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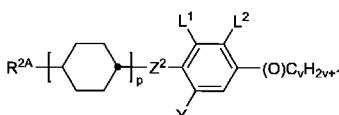
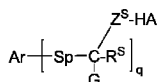
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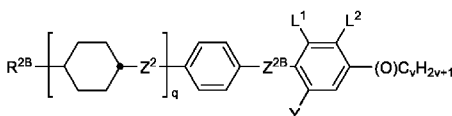
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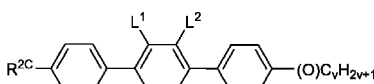
(54) Title: LIQUID-CRYSTAL MEDIUM



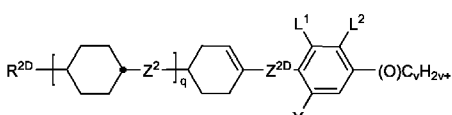
IIA



IIB



IIC



IID

(57) Abstract: The present invention relates to chiral liquid-crystal (LC) media comprising a) one or more compounds of the formula I b) one or more compounds selected from the group of compounds of the formulae IIA, IIB, IIC and IID, as defined in claim 1, and c) one or more chiral dopants; and to the use of the LC media for optical, electro-optical and electronic purposes, in particular in LC displays, preferably in LC displays for outdoor use.



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Liquid-crystal medium

5 The present invention relates to chiral liquid-crystal (LC) media and to the use of the LC media for optical, electro-optical and electronic purposes, in particular in LC displays, preferably in LC displays for outdoor use.

One of the liquid-crystal display (LCD) modes used at present is the TN ("twisted nematic") mode. However, TN LCDs have the disadvantage of a strong viewing-angle dependence of the contrast.

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In addition, so-called VA ("vertically aligned") displays are known which have a broader viewing angle. The LC cell of a VA display contains a layer of an LC medium between two transparent electrodes, where the LC medium usually has a negative dielectric anisotropy. In the switched-off state, the molecules of the LC layer are aligned perpendicular to the electrode surfaces (homeotropically) or have a tilted homeotropic alignment. On application of an electrical voltage to the two electrodes, a realignment of the LC molecules parallel to the electrode surfaces takes place.

15

Also known are so-called IPS ("in-plane switching") displays, which contain an LC layer between two substrates, where the two electrodes are arranged on only one of the two substrates and preferably have intermeshed, comb-shaped structures. On application of a voltage to the electrodes, an electric field which has a significant component parallel to the LC layer is thereby generated between them. This causes realignment of the LC molecules in the layer plane.

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Furthermore, so-called FFS ("fringe-field switching") displays have been reported (see, inter alia, S.H. Jung et al., Jpn. J. Appl. Phys., Volume **43**, No. 3, 2004, 1028), which contain two electrodes on the same substrate, one of which structured in a comb-shaped manner and the other is unstructured. A strong, so-called "fringe field" is thereby generated, i.e. a strong electric field close to the edge of the electrodes, and, throughout the cell, an electric field which has both a strong vertical component and also a strong horizontal component. FFS displays have a low viewing-angle dependence of the contrast. FFS displays usually contain an LC medium with positive dielectric anisotropy, and an alignment layer, usually of polyimide, which provides planar alignment to the molecules of the LC medium.

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FFS displays can be operated as active-matrix or passive-matrix displays. In the case of active-matrix displays, individual pixels are usually addressed by integrated, non-linear active elements, such as, for example, transistors (for example thin-film transistors ("TFTs")), while in the case of passive-matrix displays, individual pixels are usually addressed by the multiplex method, as known from the prior art.

