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SHIOMI et al.(10) **Pub. No.: US 2019/0006598 A1**(43) **Pub. Date: Jan. 3, 2019**(54) **NOVEL COMPOUND, MATERIAL FOR ORGANIC ELECTROLUMINESCENCE DEVICE, AND ORGANIC ELECTROLUMINESCENCE DEVICE****Publication Classification**

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Tokyo (JP)(72) Inventors: **Takushi SHIOMI**, Sodegaura-shi,
Chiba (JP); **Masahiro KAWAMURA**,
Sodegaura-shi, Chiba (JP)(57) **ABSTRACT**

A compound represented by the following formula (1):

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Tokyo (JP)(21) Appl. No.: **16/064,411**(22) PCT Filed: **Dec. 22, 2016**(86) PCT No.: **PCT/JP2016/088408**

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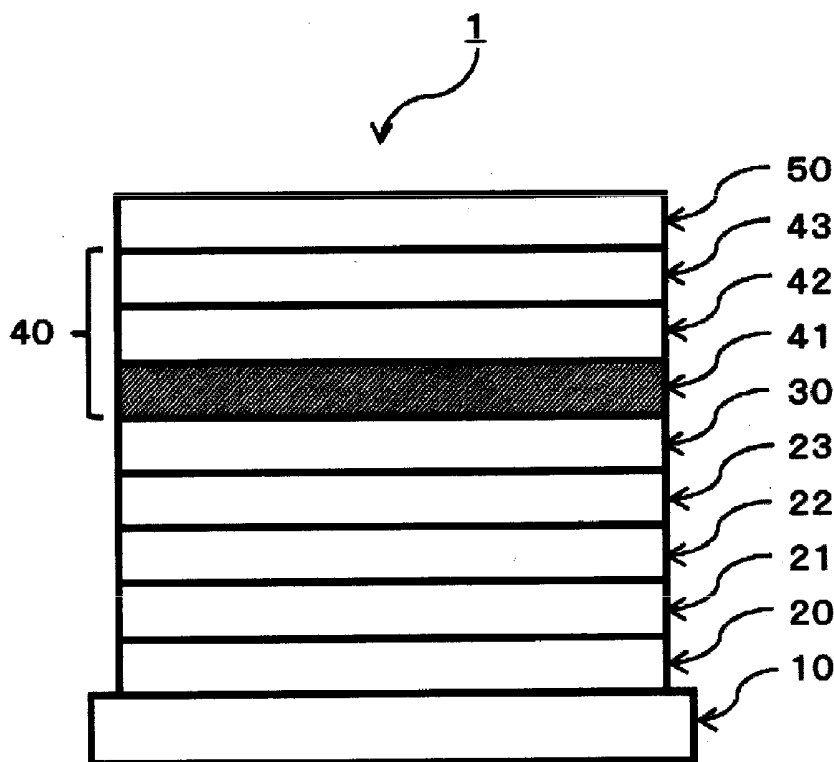
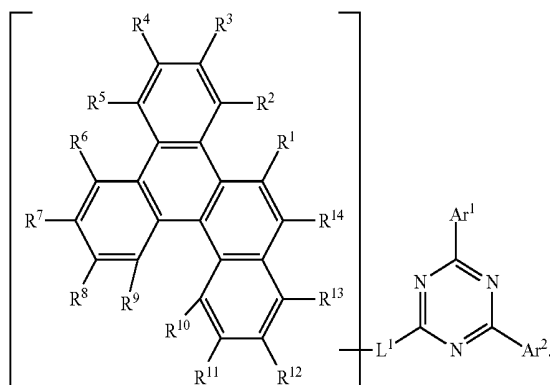
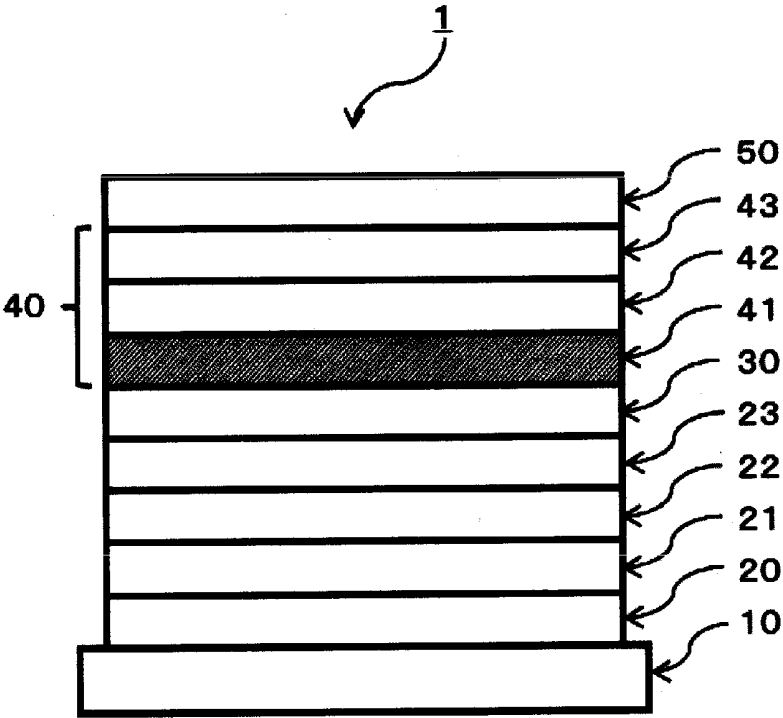


FIG. 1



NOVEL COMPOUND, MATERIAL FOR ORGANIC ELECTROLUMINESCENCE DEVICE, AND ORGANIC ELECTROLUMINESCENCE DEVICE

TECHNICAL FIELD

[0001] The invention relates to a novel compound, as well as to an organic electroluminescence device and an electronic apparatus using the same.

BACKGROUND ART

[0002] An organic electroluminescence (EL) device is regarded as a promising solid-emitting inexpensive large-area full color display device, and a large number of developments have been conducted so far. In general, an organic EL device comprises an emitting layer and a pair of opposing electrodes that sandwich the emitting layer. When an electrical field is applied between the both electrodes, electrons are injected from the cathode and holes are injected from the anode. Further, these electrons are re-combined with the holes in the emitting layer, create an excited state, and energy is emitted as light when the excited state is returned to the ground state.

[0003] In recent years, various materials for an organic EL device have been proposed (for example, see Patent Documents 1 and 2). In an organic EL device, further improvement in driving voltage, luminous efficiency, lifetime, color reproducibility, etc. is required. In particular, lowering in driving voltage is an important subject relating to consumption power of a product that is put on practical use. Therefore, a material for an organic EL device that can be driven at a lower driving voltage than conventional organic EL devices has been demanded.

[0004] Patent Document 1 states that a nitrogen-containing heterocyclic derivative that is obtained by bonding of a benzochrysene ring with a nitrogen-containing heterocyclic group through a linker or not through a linker can be used as a material for an organic EL device.

[0005] Patent Document 2 states that a nitrogen-containing heterocyclic derivative that is obtained by bonding of a benzophenanthrene ring with a nitrogen-containing heterocyclic group through a linker or not through a linker can be used as a material for an organic EL device.

RELATED ART DOCUMENTS

Patent Documents

[0006] Patent Document 1: WO2011/086935

[0007] Patent Document 2: WO2010/083869

SUMMARY OF INVENTION

[0008] An object of the invention is to provide a novel compound that is effective as a material for an organic EL device.

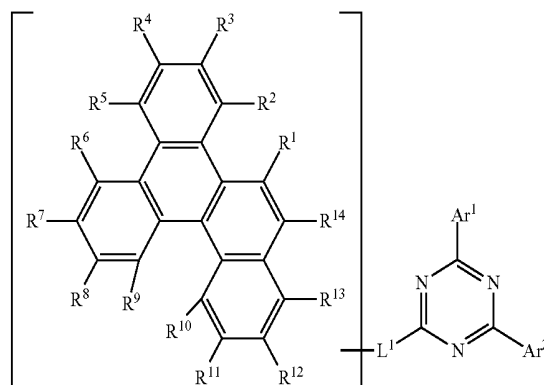
[0009] Another object of the invention is to provide an organic EL device that can be driven at a lower driving voltage.

[0010] As a result of extensive studies, the inventors have found that the driving voltage of an organic EL device containing a material for an organic EL device that contains both benzochrysene and triazine is lowered than the driving voltage of an organic EL device containing a conventional material for an organic EL device.

[0011] According to the invention, the following compound, material for an organic EL device, electron-transporting material, organic EL device and electric apparatus can be provided.

1. Compound represented by the following formula (1)

(1)



[0012] wherein in the formula (1),

[0013] any one of R¹ to R¹⁴ is a single bond and is bonded with L¹ and the remainder of R¹ to R¹⁴ are independently a hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group including 1 to 10 carbon atoms, a substituted or unsubstituted cycloalkyl group including 3 to 10 carbon atoms, a substituted or unsubstituted alkylsilyl group including 3 to 30 carbon atoms, a substituted or unsubstituted arylsilyl group including 8 to 30 carbon atoms that form a ring (hereinafter referred to as "ring carbon atoms"), a substituted or unsubstituted alkoxy group including 1 to 20 carbon atoms, a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms, a substituted or unsubstituted aryloxy group including 6 to 20 ring carbon atoms, a substituted or unsubstituted heteroaryl group including 5 to 20 atoms that form a ring (hereinafter referred to as "ring atoms"), a substituted or unsubstituted alkylthio group including 1 to 10 carbon atoms, a substituted or unsubstituted arylthio group including 6 to 20 ring carbon atoms or a substituted or unsubstituted arylamino group including 6 to 30 ring carbon atoms;

[0014] L¹ is a single bond, a substituted or unsubstituted arylene group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroarylene group including 5 to 20 ring atoms; and

[0015] Ar¹ and Ar² are independently a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms.

2. A material for an organic electroluminescence device that comprises the compound according to 1.

3. An electron-transporting material that comprises the compound according to 1.

4. An organic electroluminescence device in which one or more organic thin film layers comprising at least an emitting layer are disposed between a cathode and an anode, wherein at least one layer of the organic thin film layers comprises the compound according to 1 as a single or mixed component.

5. An electronic apparatus provided with the organic electroluminescence device according to 4.

[0016] According to the invention, a novel compound that is effective as a material for an organic EL device can be provided.

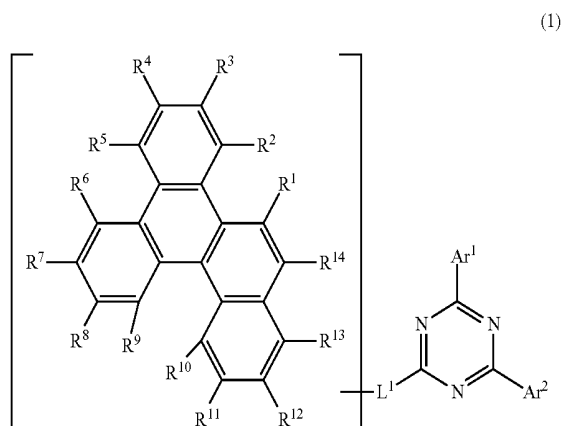
BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a schematic view showing the layer structure of organic EL devices fabricated in the Examples and the Comparative Examples.

MODE FOR CARRYING OUT THE INVENTION

[Novel Compound]

[0018] The compound according to one aspect of the invention is represented by the following formula (1):



[0019] wherein in the formula (1),

[0020] any one of R^1 to R^{14} is a single bond and is bonded with L^1 and the remainder of R^1 to R^{14} are independently a hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group including 1 to 10 carbon atoms, a substituted or unsubstituted cycloalkyl group including 3 to 10 carbon atoms, a substituted or unsubstituted alkylsilyl group including 3 to 30 carbon atoms, a substituted or unsubstituted arylsilyl group including 8 to 30 ring carbon atoms, a substituted or unsubstituted alkoxy group including 1 to 20 carbon atoms, a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms, a substituted or unsubstituted aryloxy group including 6 to 20 ring carbon atoms, a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms, a substituted or unsubstituted alkylthio group including 1 to 10 carbon atoms, a substituted or unsubstituted arylthio group including 6 to 20 ring carbon atoms or a substituted or unsubstituted arylamino group including 6 to 30 ring carbon atoms;

[0021] L^1 is a single bond, a substituted or unsubstituted arylene group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroarylene group including 5 to 20 ring atoms; and

[0022] Ar^1 and Ar^2 are independently a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms.

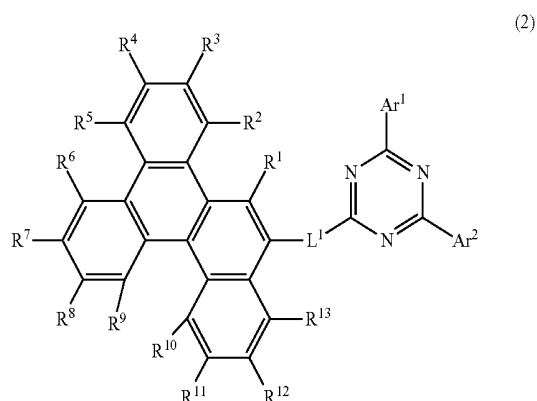
[0023] There is no case that adjacent groups of R^1 to R^{14} which are not bonded with L^1 through a single bond are bonded with each other to form a ring.

[0024] Patent Document 1 does not state specific compounds in which a benzochrysene ring is bonded with a triazine ring through or not through a linker.

[0025] Due to the above-mentioned structure, the compound according to one aspect of the invention can lower the driving voltage when used in an organic EL device.

[0026] In the formula (1), it is preferred that R^3 , R^4 , R^7 , R^8 , R^{11} , R^{12} , R^{13} or R^{14} be a single bond that is bonded with R^{14} is particularly preferable.

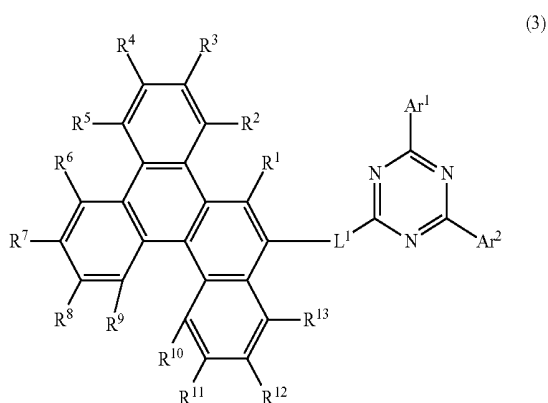
[0027] In one embodiment, it is preferred that the compound represented by the formula (1) be a compound represented by the following formula (2):



wherein in the formula (2), R^1 to R^{13} , Ar^1 and Ar^2 are as defined in the formula (1).

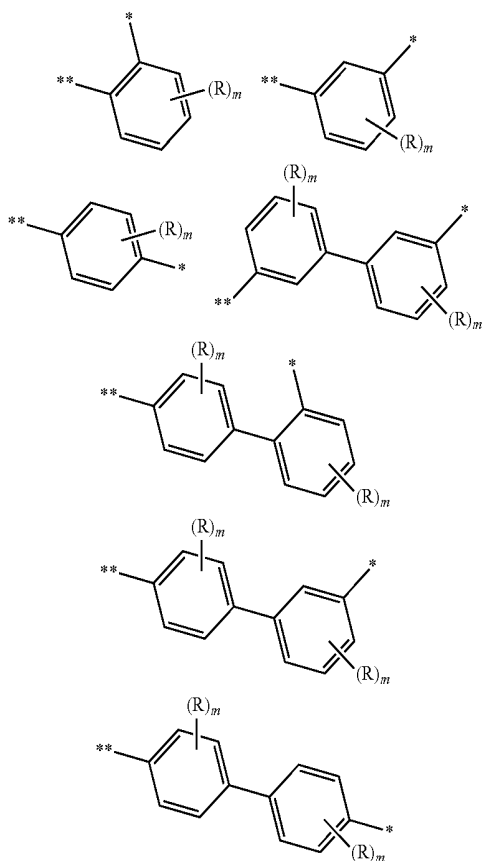
[0028] L^1 is preferably a single bond, a substituted or unsubstituted phenylene group, a substituted or unsubstituted naphthylene group, a substituted or unsubstituted anthracenylene group, a substituted or unsubstituted phenanthrylene group, a substituted or unsubstituted biphenylene group, a substituted or unsubstituted terphenylene group, a substituted or unsubstituted chrysénylene group, a substituted or unsubstituted benzophenanthrylene group, a substituted or unsubstituted benzochrysénylene group, a substituted or unsubstituted fluorenylene group, a substituted or unsubstituted fluoranthénylene group, a substituted or unsubstituted dibenzofuranylene group or a substituted or unsubstituted dibenzothiophénylene group.

[0029] In another embodiment, it is preferred that the compound represented by the formula (1) be a compound represented by the following formula (3):



[0030] wherein in the formula (3), R^1 to R^{13} , Ar^1 and Ar^2 are as defined in the formula (1); and

[0031] L^1 is a single bond or a group selected from the following groups.

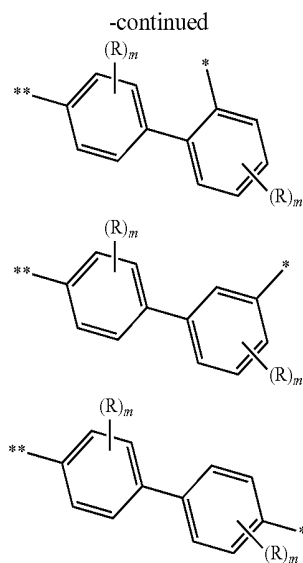
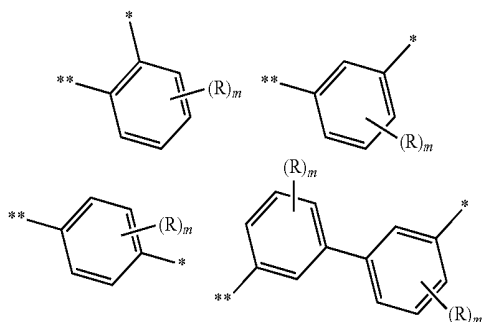


[0032] wherein in the formula, * is a single bond with a triazine ring and ** is a single bond with a benzochrysene ring;

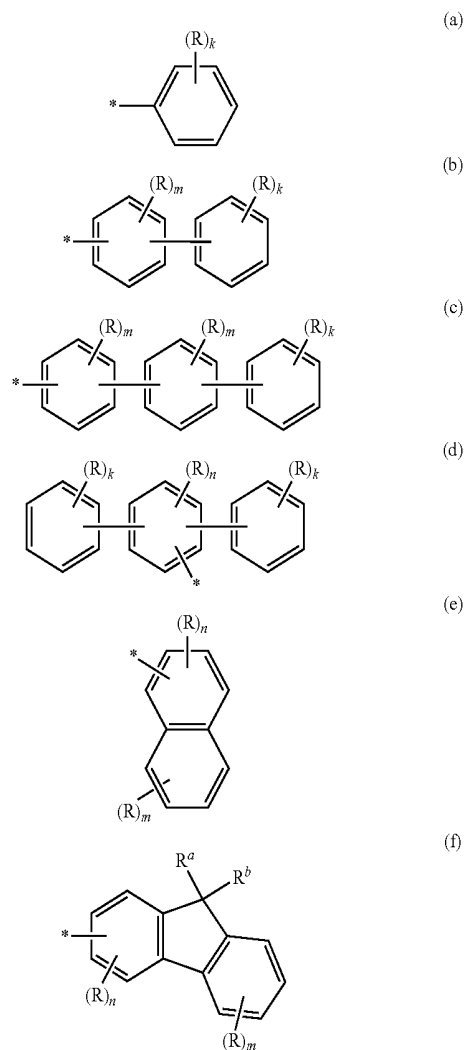
[0033] R is a substituent, and may be bonded to any position of the ring substituted by R ; and

[0034] m is an integer of 0 to 4, and when m is 2 or more, adjacent R s may be bonded with each other to form a ring.

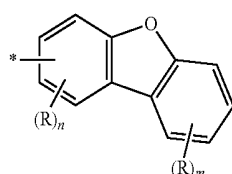
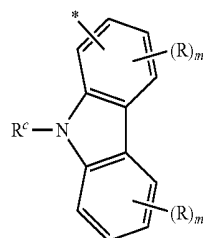
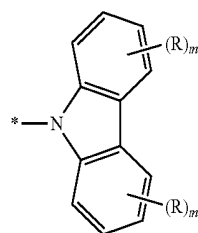
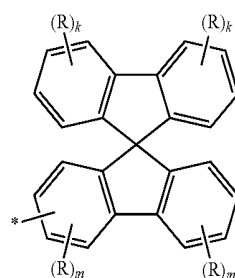
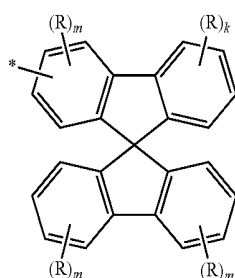
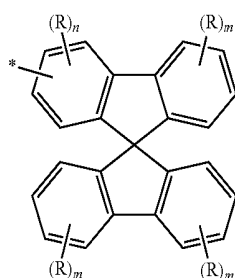
[0035] L^1 is more preferably a group selected from the following groups:



[0036] It is preferred that Ar^1 and Ar^2 be independently selected from the following groups:

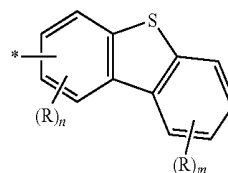


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(m)



(g)

(h)

(i)

(j)

(k)

(l)

[0037] wherein in the formulas (a) to (m), * is a single bond that is bonded with a triazine ring;

[0038] R is a substituent, and may be bonded to any position of the ring substituted by R;

[0039] k is an integer of 0 to 5, m is an integer of 0 to 4 and n is an integer of 0 to 3;

[0040] when each of k, m and n is 2 or more, adjacent Rs may be bonded with each other to form a ring;

[0041] R^a and R^b are independently a hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group including 1 to 8 carbon atoms, a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms; and

[0042] R^c is a substituted or unsubstituted alkyl group including 1 to 8 carbon atoms or a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms.

[0043] Ar^1 and Ar^2 are preferably a substituted or unsubstituted phenyl group.

[0044] R^1 to R^{13} are preferably a hydrogen atom.

[0045] The above-mentioned compound can be produced by the method mentioned in the Synthesis Examples. Further, following this reaction, the compound of the invention can be synthesized by using a known alternate reaction or materials suited to an intended product.

[0046] In the present specification, a hydrogen atom includes isomers differing in number of neutrons, i.e. protium, deuterium and tritium.

[0047] In the present specification, the number of ring carbon atoms means the number of carbon atoms among atoms constituting a ring of a compound in which atoms are bonded in the form of a ring (for example, a monocyclic compound, a fused ring compound, a cross-linked compound, a carbocyclic compound or a heterocyclic compound). When the ring is substituted by a substituent, the carbon contained in the substituent is not included in the number of ring carbon atoms. The same is applied to the "ring carbon atoms" mentioned below, unless otherwise indicated. For example, a benzene ring includes 6 ring carbon atoms, a naphthalene ring includes 10 ring carbon atoms, a pyridinyl group includes 5 ring carbon atoms, and a furanyl group includes 4 ring carbon atoms. When a benzene ring or a naphthalene ring is substituted by an alkyl group as a substituent, for example, the number of carbon atoms of the alkyl group is not included in the number of ring carbon atoms. When a fluorene ring is bonded with a fluorene ring as a substituent (including a spirofluorene ring), for example, the number of carbon atoms of the fluorene ring as the substituent is not included in the number of ring carbon atoms.

[0048] In the present specification, the number of ring atoms means the number of atoms constituting a ring of a compound having a structure in which atoms are bonded in the form of a ring (for example, monocycle, fused ring, ring assembly) (for example, a monocyclic compound, a fused

ring compound, a cross-linked compound, a carbocyclic compound or a heterocyclic compound). It does not include atoms which do not form a ring or atoms contained in a substituent when the ring is substituted by the substituent. The same is applied to the “ring atoms” mentioned below, unless otherwise indicated. For example, a pyridine ring includes 6 ring atoms, a quinazoline ring includes 10 ring atoms, and a furan ring includes 5 ring atoms. Hydrogen atoms respectively bonded with a carbon atom of a pyridine ring or a quinazoline ring or atoms constituting a substituent are not included in the number of ring atoms. When a fluorene ring is bonded with a fluorene ring as a substituent (including a spirofluorene ring), for example, the number of atoms of the fluorene ring as a substituent is not included in the number of ring atoms.

[0049] In the present specification, the “XX to YY carbon atoms” in the “substituted or unsubstituted ZZ group including XX to YY carbon atoms” means the number of carbon atoms when the ZZ group is unsubstituted. The number of carbon atoms of a substituent when the group is substituted is not included.

[0050] In the present specification, the “XX to YY atoms” in the “substituted or unsubstituted ZZ group including XX to YY atoms” means the number of atoms when the ZZ group is unsubstituted. The number of atoms of a substituent when the group is substituted is not included.

[0051] In the present specification, the “unsubstituted” in the “substituted or unsubstituted” means bonding of a hydrogen atom, not substitution by the substituent mentioned above.

[0052] Hereinbelow, a detailed explanation is given on each group represented by each of the above-mentioned formulas.

[0053] As the aryl group, a phenyl group, a naphthyl group, an anthryl group, a phenanthryl group, a naphthacenyl group, a pyrenyl group, a chrysenyl group, a benzo[c]phenanthryl group, a benzo[g]chrysenyl group, a triphenylenyl group, a fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a biphenylyl group, an o-terphenyl group, an m-terphenyl group, a p-terphenyl group, a fluoranthenyl group or the like can be given, for example. In addition, a spirofluorenyl group can be given.

[0054] It is preferred that the aryl group have 6 to 20 ring carbon atoms, more preferably 6 to 12 ring carbon atoms. As one preferable aspect of the aryl group, a phenyl group, a naphthyl group and a phenanthryl group can be given.

[0055] As the arylene group, a divalent group that corresponds to the examples of the aryl group can be given.

[0056] As the heteroaryl group, a pyrrolyl group, a triazinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridinyl group, an indolyl group, an isoindolyl group, an imidazolyl group, a furyl group, a benzofuranyl group, an isobenzofuranyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a quinolyl group, an isoquinolyl group, a quinoxalinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a phenothiazinyl group, a phenoxazinyl group, an oxazolyl group, an oxadiazolyl group, a furazanyl group, a thienyl group, a benzothiophenyl group or the like can be given, for example. Further, a benzimidazolyl group and a quinazolinyl group can be given.

[0057] The ring atoms of the heteroaryl group is preferably 5 to 20, with 5 to 14 being further preferable. As one preferable aspect of the heteroaryl group, a triazinyl group,

pyrimidinyl group, a pyridinyl group, a dibenzofuranyl group, a dibenzothiophenyl group and a carbazolyl group can be given.

[0058] As the heteroarylene group, a divalent group corresponding to the examples of the above-mentioned heteroaryl group can be given.

[0059] As the halogen atom, fluorine, chlorine, bromine, iodine or the like can be given, with a fluorine atom being preferable.

[0060] As the alkyl group, a methyl group, an ethyl group, a propyl group, an isopropyl group, a n-butyl group, a s-butyl group, an isobutyl group, a t-butyl group, a n-pentyl group, a n-hexyl group, a n-heptyl group, a n-octyl group or the like can be given.

[0061] The number of carbon atoms of the alkyl group is preferably 1 to 10, with 1 to 6 being further preferable. Among them, a methyl group, an ethyl group, a propyl group, an isopropyl group, a n-butyl group, a s-butyl group, an isobutyl group, a t-butyl group, a n-pentyl group and a n-hexyl group are preferable.

[0062] As the cycloalkyl group, a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a 4-methylcyclohexyl group, an adamantyl group, a norbornyl group or the like can be given.

[0063] The number of ring carbon atoms is preferably 3 to 10, more preferably 3 to 8, with 3 to 6 being particularly preferable.

[0064] An alkylsilyl group is a silyl group substituted by one to three alkyl group(s). As examples of an alkyl group, the above-mentioned examples of an alkyl group can be given.

[0065] As the alkylsilyl group, a trimethylsilyl group, a triethylsilyl group, a t-butyldimethylsilyl group, a vinyl dimethylsilyl group, a propyldimethylsilyl group, a triisopropylsilyl group or the like can be given.

[0066] The arylsilyl group is a silyl group substituted by one to three aryl group(s). As examples of the aryl group, the examples of the aryl group mentioned above can be given. Other than the aryl group, the arylsilyl group may be substituted by the above-mentioned alkyl group. As the arylsilyl group, a triphenylsilyl group, a phenyldimethylsilyl group or the like can be given.

[0067] The alkoxy group is represented by —OY. As examples of Y, the examples of the alkyl mentioned above can be given. The alkoxy group is a methoxy group or an ethoxy group, for example.

[0068] The aryloxy group is represented by —OZ. As examples of Z, the examples of the aryl group mentioned above can be given. The aryloxy group is a phenoxy group, for example.

[0069] The alkylthio group is represented by —SY. As examples of Y, the examples of the alkyl group mentioned above can be given.

[0070] The arylthio group is represented by —SZ. As examples of Z, the examples of the aryl group mentioned above can be given.

[0071] The arylamino group is an amino group substituted by one or two aryl groups. As examples of the aryl group, the example of the aryl group mentioned above can be given.

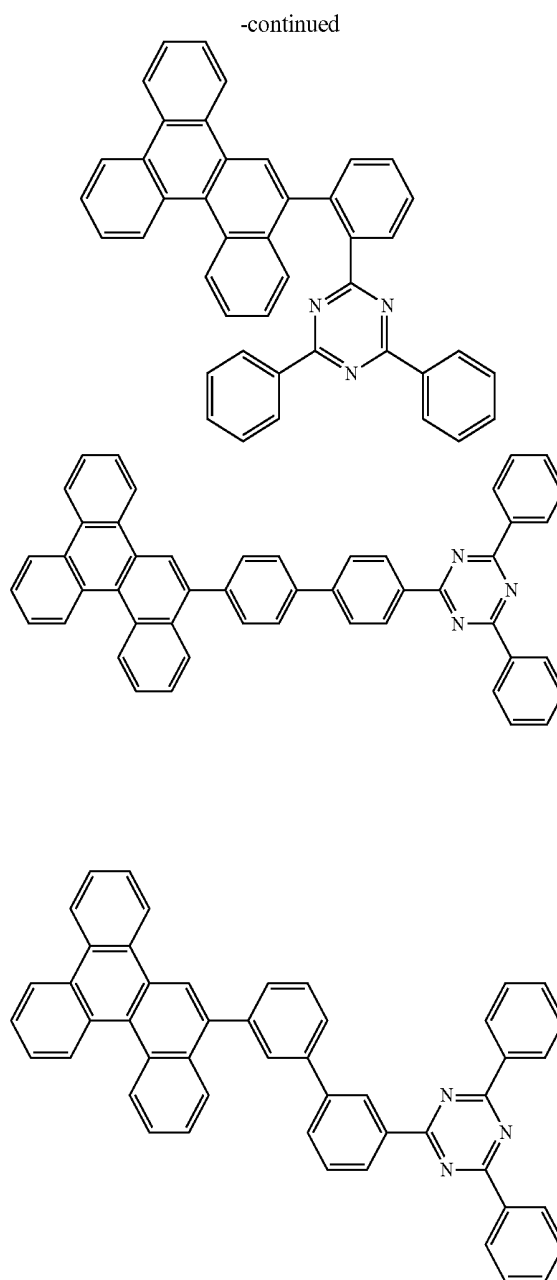
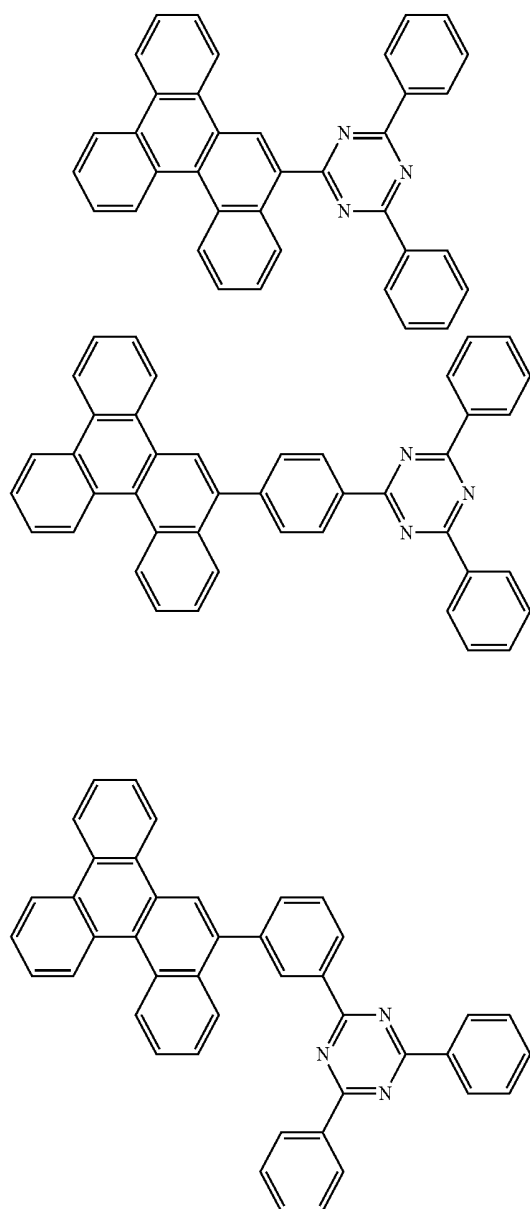
[0072] As examples of the substituent in the “substituted or unsubstituted . . .” and the substituent R, in addition to the groups explained above, a cyano group, an amino group, a carboxyl group or the like can be given. Further, a phosphoryl group can be given. Preferably, an alkyl group

including 1 to 10 carbon atoms, an aryl group including 6 to 20 ring carbon atoms, or a heteroaryl group including 5 to 20 ring atoms, a cyano group, or the like.

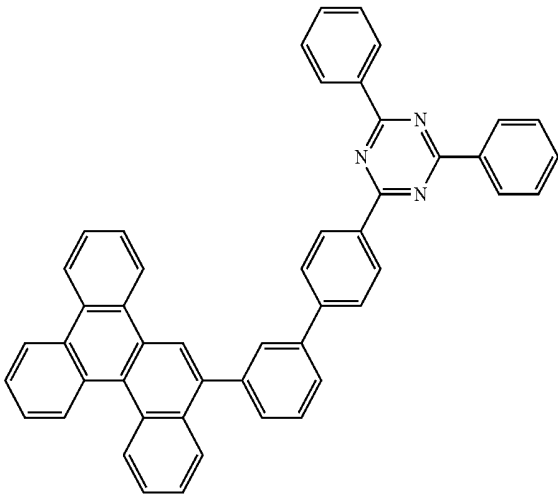
[0073] The substituent when Ar¹ and Ar² are a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms is preferably an alkyl group including 1 to 10 carbon atoms, an aryl group including 6 to 20 ring carbon atoms, a heteroaryl group including 5 to 20 ring atoms excluding a nitrogen-containing heterocyclic group, a cyano group, etc. As the heteroaryl group including 5 to 20 ring atoms excluding a nitrogen-containing heterocyclic group, an oxygen-containing heterocyclic group and a sulfur-containing heterocyclic group can be given, for example.

[0074] These substituents may be further substituted by the substituents mentioned above.

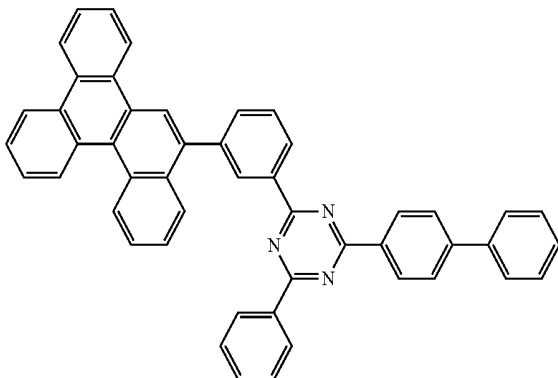
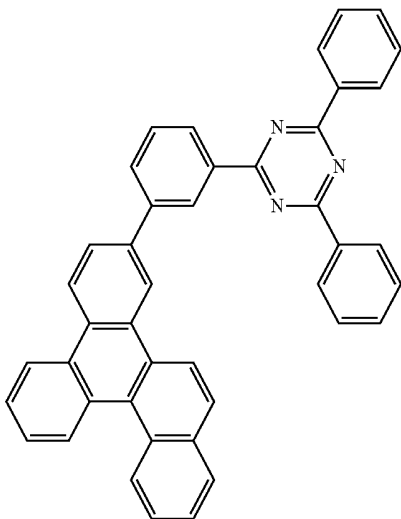
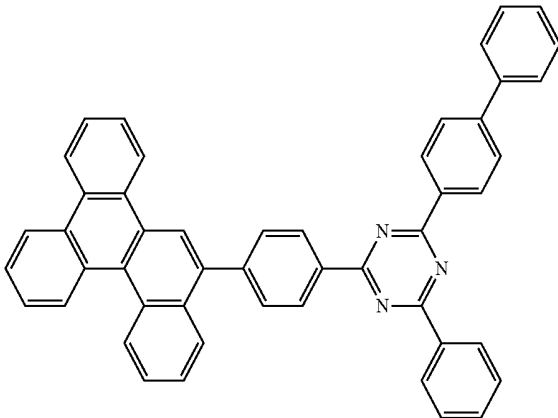
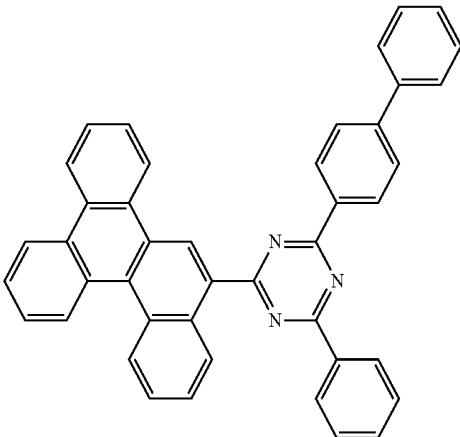
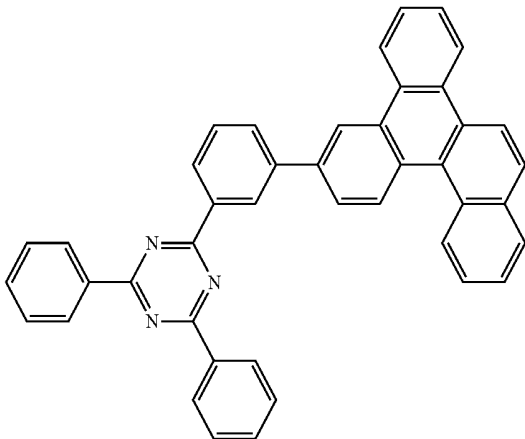
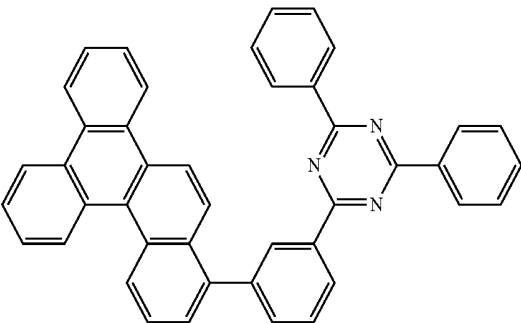
[0075] Examples of the compound according to one aspect of the invention are shown below.



