, the material is not limited to

those compounds. Hereinafter, some of the specific examples of the material will be described.

Low molecular hole-injection  
transporting material



High molecular hole-injection  
transporting material



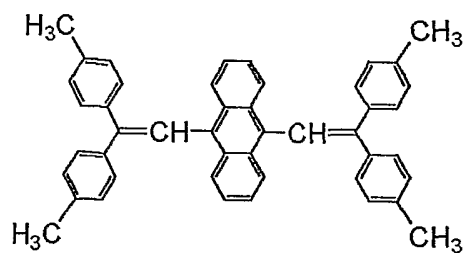
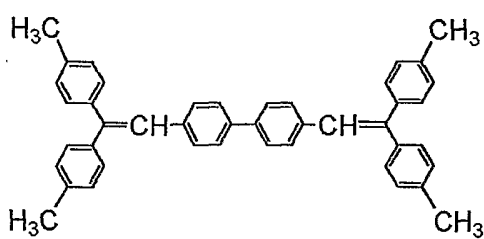
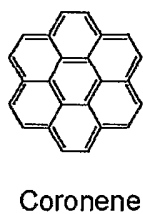
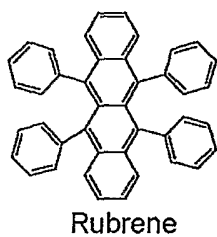
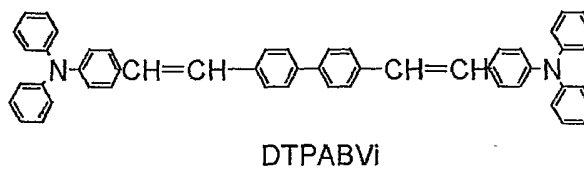
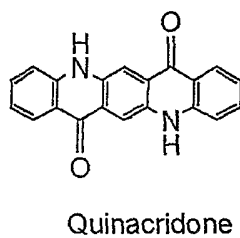
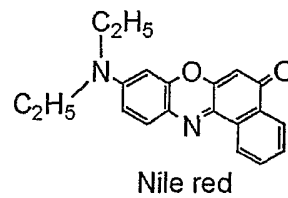
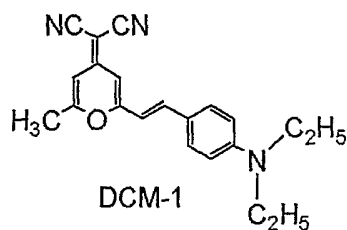
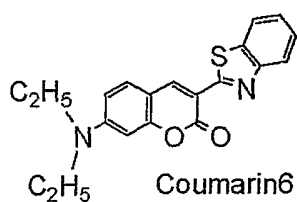
5                   Examples of available materials which are mainly  
involved in a light-emitting function except the  
anthryl derivative substitution compound represented  
by the general formulae (1) and (2) include, but not  
limited to: polycyclic condensed aromatic compounds  
10 (including naphthalene derivatives, phenanthrene  
derivatives, fluorene derivatives, pyrene derivatives,  
tetracene derivatives, coronene derivatives, chrysene

derivatives, perylene derivatives, 9,10-  
diphenylanthracene derivatives, and rubrene);  
quinacridone derivatives; acridone derivatives;  
coumarin derivatives; pyran derivatives; Nile red;  
5 pyrazine derivatives; benzoimidazole derivatives;  
benzothiazole derivatives; benzoxazole derivatives;  
stilbene derivatives; organometallic complexes  
(including organic aluminum complexes such as tris(8-  
quinolinolato)aluminum and organic beryllium  
10 complexes); and high-molecular derivatives such as  
poly(phenylene vinylene) derivatives, poly(fluorene)  
derivatives, poly(phenylene) derivatives,  
poly(thienylene vinylene) derivatives, and  
poly(acetylene) derivatives. Part of the specific  
15 examples will be shown below.

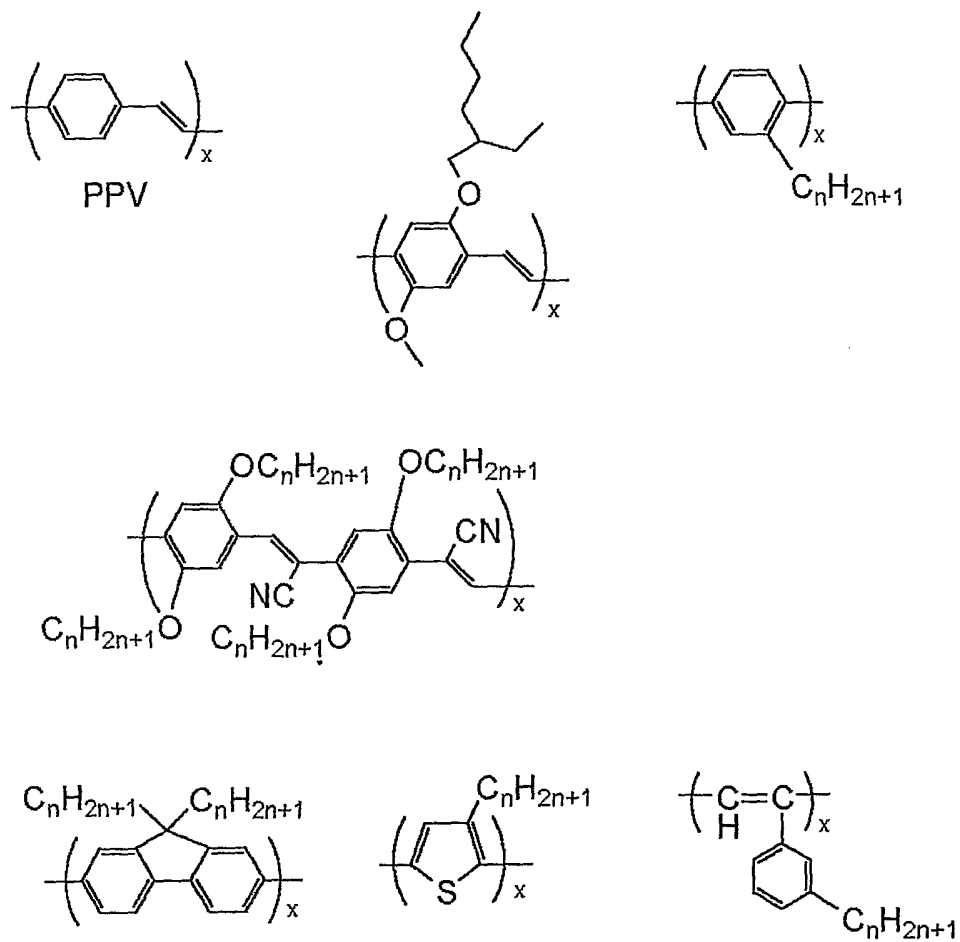
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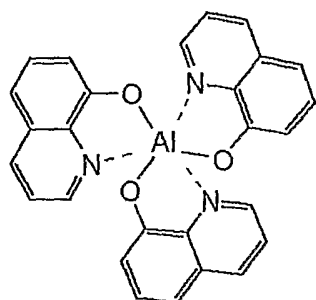
## Low molecular light-emitting material



