Claims

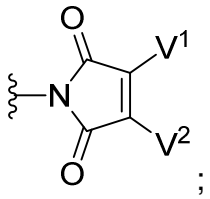
1. A polymerizable mixture comprising a first monomer and a second monomer,

wherein the first monomer is one or more compounds of Formula (1):

$$P^1\text{-}Sp^1\text{-}(MG\text{-}Sp^1)_m\text{-}P^1 \qquad \text{Formula (1)}$$

wherein:

m is an integer of 2 to 60;

P^1 denotes  ;

V^1 is H;

V^2 is alkyl with 1 to 6 carbon atoms, F, Cl or CN;

or

V^1 and V^2 are independently of one another alkyl with 1 to 6 carbon atoms, F, Cl or CN;

Sp^1 denotes at each occurrence Sp'-X';

Sp' denotes

(a) a straight chain alkylene having 1 to 40 C atoms or branched chain alkylene having 3 to 40 C atoms, which is optionally mono- or poly-substituted by F, Cl, Br, I or CN and in which one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by -O-, -S-, -NH-, $-NR^{01}$-, $-SiR^{01}R^{02}$-, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, $-NR^{01}$-CO-O-, -O-CO-NR^{01}-, $-NR^{01}$-CO-NR^{01}-, or -CH=CH- in such a way that O and/or S atoms are not linked directly to one another, or

(b) $-Sp^x$-G-Sp^y-, wherein Sp^x and Sp^y denote independently of each other alkylene having 1 to 20 C atoms or a single bond; G denotes

cycloalkylene having 3 to 20 C atoms which is optionally mono- or polysubstituted by alkyl having 1 to 20 C atoms;

X' denotes -O-, -S-, -CO-, -COO-, -OCO-, -O-COO-, -CO-NR^{01}-, -NR^{01}-CO-, -NR^{01}-CO-NR^{01}-, -OCH_2-, -CH_2O-, -SCH_2-, -CH_2S-, -CF_2O-, -OCF_2-, -CF_2S-, -SCF_2-, -CF_2CH_2-, -CH_2CF_2-, -CF_2CF_2-, -CH=N-, -N=C-, -N=N-, -CH=CR^{01}-, -CY^{11}=CY^{12}-, -C≡C-, -CH=CH-COO-, -OCO-CH=CH- or a single bond;

Y^{11} and Y^{12} each, independently of one another, denote H, F, Cl or CN;

MG is a rod-shaped mesogenic group of Formula (2):

$$-(A^{21}-Z^{21})_k-A^{22}-(Z^{22}-A^{23})_l- \qquad \text{Formula (2)}$$

A^{21} to A^{23} are independently and at each occurrence independently of one another an aryl group, heteroaryl group, heterocyclic group, alicyclic group or cyclic imide group optionally being substituted by one or more identical or different groups L;

Z^{21} and Z^{22} are independently and at each occurrence independently from each other, -O-, -S-, -CO-, -COO-, -OCO-, -S-CO-, -CO-S-, -O-COO-, -CO-NR^{01}-, -NR^{01}-CO-, -NR^{01}-CO-NR^{02}, -NR^{01}-CO-O-, -O-CO-NR^{01}-, -OCH_2-, -CH_2O-, -SCH_2-, -CH_2S-, -CF_2O-, -OCF_2-, -CF_2S-, -SCF_2-, -CH_2CH_2-, -$(CH_2)_4$-, -CF_2CH_2-, -CH_2CF_2-, -CF_2CF_2-, -CH=N-, -N=CH-, -N=N-, -CH=CR^{01}-, -CY^{01}=CY^{02}-, -CH=CH-COO-, -OCO-CH=CH-, or a single bond;

R^{01} and R^{02} each, independently of one another, denote H or alkyl having 1 to 12 C atoms;

L is F, Cl, Br, I, -CN, -NO_2, -NCO, -NCS, -OCN, -SCN, -C(=O)$NR^{xx}R^{yy}$, -C(=O)OR^{xx}, -C(=O)R^{xx}, -$NR^{xx}R^{yy}$, -OH, -SF_5, straight chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C atoms, or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 3 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl,

-CN, or straight chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms, or branched chain alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 3 to 6 C atoms;

R^{xx} and R^{yy} independently of each other denote H or alkyl with 1 to 12 C-atoms;

Y^{01} and Y^{02} each, independently of one another, denote H, alkyl having 1 to 12 C atoms, aryl, F, Cl, or CN; and

k and l are each and independently 0, 1, 2, 3 or 4; and

wherein the second monomer is one or more bi- or multifunctional compounds capable of reacting with the first monomer to give a copolymer, wherein the one or more bi- or multifunctional compounds comprise two or more polymerizable groups (P) which are selected from groups containing a C=C double bond, groups containing two conjugated C=C double bonds, nucleophilic groups, and 1,3-dipolar groups.

2. A polymerizable mixture according to claim 1, wherein at least one Sp^1 is of formula Sp'-X', so that P^1-Sp^1- is of formula P^1-Sp'-X'-,

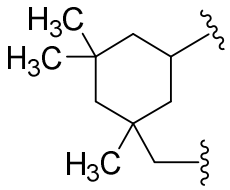
wherein:

Sp' denotes

(a) a straight chain alkylene having 1 to 40 C atoms or branched chain alkylene having 3 to 40 C atoms, which is optionally mono- or poly-substituted by F, Cl, Br, I or CN and in which one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by -O-, -S-, -NH-, $-NR^{01}-$, $-SiR^{01}R^{02}-$, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, $-NR^{01}$-CO-O-, -O-CO-NR^{01}-, $-NR^{01}$-CO-NR^{01}-, or -CH=CH- in such a way that O and/or S atoms are not linked directly to one another.

3. A polymerizable mixture according to claim 1, wherein at least one Sp^1 is selected from the group consisting of $-(CH_2)_{p1}-$, $-(CH_2CH_2O)_{q1}-CH_2CH_2-$, -

CH_2CH_2-S-CH_2CH_2-, -CH_2CH_2-NH-CH_2CH_2-, -($SiR^{01}R^{02}$-O)$_{p1}$-, -(CH_2)$_{p1}$-(cyclo-$C_6H_8R^{01}R^{02}$)-(CH_2)$_{p1}$-, and



, wherein:

p1 is an integer from 1 to 60;

q1 is an integer from 1 to 12; and

R^{01} and R^{02} each, independently of one another, denote H or alkyl having 1 to 12 C atoms.

4. A polymerizable mixture according to claim 1, wherein A^{21} to A^{23} denote independently and, in case of multiple occurrence, independently of one another, a moiety selected from the following groups a) to e):

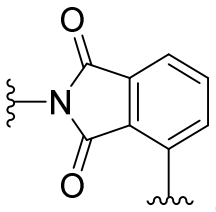
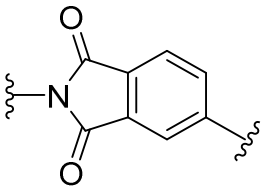
a) trans-1,4-cyclohexylene, 1,4-cyclohexenylene and 4,4'-bicyclohexylene, in which one or more non-adjacent CH_2 groups may be replaced by -O- and / or -S- and wherein one or more H atoms may be replaced by a group L;

b) 1,4-phenylene, 1,3-phenylene, 4,4'-biphenylene, 2,5-thiophene and 2,6-dithieno[3,2-b:2',3'-d]thiophene in which one or two CH groups may be replaced by N and where one or more H atoms may be replaced by a group L;

c) tetrahydropyran-2,5-diyl, 1,3-dioxane-2,5-diyl, tetrahydrofuran-2,5-diyl, cyclobut-1,3-diyl, piperidine-1,4-diyl, thiophene-2,5-diyl and selenophen-2,5-diyl, which may be substituted one or more groups L;

d) saturated, partially unsaturated or completely unsaturated, and optionally substituted, polycyclic radicals having 5 to 20 cyclic C atoms, of which one or more can each be replaced by a heteroatom;

e) cyclic imides selected from the group consisting of:

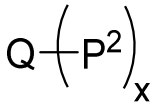
 , and  ,

where one or more H atoms may be replaced by a group L, and/or one or more double bonds may be replaced by single bonds, and/or one or more CH groups may be replaced by N.

5. A polymerizable mixture according to claim 1, wherein the second monomer is one or more bi- or multifunctional compounds selected from organic compounds, polyhedralsilsesquioxane compounds and functionalized inorganic nanoparticles.

6. A polymerizable mixture according to claim 1,
wherein the second monomer is one or more of:

(a) an organic compound represented by Formula (4):

 Formula (4),

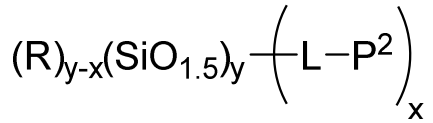
wherein:

Q denotes a hydrocarbon group having 1 to 50 carbon atoms which may be optionally substituted with one or more substituents L, wherein L is defined as for Formula (2), and which may optionally contain one or more hetero atom groups selected from N, O and S;

P^2 denotes a polymerizable group (P); and

x is an integer from 2 to 10;

(b) a polyhedralsilsesquioxane compound represented by the following structure:

 Structure (1),

wherein:

R is H, C_1-C_6-alkyl, C_2-C_6-alkenyl, C_6-C_{10}-aryl, or C_1-C_6-alkoxy;

L is C_1-C_{12}-alkylene or C_1-C_{12}-oxyalkylene, wherein one or more non-adjacent C atoms may be replaced, independently of one another, by $-SiR^{05}R^{06}-$, wherein R^{05} and R^{06} each, independently of one another, denote H or alkyl having 1 to 6 C atoms;

P^2 denotes a polymerizable group (P);

y is an integer from 6 to 12; and x is an integer from 2 to 12, wherein y-x ≥ 0; and/or

(c) a functionalized inorganic nanoparticle which comprises polymerizable groups P^2 on its surface, wherein:

P^2 denotes a polymerizable group (P).

7. A method for forming a copolymer comprising the following steps:

(i) providing a polymerizable mixture according to claim 1; and

(ii) polymerizing said polymerizable mixture to obtain a copolymer.

8. A method for forming a copolymer according to claim 7, wherein the polymerizable mixture further comprises one or more radical initiators.

9. A copolymer, which is obtained by the method for forming a copolymer according to claim 7.

10. A copolymer comprising at least one repeating unit which is derived from the first monomer and at least one repeating unit which is derived from the second monomer as defined in claim 1.

