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Kim et al.

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(45) **Date of Patent: May 19, 2020**

(54) **ORGANIC LIGHT EMITTING DISPLAY DEVICE**

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(73) Assignees: **LG DISPLAY CO., LTD**, Seoul (KR); **LG CHEM, LTD.**, Seoul (KR)

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May 10, 2016 (KR) 10-2016-0057107

(51) **Int. Cl.**
H01L 51/00 (2006.01)
H01L 51/52 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 51/0052*** (2013.01); ***C07C 255/47*** (2013.01); ***C07D 213/61*** (2013.01); ***C09K 11/06*** (2013.01); ***H01L 51/0053*** (2013.01); ***H01L 51/0064*** (2013.01); ***H01L 51/0067*** (2013.01); ***H01L 51/5056*** (2013.01); ***H01L 51/5278*** (2013.01); *C07C 2603/10* (2017.05);
(Continued)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

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Primary Examiner — Jennifer A Chriss
Assistant Examiner — Sean M DeGuire
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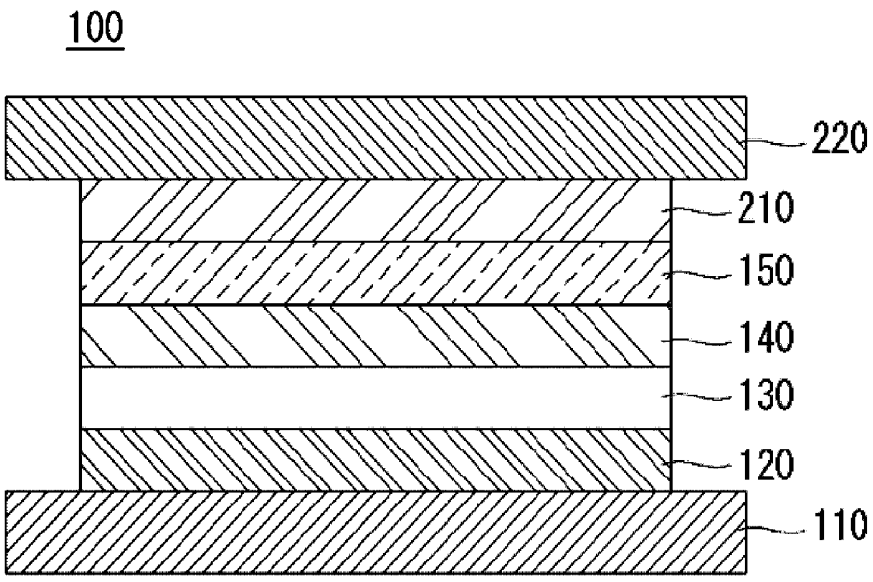
(57) **ABSTRACT**

An organic light emitting display device is provided. The organic light emitting display device may include at least one light emitting part between an anode and a cathode, and the at least one light emitting part having at least one organic layer and a light emitting layer, wherein the at least one organic layer comprises a compound represented by Chemical Formula 1 or 2.

12 Claims, 3 Drawing Sheets



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H01L 51/50	(2006.01)
C07C 255/47	(2006.01)
C07D 213/61	(2006.01)
C09K 11/06	(2006.01)

(52) **U.S. Cl.**

CPC *C09K 2211/1007* (2013.01); *C09K 2211/1011* (2013.01); *C09K 2211/1029* (2013.01); *H01L 51/5012* (2013.01); *H01L 51/5088* (2013.01); *H01L 51/5206* (2013.01); *H01L 51/5221* (2013.01)

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FIG. 1

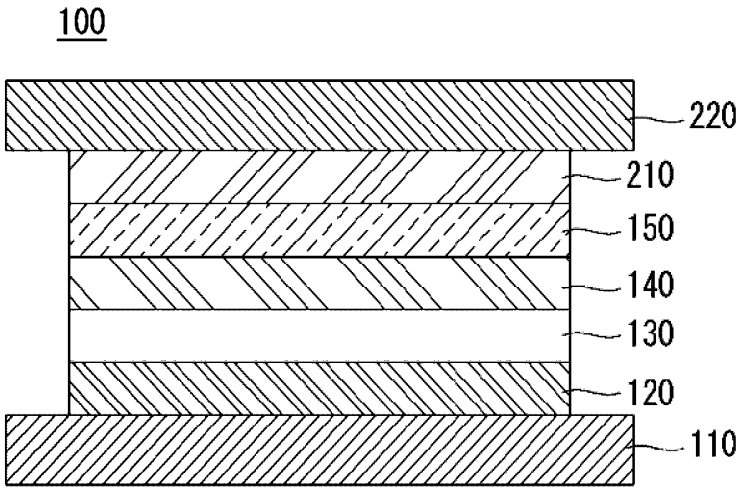
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FIG. 2

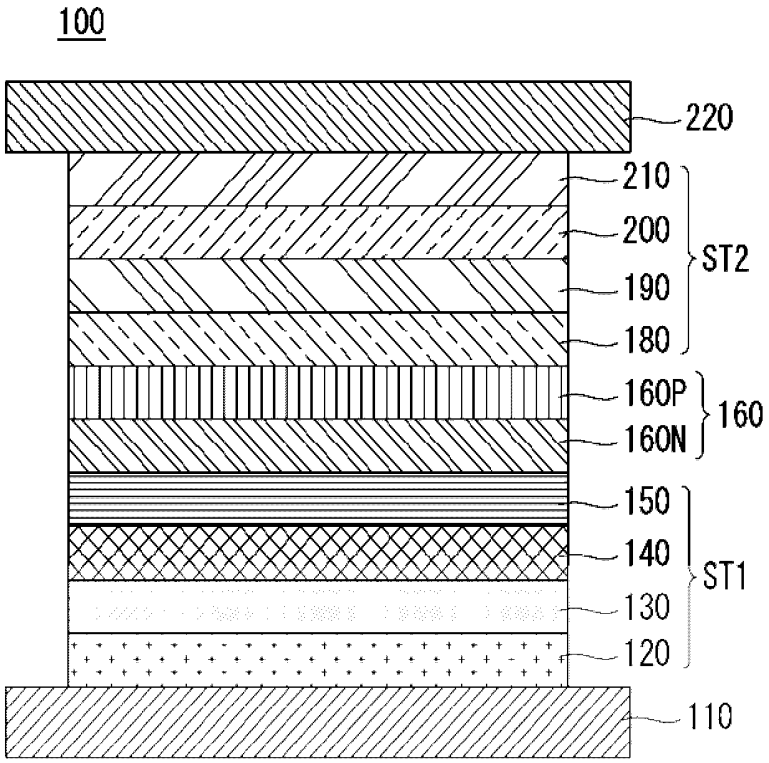
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FIG. 3

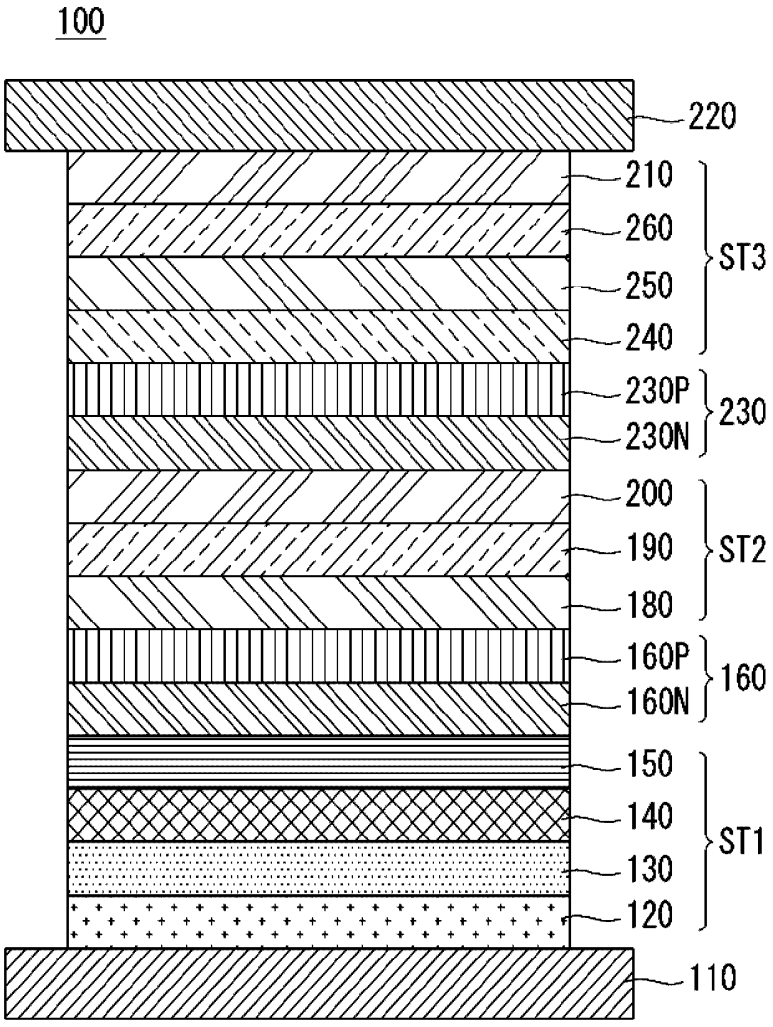
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FIG. 4

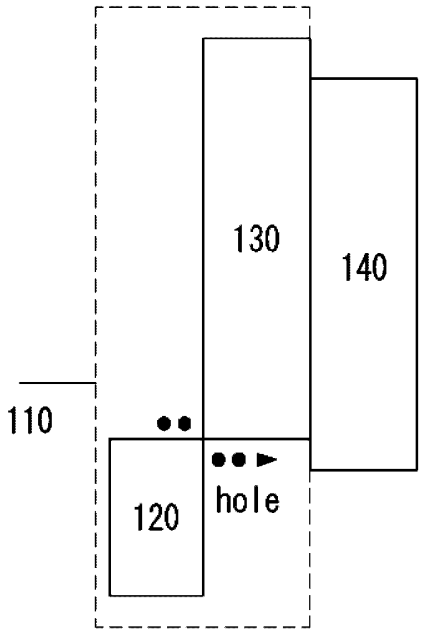
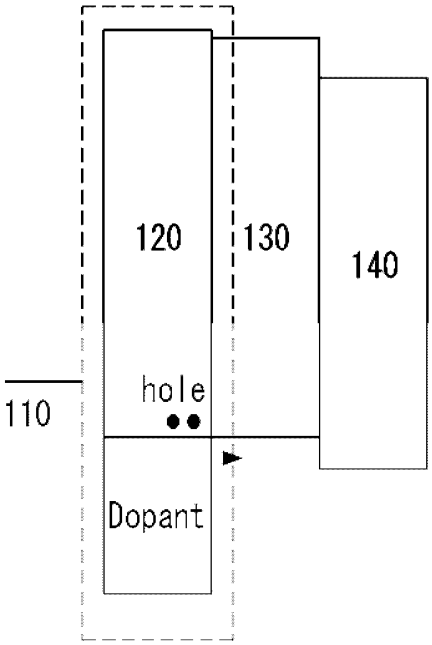


FIG. 5



ORGANIC LIGHT EMITTING DISPLAY DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the priority benefit of Korean Patent Application Nos. 10-2015-0171452 filed on Dec. 3, 2015, and 10-2016-0057107 filed on May 10, 2016, which are all incorporated herein by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE DISCLOSURE

Field of the Disclosure

The present disclosure relates to an organic light emitting display device, and more particularly, to an organic light emitting display device with reduced operating voltage and improved efficiency.

Discussion of the Related Art

Image displays used for displaying a variety of information on the screen are one of the core technologies of the information and communication era. Such image displays have been developed to be thinner, lighter, more portable, and to have high performance. With the development of the information society, various demands for display devices are on the rise. To meet these demands, research on panel displays such as liquid crystal displays (LCD), plasma display panels (PDP), electroluminescent displays (ELD), field emission displays (FED), organic light emitting diodes (OLED), etc. is actively under way.

Among these types of displays, the organic light emitting display devices are a type of devices that, when the charges are injected into an organic emissive layer formed between an anode and a cathode, the emission of light due to the formation of electron-hole pairs takes place and extinguishes. The organic light emitting display devices are advantageous in that they can be fabricated on a flexible transparent substrate such as plastic substrate, can be operated at a relatively low voltage, have less power consumption, and deliver vivid color reproduction, as compared with the plasma display panels or the inorganic light emitting displays. Particularly, the white OLED devices are used for various purposes in lighting, thin light sources, backlights for liquid crystal displays, or full-color displays employing color filters.

An organic light emitting display device has a lamination structure of an anode, a hole injection layer, a hole transport layer, an light emitting layer, an electron transport layer, an electron injection layer, and a cathode, and the hole injection layer and the electron injection layer are used to facilitate charge injection. A P-type hole injection layer, which is a type of hole injection layer, is involved in the generation, injection, and transport of holes. The P-type hole injection layer is a layer formed of a single P-type material, or includes a host and a P-type material therein. The host serves to inject holes from the anode into the light emitting layer through the HOMO (highest occupied molecular orbital) energy level, and is a material commonly used as the hole injection layer. The P-type dopant is a material that has a strong electron-attracting substituent and attracts electrons from the LUMO (lowest unoccupied molecular orbital) energy level of the hole transport layer adjacent to the P-type hole injection layer to the HOMO energy level of the P-type dopant. The P-type hole injection layer with a strong electron-attracting substituent forms a hole transport path by accepting electrons from the HOMO energy level of the host

or the HOMO energy level of the hole injection layer or hole transport layer to the LUMO energy level of the P-type hole injection layer. After all, the LUMO energy level of the P-type hole injection layer and the HOMO energy level of the hole transport layer adjacent to the P-type hole injection layer or the host may be similar in energy level to enable efficient hole generation, so P-type hole injecting materials having a strong electron-attracting substituent are needed.

However, the P-type hole injecting materials are not easy to synthesize due to their strong electron-attracting substituent, and have problems with thermal stability and deposition stability. Particularly, F_4-TCNQ, one of the P-type hole injecting materials, sublimes easily, which affects the contamination of deposition sources, the performance reproducibility and thermal stability of devices during device fabrication. Moreover, it is not easy to develop P-type hole injecting materials whose LUMO energy level is similar to the HOMO energy level of the host or the HOMO energy level of the hole transport layer. In order to make the LUMO energy level similar to the HOMO energy level, it is necessary to introduce a strong electron-attracting substituent into the P-type hole injecting material. However, the stronger the electron-attracting substituent is, the harder it is to improve the purity of the material, making the synthesis of the material difficult. Besides, it is necessary that the strong electron-attracting substituent does not absorb visible light, which makes the development of P-type hole injecting materials difficult.

SUMMARY OF THE DISCLOSURE

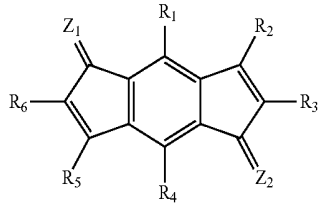
Accordingly, the present disclosure is directed to an organic light emitting display device that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present disclosure is to provide an organic light emitting display device with reduced operating voltage and improved efficiency.

Additional features and advantages of the disclosure will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the disclosure. The objectives and other advantages of the disclosure will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the disclosure, as embodied and broadly described, an organic light emitting display device comprises at least one light emitting part between an anode and a cathode, and the at least one light emitting part having at least one organic layer and a light emitting layer, wherein the at least one organic layer comprises a compound represented by the following Chemical Formula 1 or 2:

[Chemical Formula 1]



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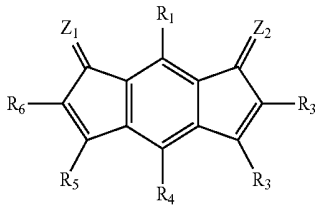
[Chemical Formula 2]



where R_1 to R_6 each independently represents one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group, and at least one among R_1 to R_6 comprises a cyano group, and

Z_1 and Z_2 are independently represented by the following Chemical Formula 3:

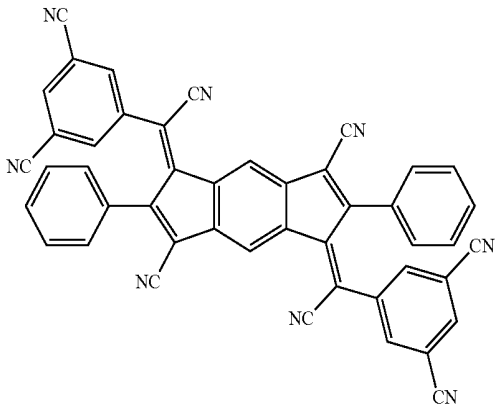
[Chemical Formula 3]

where A and B are independently represented by one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

The substituent of the aryl group, heteroaryl group, alkyl group, alkoxy group, and ether group is one among an alkyl with 1 to 12 carbon atoms, an aryl with 6 to 15 carbon atoms, a hetero alkyl with 1 to 15 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

The compound represented by Chemical Formula 1 is represented by one among the following compounds:

A01



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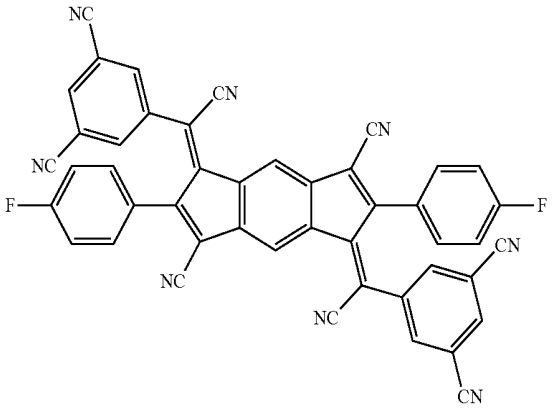

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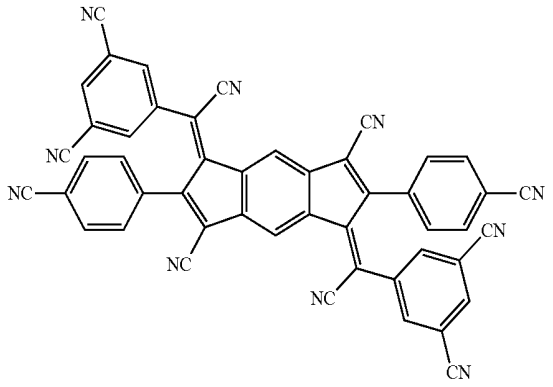

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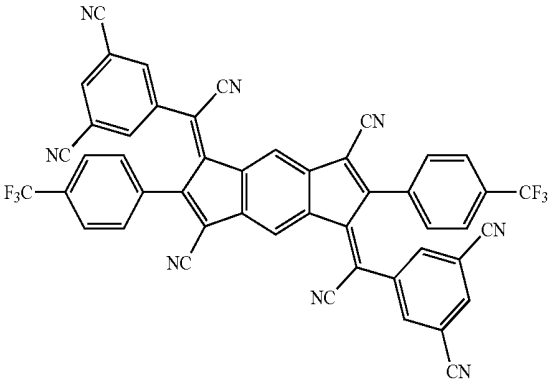

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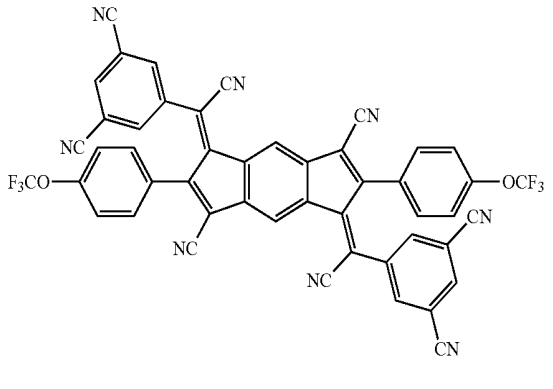

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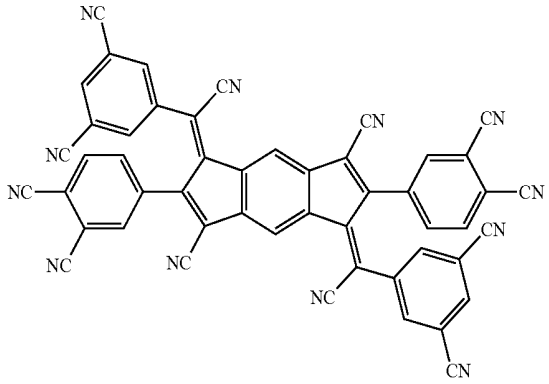

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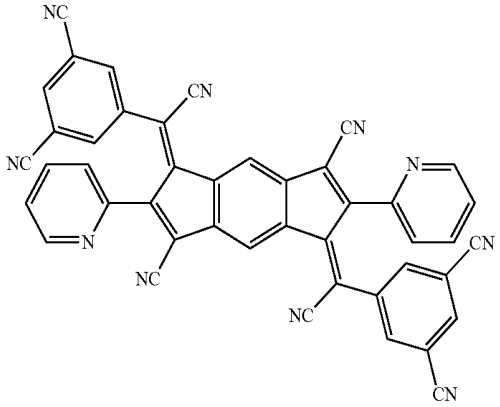

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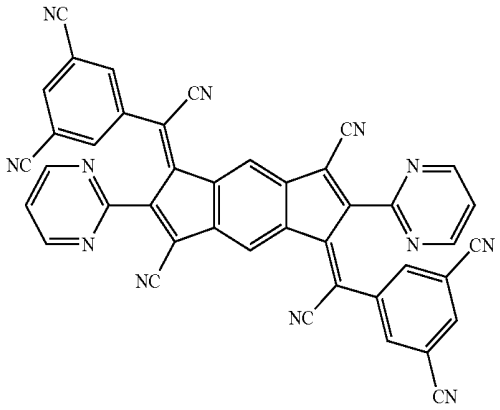

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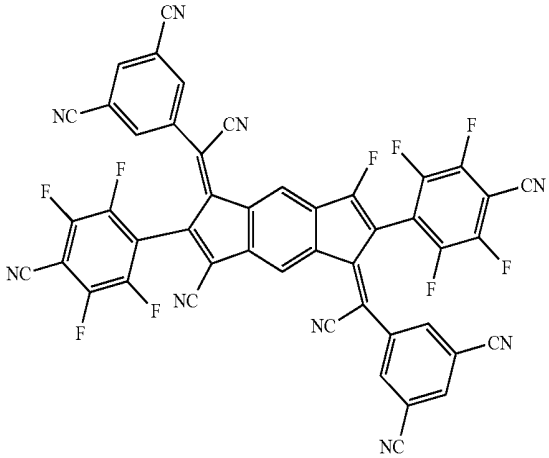

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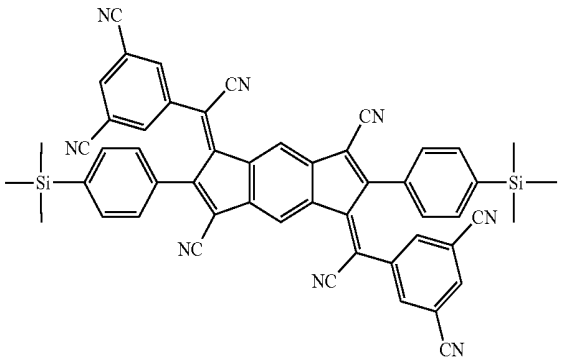

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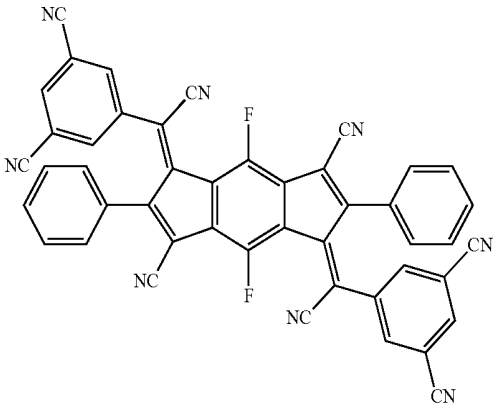

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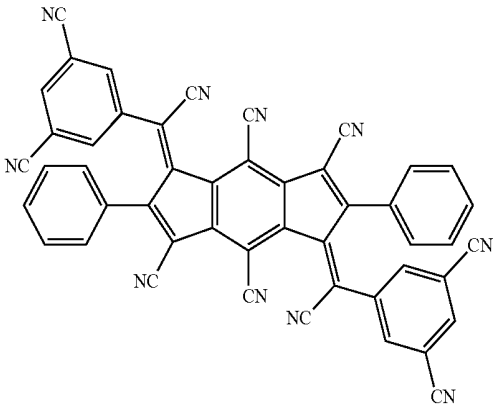

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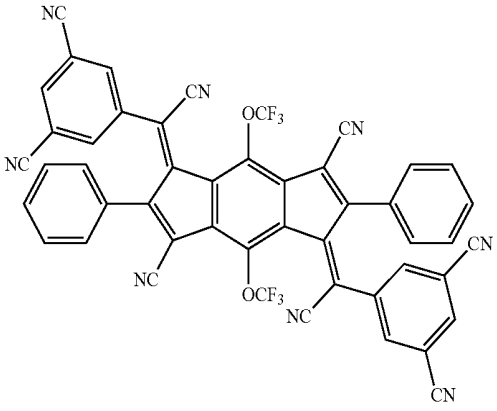

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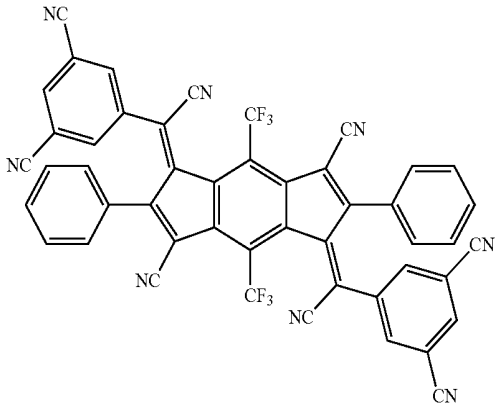

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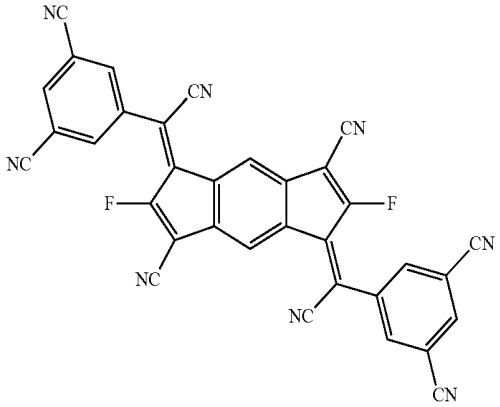

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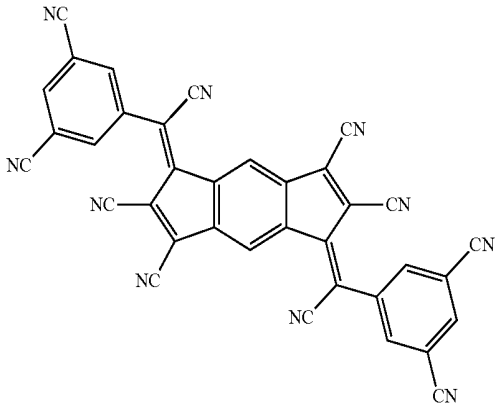

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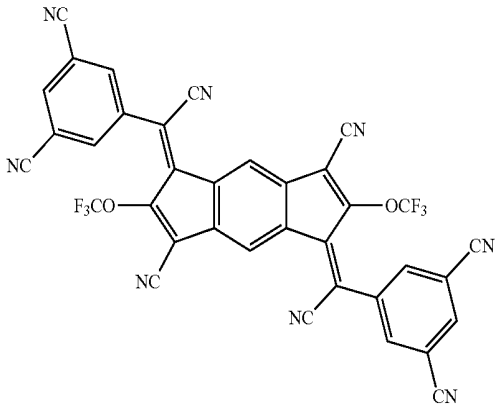

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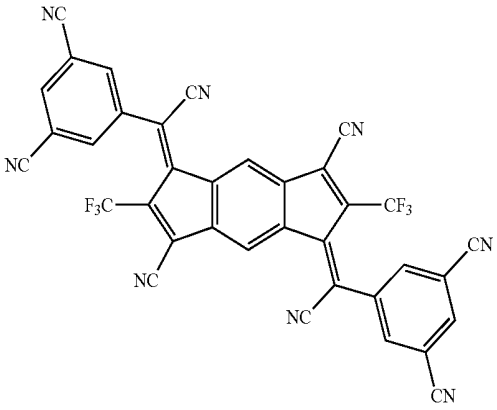

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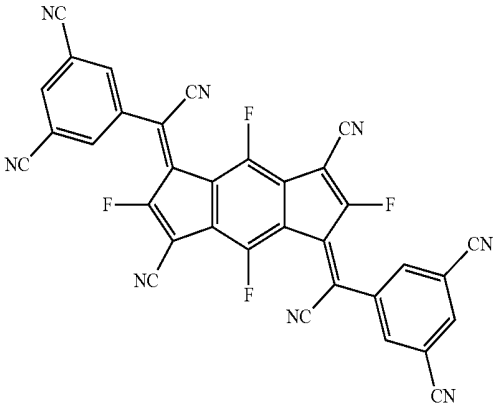

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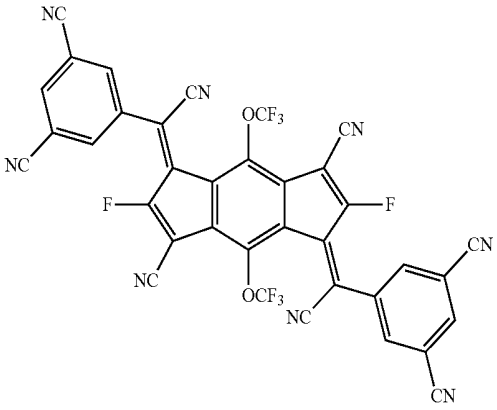

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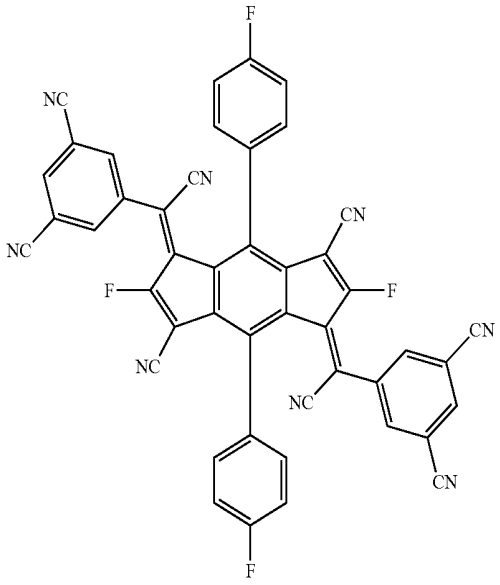

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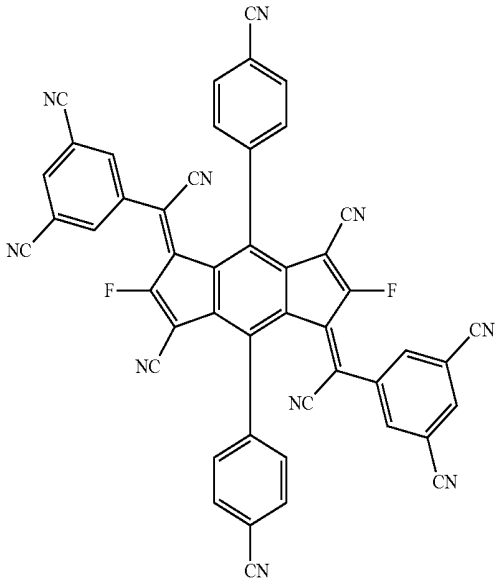

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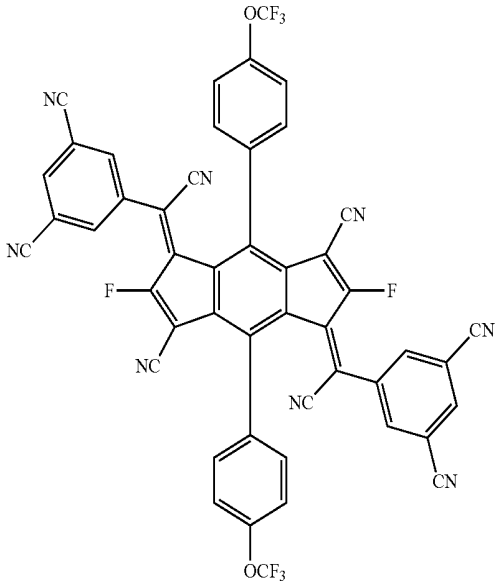

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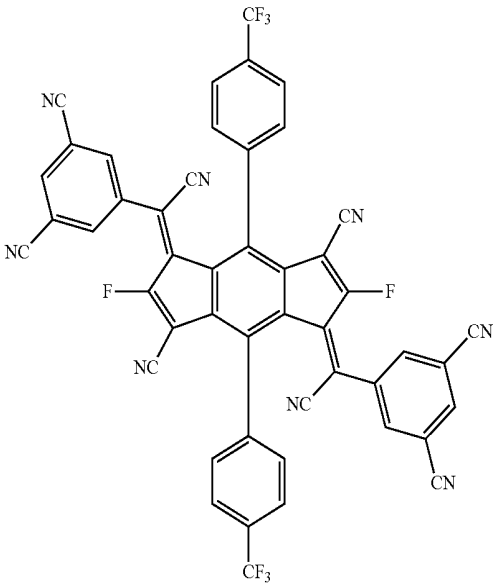

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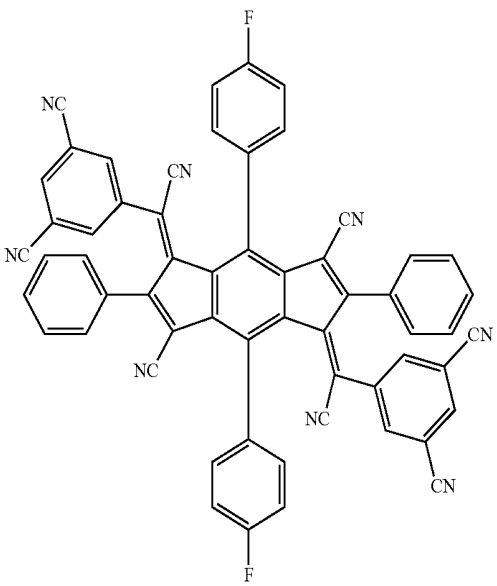

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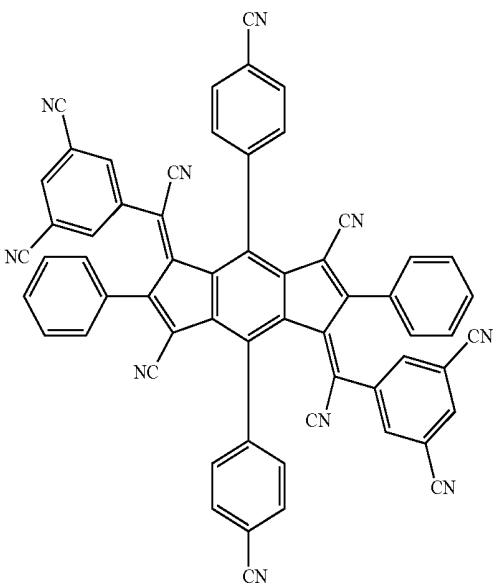

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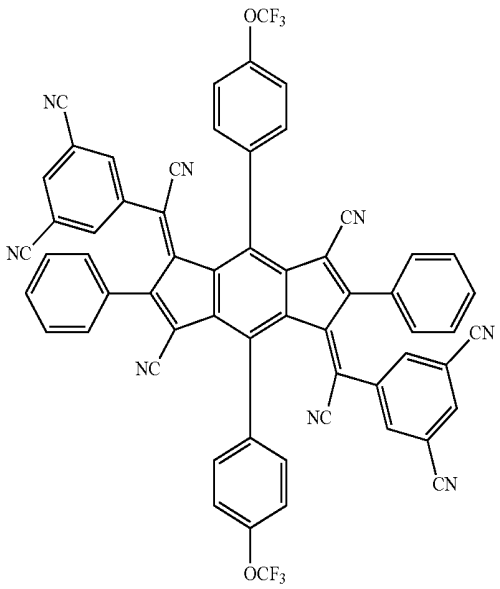

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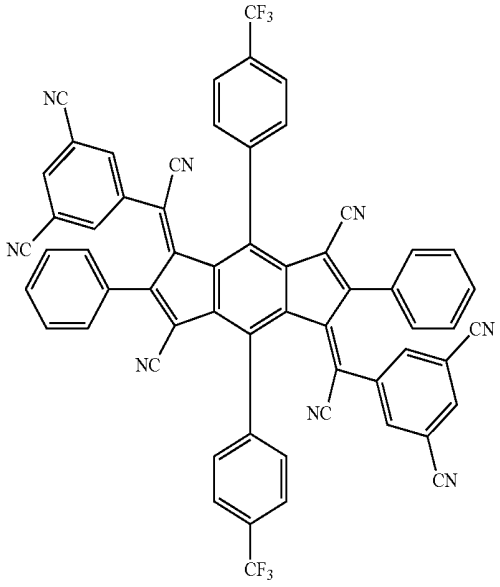

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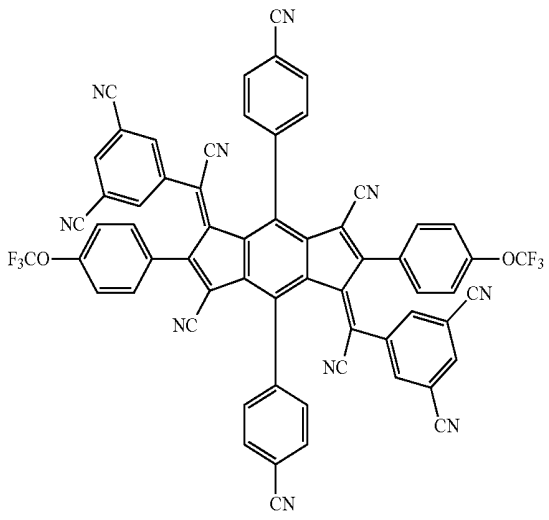

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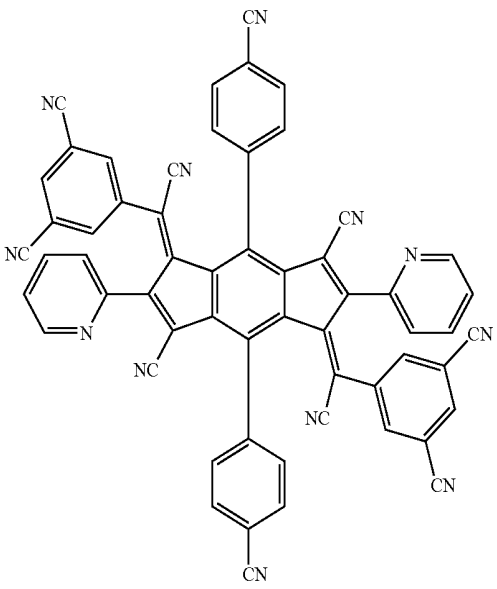

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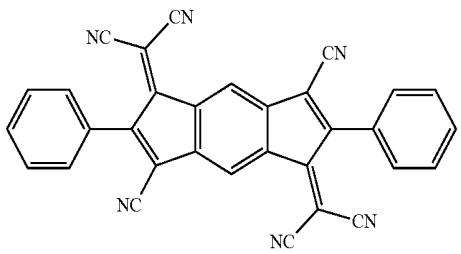

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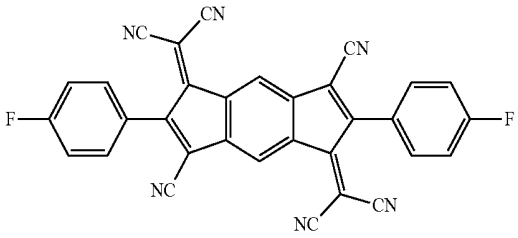

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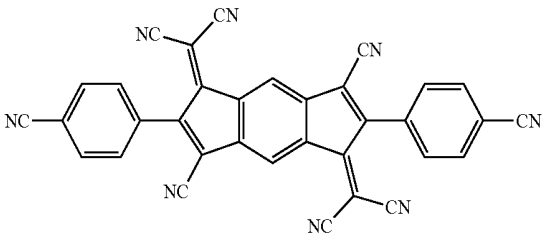

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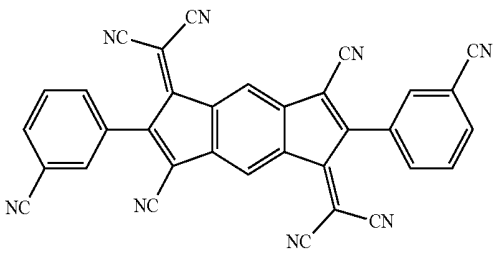

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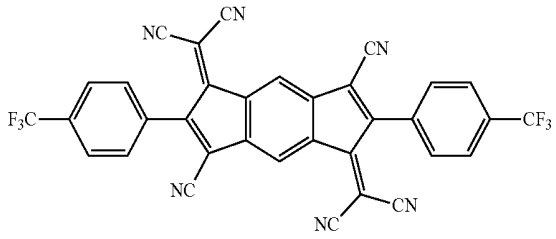

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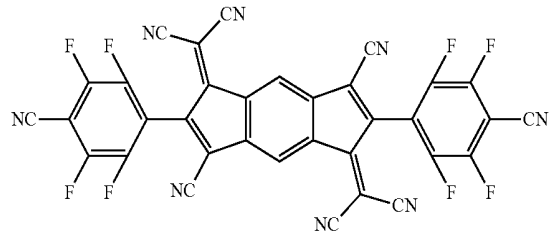

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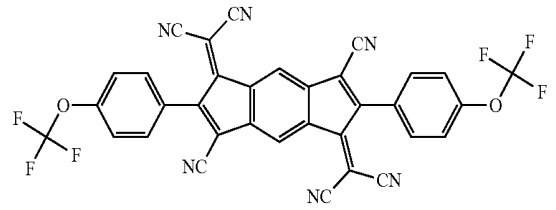

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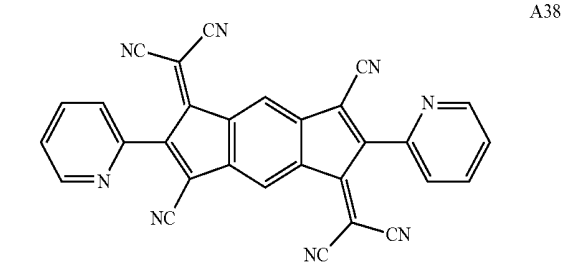

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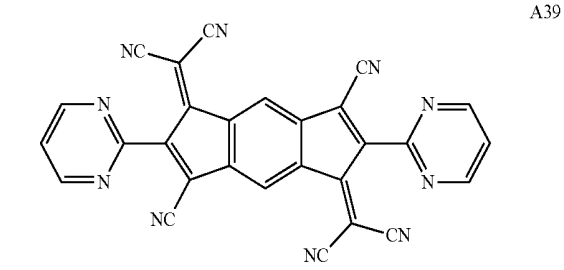

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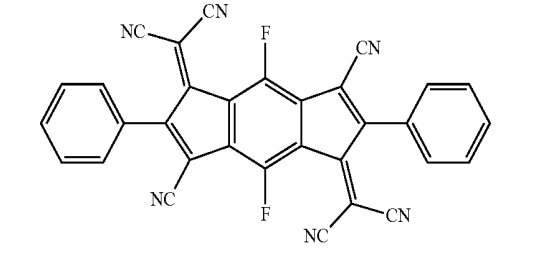