Furthermore, FFS displays have been disclosed (see S.H. Lee et al., Appl. Phys. Lett. 73(20), 1998, 2882-2883 and S.H. Lee et al., Liquid Crystals 39(9), 2012, 1141-1148), which have similar electrode design and layer thickness as FFS displays but comprise a layer of an LC medium with negative dielectric anisotropy instead of an LC medium with positive dielectric anisotropy. The LC medium with negative dielectric anisotropy shows a more favourable director orientation that has less tilt and more twist orientation compared to the LC medium with positive dielectric anisotropy, as a result of which these displays have a higher transmission. The displays further comprise an alignment layer, preferably of polyimide provided on at least one of the substrates that is in contact with the LC medium and induces planar alignment of the LC molecules of the LC medium. These displays are also known as "Ultra Brightness FFS (UB-FFS)" mode displays. These displays require an LC medium with high reliability.

In VA displays of the more recent type, uniform alignment of the LC molecules is restricted to a plurality of relatively small domains within the LC cell. Disclinations may exist between these domains, also known as tilt domains. VA displays having tilt domains have, compared with conventional VA displays, a greater viewing-angle independence of the contrast and the grey shades. In addition, displays of this type are simpler to produce since additional treatment of the electrode surface for uniform alignment of the molecules in the switched-on state, such as, for example, by rubbing, is no longer necessary. Instead, the preferential direction of the tilt or pretilt angle is controlled by a special design of the electrodes.

In so-called MVA ("multidomain vertical alignment") displays, this is usually achieved by the electrodes having protrusions which cause a local pretilt. As a consequence, the LC molecules are aligned parallel to the electrode surfaces in different directions in different, defined regions of the cell on application of a voltage. "Controlled" switching is thereby achieved, and the formation of interfering disclination lines is prevented. Although this arrangement improves the viewing angle of the display, it

results, however, in a reduction in its transparency to light. A further development of MVA uses protrusions on only one electrode side, while the opposite electrode has slits, which improves the transparency to light. The slitted electrodes generate an inhomogeneous electric field in the LC cell on application of a voltage, meaning that controlled switching is still achieved. For further improvement of the transparency to light, the separations between the slits and protrusions can be increased, but this in turn results in a lengthening of the response times. In so-called PVA ("patterned VA") displays, protrusions are rendered completely superfluous in that both electrodes are structured by means of slits on the opposite sides, which results in increased contrast and improved transparency to light, but is technologically difficult and makes the display more sensitive to mechanical influences ("tapping", etc.). For many applications, such as, for example, monitors and especially TV screens, however, a shortening of the response times and an improvement in the contrast and luminance (transmission) of the display are demanded.

A further development are displays of the so-called PS ("polymer sustained") or PSA ("polymer sustained alignment") type, for which the term "polymer stabilised" is also occasionally used. In these, a small amount (for example 0.3% by weight, typically < 1% by weight) of one or more polymerisable, compound(s), preferably polymerisable monomeric compound(s), is added to the LC medium and, after filling the LC medium into the display, is polymerised or crosslinked in situ, usually by UV photopolymerisation, optionally while a voltage is applied to the electrodes of the display. The polymerisation is carried out at a temperature where the LC medium exhibits a liquid crystal phase, usually at room temperature. The addition of polymerisable mesogenic or liquid-crystalline compounds, also known as reactive mesogens or "RMs", to the LC mixture has proven particularly suitable.

In the meantime, the PS(A) principle is being used in various conventional LC display modes. Thus, for example, PS-VA, PS-OCB, PS-IPS, PS-FFS, PS-UB-FFS and PS-TN displays are known. The polymerisation of the RMs preferably takes place with an applied voltage in the case of PS-VA and PS-OCB displays, and with or without, preferably without, an applied voltage in the case of PS-IPS displays. As can be demonstrated in test cells, the PS(A) method results in a pretilt in the cell. In the case of PS-VA displays, the pretilt has a positive effect on response times. For PS-VA displays, a standard MVA or PVA pixel and electrode layout can be used. In addition, however, it is also possible, for example, to manage with only one

structured electrode side and no protrusions, which significantly simplifies production and at the same time results in very good contrast and in very good transparency to light.

