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(54) **AROMATIC COMPOUND AND ORGANIC ELECTROLUMINESCENCE DEVICE INCLUDING THE SAME**

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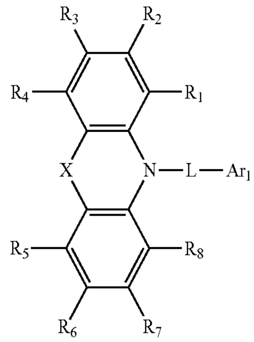
(57) **ABSTRACT**

Provided are an aromatic compound enhancing emission efficiency of blue light emitting region and an organic electroluminescence device including the same. The aromatic compound according to an embodiment of the inventive concept is represented by Formula 1, and more details about the constituents are provided in the disclosure.

[Formula 1]



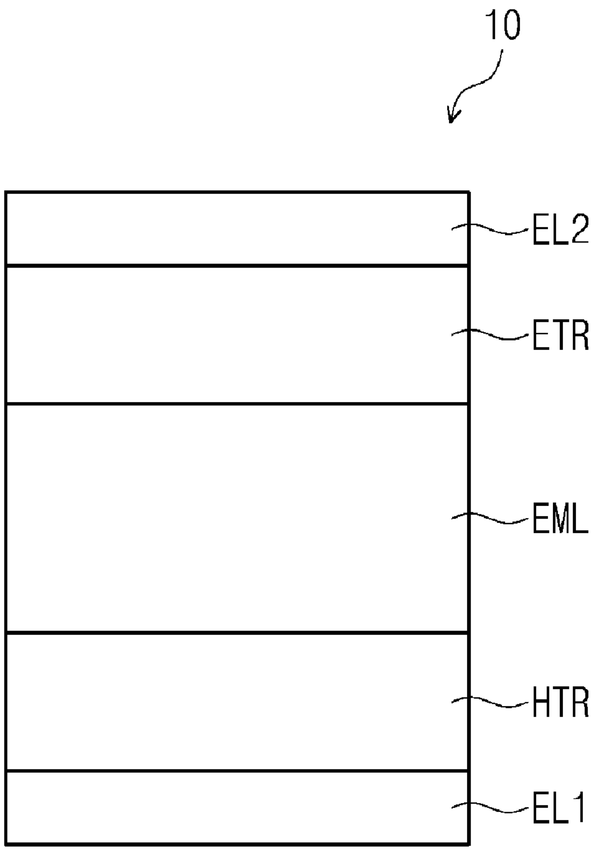


FIG. 1

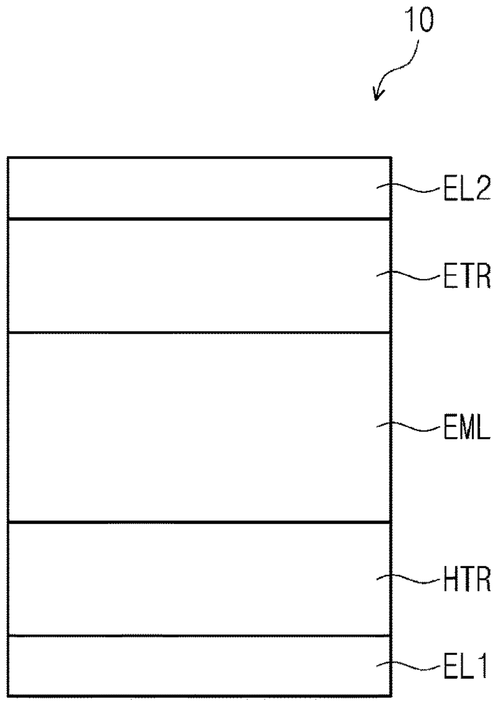
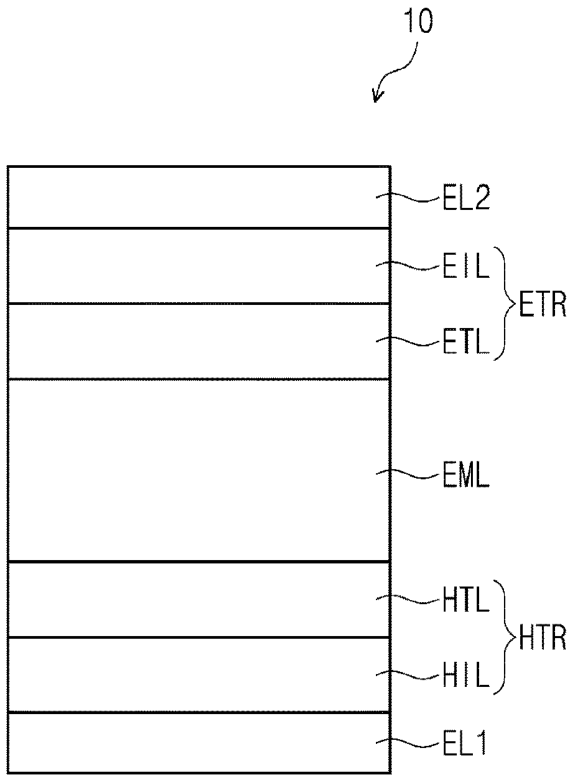


FIG. 2



AROMATIC COMPOUND AND ORGANIC ELECTROLUMINESCENCE DEVICE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. non-provisional patent application claims priority, under 35 U.S.C. § 119, from Korean Patent Application No. 10-2016-0162998 filed on Dec. 1, 2016, the entire content of which is hereby incorporated by reference.

BACKGROUND

[0002] The present disclosure herein relates to an aromatic compound and an organic electroluminescence device including the same.

[0003] Active development of organic electroluminescence displays as an image display is on-going. An organic electroluminescence display is different from a liquid crystal display, and is called a self-luminescent display because it recombines holes and electrons injected from a first electrode and a second electrode in an emission layer and emits light from a luminescent material that includes an organic compound in the emission layer.

[0004] As an organic electroluminescence device, for example, an organic electroluminescence device composed of a first electrode, a hole transport layer disposed on the first electrode, an emission layer disposed on the hole transport layer, an electron transport layer disposed on the emission layer, and a second electrode disposed on the electron transport layer is known. Holes are injected from the first electrode, and the injected holes move via the hole transport layer to be injected into the emission layer. Meanwhile, electrons are injected from the second electrode, and the injected electrons move via the electron transport layer to be injected into the emission layer. By recombining the holes and electrons injected into the emission layer, excitons are generated in the emission layer. The organic electroluminescence device emits light using light emitted by radiation non-activation of the excitons. In addition, the configuration of an organic electroluminescence device is not limited to those described above, and various modifications may be possible.

[0005] In an application of an organic electroluminescence device to a display, the decrease of a driving voltage, increase of emission efficiency and extension of life for the organic electroluminescence device are required, and the development of materials which may stably implement these requirements in an organic electroluminescence is also continuously required.

[0006] Meanwhile, the development on phosphorescence using triplet state energy or delayed fluorescence using triplet-triplet annihilation (TTA) in which singlet excitons are generated by the collision of triplet excitons is being conducted for achieving a high efficiency organic electroluminescence device.

[0007] In particular, thermally activated delayed fluorescence (TADF) materials are being developed as a technology for achieving about 100% internal quantum yield.

[0008] Whereas a plurality of high efficiency TADF materials emitting red or green light is currently presented, reports on high efficiency TADF materials emitting blue light with a light emitting wavelength of about 480 nm or lower are limited.

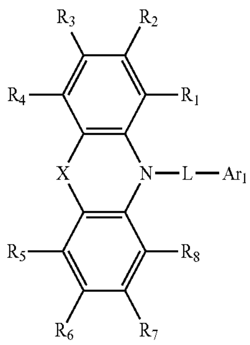
SUMMARY

[0009] The present disclosure provides an aromatic compound used in a high efficiency organic electroluminescence device.

[0010] The present disclosure also provides a high efficiency organic electroluminescence device including an aromatic compound in an emission layer.

[0011] An embodiment of the inventive concept provides an aromatic compound represented by the following Formula 1.

[Formula 1]



[0012] In Formula 1, Ar_1 is a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, L is a direct linkage, or a substituted or unsubstituted phenylene group, X is a direct linkage, O, S, NR_a, CR_bR_c, SiR_dR_e, GeR_fR_g, $P(=O)R_h$, or $P(=S)R_1$.

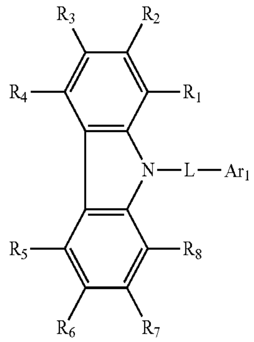
[0013] In Formula 1, R_1 to R_8 are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0014] R_a to R_i are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other, and R_d and R_e are not phenyl group concurrently.

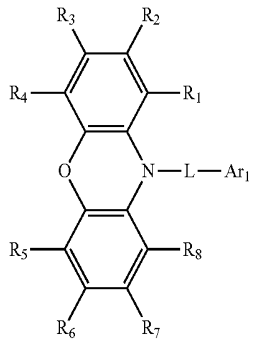
[0015] In an embodiment, the aromatic compound represented by Formula 1 may have an absolute value of the difference between the singlet energy level and the triplet energy level of about 0.2 eV or less.

[0016] In an embodiment, Formula 1 may be represented by one of the following Formulae 1-1 to 1-10.

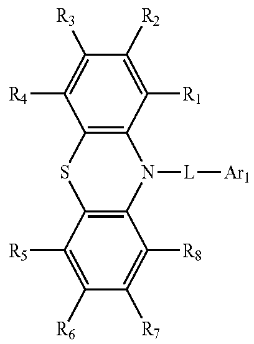
[Formula 1-1]



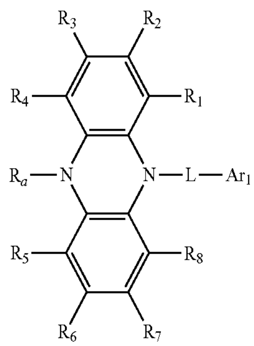
[Formula 1-2]



[Formula 1-3]



[Formula 1-4]



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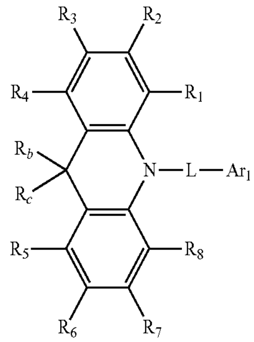
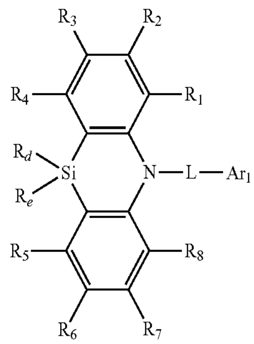
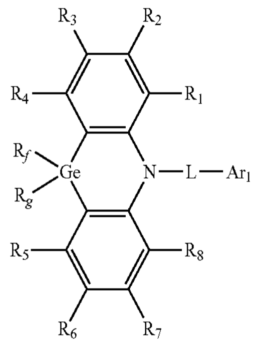
[Formula 1-5]



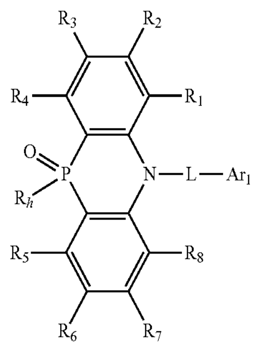
[Formula 1-6]



[Formula 1-7]



[Formula 1-8]



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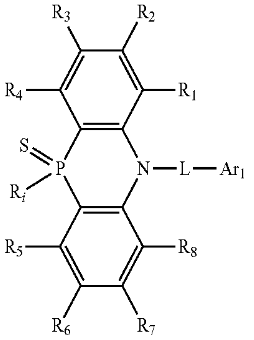
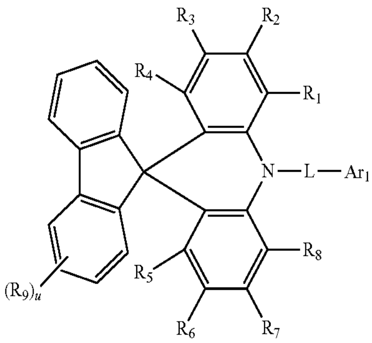
[Formula 1-9]



[Formula 1-10]

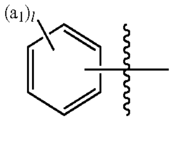


[0017] In Formula 1-10, R_9 is a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other, u is an integer of 0 to 4, and Ar_1, L, R_1 to R_8, and R_a to R_i are the same as defined in Formula 1.

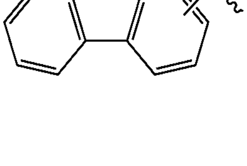
[0018] In an embodiment, R_a to R_i may be each independently unsubstituted or substituted with at least one of a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0019] In an embodiment, R_a to R_i may be each independently represented by one of the following Formulae 2-1 to 2-4.

[Formula 2-1]



[Formula 2-2]



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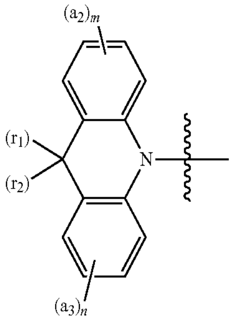
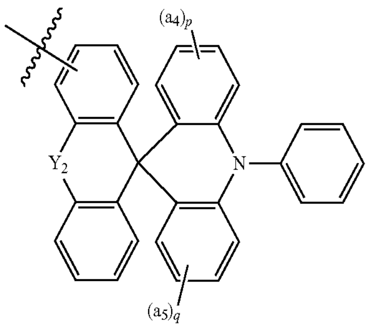
[Formula 2-3]



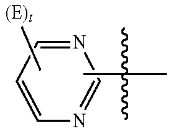
[Formula 2-4]



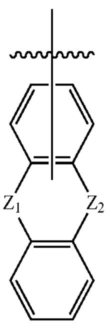
[0020] In Formulae 2-1 to 2-4, a_1 to a_5 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, r_1 and r_2 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other, l, m, n, p, and q are each independently an integer of 0 to 4. In Formula 2-2, Y_1 is NR_a, O, or S. In Formula 2-4, Y_2 is a direct linkage, O, or S, and R_a is the same as defined in Formula 1.

[0021] In an embodiment, Ar_1 may be represented by the following Formula 3-1 or 3-2.

[Formula 3-1]



[Formula 3-2]

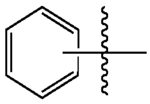


[0022] In Formula 3-1, E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for

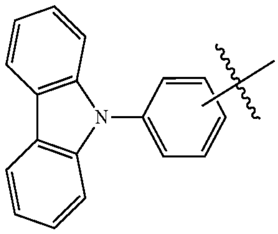
[0023] In Formula 3-2, Z_1 and Z_2 are each independently BR', NR", O, S, or C(═O), and R' and R" are each independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0024] In an embodiment, each of R_a to R_i may independently be represented by one of the following Formulae S1 to S18.

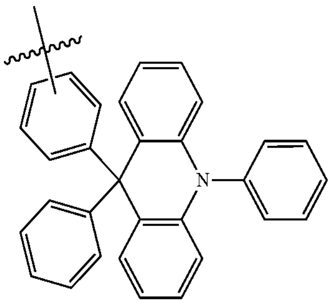
S1



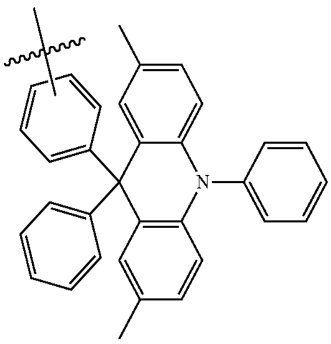
S2



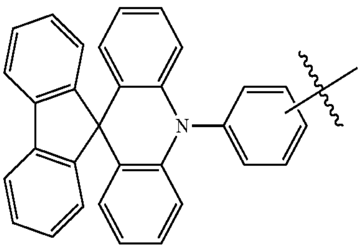
S3



S4



S5



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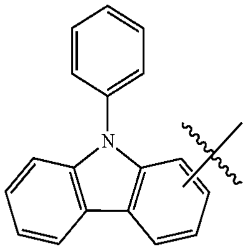
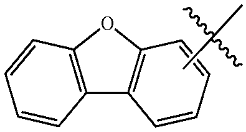
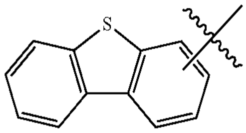
S6



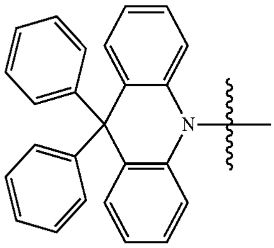
S7



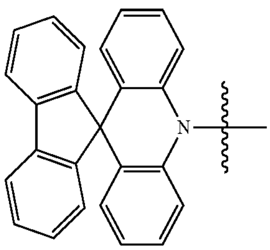
S8



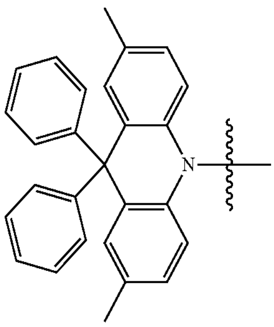
S9



S10



S11



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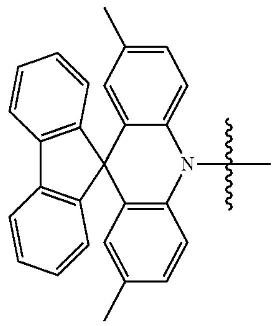
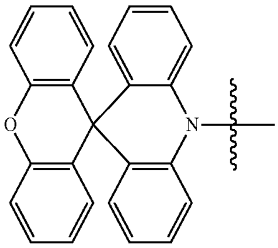
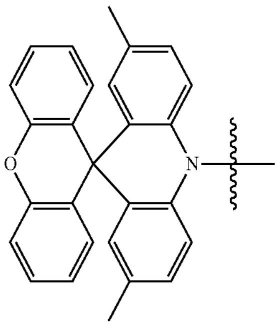
S12



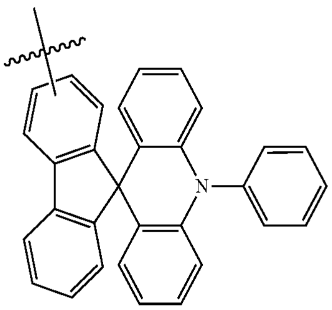
S13



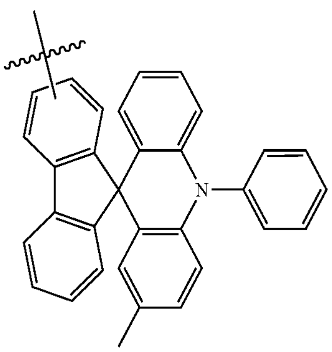
S14



S15



S16



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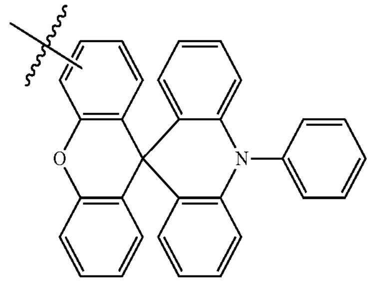
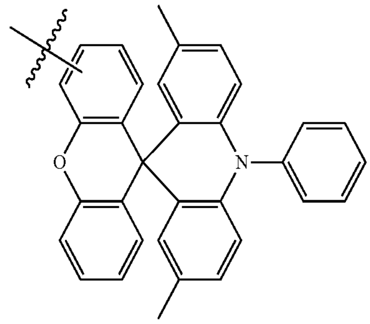
S17

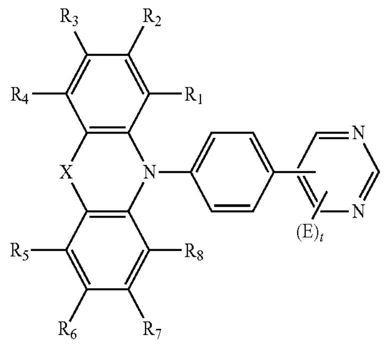


S18



[0025] In an embodiment, Formula 1 may be represented by the following Formula 4.

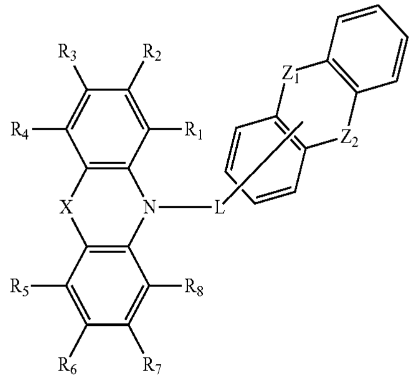
[Formula 4]



[0026] In Formula 4, E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, t is an integer of 0 to 3, and X and R_1 to R_8 are the same as defined in Formula 1.

[0027] In an embodiment, Formula 1 may be represented by the following Formula 5.

[Formula 5]

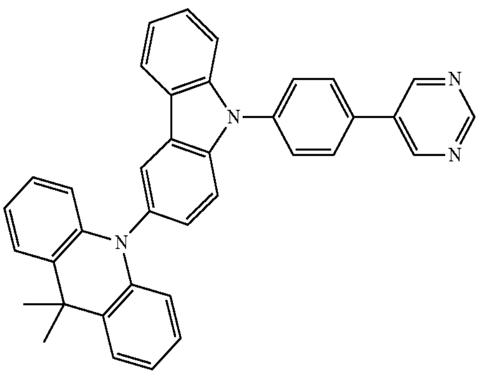


[0028] In Formula 5, Z_1 and Z_2 are each independently BR', NR", O, S, or C(=O), R' and R" are each independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and X, L, and R_1 to R_8 are the same as defined in Formula 1.

[0029] In an embodiment, the aromatic compound represented by Formula 1 may be one selected from the group consisting of compounds represented in the following Compound Group 1.

[Compound Group 1]

1



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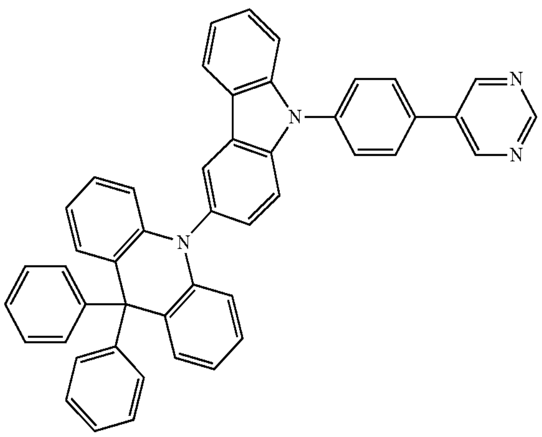

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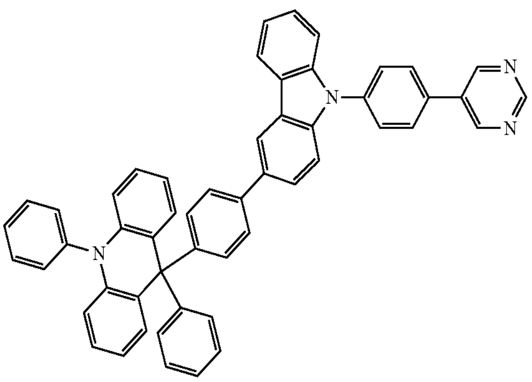

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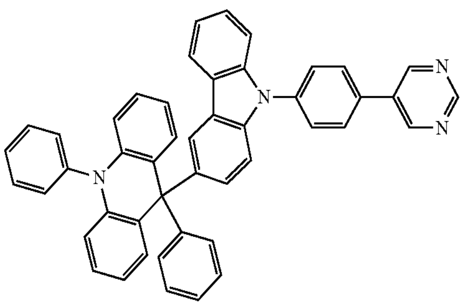

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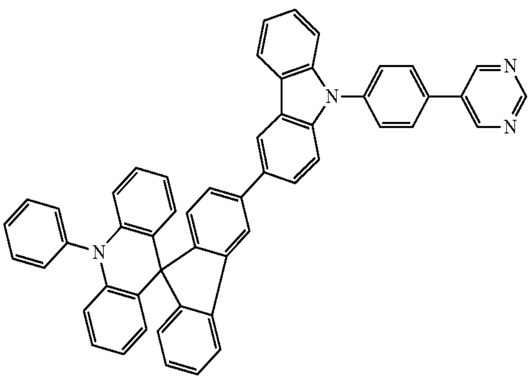

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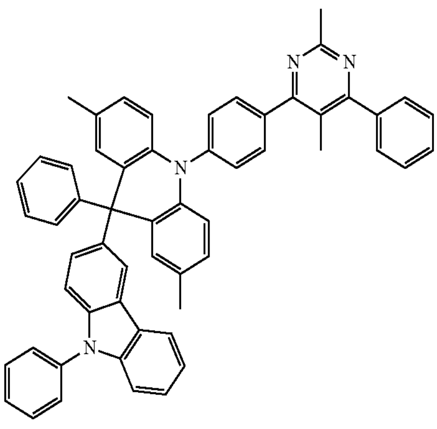

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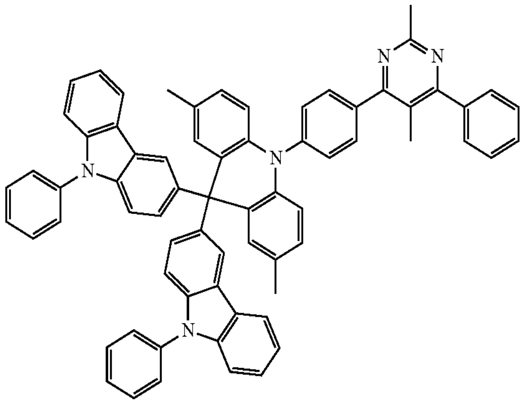

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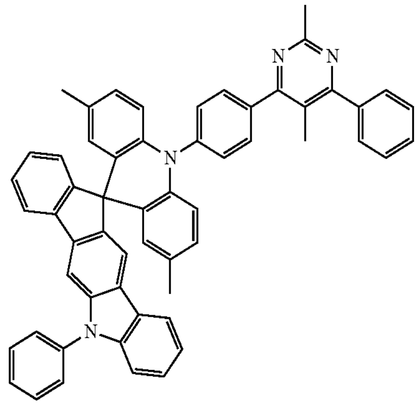

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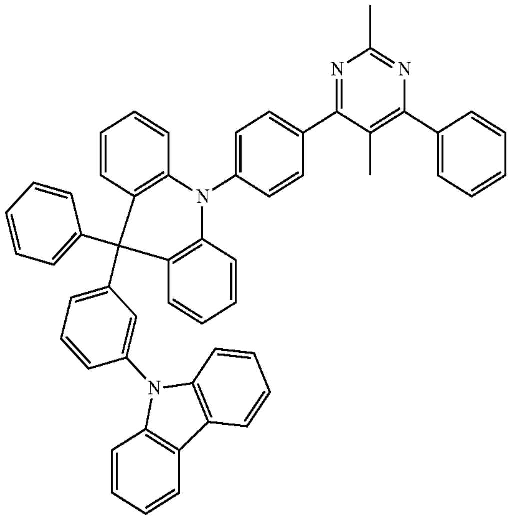

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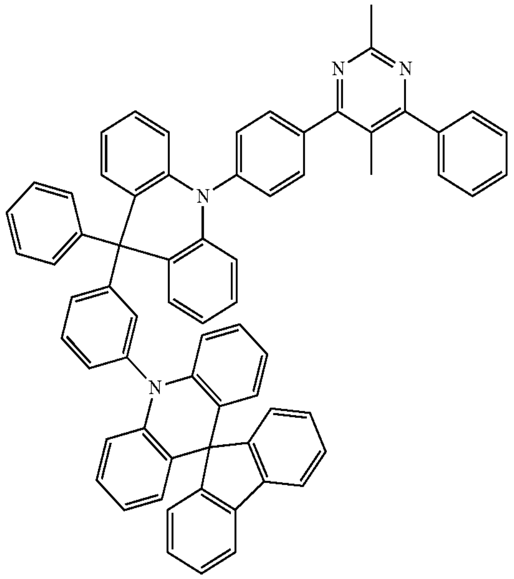

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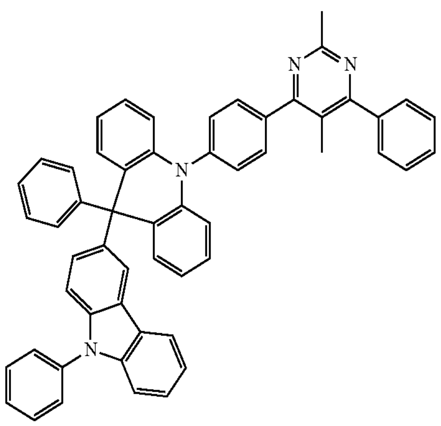

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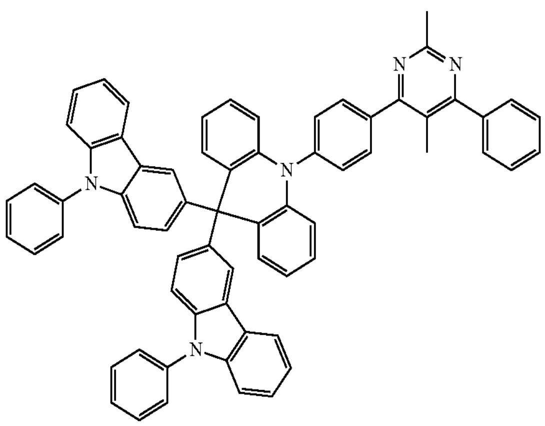

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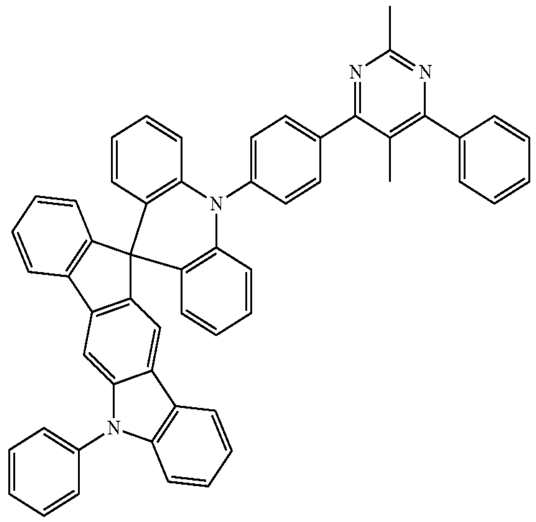

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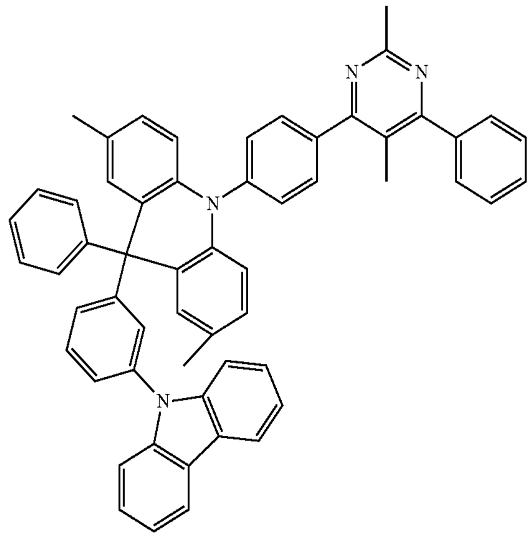

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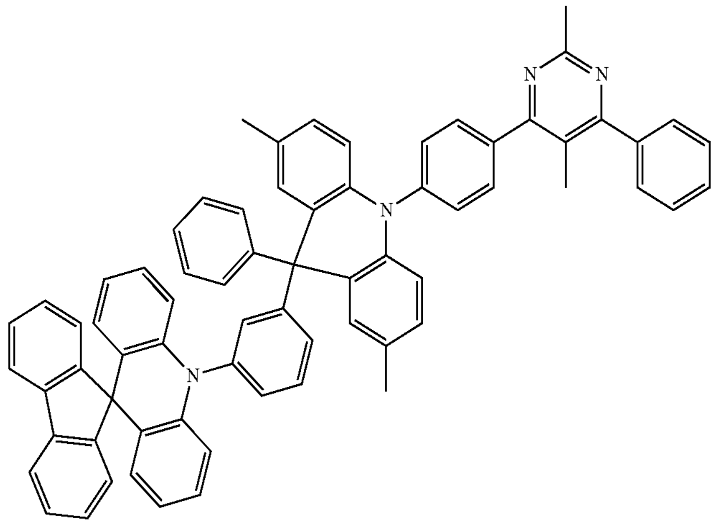

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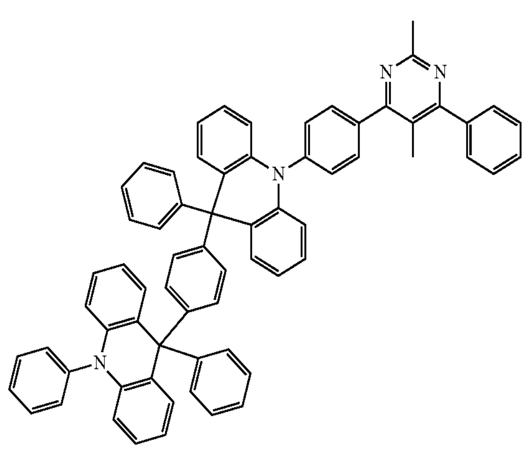