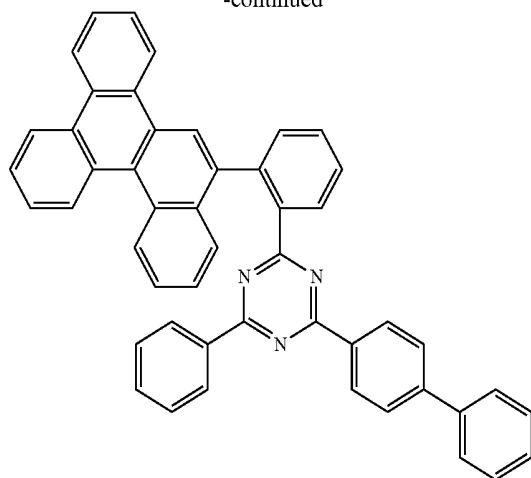
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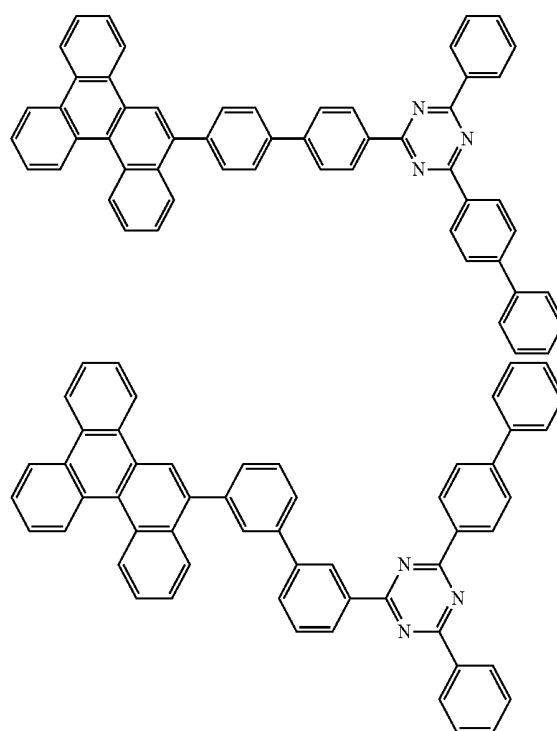
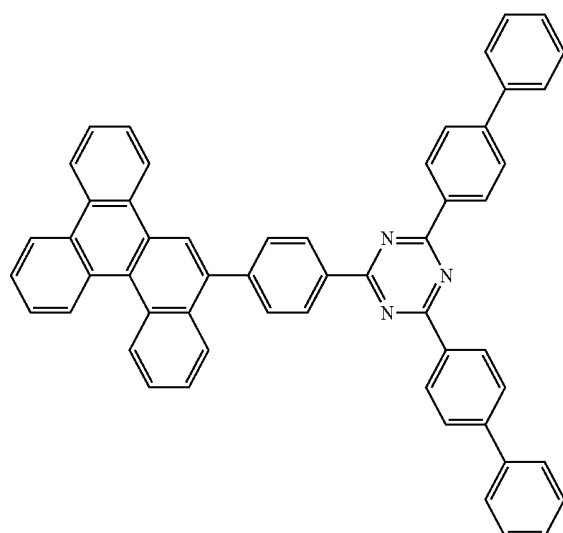
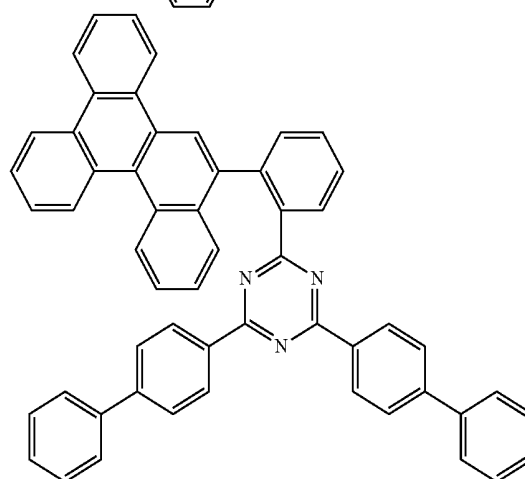
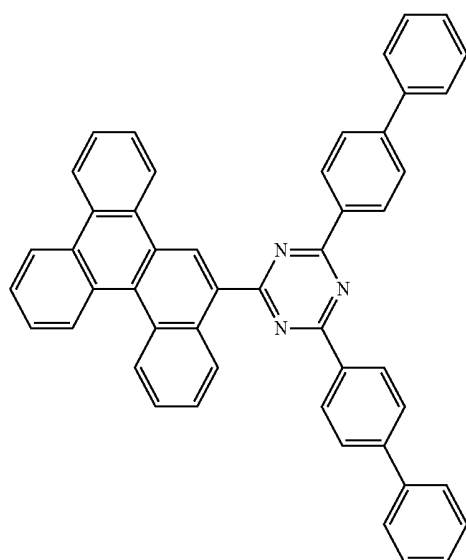
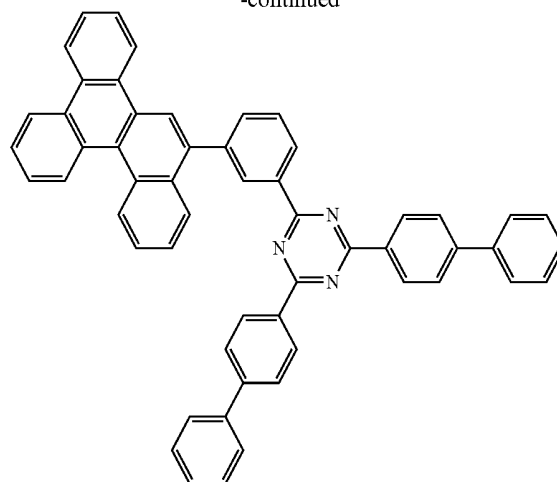
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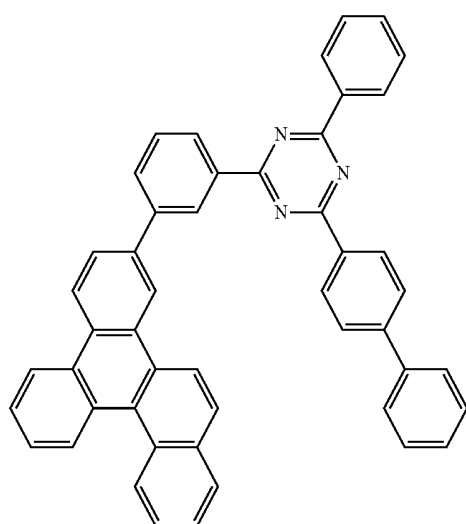
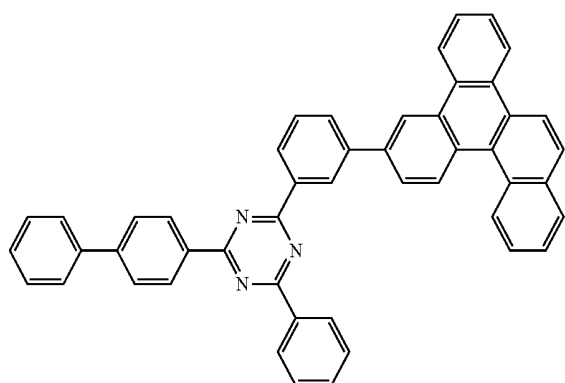
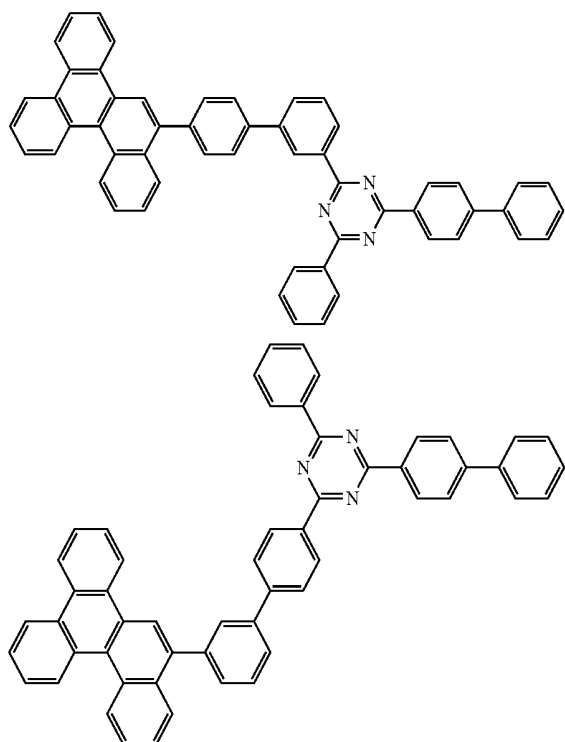
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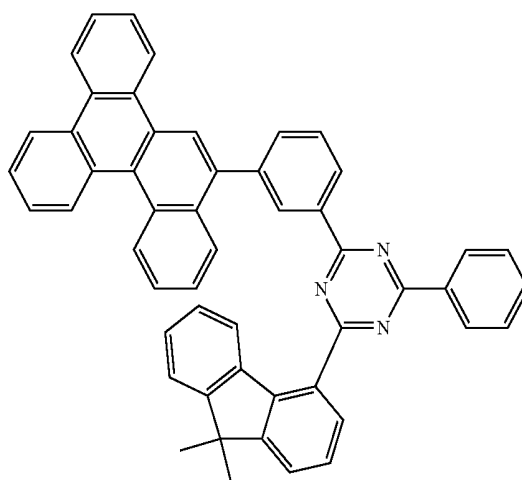
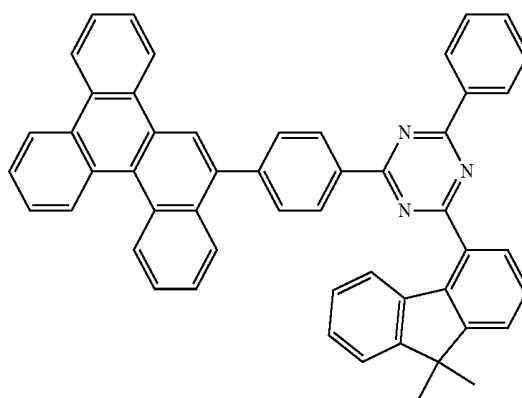
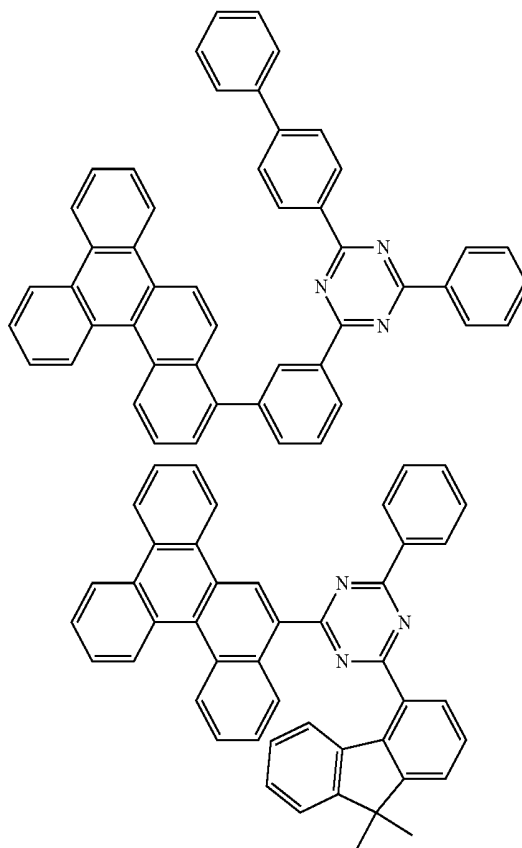
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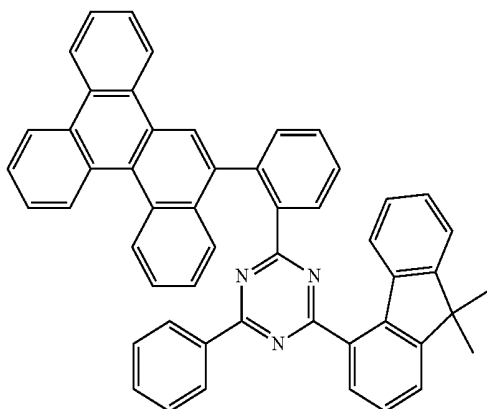
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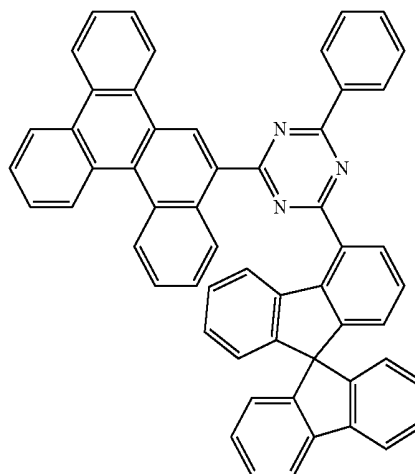
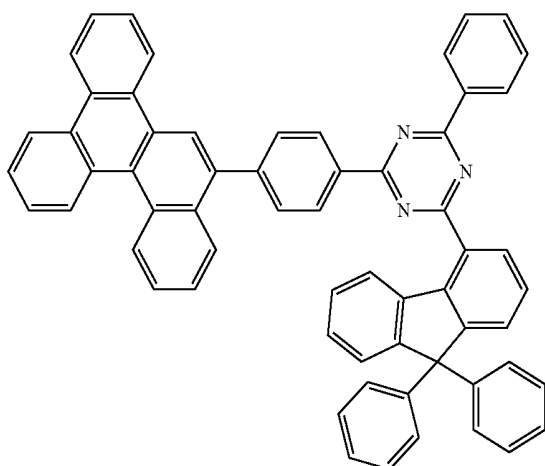
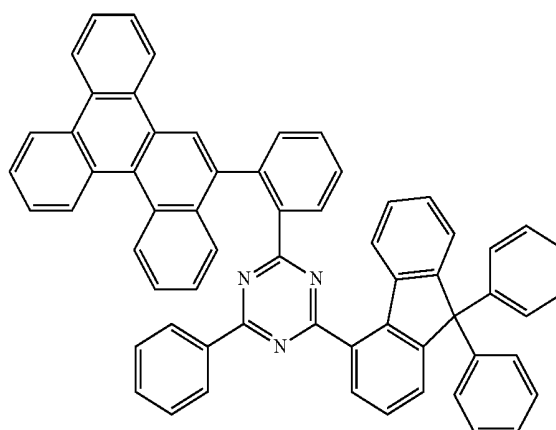
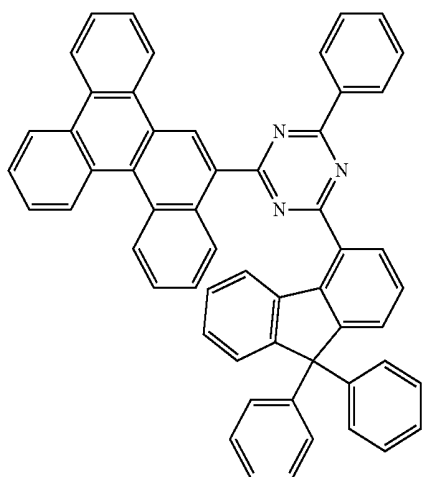
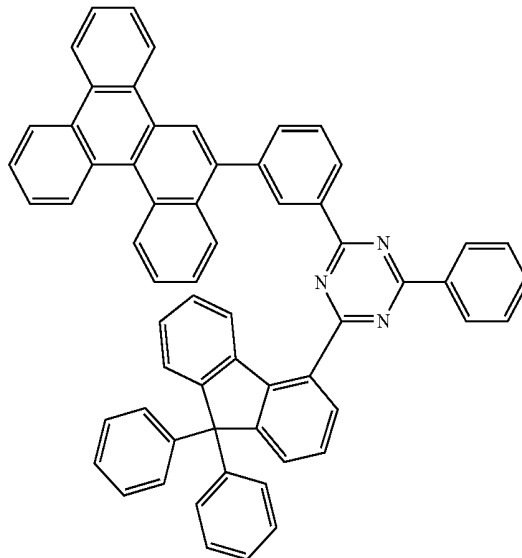
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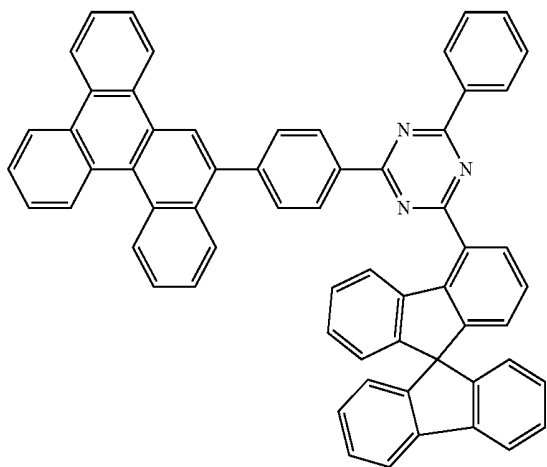
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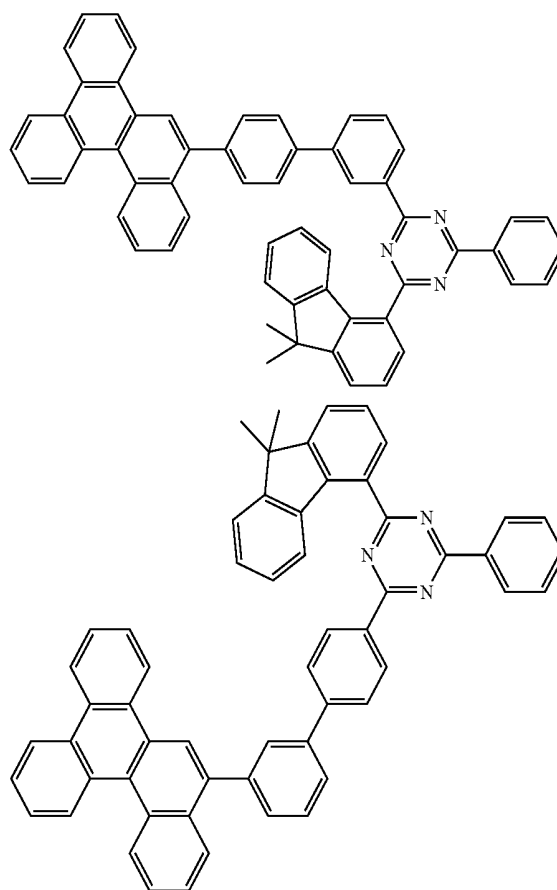
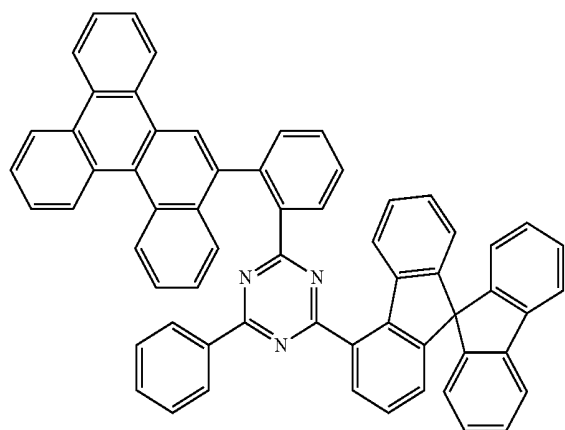
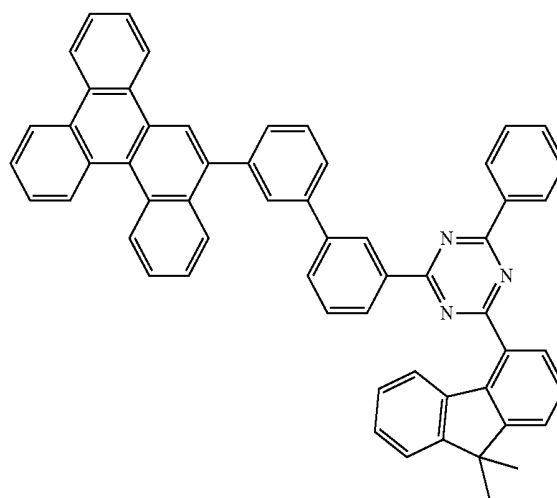
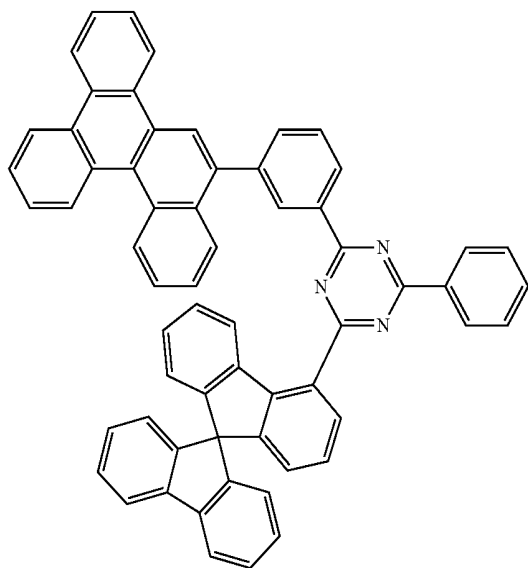
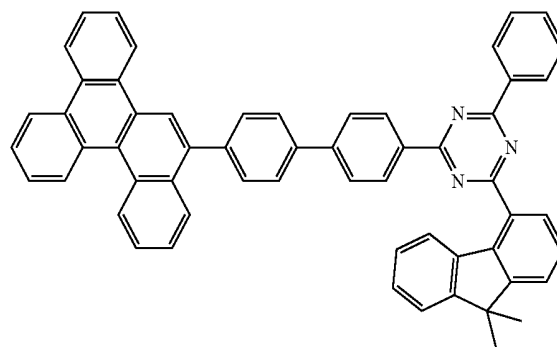
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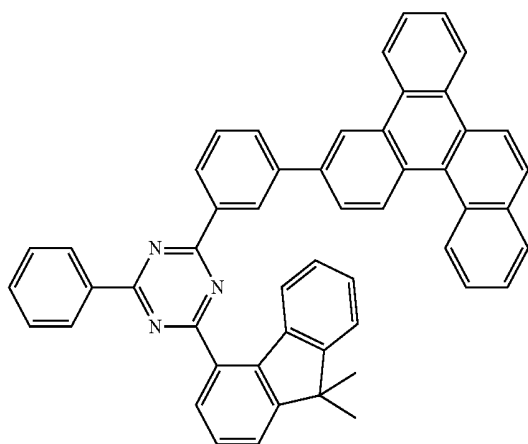
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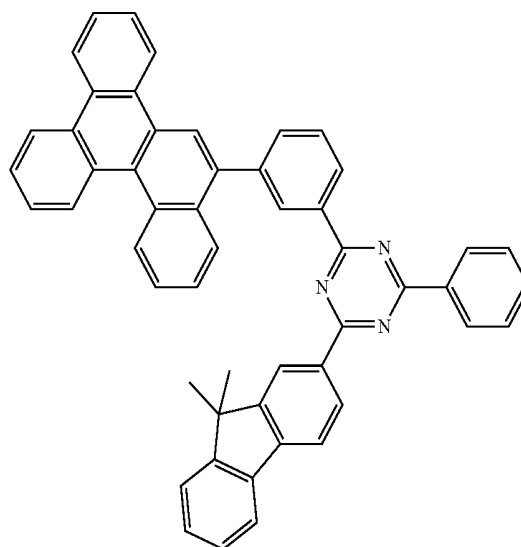
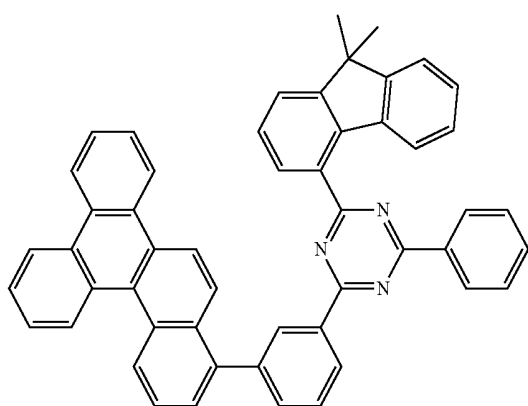
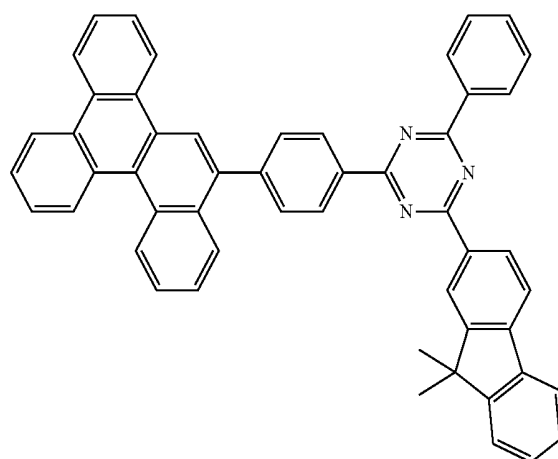
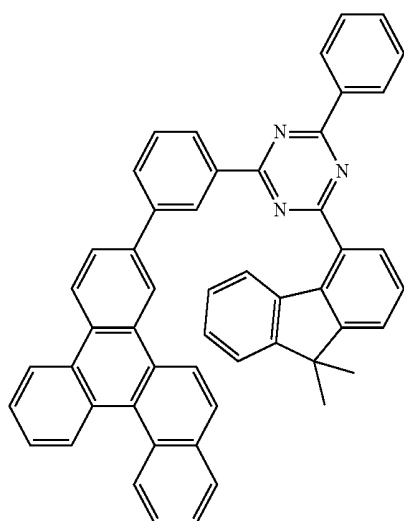
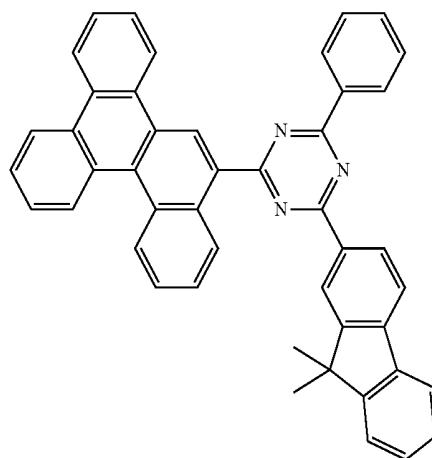
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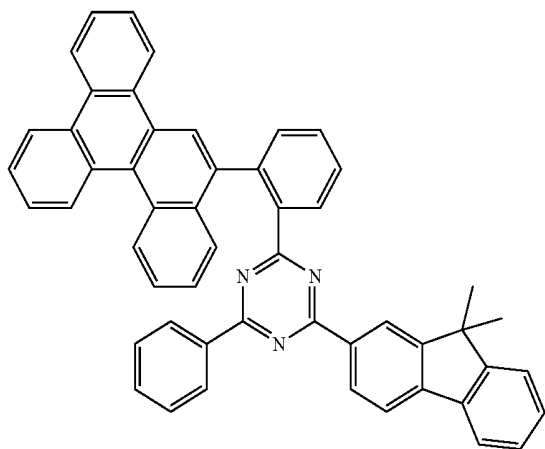
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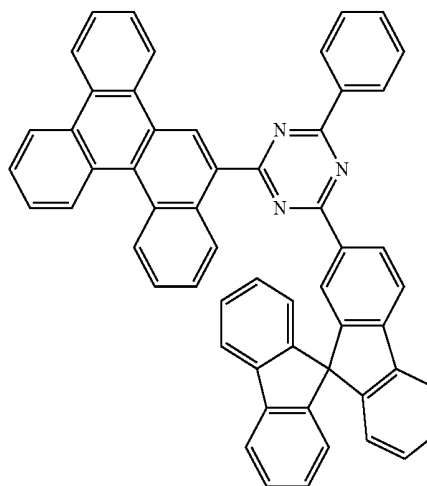
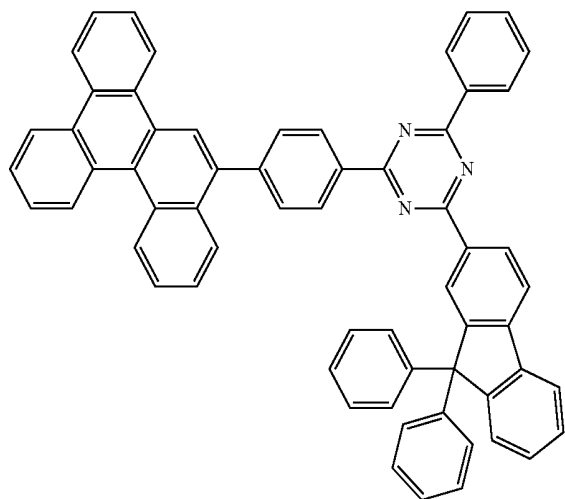
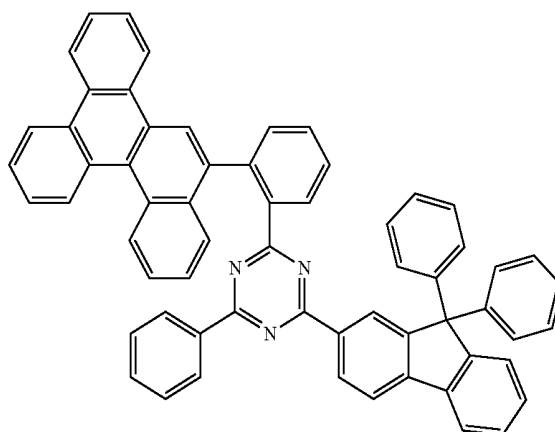
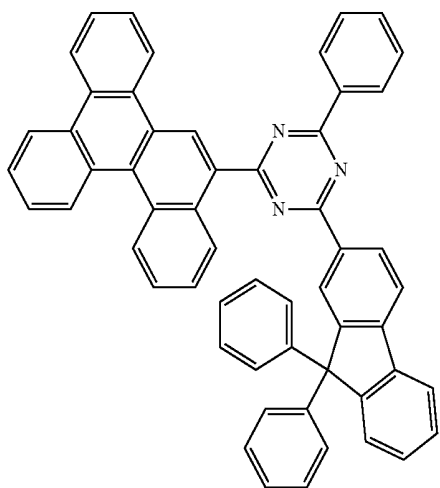
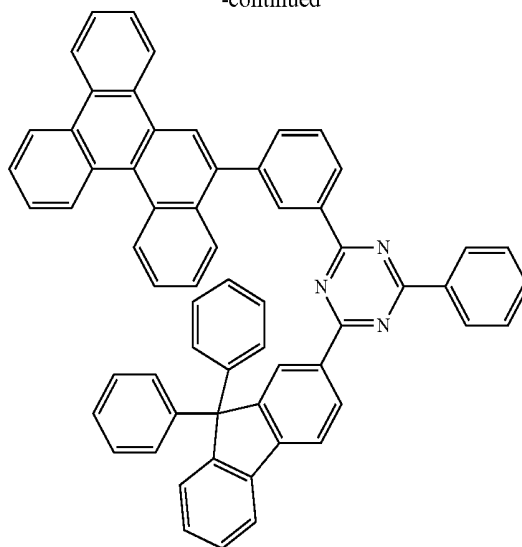
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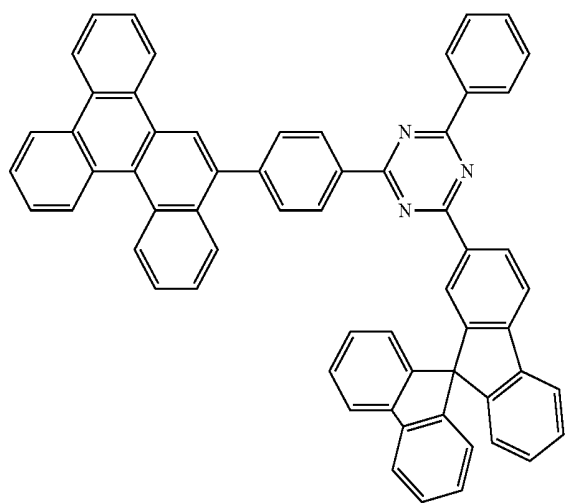
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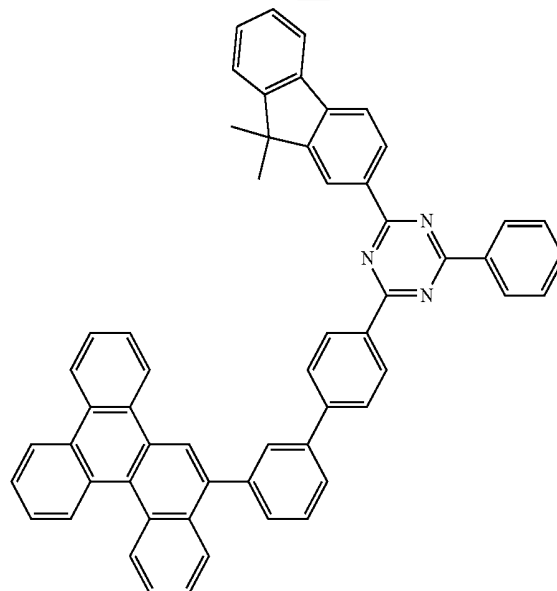
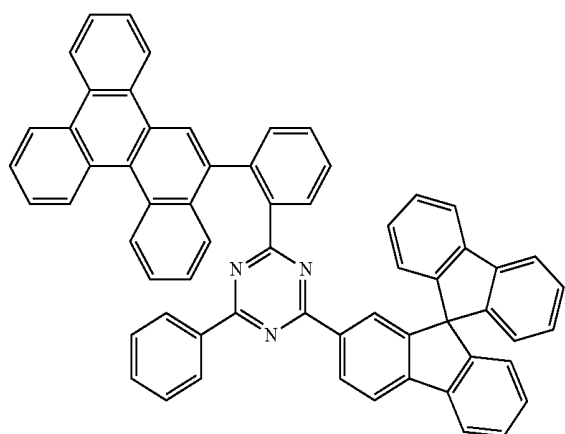
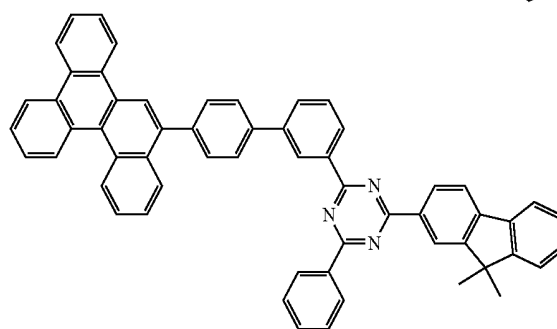
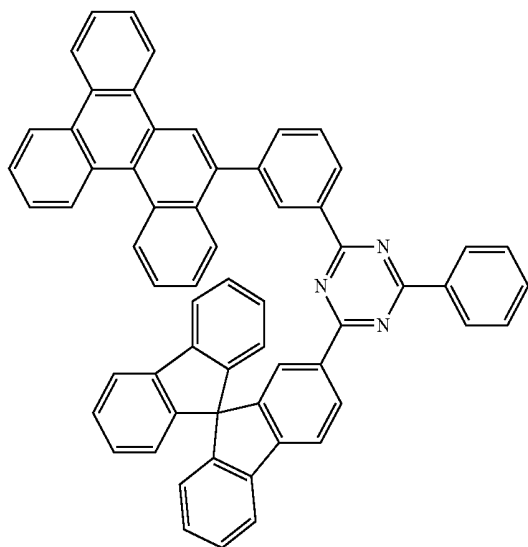
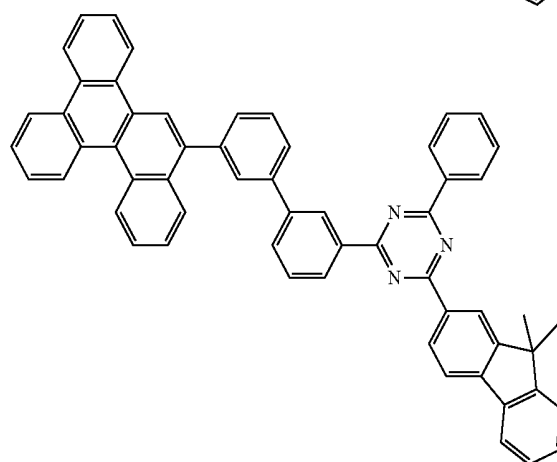
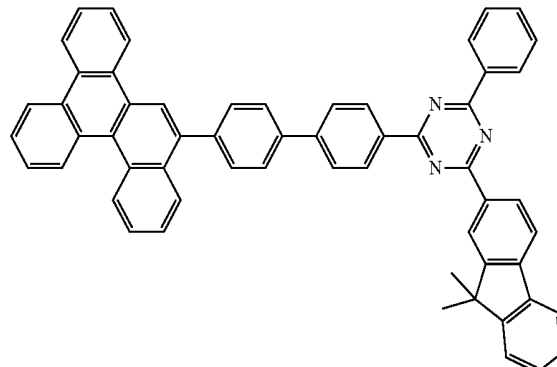
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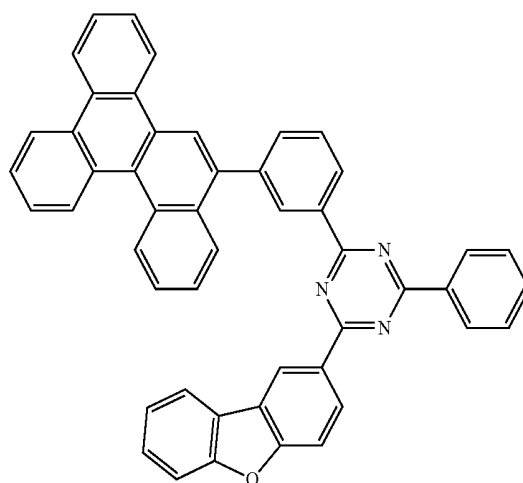
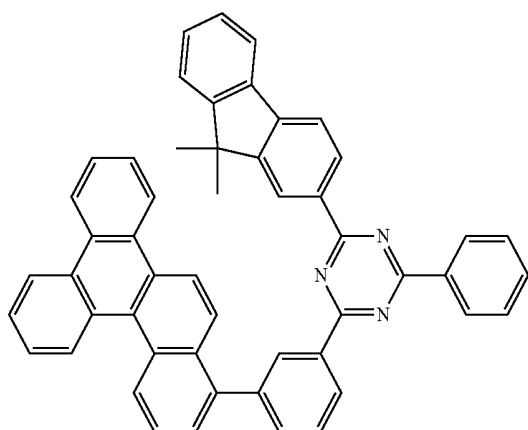
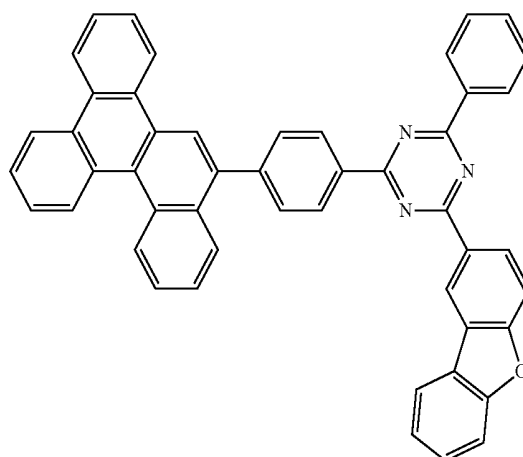
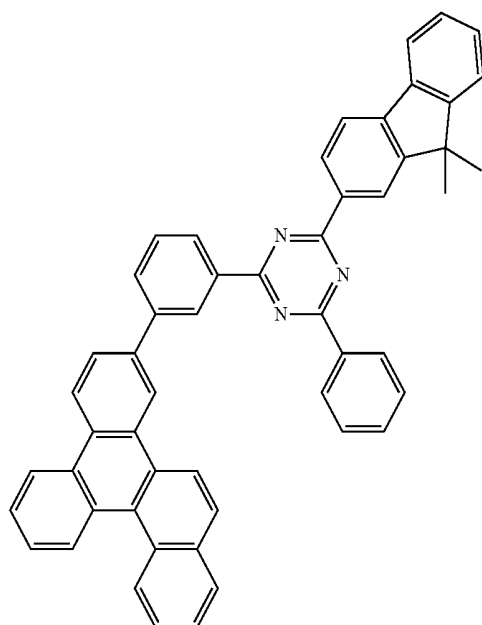
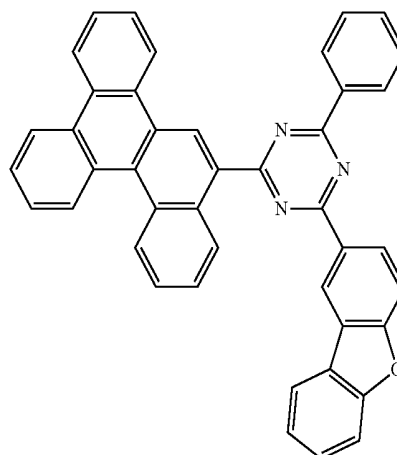
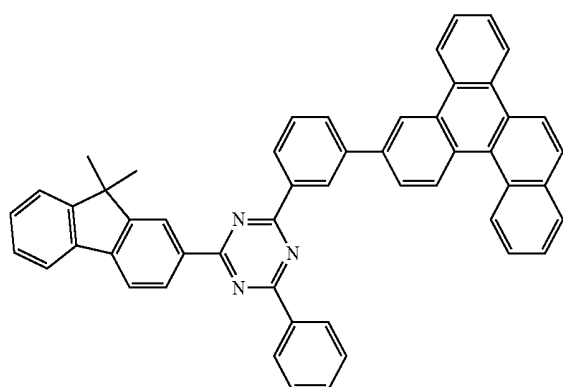
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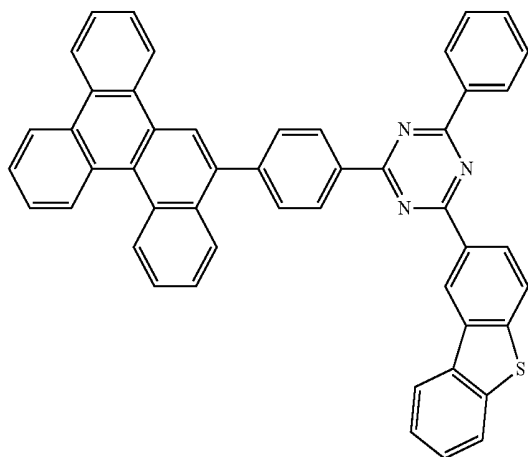
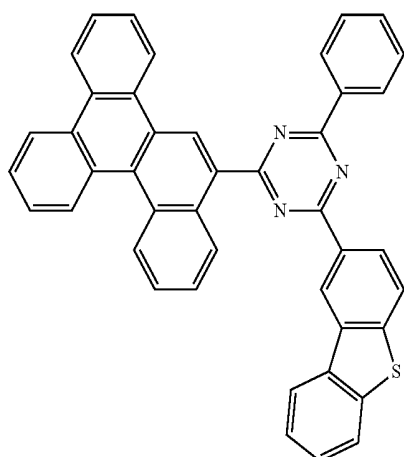
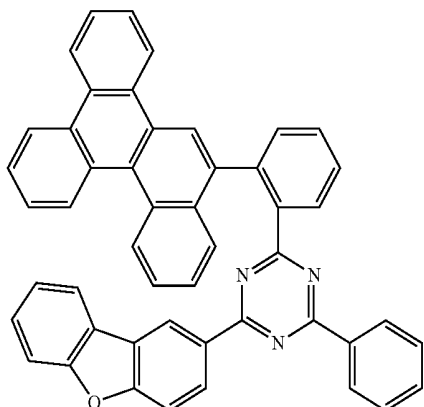
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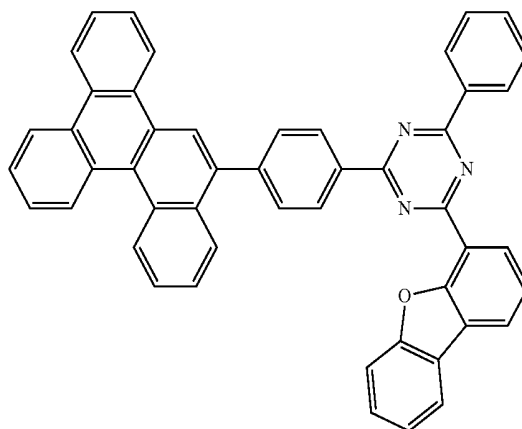
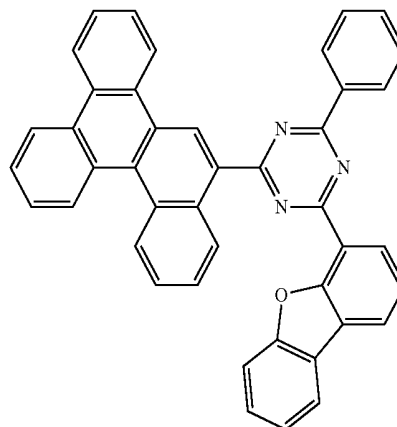
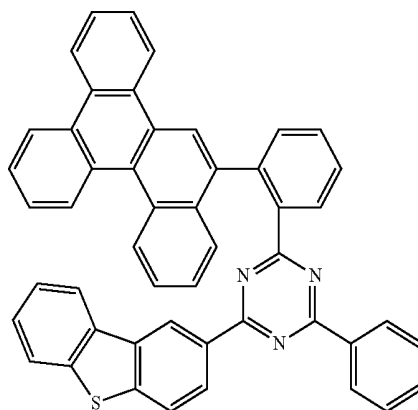
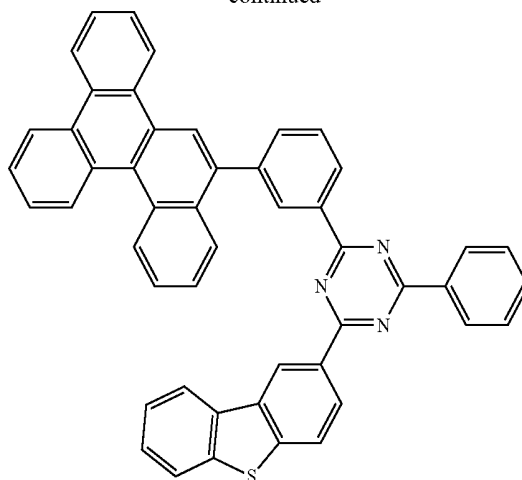
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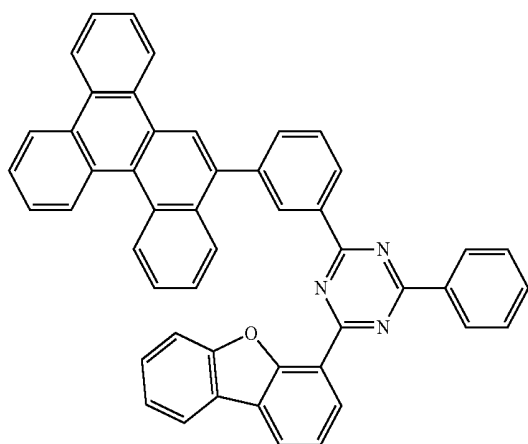
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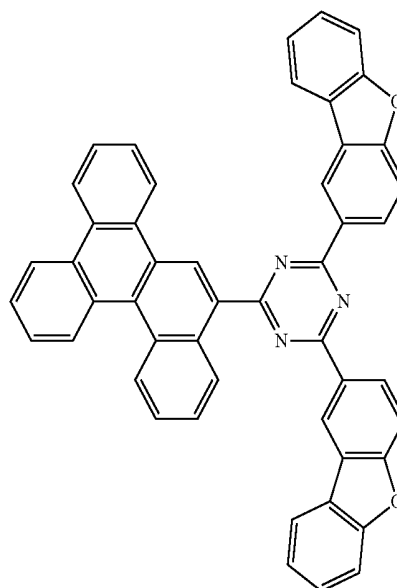
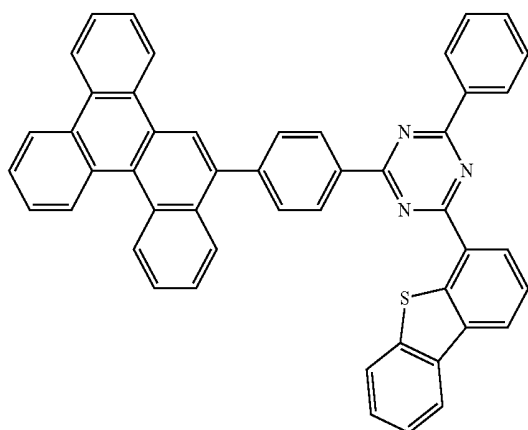
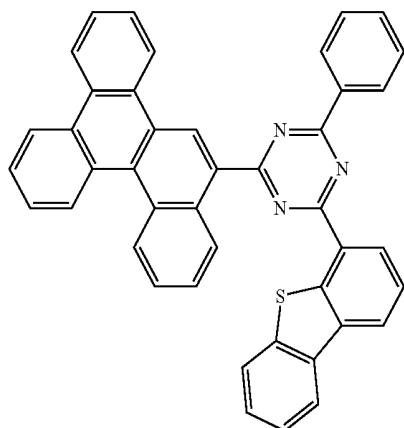
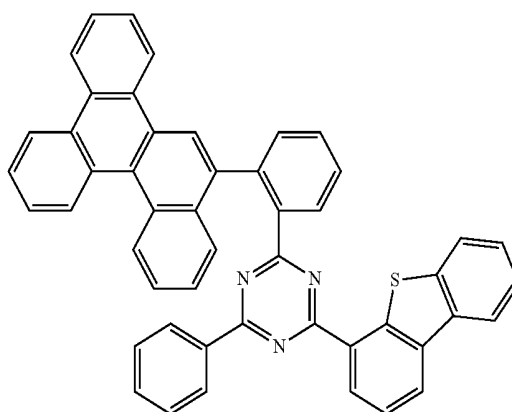
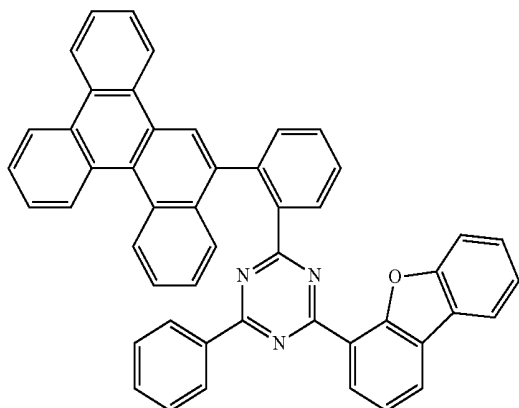
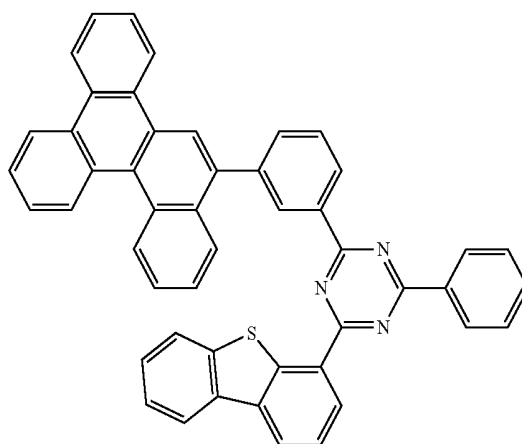
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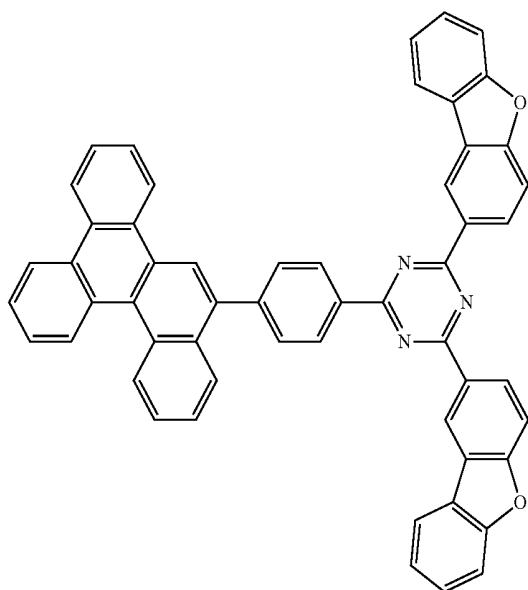
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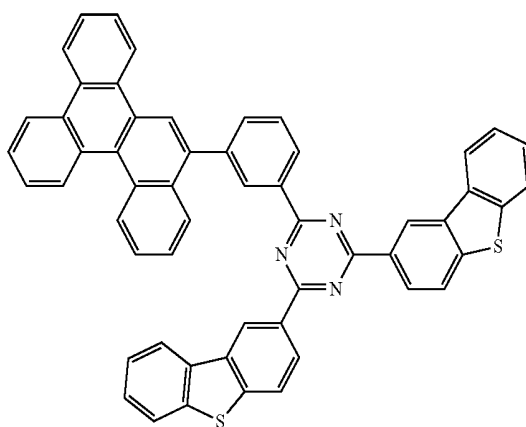
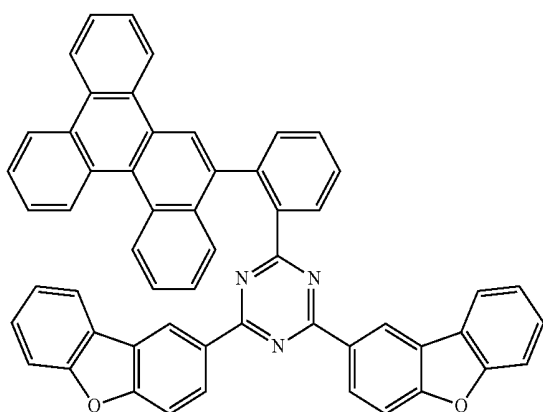
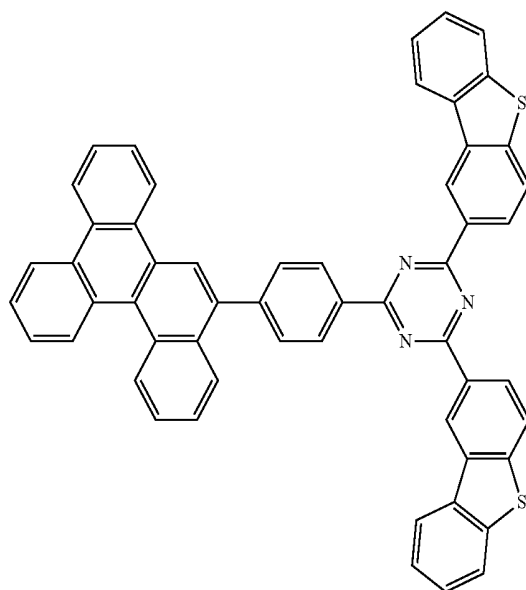
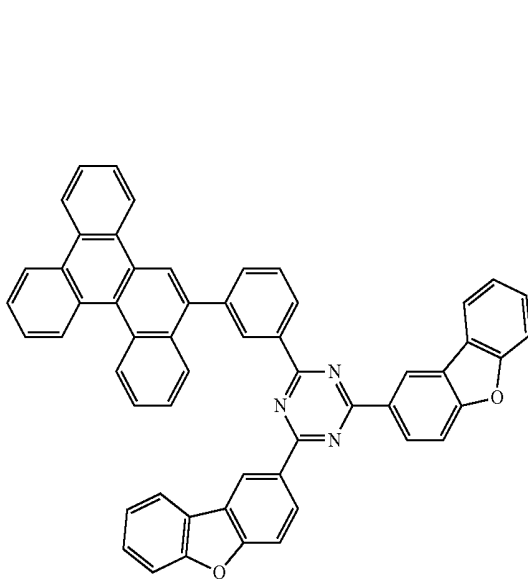
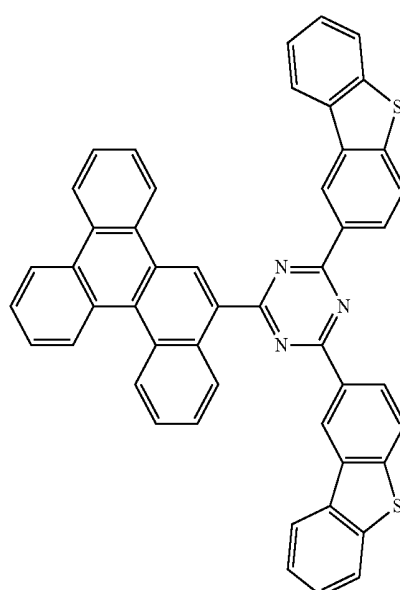
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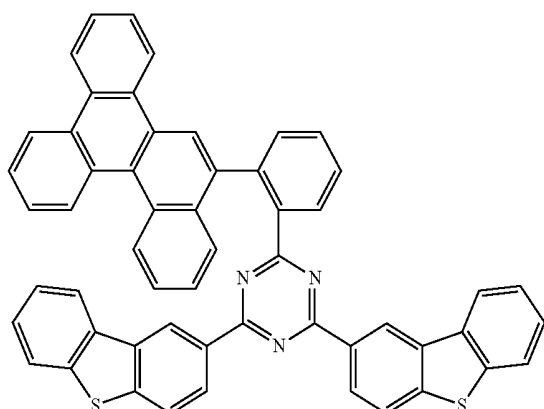
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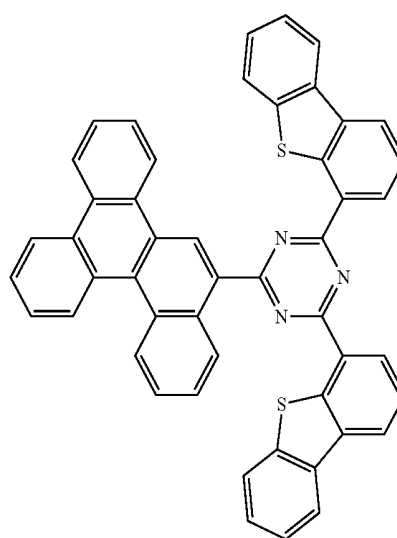
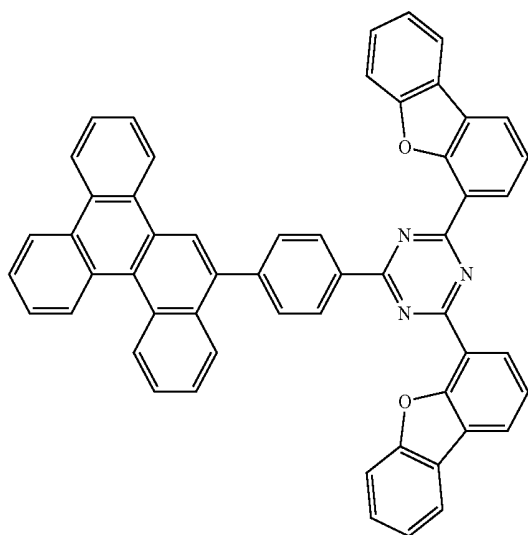
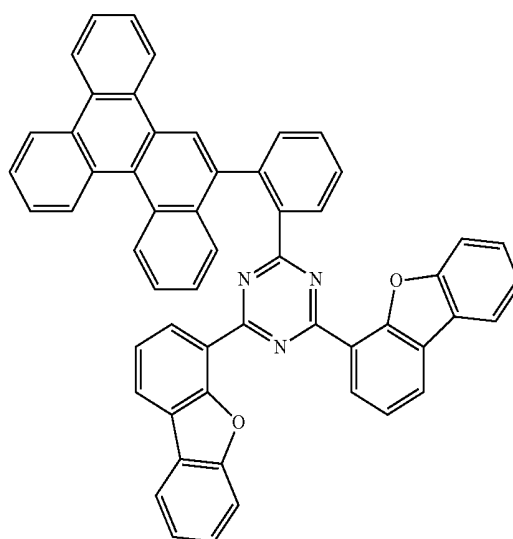
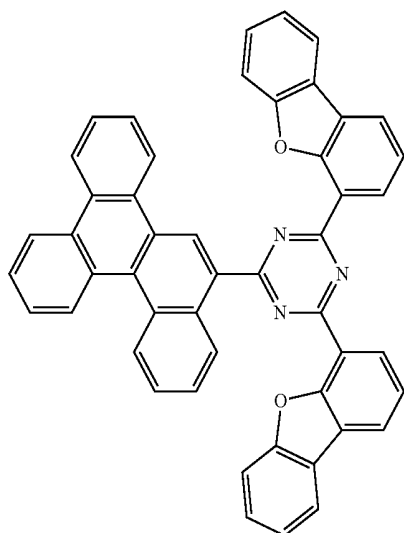
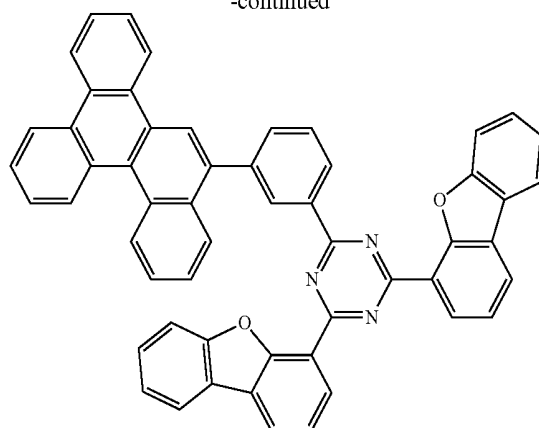
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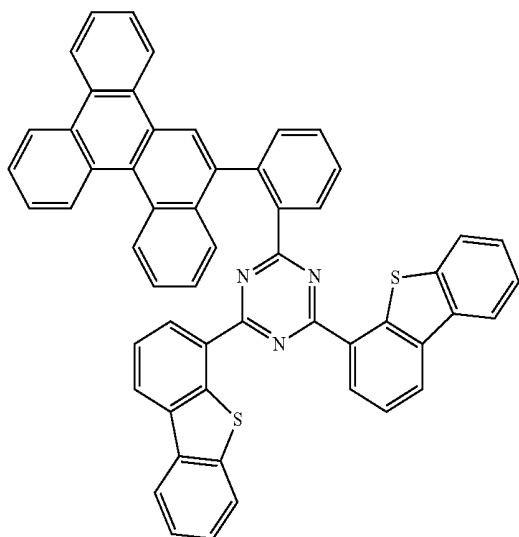
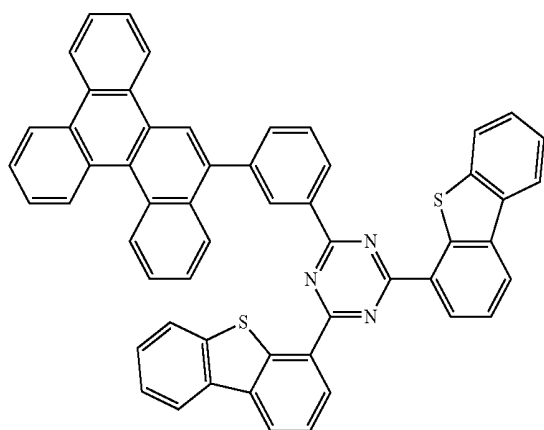
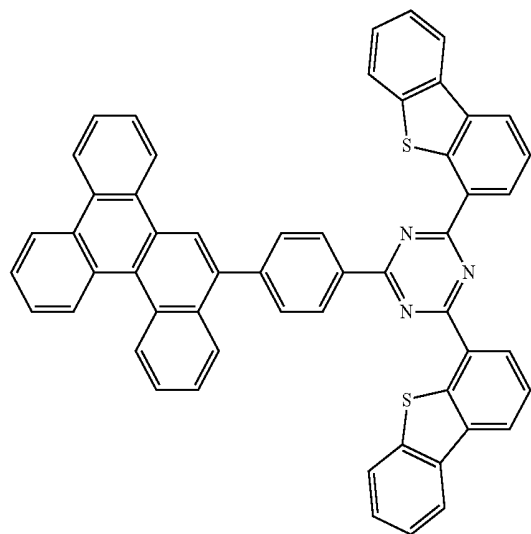
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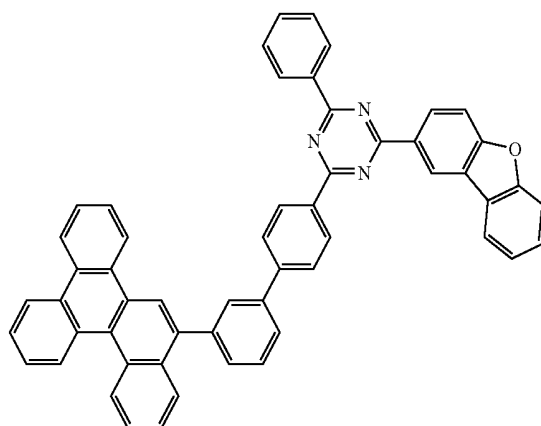
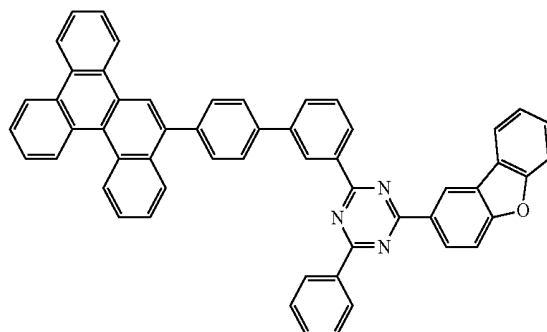
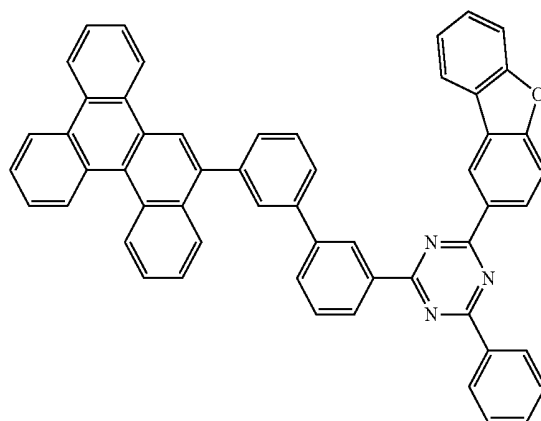
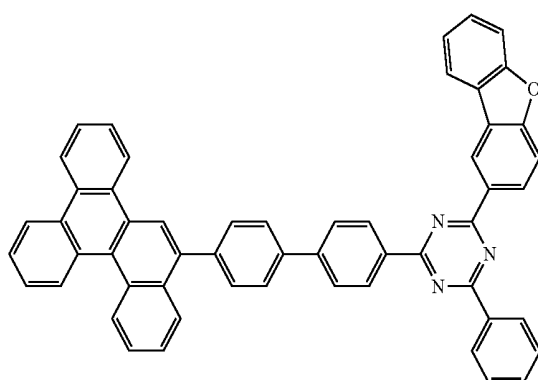
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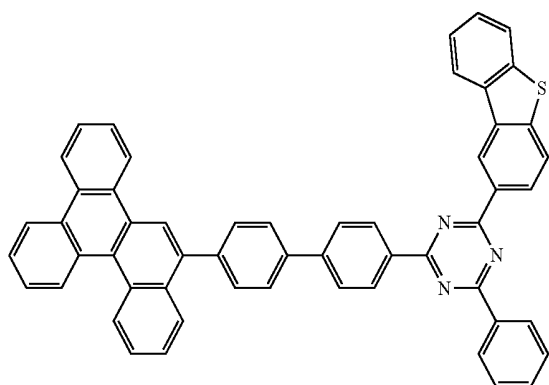
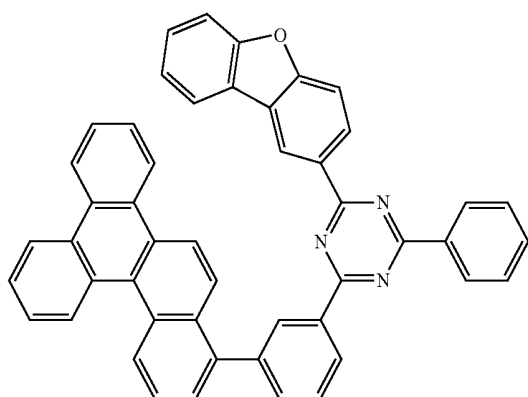
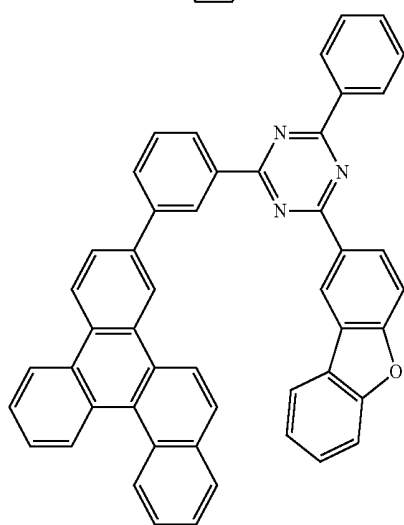
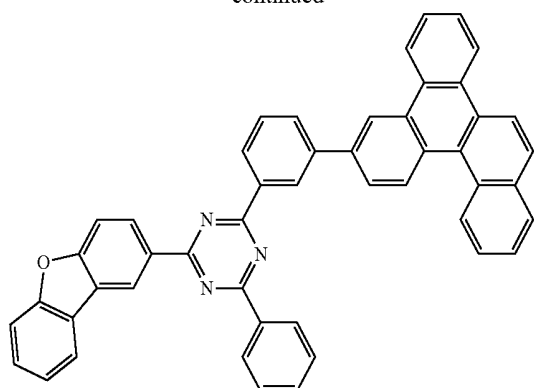
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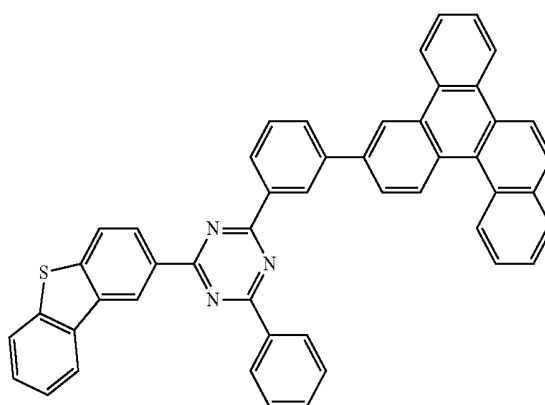
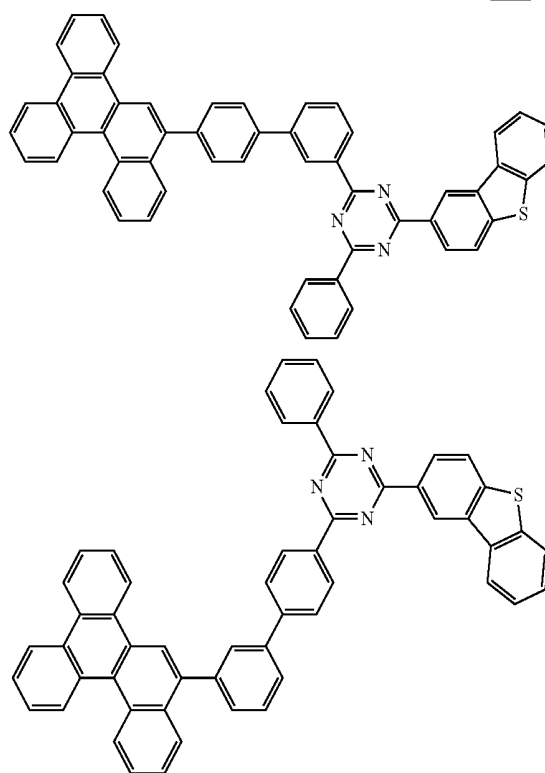
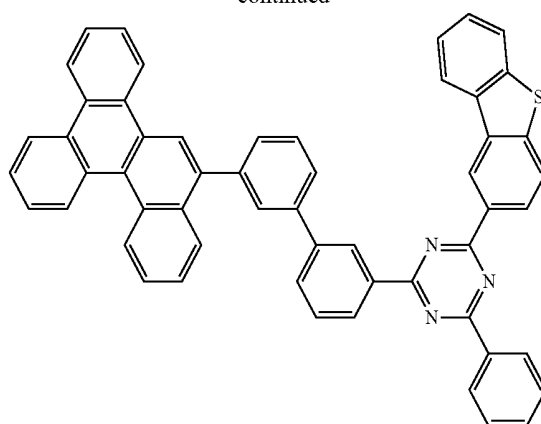
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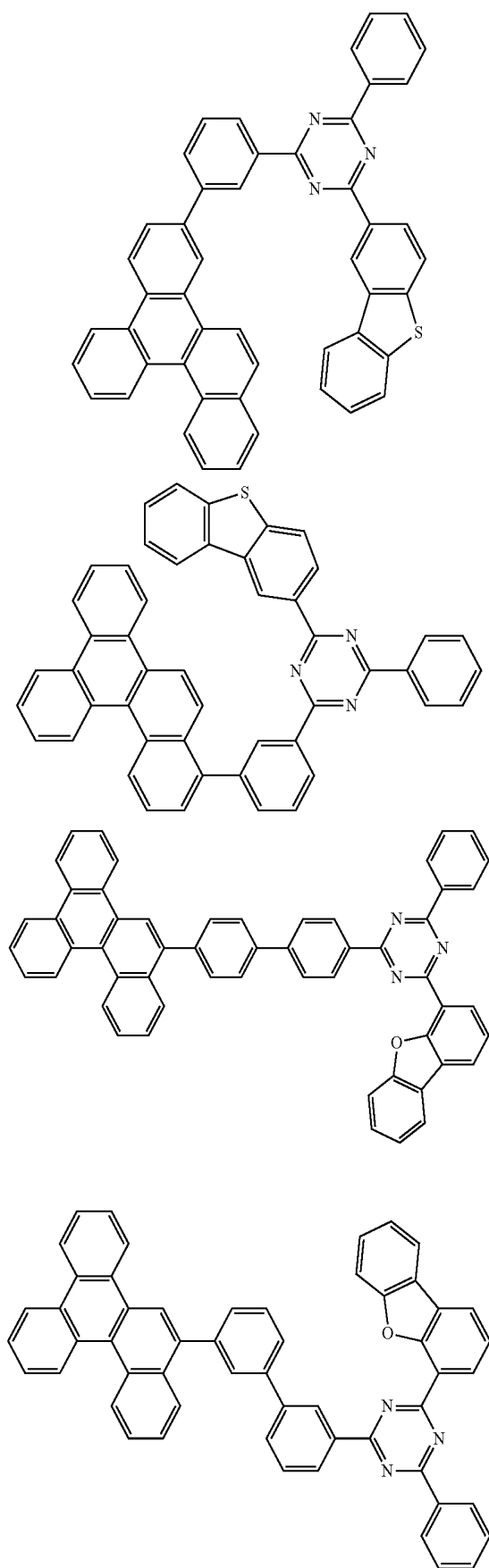
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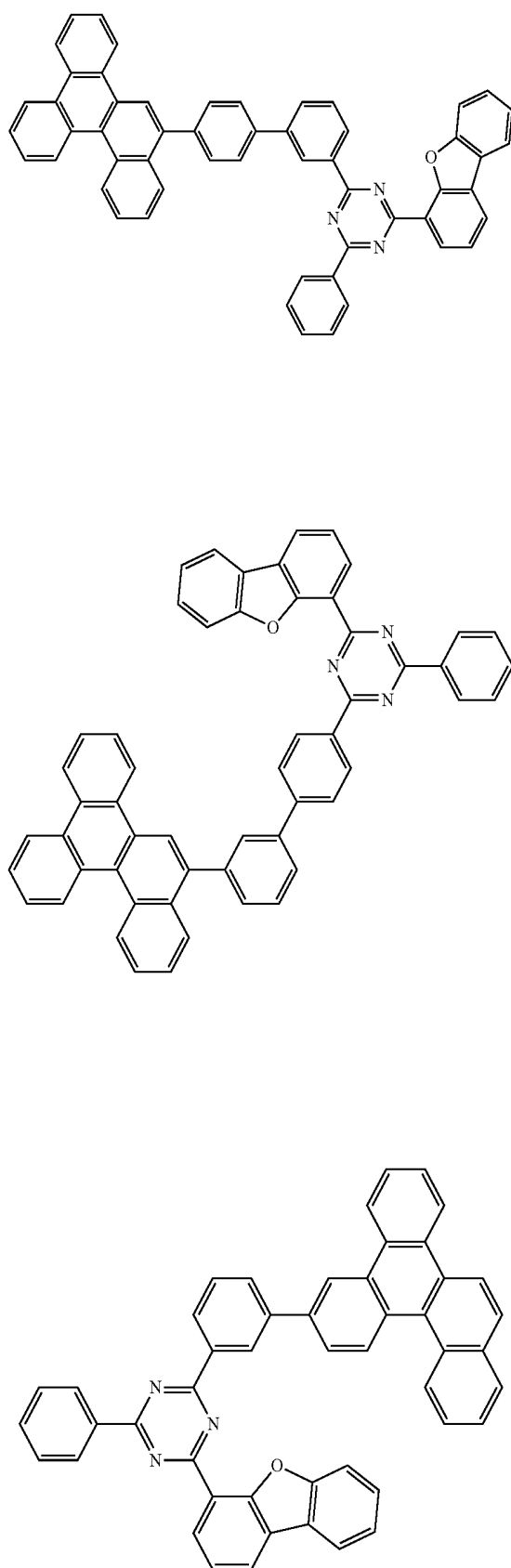
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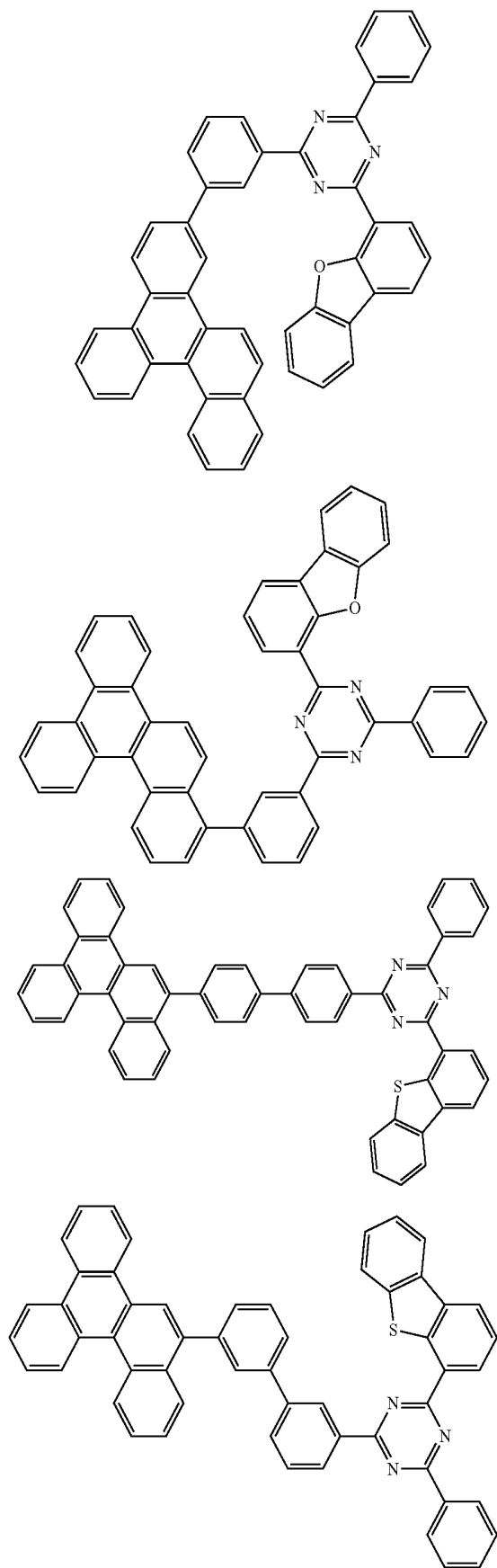
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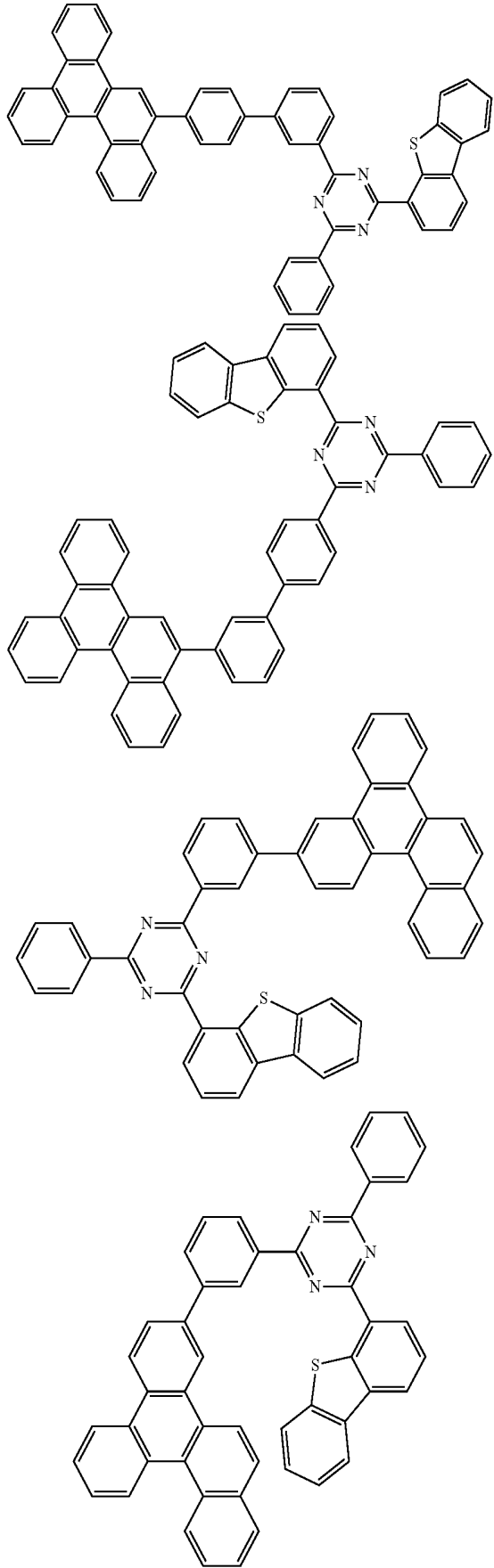
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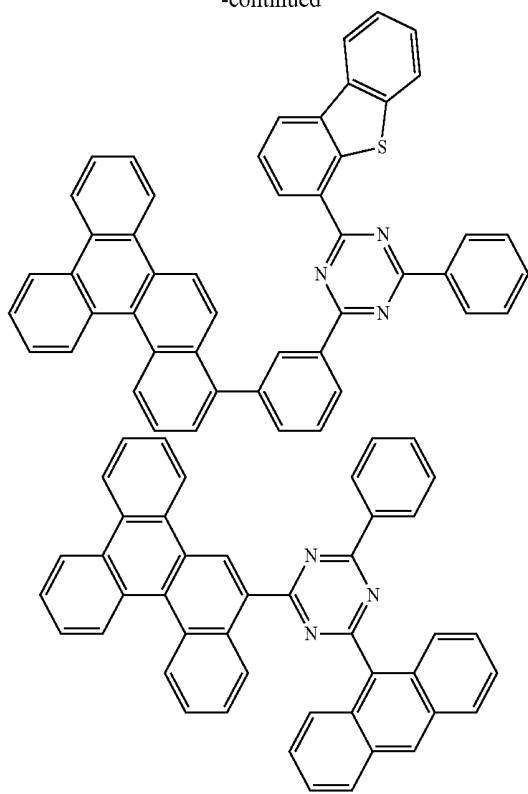
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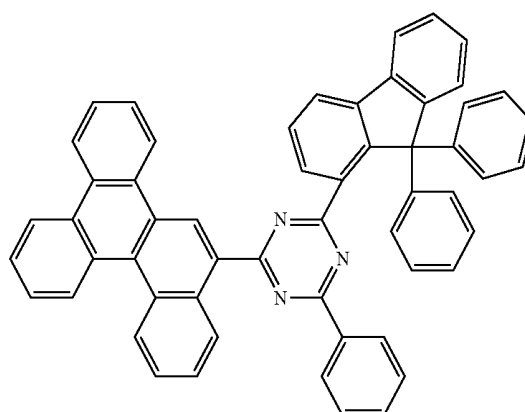
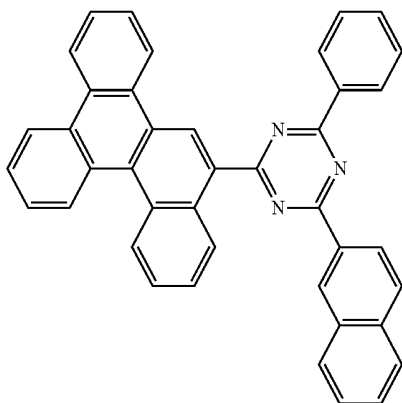
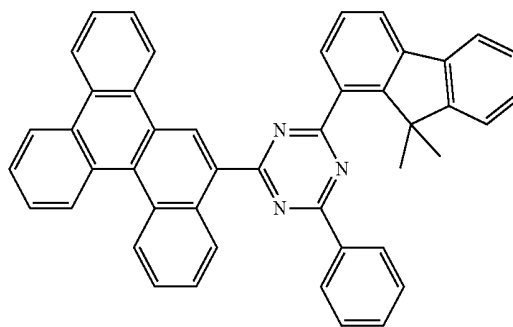
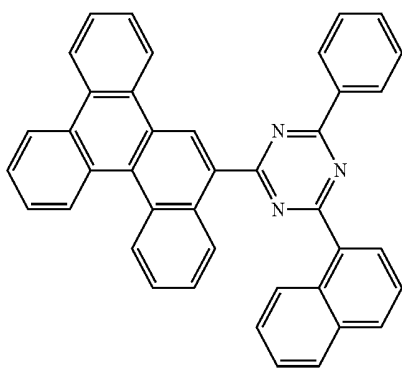
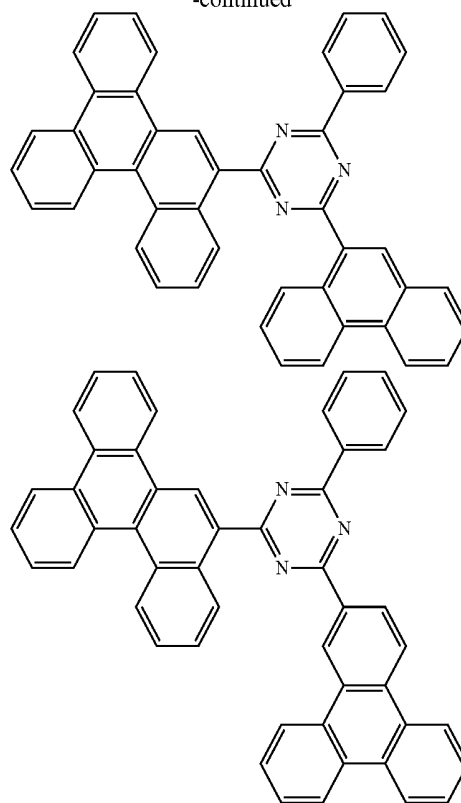
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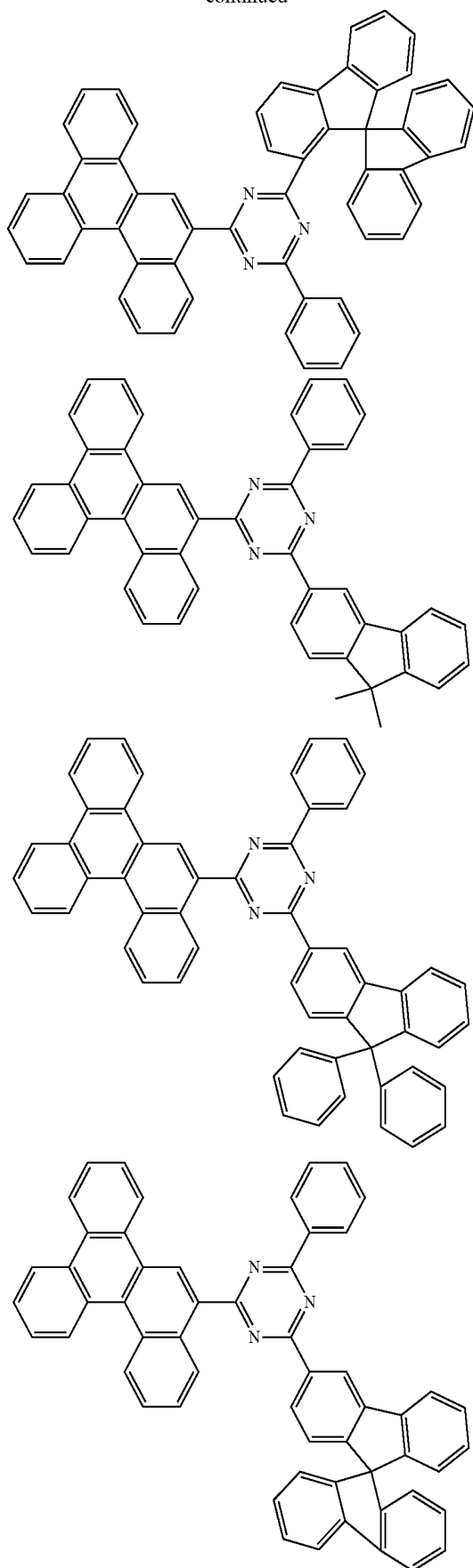
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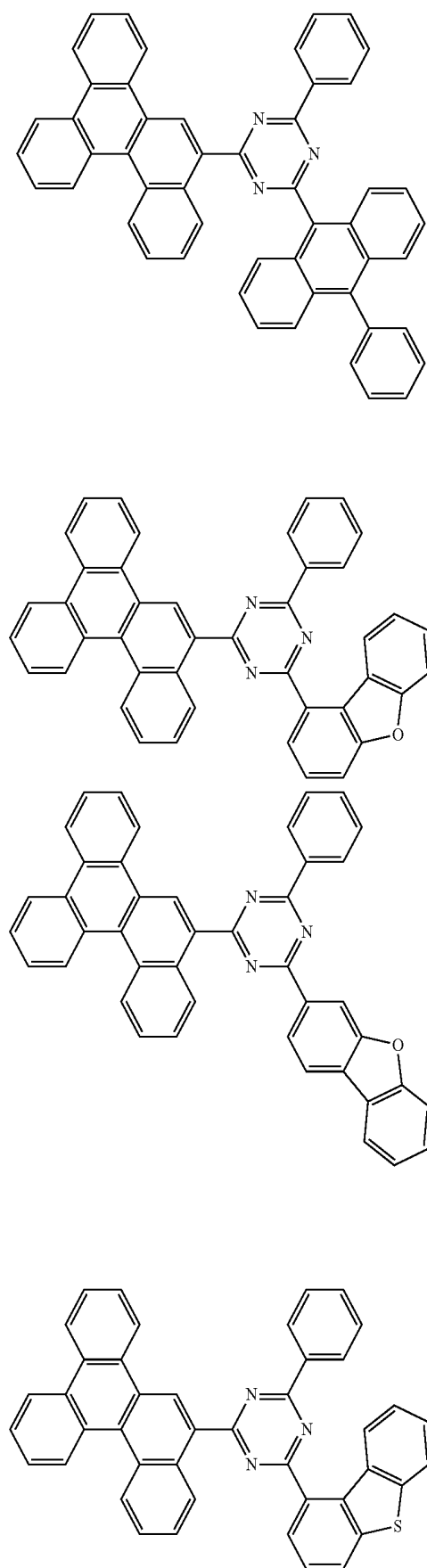
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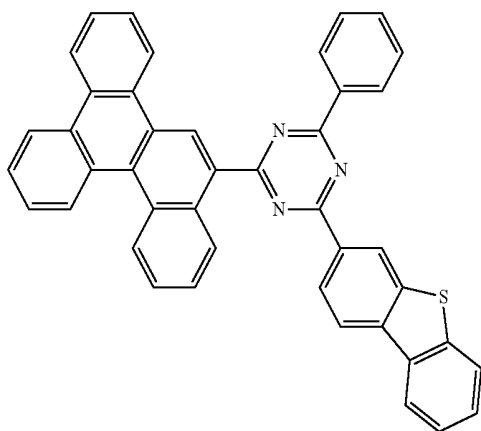
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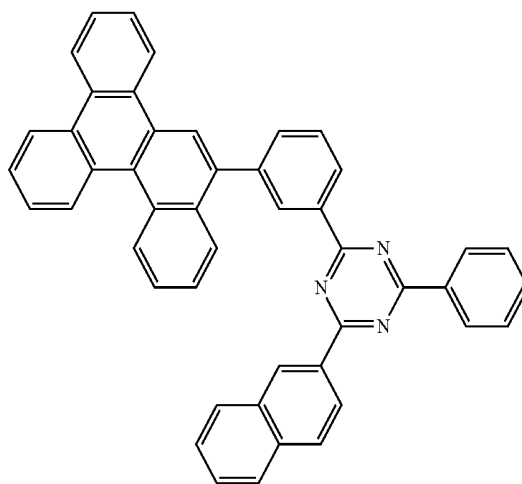
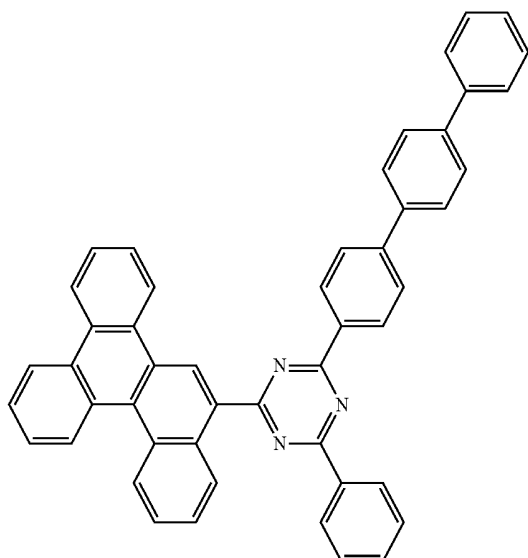
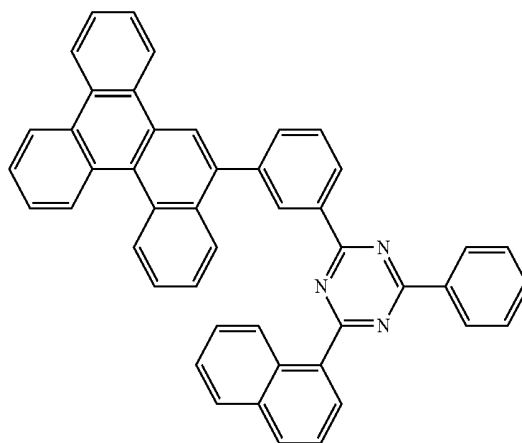
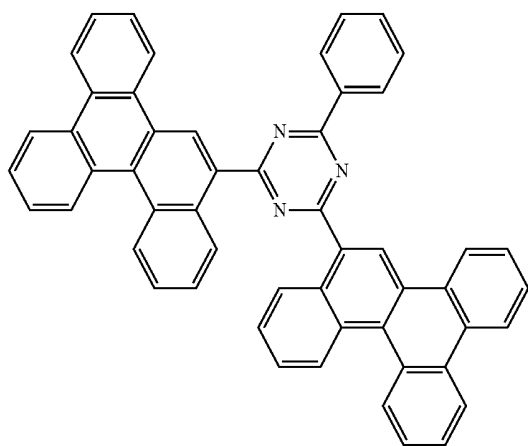
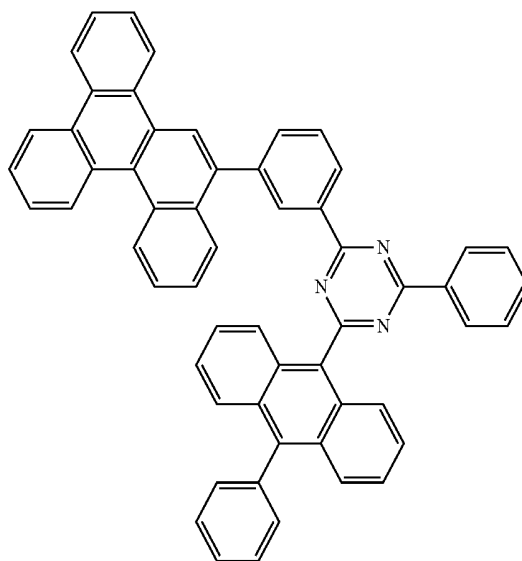
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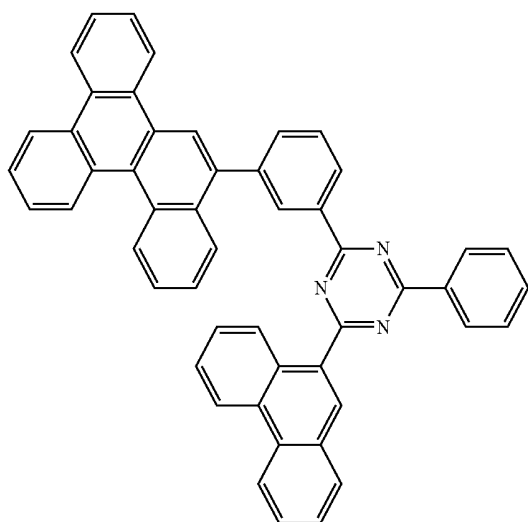
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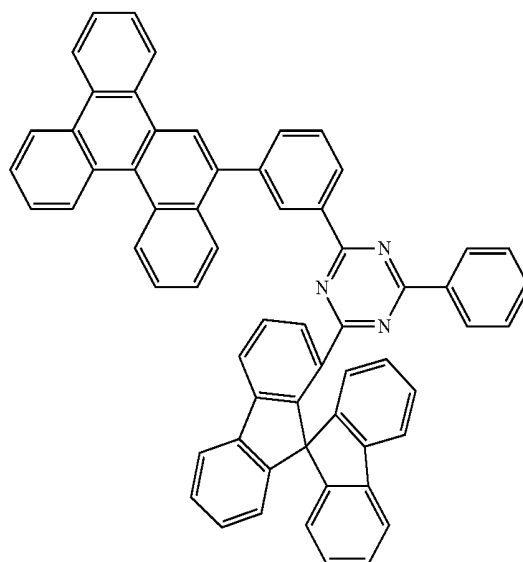
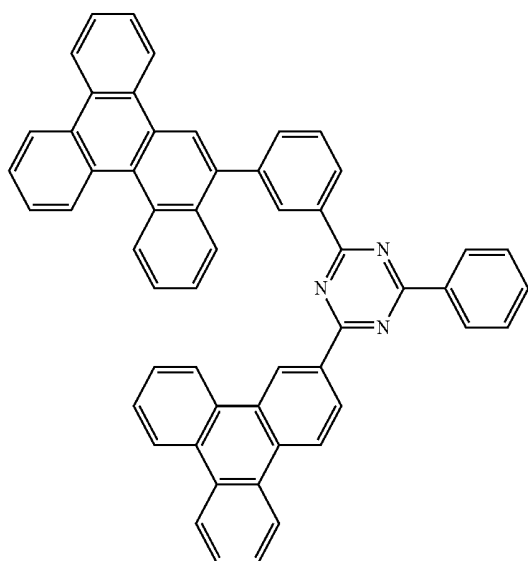
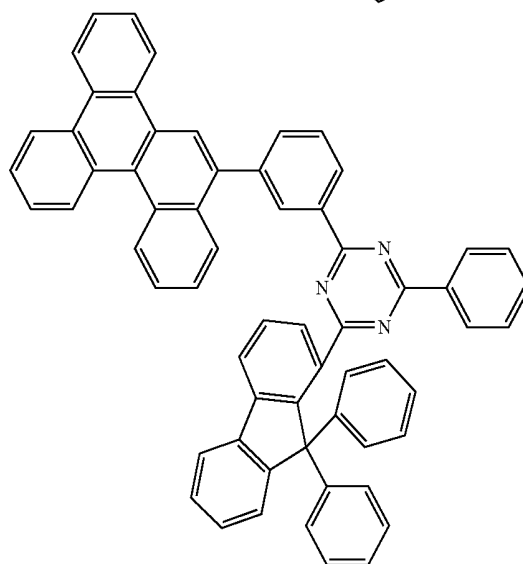
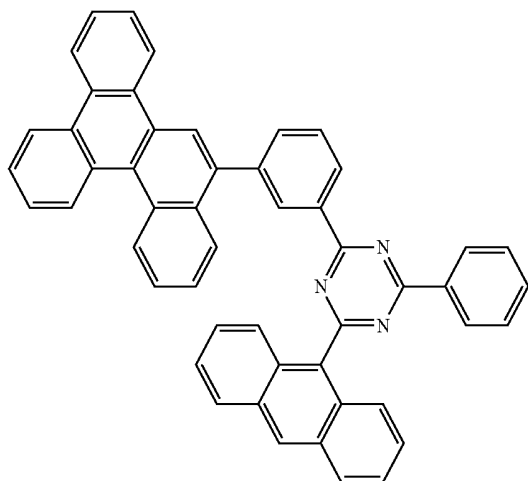
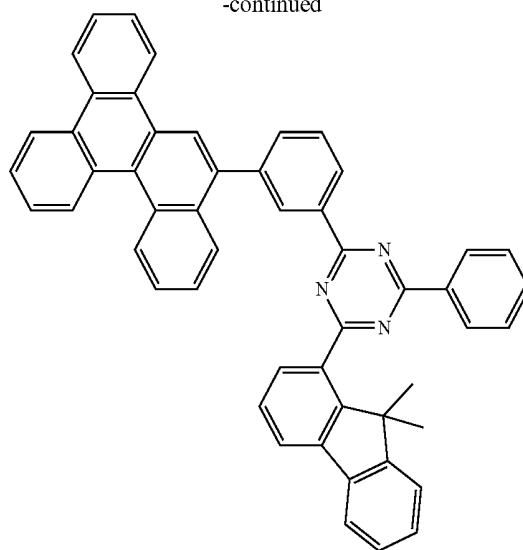
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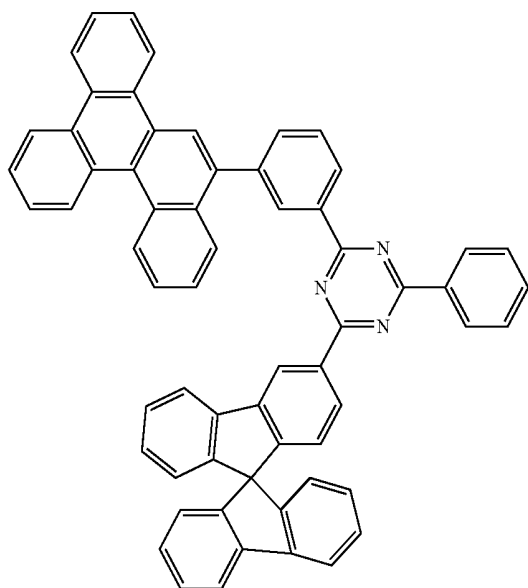
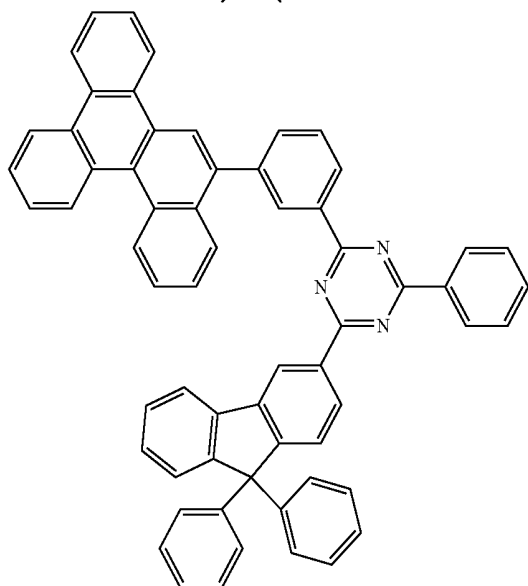
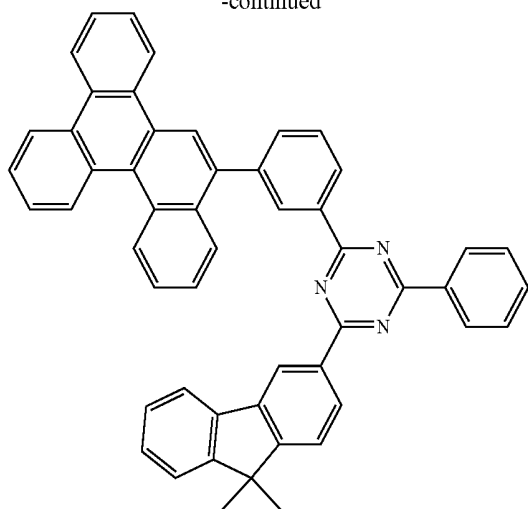
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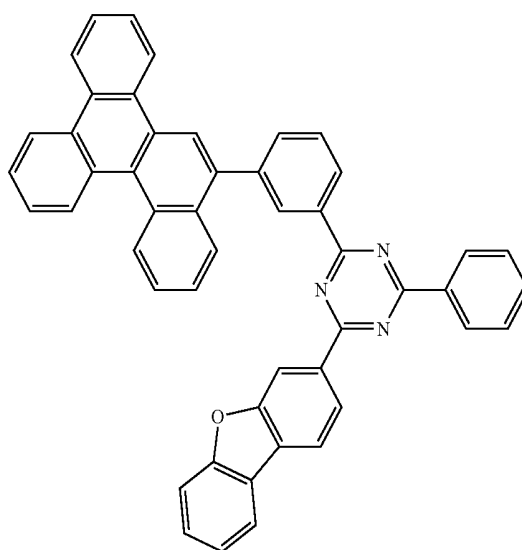
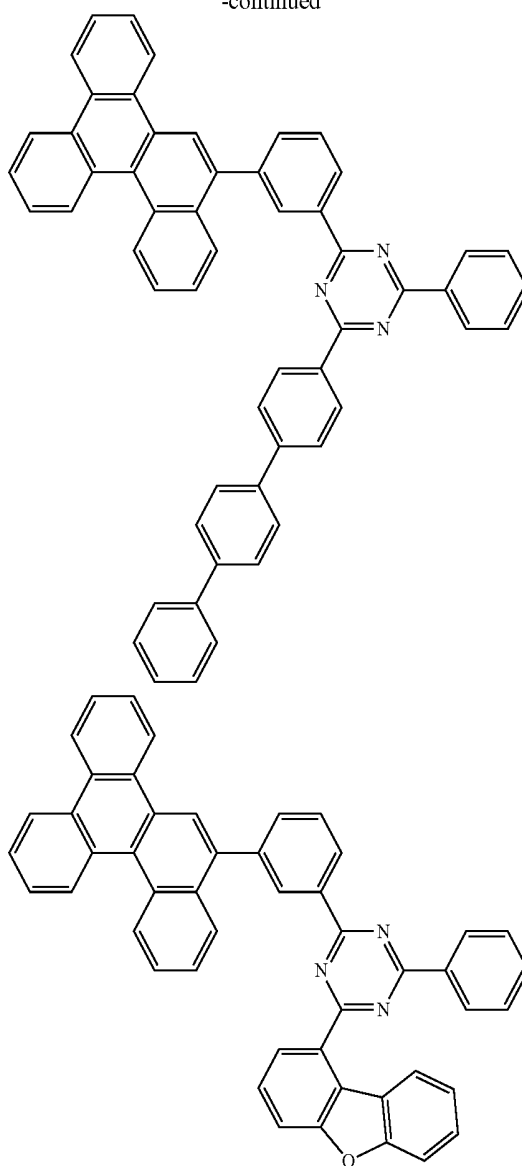
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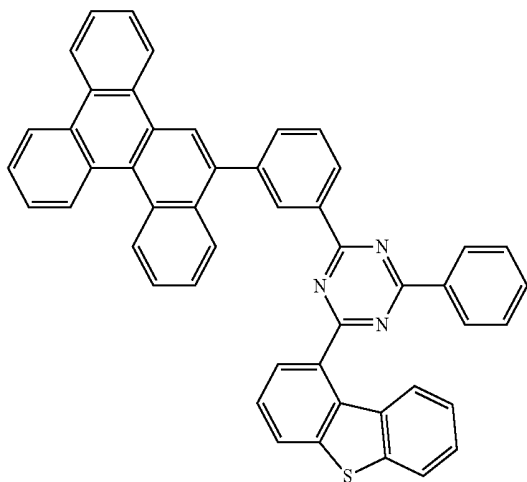
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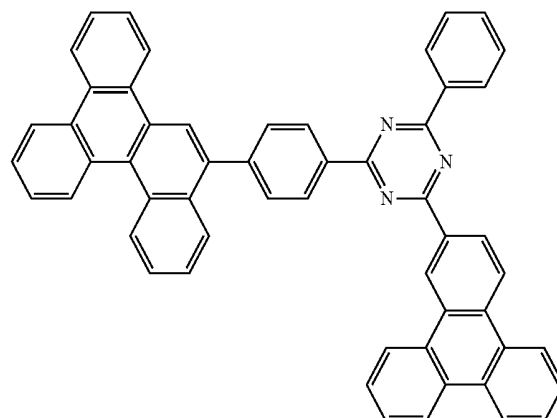
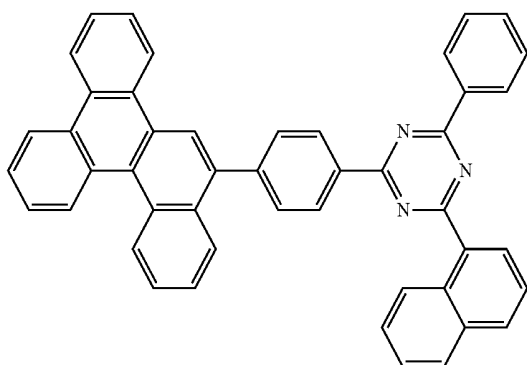
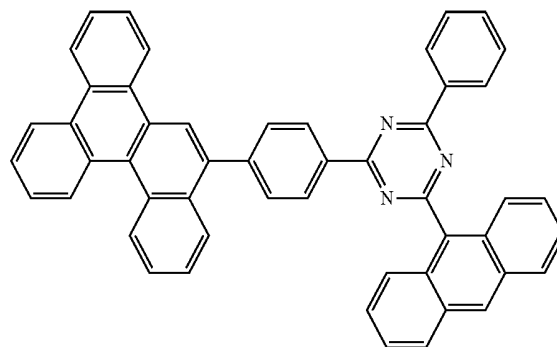
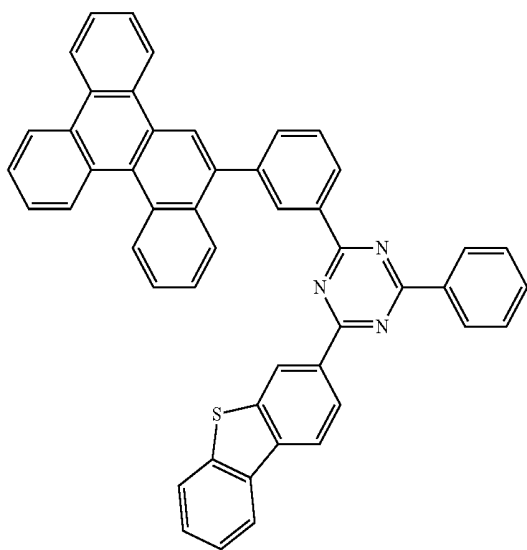
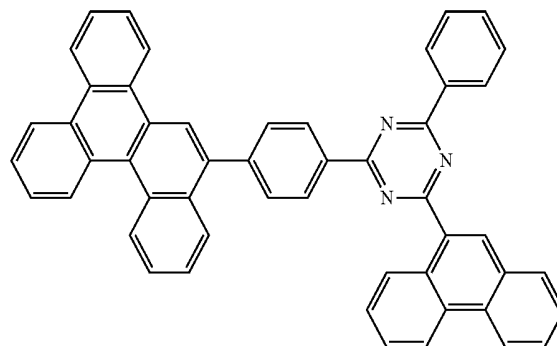
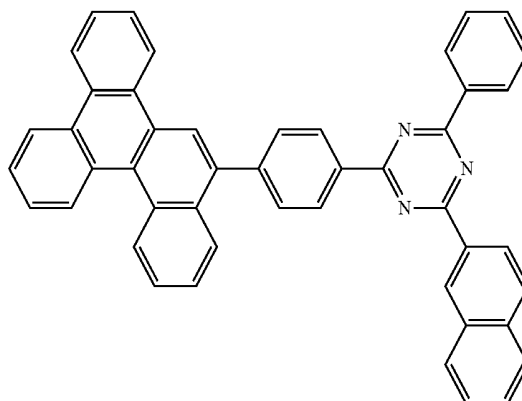
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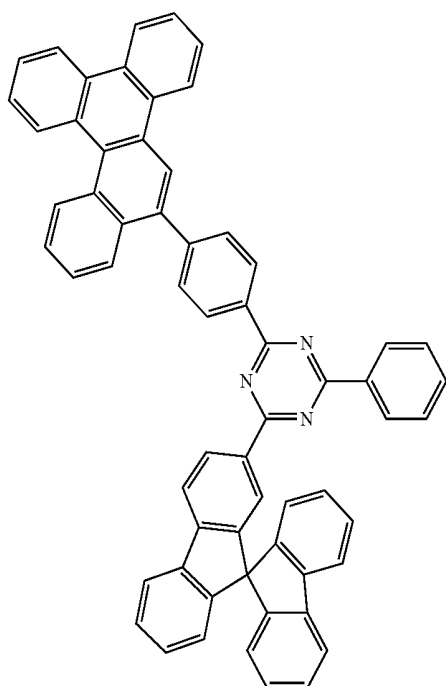
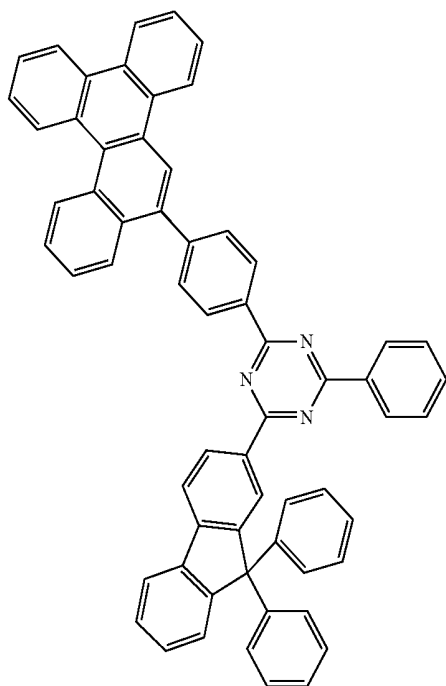
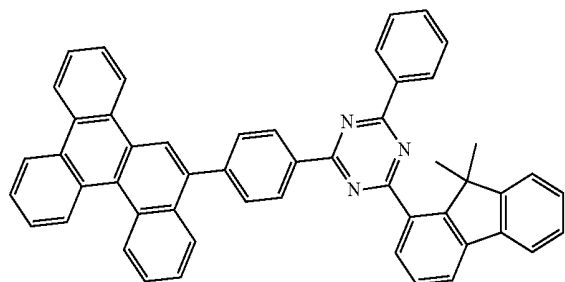
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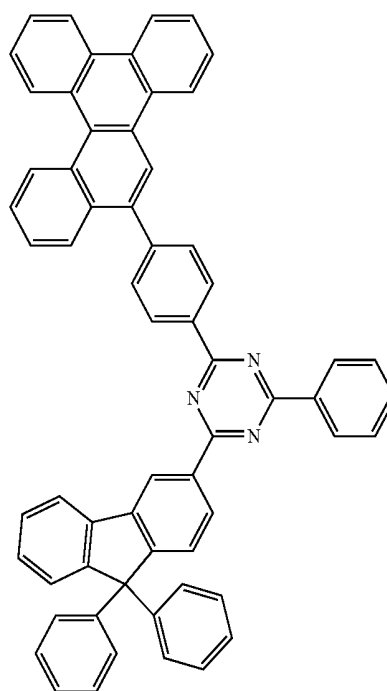
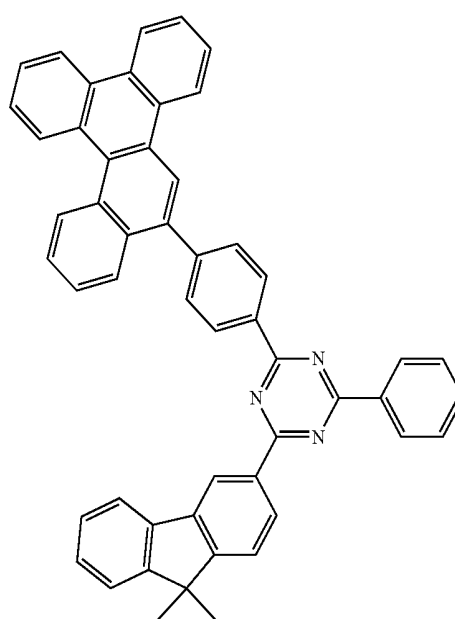
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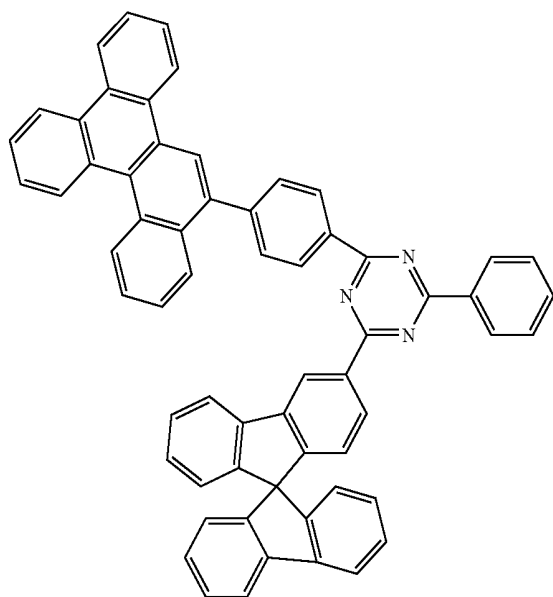
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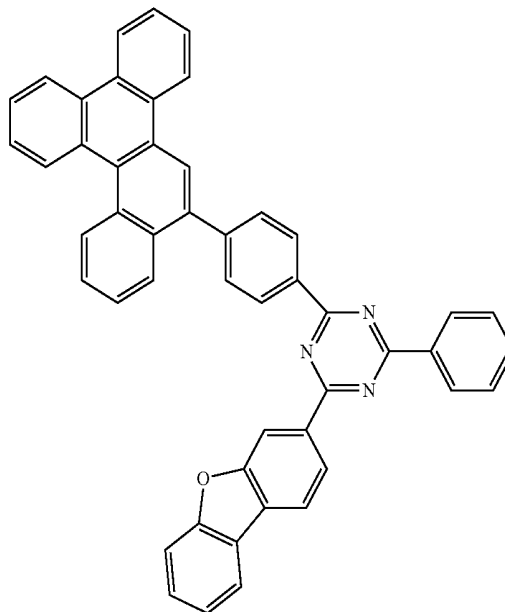
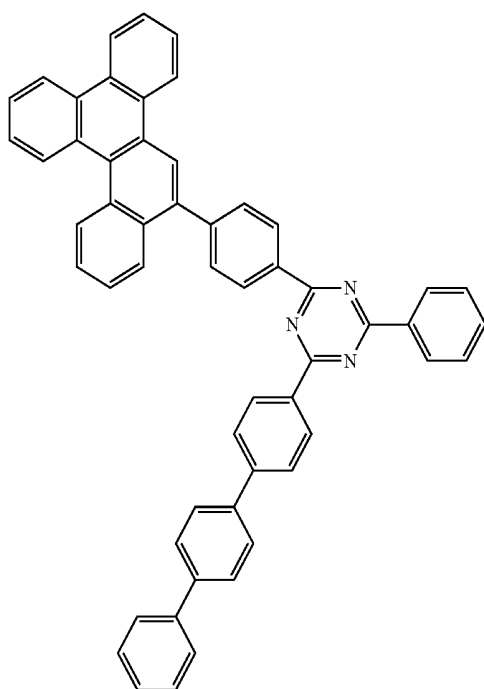
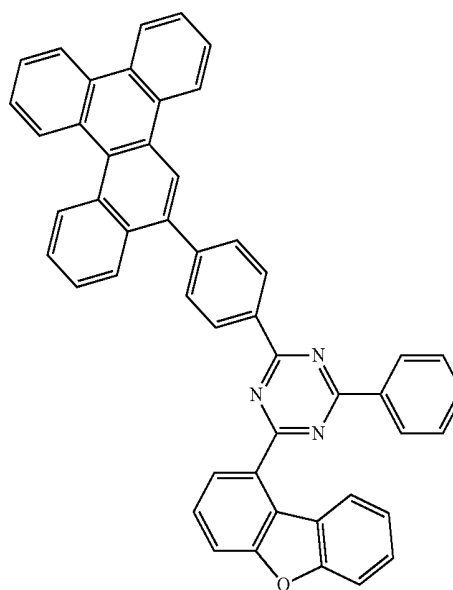
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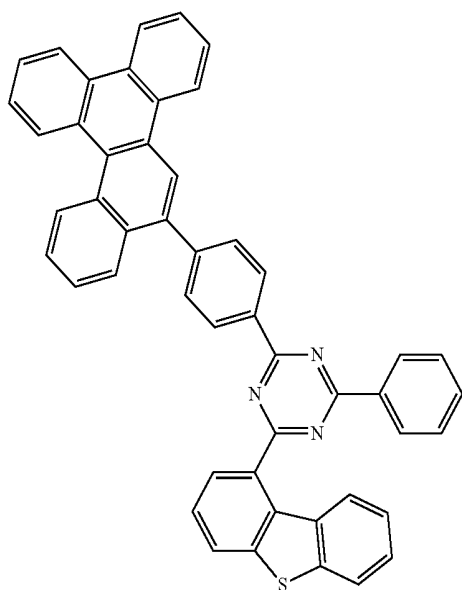
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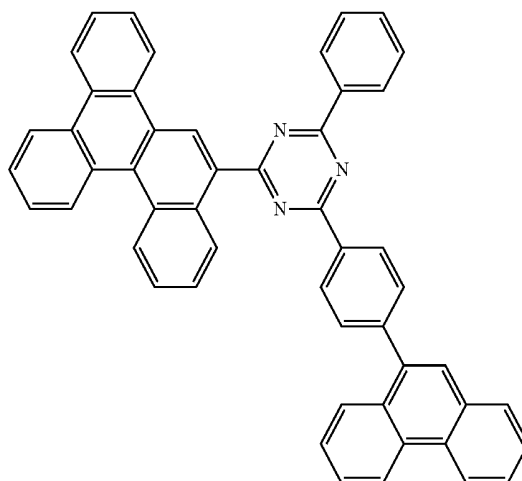
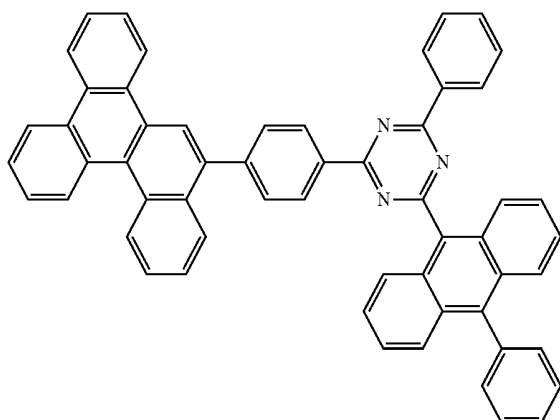
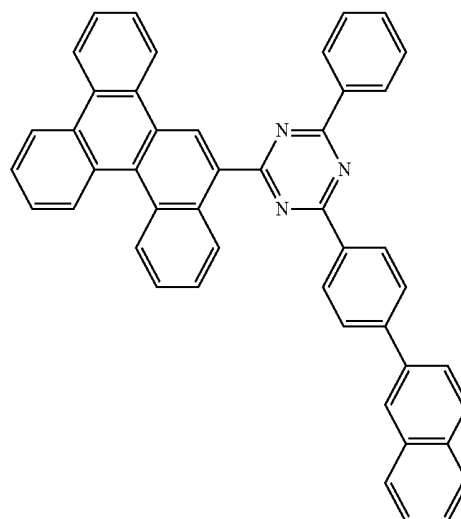
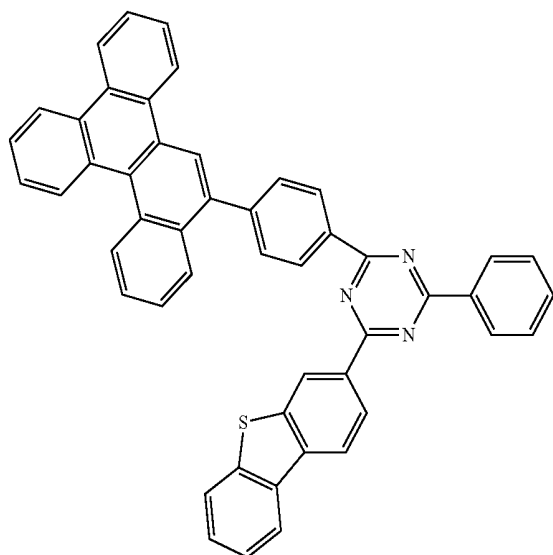
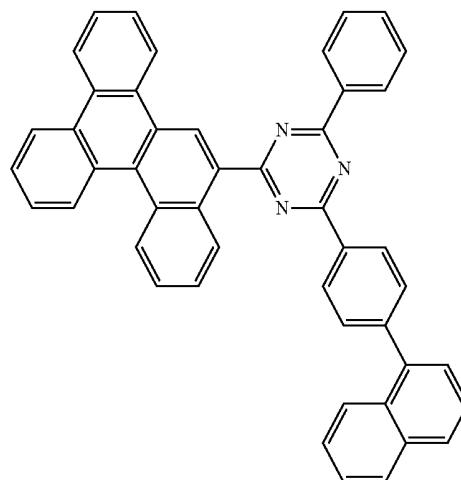
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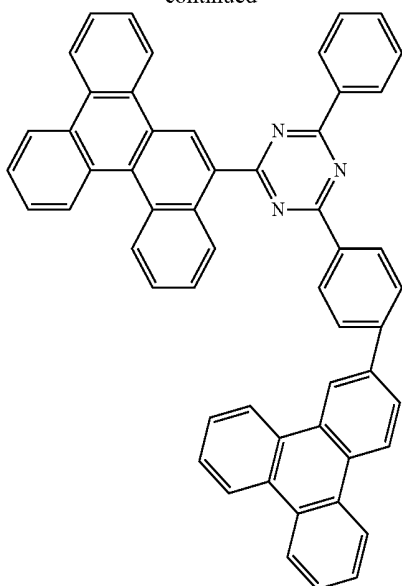
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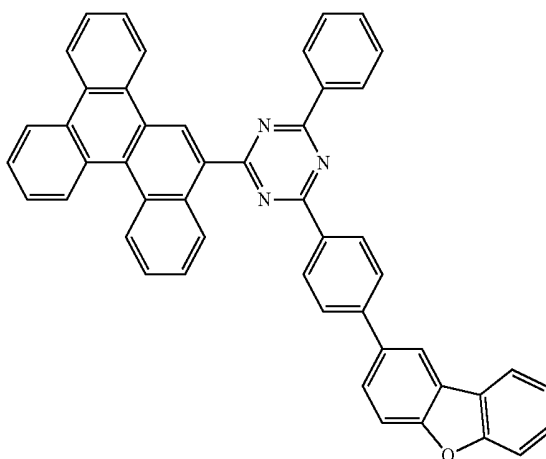
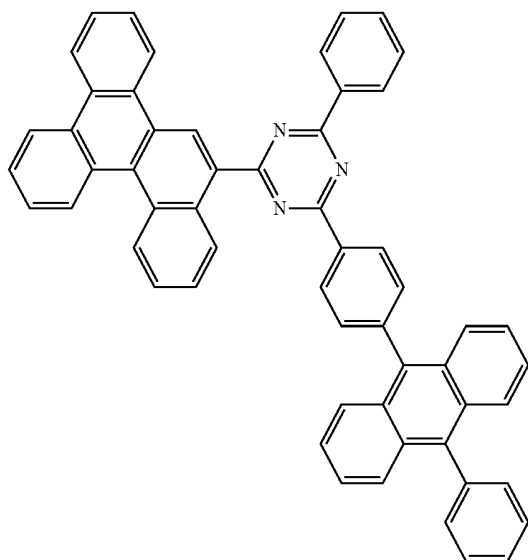
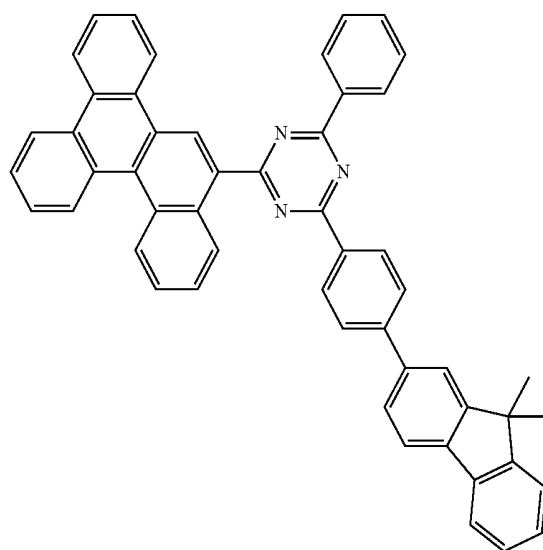
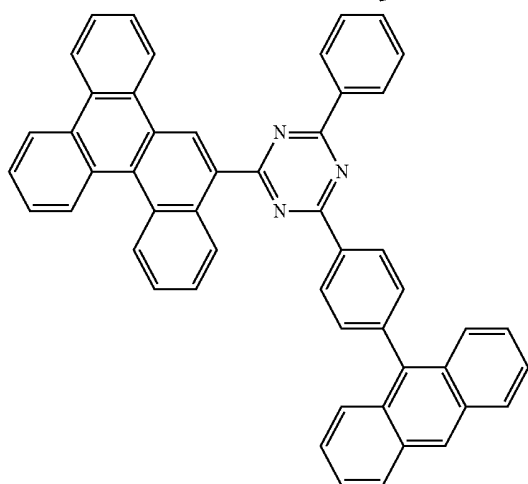
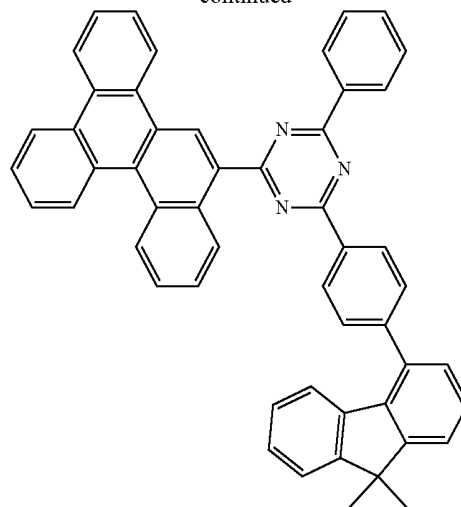
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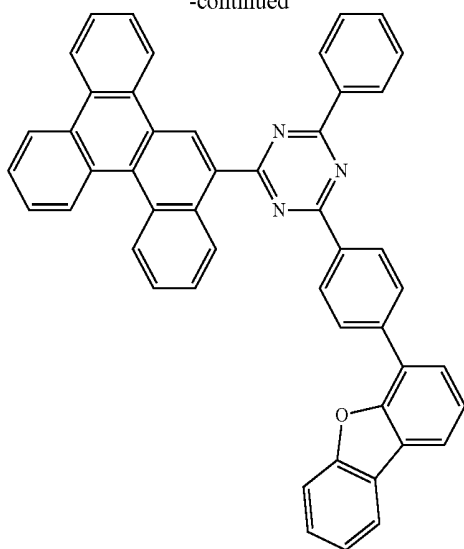
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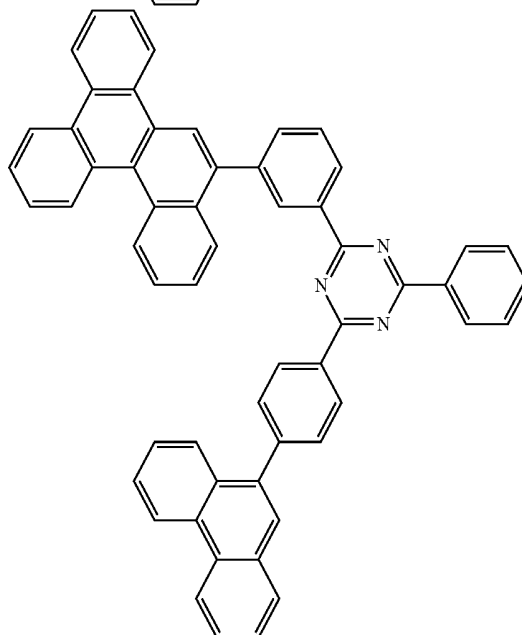
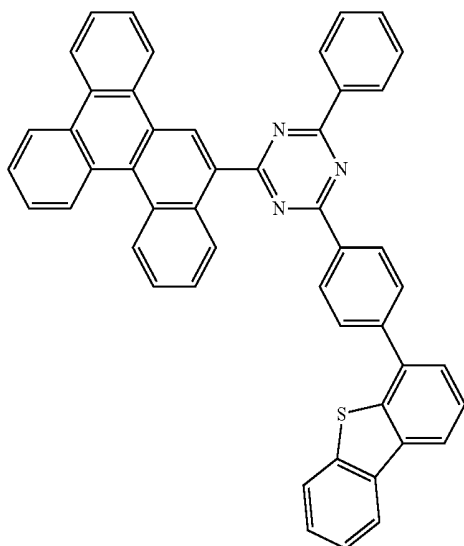
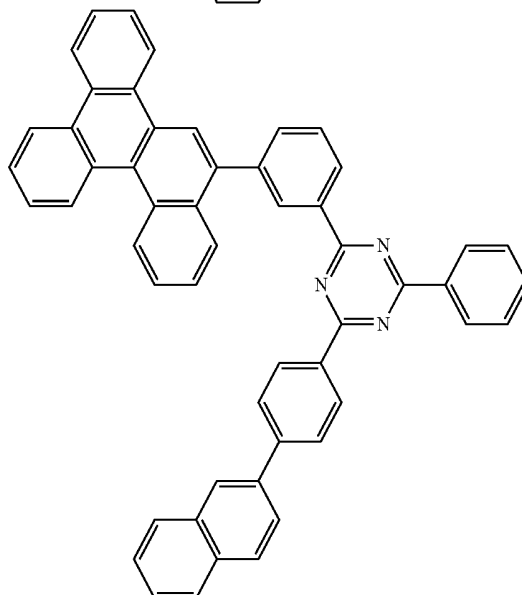
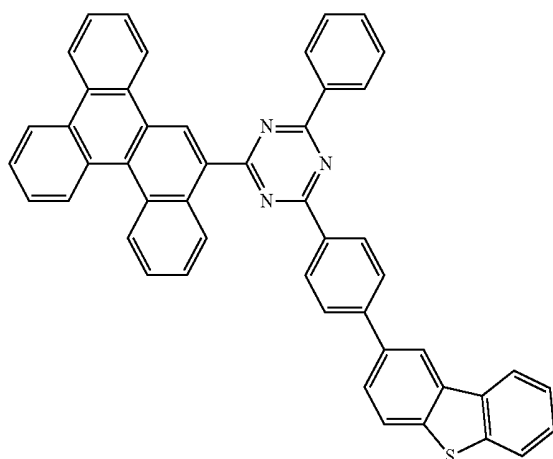
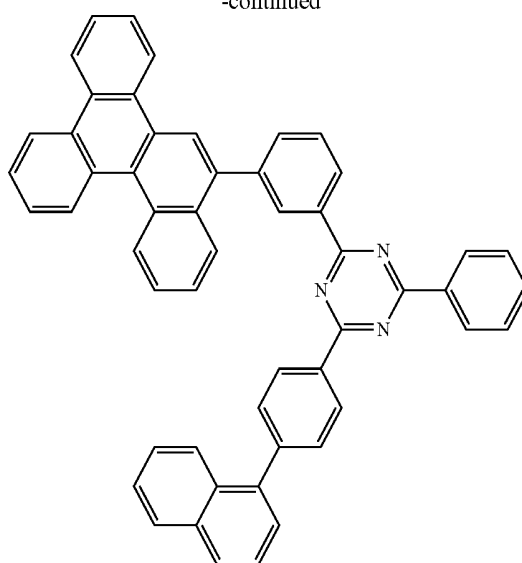
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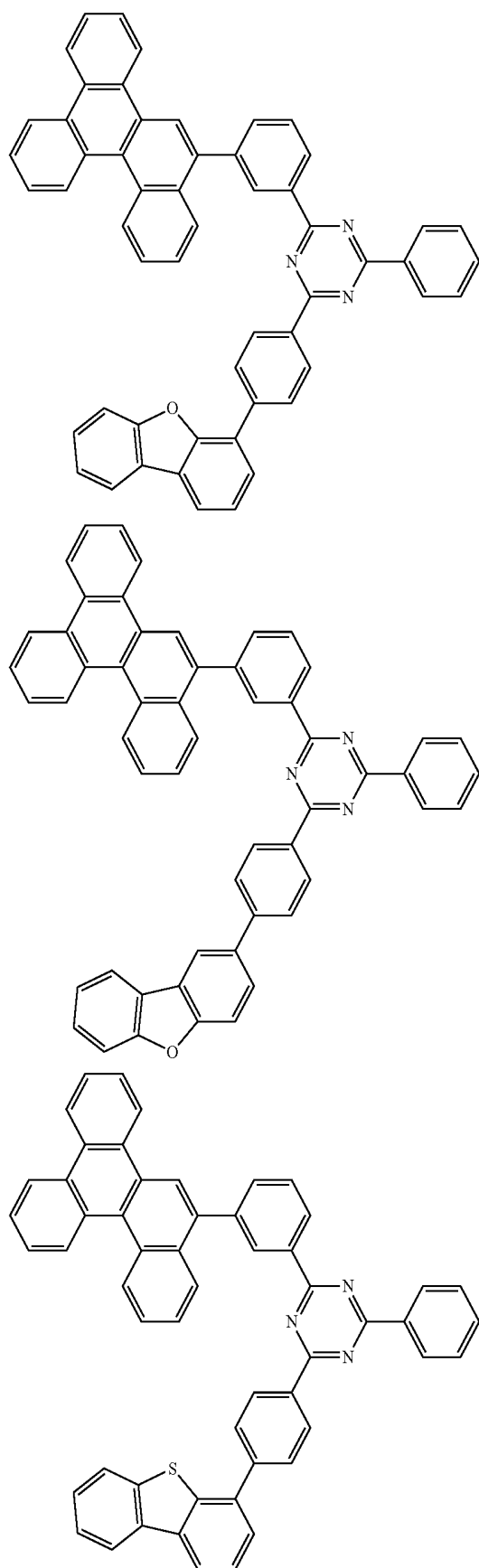
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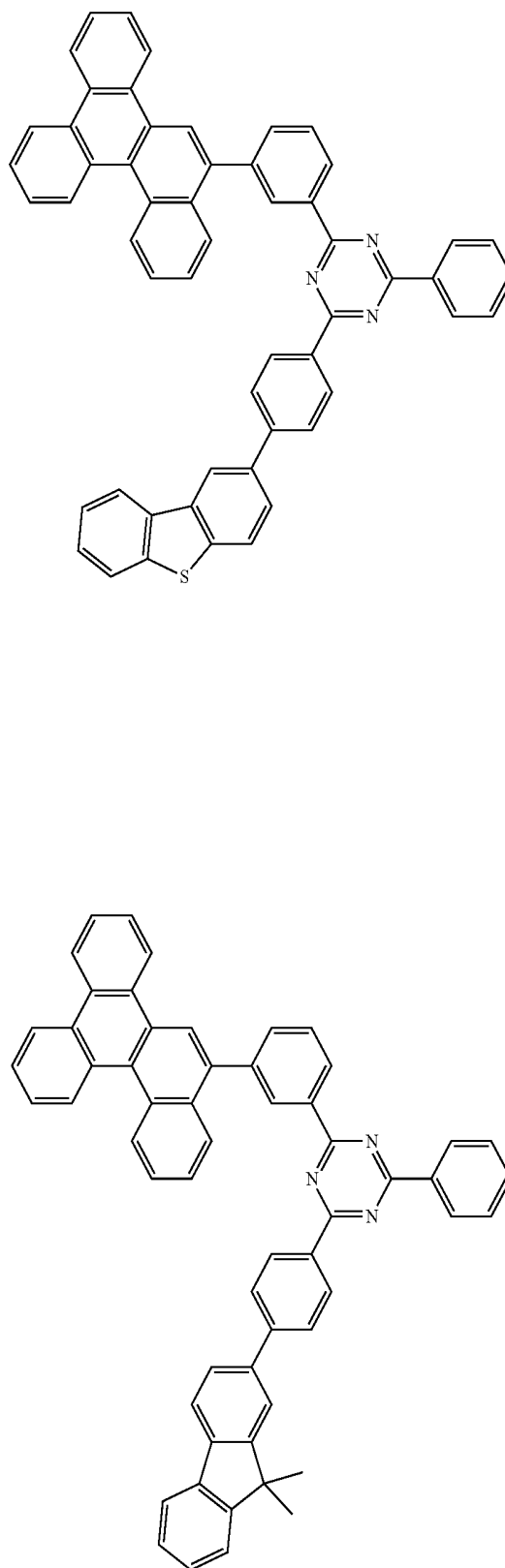
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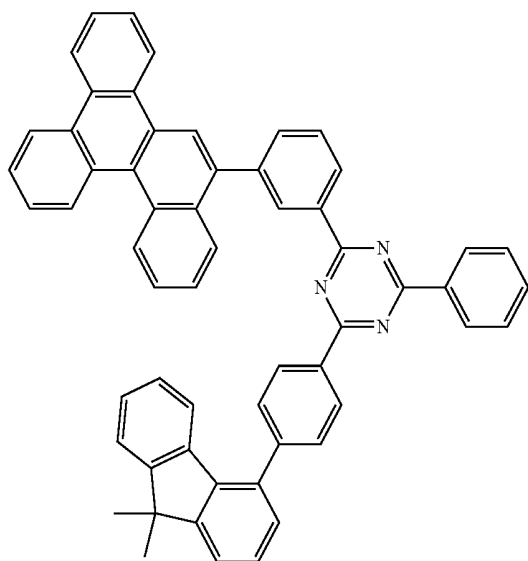
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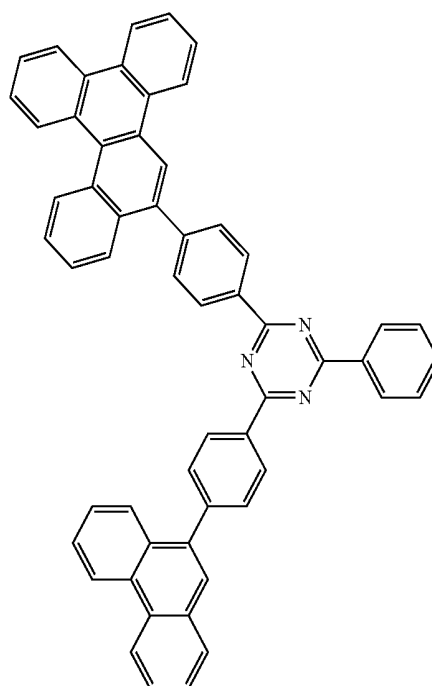
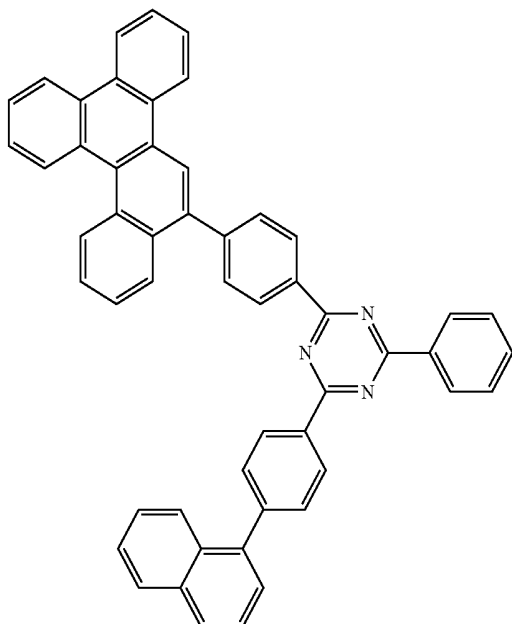
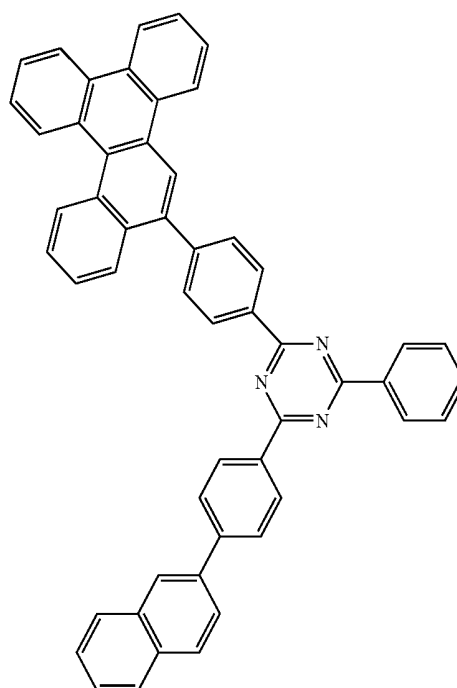
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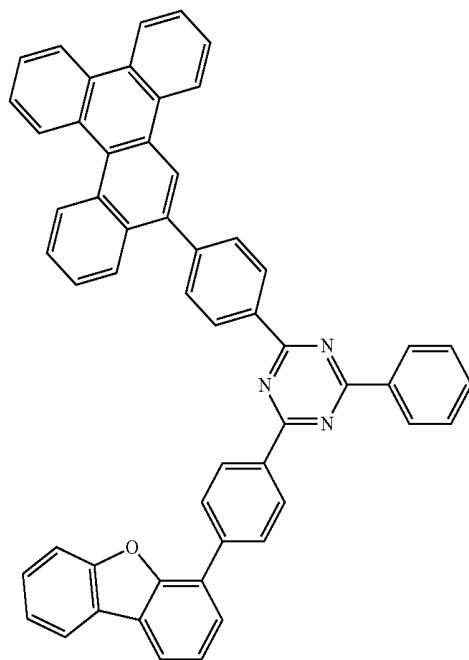
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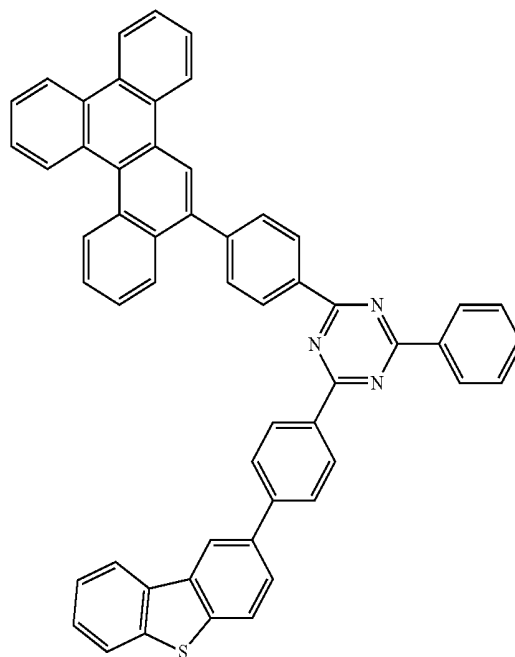
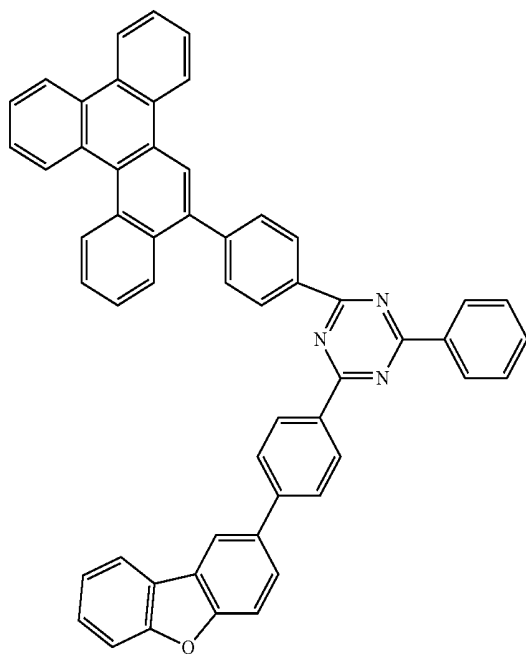
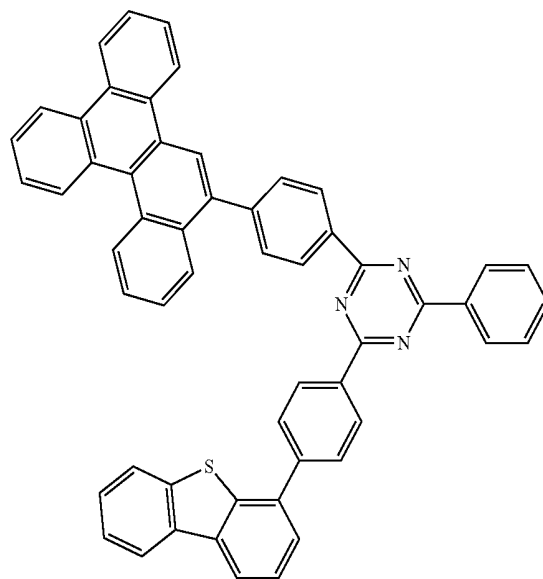
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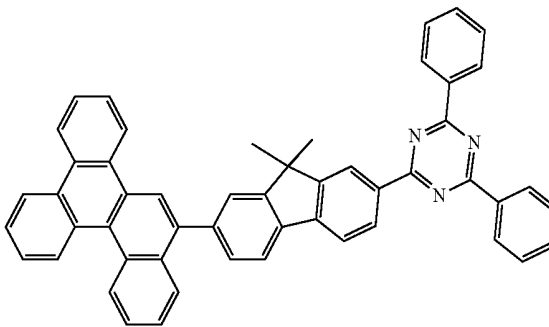
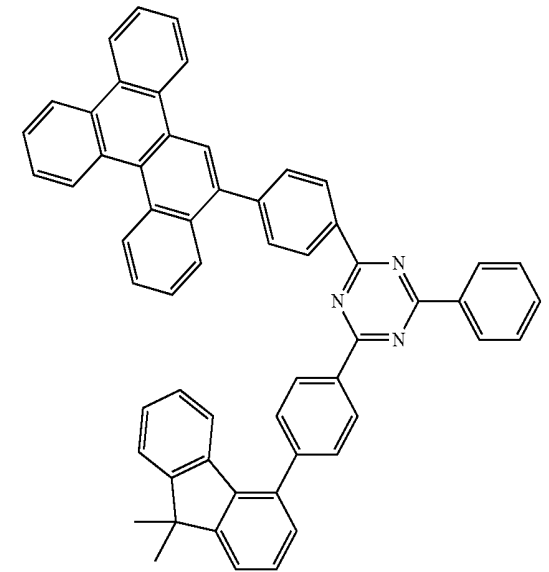
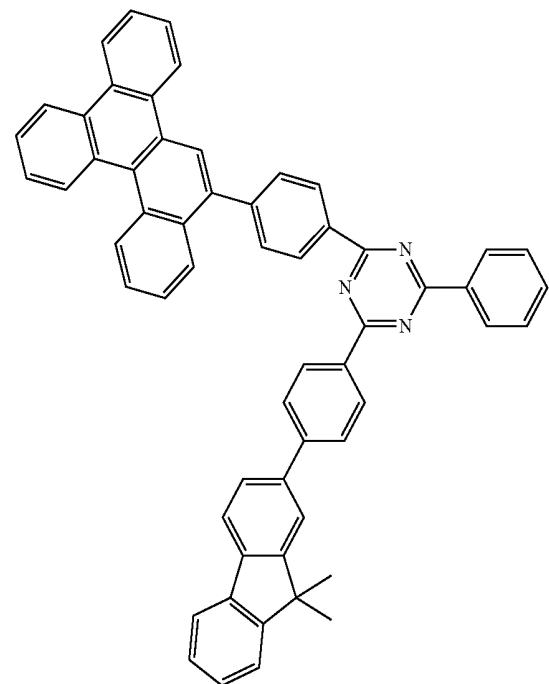
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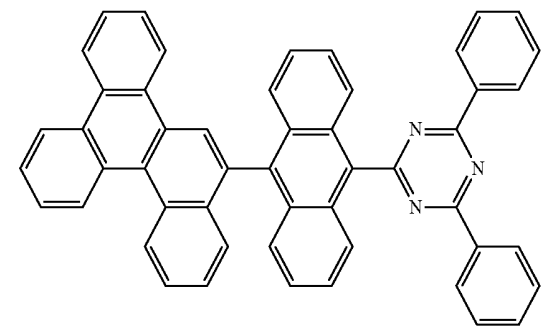
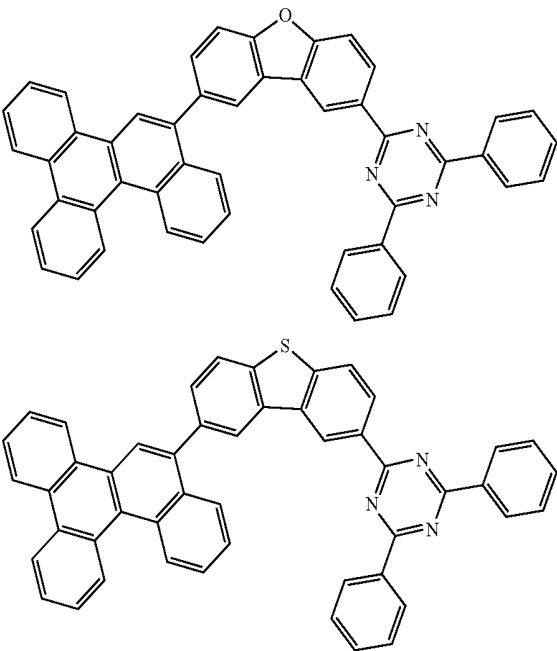
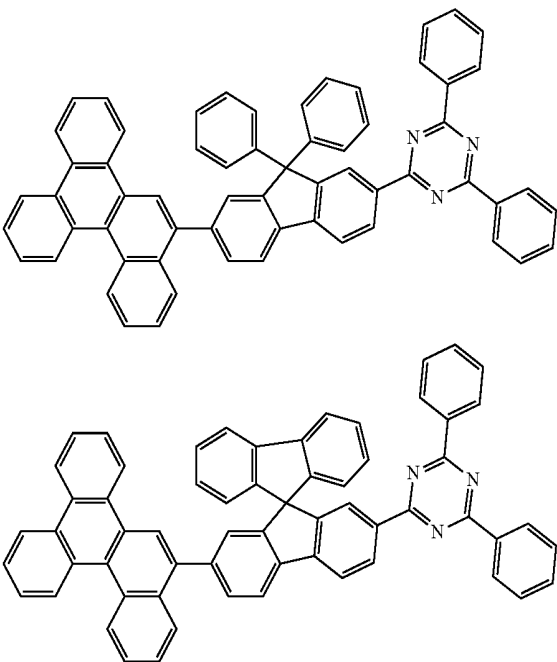
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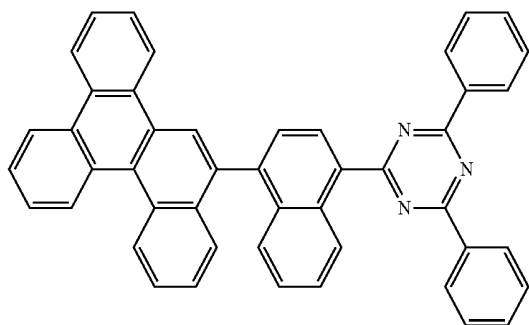
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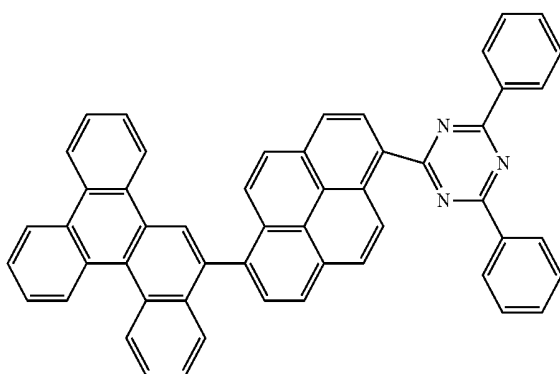
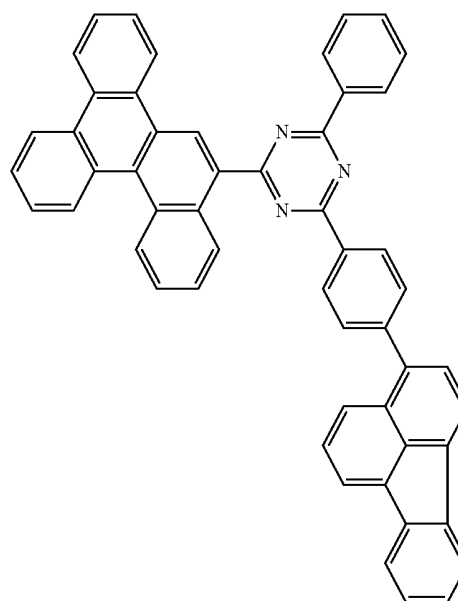
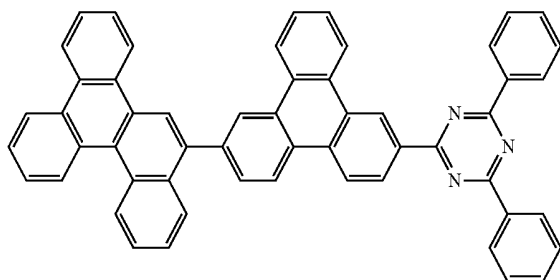
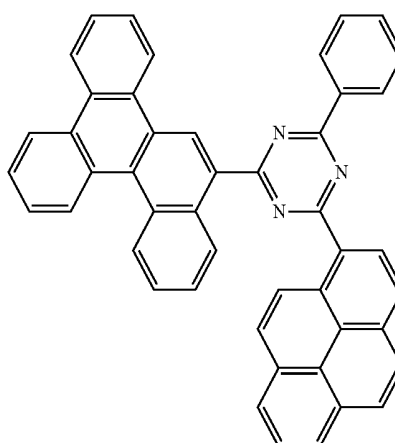
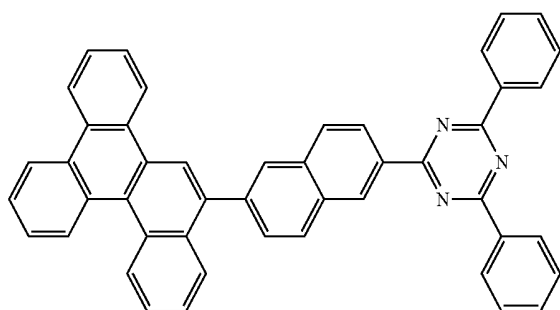
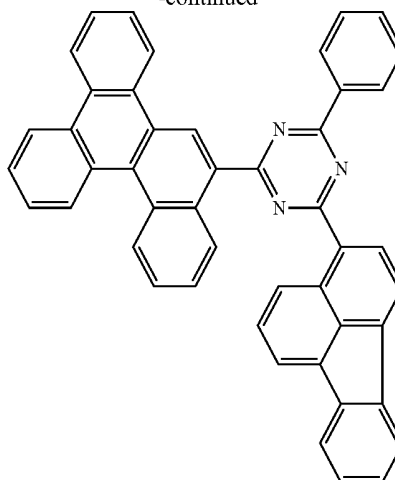
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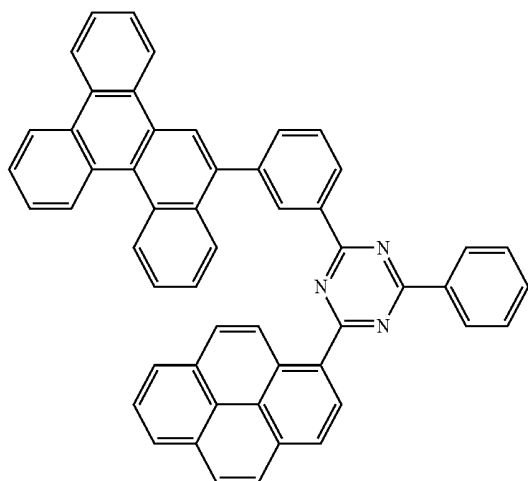
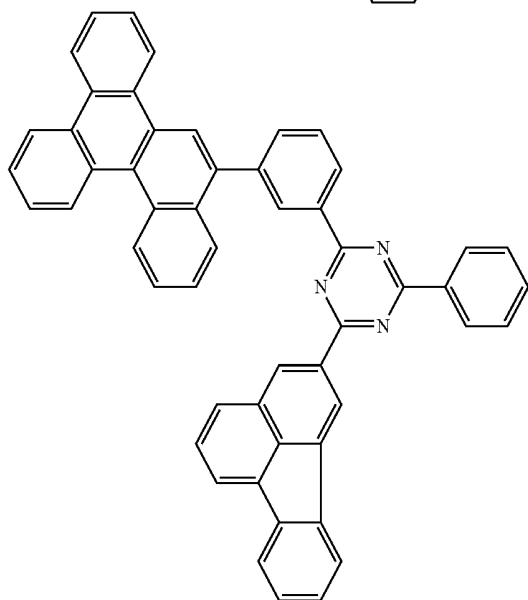
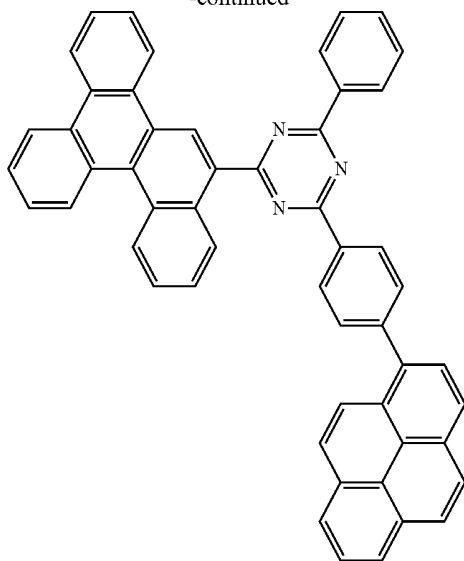
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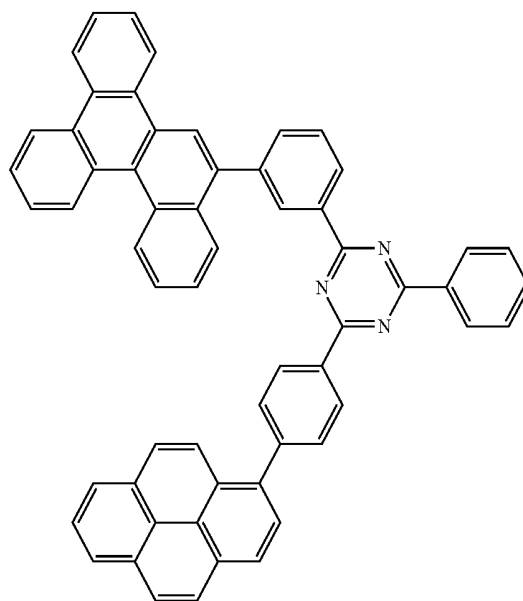
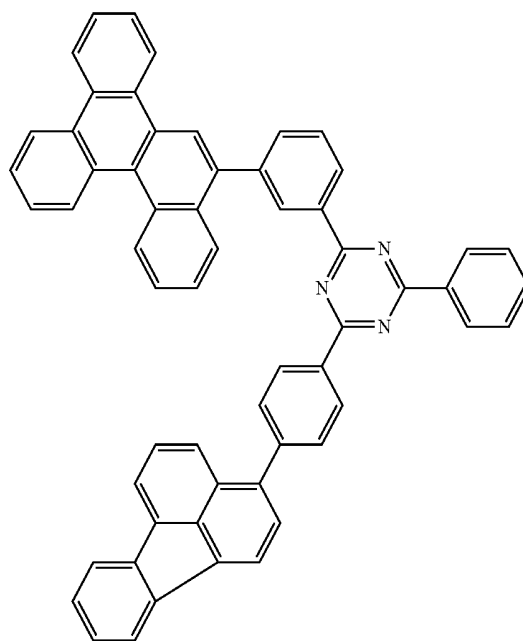
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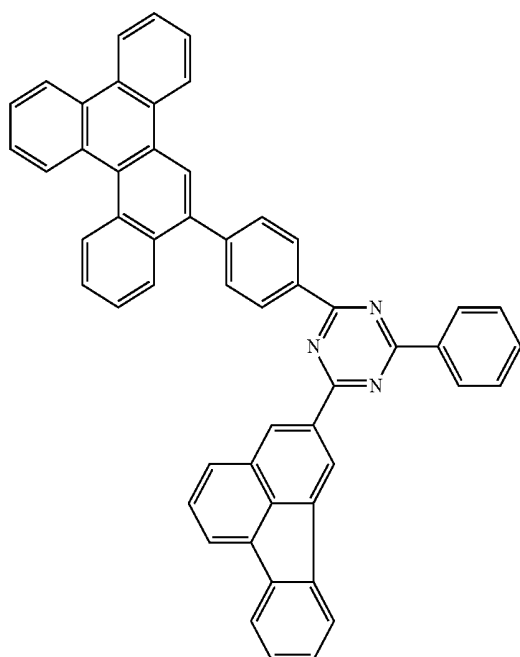
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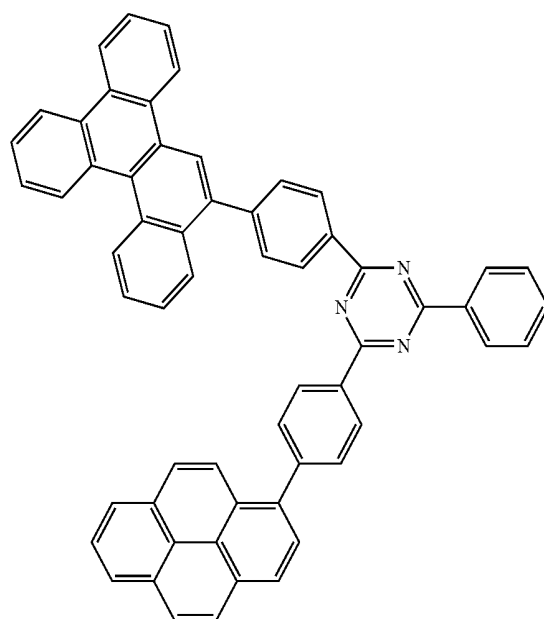
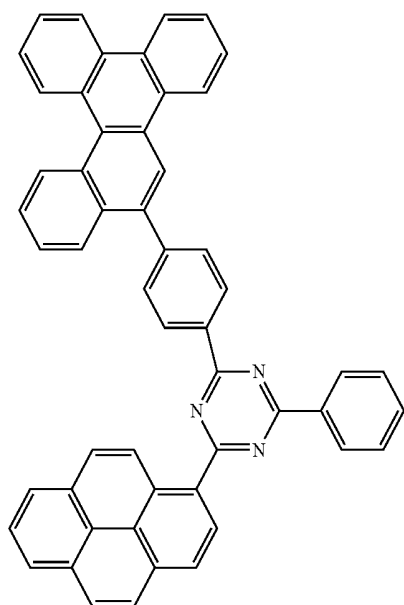
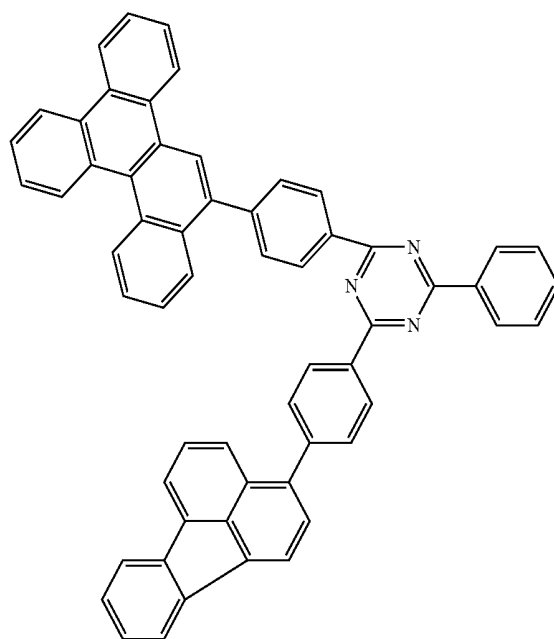
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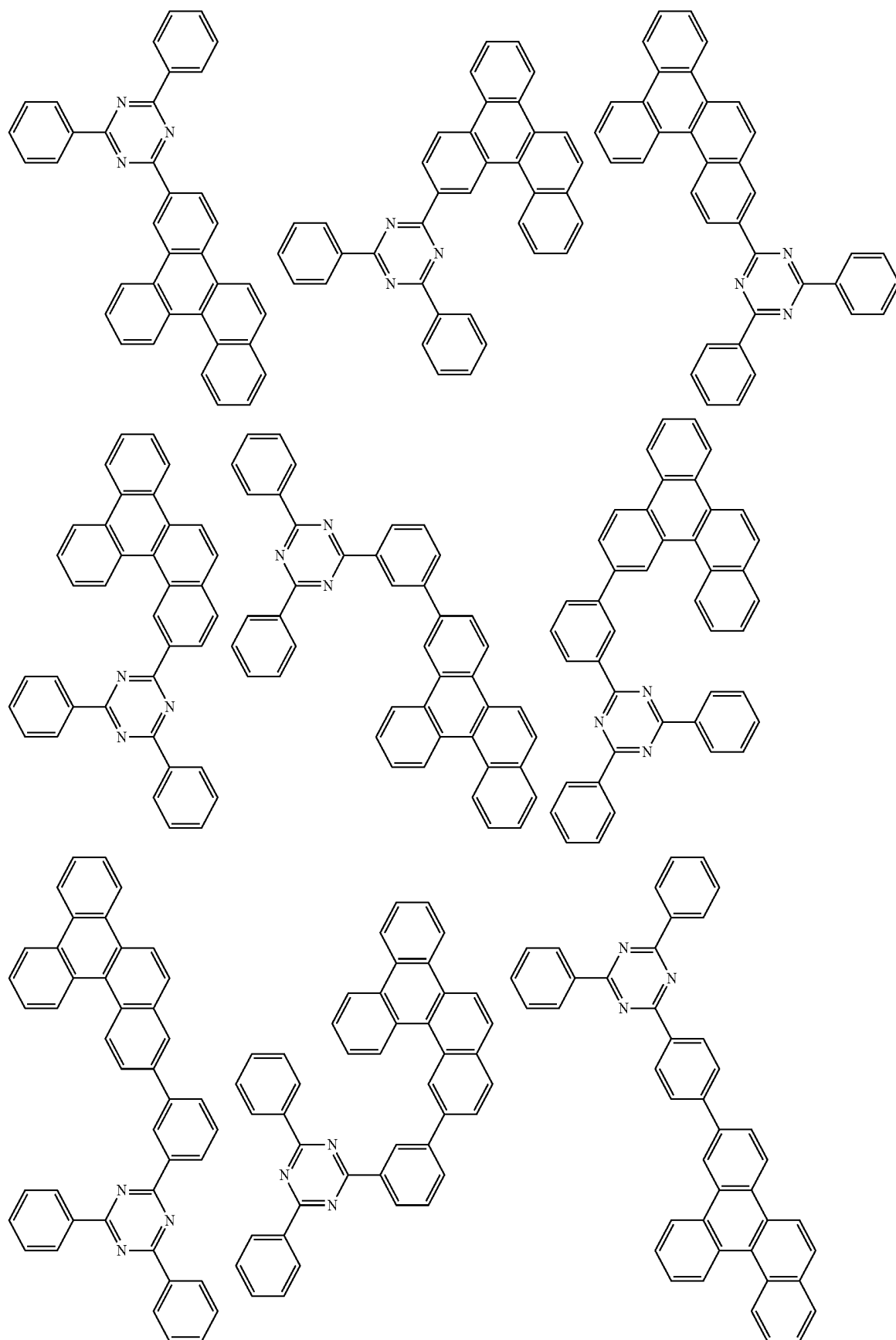