5 PS-VA displays are described, for example, in EP 1 170 626 A2, US 6,861,107, US 7,169,449, US 2004/0191428 A1, US 2006/0066793 A1 and US 2006/0103804 A1. PS-OCB displays are described, for example, in T.-J- Chen et al., Jpn. J. Appl. Phys. 45, 2006, 2702-2704 and S. H. Kim, L.-C- Chien, Jpn. J. Appl. Phys. 43, 2004, 7643-7647. PS-IPS displays are described, for example, in US 6,177,972 and
10 Appl. Phys. Lett. 1999, 75(21), 3264. PS-TN displays are described, for example, in Optics Express 2004, 12(7), 1221.

Below the layer formed by the phase-separated and polymerised RMs which induce the above mentioned pretilt angle, the PSA display typically contains an alignment
15 layer on one or both of the substrates forming the display cell, that provides the initial alignment of the LC molecules before the polymer stabilisation step. The alignment layer is usually applied on the electrodes (where such electrodes are present) such that it is in contact with the LC medium and induces initial alignment of the LC molecules. The alignment layer may comprise or consist of, for example, a
20 polyimide, which may also be rubbed, or may be prepared by a photoalignment method.

Like the conventional LC displays described above, PSA displays can be operated as active-matrix or passive-matrix displays. In the case of active-matrix displays,
25 individual pixels are usually addressed by integrated, non-linear active elements, such as, for example, transistors (for example thin-film transistors ("TFTs")), while in the case of passive-matrix displays, individual pixels are usually addressed by the multiplex method, as known from the prior art.

30 In particular for monitor and especially TV applications, optimisation of the response times, but also of the contrast and luminance (thus also transmission) of the LC display continues to be demanded. The PSA method can provide significant advantages here. In particular in the case of PS-VA, PS-IPS and PS-FFS displays, a shortening of the response times, which correlate with a measurable pretilt in test
35 cells, can be achieved without significant adverse effects on other parameters.

Another problem observed in prior art is that the use of conventional LC media in LC displays, including but not limited to displays of the PSA type, often leads to the occurrence of mura in the display, especially when the LC medium is filled in the display cell manufactured using the one drop filling (ODF) method. This
5 phenomenon is also known as "ODF mura". It is therefore desirable to provide LC media which lead to reduced ODF mura.

Another problem observed in prior art is that LC media for use in PSA displays, including but not limited to displays of the PSA type, do often exhibit high viscosities and, as a consequence, high switching times. In order to reduce the viscosity and switching time of the LC medium, it has been suggested in prior art to add LC
10 compounds with an alkenyl group. However, it was observed that LC media containing alkenyl compounds often show a decrease of the reliability and stability, and a decrease of the VHR especially after exposure to UV radiation. Especially for
15 use in PSA displays this is a considerable disadvantage, because the photo-polymerisation of the RMs in the PSA display is usually carried out by exposure to UV radiation, which may cause a VHR drop in the LC medium.

Especially in view of mobile devices there is great demand for displays with high
20 transmission, which enable the use of less intensive backlight, and, hence, leads to longer battery lifetime. Alternatively, of course, displays with higher brightness can be achieved having improved contrast especially under ambient light.

In addition there is a great demand for PSA displays, and LC media and
25 polymerisable compounds for use in such PSA displays, which enable a high specific resistance at the same time as a large working-temperature range, short response times, even at low temperatures, and a low threshold voltage, a low pretilt angle, a multiplicity of grey shades, high contrast and a broad viewing angle, have high reliability and high values for the VHR after UV exposure, and, in case of the
30 polymerisable compounds, have low melting points and a high solubility in the LC host mixtures. In PSA displays for mobile applications, it is especially desired to have available LC media that show low threshold voltage and high birefringence.

The invention is based on the object of providing novel suitable materials, in LC
35 media comprising reactive mesogens (RM), for use in PSA displays, which do not have the disadvantages indicated above or do so to a reduced extent.

