US 20110001129A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2011/0001129 A1**

(43) **Pub. Date: Jan. 6, 2011**

Yokoyama et al.

(54) **SUBSTITUTED BIPYRIDYL COMPOUND AND ORGANIC ELECTROLUMINESCENT DEVICE**

(75) Inventors: **Norimasa Yokoyama**, Tsukuba-shi (JP); **Shuichi Hayashi**, Tsukuba-shi (JP); **Makoto Nagaoka**, Tsukuba-shi (JP); **Yoshio Taniguchi**, Ueda City (JP); **Musubu Ichikawa**, Ueda City (JP)

Correspondence Address:
EDWARDS ANGELL PALMER & DODGE LLP
P.O. BOX 55874
BOSTON, MA 02205 (US)

(73) Assignees: **HODOGAYA CHEMICAL CO., LTD.**, Tokyo (JP); **Shinshu University, National University Corporatio**, Nagano (JP)

(21) Appl. No.: **12/735,885**

(22) PCT Filed: **Feb. 25, 2009**

(86) PCT No.: **PCT/JP2009/053396**

§ 371 (c)(1),
(2), (4) Date: **Aug. 24, 2010**

(30) **Foreign Application Priority Data**

Feb. 26, 2008 (JP) 2008-043788

Publication Classification

(51) **Int. Cl.**

H01L 51/50	(2006.01)
C07D 401/14	(2006.01)
C07D 403/14	(2006.01)
C07D 471/04	(2006.01)

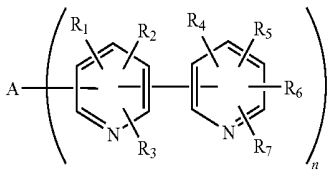
(52) **U.S. Cl.** **257/40**; 546/257; 544/180; 544/333; 546/88; 257/E51.018

(57) **ABSTRACT**

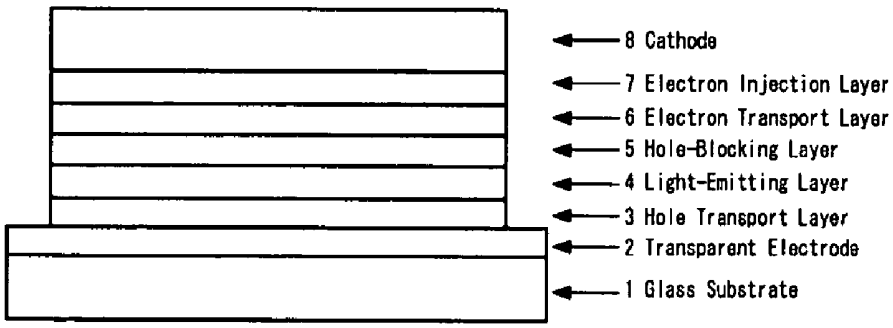
[Problem] To provide an organic compound which shows an excellent electron-injecting/transporting performance, has a hole-blocking ability and shows a high stability as a film, that is, having excellent characteristics as a material for organic electroluminescent device having high efficiency and high durability; and to provide an organic EL device comprising the compound and having high efficiency and high durability. [Means for Solution] A substituted bipyridyl compound represented by the general formula (1); and an organic electroluminescent device comprising a pair of electrodes and at least one organic layer sandwiched between then, wherein the compound is used as the constitutive material of at least one organic layer.

[Formula 1]

(1)

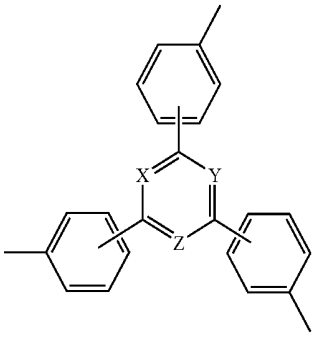


(wherein R^1 to R^7 may be the same or different, each representing a hydrogen atom, a fluorine atom, a chlorine atom, a cyano group, a trifluoromethyl group, a linear or branched alkyl group having from 1 to 6 carbon atoms, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; n indicates an integer of from 2 to 4; A represents a di- to tetravalent, substituted or unsubstituted aromatic hydrocarbon group, a di- to tetra-valent, substituted or unsubstituted aromatic heterocyclic group, a di- to tetra-valent, substituted or unsubstituted condensed polycyclic aromatic group, or a trivalent group represented by the following general formula (2):



[Formula 2]

(2)



(wherein X, Y and Z each represents a carbon atom or a nitrogen atom); provided that when n=2, the two bipyridyl structures may direct bond to each other, and in the case, A is absent).

Fig.1

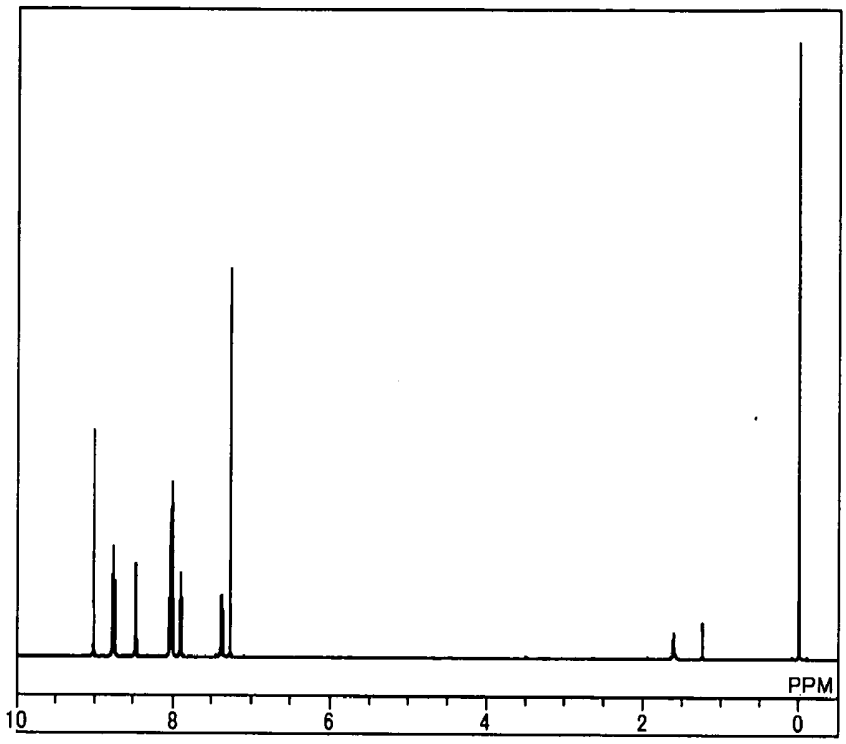


Fig.2

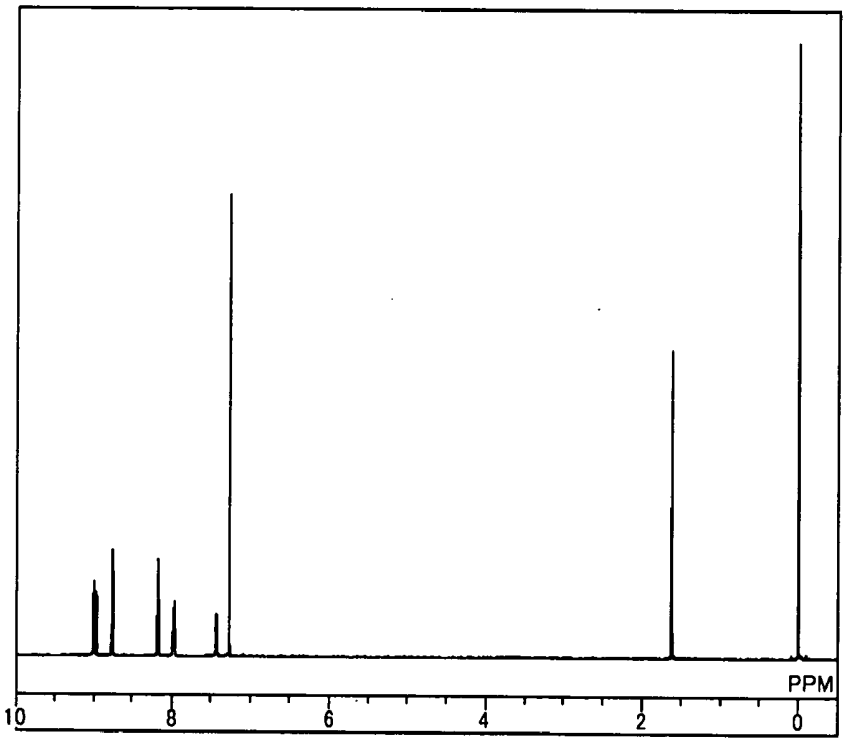


Fig.3

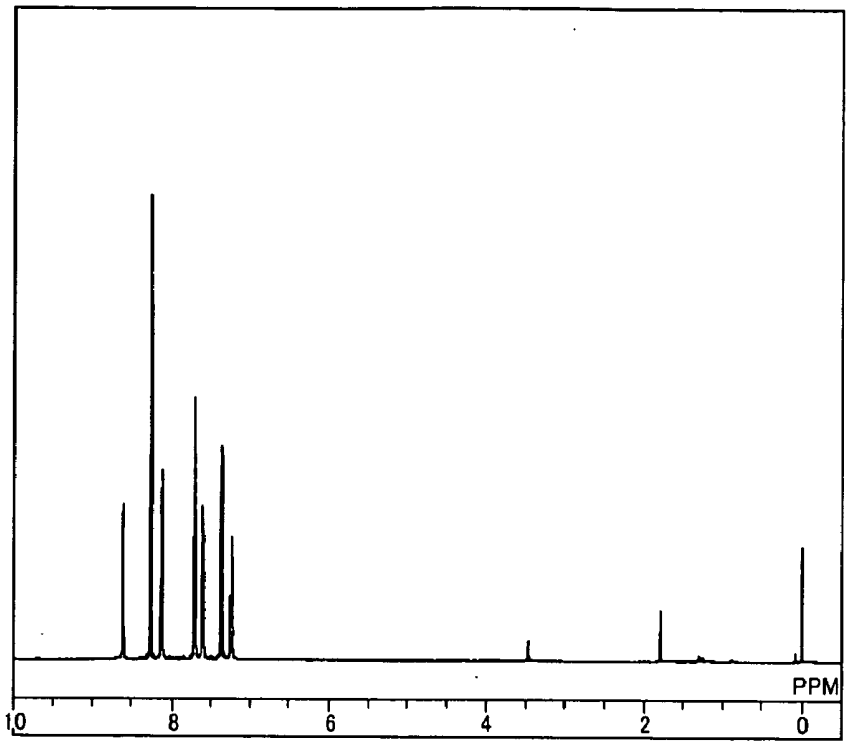


Fig.4

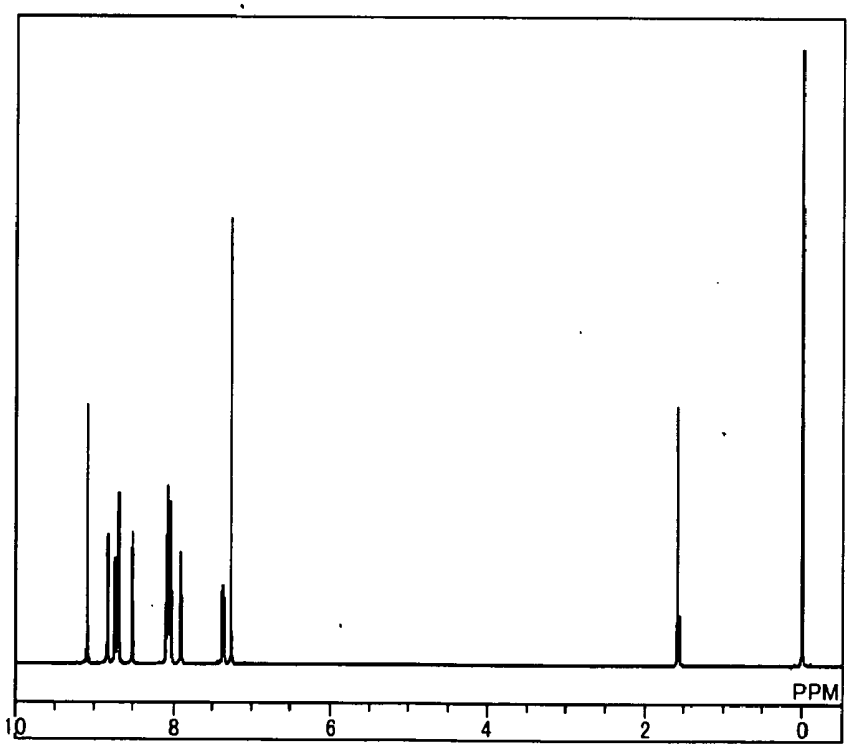


Fig.5

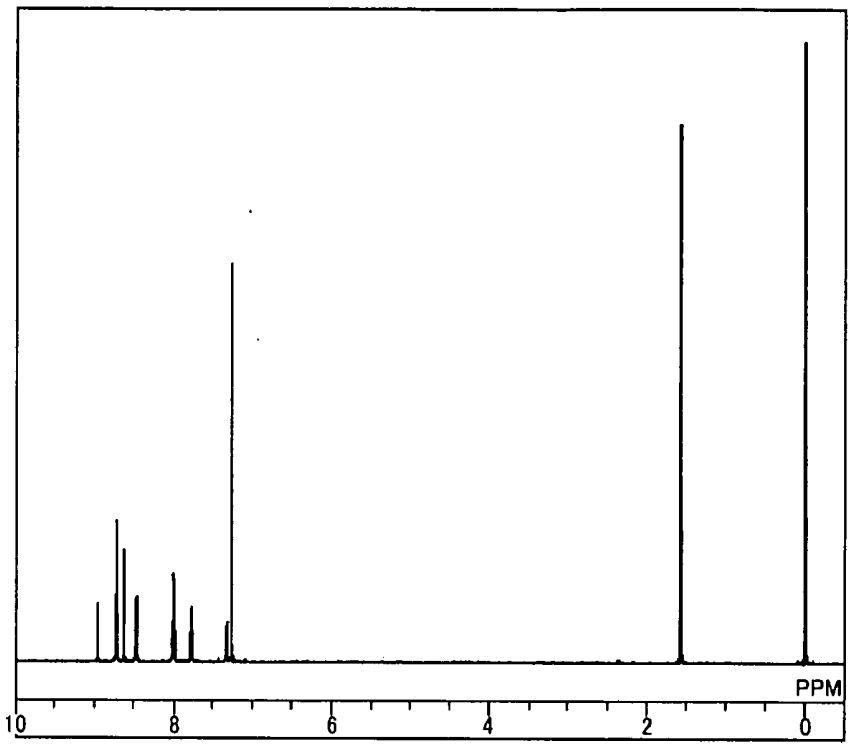

PPM
10
8
6
4
2
0

Fig.6

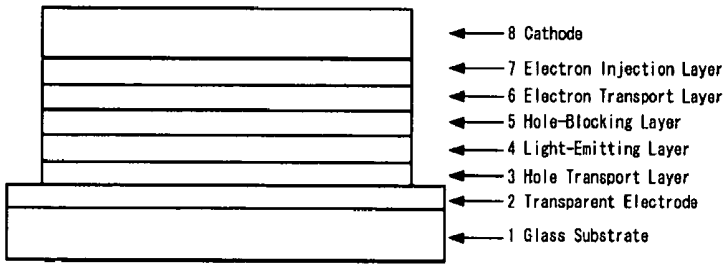

8 Cathode
7 Electron Injection Layer
6 Electron Transport Layer
5 Hole-Blocking Layer
4 Light-Emitting Layer
3 Hole Transport Layer
2 Transparent Electrode
1 Glass Substrate

