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(54) LUMINESCENT MATERIAL AND ORGANIC ELECTROLUMINESCENT DEVICE USING THE SAME

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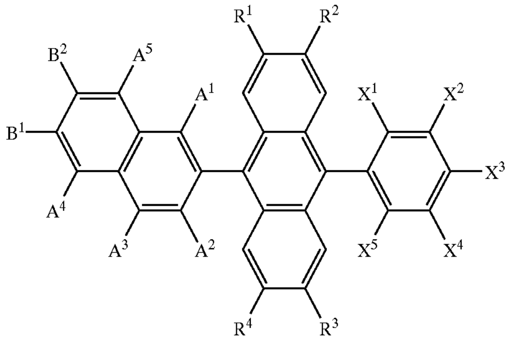
(57) ABSTRACT

To provide a luminescent material, especially one superior in blue light emission, which is used in an OEL device and allows the device to have higher luminescence efficiency, lower driving voltage, better thermal resistance and longer lifetime, as well as to provide an OEL device using the luminescent material. SOLUTION: A new luminescent material having an asymmetric structure with a basic anthracene skeleton is provided:

(1)



In formula (1), each of R^1—R^4 represents hydrogen, a C_1-C_{24} alkyl group or a C_1-C_{24} alkoxy group. Each of A^1-A^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group. Each of B^1 and B^2 represents hydrogen, a C_6-C_{24} aryl group, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group. Each of X^1—X^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group.

LUMINESCENT MATERIAL AND ORGANIC ELECTROLUMINESCENT DEVICE USING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a new luminescent material having an anthracene skeleton, and to an organic electroluminescent (abbreviated to OEL, hereinafter) device using the luminescent material.

[0003] 2. Description of the Related Art

[0004] Recently, the OEL device has drawn a great deal of attention as a full-color flat-panel display of the next generation, and the luminescent materials of blue, green and red colors have been actively studied and developed. However, the improvement of the luminescent materials, especially the blue-luminescent materials, is desired. The blue-luminescent materials that have been reported so far include distyrylarylene derivatives like those mentioned in Patent Document 1 (defined later), zinc complexes like those in Patent Document 2, aluminum complexes like those in Patent Document 3, aromatic amine derivatives like those in Patent Document 4, and anthracene derivatives like those in Patent Document 5, etc. Other than Patent Document 5, examples of using anthracene derivatives as luminescent materials are further disclosed in Non-patent Document 1 and Patent Documents 6-8. In Non-patent Document 1, a diphenylanthracene compound is used. However, forming a film with the diphenylanthracene compound is difficult due to its high crystallinity. Patent Documents 6-8 disclose OEL devices that use phenylanthracene derivatives as luminescent materials. In Patent Document 5, an OEL device is disclosed using a naphthalene-substituted anthracene derivative as a luminescent material. However, since each of the above compounds has a symmetric molecular structure, their crystallinities tend to be higher. In Patent Documents 9-12, OEL devices that use compounds having two or more anthracene rings as luminescent materials are proposed to lower the crystallinity and form a high-quality amorphous film. These materials were reported to emit blue-green light.

[0005] Moreover, to produce blue OEL devices of high brightness and long lifetime, it has been proposed to dope the luminescent layer with a small amount of fluorescent pigment. For example, Non-patent Document 2 discloses an OEL device that uses a naphthalene-substituted anthracene derivative as a host compound and a perylene derivative as a dopant. Patent Document 13 discloses an OEL device that uses an anthracene derivative as a host compound and an amine-containing styryl derivative as a dopant.

[0006] Furthermore, though Patent Document 14 discloses an example that uses a naphthalene-substituted phenylanthracene derivative as a hole-transporting material, the derivative has never been used as a luminescent material. Patent Documents 1-14 and Non-patent Documents 1-2 are defined below. Patent Document 1: Japanese Patent Publication No. Hei 02-**247278** **Patent Document** 2: Japanese Patent Publication No. Hei 06-**336586** **Patent Document** 3: Japanese Patent Publication No. Hei 05-**198378** **Patent Document** 4: Japanese Patent Publication No. Hei 06-**240248** **Patent Document** 5: Japanese Patent Publication No. Hei 11-**3782** **Patent Document** 6: Japanese Patent Publication No. Hei 11-**312588** **Patent Document** 7: Japanese Patent Publication No. Hei 11-**323323** **Patent Document** 8: Japanese Patent Publication No. Hei 11-**329732** **Patent Document** 9: Japanese Patent Publication No. Hei 8-**12600** **Patent Document** 10: Japanese Patent Publication No. Hei 11-**111458** **Patent Document** 11: Japanese Patent Publication No. 2000-**344691** **Patent Document** 12: Japanese Patent Publication No. 2002-**154993** **Patent Document** 13: PCT Patent Publication No. WO **01/21729** **Patent Document** 14: Japanese Patent Publication No. 2000-**182776** **Non-patent Document** 1: *Applied Physics Letters,* 56 (9), 799 (1990) Non-patent Document 2: *Applied Physics Letters,* 80 (17), 3201 (2002)

SUMMARY OF THE INVENTION

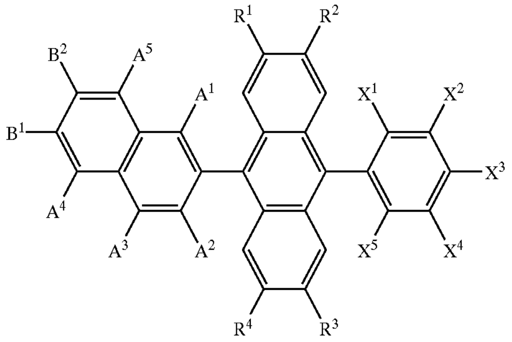
[0007] This invention is provided in view of the foregoing issues of the prior art. Specifically, one object of this invention is to provide a luminescent material, especially one superior in emission of blue light, which is used in an OEL device and allows the OEL device to have higher luminescence efficiency, lower driving voltage, better thermal resistance and longer lifetime. Another object of this invention is to provide an OEL device that uses the same luminescent material.

[0008] This invention is based on the discovery by the inventors that by using a specific compound having an asymmetric structure with a basic anthracene skeleton in the luminescent layer of an OEL device, either alone or in combination with other luminescent material, the OEL device can have higher luminescence efficiency, higher brightness, longer lifetime and lower driving voltage.

[0009] The terms used in this invention are defined as follows. An alkyl group means a straight alkyl group or a branched alkyl group, or a group obtained by substituting any methylene group (—CH_2—) of an alkyl group by an oxy moiety (—O—) or an arylene group. The word "any" used in this invention not only means "any position", but also means "any number". Meanwhile, when multiple groups or atoms are to be substituted by other groups, they can be substituted by different groups. For example, when any methylene group of an alkyl group can be substituted by an oxy moiety or an arylene group, the derivative group can be an alkoxyphenyl, alkoxyphenylalkyl, alkoxyalkyl-phenylalkyl, phenoxy, phenylalkoxy, phenylalkoxyalkyl, alkylphenoxy, alkylphenyl-alkoxy or alkylphenylalkoxyalkyl group, etc. Moreover, the alkoxy groups and the alkoxyalkyl groups in the above groups can also be straight groups or branched groups. However, the cases where any methylene group is substituted by an oxy moiety do not include the cases where each of multiple contiguous methylene groups is substituted by an oxy moiety. Moreover, in this specification, "the luminescent material expressed by formula (1)" is often described as "luminescent material (1)" for short, and so on.

[0010] The above issues can be solved at least with the following items of this invention. The 1st item is a luminescent material expressed by formula (1):

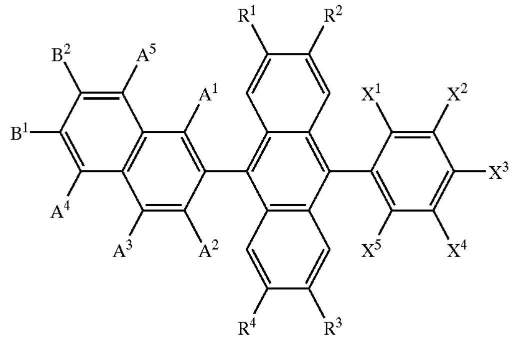
(1)



In formula (1), each of R^1—R^4 represents hydrogen, a C_1-C_{24} alkyl group or a C_1-C_{24} alkoxy group. Each of A^1-A^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group. Each of B^1 and B^2 represents hydrogen, a C_6-C_{24} aryl group, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group, wherein any hydrogen on the C_6-C_{24} aryl group can be substituted by a C_1-C_{12} alkyl group, a C_3-C_{12} cycloalkyl group or a C_6-C_{12} aryl group. Any methylene group (—CH_2—) of the C_1-C_{24} alkyl group can be substituted by an oxy moiety (—O—). Any methylene group of the C_1-C_{24} alkyl group except the one directly bonded to the naphthyl group can be substituted by a C_6-C_{24} arylene group. Any hydrogen on the C_3-C_{24} cycloalkyl group can be substituted by a C_1-C_{24} alkyl group or a C_6-C_{24} aryl group. Each of X^1—X^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group, wherein any methylene group of the C_1-C_{24} alkyl group can be substituted by an oxy moiety. Any methylene group of the C_1-C_{24} alkyl group except the one directly bonded to the phenyl group can be substituted by a C_6-C_{24} arylene group. Any hydrogen on the C_3-C_{24} cycloalkyl group can be substituted by a C_1-C_{24} alkyl group or a C_6-C_{12} aryl group.

[0011] The 2nd item is about the luminescent material of the 1st item, wherein each of R^1—R^4 represents hydrogen, methyl or t-butyl. Each of A^1-A^5 represents hydrogen, methyl, t-butyl or cyclohexyl. Each of B^1 and B^1 represents hydrogen, methyl or t-butyl, or is a functional group selected from phenyl, biphenylyl, terphenylyl, quaterphenylyl, naphyhyl, phenanthryl, crycenyl and triphenylenyl, on which any hydrogen can be substituted by a C_1-C_{12} alkyl group, a C_3-C_{12} cycloalkyl group or a C_6-C_{12} aryl group. Each of X^1—X^5 represents hydrogen, a C_1-C_{12} alkyl group or a C_3-C_{12} cycloalkyl group. The 3rd item is a luminescent material expressed by formula (1):

(1)



In this formula (1), each of R^1—R^4 represents hydrogen, methyl or t-butyl, and each of A^1-A^5 represents hydrogen. Each of B^1 and B^2 represents hydrogen, phenyl, 2-biphenylyl, 3-biphenylyl, m-terphenyl-5'-yl, m-terphenyl-3-yl, 1-naphthyl, 2-naphthyl, 2-(2-naphthyl)phenyl, 3,5-di(1-naphthyl)phenyl, 3,5-di(2-naphthyl)phenyl, p-terphenyl-2'-yl, m-terphenyl-2-yl, o-terphenyl-2-yl, p-terphenyl-2-yl, 5'-phenyl-m-terphenyl-2-yl, 5'-phenyl-m-terphenyl-3-yl, 5'-phenyl-m-terphenyl-3-yl, m-quaterphenyl-2-yl, m-quaterphenyl-3-yl, 6-(m-terphenyl-5'-yl)-2-naphthyl or 4-(m-terphenyl-5'-yl)-1-naphthyl. Each of X^1—X^5 represents hydrogen, methyl, t-butyl or cyclohexyl.

[0012] The 4th item is about the luminescent material of the above 3rd item, wherein each of X^1—X^5 represents hydrogen. The 5th item is about the luminescent material of the 3rd item, wherein X^3 represents t-butyl and each of X^1, X^2, X^4 and X^5 represents hydrogen. The 6th item is about the luminescent material of the 3rd item, wherein among X^1, X^3 and X^5, at least one represents methyl and the rest represent hydrogen, and each of X^2 and X^4 represents hydrogen. The 7th item is about the luminescent material of the 3rd item, wherein each of B^1 and B^2 represents phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 8th item is about the luminescent material of the 3rd item, wherein B^1 represents phenyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 9th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[0013] The 10th item is about the luminescent material of the 3rd item, wherein each of B^1 and B^2 represents 2-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 11th item is about the luminescent material of the 3rd item, wherein B^1 represents 2-biphenylyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 12th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 2-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^1 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[0014] The 13th item is about the luminescent material of the 3rd item, wherein each of B^1 and B^2 represents 3-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^1 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 14th item is about the luminescent material of the 3rd item, wherein B^1 represents 3-biphenylyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 15th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B represents 3-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[0015] The 16th item is about the luminescent material of the 3rd item, wherein B^1 represents m-terphenyl-5'-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 17th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents m-terphenyl-5'-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[0016] The 18th item is about the luminescent material of the 3rd item, wherein B^1 represents m-terphenyl-3-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 19th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents m-terphenyl-3-yl, each of X^1 and X^5represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0017**] The 20th item is about the luminescent material of the 3 item, wherein B^1 represents 1-naphthyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 21st item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 1-naphthyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0018**] The 22nd item is about the luminescent material of the 3rd item, wherein B^1 represents 2-naphthyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 23rd item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 2-naphthyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0019**] The 24th item is about the luminescent material of the 3rd item, wherein B^1 represents 2-(2-naphthyl)phenyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 25th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 2-(2-naphthyl)phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0020**] The 26th item is about the luminescent material of the 3rd item, wherein B^1 represents 3,5-di(1-naphthyl)phenyl or 3,5-di(2-naphthyl)phenyl, B^2 represents H, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 27th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 3,5-di(1-naphthyl)phenyl or 3,5-di(2-naphthyl)phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0021**] The 28th item is about the luminescent material of the 3rd item, wherein B^1 represents a group selected from p-terphenyl-2'-yl, m-terphenyl-2-yl, o-terphenyl-2-yl and p-terphenyl-2-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 29th is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents a group selected from p-terphenyl-2'-yl, m-terphenyl-2-yl, o-terphenyl-2-yl and p-terphenyl-2-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0022**] The 30th item is about the luminescent material of the 3rd item, wherein B^1 represents 5'-phenyl-m-terphenyl-2-yl or 5'-phenyl-m-terphenyl-3-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 31st item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 5'-phenyl-m-terphenyl-2-yl or 5'-phenyl-m-terphenyl-3-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0023**] The 32nd item is about the luminescent material of the 3rd item, wherein B^1 represents m-quaterphenyl-2-yl or m-quaterphenyl-3-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 33rd item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents m-quaterphenyl-2-yl or m-quaterphenyl-3-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0024**] The 34th item is about the luminescent material of the 3rd item, wherein B^1 represents 6-(m-terphenyl-5'-yl)-2-naphthyl or 4-(m-terphenyl-5'-yl)-1-naphthyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl. The 35th item is also about the luminescent material of the 3rd item, wherein B^1 represents hydrogen, B^2 represents 6-(m-terphenyl-5'-yl)-2-naphthyl or 4-(m-terphenyl-5'-yl)-1-naphthyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

[**0025**] The 36th item is an organic electroluminescent (OEL) device, which includes at least a hole-transporting layer, a luminescent layer and an electron-transporting layer that are sandwiched between an anode and a cathode on a substrate, wherein the luminescent layer includes the luminescent material of any one of the 1 to 35th items of this invention. The 37th item is about the OEL device of the 36th item, wherein the luminescent layer contains at least one luminescent dopant selected from perylene derivatives, borane derivatives, amine-containing styryl derivatives, aromatic amine derivatives, coumarin derivatives, pyran derivatives, iridium complexes and platinum complexes. The 38th item is also about the OEL device of the 36th item, wherein the luminescent layer contains a perylene derivative as a luminescent dopant.

[**0026**] The 39th item is about the OEL device of the 36th item, wherein the luminescent layer contains a borane derivative as a luminescent dopant. The 40th item is about the OEL device of the 36th item, wherein the luminescent layer contains an amine-containing styryl derivative as a luminescent dopant. The 41st item is about the OEL device of the 36th item, wherein the luminescent layer contains an aromatic amine derivative as a luminescent dopant. The 42nd item is about the OEL device of the 36th item, wherein the luminescent layer contains a coumarin derivative as a luminescent dopant. The 43rd item is about the OEL device of the 36th item, wherein the luminescent layer contains a pyran derivative as a luminescent dopant. The 44th item is about the OEL device of the 36th item, wherein the luminescent layer contains an iridium complex as a luminescent dopant. The 45th item is also about the OEL device of the 36th item, wherein the luminescent layer contains a platinum complex as a luminescent dopant.

[**0027**] The 46th item is about the OEL device of any one of the 36th to 45th items, wherein the electron-transporting layer contains a quinolinol metal complex. The 47th item is also about the OEL device of any one of the 36th to 45th items, wherein the electron-transporting layer contains at least one of a pyridine derivative and a phenanthroline derivative.

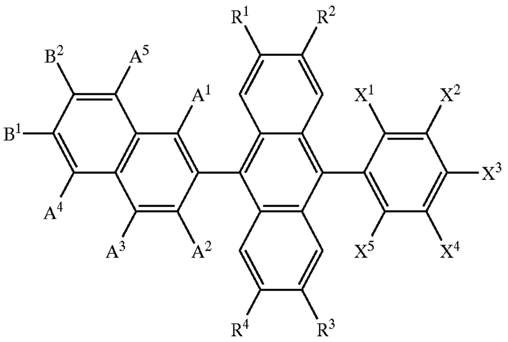
Effect of this Invention

[**0028**] Because the luminescent material of this invention has higher fluorescence quantum yield and thermal resistance, it is suitably used, particularly as a host material, in the luminescent layer of an OEL device. Though the luminescent material can be used for emission of various color lights, it is particularly suitable for blue emission. By using the luminescent material, OEL devices with higher luminescence efficiency, lower driving voltage, better thermal resistance and longer lifetime can be obtained. Therefore, a display apparatus that has high performances including full-color display capability can be obtained based on the OEL device of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] This invention is explained in more details as follows. The first point of this invention is a luminescent material expressed by formula (1) that has an anthracene skeleton.

