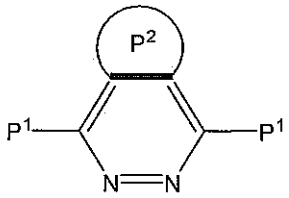
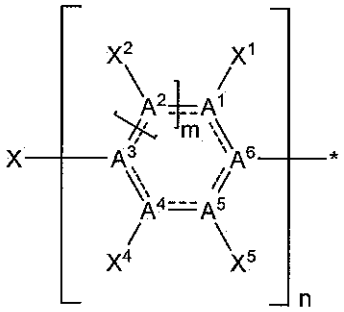
Summary

There is provided a compound having the following Formula (I);

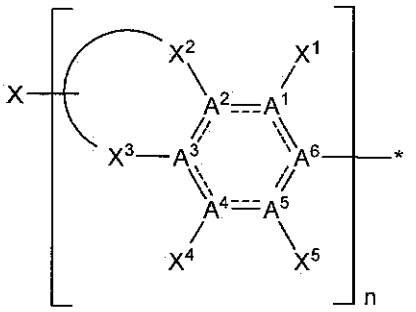


(I)

wherein P^1 has the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

$\cdots\cdots$ is a single or double bond, as valency allows;

m is 0 or 1;

n is an integer selected from 1 to 4;

X, X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

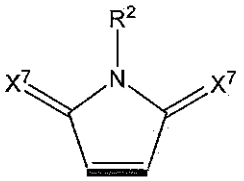
wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^1 is selected from the group consisting of O, S, Se, Te, C and N

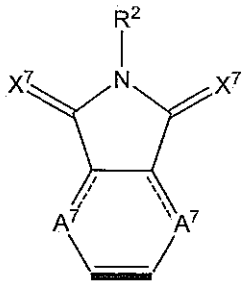
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

wherein any two substituents selected from the group consisting of X^1, X^2, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

and wherein P^2 has the following formula (IIIa) or (IIIb);



(IIIa)



(IIIb)

wherein

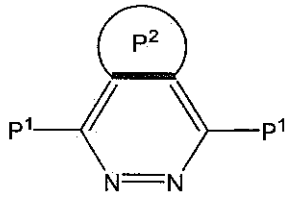
R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S;

A^7 is CH, CH_2 or N;

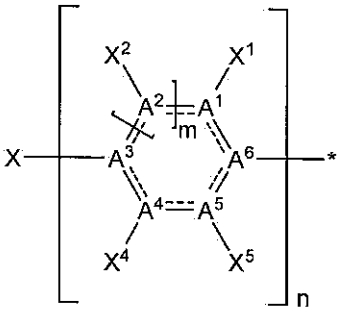
and —— is where the compound of Formula (IIIa) or (IIIb) is fused to the compound of Formula (I).

In an aspect, there is provided a compound having the following Formula (I);

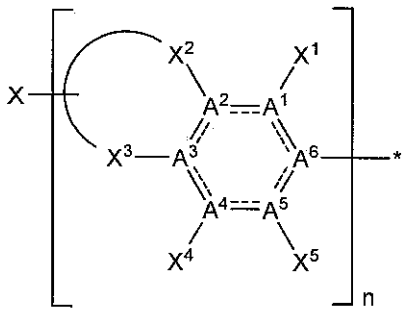


(I)

wherein P^1 is an electron-donating group having the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

----- is a single or double bond, as valency allows;

m is 0;

n is an integer selected from 1 to 4;

X is absent, or selected from the group consisting of H, halogen, CN, R^1, OR^1 or SR^1;

X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

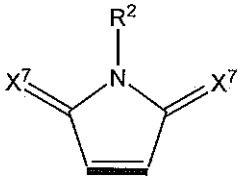
wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^1 is selected from the group consisting of O, S, Se, Te, C and N

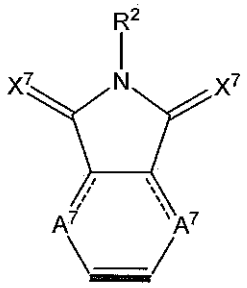
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

wherein any two substituents selected from the group consisting of X^1, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

and wherein P^2 has the following formula (IIIa) or (IIIb);



(IIIa)



(IIIb)

wherein

R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S;

A^7 is CH, CH_2 or N;

and —— is where the compound of Formula (IIIa) or (IIIb) is fused to the compound of Formula (I).

Advantageously, the compound of Formula (I) as defined above may combine an electron withdrawing imide group to an electron deficient pyridazine or phthalazine group, resulting in the compound having ultra-high electron affinity. The compound of Formula (I) as defined above may be used as electron-deficient acceptors with unprecedentedly high electron affinity. The compound of Formula (I) as defined above may be even more electron deficient compared to conventional compounds. Further advantageously, the compound of Formula (I) may be easy to functionalize, allowing for fine-tuning of not only its electronic properties but also to enhance its processability. For example, the compound of Formula (I) as defined above may be easily functionalized to improve its solubility. More advantageously, the easily functionalizable nature of the compound of Formula (I) may facilitate its integration with donor compounds. This may be useful, for example, in the manufacture of more processable polymers which may further be used as organic electronic materials.

In many applications of organic electronics materials, the electron affinity of the building blocks may be of great importance in tuning the physical and optical properties of the materials and in most cases may be crucial to ensure that the resulting material has the correct characteristics. The electron affinity may play a vital role in controlling the band-gap of the resultant conjugated polymers formed from the electron deficient pyridazine or phthalazine group. Advantageously, by attaching an electron withdrawing imide group to an electron deficient pyridazine or phthalazine group, a compound of Formula (I), which may possess ultra-high electron affinity, may be formed. This building block defined by Formula (I) may be designed to be easily functionalizable and therefore may be of high importance for the development of organic electronics materials. More advantageously, the compound of Formula (I) may be synthesized with a good overall synthetic yield. Further, the compound of Formula (I) may be easily incorporated into donor-acceptor conjugated polymers.

There is provided a compound having repeating units of the following Formula (IV);

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N;

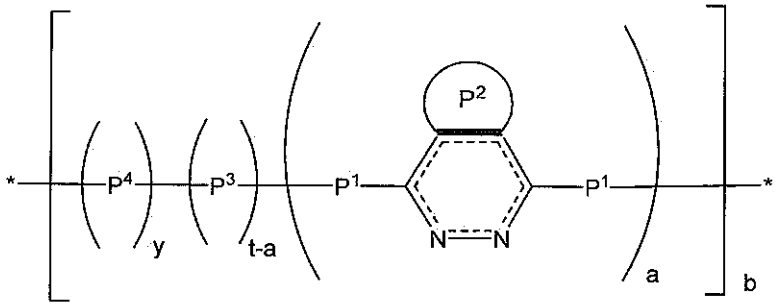
wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

and P^4 is absent, or an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl. a is any value from 0 to 1; and

b is an integer selected from 1 to 10,000; and

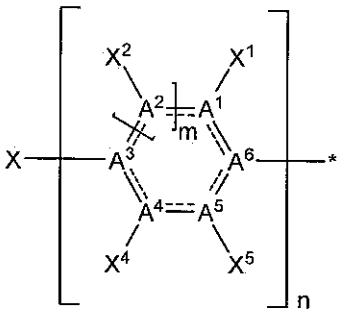
y is an integer selected from 0 to 5.