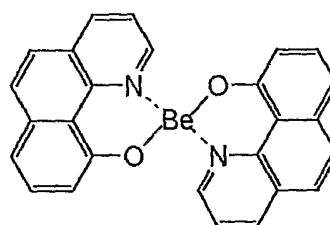
High molecular light-emitting material



## Metal complex light-emitting material

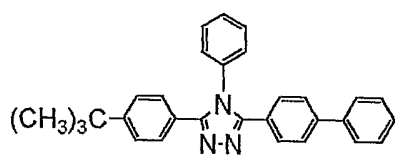
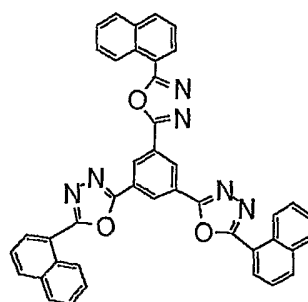
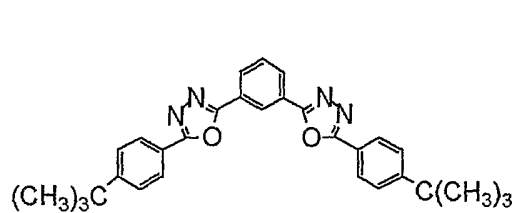


Alq

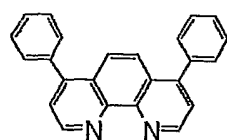
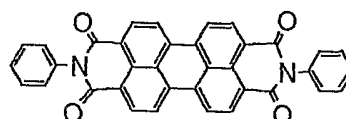
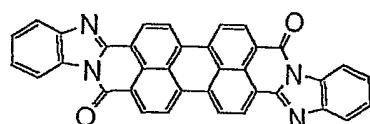
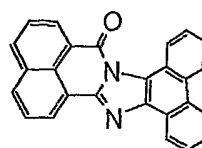


BeBq

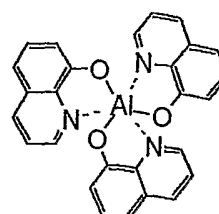
The electron-injection transporting material may  
5 be optionally chosen from materials that simplify the  
injection of an electron from a cathode, and that  
have a function of transporting the injected electron  
into the light-emitting layer. The material is chosen  
by considering the balance with the mobility of the  
10 carrier of the hole-transporting material. Examples  
of the electron-injection transporting material  
include, but not limited to, oxadiazole derivatives,  
oxazole derivatives, thiazole derivatives,  
thiadiazole derivatives, pyrazine derivatives,  
15 triazole derivatives, triazine derivatives, perylene  
derivatives, quinoline derivatives, quinoxaline  
derivatives, fluorenone derivatives, anthrone  
derivatives, phenanthroline derivatives, and  
organometallic complexes. Part of the specific  
20 examples will be shown below.



TAZ



Bphen



Alq

In the organic electroluminescence devices according to the present invention, each of layers containing anthryl derivative group substitution compounds represented by the general formulae (1) and (2) and layers containing other organic compounds is prepared as a thin film generally by a vacuum evaporation method, an ionization deposition method, sputtering, plasma, or a conventional coating method

(e.g., a spin coating, dipping, casting, LB, or inkjet method) in which the compound is dissolved in an appropriate solvent. In the case of forming a film with the coating method, in particular, a film may be  
5 formed using the compound in combination with an appropriate binder resin.

The above binder resins may be chosen from a wide variety of binder resins. Examples of the binder resin include, but not limited to, polyvinyl  
10 carbazole resins, polycarbonate resins, polyester resins, polyallylate resins, polystyrene resins, ABS resins, polybutadine resins, polyurethane resins, acrylic resins, methacrylic resins, butyral resins, polyvinyl acetal resins, polyamide resins, polyimide  
15 resins, polyethylene resins, polyethersulfone resins, diallyl phthalate resins, phenol resins, epoxy resins, silicone resins, polysulfone resins, and urea resins. Each of those may also be used singly. Alternatively, two or more of them may be mixed as copolymers.  
20 Further, additives such as known plasticizers, antioxidants, and ultraviolet absorbers may be used in combination if required.

A desirable anode material has as large a work function as possible and examples of such a material  
25 include: metal elements such as gold, platinum, silver, copper, nickel, palladium, cobalt, selenium, vanadium, and tungsten, and alloys thereof; and metal

oxides such as tin oxide, zinc oxide, indium oxide, indium tin oxide (ITO) and indium zinc oxide. Further, conductive polymers such as polyaniline, polypyrrole, polythiophene, and polyphenylene sulfide may also be  
5 used. Each of those electrode substances may be used singly. Alternatively, two or more of the substances may also be used in combination. Further, the anode may adopt any one of a single layer construction and a multilayer construction.

10 On the other hand, a desirable cathode material has as small a work function as possible and examples of such a material include: metal elements such as lithium, sodium, potassium, calcium, magnesium, aluminum, indium, ruthenium, titanium, manganese,  
15 yttrium, silver, lead, tin, and chromium; and multiple alloys such as lithium-indium, sodium-potassium, magnesium-silver, aluminum-lithium, aluminum-magnesium, and magnesium-indium. Metal oxides such as indium tin oxide (ITO) may also be  
20 used. Each of those electrode substances may be used singly. Alternatively, two or more of the substances may also be used in combination. Further, the cathode may adopt any one of a single layer construction and a multilayer construction.

25 In addition, at least one of the anode and cathode is desirably transparent or translucent.

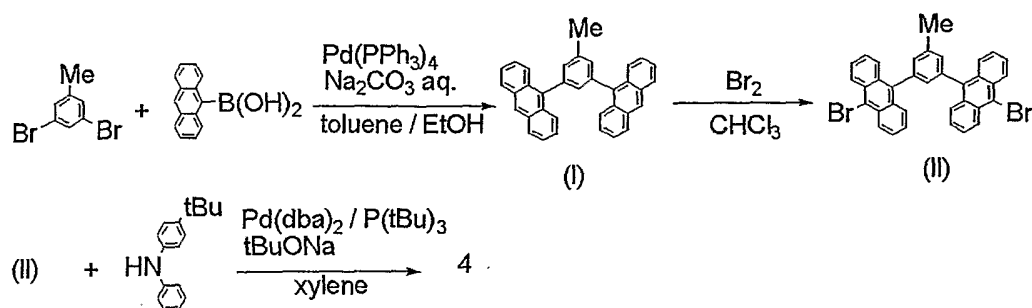
Substrates which may be used in the present

invention include: opaque substrates such as metallic substrates and ceramics substrates; and transparent substrates such as glass, quartz, and plastic sheet substrates, but are not particularly limited to these materials. In addition, the substrate may have a color filter film, a fluorescent color converting film, a dielectric reflection film, or the like to control colored light.