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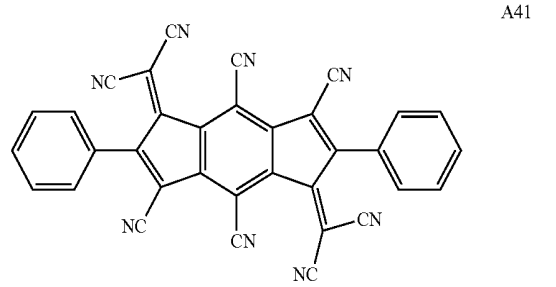

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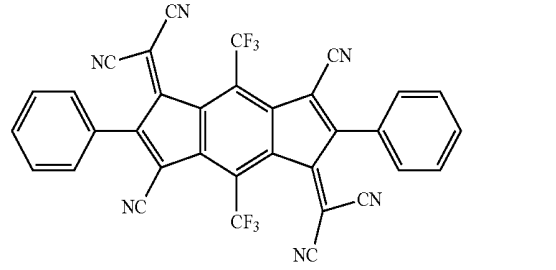

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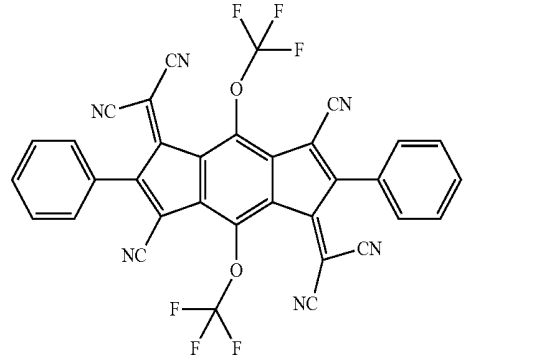

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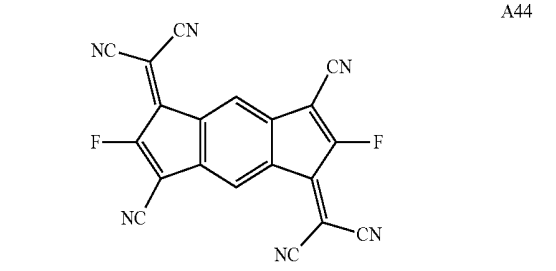

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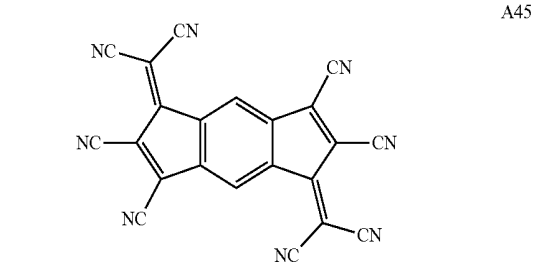

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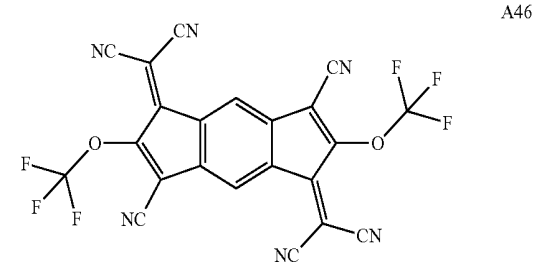

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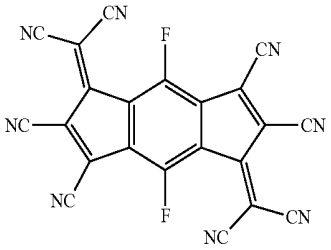

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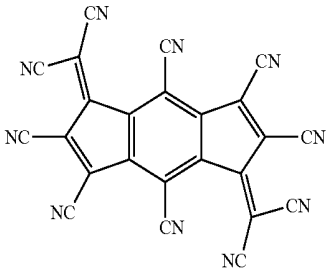

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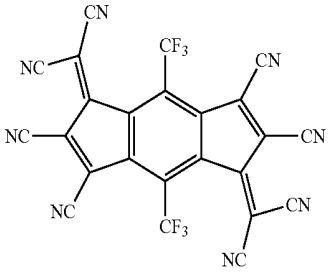

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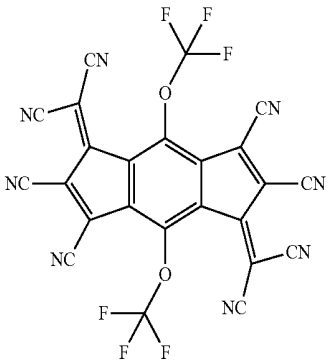

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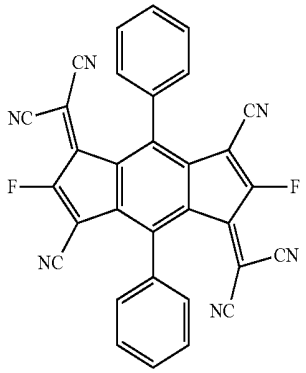

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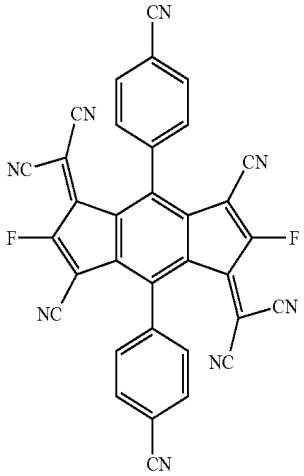

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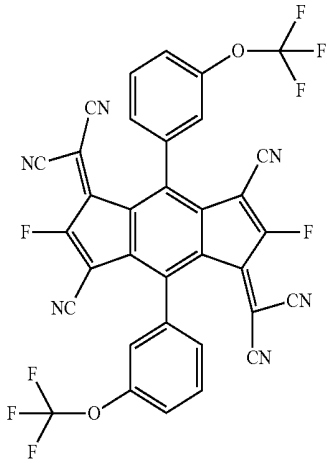

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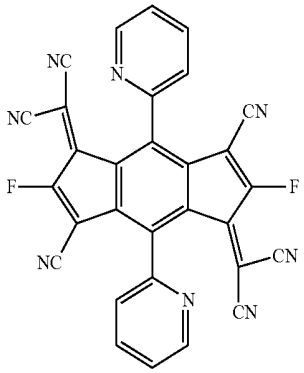

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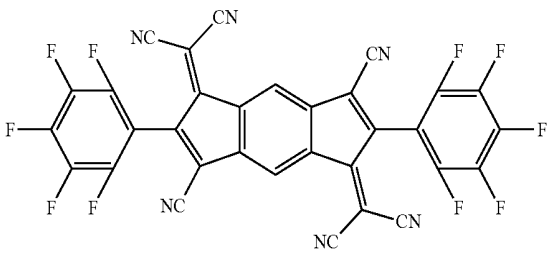

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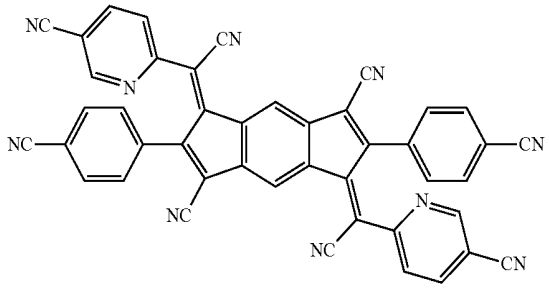

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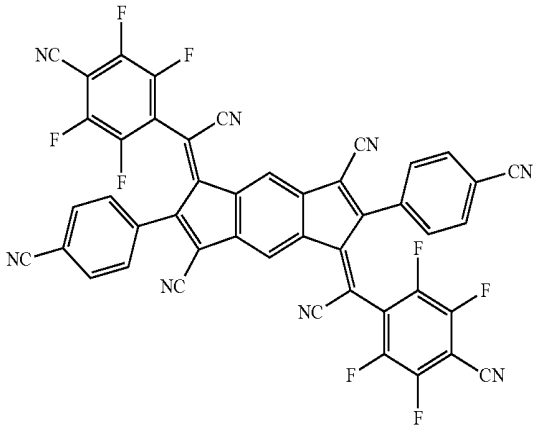

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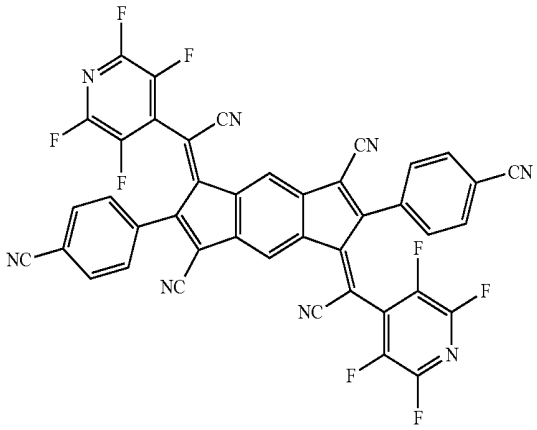

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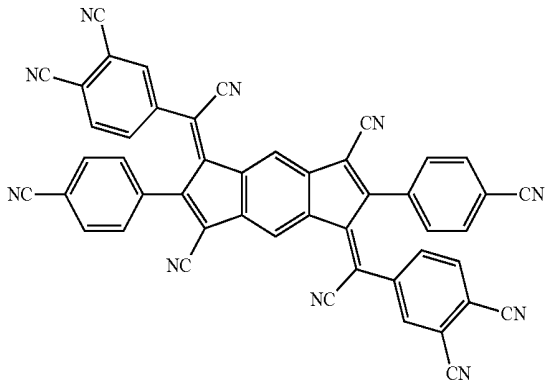

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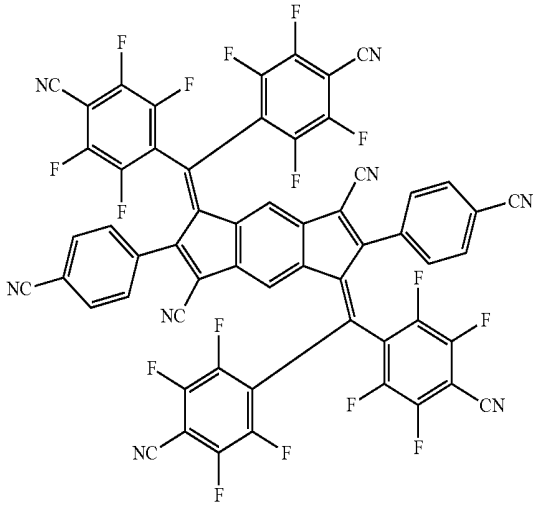

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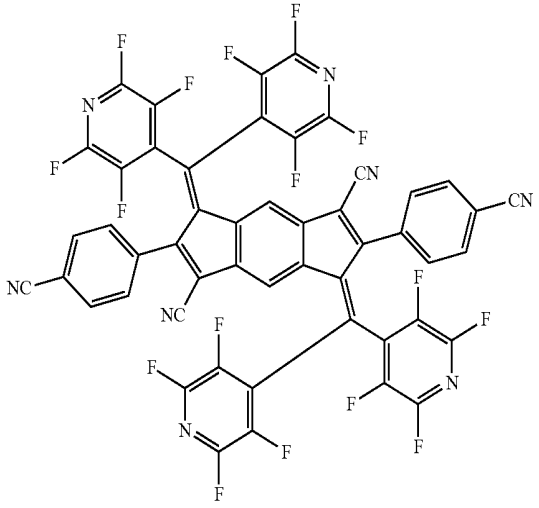

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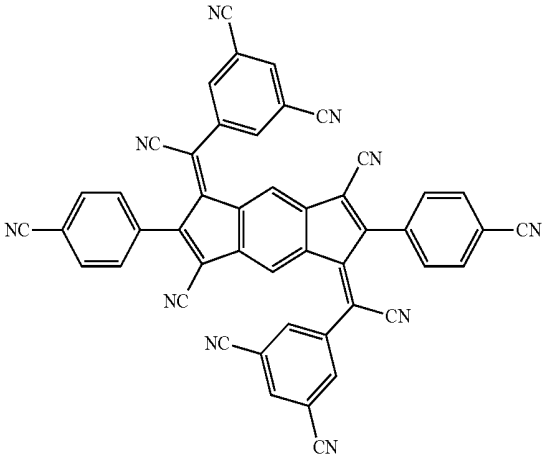

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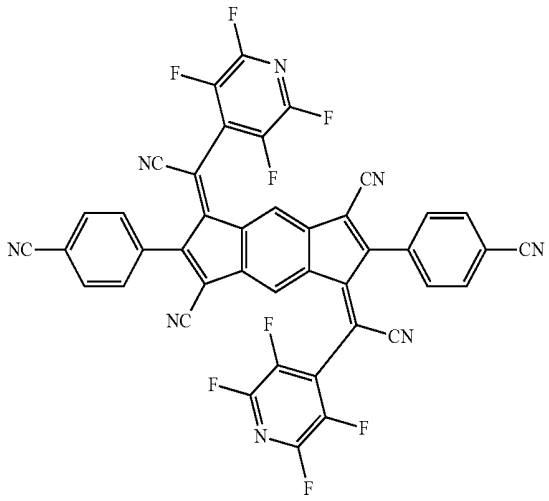

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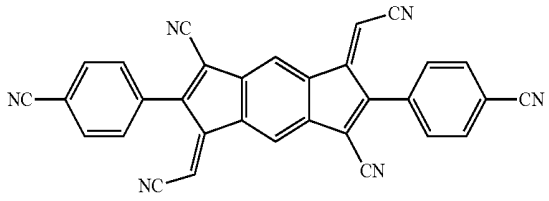

The compound represented by the above Chemical Formula 2 is represented by one among the following compounds:

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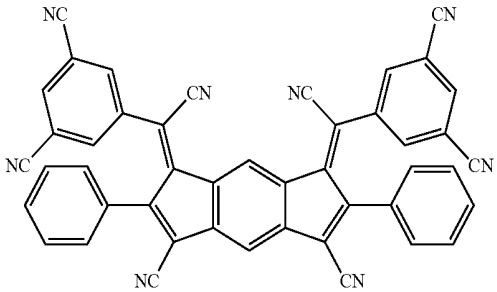

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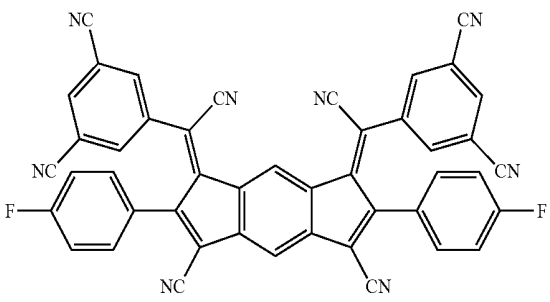

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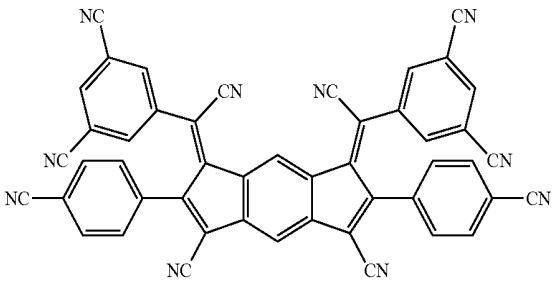

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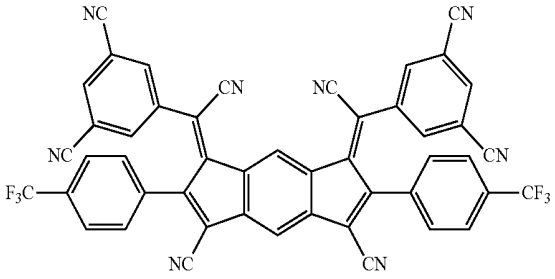

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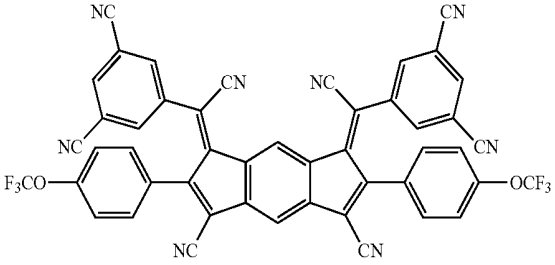

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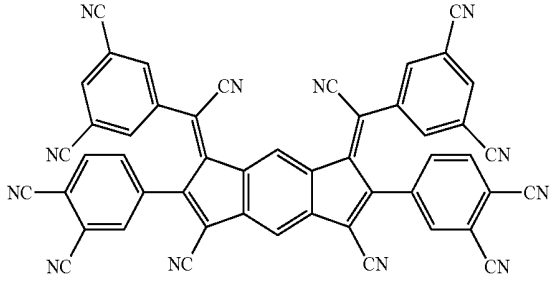

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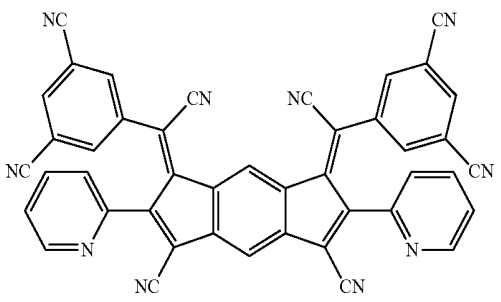

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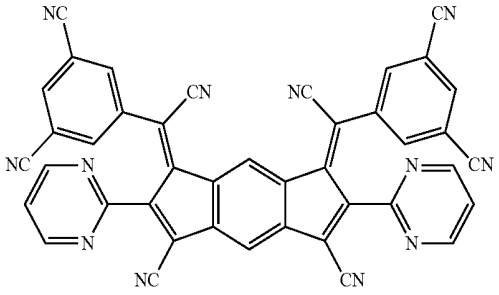

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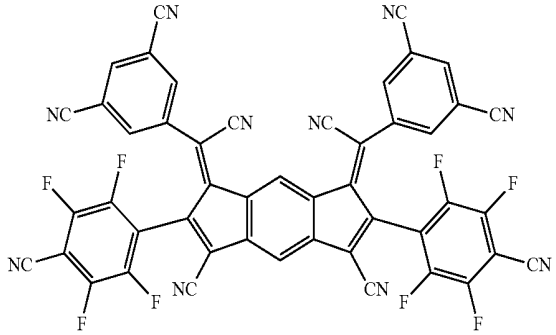

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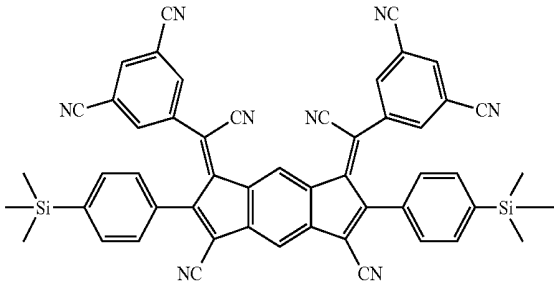

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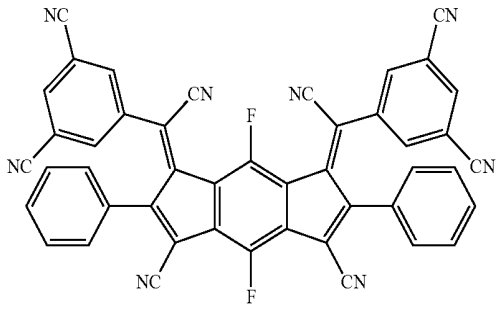

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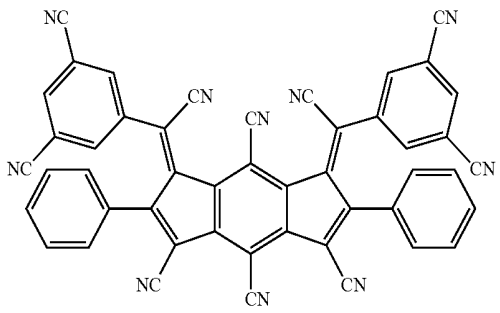

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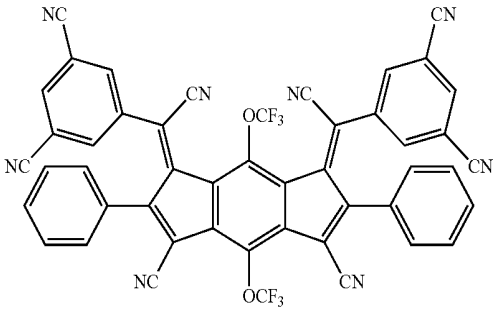

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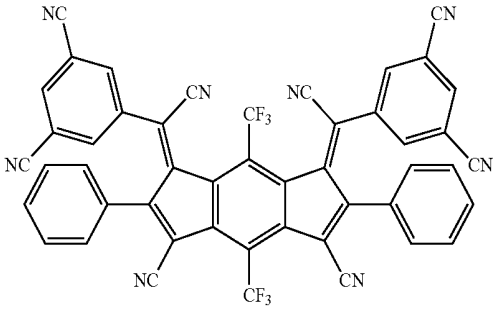

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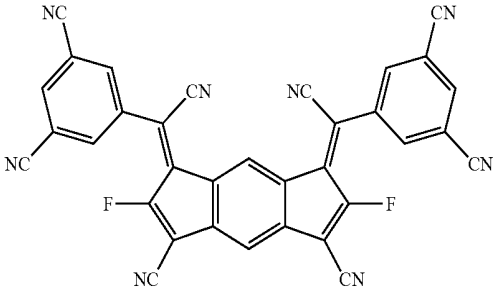

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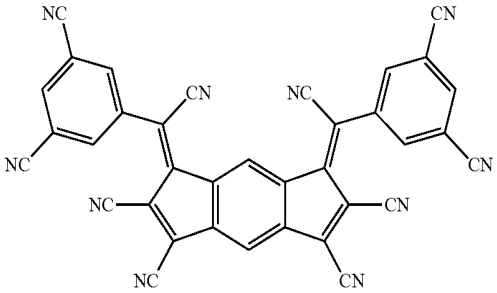

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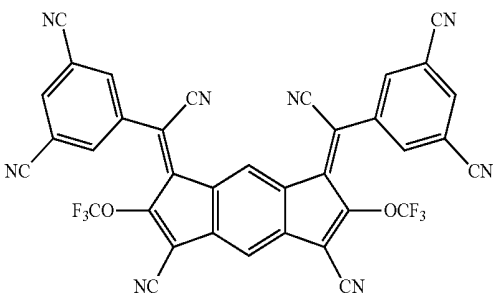

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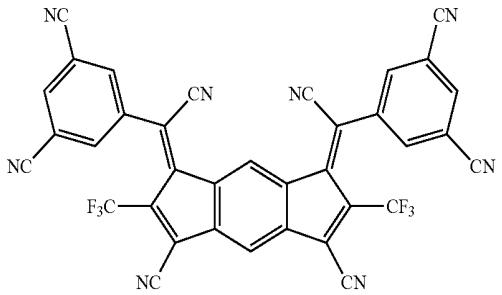

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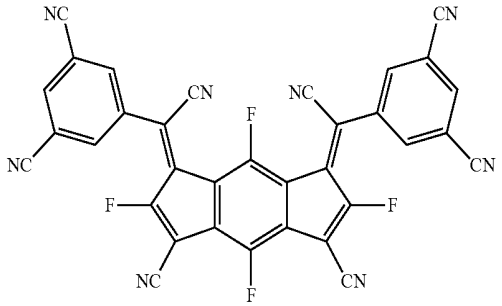

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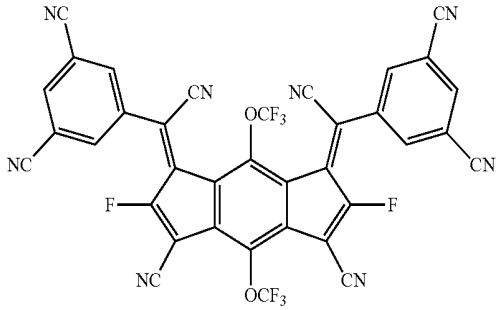

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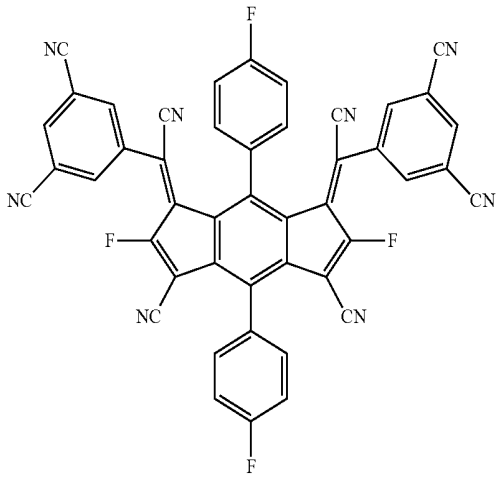

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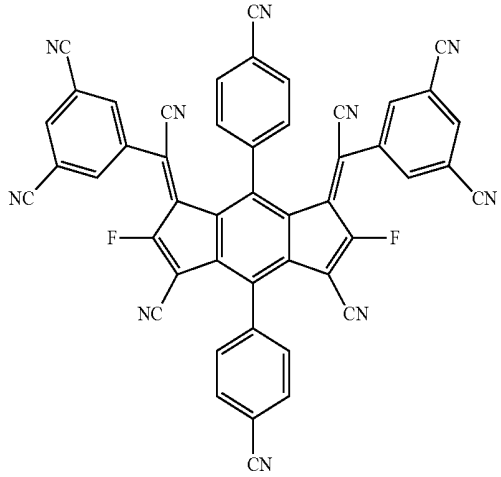

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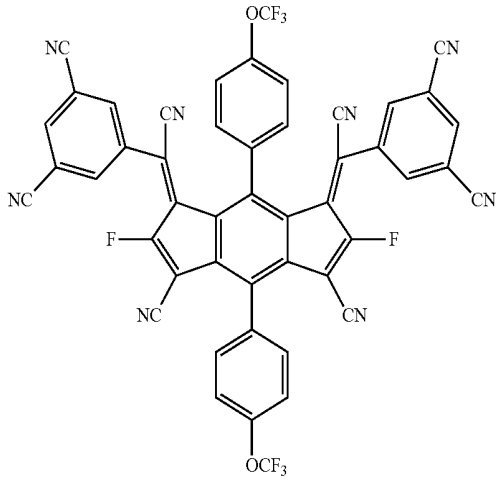

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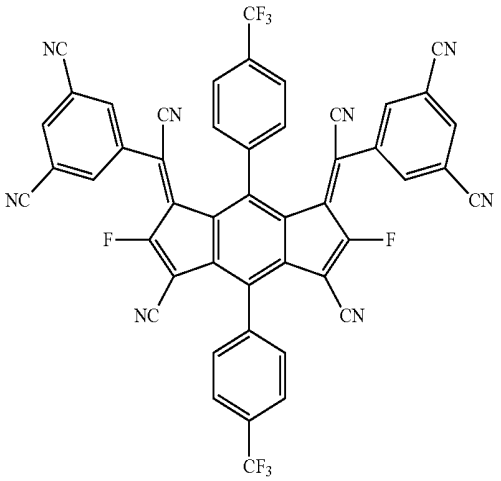

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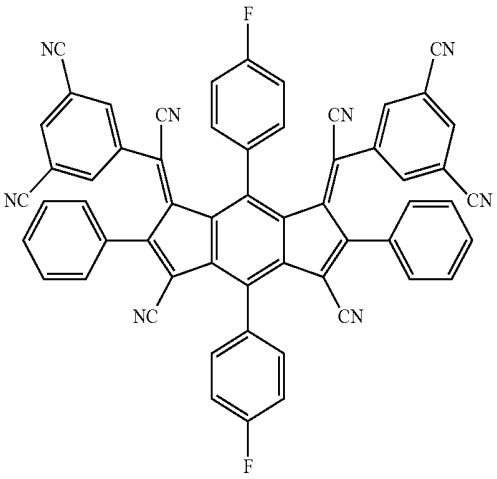

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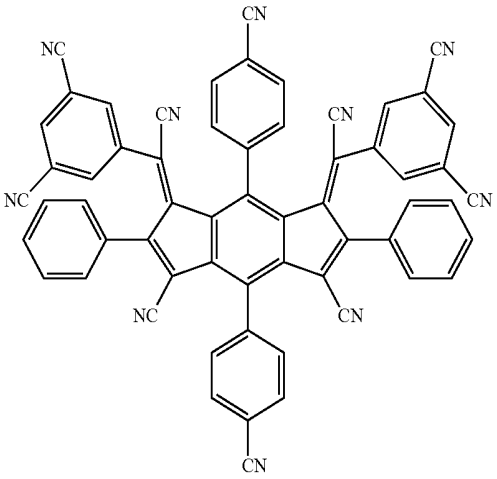

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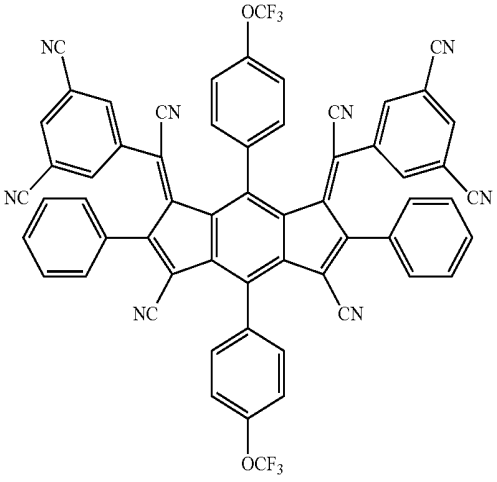

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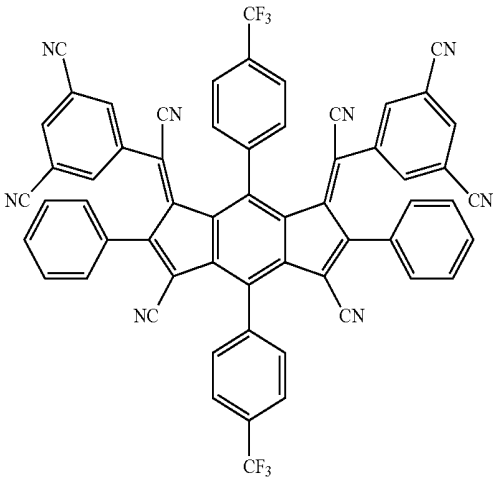

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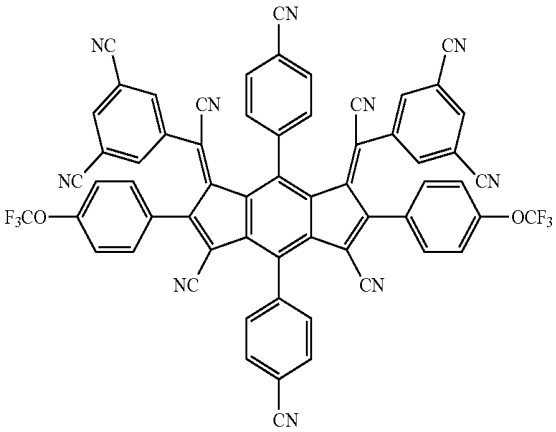

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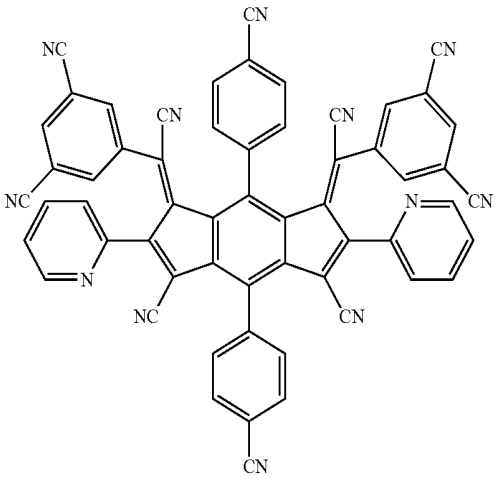

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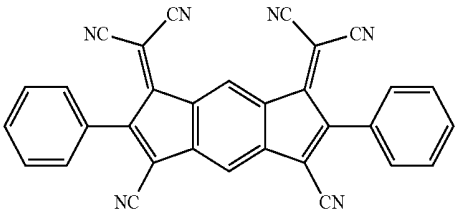

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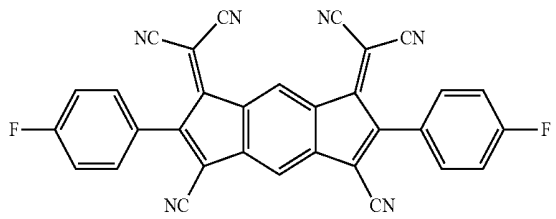

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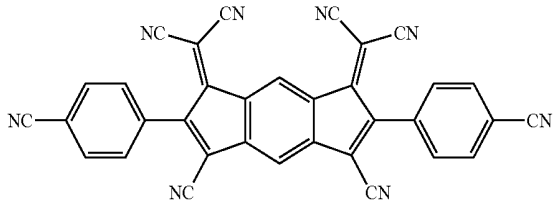

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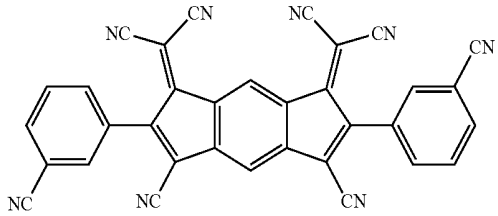

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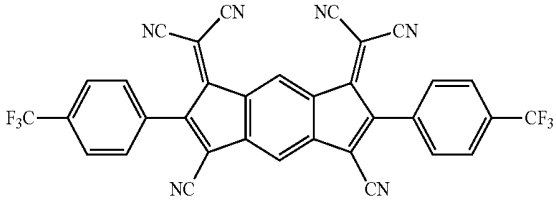

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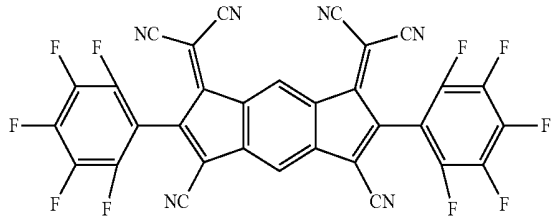

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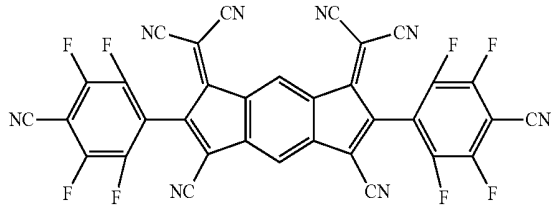

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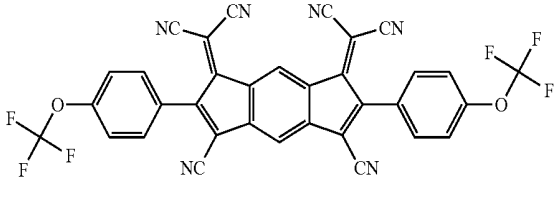

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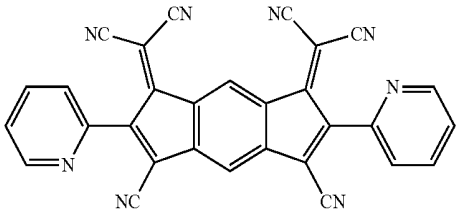

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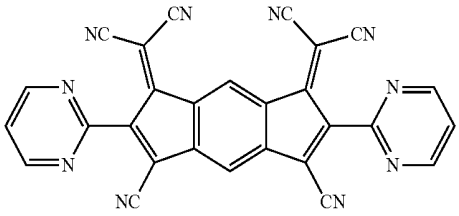

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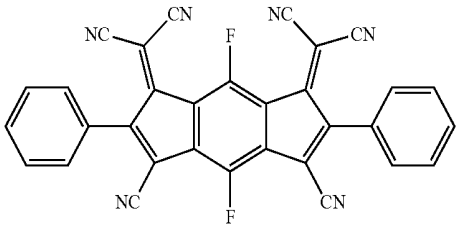

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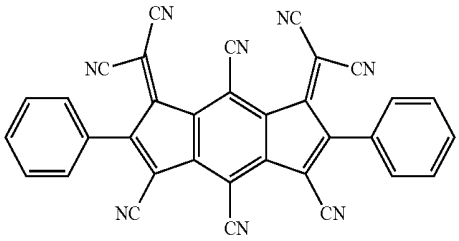

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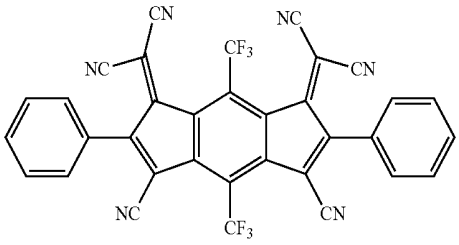

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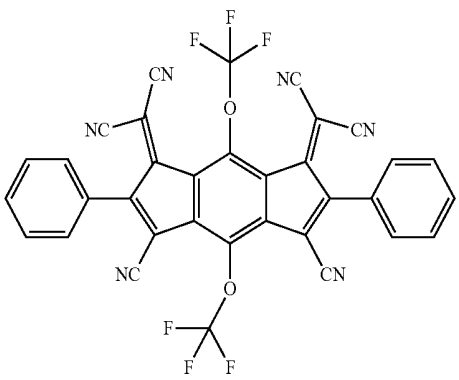

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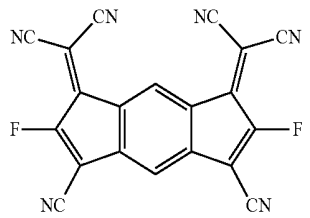

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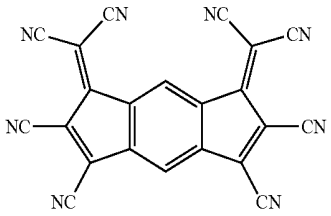

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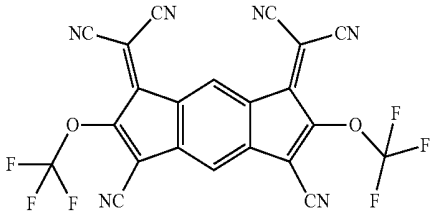

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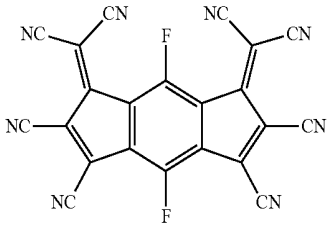

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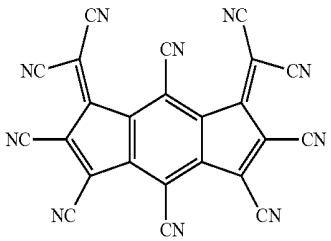

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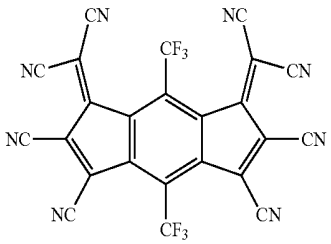

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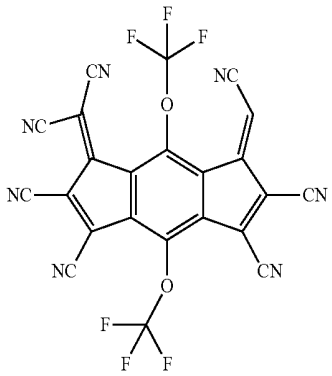

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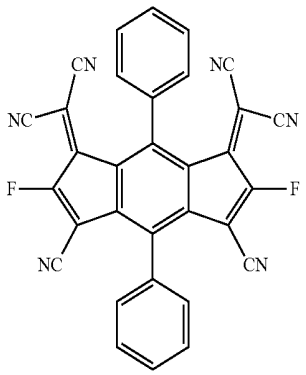

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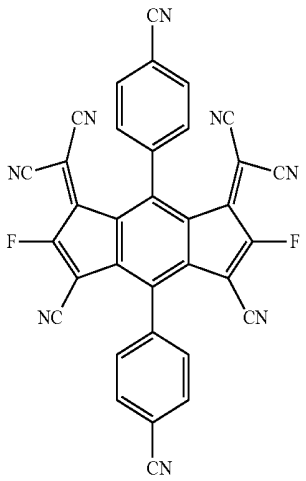

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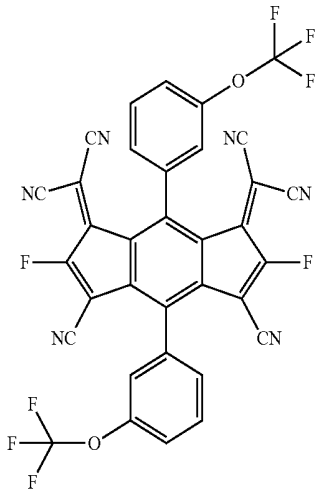

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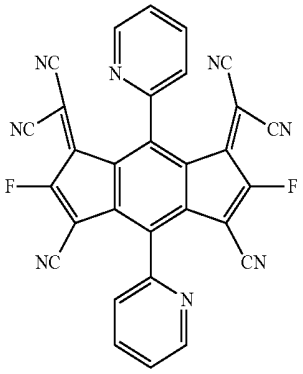

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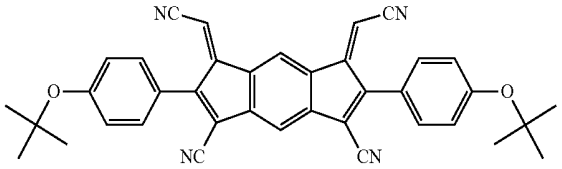


The at least one organic layer includes a hole injection layer.

A dopant of the hole injection layer includes the compound.

The hole injection layer includes the compound.

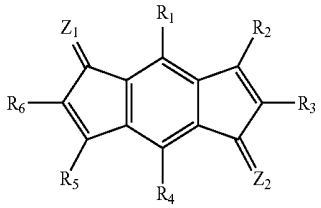
The at least one organic layer includes a P-type charge generation layer.

A dopant of the P-type charge generation layer includes the compound.

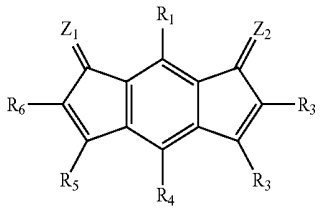
The P-type charge generation layer includes the compound.

