

Dielectric Copolymer Materials

Field of the invention

5 The present invention provides a new dielectric polymer material, which is particularly suitable for manufacturing of electronic devices. The dielectric copolymeric material is obtainable from a polymerizable mixture comprising a polymerizable compound, a second compound, and a third compound, wherein the polymerizable compound is one or more polymerizable maleimide compound having mesogenic groups, wherein the second
10 compound is a bi-or multifunctional compound capable of reacting with the polymerizable compound, and wherein the third compound is a multifunctional compound capable of reacting with the polymerizable compound. The polymerizable compound may be also referred to as a reactive mesogen (RM). The dielectric material shows an advantageous well-
15 balanced profile of favorable material properties, particularly with regard to the requirements in advanced electronic packaging applications such as e.g. wafer level packaging (WLP) as well as for low-dielectric adhesive applications. For instance, the inventive material has (a) favorable thermomechanical properties such as e.g. high glass transition temperature
20 (T_g), low coefficient of thermal expansion (CTE), high elongation at break and high tensile strength; (b) favorable dielectric properties such as e.g. low dielectric constant and low dielectric loss tangent; (c) high adhesive strength; and/or (d) beneficial spin coating behavior compared to prior art materials.

25 Background of the invention

Reactive mesogens (RMs), when polymerized at temperatures at which they exhibit thermotropic liquid crystal (LC) phases (typically nematic, cholesteric or smectic), give anisotropic polymers which conserve the liquid crystalline state. In particular, optical anisotropy has been widely exploited in the field
30 of optical films for compensation and brightness enhancement in flat panel displays, especially in liquid crystal displays.

In addition to their wide use in liquid crystal displays and displays, liquid crystalline materials are investigated for their advantages in other application types due to their special physical properties (R. Stannarius, Nat. Mat. 2009, 8, 617-618; and J.P.F. Lagerwall et al., Current Appl. Phys. 2012, 12, 1387-1412). In particular, highly ordered anisotropic polymer networks are an interesting material class with a diverse range of applications (D.J. Broer et al., Lagmuir 2014, 30, 13499-13509; and R. Zentel et al., Adv. Mater. 2010, 22, 3366-3387). However, in most cases the LC polymers or corresponding monomers from which the polymers are made do not have optimum properties required for the respective application.

WO 2012/152409 A1 relates to polymer particles with optical anisotropy and shape anisotropy comprising monomer units of at least one reactive mesogen, a process for their preparation, the use of these particles for the preparation of optical, electrooptical, electronic, electrochemical, electrophotographic, electrowetting and electrophoretic displays and/or devices and security, cosmetic, decorative, and diagnostic applications, and electrophoretic fluids and displays comprising said polymer particles. In particular, the polymer particles have monomer units of at least one RM with at least two polymerizable groups, at least one polymerizable dye as co-monomer, optionally at least one co-monomer, optionally at least one cross-linking co-monomer, optionally at least one ionic co-monomer, and optionally at least one polymerizable stabilizer.

Various processes for the preparation of liquid-crystalline polymers from RMs and for the preparation of the RM starting materials are known from the state of the art. For example, Siemensmeyer et al. describes a process for producing mixtures of LC compounds, wherein at least one of the starting components consists of a mixture of at least two compounds and this mixture is reacted with at least one other starting component to form a statistic mixture (WO 96/04351 A1).

In addition to efficient preparation methods for LC compounds, suitable polymerization methods for forming anisotropic polymer networks are in the focus of interest. A variety of reactive functional groups were investigated for their applicability in photoinitiated polymerization reactions. The most
5 widespread reactive functional groups are acrylates and methacrylates, which are particularly well suited for UV-induced free-radical polymerizations due to their high polymerization rate (D.J. Broer et al., Lagmuir 2014, 30, 13499-13509). However, UV curing is not suitable for all kinds of application.

10 Mixtures of polymerizable liquid-crystalline monomers (reactive mesogens) can be used to prepare thin films which can be cured by thermal or photo-initiated polymerization. Films which are prepared in this way are relatively thin and contain a highly cross-linked duroplastic polymer which has a pronounced dimensional stability. However, these films are relatively brittle
15 and exhibit very low elasticity. If, on the other hand, the crosslinking degree is reduced, no dimensionally stable polymer films can be obtained.

US 6,261,481 B1 describes an organic insulating composition which provides a good thermal conductivity. The insulating composition contains a liquid
20 crystal (LC) resin comprising a polymerization product of a resin composition containing a monomer which has a mesogenic group. The composition has a thermal conductivity in directions mutually orthogonal to each other of ≥ 0.4 W/mK. The monomer contained in the resin composition has a mesogenic group and preferably an epoxy group which can be polymerized thermally
25 under acid catalysis. Preferably, the resin composition is heated under conditions that the monomer having the mesogenic group is partially arranged when the polymerization starts so that the anisotropic properties based on the partial arrangement are frozen in the polymer.

30 US 2008/0075961 A1 and US 2017/0152418 A1 relate to maleimide adhesive films which are prepared from thermosetting maleimide resins containing imide-extended mono-, bis- and polymaleimide compounds. The

maleimide adhesive films are photostructurable and suitable for the production of electronic equipments, integrated circuits, semiconductor devices, passive devices, solar batteries, solar modules, and/or light emitting diodes. However, the maleimide compounds do not contain any mesogenic groups which could impart a preferential direction or partial arrangement of the compound in the film. This results in poorer properties with regard to mechanical stability and thermal conductivity. These materials typically also exhibit a relatively low glass transition point, which again impact their thermal expansion properties.

KR 20160052234 A describes a photocurable insulating resin composition and printed circuit board using the same. The photocurable insulating resin composition comprises a photocurable liquid crystal oligomer; a photocurable graphene oxide; and a photocurable metal alkoxide. However, the photocurable liquid crystal oligomers do not contain multiple mesogenic groups linked together by a spacer group. This results in an unfavorable solubility profile and energies used for photocuring are very high.

- Electronic packaging

As solid-state transistors started to replace vacuum-tube technology, it became possible for electronic components, such as resistors, capacitors, and diodes, to be mounted directly by their leads into printed circuit boards of cards, thus establishing a fundamental building block or level of packaging that is still in use. Complex electronic functions often require more individual components than can be interconnected on a single printed circuit card. Multilayer card capability was accompanied by development of three-dimensional packaging of daughter cards onto multilayer mother boards. Integrated circuitry allows many of the discrete circuit elements such as resistors and diodes to be embedded into individual, relatively small components known as integrated circuit chips or dies. In spite of incredible circuit integration, however, more than one packaging level is typically

required, in part because of the technology of integrated circuits itself. Integrated circuit chips are quite fragile, with extremely small terminals. First-level packaging achieves the major functions of mechanically protecting, cooling, and providing capability for electrical connections to the delicate integrated circuit. At least one additional packaging level, such as a printed circuit card, is utilized, as some components (high-power resistors, mechanical switches, capacitors) are not readily integrated onto a chip. For very complex applications, such as mainframe computers, a hierarchy of multiple packaging levels is required.

As a consequence of Moore's law, advanced electronic packaging strategies are playing an increasingly important role in the development of more powerful electronic products. In other words, as the demand for smaller, faster, and more functional mobile and portable electronic devices increases, the demand for improved cost-effective packaging technologies is also increasing.

A wide variety of advanced packaging technologies exist to meet the requirements of today's semiconductor industry. The leading Advanced Packaging technologies - wafer-level packaging (WLP), fan-out wafer level packaging (FOWLP), 2.5D interposers, chip-on-chip stacking, package-on-package stacking, embedded IC - all require structuring of thin substrates, redistribution layers and other components like high resolution interconnects. The end consumer market presents constant push for lower prices and higher functionality on ever smaller and thinner devices. This drives the need for the next generation packaging with finer features and improved reliability at a competitive manufacturing cost.

Wafer-level packaging (WLP) is the technology of packaging an integrated circuit while still part of the wafer, in contrast to the more conventional chip scale packaging method, where the wafer is sliced into individual circuits (dices) and then packaged. WLP offers several major advantages compared

to chip scale package technologies and it is essentially a true chip-scale package (CSP) technology, since the resulting package is practically of the same size as the die. Wafer-level packaging allows integration of wafer fab, packaging, test, and burn-in at wafer level in order to streamline the manufacturing process undergone by a device from silicon start to customer shipment. Major application areas of WLP are smartphones and wearables due to their size constraints. Functions provided WLPs in smartphones or wearables include: compass, sensors, power management, wireless etc. Wafer-level chip scale packaging (WL-CSP) is one of the smallest packages currently available on the market. WLP can be categorized into fan-in and fan-out WLP (Figure 1). Both of them use a redistribution technology to form the connections between chips and solder balls.

Fan-out wafer level packaging (FOWLP) is one of the latest packaging trends in microelectronics: FOWLP has a high miniaturization potential both in the package volume as well as in the packaging thickness. Technological basis of FOWLP is a reconfigured, painted wafer with embedded chips and a thin film rewiring layer, which together form a surface-mounted device (SMD)-compatible package. The main advantages of the FOWLP are a very thin, because substrateless package, the low thermal resistance, good high-frequency properties due to short and planar electrical connections together with a bumpless chip connection instead of e.g. wire bonds or solder contacts.

With current materials, WLP processes are limited to medium chip size applications. The reasons for this restriction are mainly due to the current material selection, which shows a thermal mismatch with the silicon die (CTE: 3 ppm/K) and therefore can reduce the performance and generate stress on the dies. New materials with better physical properties (in particular, a coefficient of thermal expansion (CTE) closer to the CTE of silicon together with high mechanical flexibility) are in high demand. Currently, redistribution layers (RDLs) are made from copper layers (CTE: 16.5 ppm/K), which are

electroplated on polymer passivation layers such as polyimides (PI), butylcyclobutanes (BCB), or polybenzoxazoles (PBO). Low curing temperatures in addition to photopatternability are two further important requirements in the processing of such materials.

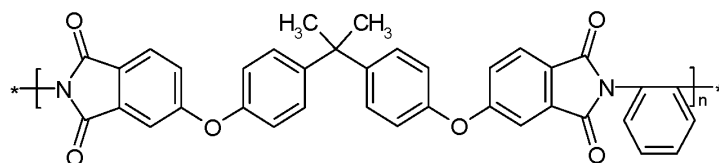
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Polyimide became the standard passivation layer for memory chips and other devices with the need of surface protection for the handling and testing procedure. Photosensitive resins have been developed to reduce processing costs.

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Polyimide-ODA was the first member of a series of new high performance polymers based on alternate aromatic homocyclic and heterocyclic rings developed by Du Pont:

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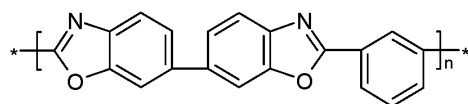


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Polyimides are quite unique to their very high decomposition temperature which can go up to over 400 °C. In addition, their mechanical properties guarantee a high flexibility (elongation at break up to 100%) with a very high tensile strength of over 200 MPa. PI is still the most popular polymer for IC passivation.

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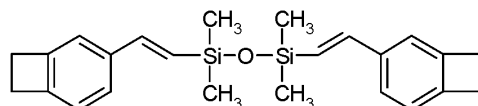
A modification to the negative-sensitive polymer PI was achieved by polybenzoxazole (PBO) which is sometime also called a positive-sensitive PI:



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The polymer film can be developed after photo-exposure using an aqueous developer.

The so-called BCB (benzocyclobutene) is an example of a siloxane-polymer group having in addition a vinyl and a benzocyclobutene ring system:



A major advantage is the polymerization reaction (Diels-Alder reaction) which has high atomic economy since no by-products occur. This highly-crosslinked thermoset polymer has excellent electrical performance, but is quite brittle with a low elongation to break value (8%) and low tensile strength of 87 MPa.

Another approach from the state of the art is imide-extended bismaleimide resins which were suggested in US 2008/0075961 A1 and US 2017/0152418 A1. They show promising results with regard to low-stress wafer passivation coatings. However, despite some improvement, there is still some room for improvement in order to meet the demanding requirements of industry.

In conclusion, the materials known from the state of the art show the following drawbacks:

- Polyimides and polybenzoxazoles typically require very high processing temperatures which increase the risk for warping, especially in multilayer redistribution layers (RDLs). In addition to that, polyimides show a high water uptake which is a problem for reliability of the devices.
- Benzocyclobutene derivatives as well as polynorbornenes show a very low dielectric constant, but this advantage is compromised by very poor adhesion to metals.
- Imide-extended bismaleimide resins so far do not show a favorable combination of advantageous mechanical and thermal properties. They are either flexible (low modulus), but have high CTE values, or they are brittle (high modulus) with low CTE values.

Hence, there is a continuous need to develop new dielectric materials which do not show the above-mentioned disadvantages known from the prior art.

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- Photolithography

Photolithography has long been the key patterning technology for structuring inorganic and organic materials used in advanced packaging applications like flip-chip wafer bumping, electroplated gold, solder bumps, copper pillar technologies and redistribution layers. Photolithography is a key manufacturing process and cost contributor; the careful selection of the right exposure solution is critical to achieve the best possible cost structure in today's industrial lithography applications.

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Current drivers and trends in the semiconductor industry clearly show that performance improvements of microelectronic devices are needed to meet the future end user requirements. For example, consumer electronic devices like tablets and smartphones are getting thinner and smaller while gaining higher computing power, increased data storage, and improved communication capabilities. In addition, cost considerations become more and more important in the competitive landscape for all parties within the supply chain, from the chip manufacturers, foundries, assembly and test suppliers to the device manufacturers. Therefore, the industry strives for innovative approaches to lower manufacturing costs coupled with enabling technologies that meet the challenging technical requirements.

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For decades, photolithography has been and still is the fundamental process used in the fabrication and packaging of microelectronic devices. A key component of any photolithography process is the exposure tool, which uses light in the ultraviolet wavelength range to pattern a photosensitive resist or polymer. The exposure tool must be able to precisely create the desired features and align them to the previously fabricated structures in the

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underlying layers. Several types of exposure technologies exist today: proximity or contact printing, laser direct imaging, and projection lithography. The corresponding equipment toolsets differ in terms of technical capability (optical resolution, overlay performance and effective throughput), and the costs related to the exposure process. (see H. Hichri et al., SÜSS Micro Tec Photonic System Inc., Corona, CA, USA).

Patent Literature

1. WO 2012/152409 A1
- 10 2. WO 96/04351 A1
3. US 6,261,481 B1
4. US 2008/0075961 A1
5. US 2017/0152418 A1
6. KR 20160052234 A

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Non- Patent Literature

1. R. Stannarius, Nat. Mat. 2009, 8, 617-618; and J.P.F. Lagerwall et al., Current Appl. Phys. 2012, 12, 1387-1412
2. D.J. Broer et al., Lagmuir 2014, 30, 13499-13509
- 20 3. R. Zentel et al., Adv. Mater. 2010, 22, 3366-3387

Summary of the invention

However, the inventors newly have found that there is still one or more of considerable problems for which improvement is desired, as listed below;

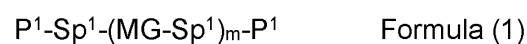
25 overcoming the disadvantages and drawbacks in the prior art and to provide a new materials which can be used as versatile dielectric material in various electronic packaging applications; providing a new class of dielectric material which shows excellent film forming capabilities, excellent thermal properties, such as e.g. a low coefficient of thermal expansion (CTE), and excellent

30 mechanical properties, such as e.g. excellent flexibility, when used for the formation of passivation layers in packaged electronic devices. It is a further

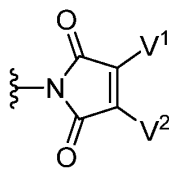
object of the present invention to provide a new class of dielectric material which allows easy processing from conventional solvents; achieving a liner CET behavior before and after T_g; providing a novel class of material mixture which is photostructurable and particularly suitable for various applications in electronic packaging such as e.g. the passivation of conductive or semiconducting components and die attach and as a major component in the preparation of substrates for printed circuit boards. An important field of application is the use as dielectric material for the structuring of RDLs in packaged microelectronic devices; providing a polymerizable mixture from which the novel material is made of. Beyond that, it is an object of the present invention to provide a method for forming said novel material using the polymerizable mixture. Finally, it is also one of objects of the present invention to provide an electronic device comprising said novel material as dielectric material, a manufacturing method for preparing a packaged microelectronic structure and a microelectronic device comprising said packaged microelectronic structure which is obtainable by said manufacturing method.

Then, the present inventors have surprisingly found that one or more of the above-described technical problems can be solved by the features as defined in the claims.

Namely, it is found a novel polymerizable mixture comprising a polymerizable compound, a second compound and a third compound, wherein the polymerizable compound is a compound represented by Formula (1),



wherein:
m is an integer from 2 to 60;



5 P_1 denotes O , wherein V^1 and V^2 are independently of one another H, alkyl with 1 to 6 carbon atoms, F, Cl or CN;

Sp^1 denotes at each occurrence a spacer group;

MG is a rod-shaped mesogenic group; and

wherein the second compound is a bi- or multifunctional compound, wherein the third compound is a multifunctional compound, and wherein the second and third compound are capable of reacting with the polymerizable compound to give a copolymer.

15 Said polymerizable mixtures are used as starting material to form a new class of copolymers which exhibit a low thermal expansion and at the same time show high mechanical flexibility. Said copolymers are prepared by the following method which also forms part of the present invention:

Method for forming a copolymer, wherein the method comprises the following steps:

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- (i) providing a polymerizable mixture according to the present invention; and
 - (ii) polymerizing said polymerizable mixture to obtain a copolymer.

25 Moreover, a copolymer is provided which is obtainable or obtained by the above-mentioned method for forming a copolymer.

Beyond that, an electronic device is provided comprising a copolymer according to the present invention.

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

- 5 (1) applying a polymerizable mixture according to the present invention to a surface of a substrate; and
(2) polymerizing said polymerizable composition to form a dielectric layer.

10 There is also provided a microelectronic device comprising a packaged microelectronic structure which is obtainable or obtained by the manufacturing method according to the present invention.

Preferred embodiments of the present invention are described hereinafter and in the dependent claims.

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Technical effects of the invention

The present invention provides one or more of the following technical effects:

20 overcoming the disadvantages and drawbacks in the prior art and to provide a new materials which can be used as versatile dielectric material in various electronic packaging applications; providing a new class of dielectric material which shows excellent film forming capabilities, excellent thermal properties, such as e.g. a low coefficient of thermal expansion (CTE), and excellent
25 mechanical properties, such as e.g. excellent flexibility, when used for the formation of passivation layers in packaged electronic devices. It is a further object of the present invention to provide a new class of dielectric material which allows easy processing from conventional solvents; matching the coefficient of thermal expansion of the dielectric with the thermal expansion
30 coefficient of e.g. silicon (Si: 3 ppm/K) or copper (Cu: 16.5 ppm/K) without adversely affecting the mechanical properties such as e.g. elongation at break after UV or thermal curing at temperatures below 200 °C; providing a

novel class of material mixture which is photostructurable and particularly suitable for various applications in electronic packaging such as e.g. the passivation of conductive or semiconducting components and die attach and as a major component in the preparation of substrates for printed circuit boards. An important field of application is the use as dielectric material for the structuring of RDLs in packaged microelectronic devices; providing a polymerizable mixture from which the novel material is made of. Beyond that, it is an object of the present invention to provide a method for forming said novel material using the polymerizable mixture. Finally, it is also one of objects of the present invention to provide an electronic device comprising said novel material as dielectric material, a manufacturing method for preparing a packaged microelectronic structure and a microelectronic device comprising said packaged microelectronic structure which is obtainable by said manufacturing method.

Detailed description

- Definitions

Unless otherwise stated, the following terms used in the specification and claims shall have the following meanings for this application.

In this application, the use of the singular includes the plural, and the word "a", "an" and "the" mean "at least one" unless specifically stated otherwise. Furthermore, the use of the term "including" as well as other forms such as "includes" and "included", is not limiting. Also, terms such as "element" or "component" encompass both elements or components including one unit and elements or components that include more than one unit, unless specifically stated otherwise. As used herein, the conjunction "and" is intended to be inclusive and the conjunction "or" is not intended to be exclusive, unless otherwise indicated. For example, the phrase "or, alternatively" is intended to be exclusive. As used herein, the term "and/or" refers to any combination of the foregoing elements including using a single element. The term "about" or "approximately", when used in connection with

a measurable numerical variable, refers to the indicated value of the variable and to all values of eth variable that are within the experimental error of the indicated value (e.g., within the 95% confidence limit for the mean) or within percentage of the indicated value (e.g., $\pm 10\%$, $\pm 5\%$), whichever is greater.