In another aspect, there is provided a compound having repeating units of the following Formula (IV);

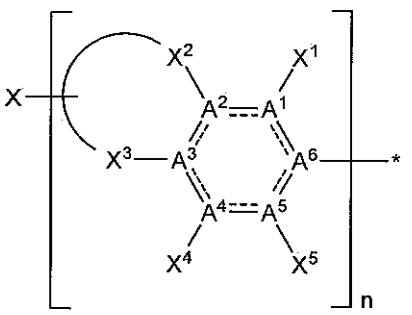


(IV)

wherein P^1 is an electron-donating group having the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

$\overline{\text{-----}}$ is a single or double bond, as valency allows;

m is 0;

n is an integer selected from 1 to 4;

X is absent, or selected from the group consisting of H, halogen, CN, R^1, OR^1 or SR^1;

X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

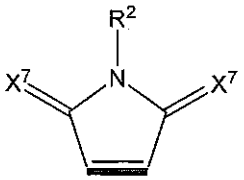
wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^1 is selected from the group consisting of O, S, Se, Te, C and N

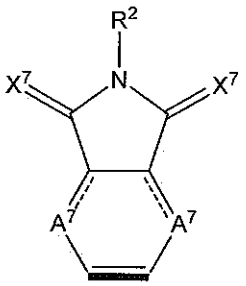
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

wherein any two substituents selected from the group consisting of X^1, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl.;

P^2 has the following formula (IIIa) or (IIIb);



(IIIa)



(IIIb)

wherein

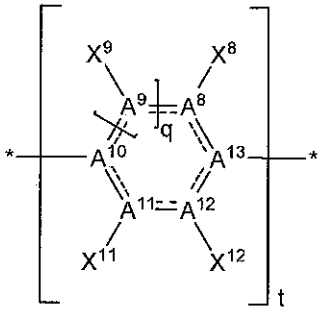
R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S;

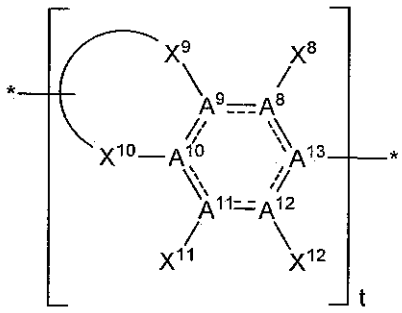
A^7 is CH, CH_2 or N;

and —— is where the compound of Formula (IIIa) or (IIIb) is fused to the compound of Formula (IV);

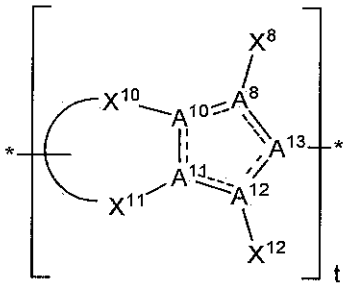
P^3 has the following Formula (Va), (Vb) or (Vc) ;



(Va)



(Vb)



(Vc)

wherein

q is 0 or 1;

t is an integer selected from 1 to 4;

X^8, X^9, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N;

wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

and P^4 is absent, or is an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

a is 1, 0.5, 0.3 or 0.1;

b is an integer selected from 1 to 10,000; and

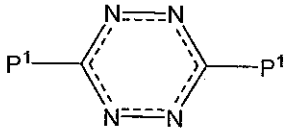
y is an integer selected from 0 to 5.

Advantageously, the compound of Formula (IV) may be a polymer. The purification of a polymer may be much easier and more convenient than purification of small molecules. Advantageously, the simple purification process may significantly reduce the cost of production of the polymer. Further advantageously, the polymer may have good solubility in a variety of solvents. The polymer may be soluble in non-chlorinated solvents, making the polymer easily processable in solution. This may further reduce the cost of production. More advantageously, the polymer may become glassy upon heating and this may be useful in manufacturing devices using the polymer material.

Further advantageously, the polymer may be a donor-acceptor polymer. Advantageously, the polymer may be comprised of donor compounds and acceptor compounds. Further advantageously, the donor compounds and acceptor compounds may be selected to confer advantageous properties to the polymer. Advantageously, the acceptor compound in the polymer may be the compound of Formula (I) as defined above. The ultra-electron deficient nature of the compound of Formula (I) as defined above may enable ease of synthesis of the polymer as well as confer advantageous properties to the polymer. Further advantageously, the pyridazine or phthalazine group of the compound of Formula (I) may lower the frontier orbitals of the polymers to make the polymer more stable under ambient conditions.

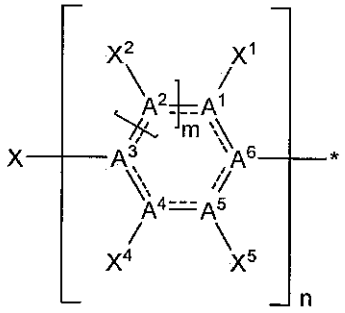
The performance of donor-acceptor type conjugated oligomers and polymers may rely on many factors, including the identity of the donor and acceptor building block of the polymer, the polymerization strategy and the molar weight of the polymer. Advantageously, the compound of Formula (IV) as defined above has been synthesized by judicious choice of the donor and acceptor building block, polymerization strategy and molecular weight of the polymer to so that the polymer has the advantageous properties such as good band-gap, good optical property, high stability and low cost of production.

There is provided a compound having the following Formula (VI);

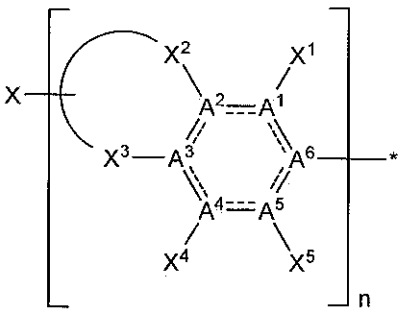


(VI)

wherein P^1 has the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

$\cdots$ is a single or double bond, as valency allows;

m is 0 or 1;

n is an integer selected from 1 to 4;

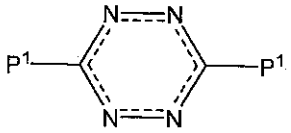
X, X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^1 is selected from the group consisting of O, S, Se, Te, C and N;

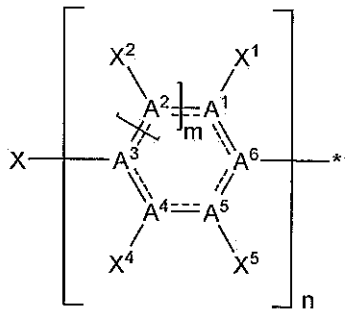
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and wherein any two substituents selected from the group consisting of X^1, X^2, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl.

In another aspect, there is provided a compound having the following Formula (VI);

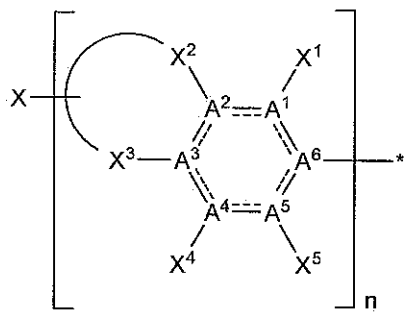


(VI)

wherein P^1 is an electron donating group having the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

$\overline{\text{-----}}$ is a single or double bond, as valency allows;

m is 0;

n is an integer selected from 1 to 4;

X is absent, or selected from the group consisting of H, halogen, CN, R^1, OR^1 or SR^1;

X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl;

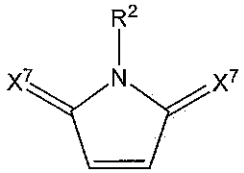
A^1 is selected from the group consisting of O, S, Se, Te, C and N;

A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

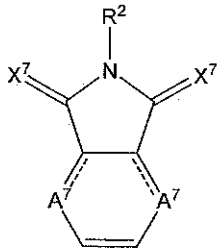
wherein any two substituents selected from the group consisting of X^1, X^2, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl.