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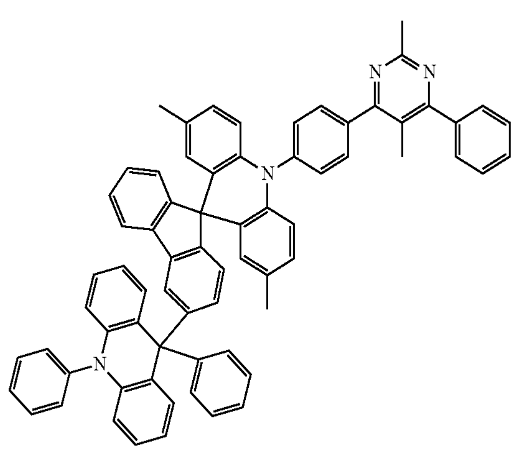

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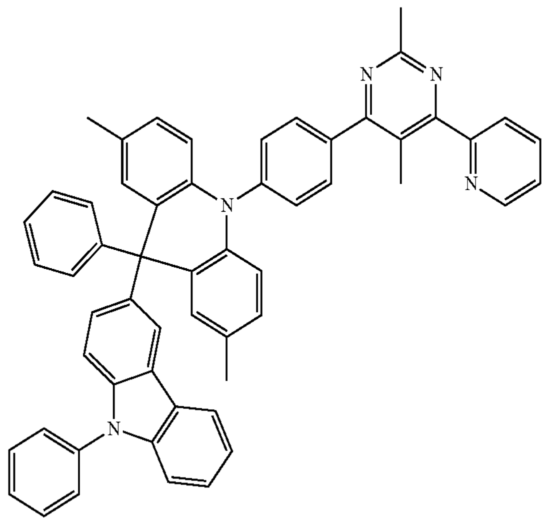

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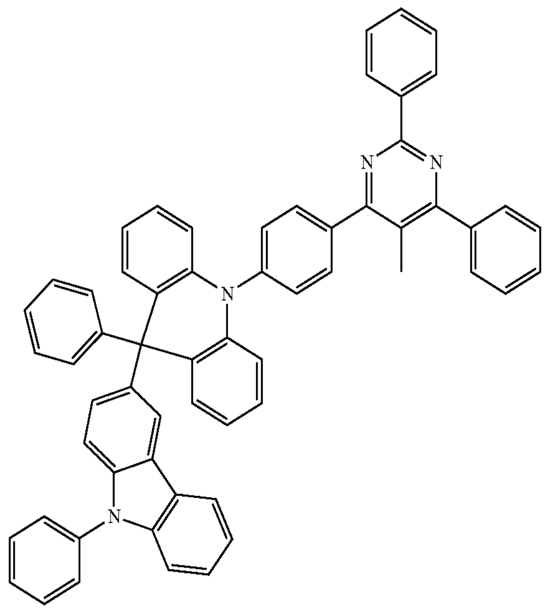

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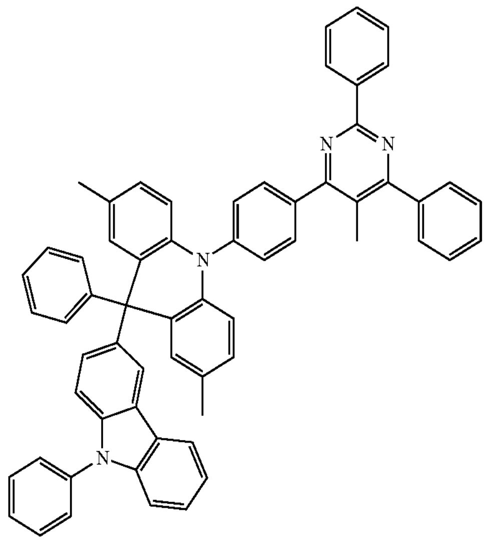

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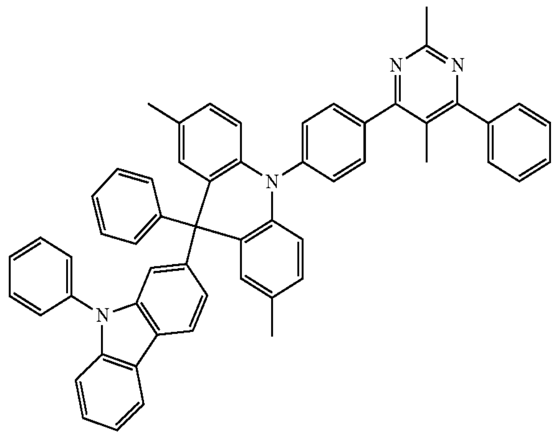

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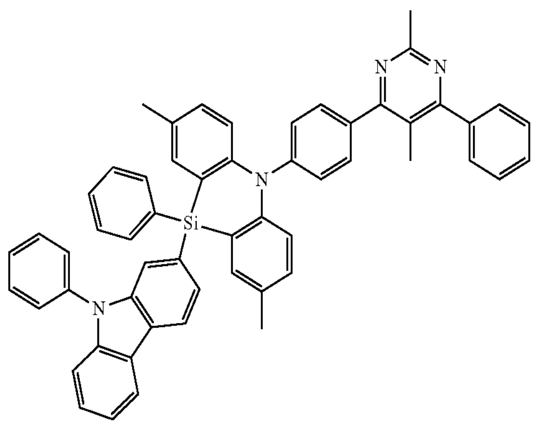

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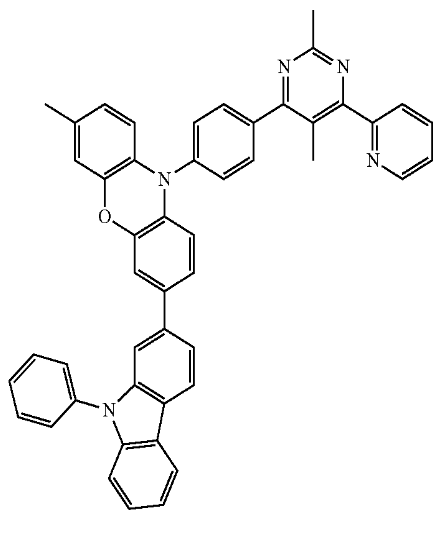

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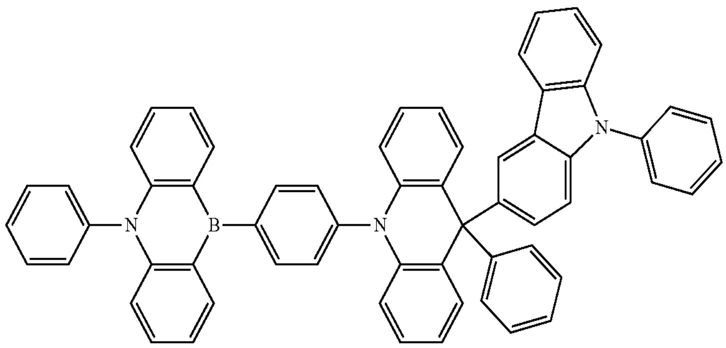

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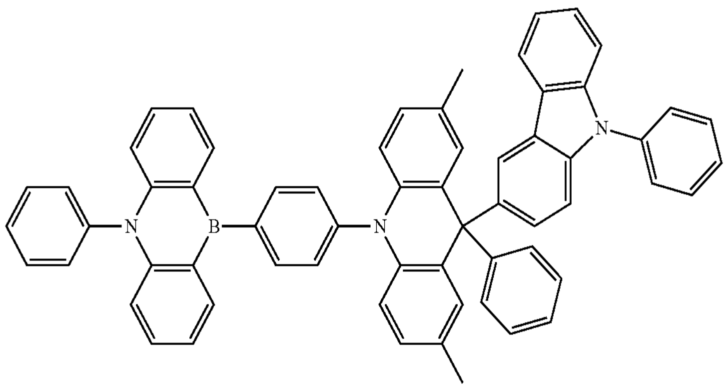

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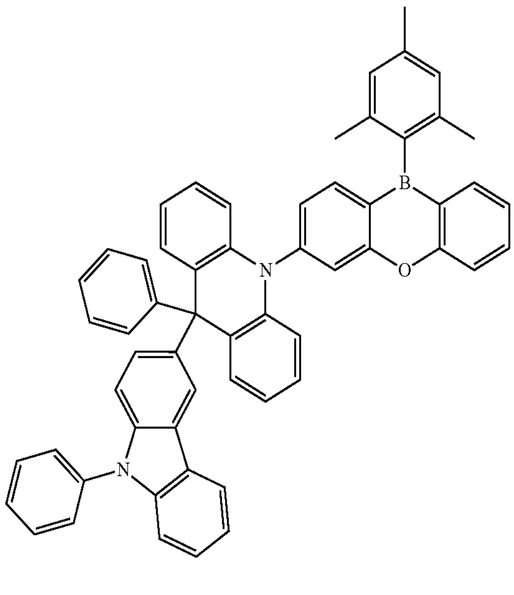

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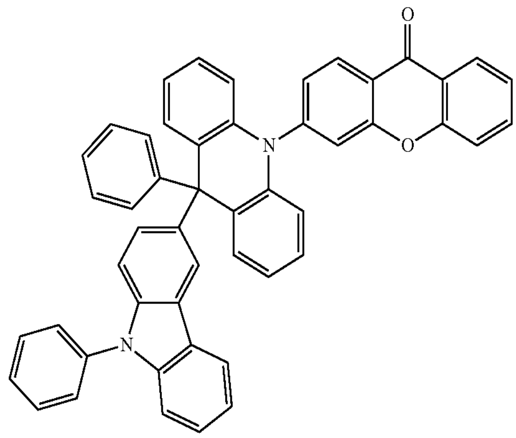
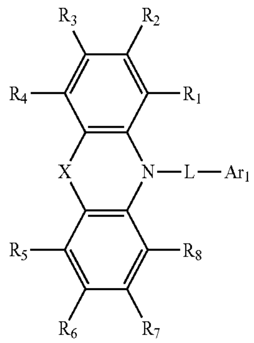


[0030] An embodiment of the inventive concept provides an organic electroluminescence device including a first electrode, a hole transport region disposed on the first electrode, an emission layer disposed on the hole transport region, an electron transport region disposed on the emission layer, and a second electrode disposed on the electron transport region, in which the emission layer includes an aromatic compound represented by the following Formula 1.

[Formula 1]



[0031] In Formula 1, Ar_1 is a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, L is a direct linkage, or a substituted or unsubstituted phenylene group, X is a direct linkage, O, S, NR_a, CR_bR_c, SiR_dR_e, GeR_fR_g, $P(=O)R_h$, or $P(=S)R_i$.

[0032] In Formula 1, R_1 to R_8 are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0033] In Formula 1, R_a to R_i are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other, and R_d and R_e are not phenyl group concurrently.

[0034] In an embodiment, the emission layer may emit blue light.

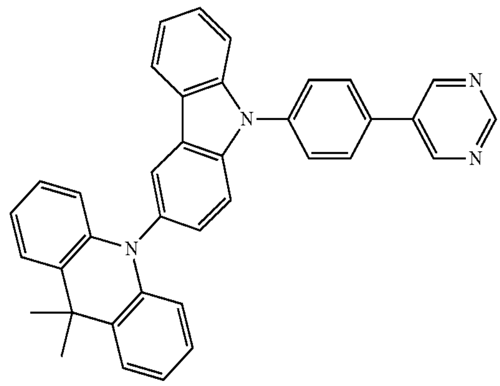
[0035] In an embodiment, the aromatic compound represented by Formula 1 may be a thermally activated delayed fluorescence compound.

[0036] In an embodiment, the aromatic compound represented by Formula 1 may have an absolute value of the difference between the singlet energy level and the triplet energy level of about 0.2 eV or less.

[0037] In an embodiment, the emission layer may include at least one of the compounds represented in the following Compound Group 1:

[Compound Group 1]

1



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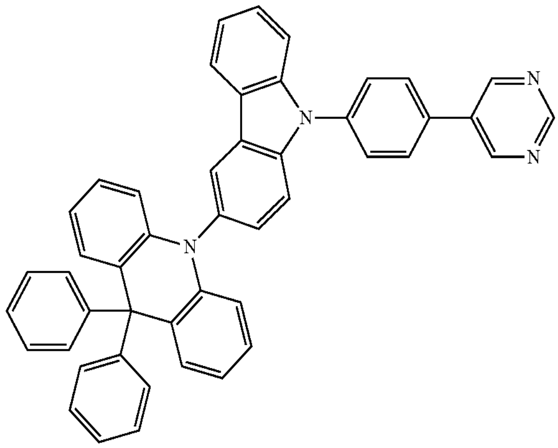

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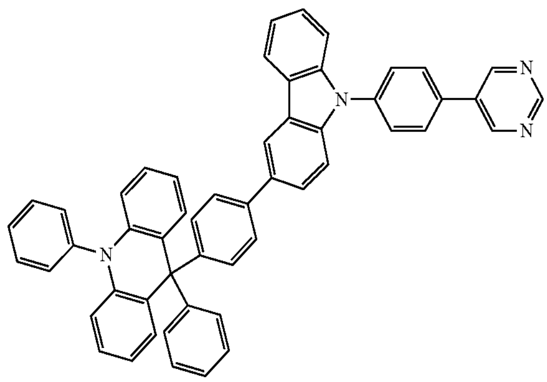

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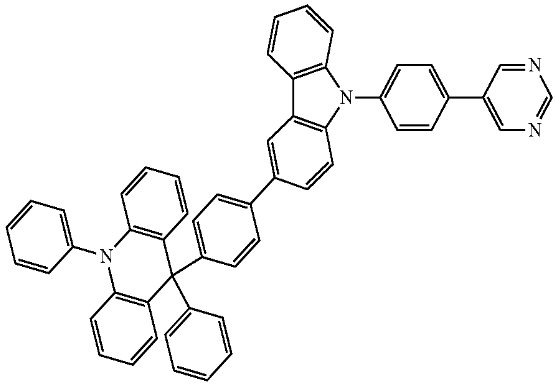

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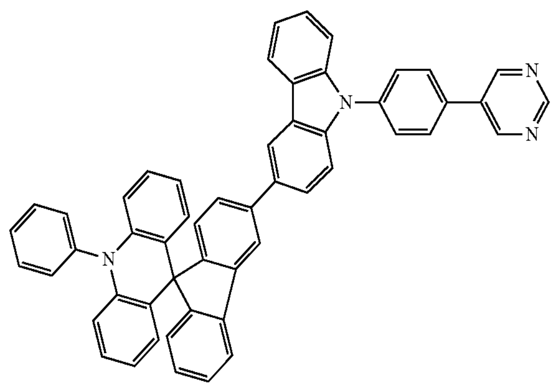

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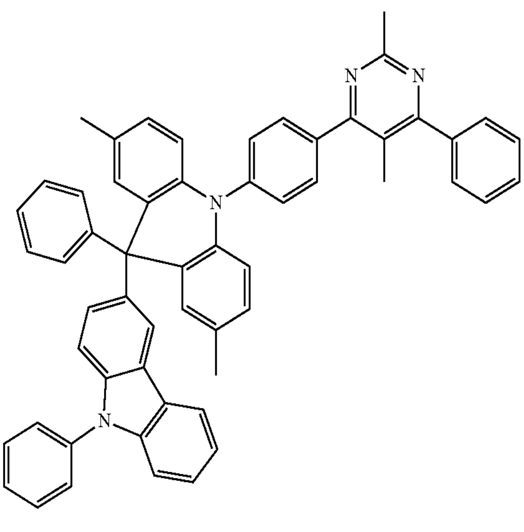

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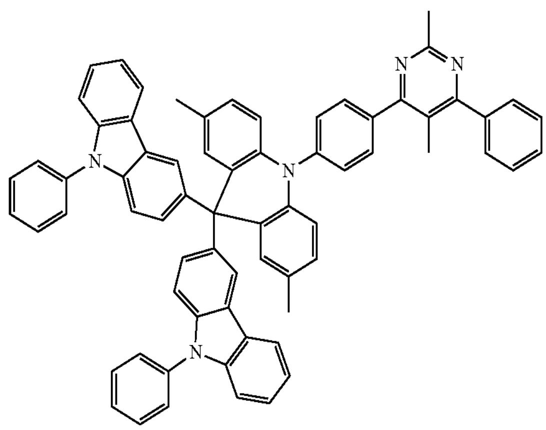

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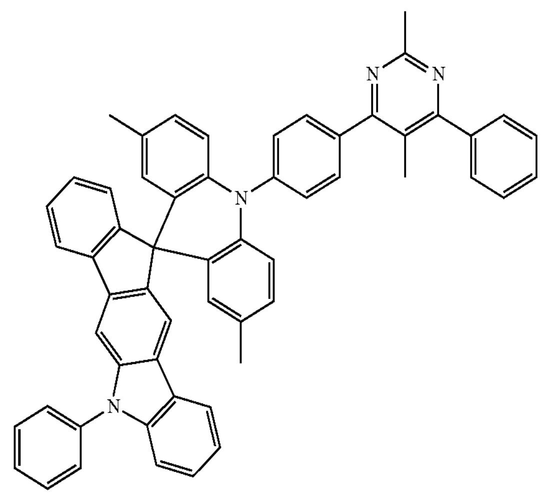

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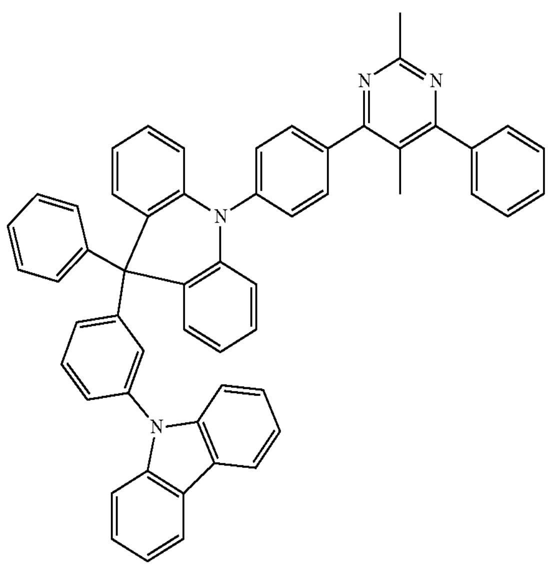

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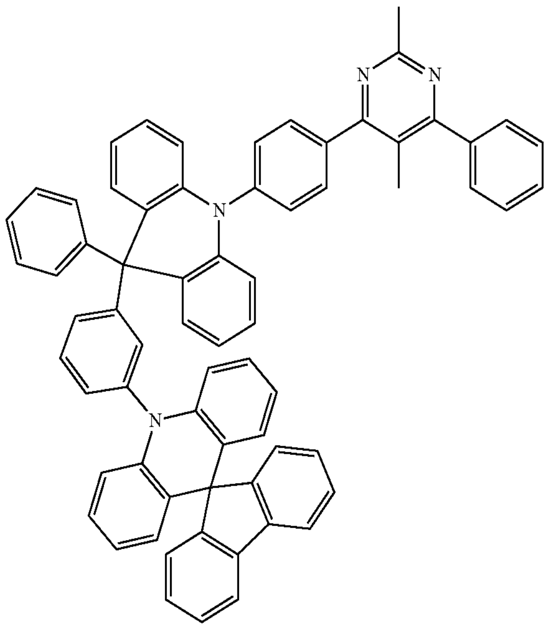

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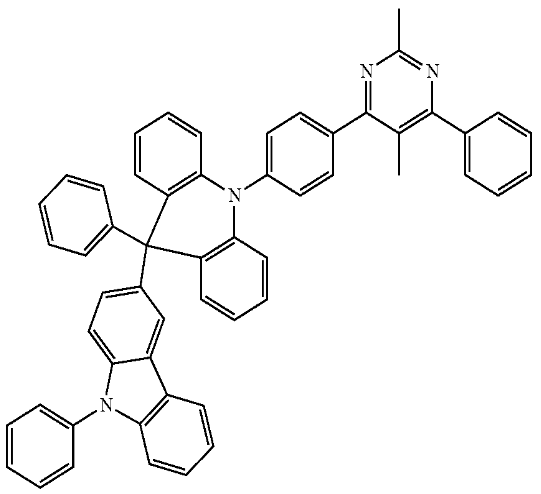

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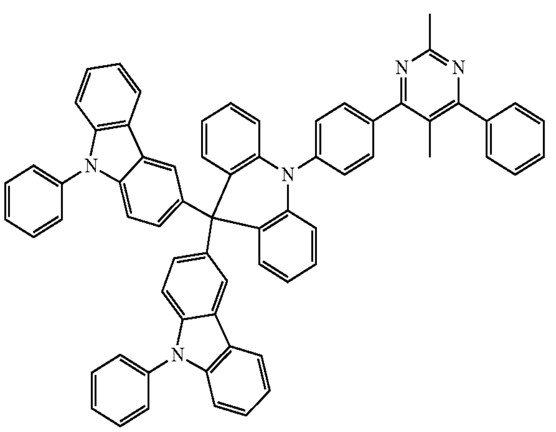

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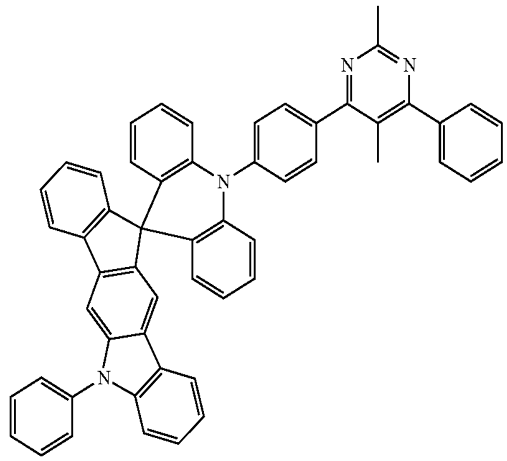

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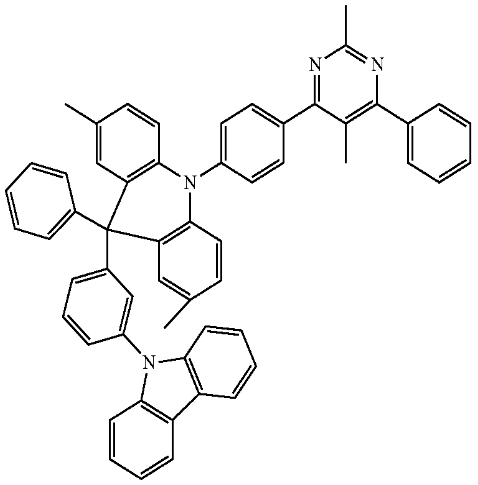

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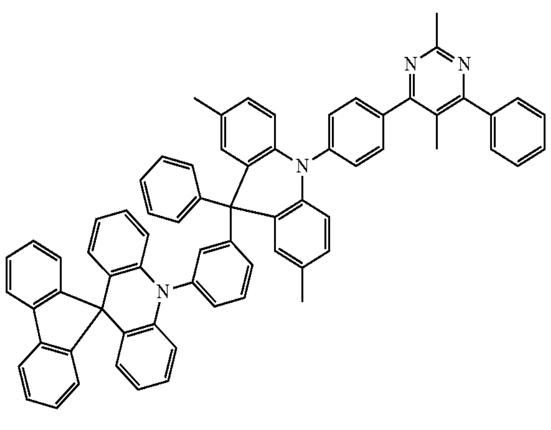

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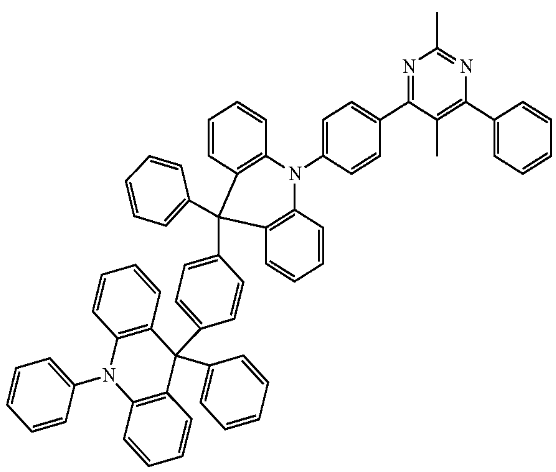

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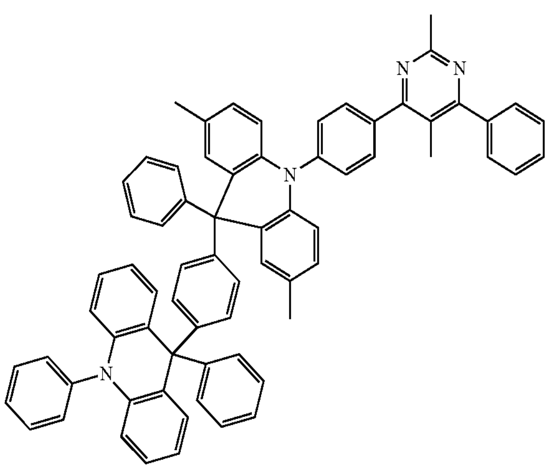

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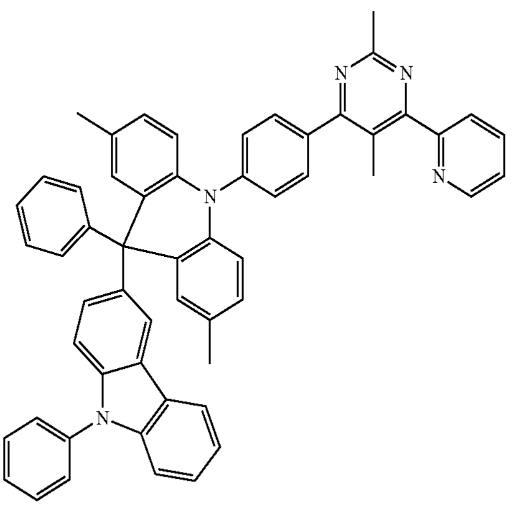

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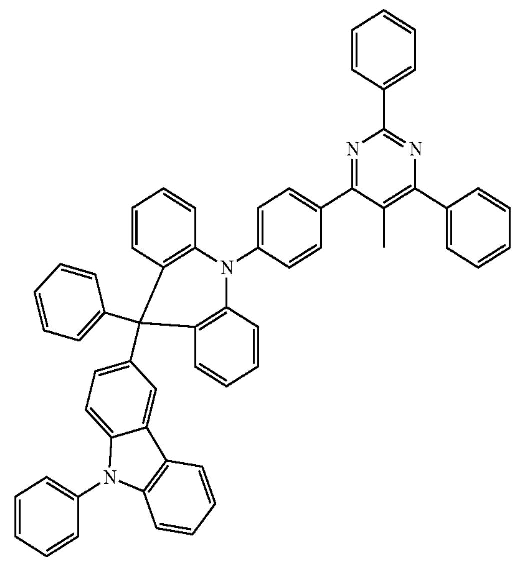

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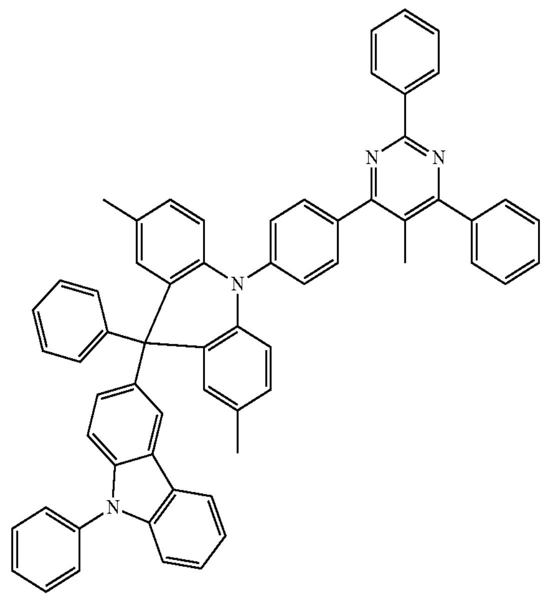

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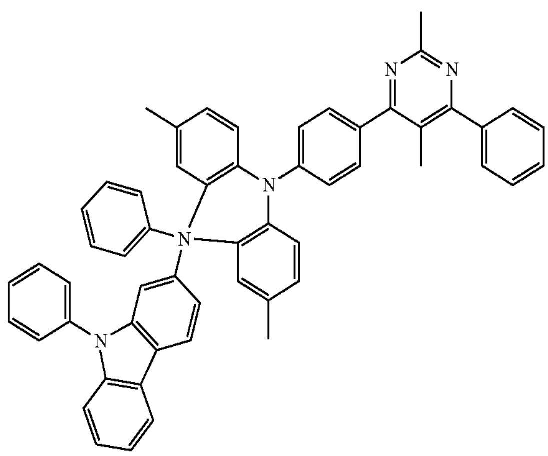

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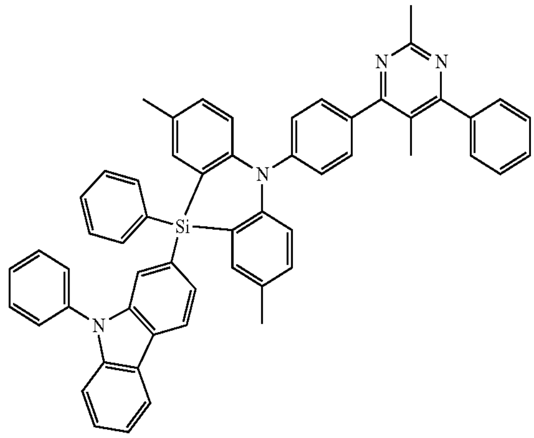

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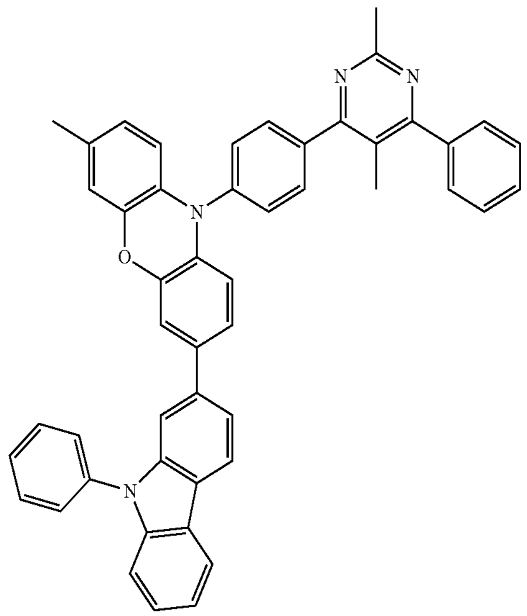

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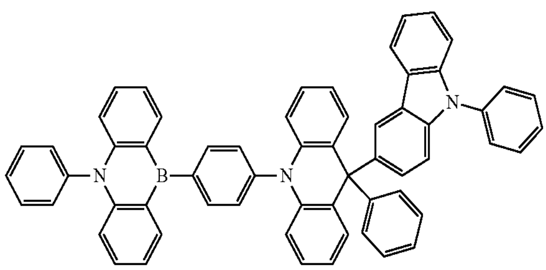

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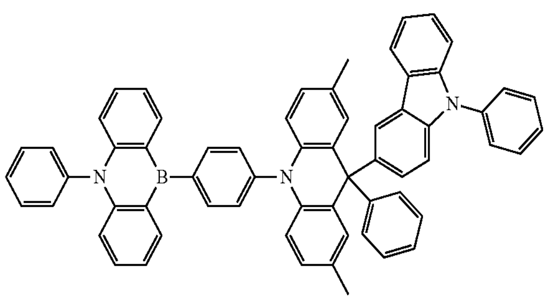

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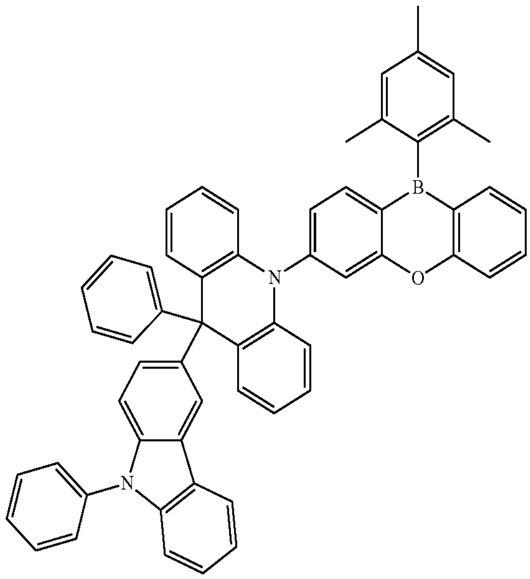

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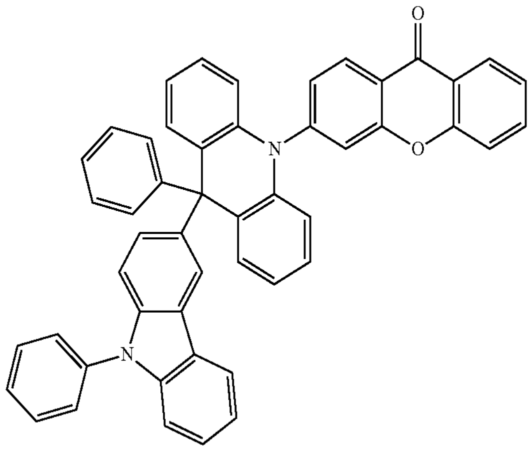


BRIEF DESCRIPTION OF THE FIGURES

[0038] The accompanying drawings are included to provide a further understanding of the inventive concept, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the inventive concept and, together with the description, serve to explain principles of the inventive concept. In the drawings:

[0039] FIG. **1** is a schematic cross-sectional view of an organic electroluminescence device according to an embodiment of the inventive concept; and

[0040] FIG. **2** is a schematic cross-sectional view of an organic electroluminescence device according to an embodiment of the inventive concept.

