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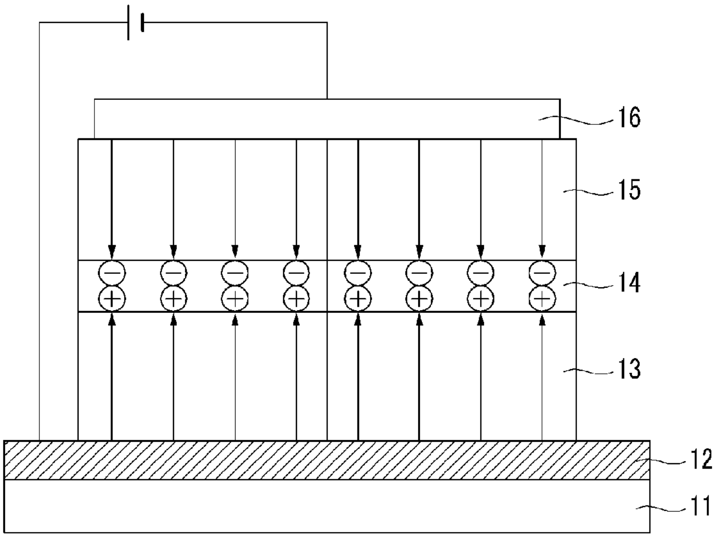
[Continued on next page]

(54) Title: BENZIMIDAZOLE COMPOUNDS AND ORGANIC PHOTOELECTRIC DEVICE WITH THE SAME

[Fig. 1]



(57) Abstract: Disclosed are benzimidazole compounds and an organic photoelectric device including the same. The novel benzimidazole compounds have high solubility in an organic solvent, and are applicable as a host material of an emission layer, an electron transporting material, or a hole blocking material of an organic photoelectric device since they emit fluorescence and phosphorescence at a red wavelength through a blue wavelength, and an organic photoelectric device including the same.

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Description

Title of Invention: BENZIMIDAZOLE COMPOUNDS AND ORGANIC PHOTOELECTRIC DEVICE WITH THE SAME

Technical Field

[1] The present invention relates to benzimidazole compounds and an organic photoelectric device including the same. More particularly, the present invention relates to novel benzimidazole compounds that have high solubility in an organic solvent, and that are applicable as a host material of an emission layer, an electron transporting material, or a hole blocking material of an organic photoelectric device since they emit fluorescence and phosphorescence at a red wavelength through a blue wavelength, and an organic photoelectric device including the same.

[2]

Background Art

[3] An organic photoelectric device has been highlighted as the next generation display device. The organic photoelectric device can be driven at a low voltage, and can solve various problems of a thin film transistor-liquid crystal display (TFT-LCD), such as is difficult to make it thinner and have a wide viewing angle and rapid response speed. The organic photoelectric device of a middle size or less also has equivalent or better image quality to a TFT-LCD compared to other displays, and its manufacturing process is very simple. Therefore, it is considered that it will be advantageous in terms of cost in the future.

[4] An organic photoelectric device includes an organic light emitting material between a rear plate including ITO transparent electrode patterns as an anode on a transparent glass substrate and an upper plate including a metal electrode as a cathode on a substrate. When a predetermined voltage is applied between the transparent electrode and the metal electrode, current flows through the organic light emitting material to emit light.

[5] Such an organic light emitting material for an organic photoelectric device was firstly developed by Eastman Kodak, Inc., in 1987. The material is a low molecular aromatic diamine and aluminum complex as an emission-layer-forming material (Applied Physics Letters. 51, 913, 1987). C. W. Tang et al. firstly disclosed a practicable device as an organic photoelectric device in 1987 (Applied Physics Letters, 51 12, 913-915, 1987).

[6] According to the reference, the organic layer has a structure in which a thin film (hole transport layer (HTL)) of a diamine derivative and a thin film of tris(8-hydroxy-quinolate)aluminum (Alq_3) are laminated. The Alq_3 thin film functions

as an electron transporting emission layer.

[7] Generally, an organic photoelectric device is composed of an anode of a transparent electrode, an organic thin layer of a light emitting region, and a metal electrode (cathode) formed on a glass substrate, in that order. The organic thin layer may include an emission layer, a hole injection layer (HIL), a hole transport layer (HTL), an electron transport layer (ETL), or an electron injection layer (EIL). It may further include an electron inhibition layer or a hole inhibition layer due to the emission characteristics of the emission layer.

[8] When the organic light emitting diode is applied with an electric field, the holes and electrons are injected from the anode and the cathode, respectively. The injected holes and electrons are recombined on the emission layer though the hole transport layer (HTL) and the electron transport layer (ETL) to provide light emitting excitons. The provided light emitting excitons emit light by transiting to the ground state.

[9] The light emission may be classified as a fluorescent material including singlet excitons and a phosphorescent material including triplet excitons according to the light emitting mechanism.

[10] Recently, it is has become known that a phosphorescent light emitting material can be used for a light emitting material of an organic photoelectric device in addition to the fluorescent light emitting material (D. F. O'Brien et al., Applied Physics Letters, 74 3, 442-444, 1999; M. A. Baldo et al., Applied Physics letters, 75 1, 4-6, 1999). Such a phosphorescent material emits light by transiting the electrons from a ground state to an excited state, non-radiance transiting of a singlet exciton to a triplet exciton through intersystem crossing, and transiting a triplet exciton to a ground state to emit light.

[11] When the triplet exciton is transited, it cannot directly transit to the ground state. Therefore, the electron spin is flipped, and then it is transited to the ground state so that it provides a characteristic of extending the lifetime (emission duration) to more than that of fluorescent emission.

[12] In other words, the duration of fluorescent emission is extremely short at several nanoseconds, but the duration of phosphorescent emission is relatively long such as at several microseconds.

[13] In addition, evaluating quantum mechanically, when holes injected from the anode are recombined with electrons injected from the cathode to provide light emitting excitons, the singlet and the triplet are produced in a ratio of 1:3, in which the triplet light emitting excitons are produced at three times the amount of the singlet light emitting excitons in the organic photoelectric device.

[14] Accordingly, the percentage of the singlet exited state is 25% (the triplet is 75%) in the case of a fluorescent material, so it has limits in luminous efficiency. On the other hand, in the case of a phosphorescent material, it can utilize 75% of the triplet exited

state and 25% of the singlet exited state, so theoretically the internal quantum efficiency can reach 100%. When a phosphorescent light emitting material is used, it has advantages in an increase in luminous efficiency of around four times that of the fluorescent light emitting material.

[15] In the above-mentioned organic photoelectric device, a light emitting colorant (dopant) may be added to an emission layer (host) in order to increase the efficiency and stability in the emission state.

[16] In this structure, the efficiency and properties of the light emission diodes are dependent on the host material in the emission layer. According to studies regarding the emission layer (host), the organic host material can be exemplified by a material including naphthalene, anthracene, phenanthrene, tetracene, pyrene, benzopyrene, chrysene, pycene, carbazole, fluorene, biphenyl, terphenyl, triphenylene oxide, dihalobi phenyl, trans-stilbene, and 1,4-diphenylbutadiene.

[17] Generally, the host material includes 4,4-N,N-dicarbazole biphenyl (CBP) having a glass transition temperature of 110 C or less and excessively high symmetry. Thereby, it tends to crystallize and cause problems such as a short circuit and a pixel defect according to results of thermal resistance tests of the devices.

[18] In addition, most host materials including CBP are materials in which the hole transporting property is greater than the electron transporting property. In other words, as the injected hole transportation is faster than the injected electron transportation, the excitons are ineffectively formed in the emission layer. Therefore, the resultant device has deteriorated luminous efficiency.

[19] Accordingly, host materials, or charge transporting materials such as electron transporting materials, hole blocking materials, and the like that have high thermal stability and triplet T1 energy, have been required to be developed.

[20]

Disclosure of Invention

Technical Problem

[21] One embodiment of the present invention provides a novel benzimidazole compound having high charge transporting properties, good film stability, and high triplet T1 energy and thus is applicable to host materials, or charge transporting materials such as electron transporting materials, hole blocking materials, and the like.

[22] Another embodiment of the present invention provides an organic photoelectric device including the benzimidazole compound.

[23]

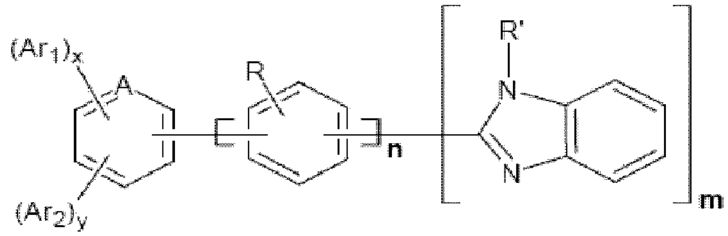
Solution to Problem

[24] According to one embodiment of the present invention, a benzimidazole compound

represented by the following Chemical Formula 1 is provided.

[25] [Chemical Formula 1]

[26]



[27] In the above Chemical Formula 1,

[28] A is C or N,

[29] Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C6 to C30 arylamine, a substituted or unsubstituted C2 to C30 heteroarylamine, a substituted or unsubstituted carbazole, and a substituted or unsubstituted fluorene,

[30] x and y are the same or different and are independently integers ranging from 0 to 5, provided that $1 \leq x+y \leq 5$,

[31] R is hydrogen or a C1 to C7 lower alkyl,

[32] n is an integer ranging from 0 to 3,

[33] R' is selected from the group consisting of a substituted or unsubstituted C1 to C50 alkyl and a substituted or unsubstituted C6 to C50 aryl, and

[34] m is 1 or 2.

[35] According to another embodiment of the present invention, an organic photoelectric device is provided that includes an anode, a cathode, and organic thin layers disposed between the anode and cathode. The organic thin layer includes the above benzimidazole compound.

[36] According to a further embodiment of the present invention, a display element is provided that includes the organic photoelectric device.

[37] Hereinafter, further embodiments of the present invention will be described in detail.

[38]

Advantageous Effects of Invention

[39] The benzimidazole compound is applicable as host materials, electron transporting materials, or hole blocking materials, and thus is used for an organic thin layer of an organic photoelectric device such as an organic emission layer, an electron transport layer (ETL), a hole blocking layer, and the like.

[40]

Brief Description of Drawings

[41] FIG. 1 is a cross-sectional view showing an organic photoelectric device according to

one embodiment of the present invention.

[42] FIG. 2 shows LC-MS data of the compound M-6 prepared in Example 4 of the present invention.

[43] FIG. 3 is a graph showing a photoluminescence (PL) wavelength of the compound M-6 prepared in Example 4.

[44] FIG. 4 is a graph showing current density versus voltage of organic photoelectric devices fabricated using a solution process according to Example 8 of the present invention and Comparative Example 1.

[45] FIG. 5 is a graph showing current density versus voltage of organic photoelectric devices fabricated using a solution process according to Example 9 of the present invention and Comparative Example 2.

[46] FIG. 6 is a graph showing luminance versus voltage of organic photoelectric devices fabricated using a solution process according to Example 8 of the present invention and Comparative Example 1.

[47] FIG. 7 is a graph showing luminance versus voltage of organic photoelectric devices fabricated using a solution process according to Example 9 of the present invention and Comparative Example 2.

[48] FIG. 8 is a graph showing luminous efficiency versus luminance of organic photoelectric devices fabricated using a solution process according to Example 8 of the present invention and Comparative Example 1.

[49] FIG. 9 is a graph showing luminous efficiency versus luminance of organic photoelectric devices fabricated using a solution process according to Example 9 of the present invention and Comparative Example 2.

[50] <Description of Reference Numerals Indicating Primary Elements in the Drawings>

[51] 11: substrate 12: anode

[52] 13: hole transport layer (HTL) 14: organic emission layer

[53] 15: electron transport layer (ETL) 16: cathode

[54]

Best Mode for Carrying out the Invention

[55] Exemplary embodiments of the present invention will hereinafter be described in detail. However, these embodiments are only exemplary, and the present invention is not limited thereto.

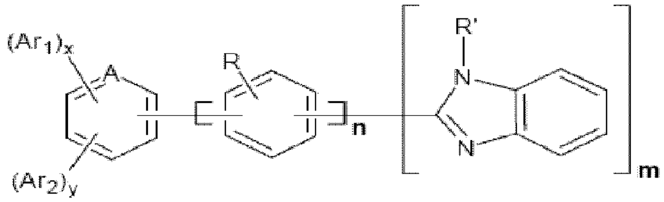
[56] As used herein, when specific definition is not provided, the term "substituted" refers to one substituted with a substituent selected from the group consisting of a halogen, a cyano, a hydroxy, an amino, a nitro, a carboxyl, an azo, a ferro, a substituted or unsubstituted C1 to C30 alkyl, a substituted or unsubstituted C1 to C20 alkenyl, a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a

substituted or unsubstituted C1 to C20 alkoxy, a substituted or unsubstituted C6 to C20 aryloxy, a substituted or unsubstituted C3 to C40 silyloxy, a substituted or unsubstituted C1 to C20 acyl, a substituted or unsubstituted C2 to C20 alkoxycarbonyl, a substituted or unsubstituted C2 to C20 acyloxy, a substituted or unsubstituted C2 to C20 heteroaryloxy, a substituted or unsubstituted C7 to C20 aryloxycarbonyl amino, a substituted or unsubstituted C1 to C20 sulfamoyl amino, a substituted or unsubstituted C1 to C20 sulfonyl, a substituted or unsubstituted C1 to C20 alkylthiol, a substituted or unsubstituted C6 to C20 arylthiol, a substituted or unsubstituted C1 to C20 heterocyclothiol, a substituted or unsubstituted C1 to C20 ureide, a substituted or unsubstituted C1 to C20 phosphoric acid amide, and a substituted or unsubstituted C3 to C40 silyl.

[57] As used herein, when specific definition is not provided, the term "hetero" refers to one including 1 to 3 heteroatoms selected from the group consisting of N, O, S, and P in one ring.

[58] According to one embodiment of the present invention, a benzimidazole compound represented by the following Chemical Formula 1 is provided.

[59] [Chemical Formula 1]

[60] 

[61] In the above Chemical Formula 1,

[62] A is C or N,

[63] Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C6 to C30 arylamine, a substituted or unsubstituted C2 to C30 heteroarylamine, a substituted or unsubstituted carbazole, and a substituted or unsubstituted fluorene,

[64] x and y are the same or different and are independently integers ranging from 0 to 5, provided that $1 \leq x+y \leq 5$,

[65] R is hydrogen or a C1 to C7 lower alkyl,

[66] n is an integer ranging from 0 to 3,

[67] R' is selected from the group consisting of a substituted or unsubstituted C1 to C50 alkyl and a substituted or unsubstituted C6 to C50 aryl, and

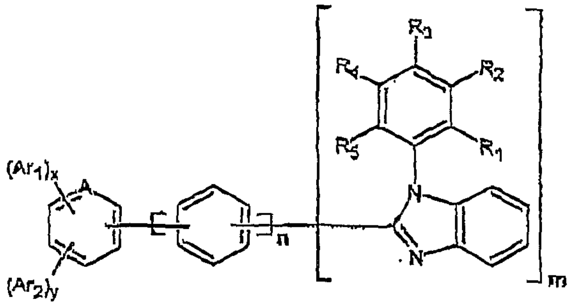
[68] m is 1 or 2.

[69] In the above Chemical Formula 1, R' is preferably a substituted or unsubstituted C6 to C50 aryl. The aryl may preferably be selected from the group consisting of a substituted or unsubstituted phenyl and a substituted or unsubstituted naphthyl.

[70] The benzimidazole compound is preferably represented by the following Chemical Formula 2.

[71] [Chemical Formula 2]

[72]



[73] In the above Chemical Formula 2,

[74] A is C or N,

[75] Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C6 to C30 arylamine, a substituted or unsubstituted C2 to C30 heteroarylamine, a substituted or unsubstituted carbazole, and a substituted or unsubstituted fluorene,

[76] x and y are the same or different and are independently integers ranging from 0 to 5, provided that $1 \leq x+y \leq 5$,

[77] n is an integer ranging from 0 to 3,

[78] R_1 to R_5 are the same or different and are independently selected from the group consisting of hydrogen, a halogen, a cyano, a hydroxy, an amino, a nitro, a carboxyl, a substituted or unsubstituted C1 to C30 alkyl, a substituted or unsubstituted C1 to C20 alkenyl, a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C1 to C20 alkoxy, a substituted or unsubstituted C6 to C20 aryloxy, a substituted or unsubstituted C3 to C40 silyloxy, a substituted or unsubstituted C1 to C20 acyl, a substituted or unsubstituted C2 to C20 alkoxycarbonyl, a substituted or unsubstituted C2 to C20 acyloxy, a substituted or unsubstituted C2 to C20 heteroaryloxy, a substituted or unsubstituted C7 to C20 aryloxycarbonyl amino, a substituted or unsubstituted C1 to C20 sulfamoyl amino, a substituted or unsubstituted C1 to C20 sulfonyl, a substituted or unsubstituted C1 to C20 alkylthiol, a substituted or unsubstituted C6 to C20 arylthiol, a substituted or unsubstituted C1 to C20 heterocyclothiol, a substituted or unsubstituted C1 to C20 ureide, a substituted or unsubstituted C1 to C20 phosphoric acid amide, and a substituted or unsubstituted C3 to C40 silyl, and

[79] m is 1 or 2.

[80] In the above formula representing the benzimidazole compound according to one

embodiment of the present invention, Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C6 to C30 arylamine, a substituted or unsubstituted C2 to C30 heteroarylamine, a substituted or unsubstituted carbazole, and a substituted or unsubstituted fluorene.

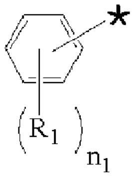
[81] Preferable examples of the aryl include one selected from the group consisting of a substituted or unsubstituted phenyl, a substituted or unsubstituted tolyl, a substituted or unsubstituted naphthyl, a substituted or unsubstituted anthracenyl, a substituted or unsubstituted terphenyl, a substituted or unsubstituted pyrenyl, a substituted or unsubstituted diphenylanthracenyl, a substituted or unsubstituted dinaphthylanthracenyl, a substituted or unsubstituted pentacenyl, a substituted or unsubstituted bromophenyl, a substituted or unsubstituted hydroxyphenyl, a substituted or unsubstituted stilbene, a substituted or unsubstituted azobenzenyl, and a substituted or unsubstituted ferrocenyl. Preferable examples of the heteroaryl include one selected from the group consisting of a substituted or unsubstituted thienyl and a substituted or unsubstituted pyridyl.

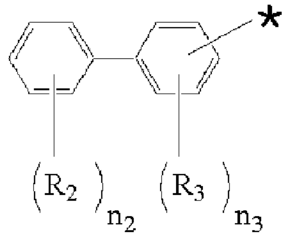
[82] Particularly, when Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 arylamine and a substituted or unsubstituted carbazole, the compound has balance between electron and hole transporting characteristics.

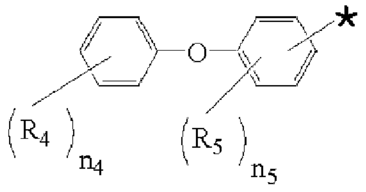
[83] Ar_1 to Ar_2 are preferably the same or different and are independently represented by the following Chemical Formulae 3 to 33.