Furthermore, a protective layer or a sealing layer may be formed on the prepared device to prevent the device from contacting with oxygen, moisture, or the like. The protective layer may be a diamond thin film, a film made of an inorganic material such as metal oxide or metal nitride, or a polymer film made of a fluorine resin, polyparaxylene, polyethylene, silicone resin, polystyrene resin, or the like, or may be a photo-curing resin, or the like. Furthermore, the device itself may be covered with glass, an airtight film, metal, or the like and packaged with an appropriate sealing resin.

Hereinafter, the present invention will be described more specifically with reference to examples thereof, but the invention is not limited to each of these examples.

(Example 1) (Method of producing Exemplified Compound No. 4)



## (Synthesis of Intermediate (II))

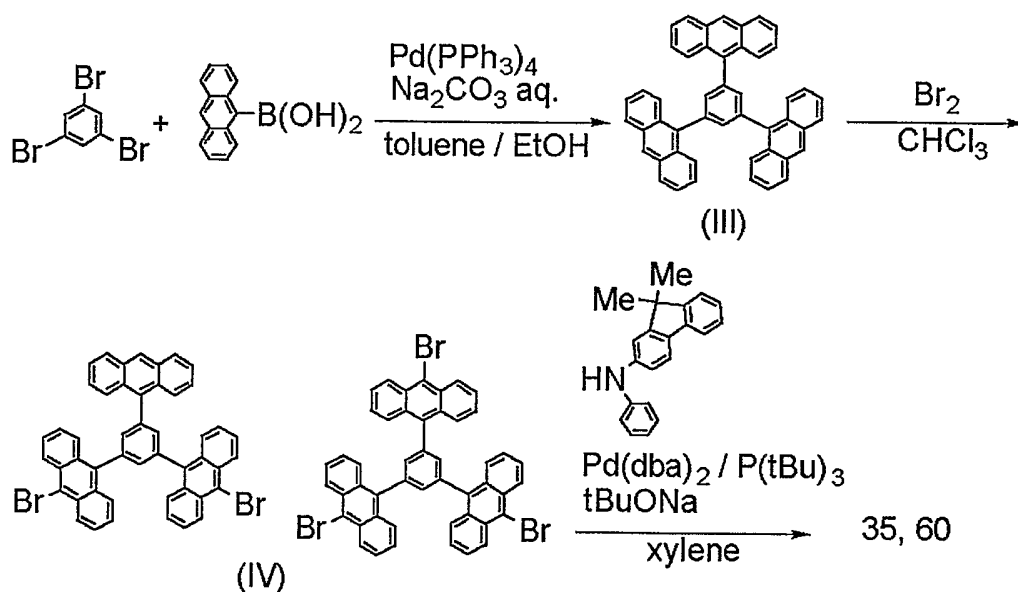
In a stream of nitrogen, 20.5 g (82 mmol) of  
 5 3,5-dibromotoluene and 73.1 g (0.328 mol) of  
 anthracene-9-boronic acid were dissolved in a  
 deaerated mixture solvent of 1 l of toluene and 500  
 ml of ethanol, and the whole was stirred. Then, a  
 sodium carbonate aqueous solution prepared by  
 10 dissolving 58 g of anhydrous sodium carbonate in 500  
 ml of water was added dropwise into the mixture. In a  
 stream of nitrogen, the mixture was stirred for 1  
 hour in an oil bath heated to 80°C, and then 9.47 g  
 (8.2 mmol) of tetrakis(triphenylphosphine)palladium  
 15 was added to the mixture. The resultant mixture was  
 heated and stirred for about 4 hours in an oil bath  
 heated to 80°C. The temperature of the reaction  
 solution was returned to room temperature, and then  
 cooled to 5°C. After that, the precipitated crystal  
 20 was filtered. The crystal was dissolved in a mixture  
 solvent of toluene and hexane under heating, and  
 purified by silica gel column chromatography  
 (toluene : hexane = 1 : 3), resulting in 22 g of

Intermediate (I).

A solution containing 15 g (33.7 mmol) of Intermediate (I) in 300 ml of chloroform was cooled to 5°C. Then, 11.8 g (74.1 mmol) of bromine dissolved in 70 ml of chloroform was gradually added dropwise into the solution. After the dropwise addition, the mixture solution was stirred for 2 hours at room temperature and then 300 ml of methanol was added to the solution, followed by stirring the mixture for 2 hours at 5°C. A precipitate was filtered, and then dispersed and washed with acetone. Subsequently, the solution was re-cooled to 5°C and a precipitate was filtered, resulting in 19.3 g of Intermediate (II). (Synthesis of Exemplified Compound No. 4)

Under a nitrogen atmosphere, 458 mg (0.797 mmol) of bis(benzylidene acetone)palladium and 0.97 g (4.78 mmol) of tri-tert-butylphosphine were dissolved in 200 ml of xylene, and the whole was stirred for 1 hour at room temperature. After 100 ml of xylene had been further added to the solution, 3 g (4.98 mmol) of Intermediate (II) was added to the mixture in a stream of nitrogen, and the whole was stirred for 5 minutes in an oil bath heated to 50°C. 2.24 g (9.96 mmol) of N-(4-t-butylphenyl)-N-phenylamine was dissolved in 50 ml of xylene, and the resultant solution was added dropwise into the mixture. Subsequently, 1.43 g (14.9 mmol) of sodium tert-

butoxide was added to the mixture. The mixture was  
 heated and stirred for about 5 hours in an oil bath  
 heated to 130°C. After the temperature of the  
 reaction solution had been returned to room  
 5 temperature, 100 ml of water was added to the  
 reaction solution, and a water layer was separated  
 from an organic layer. Furthermore, the water layer  
 was extracted with toluene and ethyl acetate, and  
 dried along with the organic layer by using sodium  
 10 sulfate. The solvent was distilled off and the  
 residue was purified by silica gel column  
 chromatography (toluene : hexane = 1 : 3), resulting  
 in 2.9 g of Exemplified Compound No. 5.  
 (Example 2) (Method of producing Exemplified  
 15 Compounds Nos. 35 and 60)



(Synthesis of Intermediate (IV))