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As used herein, "C_{x-y}" (where x and y are each integer) designates the number of carbon atoms in a chain. For example, C₁₋₆ alkyl refers to an alkyl chain having a chain of between 1 and 6 carbons (e.g., methyl, ethyl, propyl, butyl, pentyl, and hexyl). Unless specifically stated otherwise, the chain can be linear or branched. Unless otherwise indicated, "alkyl" refers to hydrocarbon groups which can be linear, branched (e.g., methyl, ethyl, propyl, isopropyl, tert-butyl, and the like), cyclic (e.g., cyclohexyl, cyclopropyl, cyclopentyl, and the like) or multicyclic (e.g., norbornyl, adamantyl, and the like). Suitable acyclic groups can be methyl, ethyl, n-or iso-propyl, n-, iso, or tert-butyl, linear or branched, pentyl, hexyl, heptyl, octyl, decyl, dodecyl, tetradecyl, and hexadecyl. Unless otherwise stated, alkyl refers to 1-10 carbon atom moieties. The cyclic alkyl groups may be mono cyclic or polycyclic. Suitable examples of mono-cyclic alkyl groups include substituted cyclopentyl, cyclohexyl, and cylcoheptyl groups. As mentioned herein the cyclic alkyl groups may have any of the acyclic alkyl groups as substituent. These alkyl moieties may be substituted or unsubstituted.

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"Alkoxy" (a.k.a. "alkyloxy") refers to an alkyl group as defined above which is attached through an oxy (-O-) moiety (e.g., methoxy, ethoxy, propoxy, butoxy, 1,2-isopropoxy, cyclopentyloxy, cyclohexyloxy, and the like). These alkoxy moieties

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"Halo" or "halide" refers to a halogen (e.g., F, Cl, Br, and I).

"Hydroxy" (a.k.a. "hydroxyl") refers to an -OH group.

The term "aryl" denotes an aromatic cyclic functional group having from 4 to 10 carbon atoms, from 5 to 10 carbon atoms, or from 6 to 10 carbon atoms.

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Exemplary aryl groups include, but are not limited to, phenyl, tolyl, furanyl, benzyl, and o-xylyl.

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In addition to known and understood representation for the attachment point of a covalent bond, points of attachment (binding sites) of structural elements

presented in this patent application may be indicated by , wherein *

5 represents the structural element and  a binding site.

“Alkylene” means a linear saturated divalent hydrocarbon radical of one or more carbon atoms or a branched saturated divalent hydrocarbon radical of three to six carbon atoms unless otherwise stated (e.g., methylene, ethylene, propylene, 1-methylpropylene, 2-methylpropylene, butylene, pentylene, and the like) serving as a linkage between R¹ and R² in the disclosed and claimed compounds such as an ethylene bridge. Specific examples of alkylene linkages include methylene (-CH₂), ethylene (-CH₂CH₂-), substituted ethylenes (e.g., -CH(CH₃)CH₂-, etc)

15 “Heteroalkylene” means an -(alkylene)- radical as defined above where one, two, or three carbons in the alkylene chain is replaced by -O-, N(H, alkyl, or substituted alkyl), S, SO, SO₂, or CO. In some preferred embodiments, the carbons are replaced by O or N.

Unless otherwise indicated, the term “substituted” when referring to an alkyl, substituted alkyl, unsubstituted aryl, substituted aryl, alkyloxy, alkylaryl, haloalkyl, halide, hydroxy, amino or amino alkyl. Similarly, the term “unsubstituted” refers to these same moieties where no substituents apart from hydrogen are present.

25 The term “liquid crystal”, “mesomorphic compound”, or “mesogenic compound” (also shortly referred to as “mesogen”) means a compound that under suitable conditions of temperature, pressure and concentration can exist as a mesophase or in particular as a LC phase. Non-amphiphilic mesogenic compounds comprise for example one or more calamitic, banana-shaped or discotic mesogenic groups.

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The term "calamitic" means a rod- or board/lath-shaped compound or group. The term "banana-shaped" means a bent group in which two, usually calamitic, mesogenic groups are linked through a semi-rigid group in such a way as not to be co-linear. The term "discotic" means a disc- or sheet-shaped compound or group.

The term "mesogenic group" or its abbreviation "MG" means a group with the ability to induce liquid crystal (LC) phase behavior. Mesogenic groups, especially those of the non-amphiphilic type, are usually either calamitic or discotic. The compounds comprising mesogenic groups do not necessarily have to exhibit an LC phase themselves. It is also possible that they show LC phase behavior only in mixtures with other compounds, or when the mesogenic compounds or the mixtures thereof are polymerized. For the sake of simplicity, the term "liquid crystal" is used hereinafter for both mesogenic and LC materials.

A calamitic mesogenic compound is usually comprising a calamitic, i.e. rod- or lath-shaped, mesogenic group consisting of one or more aromatic or alicyclic groups connected to each other directly or via linkage groups, optionally comprising terminal groups attached to the short ends of the rod, and optionally comprising one or more lateral groups attached to the long sides of the rod, wherein these terminal and lateral groups are usually selected e.g. from carbyl or hydrocarbyl groups, polar groups like halogen, nitro, hydroxy, etc., or polymerizable groups.

A discotic mesogenic compound is usually comprising a discotic, i.e., relatively flat disc- or sheet-shaped mesogenic group consisting for example of one or more condensed aromatic or alicyclic groups, like for example triphenylene, and optionally comprising one or more terminal groups that are attached to the mesogenic group and are selected from the terminal and lateral groups mentioned above.

The term "reactive mesogen" or its abbreviation "RM" means a polymerizable mesogenic or liquid crystalline compound, which is preferably a monomeric or oligomeric compound.

5 The term "spacer" or "spacer group", also referred to as "Sp" below, is known to the person skilled in the art and is described in the literature.

10 Unless stated otherwise, the term "spacer" or "spacer group" above and below denotes a flexible organic group, which in a polymerizable mesogenic compound ("RM") connects the mesogenic group and the polymerizable group(s).

15 The term "polymer" includes, but is not limited to, homopolymers, copolymers, for example, block, random, and alternating copolymers, terpolymers, quaterpolymers, etc., and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term "polymer" shall include all possible configurational isomers of the material. These configurations include, but are not limited to isotactic, syndiotactic, and atactic symmetries. A polymer is a molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of units (i.e., repeating units) derived, actually or conceptually, from molecules of low relative mass (i.e. monomers). In the context of the present invention polymers are composed of more than 60 monomers.

25 The term "oligomer" is a molecular complex that consists of a few monomer units, in contrast to a polymer, where the number of monomers is, in principle, unlimited. Dimers, trimers and tetramers are, for instance, oligomers composed of two, three and four monomers, respectively. In the context of the present invention oligomers may be composed of up to 60 monomers.

30 The term "polymerizable compound" means a compound which can undergo polymerization thereby contributing constitutional units (repeating units) to

the essential structure of a polymer or an oligomer. Polymerizable compounds are functionalized compounds having one or more polymerizable groups. Large numbers of compounds combine in polymerization reactions to form polymers. Polymerizable compounds with one polymerizable group
5 are also referred to as “monofunctional” or “monoreactive” compounds, compounds with two polymerizable groups as “bifunctional” or “direactive” compounds, and compounds with more than two polymerizable groups as “multifunctional” or “multireactive” compounds. Compounds without a polymerizable group are also referred to as “non-functional” or “non-reactive”
10 compounds.

The term “homopolymer” as used herein stands for a polymer derived from one species of (real, implicit or hypothetical) monomer.

15 The term “copolymer” as used herein generally means any polymer derived from more than one species of monomer, wherein the polymer contains more than one species of corresponding repeating unit. In one embodiment the copolymer is the reaction product of two or more species of monomer and thus comprises two or more species of corresponding repeating unit. It is
20 preferred that the copolymer comprises two, three, four, five or six species of repeating unit. Copolymers that are obtained by copolymerization of three monomer species can also be referred to as terpolymers. Copolymers that are obtained by copolymerization of four monomer species can also be referred to as quaterpolymers. Copolymers may be present as block,
25 random, and/or alternating copolymers.

The term “block copolymer” as used herein stands for a copolymer, wherein adjacent blocks are constitutionally different, i.e., adjacent blocks comprise repeating units derived from different species of monomer or from the same
30 species of monomer but with a different composition or sequence distribution of repeating units.

Further, the term “random copolymer” as used herein refers to a polymer formed of macromolecules in which the probability of finding a given repeating unit at any given site in the chain is independent of the nature of the adjacent repeating units. Usually, in a random copolymer, the sequence distribution of repeating units follows Bernoullian statistics.

The term “alternating copolymer” as used herein stands for a copolymer consisting of macromolecules comprising two species of repeating units in alternating sequence.

“Electronic packaging” is a major discipline within the field of electronic engineering and includes a wide variety of technologies. It refers to inserting discrete components, integrated circuits, and MSI (medium-scale integration) and LSI (large-scale integration) chips (usually attached to a lead frame by beam leads) into plates through hole on multilayer circuit boards (also called cards), where they are soldered in place. Packaging of an electronic system must consider protection from mechanical damage, cooling, radio frequency noise emission, protection from electrostatic discharge maintenance, operator convenience, and cost.

The term “microelectronic device” as used herein refers to electronic devices of very small electronic designs and components. Usually, but not always, this means micrometer-scale or smaller. These devices typically contain one or more microelectronic components which are made from semiconductor materials and interconnected in a packaged structure to form the microelectronic device. Many electronic components of normal electronic design are available in a microelectronic equivalent. These include transistors, capacitors, inductors, resistors, diodes and naturally insulators and conductors can all be found in microelectronic devices. Unique wiring techniques such as wire bonding are also often used in microelectronics because of the unusually small size of the components, leads and pads.

The section heading used herein are for organizational purposes and are not to be construed as limiting the subject matter described. All documents, or portions of documents, cited in this application, including, but not limited to, patents, patent applications, articles, books, and treatises, are hereby
5 expressly incorporated herein by reference in the entirety for any purpose. In the event that any of the incorporated literature and similar materials defines a term in a manner that contradicts the definition of that term in this application, this application controls.

10 Detailed description

It is to be understood that both the foregoing general description and the following detailed description are illustrative and explanatory, and are not restrictive of the subject matter, as claimed. The objects, features, advantages, and ideas of the disclosed subject matter will be apparent to
15 those skilled in the art from the description provided in the specification, and the disclosed subject matter will be readily practicable by those skilled in the art on the basis of the description appearing herein. The description of any "preferred embodiments" and/or examples which show preferred modes for practicing the disclosed subject matter are included for the purpose of
20 explanation and are not intended to limit the scope of the claims.

Preferred embodiments

- Polymerizable compound

The present invention relates to a polymerizable mixture comprising a
25 polymerizable compound, a second compound, and a third compound.

Polymerizable compound

The polymerizable compound is a compound represented by Formula (1),

$P^1-Sp^1-(MG-Sp^1)_m-P^1$ Formula (1)

30 wherein:

- 22 -

m is an integer from 2 to 60, preferably from 2 to 50, more preferably from 2 to 30, and most preferably from 3 to 20;



P¹ denotes , wherein V¹ is H, and V² is alkyl with 1 to 6 carbon atoms, F, Cl or CN; or V¹ and V² are independently of one another alkyl with 1 to 6 carbon atoms, F, Cl or CN;

Sp¹ denotes at each occurrence a spacer group (Sp) or a single bond;

10 MG is a rod-shaped mesogenic group, which is preferably selected from Formula (2):



15 wherein:

A²¹ to A²³ 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;

20 Z²¹ and Z²² are independently and at each occurrence independently from each other, -O-, -S-, -CO-, -COO-, -OCO-, -S-CO-, -CO-S-, -O-COO-, -CO-NR⁰¹-, -NR⁰¹-CO-, -NR⁰¹-CO-NR⁰²-, -NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -OCH₂-, -CH₂O-, -SCH₂-, -CH₂S-, -CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -CH₂CH₂-, -(CH₂)₄-, -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -CH=N-, -N=CH-, -N=N-, -CH=CR⁰¹-, -CY⁰¹=CY⁰²-, CH=CH-COO-, -OCO-CH=CH-, or a single bond;

25 R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms;

L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl, alkylcarbonyloxy or alkoxy carbonyloxy with 1 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, -CN or straight chain or branched chain alkyl,

30

alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms;

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

5 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.

10 The polymerizable group P^1 is capable to undergo a polymerization reaction such as, e.g., a radical or ionic chain polymerization reaction, or a polyaddition reaction (e.g. cycloadditions, such as 2+2 cycloadditions, 4+2 cycloaddition, or 1,3-dipolar cycloadditions, or nucleophilic additions), or which is capable to undergo a polymerization analogous reaction, such as, e.g. an addition to a polymer backbone by one of the aforementioned reaction

15 types.

It is preferred that V^1 and V^2 are independently from each other selected from alkyl with 1 to 3 carbon atoms, F, Cl, or CN. Preferred alkyl with 1 to 3 carbon atoms is methyl, ethyl, and propyl. Preferably, V^1 and V^2 are identical.

20 Preferably, Z^{21} and Z^{22} are independently and at each occurrence independently from each other, -COO-, -OCO-, -O-CO-, -OCH₂-, -CH₂O-, -CH₂CH₂-, -(CH₂)₄-, -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -C≡C-, -CH=CH-COO-, -OCO-CH=CH-, or a single bond. More preferably, Z^{21} and Z^{22} are

25 independently and at each occurrence independently from each other, -COO-, -OCO-, or a single bond.

Preferably, k and l are each and independently 0, 1, or 2, more preferably k and l are each 1.

30 It is preferred that the spacer groups Sp^1 are selected from the formula Sp^1-X' , so that the radical "P¹-Sp¹-" corresponds to "P¹-Sp¹-X'-", wherein:

Sp' denotes

(a) straight chain or branched chain alkylene having 1 to 40, which is optionally mono- or polysubstituted by F, Cl, Br, I, or CN and in which, in addition, one or more non-adjacent CH₂ groups may each be replaced,
 5 independently of one another, by -O-, -S-, -NH-, -NR⁰¹-, SiR⁰¹R⁰²-, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, -NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -NR⁰¹-CO-NR⁰¹-, -CH=CH-, or -C≡C- 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
 10 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-NR⁰¹-, -NR⁰¹-CO-,
 15 -NR⁰¹-CO-NR⁰¹-, -OCH₂-, -CH₂O-, -SCH₂-, -CH₂S-, -CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -CH=N-, -N=C-, -N=N-, -CH=CR⁰¹-, -CY⁰¹=CY⁰²-, -C≡C-, -CH=CH-COO-, -OCO-CH=CH- or a single bond;

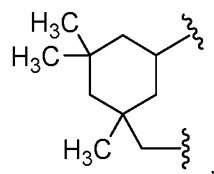
R⁰¹ and R⁰¹ each, independently of one another, denote H or alkyl having 1 to 12 C atoms; and

Y⁰¹ and Y⁰² each, independently of one another, denote H, F, Cl, or CN.

20 Preferred groups Sp' are in each case selected from straight chain methylene, ethylene, propylene, butylene, pentylene, hexylene, heptylene, octylene, nonylene, decylene, undecylene, dodecylene, and octadecylene, cyclo-hexylene, ethyleneoxyethylene, methyleneoxybutylene,
 25 ethylenethioethylene, ethylene-N-methyliminoethylene, 1-methylalkylene, ethylene, propylene and butylene.

More preferred spacer groups Sp¹ are selected from the list consisting of

30 -(CH₂)_{p1}-, -(CH₂CH₂O)_{q1}-CH₂CH₂-, -CH₂CH₂-S-CH₂CH₂-, -CH₂CH₂-NH-CH₂CH₂-, -(SiR⁰¹R⁰²-O)_{p1}-, -(CH₂)_{p1}-(cyclo-C₆H₈R⁰¹R⁰²)-(CH₂)_{p1}-, and



5 wherein:

p1 is an integer from 1 to 60, preferably from 1 to 36, more preferably from 1 to 12;

q1 is an integer from 1 to 12, preferably from 1 to 3; and

10 R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms.

Most preferred groups Sp¹ are -(CH₂)_{p1}-, -O-(CH₂)_{p1}-, -O-(CH₂)_{p1}-O-, -OCO-(CH₂)_{p1}-, -OCOO-(CH₂)_{p1}-, and -(CH₂)_{p1}-(cyclo-C₆H₈R⁰¹R⁰²)-(CH₂)_{p1}, in which p1 is an integer from 1 to 36, preferably from 1 to 12, and R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms.

In a preferred embodiment of the present invention, the groups A²¹ to A²³ denote independently and, in case of multiple occurrences, independently of one another, a moiety selected from the following groups a) to e):

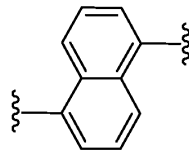
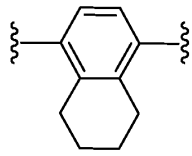
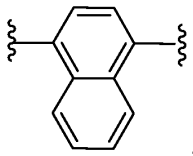
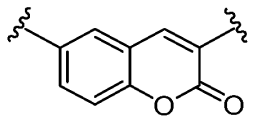
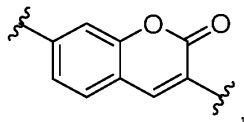
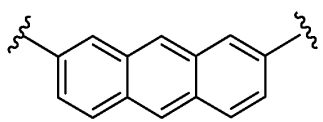
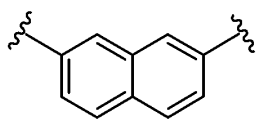
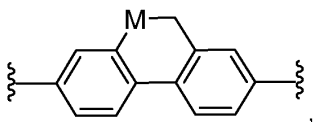
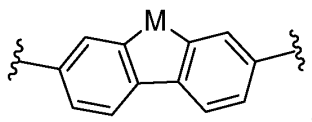
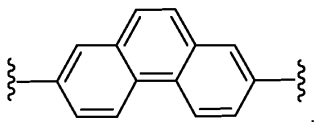
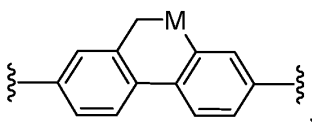
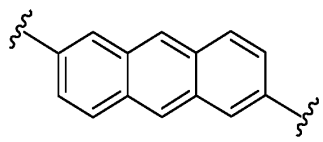
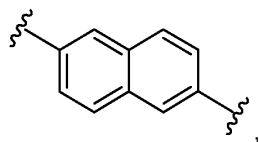
20 a) trans-1,4-cyclohexylene, 1,4-cyclohexenylene and 4,4'-bicyclohexylene, in which one or more non-adjacent CH₂ groups may be replaced by -O- and / or -S- and wherein one or more H atoms may be replaced by a group L;

25 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;

30

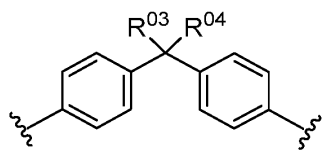
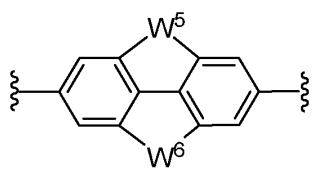
c) tetrahydropyran-2,5-diyl, 1,3-dioxane-2,5-diyl, tetrahydrofuran-2,5-diyl, cyclobut-1,3-diyl, piperidine-1,4-diyl, thiophene-2,5-diyl and selenophen-2,5-diyl, which may be substituted one or more groups L;

5 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, preferably selected from the group consisting of bicyclo [1.1.1]
10 pentane-1,3-diyl, bicyclo [2.2.2] octane-1,4-diyl, spiro [3.3] heptane-2,6-diyl,

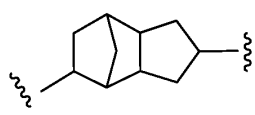
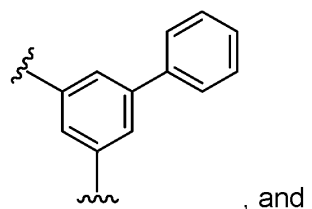


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5



10

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-, -CH₂-, -CHY⁰³- or -CY⁰³Y⁰⁴-;

15

Y⁰³, Y⁰⁴ denote independently of each other one of the meanings given above for R⁰¹, F, Cl, CN, OCF₃ or CF₃, and preferably H, F, Cl, CN, OCF₃ or CF₃;