[84] [Chemical Formula 3] [Chemical Formula 4] [Chemical Formula 5]

[85]

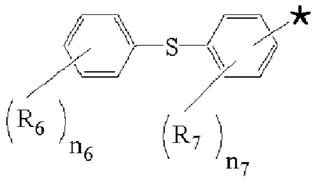


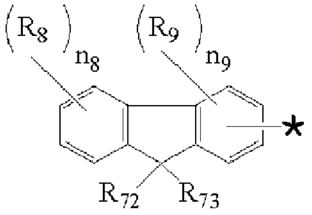


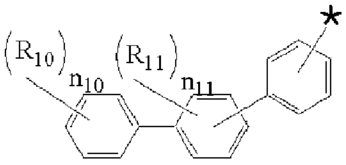


[86] [Chemical Formula 6] [Chemical Formula 7] [Chemical Formula 8]

[87]

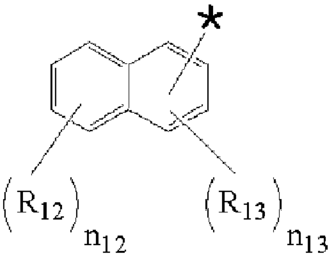


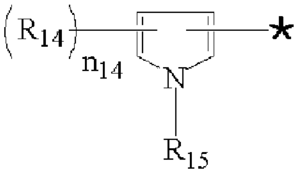


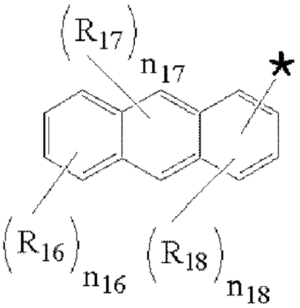


[88] [Chemical Formula 9] [Chemical Formula 10] [Chemical Formula 11]

[89]

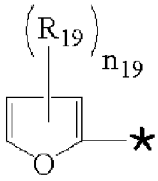


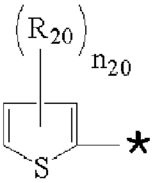


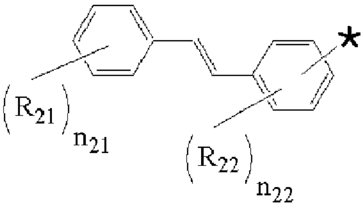


[90] [Chemical Formula 12] [Chemical Formula 13] [Chemical Formula 14]

[91]

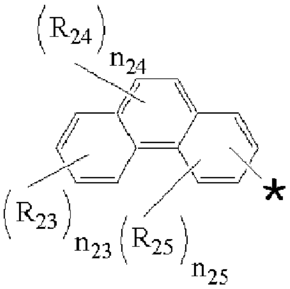


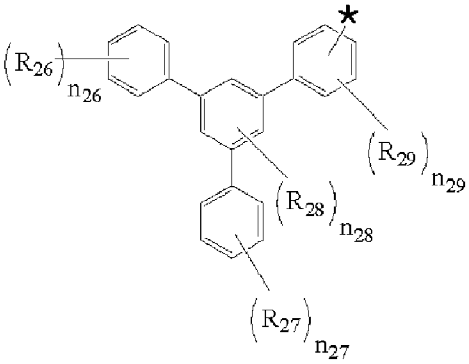


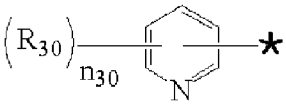


[92] [Chemical Formula 15] [Chemical Formula 16] [Chemical Formula 17]

[93]

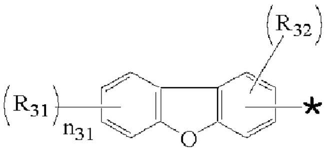


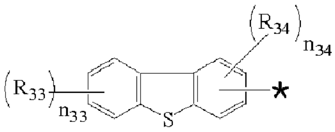


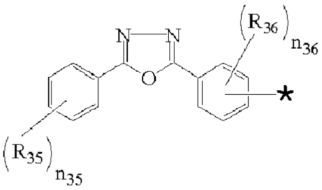


[94] [Chemical Formula 18] [Chemical Formula 19] [Chemical Formula 20]

[95]

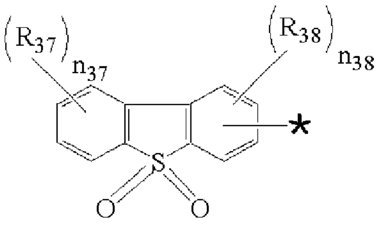


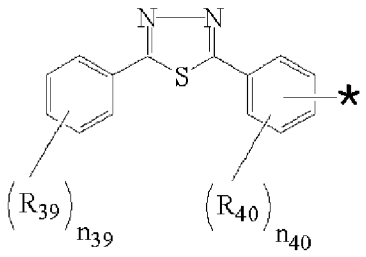


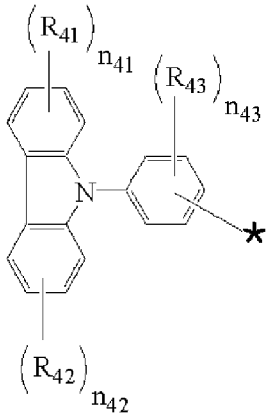


[96] [Chemical Formula 21] [Chemical Formula 22] [Chemical Formula 23]

[97]

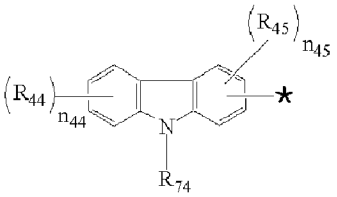


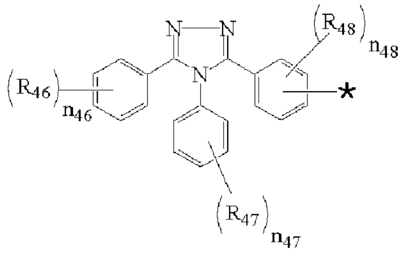


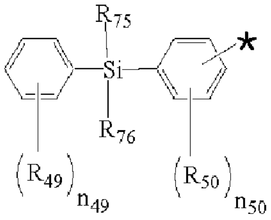


[98] [Chemical Formula 24] [Chemical Formula 25] [Chemical Formula 26]

[99]

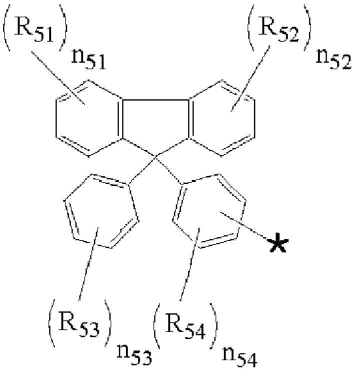


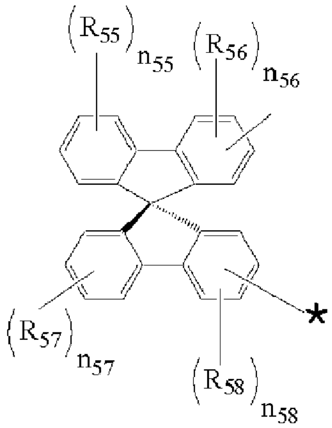


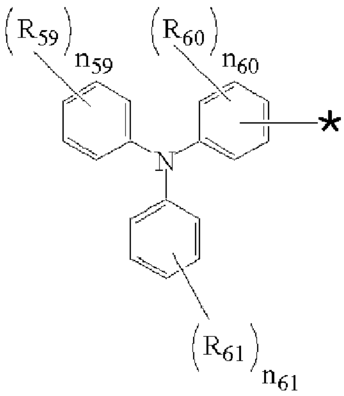


[100] [Chemical Formula 27] [Chemical Formula 28] [Chemical Formula 29]

[101]

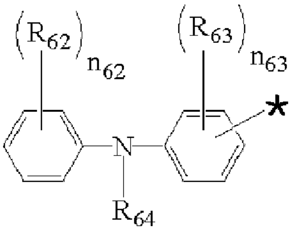


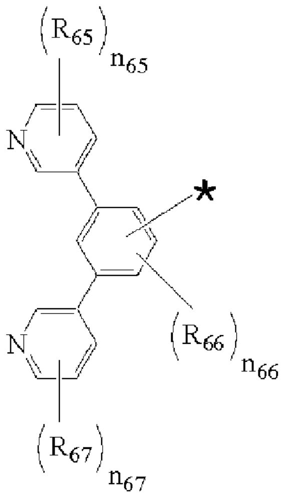


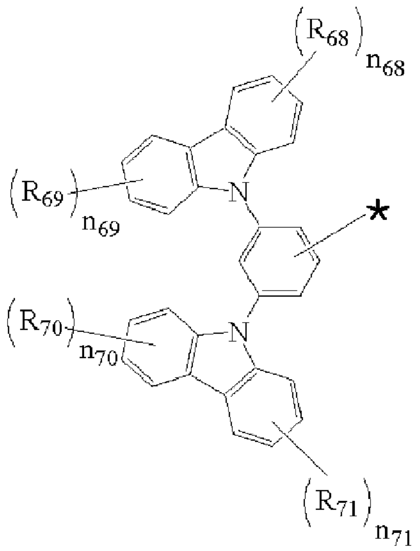


[102] [Chemical Formula 30] [Chemical Formula 31] [Chemical Formula 32]

[103]

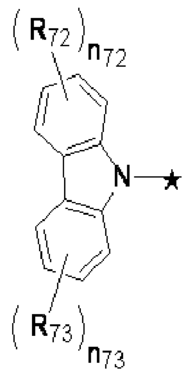






[104] [Chemical Formula 33]

[105]



[106] In the above Chemical Formulae 3 to 33,

[107] R_1 to R_{76} are the same or different, and are independently a halogen, a cyano, a hydroxy, an amino, a nitro, a carboxyl, a substituted or unsubstituted C1 to C30 alkyl, a substituted or unsubstituted C1 to C20 alkenyl, a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C1 to C20 alkoxy, a substituted or unsubstituted C6 to C20 aryloxy, a substituted or unsubstituted C3 to C40 silyloxy, a substituted or unsubstituted C1 to C20 acyl, a substituted or unsubstituted C2 to C20 alkoxycarbonyl, a substituted or unsubstituted C2 to C20 acyloxy, a substituted or unsubstituted C2 to C20 heteroaryloxy, a substituted or unsubstituted C7 to C20 aryloxycarbonyl amino, a substituted or unsubstituted C1 to C20 sulfamoyl amino, a substituted or unsubstituted C1 to C20 sulfonyl, a substituted or unsubstituted C1 to C20 alkylthiol, a substituted or unsubstituted C6 to C20 arylthiol, a substituted or unsubstituted C1 to C20 heterocyclothiol, a substituted or unsubstituted C1 to C20 ureide, a substituted or unsubstituted C1 to C20 phosphoric acid amide, and a substituted or unsubstituted C3 to C40 silyl,

[108] n_1, n_2, n_4, n_6, n_{10}, n_{21}, n_{26}, n_{27}, n_{35}, n_{39}, n_{46}, n_{47}, n_{49}, n_{53}, n_{59}, n_{61}, and n_{62} are independently integers ranging from 0 to 5,

[109] n_3, n_5, n_7, n_8, n_{11}, n_{12}, n_{16}, n_{22}, n_{23}, n_{29}, n_{30}, n_{31}, n_{33}, n_{36}, n_{37}, n_{40}, n_{41} to n_{44}, n_{48}, n_{50} to n_{52}, n_{54}, n_{55}, n_{57}, n_{60}, n_{63}, n_{65}, and n_{67} to n_{73} are independently integers ranging from 0 to 4,

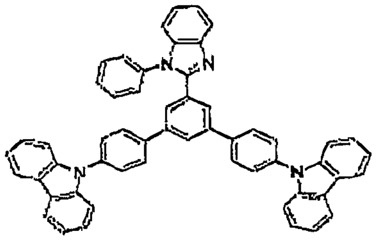
[110] n_9, n_{13}, n_{14}, n_{18}, n_{19}, n_{20}, n_{25}, n_{28}, n_{32}, n_{34}, n_{38}, n_{45}, n_{56}, n_{58}, and n_{66} are independently integers ranging from 0 to 3, and

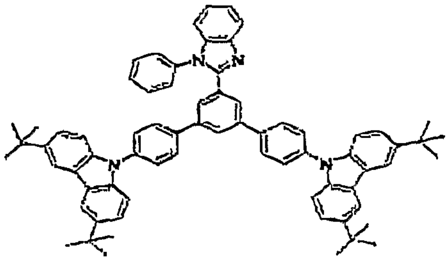
[111] n_{17} and n_{24} are independently integers ranging from 0 to 2.

[112] Preferable examples of the benzimidazole compound according to one embodiment of the present invention include the compounds represented by the following Chemical Formulae 34 to 131.

[113] [Chemical Formula 34] [Chemical Formula 35]

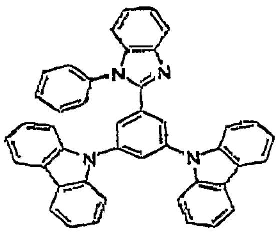
[114]

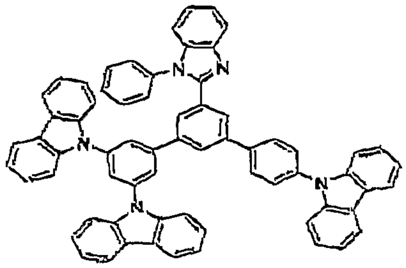




[115] [Chemical Formula 36] [Chemical Formula 37]

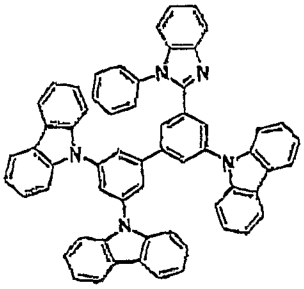
[116]

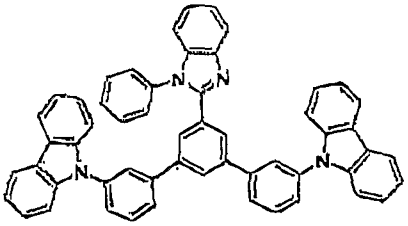




[117] [Chemical Formula 38] [Chemical Formula 39]

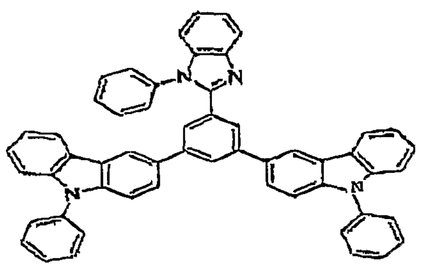
[118]

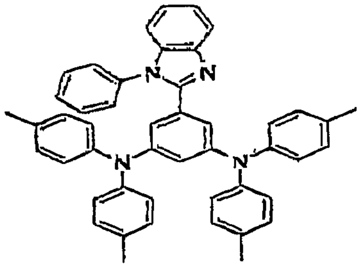




[119] [Chemical Formula 40] [Chemical Formula 41]

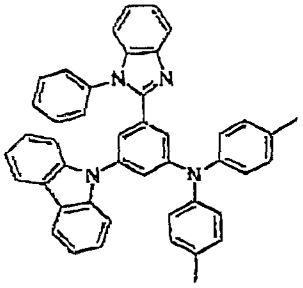
[120]

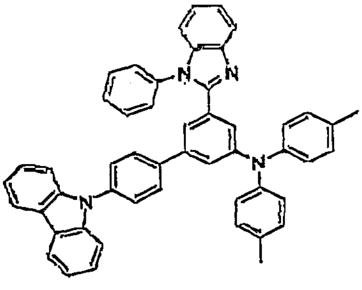




[121] [Chemical Formula 42] [Chemical Formula 43]

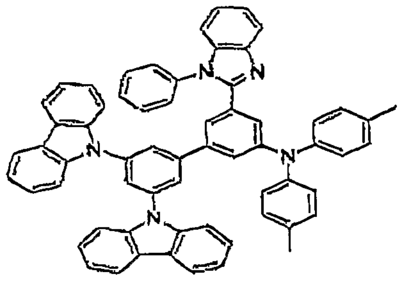
[122]

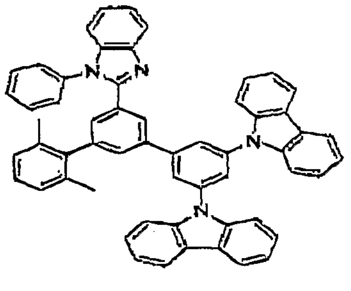




[123] [Chemical Formula 44] [Chemical Formula 45]

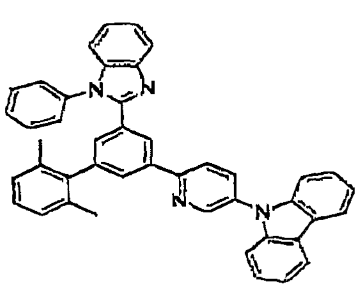
[124]

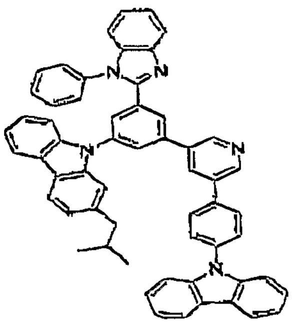




[125] [Chemical Formula 46] [Chemical Formula 47]

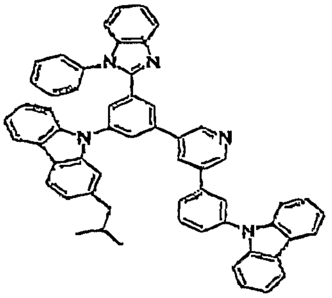
[126]

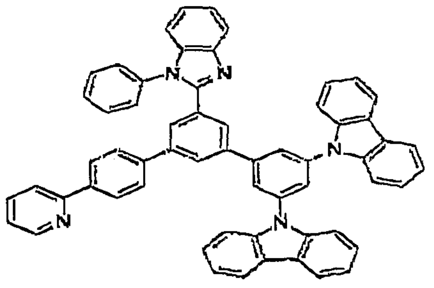




[127] [Chemical Formula 48] [Chemical Formula 49]

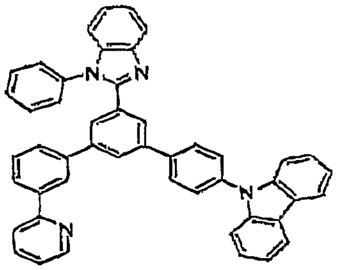
[128]

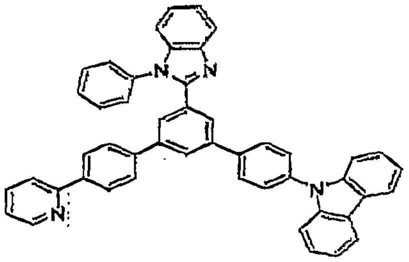




[129] [Chemical Formula 50] [Chemical Formula 51]

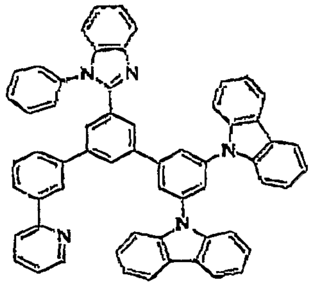
[130]

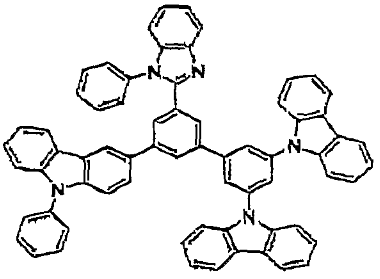




[131] [Chemical Formula 52] [Chemical Formula 53]