In a stream of nitrogen, 25.8 g (82 mmol) of tribromobenzene and 109.5 g (0.491 mol) of anthracene-9-boronic acid were dissolved in a deaerated mixture solvent of 1 l of toluene and 500 ml of ethanol and then the whole was stirred. A sodium carbonate aqueous solution prepared by dissolving 86.8 g of anhydrous sodium carbonate in 800 ml of water was added dropwise into the solution. In a stream of nitrogen, the resulting mixture was stirred for 1 hour in an oil bath heated to 80°C, followed by the addition of 14.2 g (12.3 mmol) of tetrakis(triphenylphosphine)palladium. Then, the mixture was heated and stirred for about 4 hours in an oil bath heated to 80°C. The temperature of the reaction solution was returned to room temperature and further cooled to 5°C, followed by filtering the precipitated crystal out. The crystal was dissolved in a mixture solvent of chlorobenzene and heptane under heating and then purified by silica gel column chromatography (chlorobenzene : heptane = 1 : 3), resulting in 25 g of Intermediate (III).

A solution containing 16.7 g (27.6 mmol) of Intermediate (III) in 300 ml of chloroform was cooled to 5°C and 9.69 g (60.6 mmol) of bromine dissolved in 70 ml of chloroform was gradually added dropwise into the solution. After the dropwise addition, the solution was stirred for 2 hours at room temperature.

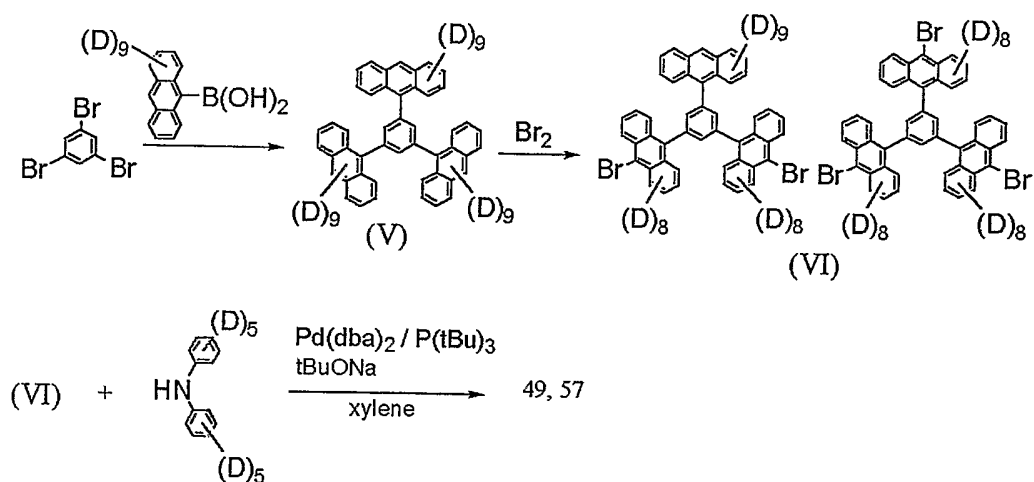
Subsequently, 300 ml of methanol was added to the solution, and the whole was stirred for 2 hours at 5°C. A precipitate was filtered, dispersed and washed with acetone, the solution was re-cooled to 5°C, and a precipitate was filtered, resulting in 21 g of Intermediate (V) as a mixture of monobromo, dibromo, and tribromo products (HPLC analysis, UV : area ratio, monobromo product : dibromo product : tribromo product = 1 : 2.3 : 3.3).

10 (Synthesis of Exemplified Compounds Nos. 35 and 60)

Under a nitrogen atmosphere, 361 mg (0.627 mmol) of bis(benzylidene acetone)palladium and 0.76 g (3.76 mmol) of tri-tert-butylphosphine were dissolved in 230 ml of xylene, and the whole was stirred for 1 hour at room temperature. After 100 ml of xylene had been further added to the solution, 3 g (3.92 mmol, in terms of dibromo product) of Intermediate (IV) was added to the mixture in a stream of nitrogen, and the whole was stirred for 5 minutes in an oil bath heated to 50°C. 2.24 g (7.84 mmol) of N-(2-(9,9-dimethylfluorenyl))-N-phenylamine was dissolved in 50 ml of xylene, and the resultant solution was added dropwise into the mixture. Subsequently, 1.13 g (11.8 mmol) of sodium tert-butoxide was added to the mixture. The mixture was heated and stirred for about 5 hours in an oil bath heated to 130°C. After the temperature of the reaction solution had been

returned to room temperature, 100 ml of water was added to the reaction solution, and a water layer was separated from an organic layer. Furthermore, the water layer was extracted with toluene and ethyl acetate, and dried along with the organic layer by using sodium sulfate. The solvent was distilled off and the residue was purified by silica gel column chromatography (toluene : hexane = 1 : 3), resulting in 1.1 g of Exemplified Compound No. 35 and 2 g of Exemplified Compound No. 60.

(Example 3) (Method of producing Exemplified Compounds Nos. 51 and 58)



# 15 (Synthesis of Intermediate (VI))

Intermediate (VI) was prepared as a mixture of monobromo, dibromo, and tribromo products in the same manner as in the synthesis of Intermediate (IV) (HPLC analysis, UV : area ratio, monobromo product :

dibromo product : tribromo product = 1 : 2.5 : 3).

(Synthesis of Exemplified Compounds Nos. 51 and 58)

Under a nitrogen atmosphere, 180 mg (0.314 mmol) of bis(benzylidene acetone)palladium and 0.38 g (1.88 mmol) of tri-tert-butylphosphine were dissolved in 150 ml of xylene, and the whole was stirred for 1 hour at room temperature. After 100 ml of xylene had been further added to the solution, 1.55 g (1.96 mmol, in terms of dibromo product) of Intermediate (VI) was added to the mixture in a stream of nitrogen, and the whole was stirred for 5 minutes in an oil bath heated to 50°C. 0.70 g (3.92 mmol) of diphenylamine-d10 was dissolved in 50 ml of xylene, and the resultant solution was added dropwise into the mixture. Subsequently, 0.565 g (5.90 mmol) of sodium tert-butoxide was added to the mixture. The mixture was heated and stirred for about 5 hours in an oil bath heated to 130°C. After the temperature of the reaction solution had been returned to room temperature, 100 ml of water was added to the reaction solution, and a water layer was separated from an organic layer. Furthermore, the water layer was extracted with toluene and ethyl acetate, and dried along with the organic layer by using sodium sulfate. The solvent was distilled off and the residue was purified by silica gel column chromatography (toluene : hexane = 1 : 3), resulting

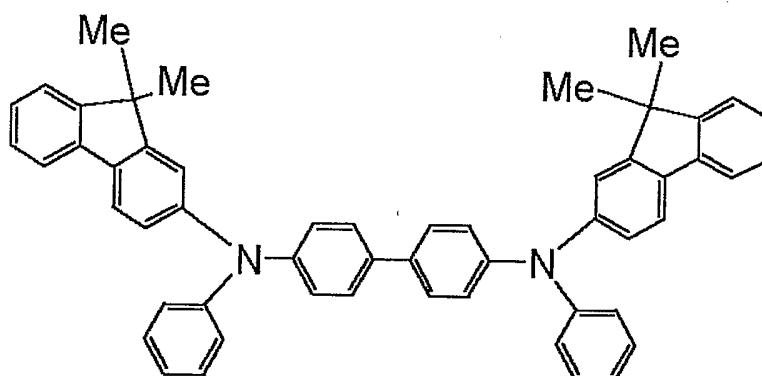
in 0.7 g of Exemplified Compound No. 51 and 0.75 g of Exemplified Compound No. 58.