In another aspect, an organic light emitting display device comprises at least one light emitting part between an anode and a cathode, and the at least one light emitting part having a hole injection layer and a light emitting layer, and a charge generation layer having a P-type charge generation layer between the at least one light emitting parts, wherein at least one among the hole injection layer and the P-type charge generation layer comprises a compound represented by the following Chemical Formula 1 or 2:

[Chemical Formula 1]



[Chemical Formula 2]



where R_1 to R_6 each independently represents one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group, and at least one among R_1 to R_6 comprises a cyano group, and

Z_1 and Z_2 are independently represented by the following Chemical Formula 3:

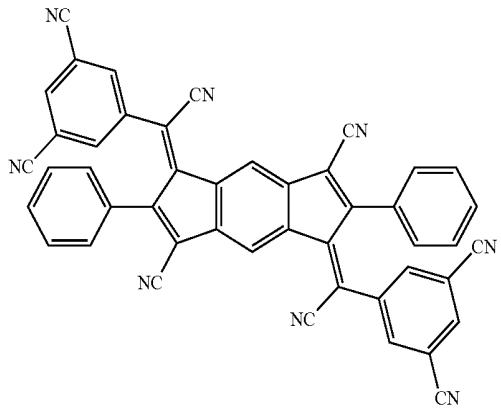
[Chemical Formula 3]

where A and B independently represent one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

The substituent of the aryl group, heteroaryl group, alkyl group, alkoxy group, and ether group is one among an alkyl with 1 to 12 carbon atoms, an aryl with 6 to 15 carbon atoms, a hetero alkyl with 1 to 15 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

The compound represented by Chemical Formula 1 is represented by one among the following compounds:

A01



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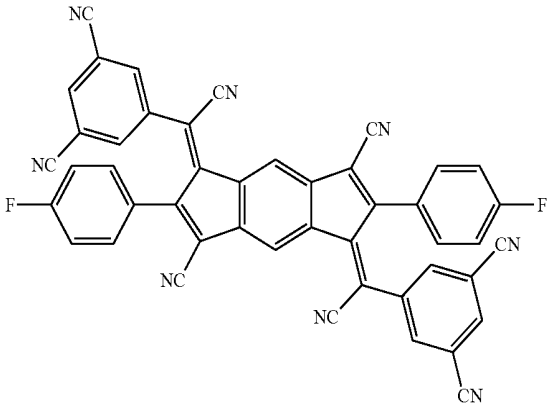

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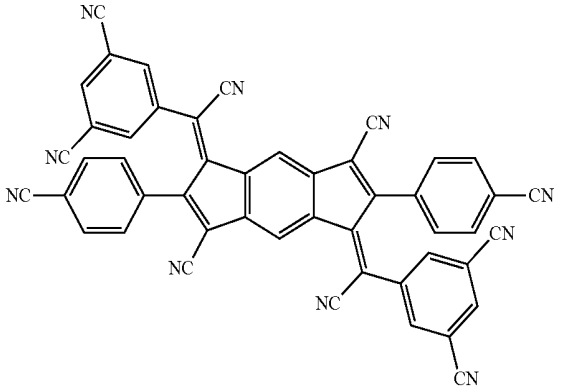

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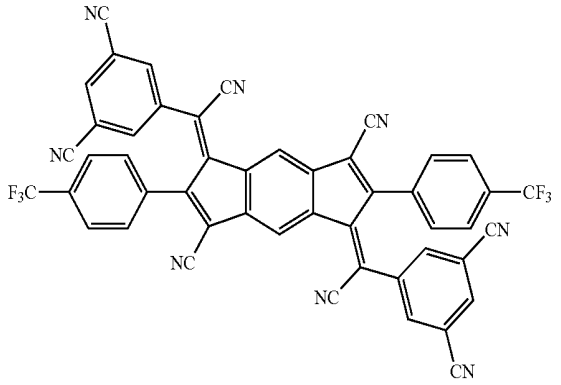

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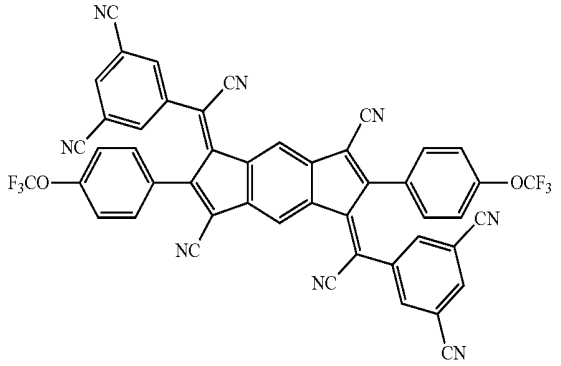

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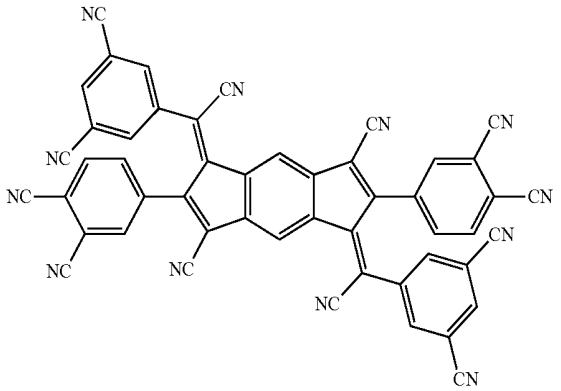

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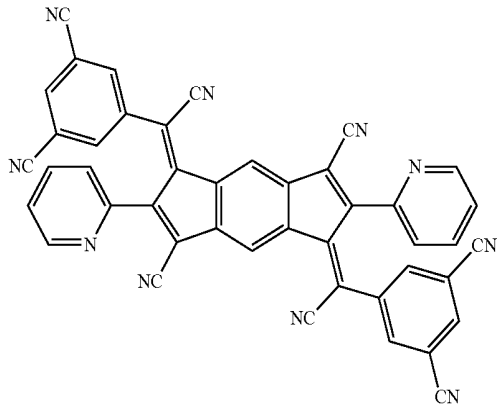

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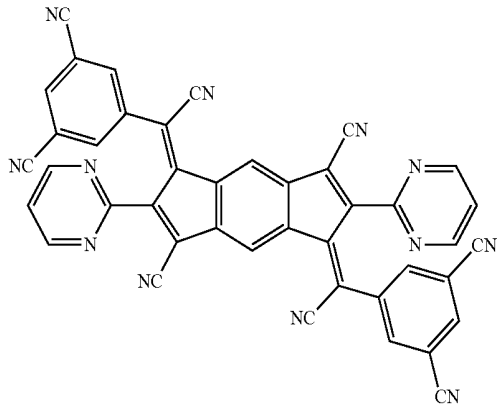

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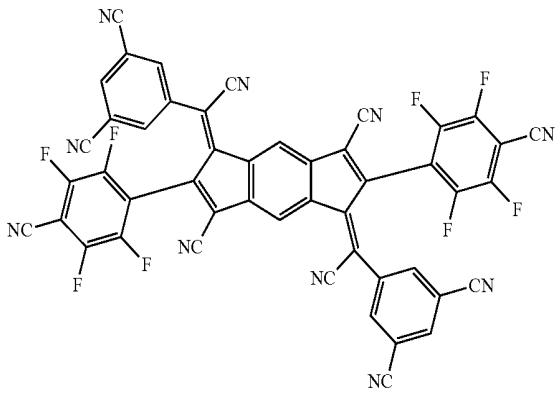

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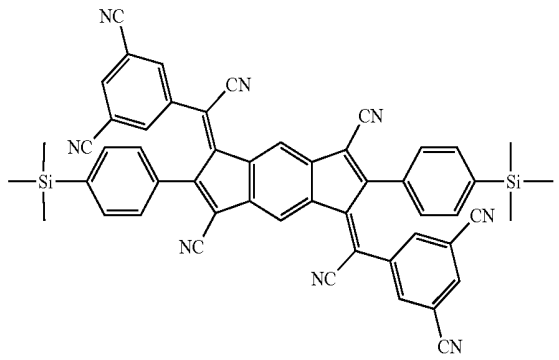

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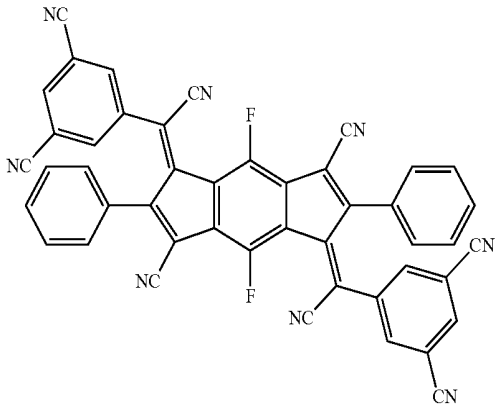

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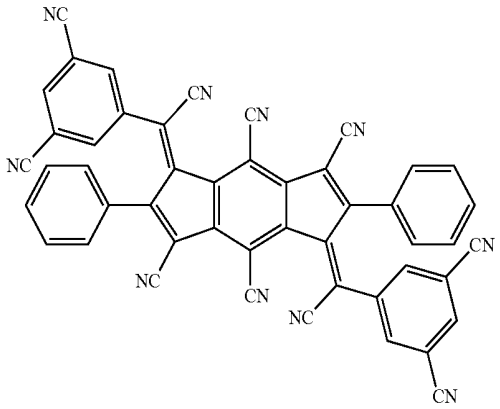

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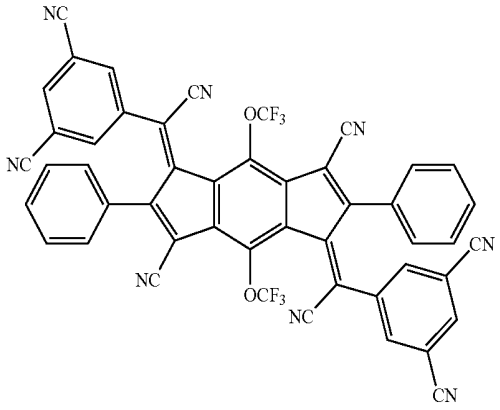

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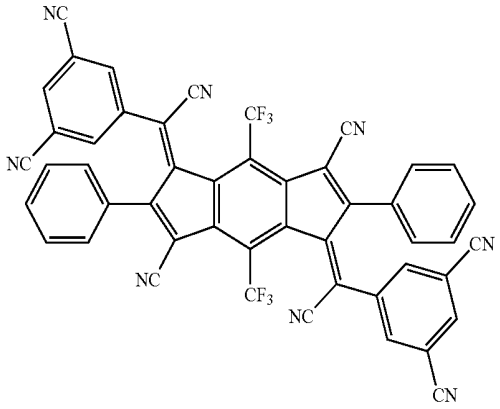

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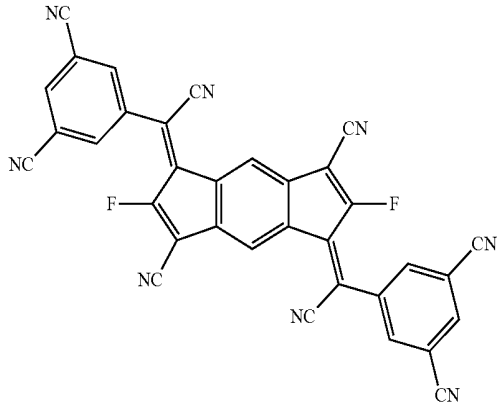

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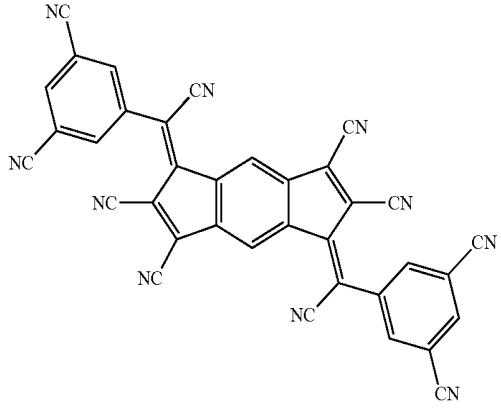

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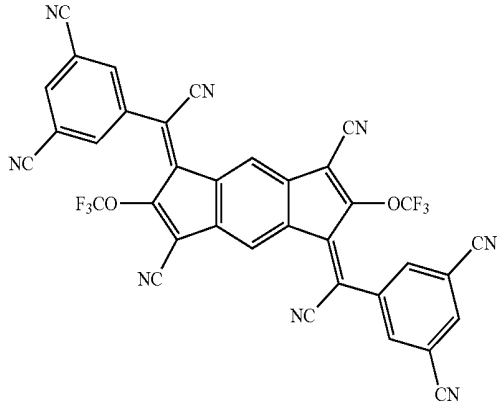

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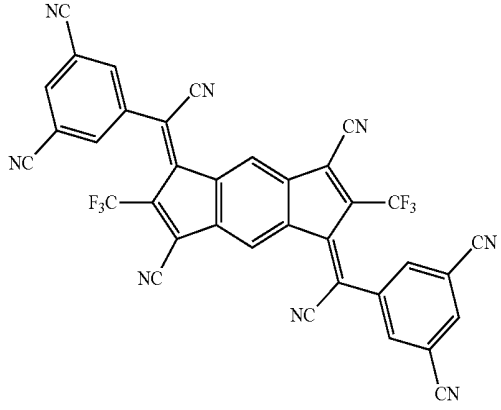

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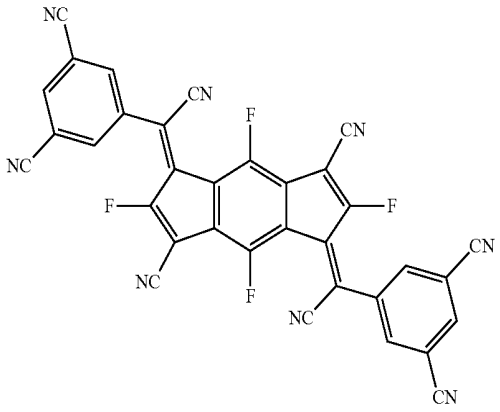
A19



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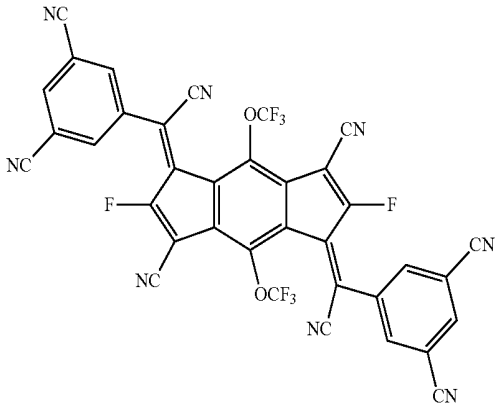

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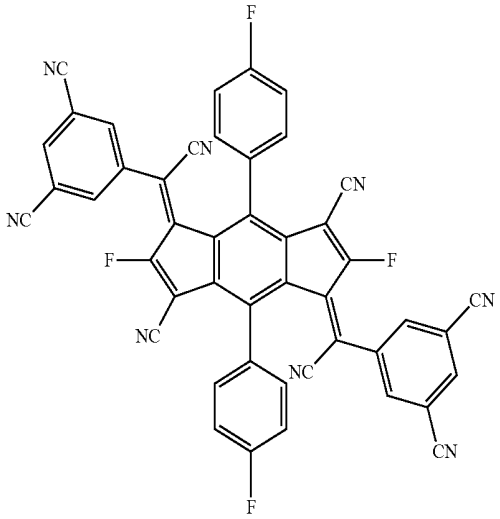

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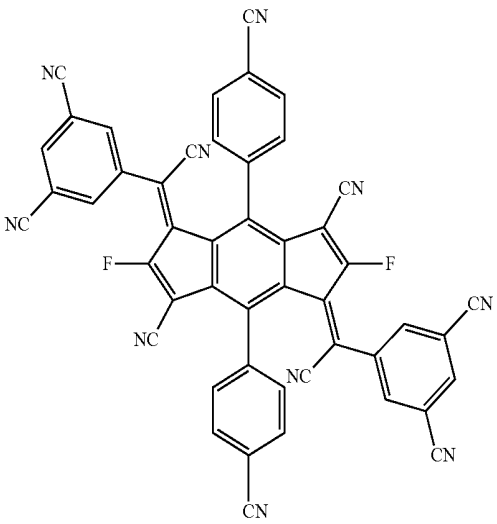

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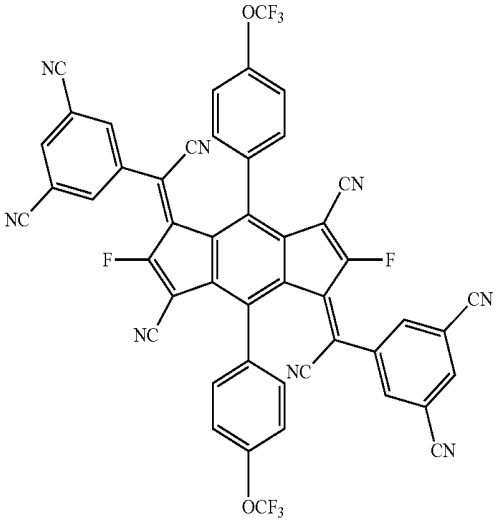

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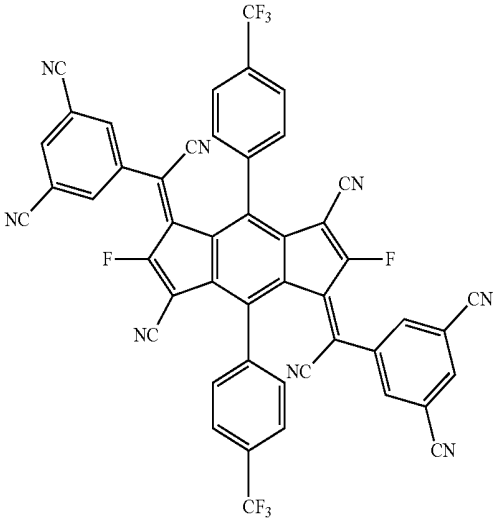

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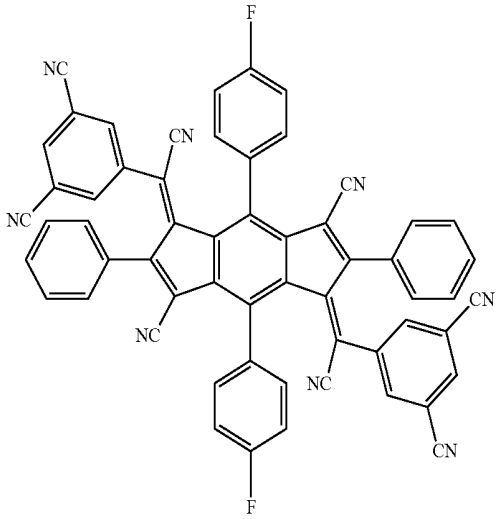

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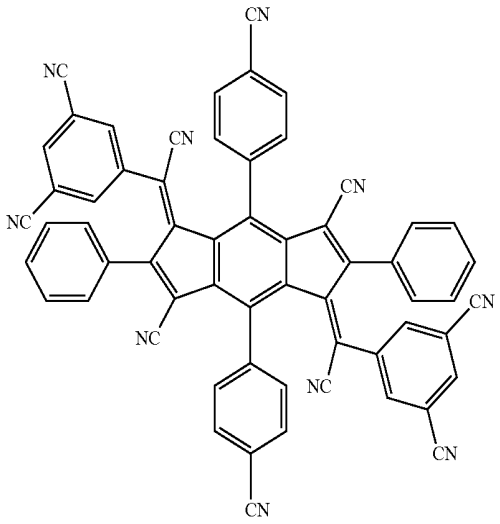

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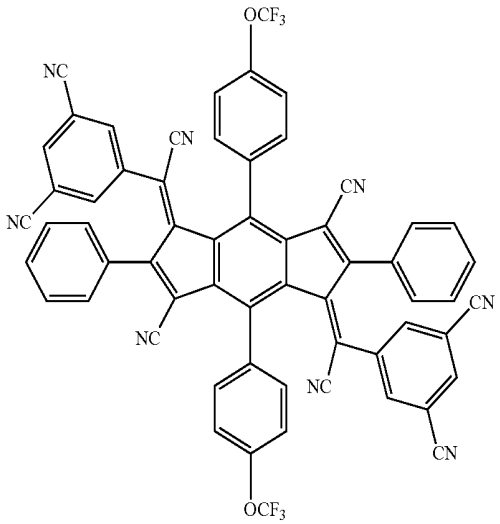

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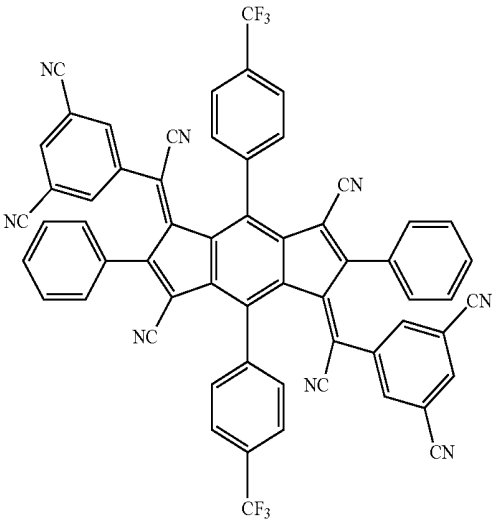

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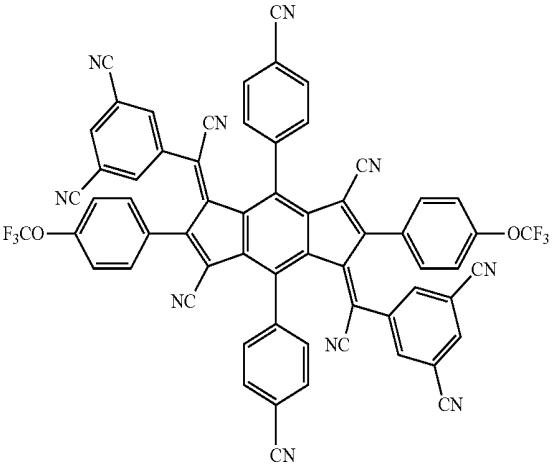

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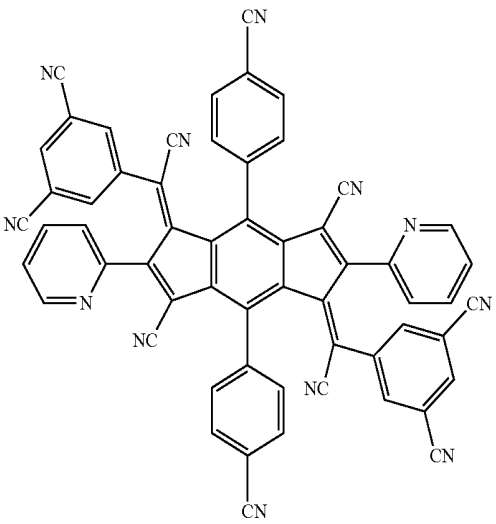

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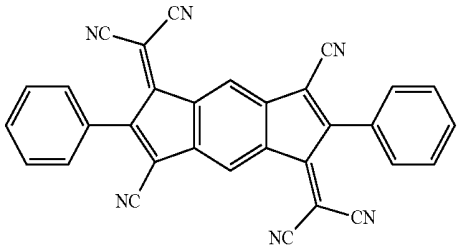

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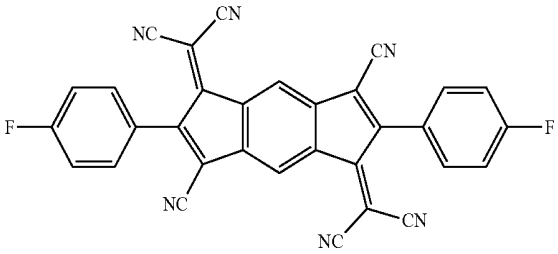

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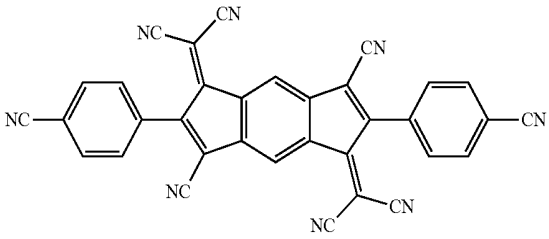

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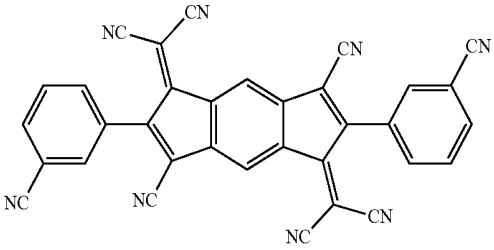

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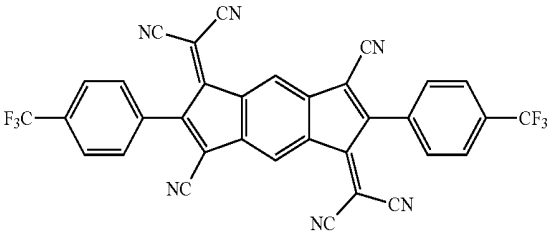

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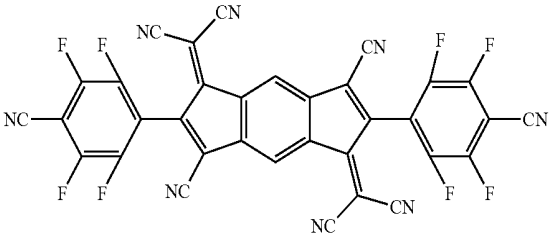

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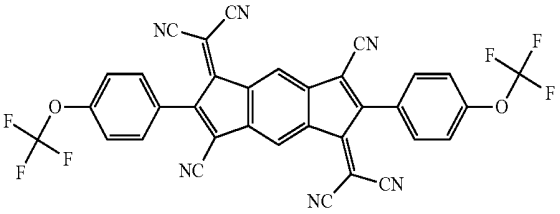

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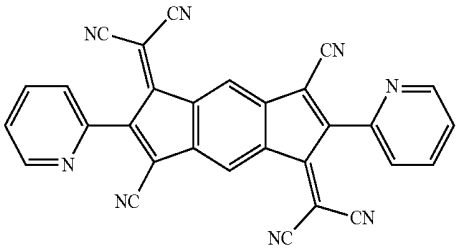

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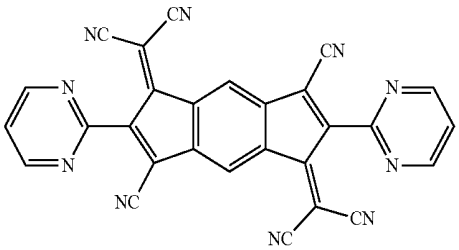

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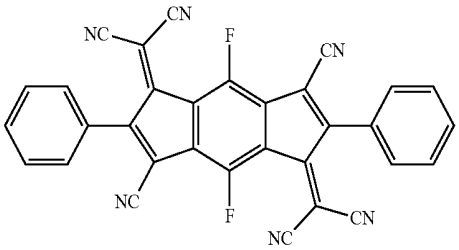

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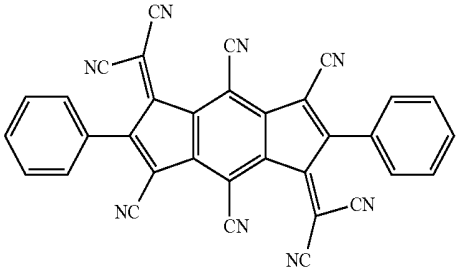

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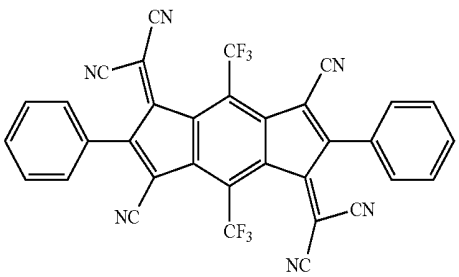

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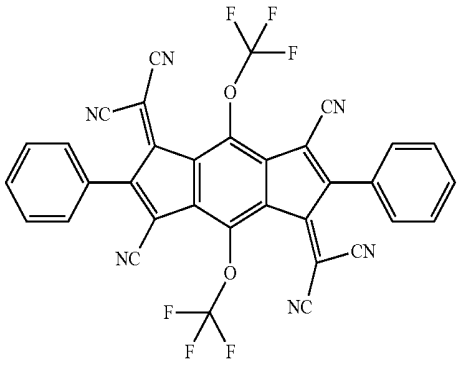

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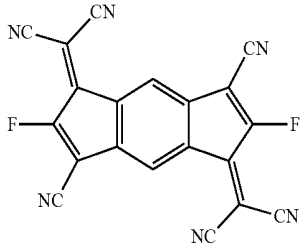

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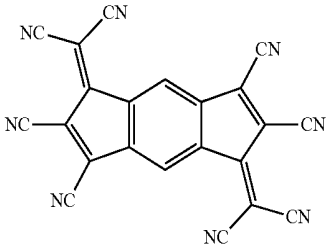

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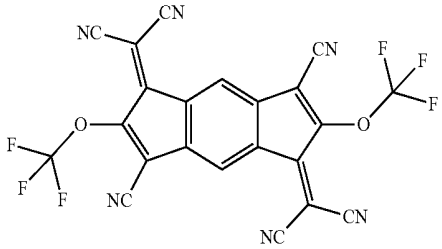

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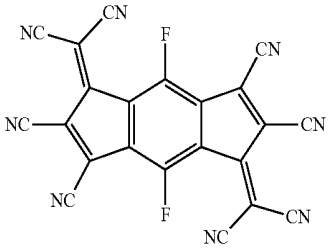

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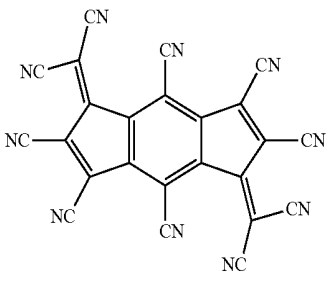

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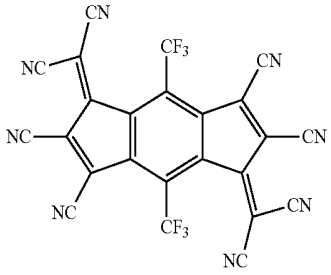

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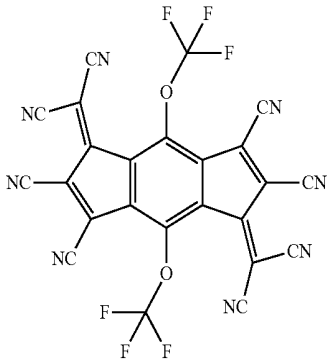

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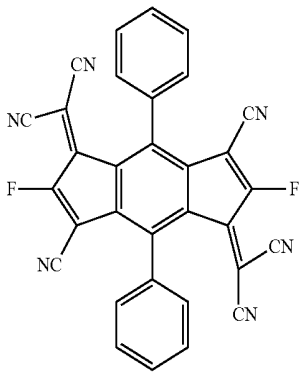

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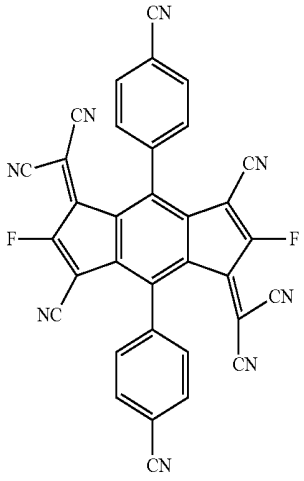

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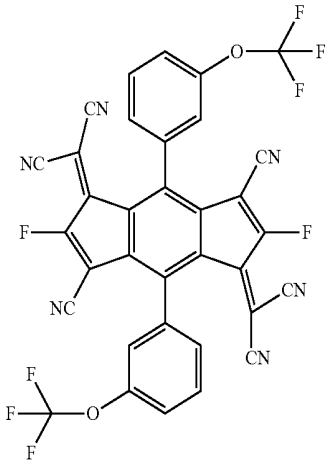

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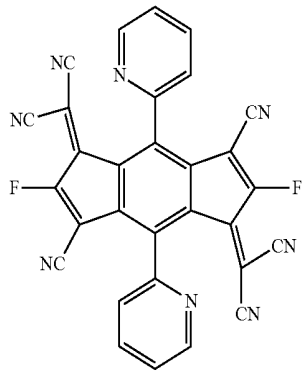

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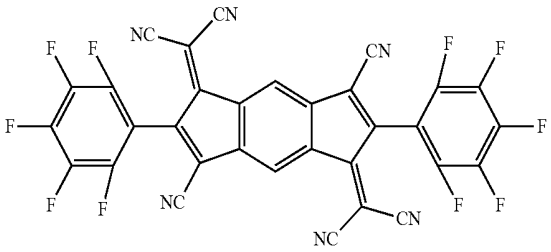

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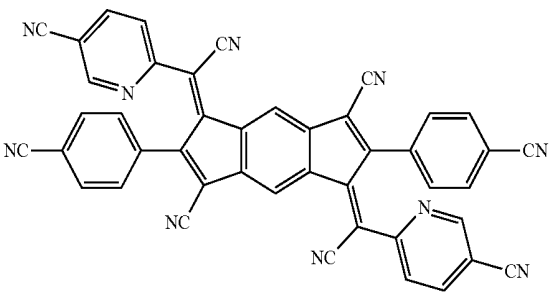

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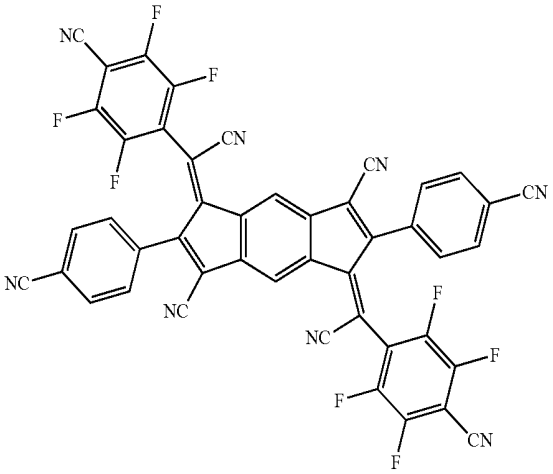

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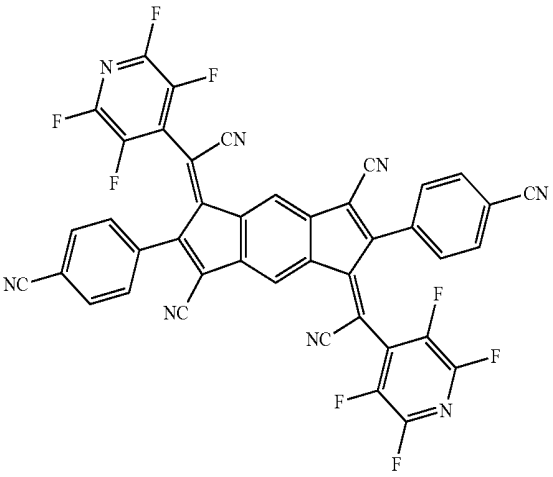

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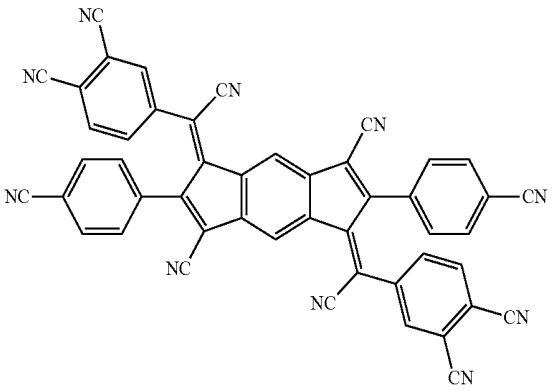

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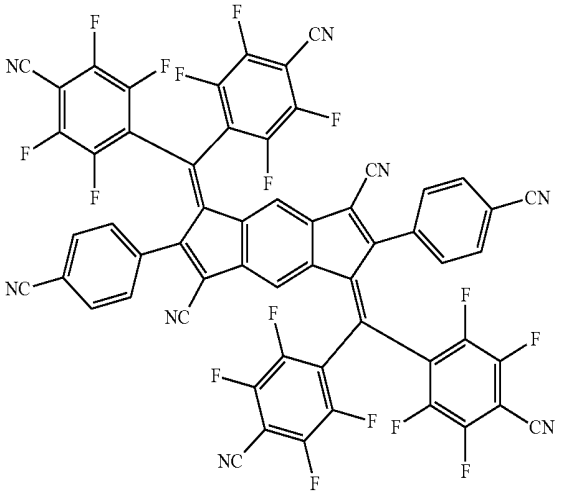

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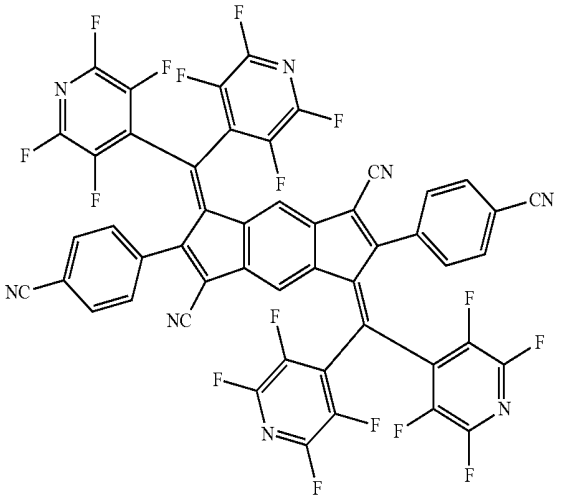

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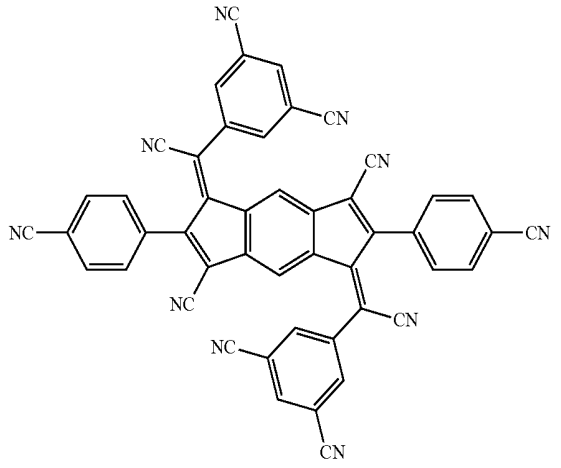

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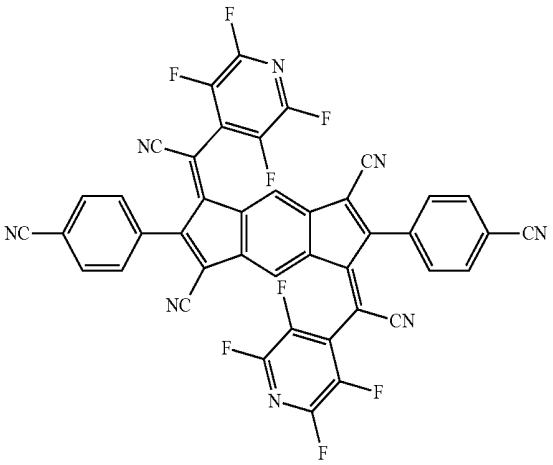

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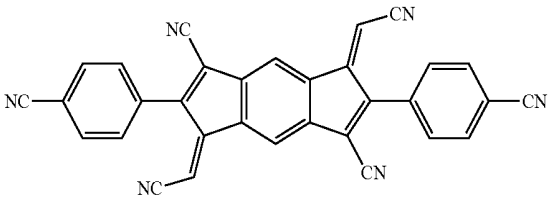

The compound represented by the above Chemical Formula 2 is represented by one among the following compounds:

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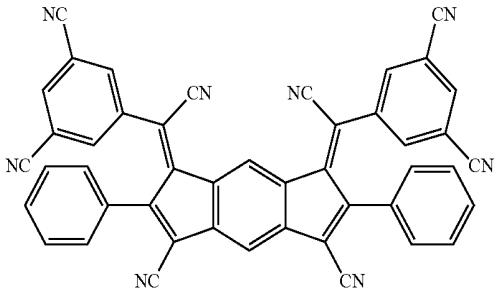

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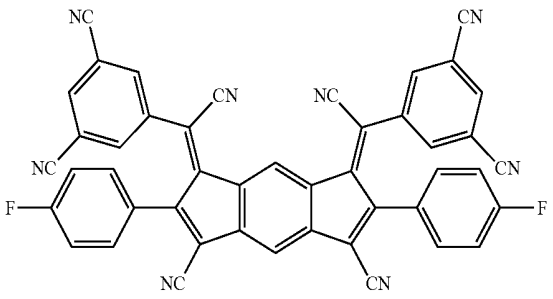

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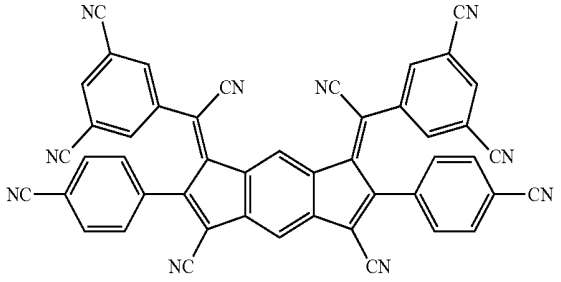

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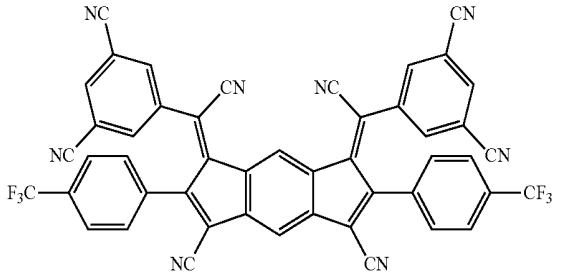

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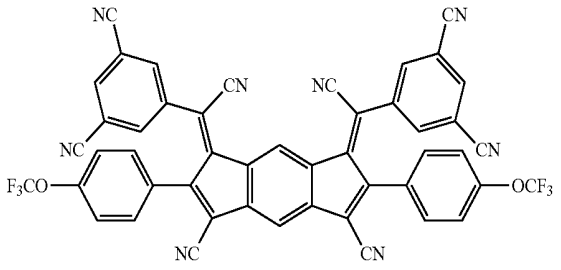

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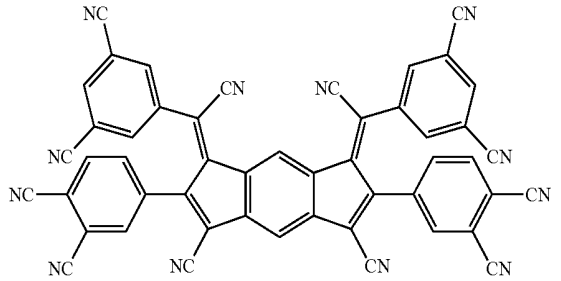

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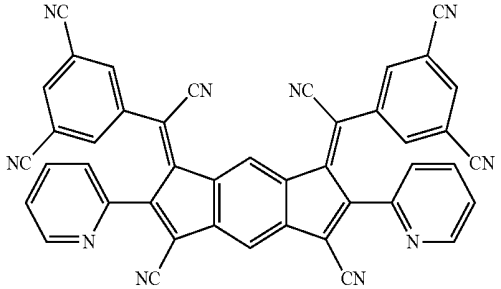

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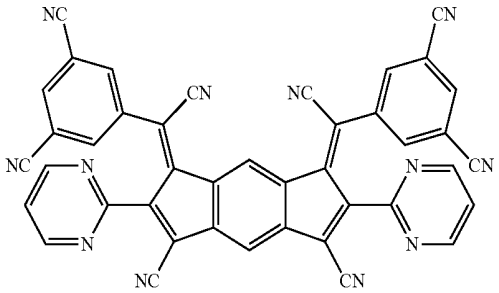

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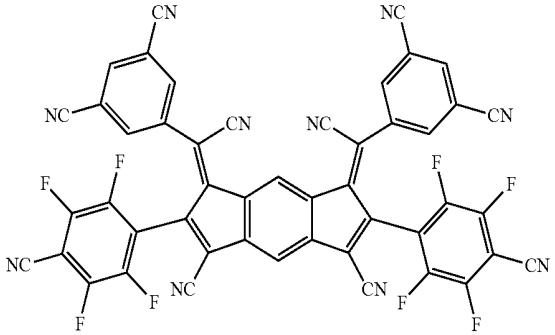