Fig.7

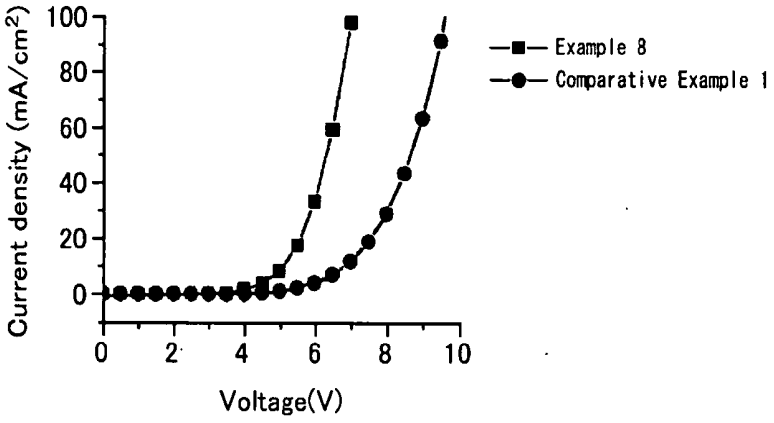
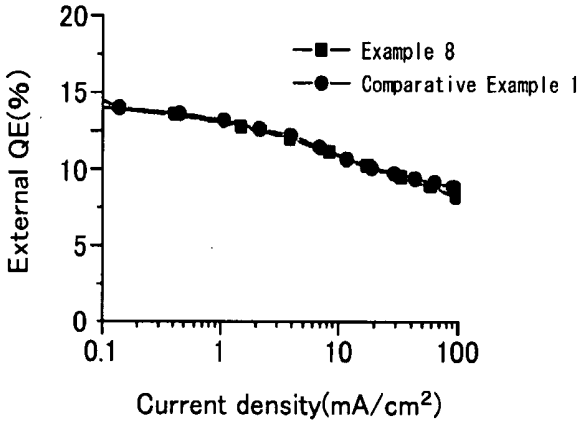

Current density (mA/cm²)
100
80
60
40
20
0
0
2
4
6
8
10
Voltage(V)
Example 8
Comparative Example 1

Fig.8


External QE(%)
20
15
10
5
0
0.1
1
10
100
Current density(mA/cm²)
Example 8
Comparative Example 1

SUBSTITUTED BIPYRIDYL COMPOUND AND ORGANIC ELECTROLUMINESCENT DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a compound suitable for organic electroluminescent (EL) device, a self-emitting device favorable for various display devices, and to the device, and precisely to a substituted bipyridyl compound and to an organic EL device comprising the compound.

BACKGROUND ART

[0002] An organic EL device is a self-emitting device and has been actively studied, since it is light and excellent in the visibility and enables vivid display as compared with liquid-crystal devices.

[0003] In 1987, Eastman Kodak's C. W. Tang, et al. developed laminate structure devices in which the constitutive materials share various roles and have thereby put organic EL materials comprising organic materials into practical use. They laminated a fluorescent material capable of transporting electrons and an organic material capable of transporting holes, and thereby injected both charges into a fluorescent material layer for light emission, and obtained a high luminance of at least 1000 cd/m^2 at a voltage of 10 V or less (for example, see Patent Reference 1 and Patent Reference 2).

[0004] Patent Reference 1: JP-A 8-48656

[0005] Patent Reference 2: Japanese Patent No. 3194657

[0006] Up to the present, various improvements have been made for practical use of organic EL devices, and an electroluminescent device has come to attain high efficiency and durability, in which various roles are further subdivided to comprise an anode, a hole injection layer, a hole transport layer, a light-emitting layer, an electron transport layer, an electron injection layer and a cathode, as provided in that order on a substrate (for example, see Non-Patent Reference 1).

[0007] Non-Patent Reference 1: Preprint in 9th Seminar of the Japan Society of Applied Physics, pp. 55-61 (2001)

[0008] For the purpose of further improvement in luminous efficiency, use of a triplet exciton has been tried, and use of a phosphorescent material is being investigated (for example, see Non-Patent Reference 2).

[0009] Non-Patent Reference 2: Preprint in 9th Seminar of the Japan Society of Applied Physics, pp. 23-31 (0.2001)

[0010] A light-emitting layer may be formed by doping a charge-transporting compound generally referred to as a host material with a fluorescent material or a phosphorescent material. As described in the above-mentioned seminar preprints, the selection of organic materials in organic EL devices has a significant influence on various characteristics such as the efficiency and the durability of the devices.

[0011] In an organic EL device, the charges injected from both electrodes are recombined in the light-emitting layer to emit light. In this, however, since the hole mobility is higher than the electron mobility, there occurs a problem of efficiency reduction owing to passing of a part of holes through the light-emitting layer. Accordingly, an electron-transporting material in which the electron mobility is high is desired.

[0012] A typical light-emitting material, tris(8-hydroxyquinoline)aluminium (hereinafter abbreviated as Alq_3) generally serves also as an electron-transporting material, but it could not be said that the material may have a hole-blocking ability.

[0013] As a measure of preventing the passing of a part of holes through a light-emitting layer and increasing the probability of charge recombination in a light-emitting layer, there is known a method of inserting a hole-blocking layer. As a hole-blocking material, heretofore proposed are triazole derivatives (for example, see Patent Reference 3), bathocuproin (hereinafter abbreviated as BCP), mixed-ligand complexes of aluminium (BAlq) (for example, see Non-Patent Reference 2), etc.

[0014] For example, as an electron-transporting material having an excellent hole-blocking ability, proposed is 3-(4-biphenylyl)-4-phenyl-5-(4-t-butylphenyl)-1,2,4-triazole (hereinafter abbreviated as TAZ) (for example, see Patent Reference 3).

[0015] Patent Reference 3: Japanese Patent No. 2734341

[0016] TAZ has a large work function of 6.6 eV and has a high hole-blocking ability, and is therefore used as an electron-transporting hole-blocking layer to be laminated on the cathode side of the fluorescent light-emitting layer or the phosphorescence-emitting layer formed through vacuum evaporation, coating or the like, and contributes toward increasing the efficiency of organic EL devices (for example, see Non-Patent Reference 3).

[0017] Non-Patent Reference 3: Preprint in 28p-A-6 Lecture of the 50th Applied Physics-Associated Joint Lecture Presentation, p. 1413 (2003)

[0018] However, TAZ has a serious problem in that its electron transportability is low, and it must be combined with an electron-transporting material having a higher electron transportability in using it for constructing organic EL devices (for example, see Non-Patent Reference 4).

[0019] Non-Patent Reference 4: Journal of the Organic Molecule/Bioelectronics Section Committee of the Japan Society of Applied Physics, Vol. 11, No. 1, pp. 13-19 (2000)

[0020] BCP has a large work function of 6.7 eV and has a high hole-blocking ability, but has a low glass transition point (Tg) of 83° C., and therefore its film stability is poor, and accordingly, it could not be said that BCP may fully function as a hole-blocking layer. Accordingly, for a phosphorescent device, use of BAlq as the hole-blocking layer is proposed as a measure for life prolongation. The life of the device could be prolonged; however, since the work function of BAlq is 5.8 eV and is small, holes could not be efficiently trapped in the light-emitting layer, and the device could not be said to be sufficient owing to efficiency reduction therein as compared with a device comprising BCP.

[0021] Non-Patent Reference 5: 9th Lecture in the Organic Molecule/Bioelectronics Section Committee of the Japan Society of Applied Physics, pp. 23-31 (2001)

[0022] All the materials are insufficient in the stability of films thereof or insufficient in the function thereof of blocking holes. For improving the characteristics of organic EL devices, desired are organic compounds showing an excellent electron-injecting/transporting performance, an excellent hole-blocking ability and showing a high stability as thin films.

DISCLOSURE OF THE INVENTION

Problems that the Invention is to Solve

[0023] An object of the invention is to provide an organic compound which shows an excellent electron-injecting/

transporting performance, has a hole-blocking ability and shows a high stability as a thin film, that is, having excellent characteristics as a material for organic electroluminescent device having high efficiency and high durability; and to provide an organic EL device comprising the compound and having high efficiency and high durability. The physical characteristics of the organic compound suitable to the invention are that the compound has (1) a good electron injection characteristic, (2) a high electron mobility, (3) an excellent hole-blocking ability, and is (4) stable as a thin film and (5) excellent in heat resistance. The physical characteristics of the device suitable to the invention are that the device has (1) a high luminous efficiency, (2) a low turn on voltage, and (3) a low practical drive voltage.

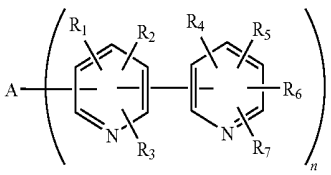
Means for Solving the Problems

[0024] For attaining the above-mentioned object, the present inventors have noted that, on the nitrogen atom thereof, an electrophilic pyridine ring has the ability to coordinate with a metal and is excellent in heat resistance, and have planned and chemically synthesized a substituted bipyridyl compound; and using the compound, the inventors have produced various organic electroluminescent devices experimentally, and have assiduously investigated and evaluated the characteristics of the devices and, as a result, have completed the present invention.

[0025] Specifically, the invention is a substituted bipyridyl compound represented by a general formula (1), and is an organic electroluminescent device having a pair of electrodes and having at least one organic layer sandwiched between them, wherein the compound is used as the constitutive material of at least one organic layer.

[Formula 1]

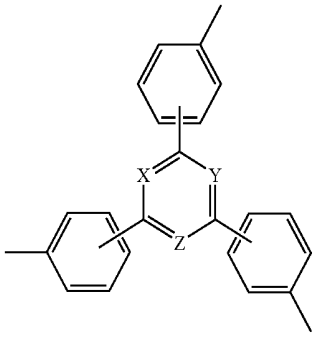
(1)



(wherein R^1 to R^7 may be the same or different, each representing a hydrogen atom, a fluorine atom, a chlorine atom, a cyano group, a trifluoromethyl group, a linear or branched alkyl group having from 1 to 6 carbon atoms, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; n indicates an integer of from 2 to 4; A represents a di- to tetravalent, substituted or unsubstituted aromatic hydrocarbon group, a di- to tetra-valent, substituted or unsubstituted aromatic heterocyclic group, a di- to tetra-valent, substituted or unsubstituted condensed polycyclic aromatic group, or a trivalent group represented by the following general formula (2):

[Formula 2]

(2)



(wherein X, Y and Z each represents a carbon atom or a nitrogen atom); provided that when n=2, the two bipyridyl structures may direct bond to each other, and in the case, A is absent).

[0026] The aromatic hydrocarbon group, the aromatic heterocyclic group or the condensed polycyclic aromatic group of the substituted or unsubstituted aromatic hydrocarbon group, the substituted or unsubstituted aromatic heterocyclic group or the substituted or unsubstituted condensed polycyclic aromatic group for A in the general formula (1) concretely include the following groups: a phenyl group, a biphenylyl group, a terphenylyl group, a tetrakisphenyl group, a styryl group, a naphthyl group, an anthryl group, an acenaphthenyl group, a fluorenyl group, a phenanthryl group, a pyrenyl group, a pyridyl group, a pyrimidyl group, a triazine group, a furanyl group, a pyronyl group, a thienyl group, a quinolyl group, a benzofuranyl group, a benzothienyl group, an indolyl group, a carbazolyl group, a benzoxazolyl group, a benzothiazolyl group, a quinoxalyl group, a benzimidazolyl group, a pyrazolyl group, a dibenzofuranyl group, a dibenzothienyl group, a naphthyridinyl group, a phenanthrolyl group.

[0027] The substituent for the substituted or unsubstituted aromatic hydrocarbon group, the substituted or unsubstituted aromatic heterocyclic group or the substituted or unsubstituted condensed polycyclic aromatic group for A in the general formula (1) concretely includes a fluorine atom, a chlorine atom, a cyano group, a hydroxyl group, a nitro group, and a linear or branched alkyl group having from 1 to 6 carbon atoms, and these may be further substituted.

[0028] The aromatic hydrocarbon group of the substituted or unsubstituted aromatic hydrocarbon group, the substituted or unsubstituted aromatic heterocyclic group or the substituted or unsubstituted condensed polycyclic aromatic group for R1 to R7 in the general formula (1) concretely include a phenyl group, a biphenylyl group, a terphenylyl group, a tetrakisphenyl group, a styryl group, a naphthyl group, an anthryl group, an acenaphthenyl group, a fluorenyl group, a phenanthryl group, an indenyl group, a pyrenyl group, a pyridyl group, a bipyridyl group, a pyrimidinyl group, a furanyl group, a pyronyl group, a thienyl group, a quinolyl group, an isoquinolyl group, a benzofuranyl group, a benzothienyl group, an indolyl group, a carbazolyl group, a benzoxazolyl group, benzothiazolyl group, a quinoxalyl group, a benzimidazolyl group, a pyrazolyl group, a dibenzofuranyl group, a dibenzothienyl group, a naphthyridinyl group, a phenanthrolinyl group, and an acridinyl group.

[0029] The substituent for the substituted or unsubstituted aromatic hydrocarbon group, the substituted or unsubstituted aromatic heterocyclic group or the substituted or unsubstituted condensed polycyclic aromatic group for R1 to R7 in the general formula (1) concretely includes a fluorine atom, a chlorine atom, a trifluoromethyl group, a linear or branched alkyl group having from 1 to 6 carbon atoms, a phenyl group, a biphenylyl group, a terphenyl group, a tetrakisphenyl group, a styryl group, a naphthyl group, a fluorenyl group, a phenanthryl group, an indenyl group, a pyrenyl group, a pyridyl group, a bipyridyl group, a pyrimidyl group, a quinolyl group, an isoquinolyl group, an indolyl group, a carbazolyl group, a quinoxalyl group, and a pyrazolyl group, which may be further substituted.

[0030] The substituted bipyridyl compound represented by the general formula (1) of the invention secures a higher transfer electron rate than conventional electron-transferring materials, and has an excellent hole-blocking ability and is stable as a thin film.