(Example 4)

5 An organic electroluminescence device having the structure shown in Fig. 3 was prepared by the method described below.

On a glass substrate as a substrate 1, indium tin oxide (ITO) as an anode 2 was formed as a film with a film thickness of 120 nm by a sputtering  
10 method and then used as a transparent conductive supporting substrate. Subsequently, the substrate was subjected to ultrasonic cleaning in acetone and isopropyl alcohol (IPA) in order. Next, the substrate was boiled and washed with IPA, followed by drying.  
15 Furthermore, the substrate was subjected to UV/ozone cleaning and used as a transparent conductive supporting substrate.

Using a compound represented by the following structural formula as a hole-transporting material, a  
20 chloroform solution was prepared to concentration of 0.5 wt%.



This solution was dropped onto the above ITO electrode. Subsequently, the ITO electrode was subjected to spin coating with the solution at a revolving speed of 500 rpm for 10 seconds at first and then 1,000 rpm for 1 minute to form a thin film thereon. After that, the resulting thin film was placed in a vacuum oven at 80°C and dried for 10 minutes to completely remove the solvent in the film. Consequently, a hole-transporting layer 5 thus obtained was 50 nm in thickness. Next, for a light-emitting layer 3, Exemplified Compound No. 27 described above was deposited on the hole-transporting layer 5. The resulting light-emitting layer 3 was 20 nm in thickness. In this case, the degree of vacuum at the time of deposition was  $1.0 \times 10^{-4}$  Pa and the film formation was performed at a rate of 0.2 to 0.3 nm/second.

Furthermore, bathophenanthroline (BPhen) was formed as an electron-transporting layer 6 to a thickness of 40 nm by a vacuum evaporation method. In

this case, the degree of vacuum at the time of deposition was  $1.0 \times 10^{-4}$  Pa and the film formation was performed at a rate of 0.2 to 0.3 nm/second.

Subsequently, using an aluminum-lithium alloy  
5 (lithium concentration = 1 atom%) as a deposition material, a metal layer film of 10 nm in thickness was formed on the organic layer mentioned above by a vacuum evaporation method, and successively an aluminum film of 150 nm in thickness was formed  
10 thereon by a vacuum evaporation method. Consequently, an organic electroluminescence device in which the aluminum-lithium alloy film was provided as an electron-injection electrode (cathode 4) was prepared. In this case, the degree of vacuum at the time of  
15 deposition was  $1.0 \times 10^{-4}$  Pa and the film formation was performed at a rate of 1.0 to 1.2 nm/second.

The resulting organic electroluminescence device was covered with a protective glass and sealed with an acrylic resin binder in a dry air atmosphere to  
20 prevent the device from deteriorating with the adsorption of moisture thereon.

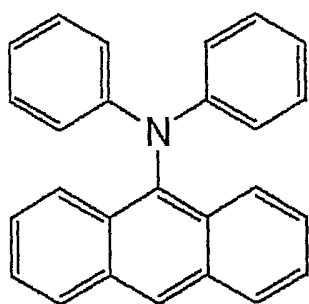
From the device thus obtained, the inventors observed the emission of green light with a light-emitting luminance of  $290 \text{ cd/m}^2$  and a luminous  
25 efficiency of 6 lm/W at an applied voltage of 3 V when the ITO electrode (anode 2) was provided as a positive electrode and the Al-Li electrode (cathode

4) was provided as a negative electrode.

Furthermore, when the current density was kept at 3.0 mA/cm<sup>2</sup> and the voltage was applied for 100 hours under a nitrogen atmosphere, the rate of luminescence degradation after 100 hours was small, changing from the initial luminance of 280 cd/m<sup>2</sup> to a luminance of 270 cd/m<sup>2</sup>.

(Comparative Example 1)

An organic electroluminescence device was prepared in the same manner as in Example 4, except that the following comparative compound was used instead of Exemplified Compound No. 27, followed by subjecting the device to the same evaluation. The inventors observed the emission of green light with a light-emitting luminance of 190 cd/m<sup>2</sup> and a luminous efficiency of 2 lm/W at an applied voltage of 3 V.



Furthermore, when the current density was kept at 3.0 mA/cm<sup>2</sup> and a voltage was applied for 100 hours under a nitrogen atmosphere, the rate of luminescence degradation after 100 hours was large, changing from the initial luminance of 180 cd/m<sup>2</sup> to a luminance of

80  $\text{cd/m}^2$ .

(Examples 5 to 7)

Organic electroluminescence devices were prepared in the same manner as in Example 4, except that the compounds listed in Table 1 were used instead of Exemplified Compound No. 27, followed by subjecting the devices to the same evaluation. The results are shown in Table 1.

Table 1

| Example | Exemplified Compound No. | Applied voltage (V) | Luminance ( $\text{cd/m}^2$ ) | Efficiency ( $\text{lm/W}$ ) |
|---------|--------------------------|---------------------|-------------------------------|------------------------------|
| 5       | 8                        | 3                   | 270                           | 6                            |
| 6       | 29                       | 3                   | 320                           | 7                            |
| 7       | 49                       | 3                   | 340                           | 8                            |

(Example 8)

An organic electroluminescence device having the structure shown in Fig. 3 was prepared in the same manner as in Example 4, except that 2,9-bis (2-(9,9-dimethylfluorenyl))phenanthroline was used for an electron-transporting layer 6 and Exemplified Compound No. 35 described above was deposited as a light-emitting layer 3.

From the device thus obtained, the inventors observed the emission of green light with a light-emitting luminance of  $340 \text{ cd/m}^2$  and a luminous

efficiency of 8 lm/W at an applied voltage of 3 V when the ITO electrode (anode 2) was provided as a positive electrode and the Al-Li electrode (cathode 4) was provided as a negative electrode.