(1)



In formula (1), each of R^1—R^4 represents hydrogen, a C_1-C_{24} alkyl group or a C_1-C_{24} alkoxy group. Specific examples of the C_1-C_{24} alkyl group include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, n-pentyl, isopentyl, t-pentyl, neopentyl, n-hexyl, isohexyl, 1-methylpentyl, 2-methylpentyl and 5-methylhexyl, etc.

[0030] Specific examples of the C_1-C_{24} alkoxy group include methoxy, ethoxy, propyloxy, isopropyloxy, n-butyloxy, isobutyloxy, sec-butyloxy, t-butyloxy, n-pentyloxy, isopentyloxy, t-pentyloxy, neopentyloxy, n-hexyloxy, isohexyloxy, 1-methylpentyloxy and 2-methylpentyloxy, etc.

[0031] Preferred examples of R^1—R^4 include hydrogen, methyl and t-butyl, wherein hydrogen is particularly preferred.

[0032] Each of A^1-A^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group. Specific examples of the C_1-C_{24} alkyl group include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, n-pentyl, isopentyl, t-pentyl, neopentyl, n-hexyl, isohexyl, 1-methylpentyl, 2-methylpentyl and 5-methylhexyl, etc.

[0033] Specific examples of the C_3-C_{24} cycloalkyl group include cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl, etc.

[0034] Preferred examples of A^1-A^5 include hydrogen, methyl, t-butyl and cyclohexyl, wherein hydrogen is more preferred.

[0035] Each of B^1 and B^2 represents hydrogen, a C_6-C_{24} aryl group, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group. These groups are described in details as follows.

[0036] Firstly, specific examples of the C_6-C_{24} aryl group include phenyl, 2-biphenylyl, 3-biphenylyl, 4-biphenylyl, m-terphenyl-2-yl, m-terphenyl-3-yl, m-terphenyl-4-yl, m-terphenyl-2'-yl, m-terphenyl-4'-yl, m-terphenyl-5'-yl, o-terphenyl-2-yl, o-terphenyl-3-yl, o-terphenyl-4-yl, o-terphenyl-3'-yl, o-terphenyl-4'-yl, p-terphenyl-2-yl, p-terphenyl-3-yl, p-terphenyl-4-yl, p-terphenyl-2'-yl, m-quaterphenyl-2-yl, m-quaterphenyl-3-yl, m-quaterphenyl-4-yl, o-quaterphenyl-2-yl, o-quaterphenyl-3-yl, o-quaterphenyl-4-yl, p-quaterphenyl-2-yl, p-quaterphenyl-3-yl, p-quaterphenyl-4-yl, 1-naphthyl, 2-naphthyl, 1-phenanthryl, 2-phenanthryl, 3-phenanthryl, 4-phenanthryl, 9-phenanthryl, 1-crycenyl, 2-crycenyl, 3-crycenyl, 5-crycenyl, 6-crycenyl, 1-triphenylenyl and 2-triphenylenyl, etc. Any hydrogen on the C_6-C_{24} aryl group can be substituted by a C_1-C_{12} alkyl group, a C_3-C_{12} cycloalkyl group or a C_6-C_{12} aryl group.

[0037] Specific examples of the C_6-C_{24} aryl group on which any hydrogen is substituted by a C_1-C_{12} alkyl group include o-tolyl, m-tolyl, p-tolyl, 2,4-dimethylphenyl, 2,6-dimethylphenyl, 3,5-dimethylphenyl, 2,4,6-trimethylphenyl, 4-t-butylphenyl, 2,4-di-t-butylphenyl, 2,4,6-tri-t-butylphenyl, 2-methyl-4-biphenylyl, 2-methyl-3-biphenylyl, 2-methyl-2-biphenyl, 3,5-di(2'-methylphenyl)phenyl, 3,5-di(3'-methyl-phenyl)phenyl, 3,5-di(4'-methylphenyl)phenyl, 3,5-di(4'-t-butylphenyl)phenyl, 3,5-bis(2',4'-dimethylphenyl)phenyl, 3,5-bis(3',5'-dimethylphenyl)phenyl, 4-methyl-1-naphthyl, 4-t-butyl-1-naphthyl, 6-methyl-2-naphthyl and 6-t-butyl-2-naphthyl, etc.

[0038] Specific examples of the C_6-C_{24} aryl group on which any hydrogen is substituted by a C_3-C_{12} cycloalkyl group include: 2-cyclohexylphenyl, 3-cyclohexylphenyl, 4-cyclohexylphenyl, 2,4-dicyclohexylphenyl, 3,5-dicyclohexylphenyl, 4-cyclohexyl-1-naphthyl and 6-cyclohexyl-2-naphthyl, etc.

[0039] Specific examples of the C_6-C_{24} aryl group on which any hydrogen is substituted by a C_6-C_{12} aryl group include 2-(1-naphthyl)phenyl, 3-(1-naphthyl)phenyl, 4-(1-naphthyl)phenyl, 2-(2-naphthyl)phenyl, 3-(2-naphthyl)phenyl, 4-(2-naphthyl)-phenyl, 3,5-di(1-naphthyl)phenyl, 3,5-di(2-naphthyl)phenyl, 2,4-di(1-naphthyl)phenyl, 2,4-di(2-naphthyl)phenyl, 5-(1-naphthyl)-3-biphenylyl, 5-(2-naphthyl)-3-biphenylyl, 3,5-bis(2-biphenylyl)phenyl, 3,5-bis(3-biphenylyl)phenyl, 3,5-bis(4-biphenylyl)phenyl, 5'-phenyl-m-terphenyl-2-yl, 5'-phenyl-m-terphenyl-3-yl, 5'-phenyl-m-terphenyl-4-yl, 5'-(1-naphthyl)-m-terphenyl-2-yl, 5'-(1-naphthyl)-m-terphenyl-3-yl, 5'-(1-naphthyl)-m-terphenyl-4-yl, 5'-(2-naphthyl)-m-terphenyl-2-yl, 5'-(2-naphthyl)-m-terphenyl-3-yl, 5'-(2-naphthyl)-m-terphenyl-4-yl, 4-phenyl-1-naphthyl, 6-phenyl-2-naphthyl, 2,2'-binaphthyl-6-yl, 1,2'-binaphthyl-6'-yl, 1,2'-binaphthyl-4-yl, 1,1'-binaphthyl-4-yl, 4-(2-biphenylyl)-1-naphthyl, 4-(3-biphenylyl)-1-naphthyl, 4-(4-biphenylyl)-1-naphth 4-(m-terphenyl-5'-yl)-1-naphthyl, 6-(2-biphenylyl)-2-naphthyl, 6-(3-biphenylyl)-2-naphthyl, 6-(4-biphenylyl)-2-naphthyl and 6-(m-terphenyl-5'-yl)-2-naphthyl, etc.

[0040] Secondly, specific examples of the C_1-C_{24} alkyl group as B^1 or B^2 include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, n-pentyl, isopentyl, t-pentyl, neopentyl, n-hexyl, isohexyl, 1-methylpentyl, 2-methylpentyl and 5-methylhexyl, etc. Any methylene group (—CH_2—) of the C_1-C_{24} alkyl group can be substituted by an oxy moiety (—O—). Moreover, any methylene group of the C_1-C_{24} alkyl group except the one directly bonded to the naphthyl group can be substituted by a C_6-C_{24}

arylene group. Specific examples of the C_6-C_{24} arylene group include 1,2-phenylene, 1,3-phenylene, 1,4-phenylene, naphthalene-1,4-diyl and naphthalene-2,6-diyl, etc.

[0041] Specific examples of the C_1-C_{24} alkyl group of which any methylene group is substituted by an oxy moiety include methoxy, ethoxy, propyloxy isopropyloxy, n-butyloxy, isobutyloxy, sec-butyloxy, t-butyloxy, n-pentyloxy, isopentyloxy, t-pentyloxy, neopentyloxy, n-hexyloxy, isohexyloxy, 1-methylpentyloxy and 2-methyl-pentyloxy, etc. Specific examples of the C_1-C_{24} alkyl group of which any methylene group except the one directly bonded to the naphthyl group is substituted by a C_6-C_{24} arylene group include 2-phenylethyl, 2-(4-methylphenyl)ethyl, 1-methyl-1-phenylethyl, 1,1-dimethyl-2-phenylethyl, trityl, 2-(4-biphenylyl)ethyl, 2-(4'-methyl-biphenylyl)ethyl, 2-(4-methyl-1-naphthyl)ethyl and 2-(6-methyl-2-naphthyl)ethyl, etc.

[0042] Specific examples of the C_1-C_{24} alkyl group of which any methylene group is substituted by an oxy moiety and any methylene group except the one directly bonded to the naphthyl group is substituted by a C_6-C_{24} arylene group include phenoxy, o-tolyloxy, m-tolyloxy, p-tolyloxy, 1-naphthoxy, 2-naphthoxy, 2,4-dimethylphenoxy, 2,6-dimethylphenoxy, 2,4,6-trimethylphenoxy, 4-t-butylphenoxy, 2,4-di-t-butylphenoxy, 2,4,6-tri-t-butylphenoxy, 2-phenylethoxy and 2-(4-methylphenyl)ethoxy, etc.

[0043] Thirdly, specific examples of the C_3-C_{24} cycloalkyl group as B^1 or B^2 include cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl, etc. Any hydrogen on the C_3-C_{24} cycloalkyl group can be substituted by a C_1-C_{24} alkyl group or a C_6-C_{24} aryl group.

[0044] Specific examples of the C_3-C_{24} cycloalkyl group on which any hydrogen is substituted by a C_1-C_{24} alkyl group include 2-methylcyclohexyl, 3-methylcyclohexyl, 4-methylcyclohexyl, 2,4,6-trimethylcyclohexyl, 2-t-butylcyclohexyl, 3-t-butyl-cyclohexyl, 4-t-butylcyclohexyl and 2,4,6-tri-t-butylcyclohexyl, etc. Specific examples of the C_3-C_{24} cycloalkyl group on which any hydrogen is substituted by a C_6-C_{24} aryl group include 2-phenylcyclohexyl, 3-phenylcyclohexyl, 4-phenyl-cyclohexyl, 2,4-diphenylcyclohexyl and 3,5-diphenylcyclohexyl, etc.

[0045] Preferred examples of B^1 and B^2 include hydrogen, methyl, t-butyl, phenyl, 2-biphenylyl, 3-biphenylyl, 4-biphenylyl, m-terphenyl-4'-yl, m-terphenyl-5'-yl, p-terphenyl-2'-yl, p-terphenyl-2-yl, m-terphenyl-2-yl, m-terphenyl-3-yl, o-terphenyl-2-yl, o-terphenyl-3-yl, 3,5-di(2-naphthyl)phenyl, 3,5-di(1-naphthyl)phenyl, 1-naphthyl, 2-naphthyl, 4-phenyl-1-naphthyl, 6-phenyl-2-naphthyl, 1,2'-binaphthyl-4-yl, 2,2'-binaphthyl-6-yl, 9-phenanthryl, 2-triphenylenyl, 2-(2-naphthyl)phenyl, 5'-phenyl-m-terphenyl-2-yl, 5'-phenyl-m-terphenyl-3-yl, m-quaterphenylyl-2-yl, m-quaterphenylyl-3-yl, 6-(m-terphenyl-5'-yl)-2-naphthyl and 4-(m-terphenyl-5'-yl)-1-naphthyl, etc., wherein 2-biphenylyl, 3-biphenylyl, m-terphenyl-5'-yl, m-terphenyl-3-yl, 1-naphthyl and 2-naphthyl are particularly preferred.

[0046] B^1 and B^2 can be both selected from the above groups, or one of B^1 and B^2 is selected from the above groups and the other is hygrogen. When B^1 or B^2 is a bulky group, the steric hindrance of the bulky group will shift the luminescence wavelength to the lower side, so that the compound preferably serves as a host material. Moreover, when B^1 or B^2 is a bulky group, the glass transition temperature (T_g) of the compound is higher and the compound is preferred for the following reasons. When an OEL device is to be fabricated, a low-T_g material tends to gradually crystallize with time so that the luminescence efficiency or stability thereof is possibly changed, while a high-T_g material does not suffer from the time-dependent changes. However, when B^1 and B^2 both are bulky groups, synthesis of the compound is difficult due to the steric hindrance.

[0047] Any of the above-mentioned groups can be introduced as B^1 or B^2 without much affecting the properties of the compound. However, introducing the group as B^1 is easier in synthesis and lower in cost than as B^2.

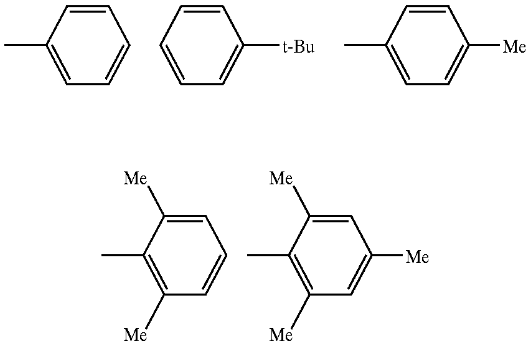
[0048] Each of X^1—X^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group. Specific examples of the C_1-C_{24} alkyl group include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, n-pentyl, isopentyl, t-pentyl, neopentyl, n-hexyl, isohexyl, 1-methylpentyl, 2-methylpentyl and 5-methylhexyl, etc. Any methylene group of the C_1-C_{24} alkyl group can be substituted by an oxy moiety. Moreover, any methylene group of the C_1-C_{24} alkyl group except the one directly bonded to the phenyl group can be substituted by a C_6-C_{24} arylene group. Examples of the C_6-C_{24} arylene group can be the same as the aforementioned.

[0049] Specific examples of the C_1-C_{24} alkyl group of which any methylene group is substituted by an oxy moiety include methoxy, ethoxy, propyloxy, isopropyloxy, n-butyloxy, isobutyloxy, sec-butyloxy, t-butyloxy, n-pentyloxy, isopentyloxy, t-pentyloxy, neopentyloxy, n-hexyloxy, isohexyloxy, 1-methylpentyloxy, 2-methyl-pentyloxy and n-hexyloxy, etc. Specific examples of the C_1-C_{24} alkyl group of which any methylene group except the one directly bonded to the phenyl group is substituted by a C_6-C_{24} arylene group include 2-phenylethyl, 2-(4-methylphenyl)ethyl, 1-methyl-1-phenylethyl, 1,1-dimethyl-2-phenylethyl, trityl, 2-(4-biphenylyl)ethyl, 2-(4'-methyl-biphenylyl)ethyl, 2-(4-methyl-1-naphthyl)ethyl and 2-(6-methyl-2-naphthyl)ethyl, etc.

[0050] Specific examples of the C_1-C_{24} alkyl group, of which any methylene group is substituted by an oxy moiety and any methylene group except the one directly bonded to the phenyl group is substituted by a C_6-C_{24} arylene group, include phenoxy, o-tolyloxy, m-tolyloxy, p-tolyloxy, 1-naphthoxy, 2-naphthoxy, 2,4-dimethylphenoxy, 2,6-dimethylphenoxy, 2,4,6-trimethylphenoxy, 4-t-butylphenoxy, 2,4-di-t-butylphenoxy, 2,4,6-tri-t-butylphenoxy, 2-phenylethoxy and 2-(4-methylphenyl)ethoxy, etc. Specific examples of the C_3-C_{24} cycloalkyl group include cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl, etc. Any hydrogen on the C_3-C_{24} cycloalkyl group can be substituted by a C_1-C_{24} alkyl group or a C_6-C_{12} aryl group.

[0051] Specific examples of the C_3-C_{24} cycloalkyl group on which any hydrogen is substituted by a C_1-C_{24} alkyl group include 2-methylcyclohexyl, 3-methylcyclohexyl, 4-methylcyclohexyl, 2,4,6-trimethylcyclohexyl, 2-t-butylcyclohexyl, 3-t-butyl-cyclohexyl, 4-t-butylcyclohexyl and 2,4,6-tri-t-butylcyclohexyl, etc. Specific examples of the C_3-C_{24} cycloalkyl group on which any hydrogen is substituted by a C_6-C_{12} aryl group include 2-phenylcyclohexyl, 3-phenylcyclohexyl, 4-phenyl- cyclohexyl, 2,4-diphenylcyclohexyl and 3,5-diphenylcyclohexyl, etc.

[0052] Preferred examples of X^1—X^5 include hydrogen, methyl, t-butyl and cyclohexyl, wherein hydrogen, methyl and t-butyl are more preferred. Preferred examples of the combinations of X^1—X^5 are shown below together with the phenyl group to which X^1—X^5 are bonded.



[0053] Specific examples of the luminescent material (1) of this invention include the following compounds of formulae (2)-(103). However, the scope of this invention is not limited by the disclosure of these specific molecular structures.