W⁵, W⁶ denote independently of each other -CH₂CH₂-, -CH=CH-, -CH₂-O-, -O-CH₂-, -C(R^cR^d)- or -O-;

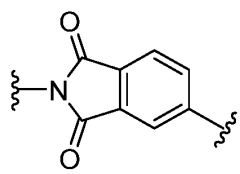
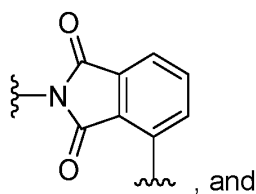
20

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

R⁰³, R⁰⁴ denote independently of each other H, F, straight chain or branched chain alkyl having 1 to 12 C atoms where one or more H atoms may be replaced by F;

25

e) cyclic imides selected from the group consisting of:

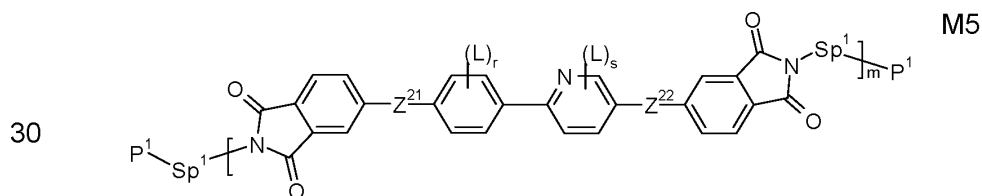
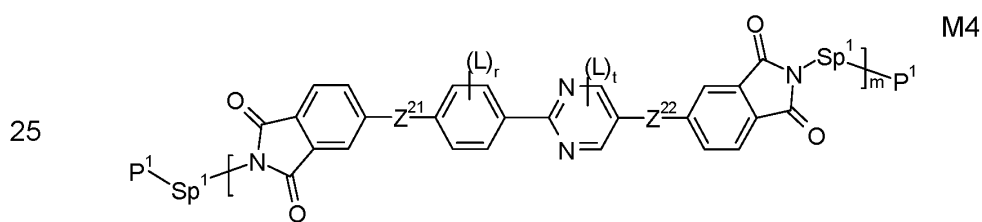
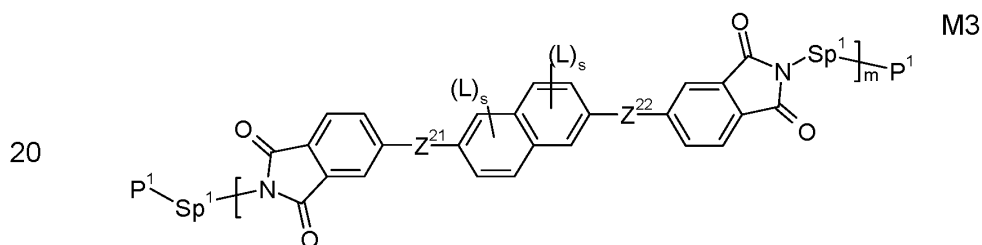
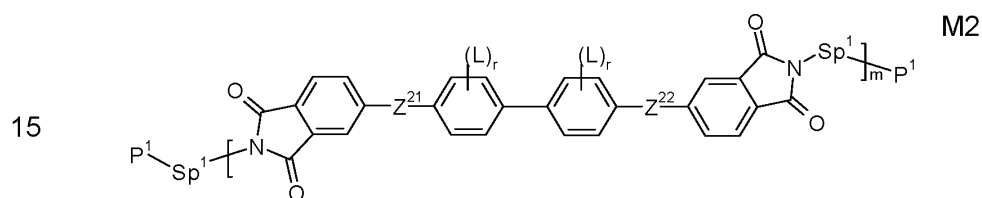
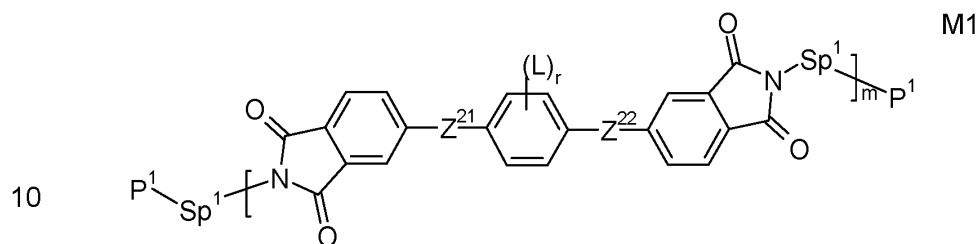


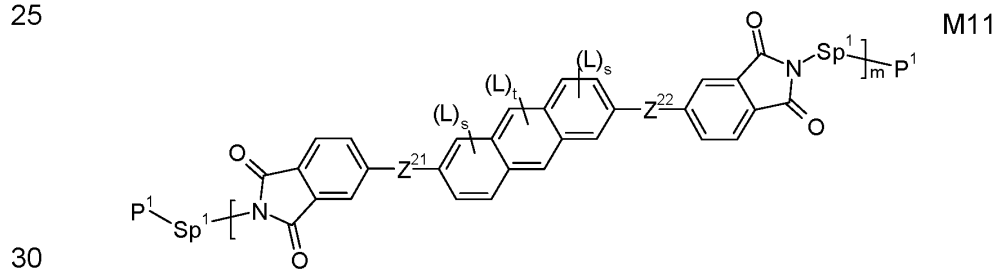
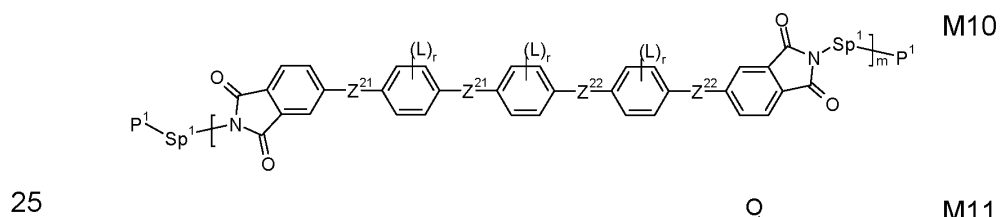
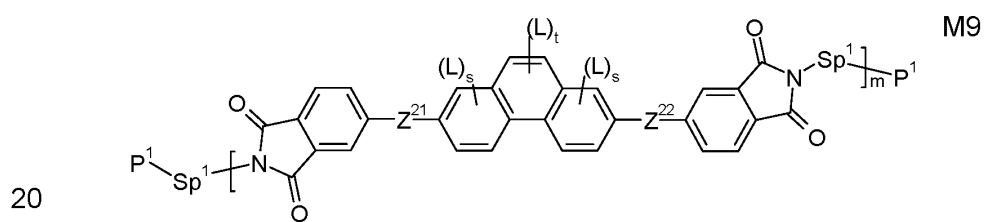
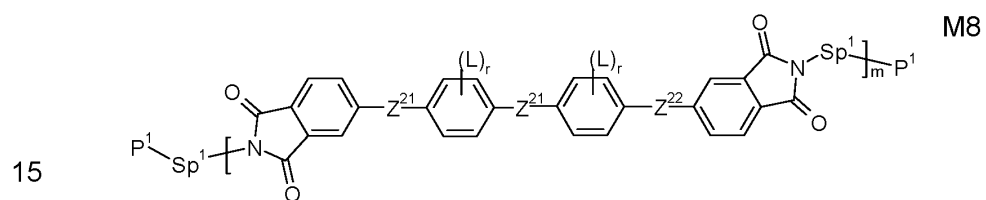
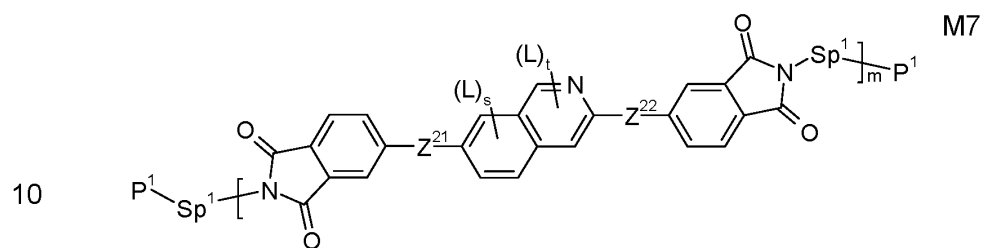
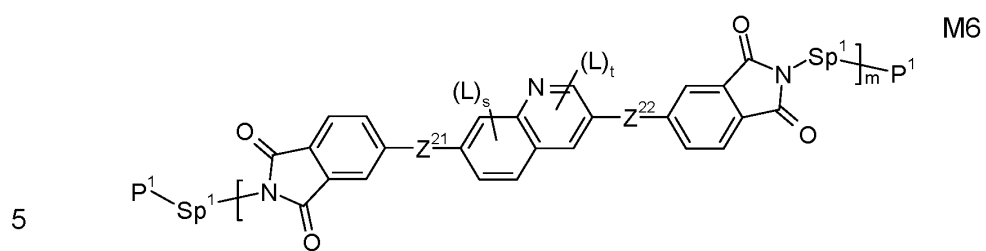
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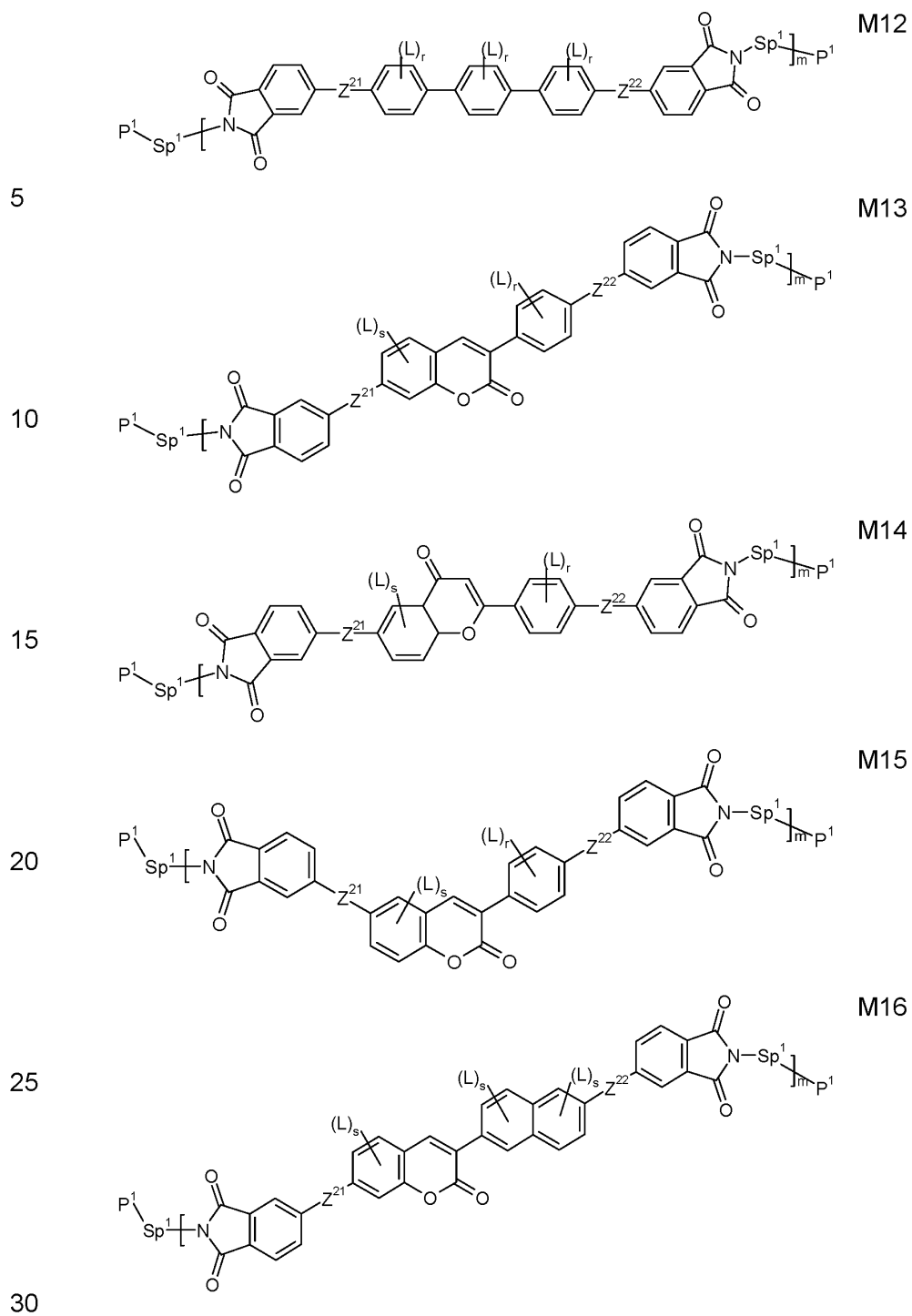
where one or more H atoms may be replaced by a group L, and/or one or more double bonds may be replaced by single bonds, and/or one or more CH groups may be replaced by N.

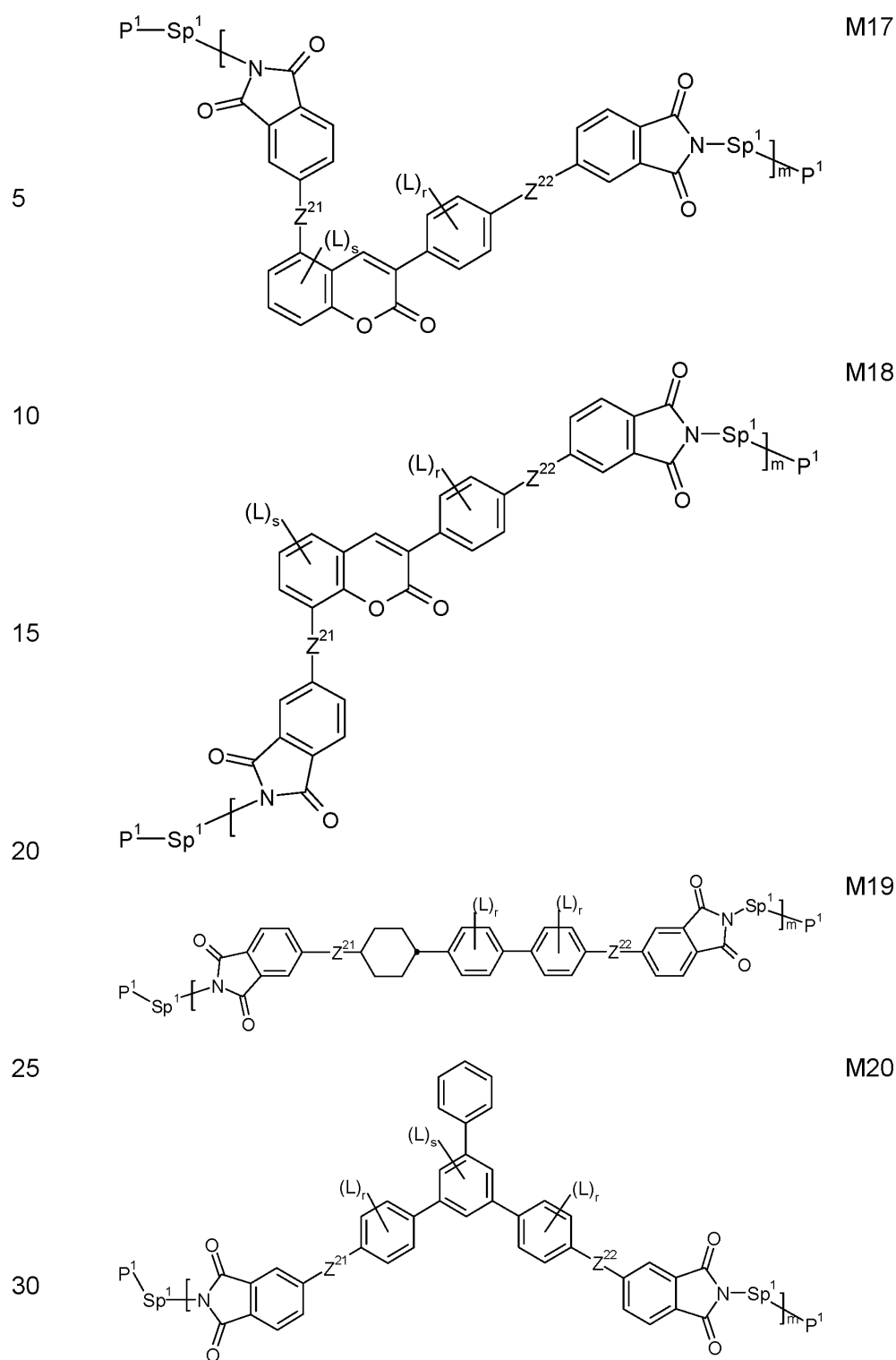
Preferred compounds according to Formula (1) are:

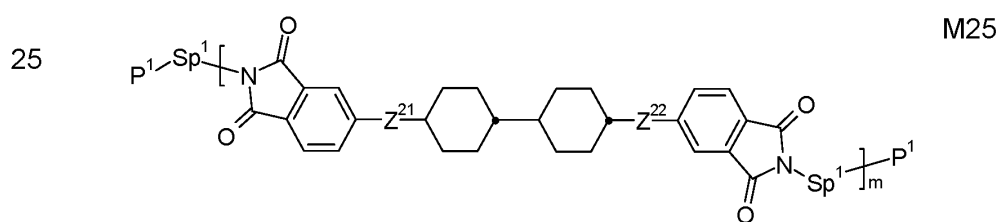
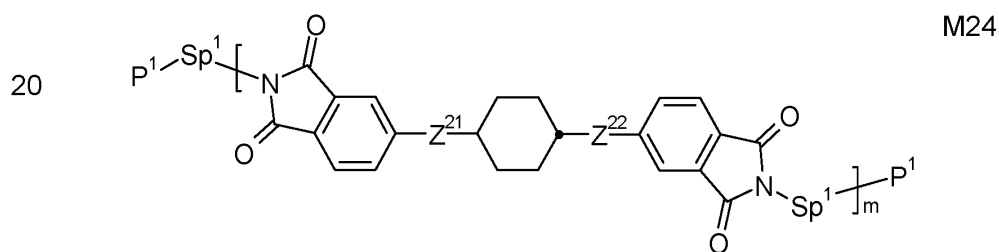
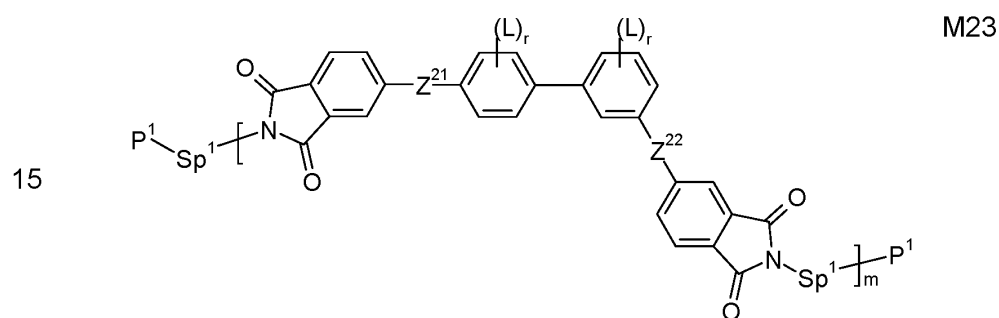
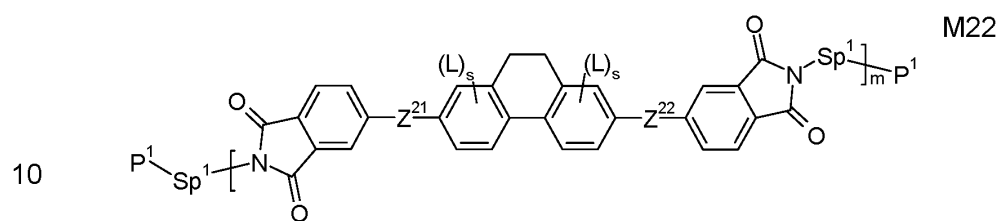
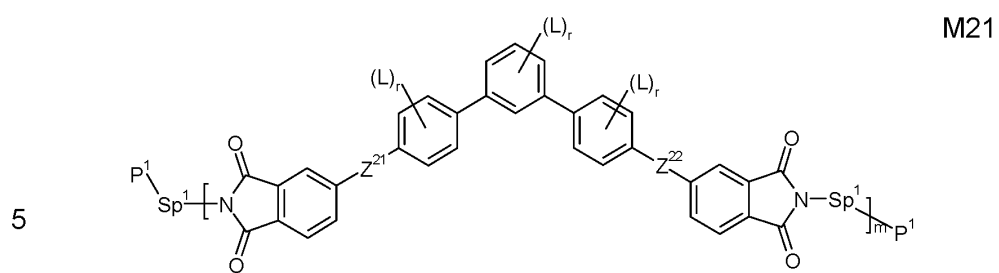
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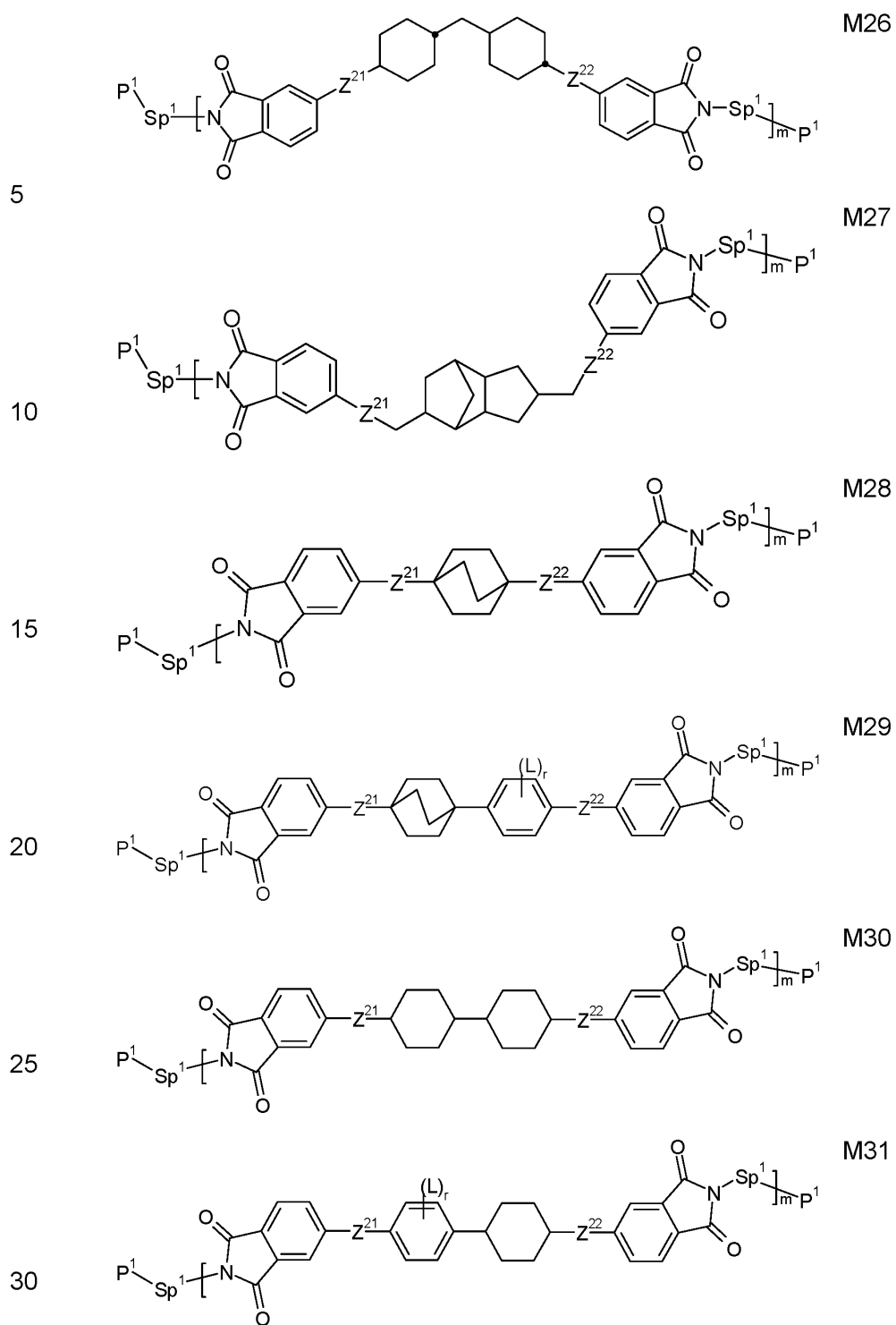


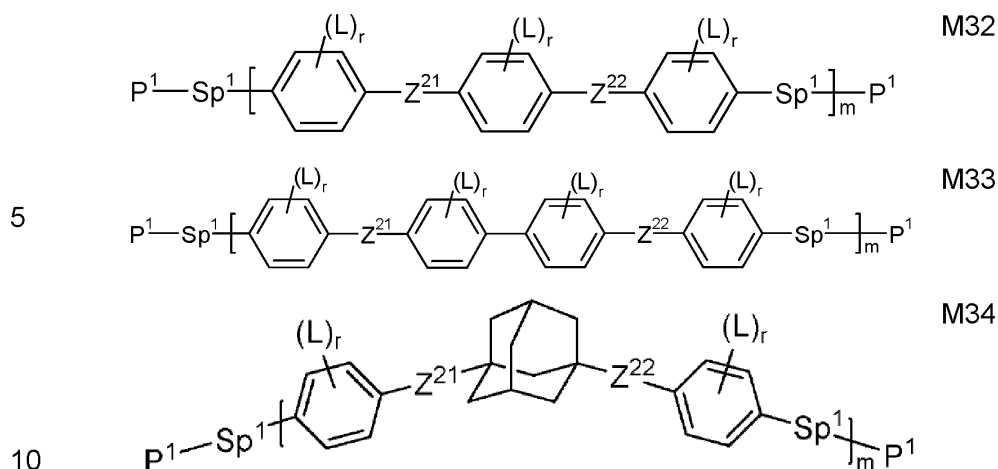






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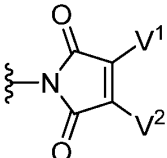
where the radicals and indices have the following meanings:

- 15 L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl, alkylcarbonyloxy or alkoxy carbonyloxy with 1 to 20 C atoms, preferably 1 to 12 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, preferably F,
- 20 -CN or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl, alkylcarbonyloxy or alkoxy carbonyloxy with 1 to 6 C atoms;
- R^{xx} and R^{yy} independently of each other denote H or alkyl with 1 to 12 C atoms;
- 25 r is 0, 1, 2, 3 or 4;
- s is 0, 1, 2 or 3;
- t is 0, 1 or 2;
- Z²¹ and Z²² are independently and at each occurrence independently from each other, -O-, -S-, -CO-, -COO-, -OCO-, -S-CO-, -CO-S-, -O-COO-, -CO-NR⁰¹-, -NR⁰¹-CO-, -NR⁰¹-CO-NR⁰²-, -NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -OCH₂-, -CH₂O-, -SCH₂-, -CH₂S-,
- 30

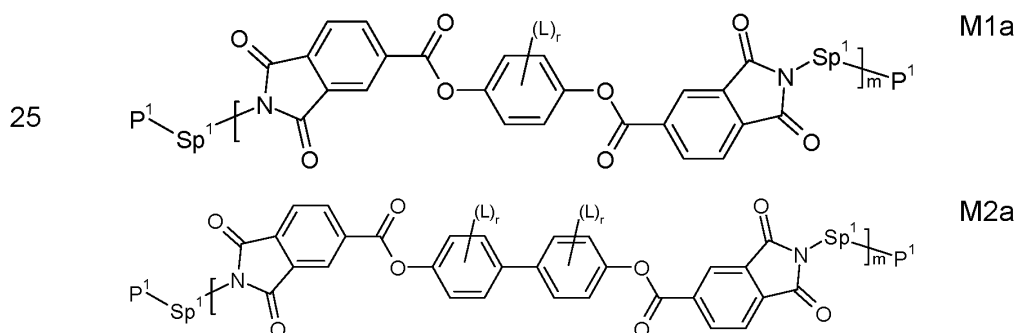
-CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -CH₂CH₂-, -(CH₂)₄-,
 -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -CH=N-, -N=CH-, -N=N-,
 -CH=CR⁰¹-, -CY⁰¹=CY⁰²-, -C≡C-, -CH=CH-COO-,
 -OCO-CH=CH-, or a single bond, preferably -COO-, -OCO-,
 5 -CO-O-, -O-CO-, -OCH₂-, -CH₂O-, -CH₂CH₂-, -(CH₂)₄-,
 -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -C≡C-, -CH=CH-COO-,
 -OCO-CH=CH-, or a single bond;

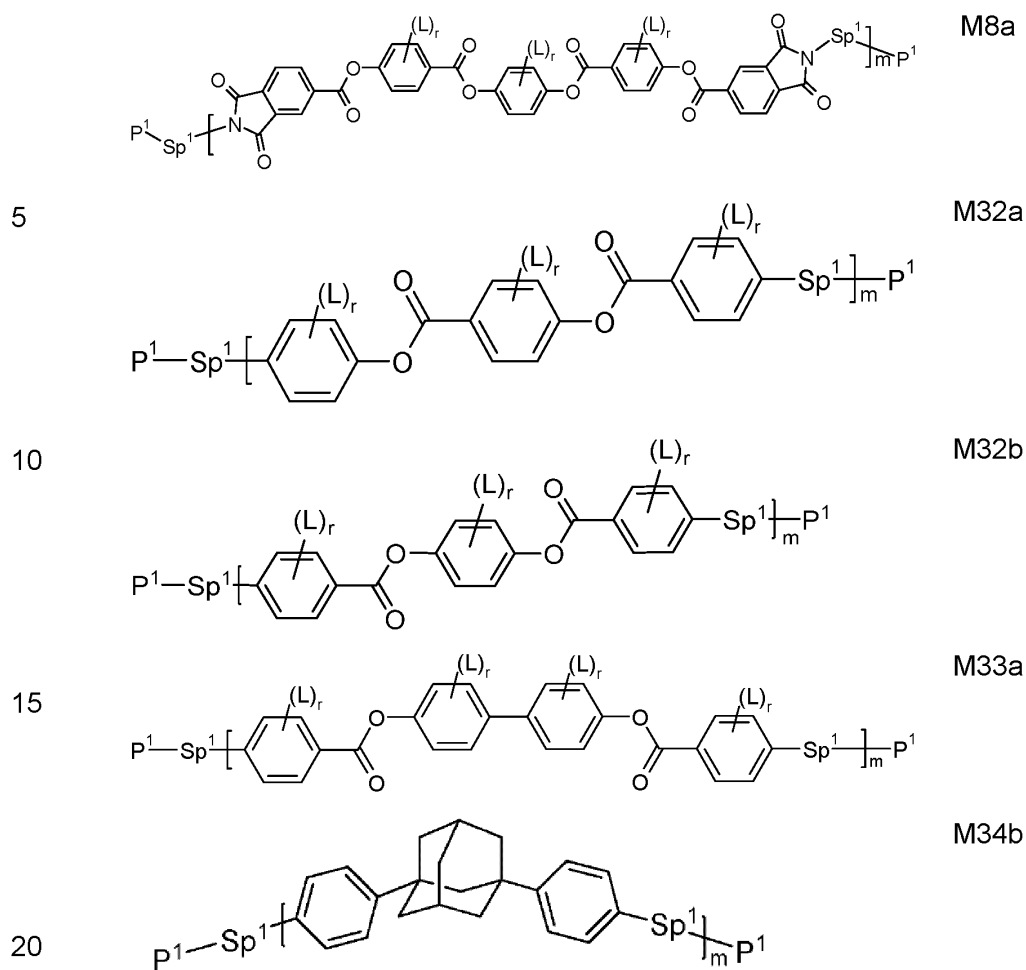
R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms;

10 Sp¹ denotes at each occurrence a space group (Sp) as defined above or a single bond;

15  P¹ denotes , where V¹ is H, and V² is alkyl with 1 to 6 carbon atoms, F, Cl or CN; or V¹ and V² are independently of one another alkyl with 1 to 6 carbon atoms, F, Cl or CN; and
 m is an integer from 1 to 60, preferably from 1 to 50, more preferably from 2 to 30, and most preferably from 3 to 20.

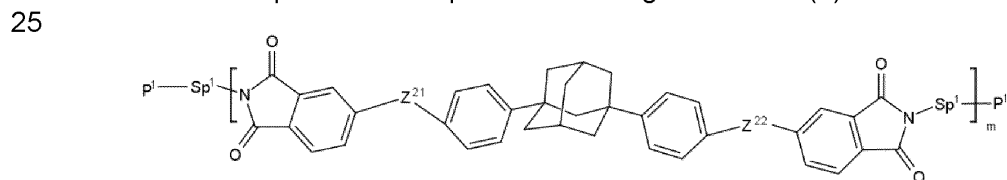
20 More preferred compounds according to Formula (1) are:





where the radicals and indices have one of the meanings as defined above.

Furthermore preferred compound according to Formula (1) is:



wherein

30 Z^{21} and Z^{22} are independently and at each occurrence independently from each other, -O-, -COO-, or -OCO-;

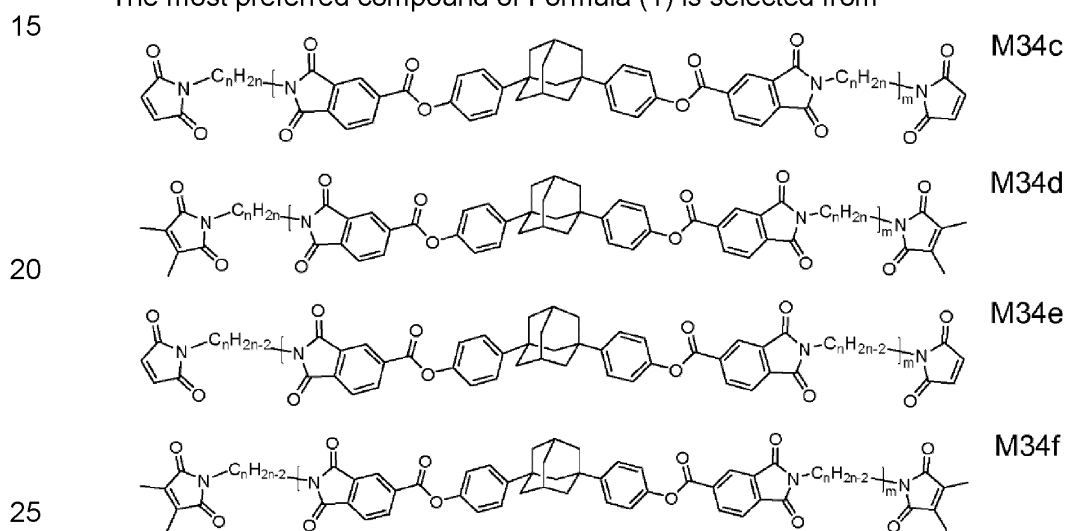
m is an integer from 1 to 60, preferably from 1 to 50, more preferably from 2 to 30, and most preferably from 3 to 20,



P¹ denotes , wherein V¹ and V² are independently of one another H or alkyl with 1 to 6 carbon atoms;

Sp¹ is selected from the group consisting of -(CH₂)_{p1}-, -O-(CH₂)_{p1}-, -O-(CH₂)_{p1}-O-, -OCO-(CH₂)_{p1}-, -OCOO-(CH₂)_{p1}-, and -(CH₂)_{p1}-(cyclo-C₆H₈R⁰¹R⁰²)-(CH₂)_{p1}, in which p₁ is an integer from 1 to 60, preferably from 1 to 36, more preferably from 6 to 12, and R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms.

The most preferred compound of Formula (1) is selected from



wherein

n is an integer from 1 to 60, preferably from 1 to 36, more preferably from 6 to 12; and

m is an integer from 1 to 60, preferably 1 to 50, more preferably from 2 to 30, and most preferably 3 to 20.

As such polymerizable compound of chemical formula (I), known chemical compounds like described in WO 2019/141833 A1 can be used and fabricated.

5

- Second compound

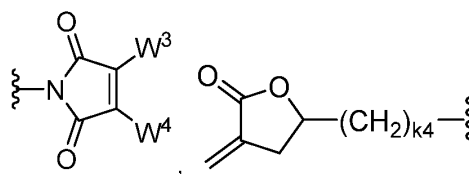
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The second compound comprised in the polymerizable mixture according to the present invention is a bi-functional or multifunctional compound capable of reacting with the polymerizable compound to give a copolymer. The second compound has at least two polymerizable groups (P^2), such as two, three, four, five, etc., which are selected from groups containing a C=C double bond, which preferably react with P^1 in a radical or ionic chain polymerization or in a 2+2 cycloaddition, groups containing two conjugated C=C double bonds, which preferably react with P^1 in a 4+2 cycloaddition (Diels-Alder reaction), nucleophilic groups, which preferably react with P^1 in a nucleophilic addition (Michaela reaction), and 1,3-dipolar groups, which preferably react with P^1 in a 1,3-dipolar cycloaddition.

15

20

Preferred polymerizable groups (P^2) containing a C=C double bond are selected from:



25

CH₂=CW¹-COO-, CH₂=CW¹-CO-,
 CH₂=CW²-(O)_{k3}-, CW¹₂=CH-CO-(O)_{k3}-, CW¹₂=CH-CO-NH-,
 CH₂=CW¹-CO-NH-, CH₃-CH=CH-O-, CH₂=CH-CH₂-O-,
 (CH₂=CH)₂CH-O-CO-, (CH₂=CH-CH₂)₂CH-O-CO-, (CH₂=CH)₂CH-O-,
 (CH₂=CH-CH₂)₂N-, (CH₂=CH-CH₂)₂N-CO-, CH₂=CW¹-CO-NH-,
 CH₂=CH-(CO-O)_{k1}-Phe-(O)_{k2}-, CH₂=CH-(CO)_{k1}-Phe-(O)_{k2}-, or Phe-CH=CH-;
 wherein

30

W^1 denotes H, F, Cl, CN, CF_3 , phenyl or alkyl having 1 to 5 C atoms, preferably H or CH_3 ;

W^2 denotes H or alkyl having 1 to 5 C atoms, preferably H or CH_3 ;

W^3 and W^4 each, independently of one another, denote H, Cl or alkyl having 1 to 5 C atoms, preferably H or CH_3 ;

Phe denotes 1,4-phenylene, which is optionally substituted by one or more radicals L as being defined above; and

k_1 , k_2 and k_3 each, independently of one another, denote 0 or 1; and

k_4 is an integer from 1 to 10.

Preferred groups containing two conjugated C=C double bonds are selected from: $CW^1_2=CW^1-CW^1=CW^1-$; wherein

W^1 denotes H, F, Cl, CN, CF_3 , phenyl or alkyl having 1 to 5 C atoms, preferably H or CH_3 .