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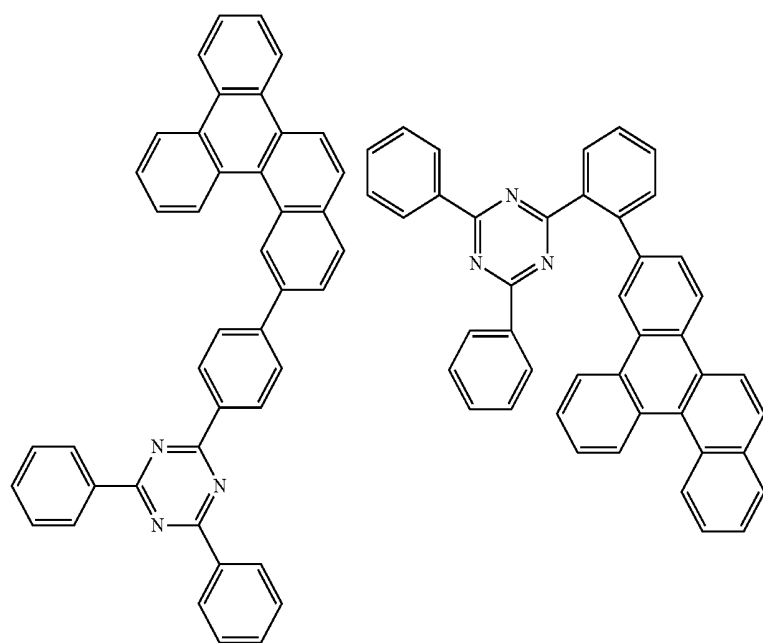
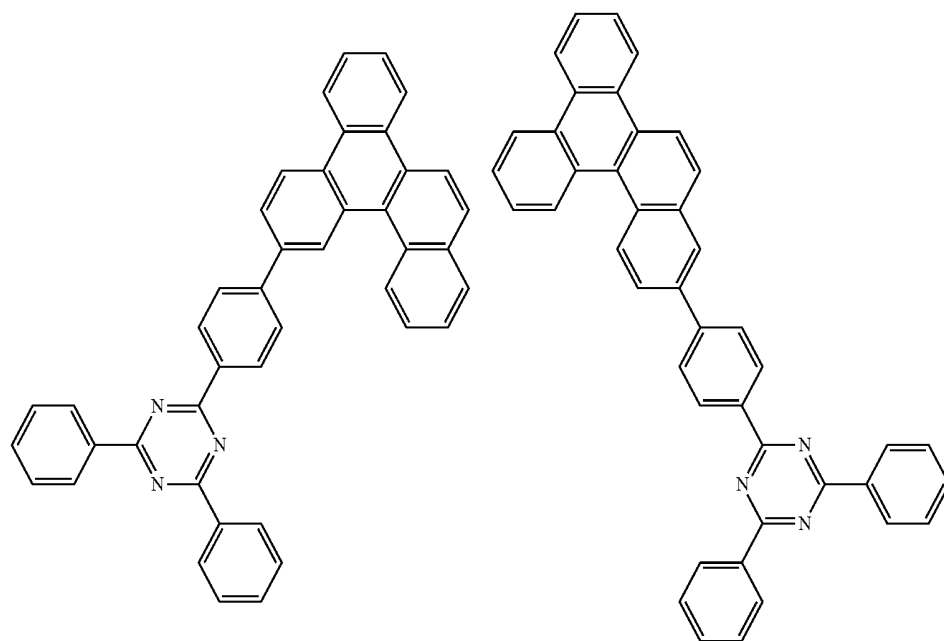