[0031] The substituted bipyridyl compound represented by the general formula (1) of the invention can be used as a constitutive material for the electron transport layer of an organic electroluminescent device (hereinafter abbreviated as organic EL device). Using the material having a higher electron injection/mobility than conventional materials brings about the advantages that the electron transportation efficiency from the electron transport layer to the light-emitting layer is improved, that the light luminous efficiency is improved, and that the drive voltage is lowered and the durability of organic EL devices is enhanced.

[0032] The substituted bipyridyl compound represented by the general formula (1) of the invention can be used as the constitutive material of the hole-blocking layer of an organic EL device. Using the material having an excellent hole-blocking ability, more excellent in electron transportability than conventional materials and highly stable as a thin film brings about the advantages that the drive voltage is lowered while high light luminous efficiency is secured, and that the current resistance is improved and therefore the maximum emission luminance of organic EL devices is thereby increased.

[0033] The substituted bipyridyl compound represented by the general formula (1) of the invention can be used as the constitutive material of the light-emitting layer of an organic EL device. Using the material of the invention that has more excellent electron transportability than conventional materials and has a broad band gap as the host material in the light-emitting layer and making the host material carry a fluorescent material or a phosphorescent material called a dopant therewith for the light-emitting layer brings about the advantage of realizing an organic EL device that has a lowered drive voltage and has improved light luminous efficiency.

[0034] The organic EL device of the invention comprises the substituted bipyridyl compound capable of securing more rapid electron transfer than conventional electron-transporting materials, having an excellent hole-blocking ability and stable as a thin film, and therefore realizes high efficiency and high durability.

ADVANTAGE OF THE INVENTION

[0035] The substituted bipyridyl compound of the invention secures rapid electron transfer, has an excellent hole-blocking ability and is stable as a thin film, and is therefore useful as a constitutive material for the electron transport layer, the hole-blocking layer or the light-emitting layer of an organic EL device. The organic EL device produced using the substituted bipyridyl compound secures the advantages that the light luminous efficiency is improved, that the drive voltage is lowered and the durability is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] FIG. **1** This is a 1H-NMR chart of the compound (compound 6) of Example 1 of the invention.

[0037] FIG. **2** This is a 1H-NMR chart of the compound (compound 8) of Example 2 of the invention.

[0038] FIG. **3** This is a 1H-NMR chart of the compound (compound 15) of Example 3 of the invention.

[0039] FIG. **4** This is a 1H-NMR chart of the compound (compound 29) of Example 4 of the invention.

[0040] FIG. **5** This is a 1H-NMR chart of the compound (compound 63) of Example 5 of the invention.

[0041] FIG. **6** This is a view showing the EL device constitution of Examples 8 to 11 and Comparative Example 1 to 2.

[0042] FIG. **7** This is a graph for comparing the voltage/current density characteristic between Example 8 and Comparative Example 1.

[0043] FIG. **8** This is a graph for comparing the current density/external quantum efficiency between Example 8 and Comparative Example 1.

DESCRIPTION OF REFERENCE NUMERALS

[0044] **1** Glass Substrate
[0045] **2** Transparent Anode
[0046] **3** Hole Transport Layer
[0047] **4** Light-Emitting Layer
[0048] **5** Hole-Blocking Layer
[0049] **6** Electron Transport Layer
[0050] **7** Electron Injection Layer
[0051] **8** Cathode

BEST MODE FOR CARRYING OUT THE INVENTION

[0052] The substituted bipyridyl compounds of the invention are novel compounds, and these substituted bipyridyl compounds may be produced by reacting a boronic acid or a boronate that is produced through reaction of a halide of various aromatic hydrocarbon compounds, condensed polycyclic aromatic compounds or aromatic heterocyclic compounds with pinacol or bis(pinacolato)diboron (for example, see Non-Patent Reference 6), with various halogenopyridines in a mode of cross-coupling such as Suzuki coupling (for example, see Non-Patent Reference 7). Through triazine ring forming reaction of using sodium hydride for various aromatic hydrocarbon compounds, condensed polycyclic aromatic compounds or aromatic heterocyclic compounds having a nitrile group (for example, see Patent Reference 4), bipyridyl compounds with a triazine ring binding thereto may be produced.

[0053] Non-Patent Reference 6: J. Org. Chem., 60 7508 (1995)

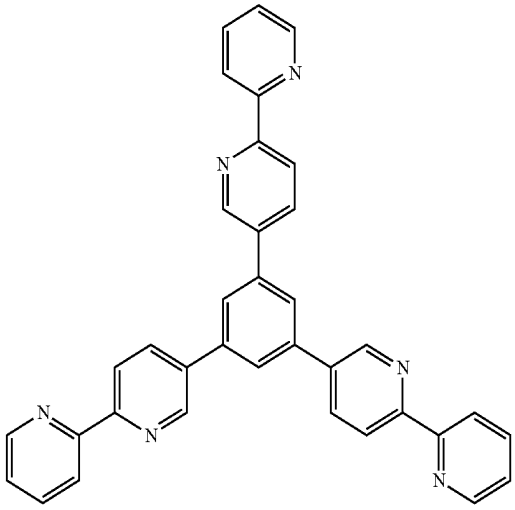
[0054] Non-Patent Reference 7: Synth. Commun., 11, 513 (1981)

[0055] Patent Reference 4: JP-A 2004-284971

[0056] Specific examples of preferred compounds of the substituted bipyridyl compounds represented by the general formula (1) are shown below; however, the invention is not limited to these compounds.

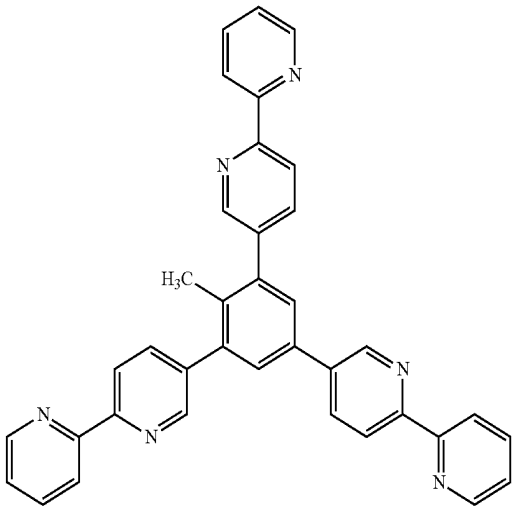
[Formula 3]

(Compound 2)



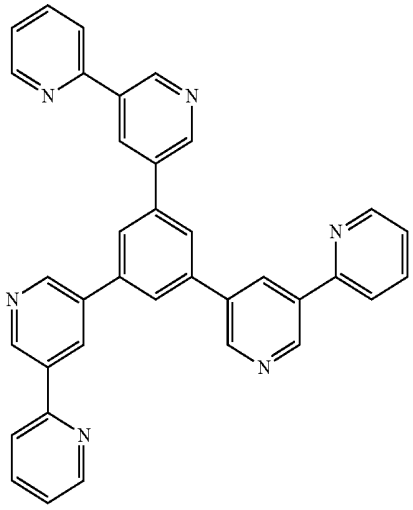
[Formula 4]

(Compound 3)



[Formula 5]

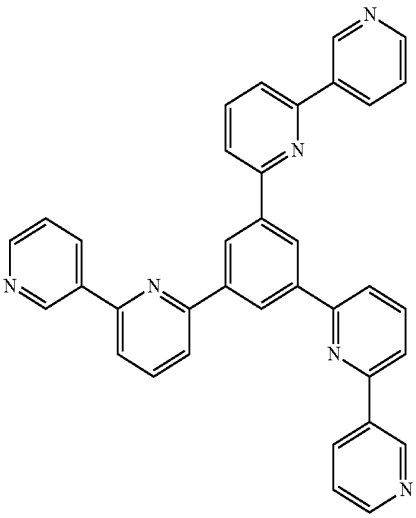
(Compound 4)



-continued

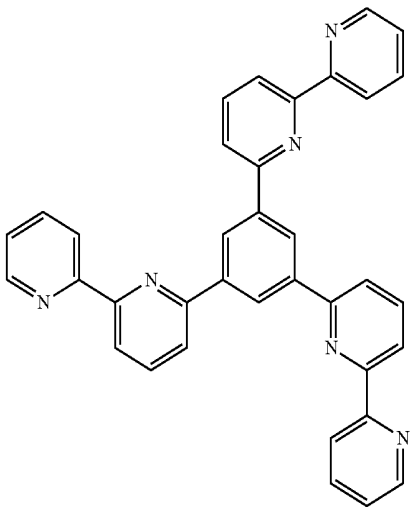
[Formula 6]

(Compound 5)



[Formula 7]

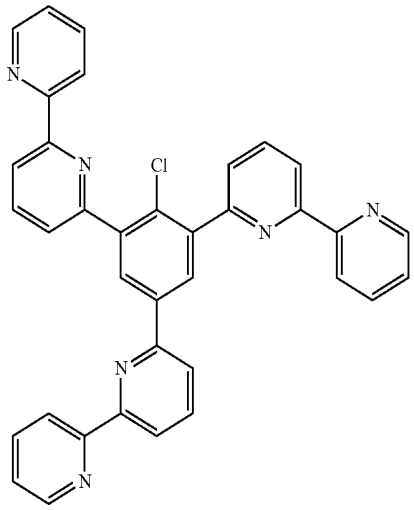
(Compound 6)



-continued

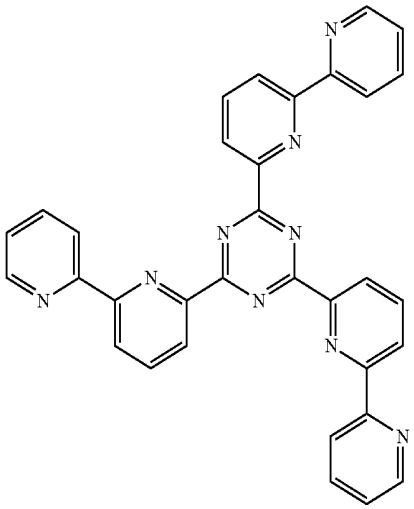
[Formula 8]

(Compound 7)



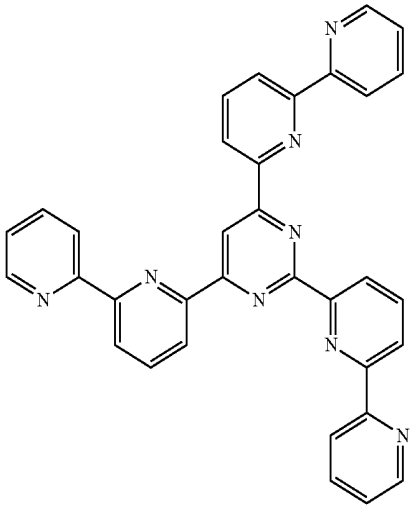
[Formula 9]

(Compound 8)



[Formula 10]

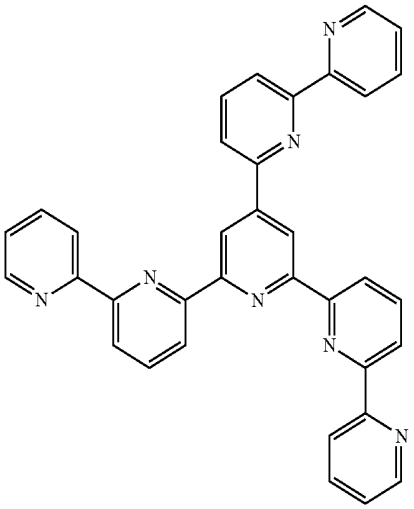
(Compound 9)



-continued

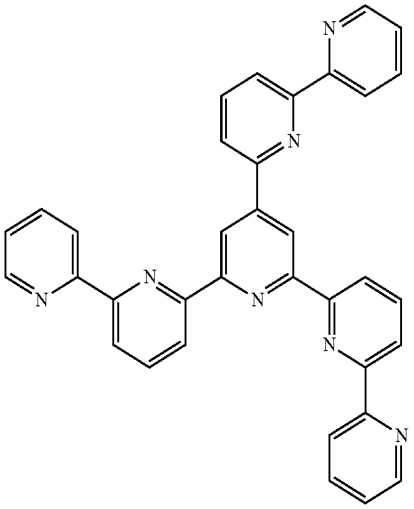
[Formula 11]

(Compound 10)



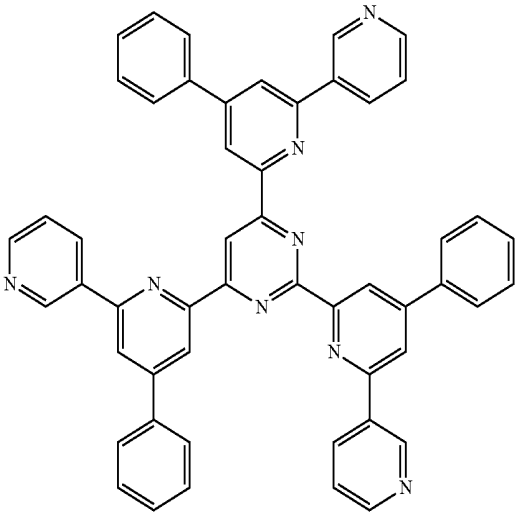
[Formula 12]

(Compound 11)



[Formula 13]

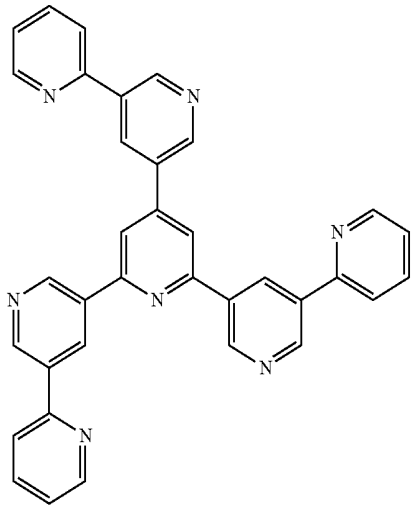
(Compound 12)



-continued

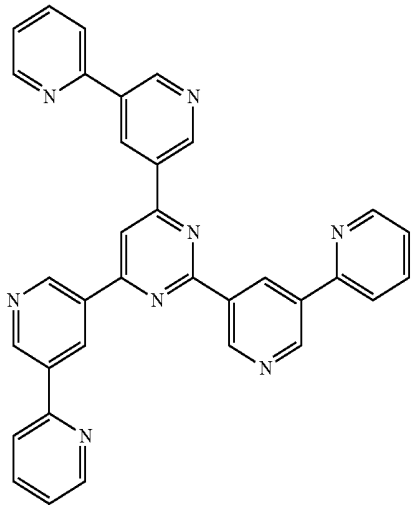
[Formula 14]

(Compound 13)



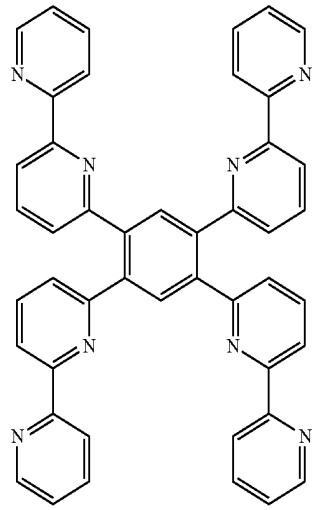
[Formula 15]