11. A copolymer comprising at least one repeating unit which is derived from the first monomer and at least one repeating unit which is derived from the second monomer as defined in claim 1, and wherein the

repeating unit derived from the first monomer comprises a structural unit represented by Formula (5):

$$[-Sp^1-(MG-Sp^1)_m-] \qquad \text{Formula (5)}$$

wherein Sp^1, MG and m are defined as for Formula (1).

12. An electronic device comprising a copolymer according to claim 9.

13. An electronic device according to claim 12, wherein the copolymer forms a dielectric layer.

14. A method for preparing a packaged microelectronic structure, in which a substrate is provided with a dielectric layer, wherein the method comprises the following steps:

(1) applying a polymerizable mixture according to claim 1 to a surface of a substrate; and

(2) curing said polymerizable mixture to form a dielectric layer.

15. A method for preparing a packaged microelectronic structure according to claim 14, wherein the polymerizable mixture further comprises one or more radical initiators.

16. A microelectronic device comprising a packaged microelectronic structure obtained by the manufacturing method according to claim 14.

17. A polymerizable mixture according to claim 1, wherein A^{21} to A^{23} denote independently and, in case of multiple occurrence, independently of one another, a moiety selected from the following groups a) to e):

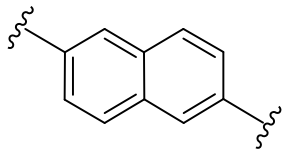
a) trans-1,4-cyclohexylene, 1,4-cyclohexenylene and 4,4'-bicyclohexylene, in which one or more non-adjacent CH_2 groups may be

replaced by -O- and / or -S- and wherein one or more H atoms may be replaced by a group L;

b) 1,4-phenylene, 1,3-phenylene, 4,4'-biphenylene, 2,5-thiophene and 2,6-dithieno[3,2-b:2',3'-d]thiophene in which one or two CH groups may be replaced by N and where one or more H atoms may be replaced by a group L;

c) tetrahydropyran-2,5-diyl, 1,3-dioxane-2,5-diyl, tetrahydrofuran-2,5-diyl, cyclobut-1,3-diyl, piperidine-1,4-diyl, thiophene-2,5-diyl and selenophen-2,5-diyl, which may be substituted one or more groups L;

d) saturated, partially unsaturated or completely unsaturated, and optionally substituted, polycyclic radicals having 5 to 20 cyclic C atoms, of which one or more can also be replaced by heteroatoms, selected from the group consisting of bicyclo [1.1.1] pentane-1,3-diyl, bicyclo [2.2.2] octane-1,4-diyl, spiro [3.3] heptane-2,6-diyl,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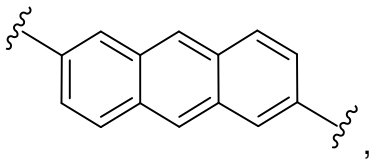
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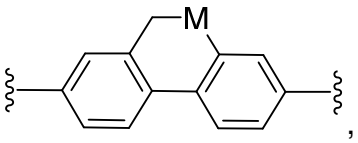

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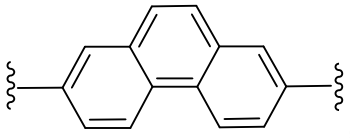
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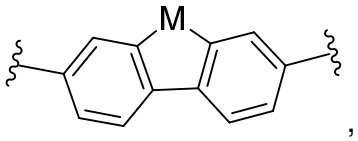

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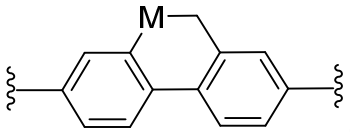

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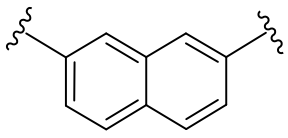
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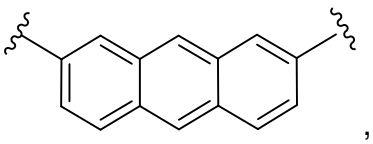
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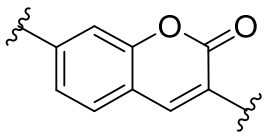

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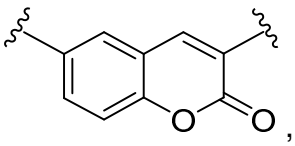

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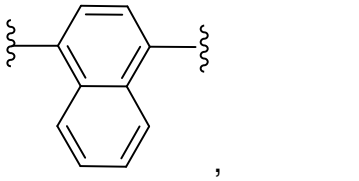
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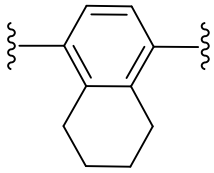
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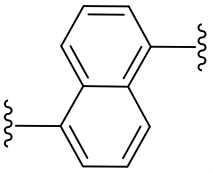
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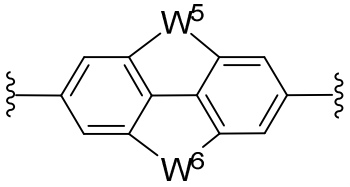

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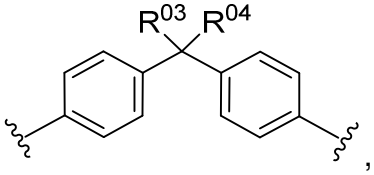

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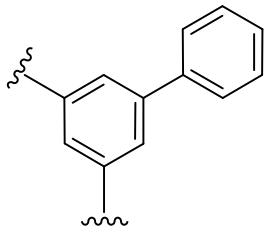
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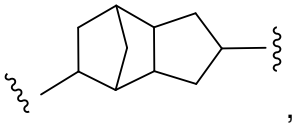
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where one or more H atoms may be replaced by a group L, and/or one or more double bonds may be replaced by single bonds, and/or one or more CH groups may be replaced by N, and where

M denotes -O-, -S-, $-CH_2-$, $-CHY^{03}-$ or $-CY^{03}Y^{04}-$;

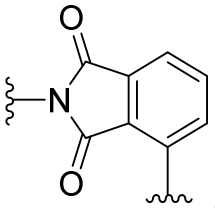
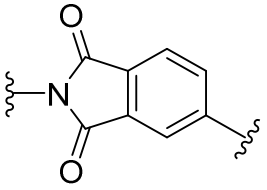
Y^{03}, Y^{04} denote independently of each other one of the meanings given above for R^{01}, F, Cl, CN, OCF_3 or CF_3;

W^5, W^6 denote independently of each other $-CH_2CH_2-$, -CH=CH-, $-CH_2-O-$, $-O-CH_2-$, $-C(R^cR^d)-$ or -O-;

R^c, R^d denote independently of each other H or alkyl having 1 to 6 C atoms; and

R^{03}, R^{04} denote independently of each other H, F, straight chain alkyl having 1 to 12 C atoms, or branched chain alkyl having 3 to 12 C atoms, where one or more H atoms may be replaced by F;

e) cyclic imides selected from the group consisting of:

 , and  ,

where one or more H atoms may be replaced by a group L, and/or one or more double bonds may be replaced by single bonds, and/or one or more CH groups may be replaced by N.

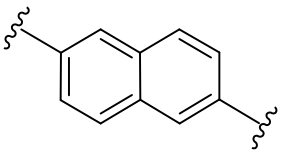
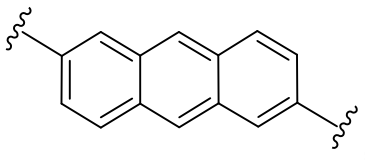
18. A polymerizable mixture according to claim 17, wherein A^{21} to A^{23} denote independently and, in case of multiple occurrence, independently of one another, a moiety selected from the following groups a), b), c), and d):

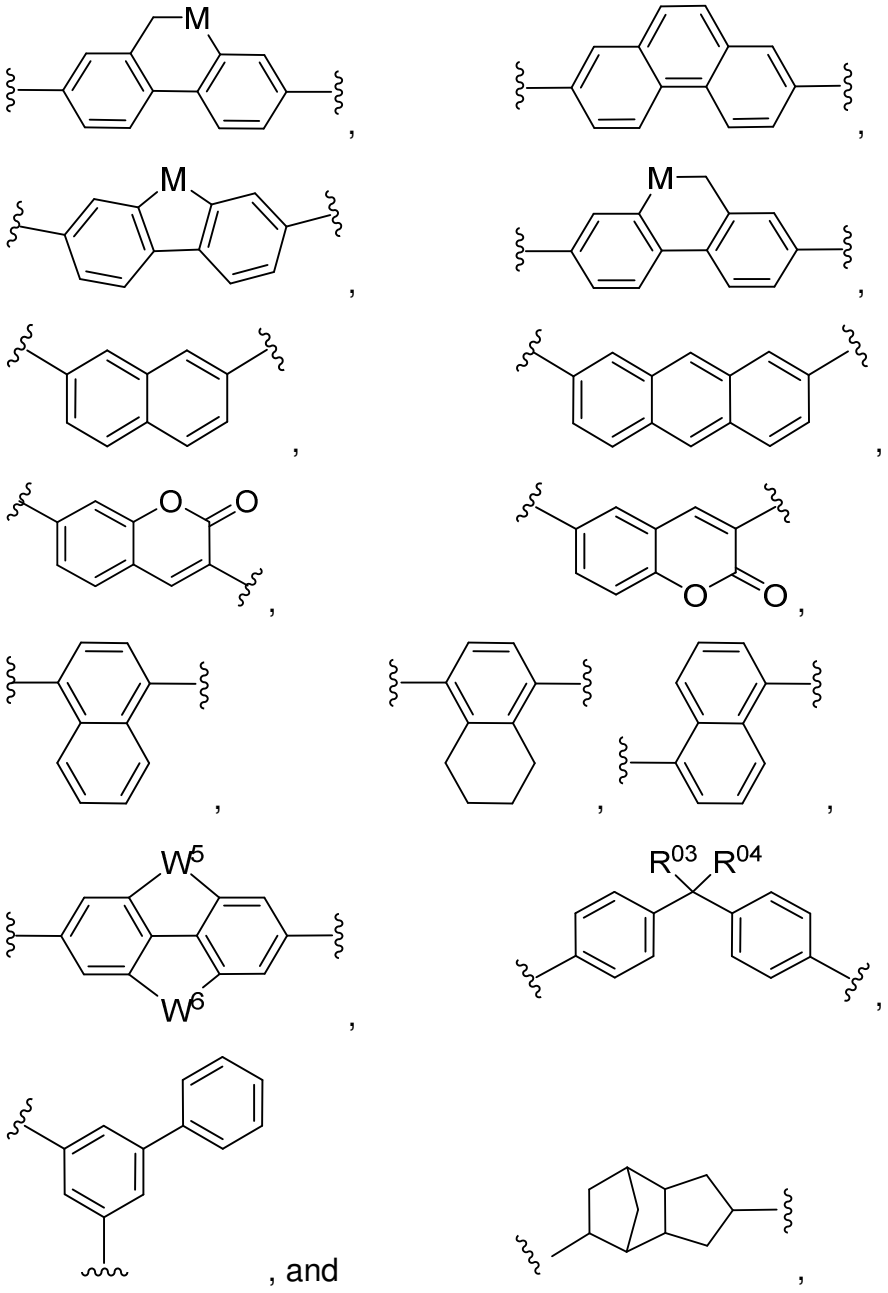
a) trans-1,4-cyclohexylene, 1,4-cyclohexenylene and 4,4'-bicyclohexylene, in which one or more non-adjacent CH_2 groups may be replaced by -O- and / or -S- and wherein one or more H atoms may be replaced by a group L;