Preferred nucleophilic groups are selected from: $HS-(CH_2)_{k_5}-CO-(O)_{k_3}-$,

$HS-(CH_2)_{k_5}-CO-$, $HS-(CH_2)_{k_5}-(O)_{k_3}-$, $HS-(CH_2)_{k_5}-O-CO-$,

$HS-(CH_2)_{k_5}-CO-NH-$, $HS-(CH_2)_{k_5}-NH-CO-$, $HS-Phe-(O)_{k_2}-$,

$H_2N-(CH_2)_{k_5}-CO-(O)_{k_3}-$, $H_2N-(CH_2)_{k_5}-CO-$, $H_2N-(CH_2)_{k_5}-(O)_{k_3}-$,

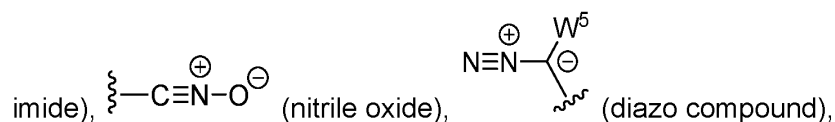
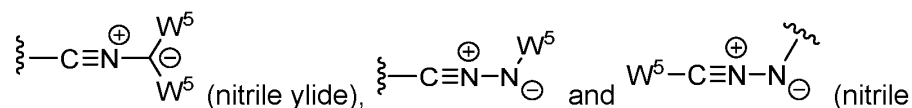
$H_2N-(CH_2)_{k_5}-O-CO-$, $H_2N-(CH_2)_{k_5}-CO-NH-$, $H_2N-(CH_2)_{k_5}-NH-CO-$, or

$H_2N-Phe-(O)_{k_2}-$; wherein

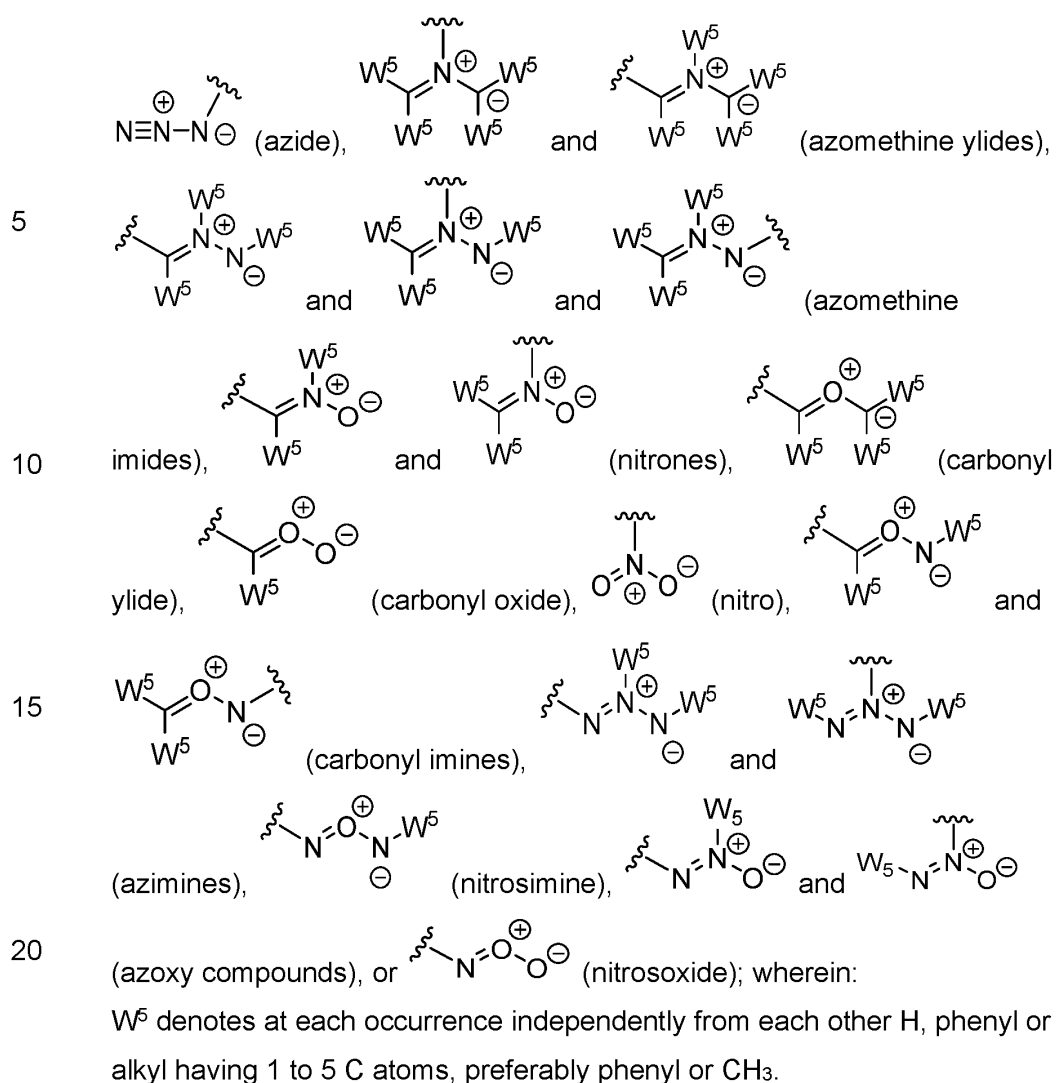
k_2 and k_3 each, independently of one another, denote 0 or 1; and

k_5 is an integer from 0 to 10, preferably from 0 to 5, more preferably 0, 1 or 2.

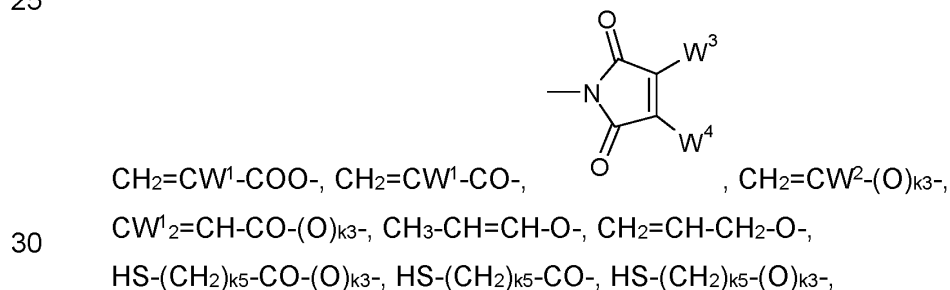
Preferred 1,3-dipolar groups are selected from:



- 40 -



25 Particularly preferred polymerizable groups (P^2) are selected from:



HS-(CH₂)_{k5}-O-CO-, H₂N-(CH₂)_{k5}-CO-(O)_{k3}-, H₂N-(CH₂)_{k5}-CO-,

H₂N-(CH₂)_{k5}-(O)_{k3}-, or H₂N-(CH₂)_{k5}-O-CO-; wherein

W¹ denotes H, F, Cl, CN, CF₃, phenyl or alkyl having 1 to 5 C atoms, preferably H or CH₃;

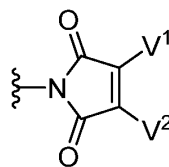
5 W² denotes H or alkyl having 1 to 5 C atoms, preferably H or CH₃;

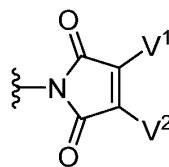
W³ and W⁴ each, independently of one another, denote H, Cl or alkyl having 1 to 5 C atoms, preferably H or CH₃;

k₃ denotes 0 or 1; and

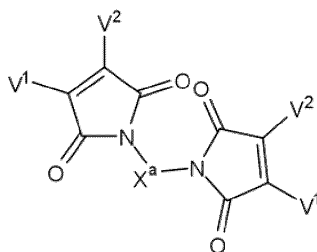
k₅ is an integer from 0 to 10, preferably from 0 to 5, more preferably 0, 1 or

10 2.



It is most preferred that P² denotes , wherein V¹ and V² are
15 independently of one another H, alkyl with 1 to 6 carbon atoms, F, Cl or CN;

In some embodiments, the second compound is represented by Formula
(3),



Formula (3)

25 wherein X^a denotes

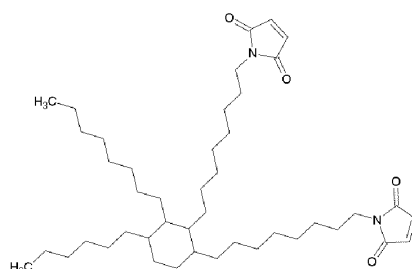
(a) Straight or branched chain alkylene having 1 to 40 C, preferably 1 to 30 C atoms, which is optionally mono- or polysubstituted by F, Cl, Br, I, or CN, and in which, in addition, one or more non-adjacent CH₂ groups may be replaced, independently of one another, by -O-, -S-, -NH-, NR⁰¹-,
30 SiR⁰¹R⁰²-, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, --NR⁰¹-CO-O,

- 42 -

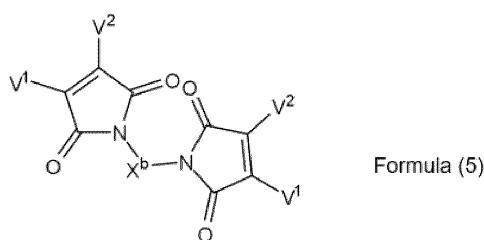
-O-CO-NR⁰¹-, -NR⁰¹-CO-NR⁰¹-, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not linked directly to one another, or

(b) -R^a-R^b-R^c-, wherein R^a and R^c denote independently of each other alkylene having 1 to 20 C atoms or a single bond; R^b denotes cycloalkylene having 3 to 20 C atoms which is optionally mono- or polysubstituted by alkyl having 1 to 20 C atoms. Publicly available chemical compound falls within chemical formula (3) can more preferably used.

A preferred monomer represented by Formula (3) is



In some embodiments, the second compound is represented by Formula (5),



wherein:

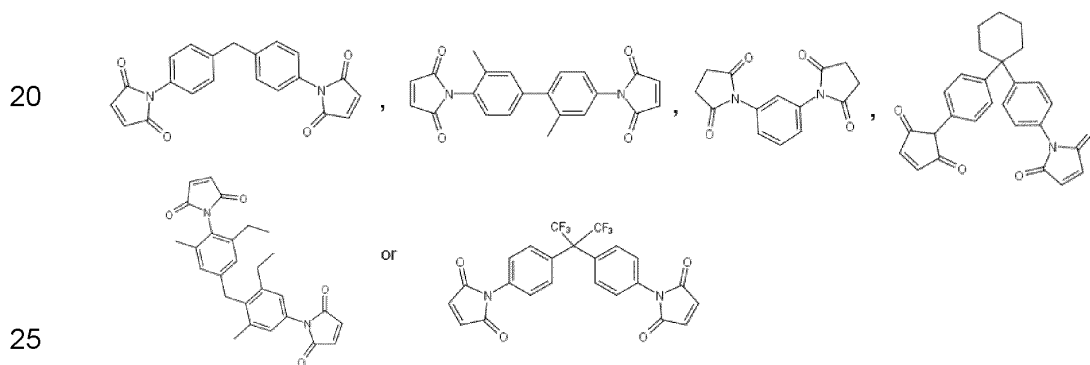
X^b denotes -(A⁴¹-Z⁴¹)_{m1}-(A⁴²)_{m2}-(Z⁴²-A⁴³)_{m3}-, wherein:

A⁴¹ to A⁴³ are independently and at each occurrence independently of one another an aryl group or a heteroaryl group, optionally being substituted by one or more identical or different groups L;

- 43 -

- L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -
 C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or
 straight chain or branched chain alkyl, alkoxy, alkylcarbonyl,
 alkoxy carbonyl, alkylcarbonyloxy or alkoxy carbonyloxy with 1 to 20 C
 5 atoms, wherein one or more H atoms are optionally replaced by F or
 Cl, -CN or straight chain or branched chain alkyl, alkoxy,
 alkylcarbonyl, alkoxy carbonyl, alkylcarbonyloxy or alkoxy carbonyloxy
 with 1 to 6 C atoms;
- R^{xx} and R^{yy} independently of each other denote H or alkyl with 1 to 12 C-
 10 atoms;
- Z⁴¹ and Z⁴² are independently and at each occurrence independently from
 each other -O-, -CO-, -COO-, -OCO-, -CH₂, (CH₂)₂-, -(CH₂)₂-, or a
 single bond;
- m¹ is 1, 2, 3, 4, 5, 6, or 7; and
- 15 m² and m³ are each and independently 0, 1, 2, 3, or 4.

Preferred monomers represented by Formula (5) are

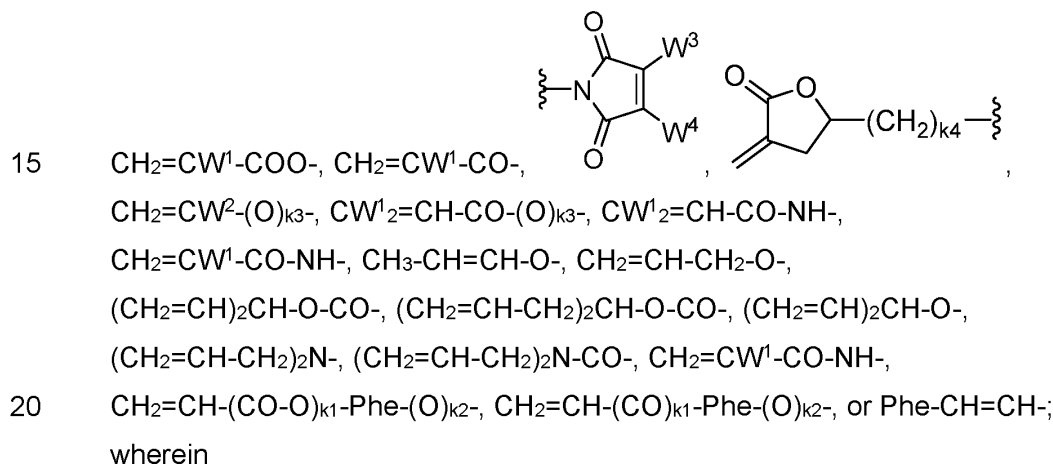


- Third compound

- 30 The third compound comprised in the polymerizable mixture according to the
 present invention is a multifunctional compound capable of reacting with the
 polymerizable compound to give a copolymer. The third compound has at

least three polymerizable groups (P^3), which are selected from groups containing a C=C double bond, which preferably react with P^1 in a radical or ionic chain polymerization or in a 2+2 cycloaddition, groups containing two conjugated C=C double bonds, which preferably react with P^1 in a 4+2 cycloaddition (Diels-Alder reaction), nucleophilic groups, which preferably react with P^1 in a nucleophilic addition (Michaela reaction), and 1,3-dipolar groups, which preferably react with P^1 in a 1,3-dipolar cycloaddition. As such third compound, publicly available one can be used preferably.

Preferred polymerizable groups (P^3) containing a C=C double bond are selected from:



W^1 denotes H, F, Cl, CN, CF_3 , phenyl or alkyl having 1 to 5 C atoms, preferably H or CH_3 ;

W^2 denotes H or alkyl having 1 to 5 C atoms, preferably H or CH_3 ;

25 W^3 and W^4 each, independently of one another, denote H, Cl or alkyl having 1 to 5 C atoms, preferably H or CH_3 ;

Phe denotes 1,4-phenylene, which is optionally substituted by one or more radicals L as being defined above; and

k_1 , k_2 and k_3 each, independently of one another, denote 0 or 1; and

30 k_4 is an integer from 1 to 10.

Preferred groups containing two conjugated C=C double bonds are selected from: $CW^1_2=CW^1-CW^1=CW^1-$; wherein

W^1 denotes H, F, Cl, CN, CF_3 , phenyl or alkyl having 1 to 5 C atoms, preferably H or CH_3 .

5

Preferred nucleophilic groups are selected from: $HS-(CH_2)_{k5}-CO-(O)_{k3}-$, $HS-(CH_2)_{k5}-CO-$, $HS-(CH_2)_{k5}-(O)_{k3}-$, $HS-(CH_2)_{k5}-O-CO-$, $HS-(CH_2)_{k5}-CO-NH-$, $HS-(CH_2)_{k5}-NH-CO-$, $HS-Phe-(O)_{k2}-$, $H_2N-(CH_2)_{k5}-CO-(O)_{k3}-$, $H_2N-(CH_2)_{k5}-CO-$, $H_2N-(CH_2)_{k5}-(O)_{k3}-$, $H_2N-(CH_2)_{k5}-O-CO-$, $H_2N-(CH_2)_{k5}-CO-NH-$, H_2N-

10

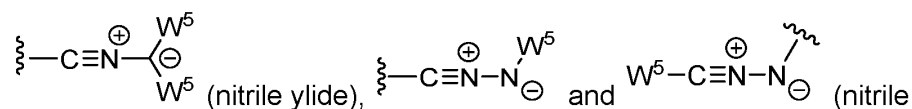
$(CH_2)_{k5}-NH-CO-$, or $H_2N-Phe-(O)_{k2}-$; wherein

k_2 and k_3 each, independently of one another, denote 0 or 1; and

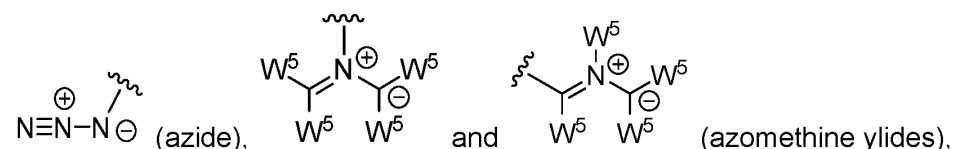
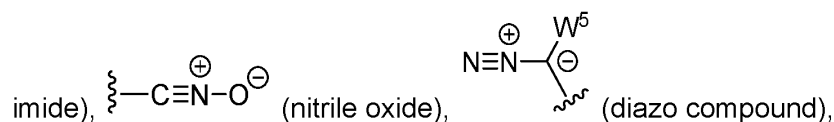
k_5 is an integer from 0 to 10, preferably from 0 to 5, more preferably 0, 1 or 2.

15

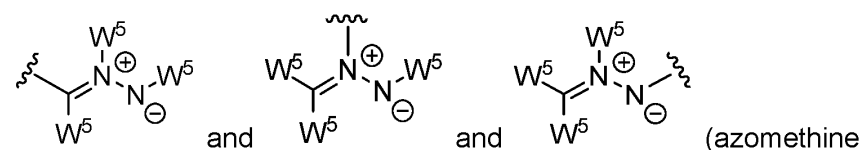
Preferred 1,3-dipolar groups are selected from:



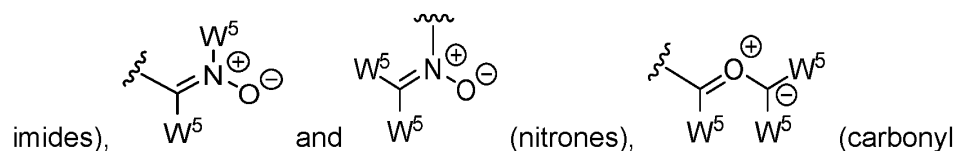
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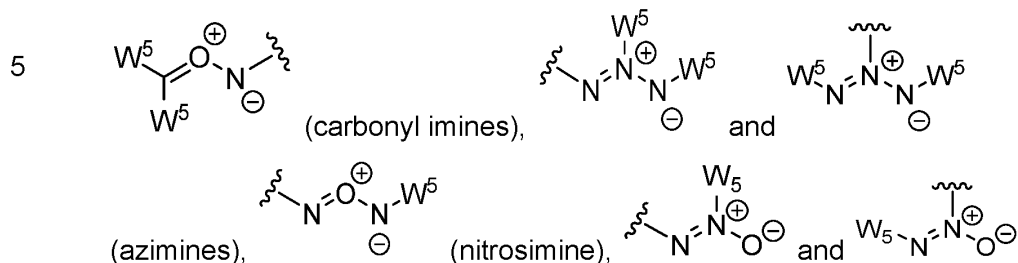
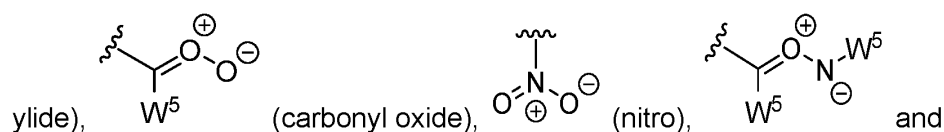
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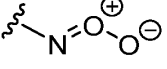


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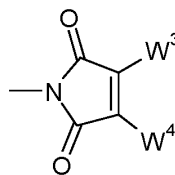
- 46 -

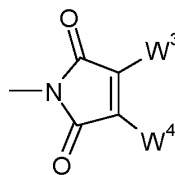


10 (azoxy compounds), or  (nitrosoxide); wherein:

W⁵ denotes at each occurrence independently from each other H, phenyl or alkyl having 1 to 5 C atoms, preferably phenyl or CH₃.

15 Particularly preferred polymerizable groups (P) are selected from:



CH₂=CW¹-COO-, CH₂=CW¹-CO-, , CH₂=CW²-(O)_{k3}-,

20 CW¹₂=CH-CO-(O)_{k3}-, CH₃-CH=CH-O-, CH₂=CH-CH₂-O-,

HS-(CH₂)_{k5}-CO-(O)_{k3}-, HS-(CH₂)_{k5}-CO-, HS-(CH₂)_{k5}-(O)_{k3}-,

HS-(CH₂)_{k5}-O-CO-, H₂N-(CH₂)_{k5}-CO-(O)_{k3}-, H₂N-(CH₂)_{k5}-CO-,

H₂N-(CH₂)_{k5}-(O)_{k3}-, or H₂N-(CH₂)_{k5}-O-CO-; wherein

W¹ denotes H, F, Cl, CN, CF₃, phenyl or alkyl having 1 to 5 C atoms,

25 preferably H or CH₃;

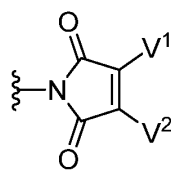
W² denotes H or alkyl having 1 to 5 C atoms, preferably H or CH₃;

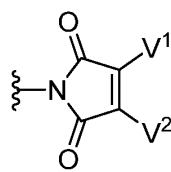
W³ and W⁴ each, independently of one another, denote H, Cl or alkyl having 1 to 5 C atoms, preferably H or CH₃;

k₃ denotes 0 or 1; and

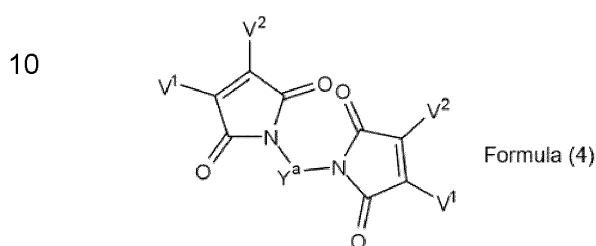
30 k₅ is an integer from 0 to 10, preferably from 0 to 5, more preferably 0, 1 or 2.