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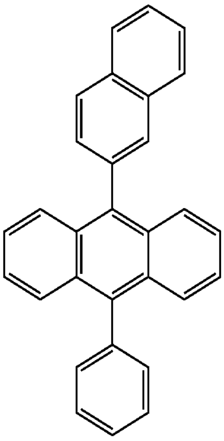

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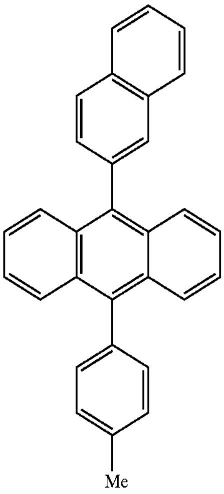

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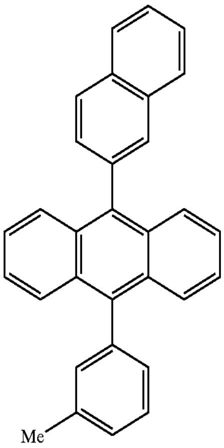

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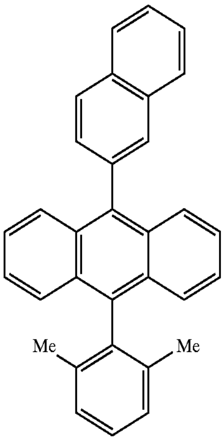

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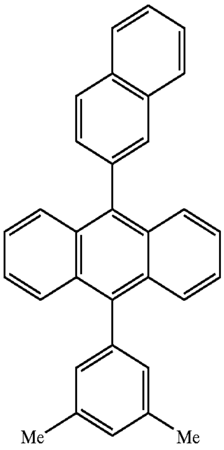

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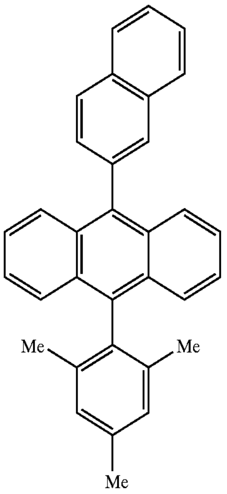

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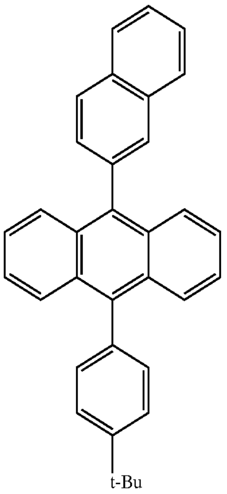

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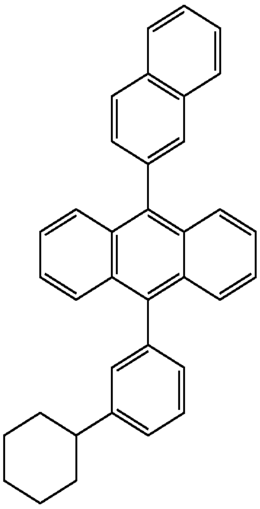

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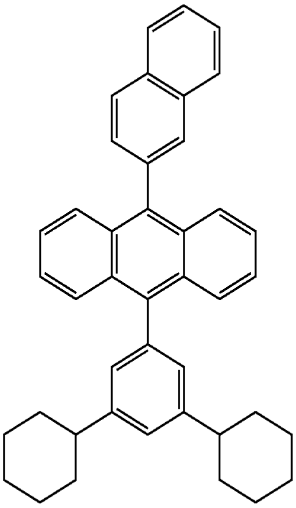

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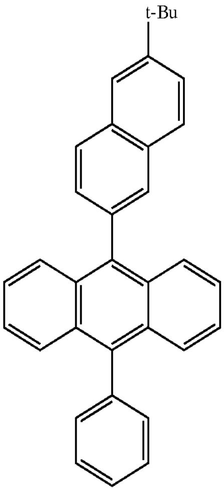

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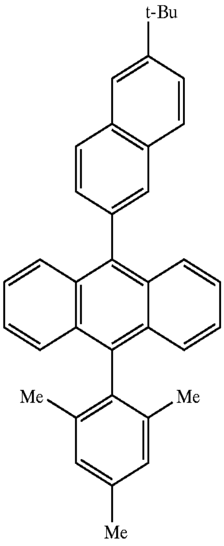

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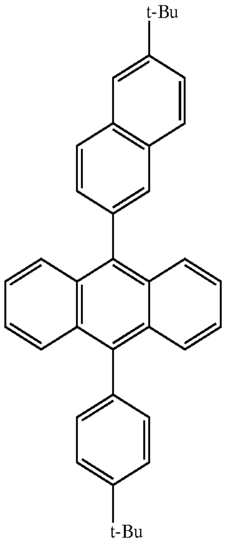

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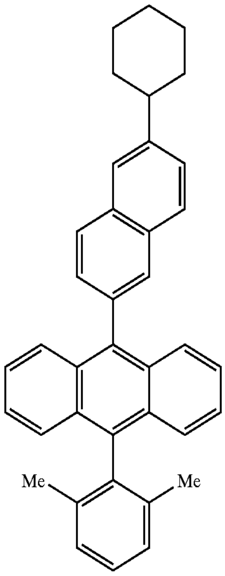

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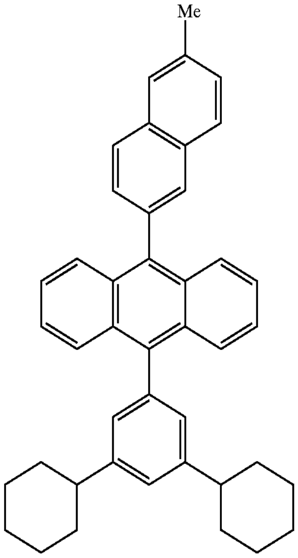

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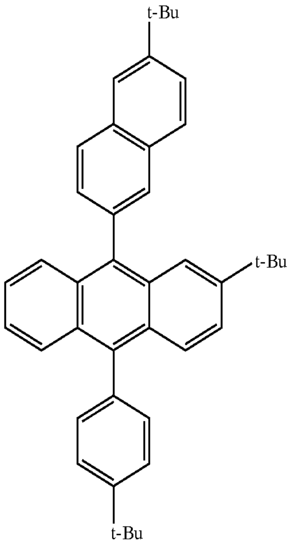

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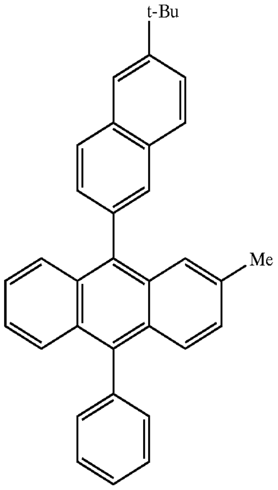

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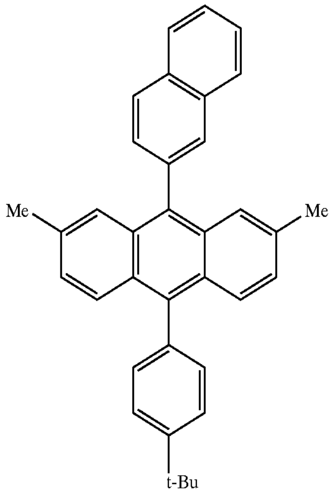

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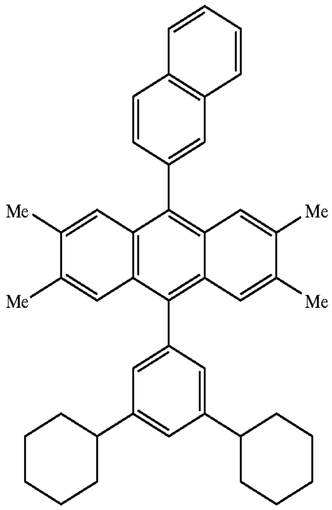

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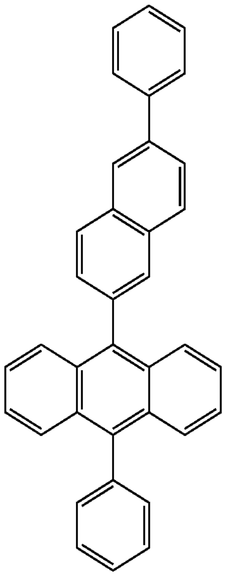

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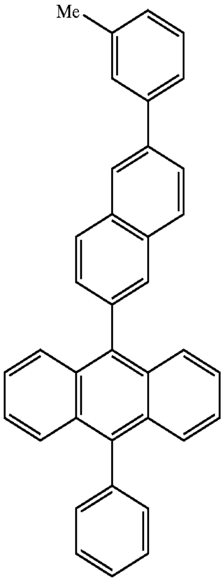

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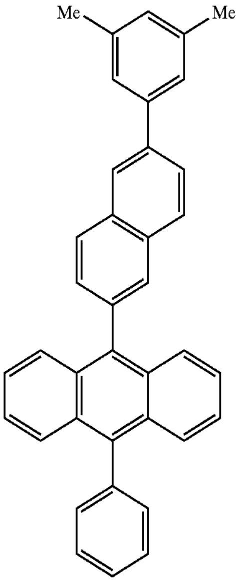

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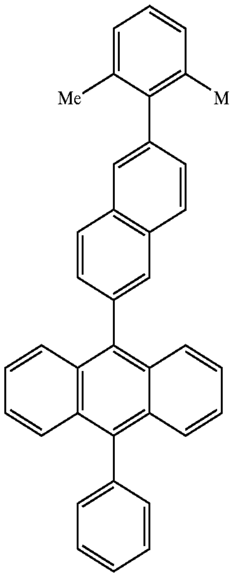

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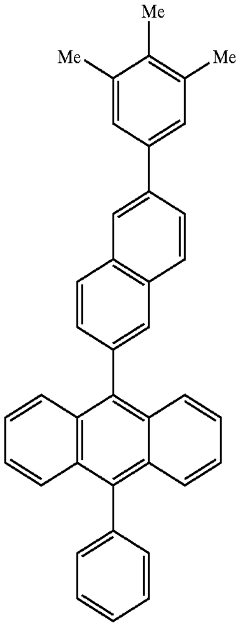

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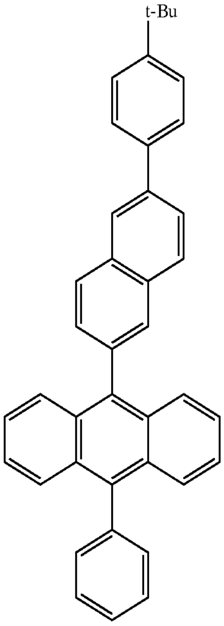

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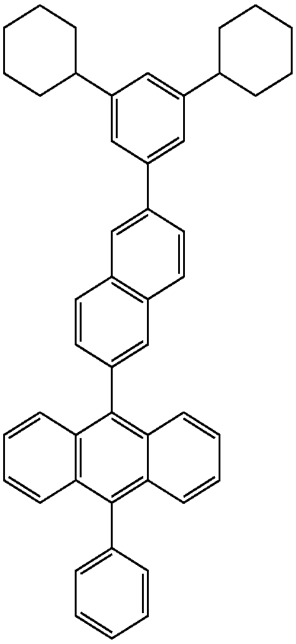

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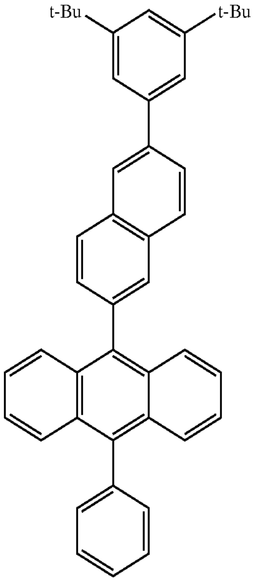

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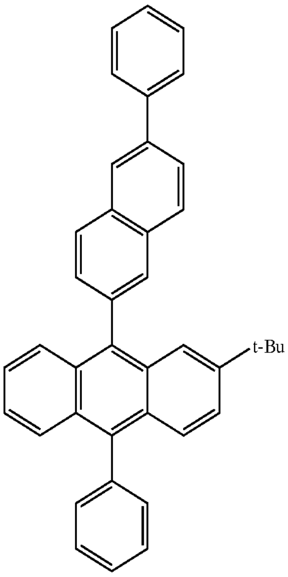

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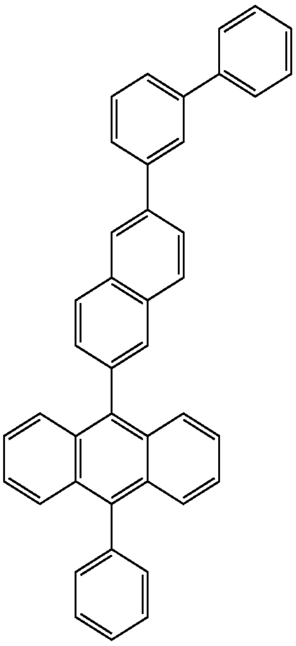

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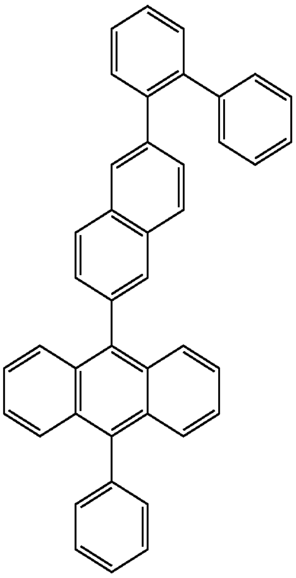

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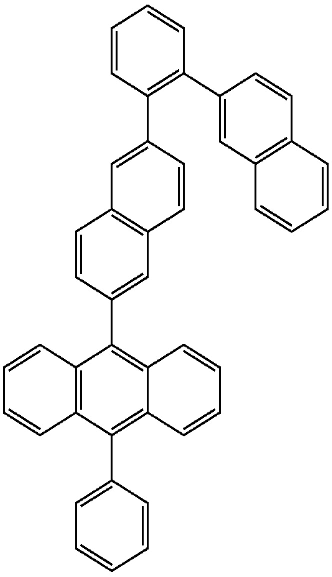

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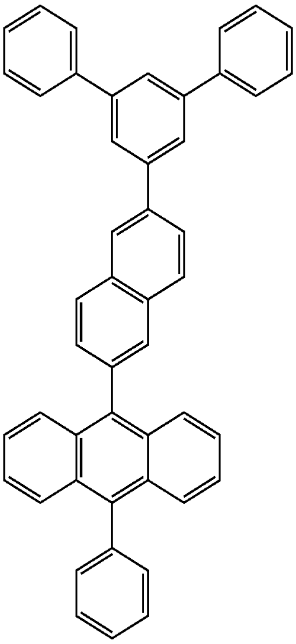

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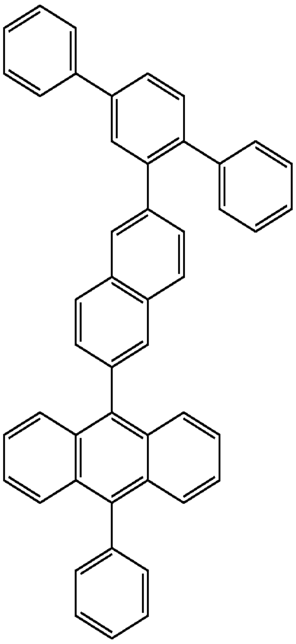

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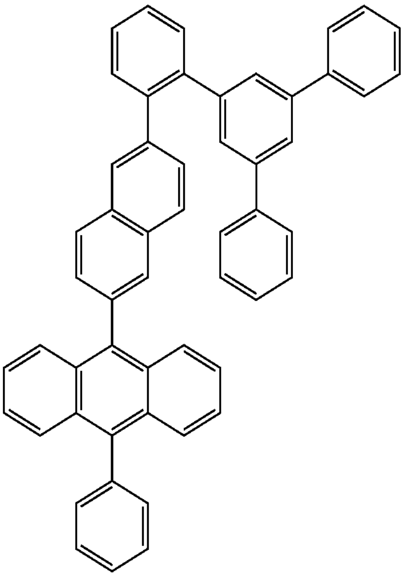

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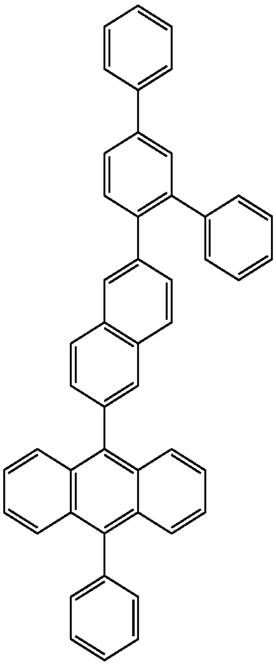

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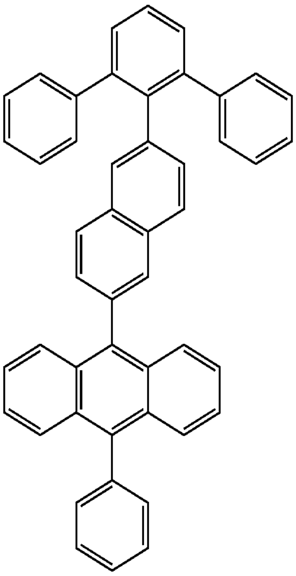

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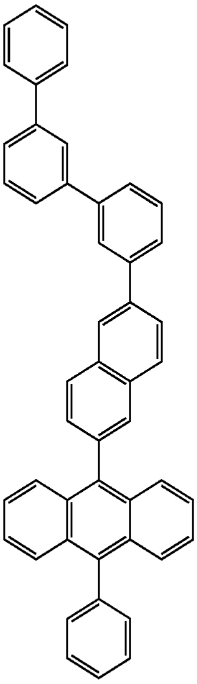

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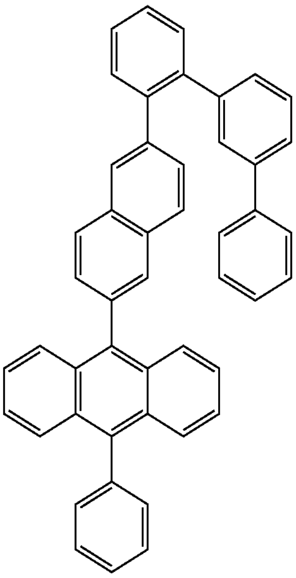

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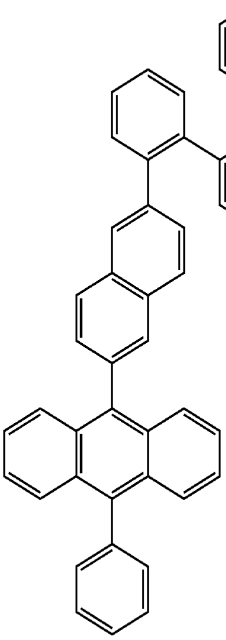