b) 1,4-phenylene, 1,3-phenylene, 4,4'-biphenylene, 2,5-thiophene and 2,6-dithieno[3,2-b:2',3'-d]thiophene in which one or two CH groups may be replaced by N and where one or more H atoms may be replaced by a group L;

c) tetrahydropyran-2,5-diyl, 1,3-dioxane-2,5-diyl, tetrahydrofuran-2,5-diyl, cyclobut-1,3-diyl, piperidine-1,4-diyl, thiophene-2,5-diyl and selenophen-2,5-diyl, which may be substituted one or more groups L;

d) saturated, partially unsaturated or completely unsaturated, and optionally substituted, polycyclic radicals having 5 to 20 cyclic C atoms, of which one or more can also be replaced by heteroatoms, selected from the group consisting of bicyclo [1.1.1] pentane-1,3-diyl, bicyclo [2.2.2] octane-1,4-diyl, spiro [3.3] heptane-2,6-diyl,

 ,  ,



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where one or more H atoms may be replaced by a group L, and/or one or more double bonds may be replaced by single bonds, and/or one or more CH groups may be replaced by N, and where

M denotes -O-, -S-, $-CH_2-$, $-CHY^{03}-$ or $-CY^{03}Y^{04}-$;

Y^{03}, Y^{04} denote independently of each other one of the meanings given above for R^{01}, F, Cl, CN, OCF_3 or CF_3;

W^5, W^6 denote independently of each other $-CH_2CH_2-$, $-CH=CH-$, $-CH_2-O-$, $-O-CH_2-$, $-C(R^cR^d)-$ or $-O-$;

R^c, R^d denote independently of each other H or alkyl having 1 to 6 C atoms; and

R^{03}, R^{04} denote independently of each other H, F, straight chain alkyl having 1 to 12 C atoms, or branched chain alkyl having 3 to 12 C atoms, where one or more H atoms may be replaced by F.

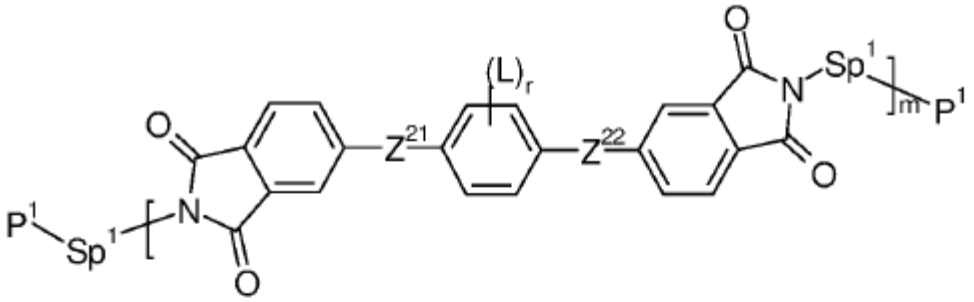
19. A polymerizable mixture according to claim 1, wherein m is 3 to 20.

20. A polymerizable mixture according to claim 1, wherein V^2 is F, Cl or CN.

21. A polymerizable mixture according to claim 1, wherein k and l are 1.

22. A polymerizable mixture according to claim 1, wherein the one or more compounds of formula (1) are of one or more of the following formulae:

M1



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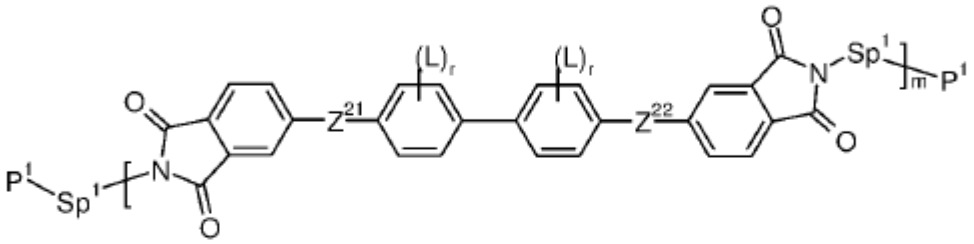

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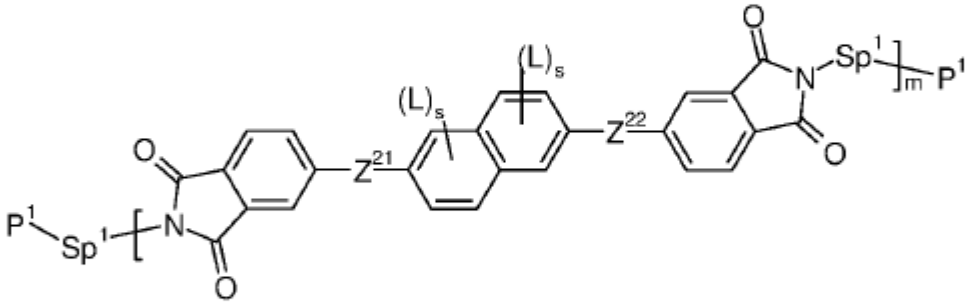

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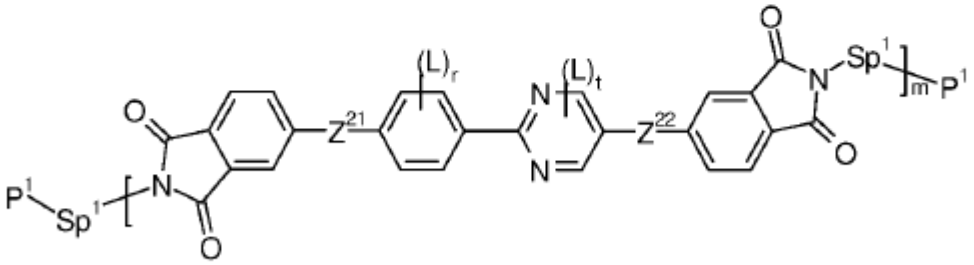

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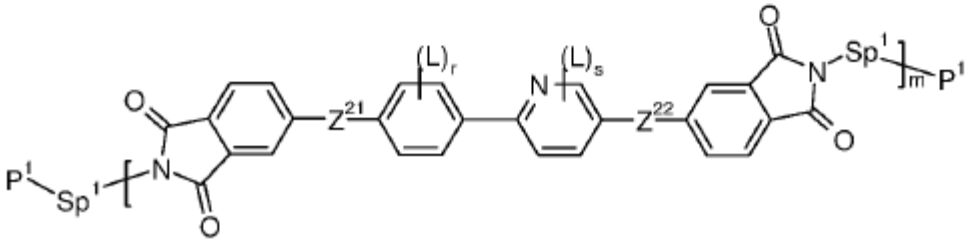

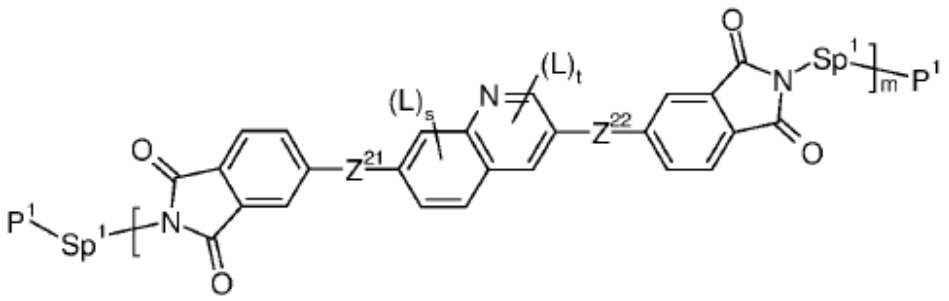

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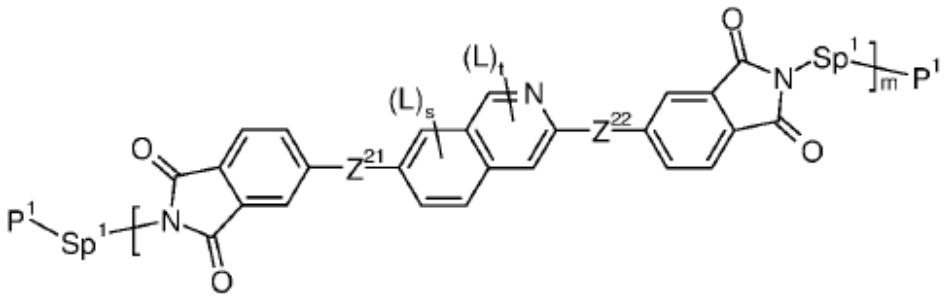

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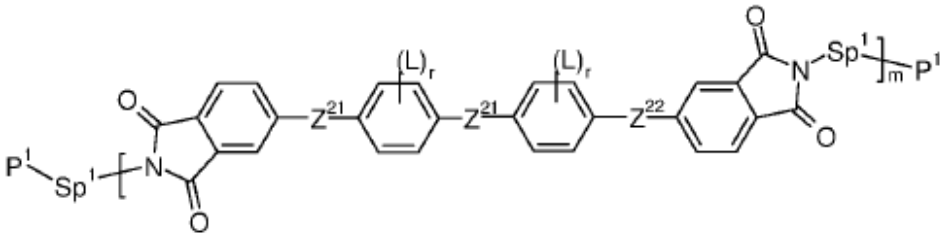