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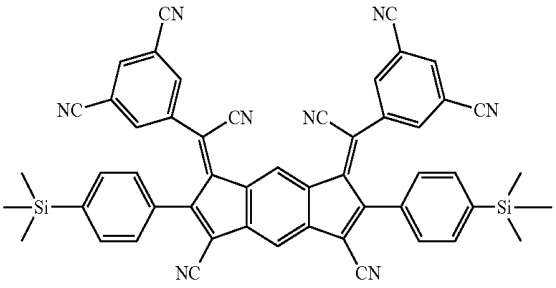

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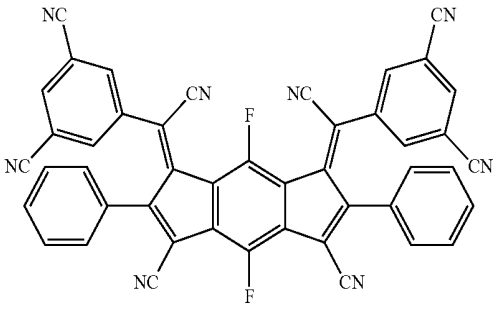

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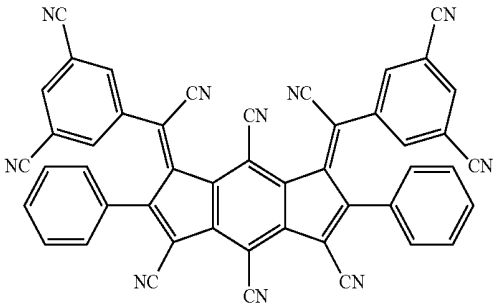

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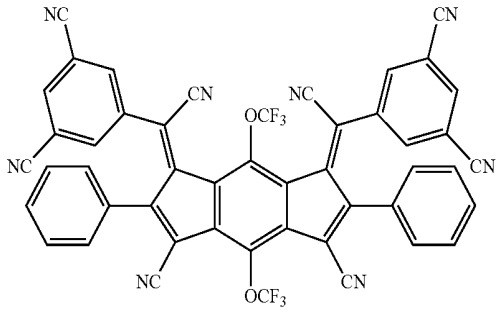

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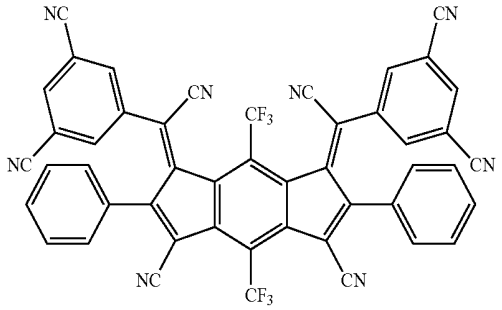

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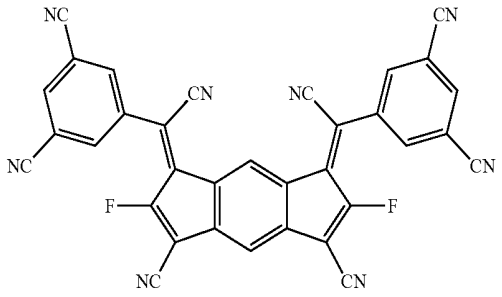

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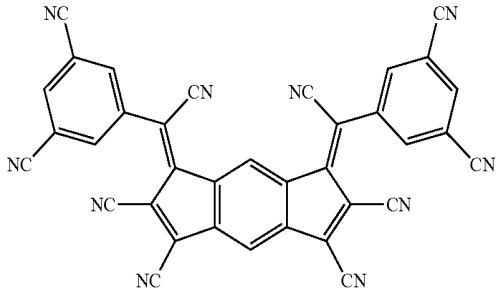

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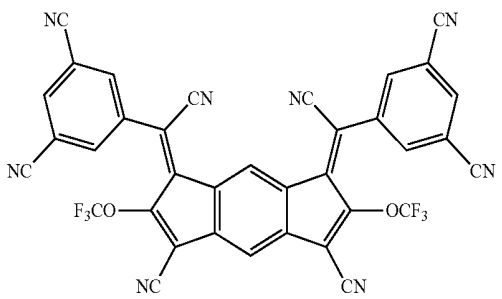

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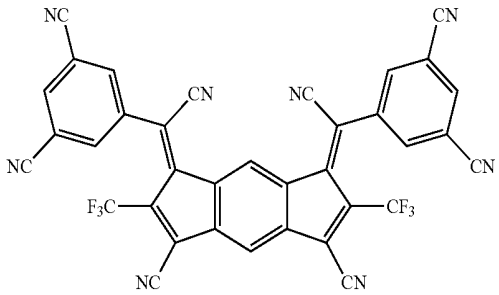

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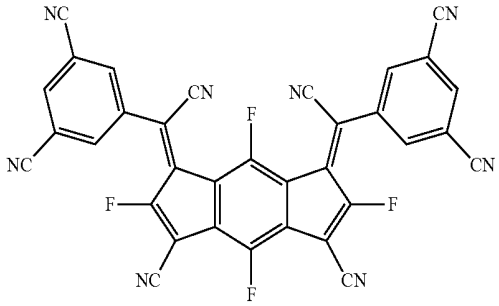

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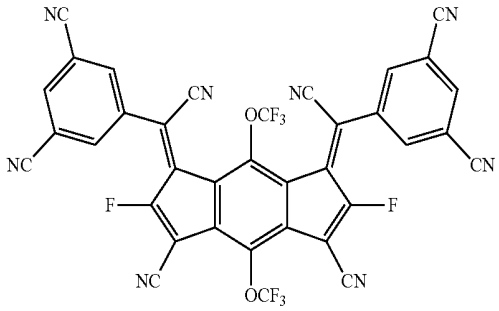

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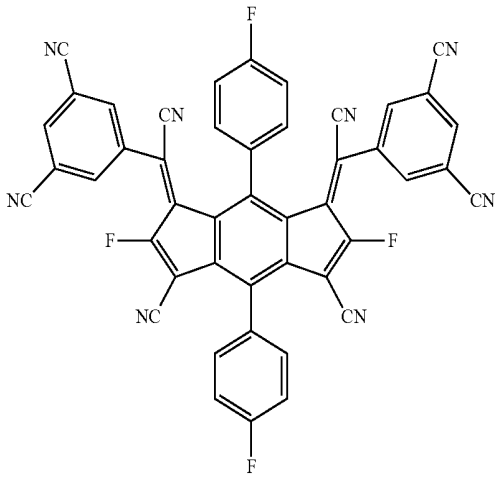

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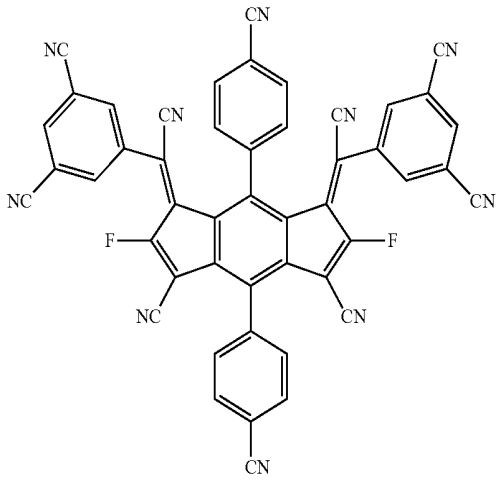

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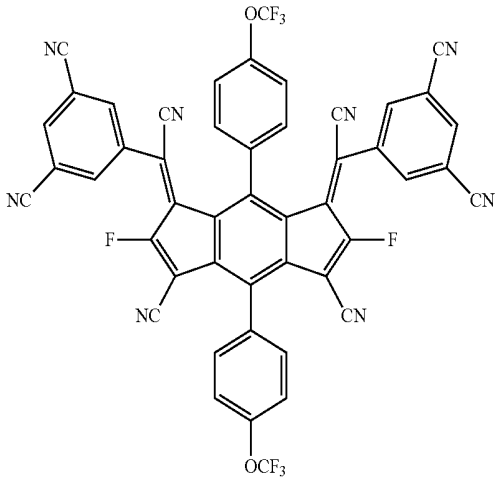

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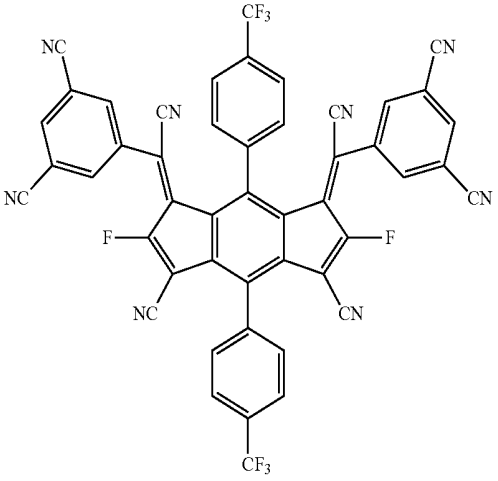

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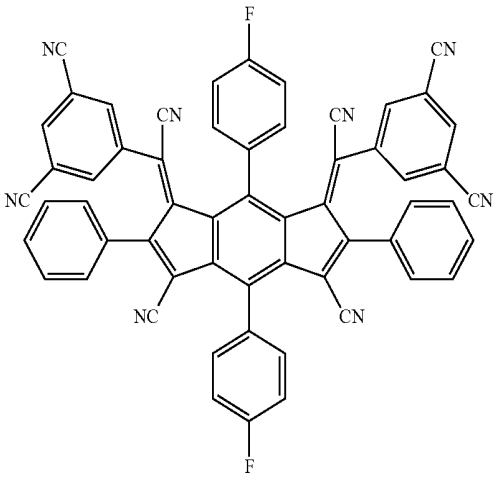

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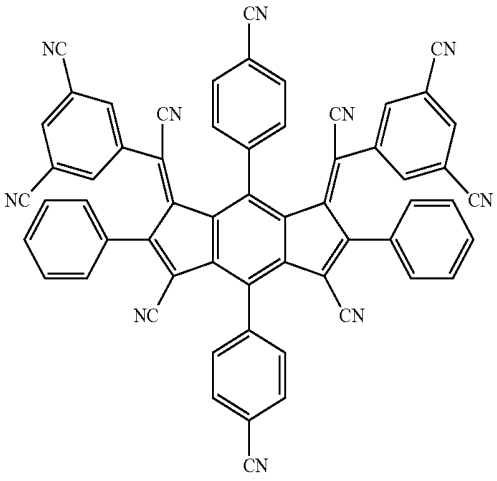

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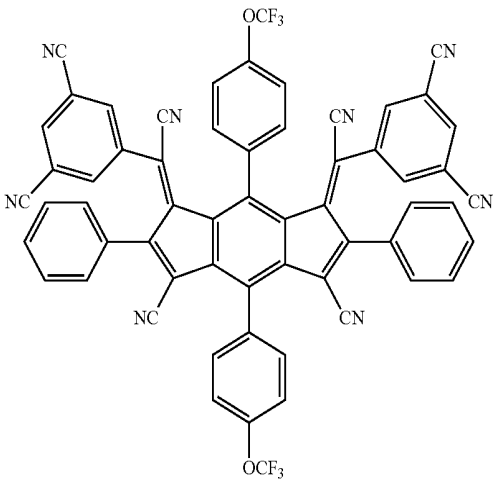

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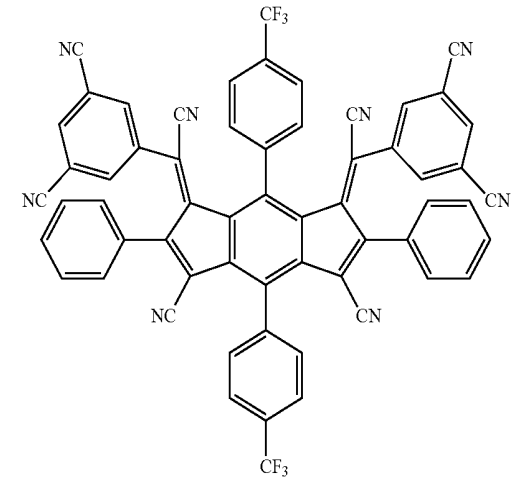

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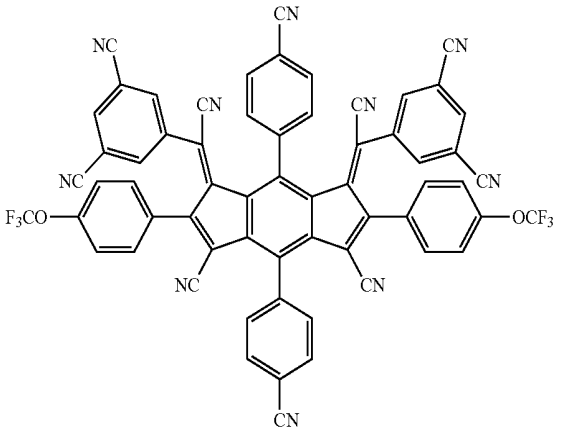

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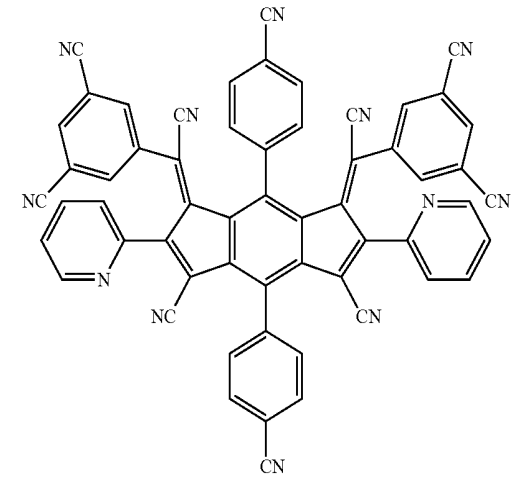

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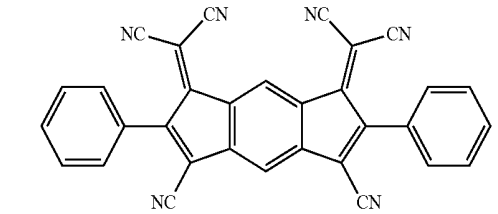

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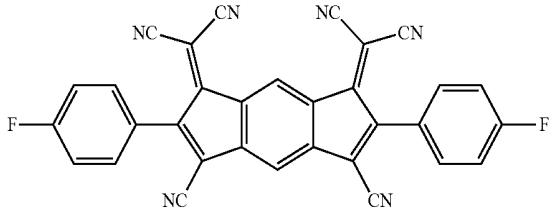

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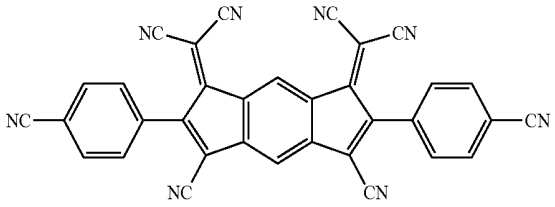

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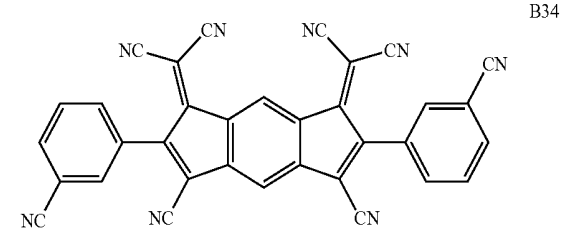

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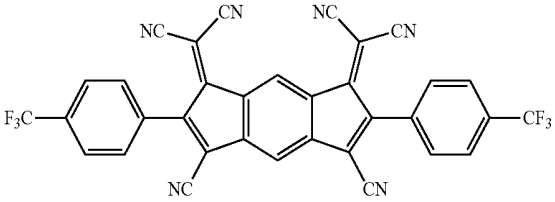

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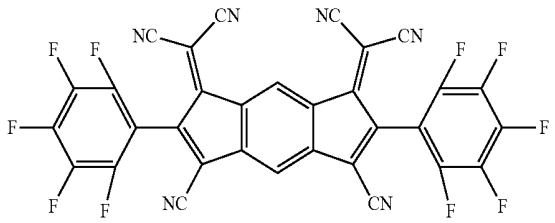

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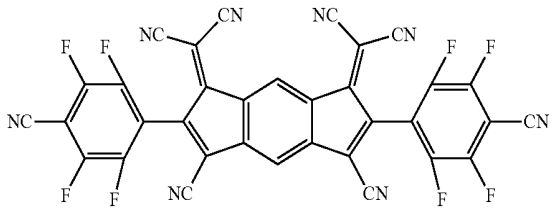

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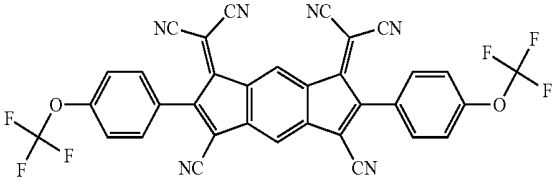

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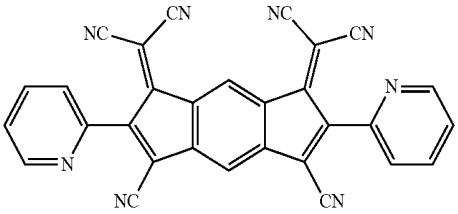

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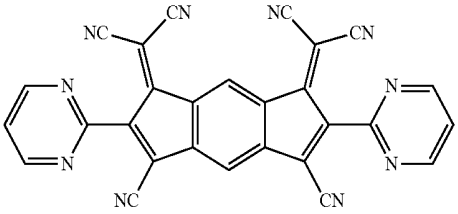

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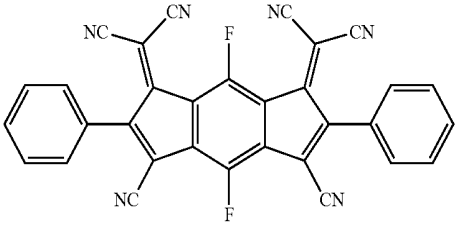

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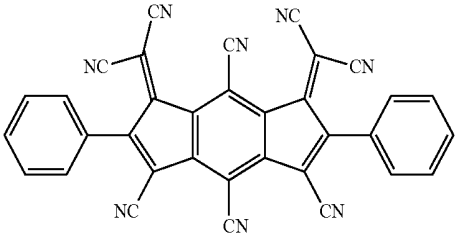

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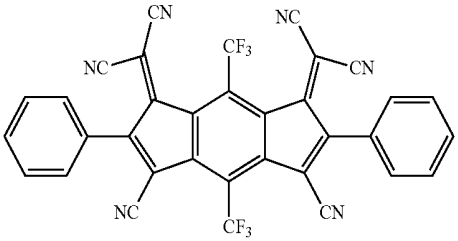

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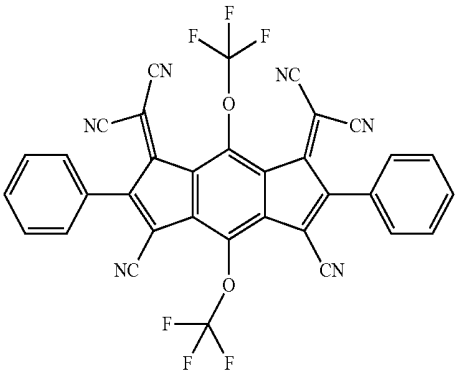

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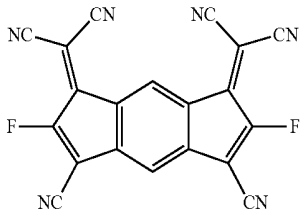

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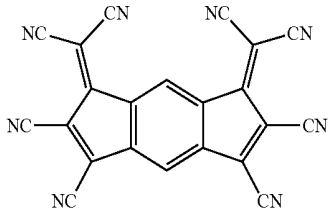

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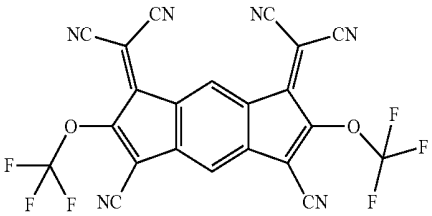

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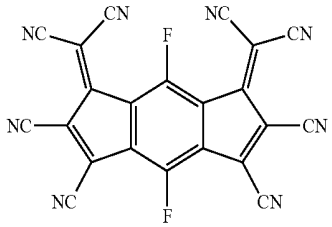

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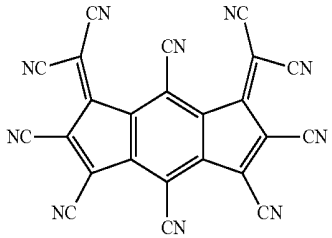

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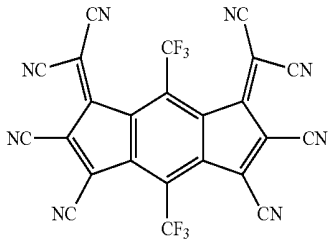

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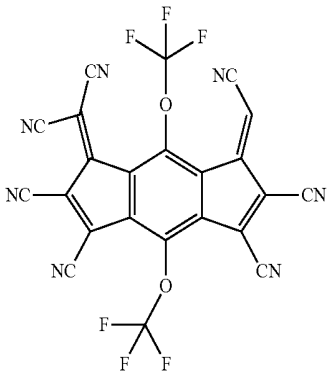

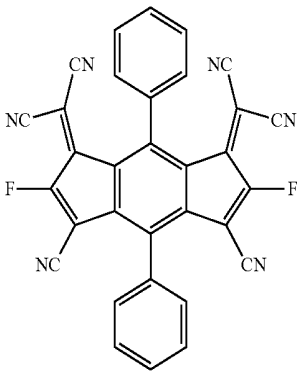

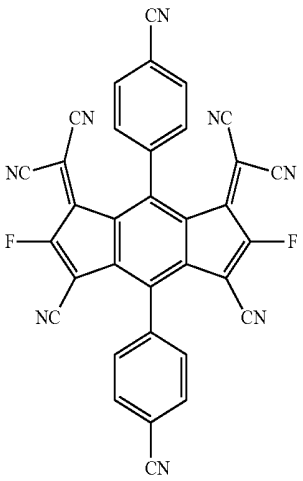

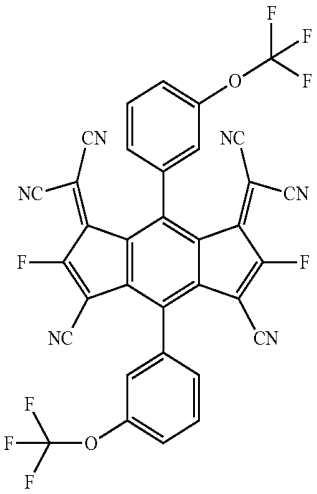

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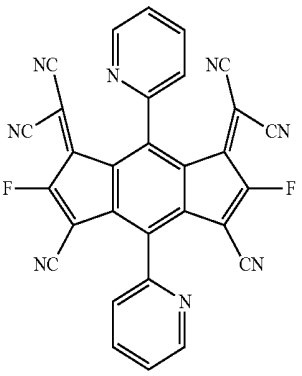

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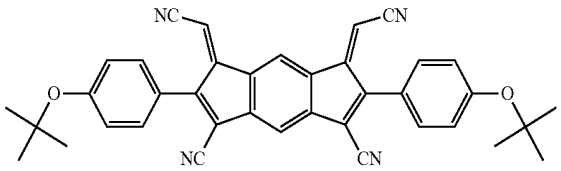

A dopant for the hole injection layer includes the compound.

The hole injection layer includes the compound.

A dopant for the P-type charge generation layer includes the compound.

The P-type charge generation layer includes the compound.

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BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the description serve to explain the principles of the disclosure.

FIG. **1** is a cross-sectional view showing an organic light emitting display device according to a first exemplary embodiment of the present disclosure.

FIG. **2** is a cross-sectional view showing an organic light emitting display device according to a second exemplary embodiment of the present disclosure.

FIG. **3** is a cross-sectional view showing an organic light emitting display device according to a third exemplary embodiment of the present disclosure.

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FIGS. **4** and **5** are energy band diagrams of an organic light emitting display device according to one or more embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The advantages and features of the present disclosure and methods for accomplishing the same may be understood more readily by reference to the following detailed descriptions of exemplary embodiments and the accompanying drawings. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the exemplary embodiments set forth herein. Rather, these exemplary embodiments are provided so that this disclosure will be thorough and complete and will fully convey the concept of the present disclosure to those skilled in the art, and the present disclosure is defined by the appended claims.

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The shapes, sizes, percentages, angles, numbers, etc shown in the figures to describe the exemplary embodiments of the present disclosure are merely examples and not limited to those shown in the figures. Like reference numerals denote like elements throughout the specification. In describing the present disclosure, detailed descriptions of related well-known technologies will be omitted to avoid unnecessary obscuring the present disclosure. When the terms 'comprise', 'have', 'consist of' and the like are used, other parts may be added as long as the term 'only' is not used. The singular forms may be interpreted as the plural forms unless explicitly stated.

The elements may be interpreted to include an error margin even if not explicitly stated.

When the position relation between two parts is described using the terms 'on', 'over', 'under', 'next to' and the like, one or more parts may be positioned between the two parts as long as the term 'immediately' or 'directly' is not used.

When the temporal relationship between two events is described using the terms 'after', 'following', 'next', 'before' and the like, the two events may not occur in succession as long as the term 'immediately' or 'directly' is not used.

It will be understood that, although the terms first, second, etc., may be used to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. Thus, a first element discussed below could be termed a second element without departing from the technical spirit of the present disclosure.

The features of various exemplary embodiments of the present disclosure may be combined with one another either partly or wholly, and may technically interact or work together in various ways. The exemplary embodiments may be carried out independently or in combination with one another.

Hereinafter, various exemplary embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

FIG. **1** is a cross-sectional view showing an organic light emitting display device according to a first exemplary embodiment of the present disclosure. All the components of the organic light emitting display device according to all embodiments of the present disclosure are operatively coupled and configured.

Referring to FIG. **1**, an organic light emitting display device **100** according to the first exemplary embodiment of the present disclosure comprises an anode **110**, a hole injection layer **120**, a hole transport layer **130**, an light emitting layer **140**, an electron transport layer **150**, an electron injection layer **210**, and a cathode **220**.

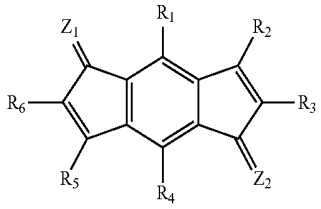
The anode **110** is a hole injection electrode, and may be formed of one among ITO (indium tin oxide), IZO (indium zinc oxide), or ZnO (zinc oxide) having a high work function. Also, if the anode **110** is a reflective electrode, the anode **110** may further comprise a reflective layer formed of one among aluminum (Al), silver (Ag), or nickel (Ni) under a layer formed of one among ITO, IZO, or ZnO.

The hole injection layer **120** is formed on the anode **110**. The hole injection layer **120** has to comprise a strong electron-attracting substituent, in order to make LUMO energy level of the hole injection layer similar to or lower than the HOMO energy level of the host of the hole injection layer or the HOMO energy level of the hole transport layer. However, compounds comprising an electron-attracting substituent are hard to synthesize because of the electron-attracting substituents, and are not easy to develop due to their low thermal and deposition stability. In view of this, the present inventors conducted various tests to improve the hole injection properties and the device's efficiency and lifetime by forming a hole injection layer of a material that ensures process stability and comprises an electron-attracting substituent.

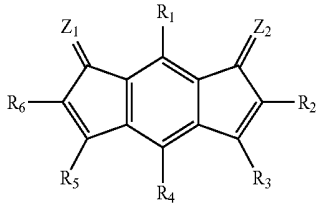
Through a number of tests or experiments which were performed on materials that do not affect the lifetime or efficiency of the organic light emitting display device and that cause no rise in operating voltage, the present inventors developed compounds that can exhibit hole injection properties by ensuring process stability and comprising an electron-attracting substituent. In the present disclosure, a hole injection layer is formed using a compound comprising indene as a core and an electron-attracting substituent. The composition and deposition of the compound is simplified because indene provides process stability against heat or deposition. Moreover, the compound of this disclosure can improve the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of the host of the hole injection layer **120**, the host of a P-type charge generation layer, or the hole transport layer.

Accordingly, the hole injection layer **120** of this disclosure comprises a compound represented by the following Chemical Formula 1 or 2:

[Chemical Formula 1]



[Chemical Formula 2]



where R_1 to R_6 each independently represents one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group, and at least one among R_1 to R_6 comprises a cyano group.

Z_1 and Z_2 are independently represented by the following Chemical Formula 3:

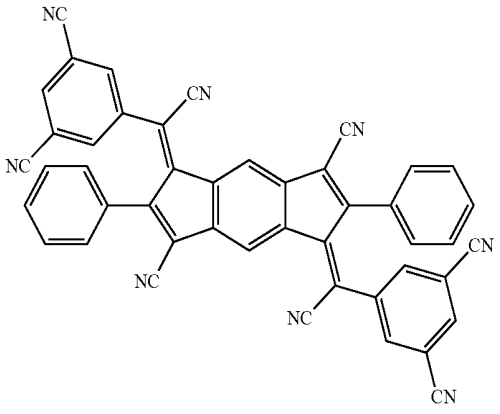
[Chemical Formula 3]

where A and B are independently represented by one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

The substituent of the aryl group, heteroaryl group, alkyl group, alkoxy group, and ether group may be one among an alkyl with 1 to 12 carbon atoms, an aryl with 6 to 15 carbon atoms, a hetero alkyl with 1 to 15 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

The compound represented by Chemical Formula 1 is represented by at least one among the following compounds:

A01



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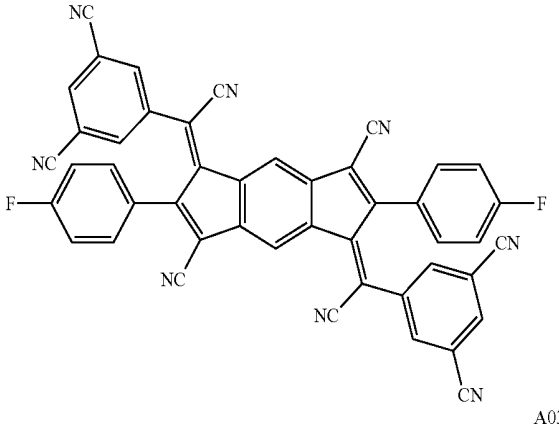

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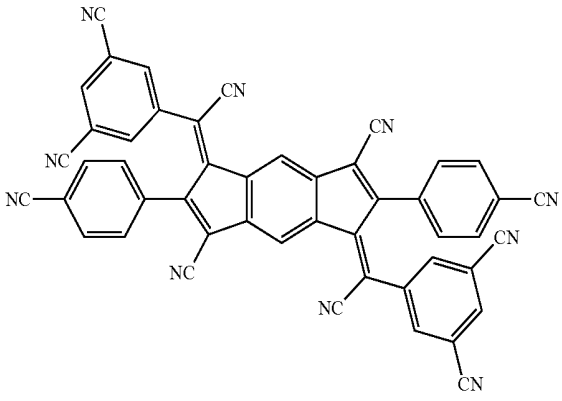

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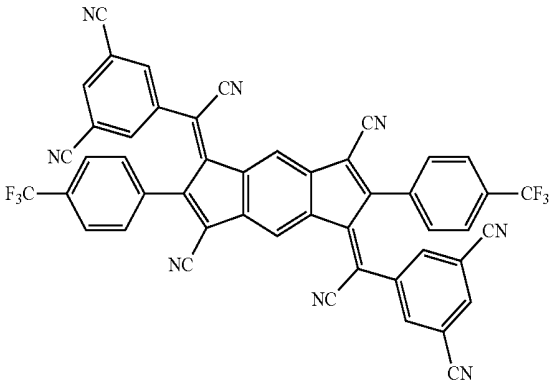

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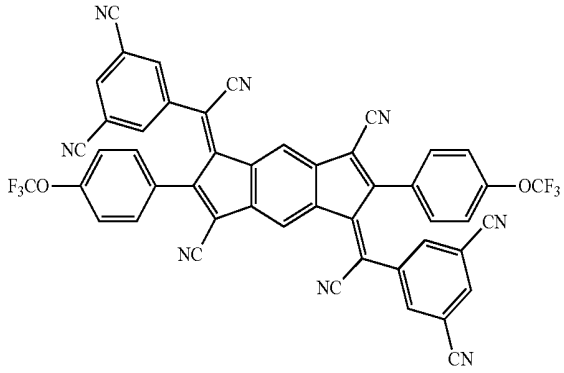

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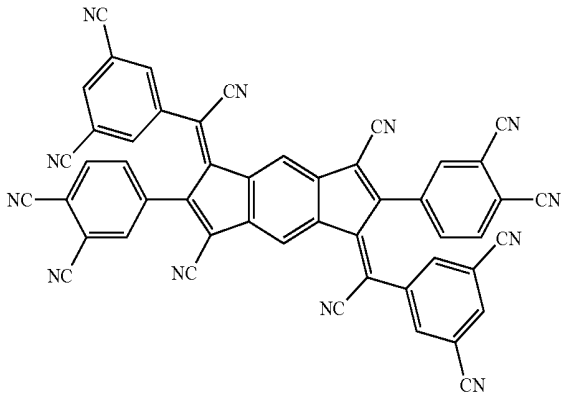

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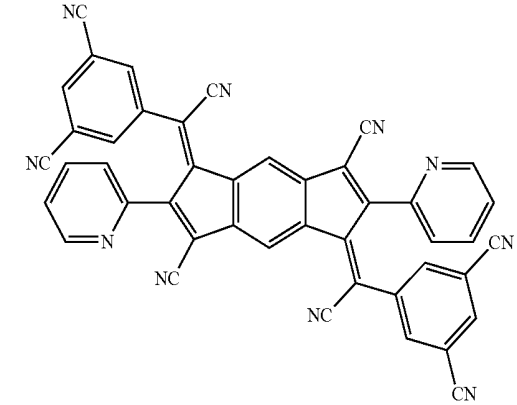

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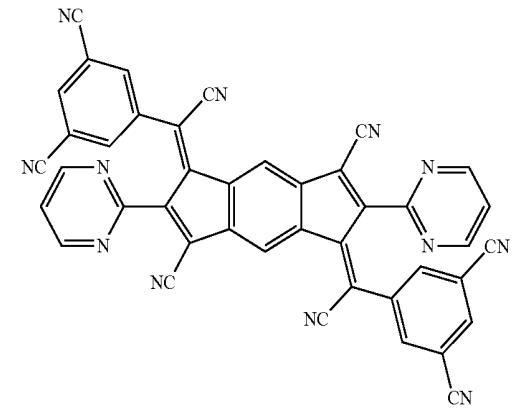

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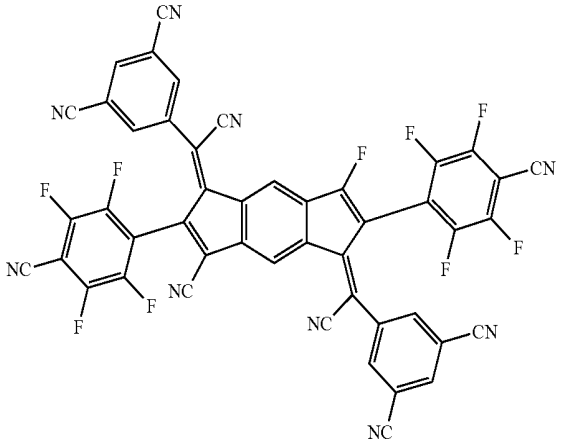

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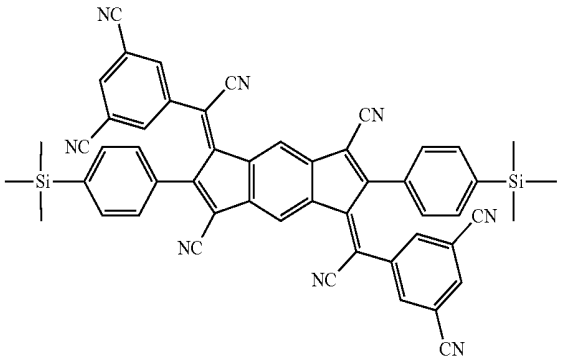

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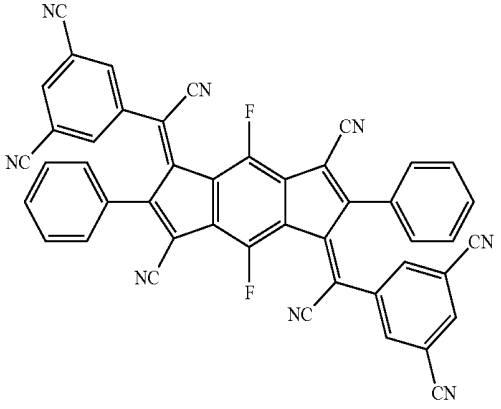

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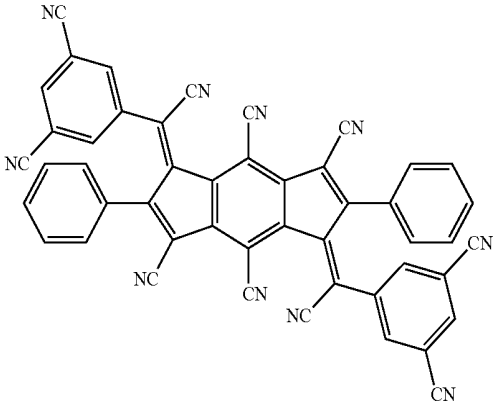

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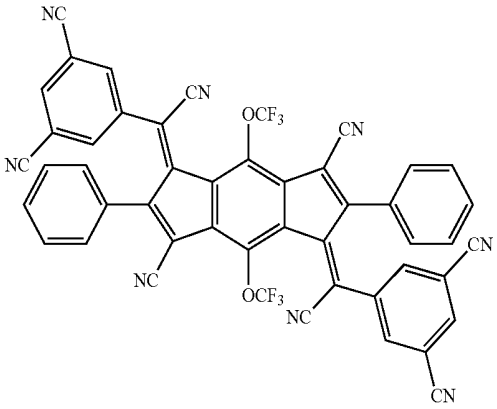

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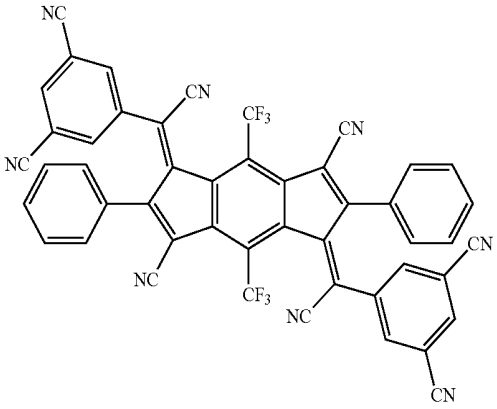

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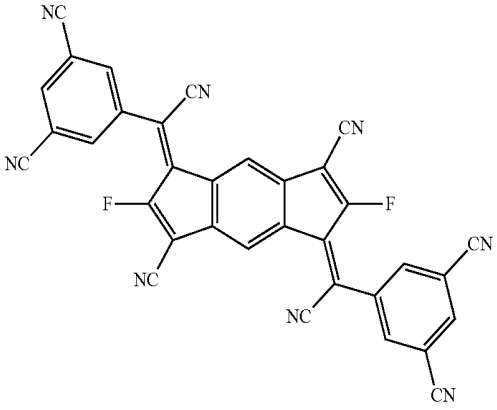

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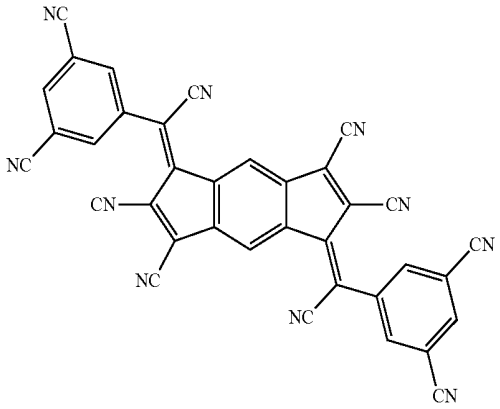

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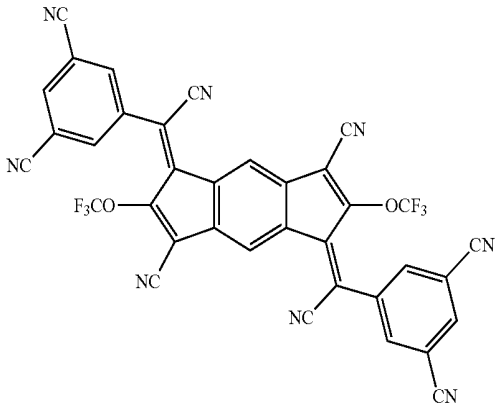

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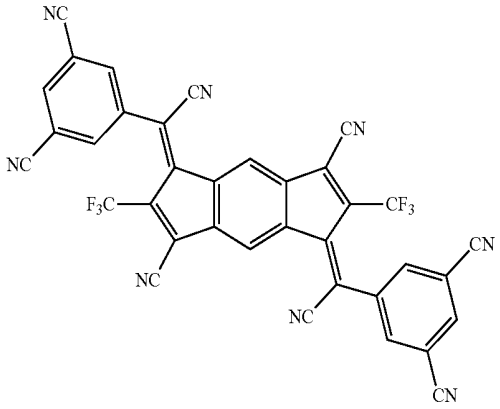

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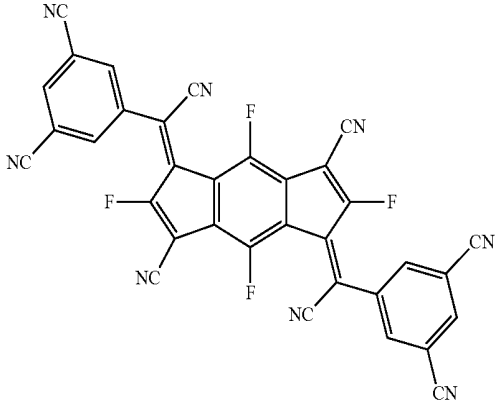

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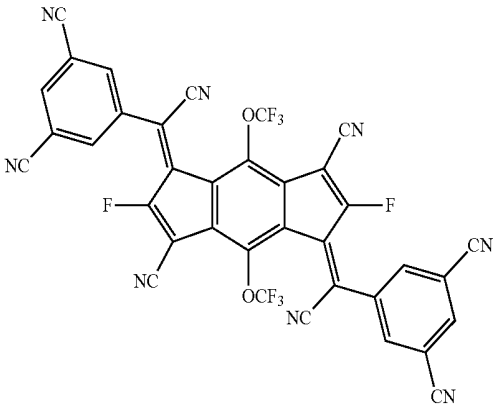