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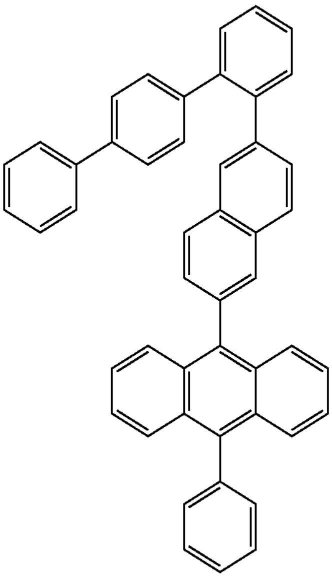

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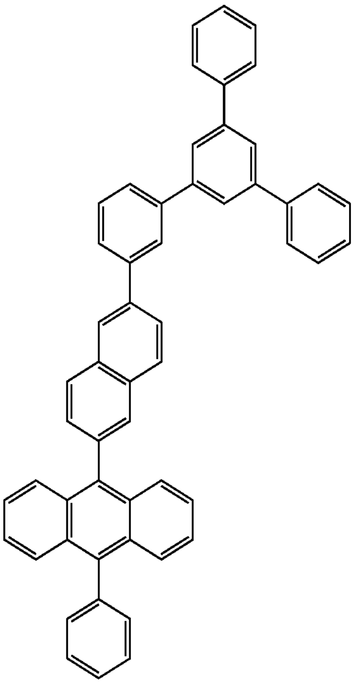

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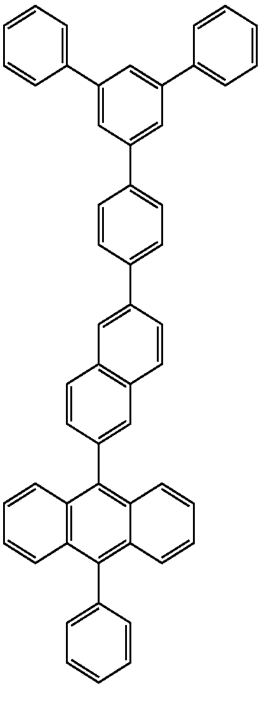

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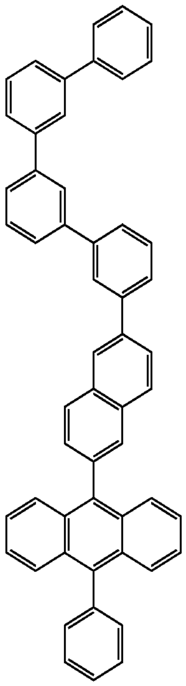

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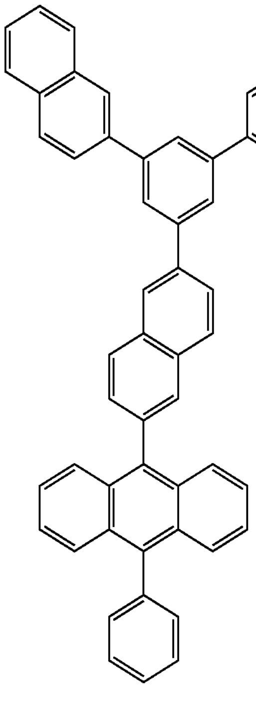

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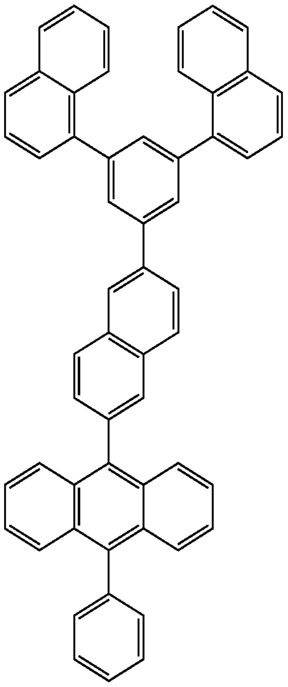

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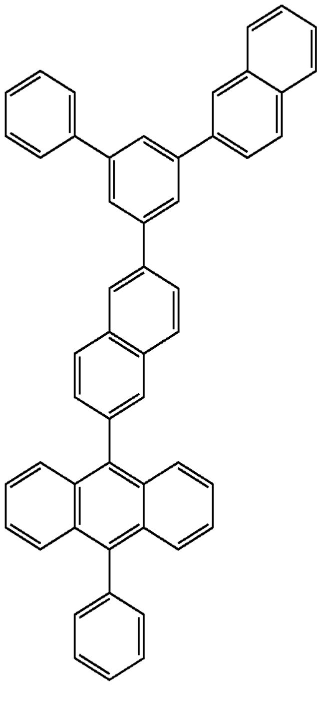

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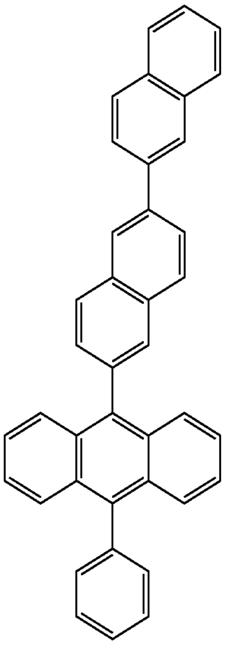

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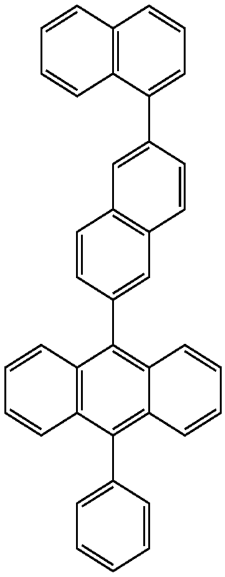

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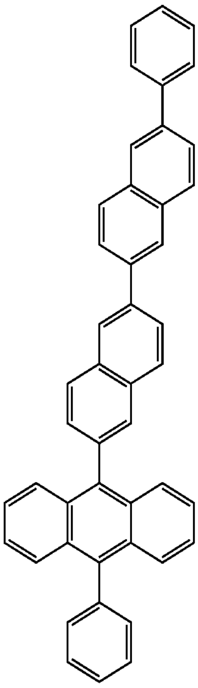

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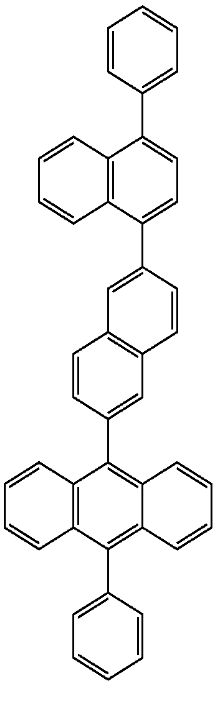

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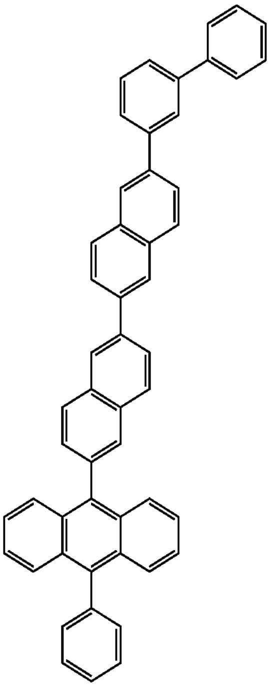

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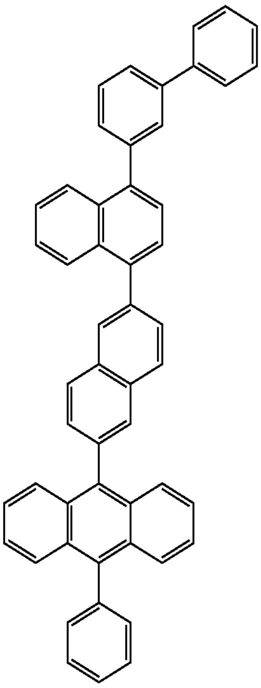

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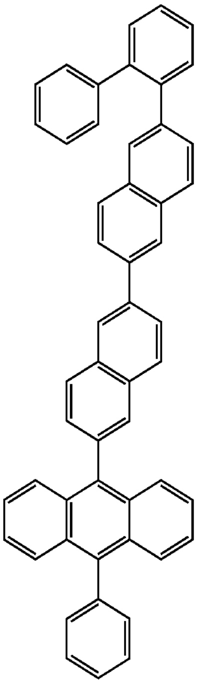

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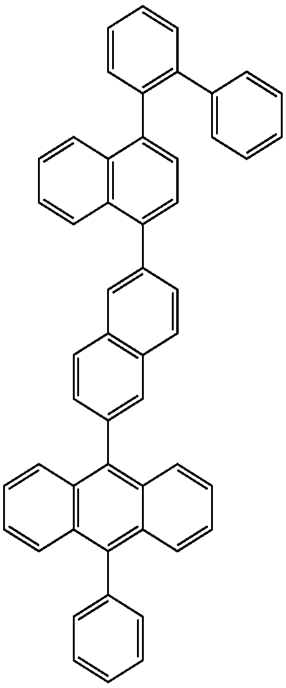

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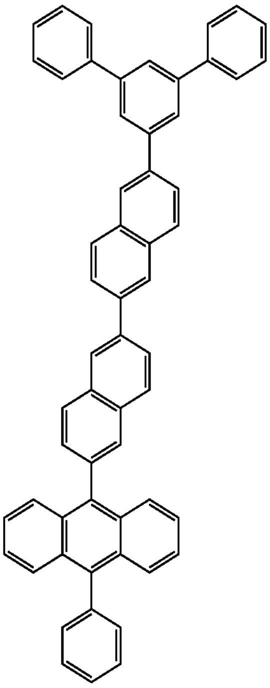

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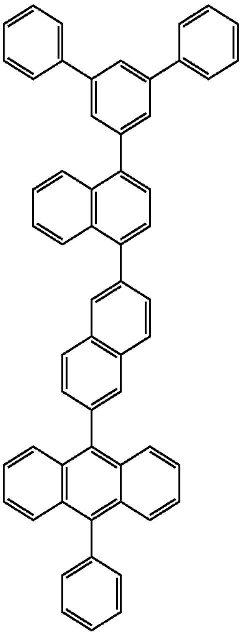

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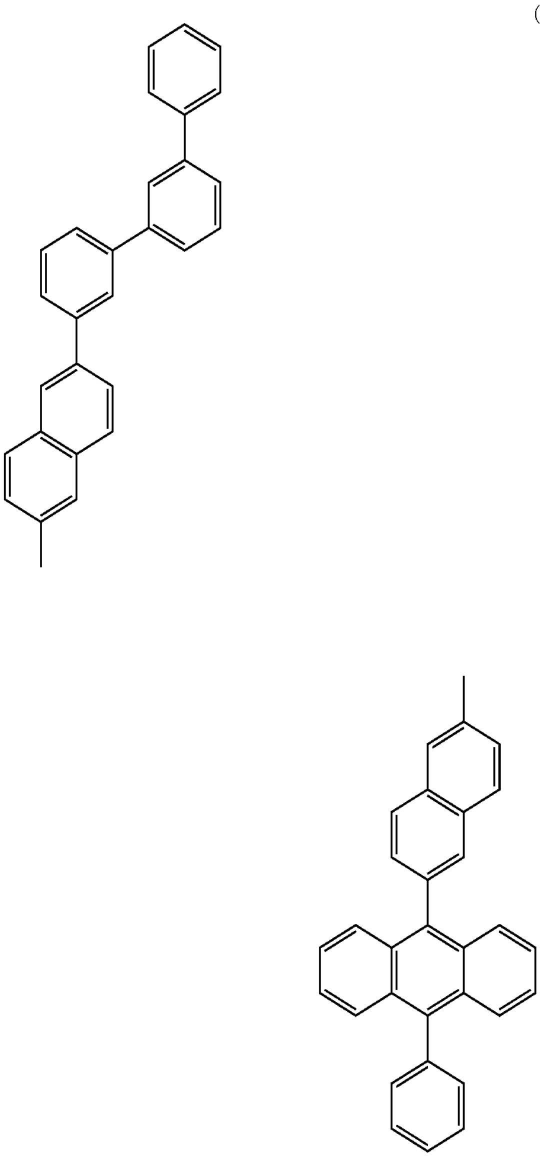

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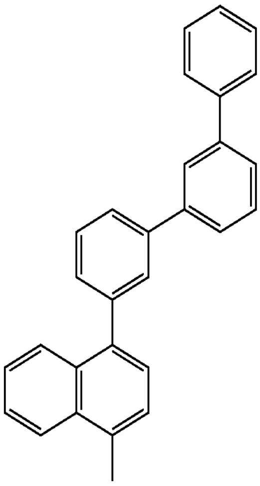

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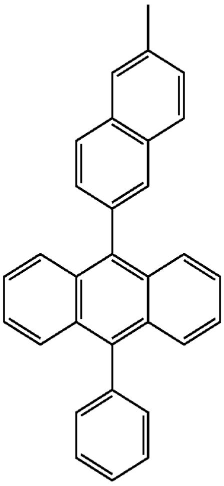

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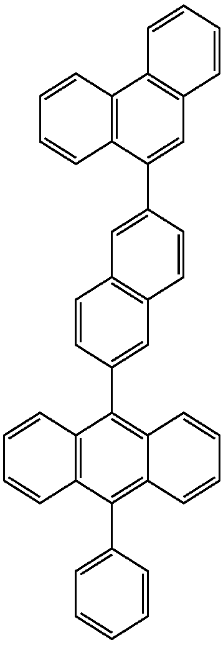

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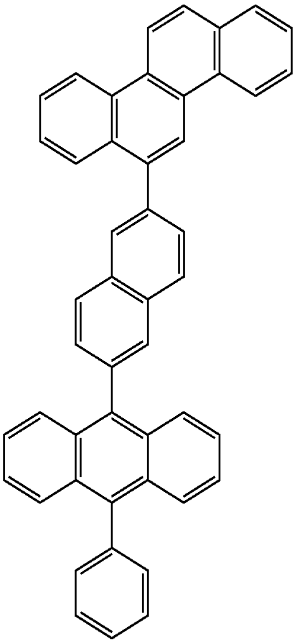

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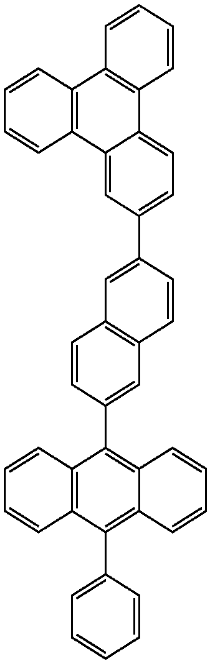

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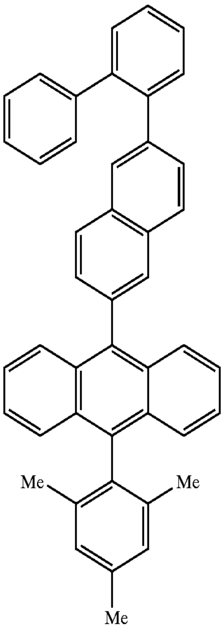

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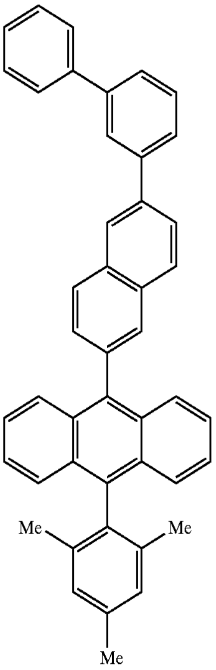

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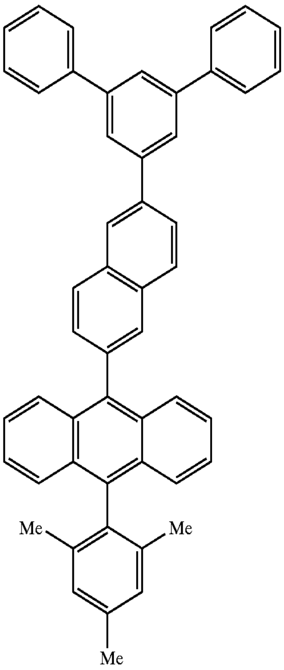

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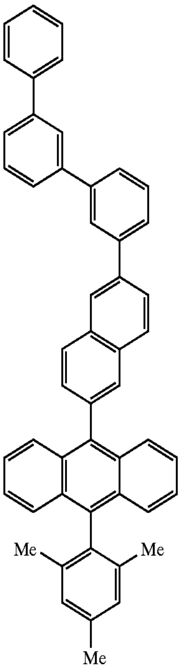

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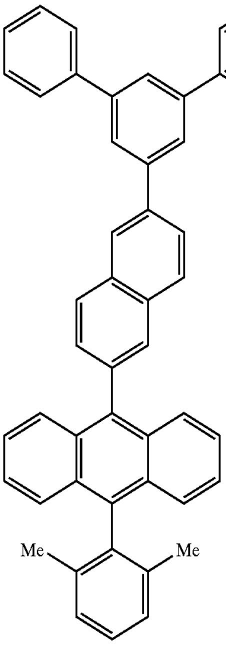

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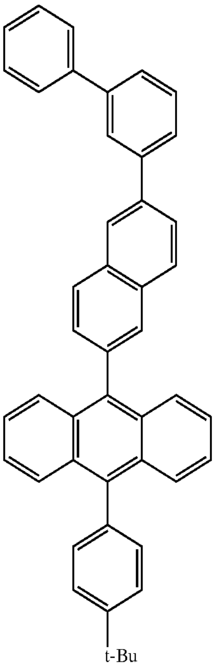

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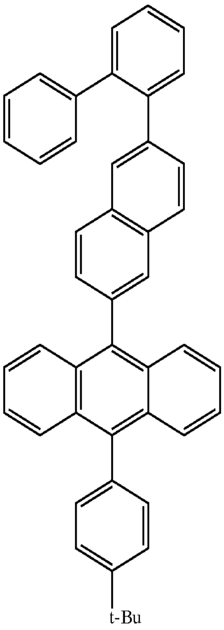