(Compound 14)



[Formula 16]

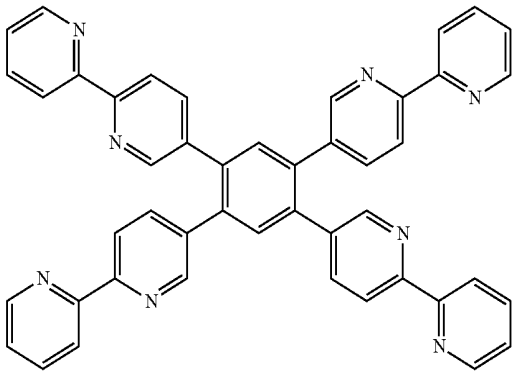
(Compound 15)



-continued

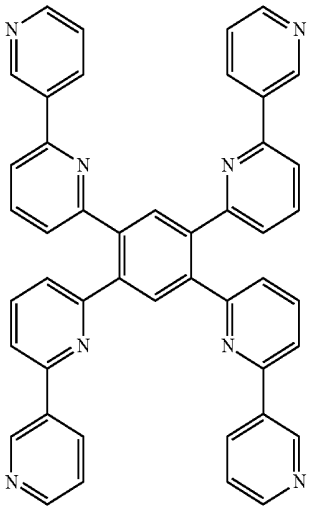
[Formula 17]

(Compound 16)



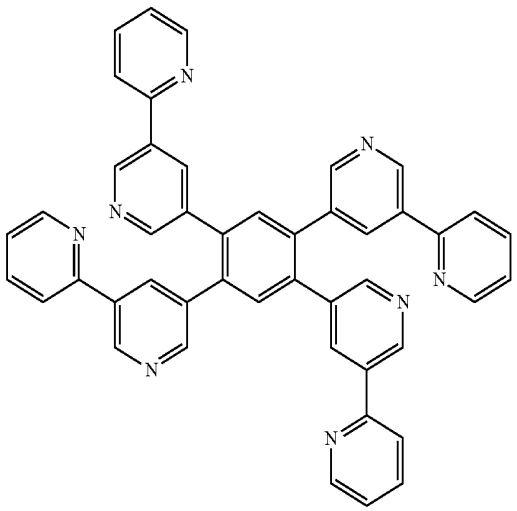
[Formula 18]

(Compound 17)



[Formula 19]

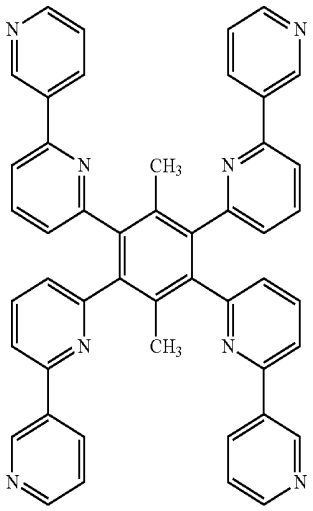
(Compound 18)



-continued

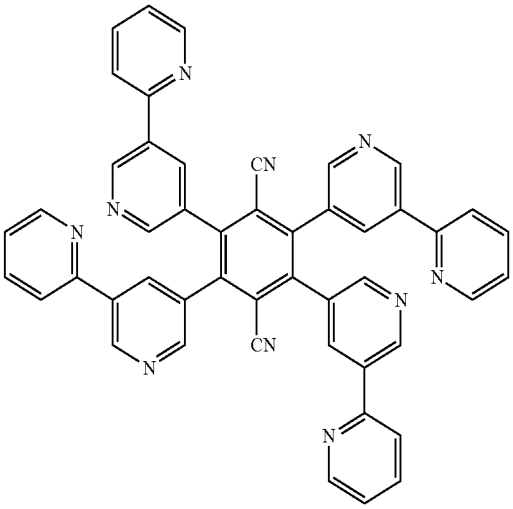
[Formula 20]

(Compound 19)



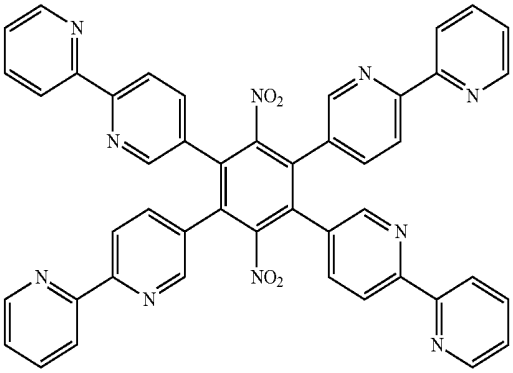
[Formula 21]

(Compound 20)



[Formula 22]

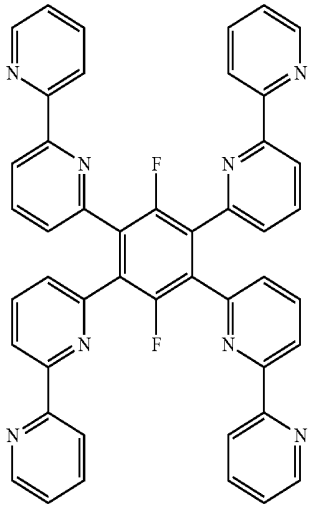
(Compound 21)



-continued

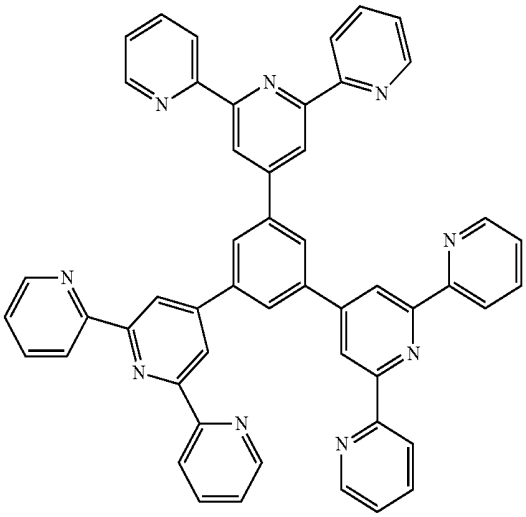
[Formula 23]

(Compound 22)



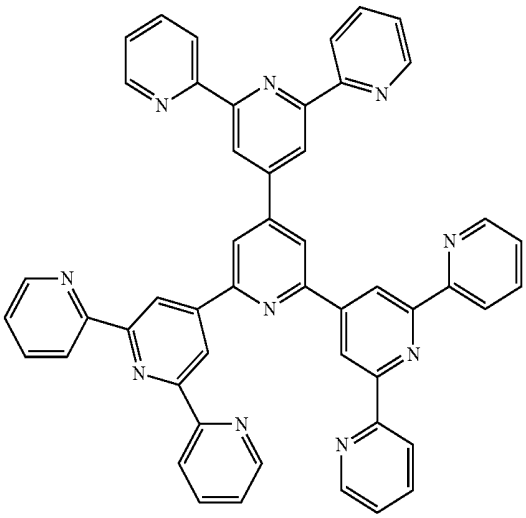
[Formula 24]

(Compound 23)



[Formula 25]

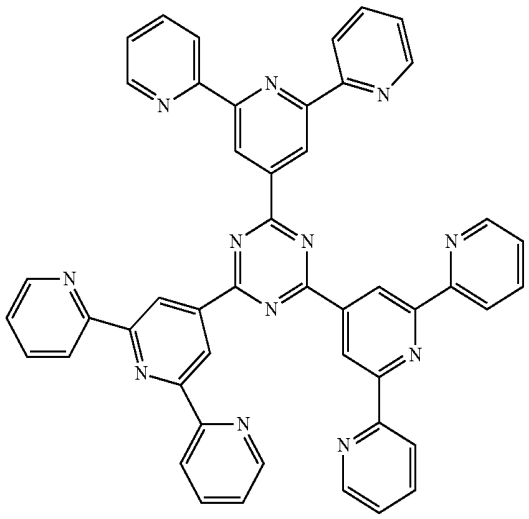
(Compound 24)



-continued

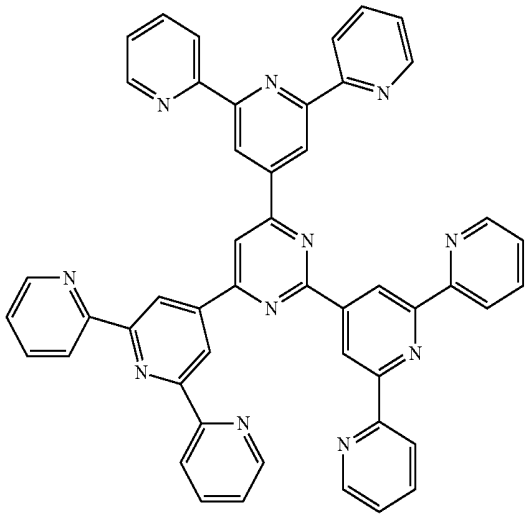
[Formula 26]

(Compound 25)



[Formula 27]

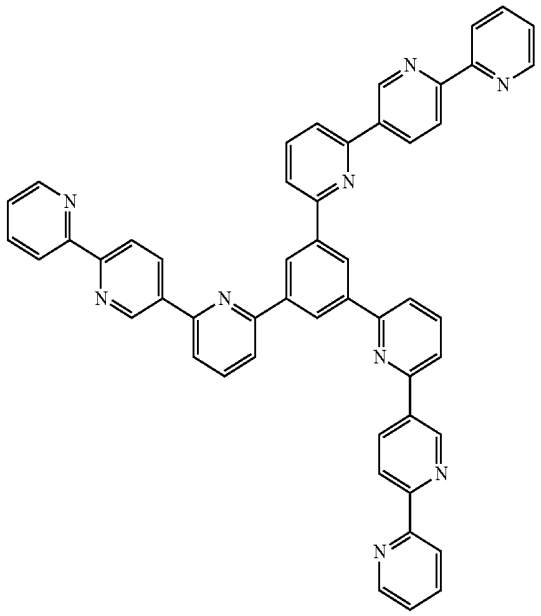
(Compound 26)



-continued

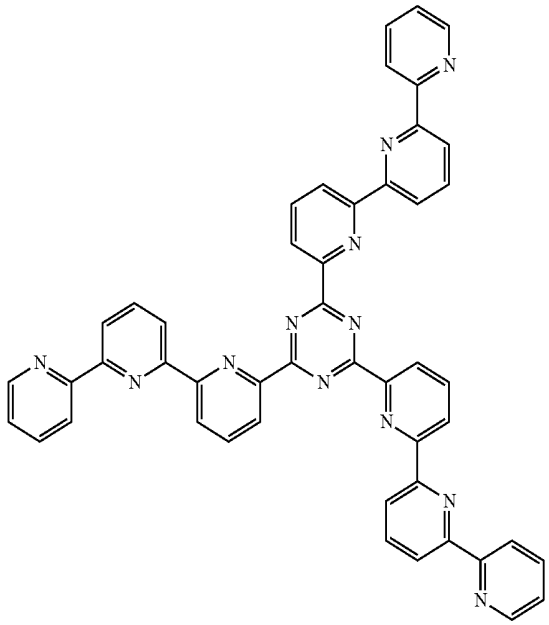
[Formula 28]

(Compound 27)



[Formula 29]

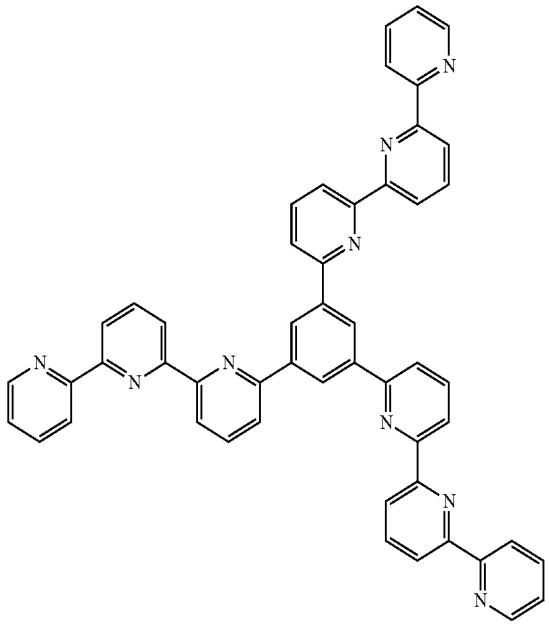
(Compound 28)



-continued

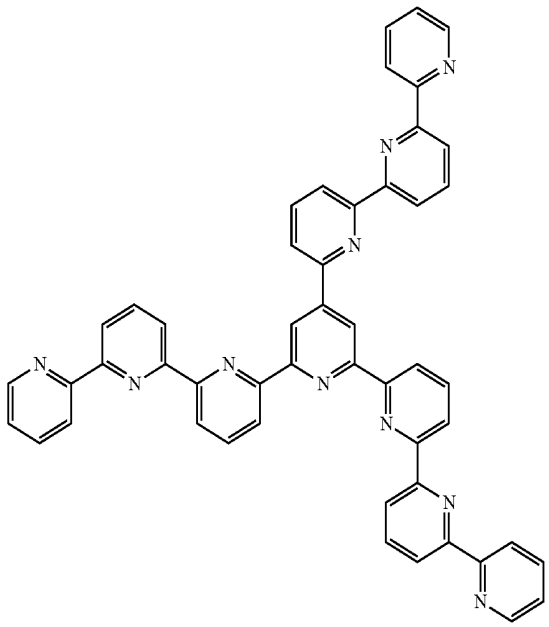
[Formula 30]

(Compound 29)



[Formula 31]

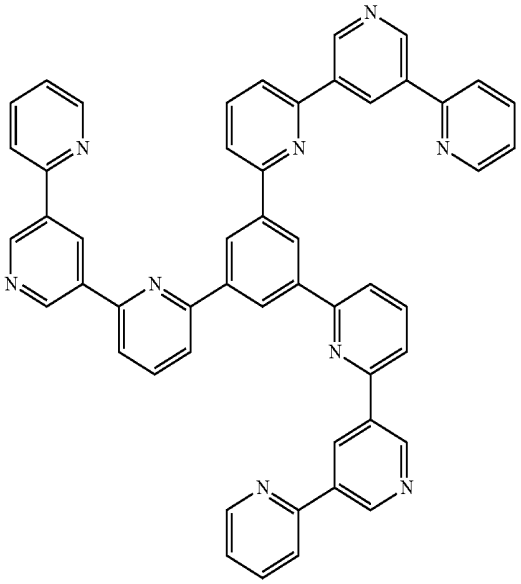
(Compound 30)