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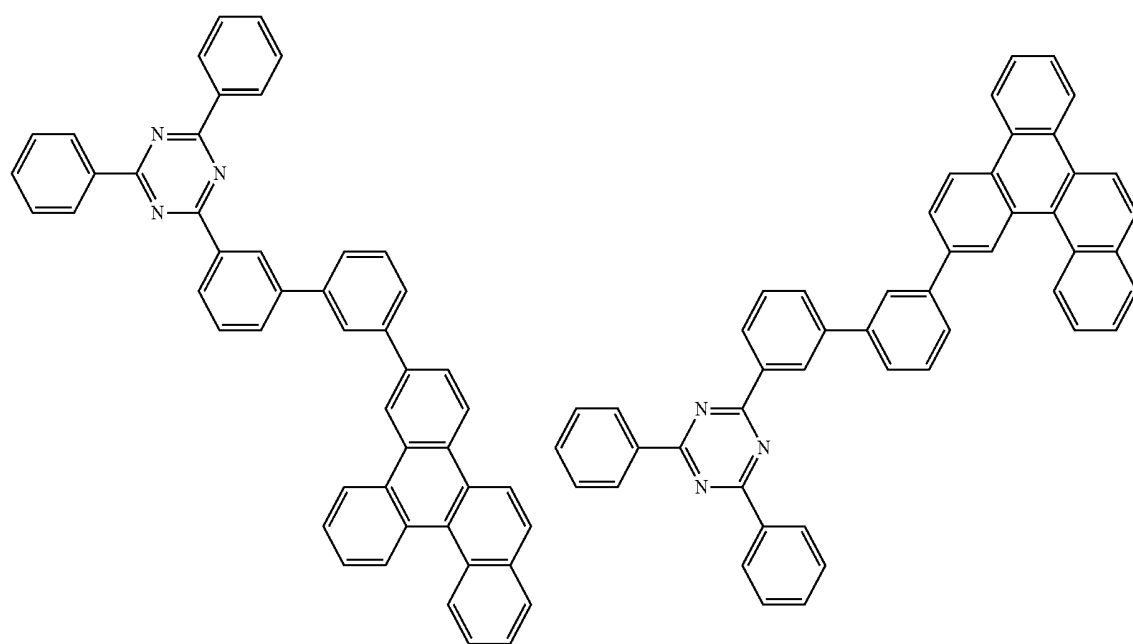
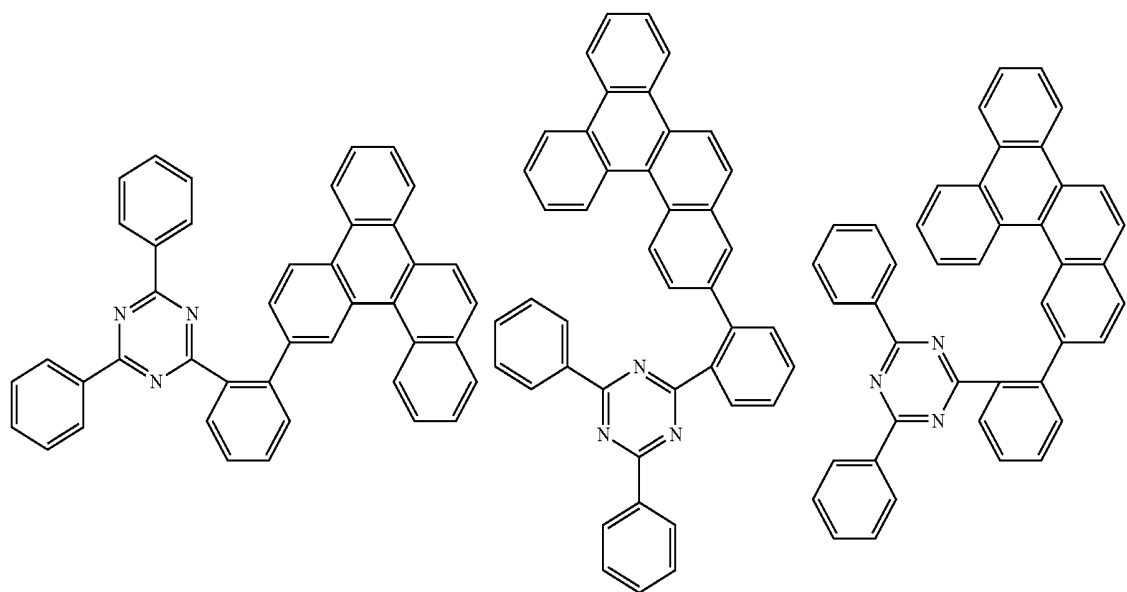