Advantageously, the compound of Formula (I) as defined above may be a useful starting material for the synthesis of compounds defined further below. Advantageously, the compound of Formula (I) as defined above may comprise a tetrazine moiety attached to two electron donating groups. Advantageously, the tetrazine moiety may be electron-rich, such that when reacted with a dienophile defined further below, the resulting product will have ultra-high electron affinity.

In another aspect, there is provided a compound having the following formula (VIIa) or (VIIb);



(VIIa)



(VIIb)

wherein

$\overline{\text{-----}}$ is a single or double bond, as valency allows;

R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S; and

A^7 is CH, CH_2 or N.

Advantageously, the compounds of formula (VIIa) or (VIIb) as defined above may be intrinsically electron-withdrawing, such that when reacted with the tetrazine compound having Formula (VI) as defined above, the resulting product will have ultra-high electron affinity. Further advantageously, the compounds of Formula (VIIa) or (VIIb) may be easy to functionalize. More advantageously, the compound of Formula (VIIa) or (VIIb) as defined above may be tunable by their R^2 functional group to enhance their solubility properties such that they may be useful in reactions performed in a variety of solvents.

In another aspect, there is provided a method for synthesizing the compound of Formula (VI) as defined above, comprising the steps of providing a hydrazine and contacting the hydrazine with a functionalized cyclic group, wherein the cyclic group of the functionalized cyclic group is selected from the group comprising of optionally substituted furan, optionally substituted thiophene, optionally substituted selenophene, optionally substituted tellurophene, optionally substituted pyrrole, optionally substituted phenylene, optionally substituted aza-phenylene, optionally substituted arylene diimide, optionally substituted fluorene, optionally substituted cabazole, optionally substituted dibenzodilole, optionally substituted benzooxodiazole, optionally substituted benzotriazole, optionally substituted benzothidiazole and any combination thereof.

In another aspect, there is provided a method for synthesizing the compound of Formula (I) as defined above, comprising the steps of:

providing the compound of Formula (VI) as defined above; and

contacting the compound of Formula (VI) as defined above with the compound of Formulae (VIIa) or (VIIb) as defined above under reaction conditions to form the compound of Formula (I) as defined above.

Advantageously, the method for synthesizing the compound of Formula (I) as defined above may be an inverse-electron demanding Diels-Alder reaction. Conventionally, for Diels-Alder reactions that are being carried out on a tetrazine, the tetrazine acts as a diene and therefore should be modified with electron withdrawing groups to enhance its reactivity. Conversely, the dienophile should be modified with electron donating groups. This is to facilitate the inverse electron demanding Diels-Alder

reaction. However, in the synthesis of the compound of Formula (I) as defined above, the tetrazine moiety has two electron donating units P1 attached. In addition, the dienophile (compounds of Formulae (VIIa) or (VIIb) as defined above) is an intrinsically electron withdrawing imide. Under such conditions, the inverse-electron demanding Diels-Alder reaction has conventionally faced challenges due to the unfavourable electronic interaction between the tetrazine and the dienophile.

However, advantageously, the compound of Formula (I) may be synthesized with a good overall yield by the method as defined above. More advantageously, the successful synthesis may be due to judicious choice of reaction solvents, reaction temperature and reaction duration. Advantageously, the solvent used for the reaction may not contain any reactivity towards the reaction mixture. More advantageously, the boiling point of the solvent may be sufficiently high to allow the reaction to proceed. Advantageously, the method as defined above may enable the synthesis of the compound of Formula (I) with an isolated yield of higher than 90%.

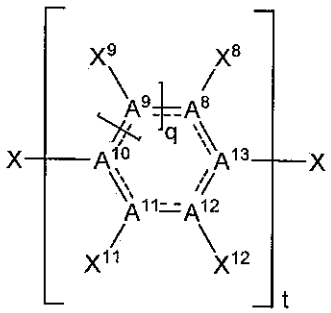
Further advantageously, the method as defined above is scalable. The compound of Formula (I) as defined above may therefore be synthesized at a larger scale of up to 500 g.

There is provided a method for synthesizing the compound of Formula (IV) as defined above, comprising the step of:

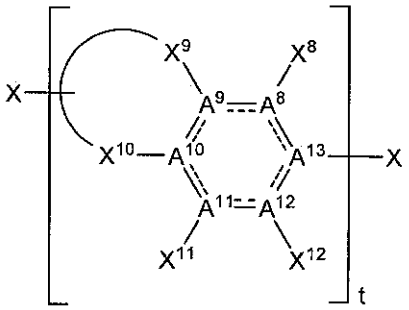
providing the compound of Formula (I) as defined above; and

contacting the compound of Formula (I) as defined above with;

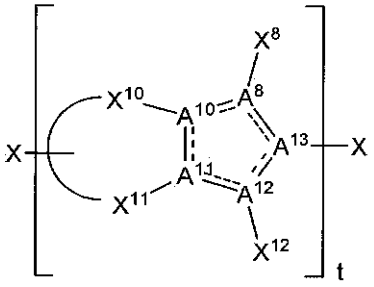
(i) a compound having the following Formula (XXVa), (XXVb) or (XXVc) ;



(XXVa)



(XXVb)



(XXVc)

wherein

$\cdots\cdots$ is a single or double bond, as valency allows;

q is 0 or 1;

t is an integer selected from 1 to 4;

X, X^8, X^9, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N; and

wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl; and

(ii) a cross-coupling reagent comprising a cyclic group; and an element selected from the group consisting of zinc, tin and boron; wherein the cyclic group is selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

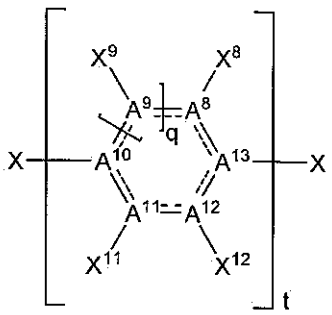
in the presence of a metal-containing catalyst.

In another aspect, there is provided a method for synthesizing the compound of Formula (IV) as defined above, comprising the step of:

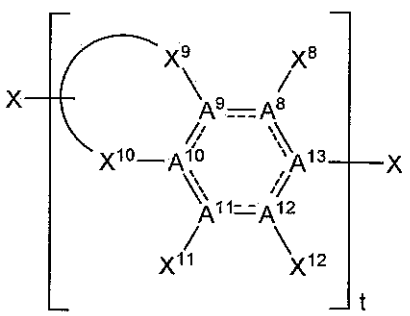
providing the compound of Formula (I) as defined above; and

contacting the compound of Formula (I) as defined above with;

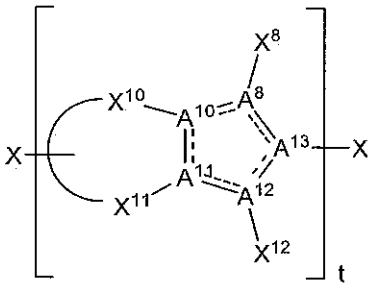
(i) a compound having the following Formula (XXVa), (XXVb) or (XXVc) ;



(XXVa)



(XXVb)



(XXVc)

wherein

$\overline{\text{-----}}$ is a single or double bond, as valency allows;

q is 0 or 1;

t is an integer selected from 1 to 4;

X is absent or selected from the group consisting of a H, halogen, CN, R^3, OR^3 or SR^3;

X^8, X^9, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N; and

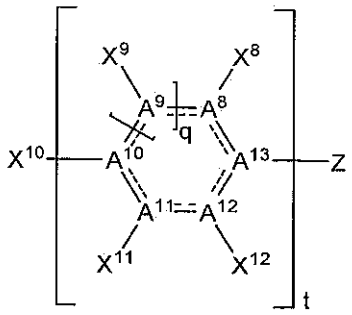
wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl; and

(i) a cross-coupling reagent comprising a cyclic group; and an element selected from the group consisting of zinc, tin and boron; wherein the cyclic group is selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl; in the presence of a metal-containing catalyst.