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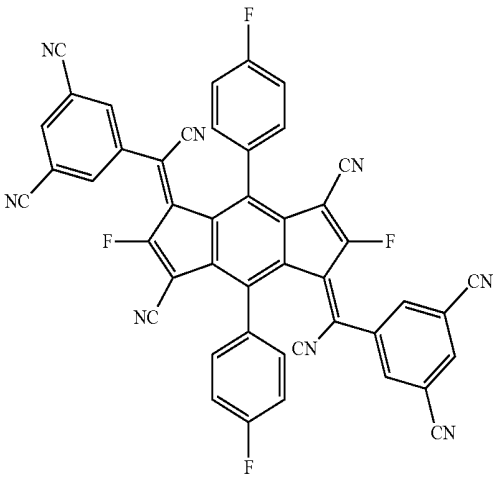

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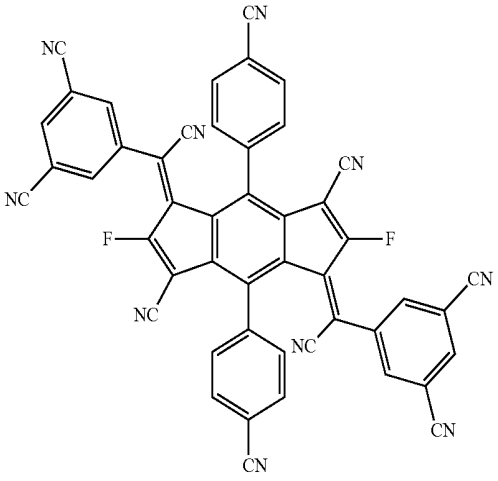

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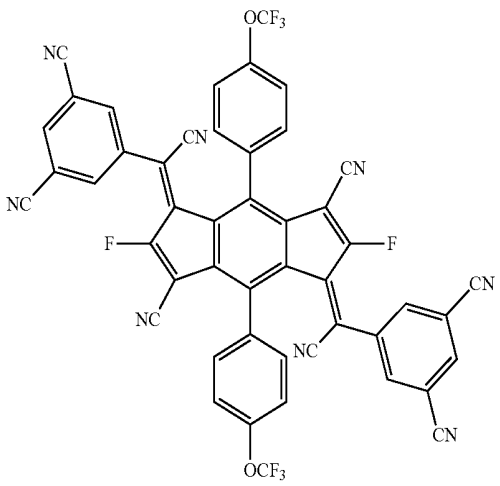

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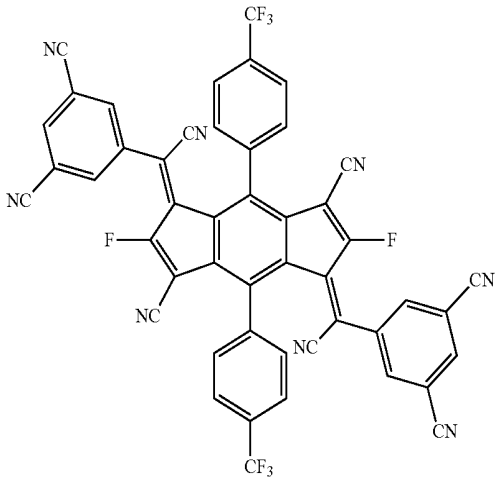

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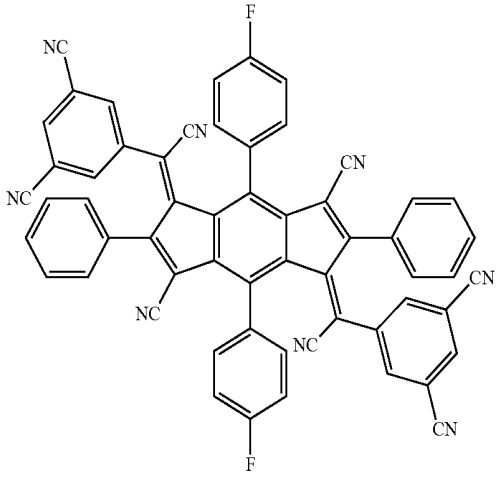

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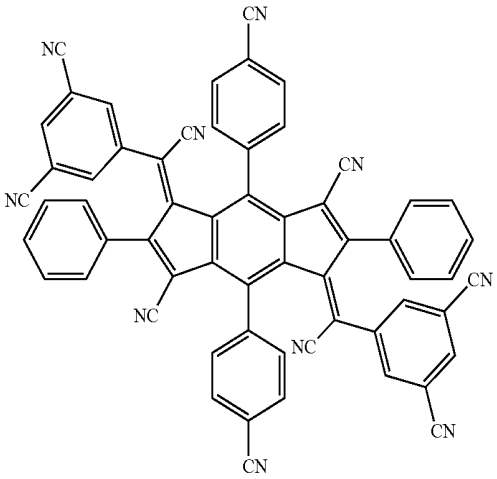

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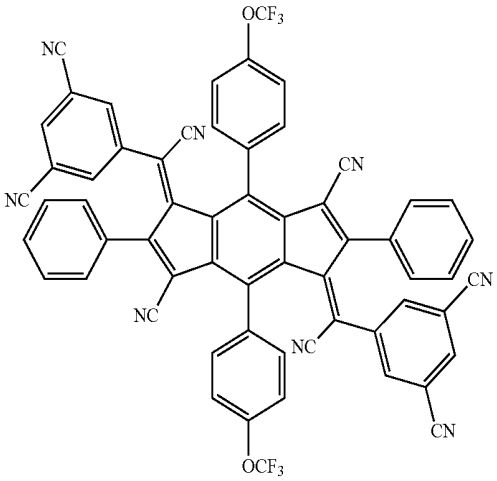

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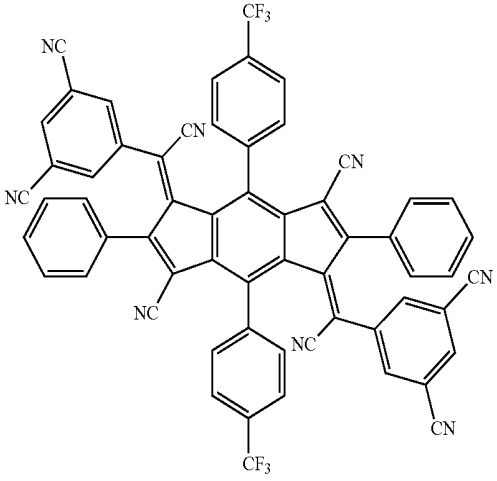

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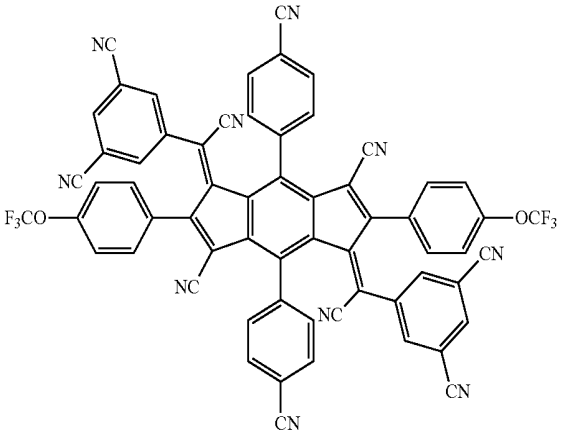

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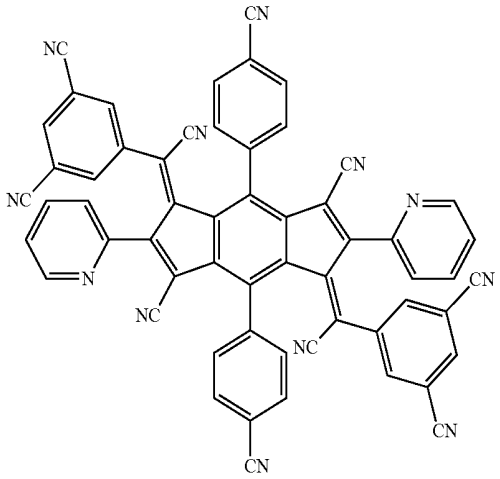

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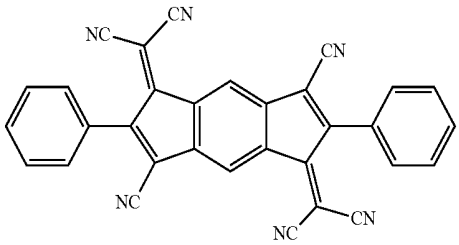

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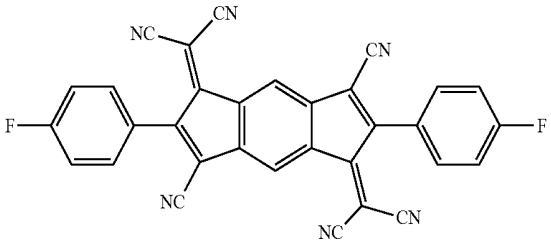

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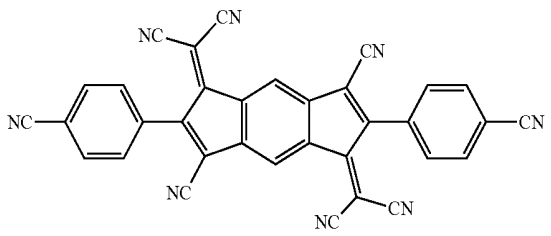

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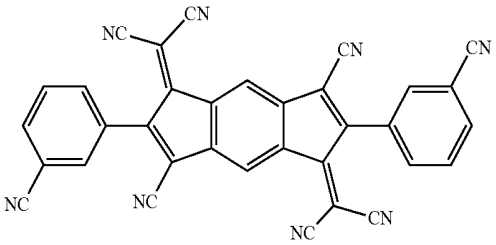

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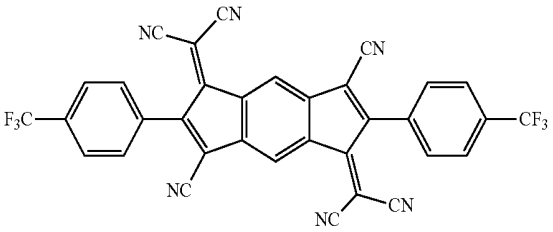

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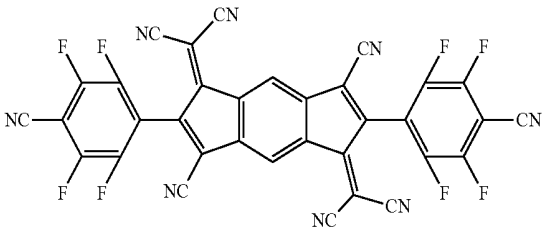

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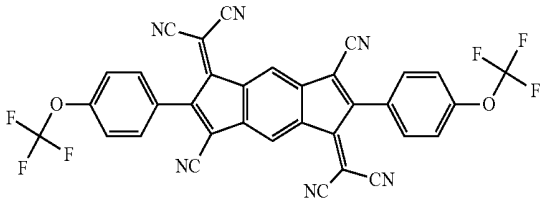

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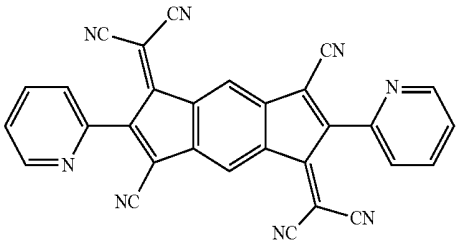

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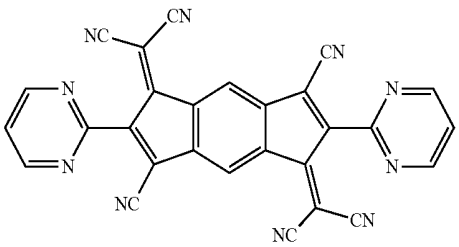

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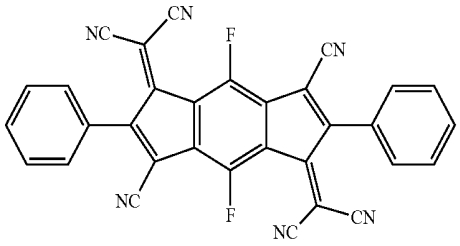

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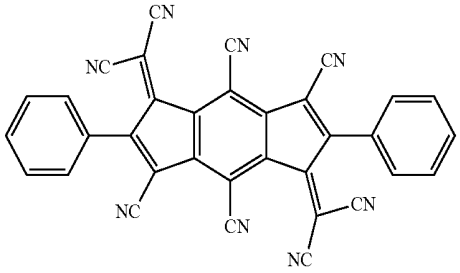

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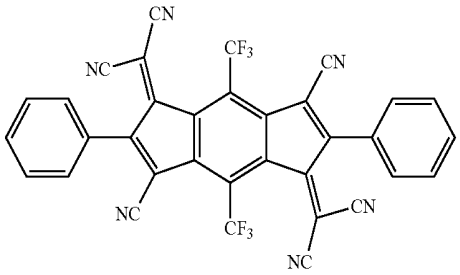

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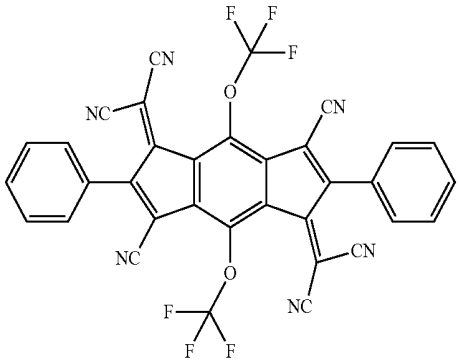

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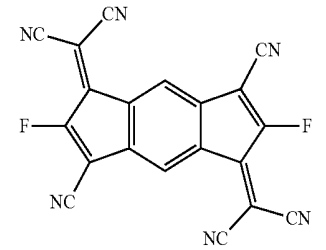

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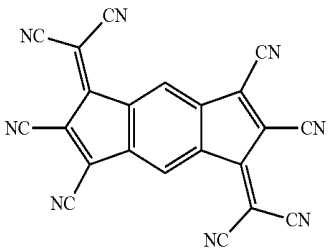

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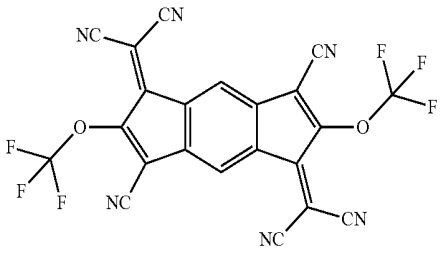

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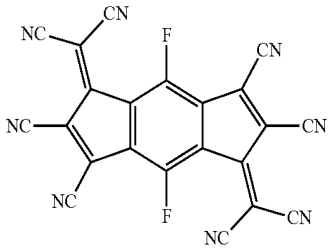

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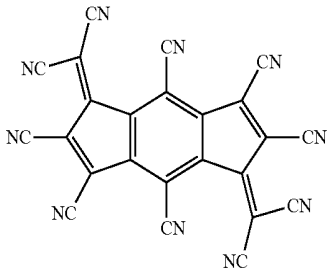

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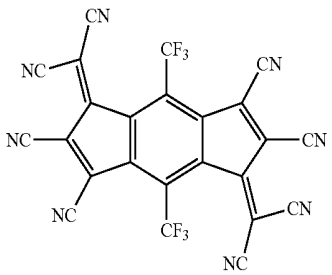

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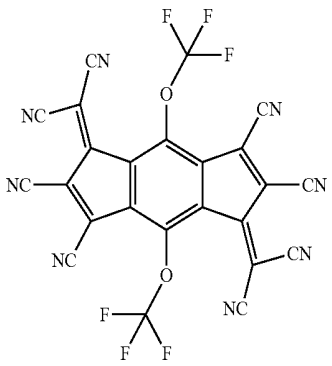

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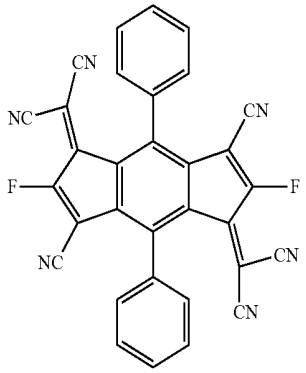

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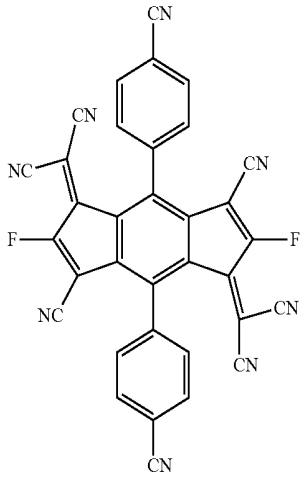

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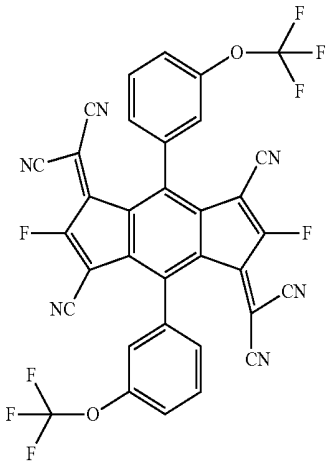

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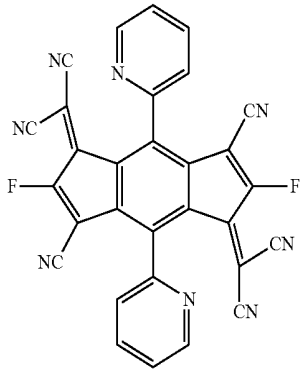

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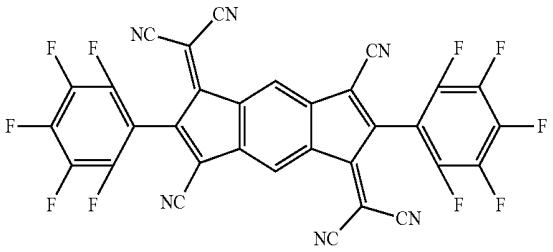

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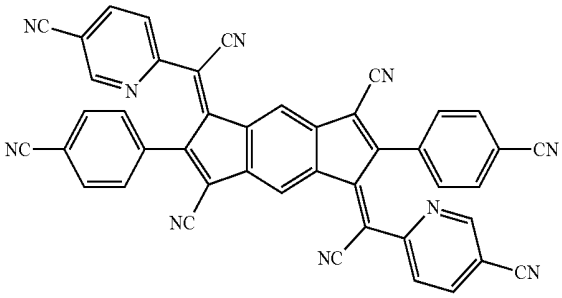

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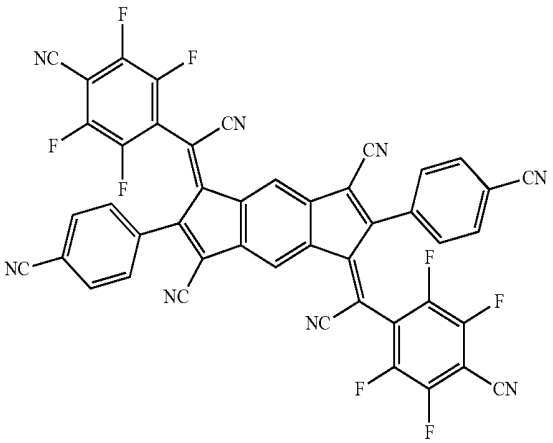

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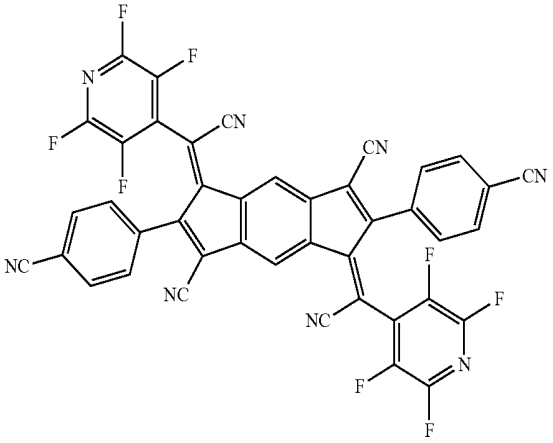

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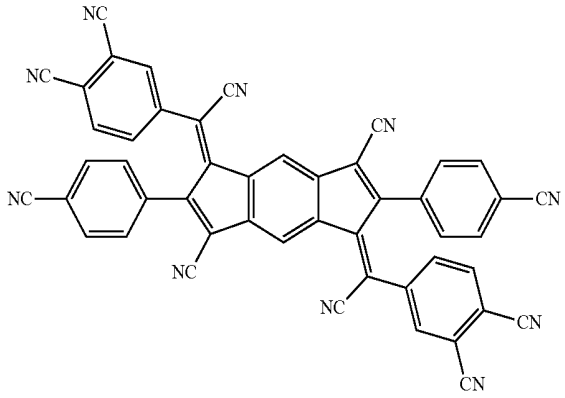

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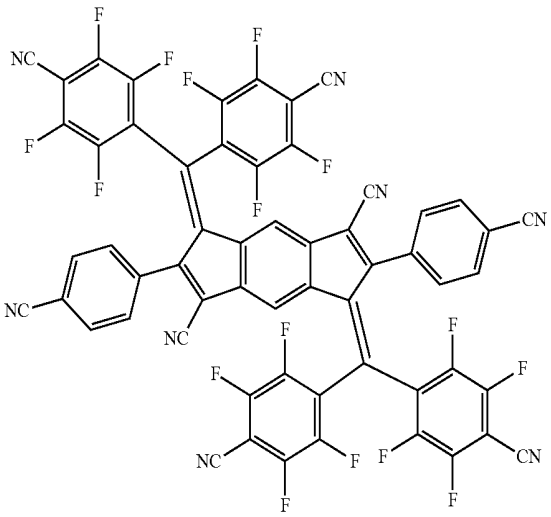

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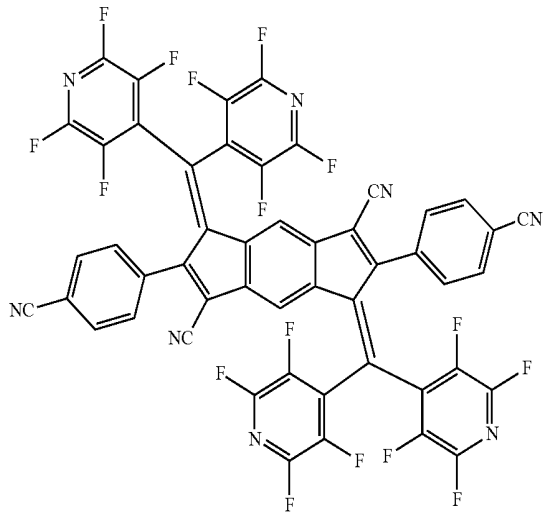

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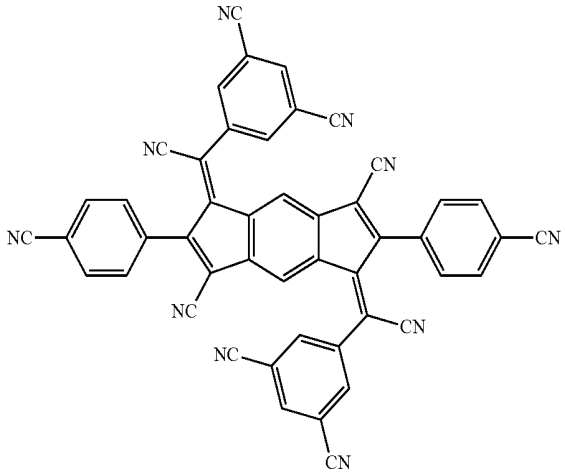

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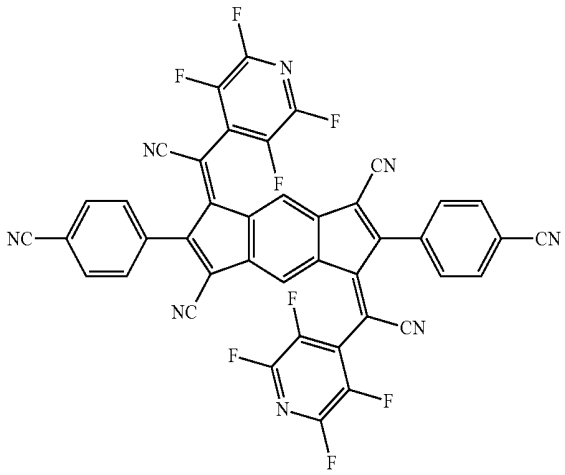

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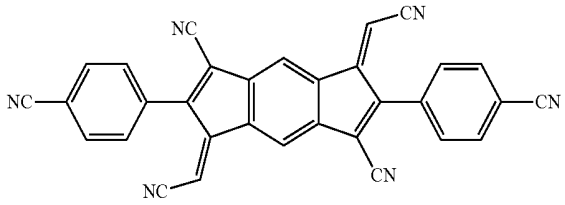
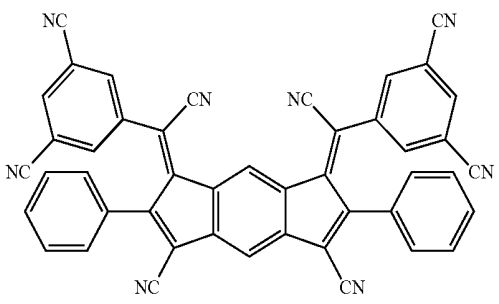


The compound represented by the above Chemical Formula 2 is represented by one among the following compounds:

B1



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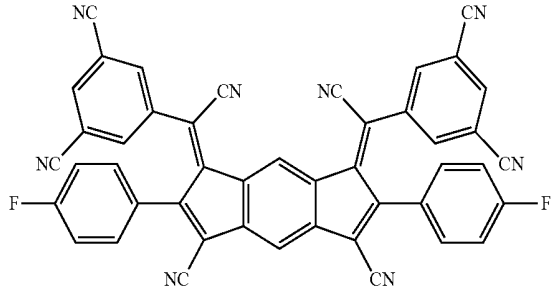

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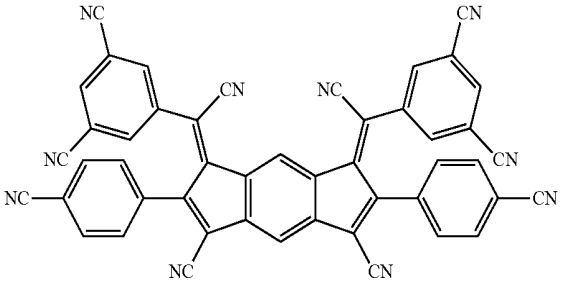

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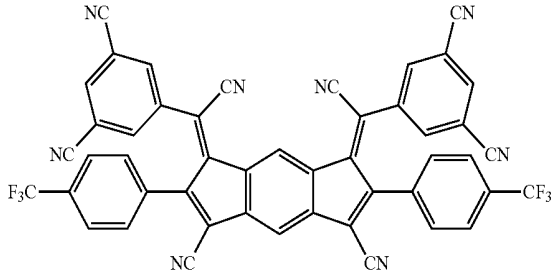

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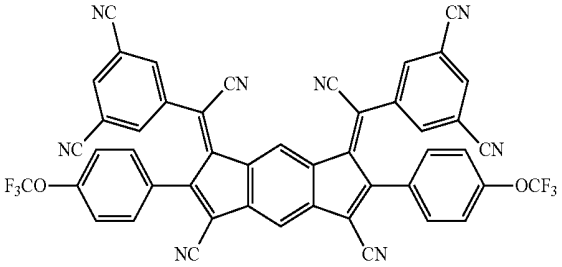

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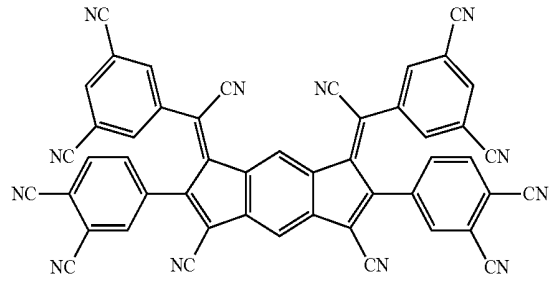

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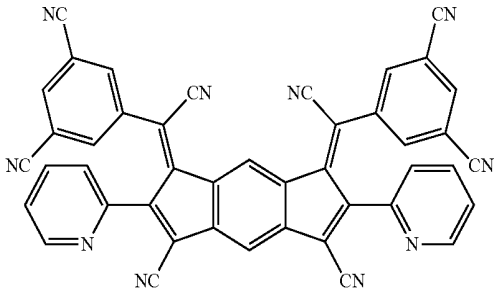

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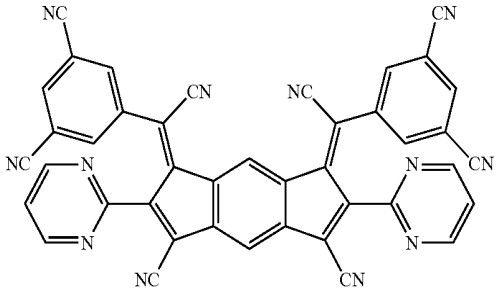

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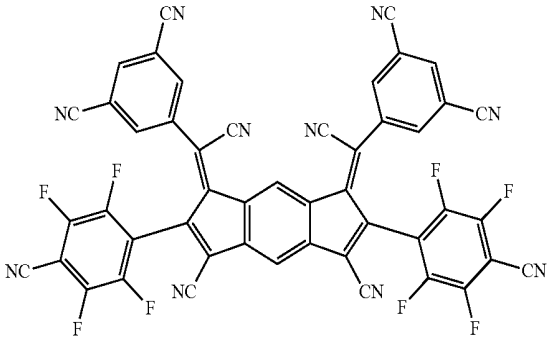

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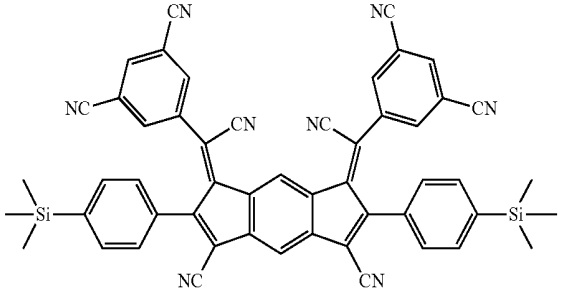

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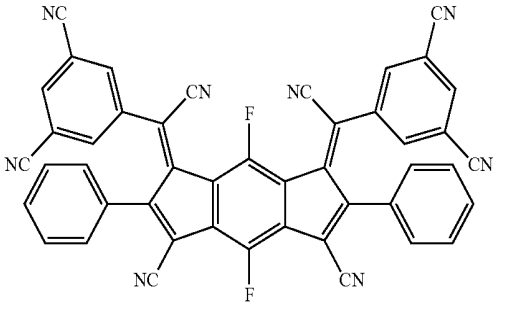

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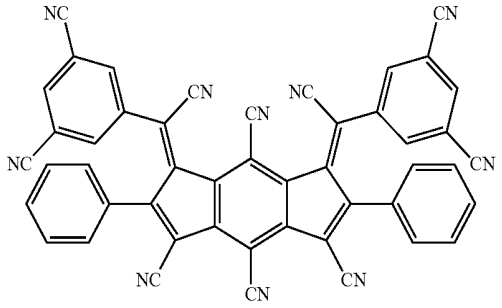

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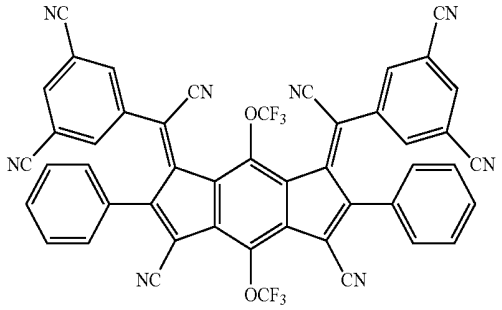

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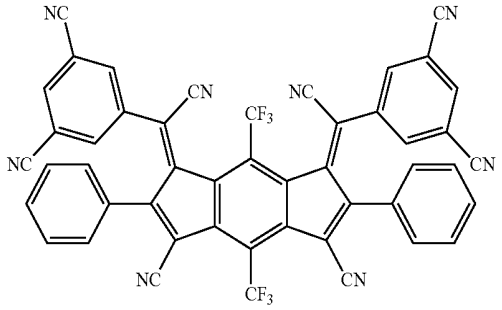

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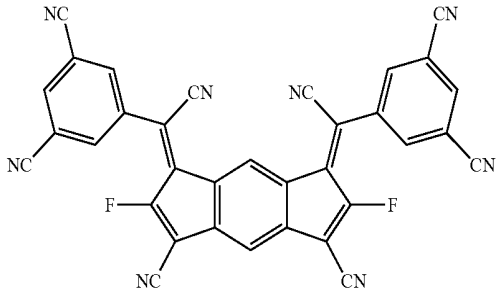

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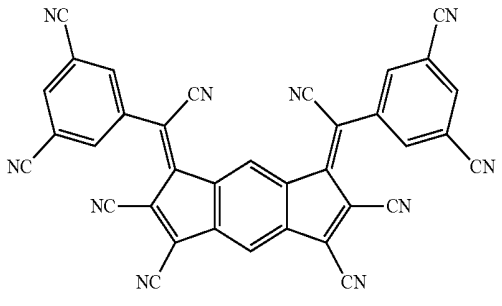

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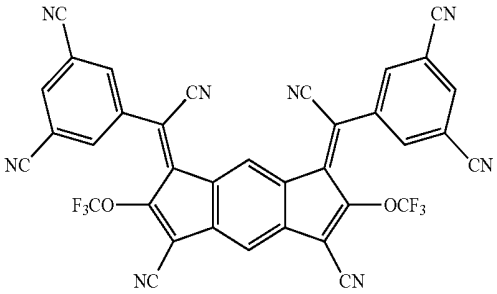

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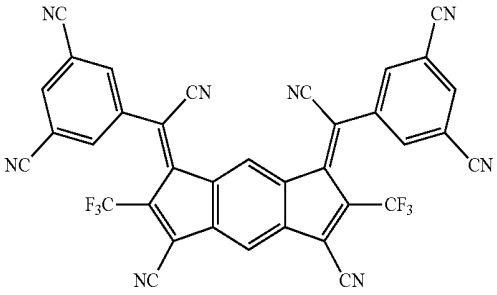

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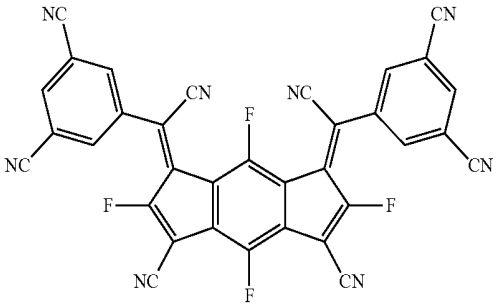

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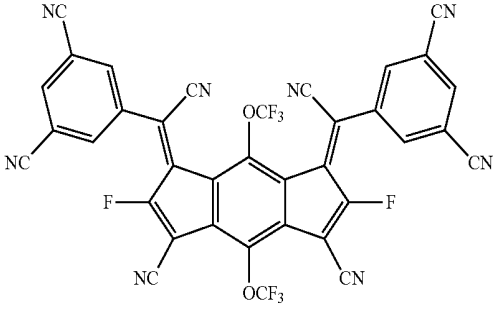

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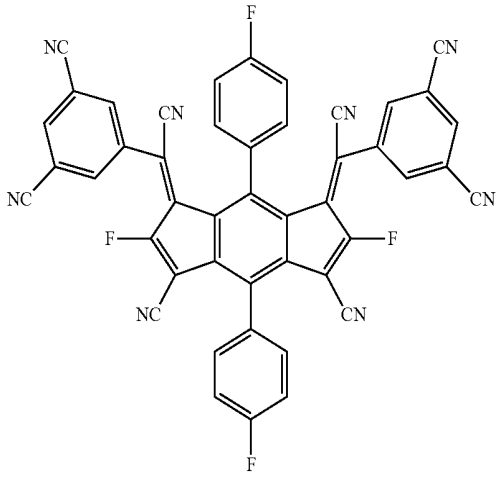

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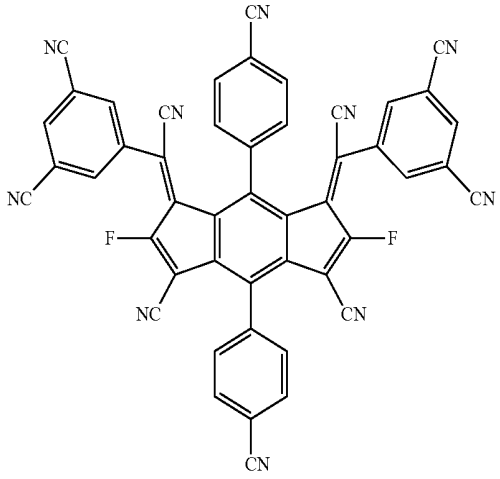

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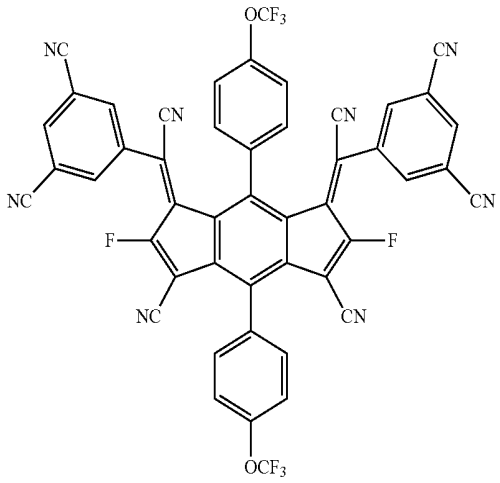

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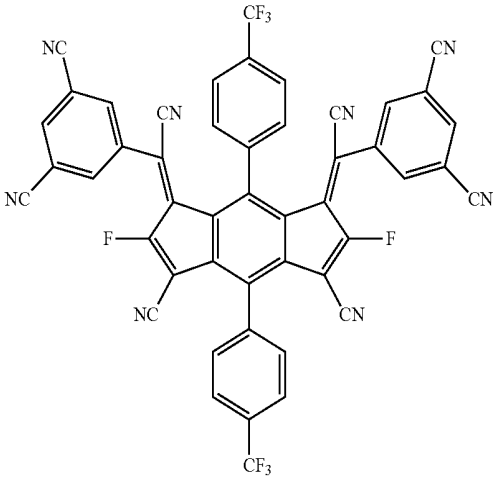

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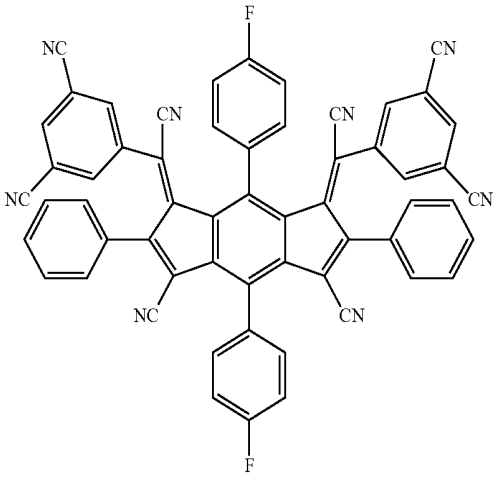

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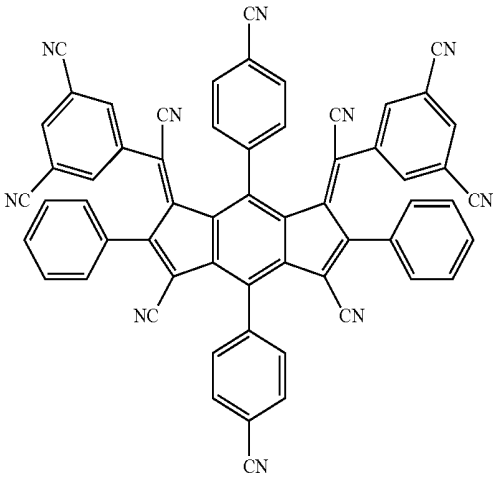

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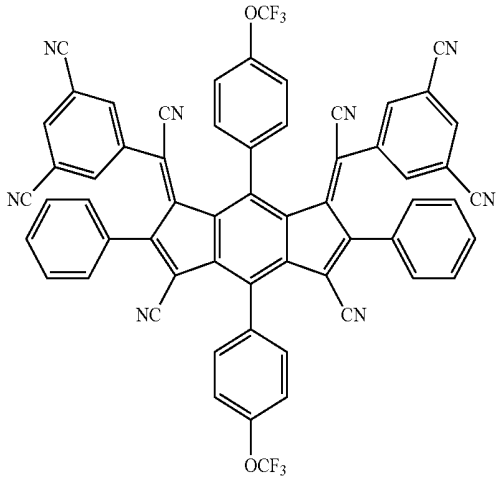

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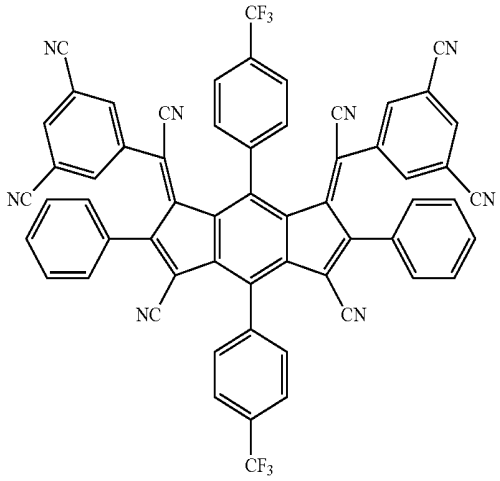

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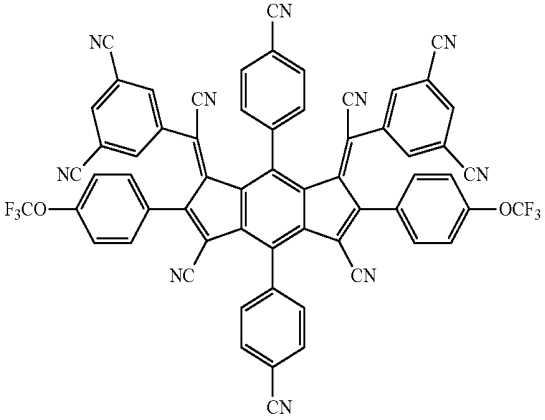

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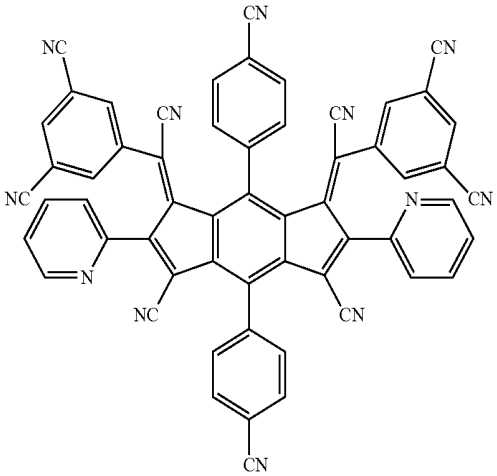

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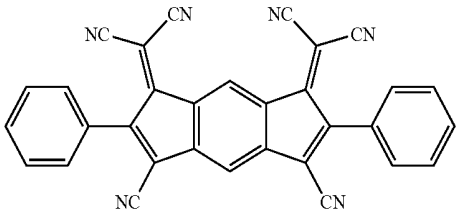