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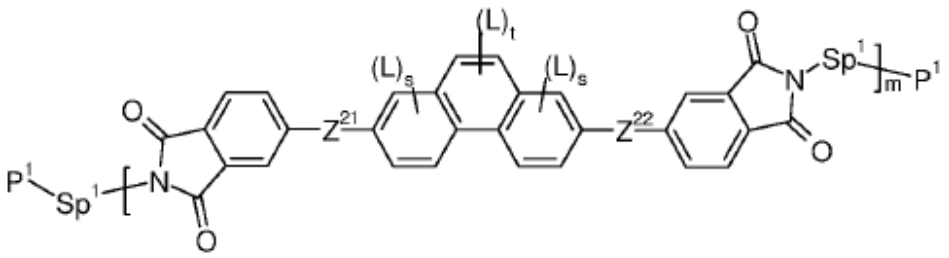

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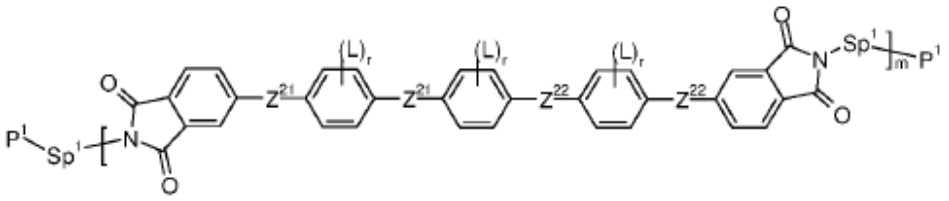

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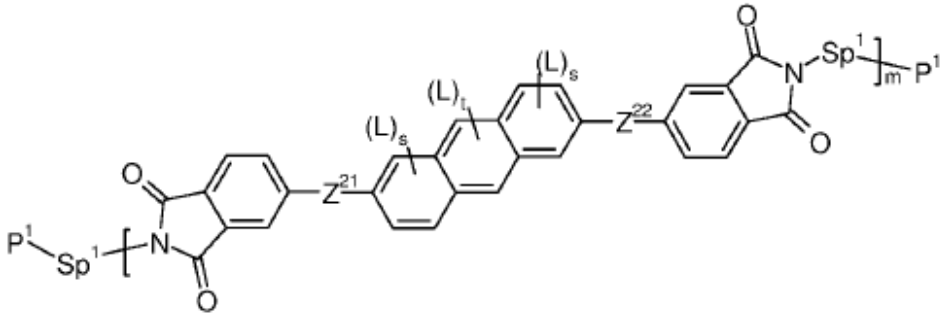

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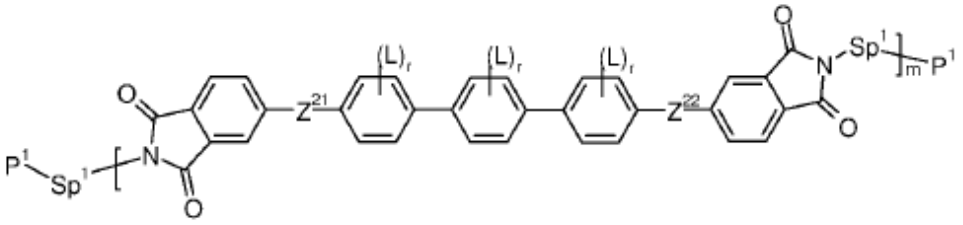

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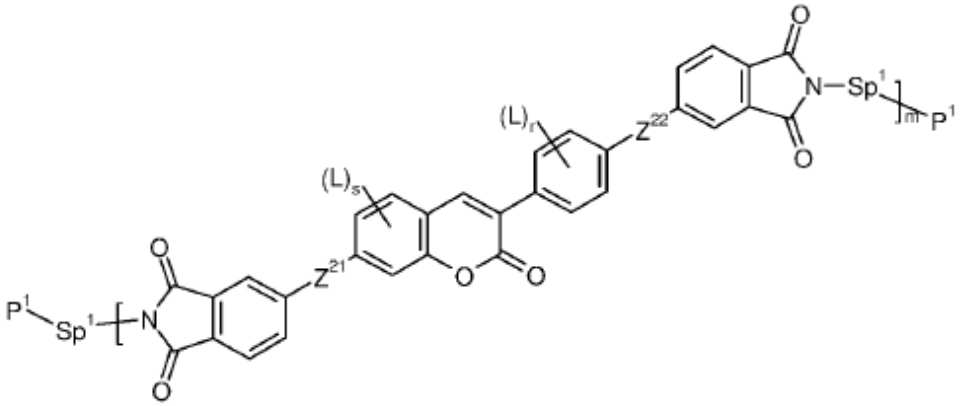

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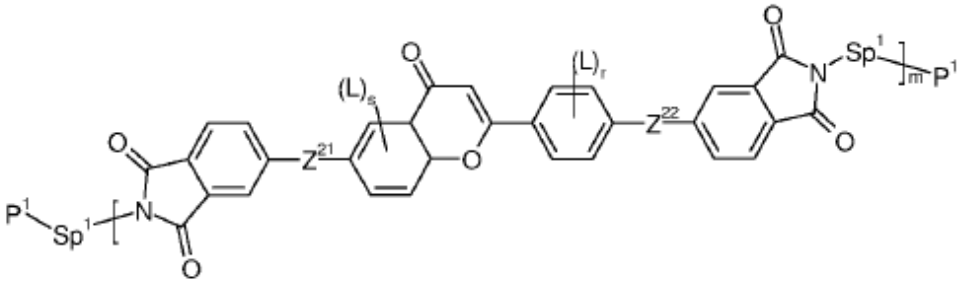

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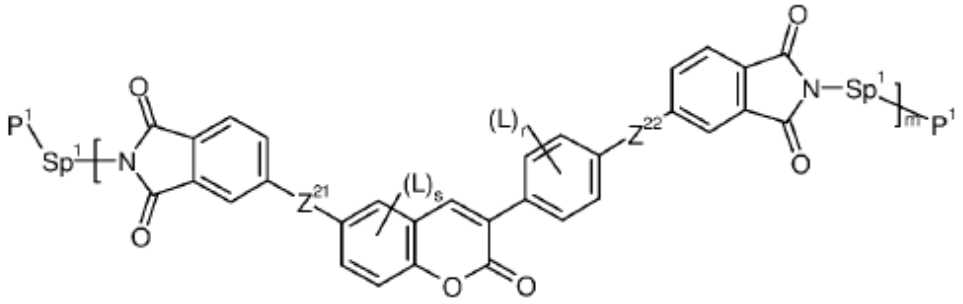

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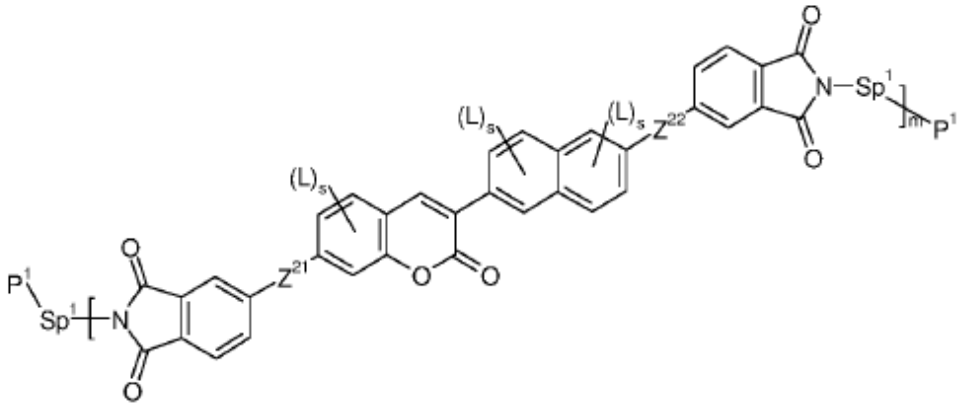

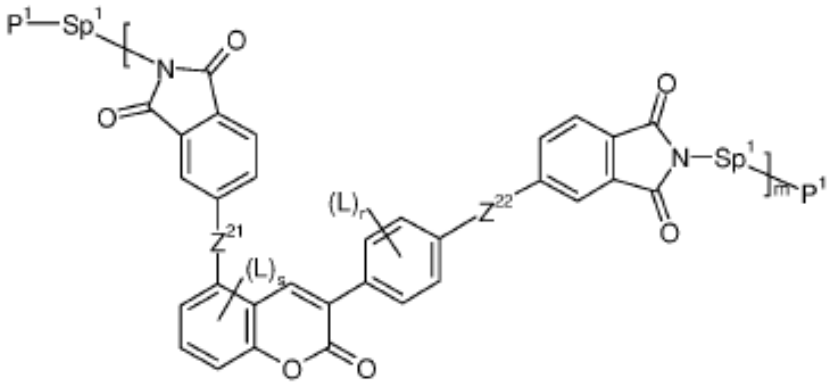

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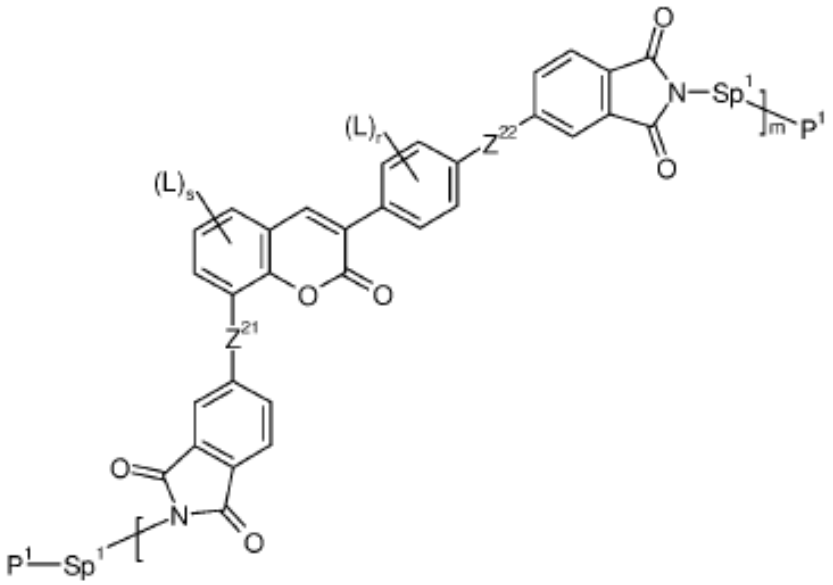