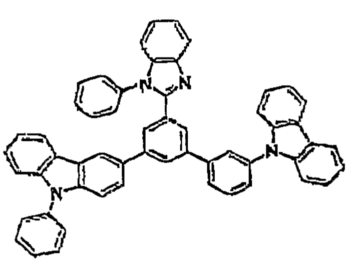
[132]

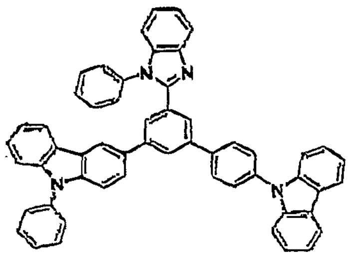




[133] [Chemical Formula 54] [Chemical Formula 55]

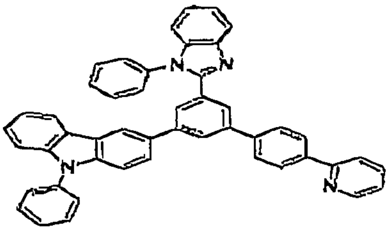
[134]

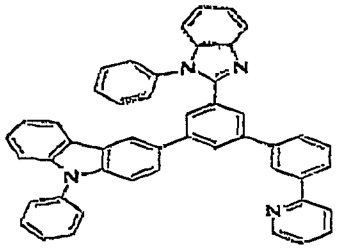




[135] [Chemical Formula 56] [Chemical Formula 57]

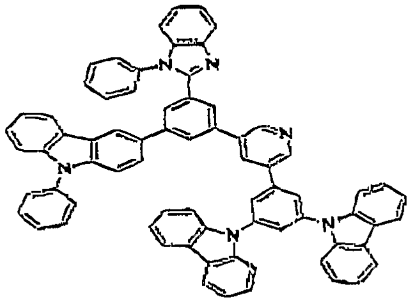
[136]

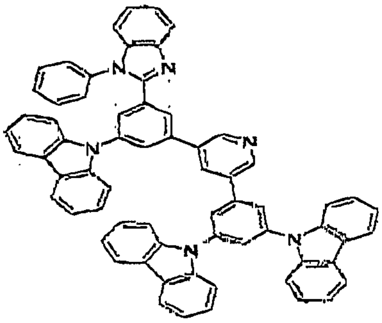




[137] [Chemical Formula 58] [Chemical Formula 59]

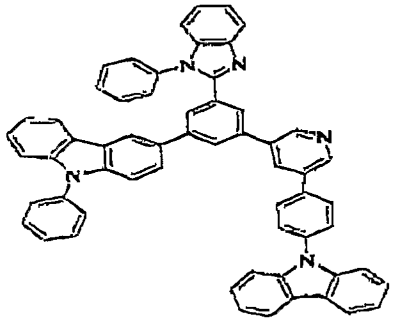
[138]

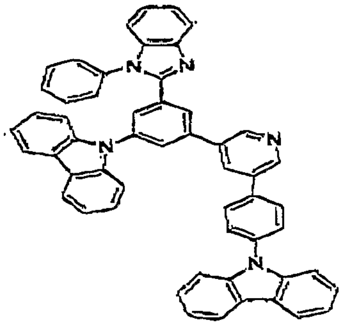




[139] [Chemical Formula 60] [Chemical Formula 61]

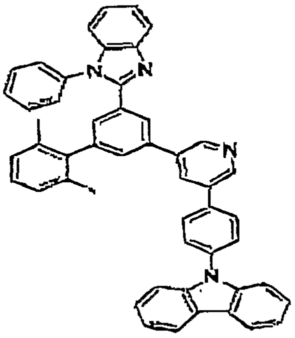
[140]

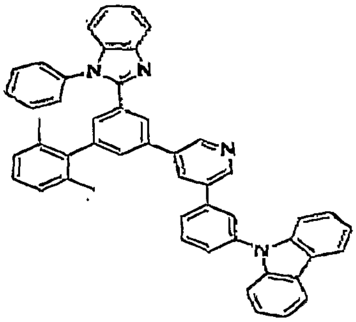




[141] [Chemical Formula 62] [Chemical Formula 63]

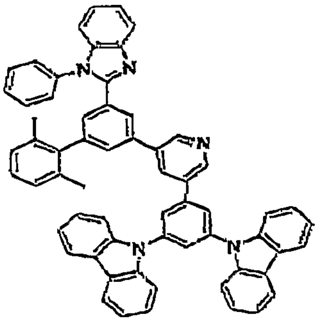
[142]

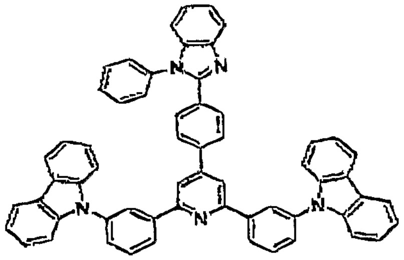




[143] [Chemical Formula 64] [Chemical Formula 65]

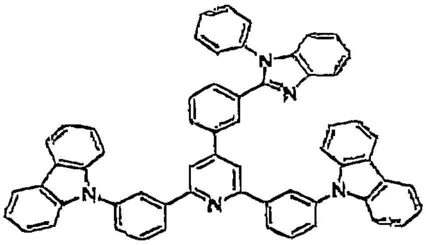
[144]

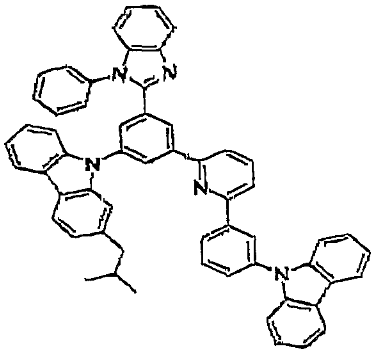




[145] [Chemical Formula 66] [Chemical Formula 67]

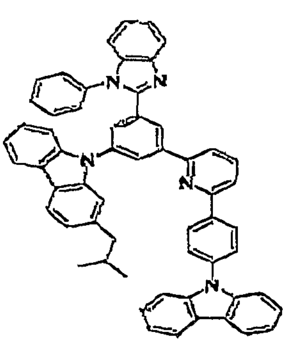
[146]

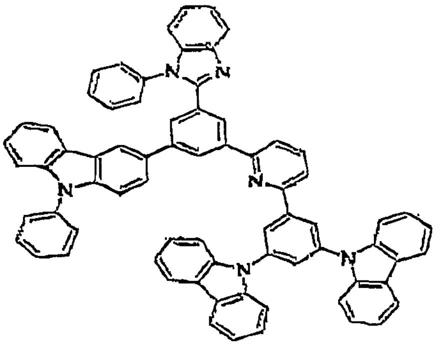




[147] [Chemical Formula 68] [Chemical Formula 69]

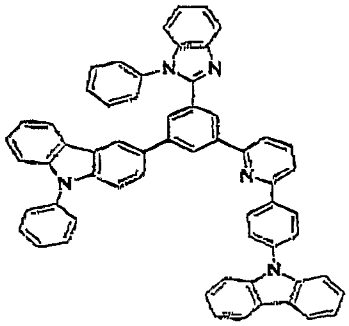
[148]

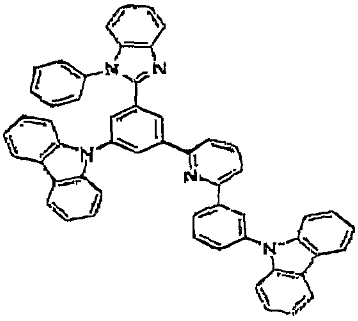




[149] [Chemical Formula 70] [Chemical Formula 71]

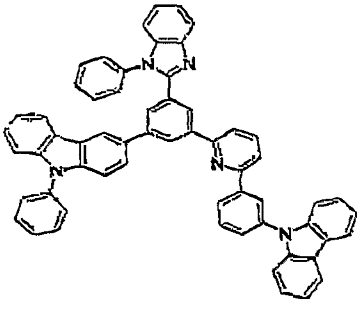
[150]

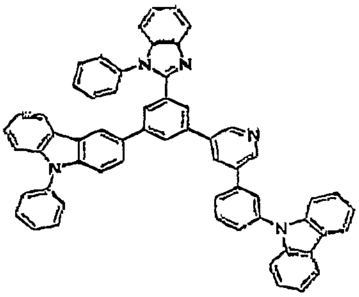




[151] [Chemical Formula 72] [Chemical Formula 73]

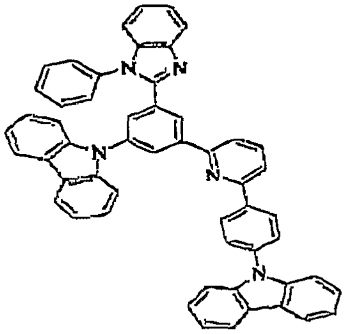
[152]

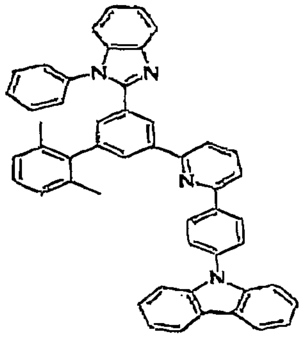




[153] [Chemical Formula 74] [Chemical Formula 75]

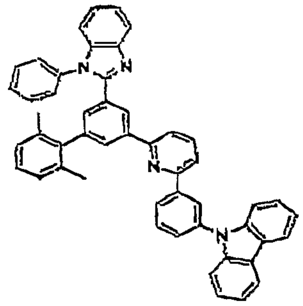
[154]

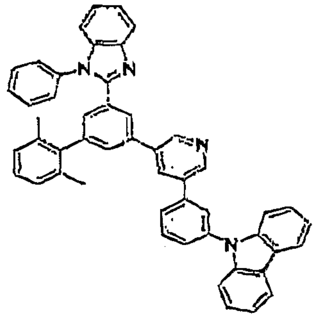




[155] [Chemical Formula 76] [Chemical Formula 77]

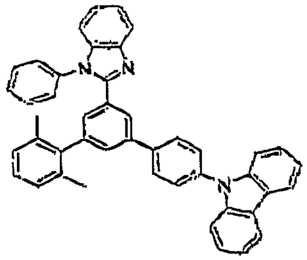
[156]

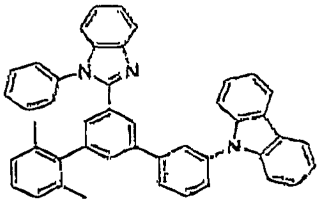




[157] [Chemical Formula 78] [Chemical Formula 79]

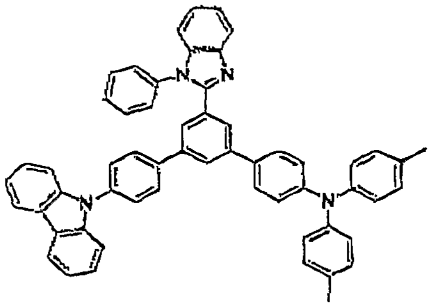
[158]

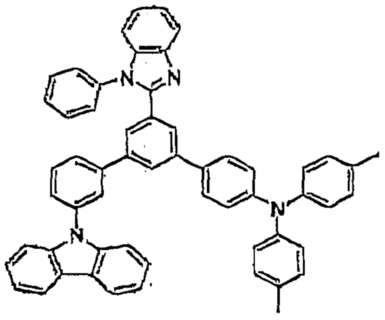




[159] [Chemical Formula 80] [Chemical Formula 81]

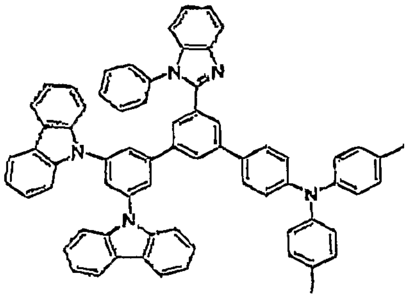
[160]

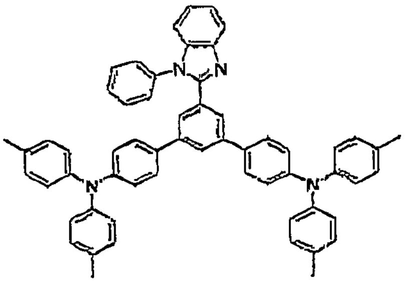




[161] [Chemical Formula 82] [Chemical Formula 83]

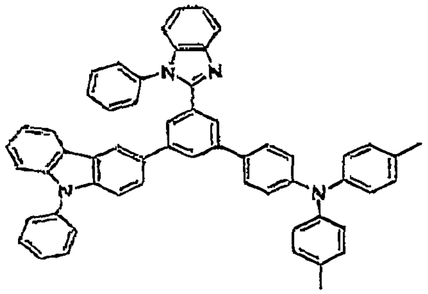
[162]

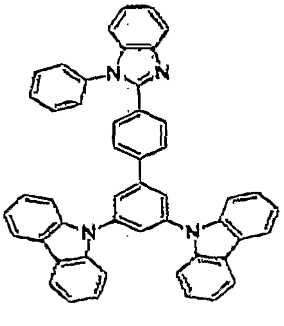




[163] [Chemical Formula 84] [Chemical Formula 85]

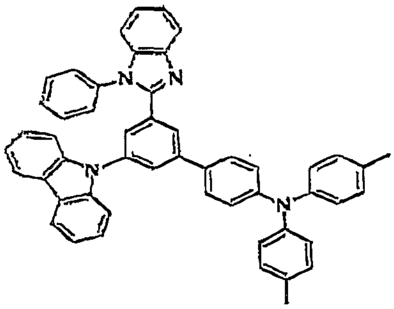
[164]

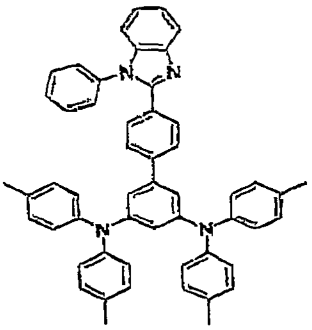




[165] [Chemical Formula 86] [Chemical Formula 87]

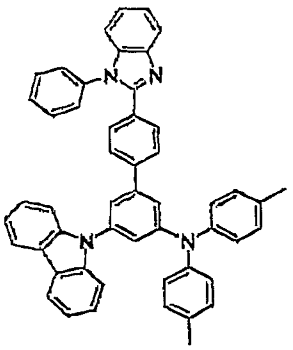
[166]

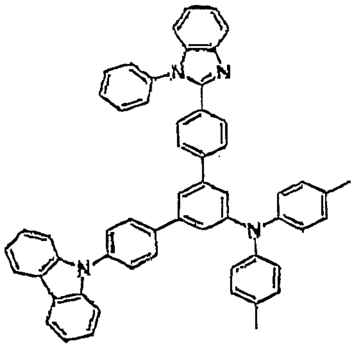




[167] [Chemical Formula 88] [Chemical Formula 89]

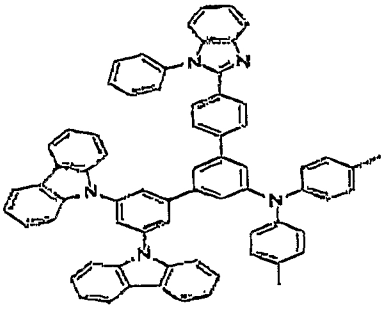
[168]

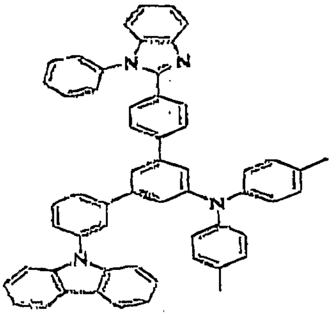




[169] [Chemical Formula 90] [Chemical Formula 91]

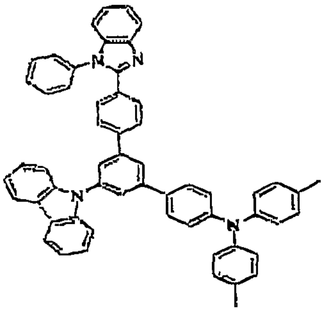
[170]

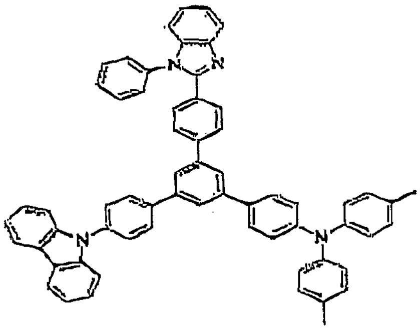




[171] [Chemical Formula 92] [Chemical Formula 93]

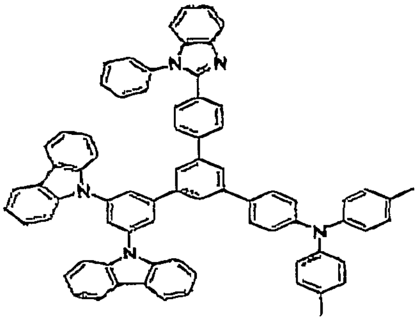
[172]

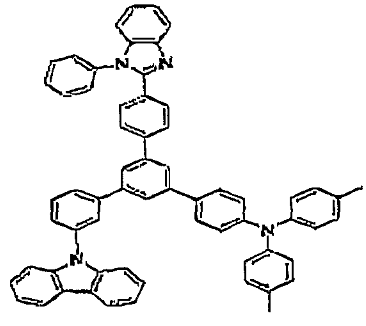




[173] [Chemical Formula 94] [Chemical Formula 95]

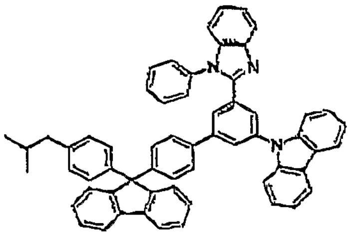
[174]

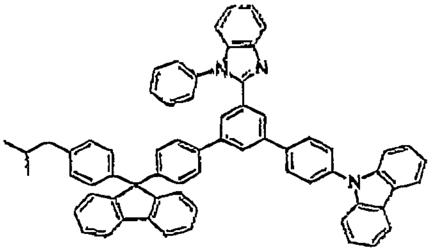




[175] [Chemical Formula 96] [Chemical Formula 97]

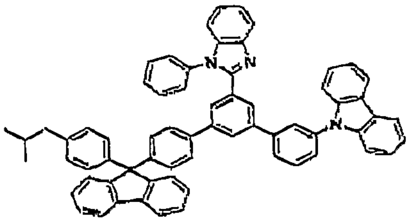
[176]

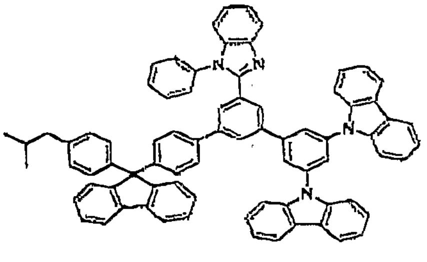




[177] [Chemical Formula 98] [Chemical Formula 99]

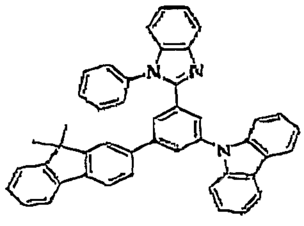
[178]

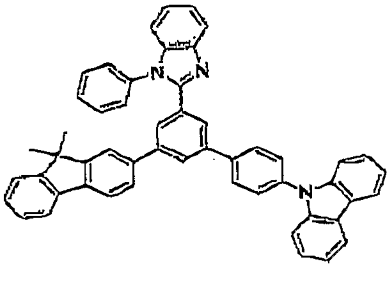




[179] [Chemical Formula 100] [Chemical Formula 101]