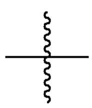
DETAILED DESCRIPTION

[0041] Exemplary embodiments of the inventive concept will be described below in more detail with reference to the accompanying drawings, since the inventive concept may be embodied in different forms. However, the inventive concept should not be construed as limited to the embodiments set forth herein. Rather, it should be understood that the scope of the inventive concept includes all modification, equivalents and alternatives within the spirit and scope of the inventive concept as hereinafter claimed.

[0042] Like reference numerals refer to like elements for explaining each drawing. In the drawings, the sizes of elements may be enlarged for clarity of the inventive concept. It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element discussed below could be termed a second element, and similarly, a second element could be termed a first element. As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0043] It will be further understood that the terms "comprises" or "comprising," when used in this specification, specify the presence of stated features, numerals, steps, operations, elements, parts, or a combination thereof, but do not preclude the presence or addition of one or more other features, numerals, steps, operations, elements, parts, or a combination thereof. It will also be understood that when a layer, a film, a region, a plate, etc. is referred to as being "on" another part, it can be directly on the other part, or intervening layers may also be present. On the contrary, when a layer, a film, a region, a plate, etc. is referred to as being "under" another part, it can be directly under the other part, or intervening layers may also be present.

[0044] In the present disclosure,



means a part to be connected.

[0045] In the present disclosure, "substituted or unsubstituted" may mean unsubstituted or substituted with at least one substituent selected from the group consisting of deuterium, halogen, nitro, amino, silyl, boron, phosphine oxide, phosphine sulfide, alkyl, alkenyl, aryl and heterocycle group. In addition, each of the substituent illustrated above may be substituted or unsubstituted. For example, biphenyl may be interpreted as aryl, or phenyl substituted with phenyl.

[0046] In the present disclosure, "forming a ring by combining adjacent groups with each other" may mean forming a substituted or unsubstituted hydrocarbon ring or a substituted or unsubstituted heterocycle by combining adjacent groups with each other. A hydrocarbon ring includes an aliphatic hydrocarbon ring and an aromatic hydrocarbon ring. The heterocycle includes an aliphatic heterocycle and an aromatic heterocycle. The hydrocarbon ring and heterocycle may be a monocycle or polycycle. In addition, the ring formed by combining adjacent groups with each other may be connected with another ring to form a spiro structure.

[0047] In the present disclosure, "an adjacent group" may mean a substituent at an atom which is directly connected with another atom at which a corresponding substituent is substituted, another substituent at an atom at which a corresponding substituent is substituted, or a substituent stereoscopically disposed at the nearest position to a corresponding substituent. For example, two methyl groups in 1,2-dimethylbenzene may be interpreted as "adjacent groups", and two ethyl groups in 1,1-diethylcyclopentene may be interpreted as "adjacent groups".

[0048] In the present disclosure, examples of a halogen atom are a fluorine atom, a chlorine atom, a bromine atom, or an iodine atom.

[0049] In the present disclosure, the alkyl group may have a linear, branched or cyclic form. The carbon number of the alkyl group may be 1 to 50, 1 to 30, 1 to 20, 1 to 10, or 1 to 6. Examples of the alkyl group may include methyl, ethyl, n-propyl, isopropyl, n-butyl, s-butyl, t-butyl, i-butyl, 2-ethylbutyl, 3,3-dimethylbutyl, n-pentyl, i-pentyl, neopentyl, t-pentyl, cyclopentyl, 1-methylpentyl, 3-methylpentyl, 2-ethylpentyl, 4-methyl-2-pentyl, n-hexyl, 1-methylhexyl, 2-ethylhexyl, 2-butylhexyl, cyclohexyl, 4-methylcyclohexyl, 4-t-butylcyclohexyl, n-heptyl, 1-methylheptyl, 2,2-dimethylheptyl, 2-ethylheptyl, 2-butylheptyl, n-octyl, t-octyl, 2-ethyloctyl, 2-butyloctyl, 2-hexyloctyl, 3,7-dimethyloctyl, cyclooctyl, n-nonyl, n-decyl, adamantyl, 2-ethyldecyl, 2-butyldecyl, 2-hexyldecyl, 2-octyldecyl, n-undecyl, n-dodecyl, 2-ethyldodecyl, 2-butyldodecyl, 2-hexyldodecyl, 2-octyldodecyl, n-tridecyl, n-tetradecyl, n-pentadecyl, n-hexadecyl, 2-ethylhexadecyl, 2-butylhexadecyl, 2-hexylhexadecyl, 2-octylhexadecyl, n-heptadecyl, n-octadecyl, n-nonadecyl, n-eicosyl, 2-ethyl eicosyl, 2-butyl eicosyl, 2-hexyl eicosyl, 2-octyl eicosyl, n-heneicosyl, n-docosyl, n-tricosyl, n-tetracosyl, n-pentacosyl, n-hexacosyl, n-heptacosyl, n-octacosyl, n-nonacosyl, n-triacontyl, etc., without limitation.

[0050] In the present disclosure, the aryl group means any functional group or substituent derived from an aromatic hydrocarbon ring. The aryl group may be monocyclic aryl or polycyclic aryl. The carbon number of the aryl group for forming a ring may be 6 to 30, 6 to 20, or 6 to 15. Examples of the aryl group may include phenyl, naphthyl, fluorenyl, anthracenyl, phenanthryl, biphenyl, terphenyl, quaterphenyl, quinqphenyl, sexiphenyl, triphenylene, pyrenyl, benzofluoranthenyl, chrysenyl, etc., without limitation.

[0051] In the present disclosure, the fluorenyl group may be substituted, and two substituents may be combined with each other to form a spiro structure.

[0052] In the present disclosure, the heteroaryl group may be heteroaryl including at least one of O, N, P, Si, or S as a heteroatom. The carbon number of the heteroaryl group for forming a ring may be 2 to 30, or 2 to 20. The heteroaryl group may be monocyclic heteroaryl or polycyclic heteroaryl. Polycyclic heteroaryl may have bicyclic or tricyclic structure, for example. Examples of the heteroaryl group may include thiophene, furan, pyrrole, imidazole, thiazole, oxazole, oxadiazole, triazole, pyridyl, bipyridyl, pyrimidyl, triazine, triazole, acridyl, pyridazine, pyrazinyl, quinolinyl, quinazoline, quinoxalinyl, phenoxazyl, phthalazinyl, pyrido pyrimidinyl, pyrido pyrazinyl, pyrazino pyrazinyl, isoquinoline, indole, carbazole, N-arylcarbazole, N-heteroaryl carbazole, N-alkyl carbazole, benzoxazole, benzoimidazole, benzothiazole, benzocarbazole, benzothiophene, dibenzothiophenyl, thienothiophene, benzofuranyl, phenanthroline, thiazolyl, isoxazolyl, oxadiazolyl, thiadiazolyl, benzothiazolyl, phenothiazinyl, dibenzosilole, dibenzofuranyl, etc., without limitation.

[0053] In the present disclosure, the above explanation on the aryl group may be applied to the arylene group, except that the arylene is divalent.

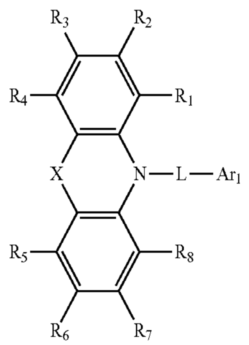
[0054] The above explanation on the heteroaryl group may be applied to the heteroarylene group, except that the heteroarylene is divalent.

[0055] In the present disclosure, the carbon number of the amino group is not specifically limited, and may be 1 to 30. The amino group may include alkyl amino and aryl amino. Examples of the amino group may include methylamino, dimethylamino, phenylamino, diphenylamino, naphthylamino, 9-methyl-anthracenylamino, triphenylamino, etc., without limitation.

[0056] Hereinafter, the aromatic compound according to an embodiment of the inventive concept will be explained.

[0057] The aromatic compound according to an embodiment of the inventive concept is represented by the following Formula 1.

[Formula 1]



[0058] In Formula 1, Ar_1 is a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, L is a direct linkage, or a substituted or unsubstituted phenylene group, and X may be a direct linkage, O, S, NR_a, CR_bR_c, SiR_dR_e, GeR_fR_g, $P(=O)R_h$, or $P(=S)R_i$.

[0059] In the present disclosure, a direct linkage may be, for example, a single bond. For example, L may be a direct linkage or an unsubstituted phenylene group.

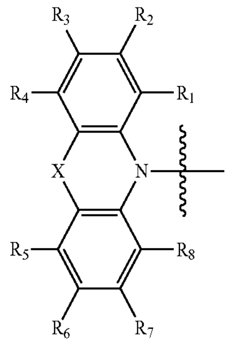
[0060] In Formula 1, each of R_1 to R_8 may independently be a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0061] In addition, R_a to R_i are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or may form a ring by combining adjacent groups with each other. Meanwhile, R_d and R_e are not phenyl group concurrently.

[0062] In case X is CR_bR_c, each of R_b and R_c may independently be a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, or a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring. Each of R_b and R_c may independently be a methyl group or a phenyl group. R_b and R_c may form a ring by combining with each other. R_b and R_c may combine with each other to form a fluorene ring.

[0063] In case X is SiR_dR_e, each of R_d and R_e may independently be a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. Each of R_d and R_e may independently be a substituted or unsubstituted phenyl group, or a substituted or unsubstituted carbazole group. Meanwhile, a case where R_d and R_e are both simultaneously an unsubstituted phenyl group is excluded.

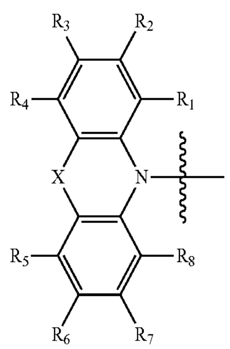
[0064] When X is a direct linkage, the following moiety connected to L in Formula 1 may be a substituted or unsubstituted carbazole group represented by following formula.



[0065] In Formula 1, each of R_1 to R_8 may independently be a hydrogen atom, a methyl group, a substituted or unsubstituted fluorenyl group, or a substituted or unsubstituted nitrogen-containing heteroaryl group having 4 to 30 carbon atoms for forming a ring. For example, a nitrogen-containing heteroaryl group may be a substituted or unsubstituted carbazole group or a substituted or unsubstituted acridyl group.

[0066] The aromatic compound represented by Formula 1 according to an embodiment of the inventive concept may include an electron acceptor, a linker and an electron donor. For example, in the aromatic compound represented by Formula 1, Ar_1 may be an electron acceptor and L may be a linker.

[0067] Furthermore, in Formula 1, the following moiety may correspond to an electron donor.

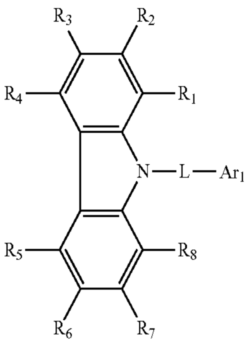


[0068] The aromatic compound according to an embodiment of the inventive concept may be an organic electroluminescence device material having an absolute value of the difference between the singlet energy level and the triplet energy level of about 0.2 eV or less.

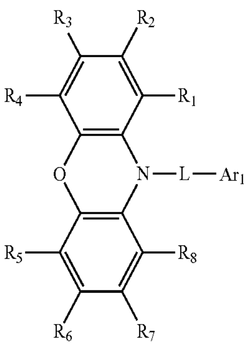
[0069] The aromatic compound according to an embodiment of the inventive concept may be a luminescence material for thermally activated delayed fluorescence (TADF). Particularly, the aromatic compound according to an embodiment of the inventive concept may be a luminescence material for thermally activated delayed fluorescence emitting blue light.

[0070] The aromatic compound represented by Formula 1 according to an embodiment of the inventive concept may be represented by one of the following Formulae 1-1 to 1-10.

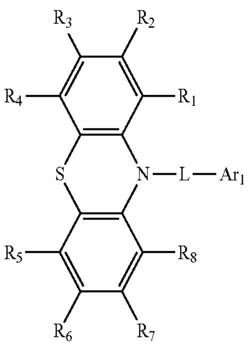
[Formula 1-1]



[Formula 1-2]



[Formula 1-3]



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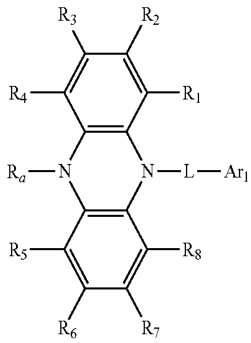
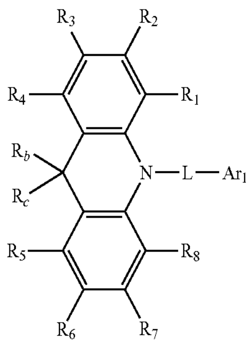
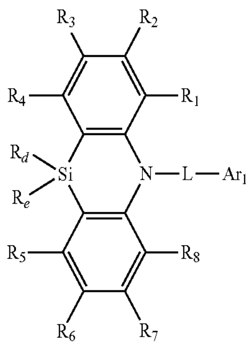
[Formula 1-4]



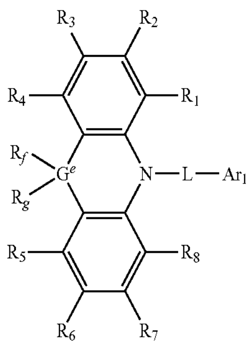
[Formula 1-5]



[Formula 1-6]



[Formula 1-7]



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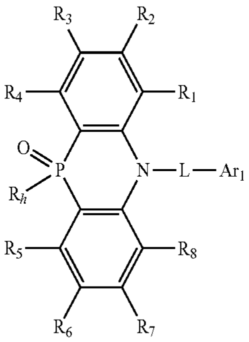
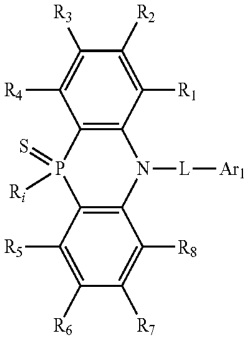
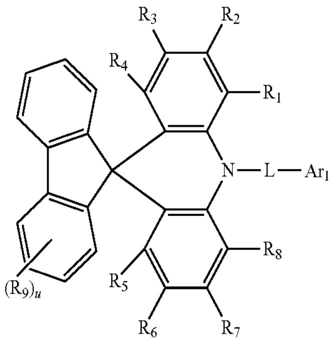
[Formula 1-8]



[Formula 1-9]



[Formula 1-10]



[0071] In Formulae 1-1 to 1-10, Ar_1, L, R_1 to R_8 and R_a to R_i may be the same as defined in Formula 1.

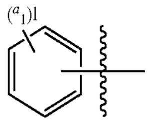
[0072] In Formula 1-10, R_9 is a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or may form a ring by combining adjacent groups with each other. u is an integer between 0 and 4, inclusive. When u is an integer of 2 or more, a plurality of R_9 may be the same or different from each other.

[0073] In the aromatic compound according to an embodiment of the inventive concept represented by Formula 1, or Formulae 1-1 to 1-10, each of R_a to R_i may independently be unsubstituted or substituted with at least one substituent of a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

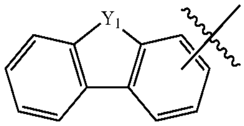
[0074] That is, each of R_a to R_i may independently be unsubstituted or substituted with at least one substituent selected from the group consisting of a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0075] Each of R_a to R_i may independently be represented by one of the following Formulae 2-1 to 2-4.

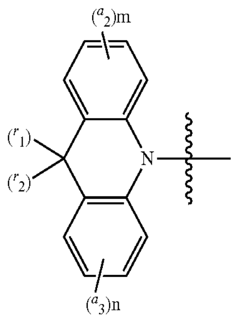
[Formula 2-1]



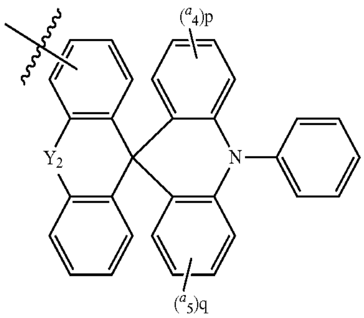
[Formula 2-2]



[Formula 2-3]



[Formula 2-4]



[0076] In Formulae 2-1 to 2-4, a_1 to a_5 may each independently be a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. For example, a_1 to a_5 may each independently be a methyl group, a substituted or unsubstituted phenyl group, or a substituted or unsubstituted carbazole group. In case each of a_1 to a_5 is a number greater than 1, each of a_1 to a_5 may be the same or different from each other.

[0077] Each of r_1 and r_2 is independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or may form a ring by combining adjacent groups with each other.

[0078] Each of l, m, n, p and q may independently be an integer between 0 and 4, inclusive.

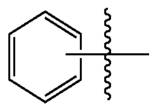
[0079] Y_1 is NR_a, O, or S, and R_a may be the same as defined in Formula 1. Y_2 may be a direct linkage, O or S.

[0080] In the aromatic compound according to an embodiment of the inventive concept represented by Formula 1, or Formulae 1-1 to 1-10, each of R_a to R_i may independently be a substituted or unsubstituted phenyl group, a substituted or unsubstituted fluorenyl group, or a substituted or unsubstituted carbazole group. For example, each of R_a to R_i may independently be a phenyl group or a phenyl carbazole group.

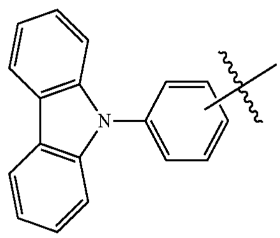
[0081] For example, R_a to R_i may be a hole transport functional group. Specifically, when a phenyl carbazole group is used as R_a to R_i, the phenyl carbazole group may be a hole transport functional group.

[0082] In the aromatic compound according to an embodiment of the inventive concept represented by Formula 1, or Formulae 1-1 to 1-10, each of R_a to R_i may independently be represented by one of the following Formulae S1 to S18.

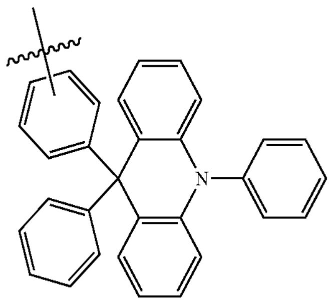
S1



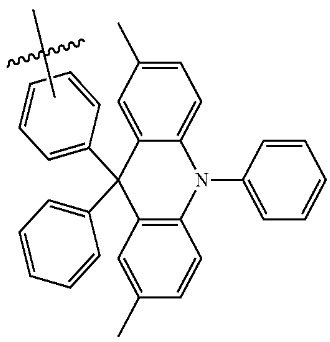
S2



S3



S4



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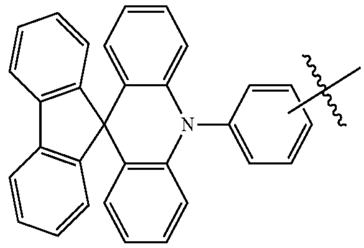
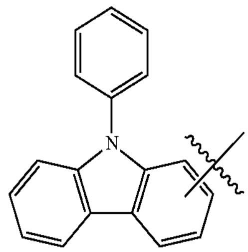
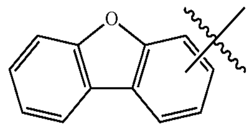
S5



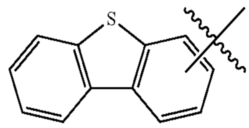
S6



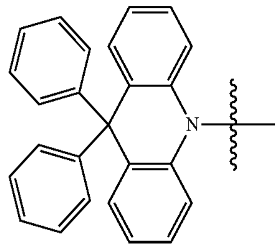
S7



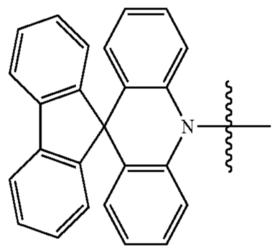
S8



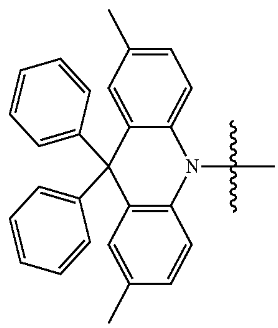
S9



S10



S11



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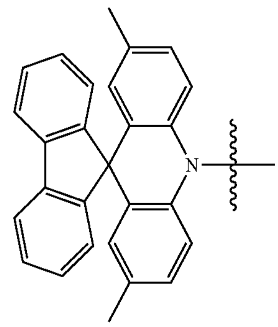
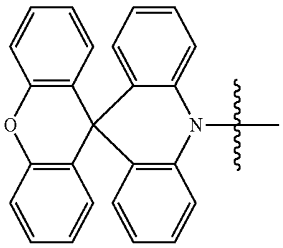
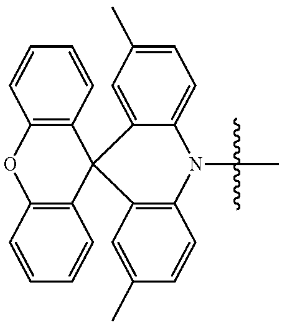
S12



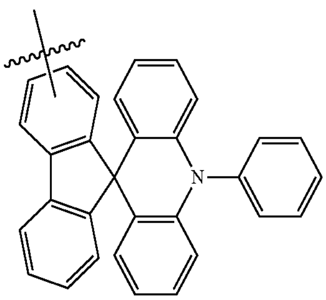
S13



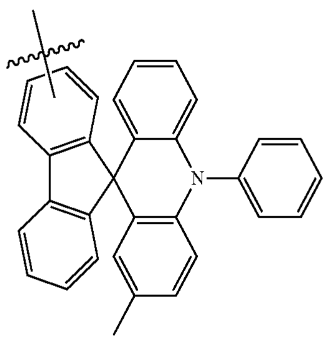
S14



S15



S16



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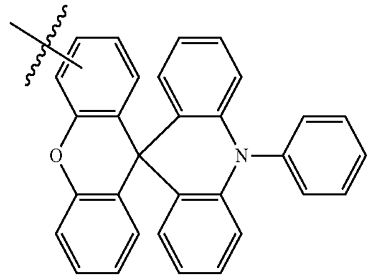
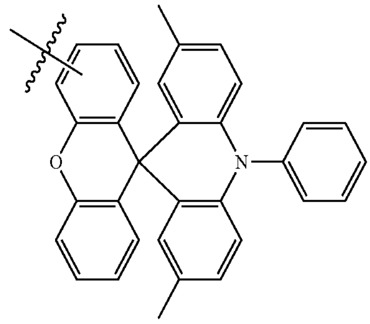
S17

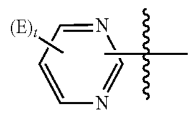


S18

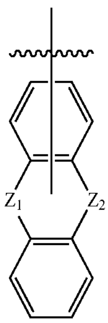


[0083] In the aromatic compound according to an embodiment of the inventive concept represented by Formula 1 or Formulae 1-1 to 1-10, Ar_1 may be an unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. Alternatively, Ar_1 may be a substituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. A heteroaryl group Ar_1 may be unsubstituted or substituted with a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. For example, Ar_1 may include a methyl group, a substituted or unsubstituted phenyl group, or a substituted or unsubstituted pyridyl group as a substituent. Ar_1 may be represented by the following Formula 3-1 or 3-2.

[Formula 3-1]



[Formula 3-2]



[0084] In Formula 3-1, E may be a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

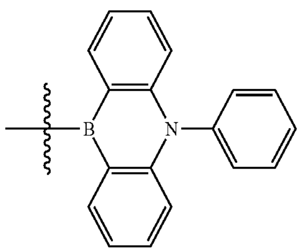
[0085] For example, E may be a methyl group, a substituted or unsubstituted phenyl group, or a substituted or unsubstituted pyridyl group.

[0086] In Formula 3-1, t may be an integer between 0 and 3, inclusive. In case t is 2 or 3, a plurality of E may be the same or different from each other. For example, in case t is 2, two E's may be the same or different from each other. In addition, in case t is 3, three E's may be different from each other, two E's may be the same and one E may be different, or all three E's may be the same.

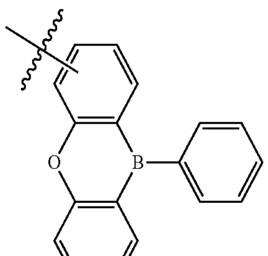
[0087] In Formula 3-2, Z_1 and Z_2 may each independently be BR', NR", O, S, or C(=O). In this case, each of R' and R" is independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

[0088] For example, Ar_1 represented by Formula 3-2 may be any one of the following Compounds A-1 to A-3, each of which may be substituted or unsubstituted. When the following compounds are substituted, the substituent may be, for example, a methyl group, etc.

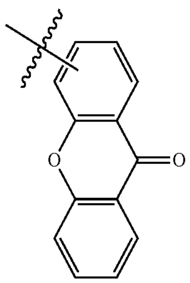
A-1



A-2



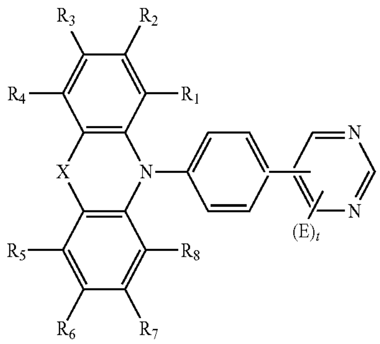
A-3



[0089] In the aromatic compound according to an embodiment of the inventive concept, Ar_1 represented by Formula 3-1 or 3-2 may be a heteroaryl group including at least one hetero atom and may serve as an electron acceptor.

[0090] The aromatic compound represented by Formula 1 according to an embodiment of the inventive concept may be represented by the following Formula 4.

[Formula 4]



[0091] In Formula 4, E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and t may be an integer between 0 and 3, inclusive.

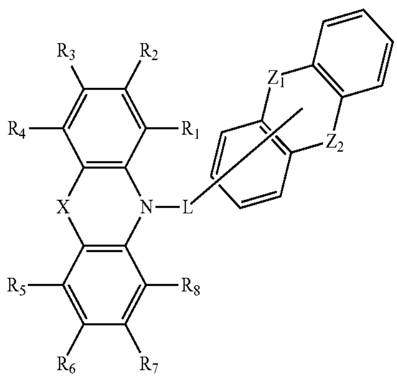
[0092] In case t is an integer of 2 or more, a plurality of E may be the same or different from each other. In addition, in case t is 3, three E's may be different from each other, or at least two E's may be the same.

[0093] For example, in Formula 4, E may be a methyl group, a substituted or unsubstituted phenyl group, or a substituted or unsubstituted pyridyl group.

[0094] In Formula 4, the explanation on Formula 1 may be applied to X and R_1 to R_8.

[0095] The aromatic compound represented by Formula 1 according to an embodiment of the inventive concept may be represented by the following Formula 5.

[Formula 5]



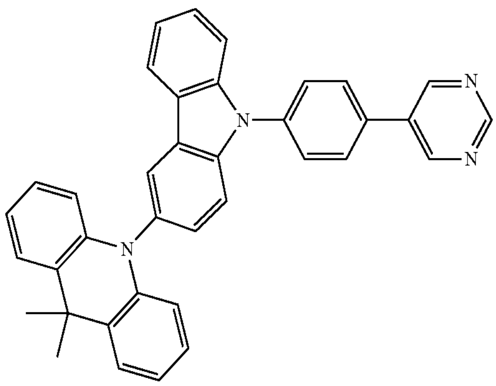
[0096] In Formula 5, each of Z_1 and Z_2 is independently BR', NR", O, S, or C(=O), each of R' and R" may independently be a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. In Formula 5, the explanation on Formula 1 may be applied to X, L, and R_1 to R_8.

[0097] In Formula 5, L may be connected with any one of Z_1 or Z_2.

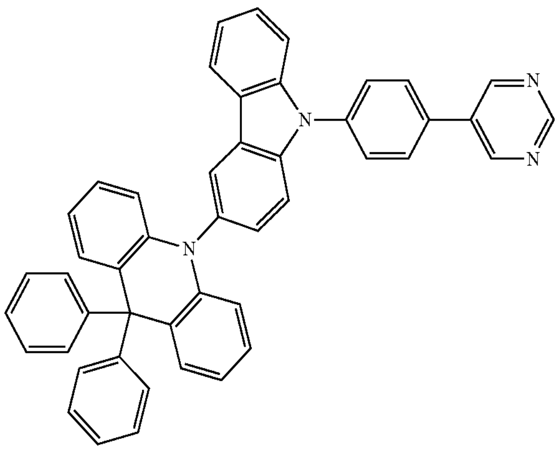
[0098] The aromatic compound represented by Formula 1 according to an embodiment of the inventive concept may be one selected from the group consisting of compounds represented in the following Compound Group 1. However, an embodiment of the inventive concept is not limited thereto.