In another aspect, there is provided a method for synthesizing the compound of Formula (IV) as defined above, comprising the steps of:

1) providing the compound of Formula (I) as defined above; and

2) contacting the compound of Formula (I) as defined above with a compound having the following Formula (XXVI);



(XXVI)

wherein

$\overline{\overline{\text{-----}}}$ is a single or double bond, as valency allows;

q is 0 or 1;

t is an integer selected from 1 to 4;

Z is a functional group containing zinc, tin or born;

X^8, X^9, X^{10}, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N; and

wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

in the presence of a metal-containing catalyst to form a monomer precursor;

3) reacting the monomer precursor of step (2) with N-bromosuccinimide to form a reactive monomer; and

4) reacting the reactive monomer of step (2) with a cross-coupling reagent comprising a cyclic group; and an element selected from the group consisting of zinc, tin and boron; wherein the cyclic group is selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

in the presence of a metal-containing catalyst.

Advantageously, the method as defined above may have a high yield of synthesis. Further advantageously, the method as defined above may facilitate a controlled polymerization of the monomers, giving rise to polymers with defined ratios of donors and acceptors.

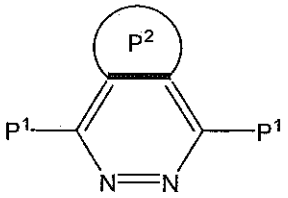
In another aspect, there is provided the use of the compound of Formula (IV) as defined above, in the manufacture of semiconductor devices.

In another aspect, there is provided a semiconductor device comprising the compound of Formula (IV) as defined above.

Advantageously, the compound of Formula (IV) as defined above may be useful in the manufacture of semiconductor devices. More advantageously, the compound of Formula (IV) as defined above may have enhanced processability, enabling them to be used in the manufacture of more processable polymers. Advantageously, the semiconductor devices manufactured using the compound of Formula (IV) as defined above may be used in a wide range of applications such as electrochromic materials, organic light-emitting diode, organic thin-film transistors and organic photovoltaic cells. Advantageously, the semiconductor devices manufactured using the compound of Formula (IV) may have higher stability, long shelf-life, high performance and may be cheaper to manufacture. Further

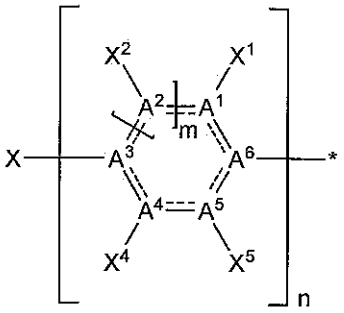
Claims

1. A compound having the following Formula (I);

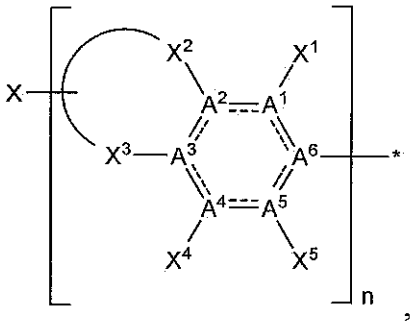


(I)

wherein P^1 is an electron-donating group having the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

$=\!=\!=\!=\!=$ is a single or double bond, as valency allows;

m is 0;

n is an integer selected from 1 to 4;

X is absent, or selected from the group consisting of H, halogen, CN, R^1, OR^1 or SR^1;

X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

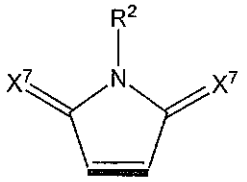
wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^1 is selected from the group consisting of O, S, Se, Te, C and N

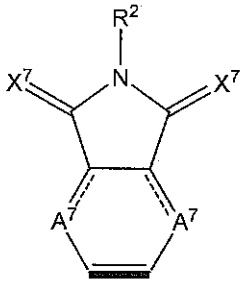
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

wherein any two substituents selected from the group consisting of X^1, X^2, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

and wherein P^2 has the following formula (IIIa) or (IIIb);



(IIIa)



(IIIb)

wherein

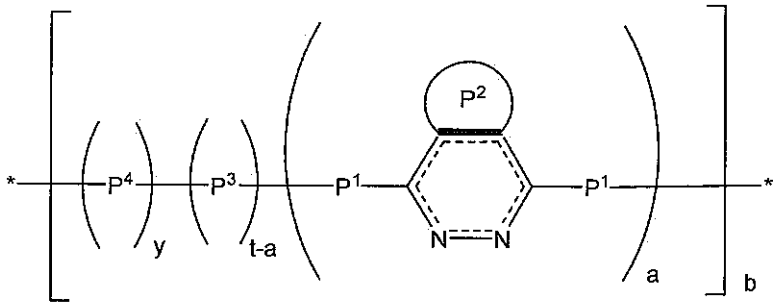
R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S;

A^7 is CH, CH_2 or N;

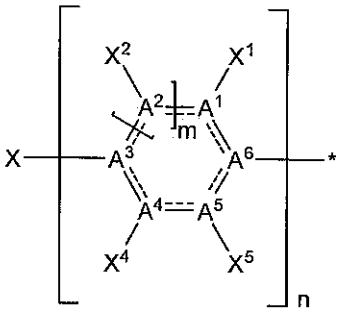
and —— is where the compound of Formula (IIIa) or (IIIb) is fused to the compound of Formula (I).