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It is most preferred that P^3 denotes , wherein V^1 and V^2 are
 5 independently of one another H, alkyl with 1 to 6 carbon atoms, F, Cl or CN.

In some embodiments, the third compound is represented by Formula (4),



15 wherein Y^a denotes $-(A^{31}-Z^{31})_{m1}-(Z^{32}-A^{32})_{m2}-(Z^{33}-A^{33})_{m3}-$, wherein:

A^{31} and A^{33} are independently and at each occurrence independently of one another an aryl group or a heteroaryl group, optionally being substituted by one or more identical or different groups L;

20 L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, -CN or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms;

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

A^{32} is an aryl group substituted with a maleimide moiety,

30 Z^{31} to Z^{33} are independently and at each occurrence independently from each other -O-, -CO-, -COO-, -OCO-, -CH₂, (CH₂)₂-, -(CH₂)₂-, or a single bond; and

- 48 -

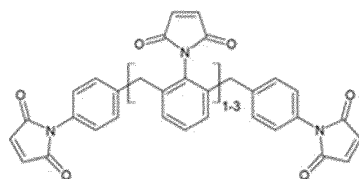
m^1 and m^3 are each and independently 0, 1, 2, 3, or 4; and

m^2 is 0, 1, 2, 3, 4, 5, 6, or 7. As the third compound, publicly available chemical compound falls within chemical formula (4) can be more preferably used.

5

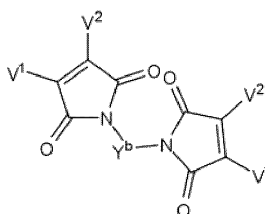
The most preferred monomer/compound represented by formula (4) is

10



In some embodiments, the third compound is represented by Formula (6)

15



Formula (6)

20

wherein Y^b denotes

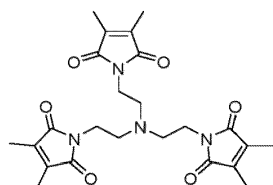
a straight or branched chain alkylene having 1 to 40, preferably 1 to 30 C atoms, which is mono or poly-substituted by bismaleimide moiety and is optionally further mono- or poly-substituted by F, Cl, Br, I, or CN and in which, in addition one or more non-adjacent CH_2 groups may be replaced.

25

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} -, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not linked directly to one another.

30

A preferred monomer/compound represented by formula (6) is



5

- Polymerizable mixture

As set forth above, the disclosed subject matter relates to polymerizable mixtures comprising a first, a second, and a third compound, as described herein.

10

The inventors have surprisingly found that the presence of at least one multifunctional monomer/compound assures that upon polymerization the desired degree of branching is reached.

15

In addition, the inventors have surprisingly found that the presence of both, a monomer/compound comprising aliphatic groups and a monomer comprising aromatic groups further improves film retention properties and positively influences the T_g of the copolymer obtainable by the polymerizable mixture.

20

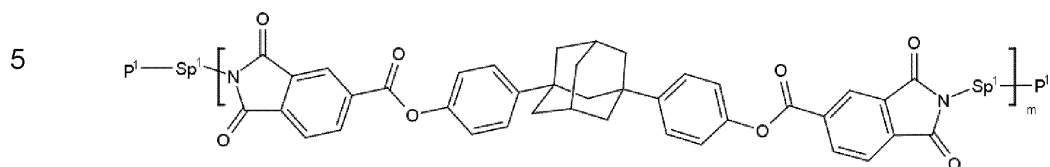
In preferred embodiments, the polymerizable mixture comprises a polymerizable compound represented by Formula (1), a second compound represented by Formula (3), and a third compound represented by Formula (4).

25

In further preferred embodiments, the polymerizable mixture comprises a polymerizable compound represented by Formula (1), a second compound represented by Formula (5), and a third compound represented by Formula (6).

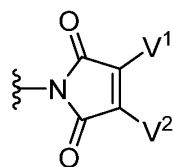
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In particularly preferred embodiments, the polymerizable mixture comprises a polymerizable compound, a second compound, and a third compound to form a copolymer, wherein the polymerizable compound is



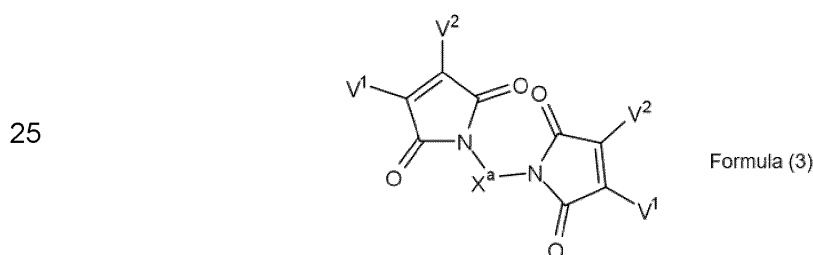
wherein

10 m is an integer from 2 to 60, preferably from 2 to 50, more preferably from 2 to 30, and most preferably from 2 to 20,



15 P^i denotes , wherein V^1 and V^2 are independently of one another H or alkyl with 1 to 6 carbon atoms;

Sp^1 is selected from the group consisting of $-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-O-$, $-OCO-(CH_2)_{p1}-$, $-OCOO-(CH_2)_{p1}-$, and $-(CH_2)_{p1}-(cyclo-C_6H_8R^{01}R^{02})-(CH_2)_{p1}$, in which $p1$ is an integer from 1 to 36, preferably 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; and wherein the second compound is represented by Formula (3)

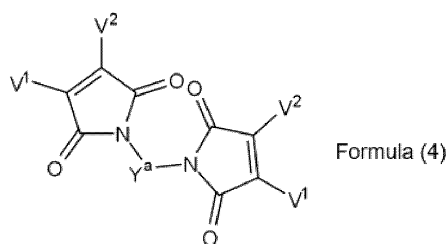


30 wherein X^a denotes

(a) straight or branched chain alkylene having 1 to 40 C, preferably 1 to 30 C atoms, which is optionally mono- or poly-substituted by F, Cl, Br,

I, or CN and in which, in addition one or more non-adjacent CH₂ groups may be replaced, independently of one another, by -O-, -S-, -NH-, NR⁰¹-, -SiR⁰¹R⁰²-, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S, -NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -NR⁰¹-CO-NR⁰¹-, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not linked directly to one another, or

(b) -R^a-R^b-R^c-, wherein R^a and R^c denote independently of each other alkylene having 1 to 20 C atoms or a single bond; R^b denotes cycloalkylene having 3 to 20 C atoms which is optionally mono- or polysubstituted by alkyl having 1 to 20 C atoms; and wherein the third compound is represented by the general formula (4)



wherein Y^a denotes -(A³¹-Z³¹)_{m1}-(Z³²-A³²)_{m2}-(Z³³-A³³)_{m3}- wherein:

A³¹ and A³³ are independently and at each occurrence independently of one another an aryl group or a heteroaryl group, optionally being substituted by one or more identical or different groups L;

L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, -CN or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms;

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

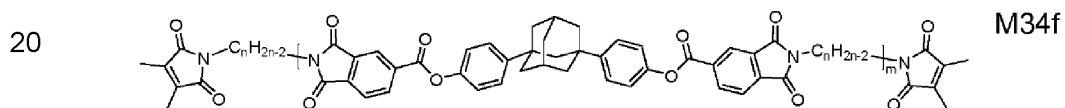
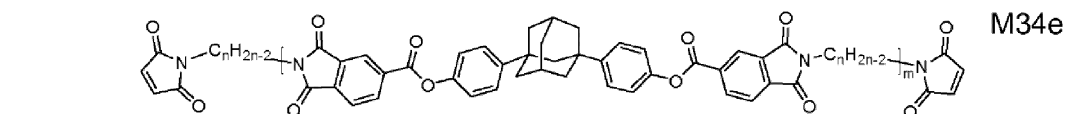
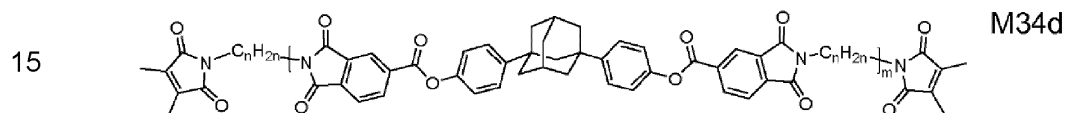
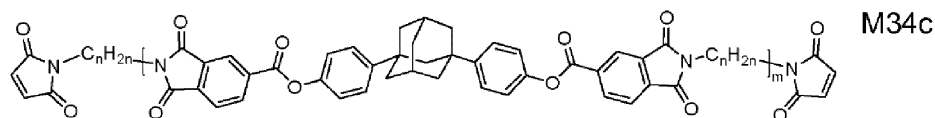
A^{32} is an aryl group substituted with a maleimide moiety,

Z^{31} to Z^{33} are independently and at each occurrence independently from each other -O-, -CO-, -COO-, -OCO-, -CH₂-(CH₂)₂-, -(CH₂)₂-, or a single bond; and

m^1 and m^3 are each and independently 0, 1, 2, 3, or 4; and

m^2 is 0, 1, 2, 3, 4, 5, 6, or 7.

Preferably, said polymerizable compound is selected from

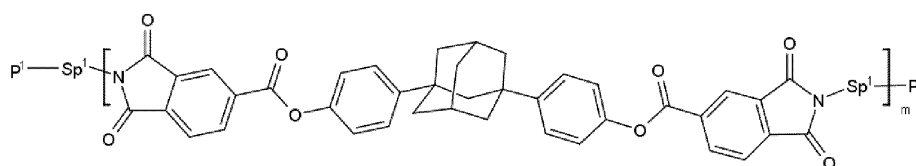


wherein

n is an integer from 1 to 60, preferably from 1 to 36, more preferably from 6 to 12; and

m is an integer from 2 to 60, preferably 2 to 50, more preferably from 2 to 30, and most preferably 3 to 20.

In further particularly preferred embodiments, the polymerizable mixture comprises a polymerizable compound, a second compound, and a third compound to form a copolymer, wherein the polymerizable compound is



5 wherein

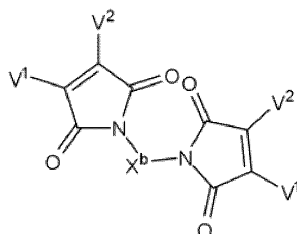
m is an integer from 2 to 60, preferably from 2 to 50, more preferably from 2 to 30, and most preferably from 2 to 20,



10 P¹ denotes , wherein V¹ and V² are independently of one another H or alkyl with 1 to 6 carbon atoms;

Sp¹ is selected from the group consisting of $-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-O-$, $-OCO-(CH_2)_{p1}-$, $-OCOO-(CH_2)_{p1}-$, and $-(CH_2)_{p1}-(cyclo-C_6H_8R^{01}R^{02})-(CH_2)_{p1}$, in which p1 is an integer from 1 to 36, preferably from 1 to 12, and R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms; and wherein the second compound is represented by Formula (5),

20



Formula (5)

25

wherein X^b denotes $-(A^{41}-Z^{41})_{m1}-(A^{42})_{m2}-(Z^{42}-A^{43})_{m3}-$

wherein:

A⁴¹ to A⁴³ are independently and at each occurrence independently of one another an aryl group or a heteroaryl group, optionally being substituted by one or more identical or different groups L;

30

L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain

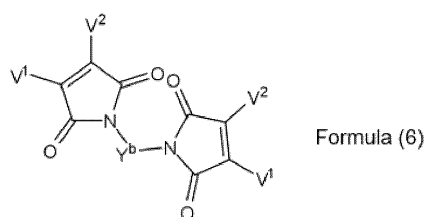
or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, -CN or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms;

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

Z^{41} and Z^{42} are independently and at each occurrence independently from each other -O-, -CO-, -COO-, -OCO-, -CH₂-(CH₂)₂-, -(CH₂)₂-, or a single bond;

m^1 is 1, 2, 3, 4, 5, 6, or 7;

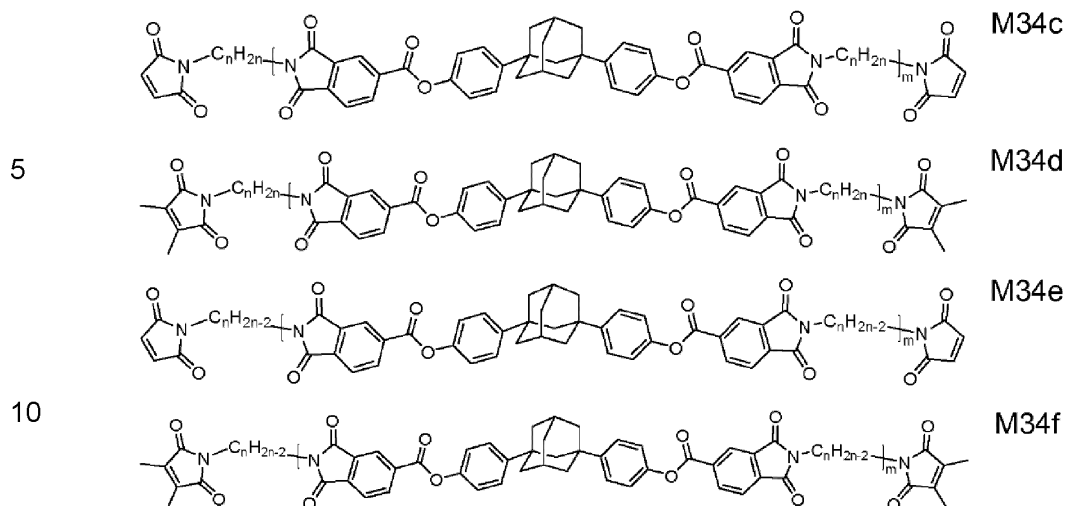
m^2 and m^3 are each and independently 0, 1, 2, 3, or 4; and wherein the third compound is represented by formula (6)



wherein Y^b denotes

a straight or branched chain alkylene having 1 to 40, preferably 1 to 30 C atoms, which is mono or poly-substituted by bismaleimide moiety, and is optionally further mono- or poly-substituted by F, Cl, Br, I, or CN and in which, in addition one or more non-adjacent CH₂ groups may 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} -, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not linked directly to one another.

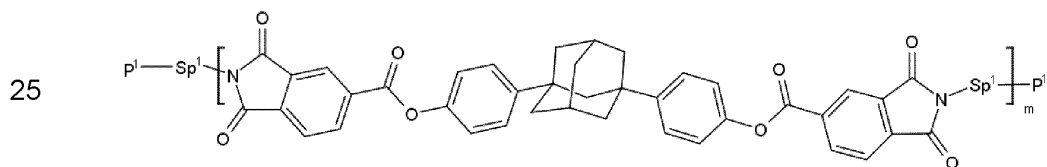
Preferably, said polymerizable compound is selected from



wherein

- 15
- 20
- 25
- 30
- n is an integer from 1 to 60, preferably from 1 to 36, more preferably from 6 to 12; and
- m is an integer from 2 to 60, preferably 2 to 50, more preferably from 2 to 30, and most preferably 3 to 20.

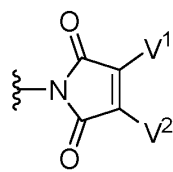
In the most preferred embodiments, the polymerizable mixture comprises a polymerizable compound, a second compound, and a third compound to form a copolymer, wherein the polymerizable compound is



wherein

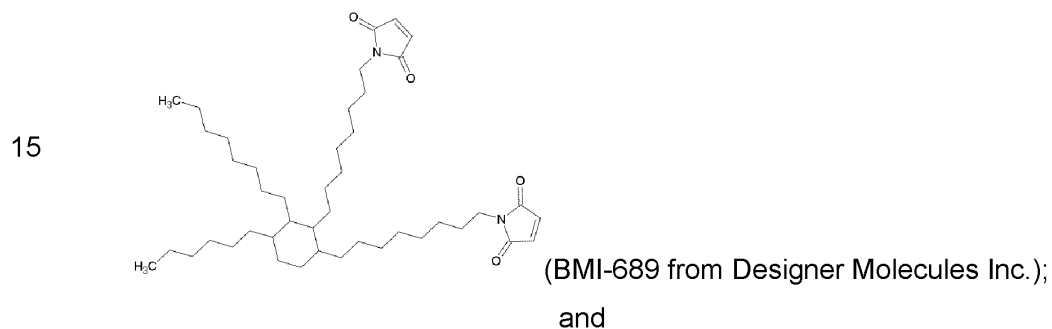
- m is an integer from 2 to 60, preferably from 2 to 50, more preferably from 2 to 30, and most preferably from 2 to 20,

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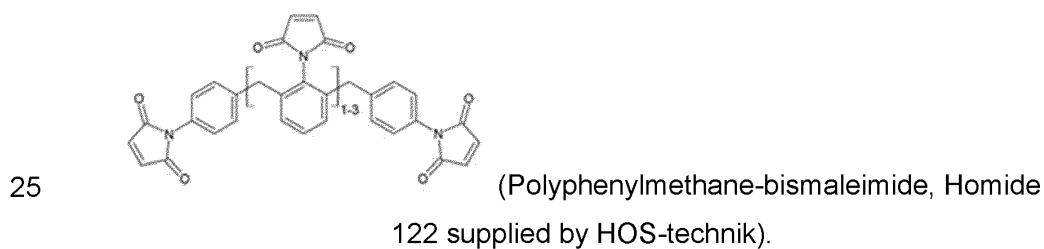


5 P^1 denotes , wherein V^1 and V^2 are independently of one another H or alkyl with 1 to 6 carbon atoms;

Sp^1 is selected from the group consisting of $-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-O-$, $-OCO-(CH_2)_{p1}-$, $-OCOO-(CH_2)_{p1}-$, and $-(CH_2)_{p1}-(cyclo-C_6H_8R^{01}R^{02})-(CH_2)_{p1}$, in which $p1$ is an integer from 1 to 36, preferably 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; and
10 wherein the second compound is

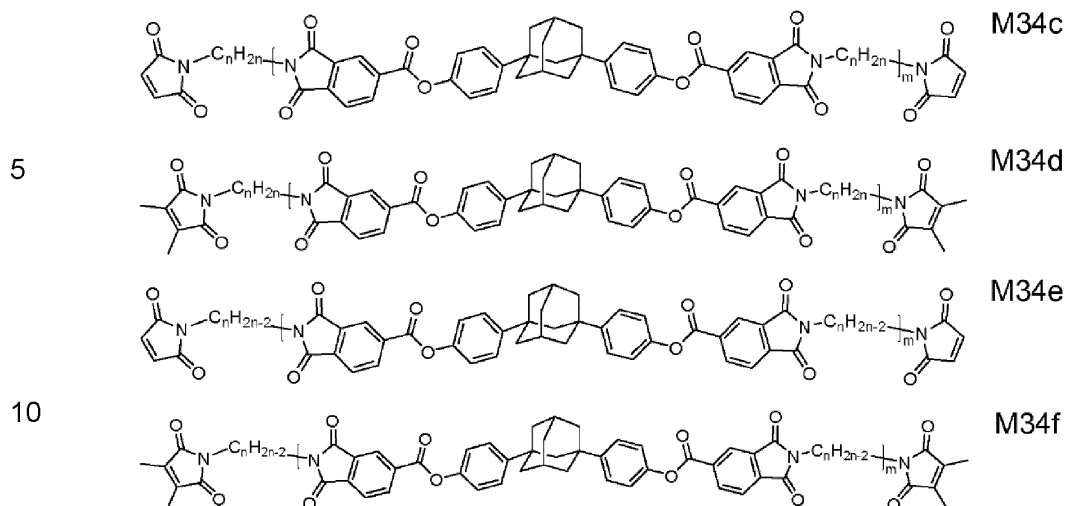


20 wherein the third compound is



30

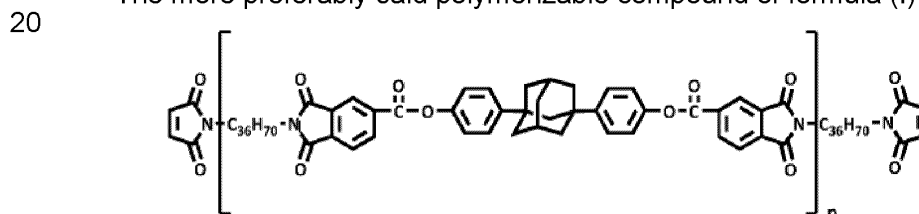
Preferably, said polymerizable compound of formula (I) is selected from



wherein

- 15
- 20
- n is an integer from 1 to 60, preferably from 1 to 36, more preferably from 6 to 12; and
- m is an integer from 2 to 60, preferably 2 to 50, more preferably from 2 to 30, and most preferably 3 to 20.