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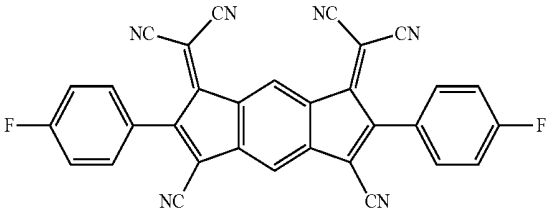

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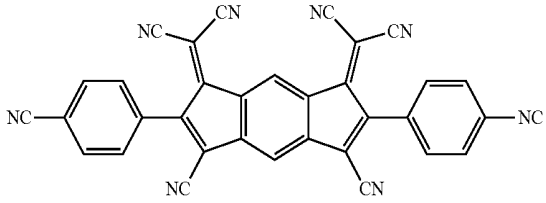

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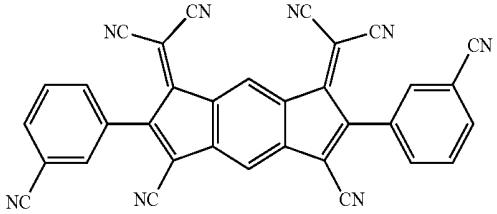

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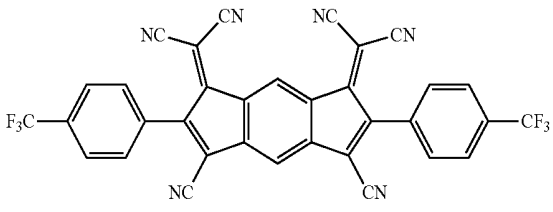

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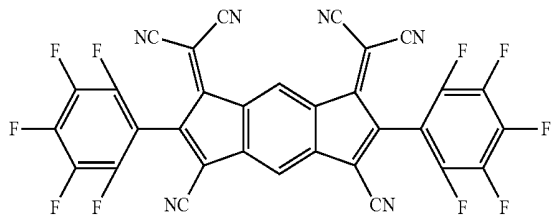

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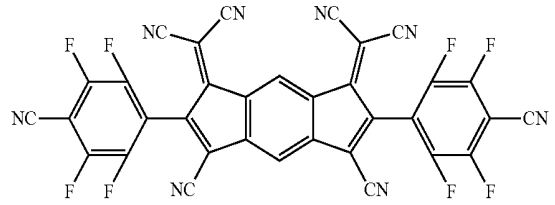

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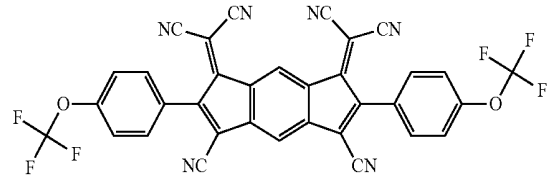

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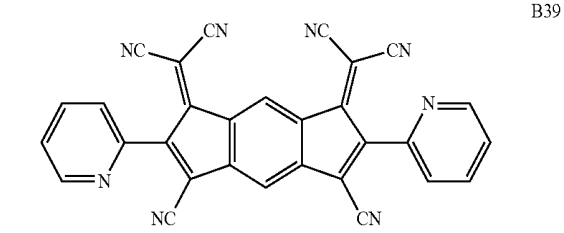

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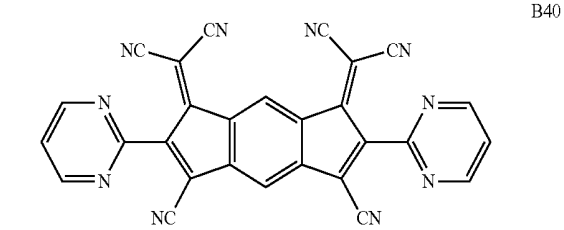

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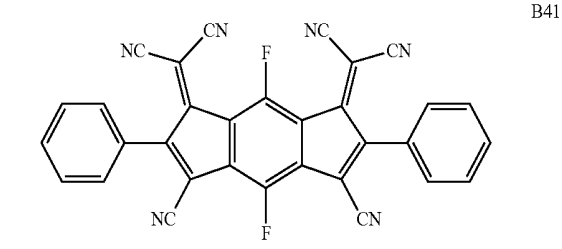

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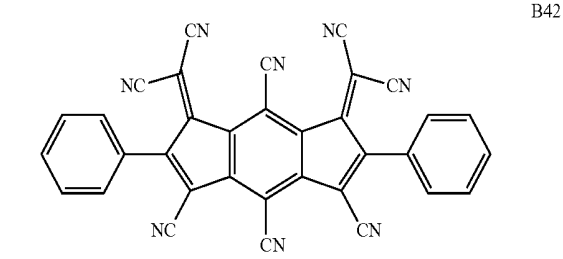

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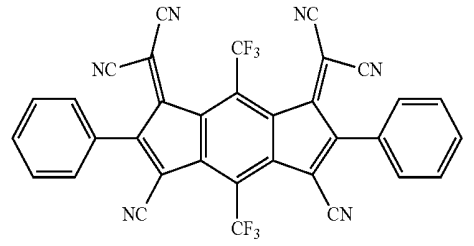

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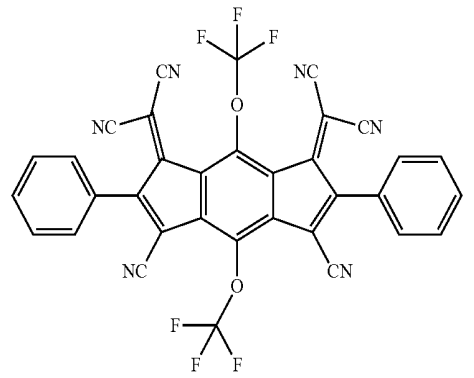

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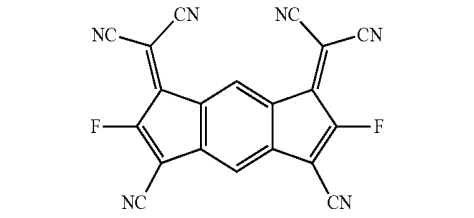

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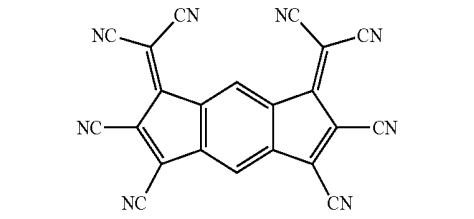

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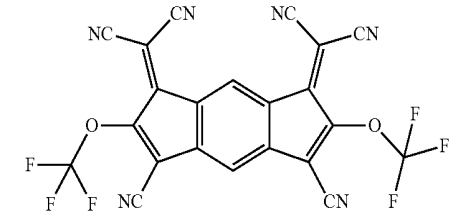

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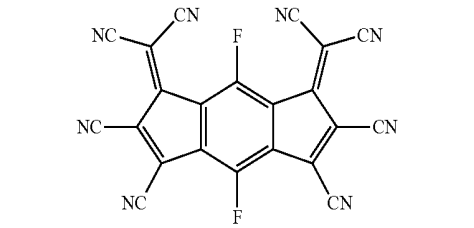

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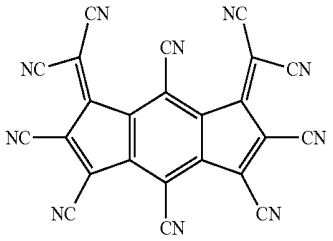

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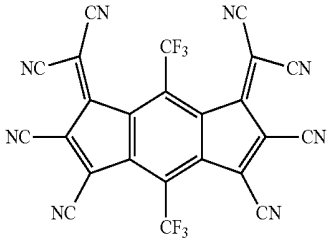

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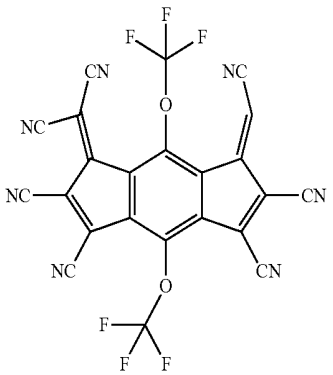

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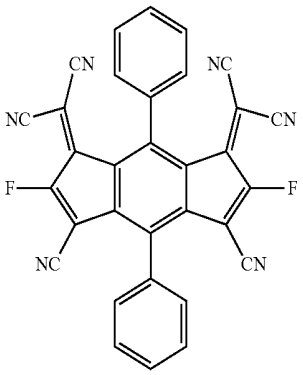

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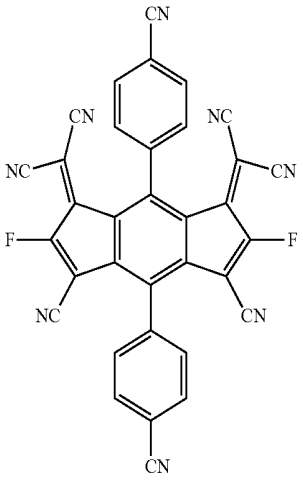

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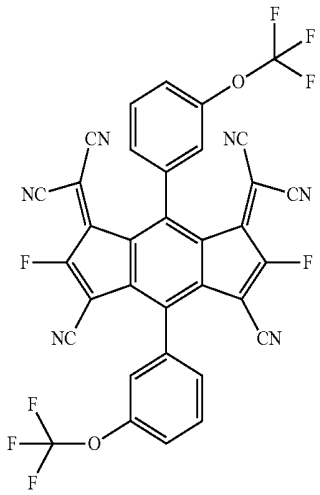
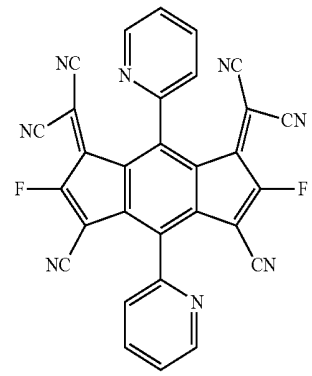
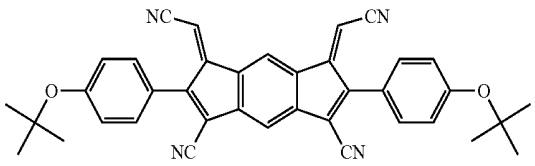
B54



B55



B56



The above-described compound of this disclosure comprises indene as a core, which provides process stability against heat or deposition, thus simplifying the composition and deposition of the compound. Moreover, the compound of this disclosure improves the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of the host of the hole injection layer, the host of the P-type charge generation layer, or the hole transport layer.

Accordingly, the hole injection layer is formed of the compound of this disclosure to ensure the process stability of the compound, simplifying the fabrication of the organic light emitting display device. Moreover, the compound of this disclosure can reduce the device's operating voltage and improve its efficiency and lifetime since the improvement in hole injection properties helps to facilitate the transfer of holes from the anode to the light emitting layer.

The hole injection layer **120** may be formed of a compound of this disclosure, or may comprise the compound as a dopant. The hole injection layer **120** may form solely of a compound of this disclosure. Also, if the hole injection layer **120** comprises a compound of this disclosure as a dopant, the hole injection layer **120** may comprise one or more hosts among CuPc(copper phthalocyanine), PEDOT(poly(3,4)-

ethylenedioxythiophene), PANI(polyaniline), DNTPD(N1', N1"-(biphenyl-4,4'-diyl)bis(N^1-phenyl-N^4,N^4-di-m-tolyl-benzene-1,4-diamine), and NPD(N,N'-bis(naphthalene-1-yl)-N,N'-bis(phenyl)-2,2'-dimethylbenzidine) and a dopant comprising the compound of this disclosure.

The hole injection layer **120** may have a 1 to 150 nm thickness. If the hole injection layer **120** has a 1 nm thickness or greater, the hole injection properties may be improved. If the hole injection layer **120** has a 150 nm thickness or less, an increase in the thickness of the hole injection layer **120** may be prevented and a rise in operating voltage may be therefore prevented.

The hole transport layer **130** may function to facilitate hole transport, and may be formed of, but is not limited to, one or more among NPD(N,N'-bis(naphthalene-1-yl)-N,N'-bis(phenyl)-2,2'-dimethylbenzidine), TPD(N,N'-bis-(3-methylphenyl)-N,N'-bis(phenyl)-benzidine), spiro-TAD(2,2'7,7'-tetrakis(N,N-diphenylamino)-9,9'-spirofluorene), NPB(N,N'-bis(naphthalene-1-yl-N,N'-bis(phenyl)-benzidine), and MTDATA(4,4',4"-Tris(N-3-methylphenyl-N-phenylamino)-triphenylamine). The hole transport layer **130** may have a 1 to 150 nm thickness. If the hole transport layer **130** has a 1 nm thickness or greater, the hole transport properties may be improved, or if the hole transport layer **130** has a 150 nm thickness or less, an increase in the thickness of the hole transport layer **130** may be prevented, and a rise in operating voltage may be therefore prevented. Moreover, an electron blocking layer may be further formed over the hole transport layer **130**.

The light emitting layer **140** may emit light of red (R), green (G), or blue (B), and may be formed of a fluorescent material or phosphorescent material.

If the light emitting layer **140** is a red light emitting layer, it may be formed of, but is not limited to, a fluorescent material comprising PBD:Eu(DBM)$_3$(Phen) or perylene. If the light emitting layer **140** is a green light emitting layer, it may be formed of, but is not limited to, a fluorescent material comprising Alq$_3$(tris(8-hydroxyquinolinato)aluminum). If the light emitting layer **140** is a blue light emitting layer, it may be formed of, but is not limited to, a fluorescent material comprising one among spiro-BDAVBi(2,7-bis[4-(diphenylamino)styryl]-9,9-spirofluorene), spiro-CBP(2,2',7,7'-tetrakis(carbozol-9-yl)-9,9-spirofluorene), distyrylbenzene (DSB), distyrylarylene (DSA), a PFO (polyfluorene) polymer, and a PPV(polyphenylenevinylene) polymer.

The electron transport layer **150** may function to facilitate the transport of electrons, and may be formed of, but is not limited to, one or more among Alq$_3$(tris(8-hydroxyquinolinato)aluminum), PBD(2-4-biphenyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole), TAZ(3-(4-biphenyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole), DPT(2-biphenyl-4-yl-4,6-bis-(4'-pyridin-2-yl-biphenyl-4-yl)-[1,3,5]triazine), and BAlq(Bis(2-methyl-8-quinolinolato)-4-(phenylphenolato)aluminum). The electron transport layer **150** may have a 1 to 150 nm thickness. If the electron transport layer **150** has a 1 nm thickness or greater, a degradation of the electron transport properties may be prevented. If the electron transport layer **150** has a 150 nm thickness or less, an increase in the thickness of the electron transport layer **150** may be prevented, and a rise in operating voltage may be therefore prevented.

The electron injection layer **210** functions to facilitate electron injection, and may be formed of, but is not limited to, one among Alq$_3$(tris(8-hydroxyquinolinato)aluminum), PBD(2-4-biphenyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole), TAZ(3-(4-biphenyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole), and BAlq(Bis(2-methyl-8-quinolinolato)-4-(phenylphenolato)aluminum). On the other hand, the electron injection layer **210** may be formed of a metal compound, and the metal compound may be, for example, but is not limited to, one or more among LiQ, LiF, NaF, KF, RbF, CsF, FrF, BeF$_2$, MgF$_2$, CaF$_2$, SrF$_2$, BaF$_2$, and RaF$_2$. The electron injection layer **210** may have a 1 to 50 nm thickness. If the electron injection layer **210** has a 1 nm thickness or greater, a degradation of the electron injection properties may be prevented. If the electron injection layer **210** has a 50 nm thickness or less, an increase in the thickness of the electron injection layer **210** may be prevented, and a rise in operating voltage may be therefore prevented. The electron injection layer **210** may not be included in the elements of the organic light emitting display device, depending on the structure or characteristics of the device.

The cathode **220** is an electron injection electrode, and may be formed of magnesium (Mg), calcium (Ca), aluminum (Al), silver (Ag), or an alloy thereof, having a low work function. If the organic light emitting display device is a top-emission type or a dual-emission type, the cathode **220** may be formed thin enough to pass light therethrough. If the organic light emitting display device is a bottom-emission type, the cathode **220** may be formed thick enough to reflect light.

As above, a compound of this disclosure comprises indene as a core, which provides process stability against heat or deposition, thus simplifying the composition and deposition of the compound. Moreover, the compound of this disclosure improves the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of the host of the hole injection layer, the host of the P-type charge generation layer, or the hole transport layer.

Accordingly, the hole injection layer is formed of the compound of this disclosure to ensure the process stability of the compound, which simplifies the fabrication of the organic light emitting display device. Moreover, the compound of this disclosure can reduce the device's operating voltage and improve its efficiency and lifetime since the improvement in hole injection properties helps to facilitate the transfer of holes from the anode to the light emitting layer.

FIG. **2** is a view showing an organic light emitting display device according to a second exemplary embodiment of the present disclosure. The same elements as the first exemplary embodiment are denoted by the same reference numerals, so descriptions of these elements will be omitted or may be brief below.

Referring to FIG. **2**, an organic light emitting display device **100** of the present disclosure comprises light emitting parts ST**1** and ST**2** between an anode **110** and a cathode **220**, and a charge generation layer **160** between the light emitting parts ST**1** and ST**2**.

The first light emitting part ST**1** comprises a first light emitting layer **140**. The first light emitting layer **140** may emit light of red (R), green (G), or blue (B), and may be formed of a fluorescent or phosphorescent material. In this exemplary embodiment, the first light emitting layer **140** may be a blue light emitting layer. The blue light emitting layer comprises one among a blue light emitting layer, a dark blue light emitting layer, and a sky blue light emitting layer. Alternatively, the first light emitting layer **140** may form of a blue light emitting layer and a red light emitting layer, a blue light emitting layer and a yellow-green light emitting layer, or a blue light emitting layer and a green light emitting

layer. If the first light emitting layer **140** is a blue light emitting layer, it may emit light over a wavelength range of 440 to 480 nm. If the first light emitting layer **140** forms of a blue light emitting layer and a red light emitting layer, it may emit light over a wavelength range of 440 to 650 nm. If the first light emitting layer **140** forms of a blue light emitting layer and a yellow-green light emitting layer, it may emit light over a wavelength range of 440 to 590 nm. If the first light emitting layer **140** forms of a blue light emitting layer and a green light emitting layer, it may emit light over a wavelength range of 440 to 580 nm.

The first light emitting part ST**1** comprises a hole injection layer **120** and a first hole transport layer **130** that are between the anode **110** and the first light emitting layer **140**, and a first electron transport layer **150** on the first light emitting layer **140**. Accordingly, the first light emitting part ST**1** comprising the hole injection layer **120**, first hole transport layer **130**, first light emitting layer **140**, and first electron transport layer **150** is formed on the anode **110**. The first hole transport layer **130** may be formed of, but is not limited to, the same material as the hole transport layer **130** explained with reference to FIG. **1**.

A charge generation layer (CGL) **160** is between the first light emitting part ST**1** and the second light emitting part ST**2**. The first light emitting part ST**1** and the second light emitting part ST**2** are connected by the charge generation layer **160**. The charge generation layer **160** may be a PN-junction charge generation layer formed by joining an N-type charge generation layer **160**N and a P-type charge generation layer **160**P. The PN junction charge generation layer **160** generates a charge, or injects the charge (i.e., electrons and holes), separately into the light emitting layer. That is, the N-type charge generation layer **160**N transfers electrons to the first electron transport layer **150**, and the first electron transport layer **150** supplies the electrons to the first light emitting layer **140** adjacent to the anode, and the P-type charge generation layer **160**P transfers holes to the second hole transport layer **180**, and the second hole transport layer **180** supplies the holes to the second light emitting layer **190** of the second light emitting part ST**2**. As such, the luminous efficiency of the first and second light emitting layers **140** and **190** may be further increased, and the operating voltage may be reduced.

The N-type charge generation layer **160**N may be formed of a metal or an N-doped organic material. The metal may be one among Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, La, Ce, Sm, Eu, Tb, Dy, and Yb. An N-type dopant and host for the N-doped organic material may be commonly-used materials. For example, the N-type dopant may be an alkali metal, an alkali metal compound, an alkali earth metal, or an alkali earth metal compound. Specifically, the N-type dopant may be one among Li, Cs, K, Rb, Mg, Na, Ca, Sr, Eu, and Yb. The host material may be an organic matter that has a nitrogen atom-containing hetero ring, with 20 to 60 carbon atoms, for example, one material among Alq_3(tris(8-hydroxyquinolinato)aluminum), triazine, a hydroxyquinoline derivative, a benzazole derivative, and a silole derivative.

The P-type charge generation layer **160**P may be formed of the same material as the hole injection layer **120** of the above-described first exemplary embodiment. A compound of this disclosure comprises indene as a core, which provides process stability against heat or deposition, thus simplifying the composition and deposition of the compound. Moreover, the compound of this disclosure improves the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of the hole transport layer.

Accordingly, the P-type charge generation layer is formed of the compound of this disclosure to ensure the process stability of the compound, which simplifies the fabrication of the organic light emitting display device. Moreover, the compound of this disclosure can reduce the device's operating voltage and improve its efficiency and lifetime since the improvement in hole injection properties helps to facilitate the transfer of holes from the anode to the light emitting layer.

The second light emitting part ST**2** comprising a second hole transport layer **180**, the second light emitting layer **190**, a second electron transport layer **200**, and an electron injection layer **210** is on the charge generation layer **160**.

The second light emitting layer **190** may emit light of red (R), green (G), blue (B), or yellow-green (YG), and may be formed of a fluorescent or phosphorescent material. In this exemplary embodiment, the second light emitting layer **190** may be a light emitting layer that emits yellow-green light. The second light emitting layer **190** may have a single layer structure of a yellow-green light emitting layer or a green light emitting layer, or a multilayer structure formed of a yellow-green light emitting layer and a green light emitting layer. The second light emitting layer **190** comprises a yellow-green light emitting layer, a green light emitting layer, or a multilayer structure formed of a yellow-green light emitting layer and a green light emitting layer, a yellow light emitting layer and a red light emitting layer, a green light emitting layer and a red light emitting layer, or a yellow-green light emitting layer and a red light emitting layer. If the second light emitting layer **190** forms of a yellow-green light emitting layer, a green light emitting layer, or a yellow-green light emitting layer and a green light emitting layer, it may emit light over a wavelength range of 510 to 590 nm. If the second light emitting layer **190** is formed of a yellow light emitting layer and a red light emitting layer, a green light emitting layer and a red light emitting layer, or a yellow-green light emitting layer and a red light emitting layer, it may emit light over a wavelength range of 510 to 650 nm.

This exemplary embodiment will be described by taking as an example a single layer structure of a second light emitting layer **190** that emits yellow-green light. The second light emitting layer **190** may comprise, but is not limited to, at least one host of CBP (4,4'-bis(carbazol-9-yl)biphenyl) and BAlq(Bis(2-methyl-8-quinolinolato)-4-(phenylphenolato)aluminum) and a phosphorescent yellow-green dopant that emits yellow-green light.

The second light emitting part ST**2** comprises the second hole transport layer **180** between the charge generation layer **160** and the second light emitting layer **190**, and comprises the second electron transport layer **200** and electron injection layer **210** on the second light emitting layer **190**. The second hole transport layer **180** may be formed of, but is not limited to, the same material as the hole transport layer **130** explained with reference to FIG. **1**.

Accordingly, the second light emitting part ST**2** comprising the second hole transport layer **180**, second light emitting layer **190**, second electron transport layer **200**, and electron injection layer **210** is formed on the charge generation layer **160**. The cathode **220** is provided on the second light emitting part ST**2** to constitute the organic light emitting display device according to the second exemplary embodiment of the present disclosure.

The above-described second exemplary embodiment of the present disclosure has disclosed that the P-type charge

generation layer **160**P comprise a compound of this disclosure. As in the above-described first exemplary embodiment, the compound of this disclosure may be also used as the hole injection layer **120**. The compound of this disclosure may be included in at least one among the hole injection layer **120** and the P-type charge generation layer **160**P.

As above, a compound of this disclosure comprises indene as a core, which provides process stability against heat or deposition, thus simplifying the composition and deposition of the compound. Moreover, the compound of this disclosure improves the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of host of the hole injection layer, the host of the P-type charge generation layer, or the hole transport layer.

Accordingly, at least one among the hole injection layer and the P-type charge generation layer is formed of the compound of this disclosure to ensure the process stability of the compound, which simplifies the fabrication of the organic light emitting display device. Moreover, the compound of this disclosure can reduce the device's operating voltage and improve its efficiency and lifetime since the improvement in hole injection properties helps to facilitate the transfer of holes from the anode to the light emitting layer.

FIG. **3** is a view showing an organic light emitting display device according to a third exemplary embodiment of the present disclosure. The same elements as the first and second exemplary embodiments are denoted by the same reference numerals, so descriptions of these elements will be omitted or may be brief below.

Referring to FIG. **3**, an organic light emitting display device **100** of the present disclosure comprises a plurality of light emitting parts ST**1**, ST**2**, and ST**3** between an anode **110** and a cathode **220**, and a first charge generation layer **160** and a second charge generation layer **230** that are between the light emitting parts ST**1**, ST**2**, and ST**3**. Although this exemplary embodiment has been illustrated and described with an example where three light emitting parts are between the anode **110** and the cathode **220**, the present disclosure is not limited to this example and four or more light emitting parts may be between the anode **110** and the cathode **220**.

Among the light emitting parts, the first light emitting part ST**1** comprises a first light emitting layer **140**. The first light emitting layer **140** may emit light one among red, green, and blue. For example, it may be a blue light emitting layer in this exemplary embodiment. The blue light emitting layer comprises one among a blue light emitting layer, a dark blue light emitting layer, and a sky blue light emitting layer. Alternatively, the first light emitting layer **140** may form of a blue light emitting layer and a red light emitting layer, a blue light emitting layer and a yellow-green light emitting layer, or a blue light emitting layer and a green light emitting layer. If the first light emitting layer **140** is a blue light emitting layer, it may emit light over a wavelength range of 440 to 480 nm. If the first light emitting layer **140** forms of a blue light emitting layer and a red light emitting layer, it may emit light over a wavelength range of 440 to 650 nm. If the first light emitting layer **140** forms of a blue light emitting layer and a yellow-green light emitting layer, it may emit light over a wavelength range of 440 to 590 nm. If the first light emitting layer **140** forms of a blue light emitting layer and a green light emitting layer, it may emit light over a wavelength range of 440 to 580 nm.

The first light emitting part ST**1** comprises a hole injection layer **120** and a first hole transport layer **130** that are between the anode **110** and the first light emitting layer **140**, and a first electron transport layer **150** on the first light emitting layer **140**. Accordingly, the first light emitting part ST**1** comprising the hole injection layer **120**, the first hole transport layer **130**, the first light emitting layer **140**, and the first electron transport layer **150** is formed on the anode **110**.

The second light emitting part ST**2** comprising a second light emitting layer **190** is on the first light emitting part ST**1**. The second light emitting layer **190** may emit light of one among red, green, blue, and yellow-green. For example, it may be a yellow-green light emitting layer in this exemplary embodiment. The second light emitting layer **190** comprises a yellow-green light emitting layer, a green light emitting layer, or a multilayer structure formed of a yellow-green light emitting layer and a green light emitting layer, a yellow light emitting layer and a red light emitting layer, a green light emitting layer and a red light emitting layer, or a yellow-green light emitting layer and a red light emitting layer. If the second light emitting layer **190** forms of a yellow-green light emitting layer, a green light emitting layer, or a yellow-green light emitting layer and a green light emitting layer, it may emit light over a wavelength range of 510 to 590 nm. If the second light emitting layer **190** forms of a yellow light emitting layer and a red light emitting layer, a green light emitting layer and a red light emitting layer, or a yellow-green light emitting layer and a red light emitting layer, it may emit light over a wavelength range of 510 to 650 nm.

The second light emitting part ST**2** further comprises a second hole transport layer **180** on the first light emitting part ST**1**, and comprises a second electron transport layer **200** on the second light emitting layer **190**. Accordingly, the second light emitting part ST**2** comprising the second hole transport layer **180**, the second light emitting layer **190**, and the second electron transport layer **200** is formed on the first light emitting part ST**1**.

A first charge generation layer **160** is between the first light emitting part ST**1** and the second light emitting part ST**2**. The first charge generation layer **160** is a PN-junction charge generation layer formed by joining an N-type charge generation layer **160**N and a P-type charge generation layer **160**P. The first charge generation layer **160** generates a charge, or injects the charge, i.e., electrons and holes, separately into the first and second light emitting layers **140** and **190**.

The third light emitting part ST**3** comprising a third light emitting layer **250** is on the second light emitting part ST**2**. The third light emitting layer **250** may emit light one among red, green, and blue, and be formed of a fluorescent material. For example, it may be a blue light emitting layer in this exemplary embodiment. The blue light emitting layer comprises one among a blue light emitting layer, a dark blue light emitting layer, and a sky blue light emitting layer. Alternatively, the third light emitting layer **250** may form of a blue light emitting layer and a red light emitting layer, a blue light emitting layer and a yellow-green light emitting layer, or a blue light emitting layer and a green light emitting layer. If the third light emitting layer **250** is a blue light emitting layer, it may emit light over a wavelength range of 440 to 480 nm. If the third light emitting layer **250** forms of a blue light emitting layer and a red light emitting layer, it may emit light over a wavelength range of 440 to 650 nm. If the third light emitting layer **250** forms of a blue light emitting layer and a yellow-green light emitting layer, it may emit light over a wavelength range of 440 to 590 nm. If the

third light emitting layer **250** forms of a blue light emitting layer and a green light emitting layer, it may emit light over a wavelength range of 440 to 580 nm.

The third light emitting part ST**3** further comprises a third hole transport layer **240** on the second light emitting part ST**2**, and a third electron transport layer **260** and an electron injection layer **210** that are on the third light emitting layer **250**. Accordingly, the third light emitting part ST**3** comprising the third hole transport layer **240**, third light emitting layer **250**, third electron transport layer **260**, and electron injection layer **210** is formed on the second light emitting part ST**2**. The electron injection layer **210** may not be included in the elements of the third light emitting part ST**3**, depending on the structure or characteristics of the device.

The second charge generation layer **230** is between the second light emitting part ST**2** and the third light emitting part ST**3**. The second charge generation layer **230** is a PN junction charge generation layer formed by joining the N-type charge generation layer **230**N and the P-type charge generation layer **230**P. The second charge generation layer **230** generates a charge, or injects the charge (i.e., electrons and holes), separately into the second and third light emitting layers **190** and **250**. The cathode **220** is provided on the third light emitting part ST**3** to constitute the organic light emitting display device according to the third exemplary embodiment of the present disclosure.

At least one among the hole injection layer **120**, the P-type charge generation layer **160**P of the first charge generation layer **160**, and the P-type charge generation layer **260**P of the second charge generation layer **260** is formed of a compound of this disclosure, as in the case of the foregoing exemplary embodiments. A compound of this disclosure comprises indene as a core, which provides process stability against heat or deposition, thus simplifying the composition and deposition of the compound. Moreover, the compound of this disclosure improves the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of host of the hole injection layer, the host of the P-type charge generation layer, or the hole transport layer.

Accordingly, at least one among the hole injection layer and the P-type charge generation layer is formed of the compound of this disclosure to ensure the process stability of the compound, which simplifies the fabrication of the organic light emitting display device. Moreover, the compound of this disclosure can reduce the device's operating voltage and improve its efficiency and lifetime since the improvement in hole injection properties helps to facilitate the transfer of holes from the anode to the light emitting layer.

Organic light emitting displays using the organic light emitting display device according to the first to third exemplary embodiments of the present disclosure may include top emission displays, bottom emission displays, dual emission displays, and vehicle lighting. The vehicle lighting may include, but are not necessarily limited to, headlights, high beams, taillights, brake lights, and back-up lights. Moreover, organic light emitting displays using the organic light emitting display devices according to the first to third exemplary embodiments of the present disclosure may be applied to mobile devices, tablet PCs, monitors, smartwatches, laptop computers, vehicle displays, etc. Besides, these organic light emitting displays may be applied to vehicle displays, wearable displays, foldable displays, rollable displays, etc.

Also, organic light emitting displays using the organic light emitting display device according to the second exemplary embodiment of the present disclosure may be applied to displays in which the first and second light emitting layers emit light of the same color.

Also, organic light emitting displays using the organic light emitting display device according to the third exemplary embodiment of the present disclosure may be applied to displays in which at least two of the first, second, and third light emitting layers emit light of the same color.

FIGS. **4** and **5** are energy band diagrams of an organic light emitting display device of the present disclosure. Referring to FIG. **4**, the anode **110**, the hole injection layer **120**, the hole transport layer **130**, and the light emitting layer **140** are illustrated. The hole injection layer **120** may be formed of a single material comprising a compound of this disclosure. The hole transport layer **130** may be formed of, for example, NPD. Since the LUMO energy level of the compound in the hole injection layer **120** is similar to or lower than the HOMO energy level of the hole transport layer **130**, electrons are accepted from the HOMO energy level of the hole transport layer **130** to the LUMO energy level of the compound, thereby forming a hole transport path. Accordingly, holes can be smoothly injected from the hole injection layer **120** into the hole transport layer **130** through the hole transport path (indicated by the arrows) between the hole injection layer **120** and the hole transport layer **130**.

Referring to FIG. **5**, the hole injection layer **120** may comprise a dopant introduced into a host. Accordingly, a compound of this disclosure acts as the dopant. Since the LUMO energy level of the compound used as a dopant for the hole injection layer **120** is similar to or lower than the HOMO energy level of the host, electrons are accepted from the HOMO energy level of the host to the LUMO energy level of the compound of this disclosure, thereby forming a hole transport path (indicated by the arrow). Accordingly, holes can be smoothly injected from the hole injection layer **120** into the hole transport layer **130** through the hole transport path between the HOMO energy level of the host and the LUMO energy level of the compound of this disclosure, within the hole injection layer **120**. As a result, the use of the compound of this disclosure as a dopant for the hole injection layer **120** facilitates the transfer of holes from the hole injection layer **120** into the hole transport layer **130**, leading to a reduction in operating voltage.

Although FIGS. **4** and **5** are explained with respect to the hole injection layer by way of example, the same may apply when the hole injection layer **120** is replaced with the P-type charge generation layer **160**P of FIG. **2** and the hole transport layer **130** is replaced with the second hole transport layer **170** of FIG. **2**. Accordingly, referring to FIG. **4**, if the hole injection layer **120** is replaced with the P-type charge generation layer **160**P of FIG. **2**, the P-type charge generation layer **160**P may be formed of a single material comprising a compound of this disclosure. Also, referring to FIG. **5**, the P-type charge generation layer **160**P may comprise a compound of this disclosure as a dopant.

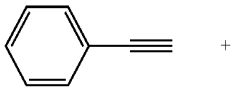
Moreover, the same applies when the hole injection layer **120** is replaced with the P-type charge generation layer **160**P of FIG. **3** and the hole transport layer **130** is replaced with the second hole transport layer **170** of FIG. **3**. Accordingly, referring to FIG. **4**, if the hole injection layer **120** is replaced with the P-type charge generation layer **160**P of FIG. **3**, the P-type charge generation layer **160**P may be formed of a single material comprising a compound of this disclosure. Also, referring to FIG. **5**, the P-type charge generation layer **160**P may comprise a compound of this disclosure as a dopant.

Furthermore, the same applies when the hole injection layer **120** is replaced with the P-type charge generation layer **230**P of FIG. **3** and the hole transport layer **130** is replaced with the third hole transport layer **240** of FIG. **3**. Accordingly, referring to FIG. **4**, if the hole injection layer **120** is replaced with the P-type charge generation layer **230**P of FIG. **3**, the P-type charge generation layer **230**P may be formed of a single material comprising a compound of this disclosure. Also, referring to FIG. **5**, the P-type charge generation layer **230**P may comprise a compound of this disclosure as a dopant.

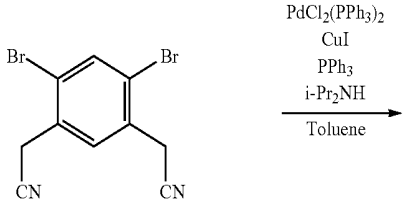
Hereinafter, synthesis examples of compounds of the present disclosure will be described in detail. However, the following examples are only for illustration, and the present disclosure is not limited thereto.

Synthesis of Compound B31

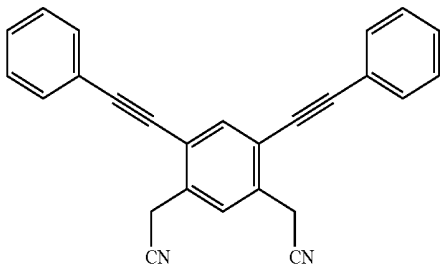
1) Preparation of 1,5-bis(chloromethyl)-2,4-bis(2-phenylethynyl)benzene



1-ethynylbenzene

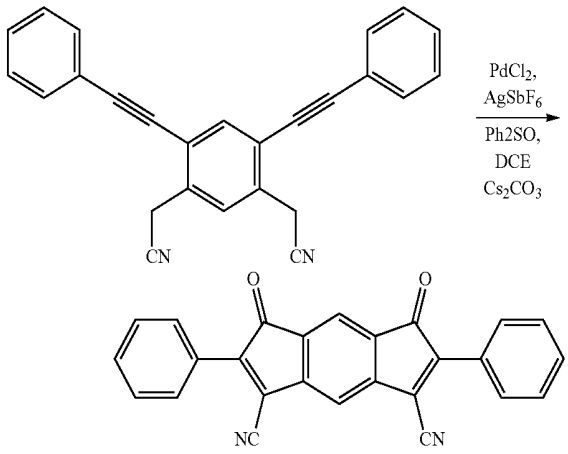


1,5-dibromophenyl-2,4-dicarbonitrile



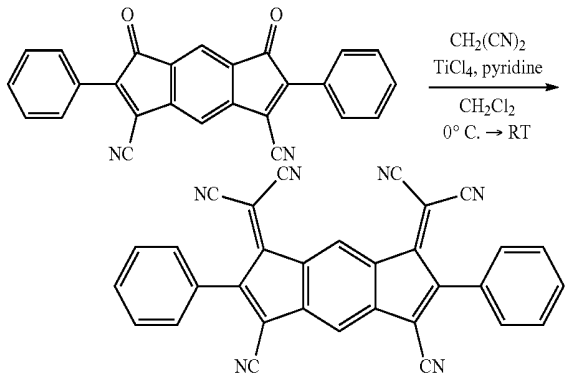
2-bromophenyl)acetonitrile (0.12 mol), bis(triphenylphosphine)palladium(II)chloride ($PdCl_2(PPh_3)_2$) (2 mmol), copper iodide (CuI) (2 mmol), triphenylphosphine (PPh_3) (4 mmol), and diisopropylamine (i-Pr_2NH) (0.1 mol) were put into a 250 ml two-necked flask under a nitrogen atmosphere and stirred for 5 min at room temperature, and then 1,5-dibromophenyl-2,4-dicarbonitrile (0.05 mol) was added to the mixture and stirred for 24 hours at 50° C. An organic layer was obtained by extraction with H_2O/ethyl acetate, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 10.9 g of solid (yield: 61%).

2) Preparation of 3,5-dihydro-3,5-dioxo-2,6-diphenyl-s-indacene-1,7-dicarbonitrile



1,5-bis(chloromethyl)-2,4-bis(2-phenylethynyl)benzene (0.03 mol), palladium(II) chloride ($PdCl_2$) (6.1 mmol), silver hexafluoroantimonate ($AgSbF_6$) (9.1 mmol), and diphenylsulfoxide (Ph_2SO) (0.18 mol) were dissolved in a 250 ml two-necked flask with dichloroethylene (DCE) and stirred for 24 hours at 60° C., and then cesium carbonate (Cs_2CO_3) (0.074 mol) was added to the mixture and stirred for 12 hours. After the reaction, an extract was obtained by extraction with dichloromethane (CH_2Cl_2), which was dried up after the extraction, and then put into 35% hydrochloric acid (HCl) and stirred for 2 hours. An organic layer was obtained by extraction with a dichloromethane/ammonium chloride (CH_2Cl_2/aq.NH_4Cl) solution, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 4.4 g of solid (yield: 38%).

3) Preparation of 3,5-bis(dicyanomethylene)-3,5-dihydro-2,6-diphenyl-s-indacene-1,7-dicarbonitrile



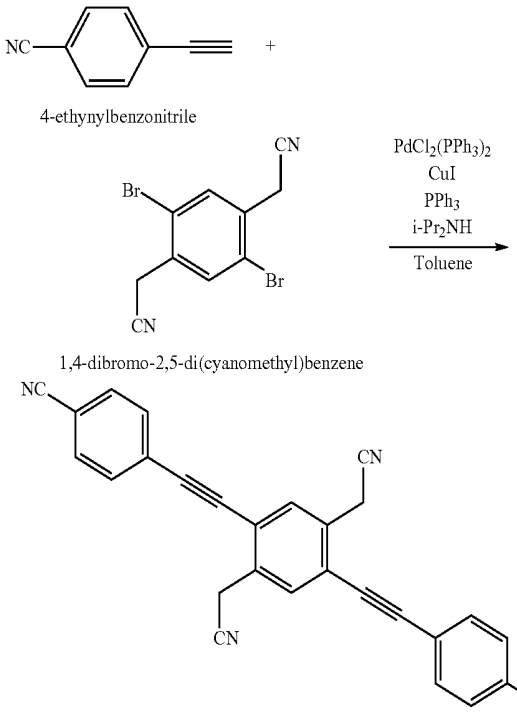
B31

3,5-dihydro-3,5-dioxo-2,6-diphenyl-s-indacene-1,7-dicarbonitrile (0.01 mol), malononitrile (0.062 mol), and dichloromethane (CH_2Cl_2) were put into a 100 ml two-necked flask and stirred for 30 min under an argon atmosphere. Titanium(IV) chloride ($TiCl_4$) (0.062 mol) was slowly added to the mixture, followed by the addition of pyridine (0.1 mol), and stirred at room temperature. An organic layer was obtained by extraction with a dichlo-

romethane/ammonium chloride (CH_2Cl_2/aq.NH_4Cl) solution, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 1.6 g of solid, i.e., Compound B31 (yield: 32%).

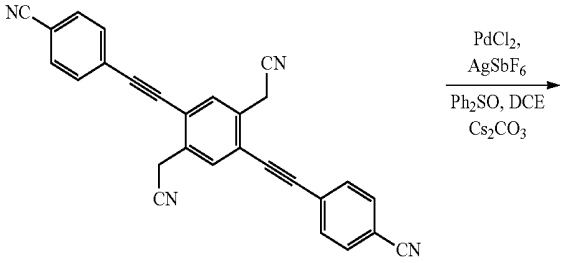
Synthesis of Intermediate

1) Preparation of 1,5-bis(chloromethyl)-2,4-bis(2-phenylethynyl)benzene



4-ethenylbenzonitrile (0.12 mol), bis(triphenylphosphine) palladium(II)chloride ($PdCl_2(PPh_3)_2$) (2 mmol), copper iodide (CuI) (2 mmol), triphenylphosphine (PPh_3) (4 mmol), and diisopropylamine (i-Pr_2NH) (0.1 mol) were put into a 250 ml two-necked flask under a nitrogen atmosphere and stirred for 5 min at room temperature, and then 1,4-dibromo-2,5-di(cyanomethyl)benzene (0.05 mol) was added to the mixture and stirred for 24 hours at 50° C. An organic layer was obtained by extraction with H_2O/ethyl acetate, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 13.8 g of solid (yield: 68%).