5 (Example 9)

An organic electroluminescence device was prepared in the same manner as in Example 8, except that Exemplified Compound No. 6 described above was deposited as a light-emitting layer 3.

10 From the device thus obtained, the inventors observed the emission of blue light with a light-emitting luminance of 210 cd/m<sup>2</sup> and a luminous efficiency of 3 lm/W at an applied voltage of 3 V when the ITO electrode (anode 2) was provided as a positive electrode and the Al-Li electrode (cathode 4) was provided as a negative electrode.

15 (Example 10)

An organic electroluminescence device was prepared in the same manner as in Example 8, except that Exemplified Compound No. 11 described above was deposited as a light-emitting layer 3.

20 From the device thus obtained, the inventors observed the emission of orange light with a light-emitting luminance of 200 cd/m<sup>2</sup> and a luminous efficiency of 2 lm/W at an applied voltage of 3 V when the ITO electrode (anode 2) was provided as a positive electrode and the Al-Li electrode (cathode 25

4) was provided as a negative electrode.

(Examples 11 to 15)

Just as in the case of Examples 9 and 10,  
organic electroluminescence devices were prepared in  
the same manner as in Example 8, except that the  
compounds listed in Table 2 were used, followed by  
subjecting the devices to the same evaluation. The  
results are shown in Table 2.

Table 2

| Example | Exemplified<br>Compound<br>No. | Applied<br>voltage<br>(V) | Luminance<br>(cd/m <sup>2</sup> ) | Efficiency<br>(lm/W) |
|---------|--------------------------------|---------------------------|-----------------------------------|----------------------|
| 11      | 3                              | 3                         | 350                               | 8                    |
| 12      | 26                             | 3                         | 335                               | 8                    |
| 13      | 28                             | 3                         | 380                               | 10                   |
| 14      | 30                             | 3                         | 240                               | 4                    |
| 15      | 45                             | 3                         | 400                               | 11                   |

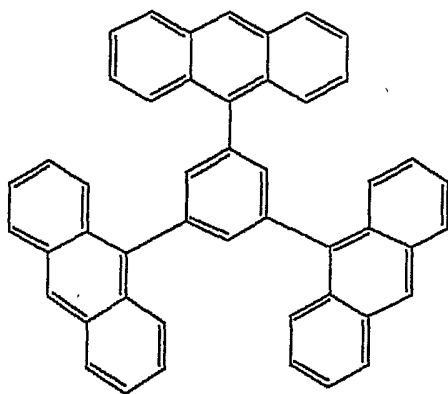
(Example 16)

A voltage was applied to the organic  
electroluminescence device prepared in Example 11 for  
100 hours while the current density was kept at 3.0  
mA/cm<sup>2</sup> under a nitrogen atmosphere. Consequently, the  
rate of luminance degradation after 100 hours was  
small, changing from the initial luminance of 345  
cd/m<sup>2</sup> to a luminance of 325 cd/m<sup>2</sup>.

(Example 17)

A voltage was applied to the organic electroluminescence device prepared in Example 12 for 100 hours while the current density was kept at 3.0 mA/cm<sup>2</sup> under a nitrogen atmosphere. Consequently, the rate of luminance degradation after 100 hours was small, changing from the initial luminance of 340 cd/m<sup>2</sup> to a luminance of 330 cd/m<sup>2</sup>.  
(Comparative Example 2)

An organic electroluminescence device was prepared in the same manner as in Example 8, except that the following unsubstituted comparative compound was used for a light-emitting layer 3.



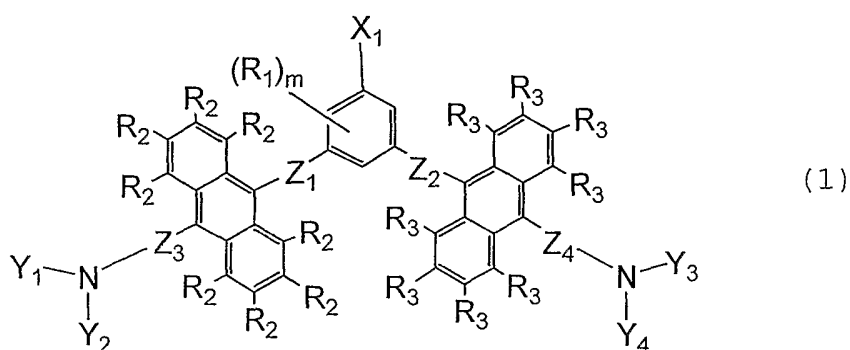
From the device thus obtained, the inventors observed the emission of light with a light-emitting luminance of 240 cd/m<sup>2</sup> and a luminous efficiency of 0.2 lm/W at an applied voltage of 6 V when the ITO electrode 2 was provided as a positive electrode and the Al-Li electrode 4 was provided as a negative electrode.

From the above description with the embodiments and examples of the present invention, the aminoanthryl derivative substitution compound of the present invention represented by the general formula (1) and by the general formula (1) in which  $X_1$  is represented by the general formula (2) or (3) was developed on the basis of the design index as described in the summary of the invention. Thus, the organic electroluminescence device using the materials of the invention allowed highly-efficient emission of light at a lower applied voltage. In addition, various luminescent colors can be easily obtained by converting the substituent from one to another, and excellent durability can be also attained.

## CLAIMS

1. An aminoanthryl derivative substitution compound represented by the following general formula (1):

5



(wherein,

each of  $Y_1$  to  $Y_4$  is one selected from the group consisting of a substituted or unsubstituted alkyl group, aralkyl group, aryl group, and heterocyclic group,  $Y_1$  to  $Y_4$  may be the same or different, and  $Y_1$  and  $Y_2$ , and  $Y_3$  and  $Y_4$  may bind to each other to form a ring;

each of  $Z_1$  and  $Z_2$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_1$  and  $Z_2$  may be the same or different;

each of  $Z_3$  and  $Z_4$  is one selected from the group

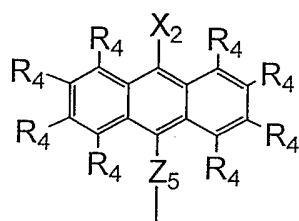
consisting of a direct bond, a substituted or unsubstituted arylene group and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_3$  and  $Z_4$  may be the same or different;

5            $X_1$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aralkyl group, alkenyl group, alkynyl group, alkoxy group, sulfide group, aryl group, and heterocyclic  
10 group, and  $X_1$  may be the same or different;

$R_1$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group and alkoxy group, and  $R_1$  may be the same or  
15 different;

          each of  $R_2$  and  $R_3$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino  
20 group, and  $R_2$  and  $R_3$  may be the same or different; and  
           $m$  is an integer of 0 to 3.).