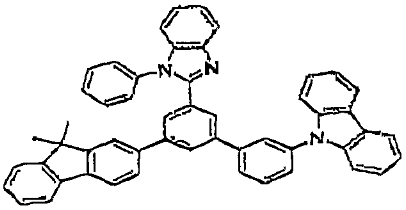
[180]

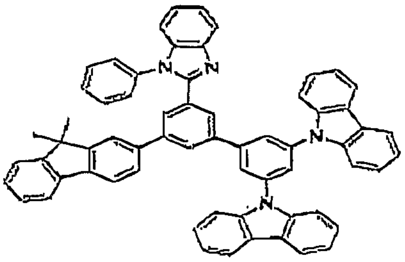




[181] [Chemical Formula 102] [Chemical Formula 103]

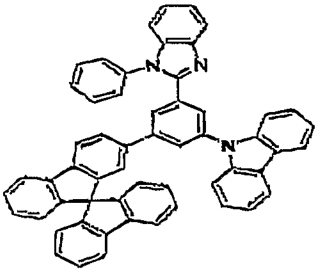
[182]

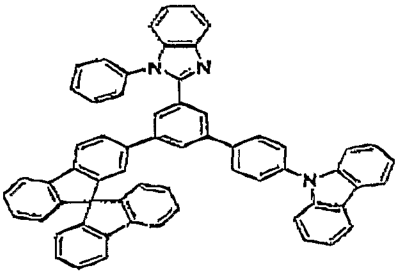




[183] [Chemical Formula 104] [Chemical Formula 105]

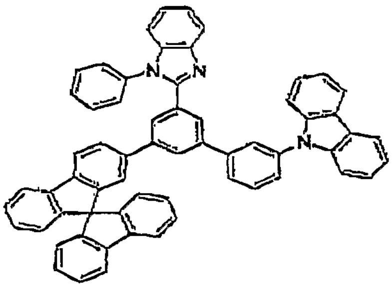
[184]

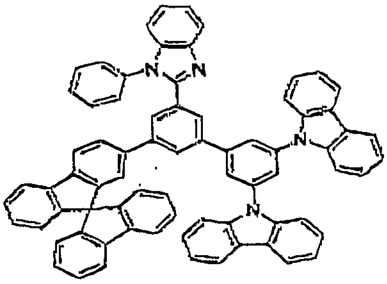




[185] [Chemical Formula 106] [Chemical Formula 107]

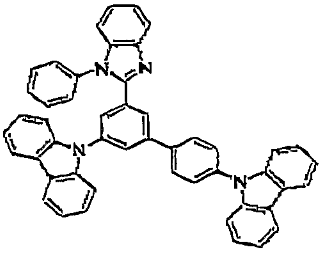
[186]

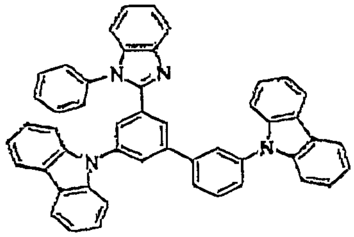




[187] [Chemical Formula 108] [Chemical Formula 109]

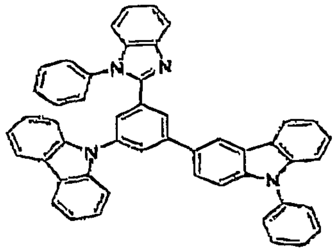
[188]

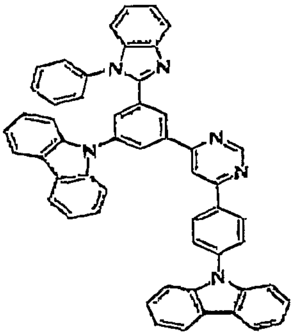




[189] [Chemical Formula 110] [Chemical Formula 111]

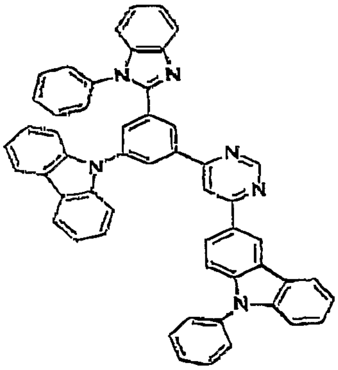
[190]

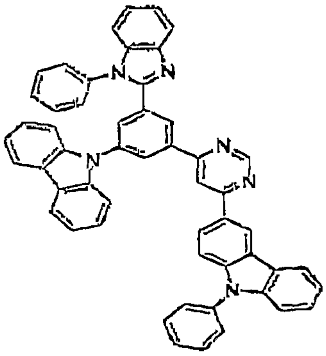




[191] [Chemical Formula 112] [Chemical Formula 113]

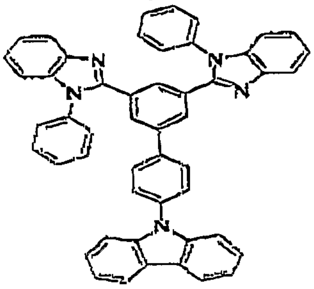
[192]

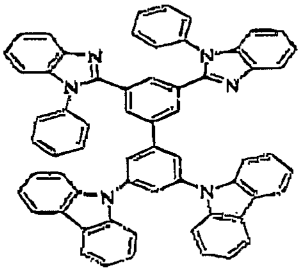




[193] [Chemical Formula 114] [Chemical Formula 115]

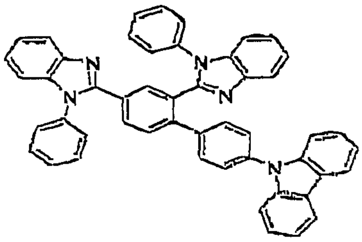
[194]

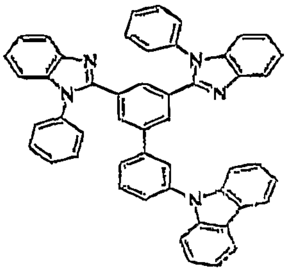




[195] [Chemical Formula 116] [Chemical Formula 117]

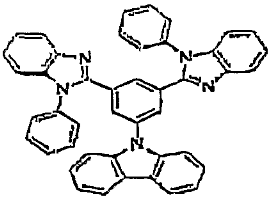
[196]

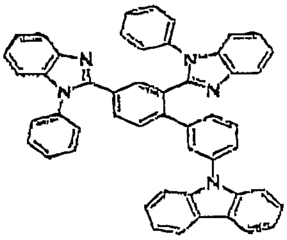




[197] [Chemical Formula 118] [Chemical Formula 119]

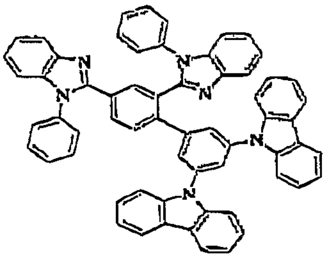
[198]

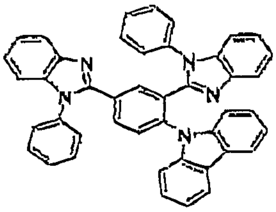




[199] [Chemical Formula 120] [Chemical Formula 121]

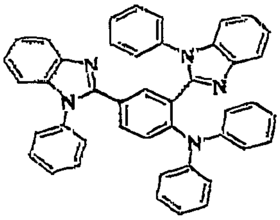
[200]

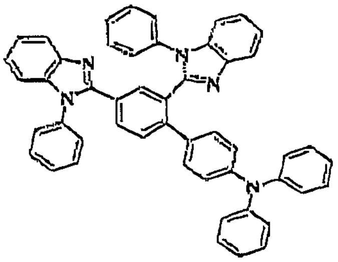




[201] [Chemical Formula 122] [Chemical Formula 123]

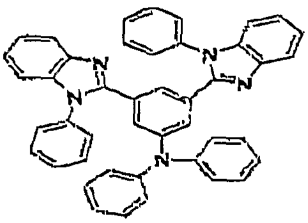
[202]

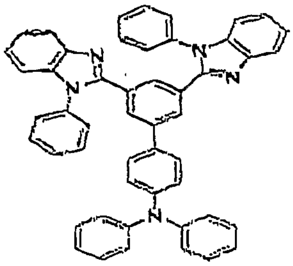




[203] [Chemical Formula 124] [Chemical Formula 125]

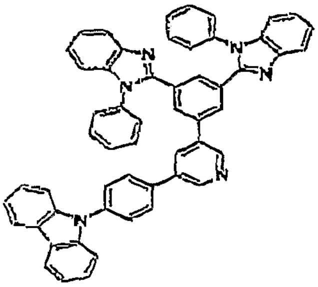
[204]

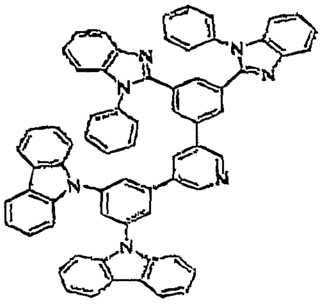




[205] [Chemical Formula 126] [Chemical Formula 127]

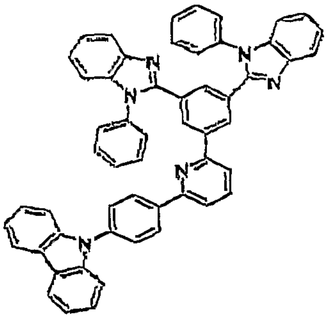
[206]

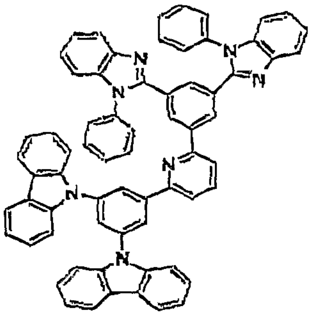




[207] [Chemical Formula 128] [Chemical Formula 129]

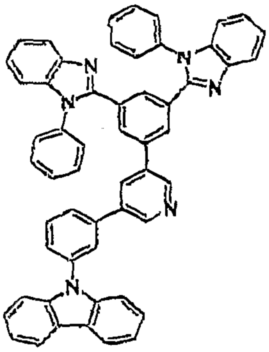
[208]

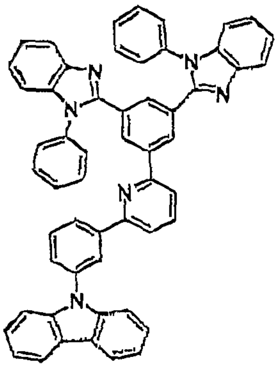




[209] [Chemical Formula 130] [Chemical Formula 131]

[210]





[211] The benzimidazole compound according to one embodiment can be applicable to a host material or a charge transporting material for an organic photoelectric device. The benzimidazole compound may be also used as a nonlinear optical material, an electrode material, a chromic material, and as materials applicable to an optical switch, a sensor, a module, a waveguide, an organic transistor, a laser, an optical absorber, a dielectric material, and a membrane due to its optical and electrical properties.

[212] When the benzimidazole compound is applied to a hole blocking layer as well as an electron transport layer (ETL) of a light emitting diode, its hole blocking properties may be reduced due to a hole transport backbone. Therefore, when the compound is applied to a hole blocking layer, it is preferable that it does not include a hole transport backbone. Such a hole transport backbone includes carbazoles, arylamines, penoxazines, and the like. However, when the compound is required to have electron transport and hole transport properties, the hole transport backbone introduction may improve life-span and reduce the driving voltage of a light emitting diode.

[213] In an organic photoelectric device according to another embodiment of the present invention including an anode, a cathode, and at least one organic thin layer interposed between the anode and cathode, at least one of the organic thin layers includes the benzimidazole compound. The organic photoelectric device includes an organic light emitting diode, an organic solar cell, an organic transistor, an organic photo-conductor drum, an organic memory device, and the like. In particular, the organic photoelectric device may preferably be an organic light emitting diode.

[214] The benzimidazole compound may be applied to an emission layer of an organic thin layer. It may also be applied to an organic thin layer selected from the group consisting of an electron injection layer (EIL), an electron transport layer (ETL), a hole blocking layer, and combinations thereof.

[215] An organic photoelectric device including an anode, a cathode, and an organic thin layer between the anode and cathode may include a general device structure including an anode, an emission layer, and a cathode. The organic thin layer of the organic photoelectric device may further include an inter-layer, a hole transport layer (HTL), and an electron transport layer (ETL). The inter-layer refers to a buffer layer such as a hole injection layer (HIL), a hole blocking layer, an electron injection layer (EIL), or an electron blocking layer.

[216] FIG. 1 is a cross-sectional schematic view of the organic photoelectric device 1 according to one embodiment. FIG. 1 shows an organic photoelectric device including a substrate 11, an anode 12, a hole transport layer (HTL) 13, an emission layer 14, an electron transport layer (ETL) 15, and a cathode 16.

[217] Referring to FIG. 1, the organic photoelectric device may be fabricated using the compound.

[218] First, an anode 12 material is coated on an upper side of the substrate 11.

[219] The substrate 11 is a glass substrate or a transparent plastic substrate having excellent general transparence, face smoothness, handling ease, and water repellency.

[220] The anode 12 material may include transparent and highly conductive indium tin oxide (ITO), tin oxide (SnO_2), zinc oxide (ZnO), or so on.

[221] Then, a hole transport layer (HTL) 13 is disposed on the anode 12 using vacuum deposition, sputtering, or spin coating, and an emission layer 14 is disposed on the hole transport layer (HTL) 13 using vacuum deposition or a solution coating method such as spin coating, Inkjet printing, and so on.

[222] An electron transport layer (ETL) 15 is disposed between the emission layer 14 and a cathode 16.

[223] The emission layer 14, the hole transport layer (HTL) 13, and the electron transport layer (ETL) 15 may have a predetermined thickness but are not specifically limited. The emission layer 14 have a thickness of 5 nm to 1 μm, and preferably 10 to 500 nm, and the hole transport layer (HTL) 13 and electron transport layer (ETL) 15 respectively have a thickness of 10 to 10,000 .

[224] The electron transport layer (ETL) 15 is formed using vacuum deposition, sputtering, or spin coating of generally-used electron transport layer (ETL) 15 materials.

[225] The hole transport layer (HTL) 13 and the electron transport layer (ETL) 15 play roles of efficiently transporting a carrier to the emission layer 14 to heighten light emitting recombination in the emission layer 14.

[226] The hole transport layer (HTL) 13 material includes, but is not limited to, poly(3,4-ethylenedioxy-thiophene) (PEDOT) doped with poly(styrenesulfonic acid) (PSS), and N,N'-bis(3-methylphenyl)-N,N-diphenyl-[1,1'-biphenyl]-4,4'-diamine (TPD).

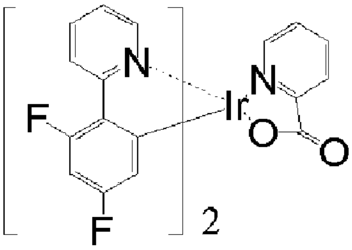
[227] The electron transport layer (ETL) 15 material includes, but is not limited to, aluminum trihydroxyquinoline (Alq_3), a 1,3,4-oxadiazole derivative such as 2-(4-biphenylyl-5-phenyl-1,3,4-oxadiazole (PBD), a quinoxaline derivative such as 1,3,4-tris[(3-phenyl-6-trifluoromethyl)quinoxalin-2-yl] benzene (TPQ), and a triazole derivative.

[228] The polymer may be mixed with a phosphorescent light emitting organic compound. The phosphorescent organic compound may be a phosphorescent light emitting organic metal complex from its triplet state, and is preferably a metal complex of at least one group Đ metal ion according to the periodic table of Gregor Johann Mendel. The group Đ metal ion includes a metal ion selected from the group consisting of Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, and Pt, and is preferably Ir or Pt.

[229] Examples of the metal complex may be represented by the following Chemical Formulae 132 to 134, but are not limited thereto.

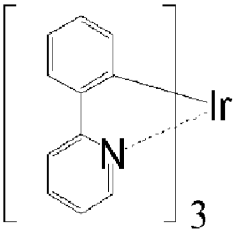
[230] [Chemical Formula 132]

[231]



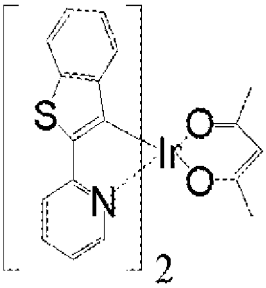
[232] [Chemical Formula 133]

[233]



[234] [Chemical Formula 134]

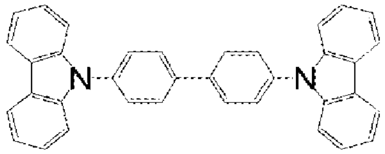
[235]



[236] When the organic layer including the organic compound is formed using a solution coating, another low molecular host material can be included along with the organic compound. Examples of the low molecular host material include the compounds of the following Chemical Formulae 135 to 138, but are not limited thereto.

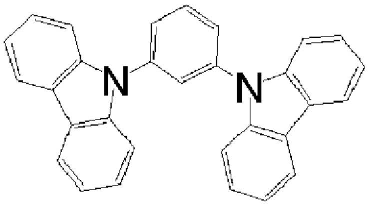
[237] [Chemical Formula 135]

[238]



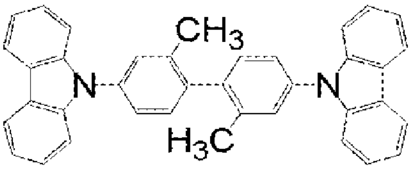
[239] [Chemical Formula 136]

[240]



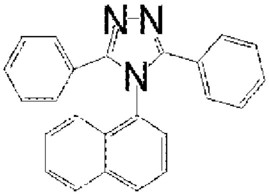
[241] [Chemical Formula 137]

[242]



[243] [Chemical Formula 138]

[244]



[245] The benzimidazole compound may be used by mixing with polymers having conjugated double bonds such as fluorine-based polymers, polyphenylenevinylene-based polymers, and polyparaphenylene-based polymers, and also by mixing with binder resins.

[246] The binder resins may include polyvinylcarbazole (PVK), polycarbonate, polyester, polyan arylate, polystyrene, acryl polymers, methacryl polymers, polybutyral, polyvinylacetal, diallylphthalate polymers, phenol resins, epoxy resins, silicone resins, polysulfone resins, or urea resins, and these resins can be used singularly and in combinations.

[247] Selectively, a hole blocking layer may be disposed using vacuum deposition to limit transport speed of holes into the emission layer 14 and thus to increase the recombination opportunity of electrons and holes.

[248] A cathode 16 material is coated on the electron transport layer (ETL).

[249] The cathode material may be lithium (Li), magnesium (Mg), calcium (Ca), aluminum (Al), Al:Li, Ba:Li, or Ca:Li having a small work function.

Mode for the Invention

[250] The following examples illustrate the present invention in more detail. However, it is understood that the present invention is not limited by these examples.

[251] A person having ordinary skill in this art can sufficiently understand parts of the

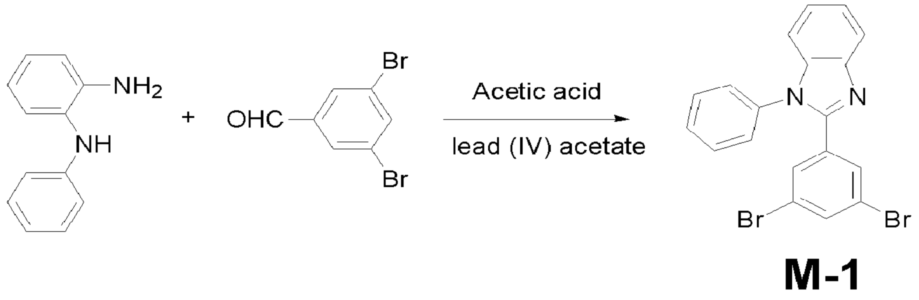
present invention that are not specifically described.