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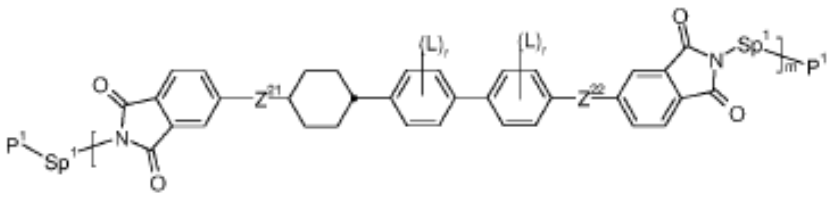

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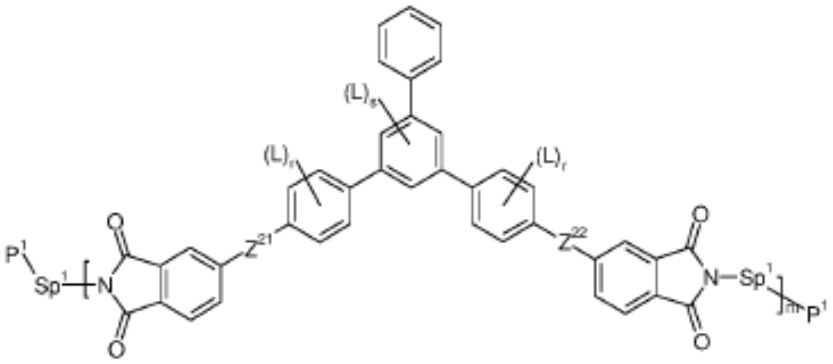

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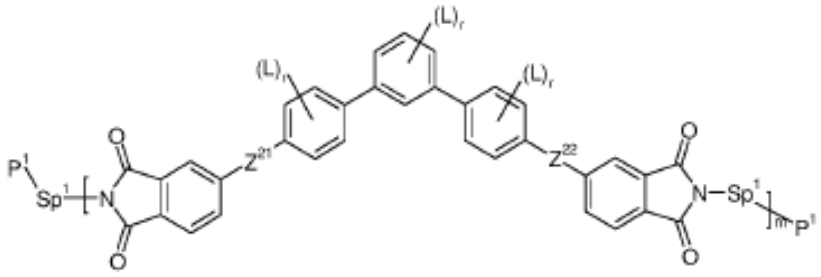

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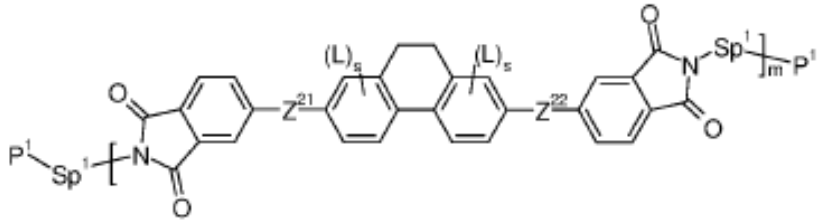

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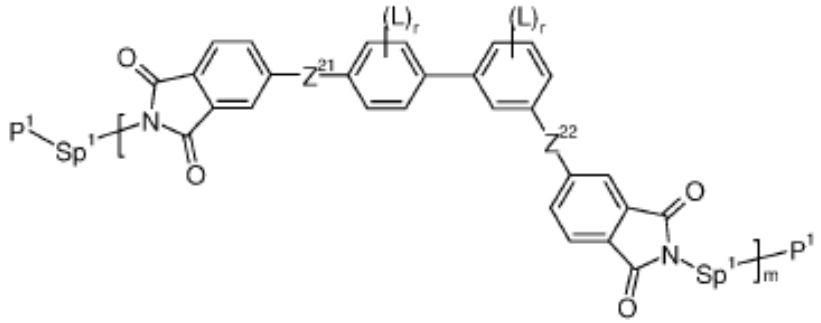

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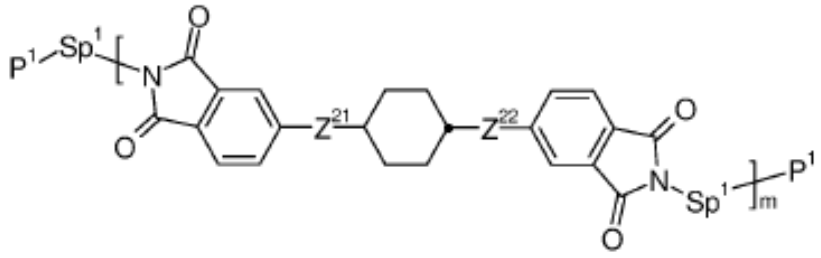

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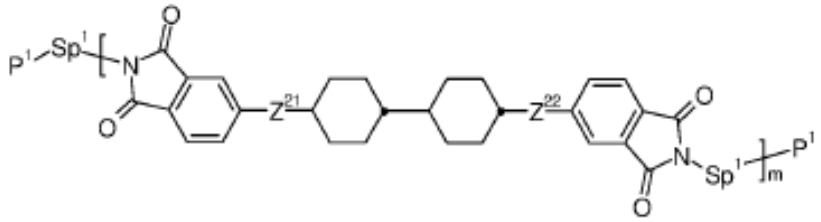

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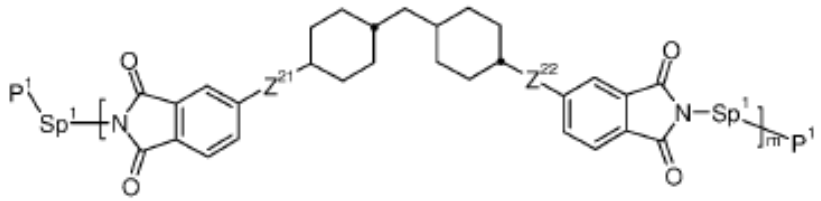

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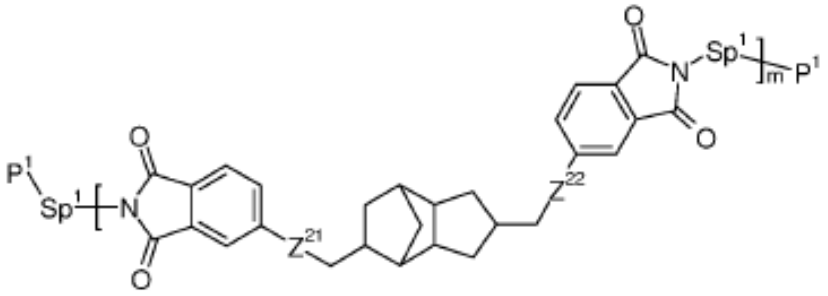

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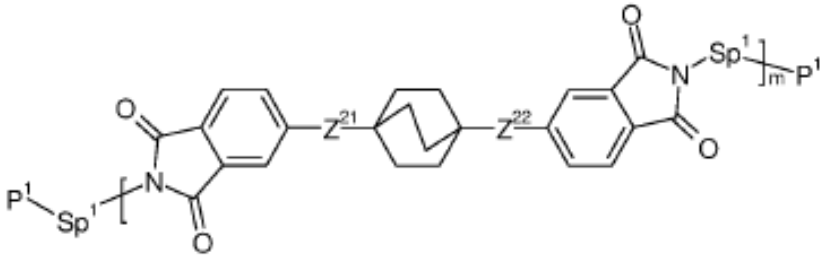

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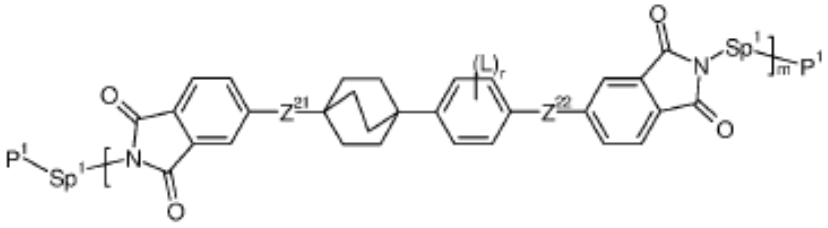

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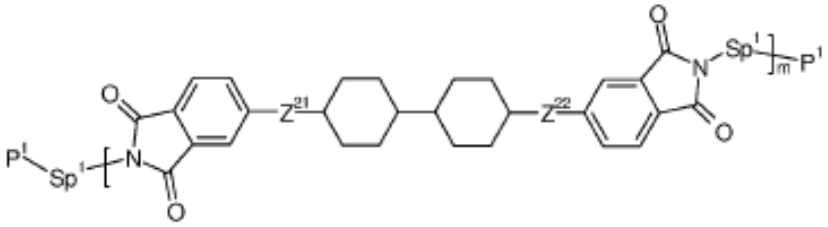

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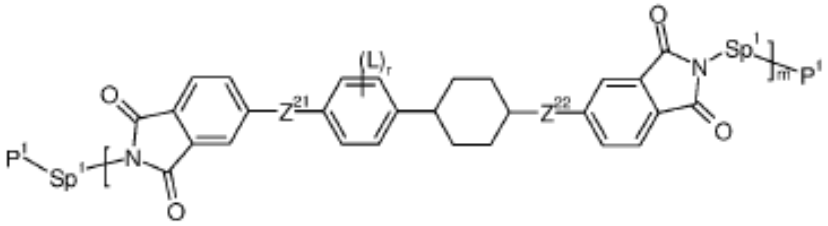

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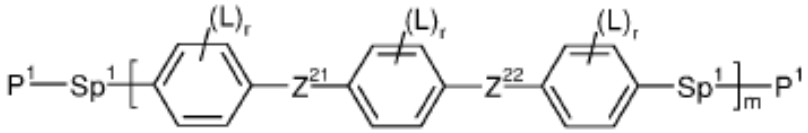

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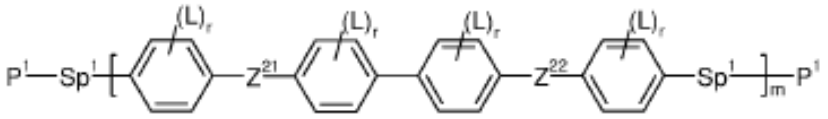


wherein

L is F, Cl, Br, I, -CN, -NO_2, -NCO, -NCS, -OCN, -SCN, -$C(=O)NR^{xx}R^{yy}$, -$C(=O)OR^{xx}$, -$C(=O)R^{xx}$, -$NR^{xx}R^{yy}$, -OH, -SF_5, or a straight chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C atoms, or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 3 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, -CN, or straight chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms, or branched chain alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 3 to 6 C atoms;