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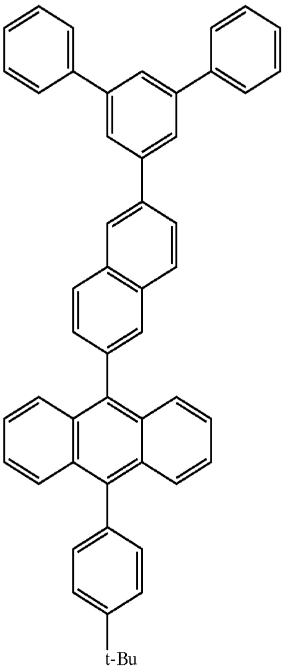

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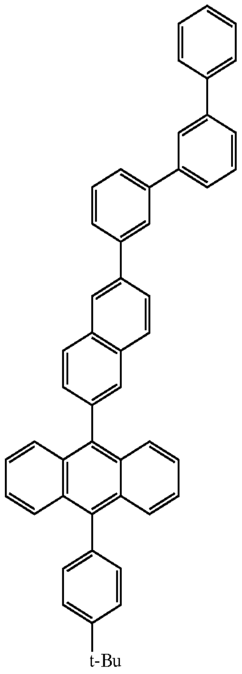

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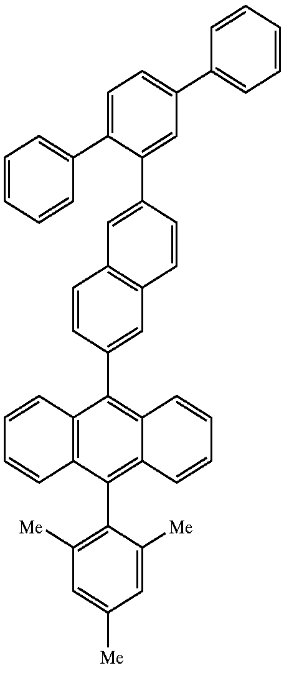

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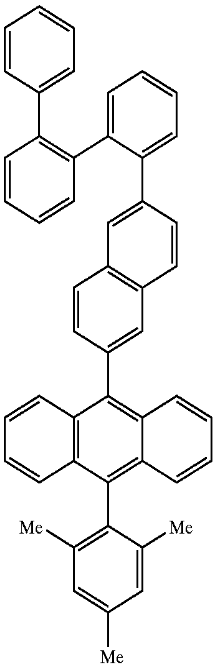

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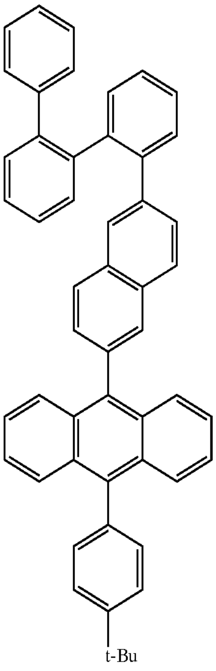

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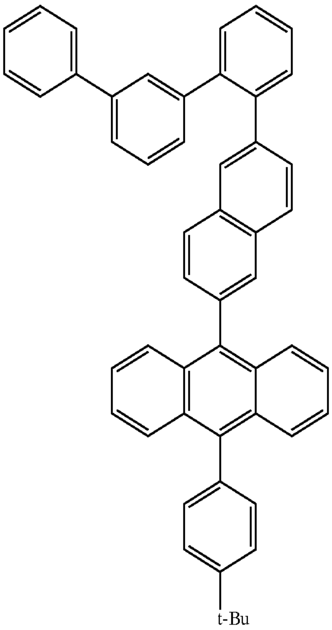

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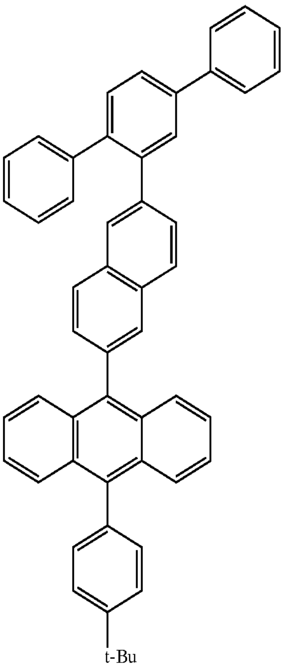

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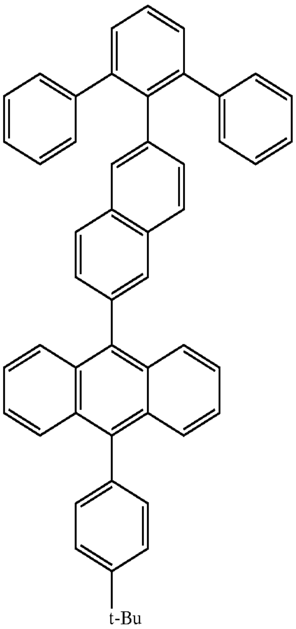

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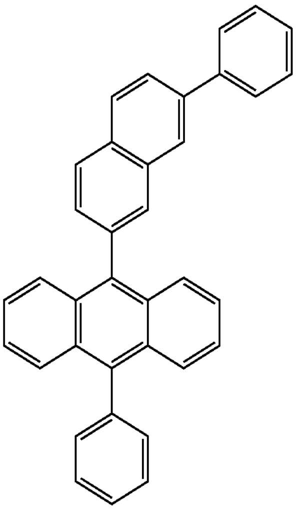

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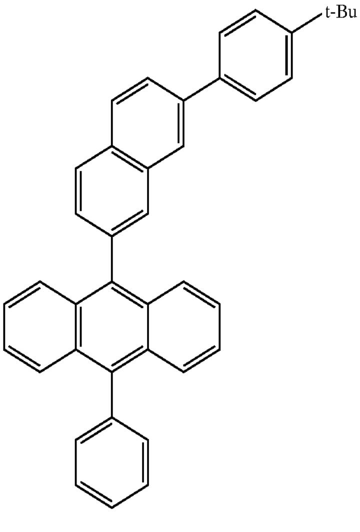

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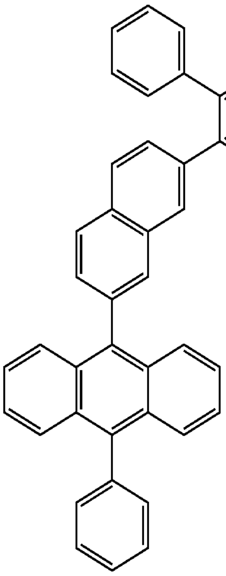

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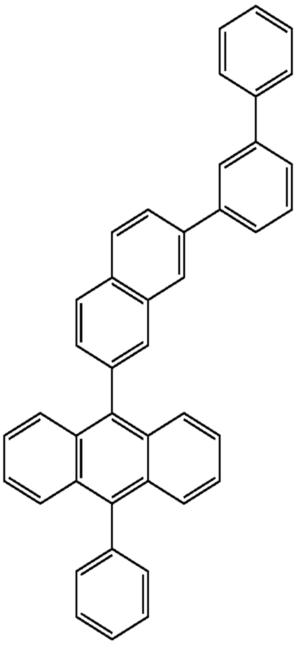

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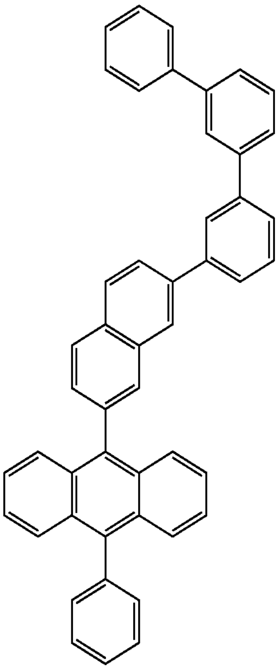

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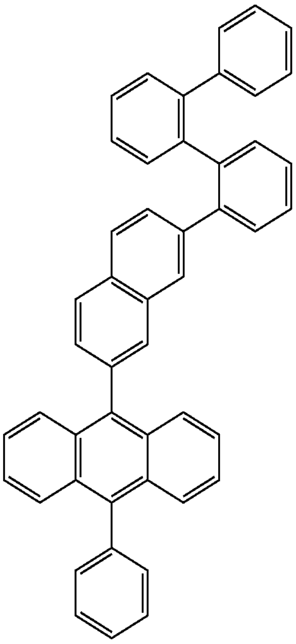

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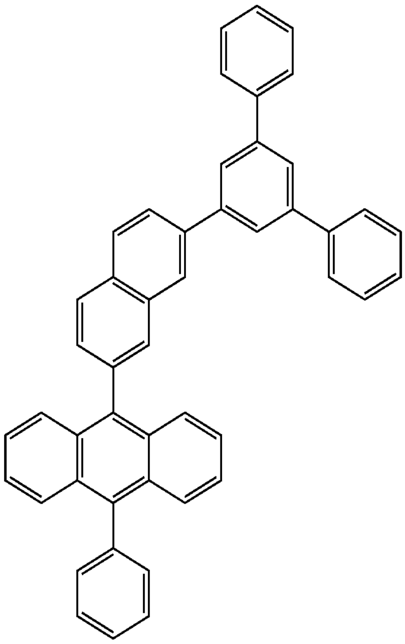

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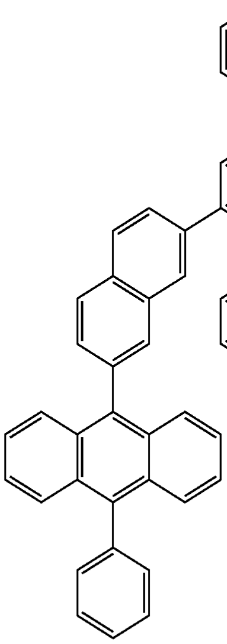

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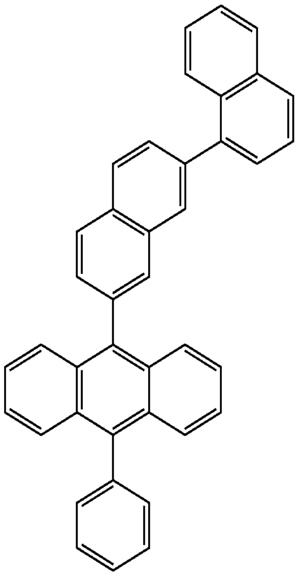

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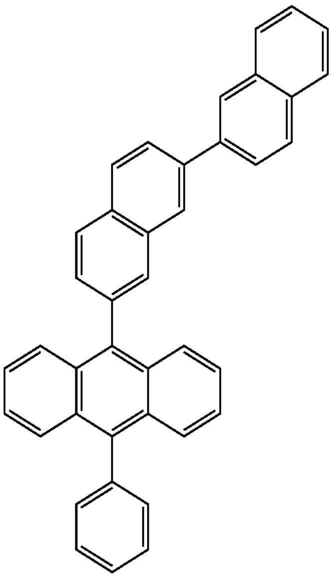

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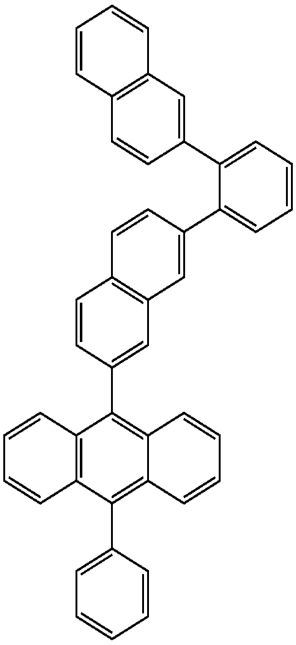

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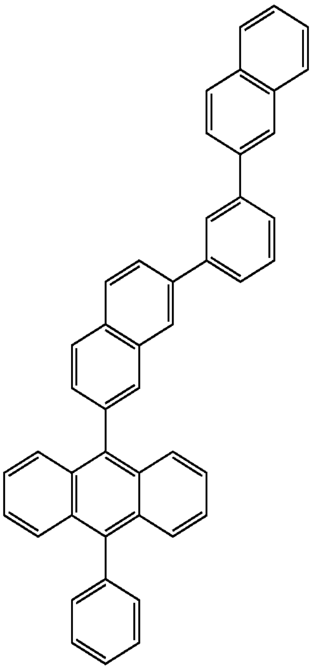

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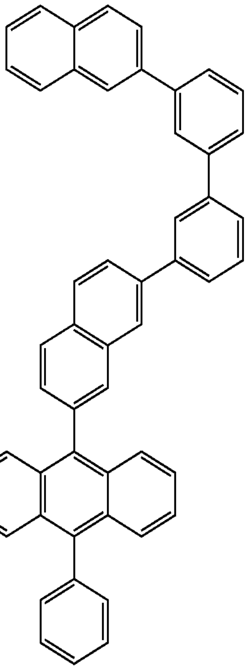

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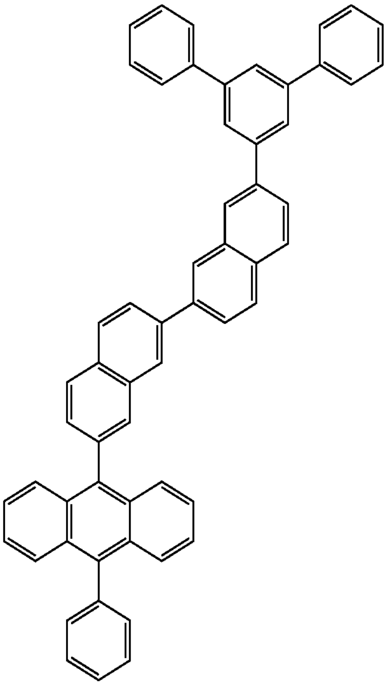

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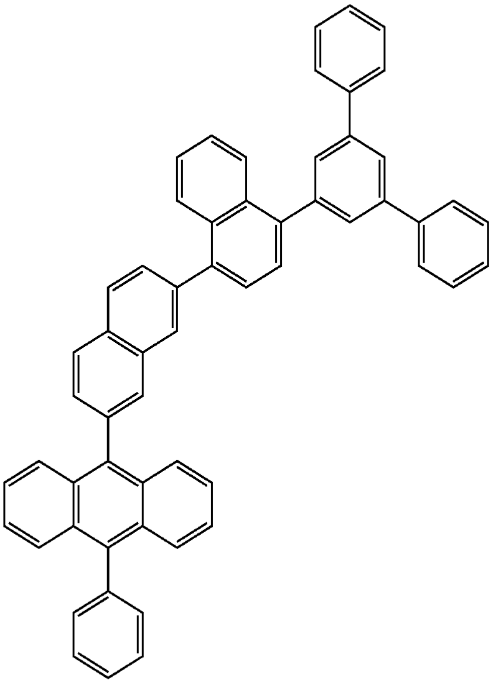

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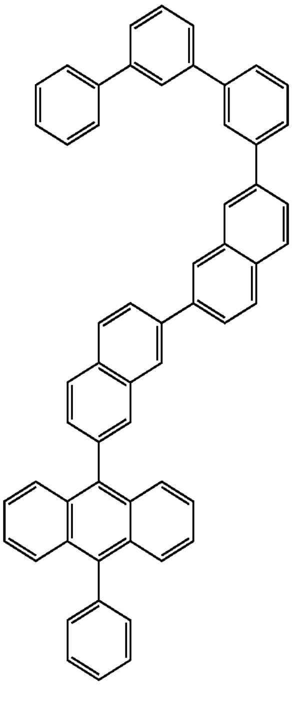

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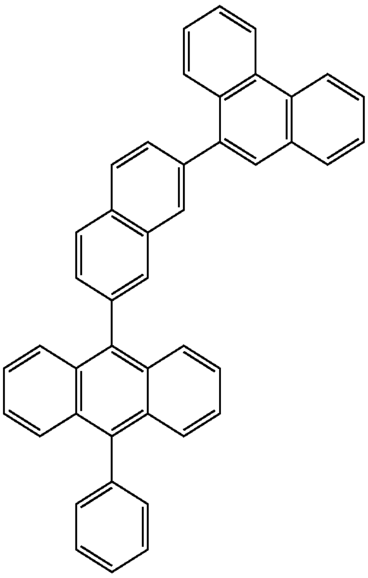

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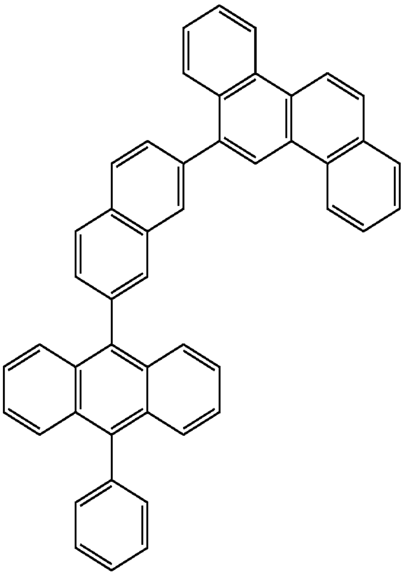

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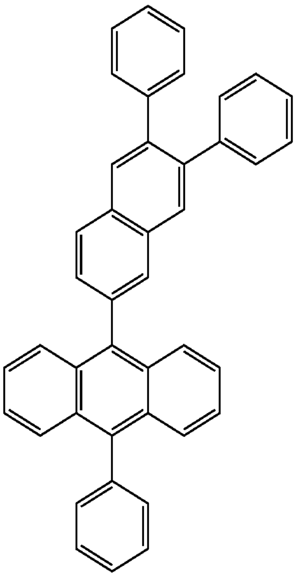

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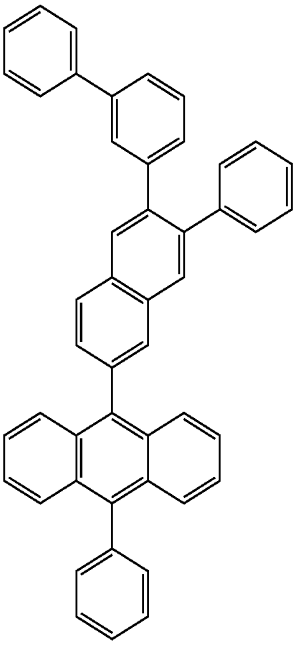