The more preferably said polymerizable compound of formula (I) is



It is preferred that the second compound and third compound are present in the polymerizable mixture in a ratio of from 10:1 to 1:10. Even more preferred the ratio of the second compound and the third compound is from 1:1 to 1:4.

- 30
- The polymerizable mixture as described herein preferably comprises the polymerizable compound in an amount of 5 to 95 wt.-%, more preferably in

an amount of 30 to 50 wt.-%, based on the total weight of the polymerizable mixture.

5 The polymerizable mixture as described herein preferably comprises the second compound in an amount of 0.1 to 50 wt.-%, more preferably in an amount of 0.5 to 5 wt.-%, based on the total weight of the polymerizable mixture.

10 The polymerizable mixture as described herein preferably comprises the third compound in an amount of 0.1 to 50 wt.-%, preferably in an amount of 0.5 to 10 wt.-%, based on the total weight of the mixture.

15 The polymerizable mixture as described herein may also comprise a curing agent. Also, or alternatively, the polymerizable mixture as described herein may comprise a solvent, such as an organic solvent. The polymerizable mixture of the present invention may not contain any curing agent and/or an organic/inorganic solvent.

- Methods for forming a copolymer

20 The method for forming a copolymer comprises the following steps:
(i) providing a polymerizable mixture as described herein; and
(ii) polymerizing said polymerizable mixture to obtain a copolymer.

25 The polymerizable mixture comprises a polymerizable compound, a second compound, and a third compound as described above. It is preferred that the total content of the polymerizable compound in the polymerizable mixture is from 5 to 95 wt.-%, more preferably from 80 to 99 wt.-% and most preferably from 90 to 95 wt.-%, based on the total weight of polymerizable monomers/compounds. It is preferred that the total content of the second
30 compound in the polymerizable mixture is from 0.1 to 50 wt.-%, more preferably from 0.5 to 10 wt.-% and most preferably from 0.5 to 5 wt.-%, based

on the total weight of polymerizable monomers/compounds. It is preferred that the total content of the third compound in the polymerizable mixture is from 0.1 to 50 wt.-%, more preferably from 0.5 to 30 wt.-% and most preferably from 0.5 to 10 wt.-%, based on the total weight of polymerizable monomers/compounds.

It is preferred that the polymerizable mixture provided in step (i) is substantially free of solvent. Substantially free of solvent means that the content of total residual solvent in the polymerizable starting material is not more than 10 wt.-%, preferably not more than 5 wt.-%, and more preferably not more than 1 wt.-%, based on the total weight of polymerizable monomers/compounds. Alternatively, it is preferred that the polymerizable mixture provided in step (i) comprises one or more solvents, preferably in an amount of more than 10 wt.-%, more preferably in an amount of more than 25 wt.-%, and most preferably in an amount of more than 50 wt.-%, based on the total weight of polymerizable monomers/compounds.

It is preferred that the polymerizable mixture is polymerized in step (ii) by a radical or ionic chain polymerization reaction or a polyaddition reaction. Preferred polyaddition reactions are cycloadditions, such as 2+2 cycloadditions, 4+2 cycloadditions or 1,3-dipolar cycloadditions, or nucleophilic additions, such as Michael reactions.

The above-mentioned reaction types and associated reaction conditions (such as e.g. catalysts, solvents, temperature, time, concentration, etc.) are known to the person skilled in the art.

For example, radical or ionic polymerizations may be carried out in the presence of radical or ionic polymerization initiators, which can be activated thermally and/or photochemically. The skilled person is familiar with suitable radical and ionic polymerization initiators. For example, cycloadditions may

occur photochemically or in the presence of Lewis acids. The skilled person is familiar with suitable photochemical conditions and suitable Lewis acids.

It is preferred that the polymerizable mixture provided in step (i) further comprises one or more radical initiators. Preferred radical initiators are thermally activated radical initiators and/or photochemically activated radical initiators.

Preferred thermally activated radical initiators are: *tert*-amyl peroxybenzoate, 4,4'-azobis(4-cyanovaleric acid), 1,1'-azobis(cyclohexanecarbonitrile), 2,2'-azobisisobutyronitrile (AIBN), benzoyl peroxide, 2,2-bis(*tert*-butylperoxy)butane, 1,1-bis(*tert*-butylperoxy)cyclohexane, 2,5-bis(*tert*-butylperoxy)-2,5-dimethylhexane, 2,5-bis(*tert*-butylperoxy)-2,5-dimethyl-3-hexyne, bis(1-(*tert*-butylperoxy)-1-methylethyl)benzene, 1,1-bis(*tert*-butylperoxy)-3,3,5-trimethylcyclohexane, *tert*-butyl hydroperoxide, *tert*-butyl peracetate, *tert*-butyl peroxide, *tert*-butyl peroxybenzoate, *tert*-butylperoxy isopropyl carbonate, cumene hydroperoxide (CHP), cyclohexanone peroxide, dicumyl peroxide (DCP), lauroyl peroxide, 2,4-pentanedione peroxide, peracetic acid, and potassium persulfate.

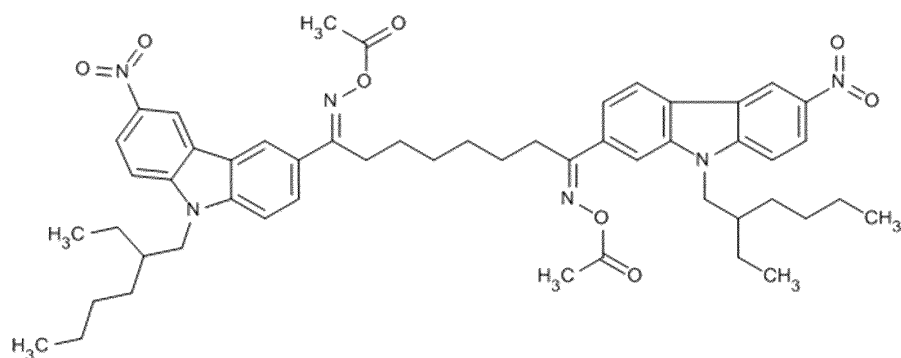
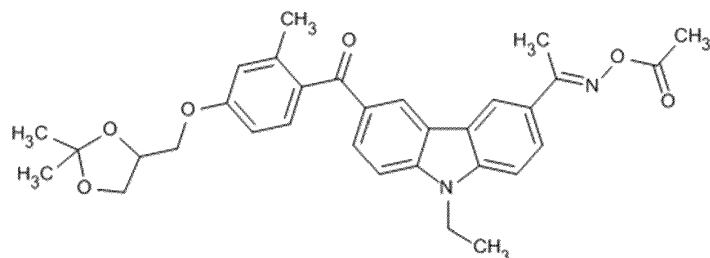
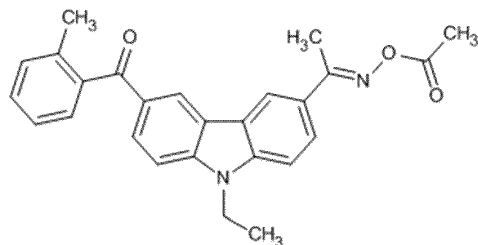
Preferred photochemically activated radical initiators are: acetophenone, *p*-anisil, benzil, benzoin, benzophenone, 2-benzoylbenzoic acid, 4,4'-bis(diethylamino)benzophenone, 4,4'-bis(dimethylamino)benzophenone, benzoin methyl ether, benzoin isopropyl ether, benzoin isobutyl ether, benzoin ethyl ether, 4-benzoylbenzoic acid, 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, methyl 2-benzoylbenzoate, 2-(1,3-benzodioxol-5-yl)-4,6-bis(trichloromethyl)-1,3,5-triazine, 2-benzyl-2-(dimethylamino)-4'-morpholinobutyrophenone, (±)-camphorquinone, 2-chlorothioxanthone, 4,4'-dichlorobenzophenone, 2,2-diethoxyacetophenone, 2,2-Dimethoxy-2-phenylacetophenone, 2,4-diethylthioxanthene-9-one, diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide, 1,4-dibenzoylbenzene, 2-ethylanthraquinone, 1-hydroxycyclohexyl phenyl

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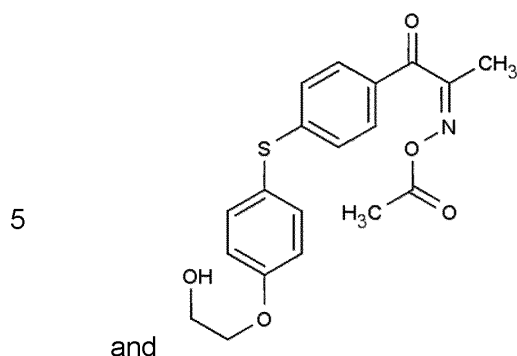
ketone, 2-hydroxy-2-methylpropiophenone, 2-hydroxy-4'-(2-hydroxyethoxy)-2-methylpropiophenone, 2-isopropylthioxanthone, lithium phenyl(2,4,6-trimethylbenzoyl)phosphinate, 2-methyl-4'-(methylthio)-2-morpholinopropiophenone, 2-isonitrosopropiophenone, 2-phenyl-2-(p-toluenesulfonyloxy)acetophenone, and phenylbis(2,4,6-trimethylbenzoyl)phosphine oxide.

Typically, such initiators are radical polymerization initiators which may be photochemically activated.

Further preferred photochemically activated radical initiators are:







10 Preferably, the initiators for radical polymerization are activated thermally by exposure to heat or photochemically by exposure to radiation such as UV and/or visible light.

15 Exposure to heat involves exposure to an elevated temperature, preferably in the range from 40 to 200 °C, more preferably 50 to 180 °C.

20 Exposure to radiation involves exposure to visible light and/or UV light. It is preferred that the visible light is electromagnetic radiation with a wavelength from > 380 to 780 nm, more preferably from > 380 to 500 nm. It is preferred that the UV light is electromagnetic radiation with a wavelength of ≤ 380 nm, more preferably a wavelength from 100 to 380 nm. More preferably, the UV light is selected from UV-A light having a wavelength from 315 to 380 nm, UV-B light having a wavelength from 280 to 315 nm, and UV-C light having a wavelength from 100 to 280 nm.

25 As UV light sources Hg-vapor lamps or UV-lasers are possible, as IR light sources ceramic-emitters or IR-laser diodes are possible and for light in the visible area laser diodes are possible.

30 Preferred UV light sources are light sources having a) a single wavelength radiation with a maximum of < 255 nm such as e.g. 254 nm and 185 nm Hg low-pressure discharge lamps, 193 nm ArF excimer laser and 172 nm Xe2

layer, or b) broad wavelength distribution radiation with a wavelength component of < 255 nm such as e.g. non-doped Hg low-pressure discharge lamps.

5 In a preferred embodiment of the present invention the light source is a xenon flashlight. Preferably, the xenon flashlight has a broad emission spectrum with a short wavelength component going down to about 200 nm.

10 It is preferred that the polymerization in step (ii) takes place in a time range of up to 5 h, more preferably up to 1 h, most preferably up to 0.5 h.

It is further preferred that the polymerization of the polymerizable mixture in step (ii) takes place at elevated temperature, preferably at a temperature in the range from 25 to 200 °C, more preferably at a temperature in the range
15 from 25 to 150 °C.

There is further provided a copolymer which is obtainable or obtained by the above-mentioned method for forming a copolymer according to the present invention. The copolymer is preferably a linear or crosslinked
20 copolymer, more preferably a linear copolymer.

There is also provided a copolymer which comprises at least one repeating unit derived from the polymerizable compound, at least one repeating unit derived from the second compound, and at least one repeating unit derived
25 from the third compound as defined above.

Preferably, the copolymers according to the present invention have a molecular weight M_w , as determined by GPC, of at least 2,000 g/mol, more preferably of at least 4,000 g/mol, even more preferably of at least 5,000
30 g/mol. Preferably, the molecular weight M_w of the copolymers is less than 50,000 g/mol. More preferably, the molecular weight M_w of the copolymers is in the range from 5,000 to 20,000 g/mol.

Moreover, there is provided an electronic device comprising a copolymer according to the present invention. For the electronic device it is preferred that the copolymer forms a dielectric layer, more preferably a dielectric layer forming part of a redistribution layer. The dielectric layer serves to electrically separate one or more electronic components being part of the electronic device from each other.

Finally, there is provided a manufacturing 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 the present invention to a surface of a substrate; and
- (2) curing said polymerizable mixture to form a dielectric layer.

It is preferred that the polymerizable mixture applied in step (1) is substantially free of solvent. Substantially free of solvent means that the content of total residual solvent in the polymerizable mixture is not more than 10 wt.-%, preferably not more than 5 wt.-%, and more preferably not more than 1 wt.-%, based on the total weight of polymerizable monomers/compounds.

However, depending on which kind of application method is used for applying the polymerizable mixture in step (1), it is preferred that the polymerizable mixture comprises one or more solvents, preferably in an amount of more than 10 wt.-%, more preferably in an amount of more than 25 wt.-%, and most preferably in an amount of more than 50 wt.-%, based on the total weight of polymerizable monomers/compounds.

The method by which the polymerizable mixture is applied in step (1) is not particularly limited. Preferred application methods for step (1) are dispensing, dipping, screen printing, stencil printing, roller coating, spray coating, slot coating, spin coating, stereolithography, gravure printing, flexo printing or inkjet printing.

The polymerizable mixtures of the present invention may be provided in the form of a formulation suitable for gravure printing, flexo printing and/or ink-jet printing. For the preparation of such formulations, ink base formulations as known from the state of the art can be used.

Alternatively, the polymerizable mixture of the present invention may be provided in the form of a formulation suitable for photolithography. The photolithography process allows the creation of a photo pattern by using light to transfer a geometric pattern from a photomask to a light-curable composition. Typically, such light-curable composition contains a photo-chemically activatable radical polymerization initiator. For the preparation of such formulations, photoresist base formulations as known from the state of the art can be used.

The layer of the polymerizable mixture, which is applied in step (1), has preferably an average thickness of 1 to 50 μm , more preferably 2 to 30 μm , and most preferably 3 to 15 μm .

It is preferred that the curing in step (2) is carried out by a radical or ionic chain polymerization reaction or a polyaddition reaction. Preferred polyaddition reactions are cycloadditions, such as 2+2 cycloadditions, 4+2 cycloadditions (Diels-Alder reactions) or 1,3-dipolar cycloadditions, or nucleophilic additions, such as Michael reactions. Preferred curing conditions correspond to the preferred polymerization conditions as given above for the method for forming a copolymer.

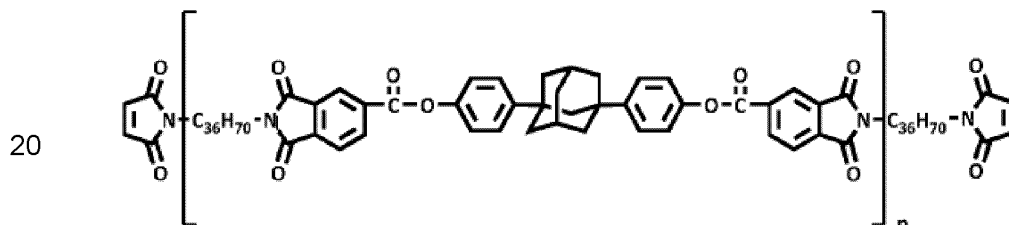
It is preferred that the polymerizable mixture applied in step (1) further comprises one or more radical initiators. Preferred radical initiators are described above.

5 There is also provided a microelectronic device which comprises the packaged microelectronic structure prepared according to the above-mentioned manufacturing method.

10 The present invention is further illustrated by the examples following herein-
after which shall in no way be construed as limiting. The skilled person will
acknowledge that various modifications, additions and alternations may be
made to the invention without departing from the spirit and scope of the
invention as defined in the appended claims.

15 Examples

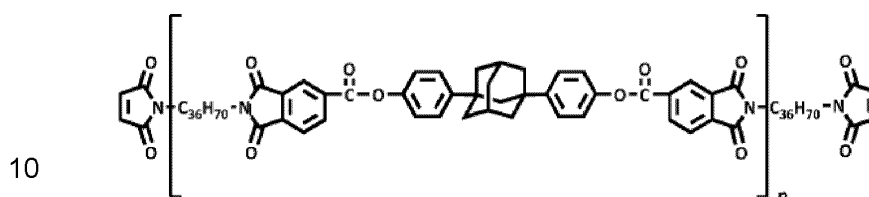
Synthesis Example: Synthesis of first polymerizable composition 1



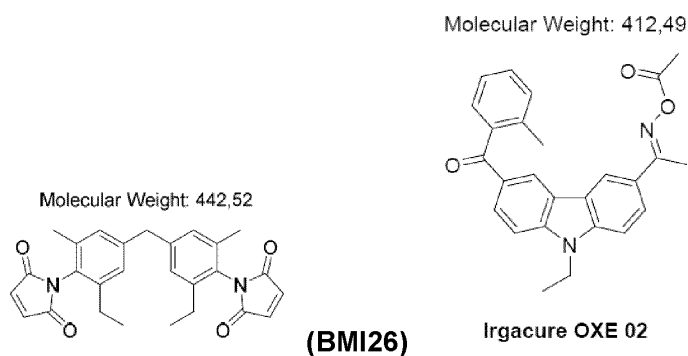
Like described in WO2019/141833 A1, Dianhydride (10 g, 0.015 mol) is dissolved in NMP/toluene (0.1 L, 1/1, v/v) followed by the addition of priamine (16.5 g, 0.03 mol). The reaction mixture is heated to reflux using a Dean-Stark apparatus for 12 h. The reaction mixture is cooled to room temperature and maleic anhydride (3.7 g, 0.04 mol) is slowly added. The mixture is heated again to reflux using a Dean-Stark apparatus for 12 h. An additional 50 mL of toluene is added after the mixture had been cooled down to room temperature. The mixture is finally added dropwise to methanol (0.2 L) to precipitate the oligomer. After removing the solvent, the crude product is washed twice with methanol and vacuum-dried to produce

20 g (71 %) of a brown waxy resin. Finally, as the chemical compound represented by Formula (I) is obtained.

Reference example 1: polymerizable mixture of polymerizable composition 1 with BMI26 and Irgacure OXE 02



polymerizable composition 1



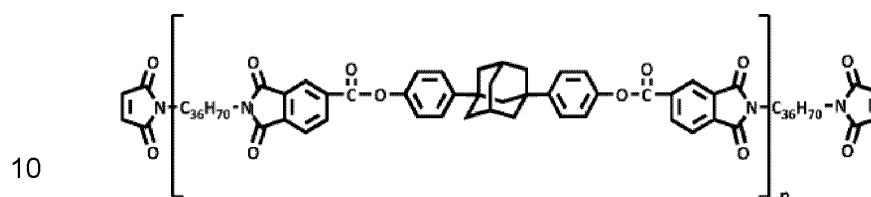
Formulation consisting of 43% polymerizable composition 1, 4,3% BMI-26, 2,15% OXE02 in remainder of CPN gives an E-modulus of around 1600 MPa, a Tg of 72.2°C and α CTE < 100 ppm/K⁻¹ between 80-150 and 150-200 when cured with Hg arc for 10J/cm², developed in CPN and hard bake of 230°C for 1 hour under nitrogen flow. It gives poor thermo-mechanical properties after i-line curing.