2. The aminoanthryl derivative substitution compound according to claim 1, wherein  $X_1$  is represented by the following general formula (2):



(2)

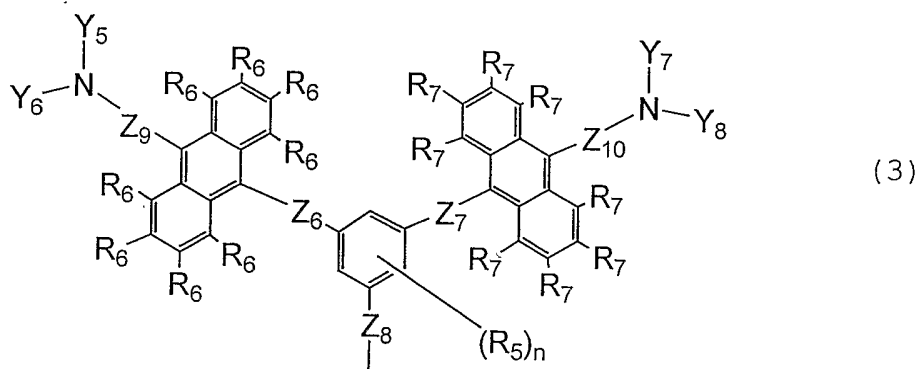
(wherein,

$Z_5$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_5$  may be the same or different;

$X_2$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group, aralkyl group, alkenyl group, alkynyl group, alkoxy group, sulfide group, amino group, aryl group, and heterocyclic group, and  $X_2$  may be the same or different; and

$R_4$  is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and  $R_4$  may be the same or different.).

3. The aminoanthryl derivative substitution compound according to claim 1, wherein  $X_1$  is represented by the following general formula (3):



(wherein,

each of  $Y_5$  to  $Y_8$  is one selected from the group consisting of a substituted or unsubstituted alkyl group, aralkyl group, aryl group, and heterocyclic group,  $Y_5$  to  $Y_8$  may be the same or different, and  $Y_5$  and  $Y_6$ , and  $Y_7$  and  $Y_8$  may bind to each other to form a ring;

each of  $Z_6$  to  $Z_8$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted alkylene group, alkenylene group, alkynylene group, aralkylene group, arylene group, and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_6$  to  $Z_8$  may be the same or different;

each of  $Z_9$  and  $Z_{10}$  is one selected from the group consisting of a direct bond, a substituted or unsubstituted arylene group and divalent heterocyclic group, and a divalent substituent having a coupling group, and  $Z_9$  and  $Z_{10}$  may be the same or different;

$R_5$  is one selected from the group consisting of

a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group and alkoxy group, and R<sub>5</sub> may be the same or different;

5           each of R<sub>6</sub> and R<sub>7</sub> is one selected from the group consisting of a hydrogen atom, a heavy hydrogen atom, a halogen atom, and a substituted or unsubstituted alkyl group, aryl group, alkoxy group, and amino group, and R<sub>6</sub> and R<sub>7</sub> may be the same or different; and  
10           n is an integer of 0 to 3.).

4. The aminoanthryl derivative substitution compound according to claim 1, wherein X<sub>1</sub> comprises an alkyl group.

5. The aminoanthryl derivative substitution  
15 compound according to claim 4, wherein each of Z<sub>1</sub> to Z<sub>4</sub> comprises a direct bond.

6. The aminoanthryl derivative substitution compound according to claim 1, wherein at least one of Y<sub>1</sub> to Y<sub>4</sub>, Z<sub>1</sub> to Z<sub>4</sub>, X<sub>1</sub>, and R<sub>1</sub> to R<sub>3</sub> comprises one  
20 of a group containing a heavy hydrogen atom and a heavy hydrogen atom.

7. The aminoanthryl derivative substitution compound according to claim 2, wherein at least one of Y<sub>1</sub> to Y<sub>4</sub>, Z<sub>1</sub> to Z<sub>5</sub>, X<sub>2</sub>, and R<sub>1</sub> to R<sub>4</sub> comprises one  
25 of a group containing a heavy hydrogen atom and a heavy hydrogen atom.

8. The aminoanthryl derivative substitution

compound according to claim 3, wherein at least one of Y<sub>1</sub> to Y<sub>8</sub>, Z<sub>1</sub> to Z<sub>4</sub>, Z<sub>6</sub> to Z<sub>10</sub>, R<sub>1</sub> to R<sub>3</sub>, and R<sub>5</sub> to R<sub>7</sub> comprises one of a group containing a heavy hydrogen atom and a heavy hydrogen atom.

5           9. The aminoanthryl derivative substitution compound according to claim 4, wherein at least one of Y<sub>1</sub> to Y<sub>4</sub>, Z<sub>1</sub> to Z<sub>4</sub>, X<sub>1</sub>, and R<sub>1</sub> to R<sub>3</sub> comprises one of a group containing a heavy hydrogen atom and a heavy hydrogen atom.

10           10. The aminoanthryl derivative substitution compound according to claim 5, wherein at least one of Y<sub>1</sub> to Y<sub>4</sub>, X<sub>1</sub>, and R<sub>1</sub> to R<sub>3</sub> comprises one of a group containing a heavy hydrogen atom and a heavy hydrogen atom.

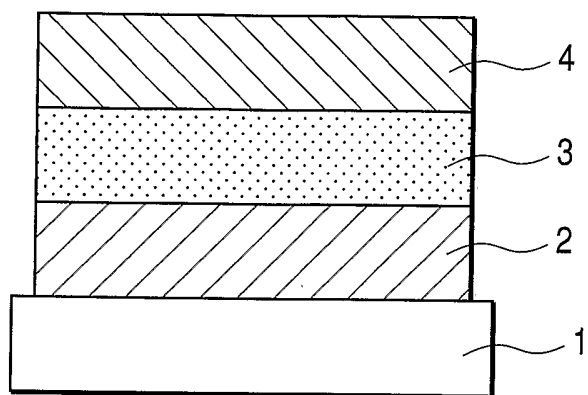
15           11. An organic electroluminescence device comprising a pair of electrodes composed of an anode and a cathode at least one of which is transparent or translucent, and one or more organic compound layers sandwiched between the pair of electrodes, wherein at  
20           least one of the organic compound layers contains at least one kind of the aminoanthryl derivative substitution compounds according to claim 1.