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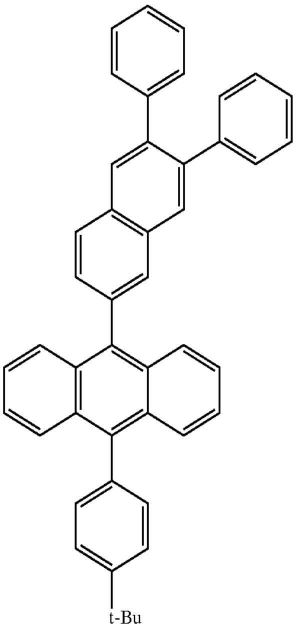

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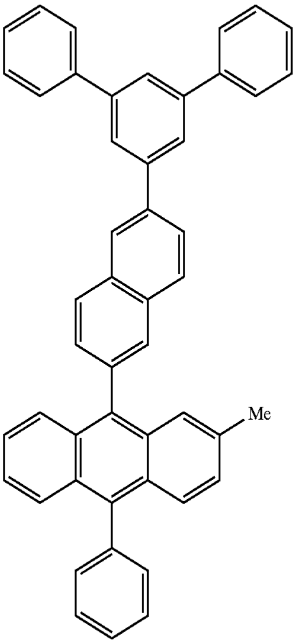

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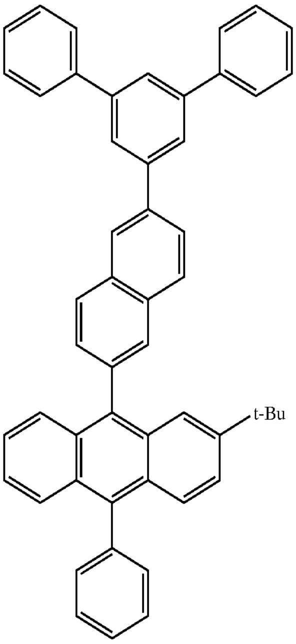

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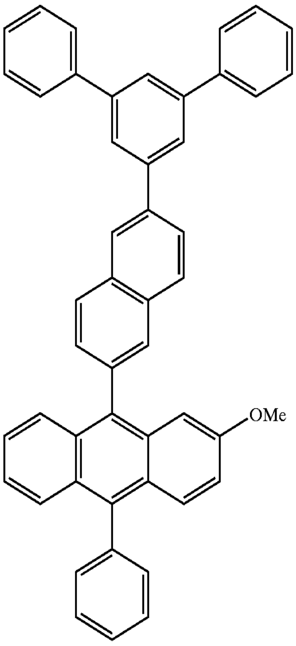

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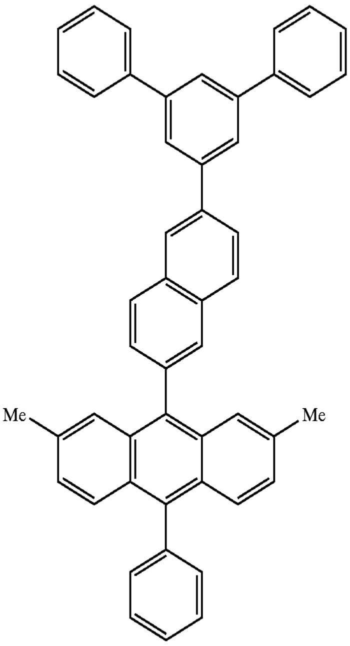

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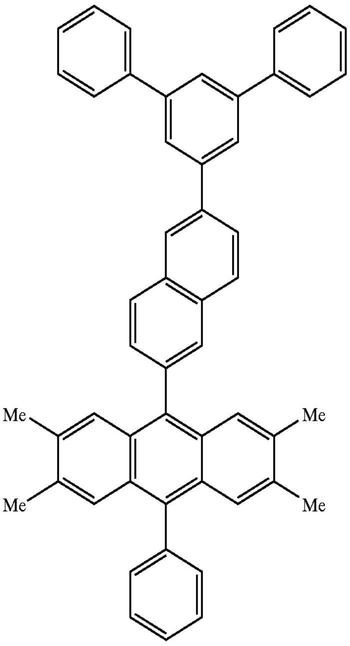

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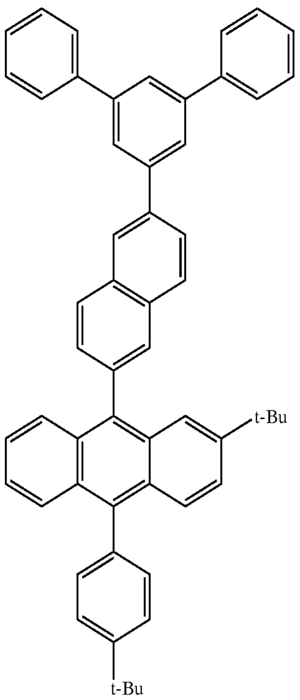
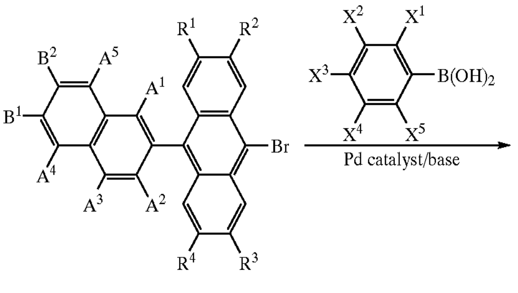


[0054] Among the above specific examples, the compounds (20), (29), (30), (31), (32), (33), (34), (37), (38), (39), (40), (41), (43), (44), (45), (47), (48), (55), (56), (64), (69), (70), (71) and (75) are preferred, wherein the compounds (31), (32), (37), (39), (40), (43), (44), (47) and (55) are more preferred.

[0055] The luminescent material of this invention can be synthesized with known methods like Suzuki coupling reaction, in which an aromatic halide is coupled with an aromatic boric acid by using a palladium catalyst in presence of a base. Two specific examples of the reaction path for synthesizing the luminescent material (1) through Suzuki coupling reaction are given below:

(1)



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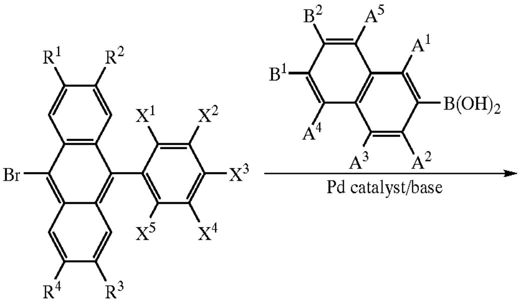
(1)



In the above formulae, R^1—R , X^1—X^5, A^1-A^5 and B^1 and B^2 are defined as above.

[0056] The specific examples of the palladium catalyst used in the reaction include $Pd(PPh_3)_4$, $PdCl_2(PPh_3)_2$, $Pd(OAc)_2$, tris(dibenzylideneacetone) dipalladium(0) and tris(dibenzylideneacetone) dipalladium chloroform complex(0), etc. If required, a phosphine compound can be added to these palladium compounds to accelerate the reaction. The specific examples of the phosphine compound include tri(t-butyl)-phosphine, tricyclohexylphosphine, 1-(N,N-dimethylaminomethyl)-2-(di-t-butyl-phosphine)ferrocene, 1-(N,N-dibutylaminomethyl)-2-(di-t-butylphosphine)ferrocene, 1-(methoxymethyl)-2-(di-t-butylphosphine)ferrocene, 1,1'-bis(di-t-butylphosphine)-ferrocene, 2,2'-bis(di-t-butylphosphine)-1,1'-binaphthyl and 2-methoxy-2'-(di-t-butyl-phosphine)-1'-binaphthyl, etc. Specific examples of the base used in the above reaction include Na_2CO_3, K_2CO_3, Cs_2CO_3, $NaHCO_3$, NaOH, KOH, $Ba(OH)_2$, sodium ethoxide, sodium t-butoxide, sodium acetate, Na_3PO_4 and potassium fluoride, etc. Moreover, specific examples of the solvent used in the reaction include benzene, toluene, xylene, N,N-dimethylformamide, tetrabydrofuran, dietbyl ether, t-butyl methyl ether, 1,4-dioxane, methanol, ethanol, and isopropyl alcohol, etc. The reaction solvent can be suitably selected from the above solvents according to the structures of the aromatic halide and the aromatic boric acid used in the reaction. In addition, the above solvents can be used alone or in combination.

[0057] The luminescent material of this invention is a compound capable of emitting intense fluorescence at the solid state and can be used for emission of various color lights. However, the luminescent material is particularly suitable for emission of blue light. Since the luminescent material of this invention has an asymmetric molecular structure, it is easily formed in an amorphous state in fabrication of OEL devices. In addition, the luminescent material has good thermal resistance and is stable under application of electric field. For the above reasons, the luminescent material of this invention well serves as a luminescent material of OEL devices.

[0058] The luminescent material of this invention is an effective host luminescent material. Though the luminescent material is good as a blue host luminescent material emitting light of short wavelength, it may be used for luminescence of other colors. By using the luminescent material of this invention as a host luminescent material, the energy transfer occurs more efficiently so that EL devices with higher efficiency and longer lifetime can be obtained.

[0059] The second point of this invention is an OEL device of which the luminescent layer contains a luminescent material expressed by formula (1) of this invention. The OEL device of this invention not only has higher efficiency and longer lifetime, but also has lower driving voltage and higher durability in preservation and in operation.

[0060] The OEL device of this invention can be formed with one of various structures, having typically a multi-layer structure in which a hole-transporting layer, a luminescent layer and an electron-transporting layer are disposed between an anode and a cathode. Specific examples of the multi-layer structure include 1) anode/hole-transporting layer/luminescent layer/electron-transporting layer/cathode, 2) anode/hole-injecting layer/hole-transporting layer/luminescent layer/electron-transporting layer/cathode and 3) anodelhole-injecting layer/hole-transporting layer/luminescent layer/electron-transporting layer/electron-injecting layer/cathode.

[0061] Because the luminescent material of this invention has higher luminescence quantum yield and is better in the properties of hole injection, hole transportation, electron injection and electron transportation, it can be used in the luminescent layer effectively. In the OEL device of this invention, the luminescent layer can be formed only from the luminescent material of this invention. However, by combining the luminescent material of this invention with other luminescent material or luminescent dopant material, the OEL device can have higher luminescence brightness or efficiency and may emit blue, green, red or white light. Moreover, when a combined luminescent material is to be used, the luminescent material of this invention may alternatively be used as a luminescent dopant. However, to improve the luminescent efficiency and the lifetime of the OEL devices, the luminescent material of this invention is preferably used together with other luminescent material or luminescent dopant.

[0062] Other luminescent materials or luminescent dopants that can be used in the luminescent layer together with the luminescent material of this invention include the daylight fluorescent materials, fluorescent whitening agents, laser pigments, organic scintillators and various fluorescence-analysis reagents described in page 236, Optical Functional Materials (Vol. 6) of *the Series of Polymer Functional Materials* (edited by the Society of Polymer Science, Japan and co-published in 1991), and the dopant materials and the triplet luminescent materials respectively described in pages 155-156 and pages 170-172, OEL Materials & Display, which is edited under the supervision of Kido Junji and published by CMC Publishing Co. Ltd.

[0063] The compounds that can be used as other luminescent materials or luminescent dopants include polycyclic aromatic compounds, heteroaromatic compounds, organometallic complexes, pigments, polymeric luminescent materials, styryl derivatives, aromatic amine derivatives, coumarin derivatives, borane derivatives, oxazine derivatives, compounds containing a spiro-ring, oxadiazole derivatives and fluorene derivatives, etc. Examples of the polycyclic aromatic compounds include anthracene derivatives, phenanthrene derivatives, naphthacene derivatives, pyrene derivatives, chrysene derivatives, perylene derivatives, coronene derivatives and rubrene derivatives, etc. Examples of the heteroaromatic compounds include oxadiazole derivatives having a dialkylamino group or a diarylamino group, pyrazoloquinoline derivatives, pyridine derivatives, pyran derivatives, phenanthroline derivatives, silole derivatives, thiophene derivatives having a triphenylamino group, and quinacridon derivatives, etc. Examples of the organometallic complexes include any combination of the following metal elements with the following organic ligands. The metal elements include Zn, Al, Be, Eu, Th, Dy, Ir and Pt, etc., and the organic ligands include quinolinol derivatives, benzoxazole derivatives, benzothiazole derivatives, oxadiazole derivatives, thiadiazole derivatives, phenylpyridine derivatives, phenylbenzoimidazole derivatives, pyrrole derivatives, pyridine derivatives and phenanthroline derivatives, etc. Examples of the pigments include xanthene derivatives, polymethine derivatives, porphyrin derivatives, coumarin derivatives, dicyanomethylenepyran derivatives, dicyanomethylenethiopyran derivatives, oxobenzanthracene derivatives, carbostyryl derivatives, perylene derivatives, benzoxazole derivatives, benzothiazole derivatives and benzoimidazole derivatives, etc. Examples of the polymeric luminescent materials include polyparaphenylvinylene derivatives, polythiophene derivatives, polyvinylcarbazole derivatives, polysilane derivatives, polyfluorene derivatives and polyparaphenylene derivatives, etc.

[0064] Examples of the styryl derivatives include amine-containing styryl derivatives and styrylarylene derivatives, etc.

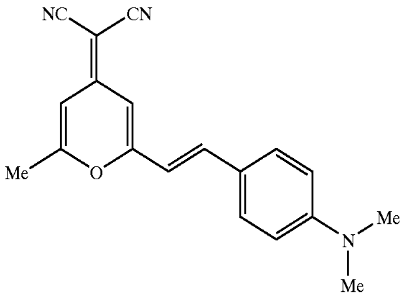
[0065] Particularly, the luminescent dopant is preferably a perylene derivative, a borane derivative, an amine-containing styryl derivative, an aromatic amine derivative, a coumarin derivative, a pyran derivative, an iridium complex or a platinum complex. Specific examples of the perylene derivatives include 3,10-bis(2,6-dimethylphenyl)-perylene, 3,10-bis(2,4,6-trimethylphenyl)perylene, 3,10-diphenylperylene, 3,4-diphenyl-perylene, 2,5,8,11-tetra-t-butylperylene, 3,4,9,10-tetraphenylperylene, 3-(1'-pyrenyl)-8,11-di(t-butyl)perylene, 3-(9'-anthryl)-8,11-di(t-butyl)perylene and 3,3'-bis(8,11-di(t-butyl)perylenyl), etc. Specific examples of the borane derivatives include 1,8-diphenyl-10-(dimesitylboryl)anthracene, 9-phenyl-10-(dimesitylboryl)-anthracene, 4-(9'-anthryl)dimesitylborylnaphthalene, 4-(10'-phenyl-9'-anthryl)-dimesitylborylnaphthalene, 9-(dimesitylboryl)anthracene, 9-(4'-biphenylyl)-10-(dimesitylboryl)anthracene and 9-(4'-(N-carbazolyl)phenyl)-10-(dimesitylboryl)-anthracene, etc. Specific examples of the coumarin derivatives include Coumarin-6 and Coumarin-334.

[0066] Specific examples of the amine-containing styryl derivatives include N,N,N',N'-tetra(4-biphenylyl)-4,4'-diaminostilbene, N,N,N',N'-tetra(1-naphthyl)-4,4'-diaminostilbene, N,N,N',N'-tetra(2-naphthyl)-4,4'-diaminostilbene, N,N'-di(2-naphthyl)-N,N'-diphenyl-4,4'-diaminostilbene, N,N'-di(9-phenanthryl)-N,N'-diphenyl-4,4'-diamino-stilbene, 4,4'-bis[4"-bis(diphenylamino)styryl]biphenyl, 1,4-bis[4'-bis(diphenylamino)-styryl]benzene, 2,7-bis[4'-bis(diphenylamino)styryl]-9,9-dimethylfluorene, 4,4'-bis(9-ethyl-3-carbazolevinylene)biphenyl, and 4,4'-bis(9-phenyl-3-carbazolevinylene)-biphenyl, etc.

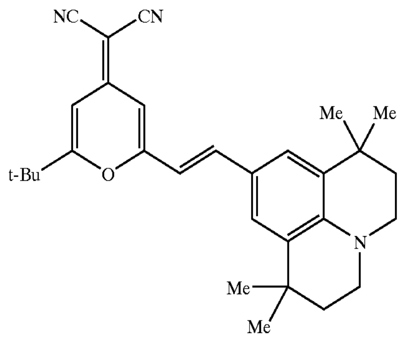
[0067] Specific examples of the aromatic amine derivatives include N,N,N,N-tetraphenylanthracene-9,10-diamine, 9,10-bis(4-diphenylamino-phenyl)anthracene, 9,10-bis(4-di(1-naphthylamino)phenyl)anthracene, 9,10-bis(4-di(2-naphthylamino)-phenyl)anthracene, 10-di-p-torylamino-9-(4-di-p-torylamino-1-naphthyl)anthracene, 10-diphenylamino-9-(4-diphenylamino-1-naphthyl)anthracene, 10-diphenylamino-9-(6-diphenylamino-2-naphthyl)anthracene, [4-(4-diphenylamino-phenyl)naphthalene-1-yl]diphenylamine, [6-(4-diphenylamino-phenyl)naphthalene-2-yl]diphenylamine, 4,4'-bis[4-diphenylaminonaphthalene-1-yl]biphenyl, 4,4'-bis[6-diphenylamino-naphthalene-2-yl]biphenyl, 4,4"-bis(4-

diphenylaminonaphthalene-1-yl)-p-terphenyl and 4,4''-bis(6-diphenylaminonaphthalene-2-yl)-p-terphenyl, etc.

[0068] Specific examples of the pyran derivatives include DCM and DCJTB, etc.