2) Preparation of 2,6-bis(4-cyanophenyl)-3,7-dihydro-3,7-dioxo-s-indacene-1,5-dicarbonitrile



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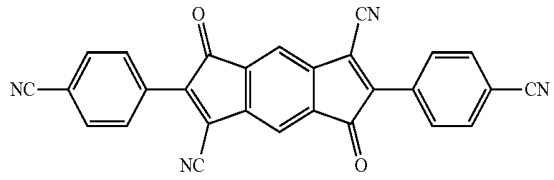
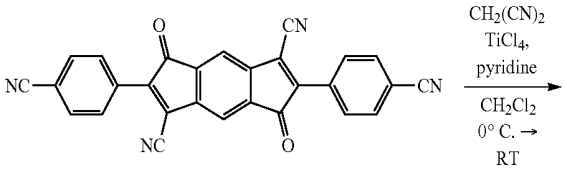
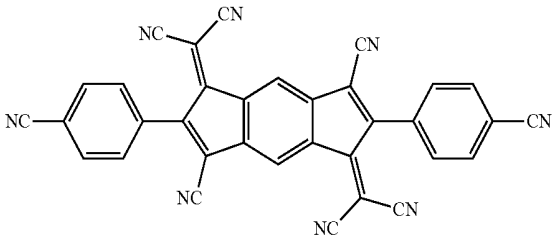


1,4-di(cyanomethyl)-2,5-bis(2-(4-cyanophenyl)ethynyl) benzene (0.034 mol), palladium(II)chloride ($PdCl_2$) (6.8 mmol), silver hexafluoroantimonate ($AgSbF_6$) (10.2 mmol), and diphenylsulfoxide (Ph_2SO) (0.2 mol) were dissolved in a 250 ml two-necked flask with dichloroethylene (DCE) and stirred for 24 hours at 60° C. After the reaction, an extract was obtained by extraction with dichloromethane (CH_2Cl_2), which was dried up after the extraction, and then put into 35% hydrochloric acid (HCl) and stirred for 2 hours. An organic layer was obtained by extraction with a dichloromethane/ammonium chloride (CH_2Cl_2/aq.NH_4Cl) solution, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 5.9 g of solid, i.e., an intermediate, (yield: 48%).

Synthesis of Compound A33

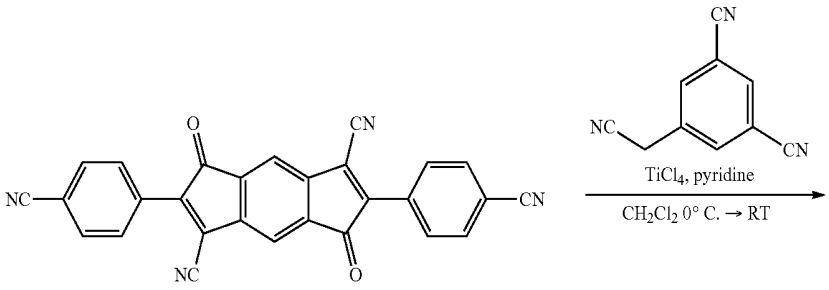


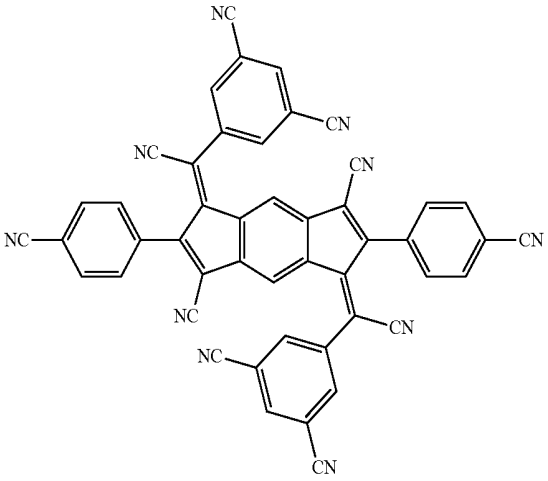


A33

2,6-bis(4-cyanophenyl)-3,7-dihydro-3,7-dioxo-s-indacene-1,5-dicarbonitrile (13.6 mmol), malononitrile (0.082 mol), and dichloromethane (CH_2Cl_2) were put into a 100 ml two-necked flask and stirred for 30 min under an argon atmosphere. Titanium(IV)chloride ($TiCl_4$) (0.082 mol) was slowly added to the mixture, followed by the addition of pyridine (0.1 mol), and stirred at room temperature. After the reaction, an organic layer was obtained by extraction with a dichloromethane/ammonium chloride (CH_2Cl_2/aq.NH_4Cl) solution, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 2.5 g of solid, i.e., Compound A33 (yield: 35%).

Synthesis of Compound A62

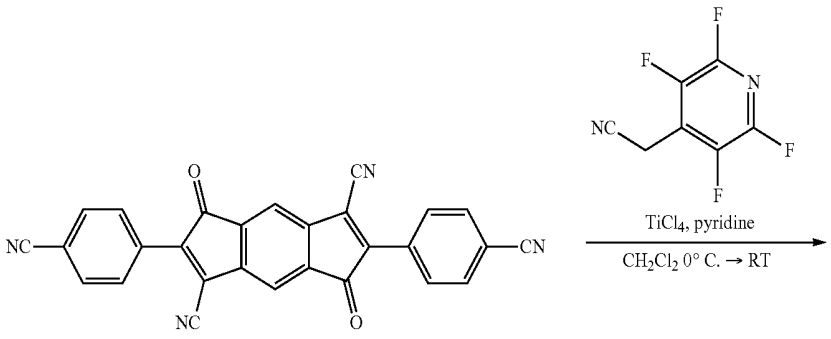




A62

2,6-bis(4-cyanophenyl)-3,7-dihydro-3,7-dioxo-s-indacene-1,5-dicarbonitrile (0.01 mol), 5-(cyanomethyl)benzene-1,3-dinitrile (0.06 mol), and chloromethane (CH_2Cl_2) were put into a 100 ml two-necked flask and stirred for 30 min under an argon atmosphere. Titanium(IV)chloride ($TiCl_4$) (0.06 mol) was slowly added to the mixture, followed by the addition of pyridine (0.1 mol), and stirred at room temperature. An organic layer was obtained by extraction with a dichloromethane/ammonium chloride (CH_2Cl_2/aq.NH_4Cl) solution, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 2.3 g of solid, i.e., Compound A62 (yield: 31%).

Synthesis of Compound A63



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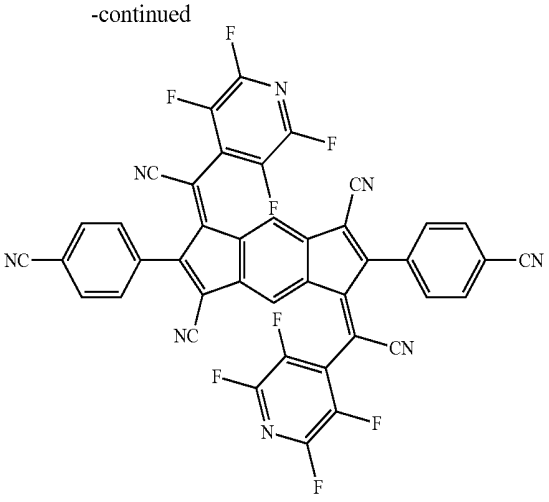


A63

2,6-bis(4-cyanophenyl)-3,7-dihydro-3,7-dioxo-s-indacene-1,5-dicarbonitrile (0.01 mol), 2-(perfluoropyridin-4-yl)acetonitrile (0.06 mol), and chloromethane (CH_2Cl_2) were put into a 100 ml two-necked flask and stirred for 30 min under an argon atmosphere. Titanium(IV)chloride ($TiCl_4$) (0.06 mol) was slowly added to the mixture, followed by the addition of pyridine (0.1 mol), and stirred at room temperature. After the reaction, an organic layer was obtained by extraction with a dichloromethane/ammonium chloride (CH_2Cl_2/aq.NH_4Cl) solution, dried over magnesium sulfate ($MgSO_4$), and then subjected to column chromatography to give 2.2 g of solid, i.e., Compound A63 (yield: 28%).

Hereinafter, examples for fabricating an organic light emitting display device of this disclosure will be disclosed. It should be noted that materials of the following hole injection layer and P-type charge generation layer do not limit the scope of this disclosure.

Test 1: Monolithic Device

Example 1

An organic light emitting display device was fabricated by forming, an anode, a hole injection layer, a hole transport layer, a blue light emitting layer, an electron transport layer, an electron injection layer, and a cathode on a substrate. Here, the hole injection layer was formed of Compound B31. After the deposition of these layers, the device was transferred from the deposition chamber into a dry box for encapsulation, and was subsequently encapsulated using an UV-curable epoxy resin and a moisture getter. The organic light emitting display device thus obtained was connected to an external power supply source, and upon application of direct current voltage, the results in Table 1 were obtained. The characteristics of all the fabricated devices were evaluated using a constant current source (KEITHLEY) and a photometer (PR650) at room temperature.

Example 2

It has the same elements as the above-described Example 1, and the hole injection layer was formed of NPD doped with 10% Compound B31.

Example 3

It has the same elements as the above-described Example 1, and the hole injection layer was formed of Compound A33.

Example 4

It has the same elements as the above-described Example 1, and the hole injection layer was formed of NPD doped with 10% Compound A33.

Example 5

It has the same elements as the above-described Example 1, and the hole injection layer was formed of Compound A62.

Example 6

It has the same elements as the above-described Example 1, and the hole injection layer was formed of NPD doped with 10% Compound A62.

Example 7

It has the same elements as the above-described Example 1, and the hole injection layer was formed of Compound A63.

Example 8

It has the same elements as the above-described Example 1, and the hole injection layer was formed of NPD doped with 10% Compound A63.

Comparative Example 1

It has the same elements as the above-described Example 1, and the hole injection layer was formed HAT-CN.

Comparative Example 2

It has the same elements as the above-described Example 2, and the hole injection layer was formed of NPD doped with 10% HAT-CN.

Comparative Example 3

It has the same elements as the above-described Example 2, but without the hole injection layer.

The operating voltage, efficiency, and external quantum efficiency of the devices fabricated according to Examples 1 to 8 of the present disclosure and Comparative Examples 1, 2, and 3 set forth above were measured and shown in the following Table 1. (The devices were driven at a drive current of 10 mA/cm^2 to measure the operating voltage, efficiency, and external quantum efficiency).

TABLE 1

	Operating voltage (V)	Efficiency (Cd/A)	External quantum efficiency (%)
Example 1	4.2	4.0	4.5
Example 2	4.1	4.4	4.9
Example 3	3.9	4.5	5.2
Example 4	3.8	4.5	5.2
Example 5	4.0	4.3	5.0
Example 6	4.0	4.4	5.1
Example 7	4.1	4.2	5.0
Example 8	4.0	4.4	5.0
Comparative Example 1	4.2	4.1	4.7
Comparative Example 2	6.0	3.0	3.9
Comparative Example 3	6.8	1.8	2.3

Referring to Table 1, Example 1 in which the hole injection layer comprises Compound B31 of this disclosure and Comparative Example 1 in which HAT-CN is used as the hole injection layer showed similar levels of operating voltage, efficiency, and external quantum efficiency. Example 2 in which a hole injection layer of NPD is doped with Compound B31 of this disclosure showed a 1.9 V decrease in operating voltage, a 1.4 cd/A increase in efficiency, and 1.0% increase in external quantum efficiency, compared to Comparative Example 2 in which a hole injection layer of NPD is doped with HAT-CN. Example 1 of this disclosure showed a 2.6 V decrease in operating voltage, a 2.2 cd/A increase in efficiency, and 2.2% increase in external quantum efficiency, and Example 2 showed a 2.7 V decrease in operating voltage, a 2.6 cd/A increase in efficiency, and a 2.6% increase in external quantum efficiency, compared to Comparative Example 3 in which the hole injection layer was not formed.

Also, Example 3 in which the hole injection layer comprises Compound A33 of this disclosure showed a 0.3 V decrease in operating voltage, a 0.4 cd/A increase in efficiency, and a 0.5% increase in external quantum efficiency, compared to Comparative Example 1 in which HAT-CN is used as the hole injection layer. Example 4 in which a hole injection layer of NPD is doped with Compound A33 of this disclosure showed a 2.2 V decrease in operating voltage, a 1.5 cd/A increase in efficiency, and 1.3% increase in external quantum efficiency, compared to Comparative Example 2 in which a hole injection layer of NPD is doped with HAT-CN. Example 3 of this disclosure showed a 2.9 V decrease in operating voltage, a 2.7 cd/A increase in efficiency, and 2.9% increase in external quantum efficiency, and Example 4 showed a 3.0 V decrease in operating voltage, a 2.7 cd/A increase in efficiency, and a 2.9% increase in external quantum efficiency, compared to Comparative Example 3 in which the hole injection layer was not formed.

Also, Example 5 in which the hole injection layer comprises Compound A62 of this disclosure showed a 0.2 V decrease in operating voltage, a 0.2 cd/A increase in efficiency, and a 0.3% increase in external quantum efficiency, compared to Comparative Example 1 in which HAT-CN is used as the hole injection layer. Example 6 in which a hole injection layer of NPD is doped with Compound A62 of this disclosure showed a 2.0 V decrease in operating voltage, a 1.4 cd/A increase in efficiency, and 1.2% increase in external quantum efficiency, compared to Comparative Example 2 in which a hole injection layer of NPD is doped with HAT-CN. Example 5 of this disclosure showed a 2.8 V decrease in operating voltage, a 2.5 cd/A increase in efficiency, and 2.7% increase in external quantum efficiency, and Example 6 showed a 2.8 V decrease in operating voltage, a 2.6 cd/A increase in efficiency, and a 2.8% increase in external quantum efficiency, compared to Comparative Example 3 in which the hole injection layer was not formed.

Also, Example 7 in which the hole injection layer comprises Compound A63 of this disclosure showed a 0.1 V decrease in operating voltage, a 0.1 cd/A increase in efficiency, and a 0.3% increase in external quantum efficiency, compared to Comparative Example 1 in which HAT-CN is used as the hole injection layer. Example 8 in which a hole injection layer of NPD is doped with Compound A63 of this disclosure showed a 2.0 V decrease in operating voltage, a 1.4 cd/A increase in efficiency, and 1.1% increase in external quantum efficiency, compared to Comparative Example 2 in which a hole injection layer of NPD is doped with HAT-CN. Example 7 of this disclosure showed a 2.7 V decrease in operating voltage, a 2.4 cd/A increase in efficiency, and 2.7% increase in external quantum efficiency, and Example 8 showed a 2.8 V decrease in operating voltage, a 2.6 cd/A increase in efficiency, and a 2.7% increase in external quantum efficiency, compared to Comparative Example 3 in which the hole injection layer was not formed

From these results, it can be concluded that the organic light emitting display devices of Examples 1 to 8 in which the hole injection layer comprises a compound of this disclosure achieved a reduction in operating voltage and improvements in efficiency and external quantum efficiency, compared to the organic light emitting display devices of Comparative Examples 1 to 3 in which the hole injection layer is formed of a well-known material. Also, the hole injection layer may form solely of a compound of this disclosure, or this compound may be used as a dopant.

Test 2: Device with Multiple Light Emitting Parts

Example 9

An organic light emitting display device was fabricated by forming, a first light emitting part comprising a hole injection layer, a first hole transport layer, a fluorescent blue light emitting layer, and a first electron transport layer, a charge generation layer comprising an N-type charge generation layer and a P-type charge generation layer, a second light emitting part comprising a second electron injection layer, a fluorescent blue light emitting layer, a second electron transport layer, and an electron injection layer, and a cathode on a substrate. Here, the hole injection layer and the P-type charge generation layer were formed of Compound B31. After the deposition of these layers, the device was transferred from the deposition chamber into a dry box for encapsulation, and was subsequently encapsulated using an UV-curable epoxy resin and a moisture getter. The organic light emitting display device thus obtained was connected to an external power supply source, and upon application of direct current voltage, the results in Table 2 were obtained. The characteristics of all the fabricated devices were evaluated using a constant current source

(KEITHLEY) and a photometer (PR650) at room temperature. Here, the light emitting layers in the first and second light emitting parts are blue light emitting layers, but is not limited thereto.

Example 10

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of NPD doped with 10% Compound B31.

Example 11

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of Compound A33.

Example 12

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of NPD doped with 10% Compound A33.

Example 13

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of Compound A62.

Example 14

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of NPD doped with 10% Compound A62.

Example 15

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of Compound A63.

Example 16

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of NPD doped with 10% Compound A63.

Comparative Example 4

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of HAT-CN.

Comparative Example 5

It has the same elements as the above-described Example 9, and the hole injection layer and the P-type charge generation layer were formed of NPD doped with 10% HAT-CN.

Comparative Example 6

It has the same elements as the above-described Example 9, but without the hole injection layer and the P-type charge generation layer.

The operating voltage, efficiency, and external quantum efficiency of the devices fabricated according to Examples 9 to 16 of the present disclosure and Comparative Examples 4, 5, and 6 set forth above were measured and shown in the following Table 2. (The devices were driven at a drive current of 10 mA/cm' to measure the operating voltage, efficiency, and external quantum efficiency).

TABLE 2

	Operating voltage (V)	Efficiency (Cd/A)	External quantum efficiency (%)
Example 9	9.2	5.3	6.4
Example 10	8.6	6.5	7.5
Example 11	8.2	7.2	8.3
Example 12	8.1	7.2	8.3
Example 13	8.4	6.7	7.8
Example 14	8.5	6.7	7.7
Example 15	8.5	6.7	7.7
Example 16	8.4	6.8	7.8
Comparative Example 4	9.1	5.4	6.6
Comparative Example 5	13.5	4.5	5.1
Comparative Example 6	—	—	—

Referring to Table 2, Example 9 in which the hole injection layer and the P-type charge generation layer comprise Compound B31 of this disclosure and Comparative Example 4 in which HAT-CN is used as the hole injection layer and the P-type charge generation layer showed similar levels of operating voltage, efficiency, and external quantum efficiency. Example 10 in which a hole injection layer and P-type charge generation layer of NPD are doped with Compound B31 of this disclosure showed a 4.9 V decrease in operating voltage, a 2.0 cd/A increase in efficiency, and 2.4% increase in external quantum efficiency, compared to Comparative Example 5 in which a hole injection layer and P-type charge generation layer of NPD are doped with HAT-CN.

Also, Example 11 in which the hole injection layer and the P-type charge generation layer comprise Compound A33 of this disclosure showed a 0.9 V decrease in operating voltage, a 1.8 cd/A increase in efficiency, and a 1.7% increase in external quantum efficiency, compared to Comparative Example 4 in which HAT-CN is used as the hole injection layer and the P-type charge generation layer. Example 12 in which a hole injection layer and P-type charge generation layer of NPD are doped with Compound A33 of this disclosure showed a 5.4 V decrease in operating voltage, a 2.7 cd/A increase in efficiency, and 3.2% increase in external quantum efficiency, compared to Comparative Example 5 in which a hole injection layer and P-type charge generation layer of NPD are doped with HAT-CN.

Also, Example 13 in which the hole injection layer and the P-type charge generation layer comprise Compound A62 of this disclosure showed a 0.7 V decrease in operating voltage, a 1.3 cd/A increase in efficiency, and a 1.2% increase in external quantum efficiency, compared to Comparative Example 4 in which HAT-CN is used as the hole injection layer and the P-type charge generation layer. Example 14 in which a hole injection layer and P-type charge generation layer of NPD are doped with Compound A62 of this disclosure showed a 5.0 V decrease in operating voltage, a 2.2 cd/A increase in efficiency, and 2.6% increase in external quantum efficiency, compared to Comparative Example 5 in which a hole injection layer and P-type charge generation layer of NPD are doped with HAT-CN.

Also, Example 15 in which the hole injection layer and the P-type charge generation layer comprise Compound A63

of this disclosure showed a 0.6 V decrease in operating voltage, a 1.3 cd/A increase in efficiency, and a 1.1% increase in external quantum efficiency, compared to Comparative Example 4 in which HAT-CN is used as the hole injection layer and the P-type charge generation layer. Example 16 in which a hole injection layer and P-type charge generation layer of NPD are doped with Compound A63 of this disclosure showed a 5.1 V decrease in operating voltage, a 2.3 cd/A increase in efficiency, and 2.7% increase in external quantum efficiency, compared to Comparative Example 5 in which a hole injection layer and P-type charge generation layer of NPD are doped with HAT-CN.

In Comparative Example 6 in which the hole injection layer was not formed, the device could not be driven.

Also, at least one among the hole injection layer and the P-type charge generation layer may form solely of a compound of this disclosure, or this compound may be used as a dopant.

For reference, the energy levels of the well-known compounds and the compounds used in the examples of the present disclosure are shown in the following Table 3. The energy levels are calculated by DFT (Density Functional Theory) simulation. The DFT is one of the electronic structure computational methods. The function (basis set) used in the simulation is B3LYP/6-31G*, but is not limited thereto.

TABLE 3

	HOMO (eV)	LUMO (eV)
NPD	−5.45	−2.30
HAT-CN	−9.55	−6.07
F_4-TCNQ	−8.33	−5.78
B31	−7.9	−5.72

Referring to Table 3, it can be found out that a compound of this disclosure showed a LUMO energy level closer to −5.45 eV, which is the HOMO energy level of NPD used as a host for the hole injection layer or P-type charge generation layer, compared to HAT-CN and F_4-TCNQ, known as p-type dopant materials. As such, the LUMO energy level of the compound of this disclosure is similar to or lower than the HOMO energy level of the host for the hole injection layer or P-type charge generation layer, which may lead to an improvement in the hole injection properties.

From these results, it can be concluded that the organic light emitting display device of Example 9 in which the hole injection layer and the P-type charge generation layer comprise a compound of this disclosure achieved almost the same levels of operating voltage, efficiency, and external quantum efficiency as the organic light emitting display device of Comparative Example 4. Also, it can be concluded that the organic light emitting display device of Example 10 in which the hole injection layer and the P-type charge generation layer comprise a compound of this disclosure achieved a 4.9 V decrease in operating voltage, a 2.0 cd/A increase in efficiency, and a 2.4% increase in external quantum efficiency, compared to the organic light emitting display device of Comparative Example 5.

As discussed above, a compound of this disclosure comprises indene as a core, which provides process stability against heat or deposition, thus simplifying the composition and deposition of the compound. Moreover, the compound of this disclosure can improve the hole injection properties by comprising an electron-attracting substituent attached to the core and making the LUMO energy level of the compound similar to or lower than the HOMO energy level of host of the hole injection layer, the host of the P-type charge generation layer, or the hole transport layer.

Accordingly, at least one among the hole injection layer and the P-type charge generation layer is formed of the compound of this disclosure to ensure the process stability of the compound, which simplifies the fabrication of the organic light emitting display device. Moreover, the compound of this disclosure can reduce the device's operating voltage and improve its efficiency and lifetime since the improvement in hole injection properties helps to facilitate the transfer of holes from the anode to the light emitting layer.

It will be apparent to those skilled in the art that various modifications and variations can be made in the organic light emitting display device of the present disclosure without departing from the spirit or scope of the disclosure. Thus, it is intended that the present disclosure cover the modifications and variations of this disclosure provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

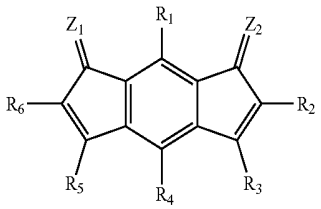
1. An organic light emitting display device, comprising:

at least one light emitting part between an anode and a cathode, the at least one light emitting part having at least one organic layer and a light emitting layer,

wherein the at least one organic layer comprises a hole injection layer,

wherein the hole injection layer comprises a compound represented by Chemical Formula 2:

[Chemical Formula 2]



in the Chemical Formula 2, R_1 to R_6 include independently one among hydrogen, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group, and at least one of R_1 to R_6 comprises a cyano group, and

in Chemical Formula 2, Z_1 and Z_2 are independently represented by the following Chemical Formula 3:

[Chemical Formula 3]

where A and B independently represent one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and

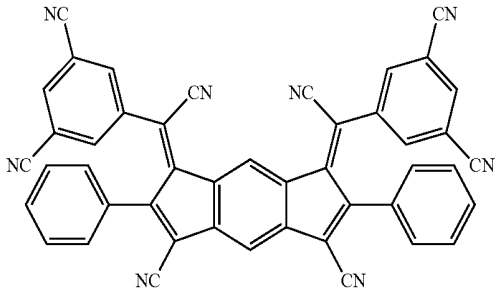
Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group,

wherein Z_1 and Z_2 are attached via a double bond between a carbon atom bound to A and B of Chemical Formula 3 and the indacene ring of Chemical Formula 2.

2. The organic light emitting display device of claim **1**, wherein the substituent of the aryl group, heteroaryl group, alkyl group, alkoxy group, and ether group is one among an alkyl with 1 to 12 carbon atoms, an aryl with 6 to 15 carbon atoms, a hetero alkyl with 1 to 15 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

3. The organic light emitting display device of claim **1**, wherein the compound represented by the above Chemical Formula 2 is one among the following compounds:

B1



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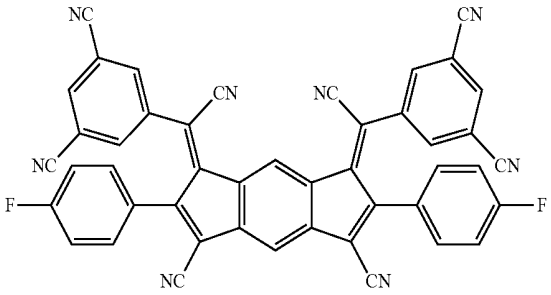

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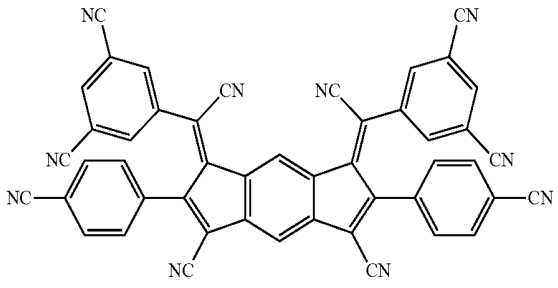

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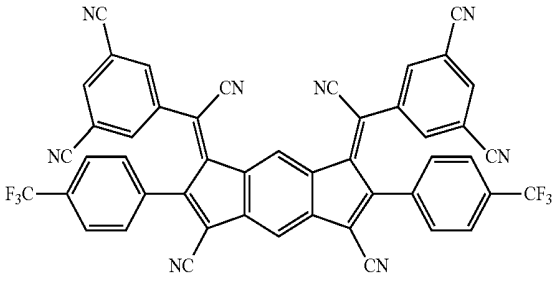

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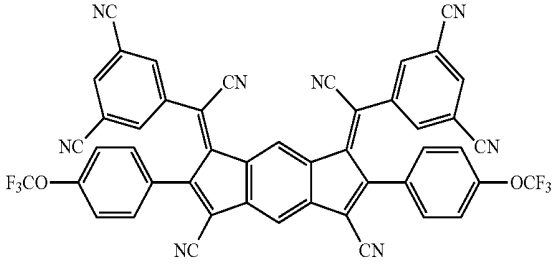

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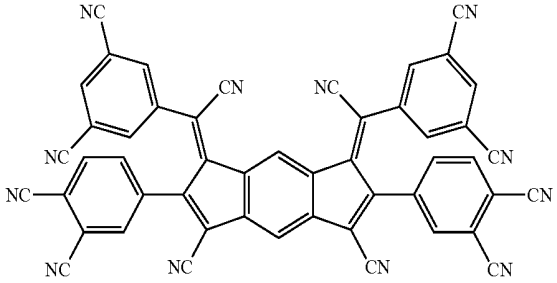

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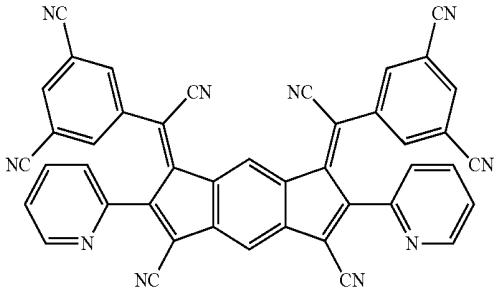

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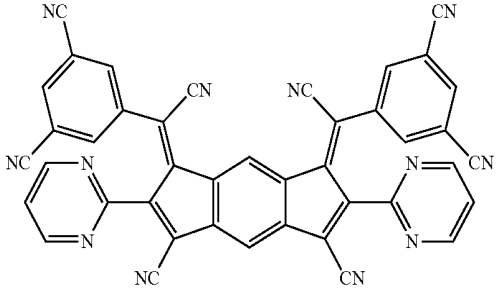

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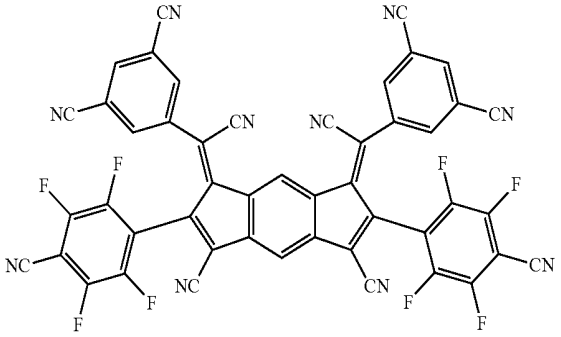

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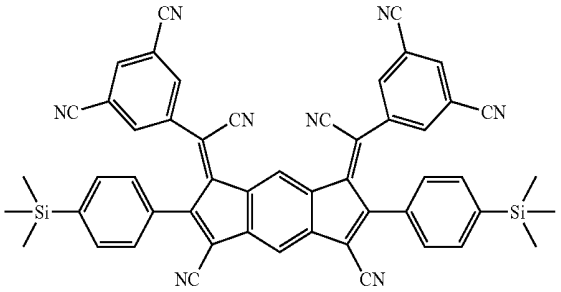

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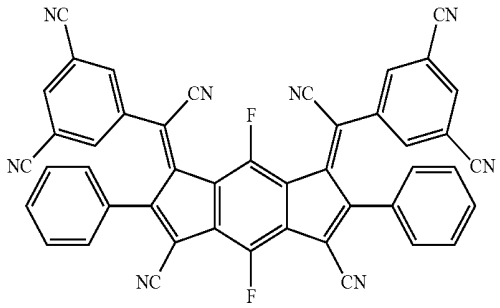

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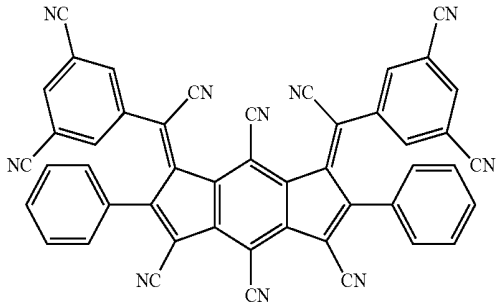

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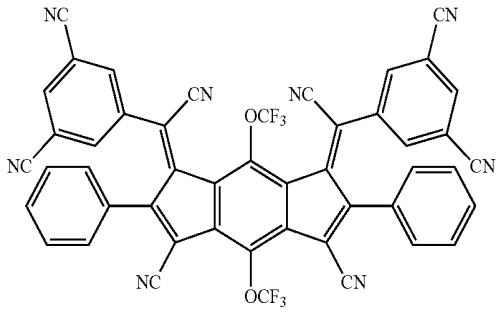

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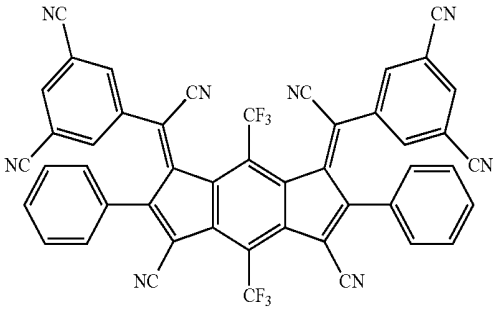

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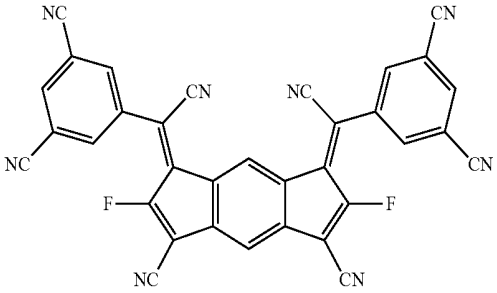

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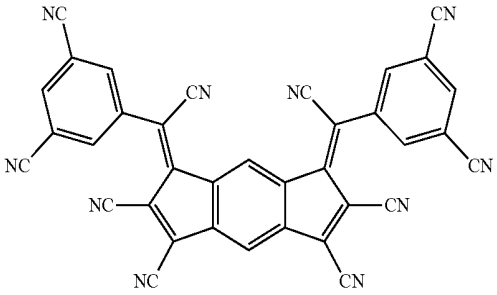

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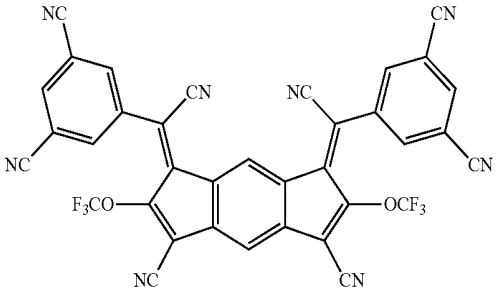

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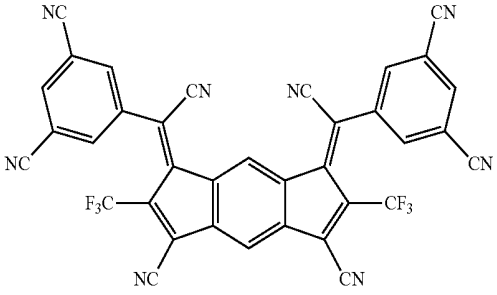

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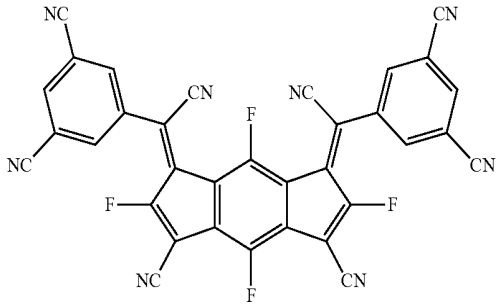

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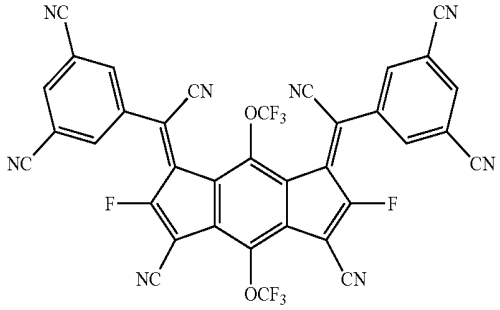

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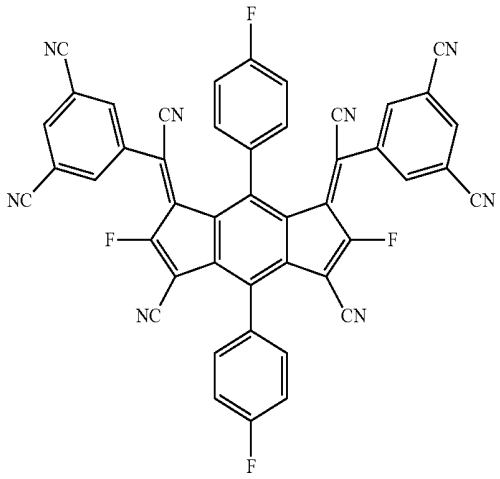

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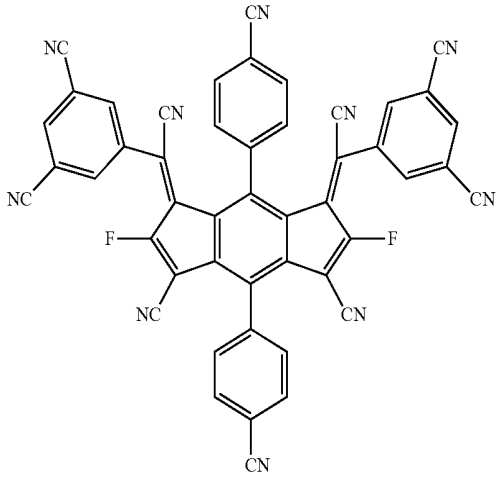

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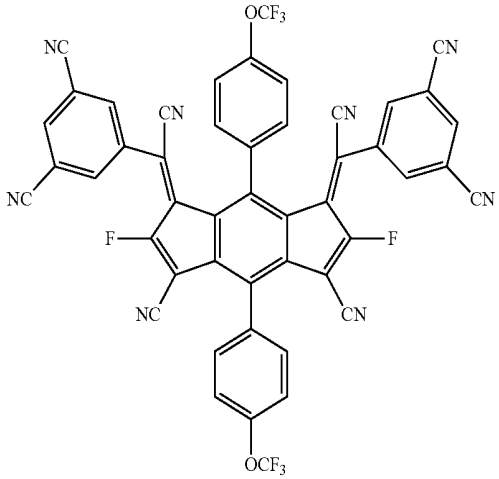

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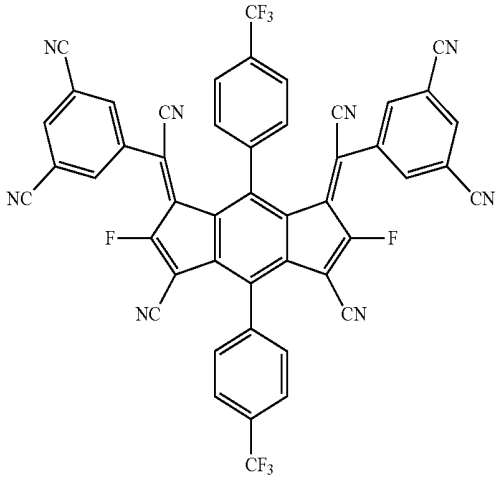

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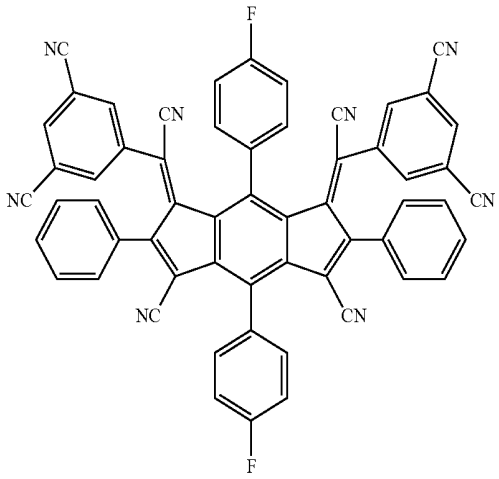

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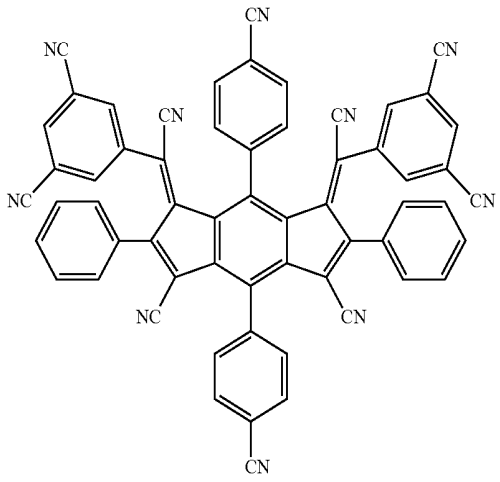

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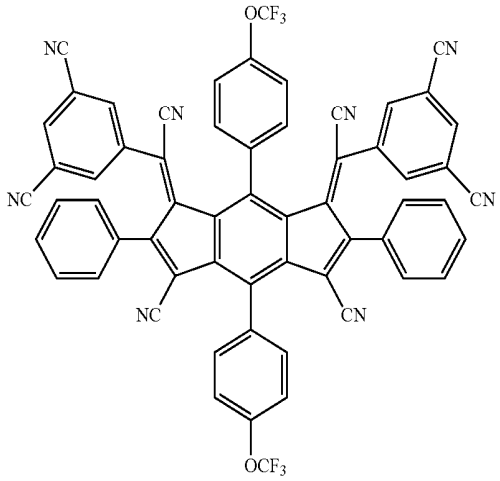

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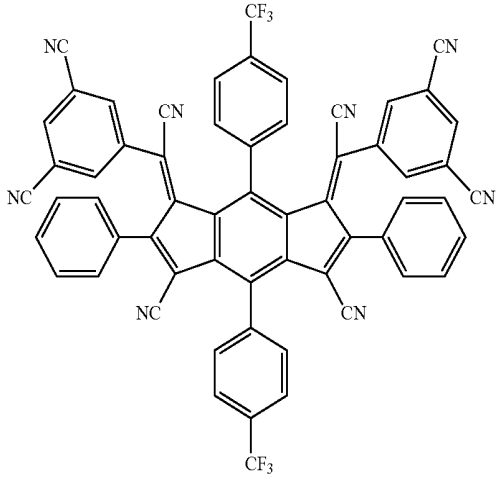

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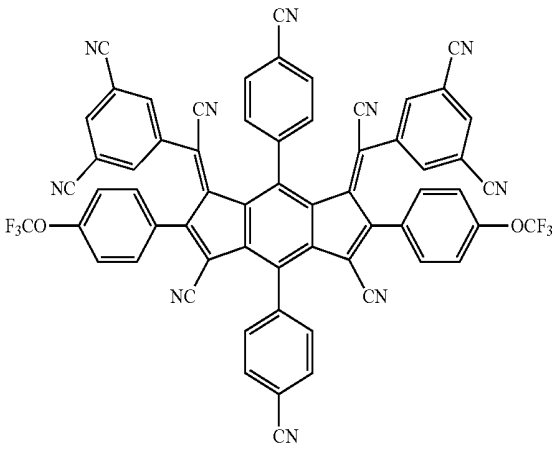

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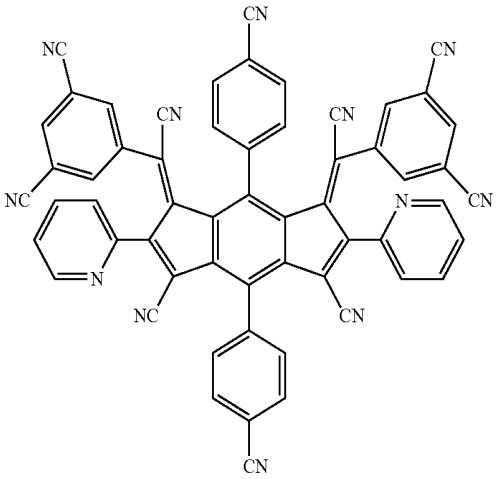

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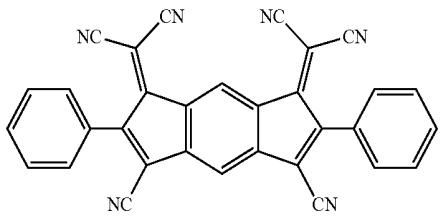