In particular, the invention is based on the object of LC media comprising RMs for use in PSA displays, which enable displays with high transmittance and at the same time very high specific resistance values, high VHR values, high reliability, low threshold voltages, short response times, high birefringence, show good UV absorption especially at longer wavelengths, enable quick and complete polymerisation of the RMs, allow the generation of a low pretilt angle, preferably as quickly as possible, enable a high stability of the pretilt even after longer time and/or after UV exposure, reduce or prevent the occurrence of "image sticking" and "ODF mura" in the display, and in case of the RMs polymerise as rapidly and completely as possible and show a high solubility in the LC media which are typically used as host mixtures in PSA displays.

Recently it has also been suggested to use VA or PSA displays in outdoor applications, like PIDs (Public information Displays). PID is one of the rising paradigms of the display market. There is an increasing number of PIDs for displaying various kinds of information in public areas such as train stations, streets, airports, hotels and shopping malls.

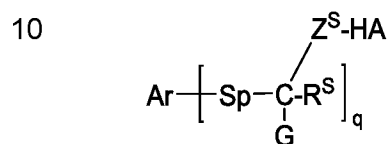
Compared to conventional LC displays as used in TV or IT applications, PIDs are particular since they are usually installed outdoors. Therefore PIDs should have higher durability to operate consistently in various environmental conditions, and should also have a broader operating temperature range compared to conventional LC displays. As a consequence, the LC media used in PIDs should have a broad LC phase and a very high value of T_{ni} (phase transition temperature from the nematic to the isotropic state, also known as "clearing temperature" or "clearing point"), which should preferably be 100°C or more.

However, the LC media which have hitherto been proposed for use in VA or PSA displays do usually have a T_{ni} value of less than 100°C.

There is thus still a great demand for PSA displays, and LC media optionally comprising polymerisable compounds for use in VA or PSA displays, especially for outdoor use, which do not show the drawbacks as described above, or only do so to a small extent, and have improved properties.

These objects have been achieved in accordance with the present invention by materials and processes as described in the present application. In particular, it has been found, surprisingly, that the use of liquid crystalline hosts as described hereinafter allows achieving the advantageous effects as mentioned above. These hosts are characterised by comprising an optically active component, also known as chiral dopant.

The invention relates to an LC medium comprising a) one or more compounds of the formula I



in which

Ar denotes an aromatic or heteroaromatic hydrocarbon group having 4 to 40 C atoms, preferably 6 to 30 C atoms;

Sp denotes a spacer group;

R^S denotes H, alkyl having 1 to 12 C atoms or alkenyl having 2 to 12 C atoms;

Z^S denotes -O-, -C(O)O-, -(CH₂)_z- or -(CH₂)_zO-, or a single bond;



R^H denotes H, O*, CH₃, OH or OR^S, preferably H or O*;

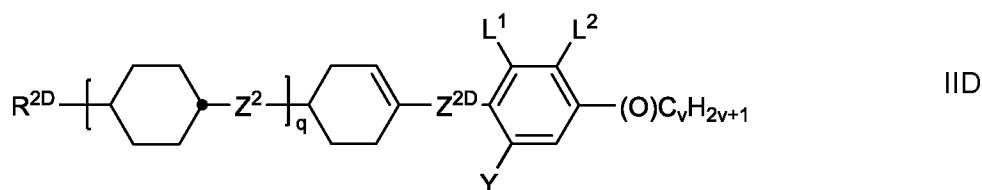
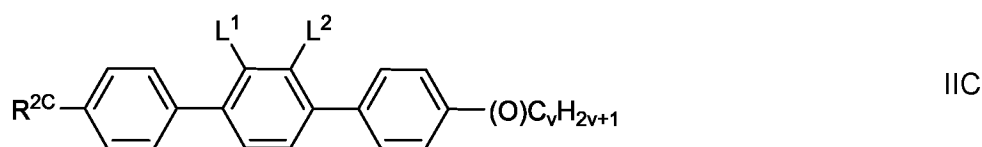
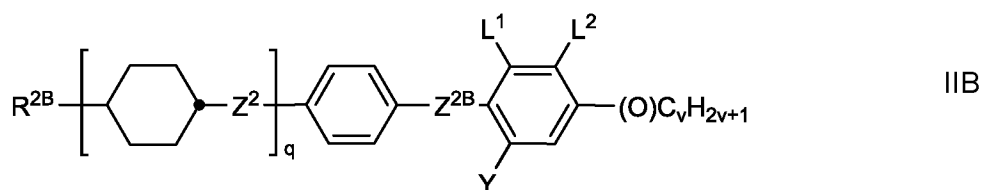
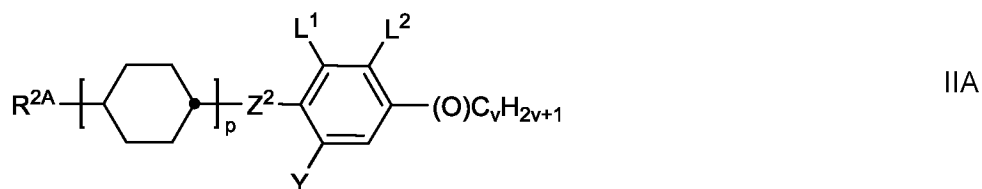
R^{S1}, R^{S2}, R^{S3} and R^{S4}, identically or differently, denote alkyl having 1 to 6 C atoms, preferably having 1 to 3 C atoms, very preferably CH₃;