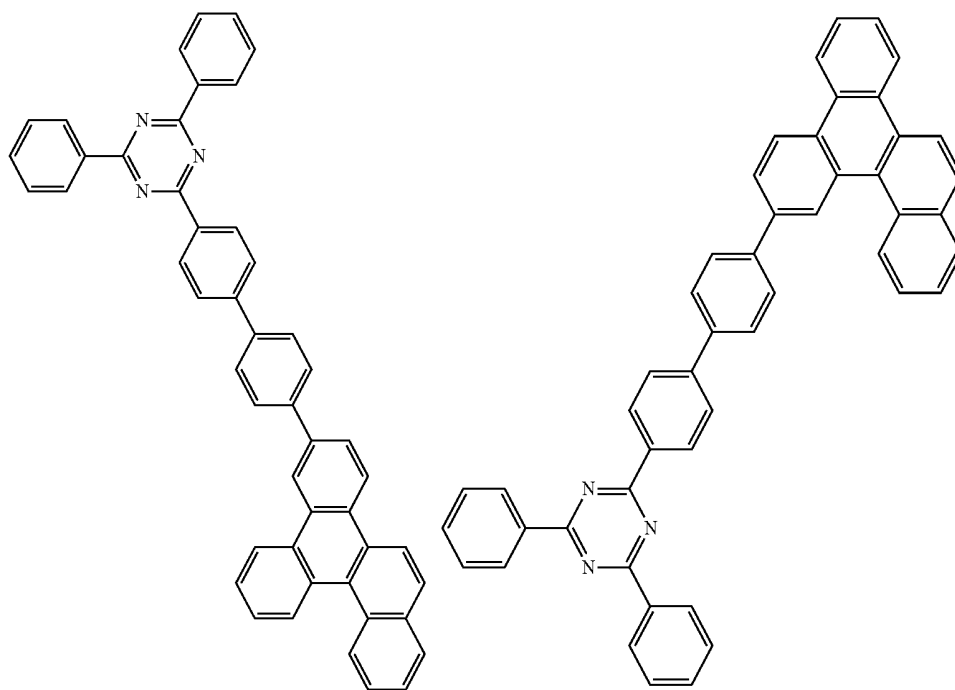
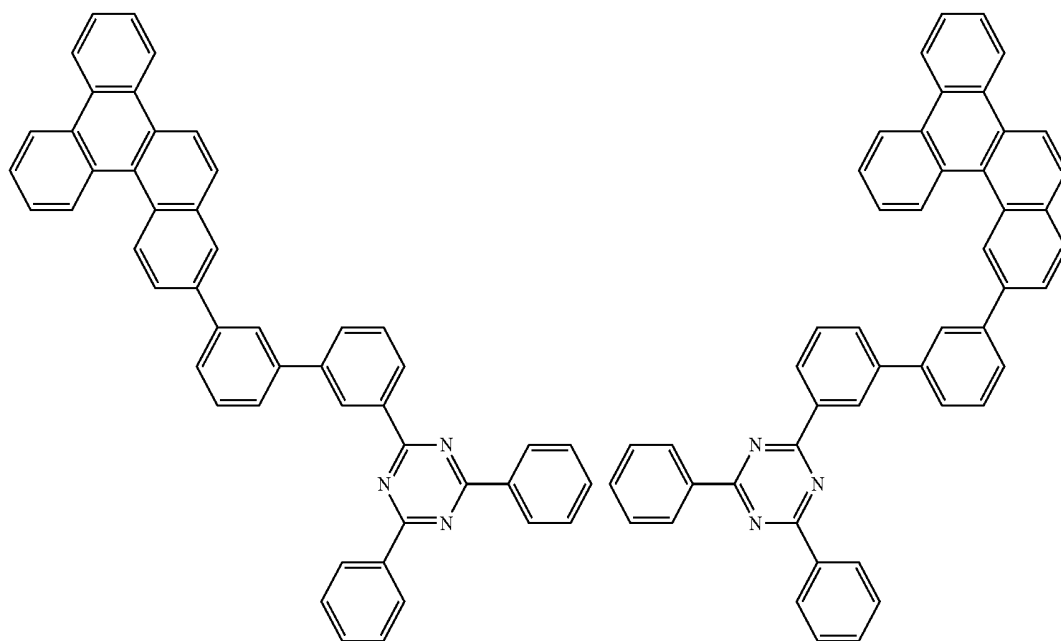
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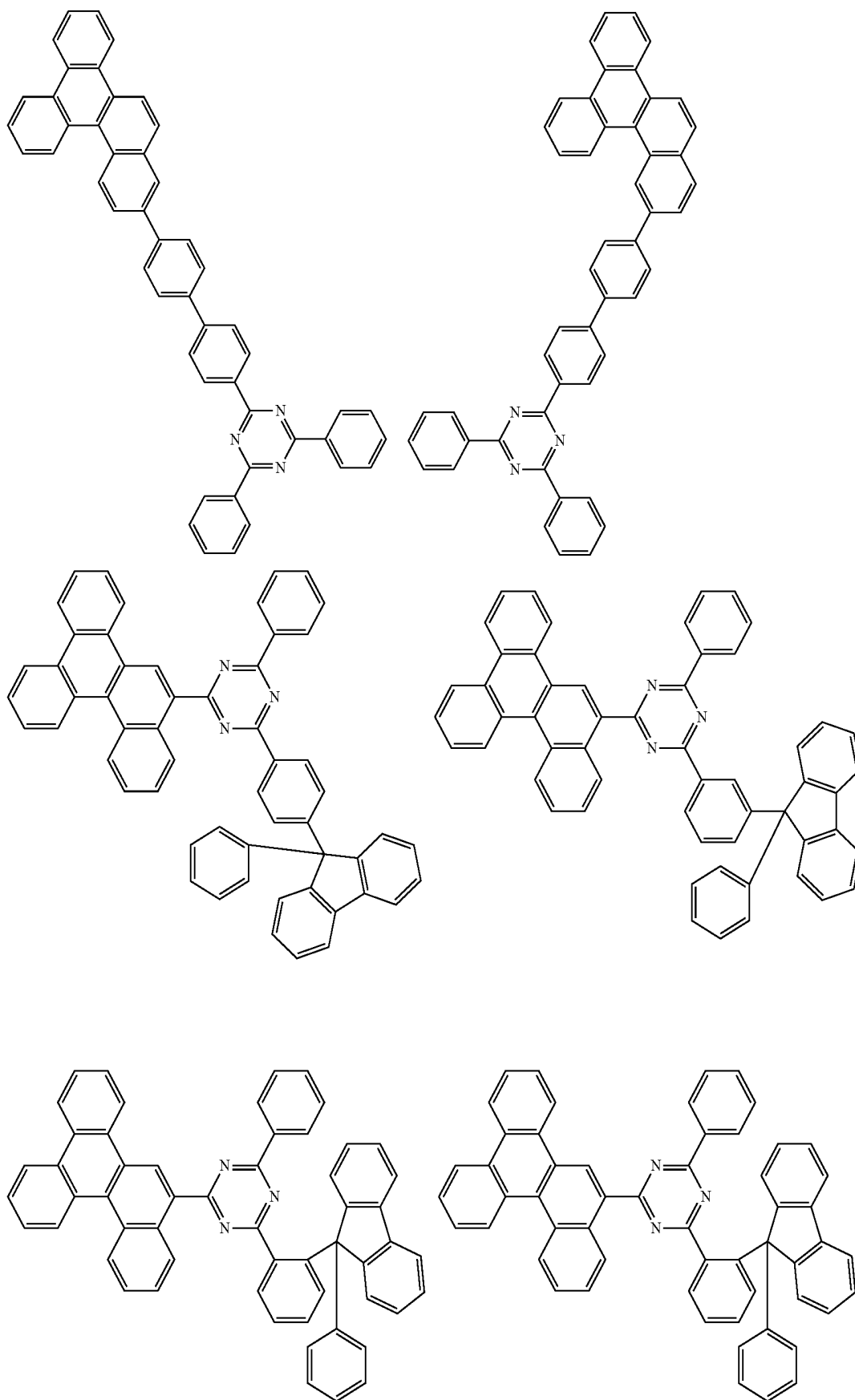
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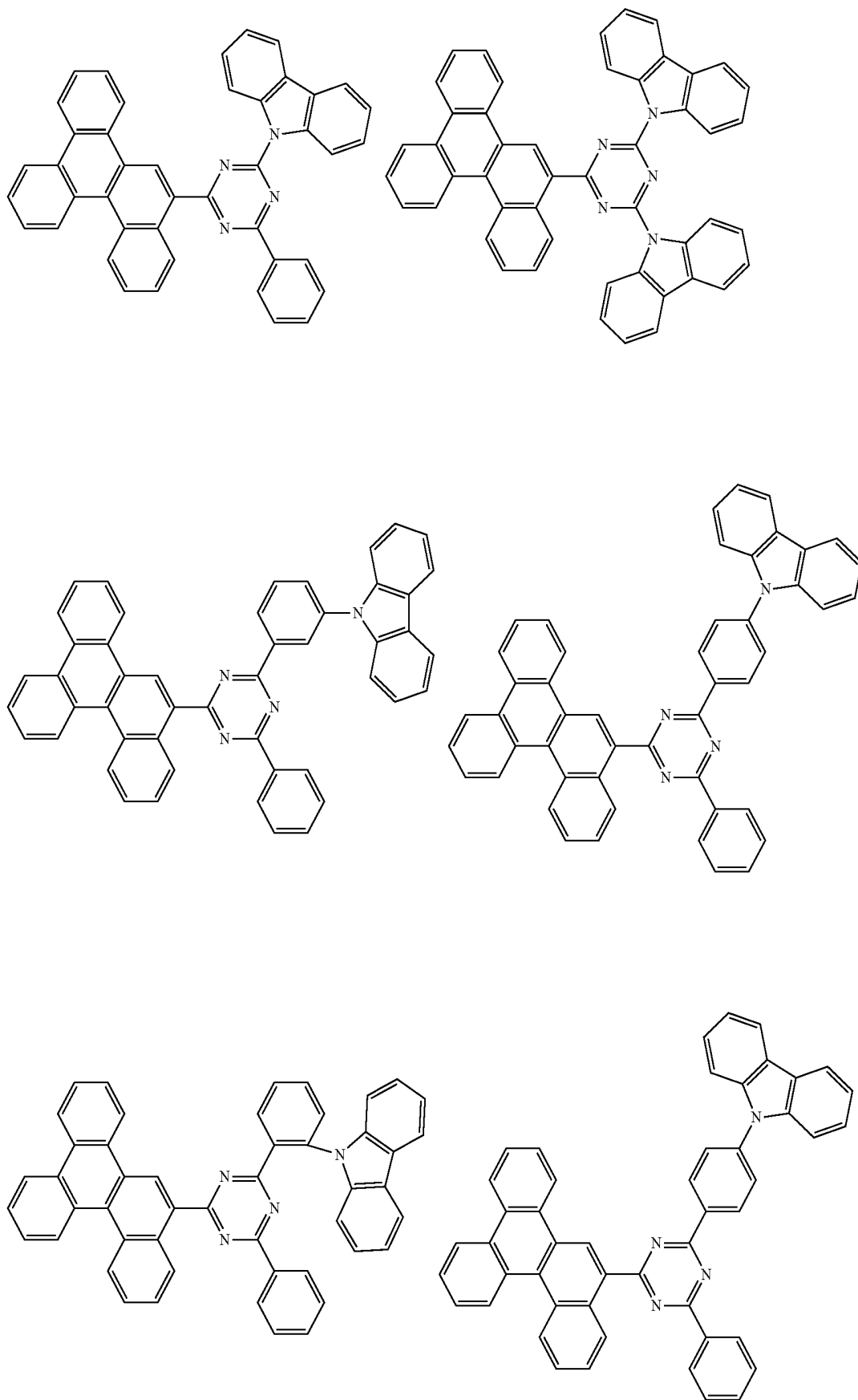
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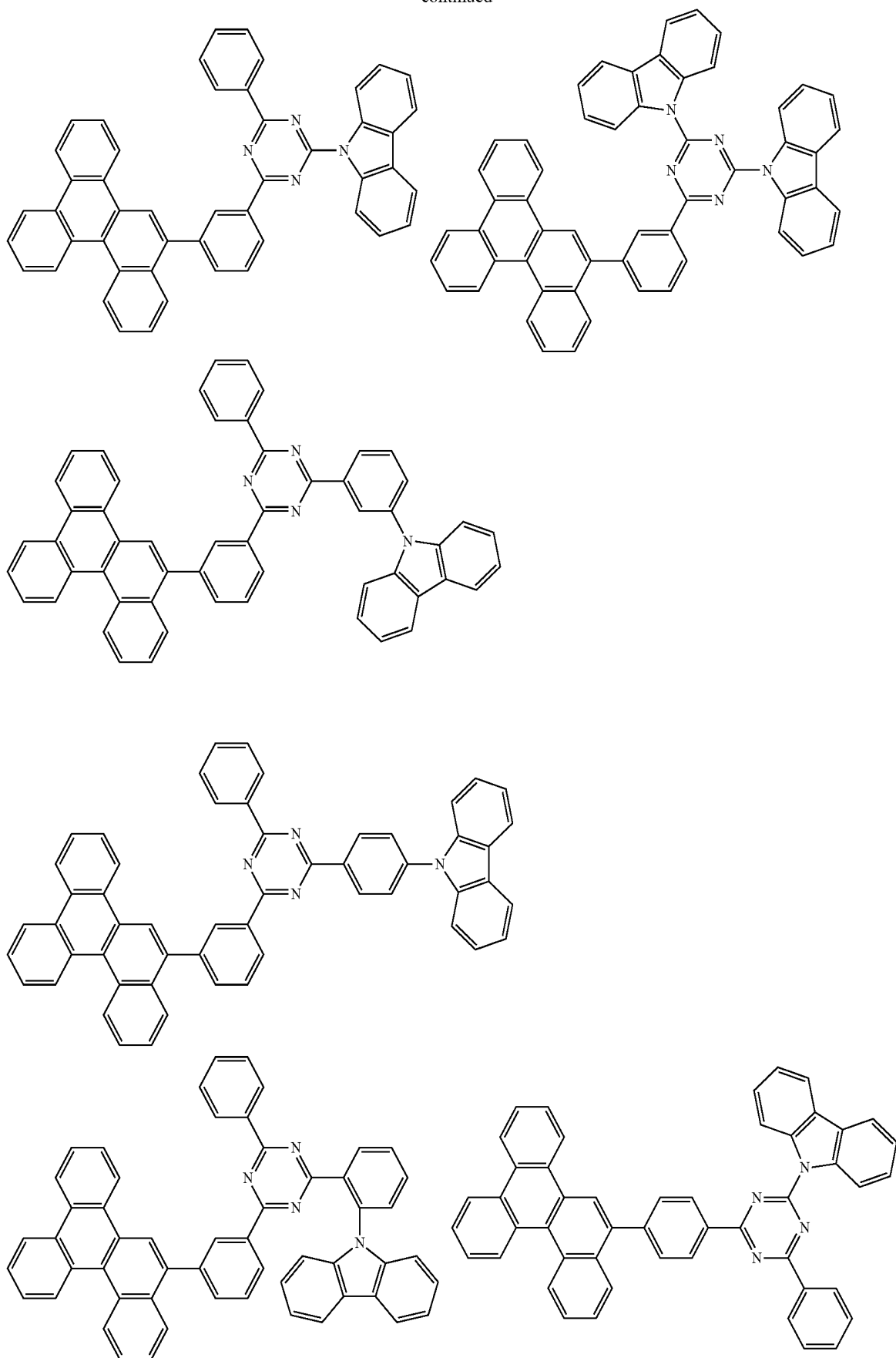
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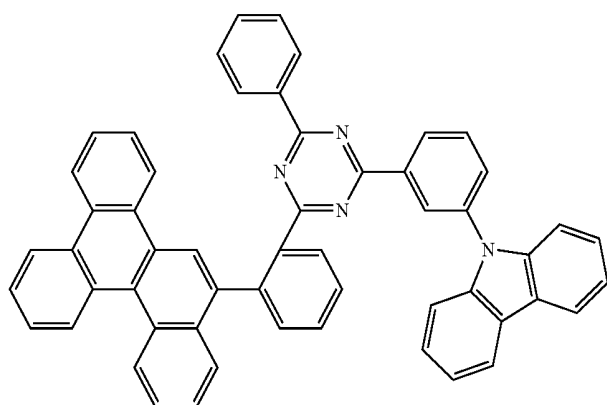
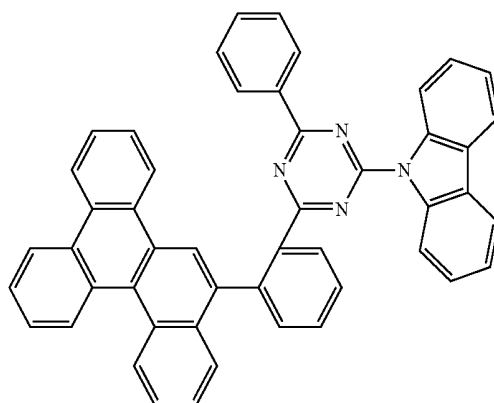
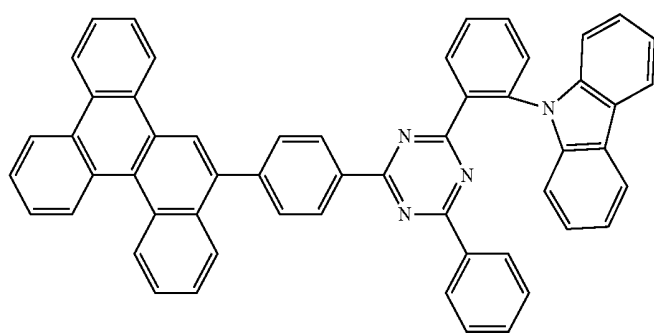
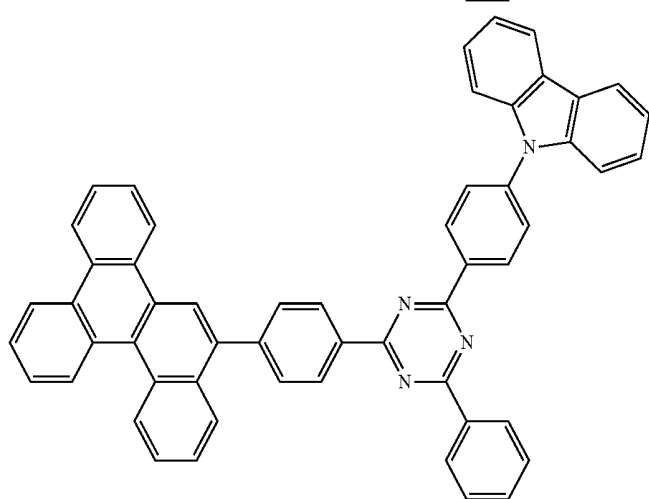
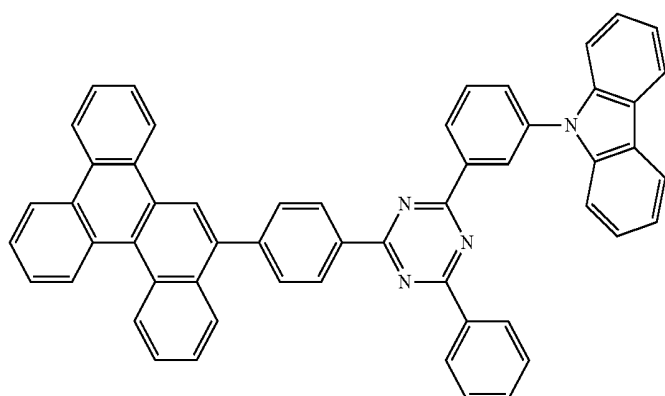
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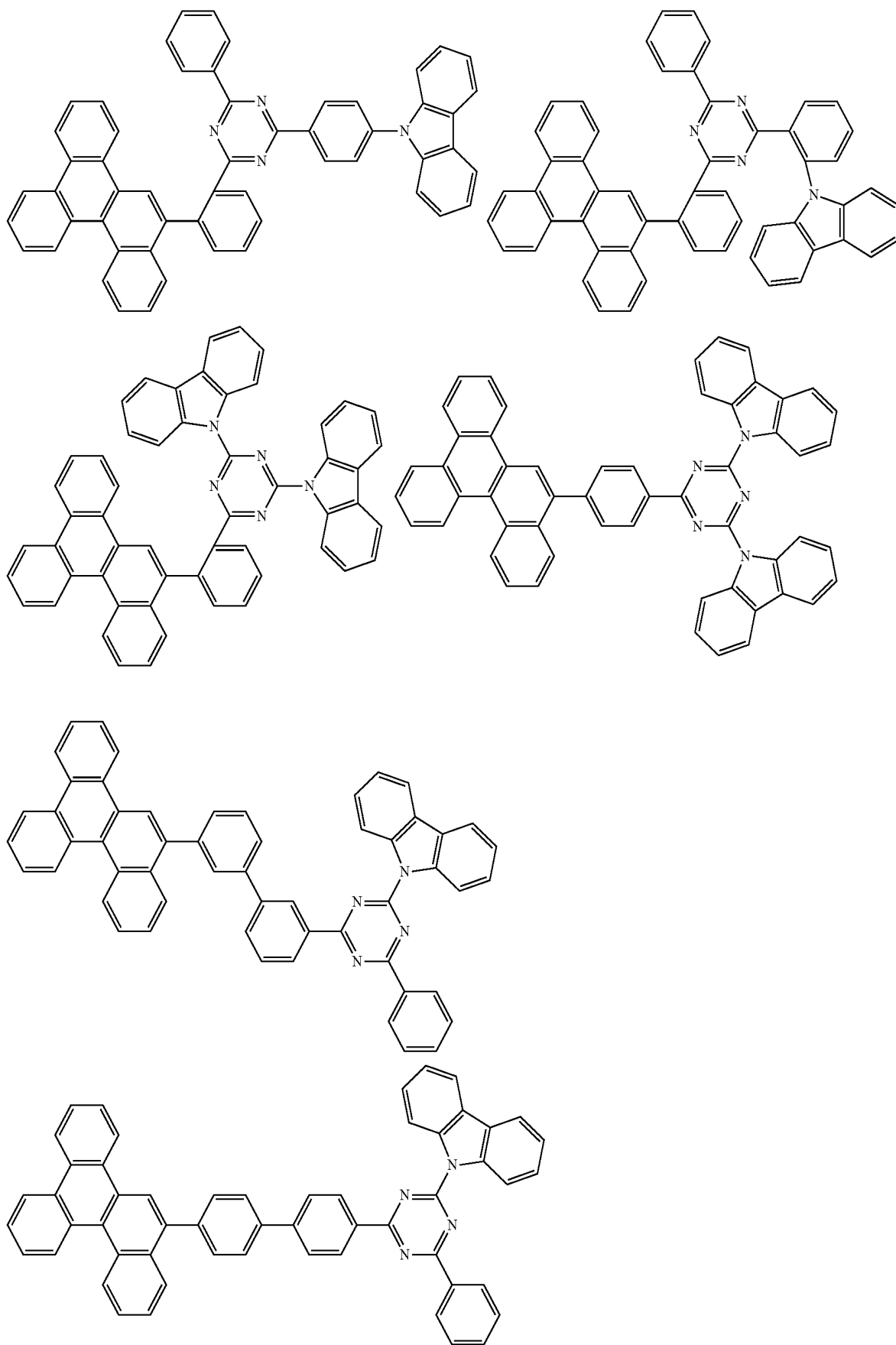
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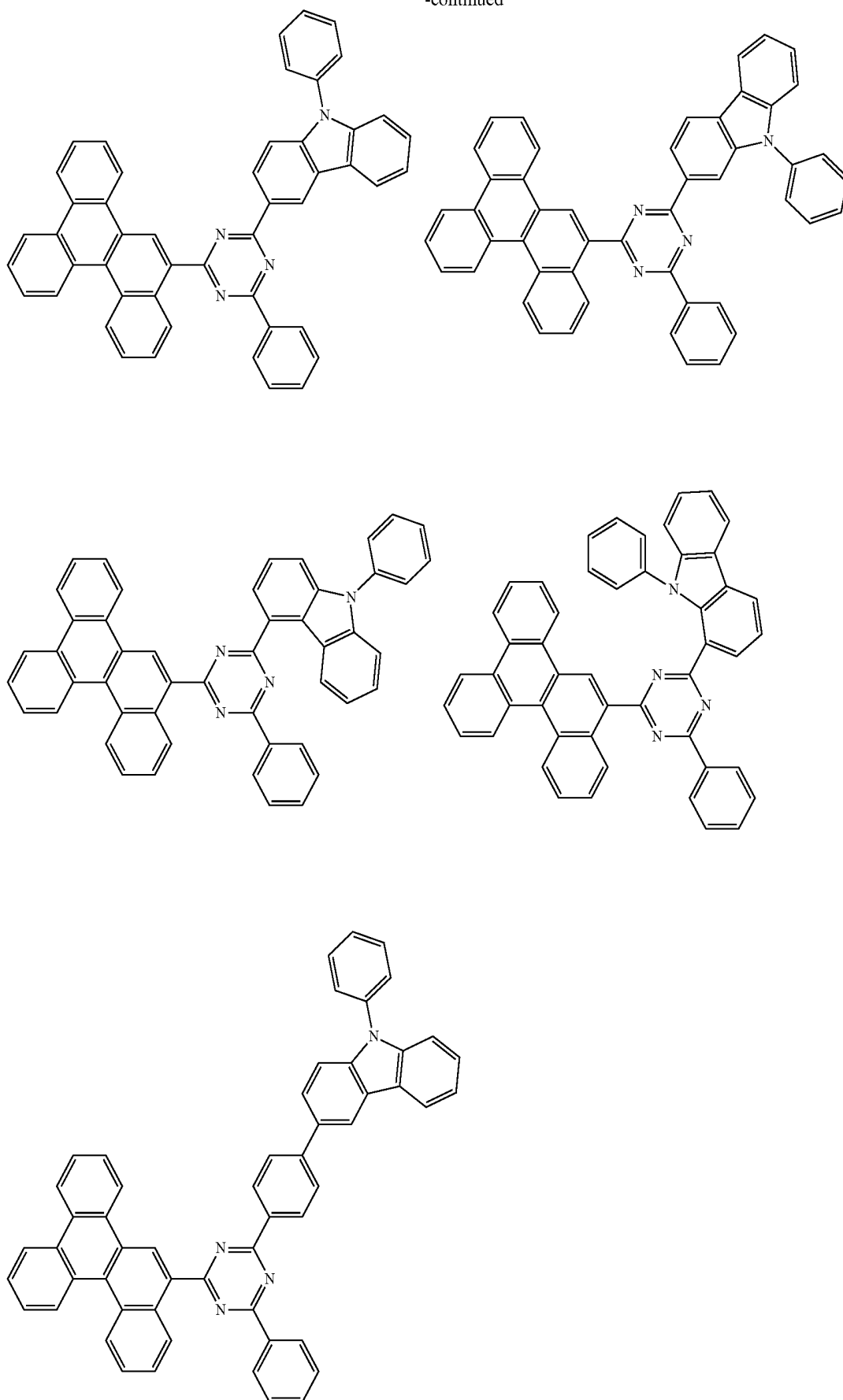
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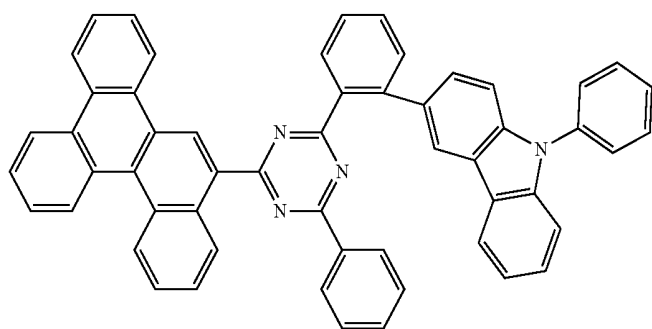
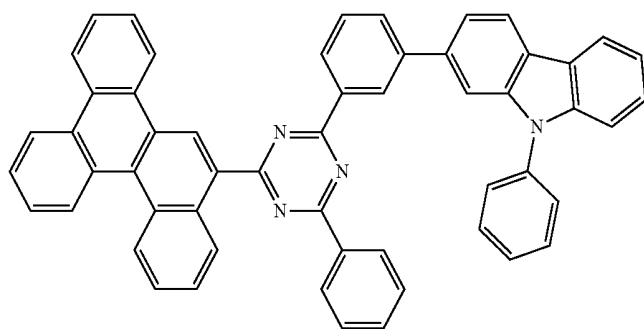
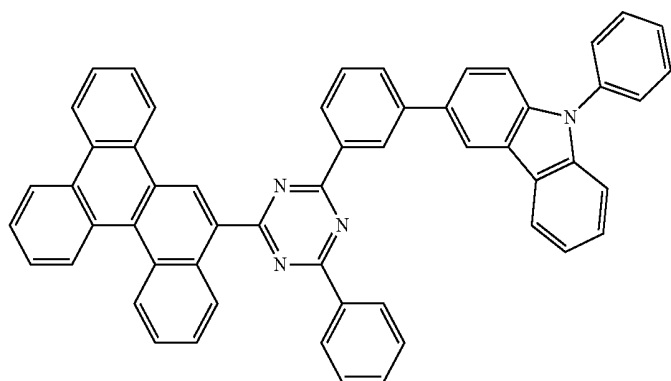
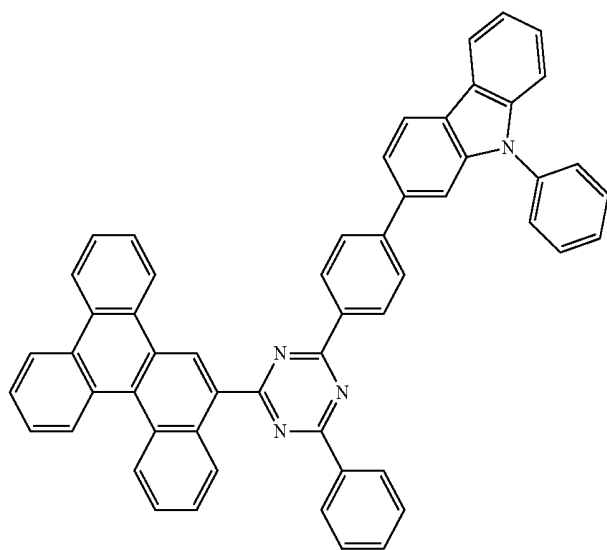
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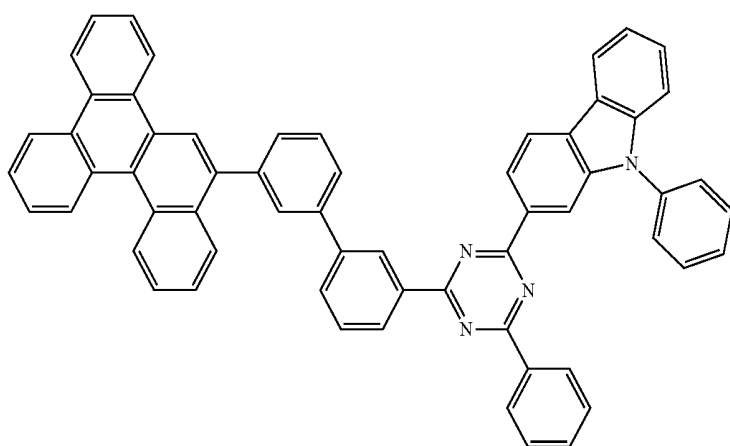
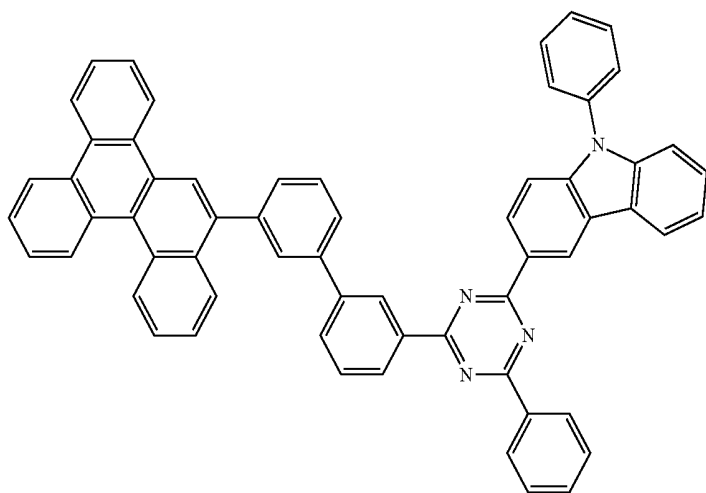
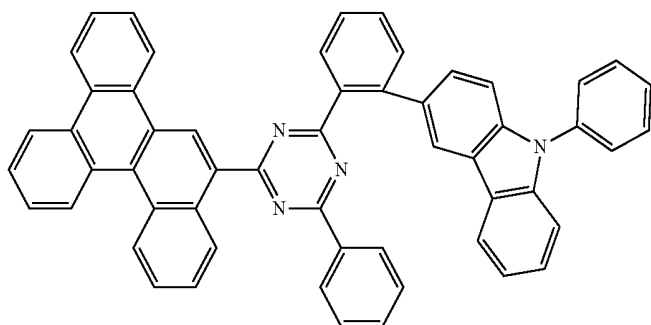
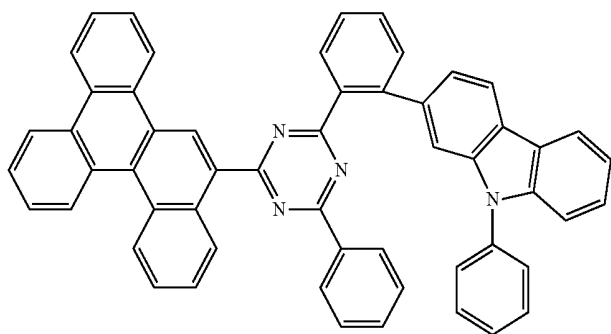
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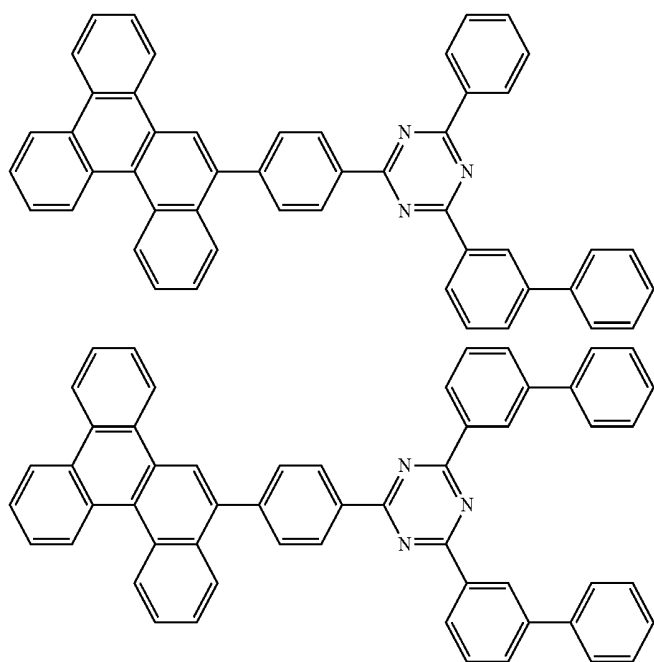
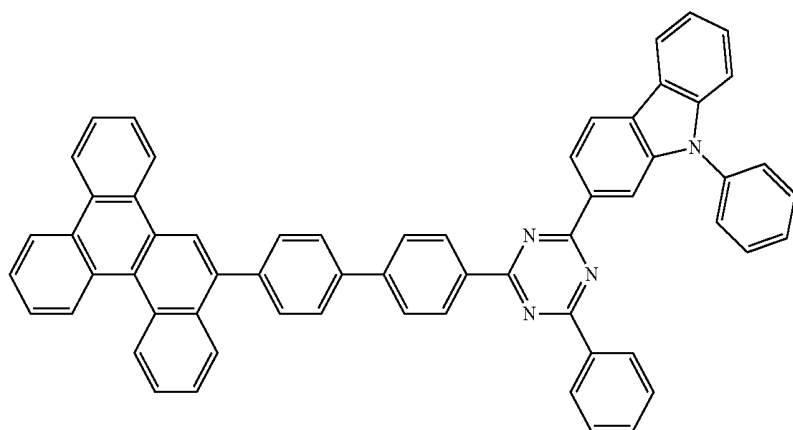
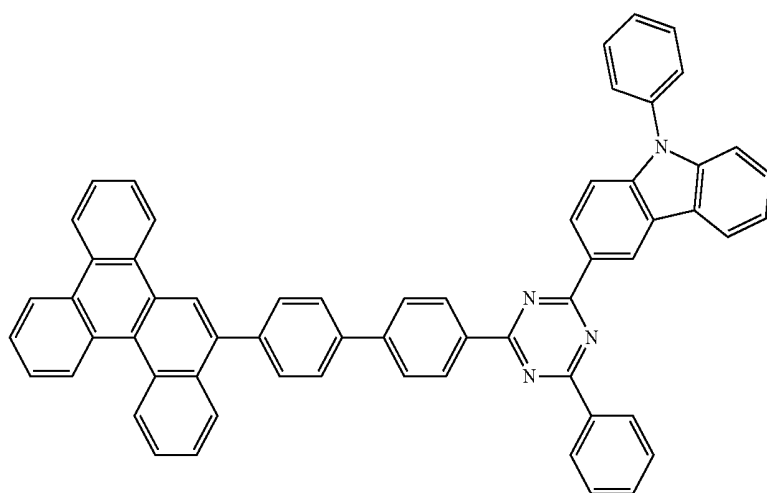
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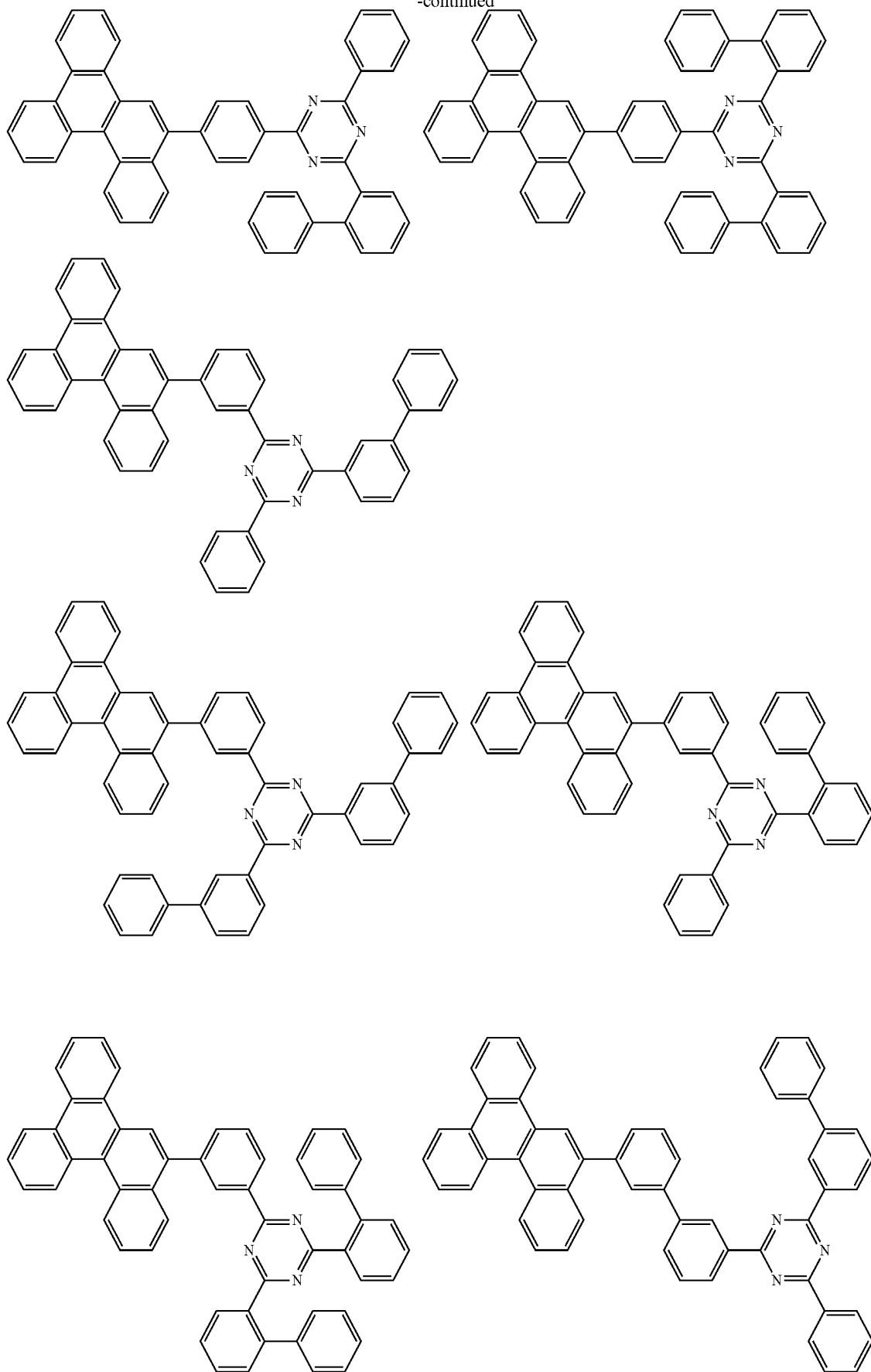
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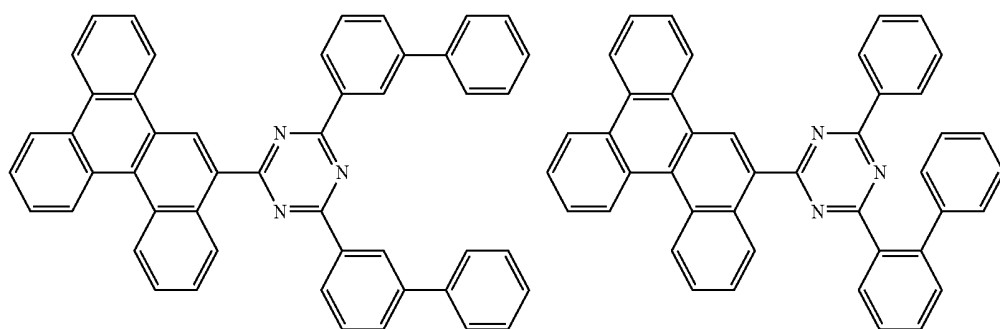
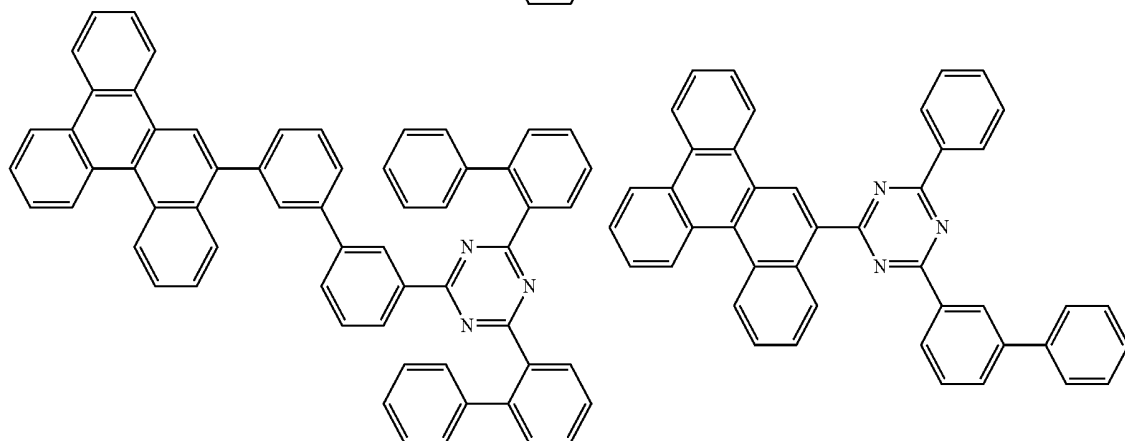
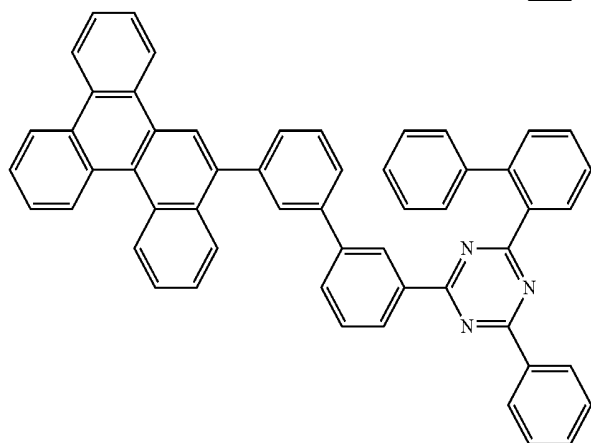
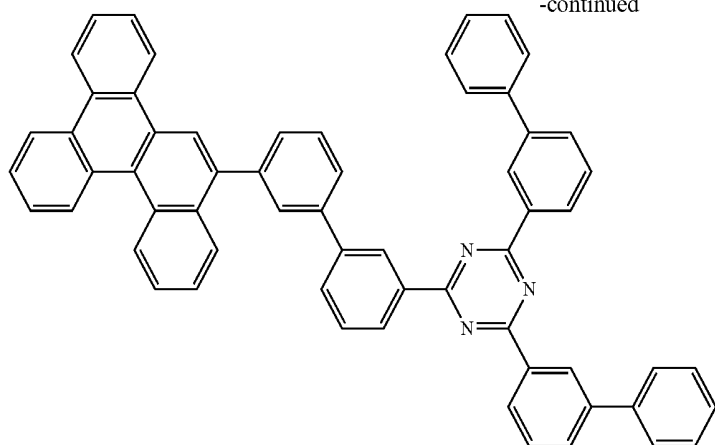
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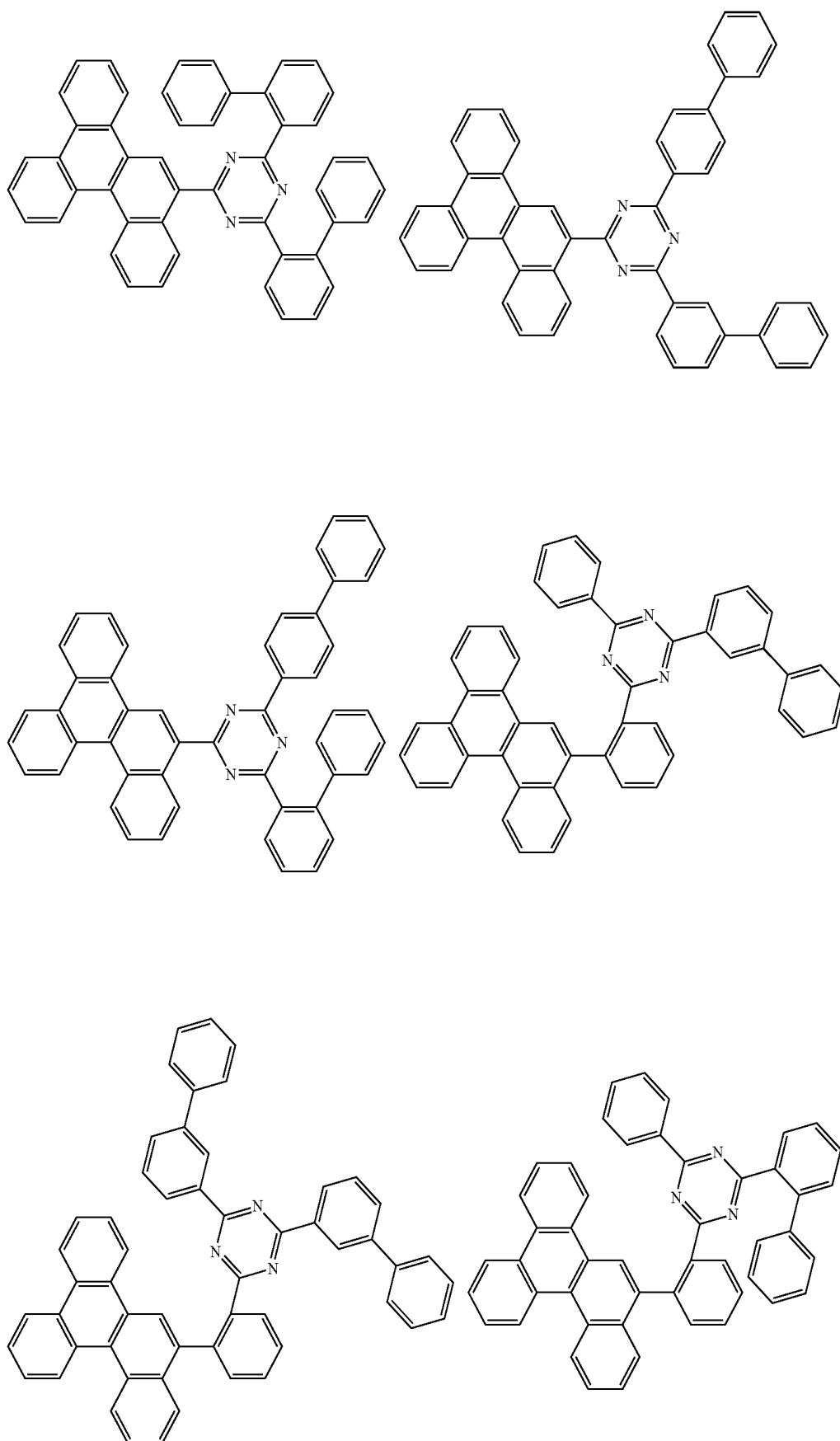
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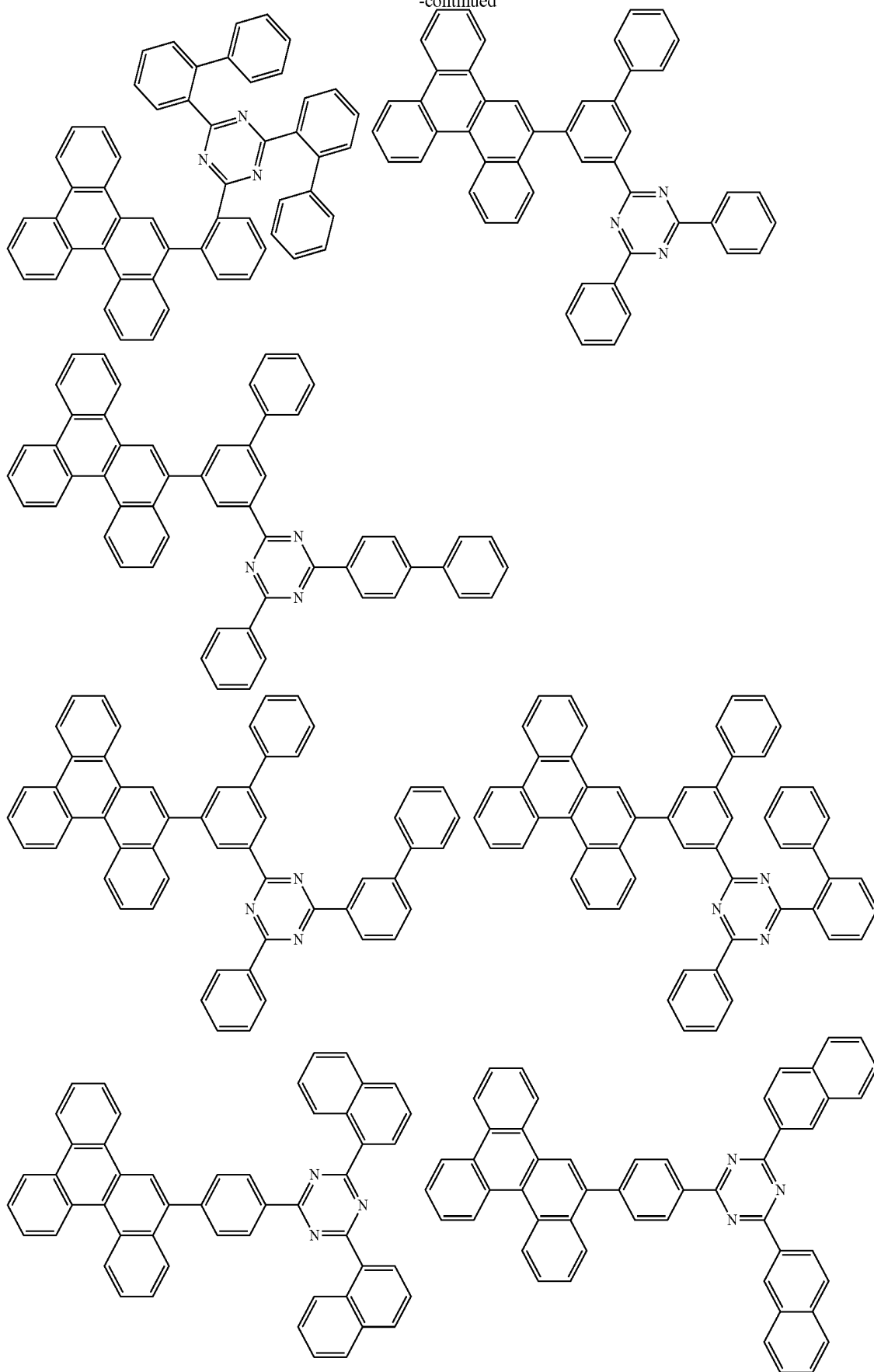
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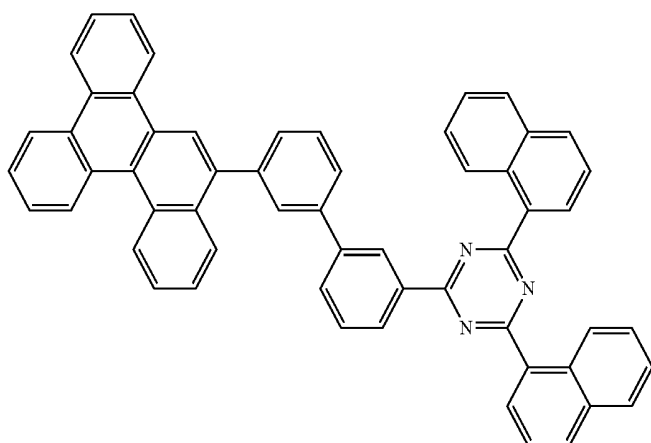
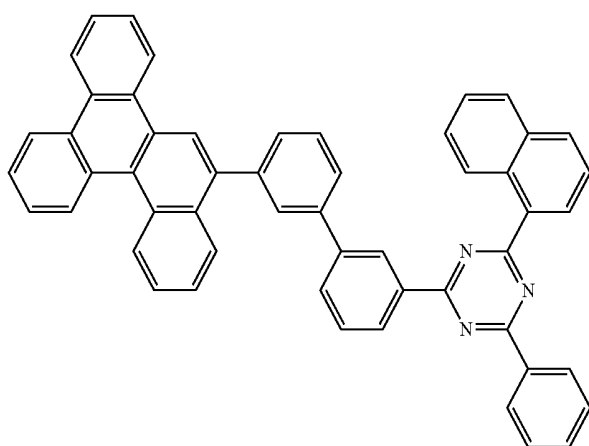
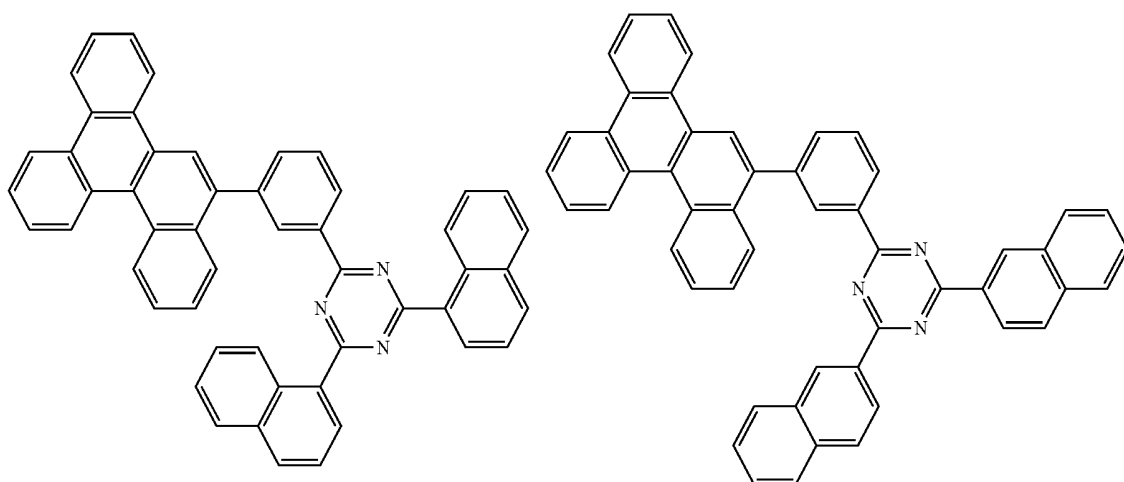
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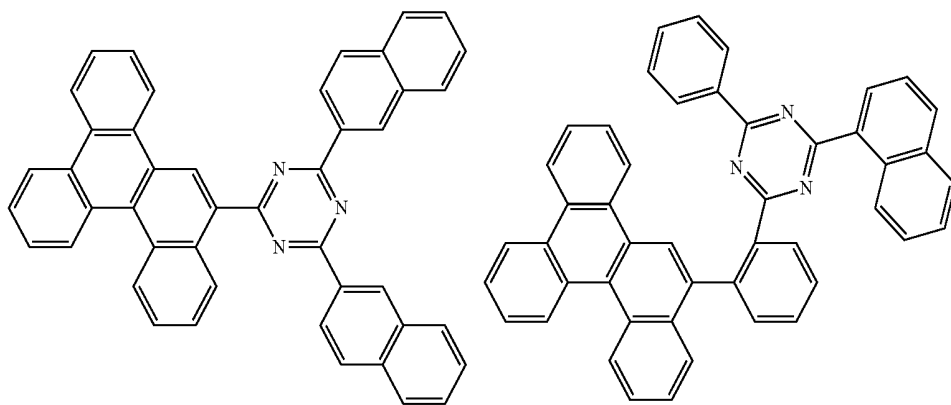
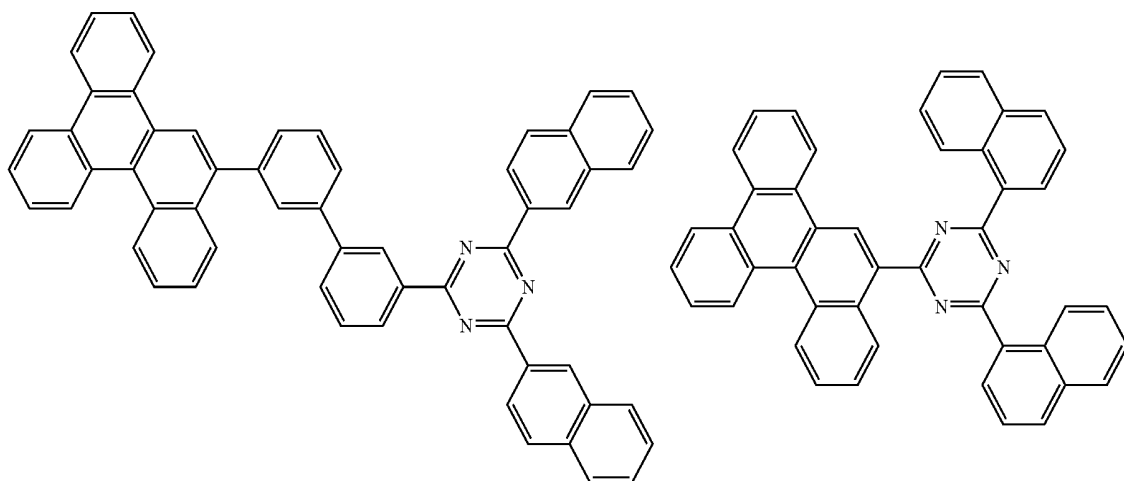
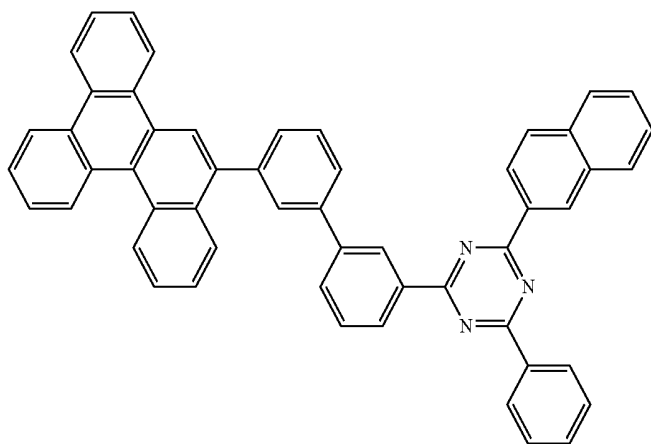
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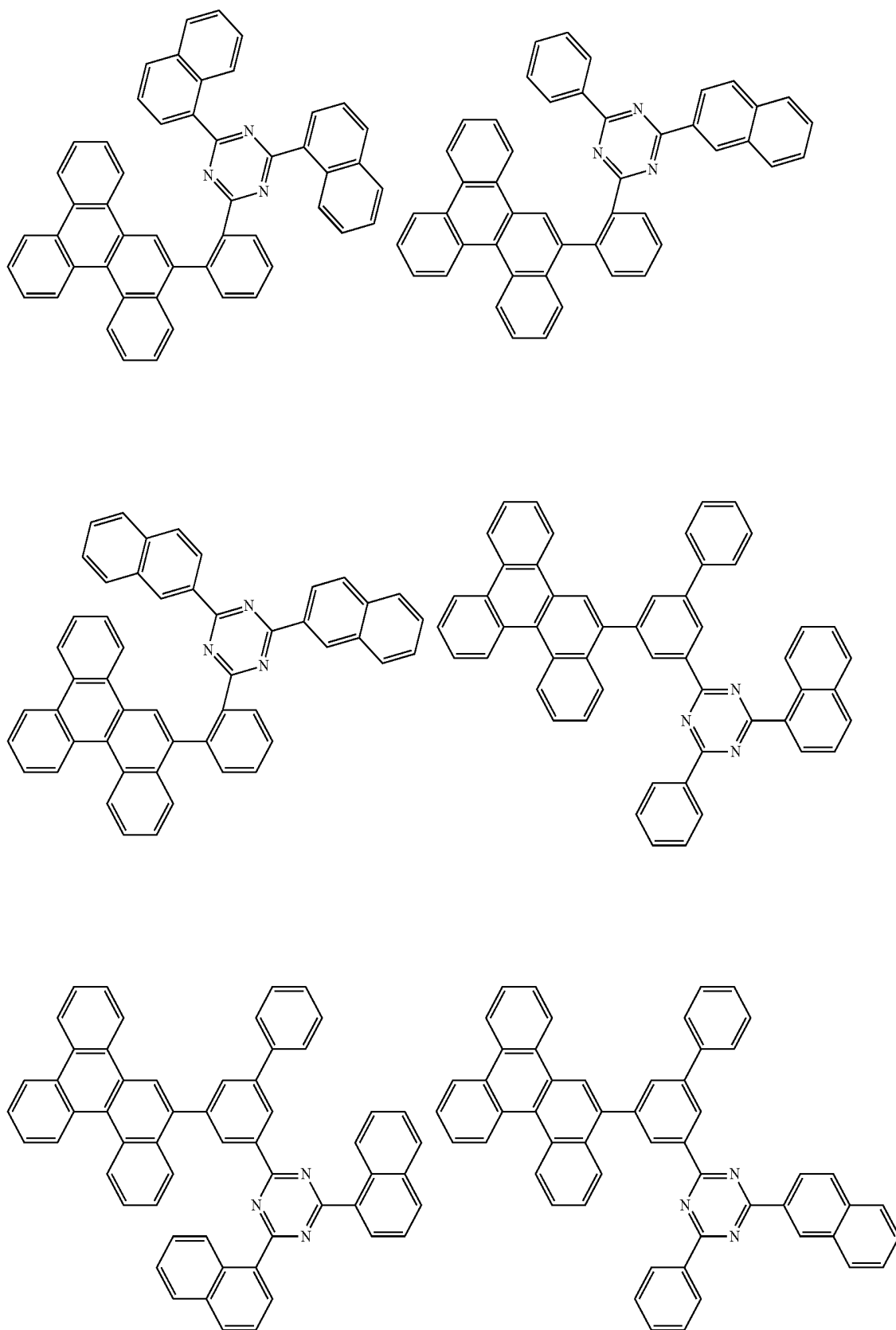
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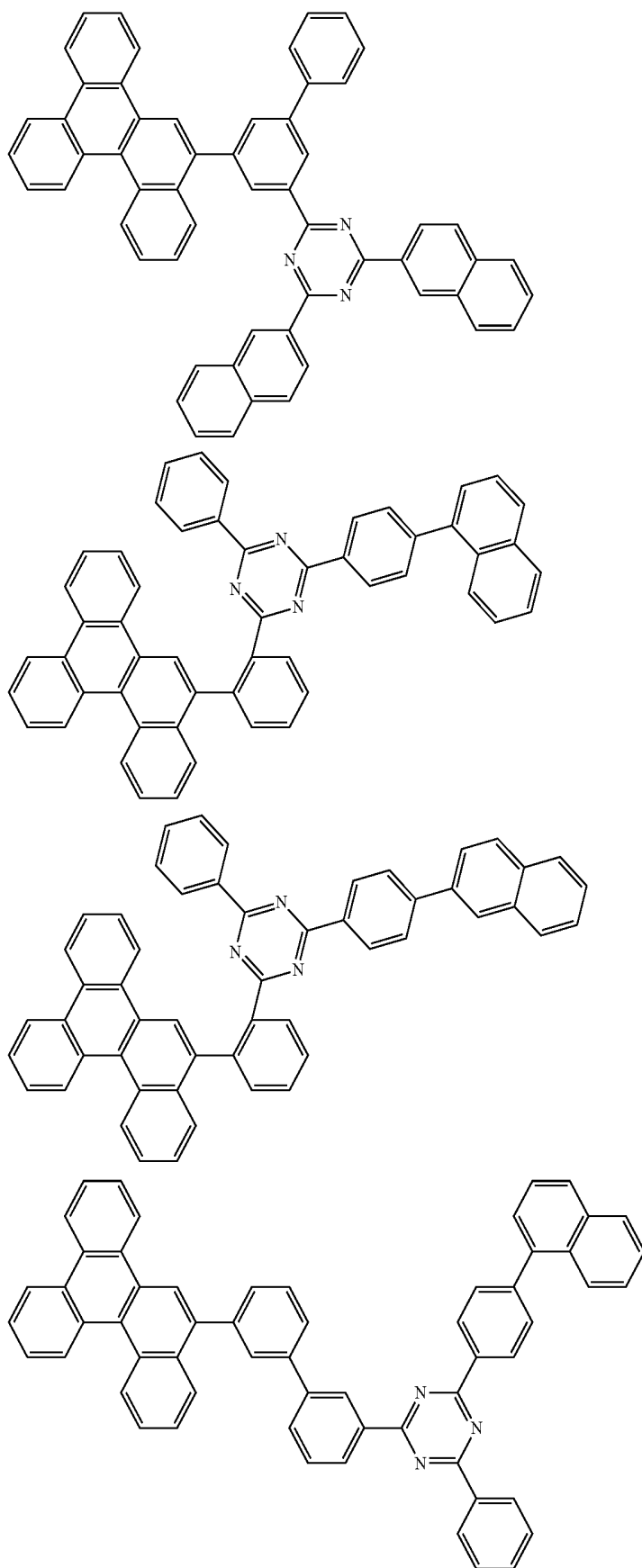
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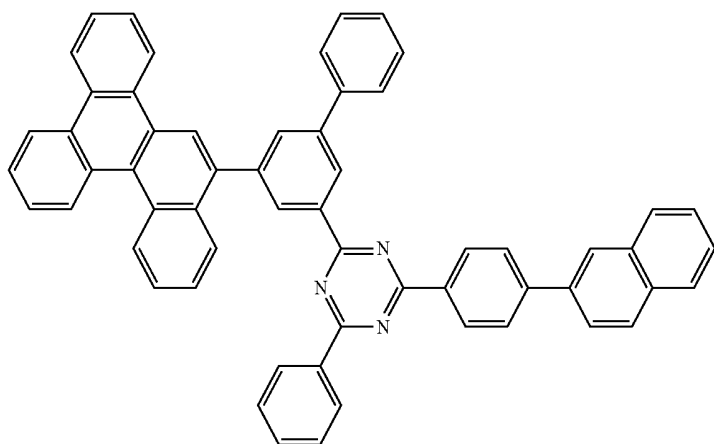
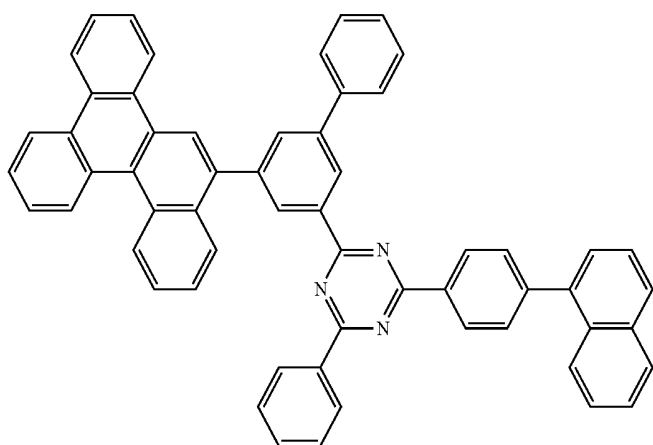
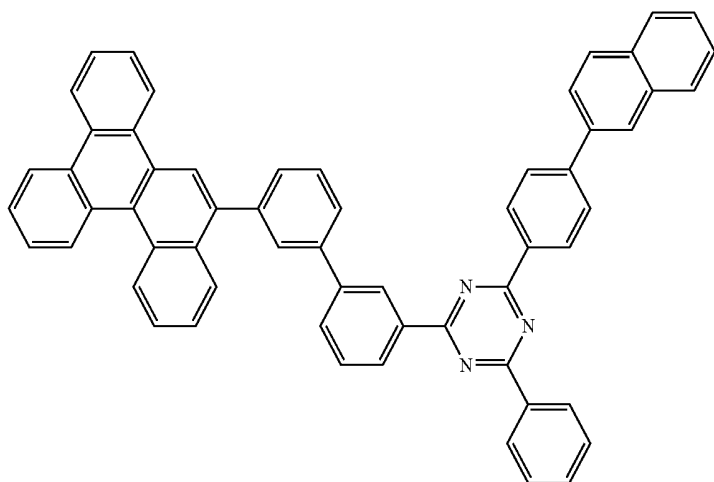
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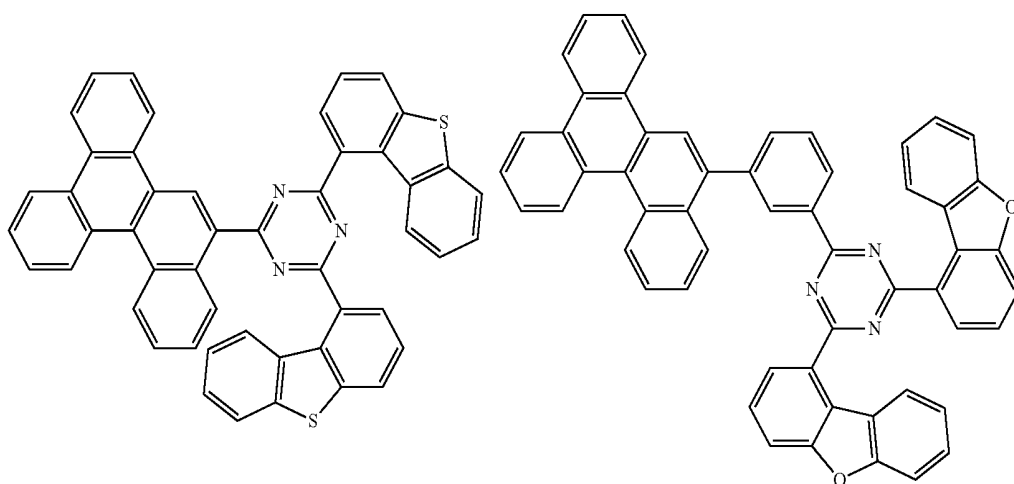
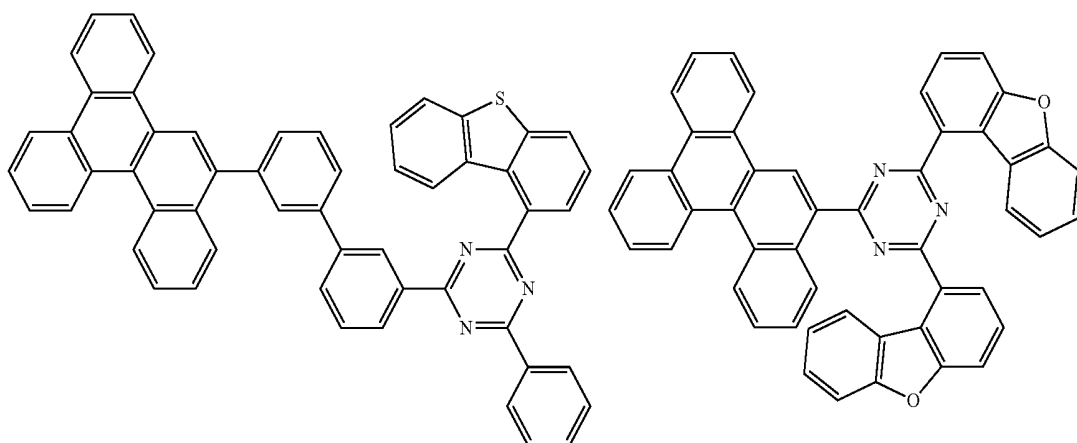
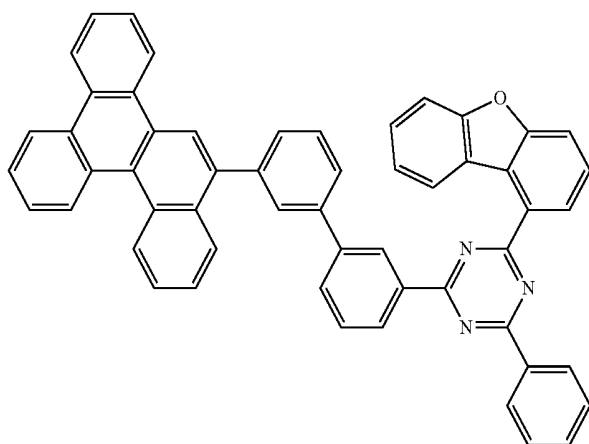
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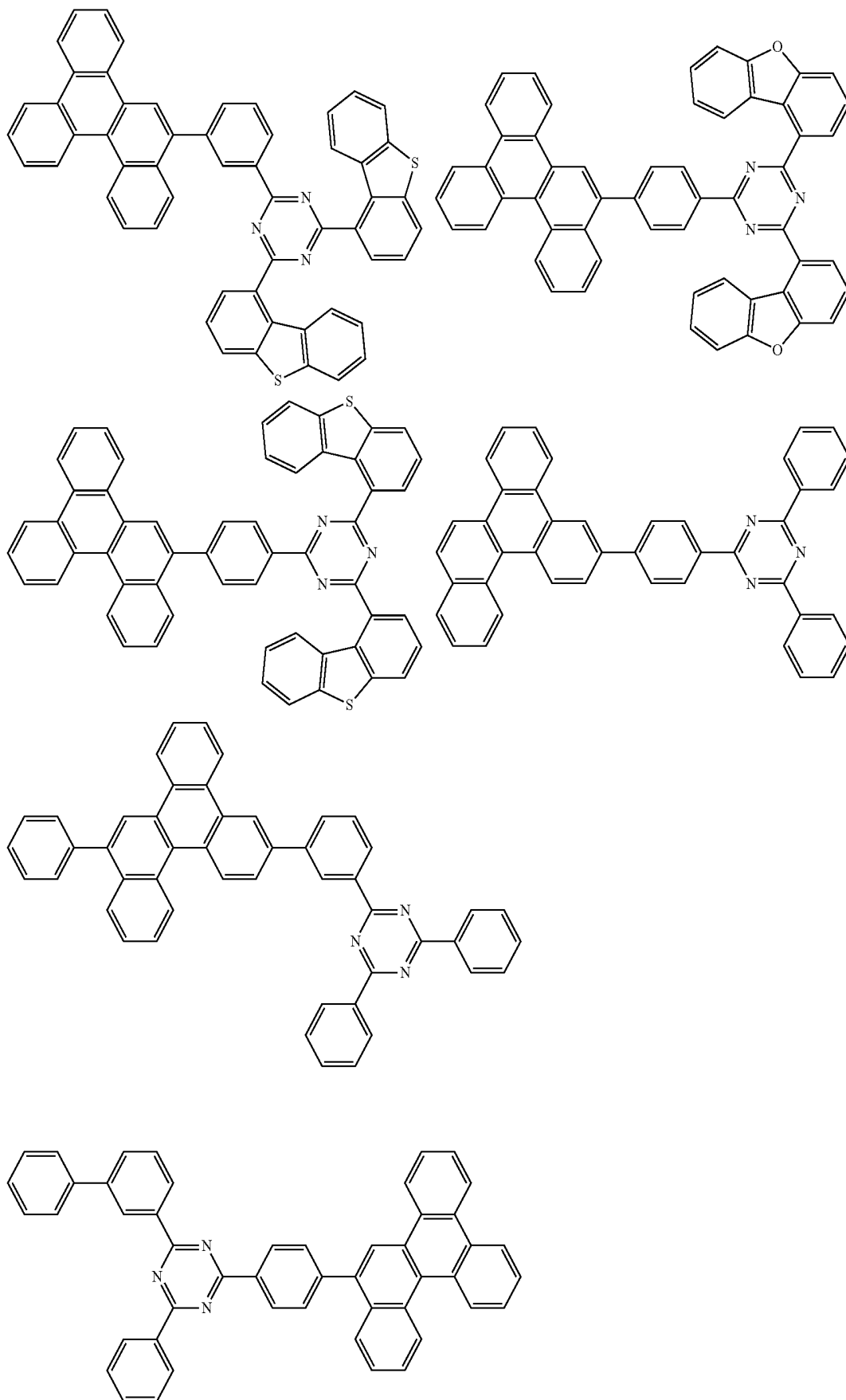
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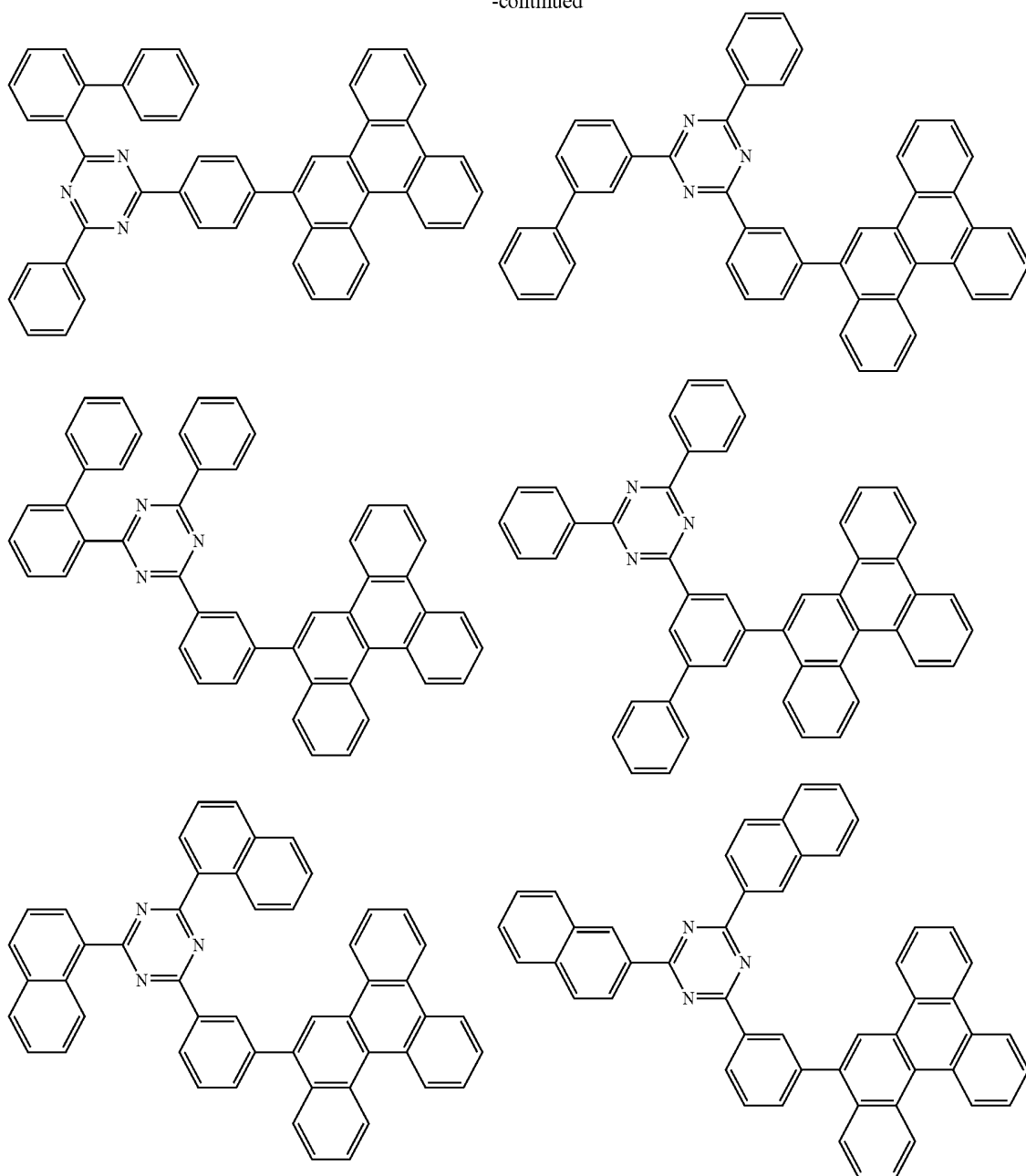
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[Material for Organic EL Device]