[252] In the following Examples 1 to 6, monomers M-1 to M-9 for preparing a polymer according to one embodiment of the present invention were respectively prepared as shown in Reaction Schemes 1 to 9.

[253] **Synthesis Example 1: Synthesis of M-1**

[254] [Reaction Scheme 1]

[255]

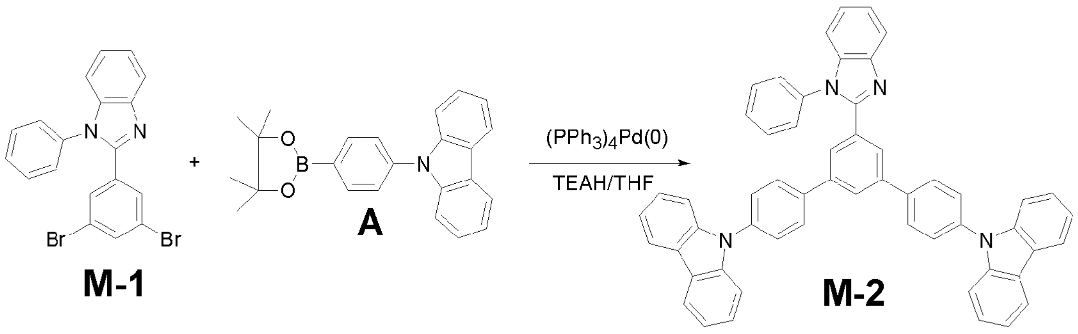


[256] 50 g (189 mmol) of 3,5-dibromobenzaldehyde and 38.3 g (208 mmol) of N-phenyl-o-phenylenediamine were put in a 500 mℓ round bottom flask, and 200 mℓ of acetic acid was added thereto. The resulting mixture was agitated for 30 minutes at room temperature, and 100 g (227 mmol) of lead acetate (lead, IV) was added thereto. The resulting product was agitated for 12 hours at room temperature. When the reaction was complete, the acetic acid was removed under reduced pressure. The reactant was dissolved in methylene chloride and washed five times with water. The organic solution was dried with anhydrous magnesium sulfate to remove the solvent. Then, the acquired solid was purified with a silica gel column in a methylene chloride solvent. The resulting product was recrystallized in a mixed solvent of methylene chloride/hexane in a ratio of 1:6, acquiring 34 g of a solid indicated as M-1 in the reaction scheme 1 (yield: 42%).

[257] **Example 1: Synthesis of M-2**

[258] [Reaction Scheme 2]

[259]



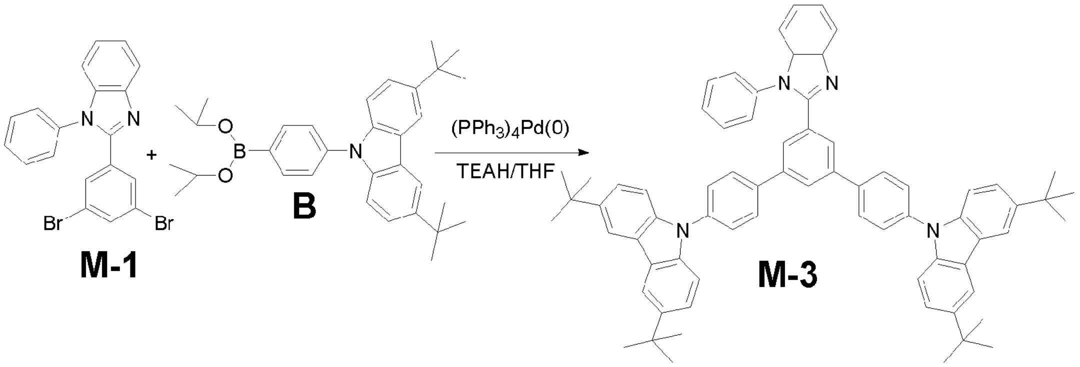
[260] 1.0g of M-1 (2.3 mmol), 1.89g of a material A (5.1 mmol), and 0.23 g of tetrakistriphenyl phosphine palladium (0.19 mmol) were dissolved in 30 mL of tetrahydrofuran (THF) under an argon atmosphere in a 100 mℓ round bottom flask having a

thermometer, a reflux condenser, and an agitator. Then, 15 mL of 20% tetratriethylammonium hydroxide was added thereto. The resulting product was agitated at 75 °C for 24 hours. When the reaction was complete, the reactant was cooled to room temperature and then extracted several times with methylene chloride and washed with water. The washed reactant was treated with anhydrous magnesium sulfate to remove moisture therefrom. The resulting reactant was filtrated to remove the solvent. When the solvent was removed, the acquired solid was recrystallized with a mixed solvent of methylene chloride/hexane in a ratio of 1:6, preparing 1.2 g of a white M-2 (yield: 68.4%). This was sublimated and purified to prepare 0.79 g of a white crystal. This crystal had a maximum light emitting wavelength at 383 nm when it was fabricated into a thin film. It had an LC-Mass theoretical value of $C_{55}H_{36}N_4$ $[MH]^+$ 753.2940 and a measurement value of 753.2978.

[261] **Example 2: Synthesis of M-3**

[262] [Reaction Scheme 3]

[263]

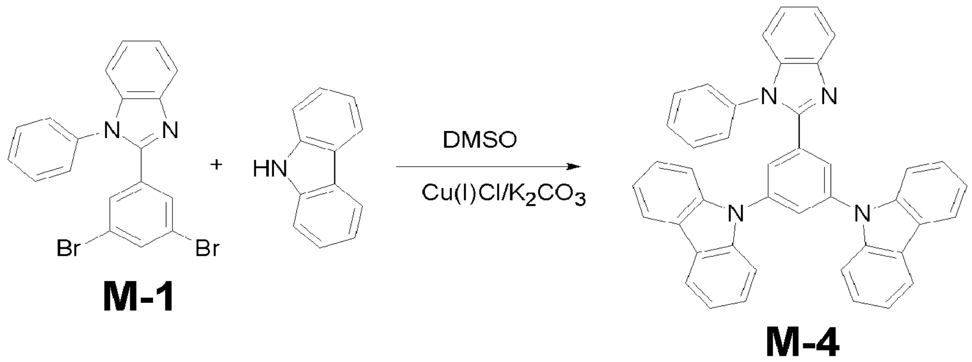


[264] 1.0 g (2.3 mmol) of M-1, 2.37 g (4.9 mmol) of a material B, and 0.23 g (0.19 mmol) of tetrakistriphenyl phosphine palladium were dissolved in 30 mL of THF under an argon atmosphere in a 100 mℓ round bottom flask having a thermometer, a reflux condenser, and an agitator, and 15 mL of 20% tetratriethylammonium hydroxide was added thereto. The resulting mixture was agitated at 75 °C for 24 hours. When the reaction was complete, the reactant was cooled to room temperature and then extracted several times with methylene chloride and washed with water. Then, the washed reactant was treated with anhydrous magnesium sulfate to remove moisture and filtrated to remove the solvent. The resulting product was purified through a silica gel column with a methylene chloride solvent, preparing 1.78 g of a white M-3 (yield: 78.1%). When it was fabricated into a thin film, it had a maximum light emitting wavelength at 388 nm. It had an LC-Mass theoretical value of $C_{71}H_{68}N_4$ $[MH]^+$ 977.5444 and measurement value of 977.5442.

[265] **Example 3: Synthesis of M-4**

[266] [Reaction Scheme 4]

[267]

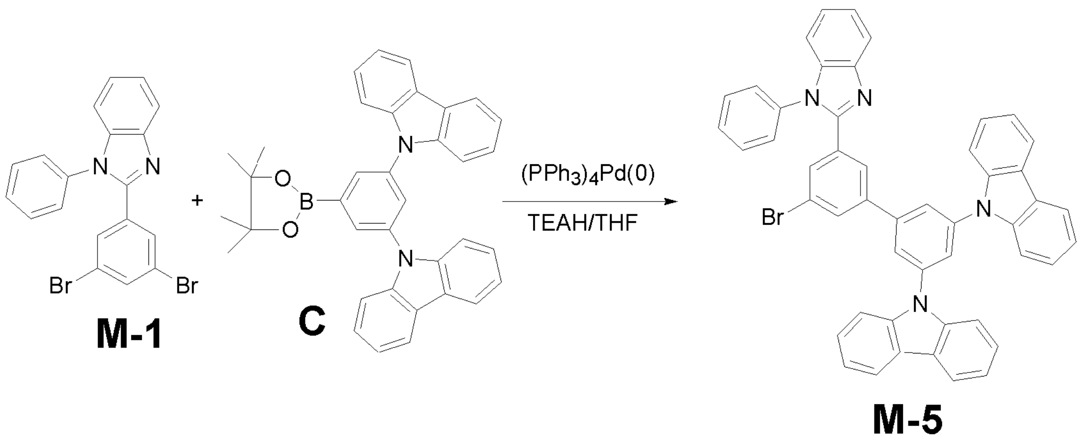


[268] 6 g (14 mmol) of M-1, 5.8 g (35 mmol) of carbazole, 1.5 g (15.1 mmol) of copper chloride, and 6g (43 mmol) of potassium carbonate were dissolved in 100 ㎖ of N,N-dimethylsulfoxide (DMSO) under an argon atmosphere in a 250 ㎖ round bottom flask having a thermometer, a reflux condenser, and an agitator. The resulting solution was agitated at 150 °C for 48 hours and cooled to room temperature. Then, DMSO was removed therefrom under reduced pressure. The remaining solid was dissolved in methylene chloride. The solution was washed several times with water to remove moisture with anhydrous magnesium sulfate. The resulting product was filtrated to remove the solvent. The acquired solid was purified through a silica gel column with a methylene chloride solvent, preparing 5.5 g of a white M-4 (yield: 65.4%). When it was prepared into a thin film, it had a maximum light emitting wavelength at 394 nm. It had an LC-Mass theoretical value of $C_{43}H_{28}N_4$ [MH]$^+$ 601.2314 and a measurement value of 601.2384.

[269] <u>Synthesis Example 2: Synthesis of M-5</u>

[270] [Reaction Scheme 5]

[271]



[272] 3.0 g (7.0 mmol) of M-1, 3.74 g (7.0 mmol) of a material C, and 0.16 g (0.14 mmol) of tetrakistriphenyl phosphine palladium were dissolved in 50 mL of tetrahydrofuran (THF) under an argon atmosphere in a 100 ㎖ round bottom flask having a

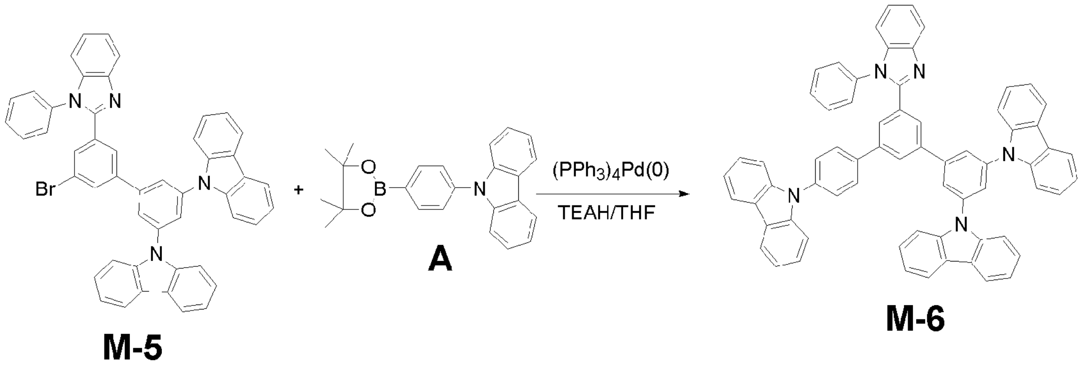
thermometer, a reflux condenser, and an agitator, and 20 mL of 20% tetratriethylammonium hydroxide was added thereto. The resulting mixture was agitated at 75 °C for 24 hours.

[273] When the reaction was complete, the reactant was cooled to room temperature and extracted several times with methylene chloride and washed with water. The washed reactant was treated with anhydrous magnesium sulfate to remove moisture. The remaining solid was filtrated to remove the solvent. The resulting product was purified through a silica gel column with a methylene chloride solvent, acquiring 3.0 g of a white M-5 (yield: 56.8%).

[274] **Example 4: Synthesis of M-6**

[275] [Reaction Scheme 6]

[276]

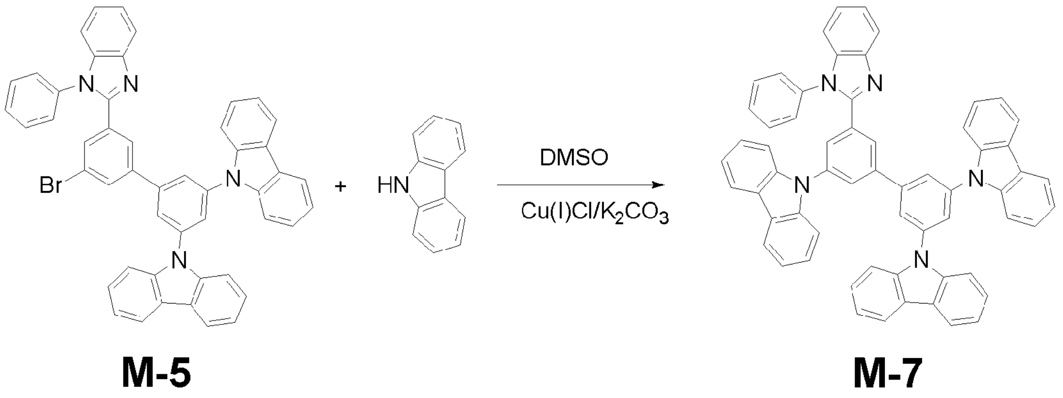


[277] 1.0 g (1.3 mmol) of M-5, 0.53 g (1.4 mmol) of a material A, and 0.15 g (0.16 mmol) of tetrakistriphenyl phosphine palladium were dissolved in 30 mL of THF under an argon atmosphere in a 100 mℓ round bottom flask having a thermometer, a reflux condenser, and an agitator, and 15 mL of 20% tetratriethylammonium hydroxide was added thereto. The resulting mixture was agitated at 75 °C for 24 hours. When the reaction was complete, the reactant was cooled to room temperature and then extracted several times with methylene chloride and washed with water. The washed reactant was treated with anhydrous magnesium sulfate to remove moisture and then filtrated to remove the solvent. The resulting product was purified through a silica gel column with a methylene chloride solvent, acquiring 1.0 g of a white M-6 (yield: 82.6%). When it was fabricated into a thin film, it had a maximum light emitting wavelength at 390 nm. It had an LC-Mass theoretical value of $C_{67}H_{43}N_5$ $[MH]^+$ 918.3518 and a measurement value of 918.3604.

[278] **Example 5: Synthesis of M-7**

[279] [Reaction Scheme 7]

[280]

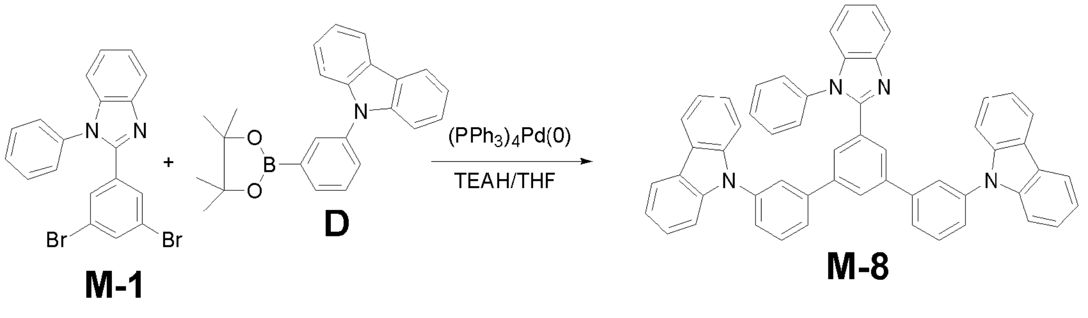


[281] 1.3 g (1.7 mmol) of M-5, 0.57 g (3.4 mmol) of carbazole, 0.08 g (0.86 mmol) of copper chloride, and 5.46 g (39 mmol) of potassium carbonate were dissolved in 30 mℓ of DMSO under an argon atmosphere in a 250 mℓ round bottom flask having a thermometer, a reflux condenser, and an agitator. The solution was agitated at 150 °C for 48 hours, and then cooled to room temperature and treated under reduced pressure to remove DMSO. The remaining solid was dissolved in methylene chloride, washed several times with water, treated with anhydrous magnesium sulfate to remove moisture, and then filtrated to remove the solvent. The resulting product was purified through a silica gel column with a methylene chloride solvent, acquiring 0.66 g of a white M-7 (yield: 45.5%). When it was fabricated into a thin film, it had a maximum light emitting wavelength at 404 nm. Its LC-Mass theoretical value was $C_{61}H_{39}N_5$ [MH]$^+$ 842.3205, and the measurement value was 842.3331.

[282] **Example 6: Synthesis of M-8**

[283] [Reaction Scheme 8]

[284]



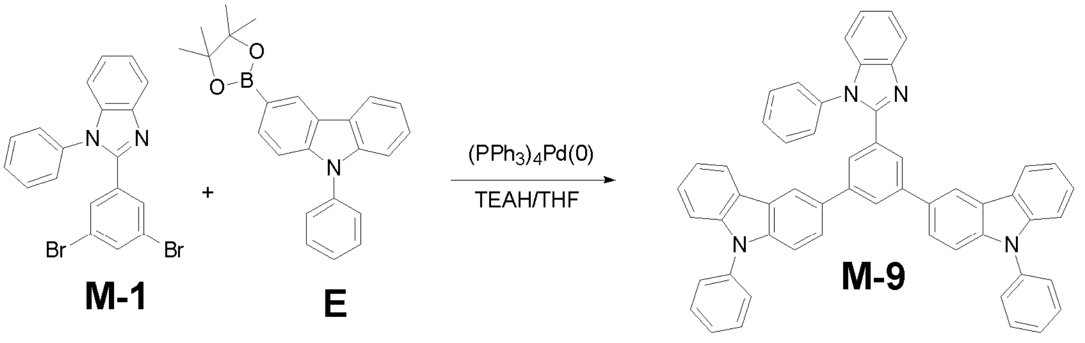
[285] 1.9 g (4.4 mmol) of M-1, 3.44 g (9.3 mmol) of a material D, and 0.4 g (0.34 mmol) of tetrakistriphenyl phosphine palladium were dissolved in 30 mL of THF under an argon atmosphere in a 100 mℓ round bottom flask having a thermometer, a reflux condenser, and an agitator, and 15 mL of 20% tetratriethylammonium hydroxide was added thereto. The solution was agitated at 75 °C for 24 hours. When the reaction was complete, the reactant was cooled to room temperature and then extracted several

times with methylene chloride and washed with water. The washed reactant was treated with anhydrous magnesium sulfate to remove moisture and filtrated to remove the solvent. The resulting product was treated with a methylene chloride solvent through a silica gel column, acquiring 1.5 g of a white M-8 (yield: 44.9%). It had an LC-Mass theoretical value of $C_{55}H_{36}N_4$ $[MH]^+$ 753.2940 and a measurement value of 753.2949.