G denotes H or R^S or a group Z^S-HA;

z is an integer from 1 to 6; and

q is 3 or 4;

and b) one or more compounds selected from the group of compounds of the formulae IIA, IIB, IIC and IID,



in which

R^{2A} , R^{2B} , R^{2C} and R^{2D} each, independently of one another, denote H, an alkyl or alkenyl radical having up to 15 C atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where, one or more CH_2 groups in these radicals may be replaced by $-O-$, $-S-$, $-C\equiv C-$, $-CF_2O-$, $-OCF_2-$, $-OC-O-$ or $-O-CO-$ in such a way that O atoms are not linked directly to one another;

L^1 and L^2 each, independently of one another, denote F, Cl, CF_3 or CHF_2 ;

Y denotes H, F, Cl, CF_3 , CHF_2 or CH_3 , preferably H or methyl, very preferably H;

Z^2 , Z^{2B} and Z^{2D} each, independently of one another, denote a single bond, $-CH_2CH_2-$, $-CH=CH-$, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-COO-$, $-OCO-$, $-C_2F_4-$, $-CF=CF-$ or $-CH=CHCH_2O-$;

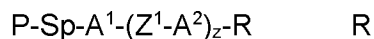
p denotes 0, 1 or 2;

q denotes 0 or 1; and

v denotes 1, 2, 3, 4, 5, or 6;

and c) one or more chiral dopants;

and d) optionally one or more polymerisable compounds of formula P



5 in which the individual radicals, independently of each other and on each occurrence identically or differently, have the following meanings:

P a polymerisable group,

Sp a spacer group or a single bond,

10 A^1, A^2 an aromatic, heteroaromatic, alicyclic or heterocyclic group, preferably having 4 to 25 ring atoms, which may also contain fused rings, and which is unsubstituted, or mono- or polysubstituted by L,

Z^1 -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -OCH₂-, -CH₂O-, -SCH₂-, -CH₂S-,
-CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -(CH₂)_{n1}-, -CF₂CH₂-, -CH₂CF₂-, -(CF₂)_{n1}-,
-CH=CH-, -CF=CF-, -CH=CF-, -CF=CH-, -C≡C-, -CH=CH-CO-O-,
15 -O-CO-CH=CH-, -CH₂-CH₂-CO-O-, -O-CO-CH₂-CH₂-, -CR⁰R⁰⁰-, or a single bond,

R⁰, R⁰⁰ H or alkyl having 1 to 12 C atoms,

R H, L, or P-Sp-,

20 L F, Cl, -CN, P-Sp- or straight chain, branched or cyclic alkyl having 1 to 25 C atoms, wherein one or more non-adjacent CH₂-groups are optionally replaced by -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a manner that O- and/or S-atoms are not directly connected with each other, and wherein one or more H atoms are each optionally replaced by P-Sp-, F or Cl,

z 0, 1, 2 or 3,

25 n_1 1, 2, 3 or 4.