[Compound Group 1]

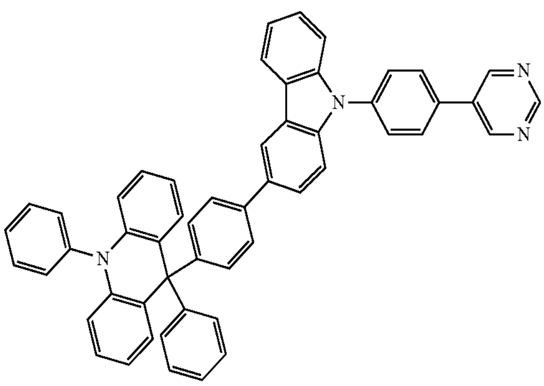
1



2



3



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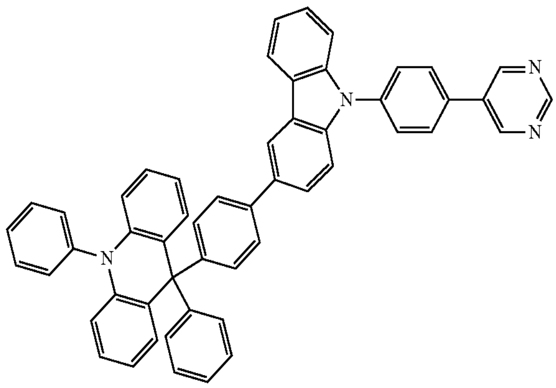

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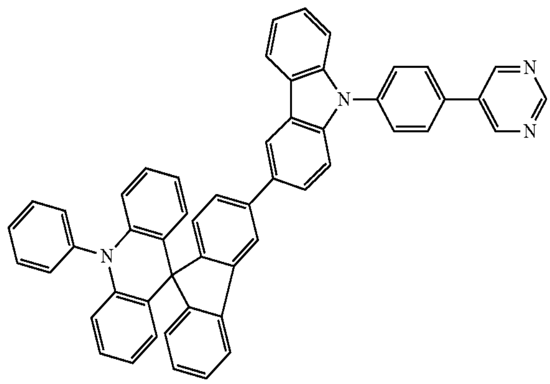

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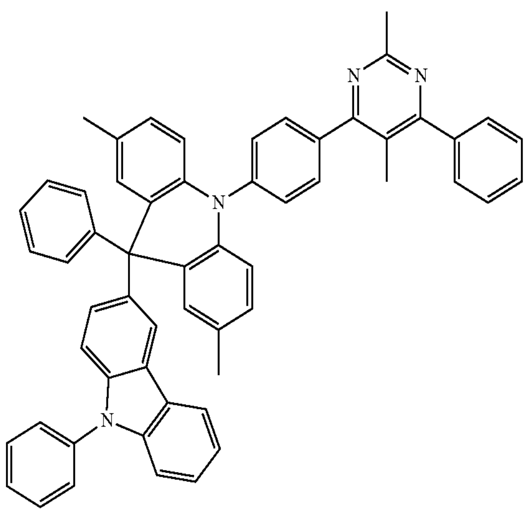

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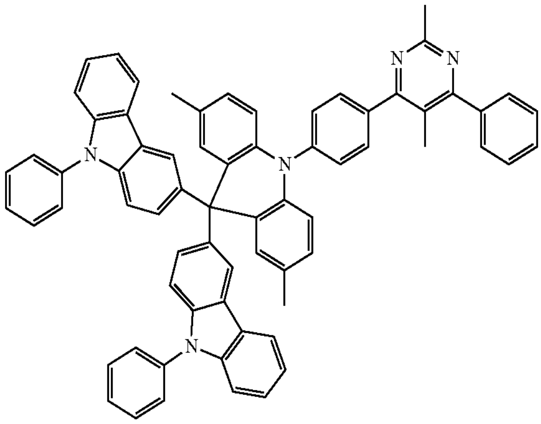

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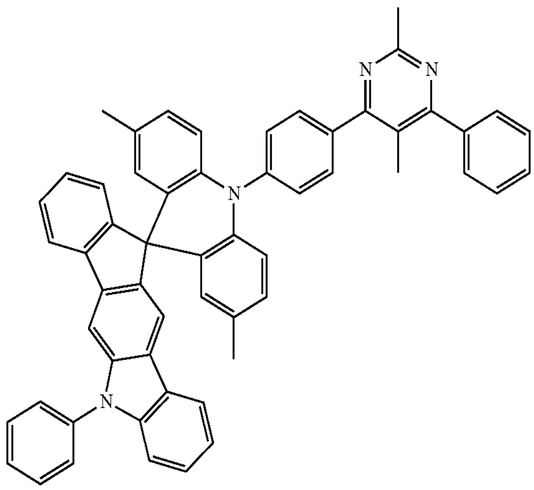

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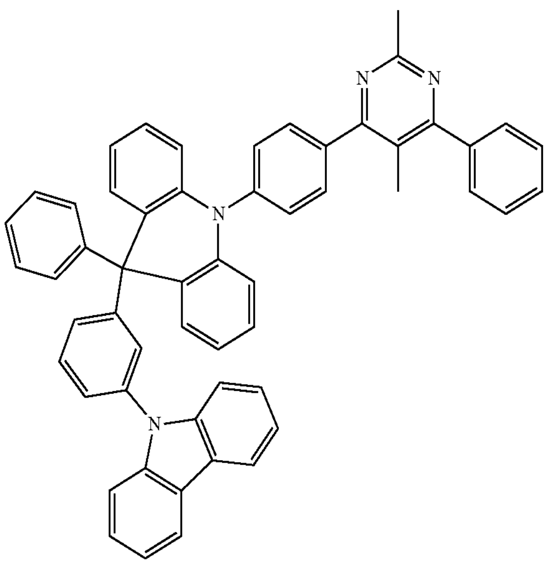

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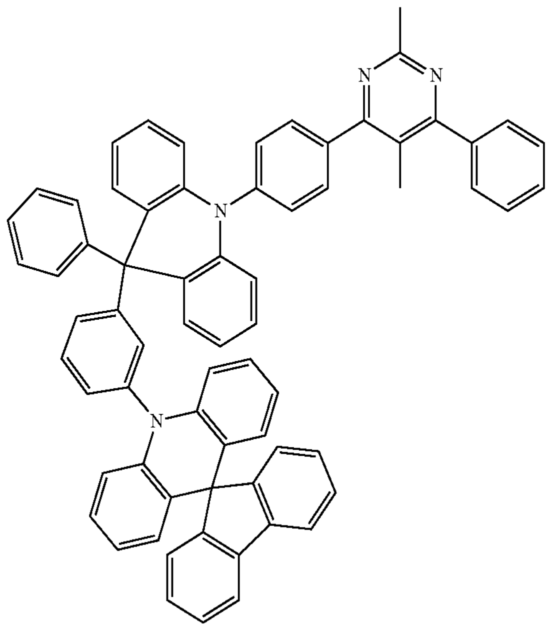

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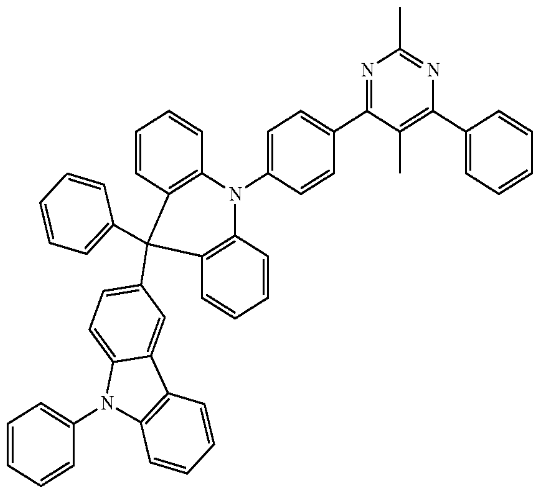

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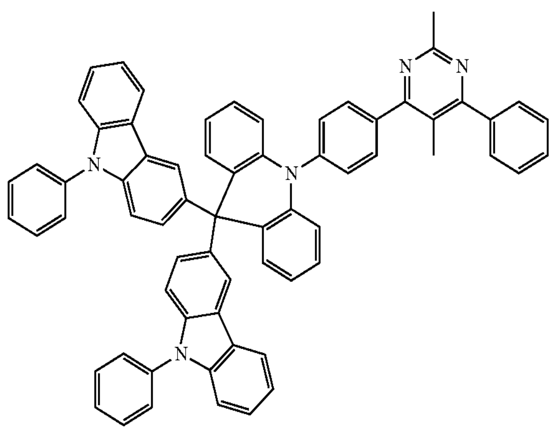

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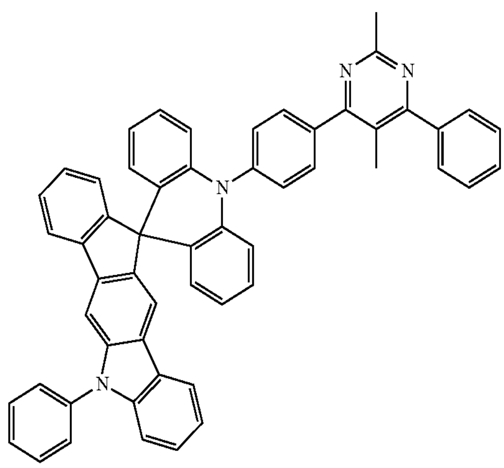

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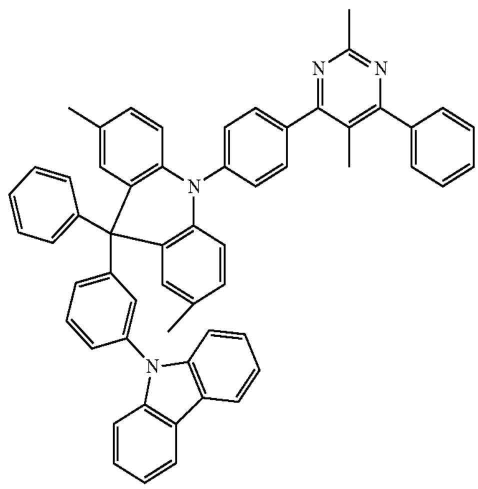

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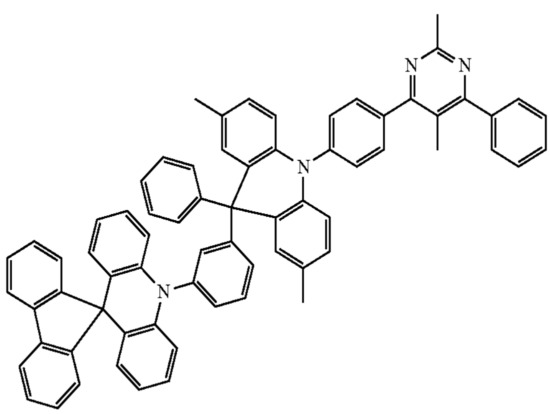

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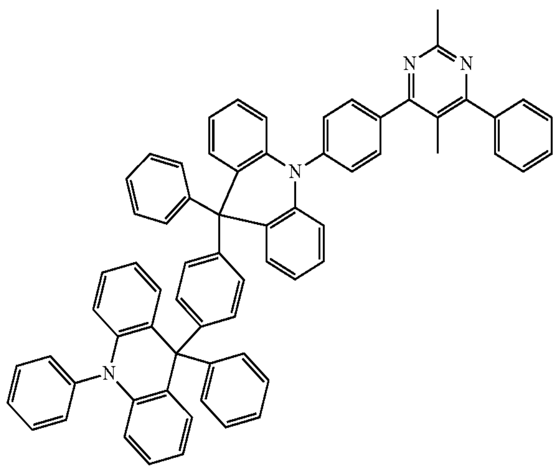

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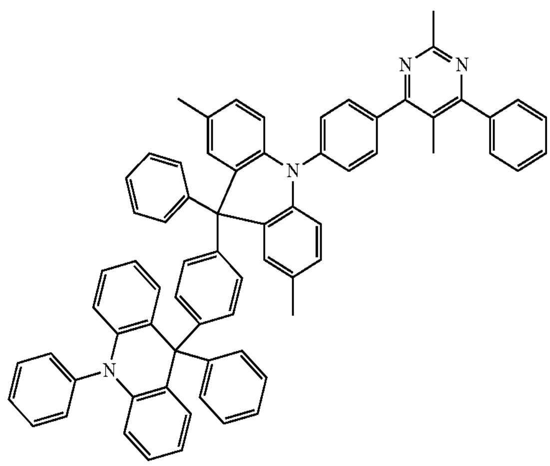

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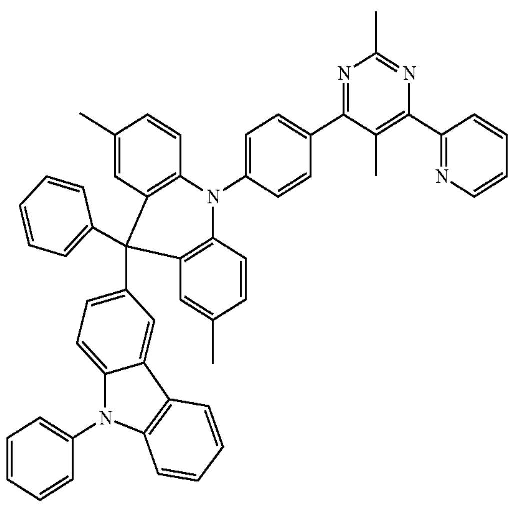

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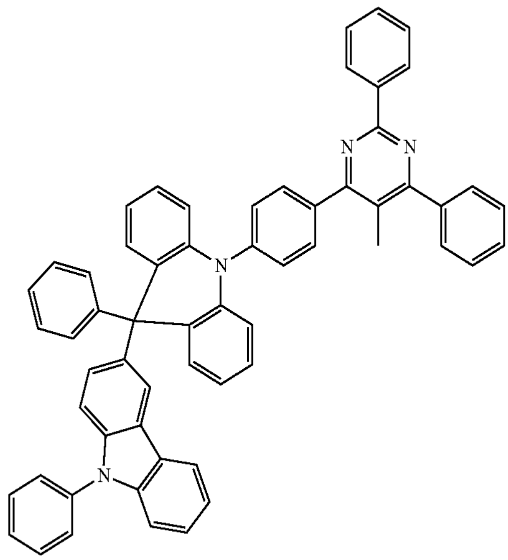

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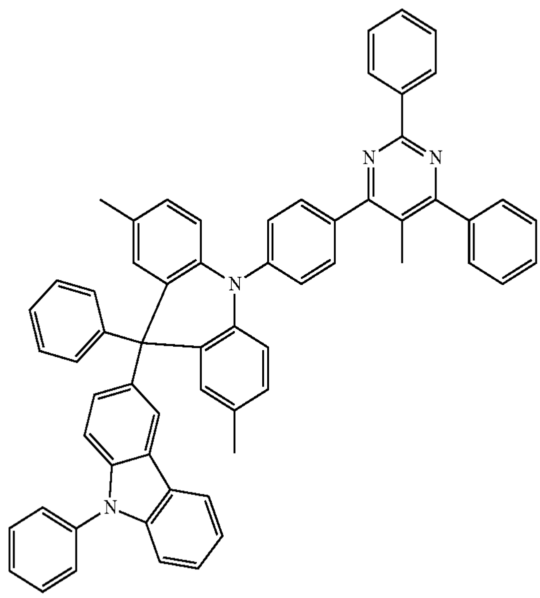

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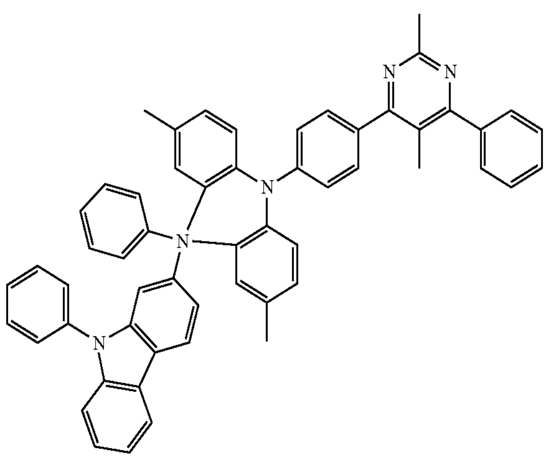

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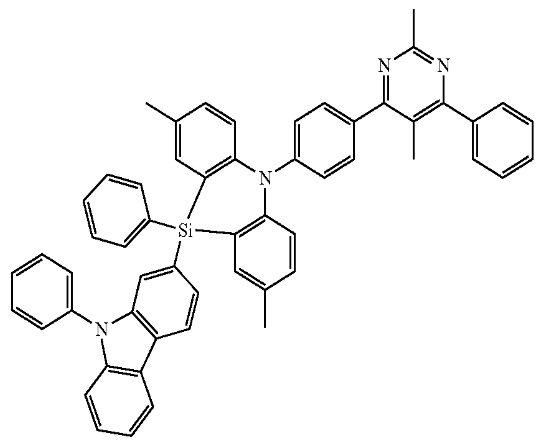

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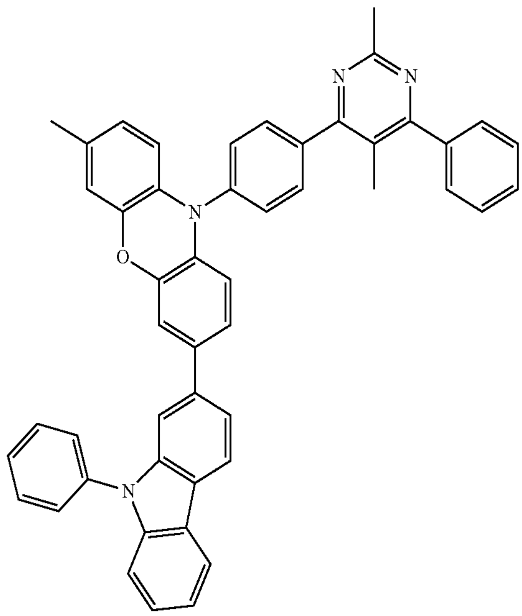

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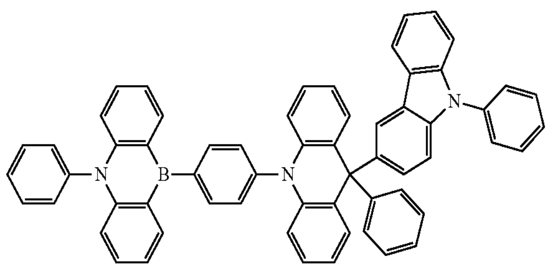

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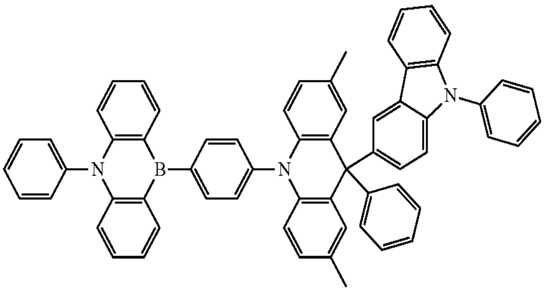

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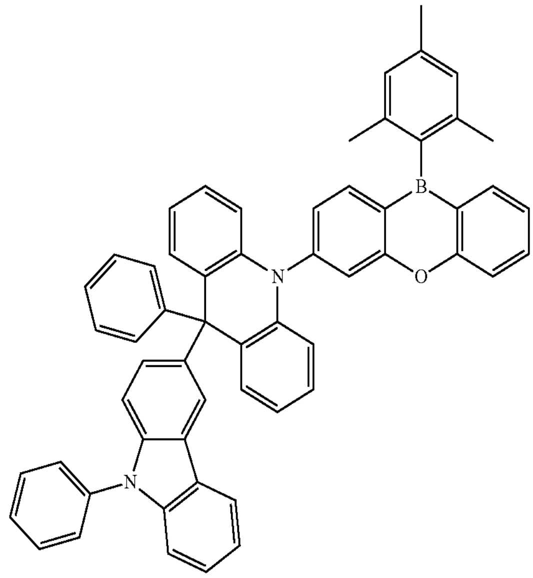

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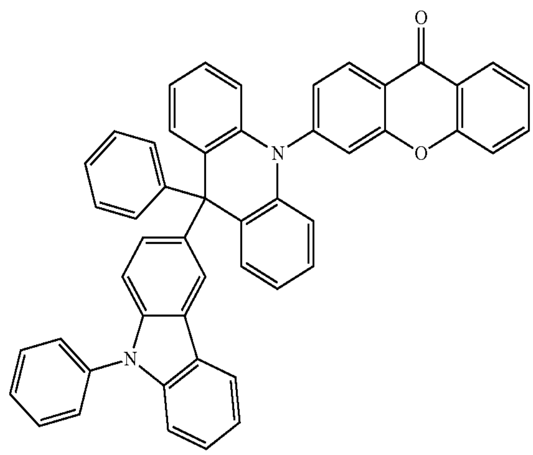
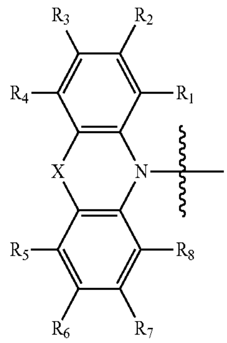


[0099] When the aromatic compound according to an embodiment of the inventive concept is applied to an organic electroluminescence device, emission efficiency of the organic electroluminescence device may be improved. The aromatic compound according to an embodiment of the inventive concept may be used as a luminescence material for thermally activated delayed fluorescence emitting blue light. The aromatic compound according to an embodiment of the inventive concept may be used in an organic electroluminescence device to attain deep blue light, and have high emission efficiency in blue light emitting region.

[0100] Especially, the aromatic compound according to an embodiment of the inventive concept has a hole transport functional group in the following moiety, which corresponds to an electron donor, to enhance a hole transport property into an emission layer, thereby achieving a charge balance and improving emission efficiency of an organic electroluminescence. Furthermore, the aromatic compound according to an embodiment of the inventive concept has a hole transport functional group in the moiety corresponding to an electron donor to enhance a hole transport property, thereby expanding emission region and attaining the effect of decreased roll-off.



[0101] Hereinafter, an organic electroluminescence device according to an embodiment of the inventive step will be explained. The explanation will be mainly given with features different from the aromatic compound according to an embodiment of the inventive concept, and unexplained parts will follow the above-description on the aromatic compound according to an embodiment of the inventive concept.

[0102] FIG. **1** is a schematic cross-sectional view illustrating an organic electroluminescence device according to an embodiment of the inventive concept. FIG. **2** is a schematic cross-sectional view illustrating an organic electroluminescence device according to an embodiment of the inventive concept.

[0103] Referring to FIGS. **1** and **2**, an organic electroluminescence device **10** according to an embodiment of the inventive concept may include a first electrode EL**1**, a hole transport region HTR, an emission layer EML, an electron transport region ETR, and a second electrode EL**2**, laminated in order.

[0104] The first electrode EL**1** and the second electrode EL**2** are disposed on oppositesides of the device, with a plurality of organic layers disposed therebetween. The plurality of organic layers may include a hole transport region HTR, an emission layer EML and an electron transport region ETR.

[0105] The organic electroluminescence device according to an embodiment of the inventive concept may include the aromatic compound according to an embodiment of the inventive concept in an emission layer EML.

[0106] In the following description of an organic electroluminescence device **10**, a case where the aromatic compound according to an embodiment of the inventive concept is included in an emission layer EML, will be explained. However, an embodiment of the inventive concept is not limited thereto. The aromatic compound according to an embodiment of the inventive concept may be included in at least one layer of a plurality of organic layers disposed between the first electrode EL1 and the second electrode EL2. For example, the aromatic compound according to an embodiment of the inventive concept may be included in a hole transport region HTR.

[0107] The first electrode EL1 has conductivity. The first electrode EL1 may be formed by a metal alloy or a conductive compound. The first electrode ELI may be an anode.

[0108] The first electrode EL1 may be a transmissive electrode, a transflective electrode, or a reflective electrode. In case the first electrode EL1 is the transmissive electrode, the first electrode EL1 may be made of a transparent metal oxide such as indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium tin zinc oxide (ITZO). In case the first electrode EL1 is the transflective electrode or reflective electrode, the first electrode EL1 may include Ag, Mg, Cu, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, LiF/Ca, LiF/Al, Mo, Ti, a compound thereof, or a mixture thereof (for example, a mixture of Ag and Mg). Also, the first electrode EL1 may have a structure including a plurality of layers including a reflective layer or transflective layer formed using the above materials, and a transparent conductive layer formed using ITO, IZO, ZnO, or ITZO.

[0109] The hole transport region HTR is disposed on the first electrode EL1. The hole transport region HTR may include at least one of a hole injection layer HIL, a hole transport layer HTL, a hole buffer layer, or an electron blocking layer. The thickness of the hole transport region HTR may be from about 1,000 Å to about 1,500 Å, for example.

[0110] The hole transport region HTR may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure including a plurality of layers formed using a plurality of different materials.

[0111] For example, the hole transport region HTR may have a single layer structure of a hole injection layer HIL or a hole transport layer HTL, or may have a single layer structure formed using a hole injection material and a hole transport material. In addition, the hole transport region HTR may have a single layer structure formed using a plurality of different materials, or a laminated structure of hole injection layer HIL/hole transport layer HTL, hole injection layer HIL/hole transport layer HTL/hole buffer layer, hole injection layer HIL/hole buffer layer, hole transport layer HTL/hole buffer layer, or hole injection layer HIL/hole transport layer HTL/electron blocking layer, laminated in order from the first electrode EL1. However, an embodiment of the inventive concept is not limited thereto.

[0112] The hole transport region HTR may be formed using various methods such as a vacuum deposition method, a spin coating method, a cast method, a Langmuir-Blodgett (LB) method, an inkjet printing method, a laser printing method, and a laser induced thermal imaging (LITI) method.

[0113] In case the hole transport region, HTR includes the hole injection layer HIL and the hole transport layer HTL, the hole injection layer HIL may include a known hole injection material.

[0114] The known hole injection material may include, for example, triphenylamine-containing polyether ketone (TPA-PEK), 4-isopropyl-4'-methyldiphenyliodiniumtetrakis(pentafluorophenyl)borate (PPBI), N,N'-diphenyl-N,N'-bis-[4-(phenyl-m-tolyl-amino)-phenyl]-biphenyl-4,4'-diamine (DNTPD), a phthalocyanine compound such as copper phthalocyanine, 4,4',4"-tris(3-methylphenylphenylamino) triphenylamine (m-MTDATA), N,N'-di(1-naphthyl)-N,N'-diphenylbenzidine (NPB), 4,4',4"-tris(N,N-diphenylamino) triphenylamine (TDATA), 4,4',4"-tris{N-(2-naphthyl)-N-phenylamino}-triphenylamine (2-TNATA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), etc. However, an embodiment of the inventive concept is not limited thereto.

[0115] In case the hole transport region HTR includes the hole injection layer HIL and the hole transport layer HTL, the hole transport layer HTL may include a known hole injection material.

[0116] The known hole transport material may include, for example, 1,1-bis[(di-4-tolylamino)phenyl]cyclohexane (TAPC), carbazole derivatives such as N-phenyl carbazole and polyvinyl carbazole, N,N'-bis(3-methylphenyl)-N,N'-diphenyl-[1,1-biphenyl]-4,4'-diamine (TPD), 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), N,N'-di(1-naphthyl)-N,N'-diphenylbenzidine (NPB), etc. However, an embodiment of the inventive concept is not limited thereto.

[0117] The thickness of the hole transport region HTR may be from about 100 Å to about 10,000 Å, for example, from about 100 Å to about 1,000 Å. In case the hole transport region HTR includes both of the hole injection layer HIL and the hole transport layer HTL, the thickness of the hole injection layer HIL may be from about 100 Å to about 10,000 Å, for example, from about 100 Å to about 1,000 Å, and the thickness of the hole transport layer HTL may be from about 30 Å to about 1,000 Å. In case the thicknesses of the hole transport region HTR, the hole injection layer HIL and the hole transport layer HTL satisfy the above-described ranges, satisfactory hole transport properties may be obtained without the substantial increase of a driving voltage.

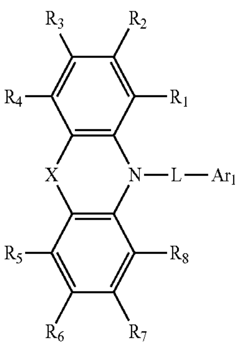
[0118] The hole transport region HTR may further include a charge generating material in addition to the above-described materials to improve conductivity. The charge generating material may be dispersed in the hole transport region HTR uniformly or non-uniformly. The charge generating material may be, for example, a p-dopant. The p-dopant may be one of quinone derivatives, metal oxides, or cyano group-containing compounds, without limitation. For example, non-limiting examples of the p-dopant may include quinone derivatives such as tetracyanoquinodimethane (TCNQ), and 2,3,5,6-tetrafluoro-tetracyanoquinodimethane (F4-TCNQ), metal oxides such as tungsten oxide and molybdenum oxide, without limitation.

[0119] As described above, the hole transport region HTR may further include at least one of the hole buffer layer or the electron blocking layer in addition to the hole injection layer HIL and the hole transport layer HTL. The hole buffer layer may compensate an optical resonance distance according to the wavelength of light emitted from the emission layer EML and increase light emission efficiency. Materials included in the hole transport region HTR may be used as materials included in the hole buffer layer. The electron blocking layer is a layer preventing electron injection from the electron transport region ETR into the hole transport region HTR.

[0120] The emission layer EML is disposed on the hole transport region HTR. The thickness of the emission layer EML may be, for example, from about 100 Å to about 600 Å. The emission layer EML may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure having a plurality of layers formed using a plurality of different materials.

[0121] The emission layer EML may include the above-described aromatic compound according to an embodiment of the inventive concept. Particularly, the emission layer EML may include the aromatic compound represented by the following Formula 1.

[Formula 1]



[0122] In Formula 1, Ar_1 is a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, L is a direct linkage, or a substituted or unsubstituted phenylene group, and X may be a direct linkage, O, S, NR_a, CR_bR_c, SiR_dR_e, GeR_fR_g, $P(=O)R_h$, or $P(=S)R_i$.

[0123] In Formula 1, each of R_1 to R_8 may independently be a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

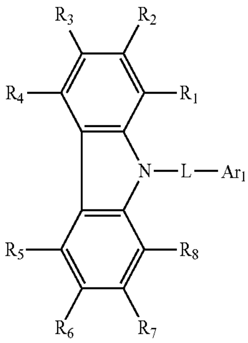
[0124] In addition, each of R_a to R_i is independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or may form a ring by combining adjacent groups with each other. Meanwhile, R_d and R_e are not both phenyl groups at the same time.

[0125] In Formula 1, the explanation on the aromatic compound according to an embodiment of the inventive concept may be applied to the particular explanation on Ar_1, L, and R_1 to R_8.

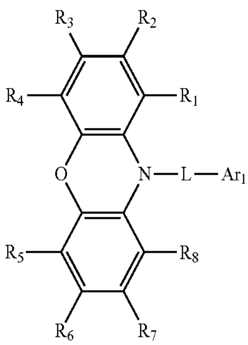
[0126] The emission layer EML may include one or more of the aromatic compound represented by Formula 1.

[0127] The emission layer EML may include at least one of the compounds represented by the following Formulae 1-1 to 1-10.

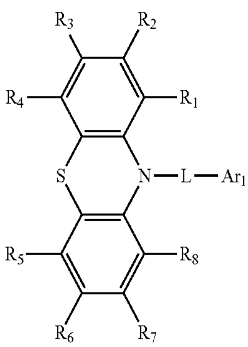
[Formula 1-1]



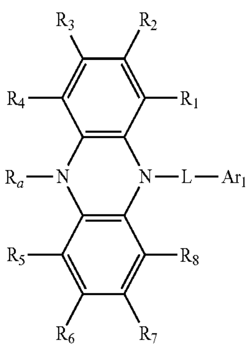
[Formula 1-2]



[Formula 1-3]



[Formula 1-4]



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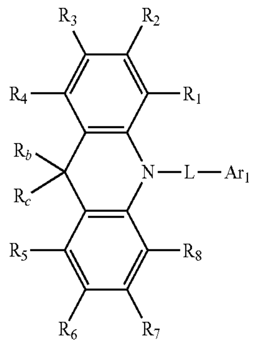
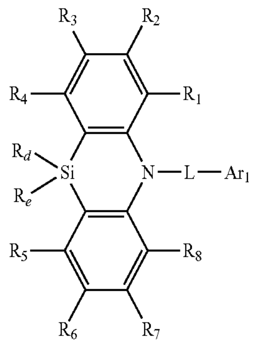
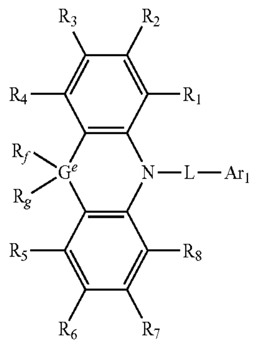
[Formula 1-5]



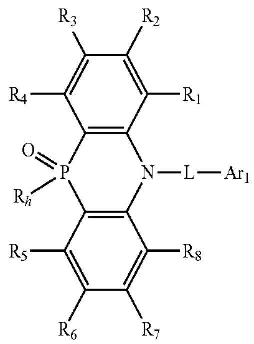
[Formula 1-6]



[Formula 1-7]



[Formula 1-8]



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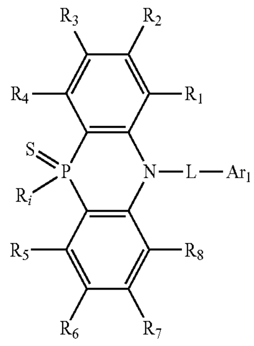
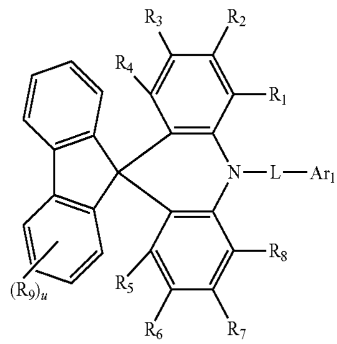
[Formula 1-9]



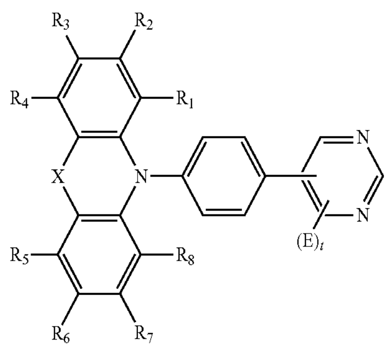
[Formula 1-10]



[0128] In Formula 1-10, R_9 is a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or may form a ring by combining adjacent groups with each other. u may be an integer between 0 and 4, inclusive. When u is an integer of 2 or more, a plurality of R_9 may be the same or different from each other. The explanation on Formula 1 may be applied to Ar_1, L, R_1 to R_8, and R_a to R_i.

[0129] The emission layer EML may include at least one of the aromatic compound represented by the following Formula 4 or 5.

[Formula 4]



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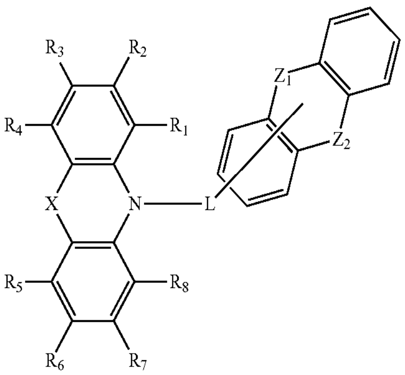
[Formula 5]



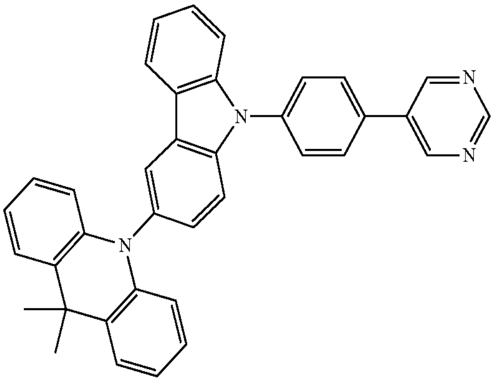
[0130] In Formula 4, E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and t may be an integer between 0 and 3, inclusive.