R^{xx} and R^{yy} independently of each other denote H or alkyl with 1 to 12 C-atoms;

r is 0, 1, 2, 3 or 4;

s is 0, 1, 2 or 3;

t is 0, 1 or 2;

Z^{21} and Z^{22} are independently and at each occurrence independently from each other, -O-, -S-, -CO-, -COO-, -OCO-, -S-CO-, -CO-S-, -O-COO-, -CO-NR^{01}-, -NR^{01}-CO-, -NR^{01}-CO-NR^{02}, -NR^{01}-CO-O-, -O-CO-NR^{01}-, -OCH_2-, -CH_2O-, -SCH_2-, -CH_2S-, -CF_2O-, -OCF_2-, -CF_2S-, -SCF_2-, -CH_2CH_2-, -$(CH_2)_4$-, -CF_2CH_2-, -CH_2CF_2-, -CF_2CF_2-, -CH=N-, -N=CH-, -N=N-, -$CH=CR^{01}$-, -$CY^{01}=CY^{02}$-, -CH=CH-COO-, -OCO-CH=CH-, or a single bond;

R^{01} and R^{02} each, independently of one another, denote H or alkyl having 1 to 12 C atoms;

Sp^1 denotes at each occurrence Sp'-X';

Sp' denotes

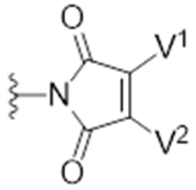
(a) a straight chain alkylene having 1 to 40 C atoms or branched chain alkylene having 3 to 40 C atoms, which is optionally mono- or poly-substituted by F, Cl, Br, I or CN and in which one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by -O-,

-S-, -NH-, -NR^{01}-, -$SiR^{01}R^{02}$-, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, -NR^{01}-CO-O-, -O-CO-NR^{01}-, -NR^{01}-CO-NR^{01}-, or -CH=CH- in such a way that O and/or S atoms are not linked directly to one another, or

(b) -Sp^x-G-Sp^y-, wherein Sp^x and Sp^y denote independently of each other alkylene having 1 to 20 C atoms or a single bond; G denotes cycloalkylene having 3 to 20 C atoms which is optionally mono- or polysubstituted by alkyl having 1 to 20 C atoms;

X' denotes -O-, -S-, -CO-, -COO-, -OCO-, -O-COO-, -CO-NR^{01}-, -NR^{01}-CO-, -NR^{01}-CO-NR^{01}-, -OCH_2-, -CH_2O-, -SCH_2-, -CH_2S-, -CF_2O-, -OCF_2-, -CF_2S-, -SCF_2-, -CF_2CH_2-, -CH_2CF_2-, -CF_2CF_2-, -CH=N-, -N=C-, -N=N-, -CH=CR^{01}-, -CY^{11}=CY^{12}-, -C≡C-, -CH=CH-COO-, -OCO-CH=CH- or a single bond;

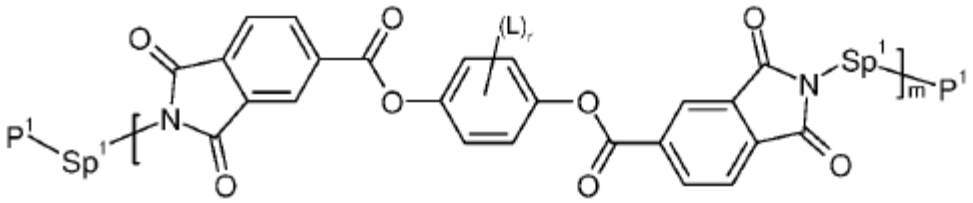
Y^{11} and Y^{12} each, independently of one another, denote H, F, Cl or CN;

P^1 denotes 

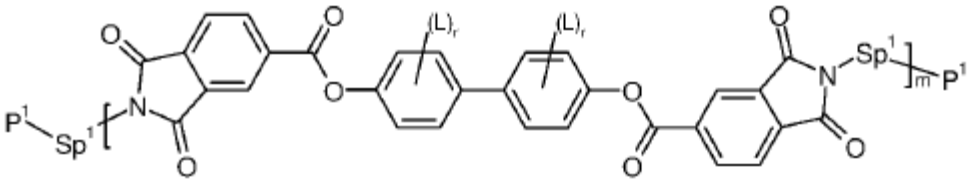
, where V^1 is H, and V^2 is alkyl with 1 to 6 carbon atoms, F, Cl or CN; or V^1 and V^2 are independently of one another alkyl with 1 to 6 carbon atoms, F, Cl or CN; and

m is an integer from 2 to 60.

23. A polymerizable mixture according to claim 22, wherein the one or more compounds of formula (1) are of one or more of the following formulae:



M1a



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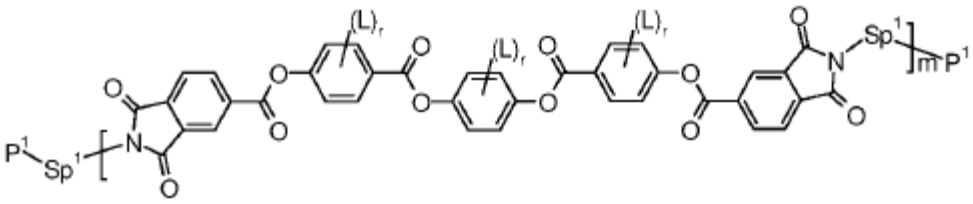

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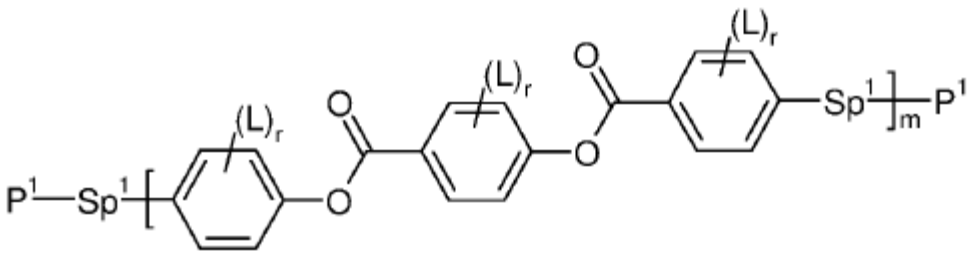

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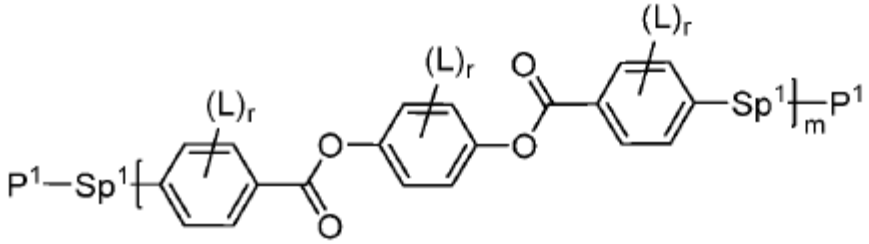
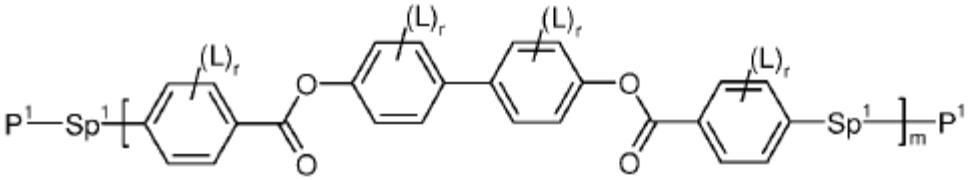


M32b



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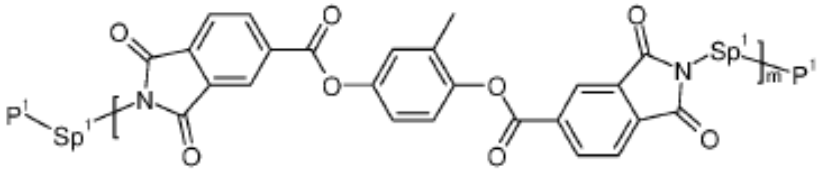
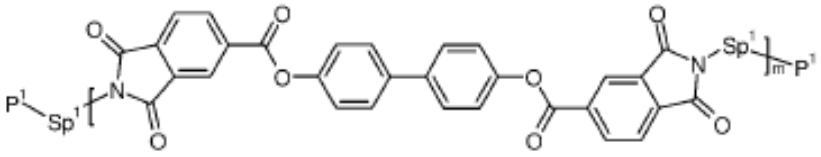
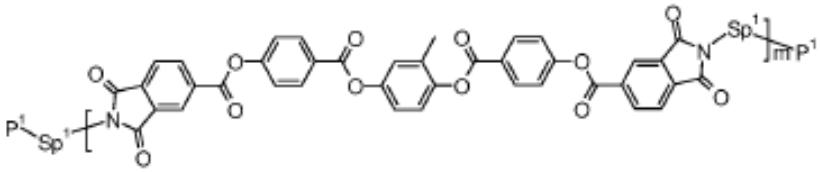


M1b



M2b



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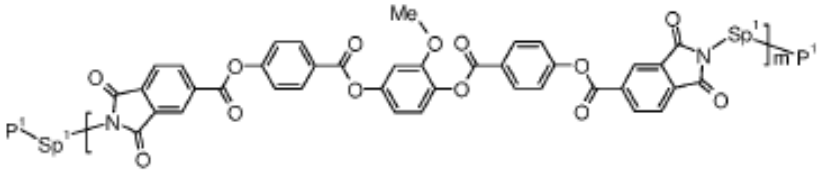

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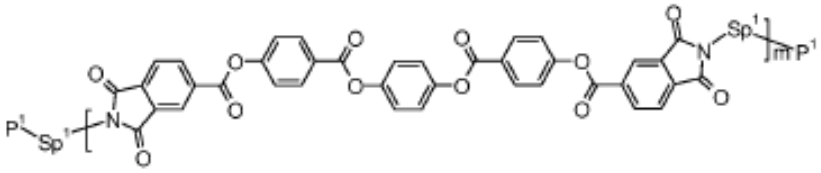

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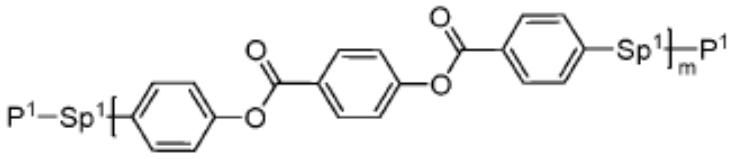