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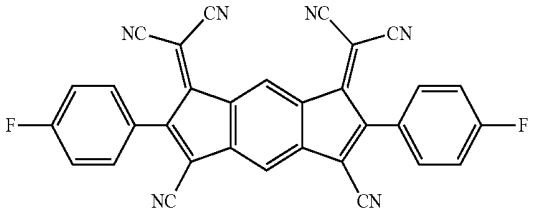

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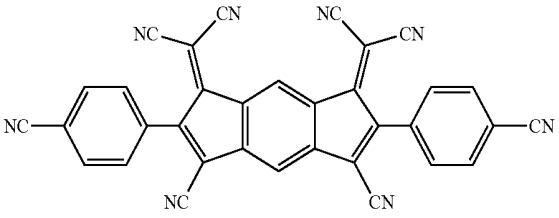

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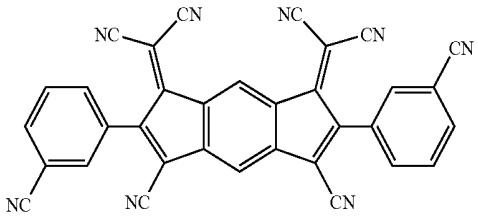

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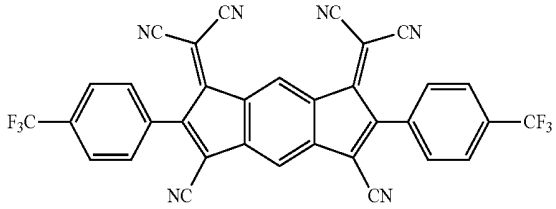

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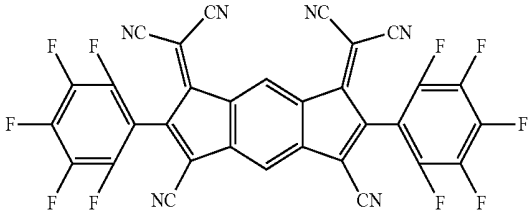

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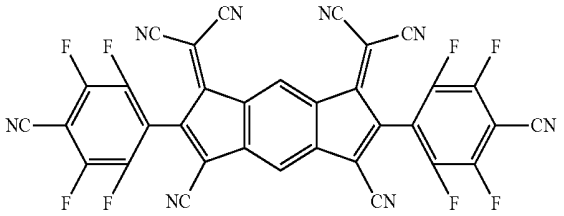

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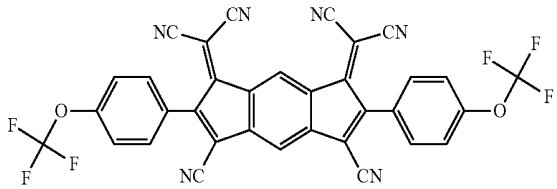

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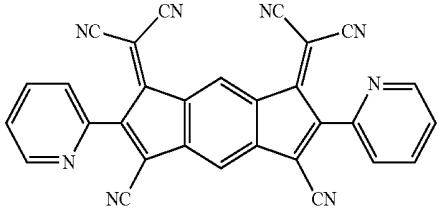

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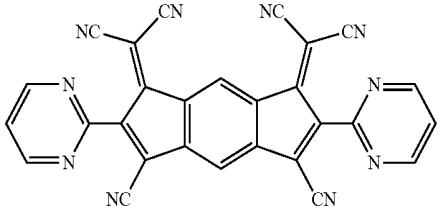

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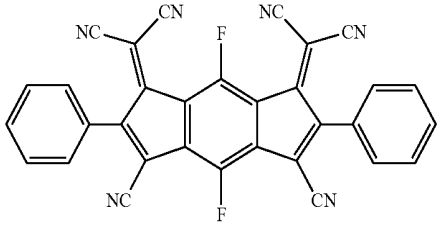

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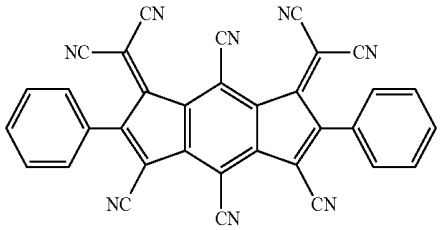

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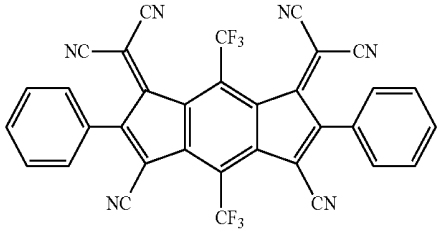

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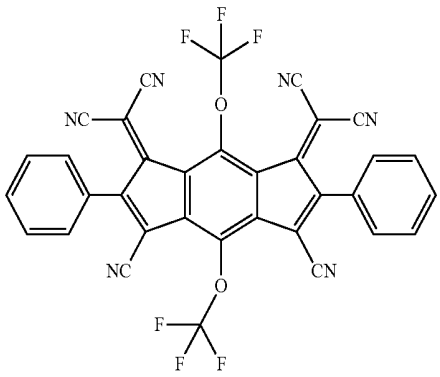

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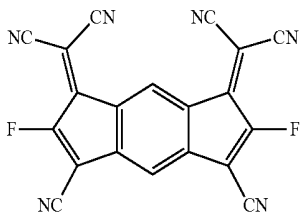

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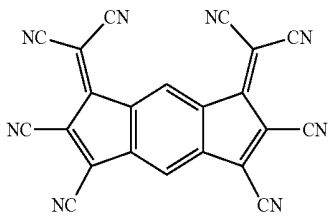

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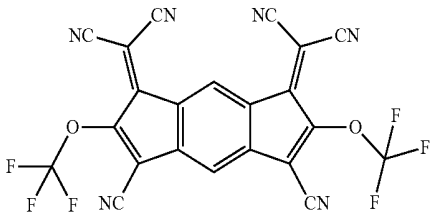

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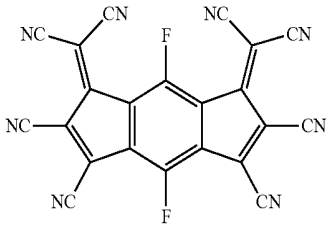

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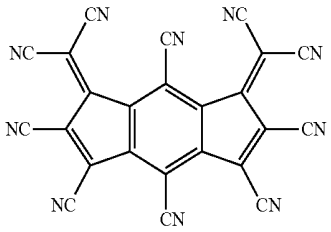

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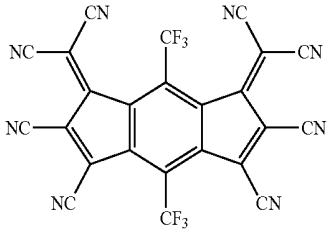

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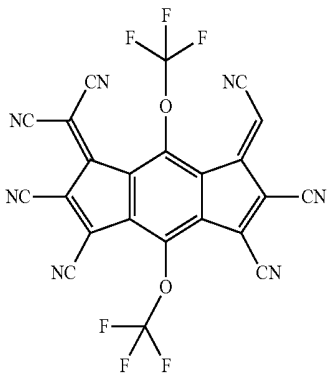

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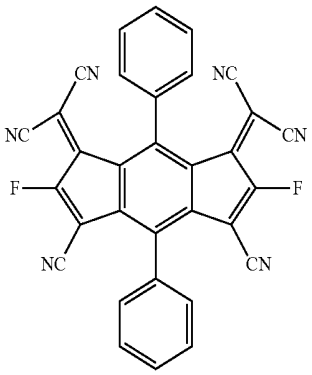

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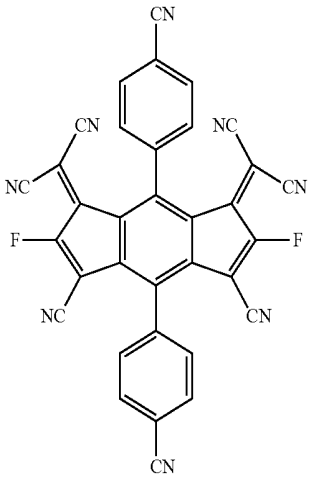
B53



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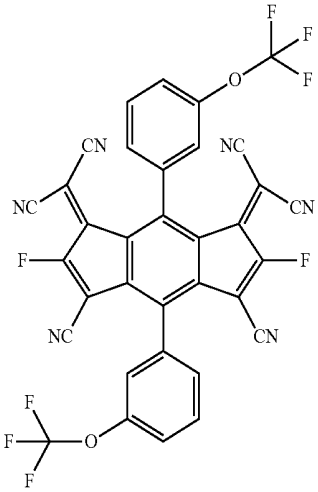

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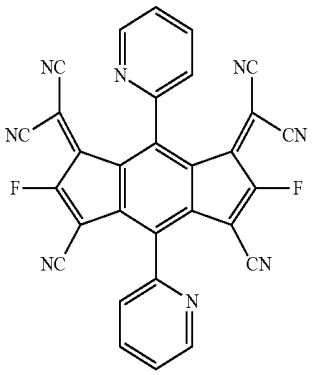

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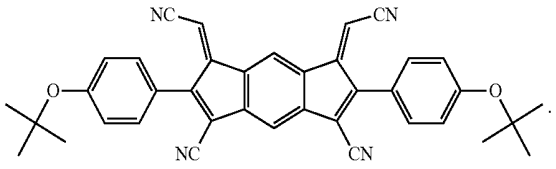


4. The organic light emitting display device of claim **1**, wherein a dopant of the hole injection layer includes the compound.

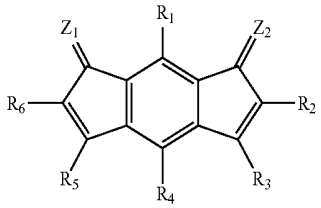
5. An organic light emitting display device, comprising:

at least one light emitting part between an anode and a cathode, the at least one light emitting part having a hole injection layer and a light emitting layer; and

a charge generation layer having a P-type charge generation layer between the at least one light emitting part and the cathode,

wherein the hole injection layer comprises a compound represented by Chemical Formula 2:

[Chemical Formula 2]



in the Chemical Formula 2, R_1 to R_6 each independently represents one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with up to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group, and at least one among R_1 to R_6 comprises a cyano group, and

in Chemical Formula 2, Z_1 and Z_2 are independently represented by the following Chemical Formula 3:

[Chemical Formula 3]

where A and B independently represent one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with up to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with up to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group,

wherein Z_1 and Z_2 are attached via a double bond between a carbon atom bound to A and B of Chemical Formula 3 and the indacene ring of Chemical Formula 2.

6. The organic light emitting display device of claim **5**, wherein the substituent of the aryl group, heteroaryl group, alkyl group, alkoxy group, and ether group is one among an alkyl with 1 to 12 carbon atoms, an aryl with 6 to 15 carbon atoms, a hetero alkyl with 1 to 15 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group.

7. The organic light emitting display device of claim **5**, wherein the compound represented by the above Chemical Formula 2 is one among the following compounds:

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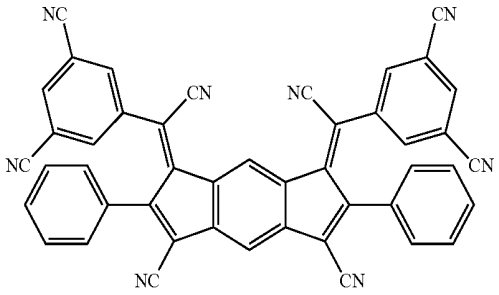

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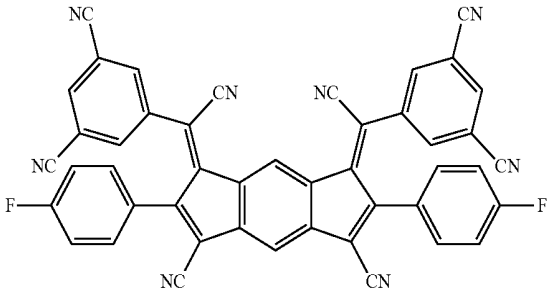

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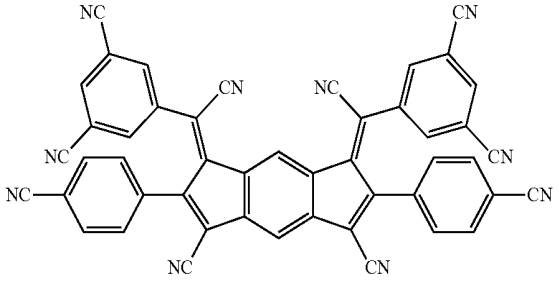

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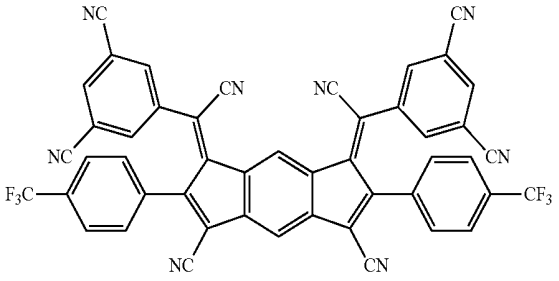

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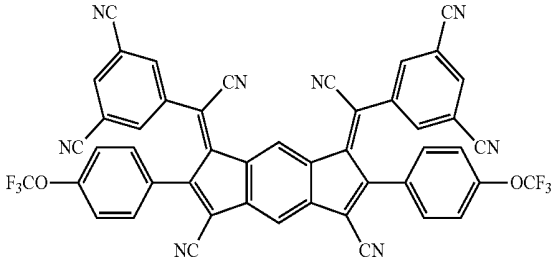

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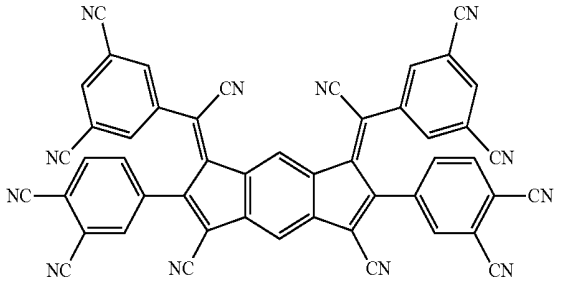

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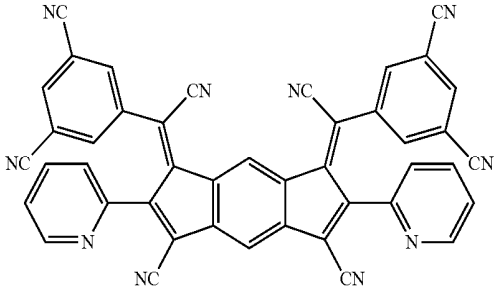

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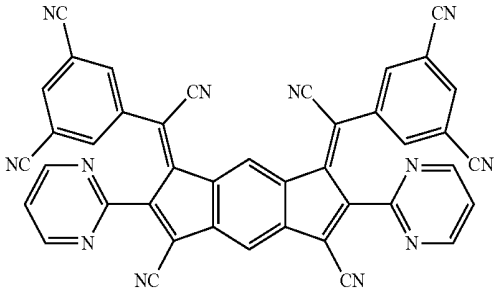

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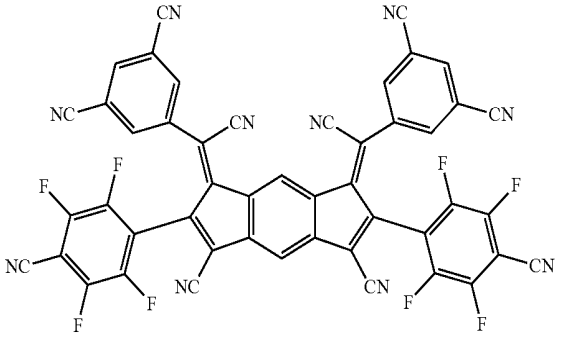

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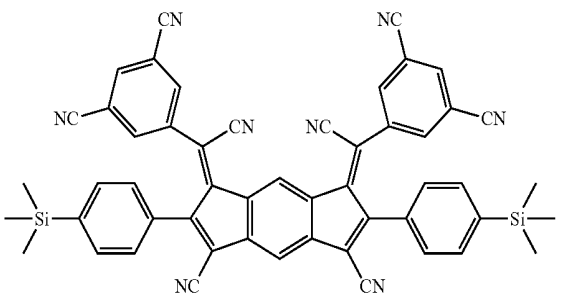

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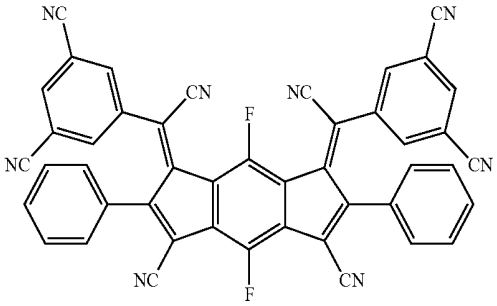

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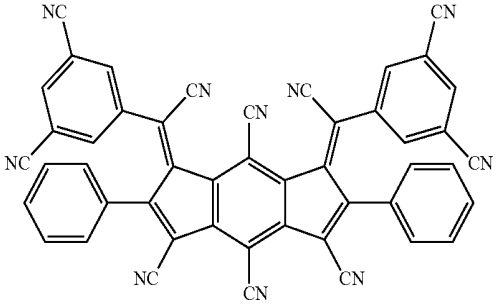

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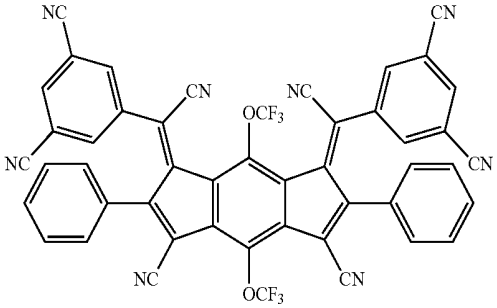

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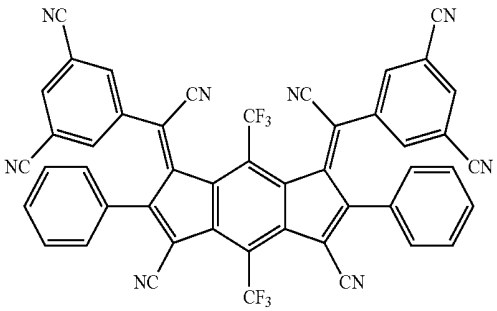

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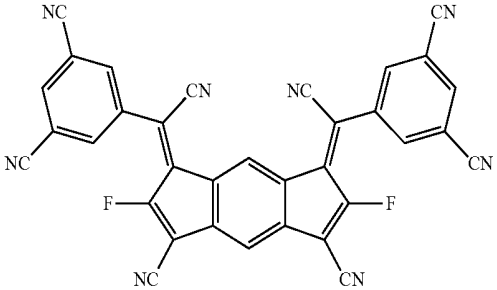

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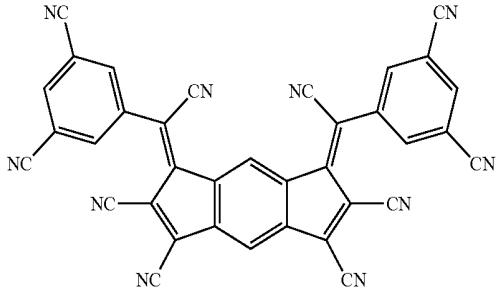

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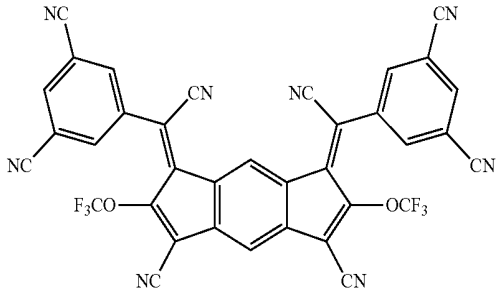

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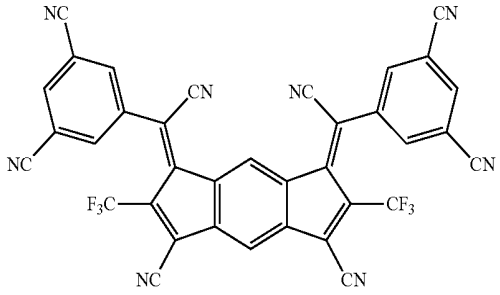

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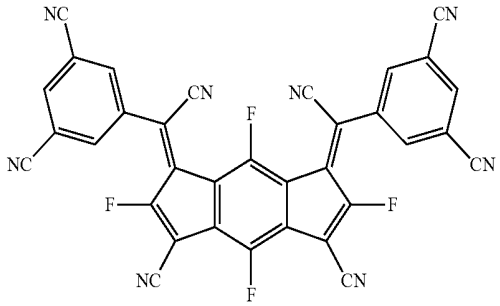

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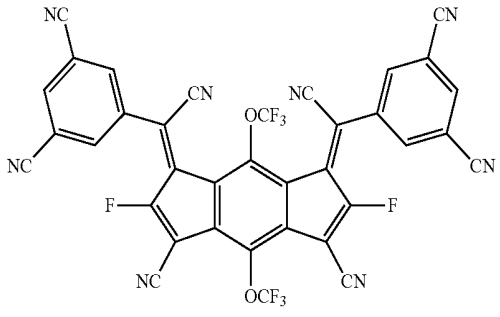

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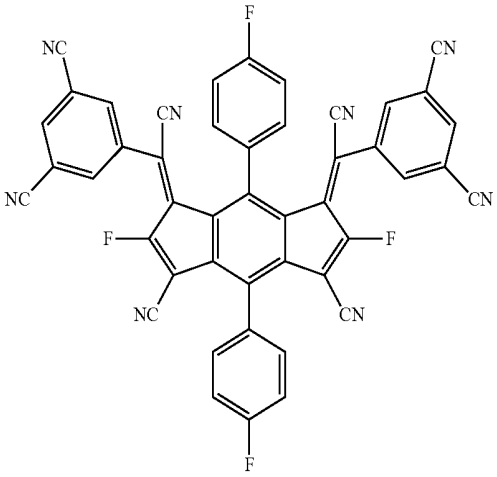

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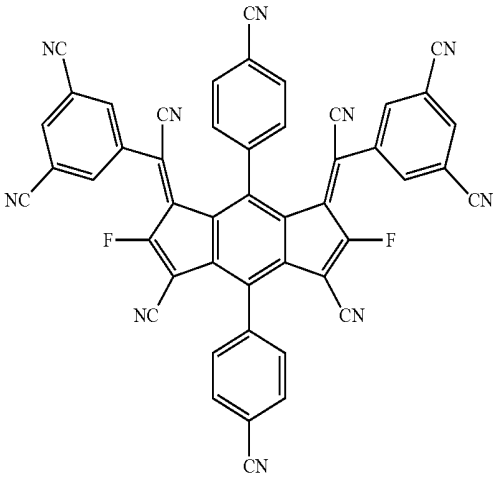

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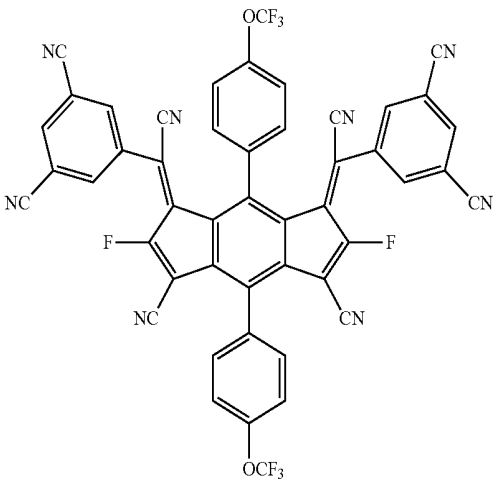

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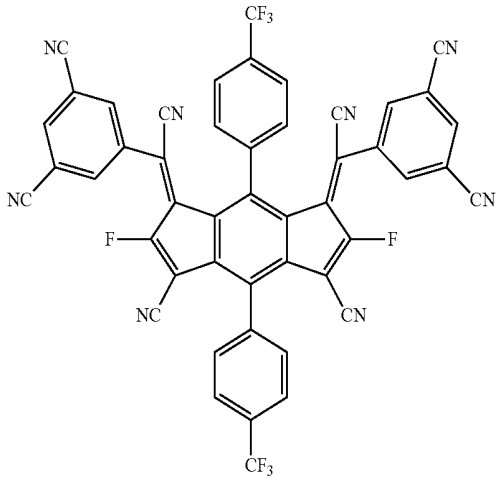

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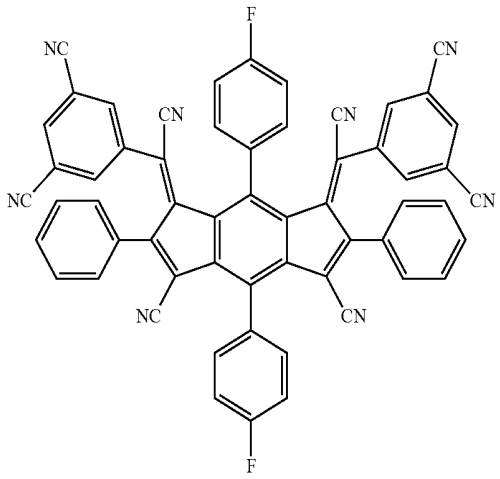

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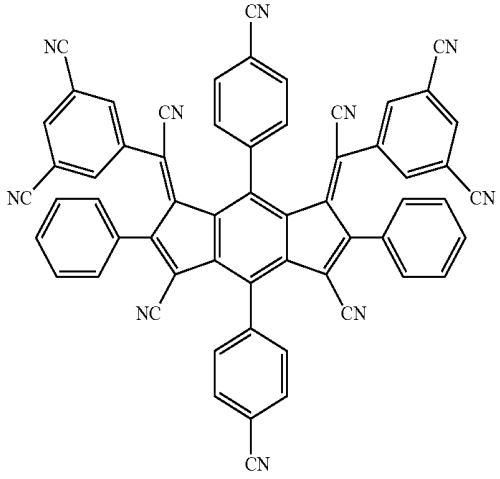

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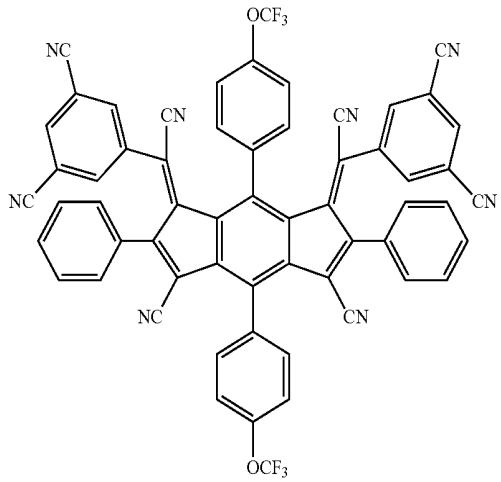

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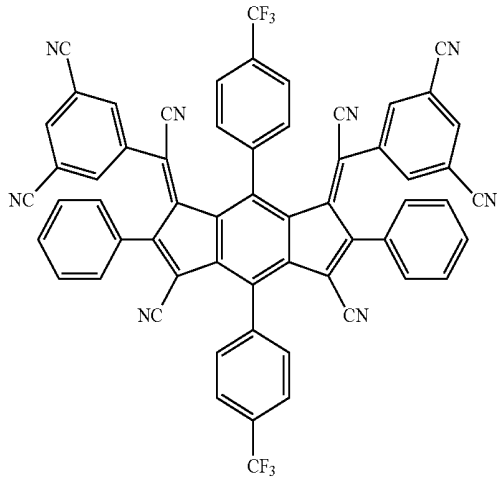

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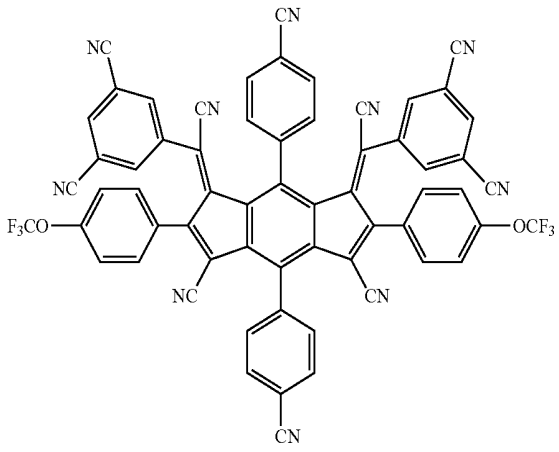

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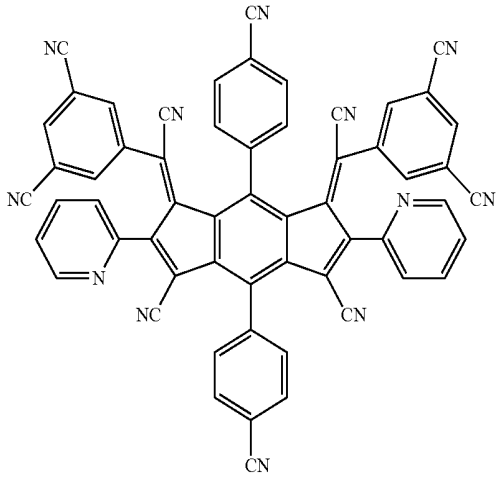

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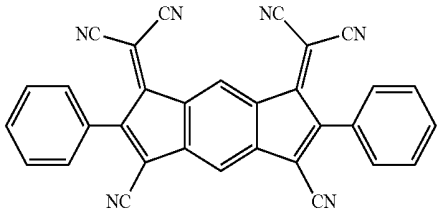

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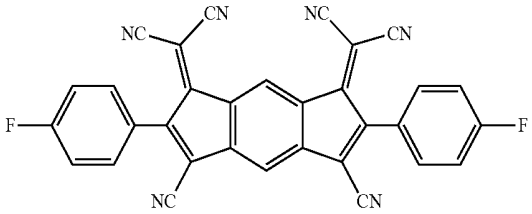

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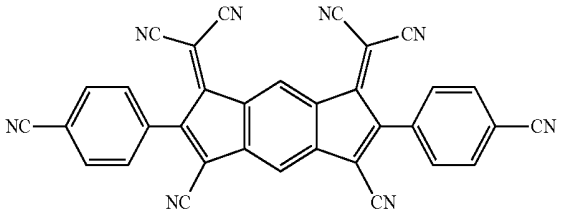

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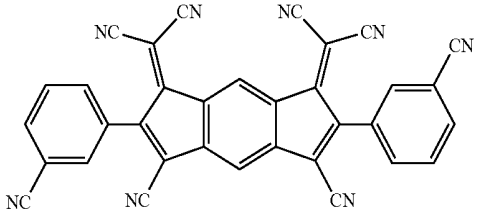

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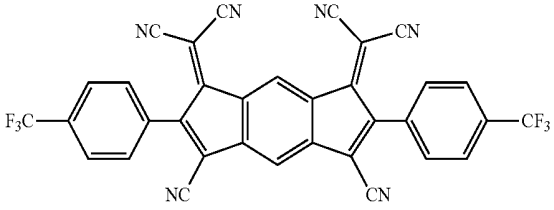

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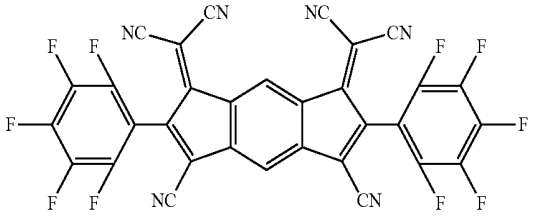

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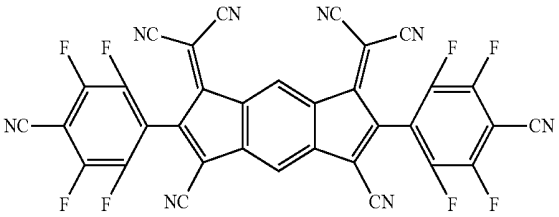

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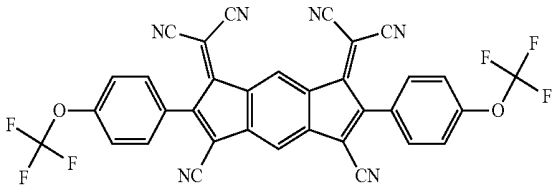

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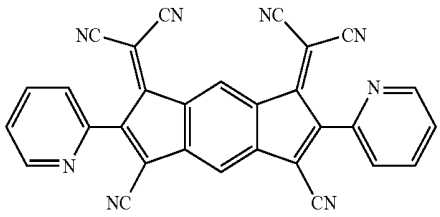

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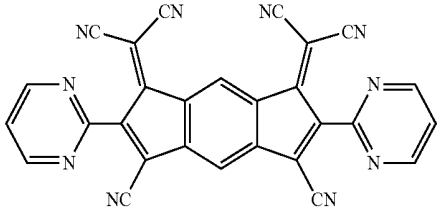

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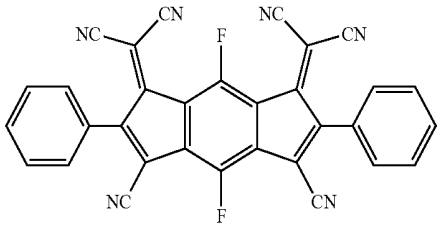

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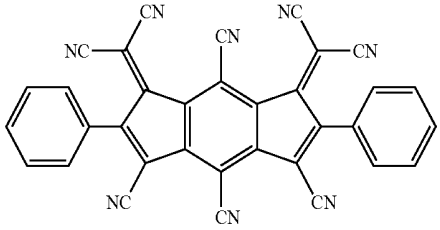

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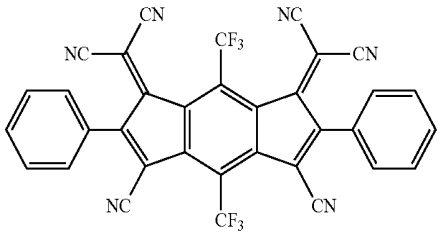

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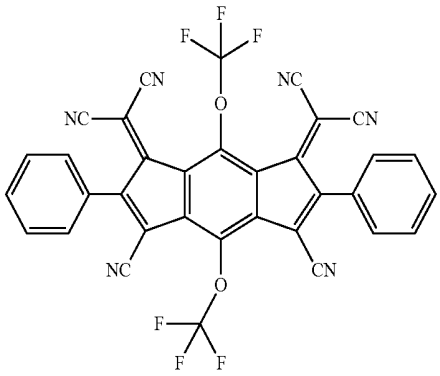

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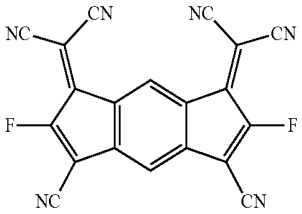

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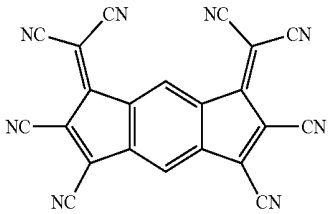

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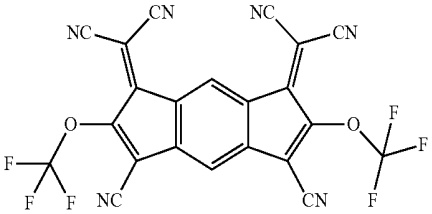

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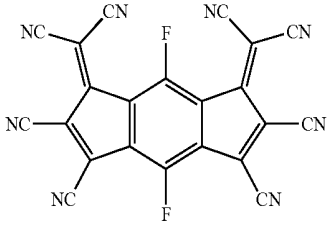

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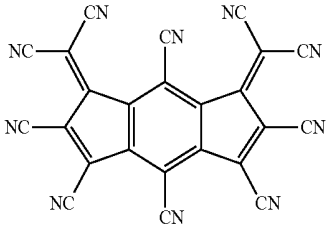

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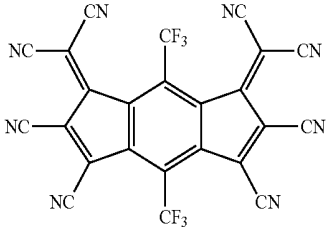

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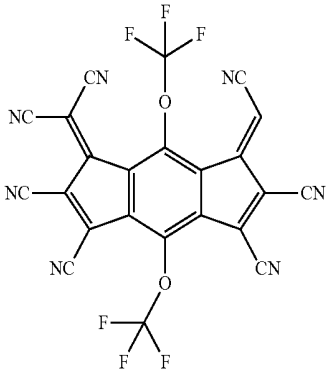

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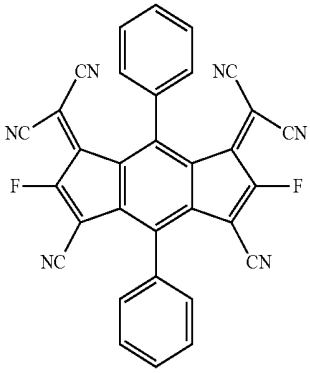

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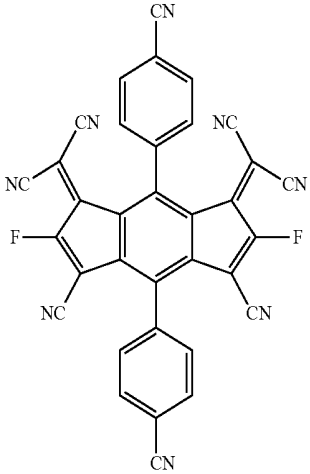

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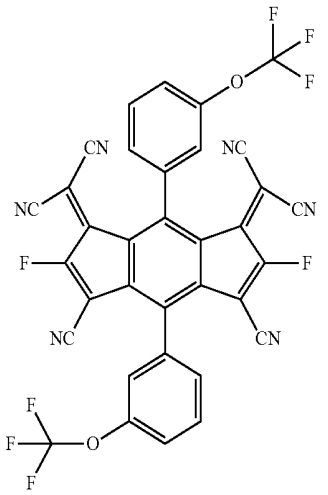

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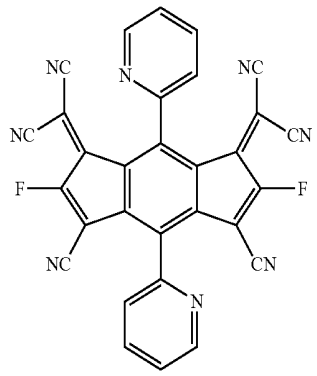

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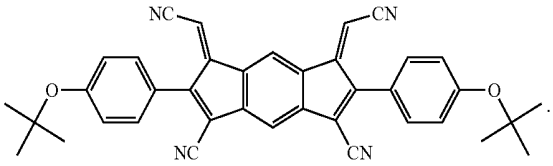


8. The organic light emitting display device of claim **5**, wherein a dopant of the hole injection layer includes the compound.

9. The organic light emitting display device of claim **5**, wherein a dopant of the P-type charge generation layer includes the compound.

10. The organic light emitting display device of claim **5**, wherein the P-type charge generation layer includes the compound.

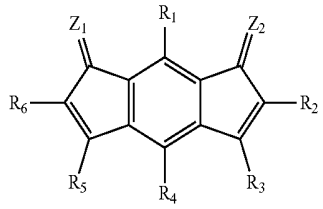
11. An organic light emitting display device, comprising:

a first and second light emitting part between an anode and a cathode, the at least one light emitting part having a hole injection layer and a light emitting layer; and

a charge generation layer having a P-type charge generation layer between the first light emitting part and the second light emitting part,

wherein the hole injection layer comprises a compound represented by Chemical Formula 2:

[Chemical Formula 2]



where R_1 to R_6 each independently represents one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with 1 to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12, carbon atoms, a substituted or unsubstituted ether group with 1 to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group, and at least one among R_1 to R_6 comprises a cyano group, and Z_1 and Z_2 are independently represented by the following Chemical Formula 3:

[Chemical Formula 3]

where A and B independently represent one among a hydrogen atom, a substituted or unsubstituted aryl group with 6 to 12 carbon atoms, a substituted or unsubstituted heteroaryl group with up to 12 carbon atoms and 1 to 4 heteroatoms one among O, N, S, and Si, a substituted or unsubstituted alkyl group with 1 to 12 carbon atoms, a substituted or unsubstituted alkoxy group with 1 to 12 carbon atoms, a substituted or unsubstituted ether group with up to 12 carbon atoms, a cyano group, a fluorine group, a trifluoromethyl group, a trifluoromethoxy group, and a trimethylsilyl group,

wherein Z_1 and Z_2 are attached via a double bond between a carbon atom bound to A and B of Chemical Formula 3.

12. The organic light emitting display device of claim **11**, further comprising:

a third light emitting part on the second light emitting part; and

a second charge generation layer having a second P-type charge generation layer between the second light emitting part and the third light emitting part,

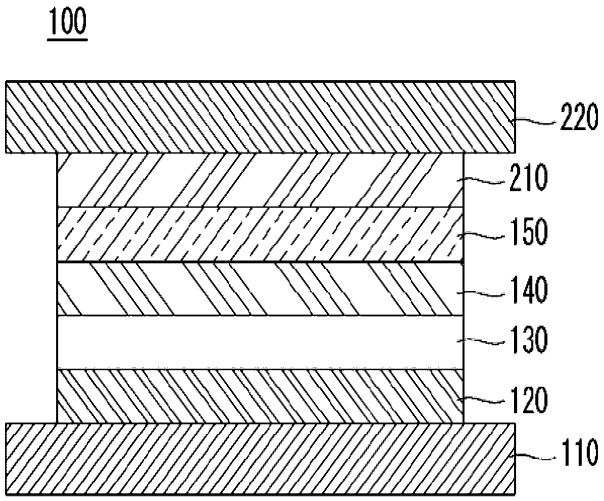
wherein at least one among the hole injection layer, the P-type charge generation layer, and the second P-type generation layer comprises the compound.

* * * * *

专利名称(译)	有机发光显示装置		
公开(公告)号	US10658593	公开(公告)日	2020-05-19
申请号	US15/250214	申请日	2016-08-29
[标]申请(专利权)人(译)	乐金显示有限公司 乐金化学股份有限公司		
申请(专利权)人(译)	LG DISPLAY CO.，LTD. LG化学有限公司.		
当前申请(专利权)人(译)	LG DISPLAY CO.，LTD LG化学有限公司.		
[标]发明人	KIM JUNGKEUN KIM DOHAN SEO JEONGDAE KIM HYOSEOK CHOI HEUNGWOO HONG WANPYO		
发明人	KIM, JUNGKEUN KIM, DOHAN SEO, JEONGDAE KIM, HYOSEOK CHOI, HEUNGWOO HONG, WANPYO		
IPC分类号	H01L51/00 H01L51/52 H01L51/50 C07C255/47 C07D213/61 C09K11/06		
CPC分类号	H01L51/0064 H01L51/0067 C07C255/47 C09K11/06 H01L51/0052 H01L51/5056 C07D213/61 H01L51/5278 H01L51/0053 C09K2211/1029 C09K2211/1007 H01L51/5012 H01L51/5206 C09K2211/1011 H01L51/5221 C07C2603/10 H01L51/5088		
代理机构(译)	桦木，STEWART，KOLASCH与桦木，LLP		
优先权	1020150171452 2015-12-03 KR 1020160057107 2016-05-10 KR		
其他公开文献	US20170162792A1		
外部链接	Espacenet		

摘要(译)

提供了一种有机发光显示装置。 所述有机发光显示装置可以包括在阳极和阴极之间的至少一个发光部分，并且所述至少一个发光部分具有至少一个有机层和发光层，其中所述至少一个有机层包括发光层。 化学式1或2表示的化合物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