[0131] In Formula 5, each of Z_1 and Z2 may independently be BR', NR'', O, S, or C(═O), each of R' and R'' is independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring. In Formula 5, the explanation on Formula 1 may be applied to X, L and R_1 to R_8.

[0132] The emission layer EML may include at least one of the compounds represented in the following Compound Group 1.

[Compound Group 1]

1



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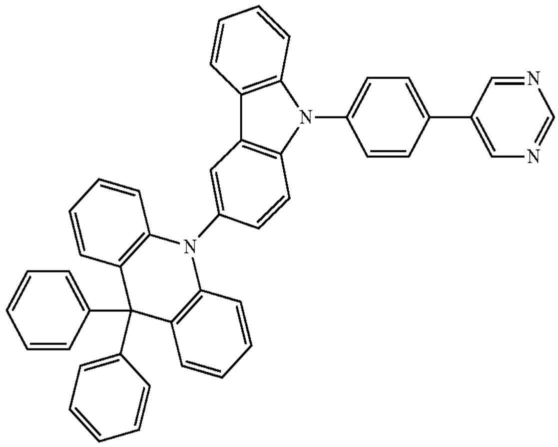

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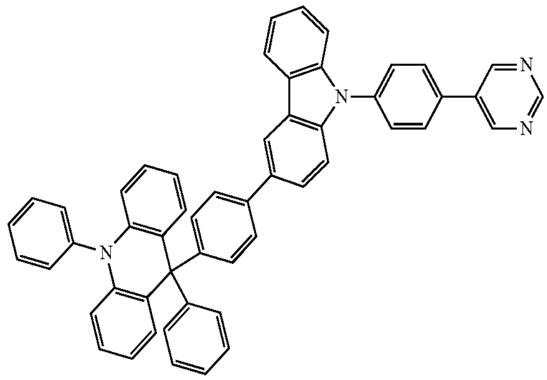

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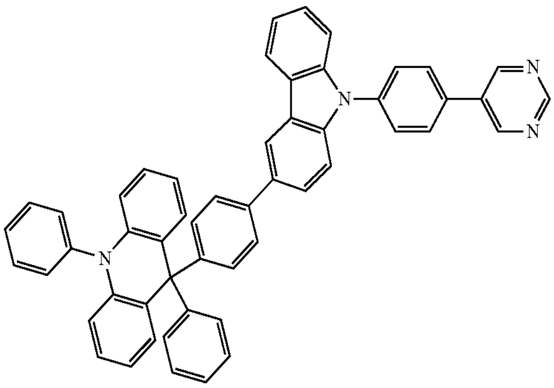

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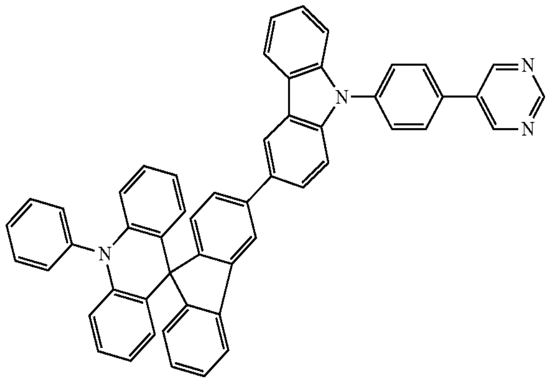

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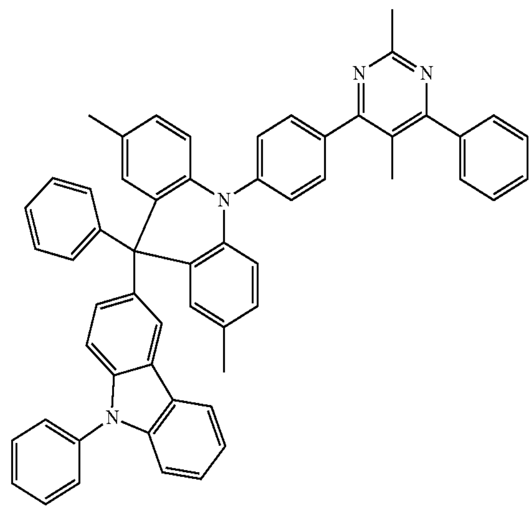

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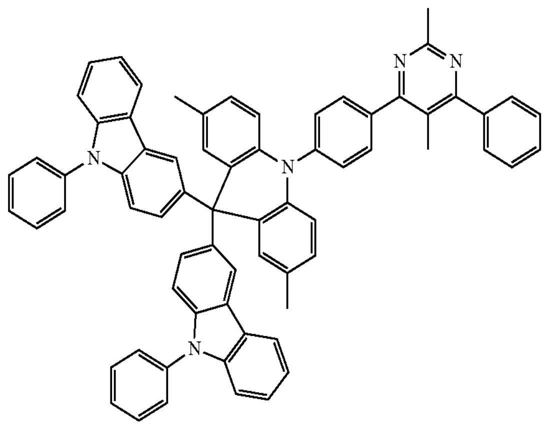

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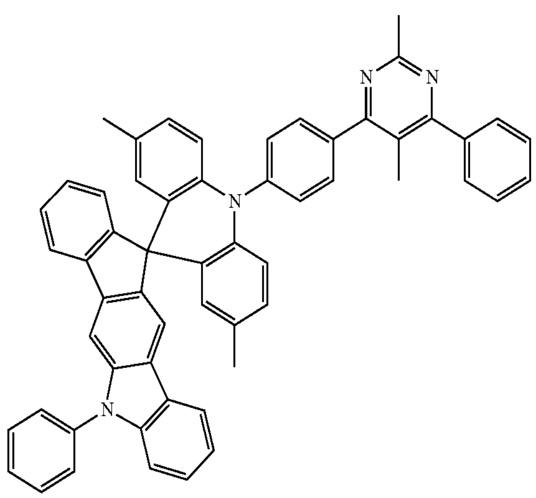

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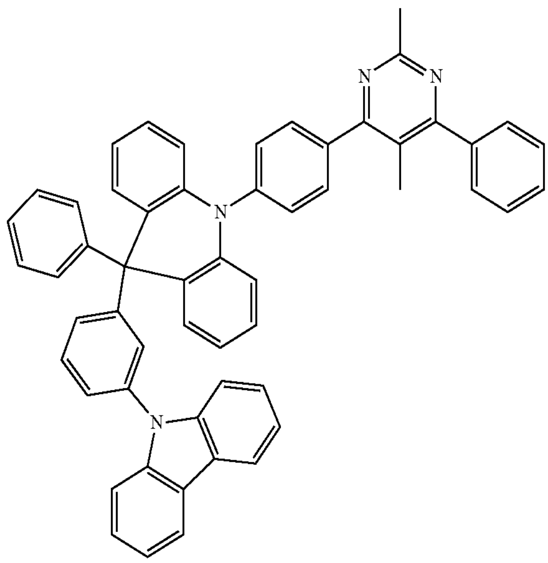

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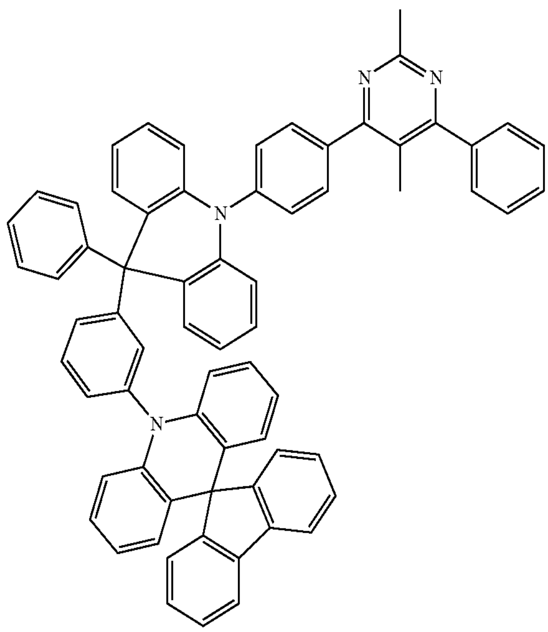

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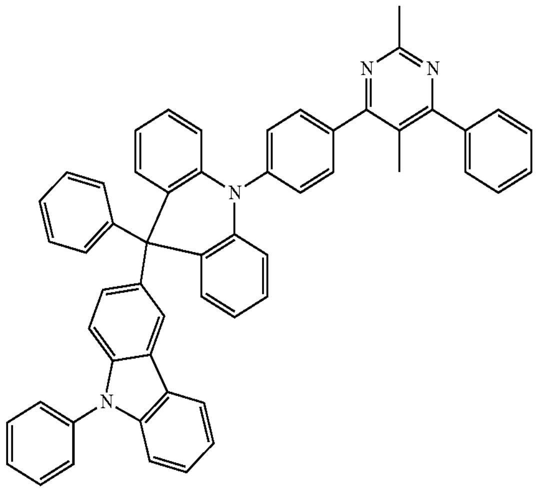

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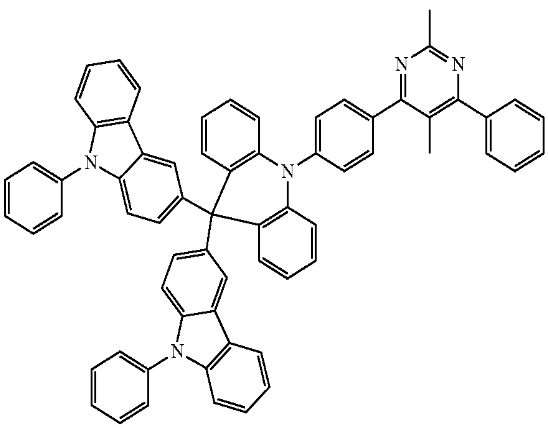

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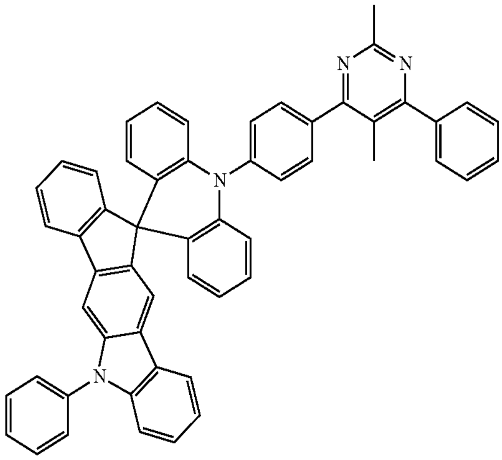

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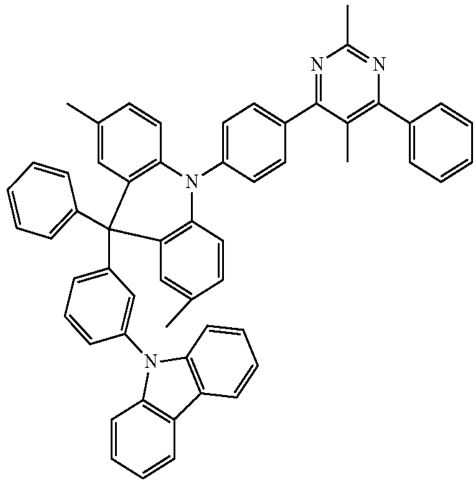

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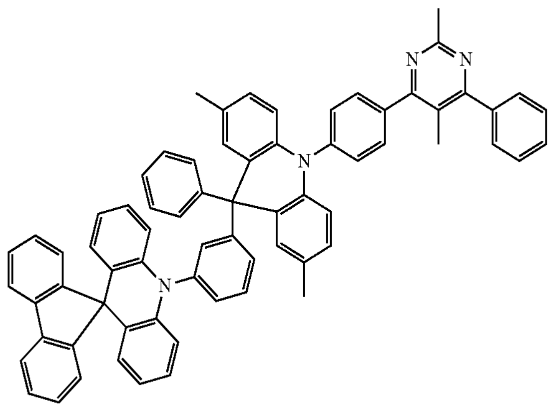

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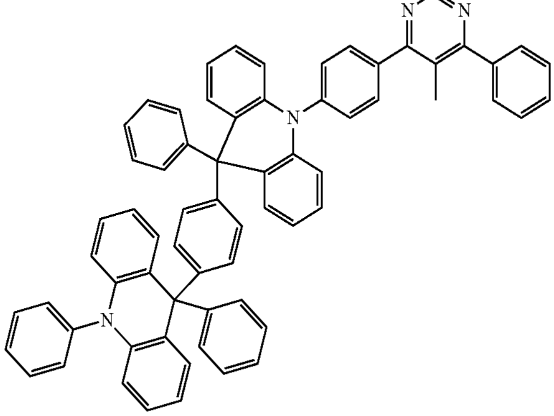

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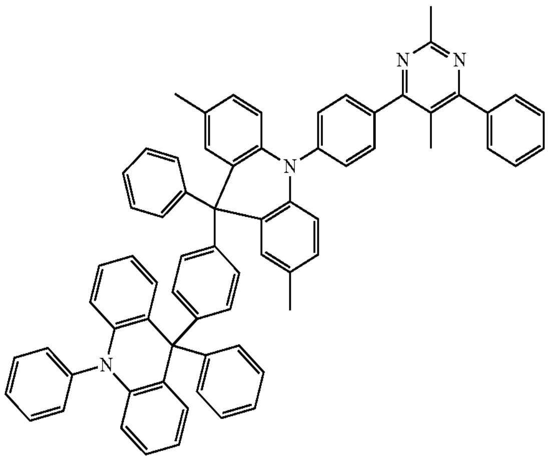

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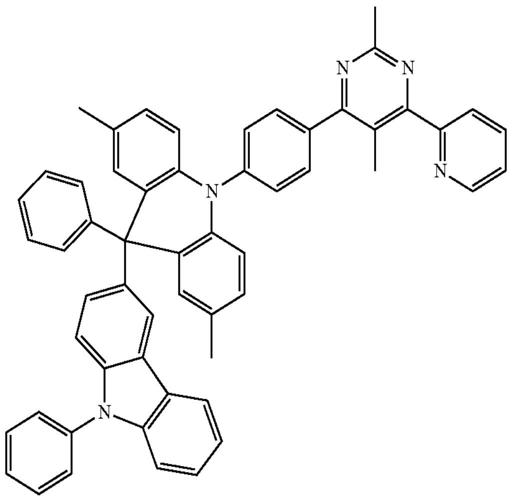

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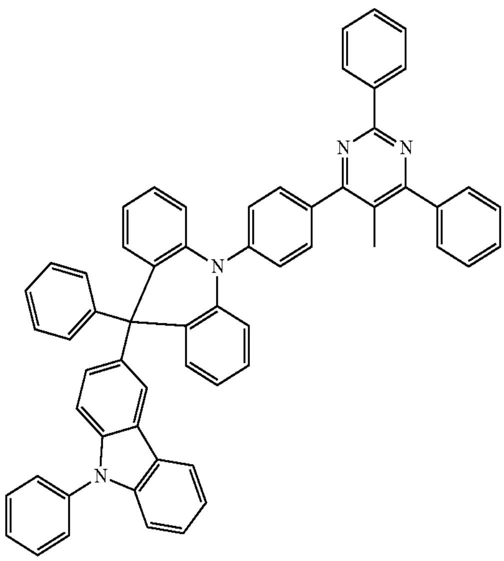

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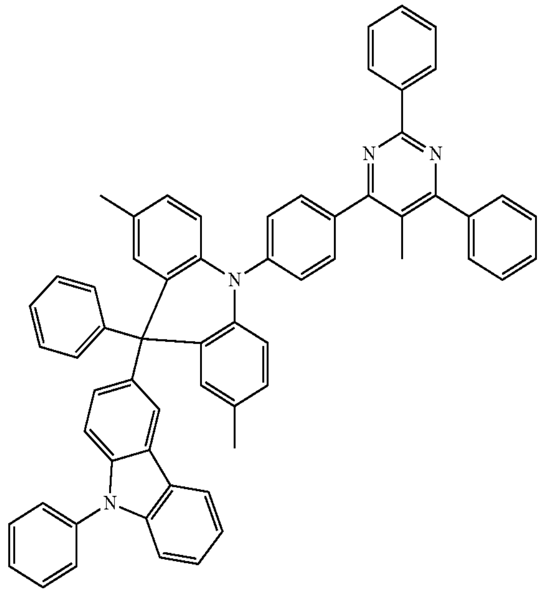

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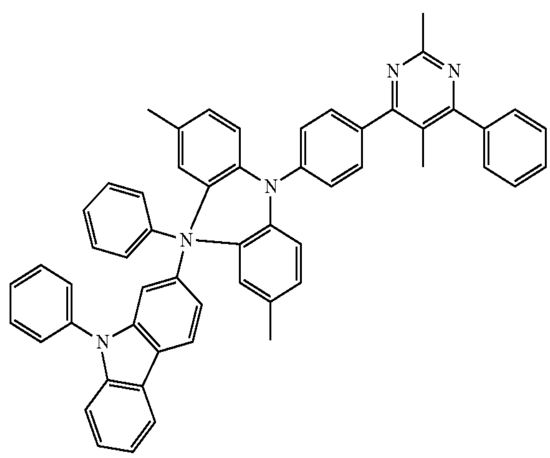

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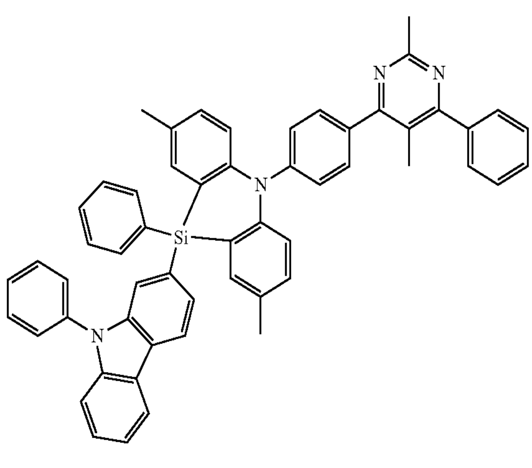

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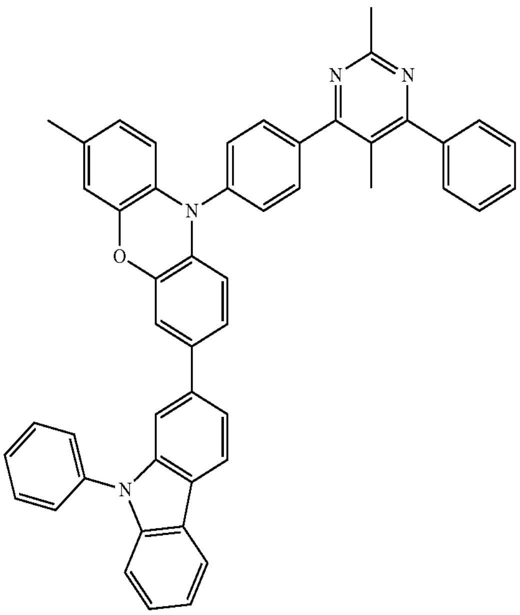

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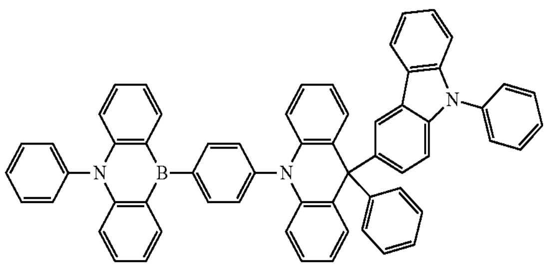

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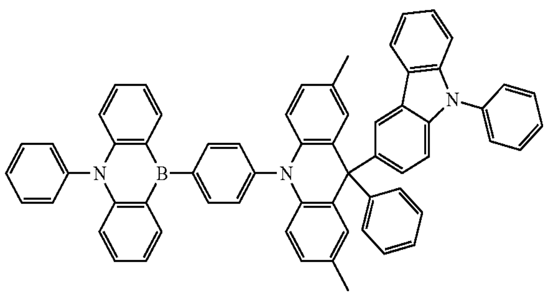

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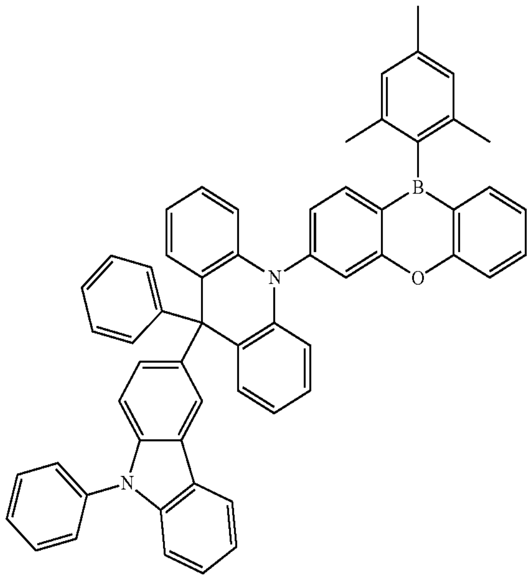

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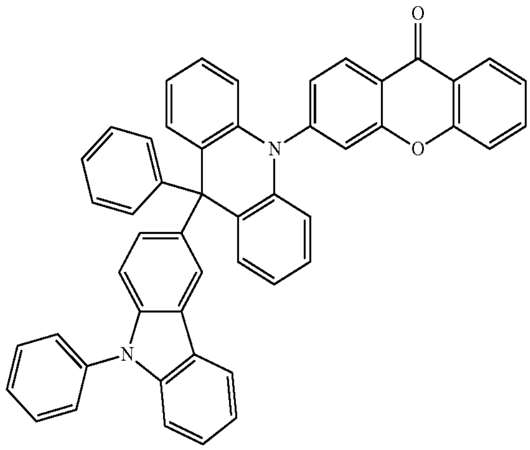
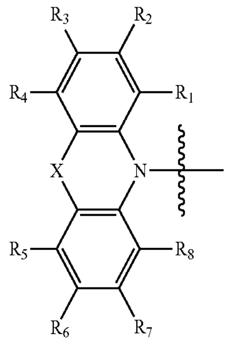


[0133] The emission layer EML may include further a known material in addition to the above-described aromatic compound according to an embodiment of the inventive concept. For example, the emission layer EML may include a fluorescent material including any one selected from the group consisting of spiro-DPVBi, 2,2',7,7'-tetrakis(biphenyl-4-yl)-9,9'-spirobifluorene(spiro-sexiphenyl) (spiro-6P), distyryl-benzene (DSB), distyryl-arylene (DSA), polyfluorene (PFO)-based polymer and poly(p-phenylene vinylene) (PPV)-based polymer, as a known material. However, an embodiment of the inventive concept is not limited thereto.

[0134] The aromatic compound according to an embodiment of the inventive concept may be included in the emission layer EML to emit delayed fluorescence. That is, the aromatic compound according to an embodiment of the inventive concept is a delayed fluorescence material. The aromatic compound represented by Formula 1 according to an embodiment of the inventive concept is a thermally activated delayed fluorescence (TADF) material.

[0135] The aromatic compound according to an embodiment of the inventive concept may include an electron acceptor, a linker and an electron donor to emit delayed fluorescence. Specifically, in the aromatic compound represented by Formula 1, Ar_1 may be an electron acceptor, L may be a linker, and the following moiety may be an electron donor.



[0136] The organic electroluminescence device according to an embodiment of the inventive concept may include the aromatic compound represented by Formula 1 according to an embodiment of the inventive concept in an emission layer to improve emission efficiency. The organic electroluminescence device according to an embodiment of the inventive concept including the aromatic compound according to an embodiment of the inventive concept may emit deep blue light. In addition, the aromatic compound according to an embodiment of the inventive concept may have the energy gap between the singlet energy level and the triplet energy level adjusted to about 0.2 eV or less, thereby enabling the organic electroluminescence device according to an embodiment of the inventive concept to emit efficiently a thermally activated delayed fluorescence.

[0137] The aromatic compound according to an embodiment of the inventive concept may be a thermally activated delayed fluorescence material emitting blue light. Accordingly, the emission layer EML of the organic electroluminescence device **10** including the aromatic compound according to an embodiment of the inventive concept may emit blue light. The emission layer EML of the organic electroluminescence device **10** according to an embodiment of the inventive concept may emit deep blue light. The emission layer EML of the organic electroluminescence device **10** according to an embodiment of the inventive concept including the aromatic compound according to an embodiment of the inventive concept may emit blue light having a wavelength range of about 440 nm to about 480 nm, about 440 nm to about 475 nm, about 440 nm to about 470 nm, or about 440 nm to about 450 nm.

[0138] The aromatic compound according to an embodiment of the inventive concept may be included in the emission layer EML as a dopant material.

[0139] The emission layer EML may further include a host. The host may be any material commonly used without specific limitation and may include, for example, tris(8-hydroxyquinolino)aluminum (Alq3), 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP), poly(N-vinylcarbazole) (PVK), 9,10-di(naphthalene-2-yl)anthracene (ADN), 4,4',4"-tris (carbazol-9-yl)-triphenylamine (TCTA), 1,3,5-tris(N-phenylbenzimidazole-2-yl)benzene (TPBi), 3-tert-butyl-9,10-di (naphth-2-yl)anthracene (TBADN), distyrylarylene (DSA), 4,4'-bis(9-carbazolyl)-2,2'-dimethyl-biphenyl (CDBP), 2-methyl-9,10-bis(naphthalen-2-yl)anthracene (MADN), bis[2-(diphenylphosphino)phenyl]ether oxide (DPEPO), hexaphenyl cyclotriphosphazene (CP1), 1,4-bis(triphenylsilyl)benzene (UGH2), hexaphenylcyclotrisiloxane ($DPSiO_3$), octaphenylcyclotetrasiloxane ($DPSiO_4$), 2,8-bis(diphenylphosphoryl)dibenzofuran (PPF), etc.

[0140] The aromatic compound according to an embodiment of the inventive concept may have an absolute value of the difference between the singlet energy level and the triplet energy level of about 0.2 eV or less. By including the aromatic compound according to an embodiment of the inventive concept having a little energy gap between the singlet energy level and the triplet energy level in the emission layer EML, the organic electroluminescence device **10** according to an embodiment of the inventive concept may efficiently emit a thermally activated delayed fluorescence, thereby improving emission efficiency.

[0141] The electron transport region ETR is provided on the emission layer EML. The electron transport region ETR may include at least one of a hole blocking layer, an electron transport layer ETL or an electron injection layer EIL. However, an embodiment of the inventive concept is not limited thereto.

[0142] The electron transport region ETR may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multi-layer structure having a plurality of layers formed using a plurality of different materials.

[0143] For example, the electron transport region ETR may have a single layer structure of the electron injection layer EIL or the electron transport layer ETL, or a single layer structure formed using an electron injection material and an electron transport material. In addition, the electron transport region ETR may have a single layer structure having a plurality of different materials, or a laminated structure of electron transport layer ETL/electron injection layer EIL, or hole blocking layer/electron transport layer ETL/electron injection layer EIL, laminated in order from the emission layer EML, without limitation. The thickness of the electron transport region ETR may be, for example, from about 1,000 Å to about 1,500 Å.

[0144] The electron transport region ETR may be formed using various methods such as a vacuum deposition method, a spin coating method, a cast method, a Langmuir-Blodgett (LB) method, an inkjet printing method, a laser printing method, and a laser induced thermal imaging (LITI) method.

[0145] In case the electron transport region ETR includes the electron transport layer ETL, the electron transport region ETR may include a known material. For example, the electron transport region ETR may include tris(8-hydroxyquinolinato)aluminum (Alq3), 1,3,5-tri[(3-pyridyl)-phen-3-yl]benzene, 2,4,6-tris(3'-(pyridin-3-yl)biphenyl-3-yl)-1,3,5-triazine, 2-(4-(N-phenylbenzoimidazolyl-1-ylphenyl)-9,10-dinaphthylanthracene, 1,3,5 -tri(1-phenyl-1H-benzo[d]imidazol-2-yl)phenyl (TPBi), 2,9-dimethyl-4,7-diphenyl-1, 10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), 3-(4-biphenylyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (TAZ), 4-(naphthalen-1-yl)-3,5-diphenyl-4H-1,2,4-triazole (NTAZ), 2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (tBu-PBD), bis(2-methyl-8-quinolinolato-N1,08)-(1,1'-biphenyl-4-olato)aluminum (BAlq), beryllium bis(benzoquinolin-10-olate) ($Bebq_2$), 9,10-di(naphthalene-2-yl)anthracene (ADN), or a mixture thereof, without limitation.

[0146] When the electron transport region ETR includes the electron transport layer ETL, the thickness of the electron transport layer ETL may be from about 100 Å to about 1,000 Å, for example, from about 150 Å to about 500 Å. If the thickness of the electron transport layer ETL satisfies the above-described range, satisfactory electron transport properties may be obtained without substantial increase of a driving voltage.

[0147] In case the electron transport region ETR includes the electron injection layer EIL, the electron transport region ETR may include a known material. For example, the electron transport region ETR may use LiF, lithium quinolate (LiQ), Li_2O, BaO, NaCl, CsF, a metal in lanthanoids such as Yb, or metal halides such as RbCl and RbI, without limitation. The electron injection layer EIL also may be formed using a mixture material of an electron transport material and an insulating organo metal salt. The organo metal salt may be a material having an energy band gap of about 4 eV or more. Particularly, the organo metal salt may include, for example, a metal acetate, a metal benzoate, a metal acetoacetate, a metal acetylacetonate, or a metal stearate.

[0148] When the electron transport region ETR includes the electron injection layer EIL, the thickness of the electron injection layer EIL may be from about 1 Å to about 100 Å, for example, from about 3 Å to about 90 Å. In case the thickness of the electron injection layer EIL satisfies the above described range, satisfactory electron injection properties may be obtained without inducing the substantial increase of a driving voltage.

[0149] The electron transport region ETR may include a hole blocking layer as described above. The hole blocking layer may include, for example, at least one of 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), or 4,7-diphenyl-1,10-phenanthroline (Bphen), without limitation.

[0150] The second electrode EL**2** is disposed on the electron transport region ETR. The second electrode EL**2** has conductivity. The second electrode EL**2** may be formed by a metal alloy or a conductive compound. The second electrode EL**2** may be a cathode. The second electrode EL**2** may be a transmissive electrode, a transflective electrode or a reflective electrode. In case the second electrode EL**2** is the transmissive electrode, the second electrode EL**2** may be formed using transparent metal oxides, for example, ITO, IZO, ZnO, ITZO, etc.

[0151] In case the second electrode EL**2** is the transflective electrode or the reflective electrode, the second electrode EL**2** may include Ag, Mg, Cu, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, LiF/Ca, LiF/Al, Mo, Ti, a compound thereof, or a mixture thereof (for example, a mixture of Ag and Mg). The second electrode EL**2** may have a multilayered structure including a reflective layer or a transflective layer formed using the above-described materials and a transparent conductive layer formed using ITO, IZO, ZnO, ITZO, etc.

[0152] Even not shown, the second electrode EL**2** may be connected with an auxiliary electrode. In case the second electrode EL**2** is connected with the auxiliary electrode, the resistance of the second electrode EL**2** may decrease.

[0153] In the organic electroluminescence device **10**, according to the application of a voltage to each of the first electrode EL**1** and second electrode EL**2**, holes injected from the first electrode EL**1** may move via the hole transport region HTR to the emission layer EML, and electrons injected from the second electrode EL**2** may move via the electron transport region ETR to the emission layer EML. The electrons and the holes are recombined in the emission layer EML to generate excitons, and light may be emitted via the transition of the excitons from an excited state to a ground state.

[0154] In case the organic electroluminescence device **10** is a top emission type, the first electrode EL**1** may be a reflective electrode, and the second electrode EL**2** may be a transmissive electrode or a transflective electrode. In case the organic electroluminescence device **10** is a bottom emission type, the first electrode EL**1** may be a transmissive electrode or a transflective electrode, and the second electrode EL**2** may be a reflective electrode.

[0155] The organic electroluminescence device according to an embodiment of the inventive concept includes the aromatic compound according to an embodiment of the inventive concept, thereby securing improved emission efficiency. In addition, the organic electroluminescence device according to an embodiment of the inventive concept includes the above-described aromatic compound in the emission layer, thereby enabling the aromatic compound to emit light by the process of thermally activated delayed fluorescence and securing high efficiency. More specifically, the organic electroluminescence device according to an embodiment of the inventive concept includes the aromatic compound according to an embodiment of the inventive concept in the emission layer, thereby attaining a high efficiency blue light emitting device by the process of thermally activated delayed fluorescence.

[0156] Hereinafter, the aromatic compound according to an embodiment of the inventive concept and the organic electroluminescence device including the aromatic compound according to an embodiment of the inventive concept will be explained in more detail with reference to embodiments and comparative embodiments. The following embodiments are illustrated only for assisting the understanding of the inventive concept, and the scope of the inventive concept is not limited thereto.