Reference example 2: polymerizable mixture of polymerizable composition 1 with BMI26 and Irgacure OXE 02

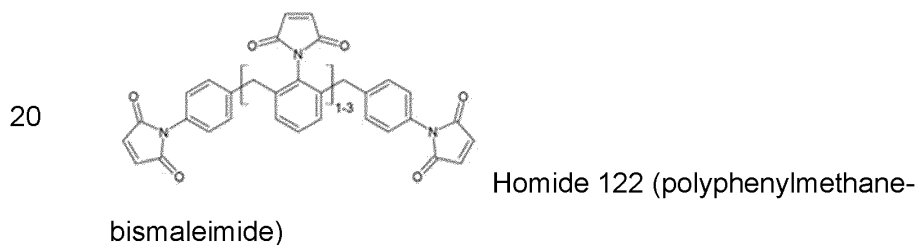
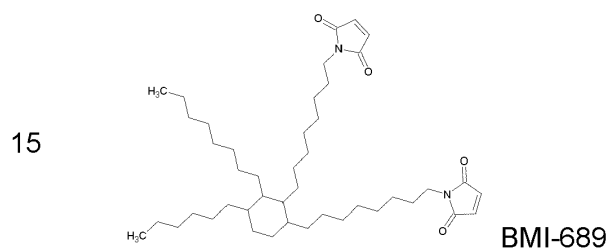
1J/cm² i-line exposure and same development method as described in

reference example 1 provides a E-modulus of around 1100 MPa and Tg of 63.5°C. The quality and film retention of the i-line cured film is also drastically worse than the UV cube.

5 Working example 1: polymerizable mixture of polymerizable composition 1 with Homide 122 and BMI-689



polymerizable composition 1



25 Formulation W.E.1 consisting of 1:1 ratio of BMI-689 and Homide 122 is use at 5% solid loading, 95wt% polymerizable composition 1 is prepared. The E-moduus and Tg can be increased to around 1700MPa and 69.9°C.

Working example 2: polymerizable mixture of polymerizable composition 1 with Homide 122 and BMI-689

30

Formulation W.E.2 consisting of 1:4 ratio of BMI-689 and Homide 122 is

use at 5% solid loading, 95wt% polymerizable composition 1 is prepared.

5 E-modules and Tg can be further increased to an E-modulus of around 1900MPa, Tg of 73.9 and improved linearity of CTE (Coefficient of Thermal Expansion) after Tg is realized.

Working example 3: polymerizable mixture of polymerizable composition 1 with Homide 122 and BMI-689

10 Formulation W.E.3 consisting of 1:1 ratio of BMI-689 and Homide 122 used at 10% solid loading, 95wt% polymerizable composition 1 is prepared. It gives lager impact on Tg which increases to 83.1°C by increasing the solid loading of the BMI689 and Homide 122 crosslinker from 5 (Working
15 example 1) to 10wt% (Working example 3). And E-modulus of around 1800MPa is obtained.

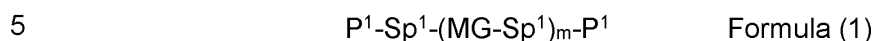
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Patent claims

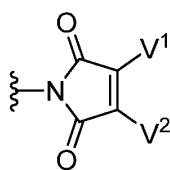
1. A polymerizable mixture comprising a polymerizable compound, a second compound and a third compound, wherein the polymerizable compound is a compound represented by Formula (1),

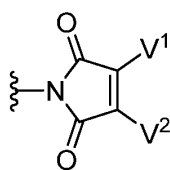


wherein:

m is an integer from 1 to 60;

10

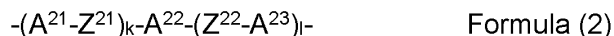


P^1 denotes , wherein V^1 and V^2 are independently of one another H, alkyl with 1 to 6 carbon atoms, F, Cl or CN;

Sp^1 denotes at each occurrence a spacer group;

15

MG is a rod-shaped mesogenic group, which is preferably selected from Formula (2):



wherein:

20

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;

25

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-NR⁰¹-, -NR⁰¹-CO-, -NR⁰¹-CO-NR⁰²-, -NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -OCH₂-, -CH₂O-, -SCH₂-, -CH₂S-, -CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -CH₂CH₂-, -(CH₂)₄-, -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -CH=N-, -N=CH-, -N=N-, -CH=CR⁰¹-, -CY⁰¹=CY⁰²-, CH=CH-COO-, -OCO-CH=CH-, or a single bond;

30

R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms;

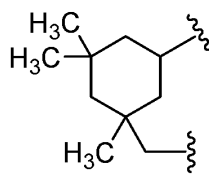
- L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)NR^{xx}R^{yy}, -
 C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain or branched
 chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or
 alkoxycarbonyloxy with 1 to 20 C atoms, wherein one or more H atoms
 5 are optionally replaced by F or Cl, -CN or straight chain or branched chain
 alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or
 alkoxycarbonyloxy with 1 to 6 C atoms;
 R^{xx} and R^{yy} independently of each other denote H or alkyl with 1 to 12 C-
 atoms;
 10 Y⁰¹ and Y⁰² 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 compound is a bi- or multifunctional compound; the
 third compound is a multifunctional compound and
 15 wherein the second and the third compound are capable of reacting with
 the polymerizable compound to give a copolymer.
2. The polymerizable mixture according to claim 1, wherein the spacer
 groups Sp¹ are selected from the formula Sp'-X', so that the radical "P¹-
 20 Sp¹-" corresponds to the formula "P¹-Sp'-X'-", wherein:
 Sp' denotes
 (a) straight chain or branched chain alkylene having 1 to 40, which is
 optionally mono- or polysubstituted by F, Cl, Br, I, or CN and in which, in
 addition, one or more non-adjacent CH₂ groups may each be replaced,
 25 independently of one another, by -O-, -S-, -NH-, -NR⁰¹-, SiR⁰¹R⁰²-, -CO-, -
 COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, -NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -
 NR⁰¹-CO-NR⁰¹-, -CH=CH-, or -C≡C- 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
 30 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-NR⁰¹-, -NR⁰¹-CO-, -NR⁰¹-CO-NR⁰¹-, -OCH₂, CH₂O-, -SCH₂-, -CH₂S-, -CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-, -CH=N-, -N=C-, -N=N-, -CH=CR⁰¹-, -CY⁰¹=CY⁰²-, -C≡C-, -CH=CH-COO-, -OCO-CH=CH- or a single bond;

R⁰¹ and R⁰¹ each, independently of one another, denote H or alkyl having 1 to 12 C atoms; and

Y⁰¹ and Y⁰² each, independently of one another, denote H, F, Cl, or CN.

3. The polymerizable mixture according to claim 1 or claim 2, wherein the spacer groups Sp are selected from the list consisting of -(CH₂)_{p1}-, -(CH₂CH₂O)_{q1}-CH₂CH₂-, -CH₂CH₂-S-CH₂CH₂-, -CH₂CH₂-NH-CH₂CH₂-, -(SiR⁰¹R⁰²-O)_{p1}-, -(CH₂)_{p1}-(cyclo-C₆H₈R⁰¹R⁰²)-(CH₂)_{p1}- and

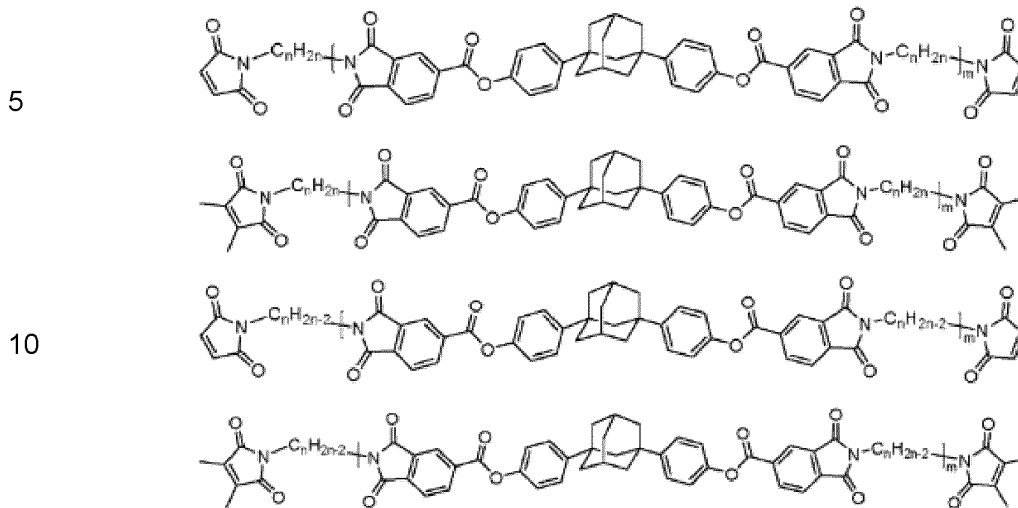


p₁ is an integer from 1 to 60;

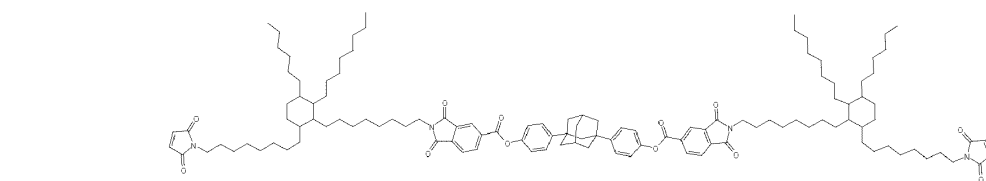
q₁ is an integer from 1 to 12; and R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms.

4. The polymerizable mixture according to any one of claims 1 to 3, wherein
- A²¹ to A²³ are independently and at each occurrence independently of one another an aryl group, a cyclic imide group or an alicyclic group;
- Z²¹ and Z²² are independently and at each occurrence independently from each other, -COO- or -OCO-; and
- Sp denotes -(CH₂)_{p1}-(cyclo-C₆H₈R⁰¹R⁰²)-(CH₂)_{p1}-, wherein p₁ is an integer between 1 and 12 and R⁰¹ and R⁰² each, independently of one another, denote H or alkyl having 1 to 12 C atoms.

5. The polymerizable mixture according to any one of claims 1 to 4, wherein the polymerizable compound is selected from



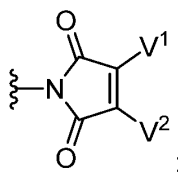
preferably said polymerizable compound is



6. The polymerizable mixture according to any one of claims 1 to 5, wherein the second compound comprises two or more polymerizable groups (P^2) which are selected from groups containing a C=C double bond, which preferably react with P^1 in radical or ionic chain polymerization or in a 2+2 cycloaddition, groups containing two conjugated C=C double bonds, which preferably react with P^1 in a 4+3 cycloaddition nucleophilic groups which preferably react with P^1 in a nucleophilic addition, and 1,3-dipolar groups, which preferably react with P^1 in a 1,3-dipolar cycloaddition.
7. The polymerizable mixture according to any one of claims 1 to 6, wherein third compound comprises three or more polymerizable

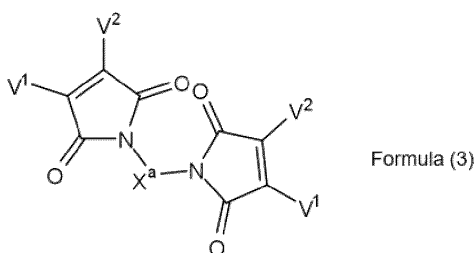
groups (P^3) which are selected from groups containing a C=C double bond, which preferably react with P^1 in radical or ionic chain polymerization or in a 2+2 cycloaddition, groups containing two conjugated C=C double bonds, which preferably react with P^1 in a 4+3 cycloaddition nucleophilic groups which preferably react with P^1 in a nucleophilic addition, and 1,3-dipolar groups, which preferably react with P^1 in a 1,3-dipolar cycloaddition.

8. The polymerizable mixture according to any one of claims 1 to 7, wherein the polymerizable groups P^1 , P^2 , and P^3 , each individually denotes



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

9. The polymerizable mixture according to any one of claims 1 to 8, wherein the second compound is represented by Formula (3),



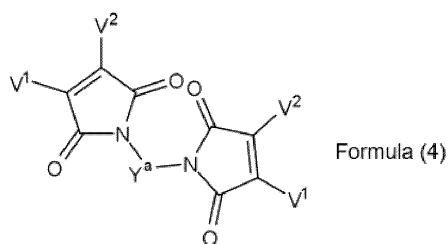
wherein X^a denotes

- (c) Straight or branched chain alkylene having 1 to 40 C, preferably 1 to 30 C atoms, which is optionally mono- or poly-substituted by F, Cl, Br, I, or CN and in which, in addition one or more non-adjacent

CH₂ groups may be replaced, independently of one another, by -O-,
 -, -S-, -NH-, NR⁰¹-, -SiR⁰¹R⁰²-, -CO-, -COO-, -OCO-, -OCO-O-, -S-
 CO-, -CO-S-, --NR⁰¹-CO-O-, -O-CO-NR⁰¹-, -NR⁰¹-CO-NR⁰¹-, -
 CH=CH- or -C≡C- in such a way that O and/or S atoms are not
 linked directly to one another, or

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

the third compound is represented by the general formula (4)



Formula (4)

wherein Y^a denotes -(A³¹-Z³¹)_{m1}-(Z³²-A³²)_{m2}-(Z³³-A³³)_{m3}-

wherein:

A³¹ and A³³ are independently and at each occurrence independently
 of one another an aryl group or a heteroaryl group, optionally being
 substituted by one or more identical or different groups L;

L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN,
 C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or
 straight chain or branched chain alkyl, alkoxy, alkylcarbonyl,
 alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C
 atoms, wherein one or more H atoms are optionally replaced by F or
 Cl, -CN or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl,
 alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C
 atoms;

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

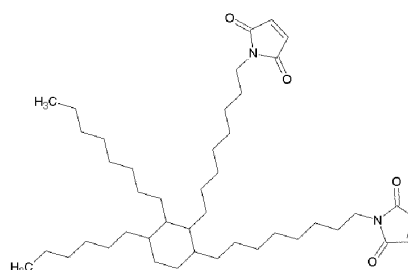
A^{32} is an aryl group substituted with a maleimide moiety,

Z^{31} to Z^{33} are independently and at each occurrence independently from each other -O-, -CO-, -COO-, -OCO-, -CH₂-(CH₂)₂-, -(CH₂)₂-, or a single bond; and

m^1 and m^3 are each and independently 0, 1, 2, 3, or 4; and

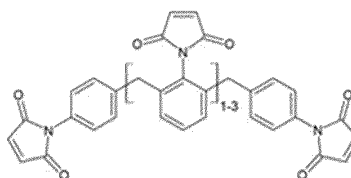
m^2 is 0, 1, 2, 3, 4, 5, 6, or 7.

10. The polymerizable mixture according to any one of claims 1 to 9,



wherein the second compound is

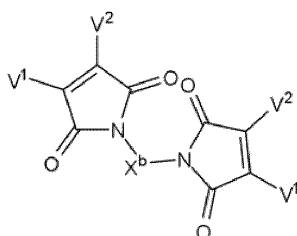
11. The polymerizable mixture according to any one of claims 1 to 10,



wherein the third compound is

12. The polymerizable mixture according to any one of claims 1 to 8,

wherein the second compound is represented by Formula (5),



Formula (5)

wherein X^b denotes $-(A^{41}-Z^{41})_{m1}-(A^{42})_{m2}-(Z^{42}-A^{43})_{m3}-$

wherein:

A⁴¹ to A⁴³ are independently and at each occurrence independently of one another an aryl group or a heteroaryl group, optionally being substituted by one or more identical or different groups L;

5 L is F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)NR^{xx}R^{yy}, -C(=O)OR^{xx}, -C(=O)R^{xx}, -NR^{xx}R^{yy}, -OH, -SF₅, or straight chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 20 C atoms, wherein one or more H atoms are optionally replaced by F or Cl, -CN or straight
10 chain or branched chain alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy with 1 to 6 C atoms;

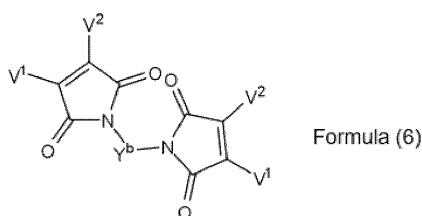
R^{xx} and R^{yy} independently of each other denote H or alkyl with 1 to 12 C-atoms;

15 Z⁴¹ and Z⁴² are independently and at each occurrence independently from each other -O-, -CO-, -COO-, -OCO-, -CH₂, (CH₂)₂-, -(CH₂)₂-, or a single bond;

m¹ is 1, 2, 3, 4, 5, 6, or 7;

m² and m³ are each and independently 0, 1, 2, 3, or 4; and wherein the third compound is represented by formula (6)

20



25

wherein Y^b denotes

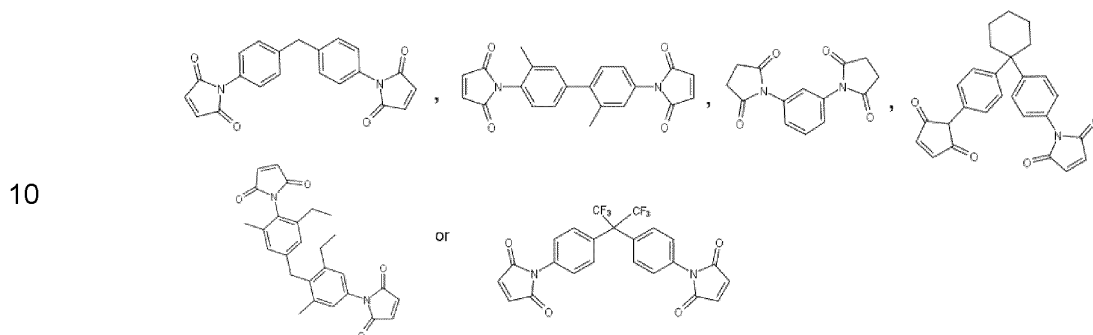
a straight or branched chain alkylene having 1 to 40, preferably 1 to 30 C atoms, which is mono or poly-substituted by bismaleimide moiety, and is optionally further mono- or poly-substituted by F, Cl, Br, I, or CN and in which, in addition one or more non-adjacent CH₂ groups may be replaced. Independently of one another, by -O-, -S-, -NH-, NR⁰¹-, -SiR⁰¹R⁰²-, -CO-, -COO-, -OCO-, -OCO-O-, -S-CO-, -CO-S-, --NR⁰¹-CO-

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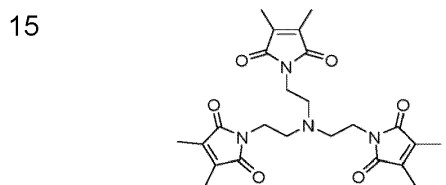
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O, -O-CO-NR⁰¹-, -NR⁰¹-CO-NR⁰¹-, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not linked directly to one another.

13. The polymerizable mixture according to any one of claims 1 to 8; and
5 12, wherein the second compound is



; and wherein the third compound is



- 20 14. The polymerizable mixture according to any one of claims 1 to 13,
wherein the ratio of the second compound to the third compound is
from 10:1 to 1:10, preferably from 1:1 to 1:4.
- 25 15. The polymerizable mixture according to any one of claims 1 to 14,
wherein the polymerizable compound is present in amount of 5 to 95
wt.-%, preferably 30-50 wt.-% based on the total weight of the mixture.
- 30 16. The polymerizable mixture according to any one of claims 1 to 15,
wherein the second compound is present in an amount of 0.1 to 50
wt.-%, preferably 0.5 to 5 wt.-% based on the total weight of the
mixture.

17. The polymerizable mixture according to any one of claims 1 to 16,
wherein the third compound is present in an amount of 0.1 to 50 wt.-%,
preferably 0.5 to 10 wt.-% based on the total weight of the mixture.
- 5 18. The polymerizable mixture according to any one of claims 1 to 17,
wherein the mixture further comprises a curing agent.
19. The polymerizable mixture according to any one of claims 1 to 18,
wherein the mixture further comprises as solvent, in particular an
10 organic solvent.
20. A method for forming a dielectric polymer material comprising the
following steps:
a. providing a polymerizable mixture according to any one of claims
15 1 to 19; and
b. curing said polymerizable mixture.
21. A dielectric polymer material obtainable by the method according to
claim 20.
20
22. An electronic device comprising a dielectric polymer material according
to claim 21.
23. The electronic device according to claim 22, wherein the electronic
25 device is a microelectronic device and the dielectric polymer material is
comprised as a repassivation material in a redistribution layer of the
microelectronic device.
- 30