-continued

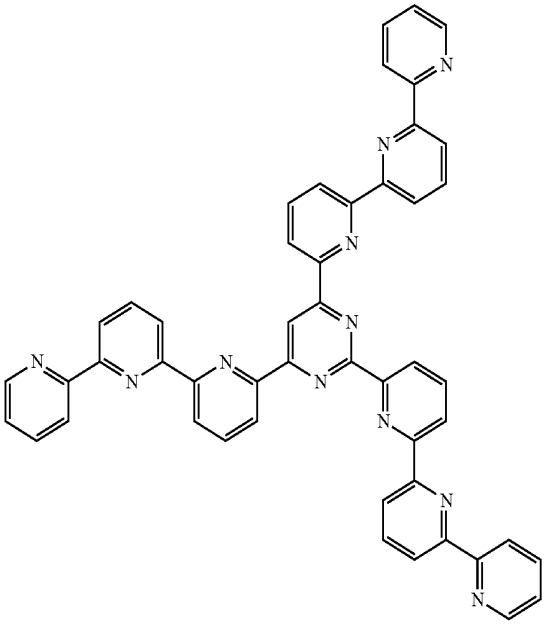
[Formula 32]

(Compound 31)



[Formula 33]

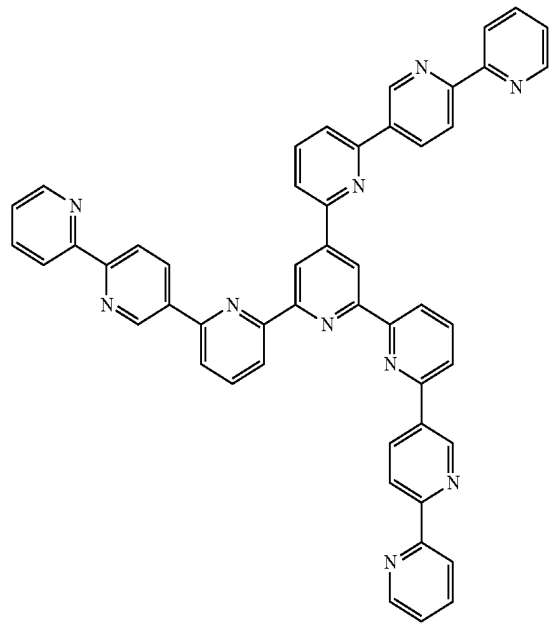
(Compound 32)



-continued

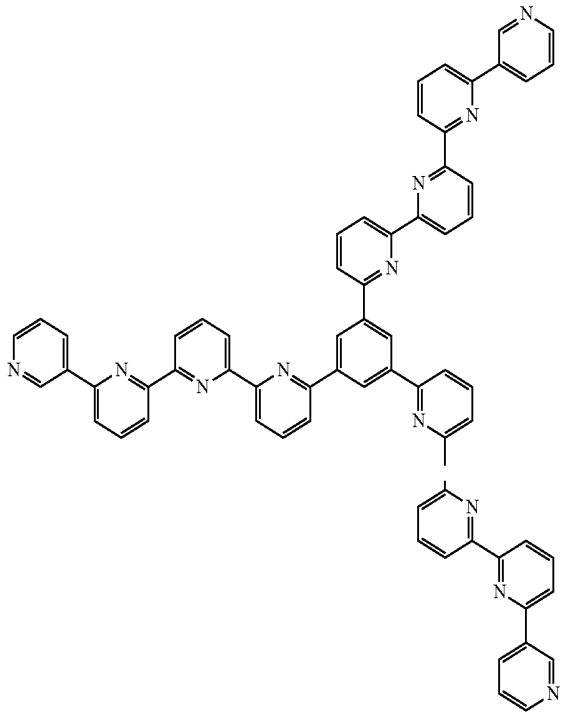
[Formula 34]

(Compound 33)



[Formula 35]

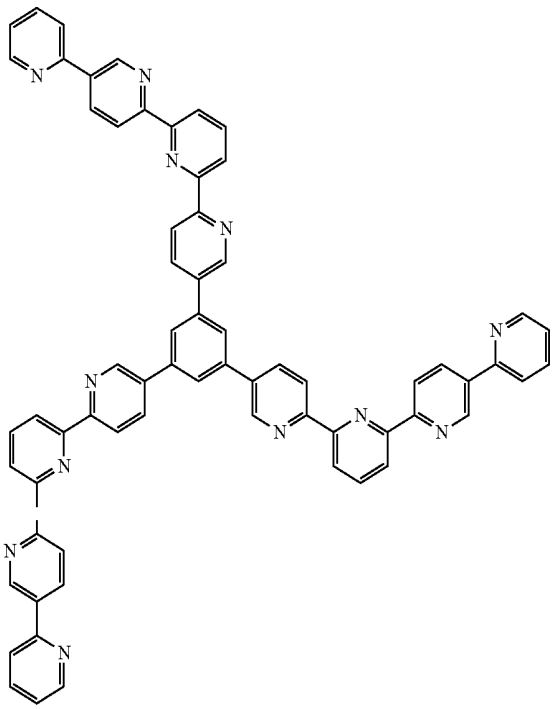
(Compound 34)



-continued

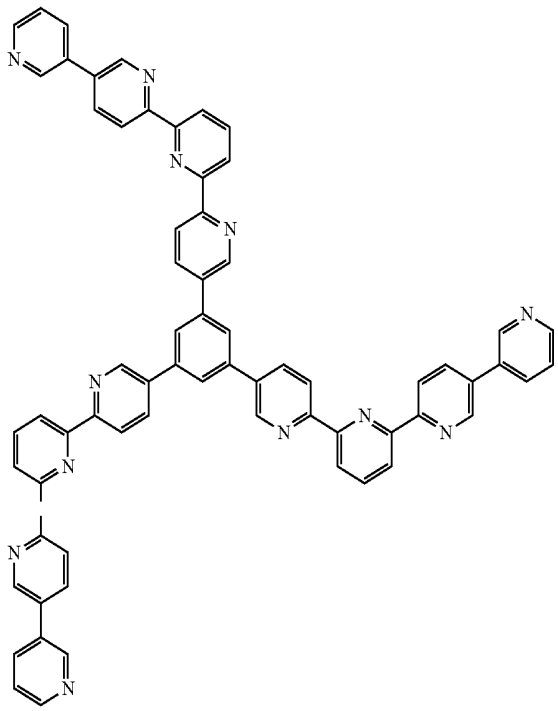
[Formula 36]

(Compound 35)



[Formula 37]

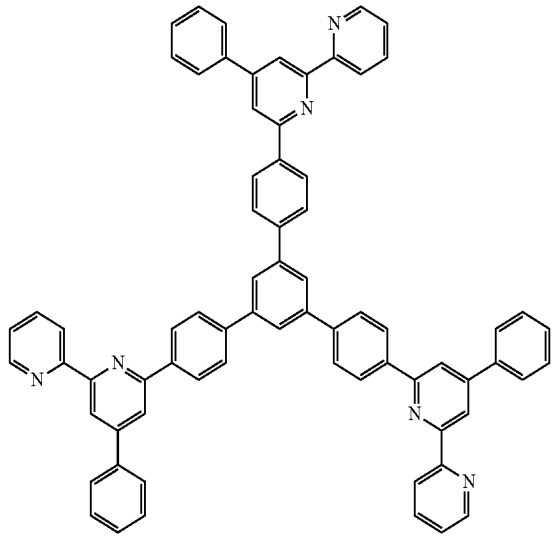
(Compound 36)



-continued

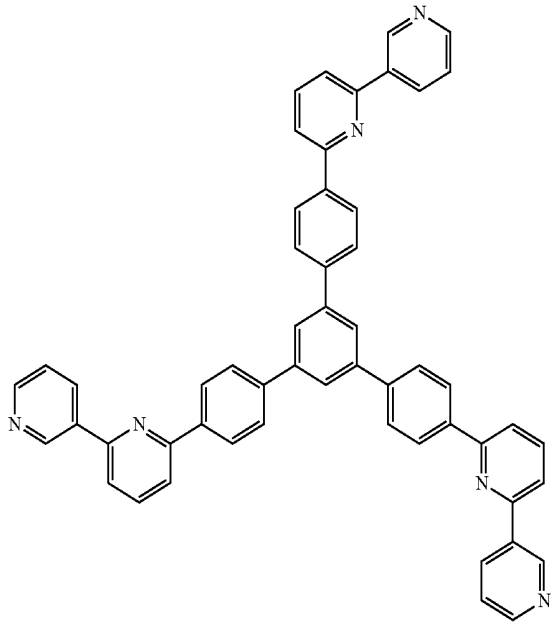
[Formula 38]

(Compound 37)



[Formula 39]

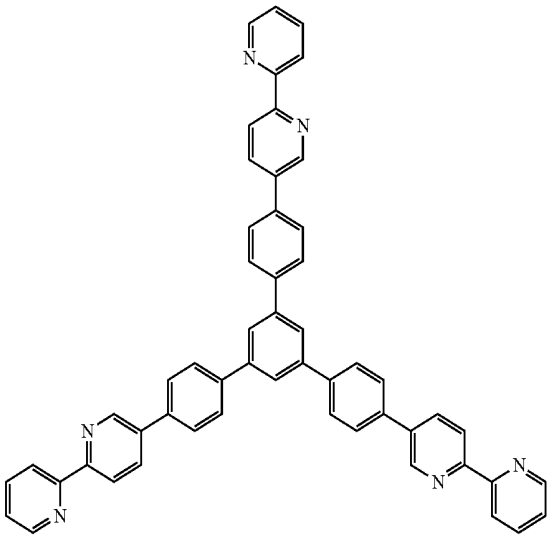
(Compound 38)



-continued

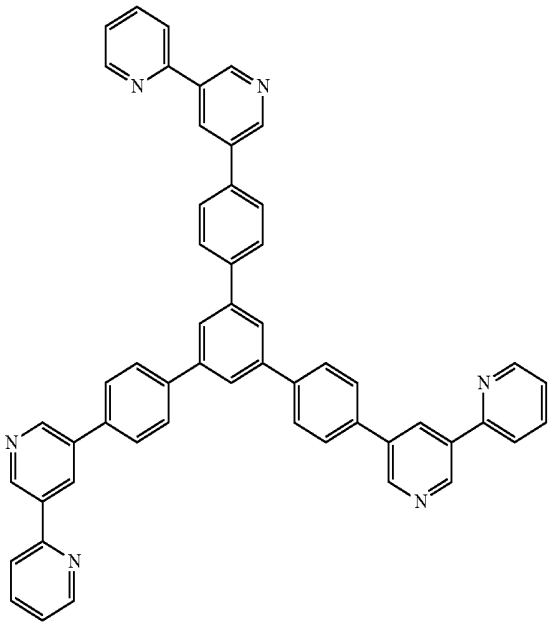
[Formula 40]

(Compound 39)



[Formula 41]

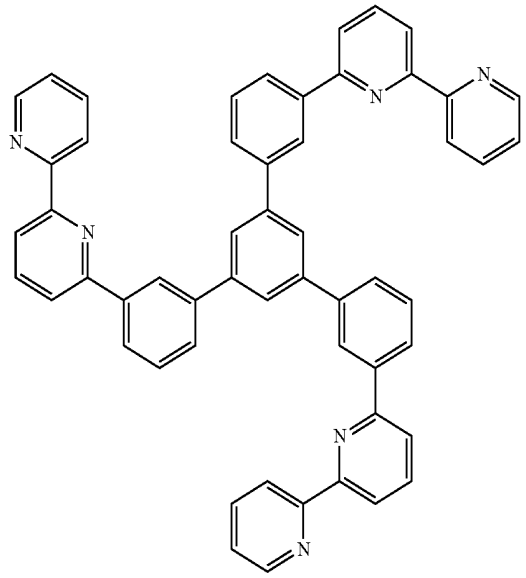
(Compound 40)



-continued

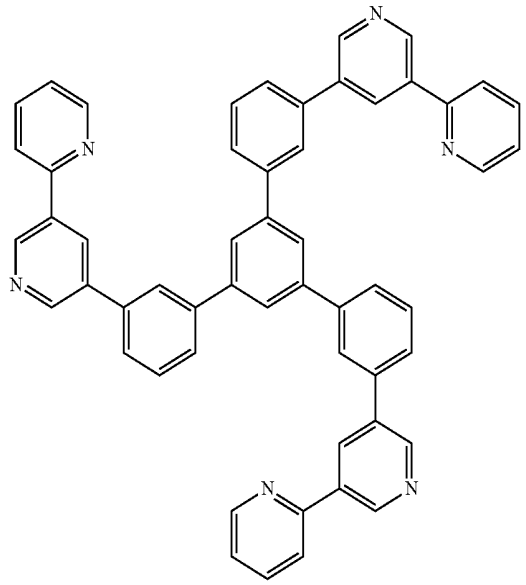
[Formula 42]

(Compound 41)



[Formula 43]

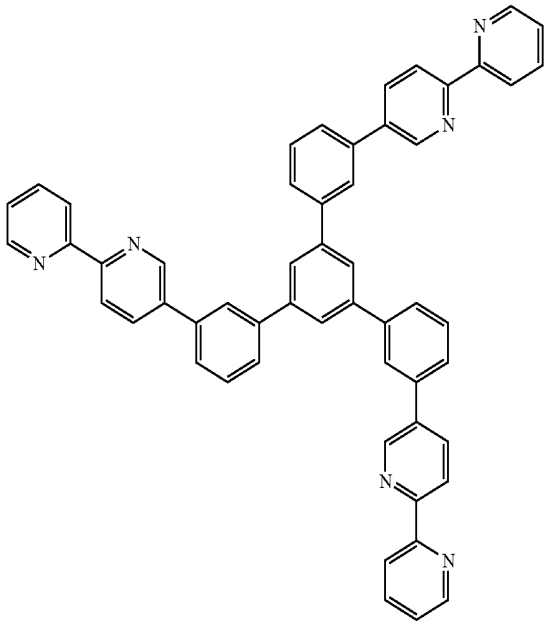
(Compound 42)



-continued

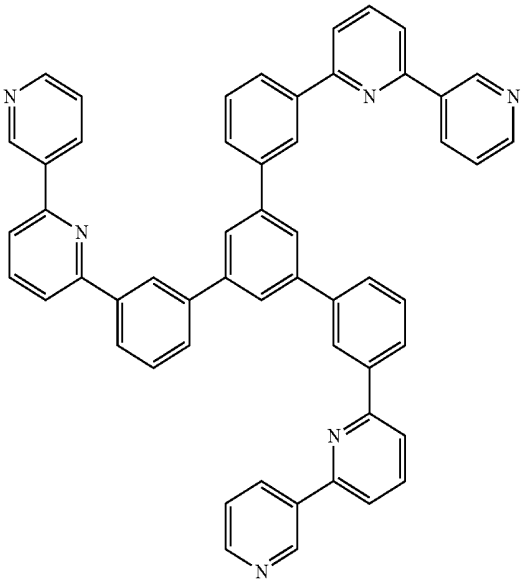
[Formula 44]

(Compound 43)



[Formula 45]