EXAMPLES

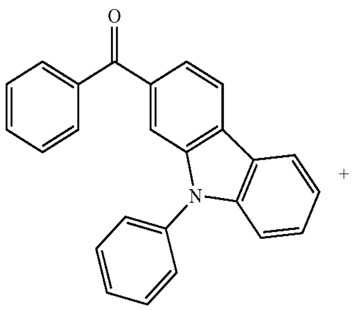
1. Synthesis of Aromatic Compound

[0157] The synthetic method of the aromatic compounds according to an embodiment of the inventive concept will be specifically explained by using the synthesis of Compounds 16 and 21 to 23 in Compound Group 1 as an example. However, the synthetic method of the aromatic compounds described below is an example, and the synthetic method of the aromatic compounds according to an embodiment of the inventive concept is not limited thereto.

(Synthesis of Compound 21)

[0158] Compound 21, the aromatic compound according to an embodiment of the inventive concept, may be synthesized, for example, by the following reaction.

[Reraction scheme 1]



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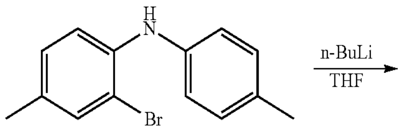

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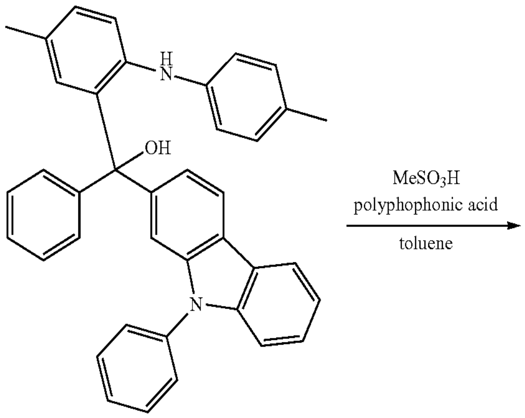

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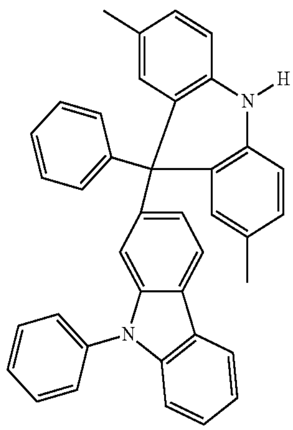

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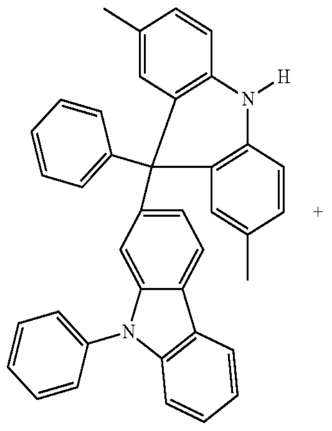

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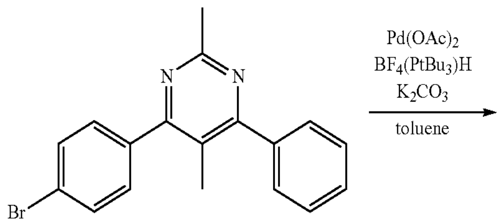

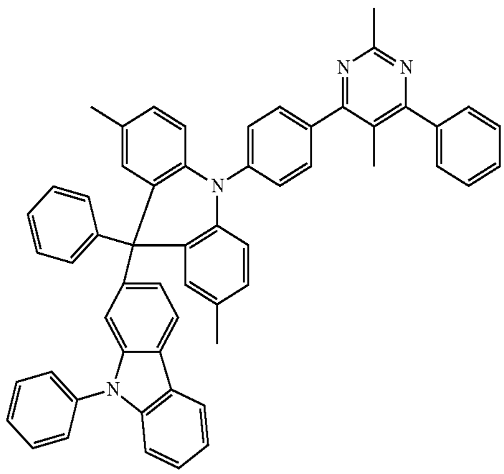

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[0159] Under an argon (Ar) atmosphere, 8 g of Compound B and 100 mL of THF were injected to a 300 mL three neck flask and the mixture was cooled to about −78° C. 39.5 mL of n-BuLi was added thereto and the mixture was stirred for about 1 hour. Under an argon atmosphere, 10 g of Compound A dissolved in 100 mL of THF was added to the solution of Compound B dropwise and the resultant solution was stirred at room temperature for about 5 hours. After water was added thereto, an organic layer was separated and solvents were evaporated.

[0160] The crude product thus obtained was purified by silica gel column chromatography (using a mixture of dichloromethane and hexane) and then recrystallized with a mixture of toluene/hexane to obtain 2.77 g (yield 82%) of Compound C as a white solid.

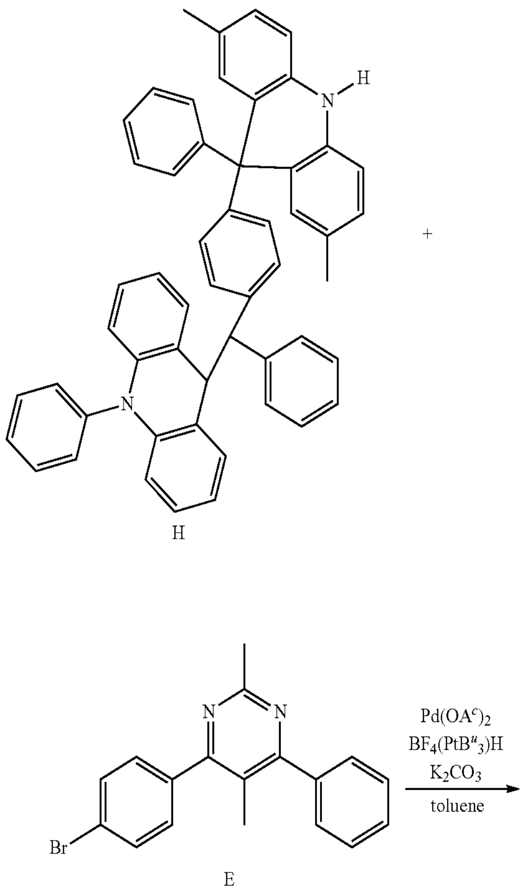
[0161] Compound C was dissolved in 100 mL of toluene, $MeSO_3H$ and polyphosphonic acid were added thereto, and the mixture was heated to reflux for about 3 hours. After cooling in the air, water was added thereto, an organic layer was separated and solvents were evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of dichloromethane and hexane) and then recrystallized with a mixture of toluene/hexane to obtain 5.97 g (yield 94%) of Compound D as a white solid.

[0162] 5 g of Compound D, 3.5 g of Compound E, 0.1 g of palladium acetate, 0.25 g of $PH(tBu)_3/BF_4$ and 1.77 g of potassium carbonate were added to 50 mL of toluene and the resultant was heated to reflux for about 6 hours. After cooling in the air, water was added thereto, an organic layer was separated and solvents were evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of dichloromethane and hexane) and then recrystallized with a mixture of toluene/hexane to obtain 6.1 g (yield 80%) of Compound 21 as a white solid

(Synthesis of Compound 16)

[0163] Compound 16, the aromatic compound according to an embodiment of the inventive concept, may be synthesized, for example, by the following reaction.

[Reaction scheme 2]



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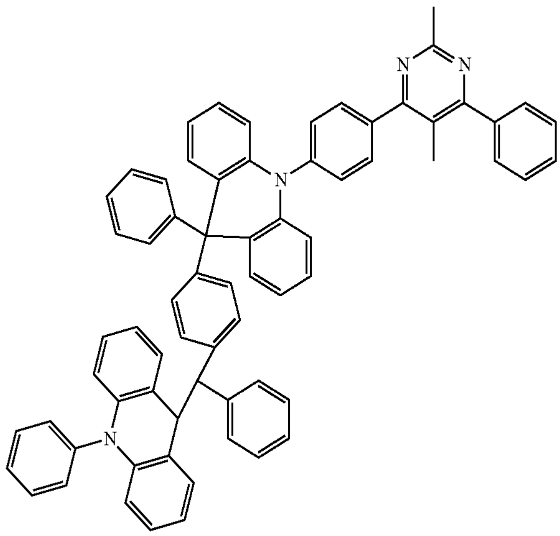


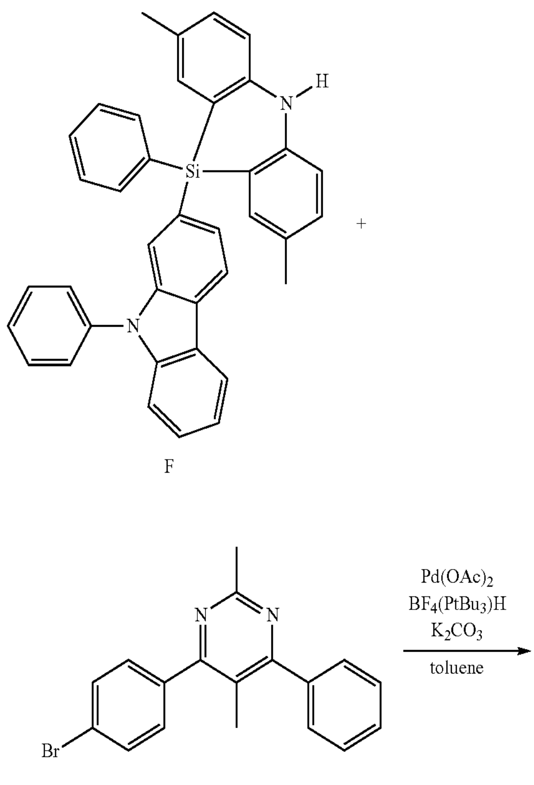
16

[0164] Compound 16 was synthesized by conducting the same synthetic method of Compound 21 except for using Compound H instead of Compound D in the synthetic method of Compound 21 (yield 70%).

(Synthesis of Compound 22)

[0165] Compound 22, the aromatic compound according to an embodiment of the inventive concept, may be synthesized, for example, by the following reaction.

[Reaction scheme 3]



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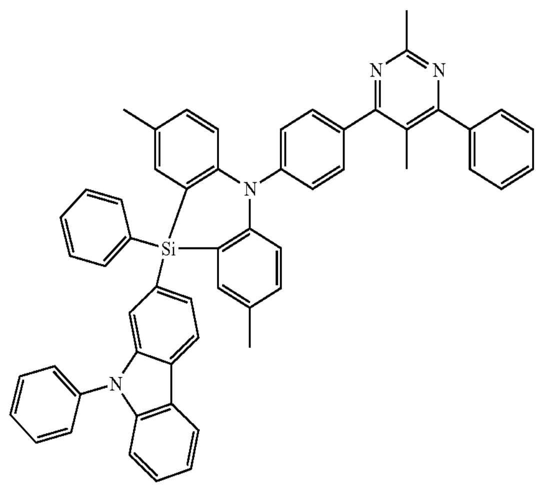


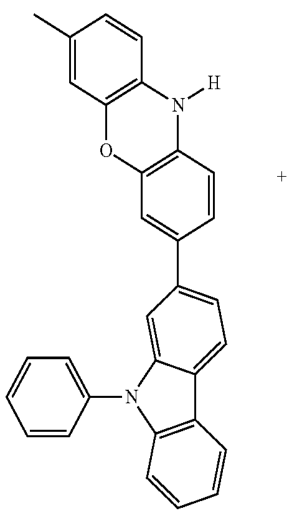
22

[0166] Compound 22 was synthesized by conducting the same synthetic method of Compound 21 except for using Compound F instead of Compound D in the synthetic method of Compound 21 (yield 75%).

(Synthesis of Compound 23)

[0167] Compound 23, the aromatic compound according to an embodiment of the inventive concept, may be synthesized, for example, by the following reaction.

[Reaction scheme 4]



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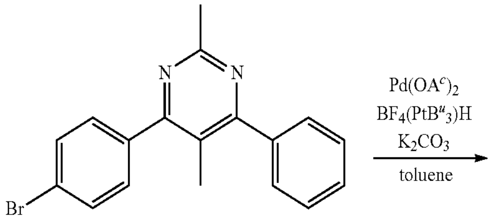

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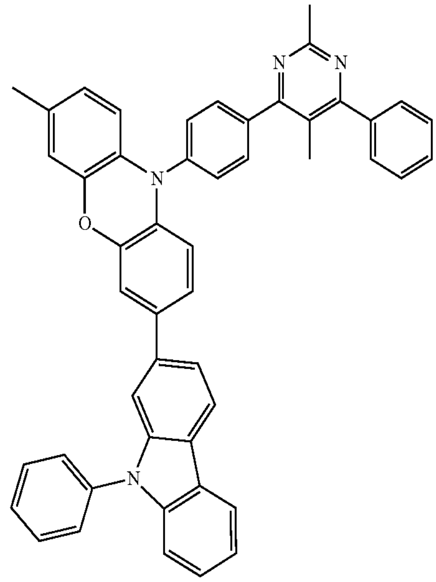


23

[0168] Compound 23 was synthesized by conducting the same synthetic method of Compound 21 except for using Compound G instead of Compound D in the synthetic method of Compound 21 (yield 78%).

2. Manufacturing of Organic Electroluminescence Devices Including Aromatic Compounds and Evaluation Thereof

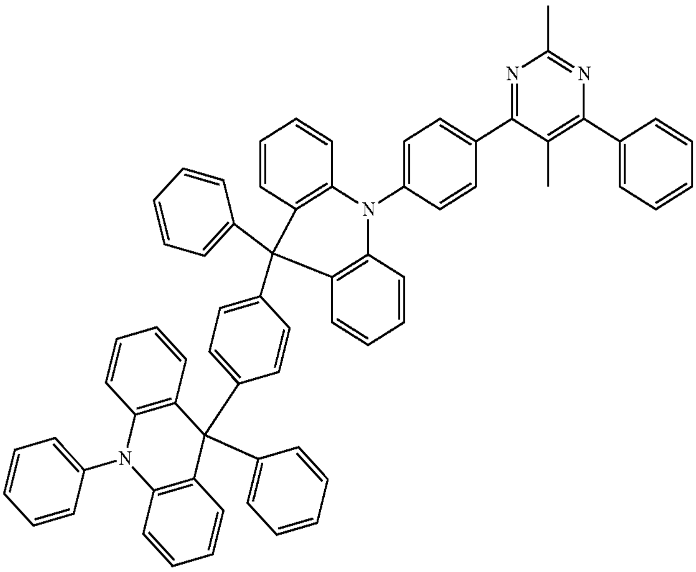
(Manufacturing of Organic Electroluminescence Devices)

[0169] Organic electroluminescence devices according to an embodiment of the inventive concept including the aromatic compounds according to an embodiment of the inventive concept were manufactured by the following method. Organic electroluminescence devices of Examples 1 to 4 were manufactured by using the above Compounds 16 and 21 to 23 as emission layer materials. Organic electroluminescent devices of Comparative Examples 1 and 2 were manufactured by using the following Comparative Compounds C1 and C2 as emission layer materials.

[0170] The compounds used for forming emission layers in Examples 1 to 4 and Comparative Examples 1 and 2 are shown in Table 1.

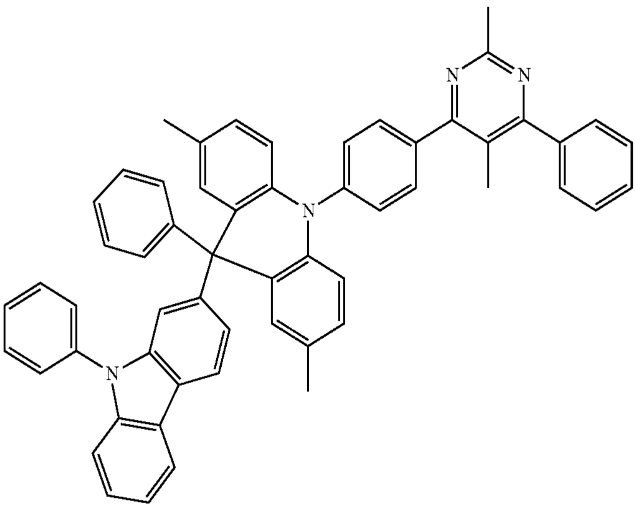
TABLE 1

Compound 16



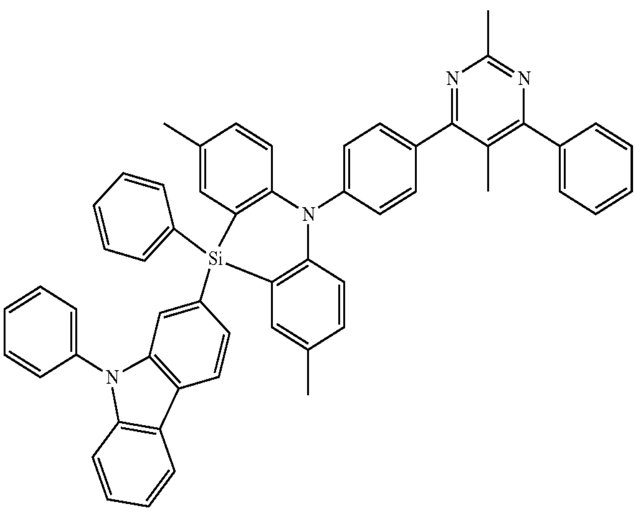
16

Compound 21



21

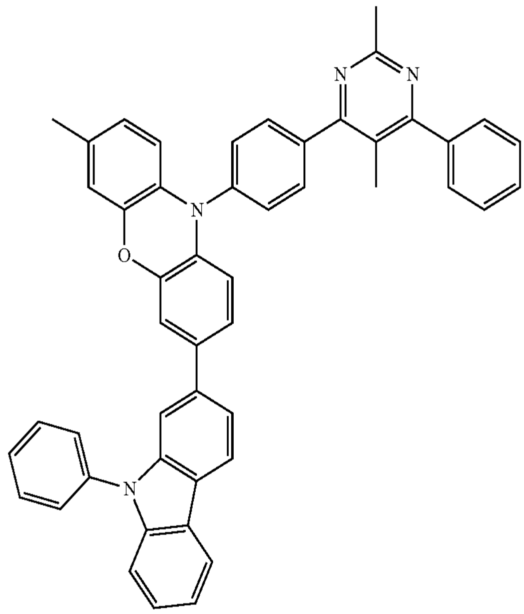
Compound 22



22

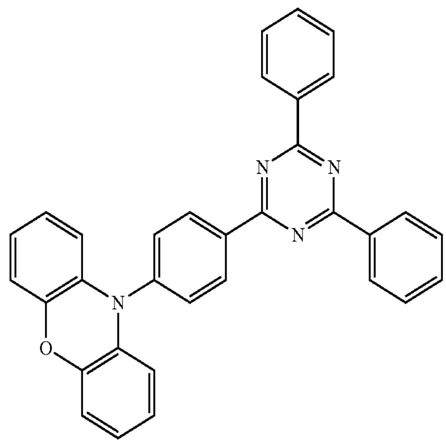
TABLE 1-continued

Compound 23



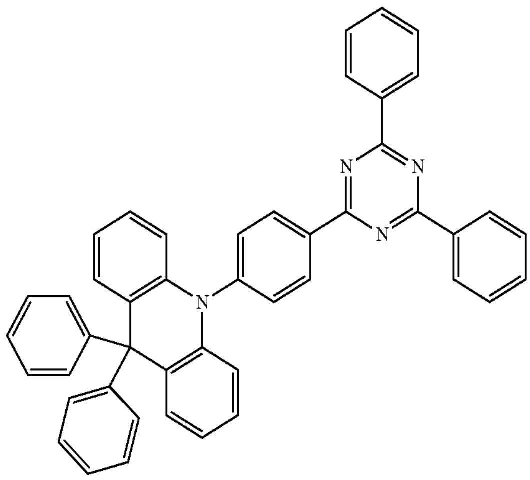
23

Comparative Compound C1



C1

Comparative Compound C2



C2

[0171] The organic electroluminescence devices of Examples and Comparative Examples were manufactured by the following method.

[0172] ITO was patterned on a glass substrate to a thickness of about 1500 Å, followed by washing with ultrapure water and performing UV ozone treatment for about 10 minutes. After that, a hole injection layer was formed by using HAT-CN to a thickness of about 100 Å, and then a hole transport layer was formed by using NPB to a thickness of about 800 Å.

[0173] Next, in Examples, an emission layer was formed by co-deposition of each of the aromatic compounds (Compound 16 and 21 to 23) and DPEPO in the ratio of 18:92. The emission layer was formed to a thickness of about 200 Å. On the emission layer, an electron transport layer was formed using TPBi to a thickness of about 300 Å, and an electron injection layer was formed using LiF to a thickness of about 5 Å. A second electrode was formed using Al to a thickness of about 1000 Å.

[0174] In Examples the hole injection layer, hole transport layer, emission layer, electron transport layer, electron injection layer and second electrode were formed by a vacuum deposition method.

[0175] The organic electroluminescence devices of Comparative Examples 1 and 2 were manufactured by conducting the same manufacturing method of Examples except that emission layer was formed by co-deposition of Comparative Compound C1 or C2 and DPEPO in the ratio of 18:92.

(Property Evaluation of Organic Electroluminescence Devices)

[0176] The values of maximum light emitting wavelength (l_{max}), external quantum efficiency (EQE) and roll-off were measured to evaluate the properties of the organic electroluminescence devices manufactured in Examples and Comparative Examples. The absolute value (ΔE_{ST}) of difference between singlet energy level and triplet energy level was also evaluated. The maximum light emitting wavelength of light emitting spectrum at ordinary temperature (about 300K) was measured by using the sample compounds to be deposited on quartz plate. The external quantum efficiency was measured by using an external quantum efficiency measurement system C9920-2-12 (Hamamatsu Photonics, Japan). Roll-off value was calculated by the following equation, in which EQE means external quantum efficiency at a current density of 10 mA/cm^2.

$$\text{Roll-off} = \text{EQE } (10 \text{ mA/cm}^2)/\text{EQE } (\text{max})$$

[0177] ΔE_{ST}, the difference between singlet energy level and triplet energy level, was calculated by functional B3LYP, 6-31G (d) using Gaussian09.

[0178] Property evaluation results of the organic electroluminescence devices are shown in Table 2 below.

TABLE 2

Examples	Dopant of emission layer	l_{max} (nm)	EQE (%)	Roll-off (%)	ΔE_{ST}
Example 1	Compound 16	450	18.0	0.78	0.02
Example 2	Compound 21	455	19.5	0.75	0.01
Example 3	Compound 22	450	19.0	0.77	0.01
Example 4	Compound 23	460	17.5	0.79	0.01

TABLE 2-continued

Examples	Dopant of emission layer	l_{max} (nm)	EQE (%)	Roll-off (%)	ΔE_{ST}
Comparative Example 1	Comparative Compound C1	529	12.5	0.66	0.01
Comparative Example 2	Comparative Compound C2	475	14.0	0.54	0.01

[0179] The organic electroluminescence devices of Examples 1, 2, 3 and 4 include Compound 16, 21, 22 and 23, respectively, as a dopant of emission layer. The organic electroluminescence devices of Comparative Examples 1 and 2 include Comparative Compounds C1 and C2, respectively, as a dopant of emission layer.

[0180] Referring to the results in Table 2, it may be found that the organic electroluminescence devices of Examples 1 to 4 have emission efficiency higher than those of Comparative Examples 1 and 2. That is, it may be found that the organic electroluminescence devices of Examples 1 to 4 have external quantum efficiency higher than those of Comparative Examples 1 and 2. Furthermore, it may be found that the organic electroluminescence devices of Examples 1 to 4 show efficiency reduction caused by roll-off lower than those of Comparative Examples 1 and 2. That is, it may be represented that the higher the value of "roll-off" described in Table 2, the lower the emission efficiency reduction.

[0181] The organic electroluminescence devices of Examples 1 to 4 show higher efficiency in blue light emitting region and lower efficiency reduction caused by roll-off when compared with those of Comparative Examples 1 and 2. These results may be due to the dopant materials used in Examples containing a nitrogen atom with a hole transport property to adjust charge balance in emission device. Furthermore, it may be considered that extended light emitting region due to enhanced hole transport property results in decreased efficiency reduction caused by roll-off.

[0182] The organic electroluminescence device according to an embodiment of the inventive concept may attain high emission efficiency by including the aromatic compound according to an embodiment of the inventive concept. The aromatic compound according to an embodiment of the inventive concept may be used as a luminescence material for thermally activated delayed fluorescence emitting blue light to improve the blue light emission efficiency of organic electroluminescence device. Furthermore, the organic electroluminescence device according to an embodiment of the inventive concept may have the aromatic compound represented by Formula 1 with an appropriate substituent introduced thereto, thereby attaining blue light emitting as well as high external quantum efficiency.

[0183] The aromatic compound according to an embodiment of the inventive concept may improve emission efficiency of an organic electroluminescence device.

[0184] The organic electroluminescence device according to an embodiment of the inventive concept including the aromatic compound according to an embodiment of the inventive concept may attain high efficiency.

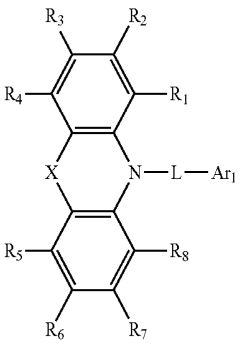
[0185] Although the exemplary embodiments of the present invention have been described, it is understood that the present invention should not be limited to these exemplary embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of the present invention as hereinafter claimed.

[0186] Thus, the scope of the inventive concept is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description.

What is claimed is:

1. An aromatic compound represented by the following Formula 1:

[Formula 1]



where Ar_1 is a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

L is a direct linkage, or a substituted or unsubstituted phenylene group,

X is a direct linkage, O, S, NR_a, CR_bR_c, SiR_dR_e, GeR_fR_g, $P(=O)R_h$, or $P(=S)R_i$,

R_1 to R_8 are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and

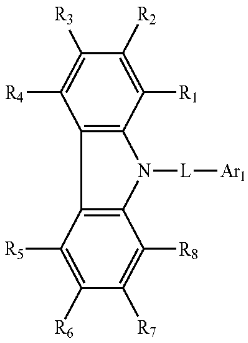
R_a to R_i are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other, and

R_d and R_e are not phenyl group concurrently.

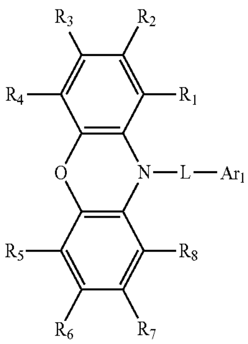
2. The aromatic compound of claim 1, wherein the aromatic compound represented by Formula 1 has an absolute value of the difference between the singlet energy level and the triplet energy level of 0.2 eV or less.

3. The aromatic compound of claim 1, wherein Formula 1 is represented by one of the following Formulae 1-1 to 1-10:

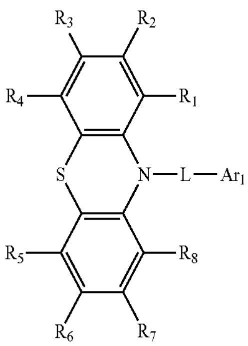
[Formula 1-1]



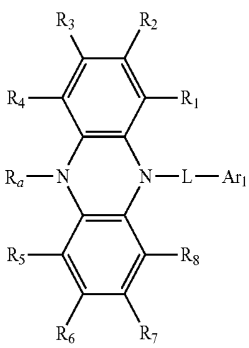
[Formula 1-2]



[Formula 1-3]



[Formula 1-4]



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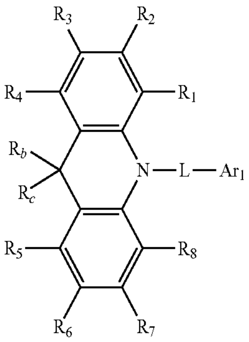
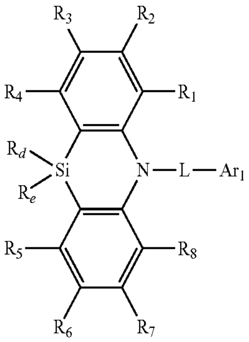
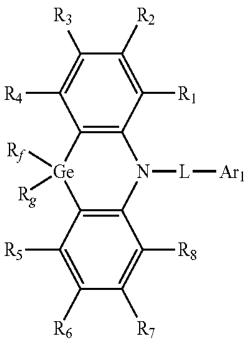
[Formula 1-5]



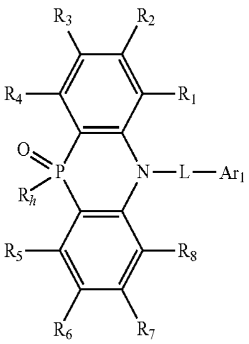
[Formula 1-6]



[Formula 1-7]



[Formula 1-8]



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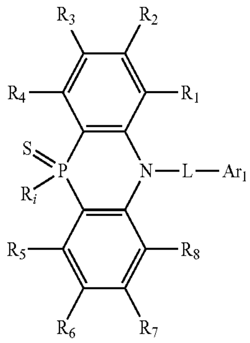
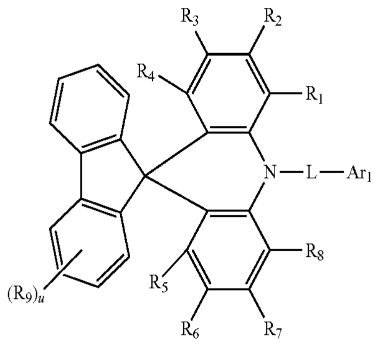
[Formula 1-9]



[Formula 1-10]



where R_9 is a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other,

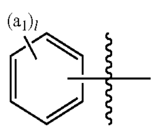
u is an integer of 0 to 4, and

Ar_1, L, R_1 to R_8, and R_a to R_i are the same as defined in Formula 1.

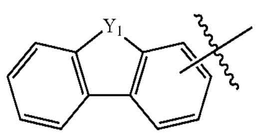
4. The aromatic compound of claim **1**, wherein R_a to R_i are each independently unsubstituted or substituted with at least one of a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

5. The aromatic compound of claim **1**, wherein R_a to R_i are each independently represented by one of the following Formulae 2-1 to 2-4:

[Formula 2-1]



[Formula 2-2]



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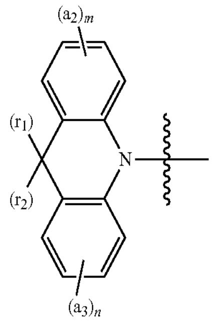
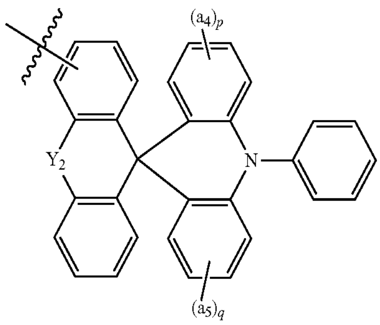
[Formula 2-3]



[Formula 2-4]



where a_1 to a_5 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

r_1 and r_2 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other,

l, m, n, p and q are each independently an integer of 0 to 4,

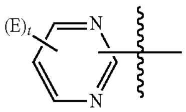
Y_1 is NR_a, O, or S,

Y_2 is a direct linkage, O, or S, and

R_a is the same as defined in Formula 1.