[0076] The above-mentioned compound can be used as a material for an organic electroluminescence (EL) device, preferably as an electron-transporting material.

[Organic EL Device]

[0077] In the organic EL device according to one aspect of the invention, one or more organic thin film layers comprising at least an emitting layer are disposed between a cathode and an anode, and at least one layer of the organic thin film layers comprises the compound represented by the formula (1).

[0078] The above-mentioned organic EL device according to one aspect of the invention preferably has an electron-

transporting zone between the emitting layer and the cathode. The electron-transporting zone has one or more organic thin film layers, and at least one layer of the organic thin film layers comprises the compound represented by the formula (1). The at least one layer is preferably an electron-transporting layer.

[0079] As the representative device configuration of the organic EL device, a configuration in which the following (1) to (4) or the like are stacked on a substrate can be exemplified.

- (1) Anode/Emitting layer/Cathode
- (2) Anode/Hole-transporting zone/Emitting layer/Cathode
- (3) Anode/Emitting layer/Electron-transporting zone/Cathode

(4) Anode/Hole-transporting zone/Emitting layer/Electron-transporting zone/Cathode

("/" means that the layers are adjacently stacked)

[0080] The electron-transporting zone is normally composed of one or more layers selected from an electron-injecting layer and an electron-transporting layer. The hole-transporting zone is normally composed of one or more layers selected from a hole-injecting layer and a hole-transporting layer.

[0081] In the organic EL device according to one aspect of the invention, it is preferred that a layer containing the compound represented by the formula (1) be provided in the electron-transporting zone in (3) or (4) mentioned above.

[0082] It is preferred that the electron-transporting zone further comprise 8-quinolinolato lithium (Liq). Liq may be contained in a layer containing the compound represented by the formula (1) or may be contained in layers in other electron-transporting zone.

[0083] It is preferred that the electron-transporting zone comprise an electron-injecting layer and at least two electron-transporting layers. Among the at least two electron-transporting layers, it is preferred that the electron-transporting layer that is not adjacent to the electron-injecting layer comprise the above-mentioned compound.

[0084] When the electron-transporting layer that is adjacent to the electron-injecting layer comprises the compound represented by the formula (1), it is preferred that the electron-transporting layer be doped with 8-quinolinolato lithium (Liq).

[0085] It is preferred that a region from the electron-transporting zone to the cathode in the organic EL device according to one aspect of the invention have the following configuration:

(a) First electron-transporting layer comprising the compound represented by the formula (1)/Second electron-transporting layer/Electron-injecting layer/Cathode

(b) Electron-transporting layer comprising the compound represented by the formula (1) and is doped with Liq/Electron-injecting layer/Cathode

(c) First electron-transporting layer comprising the compound represented by the formula (1)/Second electron-transporting layer doped with Liq/Electron-injecting layer/Cathode

(d) First electron-transporting layer/Second electron-transporting layer comprising the compound represented by the formula (1) and is doped with Liq/Electron-injecting layer/Cathode

[0086] The configuration (a) mentioned above is particularly preferable.

[0087] Hereinbelow, each layer of the organic EL device will be explained.

(Substrate)

[0088] The substrate is used as a base of an emitting device. As the substrate, glass, quartz, plastic or the like can be used, for example. A flexible substrate may be used. A flexible substrate is a substrate that can be bent. For example, a plastic substrate made of polycarbonate or polyvinyl chloride or the like can be given.

(Anode)

[0089] For an anode formed on the substrate, it is preferable to use a metal, an alloy, an electrically conductive

compound having a large work function (specifically, 4.0 eV or more), a mixture thereof or the like. Specifically, indium oxide-tin oxide (ITO: Indium Tin Oxide), indium oxide-tin oxide containing silicon or silicon oxide, indium oxide-zinc oxide, tungsten oxide, indium oxide containing zinc oxide, graphene or the like can be given, for example. In addition, gold (Au), platinum (Pt) or a nitride of a metal material (e.g. titanium nitride) or the like can be given.

(Hole-Injecting Layer)

[0090] A hole-injecting layer is a layer that contains a substance having high hole-injection property. As the substance having high hole-injection property, molybdenum oxide, titanium oxide, vanadium oxide, rhenium oxide, ruthenium oxide, chromium oxide, zirconium oxide, hafnium oxide, tantalum oxide, silver oxide, tungsten oxide, manganese oxide, an aromatic amine compound, or a polymer compound (oligomer, dendrimer, polymer, etc.) or the like can be used.

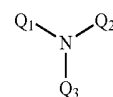
[0091] As one preferable aspect of the substance used in the hole-injecting layer, an acceptor compound can be given. As the acceptor compound, a heterocyclic derivative on which an electron-attracting group is substituted, a quinone derivative on which an electron-attracting group is substituted, an arylborane derivative, a heteroarylborane derivative or the like can be preferably used. Among these, hexacyanohexaazatriphenylene, F₄TCNQ (2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane) or 1,2,3-tris[(cyano)(4-cyano-2,3,5,6-tetrafluorophenyl) methylene]cyclopropane or the like can preferably be used.

[0092] A layer that comprises an acceptor compound may further comprise a matrix material. As the matrix material, a wide variety of materials for an organic EL device can be used. As the matrix material used together with the acceptor compound, it is preferable to use a donor compound. It is further preferable to use an aromatic amine compound.

(Hole-Transporting Layer)

[0093] A hole-transporting layer is a layer that contains a substance having high hole-transporting property. In the hole-transporting layer, aromatic amine compounds, carbazole derivatives, anthracene derivatives and the like can be used. Polymer compounds such as poly(N-vinylcarbazole) (abbreviation: PVK) or poly(4-vinyltriphenylamine) (abbreviation: PVTTPA) can also be used. As long as it has high hole-transporting property rather than electron-transporting property, other substances than those mentioned above can be used. The layer containing the substance having high hole-transporting property may be not only a single layer but also a layer obtained by stacking two or more layers containing the above-mentioned substances.

[0094] The hole-transporting material is preferably a compound represented by the following general formula (H):



(H)

[0095] In the general formula (H), Q₁ to Q₃ are independently a substituted or unsubstituted aryl group including 6 to 50 ring carbon atoms, a substituted or unsubstituted

heterocyclic group including 5 to 50 ring atoms or a group composed of a combination of a substituted or unsubstituted aryl group and a substituted or unsubstituted heterocyclic group.

[0096] As the aryl group, substituents such as a phenyl group, a biphenyl group, a terphenyl group, a fluorenyl group, a spirobifluorenyl group, an indenofluorenyl group, a naphthyl group, a phenanthryl group, an anthryl group, a triphenylenyl group and the like are preferable. As the heterocyclic group, a dibenzofuranyl group, a dibenzothiophenyl group, a carbazolyl group or the like are preferable. As the group composed of a combination of the aryl group and the heterocyclic group, a dibenzofuran-substituted aryl group, a dibenzothiophene-substituted aryl group, a carbazole-substituted aryl group and the like are preferable. These substituents may further have a substituent.

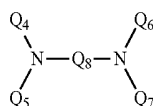
[0097] As one preferable aspect, it is preferred that at least one of Q_1 to Q_3 in the general formula (H) be a compound that is further substituted by an arylamino group. It is also preferred that at least one of Q_1 to Q_3 be a diamine derivative, a triamine derivative or a tetraamine derivative. As the diamine derivative, tetraaryl-substituted benzidine derivatives and TPTE (4,4'-bis[N-phenyl-N-[4'-diphenylamino-1,1'-biphenyl-4-yl]amino]-1,1'-biphenyl) or the like are preferably used.

(Guest Material of Emitting Layer)

[0098] An emitting layer is a layer that contains a substance having high emitting property, and various materials can be used for the emitting layer. For example, as the substance having high emitting property, a fluorescent compound that emits fluorescence or a phosphorescent compound that emits phosphorescence can be used. A fluorescent compound is a compound that can emit light from the singlet excited state, and a phosphorescent compound is a compound that can emit light from the triplet excited state.

[0099] As the blue fluorescent emitting material that can be used in the emitting layer, pyrene derivatives, styrylamine derivatives, chrysene derivatives, fluoranthene derivatives, fluorene derivatives, diamine derivatives, triarylamine derivatives and the like can be given. As the green fluorescent emitting material that can be used in the emitting layer, an aromatic amine derivative and the like can be used. As the red fluorescent emitting material that can be used in the emitting layer, tetracene derivatives, diamine derivatives and the like can be given.

[0100] As the fluorescent emitting material that can be used in the emitting layer, among others, a fused polycyclic aromatic derivative, a styrylamine derivative, a fused-ring amine derivative, a boron-containing compound, a pyrrole derivative, an indole derivative, a carbazole derivative and the like are preferable. As the fluorescent emitting material that can be used in the emitting layer, further preferably, a fused-ring amine derivative and a boron-containing compound can be given. A fused ring amine derivative is preferably a compound represented by the following general formula (J):



(J)

[0101] In the general formula (J), Q_4 to Q_7 are independently a substituted or unsubstituted aryl group including 6 to 50 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 50 ring atoms.

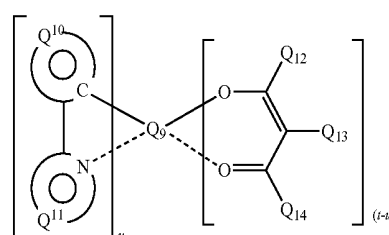
[0102] As the above-mentioned aryl group including 6 to 50 ring carbon atoms, an aromatic hydrocarbon group including 6 to 12 ring carbon atoms is further preferable, with a phenyl group being particularly preferable. As the heteroaryl group including 5 to 50 ring atoms, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group and the like can be given, with a dibenzofuranyl group being preferable.

[0103] Q_8 is a substituted or unsubstituted divalent aryl group including 6 to 50 ring carbon atoms or a substituted or unsubstituted divalent aryl group including 5 to 50 ring atoms. As the divalent aromatic aryl group including 6 to 50 ring carbon atoms, a pyrenyl group, a chrysenyl group, an anthracenyl group, a fluorenyl group or the like can be given, with a pyrenyl group being preferable. As the divalent aryl group including 6 to 50 ring carbon atoms, a fluorenyl group to which one or more benzofuro skeleton(s) is (are) fused is preferable.

[0104] Examples of the boron-containing compound include a pyrromethene derivative and a triphenylborane derivative. The derivative as used herein refers to a compound containing said skeleton as a partial structure thereof, and includes a compound further forming a fused ring and a compound forming a ring by substituents. For example, in the case of a fused polycyclic aromatic derivative, it is a compound containing a fused polycyclic aromatic skeleton as a partial structure thereof, and a compound that further forms a fused ring in the fused polycyclic aromatic skeleton, and a compound that forms a ring by substituents of the fused polycyclic aromatic skeleton.

[0105] As the blue phosphorescent emitting material that can be used in the emitting layer, a metal complex such as an iridium complex, an osmium complex and a platinum complex can be given. As the green phosphorescent emitting material that can be used in the emitting layer, an iridium complex and the like can be given. As the red phosphorescent emitting material, a metal complex such as an iridium complex, a platinum complex, a terbium complex and a europium complex can be given.

[0106] The phosphorescent emitting material that can be used in the emitting layer, and that is an ortho-metalated complex of a metal element selected from iridium, osmium and platinum, is preferably a complex represented by the following formula (K):



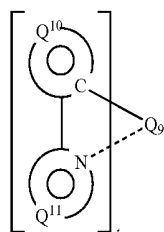
(K)

[0107] In the general formula (K), Q_9 is at least one metal selected from the group consisting of osmium, iridium and platinum, t is the valence of the metal, and u is 1 or more.

[0108] The ring Q_{10} is a substituted or unsubstituted aryl group including 6 to 24 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 30 ring atoms and the ring Q_{11} is a substituted or unsubstituted heteroaryl group including 5 to 30 ring atoms that includes a nitrogen atom as an atomic element constituting the heterocycle. Q_{12} to Q_{14} are independently a hydrogen atom or a substituent.

[0109] When u is 2 or more, plural rings Q_{10} and plural rings Q_{11} may be independently the same as or different from each other. When $(t-u)$ is 2 or more, plural Q_{12} to Q_{14} may independently be the same as or different from each other.

[0110] When $(t-u)$ is zero, the general formula (K) is represented by the following general formula (G), and Q_9 , ring Q_{10} , ring Q_{11} , Q_{12} to Q_{14} and t are as defined in the general formula (K).



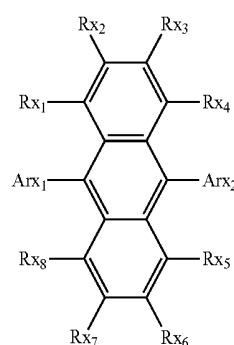
(G)

(Host Material of Emitting Layer)

[0111] The emitting layer may have a structure in which the above-mentioned substance having a high emitting property (guest material) is dispersed in other substances (host material). As the substance for dispersing the substance having high emitting property, various substances can be used. It is preferable to use a substance having a higher lowest unoccupied molecular orbital (LUMO level) than that of the substance having high emitting property, and having a lower highest occupied molecular orbital (HOMO level) than that of the substance having high emitting property.

[0112] As the substance for dispersing a substance having high emitting property (host material), 1) a metal complex such as an aluminum complex, a beryllium complex, a zinc complex or the like, 2) a heterocyclic compound such as an oxadiazole derivative, a benzimidazole derivative, a phenanthroline derivative and the like, 3) a fused aromatic compound such as a carbazole derivative, an anthracene derivative, a phenanthrene derivative, a pyrene derivative, a chrysene derivative and the like and 4) an aromatic amine compound such as a triarylamine derivative, a fused polycyclic aromatic amine derivative and the like can be given.

[0113] As the host material of the fluorescent emitting layer, among others, a compound having a fused polycyclic aromatic derivative as its main skeleton is preferable, with an anthracene derivative, a pyrene derivative, a chrysene derivative, a naphthacene derivative and the like can be given. A host that is particularly preferable as a blue host material (a host material that can be used with a blue fluorescent emitting material) and a green host material (a host material that can be used with a green fluorescent emitting material) is an anthracene derivative that is represented by the following formula (E):



(E)

[0114] In the general formula (E), Ar_{x1} and Ar_{x2} are independently a substituted or unsubstituted aryl group including 6 to 50 ring carbon atoms or a substituted or unsubstituted aromatic heterocyclic group including 5 to 50 ring atoms. Preferably, Ar_{x1} and Ar_{x2} are independently a substituted or unsubstituted aryl group including 6 to 30 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 30 ring atoms. Further preferably, Ar_{x1} and Ar_{x2} are independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted dibenzofuranyl group, a substituted or unsubstituted naphthobenzofuranyl group or a substituted or unsubstituted carbazolyl group. R_{x1} to R_{x8} are independently a hydrogen atom or a substituent.

[0115] As the host material of the phosphorescent emitting material, a carbazole derivative, a carbazole derivative substituted with carbazole, a carbazole derivative to which a benzo skeleton is fused to form a ring, a carbazole derivative to which an indeno skeleton is fused to form a ring, a carbazole derivative to which an indolo skeleton is fused to form a ring, a carbazole derivative to which a benzofuro skeleton is fused to form a ring, a triazine derivative, a pyrimidine derivative, a quinazoline derivative, a fluorene derivative, a triphenylene derivatives are preferable.

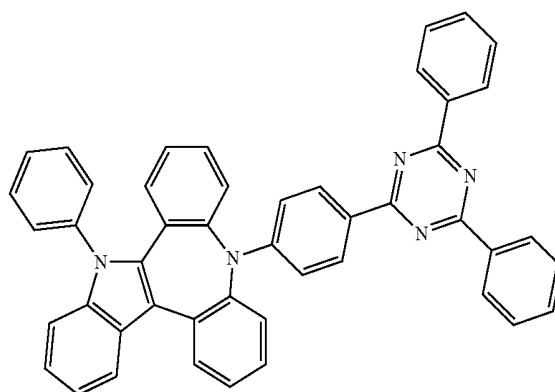
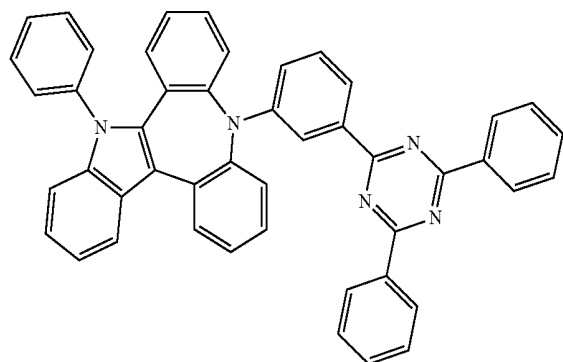
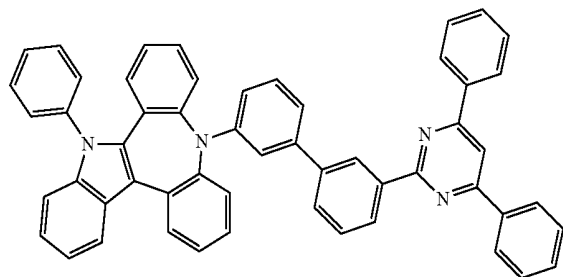
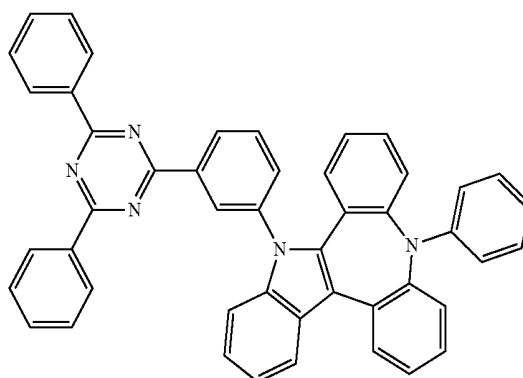
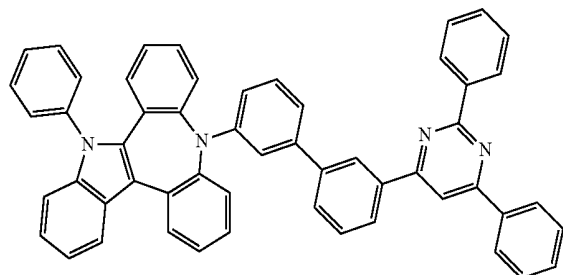
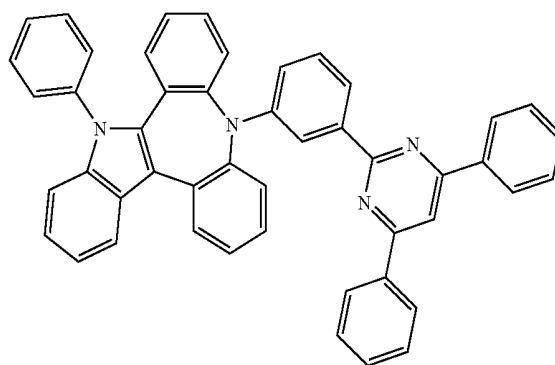
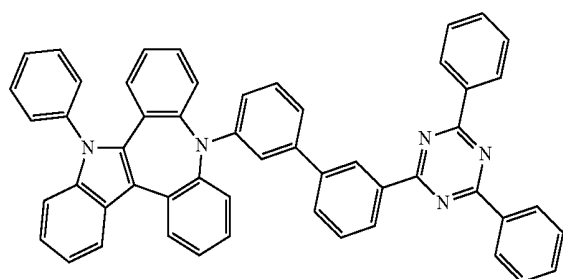
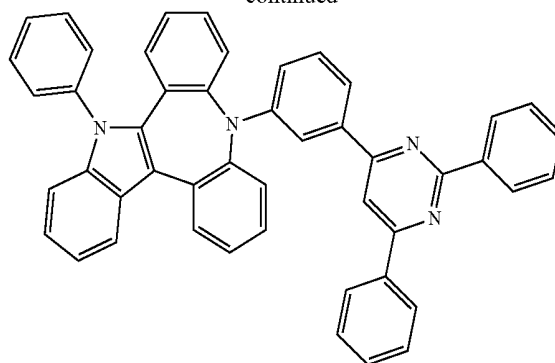
(Electron-Transporting Layer)

[0116] An electron-transporting layer is a layer containing a substance having high electron-transporting property. In the electron-transporting layer, 1) a metal complex such as an aluminum complex, a beryllium complex or a zinc complex, 2) a heteroaromatic compound such as an imidazole derivative, a benzimidazole derivative, an azine derivative, a carbazole derivative or a phenanthroline derivative, and 3) a polymer compound can be used.

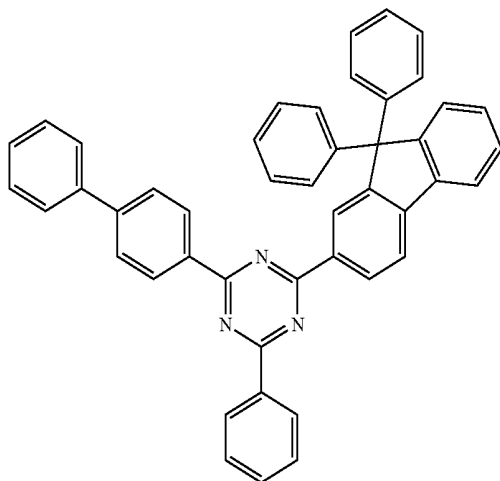
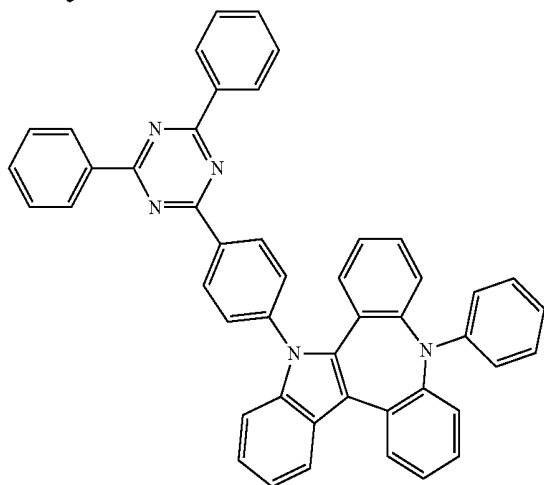
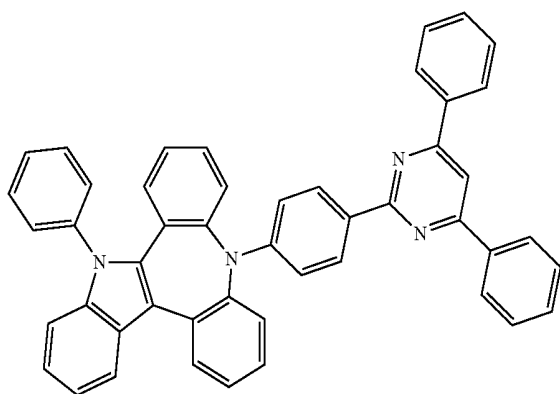
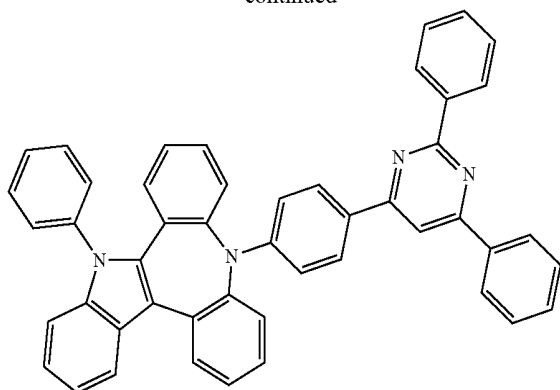
[0117] Materials to be used for the electron-transporting layer are preferably imidazole derivatives (benzimidazole derivatives, imidazopyridine derivatives, and benzimidazophenanthridine derivatives, for example), azine derivatives (pyrimidine derivatives, triazine derivatives, quinoline derivatives, isoquinoline derivatives, and phenanthroline derivatives, for example, and the heterocyclic ring thereof may be substituted with phosphine oxide-based substituents), and aromatic hydrocarbon derivatives (for example, anthracene derivatives and fluorene derivatives can be given). In one preferred embodiment, the electron-transport-

ing zone comprises two or more electron-transporting layers, and one of the electron-transporting layers comprises the compound according to one embodiment of the invention, and the other of the electron-transporting layers comprises the above-mentioned materials for the electron-transporting layer. In another preferred embodiment, one electron-transporting layer comprises both the compound according to one embodiment of the present invention and the above-mentioned materials for the electron-transporting layer. Specific examples of the materials used for the electron-transporting layer are shown below, but the materials are not limited thereto.

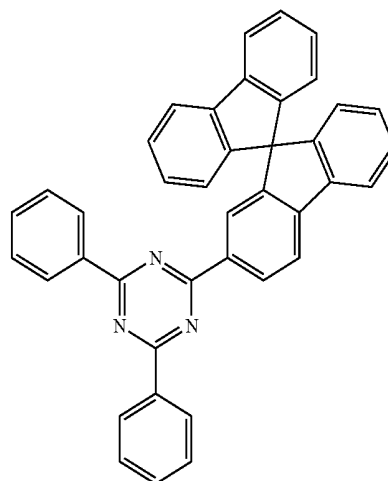
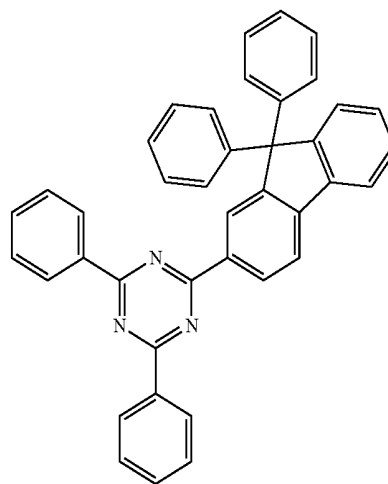
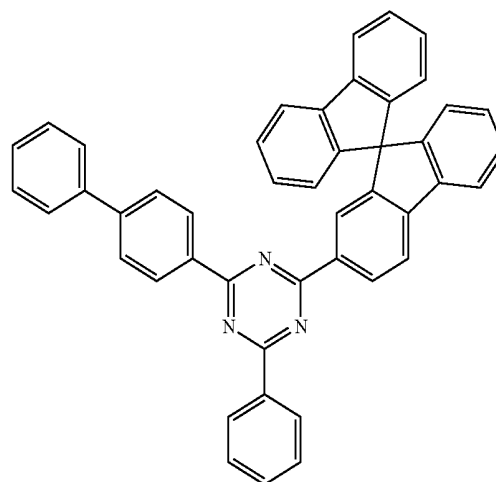
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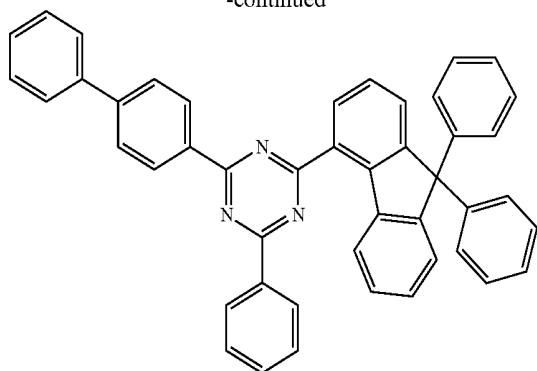
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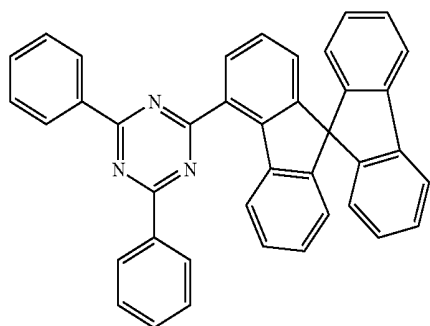
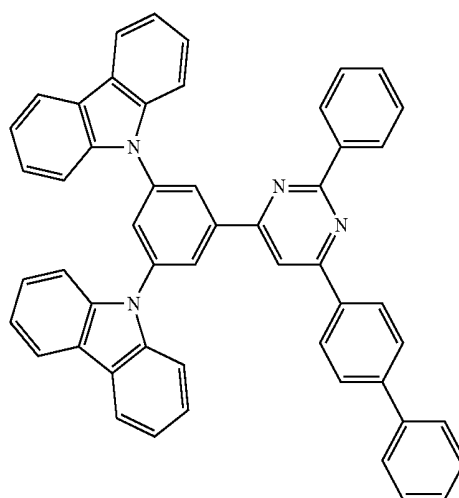
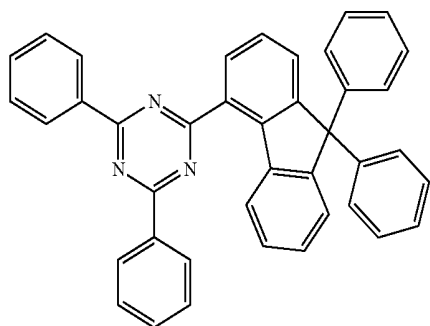
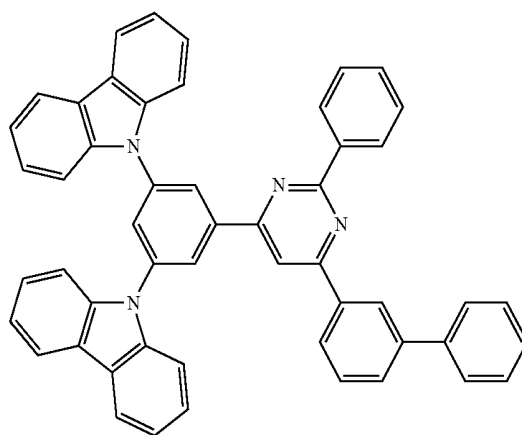
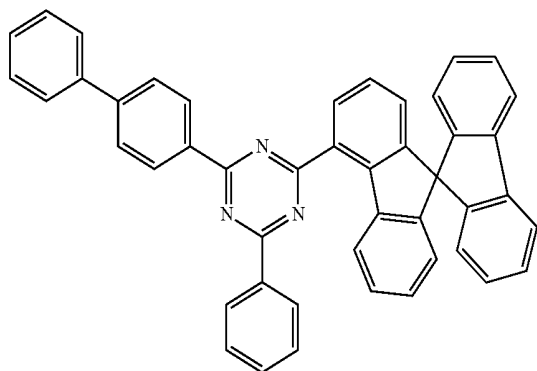
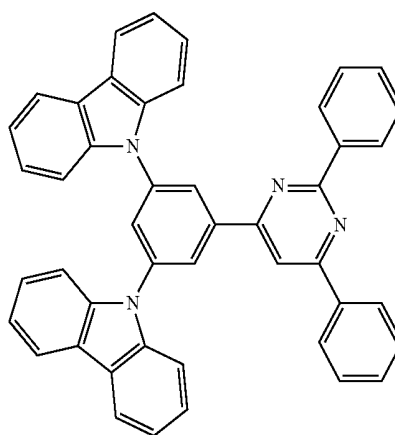
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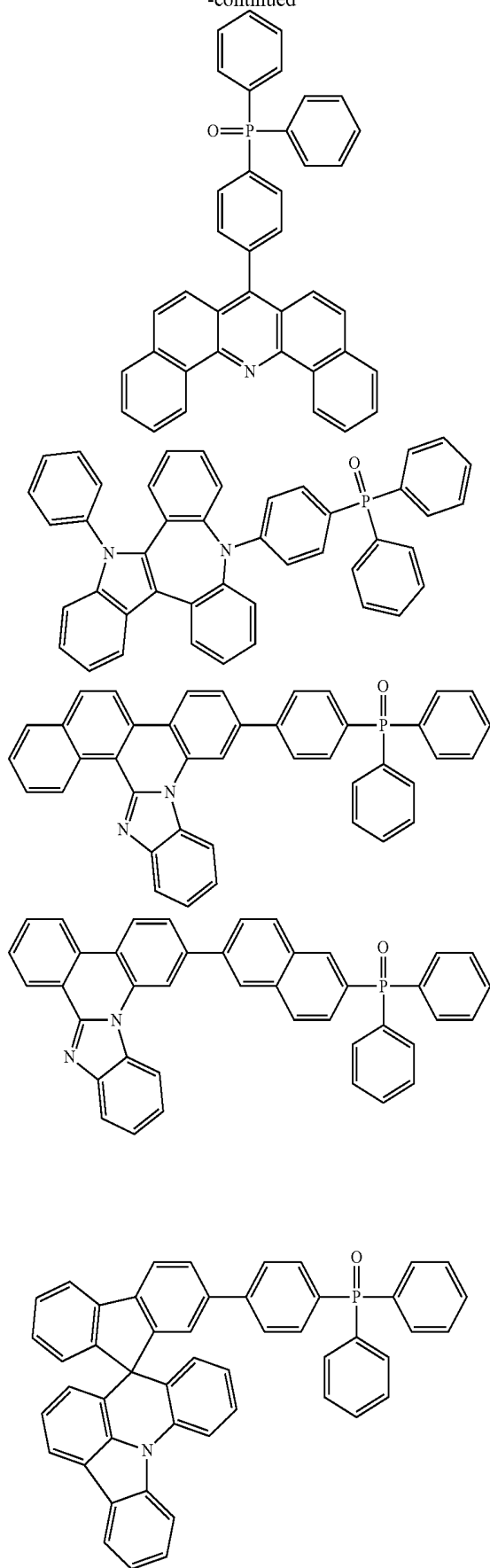
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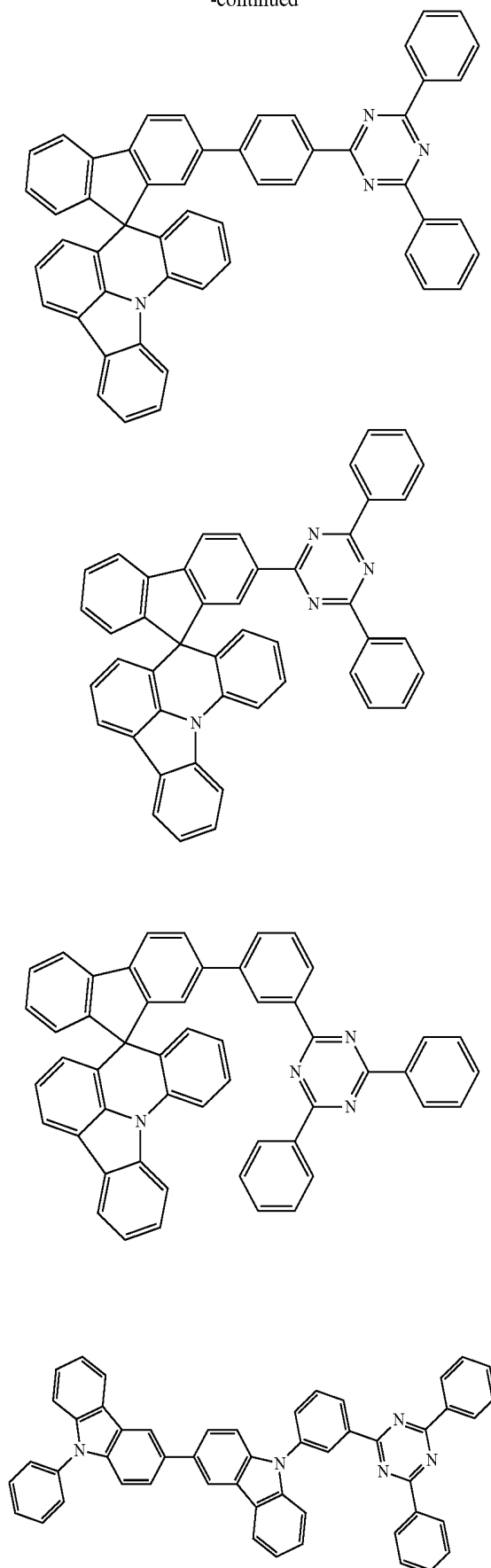
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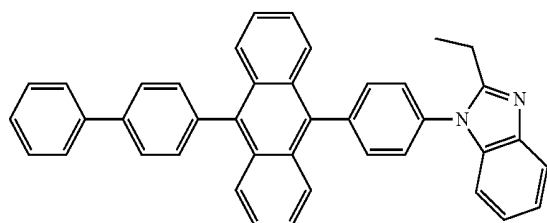
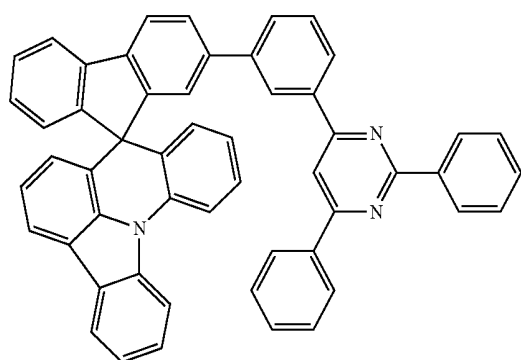
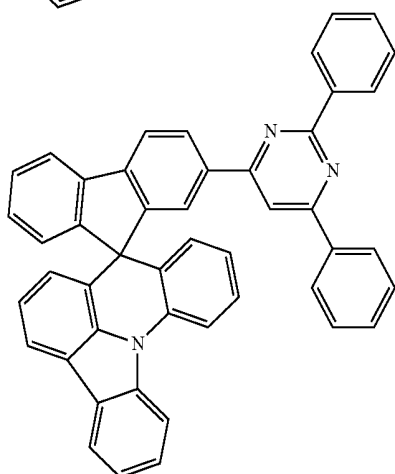
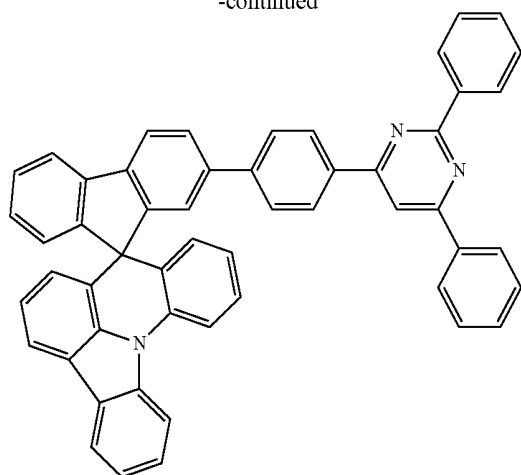
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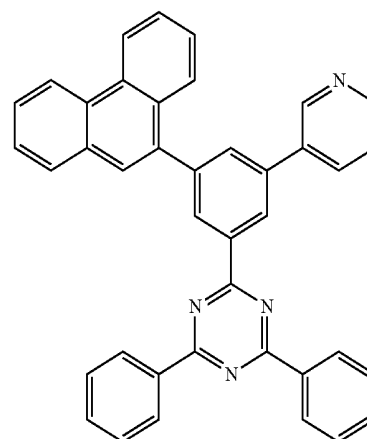
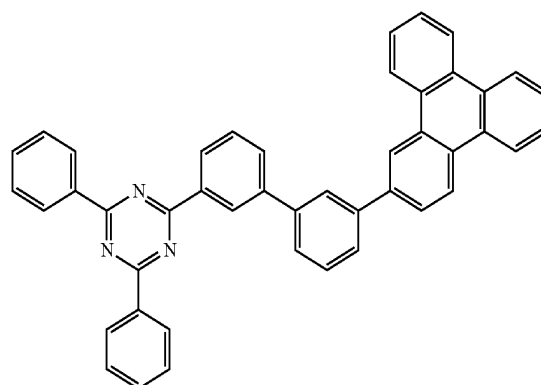
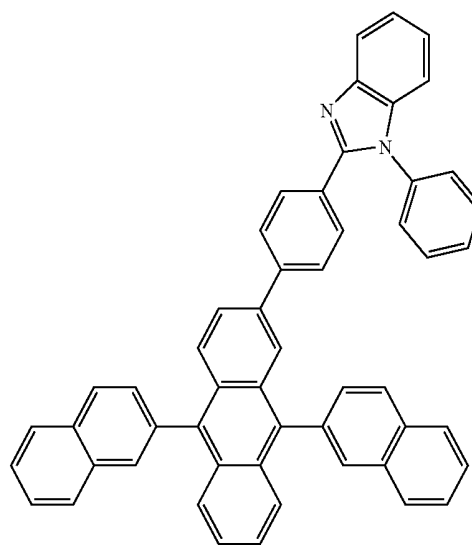
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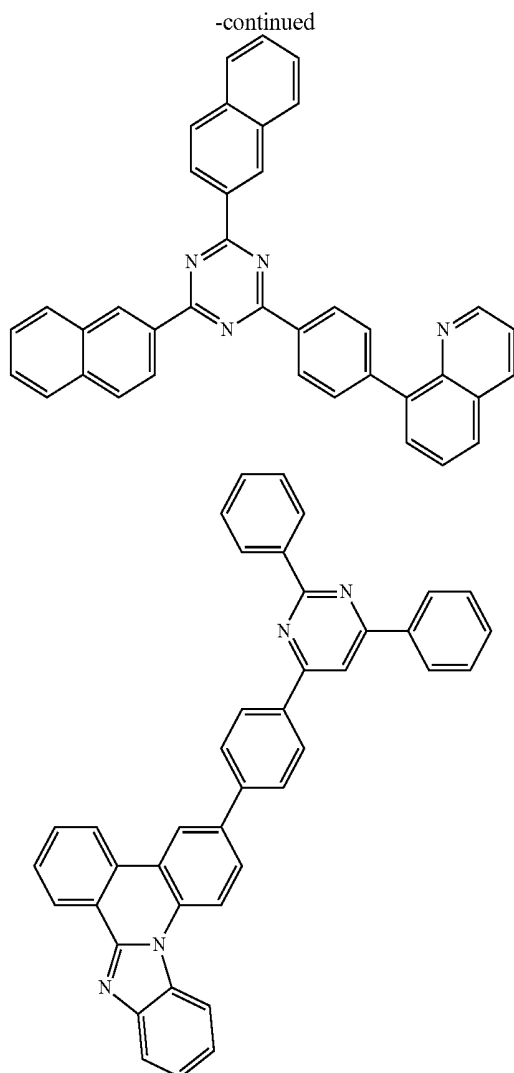


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(Electron-Injecting Layer)

[0118] An alkaline earth metal or a compound of those can be used.

[0119] For the electron-injecting layer, 8-quinolinolato lithium (Li_q) can be used.

[0120] It is preferred that the electron-transporting zone further comprise one or more selected from an electron-donating dopant and an organic metal complex.

[0121] As the electron-donating dopant, at least one selected from an alkali metal, an alkali metal compound, an alkaline earth metal, an alkaline earth metal compound, a rare earth metal and a rare earth metal compound and the like can be given.

[0122] As the organic metal complex, at least one selected from an organic metal complex containing an alkali metal, an organic metal complex containing an alkaline earth metal and an organic metal complex containing a rare earth metal can be given.

[0123] As the alkali metal, lithium (Li) (work function: 2.93 eV), sodium (Na) (work function: 2.36 eV), potassium (K) (work function: 2.28 eV), rubidium (Rb) (work function: 2.16 eV), cesium (Cs) (work function: 1.95 eV) or the like can be given.

[0124] As the alkaline earth metal, calcium (Ca) (work function: 2.9 eV), strontium (Sr) (work function: 2.0 eV or

more and 2.5 eV or less), barium (Ba) (work function: 2.52 eV) and the like can be given.

[0125] As the rare earth metal, scandium (Sc), yttrium (Y), cerium (Ce), terbium (Tb), ytterbium (Yb) and the like can be given.

[0126] As the alkali metal compound, alkali oxides such as lithium oxide (Li₂O), cesium oxide (Cs₂O) and potassium oxide (K₂O), and alkali halides such as lithium fluoride (LiF), sodium fluoride (NaF), cesium fluoride (CsF), potassium fluoride (KF) or the like can be given. Among these, lithium fluoride (LiF), lithium oxide (Li₂O) and sodium fluoride (NaF) are preferable.