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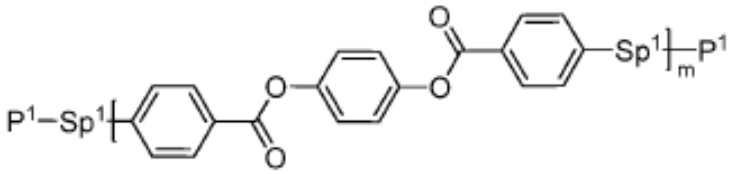

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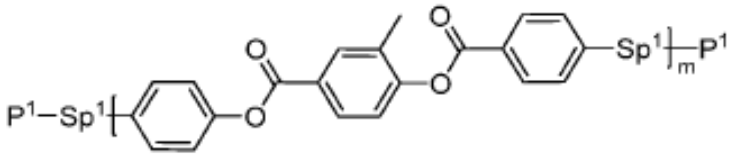

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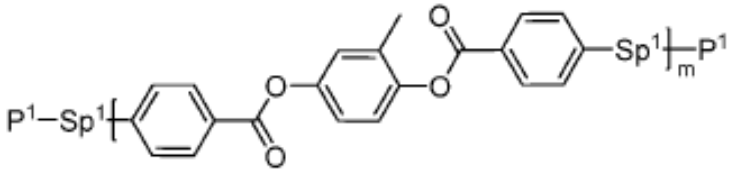
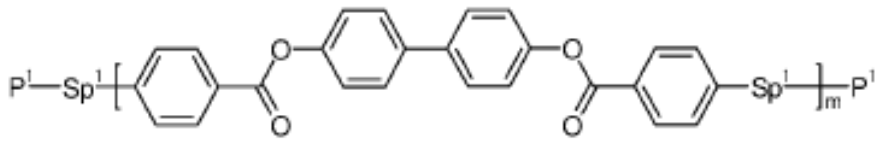
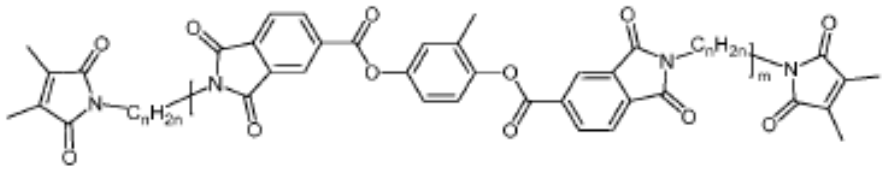


M32f

M33b



M1c



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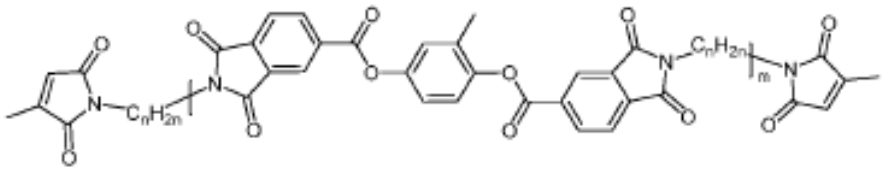

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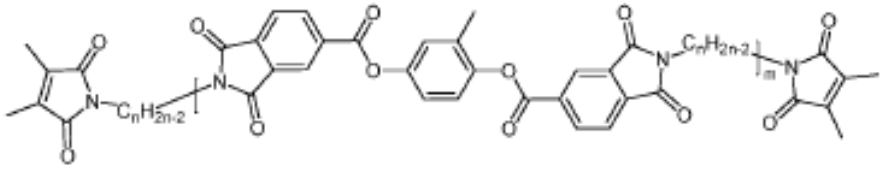

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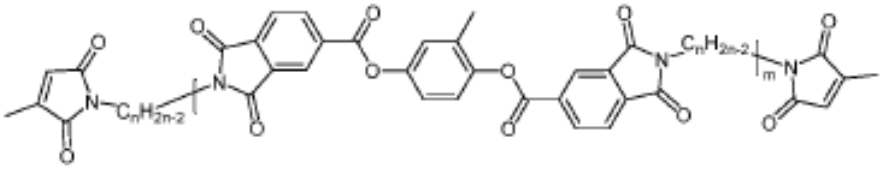

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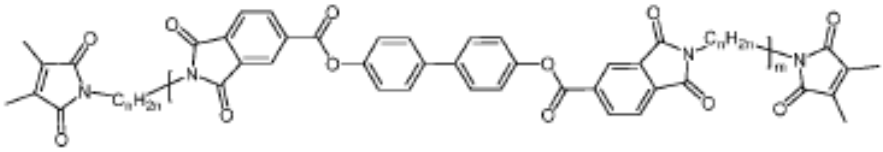

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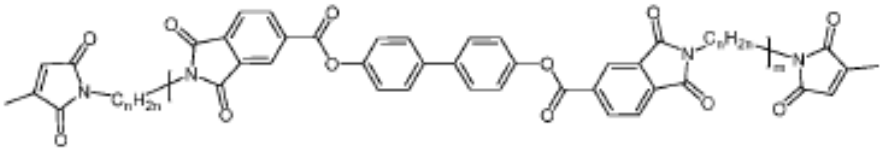

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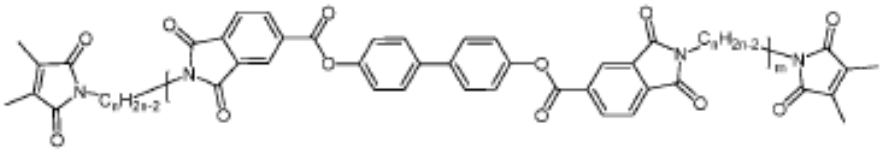

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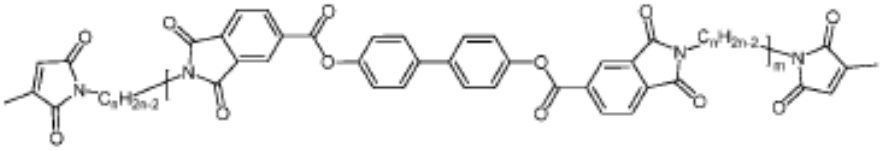
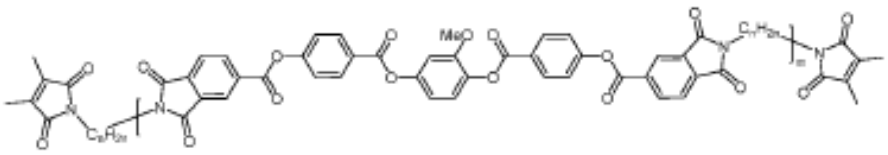
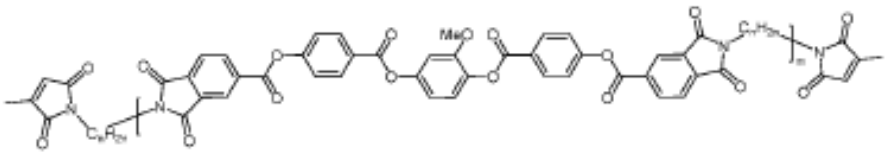




M8d



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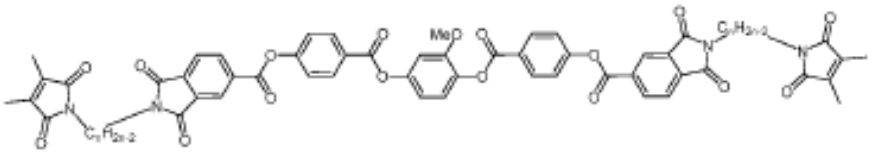

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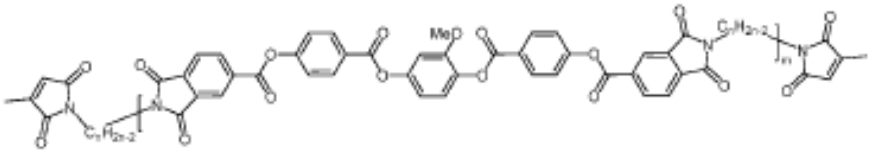

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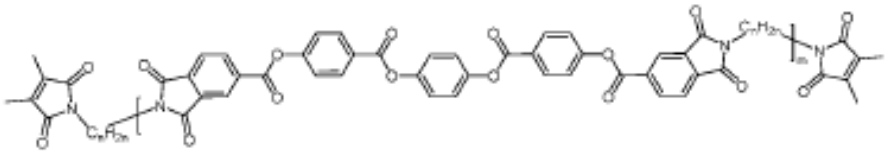

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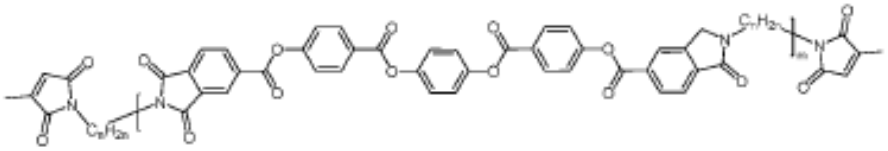

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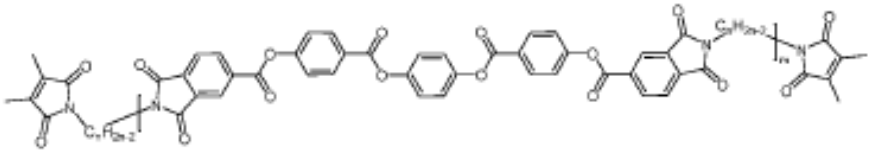

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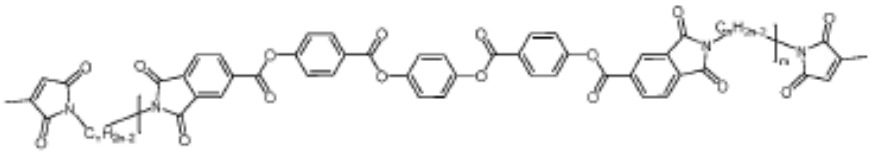

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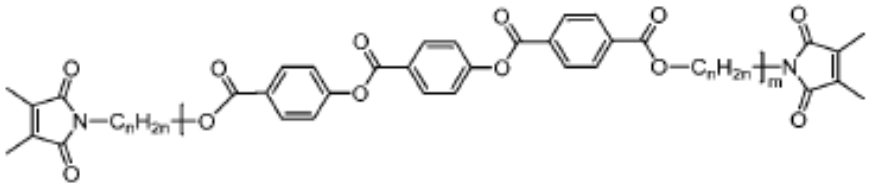