6. The aromatic compound of claim **1**, wherein Ar_1 is represented by the following Formula 3-1 or 3-2:

[Formula 3-1]



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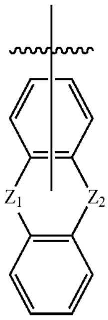
[Formula 3-2]



where E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

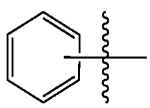
t is an integer of 0 to 3,

Z_1 and Z_2 are each independently BR', NR", O, S, or C(═O), and

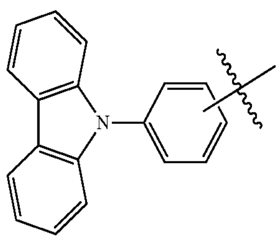
R' and R" are each independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

7. The aromatic compound of claim **1**, wherein R_a to R_i are each independently represented by one of the following Formulae S1 to S18:

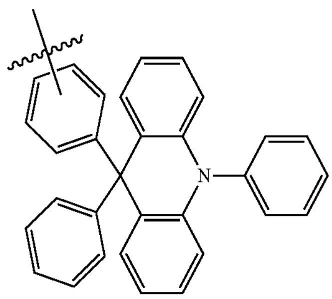
S1



S2



S3



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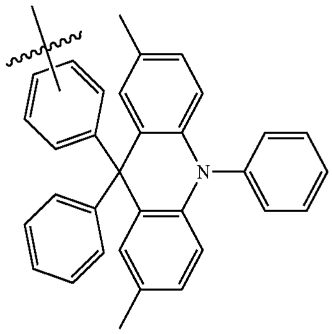
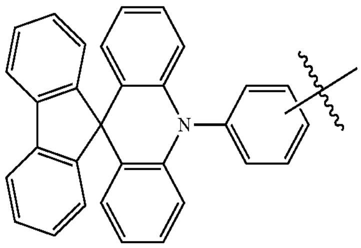
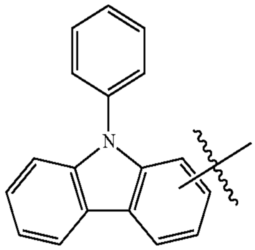
S4



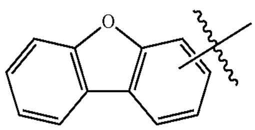
S5



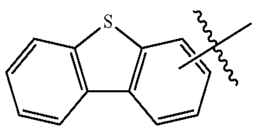
S6



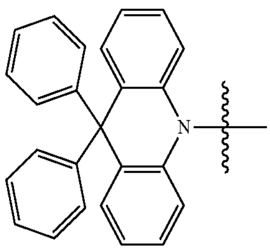
S7



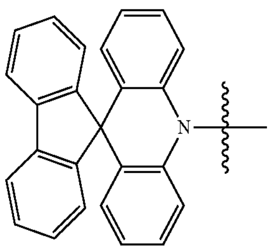
S8



S9



S10



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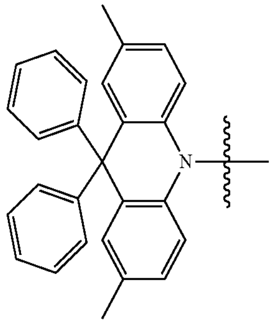
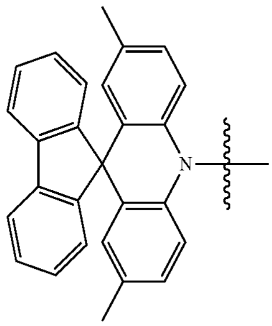
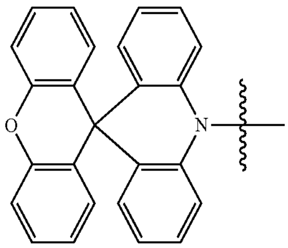
S11



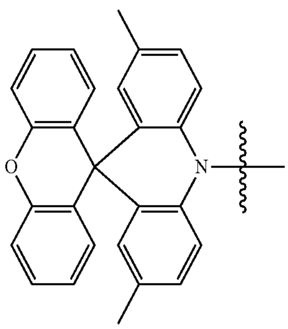
S12



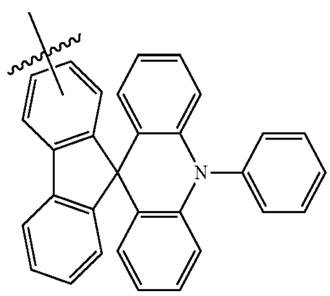
S13



S14



S15



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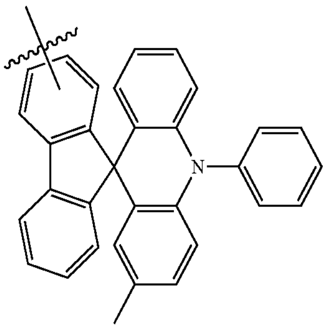
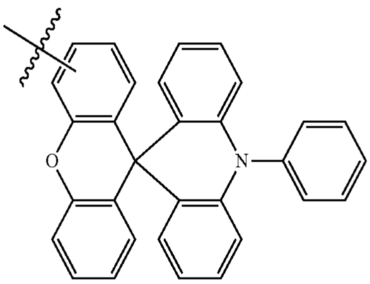
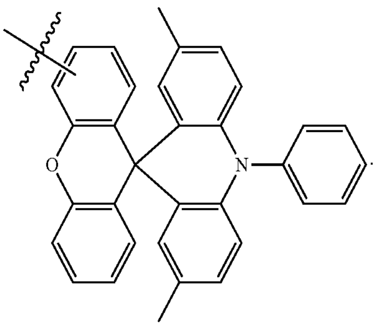
S16



S17

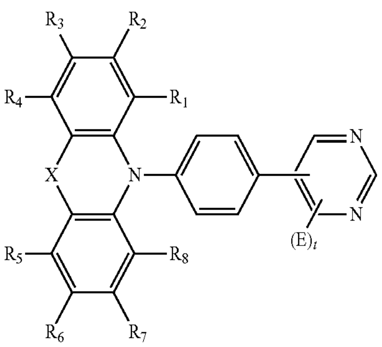


S18



8. The aromatic compound of claim 1, wherein Formula 1 is represented by the following Formula 4:

[Formula 4]



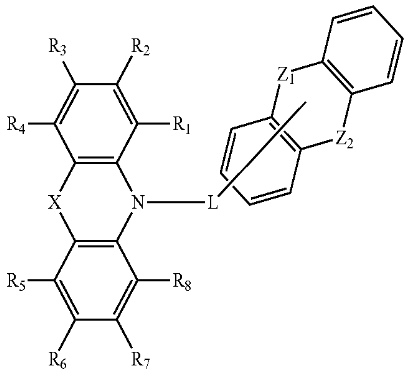
where E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

t is an integer of 0 to 3, and

X and R_1 to R_8 are the same as defined in Formula 1.

9. The aromatic compound of claim 1, wherein Formula 1 is represented by the following Formula 5:

[Formula 5]



where Z_1 and Z_2 are each independently BR', NR'', O, S, or C(=O),

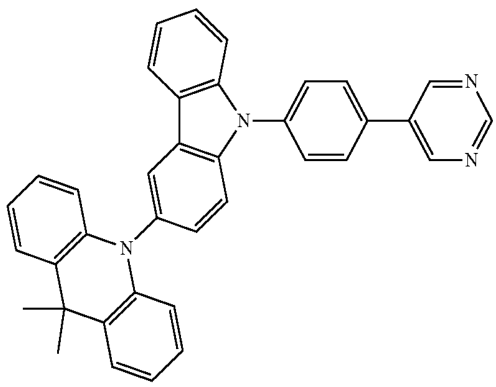
R' and R'' are each independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and

X, L, and R_1 to R_8 are the same as defined in Formula 1.

10. The aromatic compound of claim 1, wherein the aromatic compound represented by Formula 1 is one selected from the group consisting of compounds represented in the following Compound Group 1:

[Compound Group 1]

1



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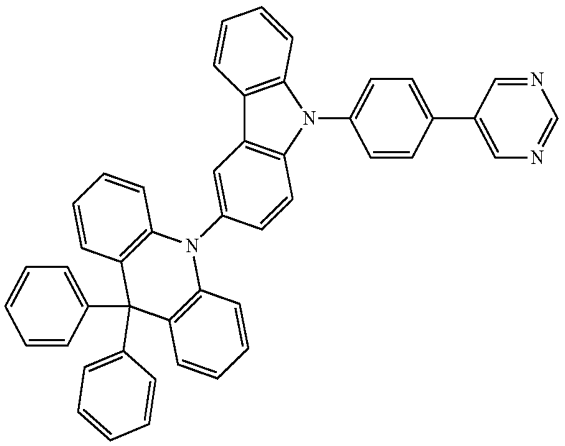
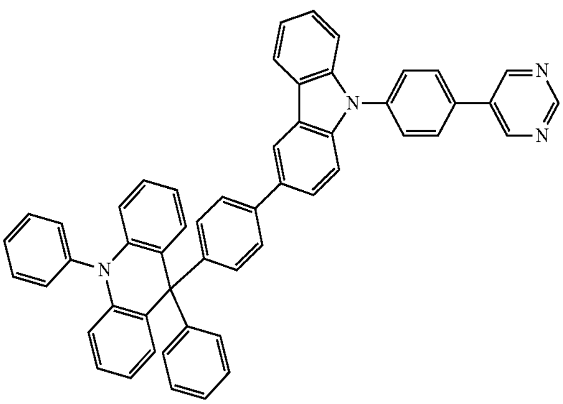


3



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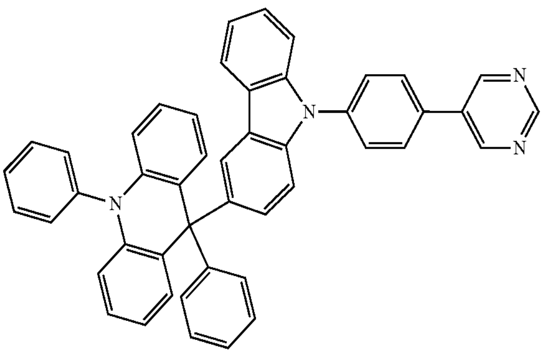

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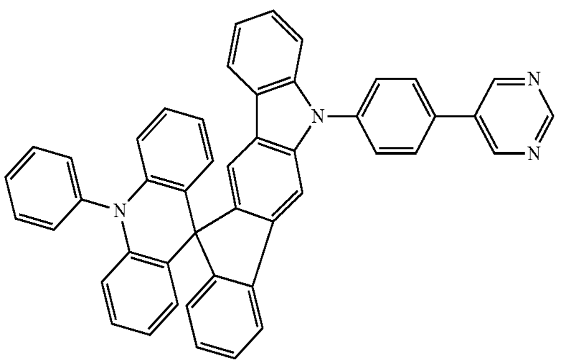

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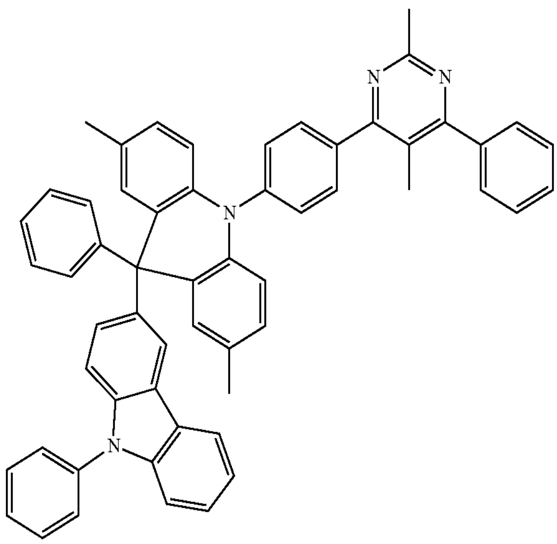

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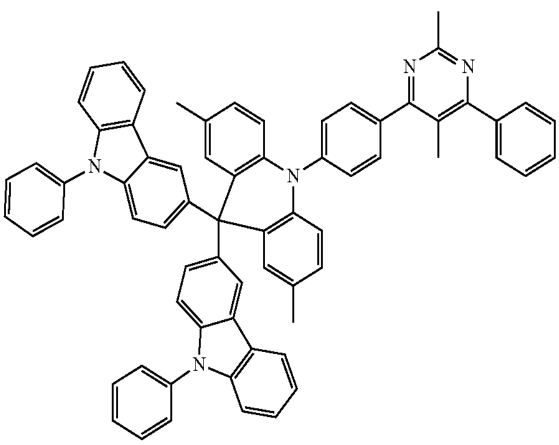

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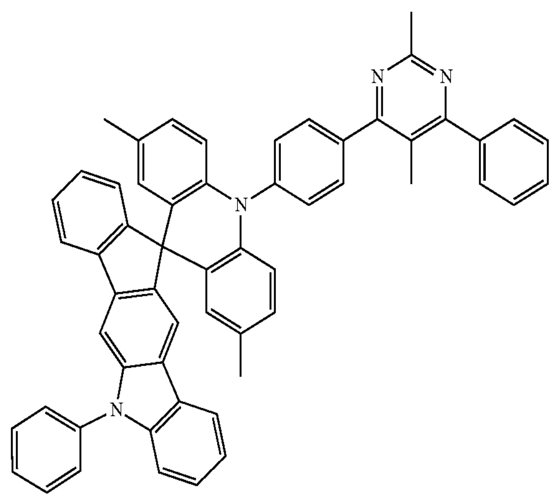

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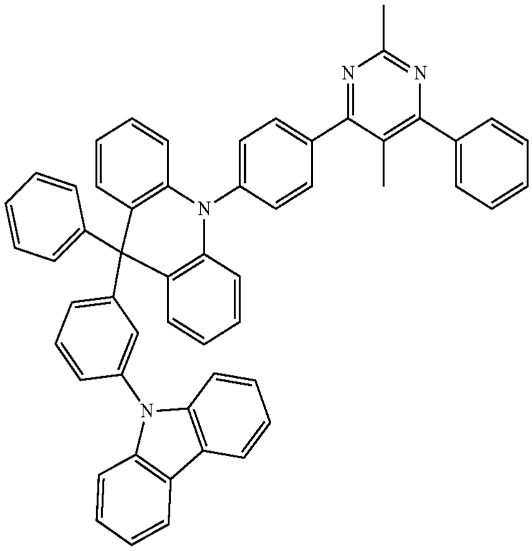

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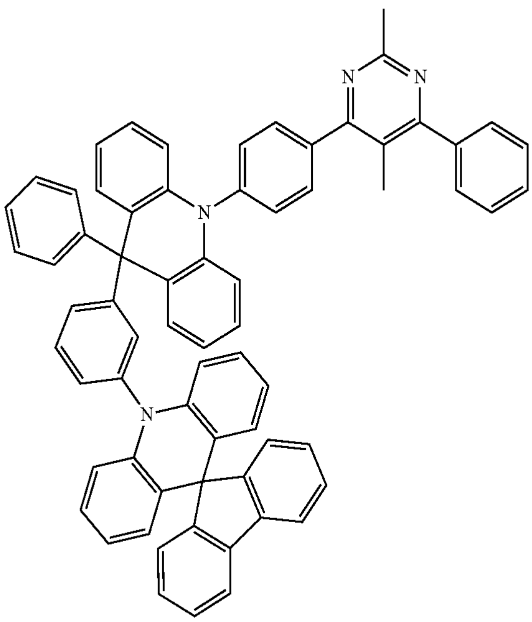

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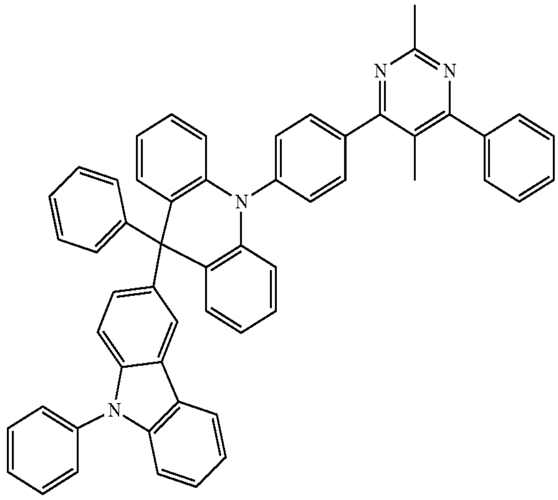

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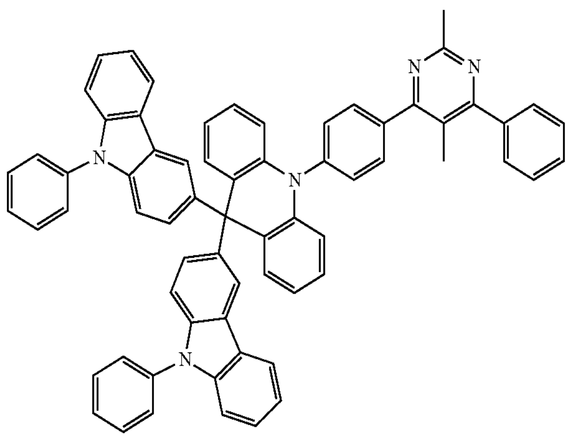

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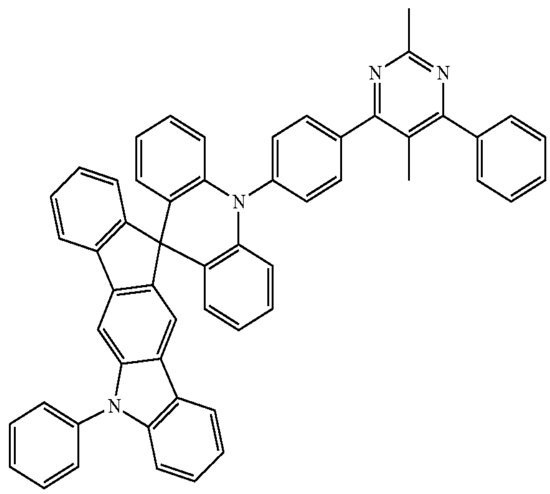

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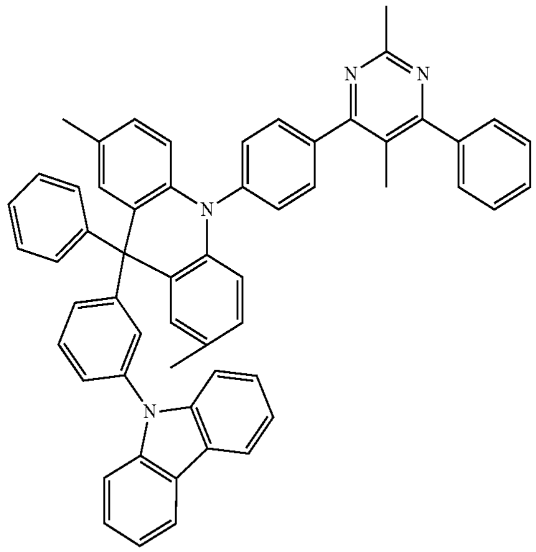

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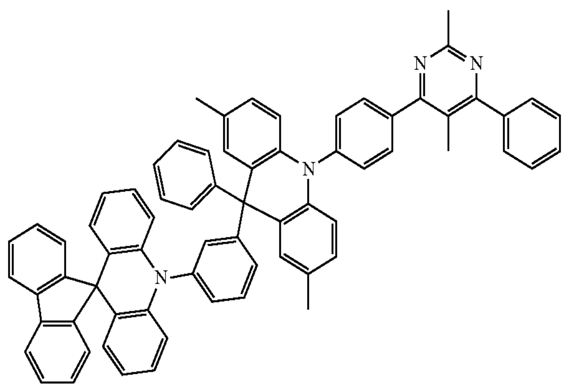

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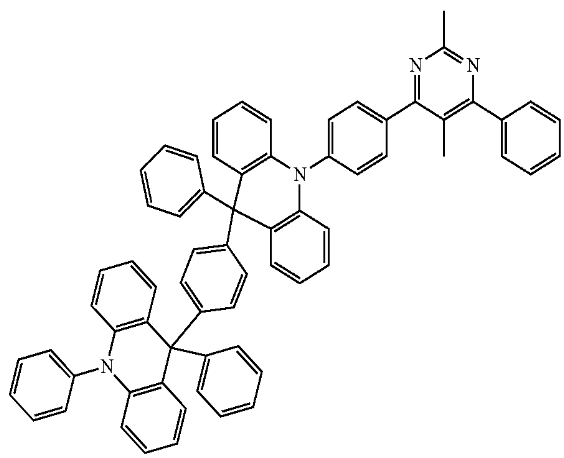

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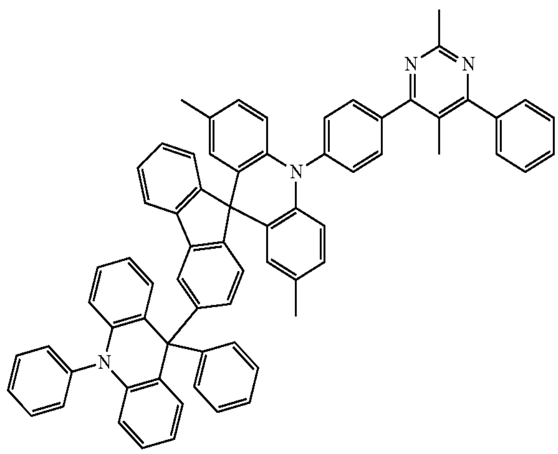

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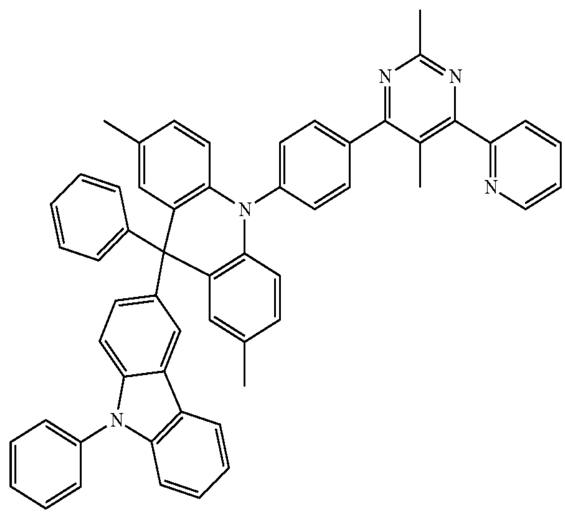

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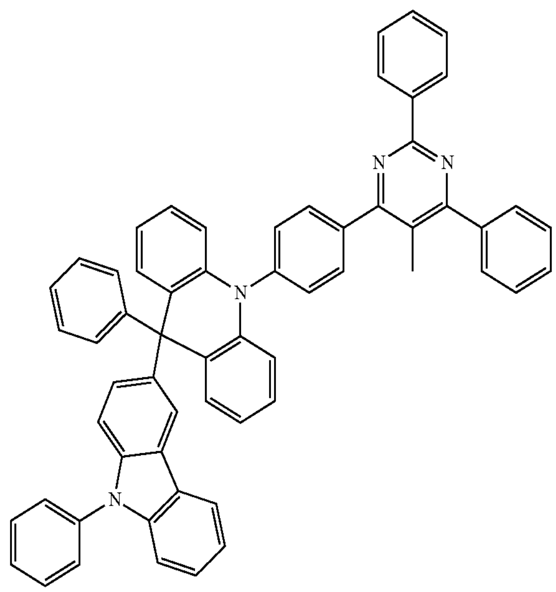

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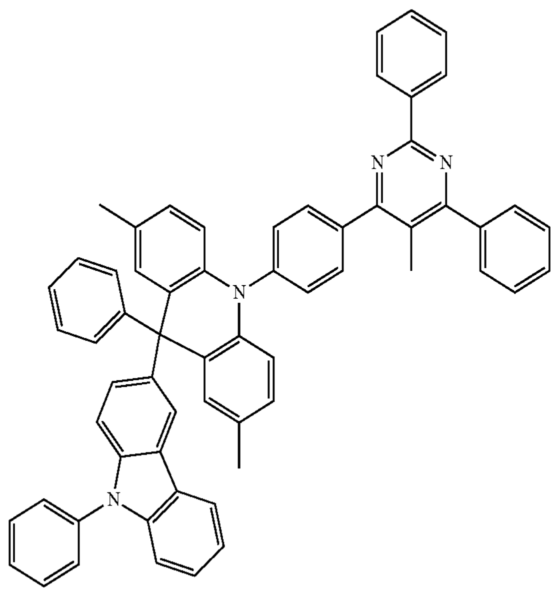

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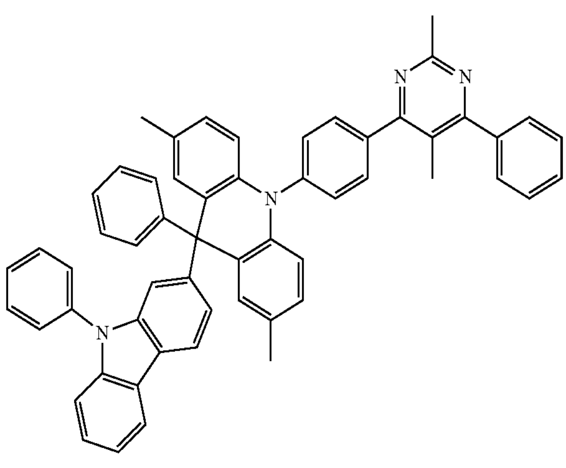

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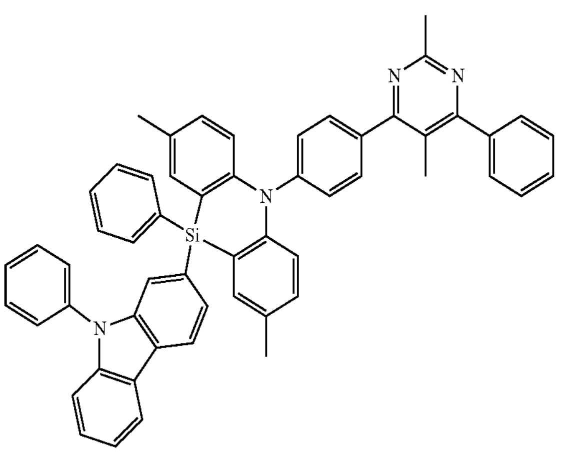

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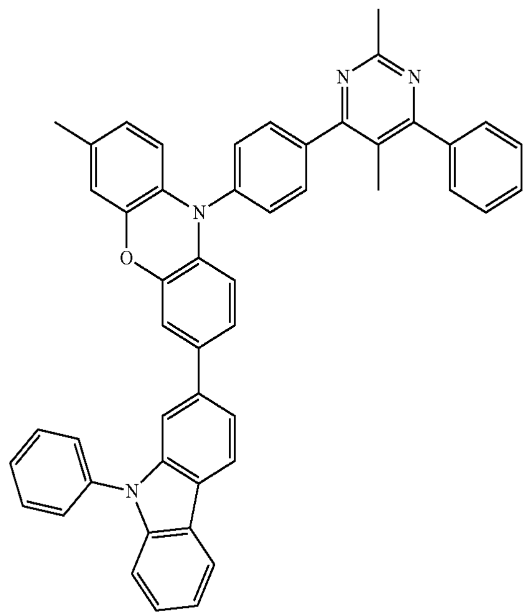

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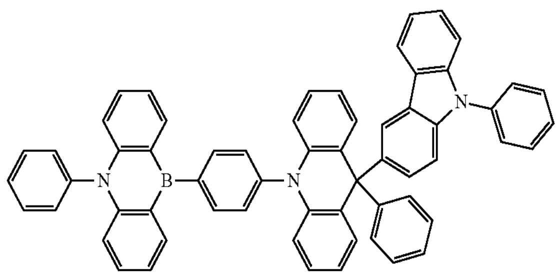

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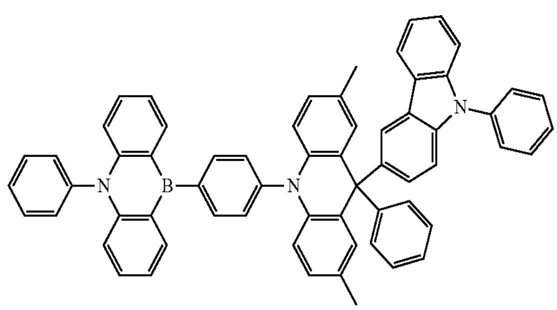

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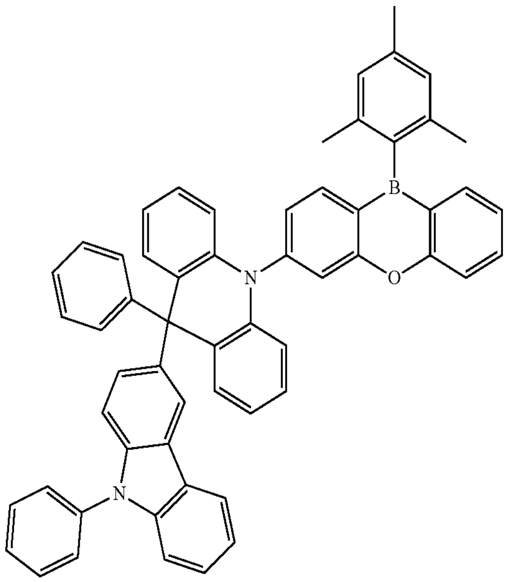

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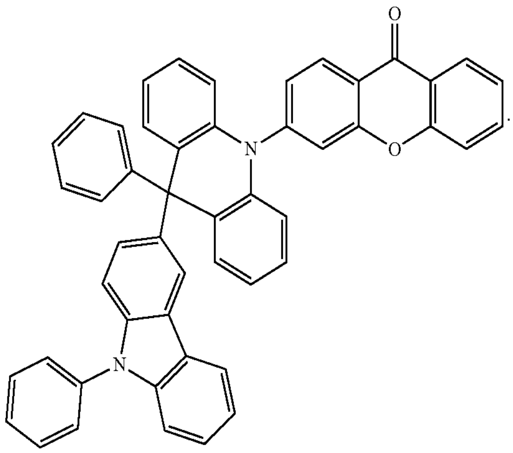
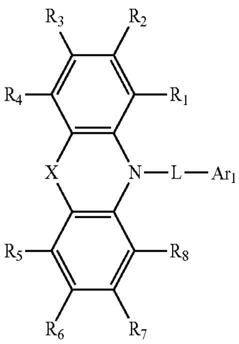


11. An organic electroluminescence device, comprising:
a first electrode;
a hole transport region disposed on the first electrode;
an emission layer disposed on the hole transport region;
an electron transport region disposed on the emission layer; and
a second electrode disposed on the electron transport region,
wherein the emission layer comprises an aromatic compound represented by the following Formula 1:

[Formula 1]



where Ar_1 is a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,
L is a direct linkage, or a substituted or unsubstituted phenylene group,
X is a direct linkage, O, S, NR_a, CR_bR_c, SiR_dR_e, GeR_fR_g, $P(=O)R_h$, or $P(=S)R_i$,
R_1 to R_8 are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and
R_a to R_i are each independently a hydrogen atom, a deuterium atom, a halogen atom, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other, and
R_d and R_e are not phenyl group concurrently.

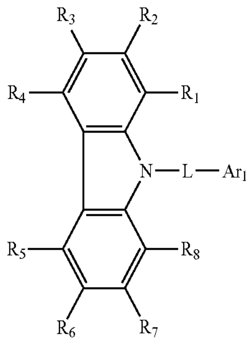
12. The organic electroluminescence device of claim 11, wherein the emission layer emits blue light.

13. The organic electroluminescence device of claim 11, wherein the aromatic compound represented by Formula 1 is a thermally activated delayed fluorescence compound.

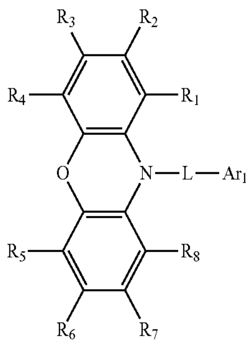
14. The organic electroluminescence device of claim 11, wherein the aromatic compound represented by Formula 1 has an absolute value of the difference between the singlet energy level and the triplet energy level of 0.2 eV or less.

15. The organic electroluminescence device of claim 11, wherein Formula 1 is represented by one of the following Formulae 1-1 to 1-10:

[Formula 1-1]



[Formula 1-2]



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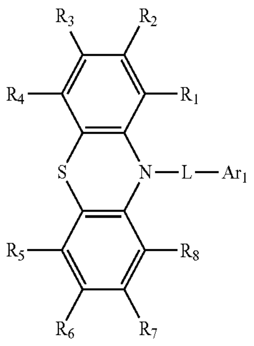
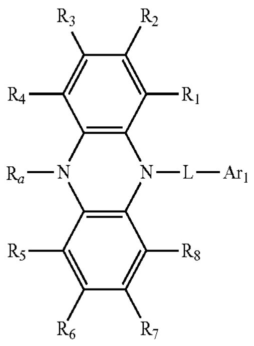
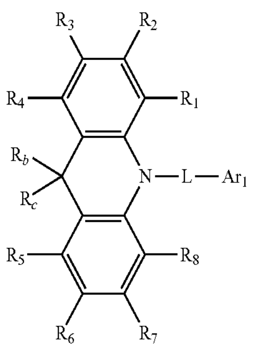
[Formula 1-3]



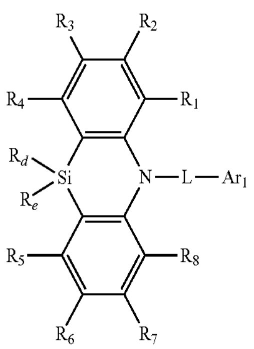
[Formula 1-4]



[Formula 1-5]



[Formula 1-6]



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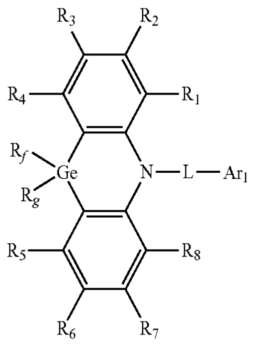
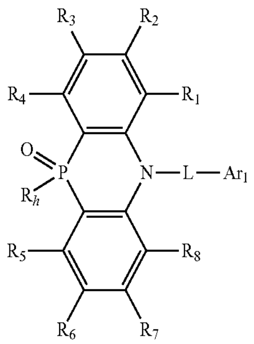
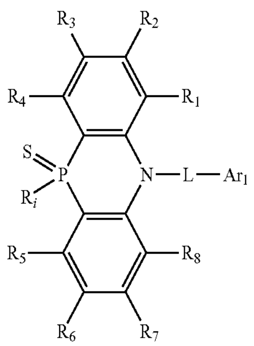
[Formula 1-7]



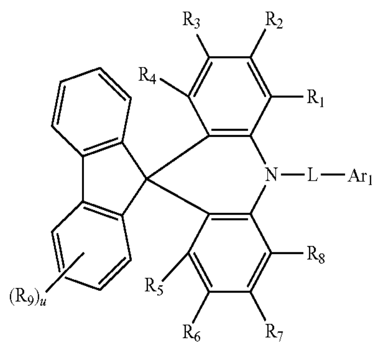
[Formula 1-8]



[Formula 1-9]



[Formula 1-10]



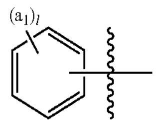
where R_9 is a deuterium atom, a halogen atom, an amino group, a substituted or unsubstituted silyl group, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other,

u is an integer of 0 to 4, and

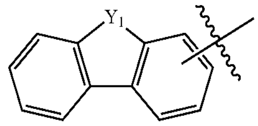
Ar_1, L, R_1 to R_8, and R_a to R_i are the same as defined in Formula 1.