2. A compound having repeating units of the following Formula (IV);

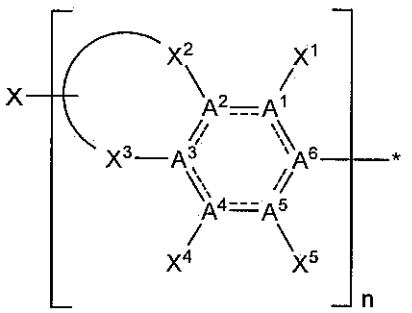


(IV)

wherein P^1 is an electron-donating group having the following Formula (IIa) or (IIb);



(IIa)



(IIb),

wherein

===== is a single or double bond, as valency allows;

m is 0;

n is an integer selected from 1 to 4;

X is absent, or selected from the group consisting of H, halogen, CN, R^1, OR^1 or SR^1;

X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

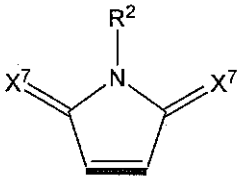
wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^1 is selected from the group consisting of O, S, Se, Te, C and N

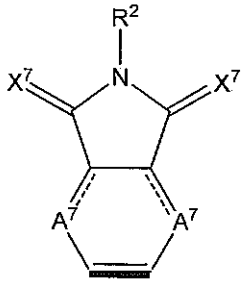
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

wherein any two substituents selected from the group consisting of X^1, X^2, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl.;

P^2 has the following formula (IIIa) or (IIIb);



(IIIa)



(IIIb)

wherein

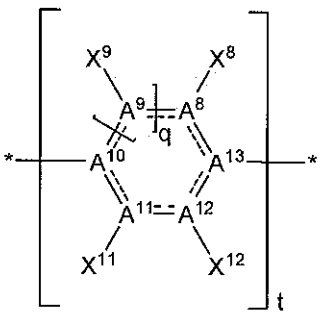
R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S;

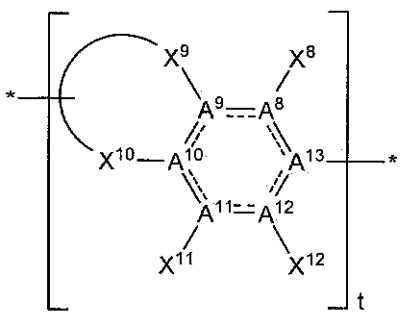
A^7 is CH, CH_2 or N;

and —— is where the compound of Formula (IIIa) or (IIIb) is fused to the compound of Formula (IV);

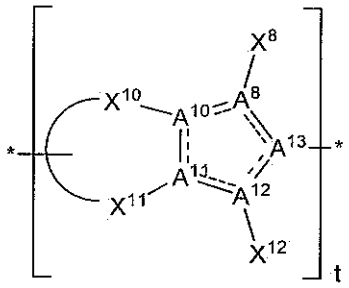
P^3 has the following Formula (Va), (Vb) or (Vc) ;



(Va)



(Vb)



(Vc)

wherein

q is 0 or 1;

t is an integer selected from 1 to 4;

X^8, X^9, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N;

wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

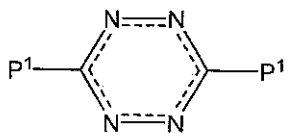
and P^4 is absent, or is an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

a is 1, 0.5, 0.3 or 0.1;

b is an integer selected from 1 to 10,000; and

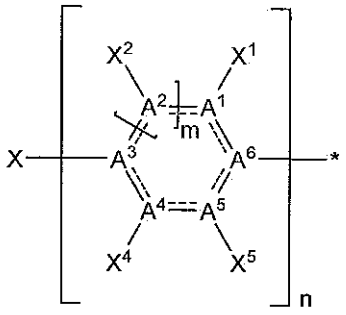
y is an integer selected from 0 to 5.

3. A compound having the following Formula (VI);

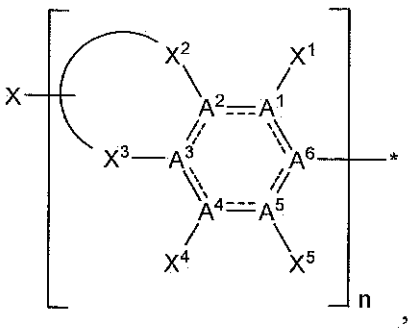


(VI)

wherein P^1 is an electron donating group having the following Formula (IIa) or (IIb);



(IIa)



(IIb)

wherein

$\equiv\equiv\equiv$ is a single or double bond, as valency allows;

m is 0;

n is an integer selected from 1 to 4;

Xis absent, or selected from the group consisting of H, halogen, CN, R^1, OR^1 or SR^1;

X^1, X^2, X^3, X^4 and X^5 are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^1, OR^1 or SR^1;

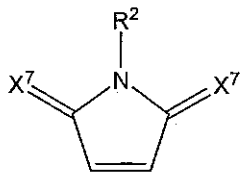
wherein R^1 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl;

A^1 is selected from the group consisting of O, S, Se, Te, C and N;

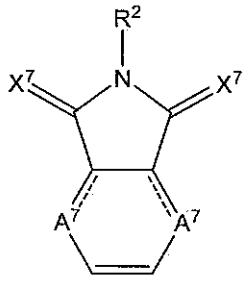
A^2, A^3, A^4, A^5 and A^6 are independently C or N; and

wherein any two substituents selected from the group consisting of X^1, X^2, X^3, X^4 and X^5 may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl.

4. A compound having the following formula (VIIa) or (VIIb);



(VIIa)



(VIIb)

wherein

$\equiv\equiv\equiv$ is a single or double bond, as valency allows;

R^2 is an optionally substituted alkyl or optionally substituted aryl;

X^7 is O or S; and

A^7 is CH, CH_2 or N.

5. The compound according to any one of claims 1 to 3, wherein halogen is selected from the group consisting of F, Cl, Br and I.

6. The compound according to any one of claims 1 to 3, wherein the optionally substituted alkyl is an optionally substituted C_1-C_{25} alkyl, the optionally substituted alkenyl is an optionally substituted C_2-C_{25} alkenyl, the optionally substituted alkynyl is an optionally substituted C_2-C_{25} alkynyl, the optionally substituted cycloalkyl is an optionally substituted C_3-C_{12} cycloalkyl, the optionally substituted heterocycloalkyl is an optionally substituted C_3-C_{12} heterocycloalkyl, the optionally substituted cycloalkenyl is an optionally substituted C_3-C_{12} cycloalkenyl, the optionally substituted heterocycloalkenyl is an optionally substituted C_3-C_{12} heterocycloalkenyl, the optionally substituted aryl is an optionally substituted C_3-C_{18} aryl and the optionally substituted heteroaryl is an optionally substituted C_3-C_{18} heteroaryl.

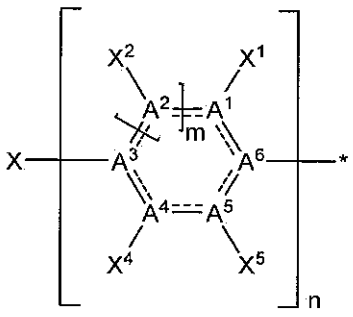
7. The compound according to claim 6, wherein the optionally substituted heterocycloalkyl and optionally substituted heteroaryl are independently a 3- to 18-membered monocyclic, bicyclic, or polycyclic ring.

8. The compound of claim 7, wherein X is selected from the group consisting of halogen, CN, R^1 and OR^1.

9. The compound according to claim 8, wherein R^1 is optionally substituted alkyl.

10. The compound according to any one of claims 1 to 3, wherein P^1 is selected from the group consisting of optionally substituted furan, optionally substituted thiophene, optionally substituted selenophene, optionally substituted tellurophene, optionally substituted pyrrole, optionally substituted fluorene, optionally substituted cabazole, optionally substituted dibenzodiole, optionally substituted benzooxodiazole, optionally substituted benzotriazole, optionally substituted benzothidiazole and any combination thereof.

11. The compound according to any one of claims 1 to 3, wherein P^1 is an electron-donating group having the following Formula (IIa);



(IIa).

12. The compound according to claim 11, wherein A^1 is N.

13. The compound according to claim 12, wherein X^1 is H.

14. The compound according to claim 11, wherein A^3, A^4, A^5 and A^6 are C.

15. The compound according to claim 14, wherein X^4 and X^5 are independently selected from the group consisting of H, R^1 and OR^1.