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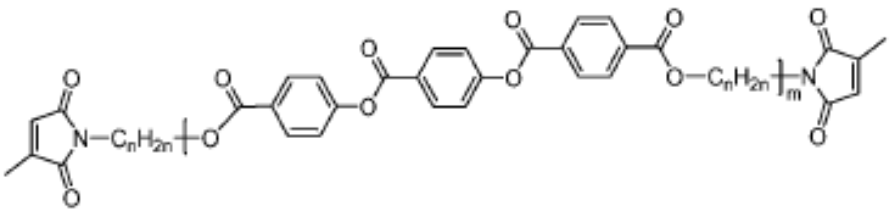

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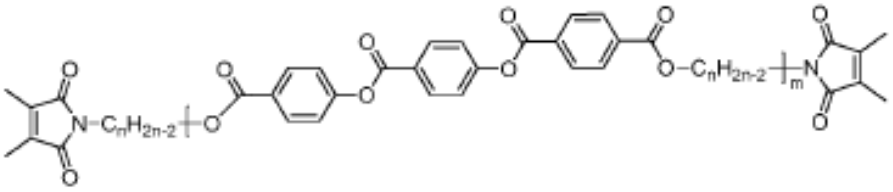

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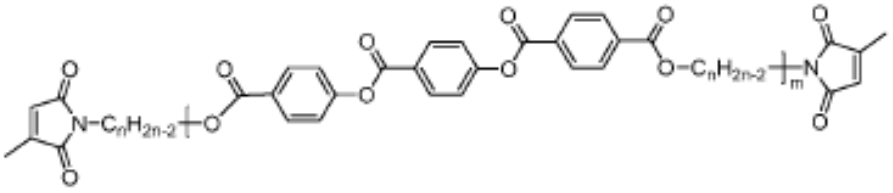

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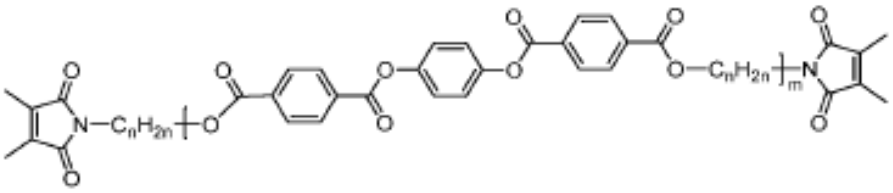

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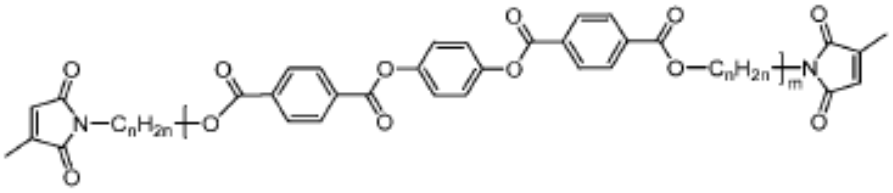

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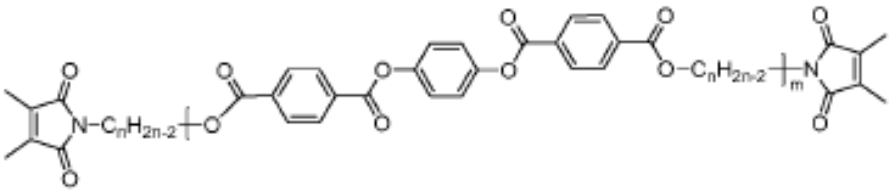

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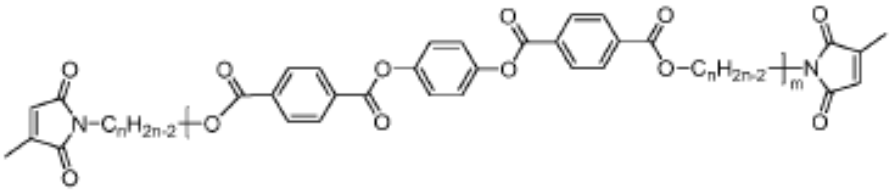

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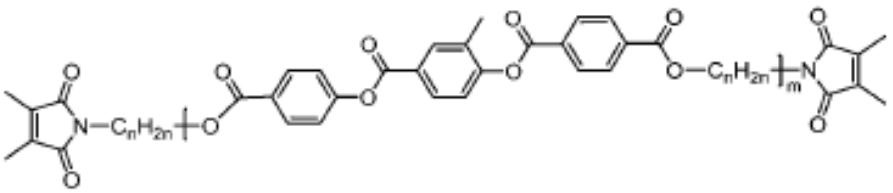

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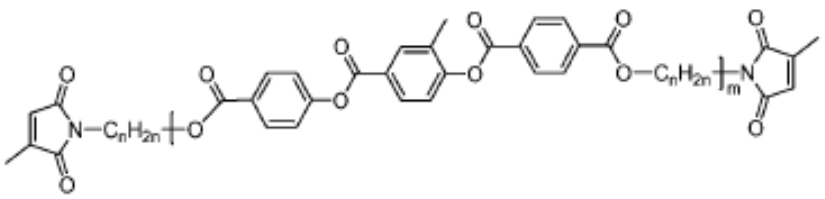

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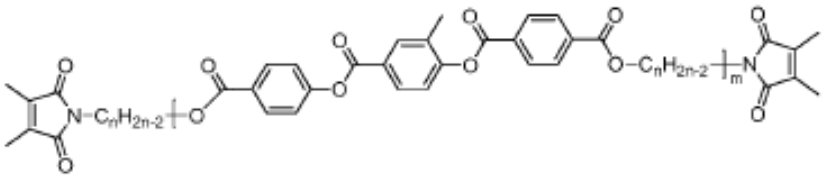

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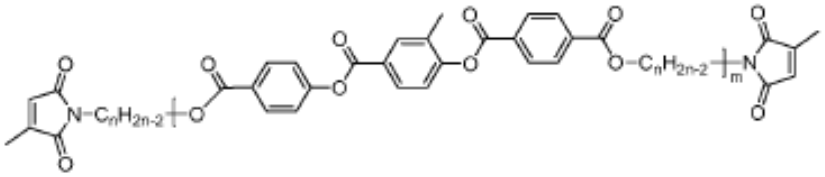

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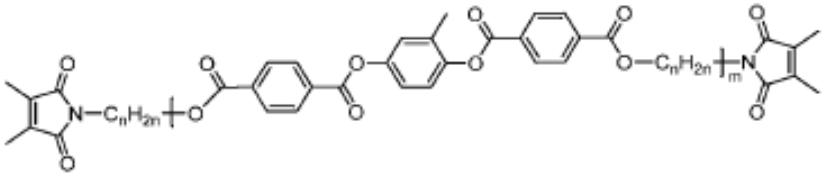

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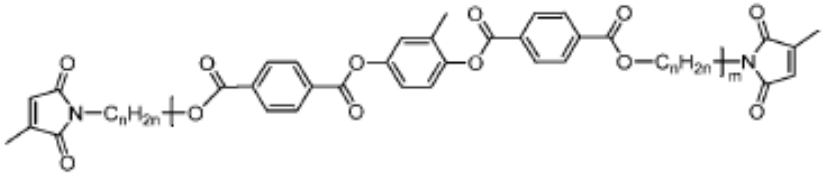

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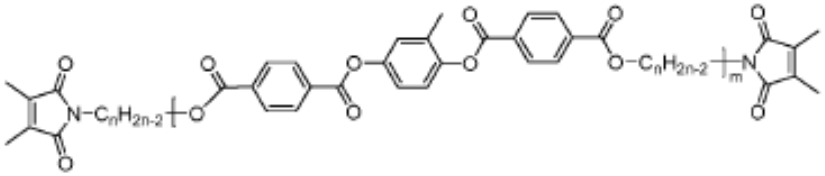

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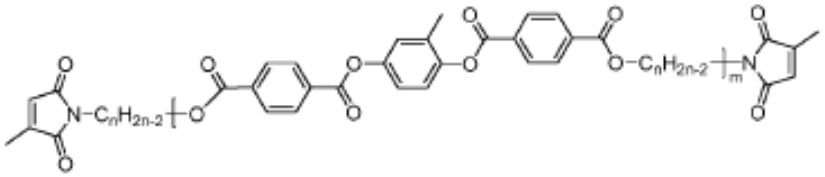

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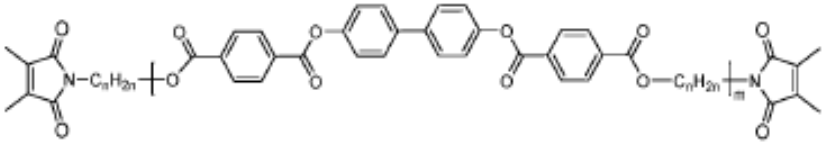

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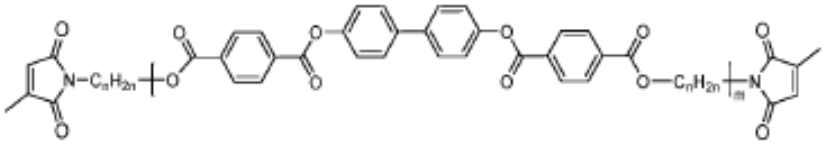

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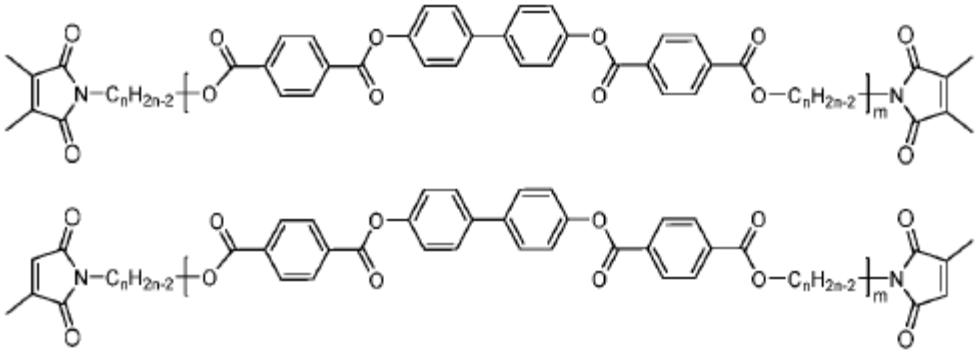

wherein

n is an integer from 1 to 60.