[286] **Example 7: Synthesis of M-9**

[287] [Reaction Scheme 9]

[288]



[289] 2.0 g (4.6 mmol) of M-1, 3.62 g (9.8 mmol) of a material E, and 0.4g (0.34 mmol) of tetrakistriphenyl phosphine palladium were dissolved in 30 mL of THF under an argon atmosphere in a 100 mℓ round bottom flask having a thermometer, a reflux condenser, and an agitator, and 15 mL of 20% tetratriethylammonium hydroxide was added thereto. The solution was agitated at 75 °C for 24 hours. When the reaction was complete, the reactant was cooled to room temperature and then extracted several times with methylene chloride and washed with water. The washed reactant was treated with anhydrous magnesium sulfate to remove moisture and filtrated to remove the solvent. The remaining solid was purified with a methylene chloride solvent through a silica gel column, acquiring 1.6 g of a white M-8 (yield: 47.9%). It had a theoretical value of LC-Mass $C_{55}H_{36}N_4$ $[MH]^+$ 753.2940 and a measurement value of 753.2980.

[290] **Analysis and Characteristic Measurement of Compounds**

[291] The compounds (M-2 to M-4 and M-6 to M-9) of Examples 1 to 7 were measured regarding molecular weight to analyze the structure by using a liquid chromatography-mass analyzer (LC-MS, liquid chromatograph-mass spectrometry). LC-MS data of the compound M-6 prepared in Example 4 is shown in FIG. 2.

[292] The compounds (M-2 to M-4 and M-6 to M-9) of Examples 1 to 7 were measured regarding photoluminescence (PL) wavelength by forming a thin film on a glass substrate by using a HITACHI F-4500 instrument to measure fluorescence characteristics. FIG. 3 shows the PL wavelength result of the M-6 according to Example 4.

Referring to FIG. 3, when it was fabricated into a thin film, the M-6 had a maximum light emitting wavelength at 390 nm.

[293] **Fabrication of an Organic Photoelectric Device**

[294] **Example 8: Device fabrication using a solution process**

[295] An ITO substrate was used as an anode. The anode was spin-coated to form poly(3,4-ethylenedioxy-thiophene) (PEDOT) on the top thereof. Next, an emission layer 400 was spin-coated on the surface of the PEDOT by doping M-6 of Example 4 as a host and about 13 wt% of Ir(mppy)$_3$ as a dopant. On the emission layer, BAlq was vacuum-deposited to be 50 thick to form a hole blocking layer. Then, Alq$_3$ was vacuum-deposited to be 200 thick on top of the emission layer to form an electron transport layer (ETL). On the electron transport layer (ETL), 10 LiF and 1000 Al were sequentially vacuum-deposited to fabricate a cathode. Then, the anode and the cathode were used to fabricate an organic photoelectric device.

[296] The organic photoelectric device included a 5-layered organic thin layer, and in particular, it was ITO 1500Å PEDOT 600Å EML (M-6:Ir(mppy)$_3$) 400Å/BAlq 50Å/Alq$_3$ 200Å/LiF 10Å/Al 1000Å.

[297] **Comparative Example 1: Device fabrication using a solution process**

[298] According to Comparative Example, a device included ITO 1500Å/PEDOT 600Å/EML (TCTA:TPBI 1:1, Ir(mppy)$_3$) 400Å/BAlq 50Å/Alq$_3$ 200Å/LiF 10Å/Al 1000Å.

[299] Herein, the emission layer was spin-coated to be 400 thick by doping a mixture of 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA) and 2,2',2"-(1,3,5-benzenetriyl)tris(1-phenyl-1H-benzimidazole) (TPBI) prepared in a weight ratio of 1:1 as a host and about 13 wt% of Ir(mppy)$_3$ as a dopant.

[300] A device using a solution process was fabricated according to the same method as in Example 8, except for the above.

[301] **Example 9: Device fabrication using a deposition process**

[302] An ITO substrate was used as an anode, and a device was fabricated by vacuum-depositing a layer thereon.

[303] ITO/ DNTPD 600Å/NPB 200Å/M-4:Ir(ppy)$_3$,7 wt% 300Å/ BCP 50Å/ Alq$_3$ 250Å/ LiF 10Å/ Al 1000Å.

[304] The device of Example 9 included a hole transport layer (HTL) formed by vacuum-depositing 4,4'-bis[N-[4-(N,N-di-m-tolylamino)phenyl]-N-phenylamino]biphenyl (DNTPD) and N-(1-naphthyl)-N-phenyl-amino]biphenyl (NPB) to be respectively 600Å and 200Åthick.

[305] In addition, a 50 Å thick 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP) was used to form a hole blocking layer. It also included an emission layer formed to be 300 thick by vacuum-depositing M-4 of Example 3 as a host and about 7 wt% of Ir(ppy)$_3$

as a dopant.

[306] The device using a deposit process was fabricated in the same method as in Example 8.

[307] **Comparative Example 2: Device fabrication using deposition process**

[308] ITO/ DNTPD 600Å/NPB 200Å/CBP:Ir(ppy)$_3$, 7wt% 300Å/CBP 50Å/ Alq$_3$ 250Å/ LiF 10Å/ Al 1000Å.

[309] According to Comparative Example 2, a device including an emission layer was formed by vacuum-depositing 4,4'-N,N'-dicarbazole-bipheyl (CBP) as a host and 7 wt% of Ir(ppy)$_3$ as a dopant to be 300 Åthick.

[310] The device using a deposition process device was fabricated according the same method as in Example 9 except for the above.

[311] **Performance Measurement of Organic Light Emitting Diodes**

[312] The organic light emitting diodes according to Examples 8 to 9 and Comparative Examples 1 and 2 were measured regarding current density and luminance change depending on voltage change and luminous efficiency change depending on luminance change. Specifically, they were measured as follows.

[313] 1) Current density change depending on voltage change

[314] Each organic light emitting diode was measured regarding current value by using a current-voltage device (Keithley 2400) while its voltage was increased from 0. The current value was divided by area to calculate current density. The results are provided in FIGs. 4 and 5.

[315] 2) Luminance change depending on voltage change

[316] The organic light emitting diodes were measured regarding luminance by using a luminance meter (Minolta Cs-1000A) while its voltage was increased from 0. The results are provided in FIGs. 6 and 7.

[317] 3) Luminous efficiency measurement depending on luminance change

[318] The organic light emitting diodes were measured regarding luminous efficiency change depending on luminance change. The results are provided in FIGs. 8 and 9.

[319] Tables 1 and 2 comprehensively show all the results. In particular, Table 1 shows performance evaluation results of the solution process devices according to Comparative Example 1 and Example 8.

[320] Table 1

[Table 1]

[Table]

	Emission layer material	at 1000 cd/m^2			Thresholdvoltage$V_{\text{turn on}}$	Max. luminous efficiency	
		Driving voltage	Luminous efficiency				
		(V)	(cd/A)	(lm/W)	(V)	(cd/A)	(lm/W)
Comp. Ex. 1	TCTA:TPBI(1:1)	9.80	13.90	4.45	4.80	16.50	4.71
Ex. 8	M-6	8.2	21.7	8.3	4.0	22.8	10.4

[321]

[322] Referring to Table 1 and FIGs. 4, 6, and 8, a benzimidazole compound according to one embodiment of the present invention turned out to decrease the driving voltage of an organic light emitting diode as a host material and improve luminance and efficiency.

[323] Table 2 shows performance evaluation results of the deposition process devices according to Comparative Example 2 and Example 9.

[324] Table 2

[Table 2]

[Table]

	Emission layer material	at 1000 cd/m^2			ThresholdvoltageV_{turnon}	Max. luminous efficiency	
		Driving voltage	Luminous efficiency				
		(V)	(cd/A)	(lm/w)	(V)	(cd/A)	(lm/W)
Comp. Ex. 2	CBP	8.8	17.8	7.6	5	19.7	11.3
Ex. 9	M-4	7.0	35.4	19.3	3.5	43.5	43.2

[325] Referring to Table 2 and FIGs. 5, 7, and 9, a benzimidazole compound according to one embodiment of the present invention turned out to decrease the driving voltage of an organic light emitting diode as a host material and improve luminance and efficiency.

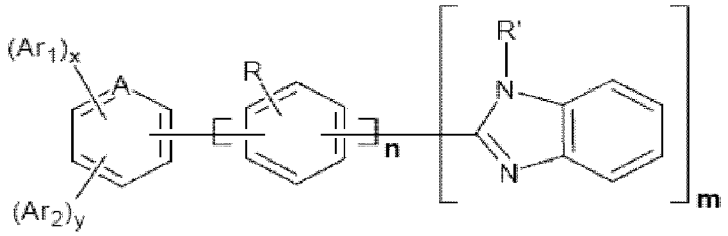
[326] The present invention is not limited to the embodiments, but can be fabricated with various modifications andequivalent arrangements included within the spirit and scope of the appended claims by a person who is ordinarily skilled in this field. Therefore, the aforementioned embodiments should be understood to be exemplary but not

limiting the present invention in any way.

Claims

[Claim 1] A benzimidazole compound represented by the following Chemical Formula 1:

[Chemical Formula 1]



wherein, in the above Chemical Formula 1,

A is C or N,

Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C6 to C30 arylamine, a substituted or unsubstituted C2 to C30 heteroarylamine, a substituted or unsubstituted carbazole, and a substituted or unsubstituted fluorene,

x and y are the same or different and are independently integers ranging from 0 to 5, provided that $1 \leq x+y \leq 5$,

R is hydrogen or a C1 to C7 lower alkyl,

n is an integer ranging from 0 to 3,

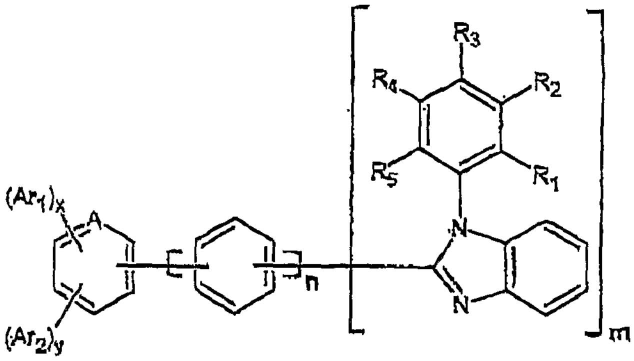
R' is selected from the group consisting of a substituted or unsubstituted C1 to C50 alkyl and a substituted or unsubstituted C6 to C50 aryl, and

m is 1 or 2.

[Claim 2] The benzimidazole compound of claim 1, wherein R' in the above Chemical Formula 1 is a substituted or unsubstituted C6 to 50 aryl.

[Claim 3] The benzimidazole compound of claim 1, wherein the benzimidazole compound is represented by the following Chemical Formula 2:

[Chemical Formula 2]



wherein, in the above Chemical Formula 2,

A is C or N,

Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C6 to C30 arylamine, a substituted or unsubstituted C2 to C30 heteroarylamine, a substituted or unsubstituted carbazole, and a substituted or unsubstituted fluorene,

x and y are the same or different and are independently integers ranging from 0 to 5, provided that $1 \leq x+y \leq 5$,

n is an integer ranging from 0 to 3,

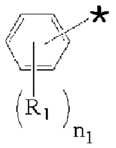
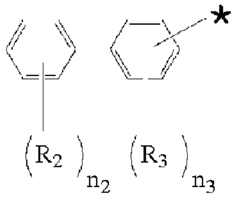
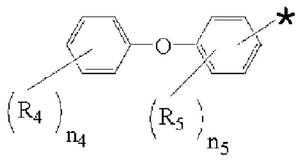
R_1 to R_5 are the same or different and are independently selected from the group consisting of hydrogen, a halogen, a cyano, a hydroxy, an amino, a nitro, a carboxyl, a substituted or unsubstituted C1 to C30 alkyl, a substituted or unsubstituted C1 to C20 alkenyl, a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C1 to C20 alkoxy, a substituted or unsubstituted C6 to C20 aryloxy, a substituted or unsubstituted C3 to C40 silyloxy, a substituted or unsubstituted C1 to C20 acyl, a substituted or unsubstituted C2 to C20 alkoxycarbonyl, a substituted or unsubstituted C2 to C20 acyloxy, a substituted or unsubstituted C2 to C20 heteroaryloxy, a substituted or unsubstituted C7 to C20 aryloxycarbonyl amino, a substituted or unsubstituted C1 to C20 sulfamoyl amino, a substituted or unsubstituted C1 to C20 sulfonyl, a substituted or unsubstituted C1 to C20 alkylthiol, a substituted or unsubstituted C6 to C20 arylthiol, a substituted or unsubstituted C1 to C20 heterocyclothiol, a substituted or unsubstituted C1 to C20 ureide, a substituted or unsubstituted C1 to C20 phosphoric acid amide, and a substituted or unsubstituted C3 to C40 silyl, and

m is 1 or 2.

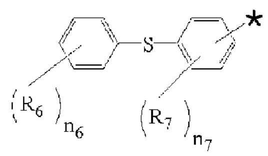
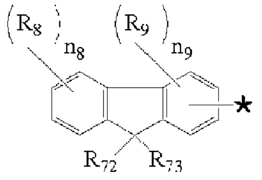
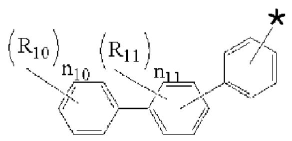
[Claim 4] The benzimidazole compound of claim 1, wherein Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of a substituted or unsubstituted C6 to C30 arylamine and a substituted or unsubstituted carbazole.

[Claim 5] The benzimidazole compound of claim 1, wherein Ar_1 to Ar_2 are the same or different and are independently selected from the group consisting of the following Chemical Formulae 3 to 33:

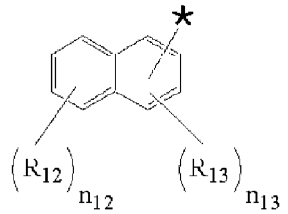
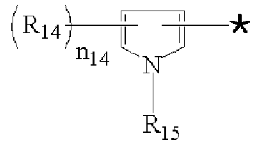
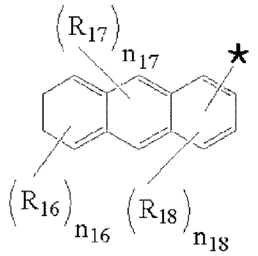
[Chemical Formula 3] [Chemical Formula 4] [Chemical Formula 5]

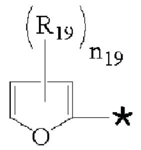
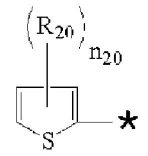
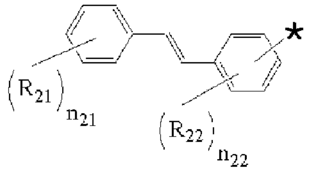
[Chemical Formula 6] [Chemical Formula 7] [Chemical Formula 8]

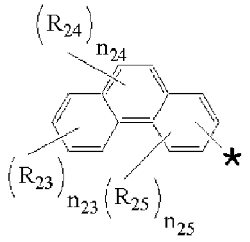
[Chemical Formula 9] [Chemical Formula 10] [Chemical Formula 11]

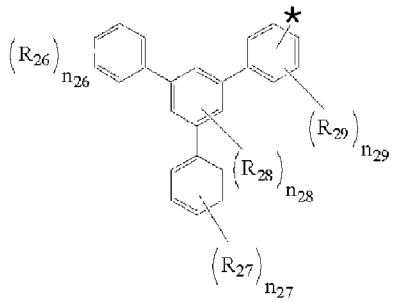




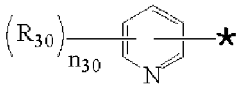
[Chemical Formula 12] [Chemical Formula 13] [Chemical Formula 14]

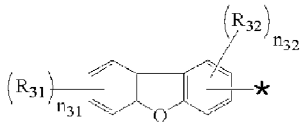
[Chemical Formula 15] [Chemical Formula 16] [Chemical Formula 17]

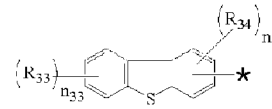


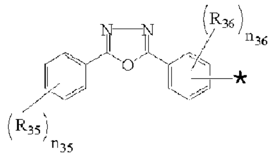




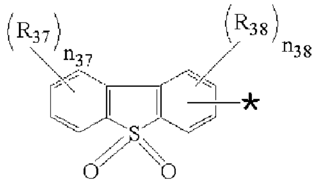
[Chemical Formula 18] [Chemical Formula 19] [Chemical Formula 20]

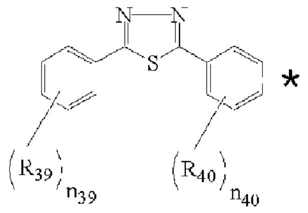


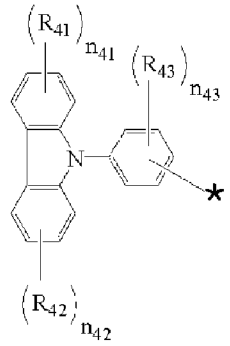




[Chemical Formula 21] [Chemical Formula 22] [Chemical Formula 23]







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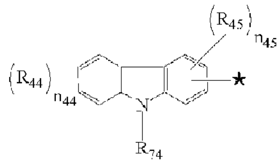
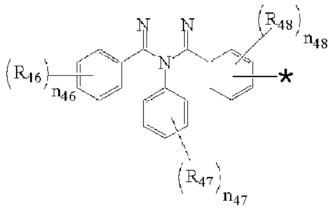
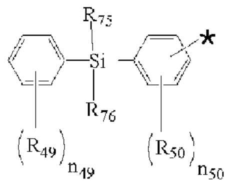
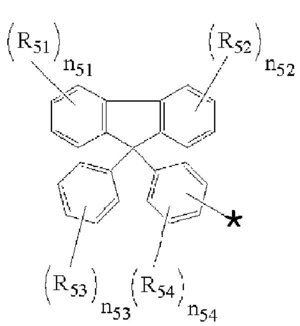
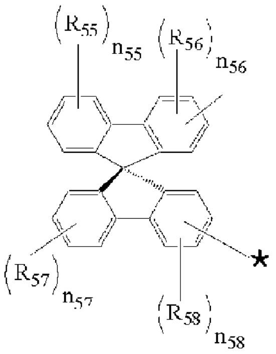


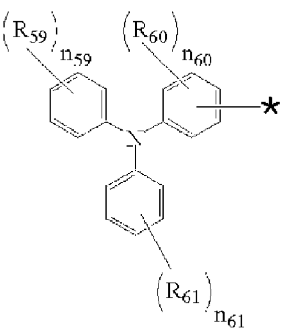




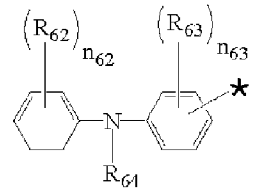
[Chemical Formula 27] [Chemical Formula 28] [Chemical Formula 29]