16. The compound according to claim 15, wherein R^1 is optionally substituted alkyl.

17. The compound according to claim 11, wherein A^1 is S; X^1 is absent; A^3, A^4, A^5 and A^6 are C, X^4 and X^5 are H and X is Br.

18. The compound according to claim 11, wherein A^1 is O; X^1 is absent; A^3, A^4, A^5 and A^6 are C, X^4 and X^5 are H and X is Br.

19. The compound according to any one of claims 1 or 2, wherein P^2 is selected from the group consisting of optionally substituted imide and optionally substituted phthalamide.

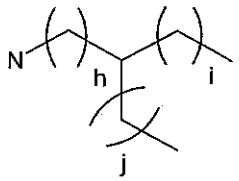
20. The compound according to any one of claims 1, 2 or 4, wherein R^2 is an optionally substituted alkyl.

21. The compound according to claim 20, wherein the optionally substituted alkyl is an optionally substituted linear alkyl or an optionally substituted branched alkyl.

22. The compound according to claim 21, wherein the optionally substituted linear alkyl is an optionally substituted C_1 to C_{25} linear alkyl.

23. The compound according to claim 21, wherein the optionally substituted branched alkyl is an optionally substituted C_1 to C_{25} branched alkyl.

24. The compound according to claim 23, wherein the optionally substituted branched alkyl has the following formula (XII).



(XII)

wherein

h is 0 or 1;

i and j are independently integers selected from 1 to 13, and

wherein N of Formula (XII) is where the R^2 group is connected to the rest of the compound in Formulae (IIIa), (IIIb), (IIIc) or (IIId).

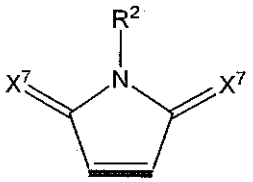
25. The compound according to claim 24, wherein h is 1.

26. The compound according to claim 25, wherein i is 7; and j is 9.

27. The compound according to claim 26, wherein the optionally substituted alkyl is 2-octyldodecyl.

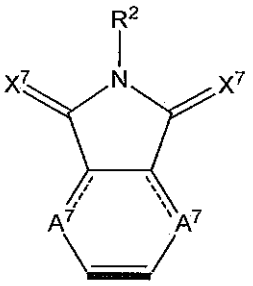
28. The compound according to any one of claims 1, 2 or 4, wherein X^7 is O.

29. The compound according to any one of claims 2 or 4, wherein P^2 has the following formula (IIIa):



(IIIa).

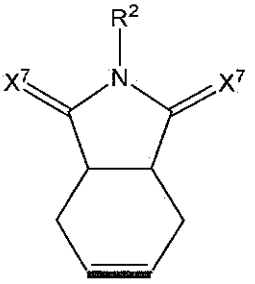
30. The compound according to any one of claims 2 or 4, wherein P^2 has the following formula (IIIb):



(IIIb)

31. The compound according to claim 30, wherein A^7 is CH_2.

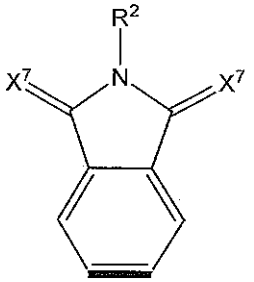
32. The compound according to claim 31, wherein P^2 has the following Formula (IIIc):



(IIIc).

33. The compound according to claim 30, wherein A^7 is CH.

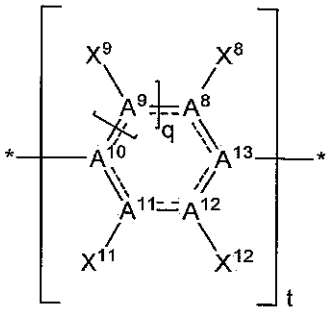
34. The compound according to claim 33, wherein P^2 has the following Formula (IIId):



(IIId).

35. The compound according to claim 2, wherein P^3 is selected from the group consisting of optionally substituted furan, optionally substituted thiophene, optionally substituted selenophene, optionally substituted pyrrole, optionally substituted phenyl, optionally substituted fluorenes, optionally substituted carbazoles, optionally substituted fused furans and optionally substituted fused thiophenes.

36. The compound according to claim 2, wherein P^3 has the following formula (Va);



(Va).

37. The compound according to claim 36, wherein q is 0.

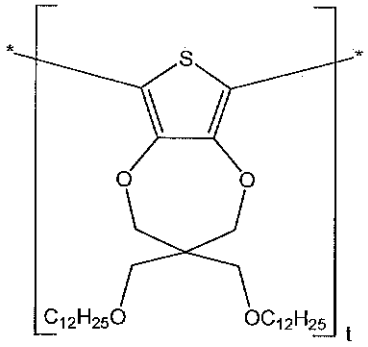
38. The compound according to claim 37, wherein A^8 is N.

39. The compound according to claim 38, wherein X^8 is H.

40. The compound according to claim 37, wherein A^8 is S; X^8 is absent; and A^{10}, A^{11}, A^{12} and A^{13} are C.

41. The compound according to claim 40, wherein X^{11} and X^{12} are taken together to form an optionally substituted 7-membered heterocycloalkyl.

42. The compound according to claim 41, wherein P^3 has the following Formula (XVI);



(XVI).

43. The compound according to claim 36, wherein q is 1.

44. The compound according to claim 43, wherein A^{10} and A^{13} are C.

45. The compound according to claim 44, wherein X^8, X^9, X^{11} and X^{12} are independently selected from the group consisting of H, halogen, R^3 and OR^3.

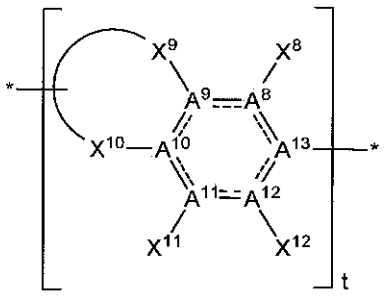
46. The compound according to claim 45, wherein R^3 is optionally substituted alkyl.

47. The compound of claim 46, wherein A^8, A^9 A^{10}, A^{11}, A^{12} and A^{13} are C.

48. The compound according to claim 47, wherein X^8, X^9, X^{11} and X^{12} are independently selected from the group consisting of H, halogen, OR^{10} and SR^{10}.

49. The compound according to claim 48, wherein R^{10} is an optionally substituted alkyl.

50. The compound according to claim 2, wherein P^3 has the following formula (Vb);



(Vb).

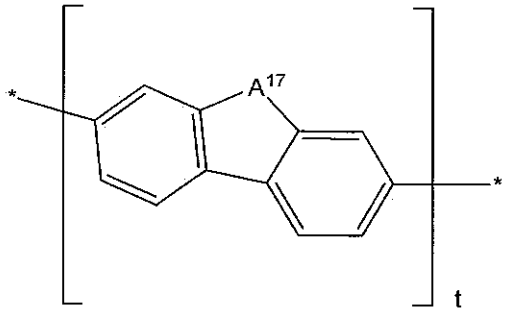
51. The compound according to claim 50, wherein A^8, A^9 A^{10}, A^{11}, A^{12} and A^{13} are C.

52. The compound according to claim 51, wherein X^8, X^{11} and X^{12} are H.

53. The compound according to claim 52, wherein X^9 and X^{10} are taken together to form an optionally substituted 5-membered heterocycloalkyl.

54. The compound according to claim 53, wherein the optionally substituted 5-membered heterocycloalkyl is further fused with an optionally substituted 6-membered aryl.