[0127] As the alkaline-earth metal compound, barium oxide (BaO), strontium oxide (SrO), calcium oxide (CaO), and mixtures thereof such as barium strontium acid (Ba_xSr_{1-x}O) (0 < x < 1) and barium calcium acid (Ba_xCa_{1-x}O) (0 < x < 1) can be given. Among these, BaO, SrO and CaO are preferable.

[0128] As the rare-earth metal compound, ytterbium fluoride (YbF₃), scandium fluoride (ScF₃), scandium oxide (ScO₃), yttrium oxide (Y₂O₃), cerium oxide (Ce₂O₃), gadolinium fluoride (GdF₃) and terbium fluoride (TbF₃) can be given. Among these, YbF₃, ScF₃ and TbF₃ are preferable.

[0129] The organic metal complexes are not particularly limited as long as they each contain, as a metal ion, at least one of alkali metal ions, alkaline-earth metal ions, and rare-earth metal ions, as mentioned above. Meanwhile, preferred examples of the ligand include, but are not limited to, quinolinol, benzoquinolinol, acridinol, phenanthridinol, hydroxyphenyloxazole, hydroxyphenylthiazole, hydroxydiaryloxadiazole, hydroxydiarylthiadiazole, hydroxyphenylpyridine, hydroxyphenylbenzimidazole, hydroxybenzotriazole, hydroxyfluorane, bipyridyl, phenanthroline, phthalocyanine, porphyrin, cyclopentadiene, β-diketones, azomethines, and derivatives thereof.

[0130] As the organic metal complex, 8-quinolinolato lithium and the like can be given.

[0131] When the electron-transporting layer contains at least one of an alkali metal and an alkaline earth metal, the content ratio thereof in the electron-transporting layer is preferably 0.1 to 50 mass %, more preferably 0.1 to 20 mass %, further preferably 1 to 10 mass %, and when the electron-transporting layer contains at least one of an organometallic complex containing an alkali metal and an organometallic complex containing an alkaline earth metal, the content ratio thereof in the electron-transporting layer is 1 to 99 mass %, and more preferably 10 to 90 mass %.

(Cathode)

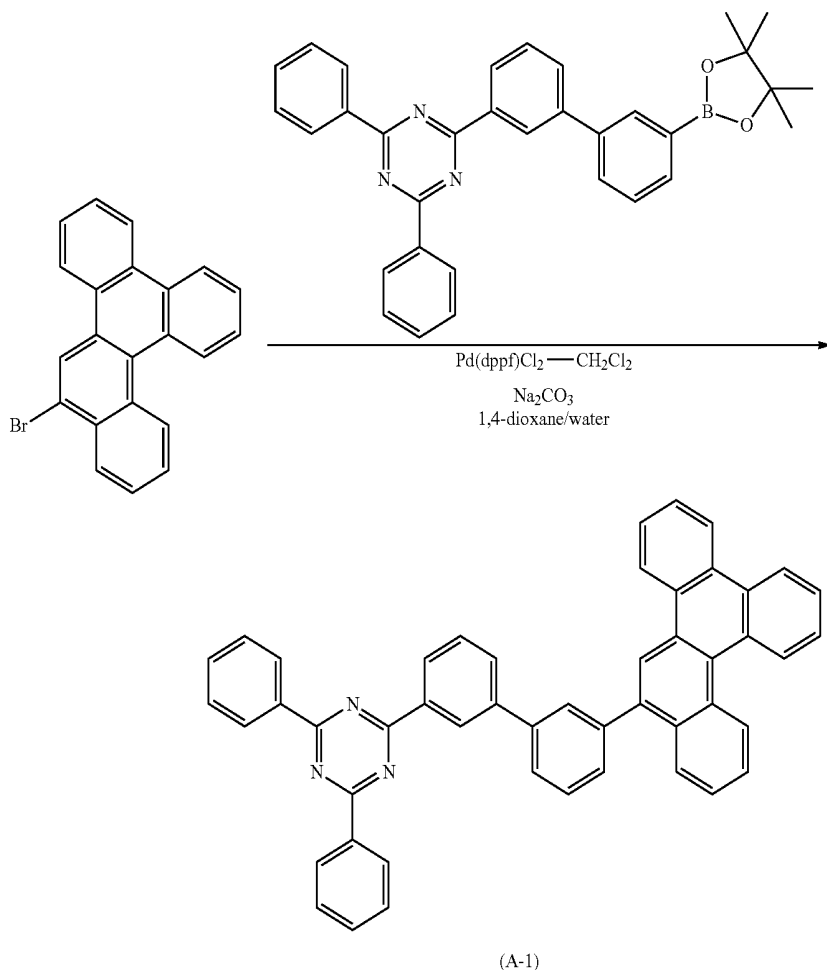
[0132] For a cathode, it is preferable to use a metal having a small work function (specifically, 3.8 eV or less), an alloy, an electrically conductive compound, a mixture of those or the like. As specific examples of the cathode material, an element belonging to Group 1 or Group 2 of the periodic table of the elements, i.e., an alkali metal such as lithium (Li) or cesium (Cs), an alkaline earth metal such as magnesium (Mg), alloys containing the alkali metal and the alkaline earth metal (e.g. MgAg, AlLi) and a rare earth metal and an alloy containing the rare earth metal and the like can be given.

[0133] The above-mentioned organic EL device can be used in various electronic apparatuses. For example, it can be used in a planar luminous body such as a flat panel display of a wall-hanging TV, a backlight of a copier, a printer and a crystal liquid display, or a light source of instruments, a displaying board, sign lighting or the like. Further, the compound of the invention can be used not only in an organic EL device but also in the field of an electrophotographic photoreceptor, a photoelectric conversion device, a solar cell, an image sensor or the like.

EXAMPLES

Synthesis Example 1: Synthesis of Compound A-1

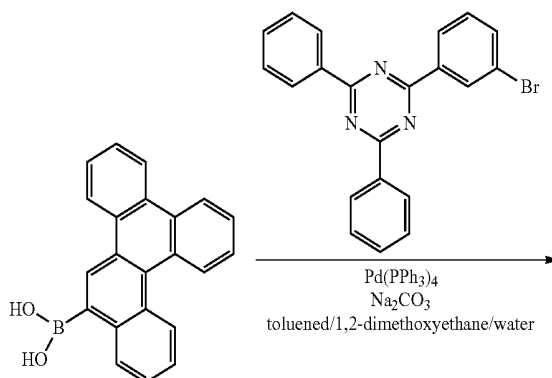
[0134] The synthesis scheme of Compound A-1 is shown below.

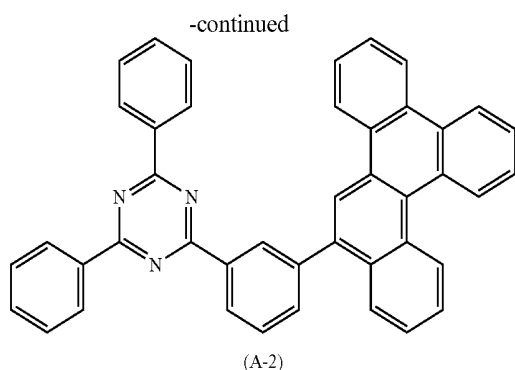


[0135] In an argon atmosphere, to a mixture of 10-bromo-6-glycylchrysene (2.50 g, 7.00 mmol), 2,4-bis(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)phenyl-1,3,5-triazine (3.58 g, 7.00 mmol), [1,1'-bis(diphenylphosphino)ferrocene] palladium (II) dichloride sodium carbonate adduct (0.229 g, 0.280 mmol) and sodium carbonate (2.23 g, 21.0 mmol), 1,4-dioxane (85 mL) and water (10.5 mL) were added, and the resultant was stirred at 100° C. for 17 hours. After completion of the reaction, the mixture was cooled to room temperature, and toluene (200 mL) and water (200 mL) were added. After liquid separation, an organic layer was concentrated under reduced pressure. The organic layer concentrated under reduced pressure was dissolved in toluene and the solution was passed through silica gel column chromatography. The obtained solution was concentrated under reduced pressure, and the concentrated solution was purified by a recrystallization method by using a mixed solvent of toluene and methanol, whereby compound A-1 (2.21 g, 3.31 mmol) was obtained. The yield of compound A-1 was 47%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-1 (Exact mass: 661.25).

Synthesis Example 2: Synthesis of Compound A-2

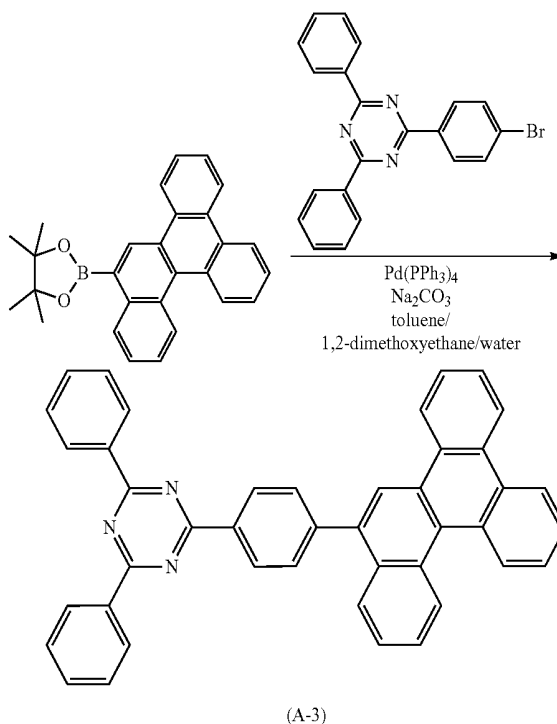
[0136] The synthesis scheme of compound A-2 is shown below.





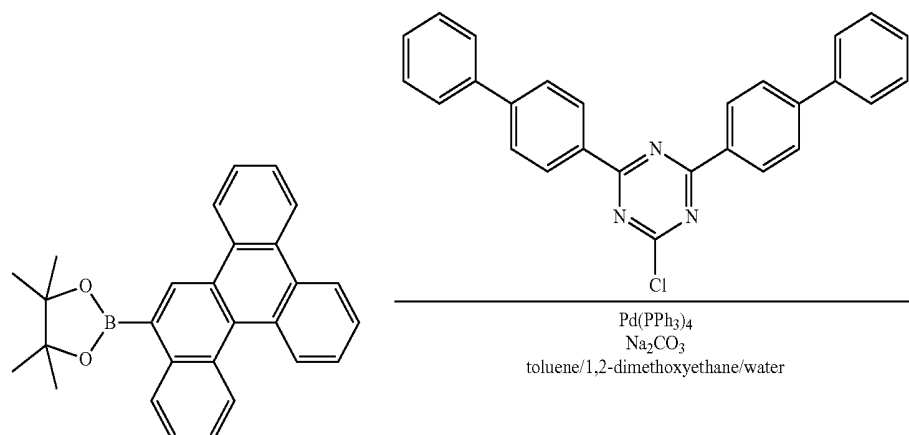
[0137] In an argon atmosphere, to a mixture of benzo[g]chrysene-10-ylboronic acid (3.44 g, 10.7 mmol), 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine (4.15 g, 10.7 mmol), tetrakis(triphenylphosphine)palladium (0) (0.247 g, 0.214 mmol), sodium carbonate (3.39 g, 32.0 mmol), toluene (18 mL), 1,4-dimethoxyethane (53 mL) and water (16 mL) were added, and the resultant was stirred at 100° C. for 7 hours. After completion of the reaction, the mixture was cooled to room temperature, and deposited crystals were separated by filtration. The collected crystals were dissolved in toluene and passed through silica gel column chromatography. The resulting solution was concentrated under reduced pressure, and the concentrated solution was purified by a recrystallization method by using toluene, whereby compound A-2 (3.45 g, 5.89 mmol) was obtained. The yield of compound A-2 was 55%. As a result of mass spectrometry, the compound was found to have a m/e of 585, and was identified to be the above compound A-2 (Exact mass: 585.22).

Synthesis Example 3: Synthesis of Compound A-3 [0138]

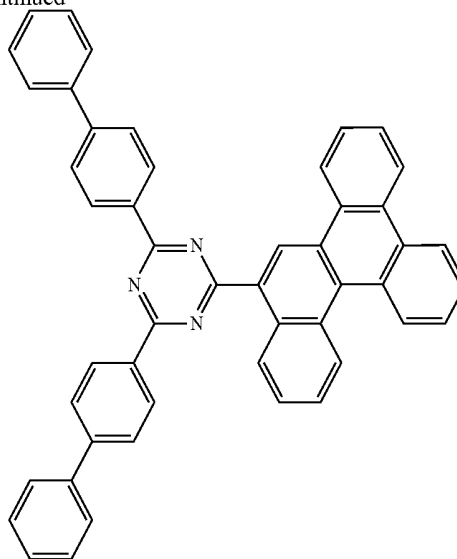


[0139] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, 2-(4-bromophenyl)-4,6-diphenyl-1,3,5-triazine was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-3 was obtained. The yield was 86%. As a result of mass spectrometry, the compound was found to have a m/e of 585, and was identified to be the above compound A-3 (Exact mass: 585.22).

Synthesis Example 4: Synthesis of Compound A-4 [0140]



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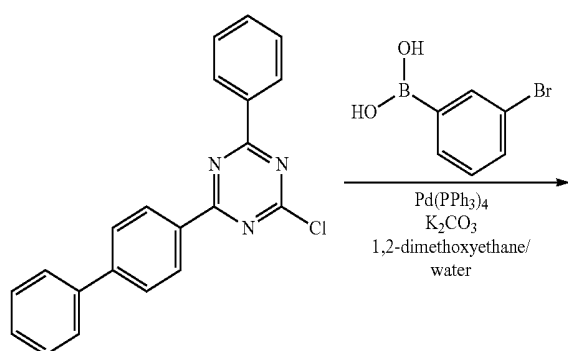
(A-4)

[0141] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, 2-chloro-4,6-bis(4-phenylphenyl)-1,3,5-triazine was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-4 was obtained. The yield was 70%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-4 (Exact mass: 661.25).

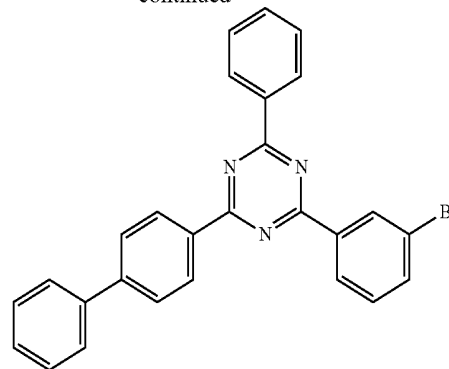
Synthesis Example 5: Synthesis of Compound A-5

(5-1): Synthesis of Intermediate (5-1)

[0142]



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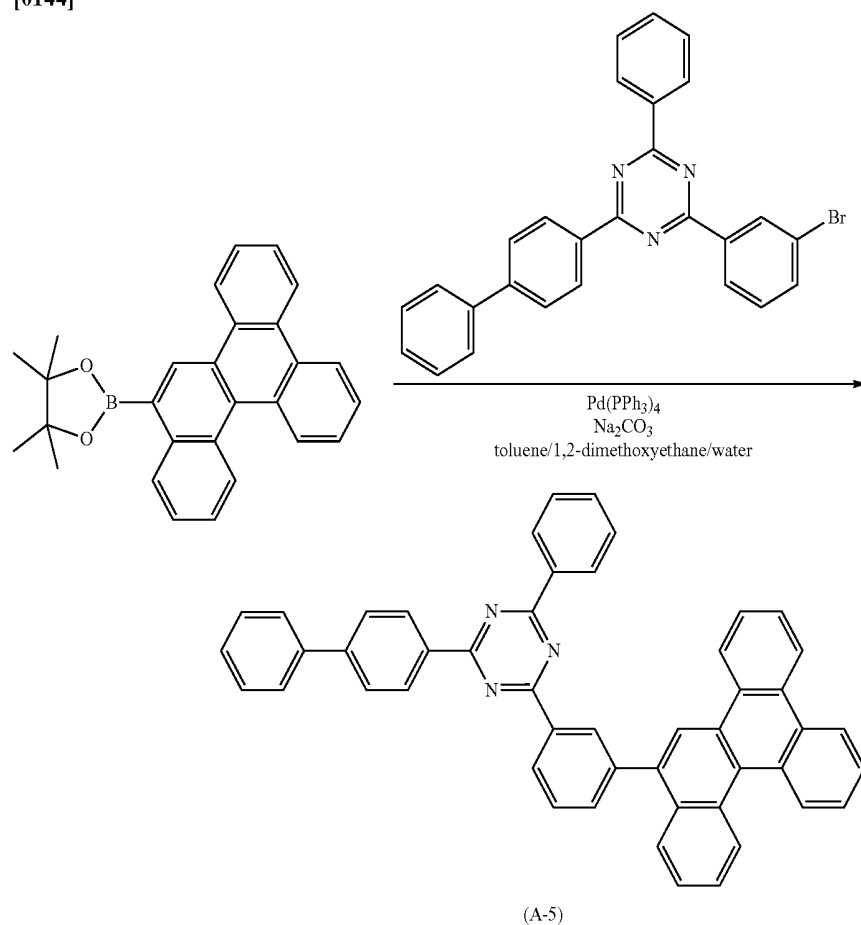


(5-1)

[0143] In an argon atmosphere, to a mixture of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine (20.6 g, 60.0 mmol), 3-bromophenylboronic acid (12.0 g, 60.0 mmol), tetrakis(triphenylphosphine)palladium (0) (1.39 g, 1.2 mmol) and potassium carbonate (24.9 g, 180 mmol), 1,4-dimethoxyethane (300 mL) and water (60 mL) were added, and the resultant was stirred at 80° C. for 7 hours. After completion of the reaction, the mixture was cooled to room temperature. After liquid separation, an organic layer was concentrated under reduced pressure. The concentrated organic layer was dissolved in dichloromethane and the solution was passed through silica gel column chromatography. The resulting solution was concentrated under reduced pressure, whereby intermediate 5-1 (12.5 g, 27.0 mmol) was obtained. The yield of the intermediate 5-1 was 45%.

(5-2): Synthesis of Compound A-5

[0144]

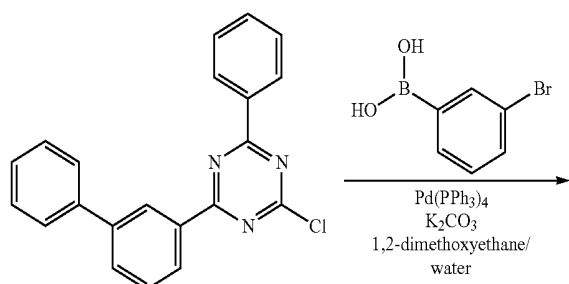


[0145] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 5-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-5 was obtained. The yield was 85%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-5 (Exact mass: 661.25).

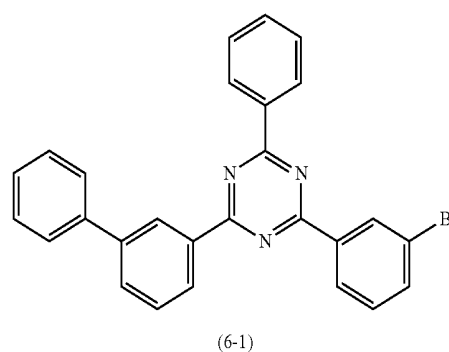
Synthesis Example 6: Synthesis of Compound A-6

(6-1): Synthesis of Intermediate (6-1)

[0146]



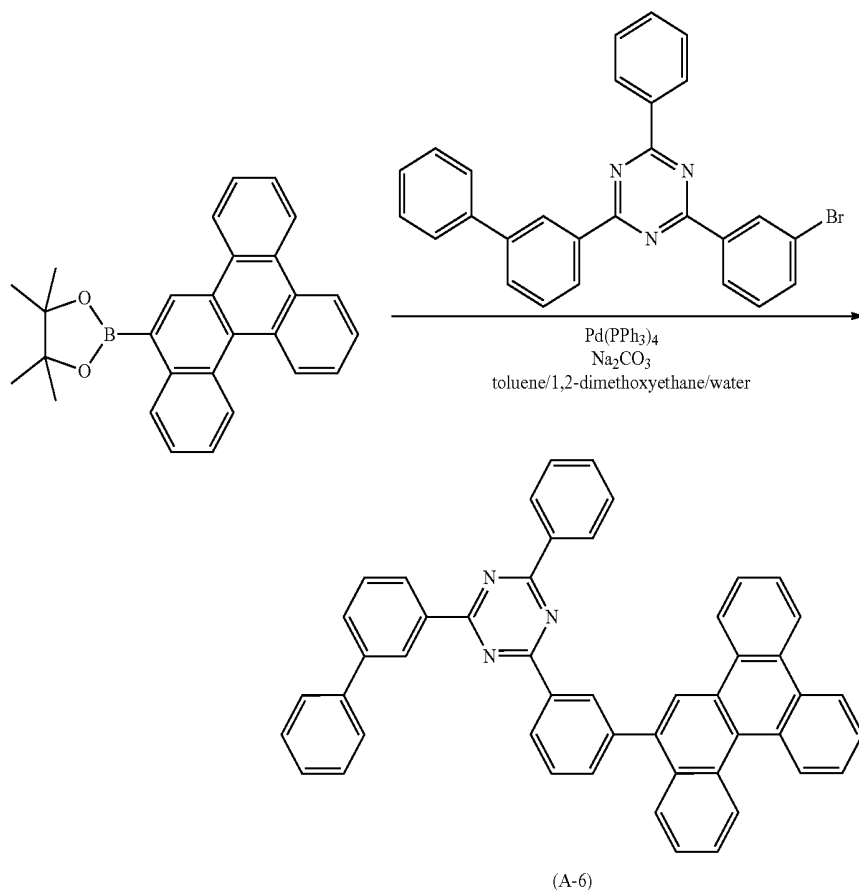
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[0147] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4-phenyl-6-(3-phenylphenyl)-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 6-1 was obtained. The yield was 40%.

(6-2): Synthesis of Compound A-6

[0148]

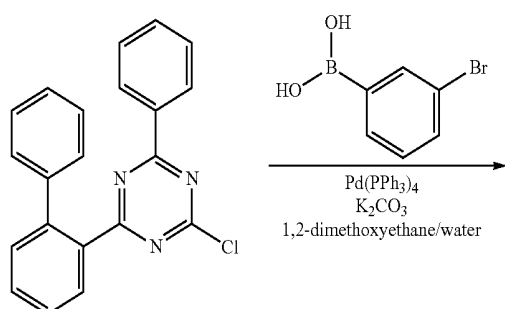


[0149] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 6-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-6 was obtained. The yield was 81%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-6 (Exact mass: 661.25).

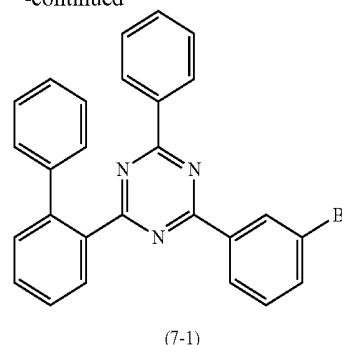
Synthesis Example 7: Synthesis of Compound A-7

(7-1): Synthesis of Intermediate (7-1)

[0150]



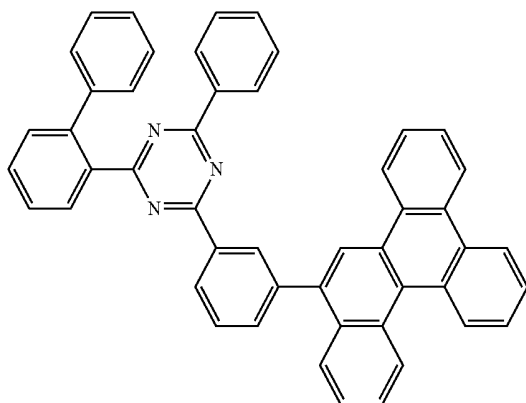
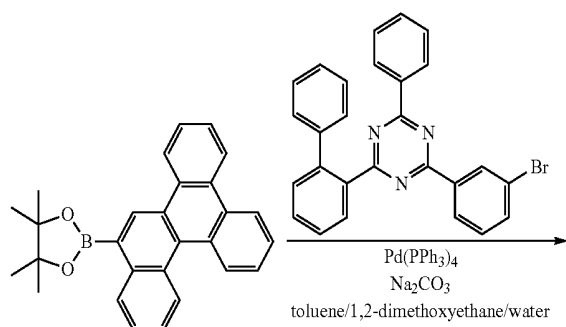
-continued



[0151] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4-phenyl-6-(2-phenylphenyl)-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 7-1 was obtained. The yield was 45%.

(7-2): Synthesis of Compound A-7

[0152]



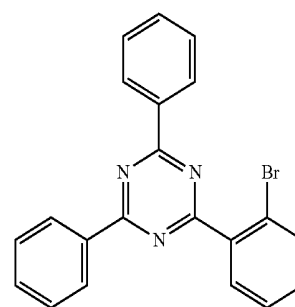
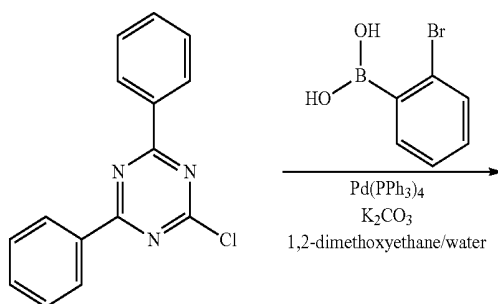
(A-7)

[0153] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 7-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-7 was obtained. The yield was 75%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-7 (Exact mass: 661.25).

Synthesis Example 8: Synthesis of Compound A-8

(8-1): Synthesis of Intermediate (8-1)

[0154]

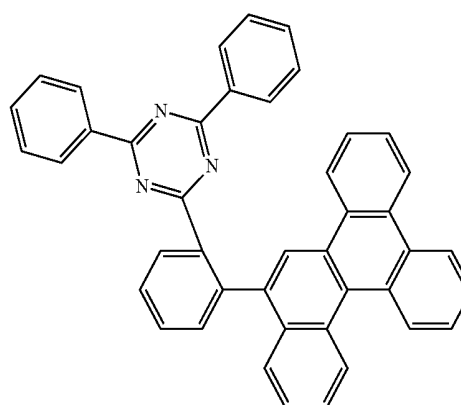
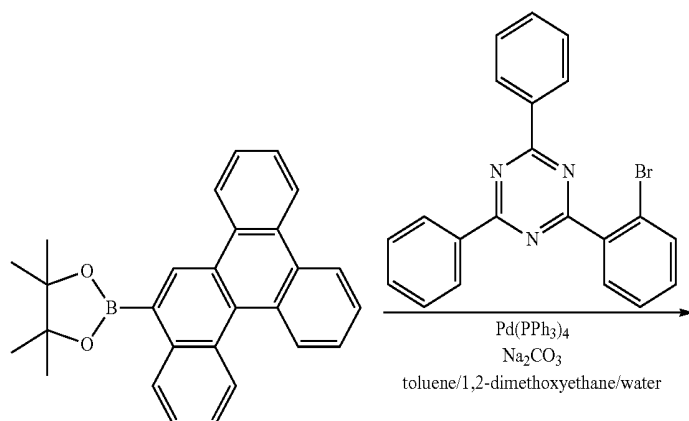


(8-1)

[0155] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4,6-diphenyl-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, and 2-bromophenylboronic acid was used instead of 3-bromophenylboronic acid, whereby intermediate 8-1 was obtained. The yield was 51%.

(8-2): Synthesis of Compound A-8

[0156]



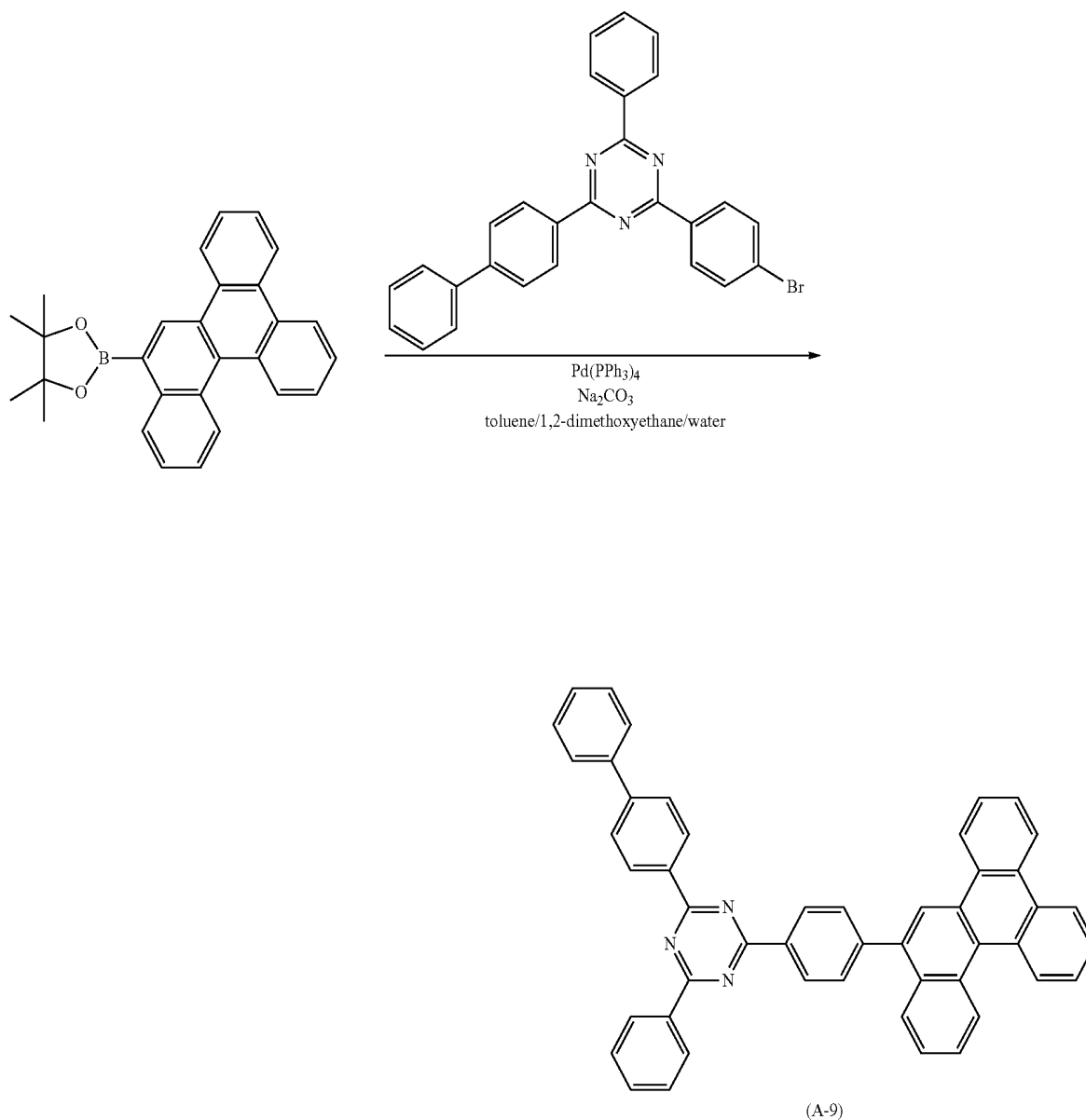
(A-8)

[0157] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 8-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-8 was obtained. The yield was 75%. As a result of mass spectrometry, the compound was found to have a m/e of 585, and was identified to be the above compound A-8 (Exact mass: 585.22).

Synthesis Example 9: Synthesis of Compound A-9

[0158]

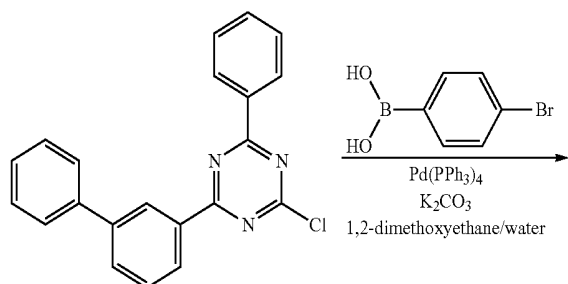
[0159] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, 2-(4-bromophenyl)-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-9 was obtained. The yield was 85%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-9 (Exact mass: 661.25).



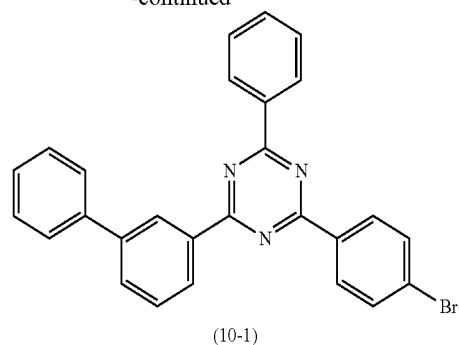
Synthesis Example 10: Synthesis of Compound A-10

(10-1): Synthesis of Intermediate (10-1)

[0160]



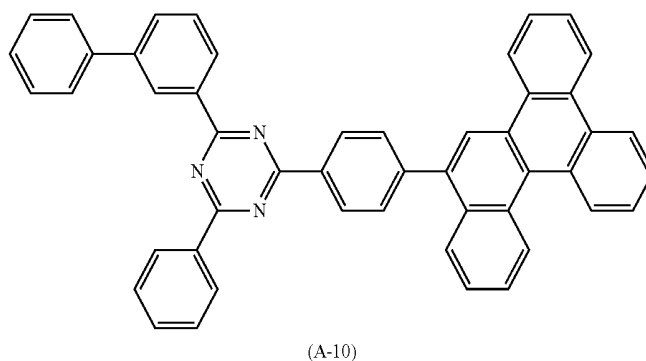
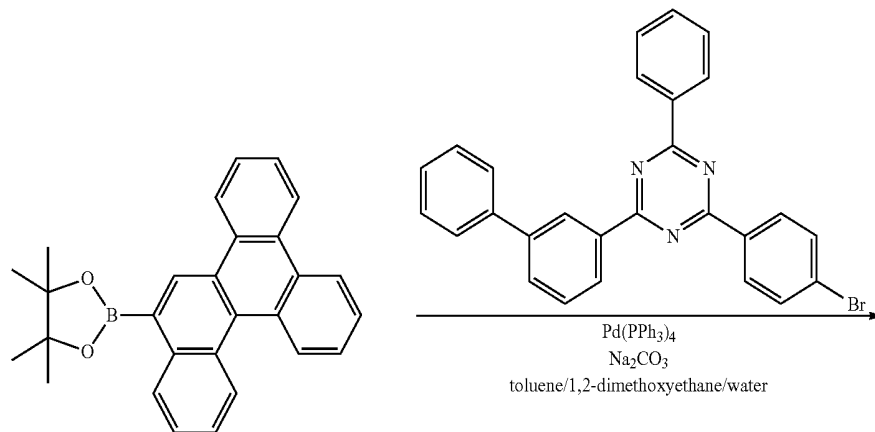
-continued



[0161] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4-phenyl-6-(3-phenylphenyl)-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, and 4-bromophenylboronic acid was used instead of 3-bromophenylboronic acid, whereby intermediate 10-1 was obtained. The yield was 45%.

(10-2): Synthesis of Compound A-10

[0162]

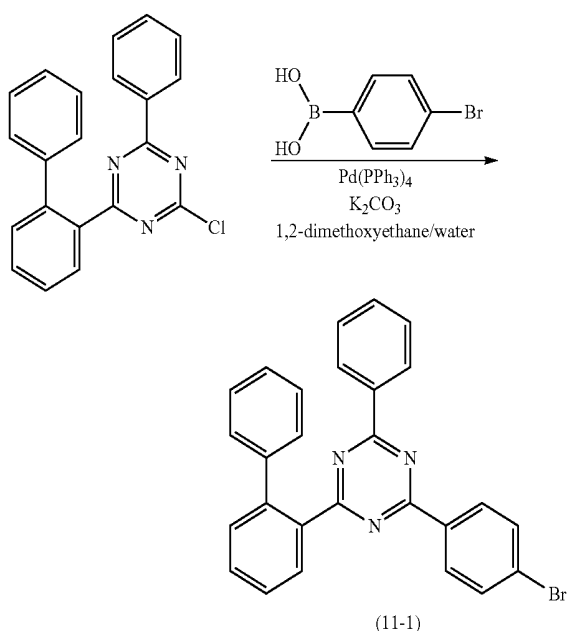


[0163] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 10-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-10 was obtained. The yield was 82%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-10 (Exact mass: 661.25).

Synthesis Example 11: Synthesis of Compound A-11

(11-1): Synthesis of Intermediate (11-1)

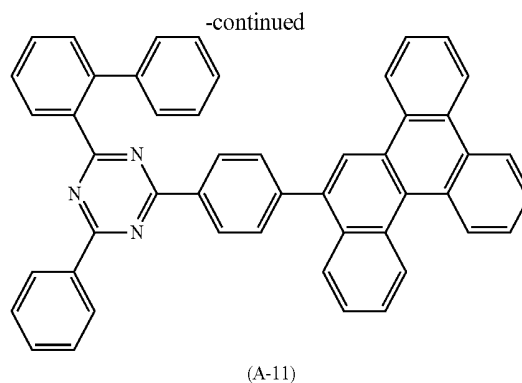
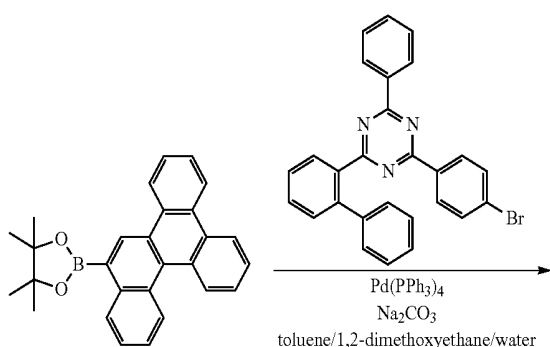
[0164]



[0165] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4-phenyl-6-(2-phenylphenyl)-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, and 4-bromophenylboronic acid was used instead of 3-bromophenylboronic acid, whereby intermediate 11-1 was obtained. The yield was 40%.

(11-2): Synthesis of Compound A-11

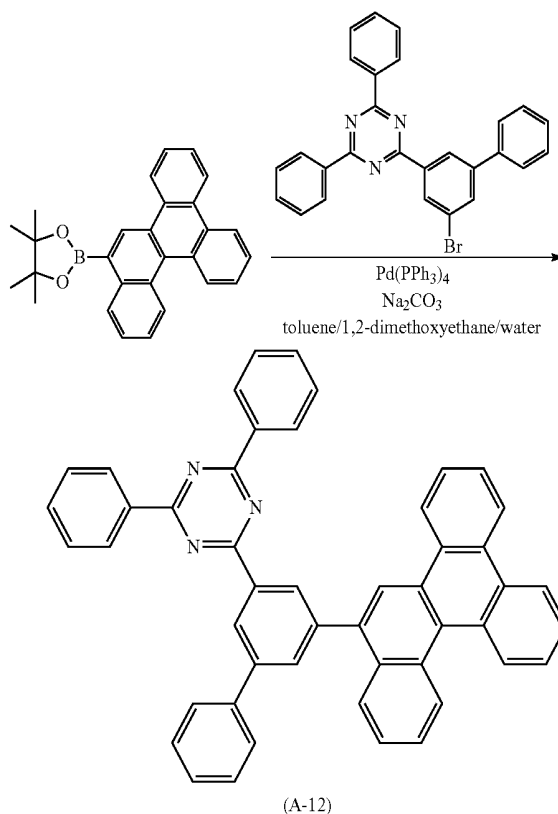
[0166]



[0167] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 11-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-11 was obtained. The yield was 70%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-11 (Exact mass: 661.25).

Synthesis Example 12: Synthesis of Compound A-12

[0168]



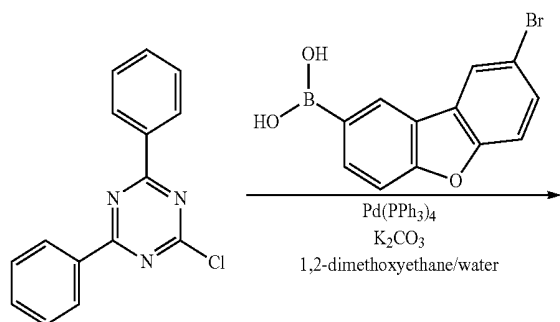
[0169] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, 2-(3-bromo-5-phenylphenyl)-4,6-diphenyl-1,3,5-triazine was used instead of 2-(3-bromophenyl)-4,6-

diphenyl-1,3,5-triazine, whereby compound A-12 was obtained. The yield was 80%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-12 (Exact mass: 661.25).

Synthesis Example 13: Synthesis of Compound A-13

(13-1): Synthesis of Intermediate (13-1)

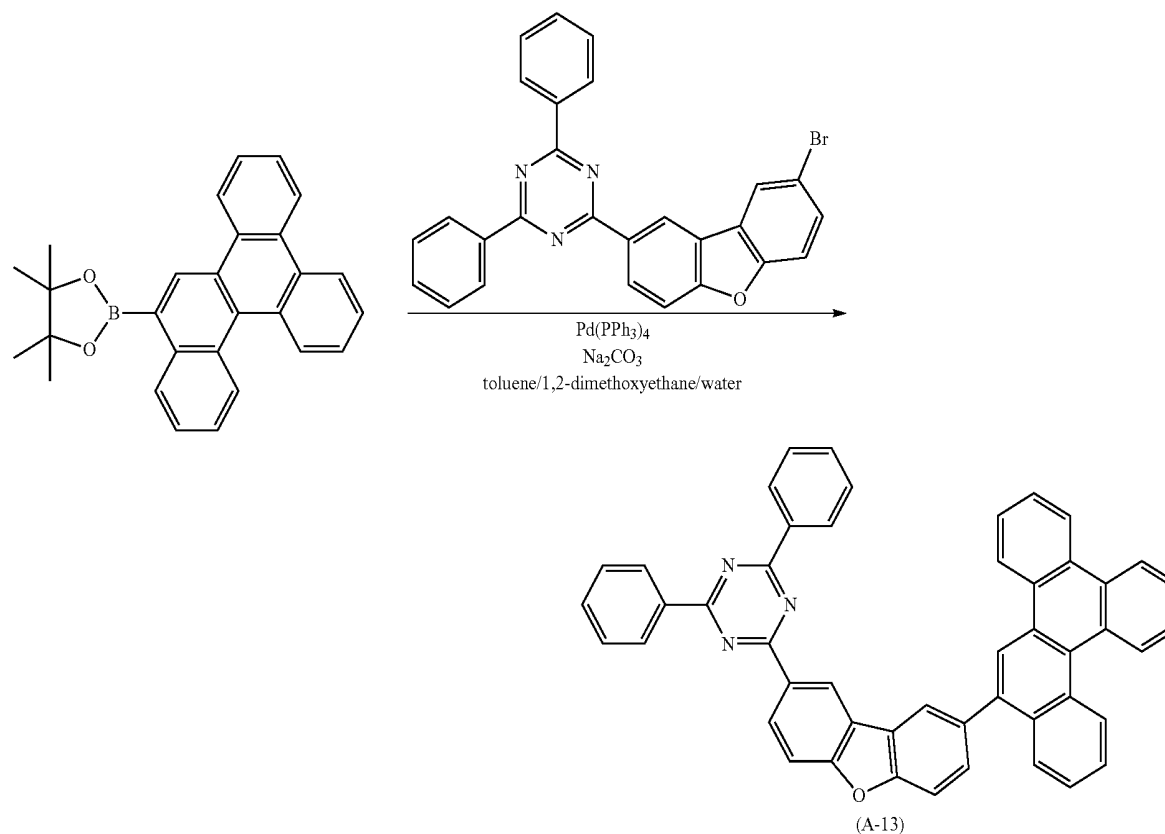
[0170]



[0171] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4,6-diphenyl-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, and (8-bromobenzofuran-2-yl)boronic acid was used instead of 3-bromophenylboronic acid, whereby intermediate 13-1 was obtained. The yield was 65%.

(13-2): Synthesis of Compound A-13

[0172]

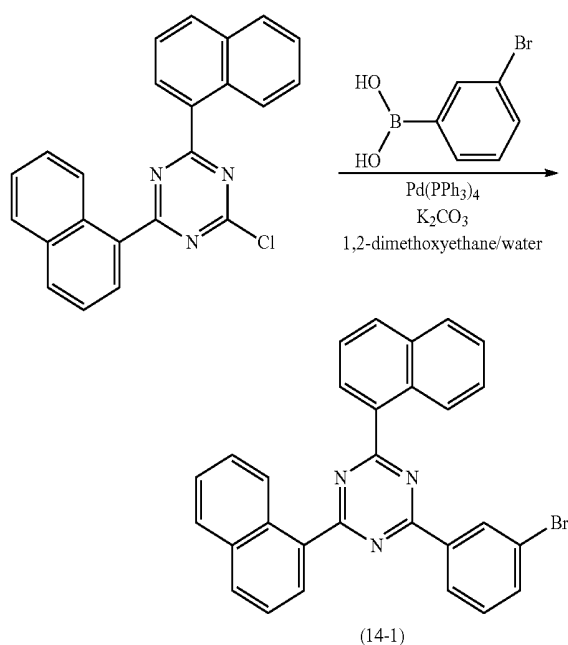


[0173] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 13-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-13 was obtained. The yield was 71%. As a result of mass spectrometry, the compound was found to have a m/e of 675, and was identified to be the above compound A-13 (Exact mass: 675.23).

Synthesis Example 14: Synthesis of Compound A-14

(14-1): Synthesis of Intermediate (14-1)

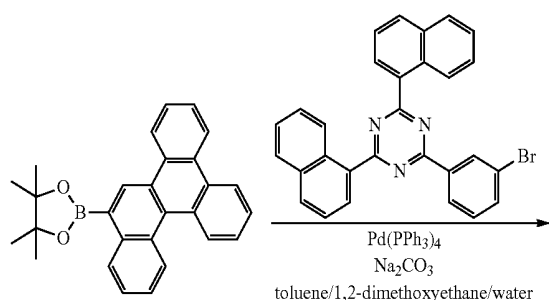
[0174]



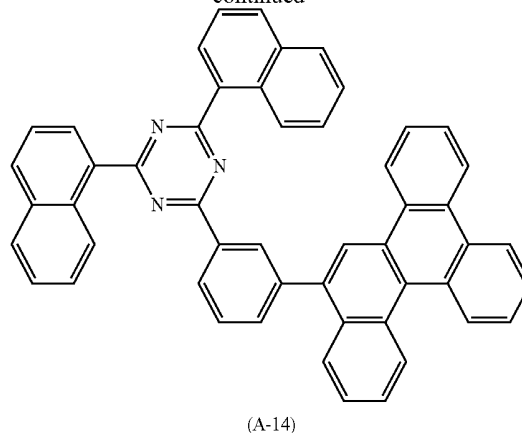
[0175] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4,6-bis(1-naphthyl)-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 14-1 was obtained. The yield was 44%.

(14-2): Synthesis of Compound A-14

[0176]



-continued

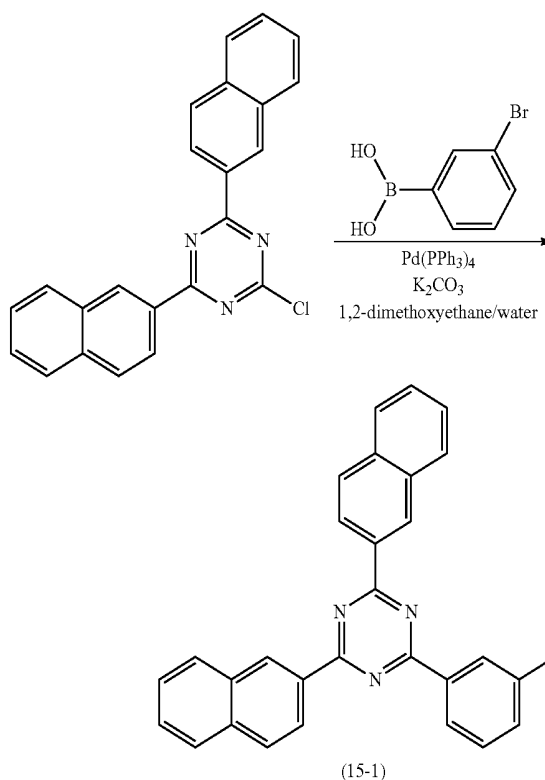


[0177] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 14-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-14 was obtained. The yield was 58%. As a result of mass spectrometry, the compound was found to have a m/e of 685, and was identified to be the above compound A-14 (Exact mass: 685.25).

Synthesis Example 15: Synthesis of Compound A-15

(15-1): Synthesis of Intermediate (15-1)

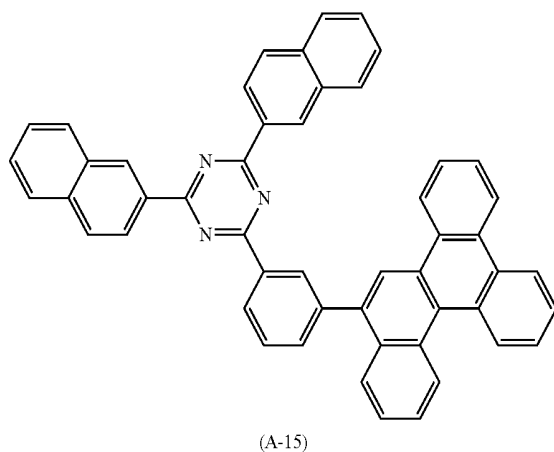
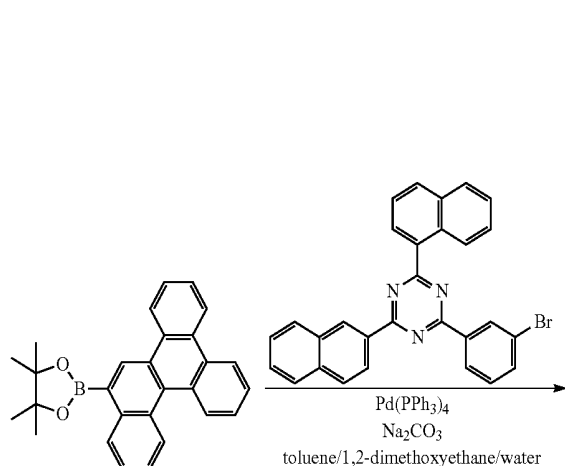
[0178]



[0179] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4,6-bis(2-naphthyl)-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 15-1 was obtained. The yield was 51%.

(15-2): Synthesis of Compound A-15

[0180]

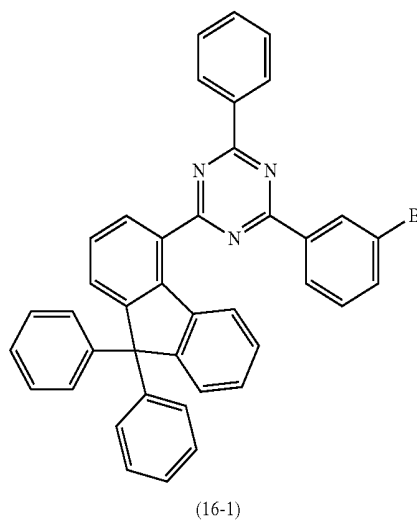
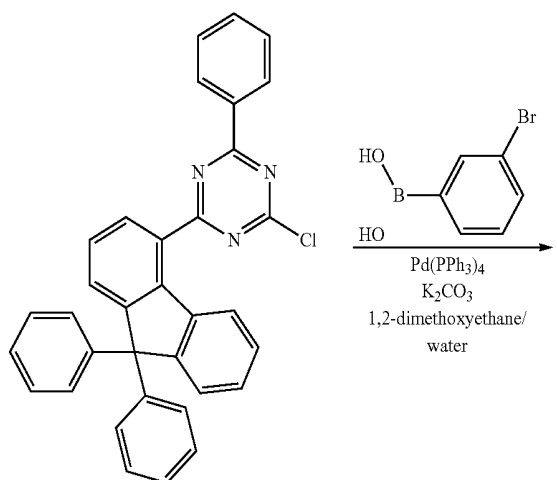


[0181] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 15-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-15 was obtained. The yield was 73%. As a result of mass spectrometry, the compound was found to have a m/e of 685, and was identified to be the above compound A-15 (Exact mass: 685.25).

Synthesis Example 16: Synthesis of Compound A-16

(16-1): Synthesis of Intermediate (16-1)

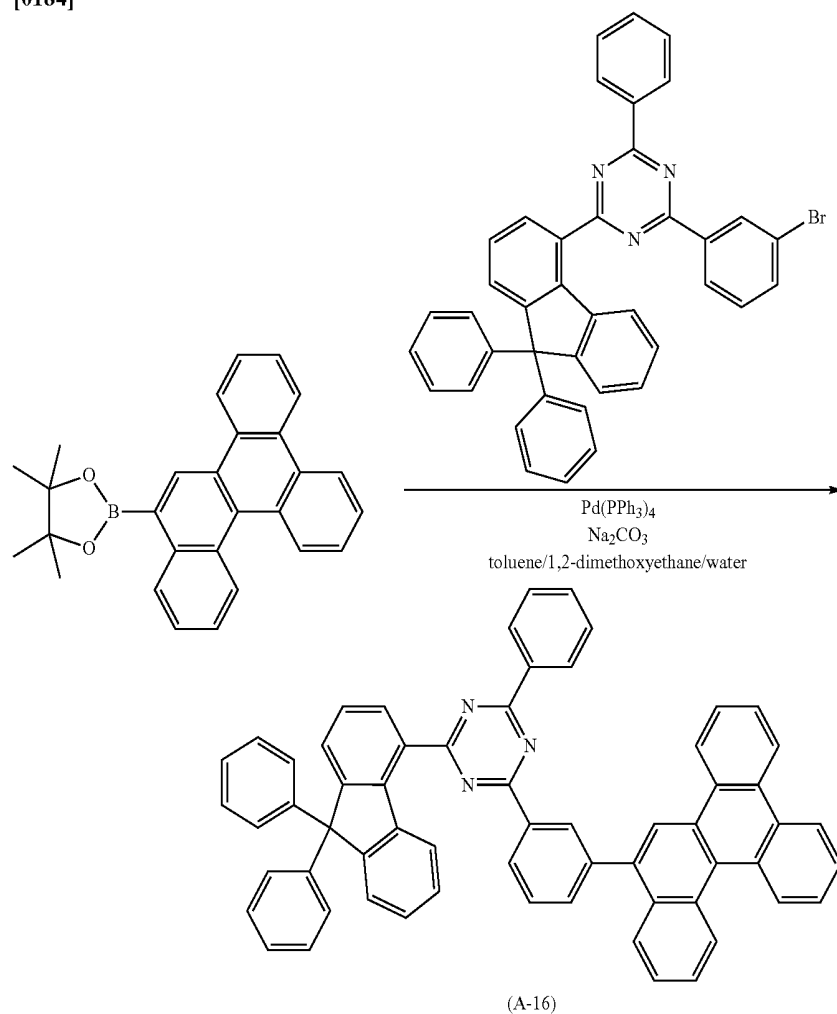
[0182]



[0183] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4-(9,9-diphenylfluorene-4-yl)-6-phenyl-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 16-1 was obtained. The yield was 62%.

(16-2): Synthesis of Compound A-16

[0184]

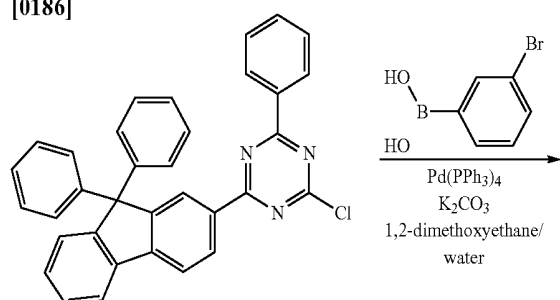


[0185] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 16-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-16 was obtained. The yield was 73%. As a result of mass spectrometry, the compound was found to have a m/e of 825, and was identified to be the above compound A-16 (Exact mass: 825.31).