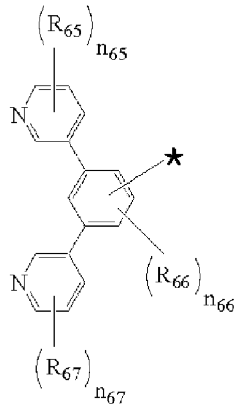


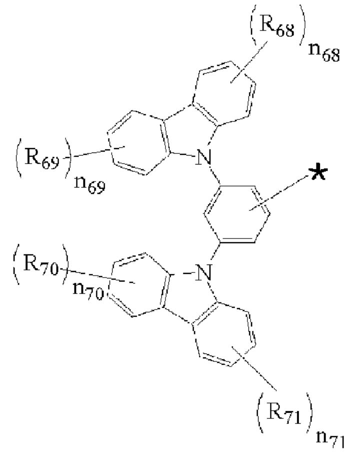




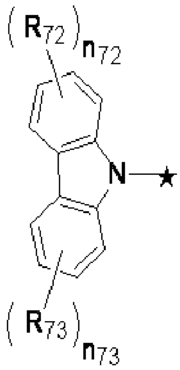
[Chemical Formula 30] [Chemical Formula 31] [Chemical Formula 32]







[Chemical Formula 33]



wherein in the above Chemical Formulae 3 to 33,

R_1 to R_{76} are the same or different and are independently a halogen, a cyano, a hydroxy, an amino, a nitro, a carboxyl, a substituted or unsubstituted C1 to C30 alkyl, a substituted or unsubstituted C1 to C20 alkenyl, a substituted or unsubstituted C6 to C30 aryl, a substituted or unsubstituted C2 to C30 heteroaryl, a substituted or unsubstituted C1 to C20 alkoxy, a substituted or unsubstituted C6 to C20 aryloxy, a substituted or unsubstituted C3 to C40 silyloxy, a substituted or unsubstituted C1 to C20 acyl, a substituted or unsubstituted C2 to C20 alkoxycarbonyl, a substituted or unsubstituted C2 to C20 acyloxy, a substituted or unsubstituted C2 to C20 heteroaryloxy, a substituted or unsubstituted C7 to C20 aryloxycarbonyl amino, a substituted or unsubstituted C1 to C20 sulfamoyl amino, a substituted or unsubstituted C1 to C20 sulfonyl, a substituted or unsubstituted C1 to C20 alkylthiol, a substituted or unsubstituted C6 to C20 arylthiol, a substituted or unsubstituted C1 to C20 heterocyclothiol, a substituted or unsubstituted

C1 to C20 ureide, a substituted or unsubstituted C1 to C20 phosphoric acid amide, and a substituted or unsubstituted C3 to C40 silyl,

n_1, n_2, n_4, n_6, n_{10}, n_{21}, n_{26}, n_{27}, n_{35}, n_{39}, n_{46}, n_{47}, n_{49}, n_{53}, n_{59}, n_{61}, and n_{62} are independently integers ranging from 0 to 5,

n_3, n_5, n_7, n_8, n_{11}, n_{12}, n_{16}, n_{22}, n_{23}, n_{29}, n_{30}, n_{31}, n_{33}, n_{36}, n_{37}, n_{40}, n_{41} to n_{44}, n_{48}, n_{50} to n_{52}, n_{54}, n_{55}, n_{57}, n_{60}, n_{63}, n_{65}, and n_{67} to n_{73} are independently integers ranging from 0 to 4,

n_9, n_{13}, n_{14}, n_{18}, n_{19}, n_{20}, n_{25}, n_{28}, n_{32}, n_{34}, n_{38}, n_{45}, n_{56}, n_{58}, and n_{66} are independently integers ranging from 0 to 3, and

n_{17} and n_{24} are independently integers ranging from 0 to 2.

[Claim 6] A benzimidazole compound, wherein the benzimidazole compounds according to one of claim 1 to 5 is applied to a charge transporting material or a host material for an organic photoelectric device.

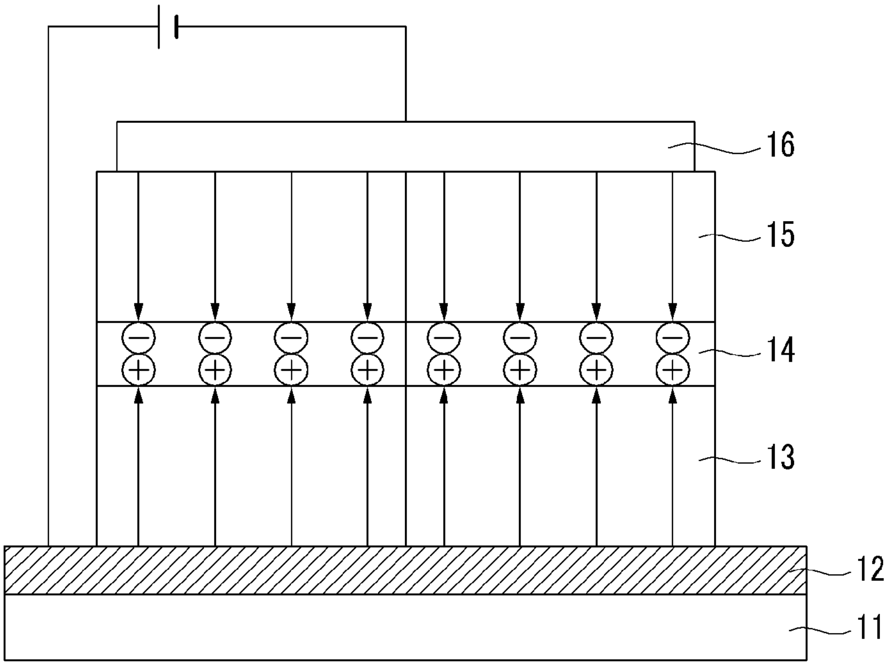
[Claim 7] An organic photoelectric device comprising an anode, a cathode, and at least one organic thin layer disposed between the anode and cathode, wherein at least one organic thin layer comprises the benzimidazole compound according to one of claims 1 to 5.

[Claim 8] The organic photoelectric device of claim 7, wherein the organic thin layer is an emission layer.

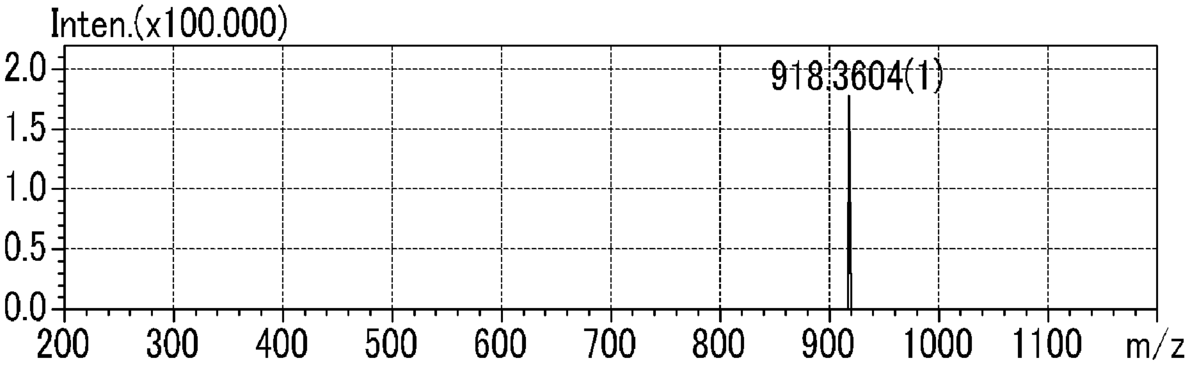
[Claim 9] The organic photoelectric device of claim 7, wherein the organic thin layer is selected from the group consisting of an electron injection layer (EIL), an electron transport layer (ETL), a hole blocking layer, and combinations thereof.

[Claim 10] A display element comprising the organic photoelectric device according to claim 7.

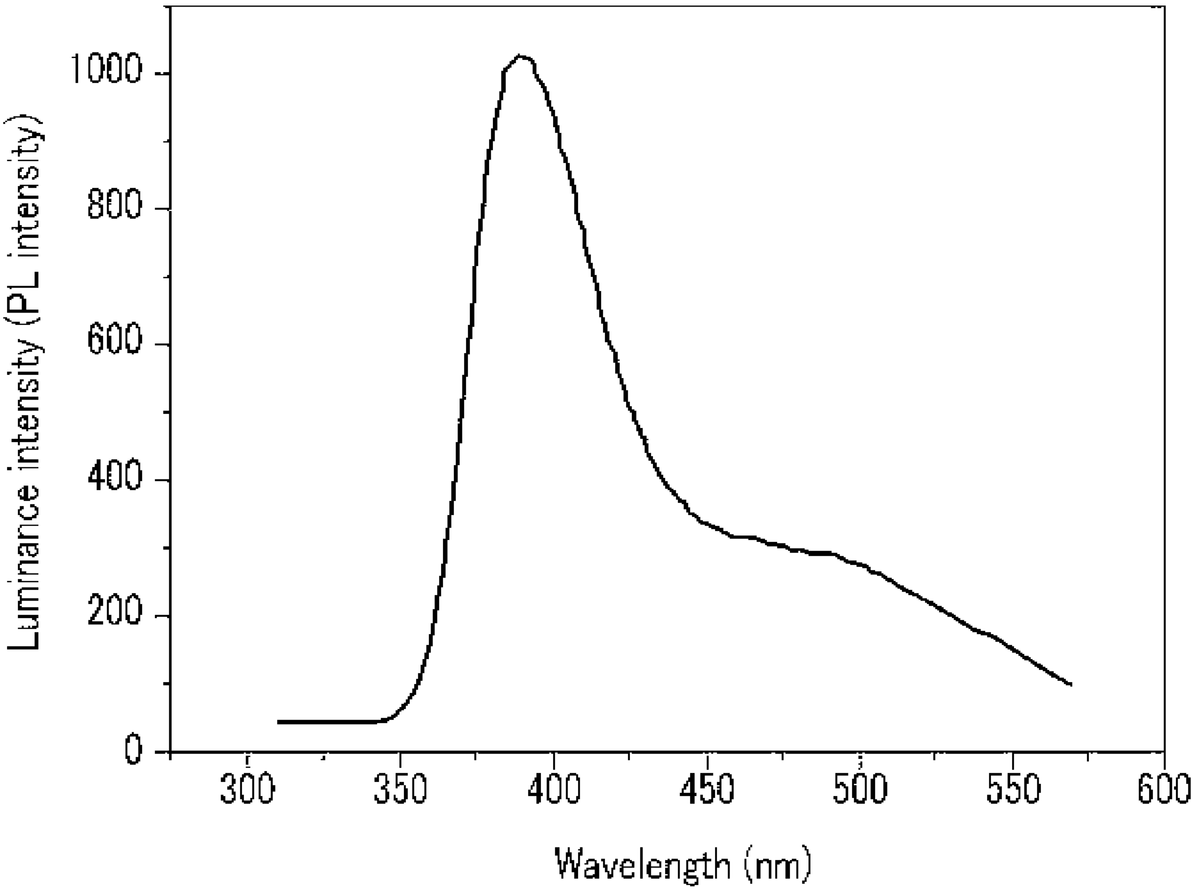
[Fig. 1]


16
15
14
13
12
11

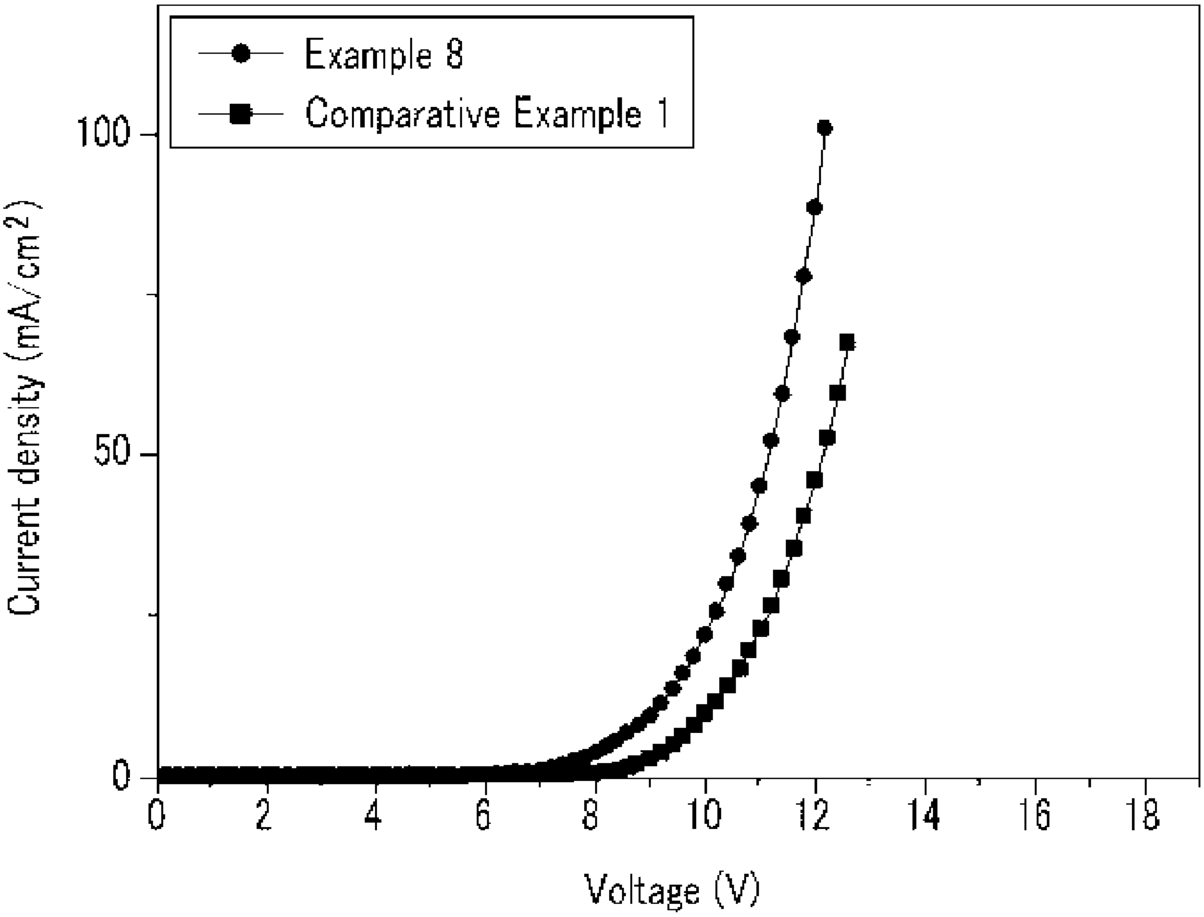
[Fig. 2]


Inten.(x100.000)
2.0
1.5
1.0
0.5
0.0
918.3604(1)
200
300
400
500
600
700
800
900
1000
1100
m/z

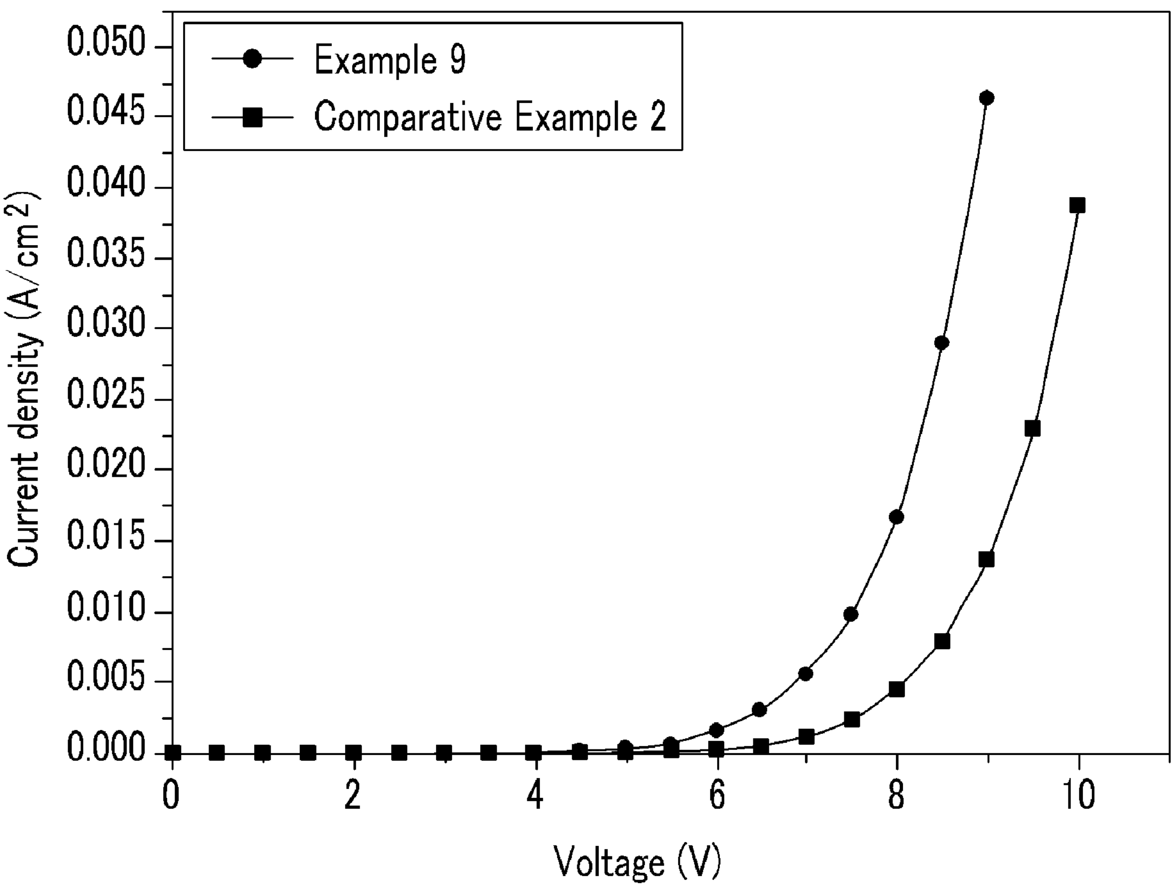
[Fig. 3]


Luminance intensity (PL intensity)
0
200
400
600
800
1000
300
350
400
450
500
550
600
Wavelength (nm)