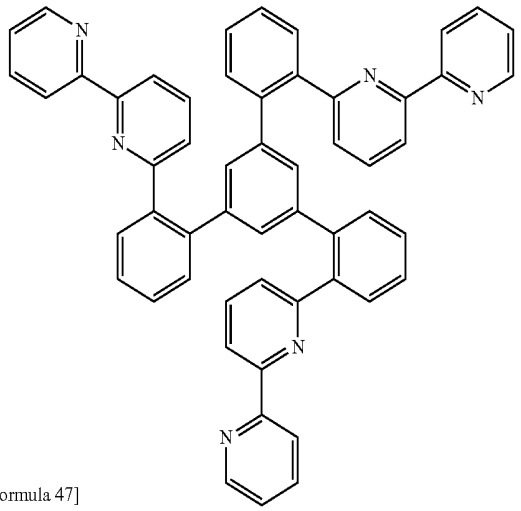
(Compound 44)



-continued

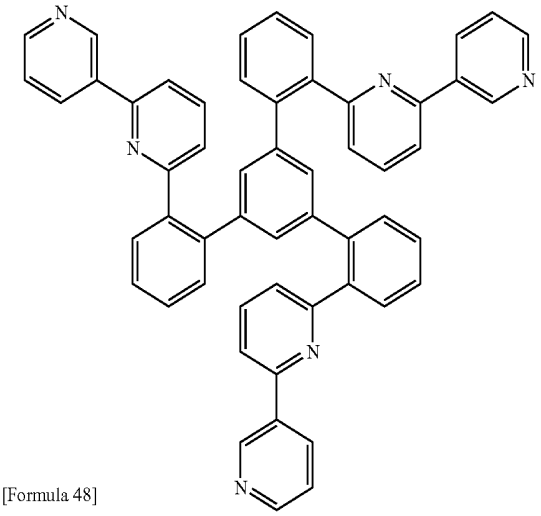
[Formula 46]

(Compound 45)



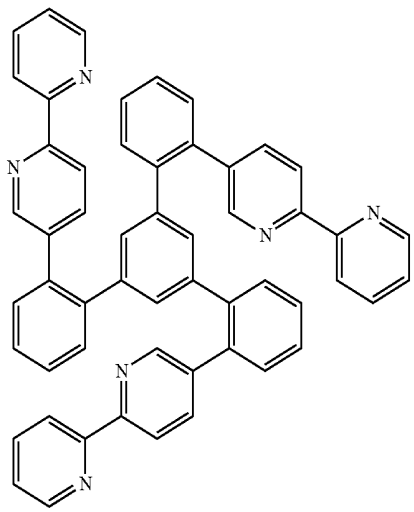
[Formula 47]

(Compound 46)



[Formula 48]

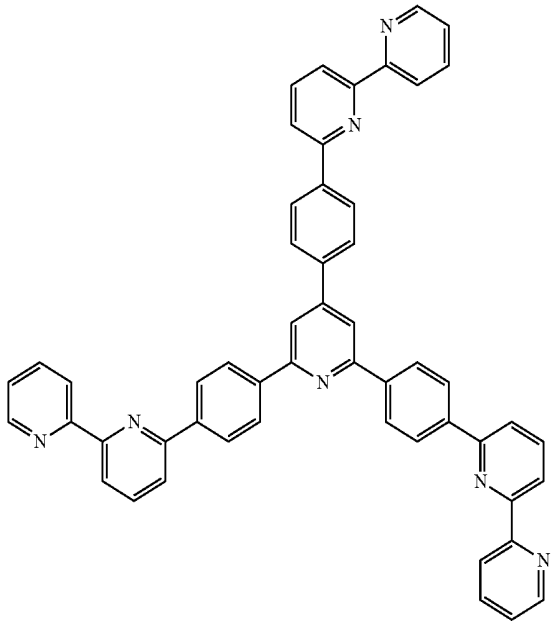
(Compound 47)



-continued

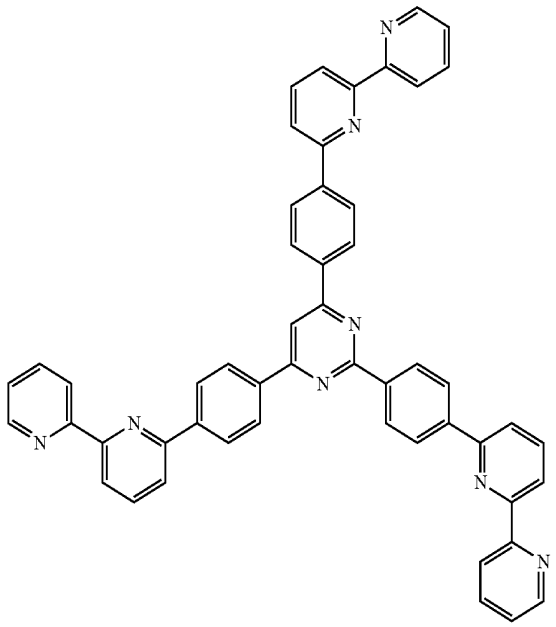
[Formula 49]

(Compound 48)



[Formula 50]

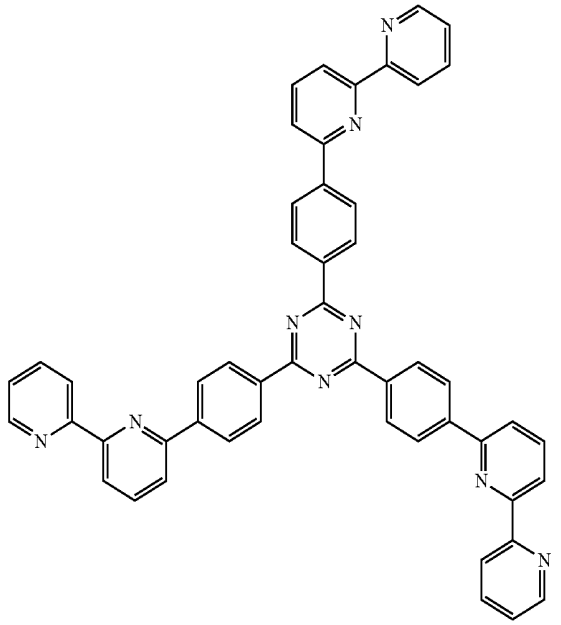
(Compound 49)



-continued

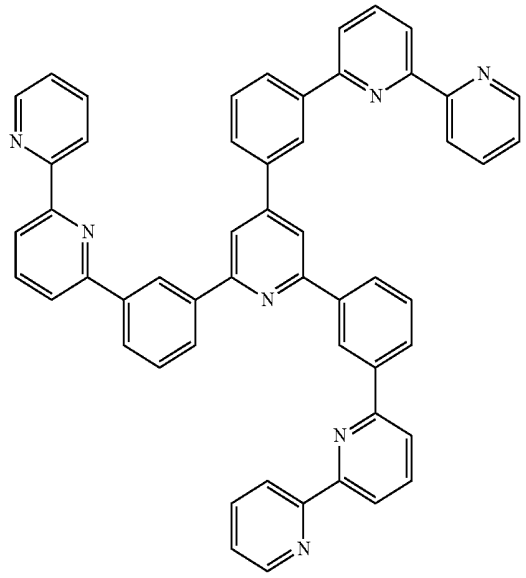
[Formula 51]

(Compound 50)



[Formula 52]

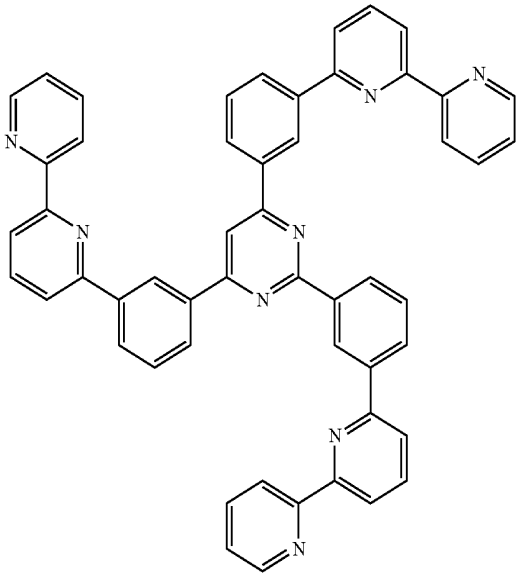
(Compound 51)



-continued

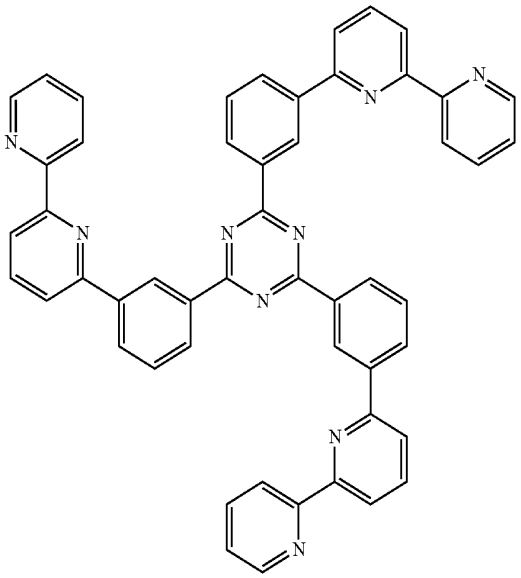
[Formula 53]

(Compound 52)



[Formula 54]

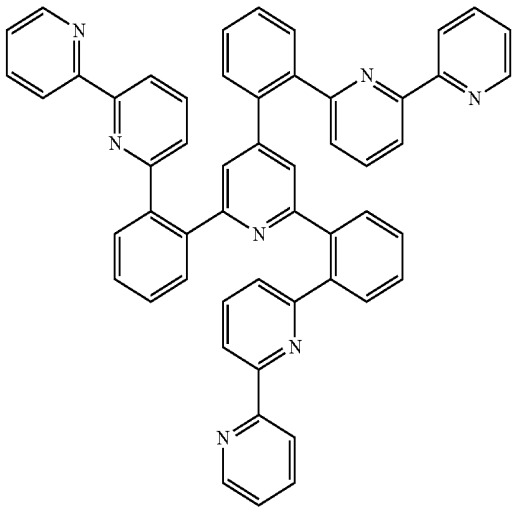
(Compound 53)



-continued

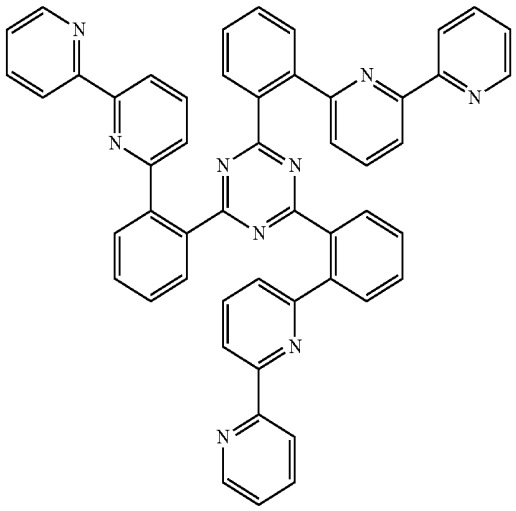
[Formula 55]

(Compound 54)



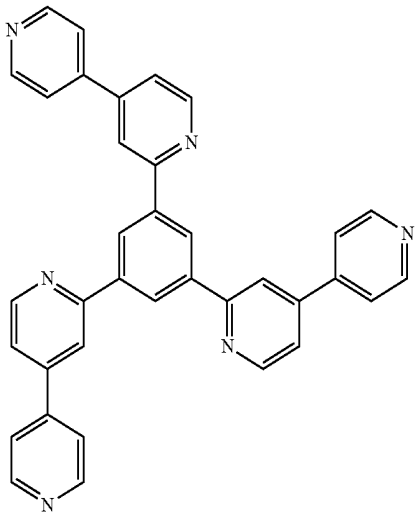
[Formula 56]

(Compound 55)



[Formula 57]

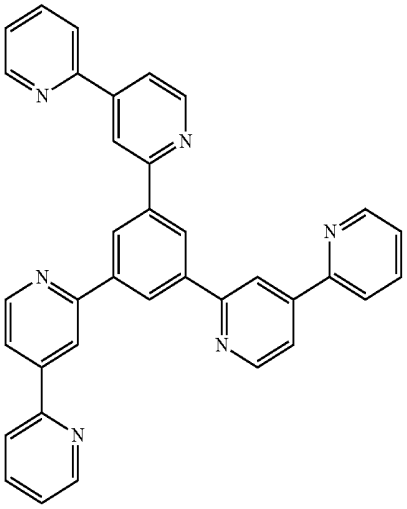
(Compound 56)



-continued

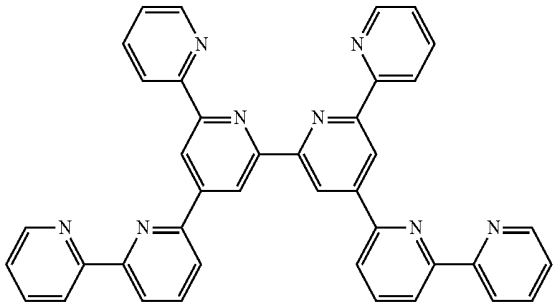
[Formula 58]

(Compound 57)



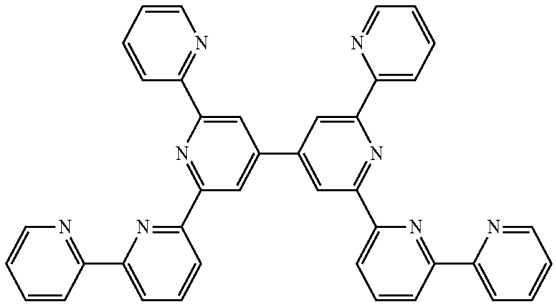
[Formula 59]

(Compound 58)



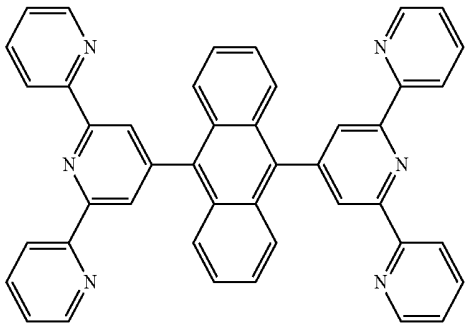
[Formula 60]

(Compound 59)



[Formula 61]

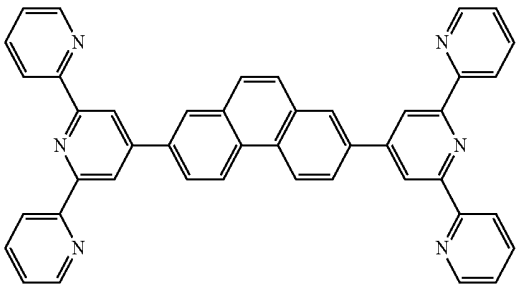
(Compound 60)



-continued

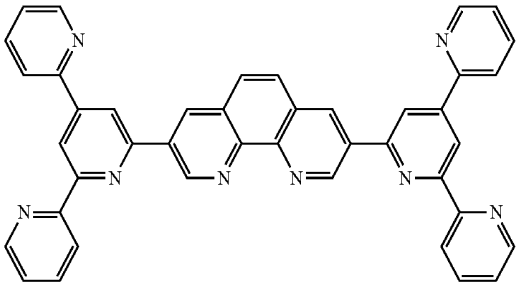
[Formula 62]

(Compound 61)



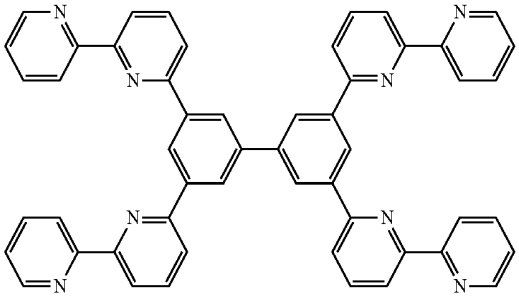
[Formula 63]

(Compound 62)



[Formula 64]

(Compound 63)



[0057] These compounds are purified through column chromatography purification, adsorption purification, or recrystallization or crystallization with solvent, etc. The compounds are identified through NMR analysis. DSC measurement (Tg) and melting point measurement are made for the physical data. The melting point can be an index of vapor deposition, and the glass transition point (Tg) can be an index of thin film stability.