16. The organic electroluminescence device of claim **11**, wherein R_a to R_i are each independently represented by one of the following Formulae 2-1 to 2-4:

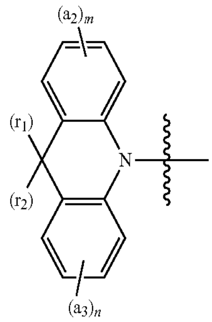
[Formula 2-1]



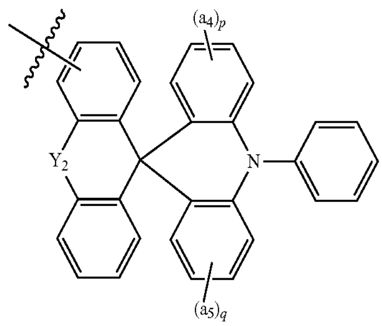
[Formula 2-2]



[Formula 2-3]



[Formula 2-4]



where a_1 to a_5 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

r_1 and r_2 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, or form a ring by combining adjacent groups with each other,

l, m, n, p and q are each independently an integer of 0 to 4,

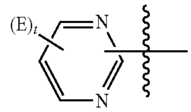
Y_1 is NR_a, O, or S,

Y_2 is a direct linkage, O, or S, and

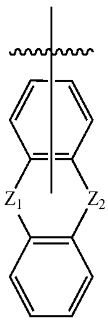
R_a is the same as defined in Formula 1.

17. The organic electroluminescence device of claim **11**, wherein Ar_1 is represented by the following Formula 3-1 or 3-2:

[Formula 3-1]



[Formula 3-2]



where E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

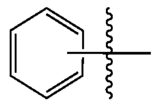
t is an integer of 0 to 3,

Z_1 and Z_2 are each independently BR', NR", O, S, or C(=O), and

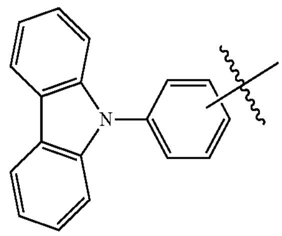
R' and R" are each independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring.

18. The organic electroluminescence device of claim **11**, wherein R_a to R_i are each independently represented by one of the following Formulae S1 to S18:

S1



S2



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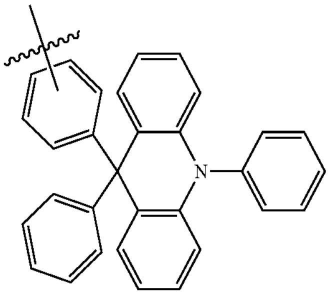
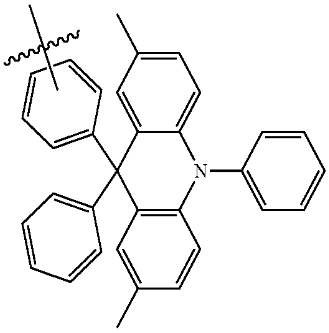
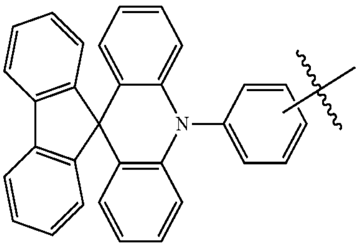
S3



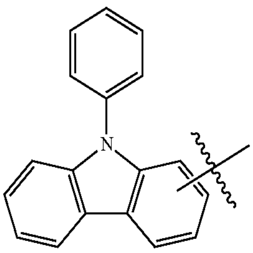
S4



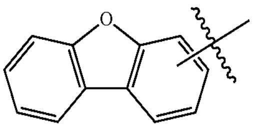
S5



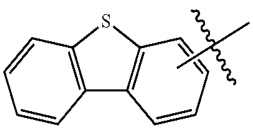
S6



S7



S8



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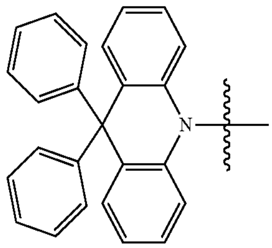
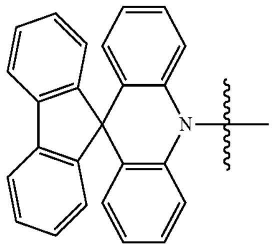
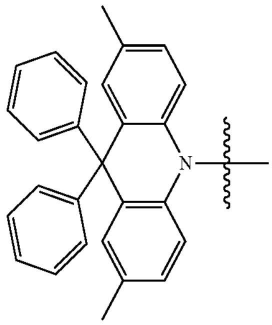
S9



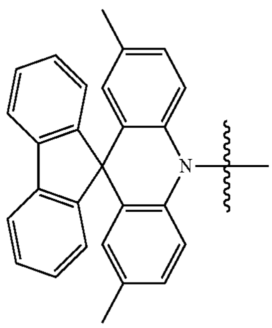
S10



S11



S12



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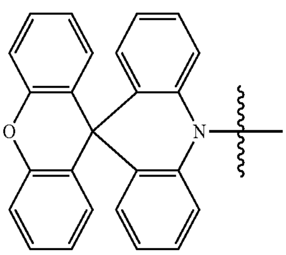

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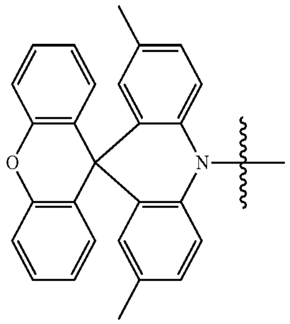
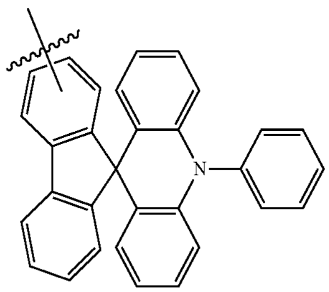
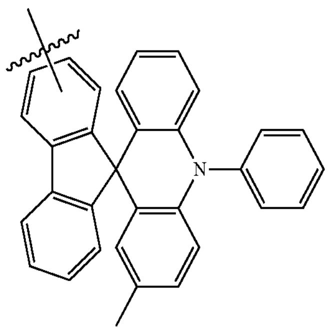
S14



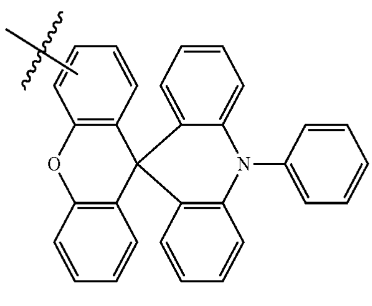
S15



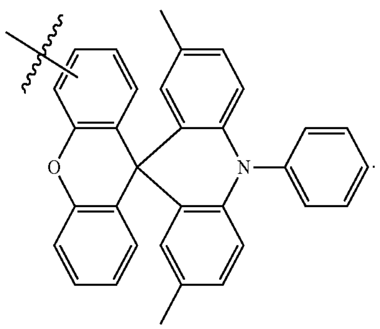
S16



S17

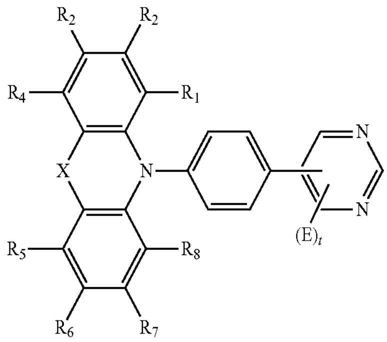


S18

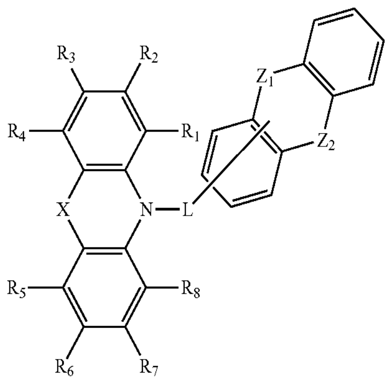


19. The organic electroluminescence device of claim **11**, wherein Formula 1 is represented by the following Formula 4 or 5:

[Formula 4]



[Formula 5]



where E is a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring,

t is an integer of 0 to 3,

Z_1 and Z_2 are each independently BR', NR", O, S, or C(=O),

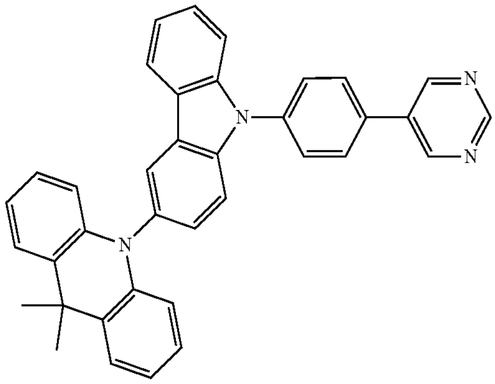
R' and R" are each independently a hydrogen atom, a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted aryl group having 6 to 30 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 4 to 30 carbon atoms for forming a ring, and

X, L, and R_1 to R_8 are the same as defined in Formula 1.

20. The organic electroluminescence device of claim **11**, wherein the emission layer comprises at least one of the compounds represented in the following Compound Group 1:

[Compound Group 1]

1



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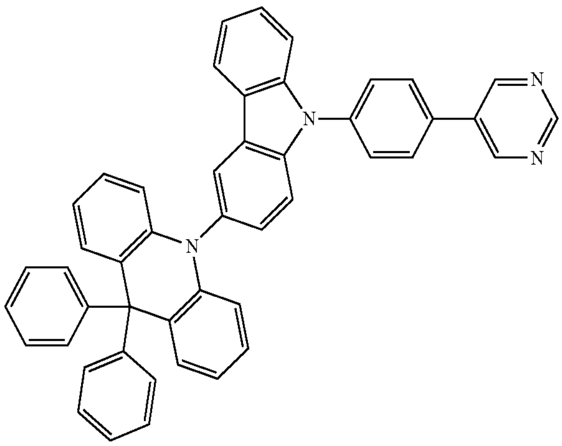

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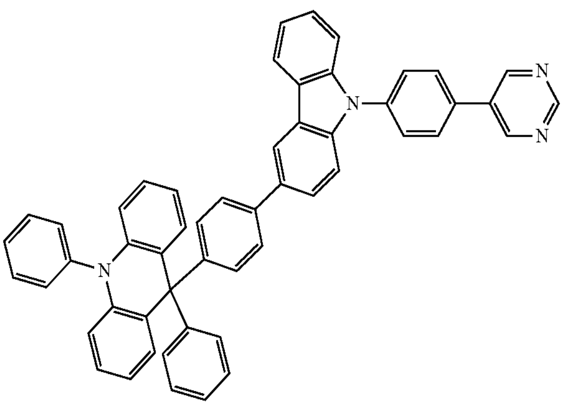

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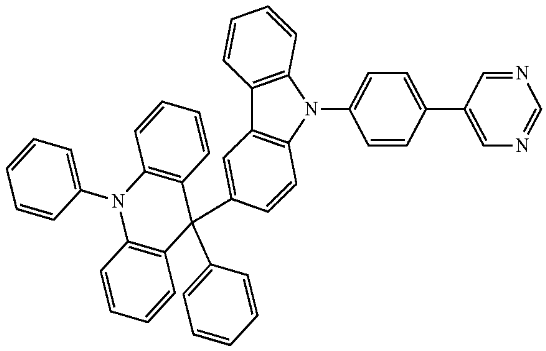

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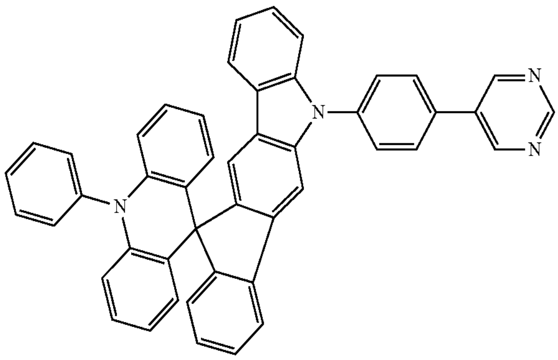

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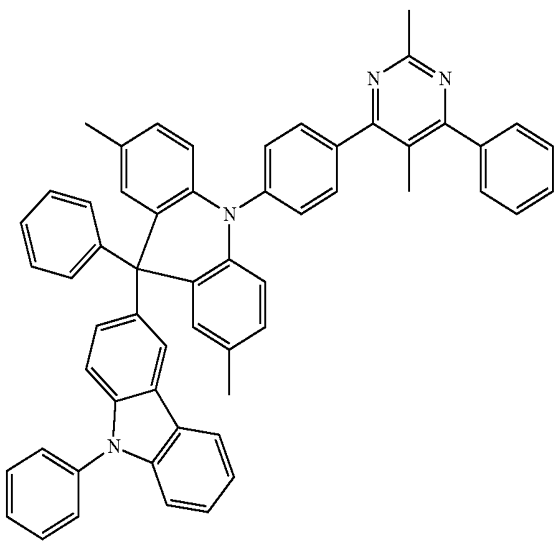

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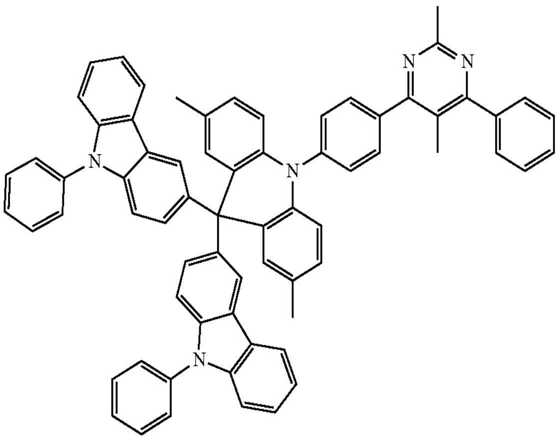

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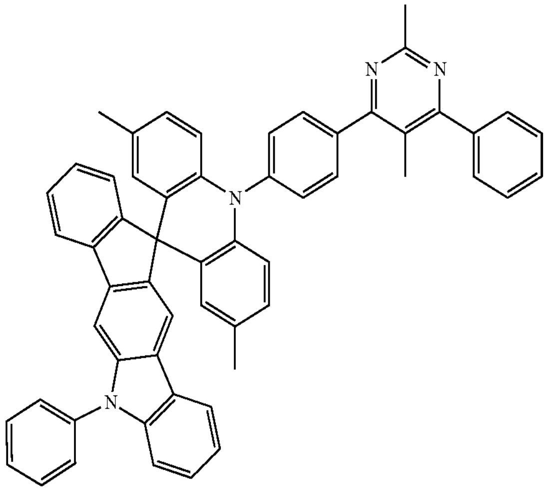

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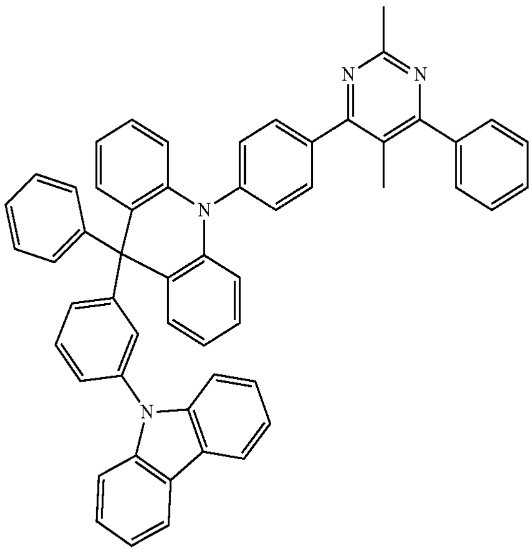

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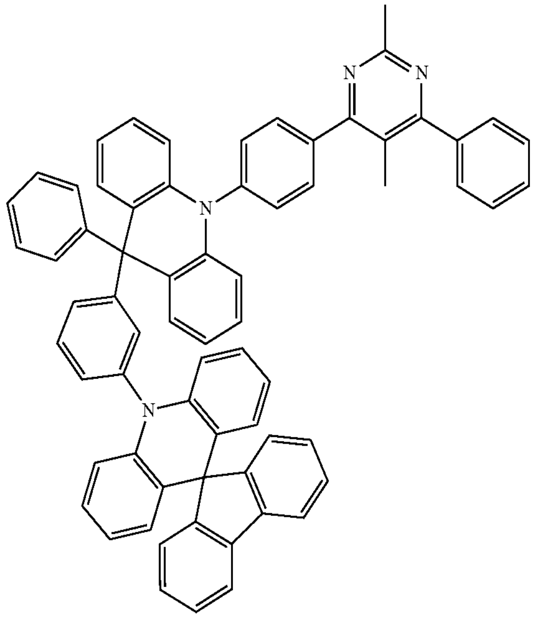

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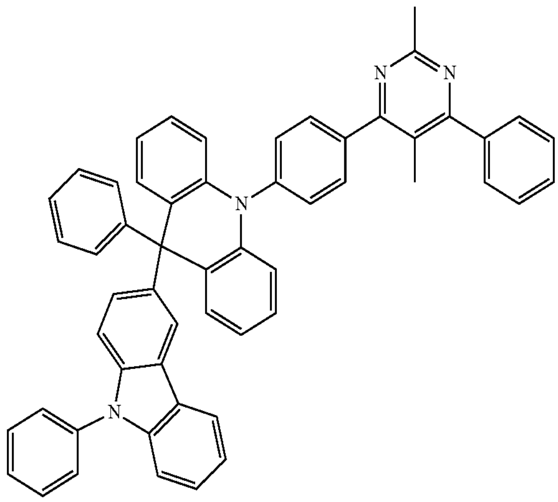

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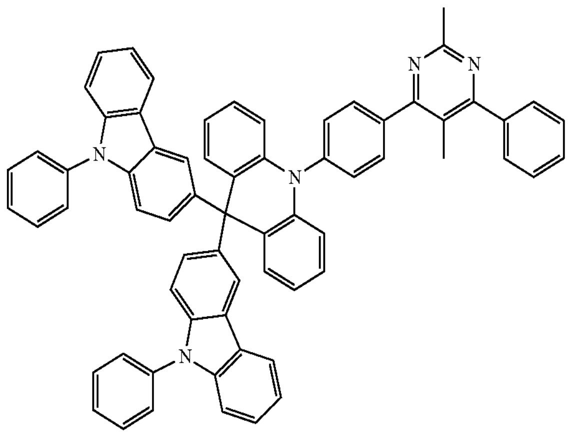

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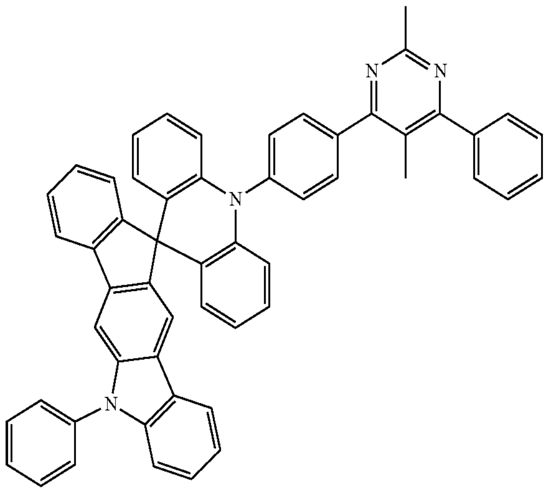

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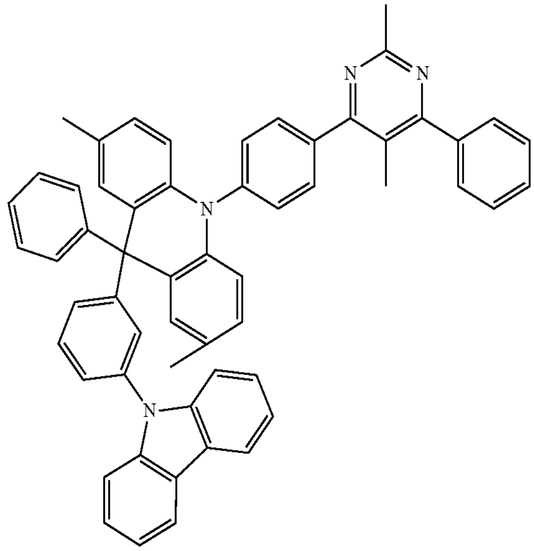

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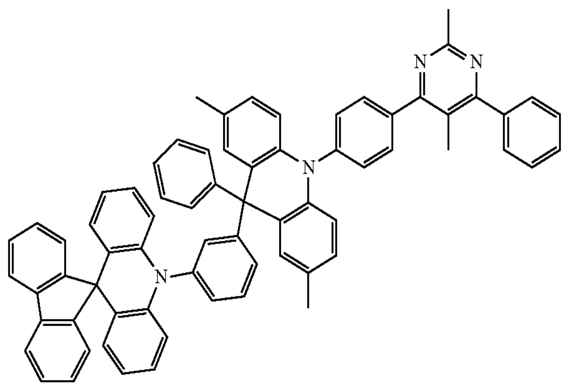

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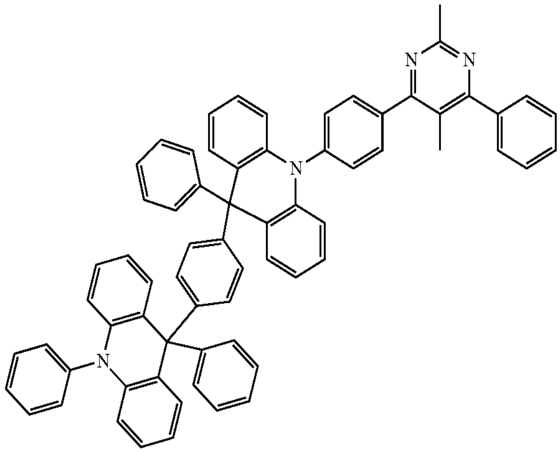

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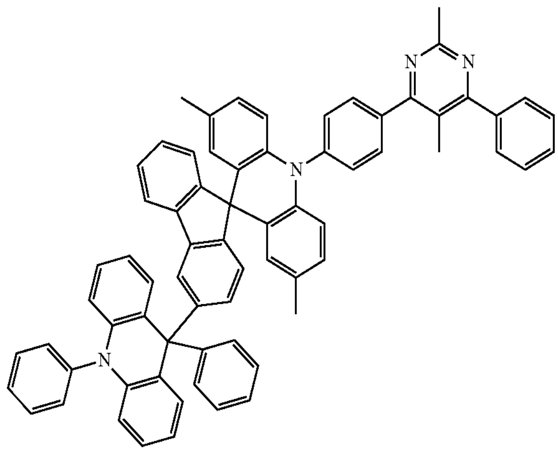

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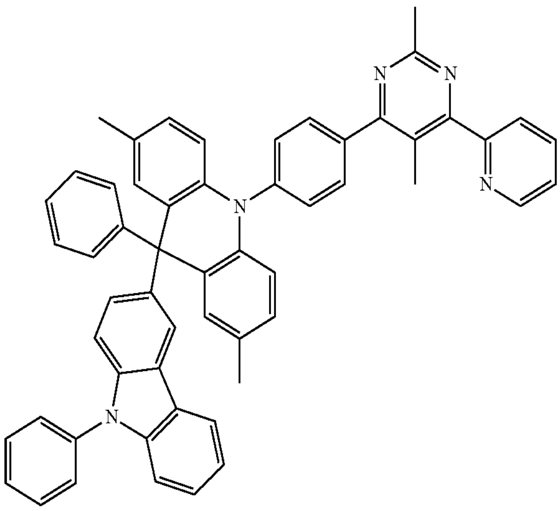

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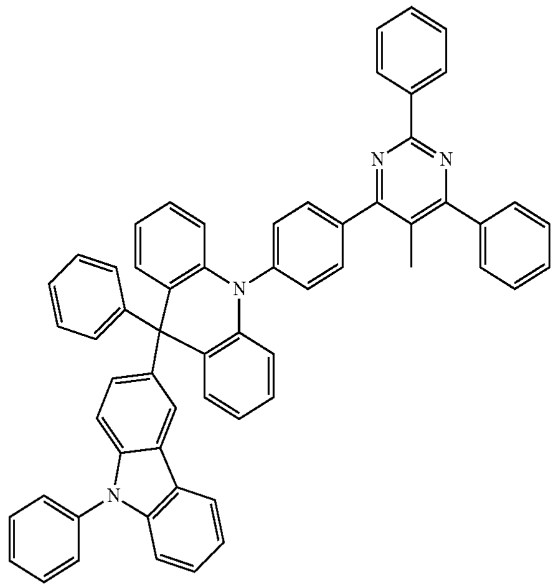

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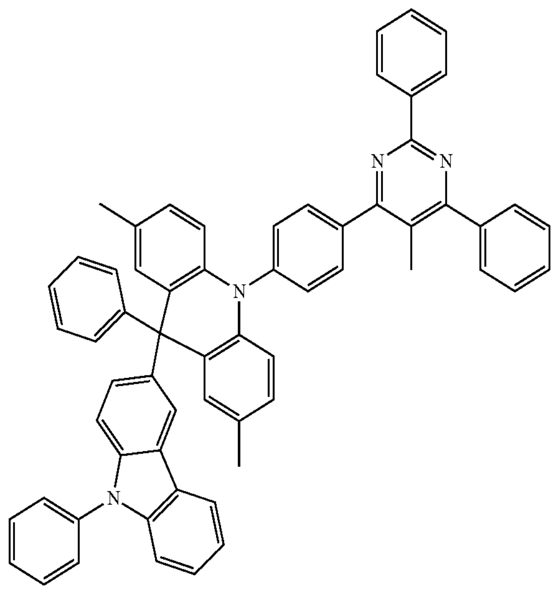

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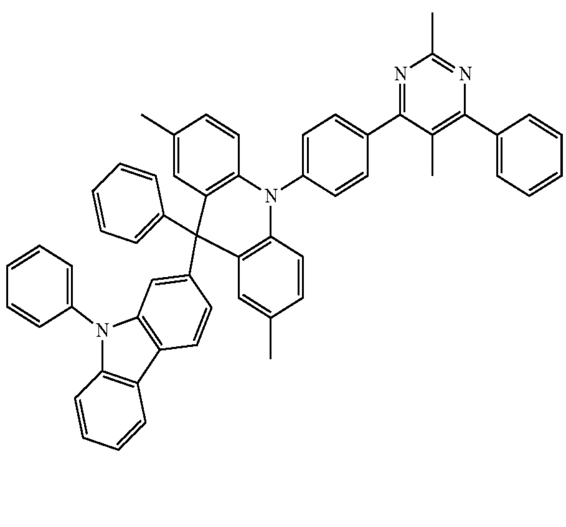

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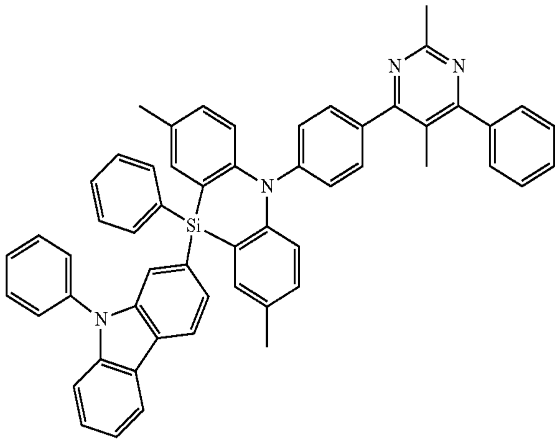

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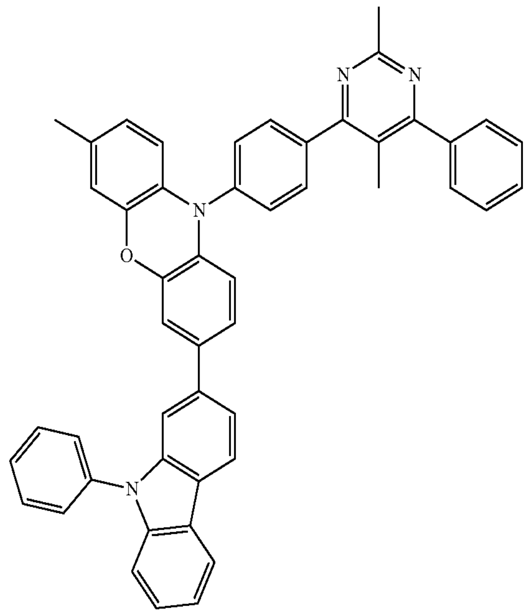

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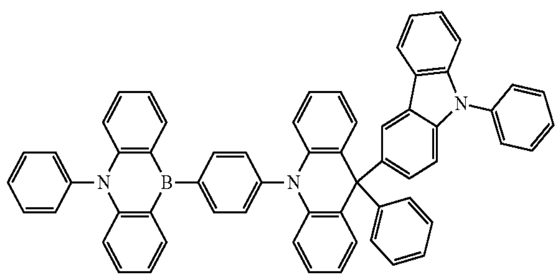

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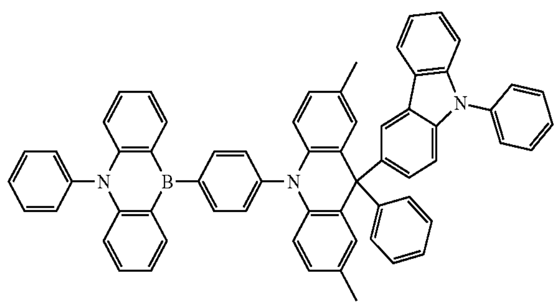

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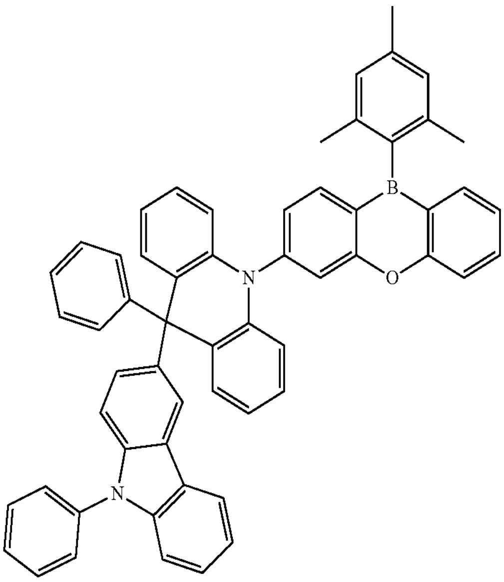

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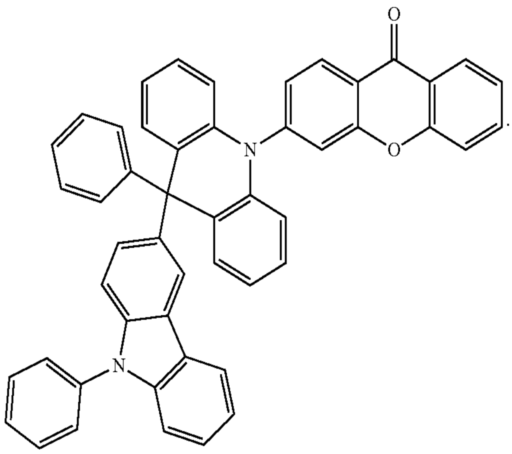

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专利名称(译)	芳族化合物和包括其的有机电致发光器件		
公开(公告)号	US20180155617A1	公开(公告)日	2018-06-07
申请号	US15/827078	申请日	2017-11-30
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	NAKANO HIROMI AKASHI NOBUTAKA		
发明人	NAKANO, HIROMI AKASHI, NOBUTAKA		
IPC分类号	C09K11/06 C09K11/08 H01L51/50 H01L51/00		
CPC分类号	C09K11/06 C09K11/0844 C09K11/0855 H01L51/5016 H01L51/5056 H01L51/0052 H01L51/0072 C09K2211/1011 C09K2211/1029 C09K2211/1033 C09K2211/1037 H01L2251/5307 H01L51/5012		
优先权	1020160162998 2016-12-01 KR		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供增强蓝色发光区域的发光效率的芳香族化合物和包含该芳香族化合物的有机电致发光元件。根据本发明构思的实施方案的芳族化合物由式1表示，并且在本公开中提供关于组分的更多细节。