          12. An organic electroluminescence device comprising a light-emitting layer, a pair of  
25           electrodes composed of an anode and a cathode at least one of which is transparent or translucent, and one or more organic compound layers sandwiched

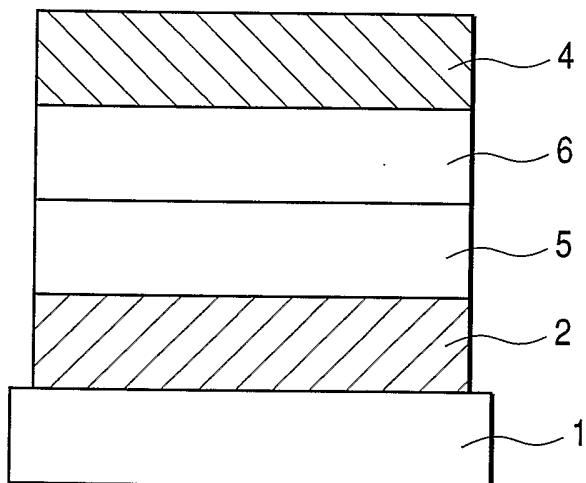
between the pair of electrodes, wherein the light-emitting layer contains at least one kind of the aminoanthryl derivative substitution compounds according to claim 1.

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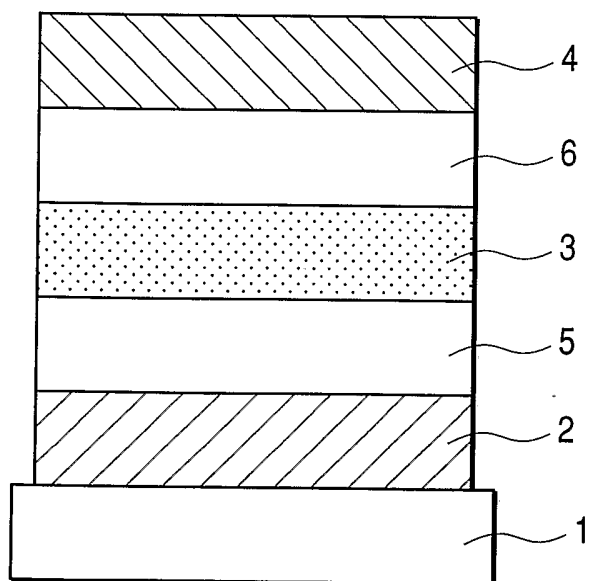
**FIG. 1**



**FIG. 2**

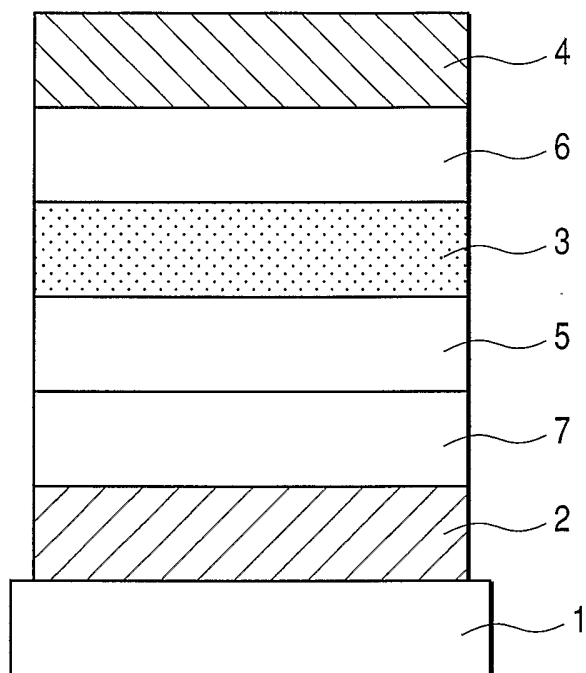


**FIG. 3**

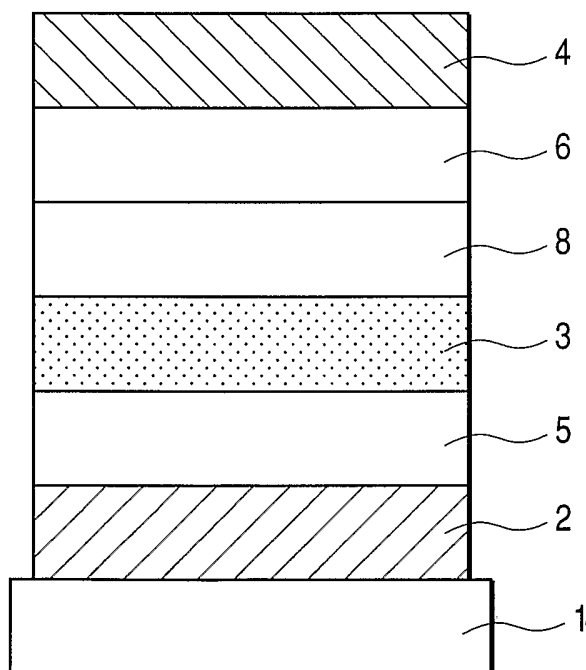


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**FIG. 4**



**FIG. 5**



## INTERNATIONALSEARCHREPORT

International application No.

PCT/JP2004/009372

## A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl<sup>7</sup> C07C211/61, C09K11/06, H05B33/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl<sup>7</sup> C07C211/61, C09K11/06, H05B33/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
 Japanese Utility Model Gazette 1922-1996, Japanese Publication of Unexamined Utility Model Applications 1971-2004, Japanese Registered Utility Model Gazette 1994-2004, Japanese Gazette Containing the Utility Model 1996-2004

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

CA (STN)

REGISTRY (STN)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages       | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------|-----------------------|
| X         | JP 2-282262 A (Kao Corporation) 1990.11.19<br>(Family:none)                              | 1, 4                  |
| X         | JP 3-248160 A (Kao Corporation) 1991.11.06<br>(Family:none)                              | 1, 2                  |
| X<br>Y    | JP 8-12600 A (TDK Corporation) 1996.01.16, &<br>EP 681019 A2 & US 5635308 A              | 1, 11, 12<br>6        |
| X<br>Y    | JP 10-251633 A (TOYO INK MANUFACTURING CO.)<br>1998.09.22, & EP 866110 A1 & US 6280859 A | 1, 4, 11, 12<br>6, 9  |
| Y         | JP 2001-240854 A (Ricoh Corporation)<br>2001.09.04 (Family:none)                         | 6, 9                  |
| X, P      | WO 03/094926 A1 (NORTH CAROLINA STATE<br>UNIVERSITY) 2003.11.20, & US 2004/0048390 A     | 1                     |

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

\* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

16.08.2004

Date of mailing of the international search report

31.8.2004

Name and mailing address of the ISA/JP

Japan Patent Office

3-4-3, Kasumigasaka, Chiyoda-ku, Tokyo 100-8915, Japan

Authorized officer

KAZUYUKI YOSIZUMI

Telephone No. +81-3-3581-1101 Ext. 3443

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