[0058] For measurement of the melting point and the glass transition point thereof, the powder of the compound is analyzed with a high-sensitivity differential scanning calorimeter, Seiko Instruments' DSC6200.

[0059] The work function is measured as follows; A 100-nm thin film of the compound is formed on an ITO substrate, and analyzed with an atmospheric photoelectron spectrometer, Riken Keiki's AC3 Model. The work function can be an index of hole-blocking capability.

[0060] The structure of the organic EL device of the invention includes one comprising an anode, a hole transport layer, a light-emitting layer, a hole-blocking layer, an electron transport layer and a cathode in that order on a substrate, one having a hole injection layer between the anode and the hole transport layer, or one having an electron injection layer between the electron transport layer and the cathode. In the multilayer structure, some organic layers may be omitted; and for example, an anode, a hole transport layer, a light-emitting layer, an electron transport layer and a cathode may be formed in that order on a substrate.

[0061] As the anode of the organic EL device, used is an electrode material having a large work function, such as ITO or gold. For the hole injection layer, usable is copper phthalocyanine (hereinafter abbreviated as CuPc) as well as a material of a starburst-type triphenylamine derivative or the like, or a coating type material.

[0062] For the hole transport layer, usable are benzidine derivatives such as N,N'-diphenyl-N,N'-di(m-tolyl)-benzidine (hereinafter abbreviated as TPD) and N,N'-diphenyl-N,N'-di(α-naphthyl)-benzidine (hereinafter abbreviated as NPD), various triphenylamine tetramers, etc. As the hole injection/transport layer, usable is a coating type polymer material such as PEDOT/PSS.

[0063] For the light-emitting layer, the hole-blocking layer and the electron transport layer of the organic EL device of the invention, usable are compounds having a hole-blocking effect, for example, complexes with aluminium such as BAlq, thiazole derivatives, oxazole derivatives, carbazole derivatives, polydialkylfluorene derivatives, phenanthroline derivatives such as BCP, triazole derivatives such as TAZ and the like, in addition to the substituted bipyridyl compounds.

[0064] Using a conventional light-emitting material such as a complex with aluminum or a styryl derivative as the light-emitting layer and using the substituted bipyridyl compound as the hole-blocking layer and the electron transport layer provides high-efficiency organic EL devices. As the host material for the light-emitting layer, for example, usable is a fluorescent material such as quinacridone, coumarin or rubrene. As the phosphorescent material, usable are green phosphorescent materials such as iridium complex of phenylpyridine Ir(ppy)3; blue phosphorescent material such as FIrpic, FIr6; red phosphorescent material such as Btp2Ir (acac), etc. Regarding the host material for this, carbazole derivatives such as 4,4'-di(N-carbazolyl)biphenyl (hereinafter abbreviated as CBP), 4,4',4"-tri(N-carbazolyl)triphenylamine (hereinafter abbreviated as TCTA), 1,3-bis(carbazol-9-yl)benzene (hereinafter abbreviated as mCP) are usable as the hole-injecting/transporting host materials; and 2,2',2"-(1,3,5-phenylene)-tris(1-phenyl-1H-benzimidazole) (hereinafter abbreviated as TPBI) and the like are usable as the electron-transporting host material. With these, a high-efficiency organic EL device can be produced.

[0065] A conventional electron-transporting material may be superposed or co-deposited on the substituted bipyridyl compound to obtain an electron transport layer for use herein.

[0066] The organic EL device of the invention may have an electron injection layer. For the electron injection layer, usable is lithium fluoride or the like. As the cathode, usable is an electrode material having a low work function such as aluminum, or an alloy having a lower work function such as aluminum-magnesium is also usable as the electrode material for the cathode.

[0067] Embodiments of the invention will be described in detail with reference to the following Examples; however, not

overstepping the scope and the sprit thereof, the invention should not be limited to the following Examples.

Example 1

Synthesis of 1,3,5-tris(2,2-'bipyridin-6-yl)benzene (compound 6)

[0068] 8.6 g of 1,3,5-tribromobenzene, 25.0 g of bis(pinacolato)diboron, 24.1 g of potassium acetate, 250 ml of dimethyl sulfoxide previously dewatered with Molecular Sieves 4A, and 1.4 g of $PdCl_2(dppf)$-CH_2Cl_2 were put into a nitrogen-purged reactor, then heated, and stirred at 80° C. for 20 hours. After cooled to room temperature, the reaction liquid was put into 1000 ml of water, and stirred for 30 minutes. The precipitate was collected through filtration, and the precipitate was washed with methanol to obtain a crude product. The crude product was dissolved in 200 ml of ethyl acetate, the insoluble matter was removed through filtration, and the filtrated was concentrated to dryness to obtain 7.1 g (yield 57%) of a white powder, 1,3,5-tris(4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)benzene.

[0069] 2.5 g of the obtained 1,3,5-tris(4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)benzene, 3.8 g of 6-bromo-[2,2']-bipyridine, 32.3 ml of aqueous 1 M potassium carbonate solution, 0.3 g of tetrakis(triphenylphosphine)palladium(0), 108 ml of toluene and 27 ml of ethanol were put into a nitrogen-purged reactor, and heated under reflux with stirring for hours. After cooled to room temperature, this was processed for liquid-liquid separation with 100 ml of water and 100 ml of toluene added thereto, and the organic layer was further washed with 100 ml of water. The organic layer was dewatered with anhydrous magnesium sulfate and then concentrated to obtain a crude product. The crude product was purified through column chromatography (carrier: NH silica gel, eluent: chloroform/n-hexane) to obtain 1.1 g (yield 38%) of a white powder, 1,3,5-tris(2,2'-bipyridin-6-yl)benzene (compound 6).

[0070] The structure of the obtained white powder was identified through NMR. The 1H-NMR data are shown in FIG. **1**.

[0071] In the 1H-NMR (CDCl3), the following 24 hydrogen signals were detected: δ (ppm)=9.02 (3H), 8.76 (6H), 8.47 (3H), 7.99-8.04 (6H), 7.69 (3H), 7.37 (3H).

Example 2

Synthesis of 2,4,6-tris(2,2'-bipyridin-6-yl)-[1,3,5] triazine (compound 8)

[0072] 5.0 g of [2,2']-bipyridine-6-carbonitrile, and 0.2 g of sodium hydride were put into a nitrogen-purged reactor, then heated and stirred at 150° C. for 7 hours. After cooled to room temperature, 15 ml of methanol was added to the reaction liquid, and further stirred for 1 hour. Subsequently, this was processed for liquid-liquid separation with 70 ml of water and 100 ml of chloroform added thereto, and the organic layer was further washed with 50 ml of water. The organic layer was dewatered with anhydrous sodium carbonate and concentrated to obtain a crude product. The crude product was purified through recrystallization with 70 ml of orthodichlorobenzene to obtain 2.3 g (yield 46%) of a pale yellow powder, 2,4,6-tris(2,2'-bipyridin-6-yl)-[1,3,5]triazine (compound 8).

[0073] The structure of the obtained pale yellow powder was identified through NMR. The 1H-NMR data are shown in FIG. **2**.

[0074] In the 1H-NMR (CDCl3), the following 21 hydrogen signals were detected: δ (ppm)=8.99 (6H), 8.75 (6H), 8.17 (3H), 7.97 (3H), 7.42 (3H).

Example 3

Synthesis of 1,2,4,5-tetrakis(2,2'-bipyridin-6-yl)benzene (compound 15)

[0075] Like in the above-mentioned Example 1, 1,2,4,5-tetrakis(4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)benzene was produced from 1,2,4,5-tetrabromobenzene and bis(pinacolato)diboron. 2.1 g of the obtained 1,2,4,5-tetrakis(4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)benzene, 4.1 g of 6-bromo-2,2'-bipyridine, 21.8 ml of aqueous 2 M potassium carbonate solution, 0.2 g of tetrakis(triphenylphosphine)palladium(0), 120 ml of toluene and 30 ml of ethanol were put into a nitrogen-purged reactor, and heated under reflux with stirring for hours. After cooled to room temperature, this was processed for liquid-liquid separation with 100 ml of water and 300 ml of chloroform added thereto, and the organic layer was further washed with 100 ml of water. The organic layer was dewatered with anhydrous magnesium sulfate and then concentrated to obtain a crude product. The crude product was purified through column chromatography (carrier: NH silica gel, eluent: chloroform/n-hexane) to obtain 0.3 g (yield 12%) of a white powder, 1,2,4,5-tetrakis(2,2'-bipyridin-6-yl)benzene (compound 15).

[0076] The structure of the obtained white powder was identified through NMR. The 1H-NMR data are shown in FIG. **3**.

[0077] In the 1H-NMR (CDCl3), the following 30 hydrogen signals were detected: δ (ppm)=8.62 (4H), 8.26 (6H), 8.12 (4H), 7.71 (4H), 7.60 (4H), 7.37 (4H), 7.23 (4H).

Example 4

Synthesis of 1,3,5-tris(2,2';6',2"-terpyridin-6-yl)benzene (compound 29)

[0078] 3.0 g of 1,3,5-tris(4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)benzene obtained in the above-mentioned Example 1, 6.2 g of 6-bromo-[2,2';6',2"]-terpyridine, 59.2 ml of aqueous 1 M potassium carbonate solution, 0.39 g of tetrakis(triphenylphosphine)palladium(0), 131 ml of toluene and 33 ml of ethanol were put into a nitrogen-purged reactor, and heated under reflux with stirring for hours. After cooled to room temperature, this was processed for liquid-liquid separation with 100 ml of water and 100 ml of toluene added thereto, and the organic layer was further washed with 100 ml of water. The organic layer was dewatered with anhydrous magnesium sulfate and then concentrated to obtain a crude product. The crude product was purified through column chromatography (carrier: NH silica gel, eluent: chloroform/n-hexane) to obtain 1.8 g (yield 35%) of a white powder, 1,3,5-tris(2,2';6',2"-terpyridin-6-yl)benzene (compound 29).

[0079] The structure of the obtained white powder was identified through NMR. The 1H-NMR data are shown in FIG. **4**.

[0080] In the 1H-NMR (CDCl3), the following 33 hydrogen signals were detected: δ (ppm)=9.09 (3H), 8.83 (3H), 8.74 (3H), 8.70 (6H), 8.51 (3H), 8.06 (9H), 7.90 (3H), 7.37 (3H).

Example 5

Synthesis of 3,5,3',5'-tetrakis(2,2'-bipyridin-6-yl) biphenyl (compound 63)

[0081] Like in the above-mentioned Example 1,3,5,3',5'-tetrakis(4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)bi-

phenyl was produced from 3,5,3',5'-tetrabromobiphenyl and bis(pinacolato)diboron. 3.2 g of the obtained 3,5,3',5'-tetrakis (4,4,5,5-tetramethyl-[1,3,2]dioxabororan-2-yl)biphenyl, 4.5 g of 6-bromo-2,2'-bipyridine, 28.7 ml of aqueous 2 M potassium carbonate solution, 0.3 g of tetrakis(triphenylphosphine)palladium(0), 110 ml of toluene and 25 ml of ethanol were put into a nitrogen-purged reactor, and heated under reflux with stirring for hours. After cooled to room temperature, this was processed for liquid-liquid separation with 100 ml of water and 300 ml of chloroform added thereto, and the organic layer was further washed with 100 ml of water. The organic layer was dewatered with anhydrous magnesium sulfate and then concentrated to obtain a crude product. The crude product was purified through column chromatography (carrier: NH silica gel, eluent: chloroform/n-hexane) to obtain 2.4 g (yield 64%) of a white powder, 3,5,3',5'-tetrakis (2,2'-bipyridin-6-yl)biphenyl (compound 63).

[0082] The structure of the obtained white powder was identified through NMR. The 1H-NMR data are shown in FIG. **5**.

[0083] In the 1H-NMR (CDCl3), the following 34 hydrogen signals were detected: δ (ppm)=8.96 (2H), 8.72 (8H), 8.63 (4H), 8.47 (4H), 8.00 (8H), 7.77 (4H), 7.32 (4H).

Example 6

[0084] The compounds of the invention were analyzed with a high-sensitivity differential scanning calorimeter, Seiko Instruments' DSC6200 to determine the melting point and the glass transition point thereof.

	Melting Point	Glass Transition Point
Compound of Example 1 of the invention	240° C.	74° C.
Compound of Example 2 of the invention	327° C.	86° C.
Compound of Example 3 of the invention	310° C.	115° C.
Compound of Example 4 of the invention	305° C.	110° C.
Compound of Example 5 of the invention	310° C.	none

[0085] The compounds of the invention had a glass transition point of not lower than 70° C. or did not have a glass transition point. This indicates the stability of the compounds of the invention as thin films.

Example 7

[0086] Using the compound of the invention, a deposited film having a thickness of 100 nm was formed on an ITO substrate, and this was analyzed with an atmospheric photoelectron spectrometer (Riken Keiki's AC3 Model) to determine the work function thereof.

	Work Function
Compound of Example 1 of the invention	6.45 eV
Compound of Example 2 of the invention	6.70 eV
Compound of Example 3 of the invention	6.58 eV
Compound of Example 4 of the invention	6.60 eV
Compound of Example 5 of the invention	6.38 eV

[0087] As in the above, the compounds of the invention have a larger work function than that, 5.4 eV of ordinary hole-transporting materials such as NPD and TPD, and therefore have a larger hole-blocking ability.

Example 8

[0088] An organic EL device was produced by forming a hole transport layer **3**, a light-emitting layer **4**, a hole-blocking layer **5**, an electron transport layer **6**, an electron injection layer **7** and a cathode (aluminum electrode) **8** through vapor deposition in that order on a glass substrate **1** on which an ITO transparent electrode had been previously formed as an anode **2**, as in FIG. **6**. A glass substrate **1** with, as formed thereon, an ITO film having a thickness of 150 nm was washed with an organic solvent, and then its surface was washed through UV ozone treatment. This was set in a vacuum evaporation chamber, in which the pressure was reduced to 0.001 Pa or less.