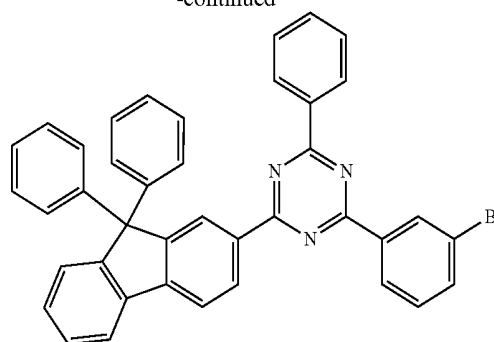
Synthesis Example 17: Synthesis of Compound A-17

(17-1): Synthesis of Intermediate (17-1)

[0186]



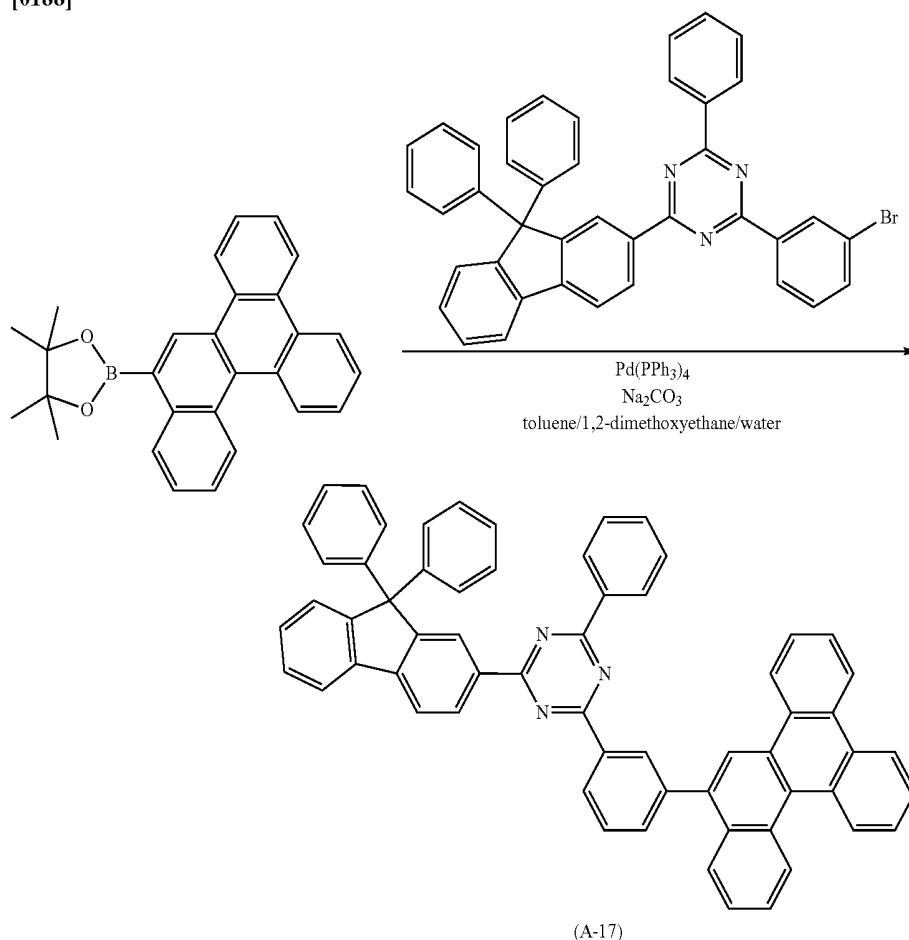
-continued



[0187] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2-chloro-4-(9,9-diphenylfluorene-2-yl)-6-phenyl-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 17-1 was obtained. The yield was 58%.

(17-2): Synthesis of Compound A-17

[0188]



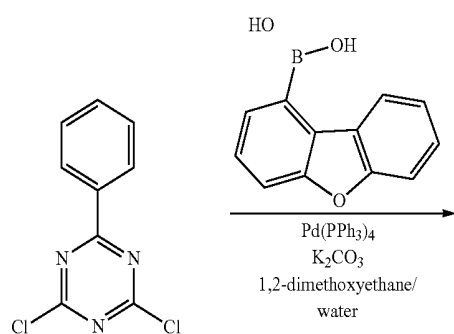
[0189] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 17-1 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-17 was obtained. The yield was 73%. As a result of mass spectrometry, the compound was found to have a m/e of 825, and was identified to be the above compound A-17 (Exact mass: 825.31).

-continued

Synthesis Example 18: Synthesis of Compound A-18

(18-1): Synthesis of Intermediate (18-1)

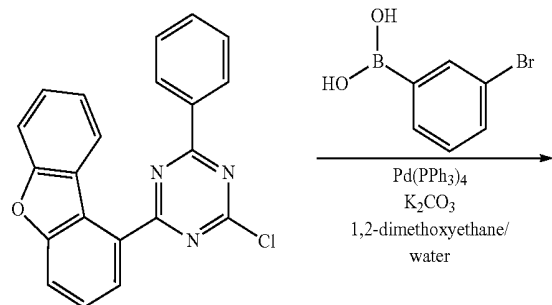
[0190]



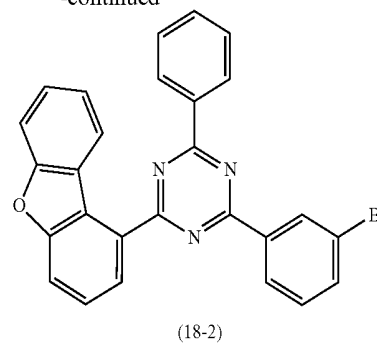
[0191] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, 2,4-dichloro-6-phenyl-1,3,5-triazine was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, and dibenzofuran-1-ylboronic acid was used instead of 3-bromophenylboronic acid, whereby intermediate 18-1 was obtained. The yield was 42%.

(18-2): Synthesis of Intermediate (18-2)

[0192]



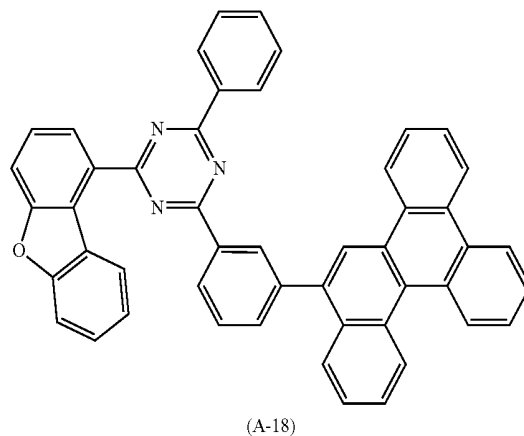
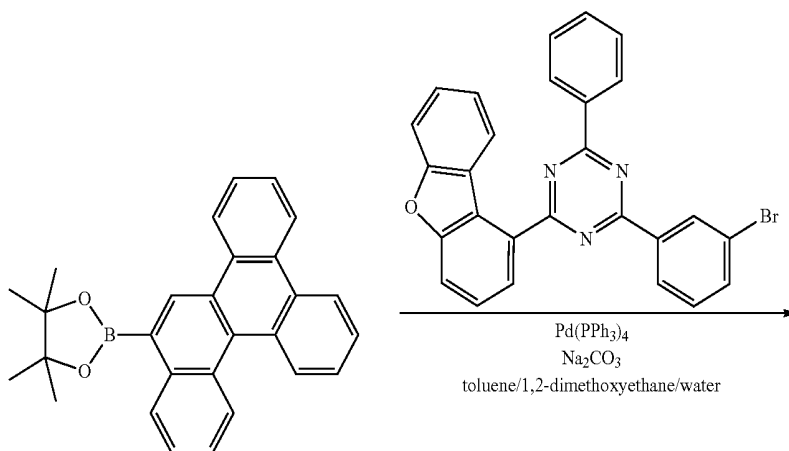
-continued



[0193] Synthesis was conducted in the same manner as the synthesis of intermediate 5-1, except that, in the synthesis of intermediate 5-1, intermediate 18-1 was used instead of 2-chloro-4-phenyl-6-(4-phenylphenyl)-1,3,5-triazine, whereby intermediate 18-2 was obtained. The yield was 51%.

(18-3): Synthesis of Compound A-18

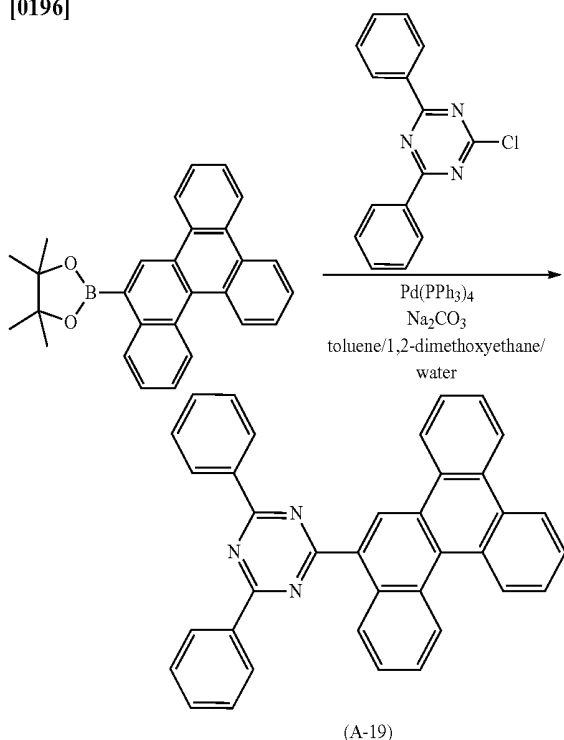
[0194]



[0195] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, intermediate 18-2 was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-18 was obtained. The yield was 73%. As a result of mass spectrometry, the compound was found to have a m/e of 675, and was identified to be the above compound A-18 (Exact mass: 675.23).

Synthesis Example 19: Synthesis of Compound A-19

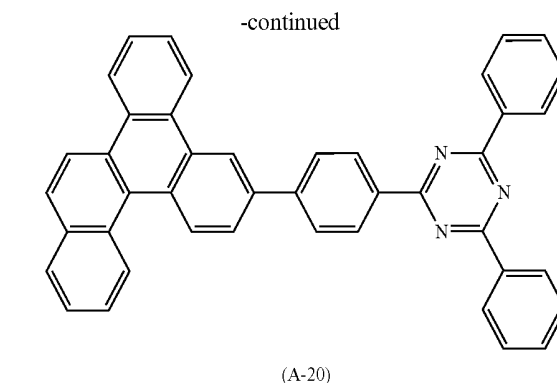
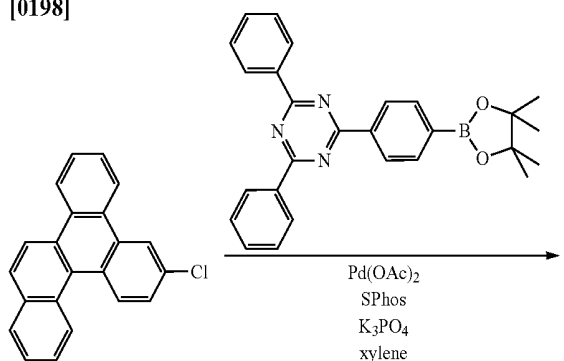
[0196]



[0197] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-2, 2-chloro-4,6-diphenyl-1,3,5-triazine was used instead of 2-(3-bromophenyl)-4,6-diphenyl-1,3,5-triazine, whereby compound A-19 was obtained. The yield was 53%. As a result of mass spectrometry, the compound was found to have a m/e of 509, and was identified to be the above compound A-19 (Exact mass: 509.19).

Synthesis Example 20: Synthesis of Compound A-20

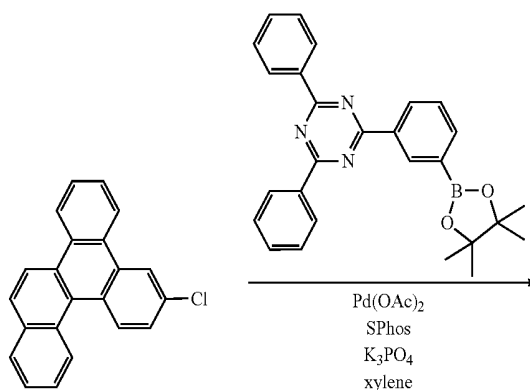
[0198]



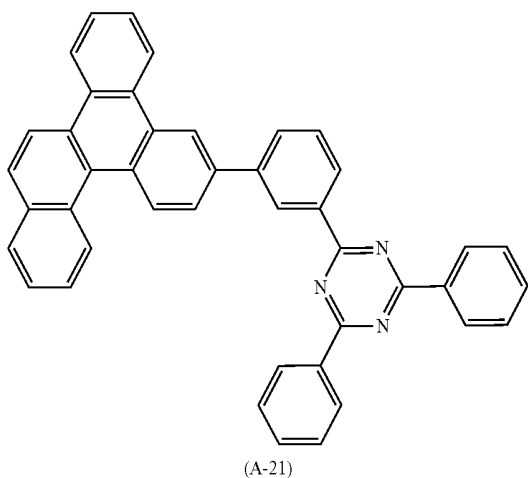
[0199] In an argon atmosphere, to a mixture of 3-chlorobenzo[a]triphenylene (2.19 g, 7.00 mmol), 2,4-diphenyl-6-[4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl]-1,3,5-triazine (3.05 g, 7.00 mmol), palladium acetate (0.079 g, 0.350 mmol), SPhos (0.287 g, 0.700 mmol), potassium phosphate (4.46 g, 21.0 mmol), xylene (80 mL), was added, and the resultant was stirred at 100° C. for 12 hours. After completion of the reaction, the mixture was cooled to room temperature, and deposited crystals were separated by filtration. The collected crystals were dissolved in toluene and passed through silica gel column chromatography. The resulting solution was concentrated under reduced pressure, and the concentrated solution was purified by a recrystallization method by using toluene, whereby compound A-20 (2.66 g, 4.55 mmol) was obtained. The yield of compound A-20 was 65%. As a result of mass spectrometry, the compound was found to have a m/e of 585, and was identified to be the above compound A-20 (Exact mass: 585.22). 3-chlorobenzo[a]triphenylene was synthesized by using the method stated in JP-A-2014-19679.

Synthesis Example 21: Synthesis of Compound A-21

[0200]



-continued

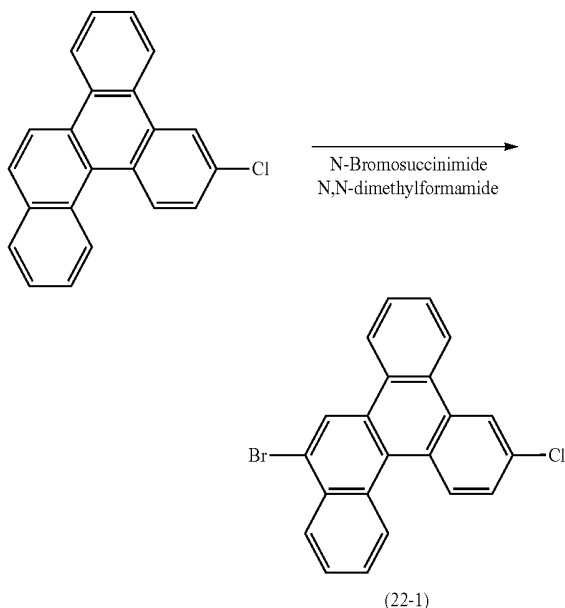


[0201] Synthesis was conducted in the same manner as the synthesis of compound A-20, except that, in the synthesis of compound A-20, 2,4-diphenyl-6-[3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolane-2-yl)phenyl]-1,3,5-triazine was used instead of 2,4-diphenyl-6-[4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolane-2-yl)phenyl]-1,3,5-triazine, whereby compound A-21 was obtained. The yield was 60%. As a result of mass spectrometry, the compound was found to have a m/e of 585, and was identified to be the above compound A-21 (Exact mass: 585.22).

Synthesis Example 22: Synthesis of Compound A-22

(22-1): Synthesis of Intermediate (22-1)

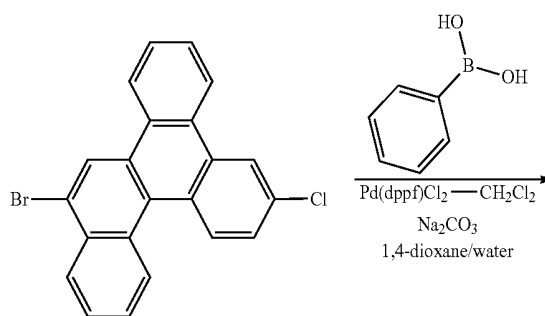
[0202]



[0203] In an argon atmosphere, to a mixture of 3-chlorobenzo[a]triphenylene (15.6 g, 50.0 mmol) and N-bromosuccinimide (10.7 g, 60.2 mmol), N,N-dimethylformamide (170 mL) was added, and the resultant was stirred at 100° C. for 12 hours. After completion of the reaction, the mixture was cooled to room temperature, the reaction solution was poured to water, and deposited crystals were separated by filtration. The filtrated crystals were washed with water and methanol, whereby intermediate 22-1 (10.8 g, 27.5 mmol) was obtained. The yield of the intermediate 22-1 was 55%.

(22-2): Synthesis of Intermediate (22-2)

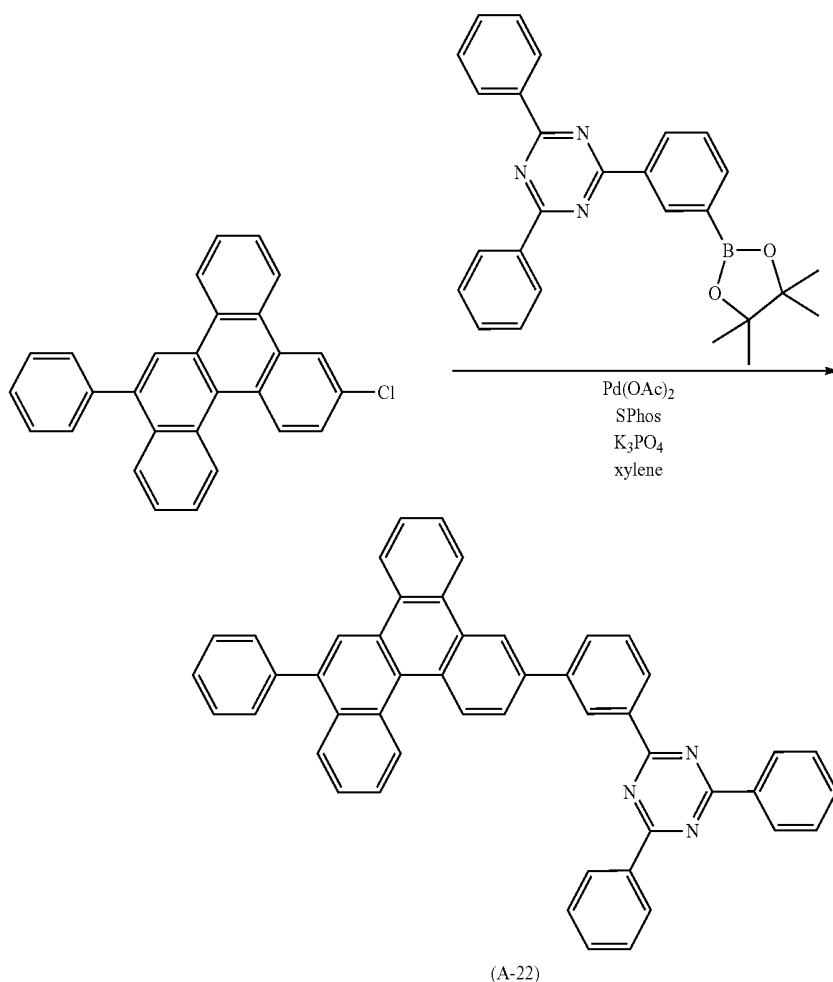
[0204]



[0205] Synthesis was conducted in the same manner as the synthesis of compound A-2, except that, in the synthesis of compound A-1, phenylboronic acid was used instead of 2,4-diphenyl-6-[3-[3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolane-2-yl)phenyl]phenyl]-1,3,5-triazine, whereby intermediate 22-2 was obtained. The yield was 90%.

(22-3): Compound A-22

[0206]



[0207] Synthesis was conducted in the same manner as the synthesis of compound A-20, except that, in the synthesis of compound A-20, intermediate 22-2 was used instead of 3-chlorobenzophenone, whereby compound A-22 was obtained. The yield was 62%. As a result of mass spectrometry, the compound was found to have a m/e of 661, and was identified to be the above compound A-22 (Exact mass: 661.25).

Fabrication and Evaluation of Organic EL Emitting Device

Example 1

[0208] A glass substrate with an ITO transparent electrode (anode) having a dimension of 25 mm×75 mm×1.1 mm in thickness (manufactured by GEOMATIC Co., Ltd.) was subjected to ultrasonic cleaning in isopropyl alcohol for 5 minutes and then to UV ozone cleaning for 30 minutes. The thickness of the ITO transparent electrode was 130 nm.

[0209] The cleaned glass substrate with transparent electrode lines was mounted on a substrate holder in a vacuum deposition apparatus. First, compound HI was deposited on the surface on which the transparent electrode lines had been

formed so as to cover the transparent electrode, whereby a 5 nm-thick HI film was formed. The HI film functions as a hole-injecting layer.

[0210] On this compound HI film, the following aromatic amine derivative (compound HT-1) was deposited as the first hole-transporting material, whereby a 80 nm-thick first hole-transporting layer was formed.

[0211] Subsequent to formation of the first hole-transporting layer, the following aromatic amine derivative (compound HT-2) was deposited as the second hole-transporting material, whereby a 10 nm-thick second hole-transporting layer was formed.

[0212] Further, on this second hole-transporting layer, the following compound BH as the host material and the following compound BD as the phosphorescent emitting dopant were co-deposited, whereby a 25 nm-thick emitting layer was formed. The concentration of the compound BD in the emitting layer was 4.0 mass %. This co-deposited layer functions as an emitting layer.

[0213] Subsequent to the formation of the emitting layer, the following compound A-1 was formed into a 10 nm-thick film. This compound A-1 film functions as a first electron-transporting layer was formed.

[0214] On the first electron-transporting layer, the following compound ET-1 was deposited, whereby a 15 nm-thick second electron-transporting layer was formed.

[0215] Further, on the second electron-transporting layer, LiF was deposited, whereby a 1 nm-thick LiF film was formed.

[0216] Metal Al was deposited on this LiF film, whereby a 80 nm-thick metal cathode was formed.

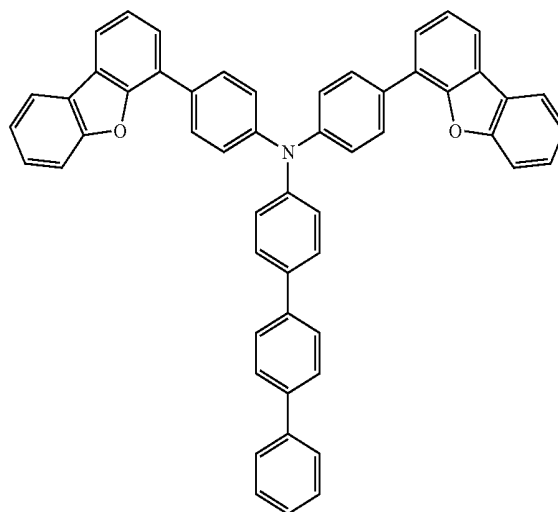
[0217] The organic EL device of Example 1 has a layer structure shown in FIG. 1, and each layer has the following configuration.

ITO(130 nm)/HI(5 nm)/HT-1(80 nm)/HT-2(10 nm)/BH:BD
(25 nm:4 mass %)/Compound

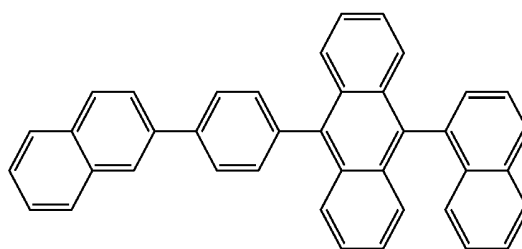
A-1(10 nm)/ET-1(15 nm)/LiF(1 nm)/Al(80 nm)

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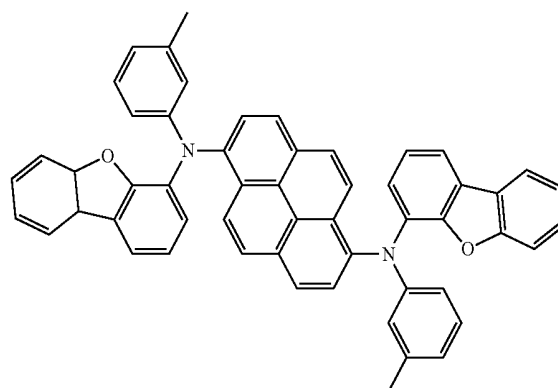
HT-2



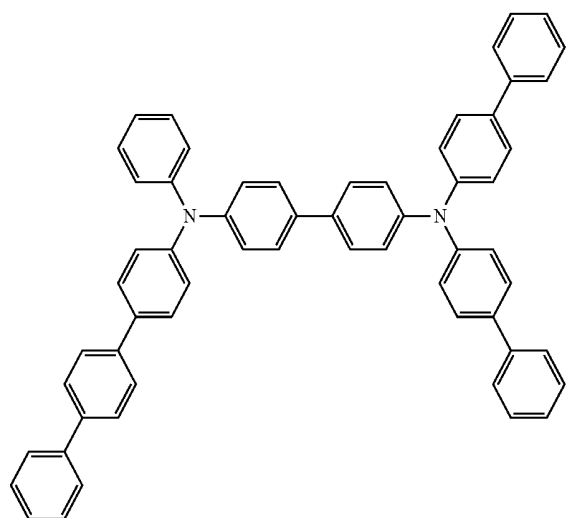
BH



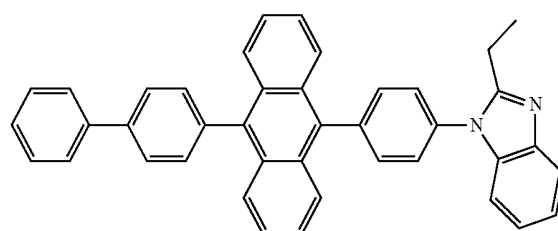
BD



HT-1

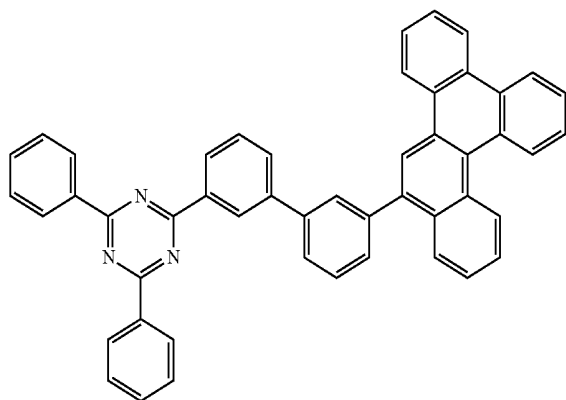


ET-1



-continued

A-1



[0218] For the fabricated organic EL device, the driving voltage and the external quantum efficiency (EQE) were measured as follows. The results are shown in Table 1.

[0219] Driving Voltage (V)

[0220] A voltage (unit: V) when electric current was passed between the ITO transparent electrode and the metal Al cathode such that the current density became 10 mA/cm² was measured.

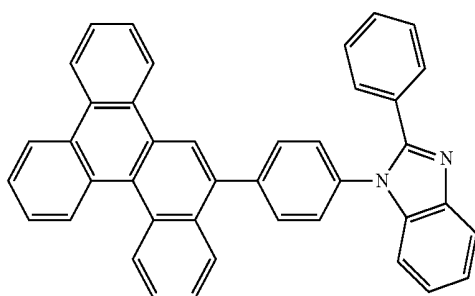
[0221] External Quantum Efficiency (EQE)

[0222] From a spectral radiance spectrum, an external quantum efficiency EQE (unit: %) was calculated on the assumption that lambertian radiation was conducted.

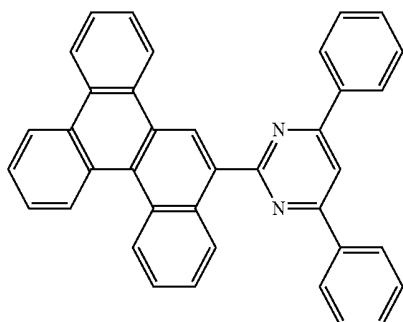
Comparative Examples 1, 3 and 4

[0223] Organic EL devices were fabricated and evaluated in the same manner as in Example 1, except that comparative compounds B-1, B-2 or B-3 was used instead of compound A-1. The results are shown in Table 1.

B-1



B-2



-continued

B-3

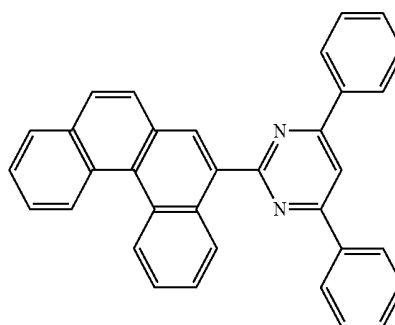


TABLE 1

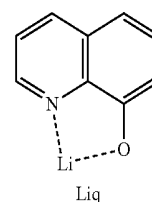
	Material of first electron-transporting layer	Driving voltage [V]	External quantum efficiency [%]
Ex. 1	Compound A-1	3.75	10.4
Comp. Ex. 1	Compound B-1	4.07	10.3
Comp. Ex. 3	Compound B-2	4.15	8.9
Comp. Ex. 4	Compound B-3	4.31	8.8

[0224] From Table 1, it is understood that the driving voltage is lowered when the compound according to one aspect of the invention is used as an electron-transporting material.

Example 2

[0225] Organic EL devices were fabricated in the same manner as in Example 1, except that the configurations of the first electron-transporting layer, the second electron-transporting layer and the metal cathode in Example 1 were changed as follows. For the obtained organic EL devices, the driving voltage, the external quantum efficiency (EQE) and the device lifetime (LT95) were measured. The results are shown in Table 2.

Compound A-1: Liq(25:50%)/Liq(1 nm)/Al(80)



[0226] Device Lifetime (LT95)

[0227] The time until the initial luminance was reduced by 3% at a current density of 50 mA/cm² was measured.

Example 3

[0228] A device was fabricated and evaluated in the same manner as in Example 2, except that compound A-1 in Example 2 was changed to compound A-2. The results are shown in Table 2.

Compound A-2: Liq (25:50%)/Liq(1 nm)/Al(80)

Comparative Example 2

[0229] A device was fabricated and evaluated in the same manner as in Example 2, except that compound A-1 in

Example 2 was changed to comparative compound B-1. The results are shown in Table 2.

Compound B-1: Liq(25:50%)/Liq(1 nm)/Al(80)

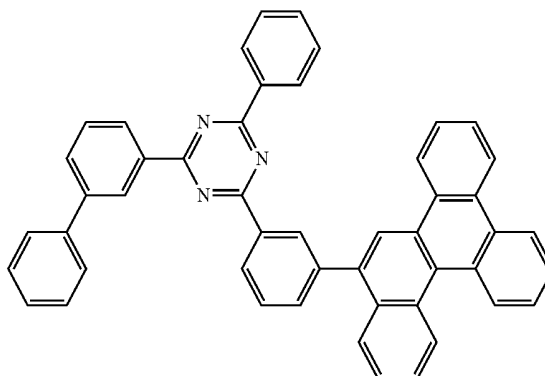
Examples 4 to 23 and Comparative Examples 5 and 6

[0230] Devices were fabricated and evaluated in the same manner as in Example 2, except that compound A-1 in Example 2 was changed to compounds shown in Table 2. The results are shown in Table 2.

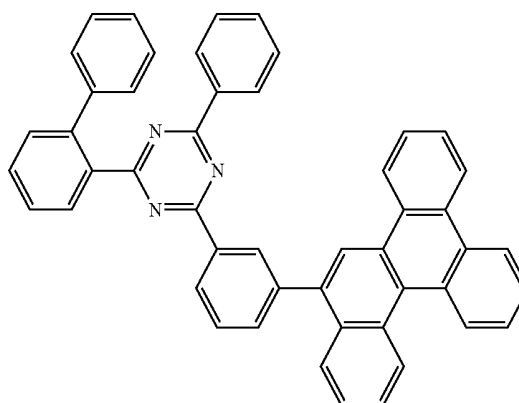
[0231] The compounds used are as follows.

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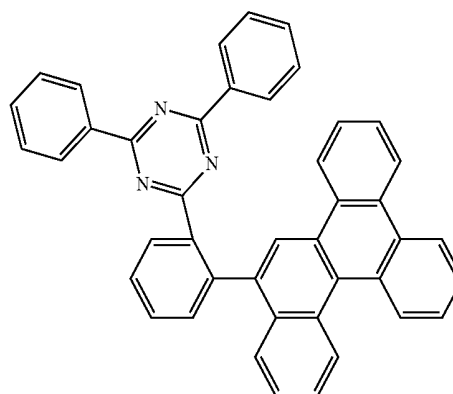
Compound A-6



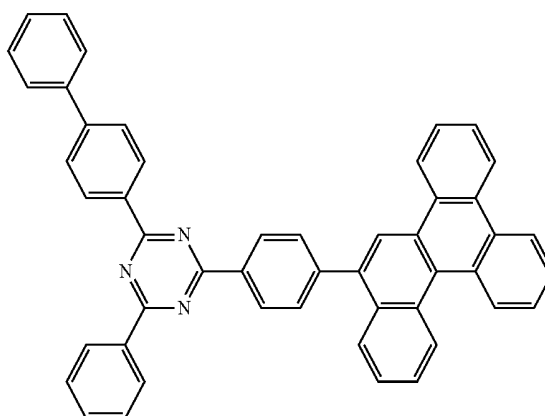
Compound A-7



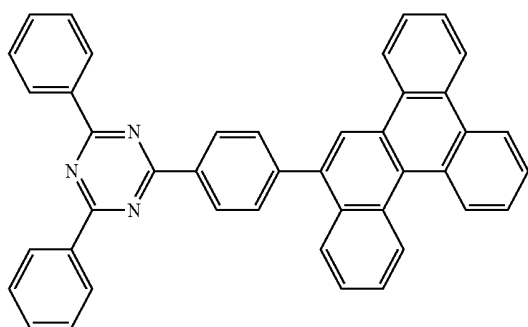
Compound A-8



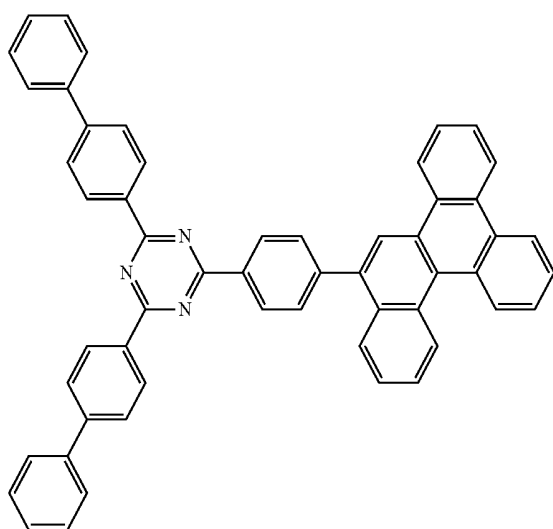
Compound A-9



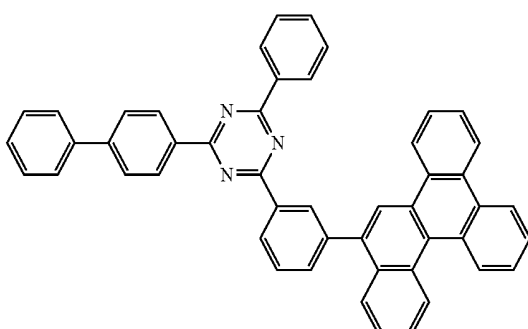
Compound A-3



Compound A-4

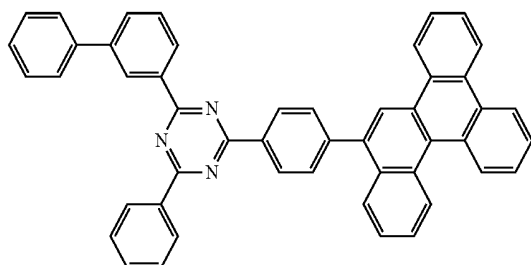


Compound A-5

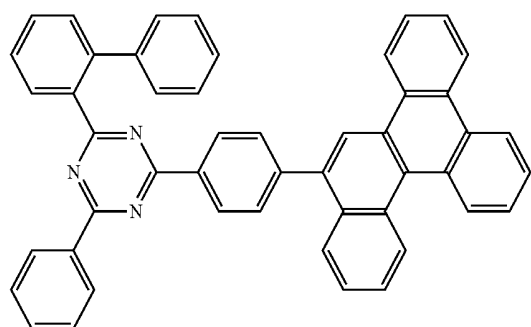


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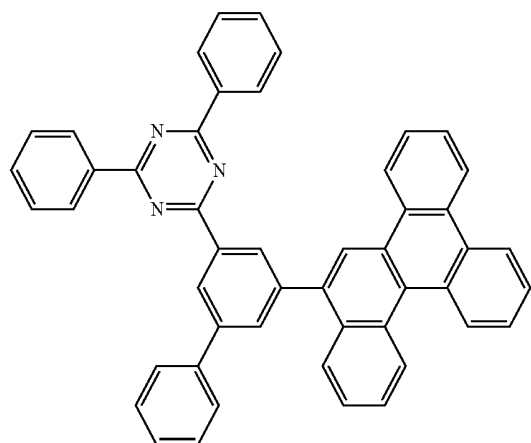
Compound A-10



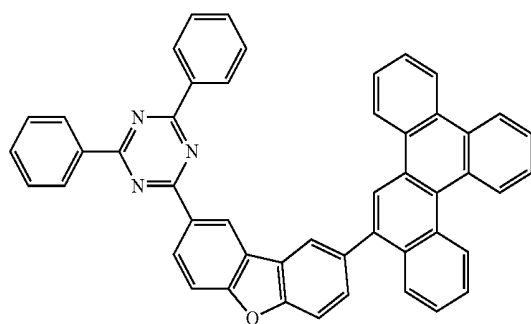
Compound A-11



Compound A-12

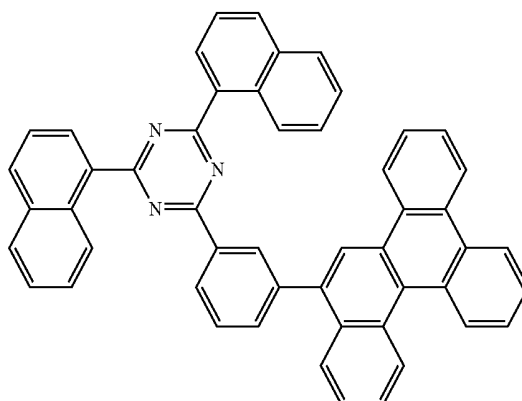


Compound A-13

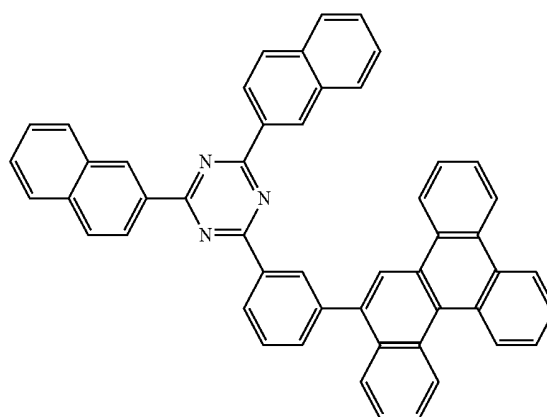


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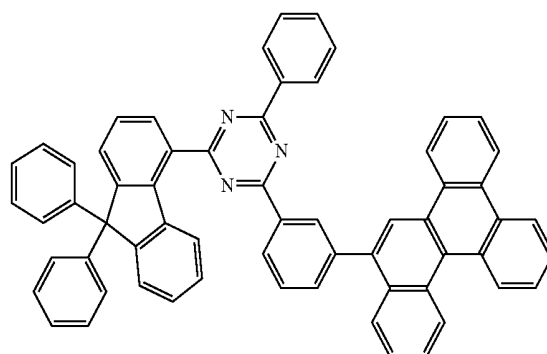
Compound A-14



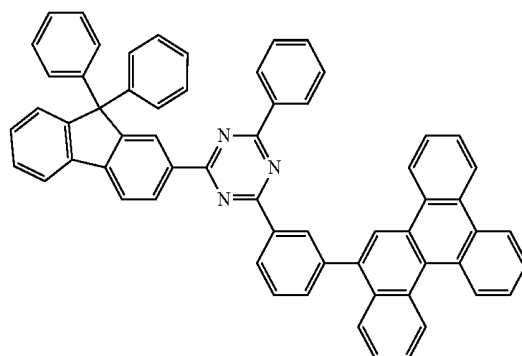
Compound A-15



Compound A-16

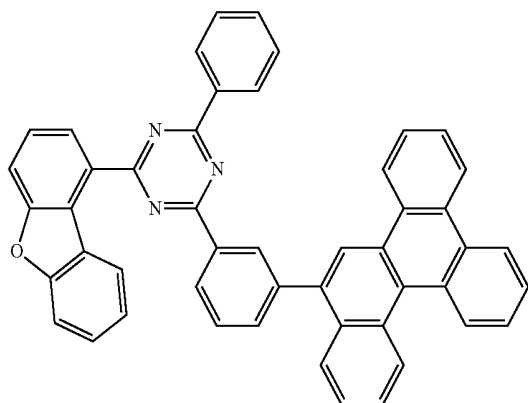


Compound A-17



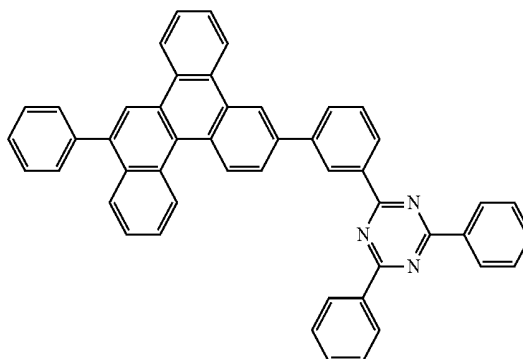
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Compound A-18

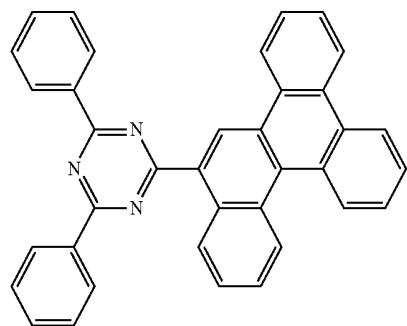


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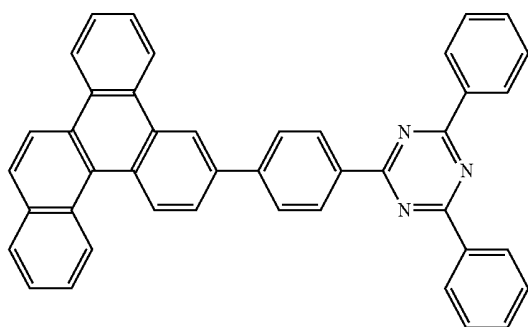
Compound A-22



Compound A-19



Compound A-20



Compound A-21

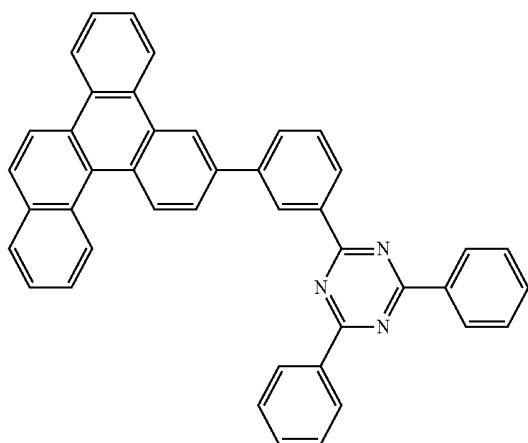


TABLE 2

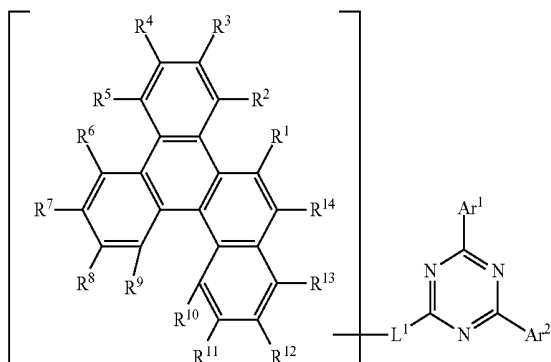
	Material of first electron-transporting layer	Driving voltage [V]	External quantum efficiency [%]	Device lifetime LT95 [hr]
Ex. 2	Compound A-1:Liq	4.19	9.0	82
Ex. 3	Compound A-2:Liq	3.97	9.8	95
Ex. 4	Compound A-3:Liq	3.85	10.0	91
Ex. 5	Compound A-4:Liq	4.60	8.9	79
Ex. 6	Compound A-5:Liq	4.00	9.7	90
Ex. 7	Compound A-6:Liq	4.01	9.7	95
Ex. 8	Compound A-7:Liq	4.17	9.7	95
Ex. 9	Compound A-8:Liq	3.97	9.6	94
Ex. 10	Compound A-9:Liq	3.90	9.8	90
Ex. 11	Compound A-10:Liq	3.92	9.9	93
Ex. 12	Compound A-11:Liq	4.15	9.7	95
Ex. 13	Compound A-12:Liq	4.10	9.7	90
Ex. 14	Compound A-13:Liq	4.29	9.1	65
Ex. 15	Compound A-14:Liq	4.33	9.0	52
Ex. 16	Compound A-15:Liq	4.30	9.0	51
Ex. 17	Compound A-16:Liq	4.35	9.0	50
Ex. 18	Compound A-17:Liq	4.30	9.0	50
Ex. 19	Compound A-18:Liq	4.35	9.1	67
Ex. 20	Compound A-19:Liq	4.65	8.8	75
Ex. 21	Compound A-20:Liq	4.36	9.0	48
Ex. 22	Compound A-21:Liq	4.40	9.0	49
Ex. 23	Compound A-22:Liq	4.41	9.1	49
Comp. Ex. 2	Compound B-1:Liq	5.15	8.7	24
Comp. Ex. 5	Compound B-2:Liq	5.35	7.5	25
Comp. Ex. 6	Compound B-3:Liq	5.01	8.4	29

[0232] From Table 2, it can be understood that the device that comprises the electron-transporting layer containing the compound according to one aspect of the invention and is doped with Liq has a low driving voltage, an improved external quantum efficiency and a significantly prolonged lifetime.

[0233] Although only some exemplary embodiments and/or examples of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments and/or examples without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention.

[0234] The documents described in the specification are incorporated herein by reference in its entirety.

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



wherein in the formula (1),

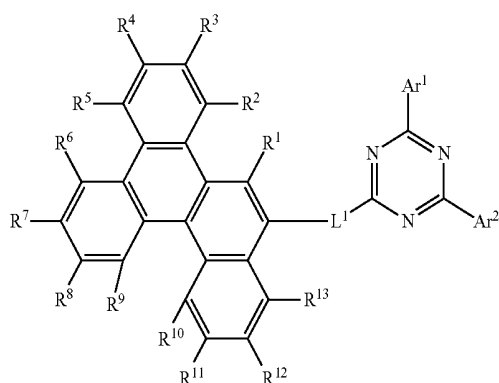
any one of R¹ to R¹⁴ is a single bond and is bonded with L¹ and the remainder of R¹ to R¹⁴ are independently a hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group including 1 to 10 carbon atoms, a substituted or unsubstituted cycloalkyl group including 3 to 10 carbon atoms, a substituted or unsubstituted alkylsilyl group including 3 to 30 carbon atoms, a substituted or unsubstituted arylsilyl group including 8 to 30 ring carbon atoms, a substituted or unsubstituted alkoxy group including 1 to 20 carbon atoms, a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms, a substituted or unsubstituted aryloxy group including 6 to 20 ring carbon atoms, a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms, a substituted or unsubstituted alkylthio group including 1 to 10 carbon atoms, a substituted or unsubstituted arylthio group including 6 to 20 ring carbon atoms or a substituted or unsubstituted arylamino group including 6 to 30 ring carbon atoms;

L¹ is a single bond, a substituted or unsubstituted arylene group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroarylene group including 5 to 20 ring atoms; and

Ar¹ and Ar² are independently a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms.

2. The compound according to claim 1, wherein R³, R⁴, R⁷, R⁸, R¹¹, R¹², R¹³ or R¹⁴ is a single bond that is bonded with L¹.

3. The compound according to claim 1 that is represented by the following formula (2):

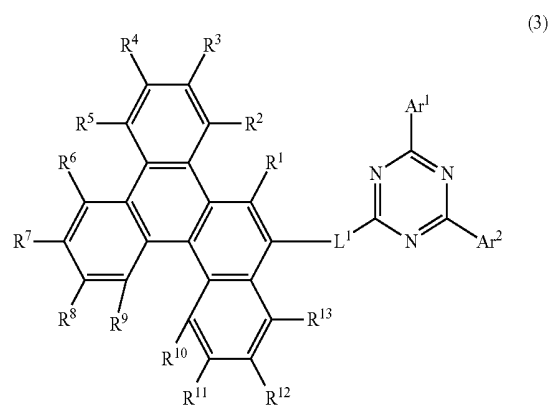


(2)

wherein in the formula (2), R¹ to R¹³, L¹, Ar¹ and Ar² are as defined in the formula (1).

4. The compound according to claim 1, wherein L¹ is a single bond, a substituted or unsubstituted phenylene group, a substituted or unsubstituted naphthylene group, a substituted or unsubstituted anthracenylene group, a substituted or unsubstituted phenanthrylene group, a substituted or unsubstituted biphenylene group, a substituted or unsubstituted terphenylene group, a substituted or unsubstituted chrysenylene group, a substituted or unsubstituted benzophenanthrylene group, a substituted or unsubstituted benzochrysenylene group, a substituted or unsubstituted fluorenylene group, a substituted or unsubstituted fluoranthrylene group, a substituted or unsubstituted dibenzofuranylene group or a substituted or unsubstituted dibenzothiophenylylene group.

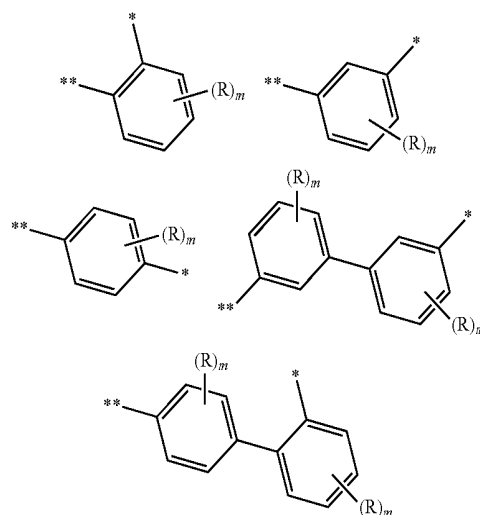
5. The compound according to claim 1, that is represented by the following formula (3):

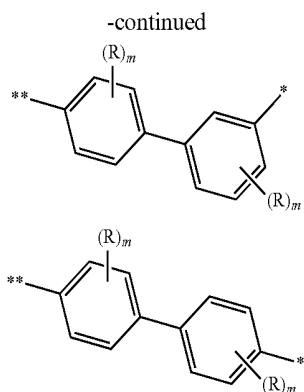


(3)

wherein in the formula (3), R¹ to R¹³, Ar¹ and Ar² are as defined in the formula (1); and

L¹ is a single bond or a group selected from the following groups;



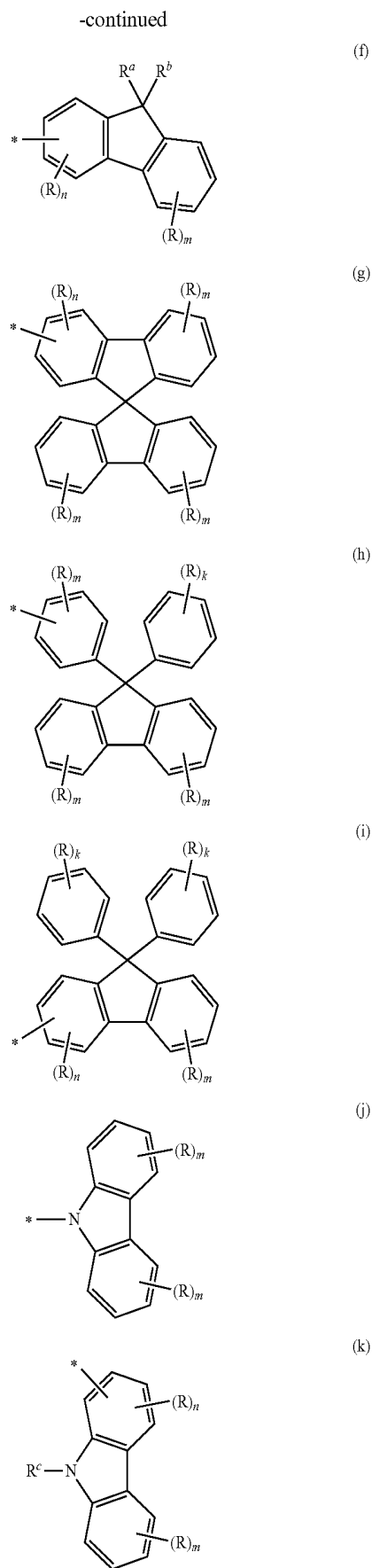
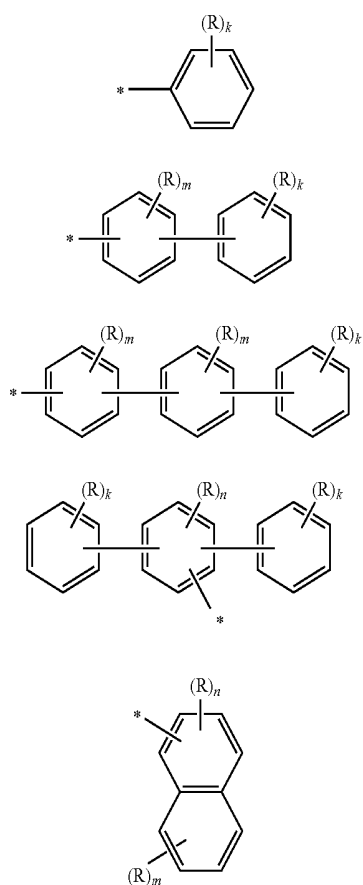


wherein in the formula, * is a single bond that is bonded with a triazine ring and ** is a single bond that is bonded with a benzochrysene ring;

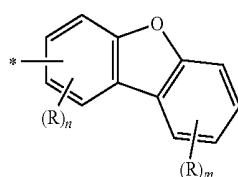
R is a substituent, and may be bonded to any position of the ring that is substituted by R; and

m is an integer of 0 to 4, and when m is 2 or more, adjacent Rs may be bonded with each other to form a ring.

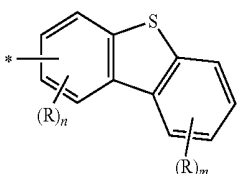
6. The compound according to claim 1, wherein Ar¹ and Ar² are independently a group selected from the following groups:



-continued



(l)



(m)

wherein in the formulas (a) to (m),

* is a single bond that is bonded with a triazine ring;

R is a substituent and may be bonded to any position of the ring that is substituted by R;

k is an integer of 0 to 5, m is an integer of 0 to 4 and n is an integer of 0 to 3;

when k, m and n are 2 or more, adjacent Rs may be bonded with each other to form a ring;

R^a and R^b are independently a hydrogen atom, a halogen atom, a substituted or unsubstituted alkyl group including 1 to 8 carbon atoms, a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms or a substituted or unsubstituted heteroaryl group including 5 to 20 ring atoms; and

R^c is a substituted or unsubstituted alkyl group including 1 to 8 carbon atoms or a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms.

7. The compound according to claim 1, wherein Ar¹ and Ar² are a substituted or unsubstituted phenyl group.

8. The compound according to claim 1, wherein, when Ar¹ and Ar² are a substituted or unsubstituted aryl group including 6 to 20 ring carbon atoms, the substituent is selected from an alkyl group including 1 to 10 carbon atoms, an aryl group including 6 to 20 ring carbon atoms, a heteroaryl group including 5 to 20 ring atoms excluding a nitrogen-containing heterocyclic group and a cyano group.

9. The compound according to claim 8, wherein the heteroaryl group including 5 to 20 ring atoms excluding the nitrogen-containing heterocyclic group is selected from an oxygen-containing heterocyclic group and a sulfur-containing heterocyclic group.

10. The compound according to claim 1, wherein R¹ to R¹³ are a hydrogen atom.

11. A material for an organic electroluminescence device that comprises the compound according to claim 1.

12. An electron-transporting material of an organic electroluminescence device that comprises the compound according to claim 1.

13. An organic electroluminescence device in which one or more organic thin film layers comprising at least an emitting layer are disposed between a cathode and an anode, wherein at least one layer of the organic thin film layers comprises the compound according to claim 1 as a single or mixed component.

14. The organic electroluminescence device according to claim 13, wherein an electron-transporting zone is provided between the emitting layer and the cathode, and the electron-transporting zone comprises one or more organic thin film layers and at least one layer of the organic thin film layers comprises the compound.

15. The organic electroluminescence device according to claim 14, wherein, at least one layer of the organic thin film layers in the electron-transporting zone is an electron-transporting layer.

16. The organic electroluminescence device according to claim 14, wherein the electron-transporting zone further comprises 8-quinolinolato lithium.

17. The organic electroluminescence device according to claim 14, wherein the electron-transporting zone comprises an electron-injecting layer and at least two electron-transporting layers, wherein, among the at least two electron-transporting layers, the electron-transporting layer that is not adjacent to the electron-injecting layer comprises the compound.

18. The organic electroluminescence device according to claim 13, wherein a hole-transporting layer is provided between the anode and the emitting layer.

19. An electronic apparatus provided with the organic electroluminescence device according to claim 13.

* * * * *

专利名称(译)	新型化合物，用于有机电致发光器件的材料和有机电致发光器件		
公开(公告)号	US20190006598A1	公开(公告)日	2019-01-03
申请号	US16/064411	申请日	2016-12-22
申请(专利权)人(译)	出光兴产股份有限公司.		
当前申请(专利权)人(译)	出光兴产股份有限公司.		
[标]发明人	SHIOMI TAKUSHI KAWAMURA MASAHIRO		
发明人	SHIOMI, TAKUSHI KAWAMURA, MASAHIRO		
IPC分类号	H01L51/00 C07D251/24 C07D405/10		
CPC分类号	H01L51/0067 C07D251/24 C07D405/10 H01L51/0073 H01L51/0077 H01L51/5012 H01L51/5056 H01L51/5076 H01L51/508 H01L51/5092		
优先权	2015252200 2015-12-24 JP 2016065382 2016-03-29 JP		
外部链接	Espacenet USPTO		

摘要(译)

由下式 (1) 表示的化合物：