55. The compound according to claim 54, wherein P^3 has the following formula (XVII);

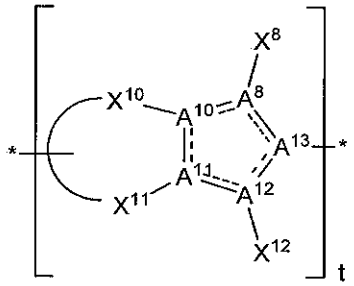


(XVII)

wherein A^{17} is selected from the group consisting of NH, CHR^{11}, $C(R^{11})_2$, $SiHR^{11}$ and $Si(R^{11})_2$; wherein R^{11} is optionally substituted alkyl.

56. The compound according to claim 55, wherein R^{11} is C_8H_{17} or $C_{12}H_{25}$.

57. The compound according to claim 2, wherein P^3 has the following Formula (Vc);



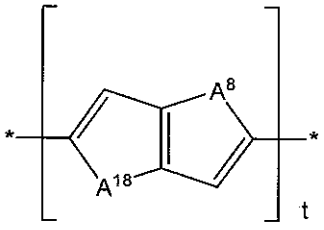
(Vc).

58. The compound according to claim 57, wherein A^{10}, A^{11}, A^{12} and A^{13} are C.

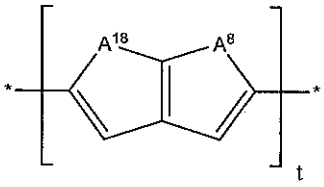
59. The compound according to claim 58, wherein X^8 and X^{12} are H.

60. The compound according to claim 29, wherein X^{10} and X^{11} are taken together to form an optionally substituted 5-membered heteroaryl.

61. The compound according to claim 60, wherein P^3 has the following Formula (XVIIIa) or (XVIIIb);



(XVIIIa)



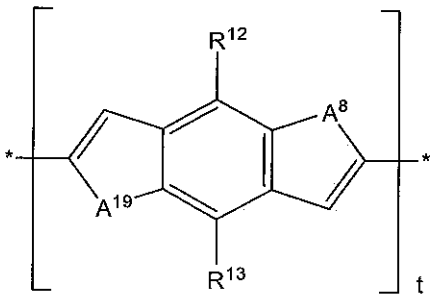
(XVIIIb)

wherein A^8 and A^{18} are independently selected from the group consisting of O, S and Se.

62. The compound according to claim 61, wherein X^{10} and X^{11} are taken together to form an optionally substituted 6-membered aryl.

63. The compound according to claim 62 wherein the optionally substituted 6-membered aryl is further fused with an optionally substituted 5-membered heteroaryl.

64. The compound according to claim 57, wherein P^3 has the following Formula (XIX);



(XIX)

wherein A^8 and A^{19} are independently selected from the group consisting of O, and Se; and R^{12} and R^{13} are independently selected from R^{14}, OR^{14}, SR^{14}, .wherein R^{14} is optionally substituted alkyl or optionally substituted aryl.

65. The compound according to claim 64, wherein R^{14} is an optionally substituted alkyl.

66. The compound according to claim 65, wherein R^{14} is C_8H_{17}.

67. The compound according to claim 65, wherein R^{14} is 2-ethylheptyl.

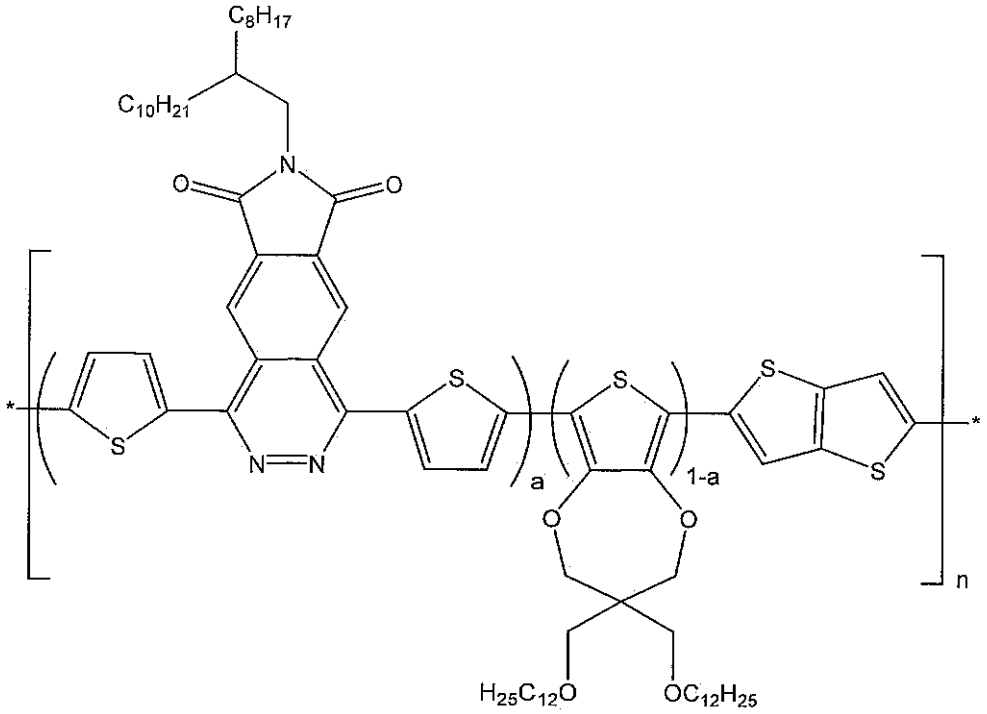
68. The compound according to claim 2, wherein b is an integer selected from 1 to 50.

69. The compound according to claim 2, wherein P^4 is selected from the group consisting of optionally substituted furan, optionally substituted thiophene, optionally substituted selenophene, optionally substituted pyrrole, optionally substituted phenyl, optionally substituted fluorenes, optionally substituted carbazoles, optionally substituted fused furans and optionally substituted fused thiophenes.

70. The compound according to claim 69, wherein P^4 is an optionally substituted thiophene or an optionally substituted fused thiophene.

71. The compound according to claim 2, wherein y is 1.

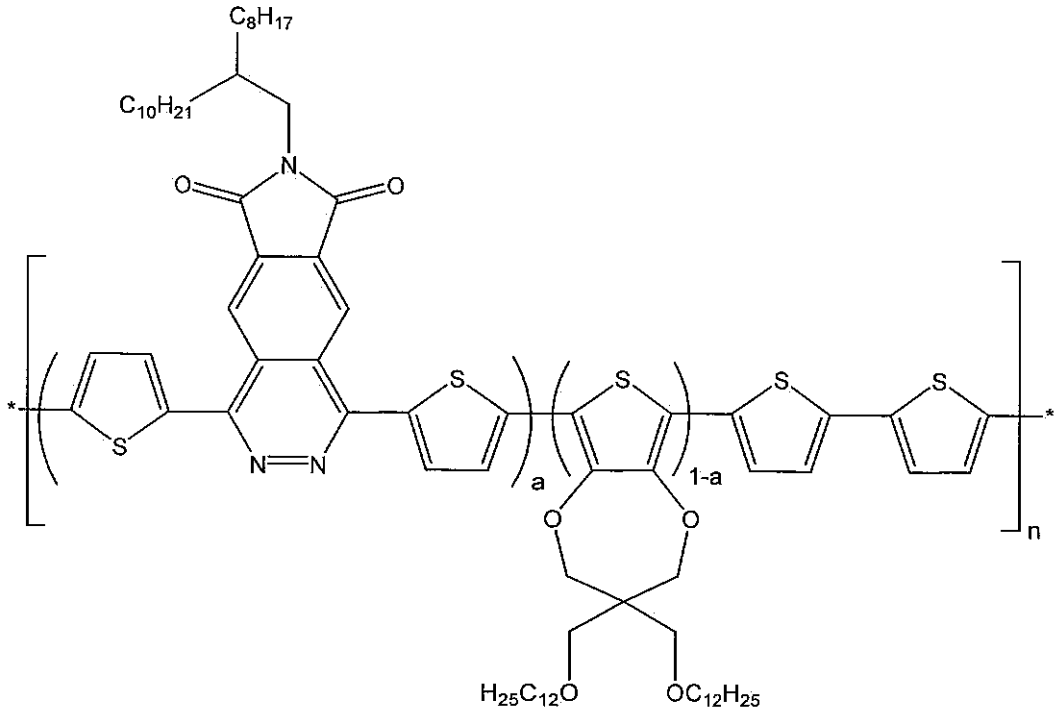
72. The compound according to claim 71, having the following formula (XX), (XXI), (XXII):