[0089] Subsequently, NPD was deposited thereon as a hole transport layer **3** to have a thickness of about 30 nm at a vapor deposition rate of 6 nm/min. Further on it, CBP with $Ir(ppy)_3$, as controlled to have a composition ratio of 7% by weight, was deposited as a light-emitting layer **4** to have a thickness of about 40 nm at a vapor deposition rate of 6 nm/min. On the light-emitting layer **4**, the compound of Example 1 of the invention (compound 6) was deposited as a hole-blocking layer also serving as an electron transport layer **5** and **6** to have a thickness of about 45 nm at a vapor deposition rate of 6 nm/min. On the hole-blocking layer/electron transport layer **5** and **6**, lithium fluoride was deposited as an electron injection layer **7** to have a thickness of about 0.5 nm at a vapor deposition rate of 0.6 nm/min. Finally, aluminum was deposited to have a thickness of about 200 nm, thereby forming a cathode **8**. The produced device was stored in a vacuum desiccator, and its characteristics were measured at room temperature in air.

[0090] A direct voltage was applied to the organic EL device thus produced with the compound of Example 1 of the invention (compound 6), and the data of the light-emitting characteristics of the device are shown in FIG. **7** and FIG. **8**. Specifically, the device gave light emission of 100 cd/m^2 from 3.3 V; and at 5.1 V, a current of 10 mA/cm^2 run through the device, and the device gave green light emission of 3900 cd/m^2. At the luminance, the external quantum efficiency of the device was 12%.

Comparative Example 1

[0091] For comparison, an organic EL device was produced under the same condition as in Example 8, for which, however, the hole-blocking layer **5** in Example 8 was changed to BCP, and the electron transport layer **6** was changed to Alq_3. Concretely, BCP was deposited as the hole transport layer **5** to have a thickness of about 15 nm at a vapor deposition rate of 6 nm/min, and Alq_3 was deposited as the electron transport layer **6** to have a thickness of about 30 nm at a vapor deposi-

tion rate of 6 nm/min. A direct voltage was applied to the produced organic EL device, and the data of the light-emitting characteristics of the device are shown in FIG. **7** and FIG. **8**. Specifically, the device gave light emission of 100 cd/m^2 from 4.2 V; and at 7.0 V, a current of 10 mA/cm^2 run through the device, and the device gave green light emission of 3800 cd/m^2. At the luminance, the external quantum efficiency of the device was 12%.

[0092] As in the above, it is known that the organic EL device of the invention attained noticeable reduction in the drive voltage not lowering the external quantum efficiency thereof, as compared with the device in which BCP was used as the hole-blocking layer and Alq_3 generally used as an ordinary electron-transporting material was used as the electron transport layer.

Example 9

[0093] Like in Example 8, a glass substrate **1** with, as formed thereon, an ITO film having a thickness of 150 nm was washed with an organic solvent, and then its surface was washed through UV ozone treatment. This was set in a vacuum evaporation chamber, in which the pressure was reduced to 0.001 Pa or less. Subsequently, NPD was deposited thereon as a hole transport layer **3** having a thickness of about 30 nm to cover the transparent anode **2**, at a vapor deposition rate of 6 nm/min. Further on it, mCP with FIr6, as controlled to have a composition ratio of 6% by weight, was deposited as a light-emitting layer **4** to have a thickness of about 40 nm at a vapor deposition rate of 6 nm/min. On the light-emitting layer **4**, the compound of Example 1 of the invention (compound 6) was deposited as a hole-blocking layer also serving as an electron transport layer **5** and **6** to have a thickness of about 45 nm at a vapor deposition rate of 6 nm/min. On the hole-blocking layer/electron transport layer **5** and **6**, lithium fluoride was deposited as an electron injection layer **7** to have a thickness of about 0.5 nm at a vapor deposition rate of 0.6 nm/min. Finally, aluminum was deposited to have a thickness of about 200 nm, thereby forming a cathode **8**. The produced device was stored in a vacuum desiccator, and its characteristics were measured at room temperature in air.

[0094] A current density of 10 mA/cm^2 was applied to the organic EL device thus produced with the compound of Example 1 of the invention (compound 6). The data of the light-emitting characteristics of the device are summarized in Table 1.

Example 10

[0095] An organic EL device was produced in the same manner as in Example 9, in which, however, the compound of Example 3 of the invention (compound 15) was used for the hole-blocking/electron transport layer **5** and **6**. A current density of 10 mA/cm^2 was applied to the produced organic EL device. The data of the light-emitting characteristics of the device are summarized in Table 1.

Example 11

[0096] An organic EL device was produced in the same manner as in Example 9, in which, however, the compound of Example 4 of the invention (compound 29) was used for the hole-blocking/electron transport layer **5** and **6**. A current density of 10 mA/cm^2 was applied to the produced organic EL device. The data of the light-emitting characteristics of the device are summarized in Table 1.

Comparative Example 2

[0097] For comparison, an organic EL device was produced in the same manner as in Example 9, in which, however, TPBI was used for the hole-blocking/electron transport layer **5** and **6**. A current density of 10 mA/cm^2 was applied to the produced organic EL device. The data of the light-emitting characteristics of the device are summarized in Table 1.

TABLE 1

		Voltage [V] (@10 mA/cm^2)	Luminance [cd/m^2] (@10 mA/cm^2)	Current Efficiency [cd/A] (@10 mA/cm^2)	Power Efficiency [Im/W] (@10mA/cm^2)
Example 9	Compound 6	7.36	1011	10.11	4.04
Example 10	Compound 15	7.41	1029	10.29	4.36
Example 11	Compound 29	7.38	986	9.86	4.20
Comparative Example 2	TPBI	8.73	881	8.81	3.17

[0098] As shown in Table 1, when a current density of. 10 mA/cm^2 was applied to the devices, the drive voltage of the devices comprising the compound of the invention was lower than the drive voltage, 8.73 V of the device comprising TPBI. In addition, when a current density of mA/cm^2 was applied thereto, the devices of the invention all had significantly higher data of luminance, current efficiency and power efficiency than that those of the device comprising TPBI.

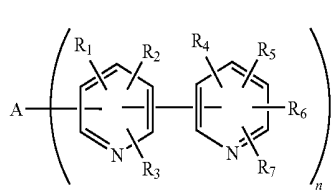
[0099] As in the above, it is known that the blue phosphorescent organic EL devices of the invention are excellent in the current efficiency and the power efficiency and can attain remarkable reduction in the practical drive voltage, as compared with the device using an ordinary electron-transporting material TPBI.

INDUSTRIAL APPLICABILITY

[0100] The substituted bipyridyl compound of the invention shows an excellent electron-injecting/transporting performance and has an excellent hole-blocking ability, and its film is stable, and therefore, it is excellent as a compound for organic EL devices. When an organic EL device is produced, using the compound, then the drive voltage of the device can be lowered and the durability thereof can be improved. For example, the invention has made it possible to develop the application of the compound to electric home appliances and lightings.

1. A substituted bipyridyl compound represented by the following general formula (1):

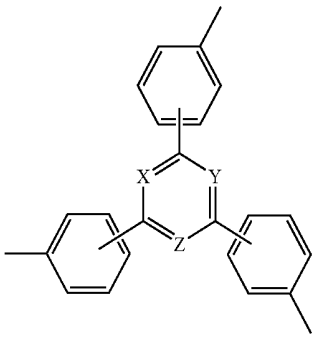
[Formula 1]



(1)

(wherein R^1 to R^7 may be the same or different, each representing a hydrogen atom, a fluorine atom, a chlorine atom, a cyano group, a trifluoromethyl group, a linear or branched alkyl group having from 1 to 6 carbon atoms, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; n indicates an integer of from 2 to 4; A represents a di- to tetra-valent, substituted or unsubstituted aromatic hydrocarbon group, a di- to tetra-valent, substituted or unsubstituted aromatic heterocyclic group, a di- to tetra-valent, substituted or unsubstituted condensed polycyclic aromatic group, or a trivalent group represented by the following general formula (2):

[Formula 2]



(2)

(wherein X, Y and Z each represents a carbon atom or a nitrogen atom); provided that when n=2, the two bipyridyl structures may direct bond to each other, and in the case, A is absent).

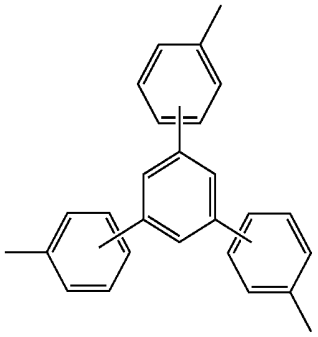
2. The substituted bipyridyl compound as claimed in claim 1, wherein in the general formula (1), A is a tri- or tetra-valent group derived from benzene by removing 3 or 4 hydrogen atoms therefrom.

3. The substituted bipyridyl compound as claimed in claim 1, wherein in the general formula (1), A is a tri- or tetra-valent group derived from biphenyl by removing 3 or 4 hydrogen atoms therefrom.

4. The substituted bipyridyl compound as claimed in claim 1, wherein in the general formula (1), A is a trivalent group derived from triazine by removing 3 hydrogen atoms therefrom.

5. The substituted bipyridyl compound as claimed in claim 1, wherein in the general formula (1), A is a trivalent group represented by the following general formula (3):

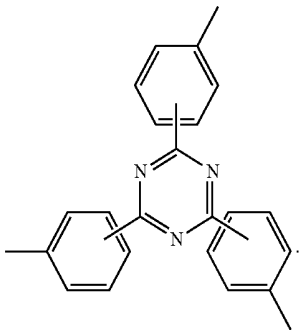
[Formula 3]



(3)

6. The substituted bipyridyl compound as claimed in claim 1, wherein in the general formula (1), A is a trivalent group represented by the following general formula (4):

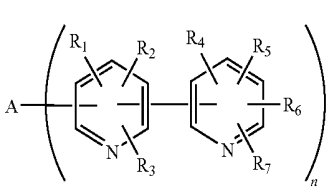
[Formula 4]



(4)

7. An organic electroluminescent device comprising a pair of electrodes and at least one organic layer sandwiched between them, wherein a substituted bipyridyl compound represented by the following general formula (1) is used as the constitutive material of at least one organic layer:

[Formula 5]

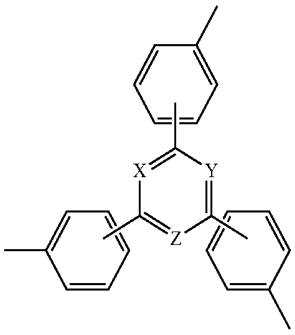


(1)

(wherein R^1 to R^7 may be the same or different, each representing a hydrogen atom, a fluorine atom, a chlorine atom, a cyano group, a trifluoromethyl group, a linear or branched alkyl group having from 1 to 6 carbon atoms, a substituted or unsubstituted aromatic hydrocarbon group, a substituted or unsubstituted aromatic heterocyclic group, or a substituted or unsubstituted condensed polycyclic aromatic group; n indicates an integer of from 2 to 4; A represents a di- to tetra-valent, substituted or unsubstituted aromatic hydrocarbon group, a di-

to tetra-valent, substituted or unsubstituted aromatic heterocyclic group, a di- to tetra-valent, substituted or unsubstituted condensed polycyclic aromatic group, or a trivalent group represented by the following general formula (2):

[Formula 6]



(2)

(2)

(wherein X, Y and Z each represents a carbon atom or a nitrogen atom); provided that when n=2, the two bipyridyl structures may direct bond to each other, and in the case, A is absent).

8. The organic electroluminescent device as claimed in claim **7**, wherein the organic layer is an electron transport layer, and the compound of the general formula (1) is used as at least one constitutive material in the electron transport layer.

9. The organic electroluminescent device as claimed in claim **7**, wherein the organic layer is a hole-blocking layer, and the compound of the general formula (1) is used as at least one constitutive material in the hole-blocking layer.

10. The organic electroluminescent device as claimed in claim **7**, wherein the organic layer is a light-emitting layer, and the compound of the general formula (1) is used as at least one constitutive material in the light-emitting layer.

11. The organic electroluminescent device as claimed in claim **7**, wherein the organic layer is an electron injection layer, and the compound of the general formula (1) is used as at least one constitutive material in the electron injection layer.

* * * * *

专利名称(译)	取代的联吡啶化合物和有机电致发光器件		
公开(公告)号	US20110001129A1	公开(公告)日	2011-01-06
申请号	US12/735885	申请日	2009-02-25
[标]申请(专利权)人(译)	保土谷化学工业株式会社 国立大学法人信州大学		
申请(专利权)人(译)	HODOGAYA化学有限公司. 信州大学国立大学CORPORATIO		
当前申请(专利权)人(译)	HODOGAYA化学有限公司. 信州大学，国立大学法人		
[标]发明人	YOKOYAMA NORIMASA HAYASHI SHUICHI NAGAOKA MAKOTO TANIGUCHI YOSHIO ICHIKAWA MUSUBU		
发明人	YOKOYAMA, NORIMASA HAYASHI, SHUICHI NAGAOKA, MAKOTO TANIGUCHI, YOSHIO ICHIKAWA, MUSUBU		
IPC分类号	H01L51/50 C07D401/14 C07D403/14 C07D471/04		
CPC分类号	C07D213/22 H01L51/0067 H01L51/0085 C09K11/06 C09K2211/1059 C09K2211/1007 C09K2211/1011 C09K2211/1029 H05B33/10		
优先权	2008043788 2008-02-26 JP		
其他公开文献	US8642189		
外部链接	Espacenet USPTO		

摘要(译)

[问题]提供一种显示出优异的电子注入/传输性能的有机化合物，具有空穴阻挡能力并且作为膜显示出高稳定性，即，作为用于具有高效率的有机电致发光器件的材料具有优异的特性高耐久性;并提供一种包含该化合物并具有高效率和高耐久性的有机EL器件。 [溶液用手段]通式（1）表示的取代联吡啶化合物;和有机电致发光器件，包括一对电极和夹在其间的至少一个有机层，其中该化合物用作至少一个有机层的组成材料。（式中，R 1~R 7可以相同或不同，分别表示氢原子，氟原子，氯原子，氰基，三氟甲基，碳原子数1~6的直链或支链的烷基，取代的或未取代的芳族烃基，取代或未取代的芳族杂环基，或取代或未取代的稠合多环芳族基团; n表示2至4的整数; A表示二价至四价，取代或未取代的芳族烃基，二至四价，取代或未取代的芳族杂环基，二价至四价，取代或未取代的稠合多环芳族基团，或由以下通式（2）表示的三价基团：（其中X，Y和Z各自代表碳原子或氮原子）;条件是当n = 2时，两个联吡啶结构可以直接相互键合，在这种情况下，A不存在）。