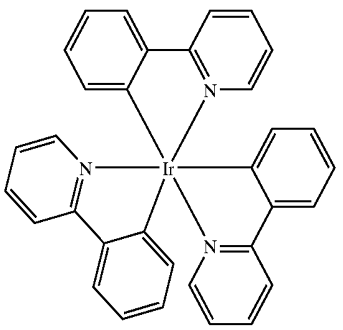


DCM



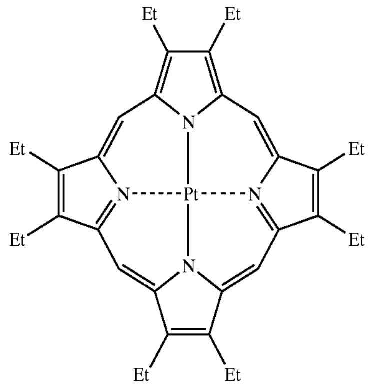
DCJTB

[0069] Specific examples of the iridium complexes include Ir(ppy)$_3$, etc.



Ir(ppy)3

[0070] Specific examples of the platinum complexes include PtOEP, etc.



PtOEP

[0071] The added amount of the dopant depends on the species thereof, and is preferably determined matching the properties of the dopant. Generally, the amount of the dopant is 0.001-50 wt %, preferably 0.1-10 wt %, relative to the total amount of the luminescent material.

[0072] The electron-transporting material and the electron-injecting material used in the OEL device of this invention can be freely selected from the compounds that can be used as electron-transfer compounds in photoconductive materials and the compounds that can be used in the electron-injecting layer and electron-transporting layer of the prior-art OEL devices.

[0073] Specific examples of such electron-transfer compounds include quinolinol metal complexes, pyridine derivatives, phenanthroline derivatives, diphenylquinone derivatives, perylene derivatives, oxadiazole derivatives, thiophene derivatives, triazole derivatives, thiadiazole derivatives, metal complexes of oxine derivatives, quinoxaline derivatives, polymers of quinoxaline derivatives, benzazole compounds, gallium complexes, pyrazole derivatives, perfluorinated phenlylene derivatives, triazine derivatives, pyrazine derivatives, benzoquinoline derivatives, imidazopyridine derivatives and borane derivatives, etc.

[0074] Preferred examples of the electron-transfer compounds include quinolinol metal complexes, pyridine derivatives and phenanthroline derivatives. Specific examples of the quinolinol metal complexes include tris(8-hydroxyquinoline) aluminum (abbre. to ALQ, hereinafter), bis(10-hydroxybenzo[h]quinoline) beryllium, tris(4-methyl-8-hydroxyquinoline)aluminum and bis(2-methyl-8-hydroxy-quinoline)-(4-phenylphenol)aluminum, etc. Specific examples of the pyridine derivatives include 2,5-bis(6'-(2',2''-bipyridyl)-1,1-dimethyl-3,4-diphenylsilole (hereinafter as PyPySPyPy), 9,10-di(2',2''-bipyridyl)anthracene, 2,5-di(2',2''-bipyridyl)thiophene, 2,5-di(3',2''-bipyridyl)thiophene and 6',6''-di(2-pyridyl)-2,2':4',3'':2'',2'''-quaterpyridine, etc. Specific examples of the phenanthroline derivatives include 4,7-diphenyl-1,10-phenanthroline, 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline, 9,10-di(1,10-phenanthroline-2-yl)anthracene, 2,6-di(1,10-phenanthroline-5-yl)pyridine, 1,3,5-tri(1,10-phenanthroline-5-yl)benzene and 9,9'-difluoro-bis(1,10-phenanthroline-5-yl), etc. Particularly, when a pyridine derivative or phenanthroline derivative is used in the electron-transporting layer or electron-injecting layer, lower driving voltage and higher luminescence efficiency can be achieved.

[0075] The hole-transporting material and the hole-injecting material used in the OEL device of this invention can be freely selected from the compounds that are conventionally used as the charge-transporting materials of electron holes in photoconductive materials and the compounds that are known to be used in the hole-injecting layers and hole-transporting layers of conventional OEL devices.

[0076] Specific examples of such compounds include carbazole derivatives, triarylamine derivatives and phthalocyanine derivatives, etc. Specific examples of the carbazole derivatives include N-phenylcarbazole and polyvinylcarbazole, etc. Specific examples of the triarylamine derivatives include polymers having aromatic tertiary amino groups on the main chain or the side chain, 1,1-bis(4-di-p-torylaminophenyl)cyclohexane, N,N'-diphenyl-N,N'-di(3-methylphenyl)-4,4'-diaminobiphenyl, N,N'-diphenyl-N,N'-dinaphthyl-4,4'-diaminobiphenyl (hereinafter as NPD), 4,4',4"-tris[N-(3-methyl-phenyl)-N-phenylamino] triphenylamine and star-burst amine derivatives, etc. Specific examples of the phthalocyanine derivatives include metal-free phthalocyanine and copper phthalocyanine, etc.

[0077] Each of the layers constituting the OEL device of this invention can be formed by making the constituent material of the layer into a film through evaporation deposition, spin cast or a casting method. Though the thickness of each film such formed is not particularly limited and can be suitably set according to the properties of the constituent material, the thickness is usually set in the range of 2 nm to 5000 nm. Moreover, in order to obtain a uniform film easily and to make pinholes difficult to form, the method for making the luminescent material into a film is preferably evaporation deposition. When evaporation deposition is utilized to make a thin film, the deposition conditions vary with the type of the luminescent material of this invention and the required crystal structure and association structure of the molecular deposition film. Generally, the deposition conditions are preferably set suitably within the following ranges: boat temperature between 50° C. and 400° C., vacuum degree between 10^{-6} Pa and 10^{-3} Pa, deposition rate between 0.01 nm/sec and 50 nm/sec, substrate temperature between −150° C. and 300° C., and film thickness between 5 nm and 5 μn.

[0078] The OEL device of this invention is preferably supported on a substrate, regardless which of the aforementioned device structures is adopted. The substrate preferably has mechanical strength, thermal stability and transparency, and can be a glass substrate or a transparent plastic film. The anode material can be metal, metal alloy or an electrically conductive compound that has a work function larger than 4 eV, or a mixture thereof. Specific examples thereof include some metals like Au, Cul, indium tin oxide (ITO), SnO_2 and ZnO, etc.

[0079] The cathode material can be metal, metal alloy or an electrically conductive compound that has a work function smaller than 4 eV, or a mixture thereof. Specific examples thereof include Al, Ca, Mg, Li, Mg-alloy and Al-alloy, etc. Specific examples of the metal alloy include Al/LiF, Al/Li, Mg/Ag and Mg/In, etc. To enhance the luminescence efficiency of the OEL device, it is desired that at least one of the anode and cathode has a transparency higher than 10%. The sheet resistance of the electrode is preferably hundreds of ohms per square or lower. Moreover, though the electrode film thickness depends on the properties of the electrode material, it is usually set within the range of 10 nm-1 μm, preferably within the range of 10-400 nm. Such an electrode can be formed as a film through evaporation deposition or sputtering deposition of an abovementioned electrode material.

[0080] An exemplary method for fabricating an OEL device using the luminescent material of this invention is described as follows, wherein the OEL device has the aforementioned structure of anode/hole-injecting layer/hole-transporting layer/luminescent layer (the luminescent material of this invention plus dopant)/electron-transporting layer/cathode. After the anode is made by forming a film of the anode material on a suitable substrate through evaporation deposition, films of the hole-injecting layer and hole-transporting layer are formed on the anode. A luminescent layer is made on the resulting structure as a film formed through co-evaporation deposition of the luminescent material of this invention and a dopant, an electron-transporting layer is formed on the luminescent layer, and then a film of a cathode material is formed through evaporation deposition as a cathode. Thus, the object OEL device is fabricated. Moreover, it is also possible to reverse the above step sequence in the fabrication of the OEL device, that is, to form a cathode, an electron-transporting layer, a luminescent layer, a hole-transporting layer, a hole-injecting layer and an anode in sequence.

[0081] Moreover, co-evaporation deposition of the luminescent material and the dopant can be done with a known method. Specifically, the substrate is placed in the upper part of a vacuum chamber, and the two evaporation sources are set in the under part of the vacuum chamber. By evaporating the materials from the two evaporation sources simultaneously, the two materials are mixed and deposited on the substrate. In addition, a partition board is disposed between the two evaporation sources, and film thickness monitors are disposed near the substrate and near each evaporation source. By evaporating the two materials at the same time in constant evaporation rates, a film with a desired mixing ratio can be obtained. Moreover, because there is a partition board between the two evaporation sources, the film-thickness monitor set near one evaporation source does not sense the molecules from the other evaporation source, so that the evaporation rate of each source can be detected using the corresponding monitor. Meanwhile, because the film thickness monitor disposed near the substrate can detect the molecules evaporated from the two evaporation sources, the thickness of the deposited film is detected continuously so that the film thickness on the substrate can be adjusted to the desired one. In this invention, the co-evaporation deposition method is not restricted to that mentioned above, and can be any known method. The principle of the co-evaporation deposition is disclosed, for example, as two-source evaporation deposition in Chapter 9.2 (page 153), 2nd version of *Optical Film* in *Series II of Optical Techniques,* published on Oct. 10, 1986 by Kyoritsu Shuppan Co., Ltd. In addition, the scheme of a practical evaporation apparatus is disclosed, for example, as an evaporation deposition apparatus of organic polymer in Chapter 1.1, Part 3 (FIG. 8 in page 125) of the enlarged and revised edition of *Manual of Light/Film Techniques,* published on Aug. 31, 1992 by Optronics Co., Ltd. Moreover, Japanese Patent Publication No. 2002-76027 discloses a method of fabricating a coevaporation-deposited organic film. In addition, the application in fabrication of

OEL devices is disclosed in, for example, C. W. Tang, S. A. VanSlyke, and C. H. Chen, *J. Appl. Phys.,* 65(9), 3610-3616, (1989).

[0082] When the OEL device such obtained is applied with a DC voltage, the anode and the cathode are preferably coupled to positive and negative polarity, respectively, and light emission can be observed from the side(s) of the transparent or semi-transparent electrode(s), i.e., the side of the anode or cathode or the sides of both, by applying a voltage of 2-40V. Moreover, the OEL device also emits light when applied with an AC voltage, wherein the AC voltage can have any waveform. This invention will be explained in more details based on the following Examples.

EXAMPLE 1

[0083] Synthesis of Compound (32)

[0084] In a nitrogen ambient, 3.33 g of 9-bromo-10-phenylanthracene and 4.8 g of 6-(m-terphenyl-5'-yl)naphthalene-2-boric acid are dissolved in 100ml of a mixed solvent of toluene and ethanol in a weight ratio of 4:1, and then 0.58 g of tetrakis(triphenylphosphine)palladium(0) is added. The solution is stirred for 5 minutes, and then 10 ml of 2M aqueous solution of sodium carbonate is added, followed by reflux of 8 hours. After the reflux, the reaction solution is cooled. The organic layer is separated and collected, washed with saturated NaCl solution, and then dried with anhydrous magnesium sulfate. After the drying agent is removed, the solvent is removed through low-pressure distillation to obtain a solid material, which is purified with a silica gel column and a solvent of heptane and toluene in a ratio of 3:1 and then purified through sublimation to obtain 3.7 g of the target compound (32). The structure of compound (32) is confirmed with mass spectrum and NMR, and the physical properties of the same are listed as follows:

[0085] Melting point: 280° C.

[0086] Glass-transition temperature (T_g): 143° C. (measuring apparatus: Diamond DSC, made by PERKIN-ELMER Company; measurement conditions: cooling rate=200° C./min, and heating rate=10° C./min)

[0087] Fluorescence quantum yield (in toluene solution): 0.82 (measuring apparatuses: V-560 and FP-777W, made by JASCO Corporation)

EXAMPLE 2

[0088] Synthesis of Compound (69)

[0089] In a nitrogen ambient, 3.89 g of 9-bromo-10-(t-butylphenyl)anthracene and 4.8 g of 6-(m-terphenyl-5'-yl-)naphthalene-2-boric acid are dissolved in 100 ml of a mixed solvent of toluene and ethanol in a weight ratio of 4:1, and then 0.58 g of tetrakis(triphenylphosphine)palladium(0) is added. The solution is stirred for 5 minutes, and then 10 ml of 2M aqueous solution of sodium carbonate is added, followed by reflux of 8 hours. After the reflux, the reaction solution is cooled. The organic layer is separated and collected, washed with saturated NaCl solution, and then dried with anhydrous magnesium sulfate. After the drying agent is removed, the solvent is removed through low-pressure distillation to obtain a solid material, which is purified with a silica gel column and a solvent of heptane and toluene in a ratio of 3:1 and then purified through sublimation to obtain 3.0 g of the target compound (69). The structure of the compound (69) is confirmed with mass spectrum and NMR, and the physical properties of the same are listed as follows:

[0090] Melting point: 300° C.

[0091] Glass-transition temperature (T_g): 162° C. (measuring apparatus: Diamond DSC, made by PERKIN-ELMER Company; measurement conditions: cooling rate=200° C./min, and heating rate=10° C./min)

EXAMPLE 3

[0092] Synthesis of Compound (40)

[0093] In a nitrogen ambient, 4.35 g of 2-(6-bromo-naphthalene-2-yl)-[1,1';4',1"]-terphenyl and 4.5 g of 10-phenyl-anthracene-9-boric acid are dissolved in 50 ml of a mixed solvent of toluene and ethanol in a weight ratio of 4:1, and then 0.34 g of tetrakis(triphenylphosphine)palladium(0) is added. The solution is stirred for 5 minutes, and then 10 ml of 2M aqueous solution of sodium carbonate is added, followed by reflux of 10 hours. After the reflux, the reaction solution is cooled. The organic layer is separated and collected, washed with saturated NaCl solution, and then dried with anhydrous magnesium sulfate. After the drying agent is removed, the solvent is removed through low-pressure distillation to obtain a solid material, which is purified with a silica gel column and a solvent of heptane and toluene in a ratio of 3:1 and then purified through sublimation to obtain 4.9 g of the target compound (40). The structure of the compound (40) is confirmed with mass spectrum and NMR, and the physical properties of the same are listed as follows:

[0094] Melting point: 305° C.

[0095] Glass-transition temperature (T_g): 147° C. (measuring apparatus: Diamond DSC, made by PERKIN-ELMER Company; measurement conditions: cooling rate=200° C./min, and heating rate=10° C./min)

[0096] By selecting suitable raw-material compounds, the other luminescent materials of this invention can be readily synthesized based on the method mentioned in the above Synthesis Examples.

EXAMPLE 4

[0097] A glass substrate of 26 mm×28 mm×0.7 mm having been deposited with ITO of 150 nm in thickness through evaporation deposition, which was produced by Tokyo Sanyo Vacuum Industries Co., Ltd., was provided as a transparent support substrate. The transparent support substrate is fixed by the substrate holder of a commercially available evaporation deposition apparatus, which was made by ULVAC KIKO, Inc. Molybdenum evaporation boats loaded with copper phthalocyanine, NPD, the compound (32), ALQ and LiF, respectively, as well as a tungsten evaporation boat loaded with Al, were installed to the apparatus. The pressure in the vacuum chamber was reduced to 1×10^{-3} Pa, and the evaporation boat loaded with copper phthalocyanine is heated to evaporate and deposit copper phthalocyanine to a thickness of 20 nm to form a hole-injecting layer. Next, the evaporation boat loaded with NPD is heated to evaporate and deposit NPD to a thickness of 30 nm to form a hole-transporting layer. The evaporation boat loaded with compound (32) is then heated to evaporate and deposit the same to a thickness of 35 nm to form a luminescent layer. Subsequently, the evaporation boat loaded with ALQ is heated to evaporate and deposit ALQ to a thickness of 15 nm to form an electron-transporting layer. The evaporation rates in the above steps were between 0.1 nm/sec and 0.2 nm/sec. Thereafter, the evaporation boat loaded with LiF is heated to evaporate and deposit LiF to a thickness of 0.5 nm in a rate of 0.003-0.01 nm/sec, and then the evaporation boat loaded with Al is heated to evaporate and deposit Al to a thickness of 100 nm in a rate of 0.2-0.5 nm/sec. Thus, an OEL device was obtained. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 4.6 V was applied between them to produce a current of about 4 mA/cm and cause emission of blue light of 438 nm in a luminescence efficiency of 31 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 1200cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 300 hours.

EXAMPLE 5

[0098] An OEL device was obtained with the same method in Example 4, except that the compound (32) was replaced by the compound (69). The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 4.8V was applied between them to produce a current of about 4.2 mA/cm and cause emission of blue light of 439 nm in a luminescence efficiency of 2.51 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 1100 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 260 hours.

EXAMPLE 6

[0099] An OEL device was obtained with the same method in Example 4, except that ALQ used as the material of the electron-transporting layer in Example 4 was replaced by PyPySPyPy. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 3V was applied between them to produce a current of about 3 mA/cm^2 and cause emission of blue light of 442 nm in a luminescence efficiency of 3.81 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 1700 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 200 hours.