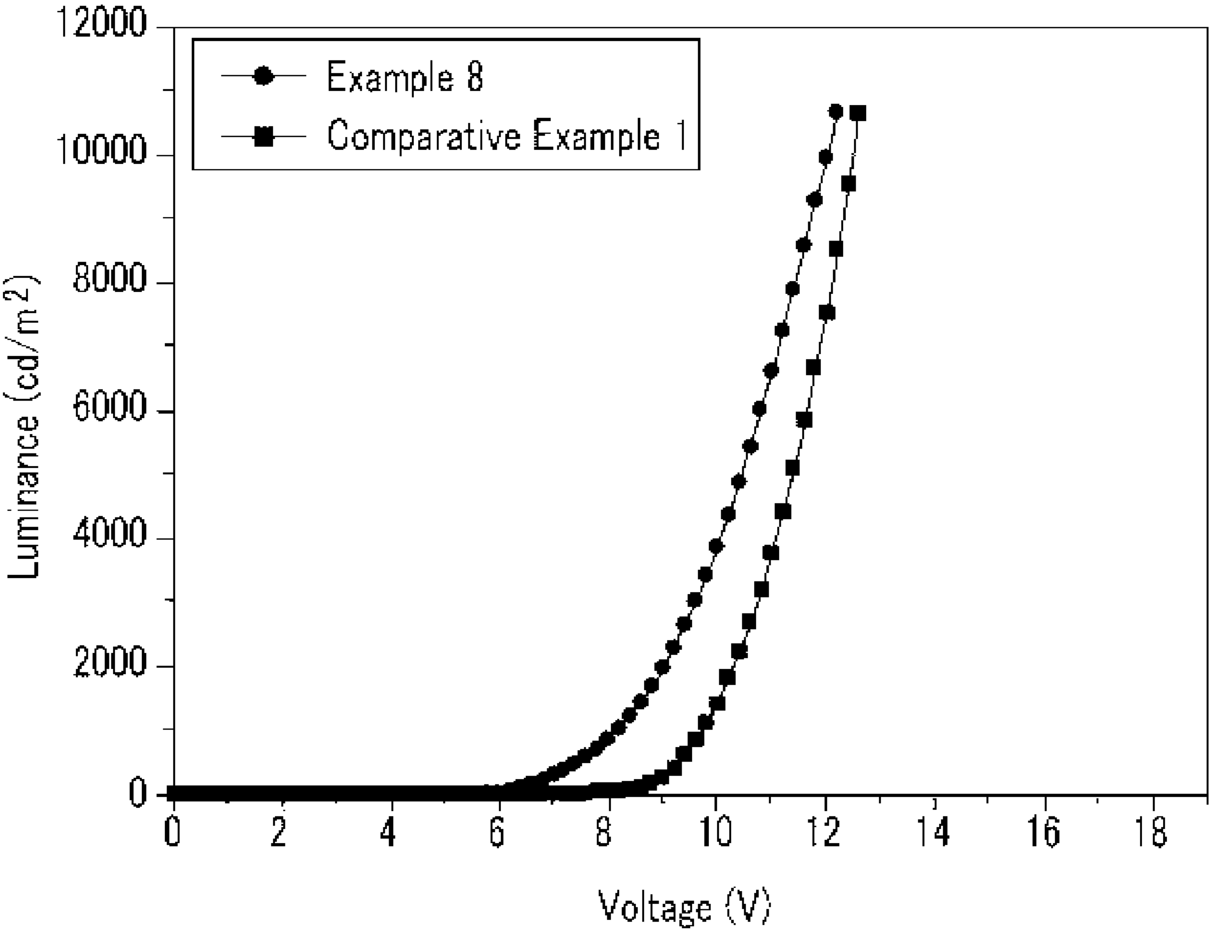
[Fig. 4]


Example 8
Comparative Example 1
Current density (mA/cm²)
0
50
100
0
2
4
6
8
10
12
14
16
18
Voltage (V)

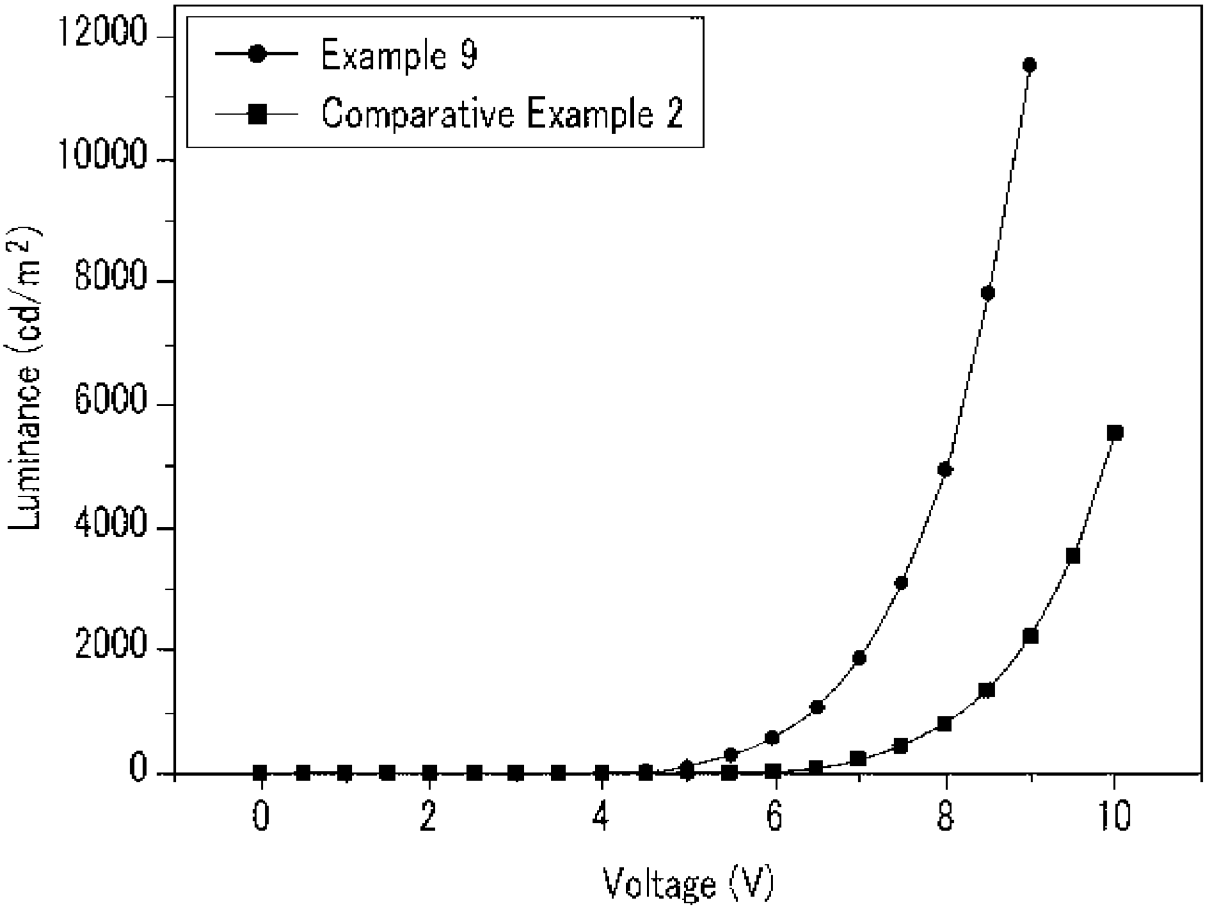
[Fig. 5]


Example 9
Comparative Example 2
Current density (A/cm^2)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
2
4
6
8
10
Voltage (V)

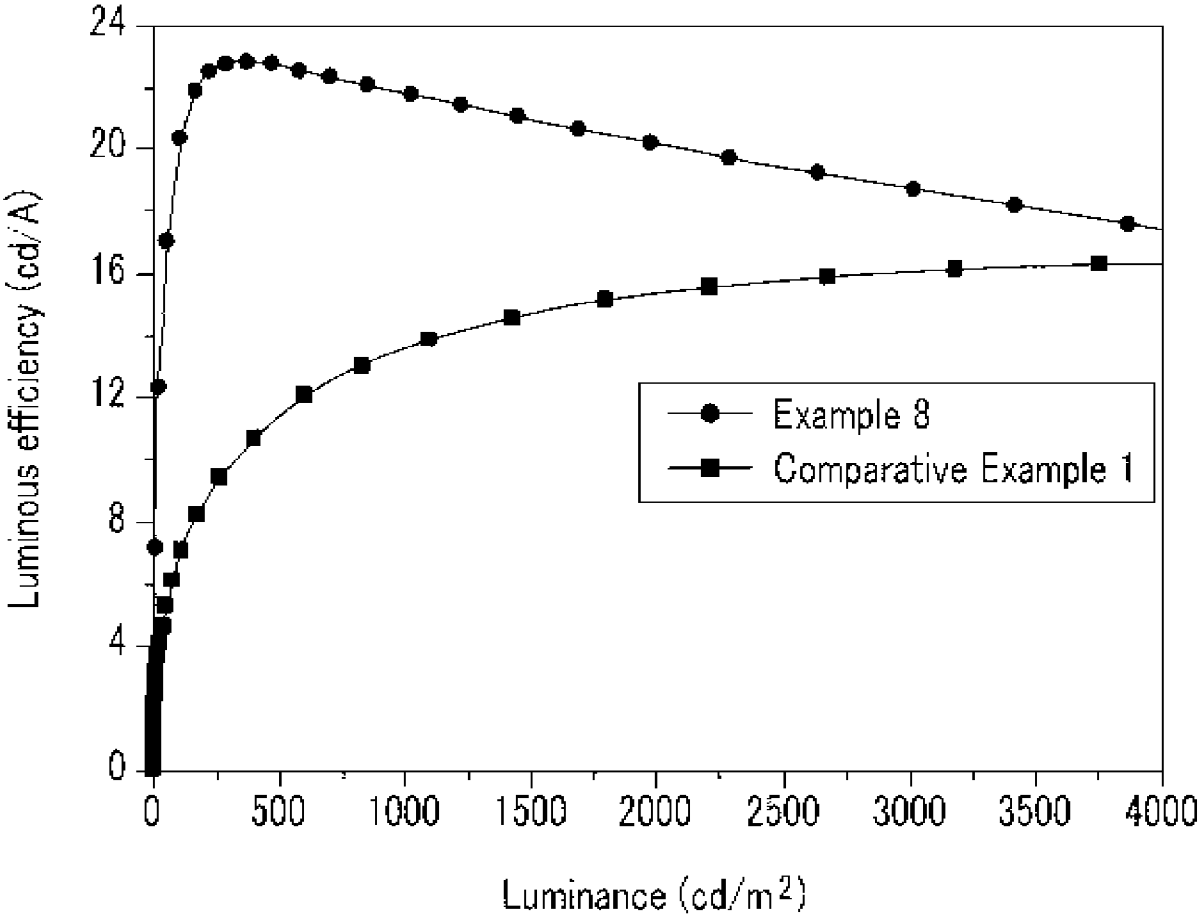
[Fig. 6]


Example 8
Comparative Example 1
Luminance (cd/m^2)
12000
10000
8000
6000
4000
2000
0
0
2
4
6
8
10
12
14
16
18
Voltage (V)

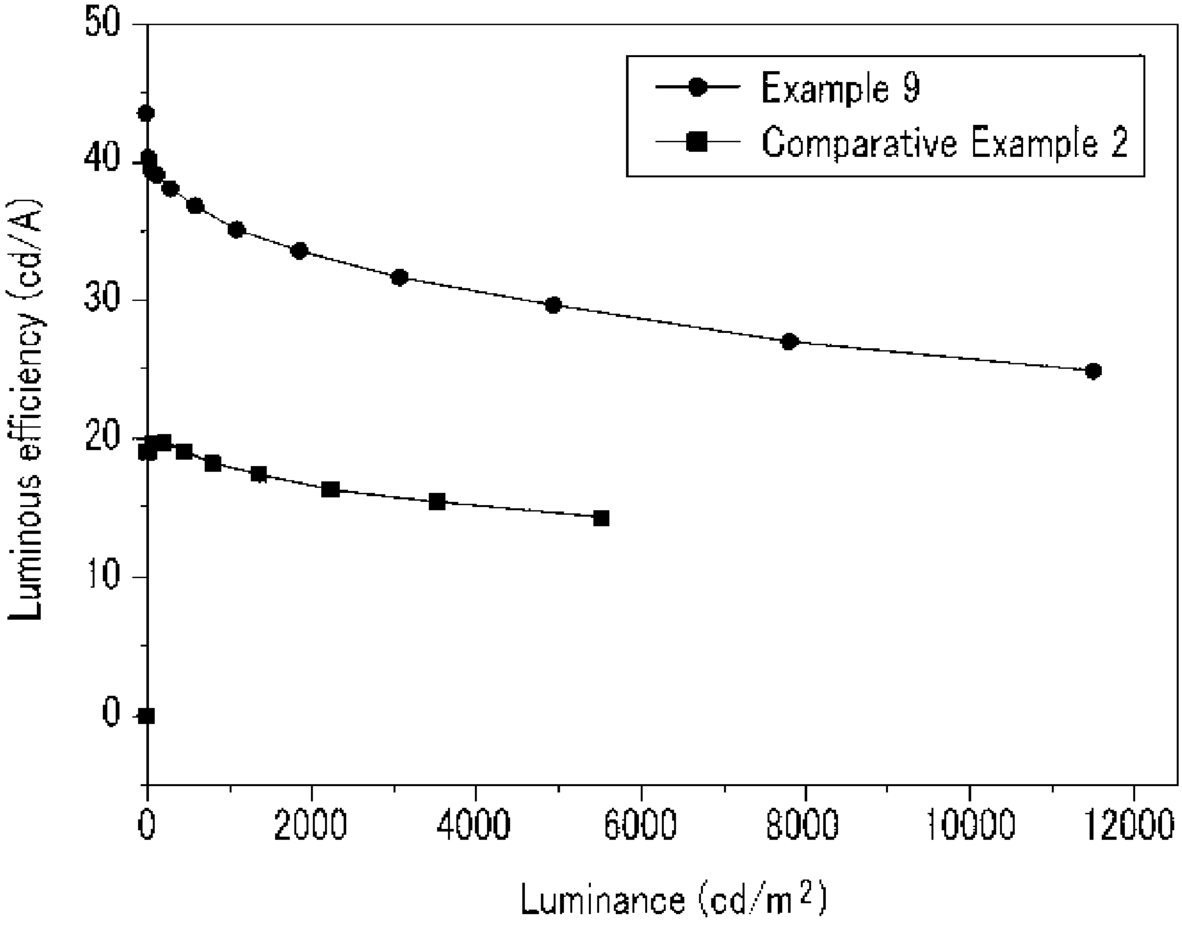
[Fig. 7]


Example 9
Comparative Example 2
Luminance (cd/m²)
0
2000
4000
6000
8000
10000
12000
Voltage (V)
0
2
4
6
8
10

[Fig. 8]


Example 8
Comparative Example 1
Luminous efficiency (cd/A)
0
4
8
12
16
20
24
Luminance (cd/m²)
0
500
1000
1500
2000
2500
3000
3500
4000

[Fig. 9]


Example 9
Comparative Example 2
Luminous efficiency (cd/A)
Luminance (cd/m 2)
50
40
30
20
10
0
0
2000
4000
6000
8000
10000
12000

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 2009/005911

A. CLASSIFICATION OF SUBJECT MATTER
IPC^8: ***C09K 19/04*** (2006.01); ***C09K 19/32*** (2006.01); ***C09K 19/34*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC^8: C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/076669 A1 (IDEMITSU KOSAN CO LTD) 18 August 2005 (18.08.2005) **Claims, pages 6, 18, 22, 25, 29** –	1-10
X	US 2007/267970 A1 (YAMAMOTO HIROSHI et al.) 22 November 2007 (22.11.2007) **Whole document** –	1-10
X	US 2008/233387 A1 (KAMBE EMIKO et al.) 25 September 2008 (25.09.2008) **Claims, Page 4, 5 ff, Tables 1-24** –	1-10

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search 5 March 2010 (05.03.2010)	Date of mailing of the international search report 17 March 2010 (17.03.2010)
Name and mailing address of the ISA/ AT **Austrian Patent Office** Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24 / 535	Authorized officer GÖRNER W. Telephone No. +43 / 1 / 534 24 / 558

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007/277306A (JSR Ltd.) 6 September 2007 (06.09.2007) . Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 147:477288. **Structure(s) with Registry Number(s) RN 953091-81-1** —	1-10
X	US 2007/205412A1 (BAE JAE-SOON et al.) 6 September 2007 (06.09.2007) **Formulas 1-10, 1-11, 1-13, 1-14, 1-16, 1-17, 1-19, 1-20, 1-22, 1-23, 1-25, 1-26, 1-28, 1-29, 1-31, 1-32, 1-34, 1-35, 1-37, 1-38, 1-40, 1-41, 1-43, 1-44, 1-46, 1-47, 1-49-53, 1-55, 1-56, 1-58, 1-59, [0072], claim 10** —	1-10
X	US 2005/186445A1 (Zeng Shiying et al.) 25 August 2005 (25.08.2005) . Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 143:256780. **Structures with Registry Numbers RN 863192-61-4, RN 863192-62-5, RN 863192-63-6** —	1-10
X	JP 2005/089543A (Toyo Ink Mfg. Co., Ltd) 7 April 2005 (07.04.2005) . Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 142:363445 **Structure with Registry Number RN 849222-66-8** —	1-10
X	WO 2005/023250A1 (BOEHRINGER INGELHEIM INT) 17 March 2005 (17.03.2005) —	1-5
X	JP 2004/352655A (Idemitsu Kosan Co., Ltd.) 16 December 2004 (16.12.2004) . Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 142:64983 **Structure with Registry Number RN 808144-15-2** —	1-10
X	Katritzky, Alan R.; De Ville, George; Patel, Ranjan C.; Harlow, Richard et al. " A 1,4-photochemical aryl shift." Tetrahedron Letters (1982), 23(12), 1241-2. Chemical Abstracts online [retrieved 18 February 2010 (18.02.2010)]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 97:109833	1-5

	Structures with Registry Numbers RN 82342-27-6, RN 82342-29-8 –	
X	Petoud, Stephane; Buenzli, Jean-Claude G.; Schenk, Kurt J.; Piguet, Claude et al. "Luminescent Properties of Lanthanide Nitrato Complexes with Substituted Bis(benzimidazolyl)pyridines." Inorganic Chemistry (1997), 36(7), 1345-1353. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 126:232625 *Structure with Registry Number RN 146887-06-1* –	1-10
X	Stibrany, Robert T.; Lobanov, Maxim V.; Schugar, Harvey J.; Potenza, Joseph A. et al. "A Geometrically Constraining Bis(benzimidazole) Ligand and Its Nearly Tetrahedral Complexes with Fe(II) and Mn(II)." Inorganic Chemistry (2004), 43(4), 1472-1480. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 140:245412 *Structure with Registry Number RN 483367-08-4* –	1-5
X	WO 2007/111262A1 (Idemitsu Kosan Co., Ltd.) 04.10.2007. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 147:406819 *Structure with Registry Number RN 950851-18-0, RN 950851-19-1, RN 950851-20-4, RN 950851-21-5* –	1-10
X	Dubey, P. K.; Kumar, C. Ravi; Reddy, P. V. V. Prasada et al. "Syntheses of 1-alkyl-2-(substituted-2-pyridyl)benzimidazoles." Indian Journal of Chemistry, Section B: Organic Chemistry Including Medicinal Chemistry (2003), 42B(9), 2115-2118. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 140:253493 *Structures with Registry Numbers RN 670750-06-8, RN 670750-08-0, RN 670750-09-1, RN 670750-10-4, RN 670750-11-5* –	1-5
X	Huang, Wei-Sheng; Lin, Jiann T.; Chien, Chin-Hsing; Tao, Yu-Tai; Sun, Shih-Sheng; Wen, Yuh-Sheng et al. "Highly	1-5

	Phosphorescent Bis-Cyclometalated Iridium Complexes Containing Benzoimidazole-Based Ligands." Chemistry of Materials (2004), 16(12), 2480-2488. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 141:140588 Structure with Registry Number RN 725251-21-8* —	
X	WO 2008/069586 A1 (LG Chem, Ltd.) 12.06.2008. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 149:67936. *Structures with Registry Numbers RN 1032763-81-7, RN 1032763-82-8, RN 1032763-83-9* —	1-10
X	US 20080100207 A1 (Park, Sang-Hoon et al.) 01.05.2008. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 148:526319 *Structure with Registry Number RN 1021857-17-9*. —	1-10
X	US 2008/079356 A1 (Park, Sang-Hoon et al.) 03.04.2008. Chemical Abstracts online [retrieved 18.02.2010]. Retrieved from: CA Database, STN International, Karlsruhe (DE), CA Accession number AN 148:437023 *Structures with Registry Numbers RN 1016653-16-9, RN 1016653-15-8*. —	1-10
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