(XXII).

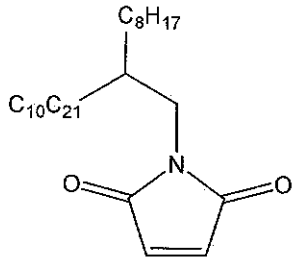
73. The compound according to claim 2, wherein y is 2.

74. The compound according to claim 73, having the following formula (XXIII),

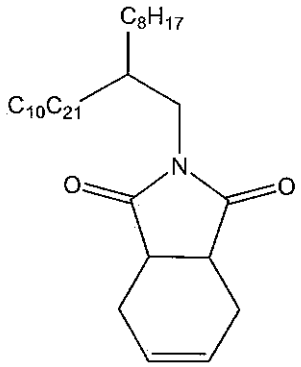


(XXIII).

75. The compound according to claim 4, having the following Formula (XXIVa) or (XXIVb)



(XXIVa)



(XXIVb).

76. A method for synthesizing the compound of Formula (VI) of claim 3, comprising the steps of providing a hydrazine and contacting the hydrazine with a functionalized cyclic group, wherein the cyclic group of the functionalized cyclic group is selected from the group comprising of optionally substituted furan, optionally substituted thiophene, optionally substituted selenophene, optionally substituted tellurophene, optionally substituted pyrrole, optionally substituted phenylene, optionally substituted aza-phenylene, optionally substituted arylene diimide, optionally substituted fluorene, optionally substituted cabazole, optionally substituted dibenzodiole, optionally substituted benzooxodiazole, optionally substituted benzotriazole, optionally substituted benzothidiazole and any combination thereof.

77. The method according to claim 76, wherein the functionalized cyclic group is functionalized with at least one nitrile group.

78. A method for synthesizing the compound of Formula (I) of claim 1, comprising the steps of:

providing the compound of Formula (VI) of claim 3; and

contacting the compound of Formula (VI) of claim 3 with the compound of Formulae (VIIa) or (VIIb) of claim 4 under reaction conditions to form the compound of Formula (I) of claim 1.

79. The method according to claim 78, further comprising the step of reacting the compound of claim 1 with N-bromosuccinimide and hydrogen peroxide, followed by a base.

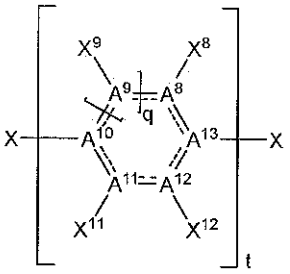
80. A method for synthesizing the compound of Formula (IV) of claim 2, comprising the step of:

providing the compound of Formula (I) of claim 1; and

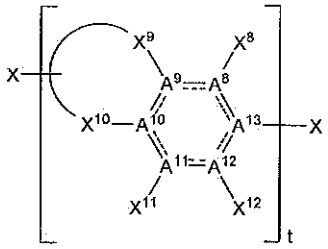
contacting the compound of Formula (I) of claim 1 with;

(i) a compound having the following Formula (XXVa), (XXVb) or (XXVc)

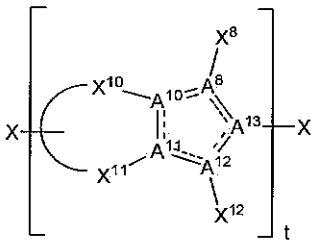
;



(XXVa)



(XXVb)



(XXVc)

wherein

$\overline{\text{-----}}$ is a single or double bond, as valency allows;

q is 0 or 1;

t is an integer selected from 1 to 4;

X is absent or selected from the group consisting of a H, halogen, CN, R^3, OR^3 or SR^3,

X^8, X^9, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N; and

wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl; and

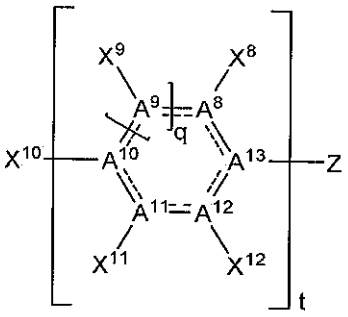
(ii) a cross-coupling reagent comprising a cyclic group; and an element selected from the group consisting of zinc, tin and boron; wherein the cyclic group is selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

in the presence of a metal-containing catalyst.

81. A method for synthesizing the compound of Formula (IV) of claim 2, comprising the steps of:

1) providing the compound of Formula (I) of claim 1; and

2) contacting the compound of Formula (I) of claim 1 with a compound having the following Formula (XXVI);



(XXVI)

wherein

⁻⁻⁻⁻⁻ is a single or double bond, as valency allows;

q is 0 or 1;

t is an integer selected from 1 to 4;

Z is a functional group containing zinc, tin or born;

X^8, X^9, X^{10}, X^{11} and X^{12} are independently absent or selected from the group consisting of a bond, H, halogen, CN, R^3, OR^3 or SR^3;

wherein R^3 is selected from the group consisting of optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl, optionally substituted heteroaryl,

A^8 is selected from the group consisting of O, S, Se, Te, C and N

A^9, A^{10}, A^{11}, A^{12} and A^{13} are independently C or N; and

wherein any two substituents selected from the group consisting of X^8, X^9, X^{10}, X^{11} and X^{12} may optionally be taken together to form an optionally substituted cyclic group selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

in the presence of a metal-containing catalyst to form a monomer precursor;

3) reacting the monomer precursor of step (2) with N-bromosuccinimide to form a reactive monomer; and

4) reacting the reactive monomer of step (2) with a cross-coupling reagent comprising a cyclic group; and an element selected from the group consisting of zinc, tin and boron; wherein the cyclic group is selected from the group consisting of an optionally substituted cycloalkyl, optionally substituted heterocycloalkyl, optionally substituted cycloalkenyl, optionally substituted heterocycloalkenyl, optionally substituted aryl and optionally substituted heteroaryl;

in the presence of a metal-containing catalyst.

82. The method of claim 80 or 81, wherein the metal in the metal-containing catalyst is selected from the group consisting of palladium, nickel and copper.

83. Use of the compound of Formula (IV) of claim 2 in the manufacture of semiconductor devices.

84. A semiconductor device comprising the compound of Formula (IV) of claim 2.