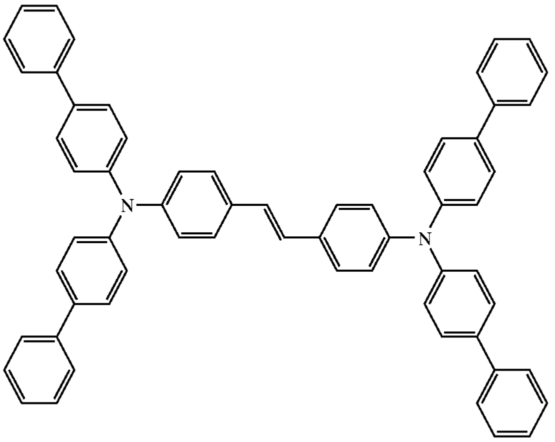
EXAMPLE 7

[0100] A glass substrate of 26 mm×28 mm×0.7 mm having been deposited with ITO of 150 nm in thickness through evaporation deposition, which was produced by Tokyo Sanyo Vacuum Industries Co., Ltd., was provided as a transparent support substrate. The transparent support substrate is fixed by the substrate holder of a commercially available evaporation deposition apparatus, which was made by ULVAC KIKO, Inc. Molybdenum evaporation boats loaded with copper phthalocyanine, NPD, the compound (32), 3,10-bis(2,6-dimethylphenyl)perylene, ALQ and LiF, respectively, as well as a tungsten evaporation boat loaded with Al, were installed to the apparatus. The pressure in the vacuum chamber was reduced to 1×10^{-3} Pa, and the evaporation boat loaded with copper phthalocyanine is heated to evaporate and deposit copper phthalocyanine to a thickness of 20 nm to form a hole-injecting layer. Next, the evaporation boat loaded with NPD is heated to evaporate and deposit NPD to a thickness of 30 nm to form a hole-transporting layer. The evaporation boat loaded with compound (32) and that loaded with 3,10-bis(2,6-dimethylphenyl)perylene are then heated to evaporate and deposit the two compounds together to a thickness of 35 nm to foor a luminescent layer, wherein the doping concentration of 3,10-bis(2,6-dimethylphenyl)perylene is about 1 wt %. Subsequently, the evaporation boat loaded with ALQ is heated to evaporate and deposit ALQ to a thickness of 15 nm to form an electron-transporting layer. The evaporation rates in the above steps were between 0.1 mm/sec and 0.2 nm/sec. Thereafter, the evaporation boat loaded with LiF is heated to evaporate and deposit LiF to a thickness of 0.5 nm in a rate of 0.003-0.01 nm/sec, and then the evaporation boat loaded with Al is heated to evaporate and deposit Al to a thickness of 100 nm in a rate of 0.2-0.5 nm/sec. Thus, an OEL device was obtained. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 4.5V was applied between them to produce a current of about 1.5 mA/cm^2 and cause emission of blue light of 468 nm in a luminescence efficiency of 4.51 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 2000 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 500 hours.

EXAMPLE 8

[0101] An OEL device was obtained with the same method in Example 7, except that 3,10-bis(2,6-dimethylphenyl)perylene used as a luminescent dopant in Example 7 was replaced by an amine-containing styryl derivative expressed by formula (104) below. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 4.3V was applied between them to produce a current of about 1.5 mA/cm^2 and cause emission of blue light of 455 nm in a luminescence efficiency of 4.81 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 3100 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 600 hours.

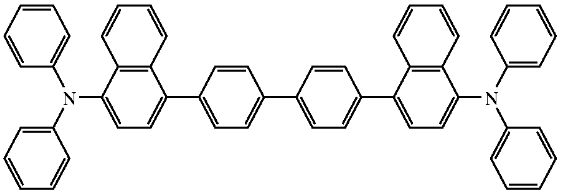
(104)



EXAMPLE 9

[0102] An OEL device was obtained with the same method in Example 7, except that 3,10-bis(2,6-dimethylphenyl)perylene used as a luminescent dopant in Example 7 was replaced by an aromatic amine derivative expressed by formula (105) below. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 5V was applied between them to produce a current of about 4.1 mA/cm^2 and cause emission of blue light of 447 nm in a luminescence efficiency of 3.21 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 1800cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 250 hours.

(105)



EXAMPLE 10

[0103] An OEL device was obtained with the same method in Example 7, except that ALQ used as the material of the electron-transporting layer in Example 7 was replaced by PyPySPyPy. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 2.8V was applied between them to produce a current of about 1 mA/cm^2 and cause emission of blue light of 468 nm in a luminescence efficiency of 81 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 2600 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 450 hours.

EXAMPLE 11

[0104] An OEL device was obtained with the same method in Example 8, except that ALQ used as the material of the electron-transporting layer in Example 8 was replaced by PyPySPyPy. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 3V was applied between them to produce a current of about 1 mA/cm^2 and cause emission of blue light of 455 nm in a luminescence efficiency of 8.51 m/W. Moreover, when the OEL device was driven with a constant current of 50 mA/cm^2, the initial brightness was 3800 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 220 hours.

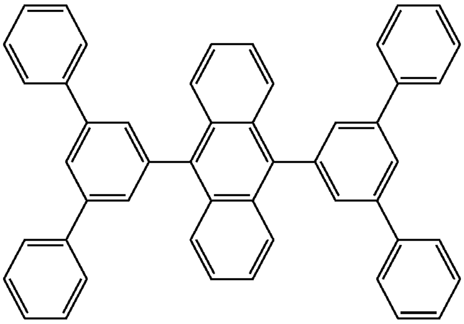
EXAMPLE 12

[0105] An OEL device was obtained with the same method in Example 11, except that the compound (32) used in Example 11 was replaced by the compound (40). The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 3.3V was applied between them to produce a current of about 1.2 mA/cm^2 and cause emission of blue light of 454 nm in a luminescence efficiency of 8.31 m/W. Moreover, when the OEL device is driven with a constant current of 50 mA/cm^2, the initial brightness was 3700 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 200 hours.

COMPARATIVE EXAMPLE 1

[0106] An OEL device was obtained with the same method in Example 7, except that the compound (32) used in Example 7 was replaced by an anthracene derivative expressed by formula (106) below. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 5V was applied between them to produce a current of about 3.5 mA/cm^2 and cause emission of blue light of 467 nm in a luminescence efficiency of 21 m/W. Moreover, when the OEL device is driven with a constant current of 50 mA/cm^2, the initial brightness was 1400 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 125 hours.

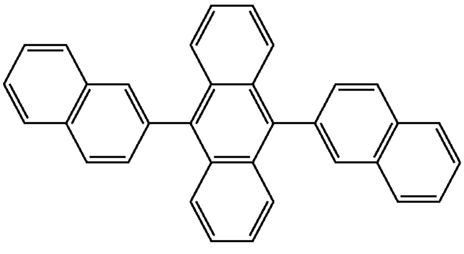
(106)



COMPARATIVE EXAMPLE 2

[0107] An OEL device was obtained with the same method in Example 10, except that the compound (32) used in Example 10 was replaced by an anthracene derivative expressed by formula (107) below. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 4V was applied between them to produce a current of about 2 mA/cm^2 and cause emission of blue light of 464 nm in a luminescence efficiency of 41 m/W. Moreover, when the OEL device is driven with a constant current of 50 mA/cm^2, the initial brightness was 2400 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 75 hours.

(107)



COMPARATIVE EXAMPLE 3

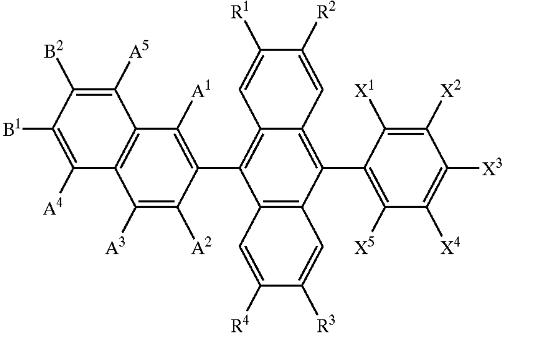
[0108] An OEL device was obtained with the same method in Example 4, except that the compound (32) used in Example 4 was replaced by the anthracene derivative (107) mentioned above. The ITO electrode served as an anode and the LiF/Al electrode as a cathode, while a DC voltage of about 6V was applied between them to produce a current of about 5 mA/cm^2 and cause emission of blue light of 440 nm in a luminescence efficiency of 1.21 m/W. Moreover, when the OEL device is driven with a constant current of 50 mA/cm^2, the initial brightness was 950 cd/m^2, and the life property of the same was indicated by the brightness half-decay time of 50 hours.

[0109] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention covers modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A luminescent material, expressed by formula (1):

(1)



wherein

each of R^1—R^4 represents hydrogen, a C_1-C_{24} alkyl group or a C_1-C_{24} alkoxy group;

each of A^1-A^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group;

each of B^1 and B^2 represents hydrogen, a C_6-C_{24} aryl group, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group, wherein any hydrogen on the C_6-C_{24} aryl group can be substituted by a C_1-C_{12} alkyl group, a C_3-C_{12} cycloalkyl group or a C_6-C_{12} aryl group; any methylene group (—CH_2—) of the C_1-C_{24} alkyl group can be substituted by an oxy moiety (—O—); any methylene group of the C_1-C_{24} alkyl group except the one directly bonded to the naphthyl group can be substituted by a C_6-C_{24} arylene group; and any hydrogen on the C_3-C_{24} cycloalkyl group can be substituted by a C_1-C_{24} alkyl group or a C_6-C_{24} aryl group; and

each of X^1—X^5 represents hydrogen, a C_1-C_{24} alkyl group or a C_3-C_{24} cycloalkyl group, wherein any methylene group of the C_1-C_{24} alkyl group can be substituted by an oxy moiety; any methylene group of the C_1-C_{24} alkyl group except the one directly bonded to the phenyl group can be substituted by a C_6-C_{24} arylene group; and any hydrogen on the C_3-C_{24} cycloalkyl group can be substituted by a C,-C_{24} alkyl group or a C_6-C_{12} aryl group.

2. The luminescent material of claim 1, wherein

each of R^1—R^4 represents hydrogen, methyl or t-butyl;

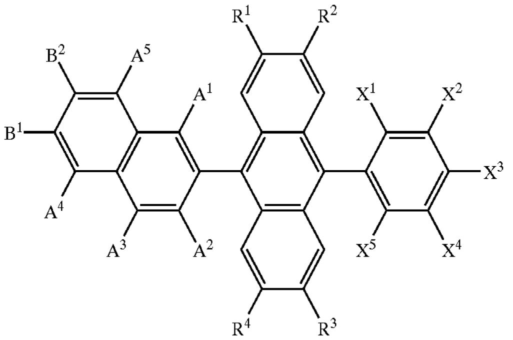
each of A^1-A^5 represents hydrogen, methyl, 1-butyl or cyclohexyl;

each of B^1 and B^2 represents hydrogen, methyl or t-butyl, or represents a phenyl, biphenylyl, terphenylyl, quaterphenylyl, naphyhyl, phenanthryl, crycenyl or triphenylenyl group, on which any hydrogen can be substituted by a C_1-C_{12} alkyl group, a C_3-C_{12} cycloalkyl group or a C_6-C_{12} aryl group; and

each of X^1—X^5 represents hydrogen, a C_1-C_{12} alkyl group or a C_3-C_{12} cycloalkyl group.

3. An luminescent material, expressed by formula (1):

(1)



wherein

each of R^1—R^4 represents hydrogen, methyl or t-butyl;

each of A^1-A^5 represents hydrogen;

each of B^1 and B^2 represents hydrogen, phenyl, 2-biphenylyl, 3-biphenylyl, m-terphenyl-5'-yl, m-terphenyl-3-yl, 1-naphthyl, 2-naphthyl, 2-(2-naphthyl)phenyl, 3,5-di(1-naphthyl)phenyl, 3,5-di(2-naphthyl)phenyl, p-terphenyl-2'-yl, m-terphenyl-2-yl, o-terphenyl-2-yl, p-terphenyl-2-yl, 5'-phenyl-m-terphenyl-2-yl, 5'-phenyl-m-terphenyl-3-yl, 5'-phenyl-m-terphenyl-3-yl, m-quaterphenyl-2-yl, m-quaterphenyl-3-yl, 6-(m-terphenyl-5'-yl)-2-naphthyl or 4-(m-terphenyl-5'-yl)-1-naphthyl; and

each of X^1—X^5 represents hydrogen, methyl, t-butyl or cyclohexyl.

4. The luminescent material of claim 3, wherein each of X^1—X^5 represents hydrogen.

5. The luminescent material of claim 3, wherein X^3 represents t-butyl and each of X^1, X^2, X^4 and X^5 represents hydrogen.

6. The luminescent material of claim 3, wherein

among X^1, X^3 and X^5, at least one represents methyl and the rest represents hydrogen; and

each of X^2 and X^4 represents hydrogen.

7. The luminescent material of claim 3, wherein each of B^1 and B^2 represents phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

8. The luminescent material of claim 3, wherein B^1 represents phenyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

9. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

10. The luminescent material of claim 3, wherein each of B^1 and B^2 represents 2-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

11. The luminescent material of claim 3, wherein B^1 represents 2-biphenylyl, B^2 represents hydrogen, each of X^1

and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

12. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 2-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

13. The luminescent material of claim 3, wherein each of B^1 and B^2 represents 3-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

14. The luminescent material of claim 3, wherein B^1 represents 3-biphenylyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

15. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 3-biphenylyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

16. The luminescent material of claim 3, wherein B^1 represents m-terphenyl-5'-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

17. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents m-terphenyl-5'-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

18. The luminescent material of claim 3, wherein B^1 represents m-terphenyl-3-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

19. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents m-terphenyl-3-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

20. The luminescent material of claim 3, wherein B^1 represents 1-naphthyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

21. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 1-naphthyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

22. The luminescent material of claim 3, wherein B^1 represents 2-naphthyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

23. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 2-naphthyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

24. The luminescent material of claim 3, wherein B^1 represents 2-(2-naphthyl)phenyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

25. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 2-(2-naphthyl)phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

26. The luminescent material of claim 3, wherein B^1 represents 3,5-di(1-naphthyl)phenyl or 3,5-di(2-naphthyl)phenyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

27. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 3,5-di(1-naphthyl)phenyl or 3,5-di(2-naphthyl)phenyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

28. The luminescent material of claim 3, wherein B^1 represents a group selected from p-terphenyl-2'-yl, m-terphenyl-2-yl, o-terphenyl-2-yl and p-terphenyl-2-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

29. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents a group selected from p-terphenyl-2'-yl, m-terphenyl-2-yl, o-terphenyl-2-yl and p-terphenyl-2-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

30. The luminescent material of claim 3, wherein B^1 represents 5'-phenyl-m-terphenyl-2-yl or 5'-phenyl-m-terphenyl-3-yl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

31. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 5'-phenyl-m-terphenyl-2-yl or 5'-phenyl-m-terphenyl-3-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

32. The luminescent material of claim 3, wherein B^1 represents m-quaterphenyl-2-yl or m-quaterphenyl-3-yl, B represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

33. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents m-quaterphenyl-2-yl or m-quaterphenyl-3-yl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

34. The luminescent material of claim 3, wherein B^1 represents 6-(m-terphenyl-5'-yl)-2-naphthyl or 4-(m-terphenyl-5'-yl)-1-naphthyl, B^2 represents hydrogen, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

35. The luminescent material of claim 3, wherein B^1 represents hydrogen, B^2 represents 6-(m-terphenyl-5'-yl)-2-naphthyl or 4-(m-terphenyl-5'-yl)-1-naphthyl, each of X^1 and X^5 represents hydrogen or methyl, each of X^2 and X^4 represents hydrogen, and X^3 represents hydrogen, t-butyl or methyl.

36. An organic electroluminescent device, comprising at least a hole-transporting layer, a luminescent layer and an electron-transporting layer that are sandwiched between an anode and a cathode on a substrate, wherein the luminescent layer contains the luminescent material of claim 1.

37. The organic electroluminescent device of claim 36, wherein the luminescent layer contains at least one luminescent dopant selected from perylene derivatives, borane derivatives, amine-containing styryl derivatives, aromatic amine derivatives, coumarin derivatives, pyran derivatives, iridium complexes and platinum complexes.

38. The organic electroluminescent device of claim 36, wherein the luminescent layer contains a perylene derivative as a luminescent dopant.

39. The organic electroluminescent device of claim 36, wherein the luminescent layer contains a borane derivative as a luminescent dopant.

40. The organic electroluminescent device of claim 36, wherein the luminescent layer contains an amine-containing styryl derivative as a luminescent dopant.

41. The organic electroluminescent device of claim 36, wherein the luminescent layer contains an aromatic amine derivative as a luminescent dopant.

42. The organic electroluminescent device of claim 36, wherein the luminescent layer contains a coumarin derivative as a luminescent dopant.

43. The organic electroluminescent device of claim 36, wherein the luminescent layer contains a pyran derivative as a luminescent dopant.

44. The organic electroluminescent device of claim 36, wherein the luminescent layer contains an iridium complex as a luminescent dopant.

45. The organic electroluminescent device of claim 36, wherein the luminescent layer contains a platinum complex as a luminescent dopant.

46. The organic electroluminescent device of claim 36, wherein the electron-transporting layer comprises a quinolinol metal complex.

47. The organic electroluminescent device of claim 36, wherein the electron-transporting layer comprises at least one of a pyridine derivative and a phenanthroline derivative.

* * * * *

专利名称(译)	发光材料和使用其的有机电致发光器件		
公开(公告)号	US20060014046A1	公开(公告)日	2006-01-19
申请号	US11/177799	申请日	2005-07-08
[标]申请(专利权)人(译)	王国芳 内田MANABU 小池俊		
申请(专利权)人(译)	王国芳 内田MANABU 小池俊		
当前申请(专利权)人(译)	Chisso公司		
[标]发明人	WANG GUOFANG UCHIDA MANABU KOIKE TOSHIHIRO		
发明人	WANG, GUOFANG UCHIDA, MANABU KOIKE, TOSHIHIRO		
IPC分类号	H05B33/14 C09K11/06 C07C15/20		
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摘要(译)

提供发光材料，尤其是蓝光发射优异的发光材料，其用于OEL装置并且允许装置具有更高的发光效率，更低的驱动电压，更好的耐热性和更长的寿命，以及提供OEL装置使用发光材料。解决方案：提供具有不对称结构和碱性蒽骨架的新发光材料： 在式（1）中，R 1 -R 4各自表示氢，C 1 -C 24烷基或C 1 -C 24烷氧基。 A1-A5中的每一个表示氢，C1-C24烷基或C3-C24环烷基。 B1和B2中的每一个表示氢，C6-C24芳基，C1-C24烷基或C3-C24环烷基。 X1-X5中的每一个表示氢，C1-C24烷基或C3-C24环烷基。

(1)