The invention furthermore relates to an LC display comprising the LC medium described above.

30 The invention furthermore relates to an LC medium or LC display as described above, wherein the compounds of formula R are polymerised.

The invention furthermore relates to a process for preparing an LC medium as described above and below, comprising the steps of mixing one or more compounds
35 of the formulae IIA, IIB, IIC and/or IID, with one or more chiral dopants and one or

more compounds of the formula I and optionally with one or more compounds of formula R, and optionally with further LC compounds and/or additives.

5 The invention furthermore relates to the use of LC media according to the invention in PSA displays, in particular to the use in PSA displays containing an LC medium, for the production of a tilt angle in the LC medium by in-situ polymerisation of the compound(s) of the formula R in the PSA display, preferably in an electric or magnetic field.

10 The invention furthermore relates to an LC display comprising an LC medium according to the invention, in particular a VA or PSA display, particularly preferably a VA or a PS-VA display.

15 The invention furthermore relates to the use of LC media according to the invention in polymer stabilised SA-VA displays, and to a polymer stabilised SA-VA display comprising the LC medium according to the invention.

20 The invention furthermore relates to an LC display of the VA or PSA type comprising two substrates, at least one which is transparent to light, an electrode provided on each substrate or two electrodes provided on only one of the substrates, and located between the substrates a layer of an LC medium that optionally comprises one or more polymerisable compounds and an LC component as described above and below, wherein the polymerisable compounds are polymerised between the substrates of the display.

25 The invention furthermore relates to a process for manufacturing an LC display as described above and below, comprising the steps of filling or otherwise providing an LC medium, which optionally comprises one or more polymerisable compounds as described above and below, between the substrates of the display, and optionally
30 polymerising the polymerisable compounds.

The PSA displays according to the invention have two electrodes, preferably in the form of transparent layers, which are applied to one or both of the substrates. In some displays, for example in PS-VA displays, one electrode is applied to each of
35 the two substrates.

In a preferred embodiment the polymerisable component is polymerised in the LC display while a voltage is applied to the electrodes of the display.

5 The polymerisable compounds of the polymerisable component are preferably polymerised by photopolymerisation, very preferably by UV photopolymerisation.

10 In the field of liquid crystals it is basically known to add a chiral dopant e.g. into a nematic liquid crystal host mixture. At low concentrations of the chiral dopant a chiral-nematic phase, also called a cholesteric phase is obtained. In the field of twisted nematic liquid crystal displays it is required to add a dopant to achieve a uniform twist direction and thus to avoid disclination lines. Increased concentrations are used in order to achieve a shorter pitch, required e.g. in super twist LCDs (STN displays).

15 It was surprisingly found that the use of the liquid crystalline hosts according to the invention and of LC media comprising them, in VA or PS-VA displays, enables displays with improved transmission while maintaining excellent performance regarding process relevant parameters, i.e. in the case of PSA displays a quick and complete UV-photopolymerisation reaction in particular at longer UV wavelengths in
20 the range from 300-380nm and especially above 320nm, even without the addition of photoinitiator, a fast generation of a large and stable pretilt angle, reduced image sticking and ODF mura in the display, a high reliability and a high VHR value after UV photopolymerisation, especially in case of LC host mixtures containing LC compounds with an alkenyl group, and generally and fast response times, a low
25 threshold voltage and a high birefringence, as well as high reliability when exposed to the environment when used outdoors.

The LC media according to the invention show the following advantageous properties when used in VA displays:

30 - improved transmission of the display,
- a high clearing temperature,
- a high voltage-holding-ratio,
- fast switching,
- good tilt stability,
35 - sufficient stability against heat and/or UV in particular when used outdoors,

The LC media according to the invention show the following advantageous properties when used in PSA displays:

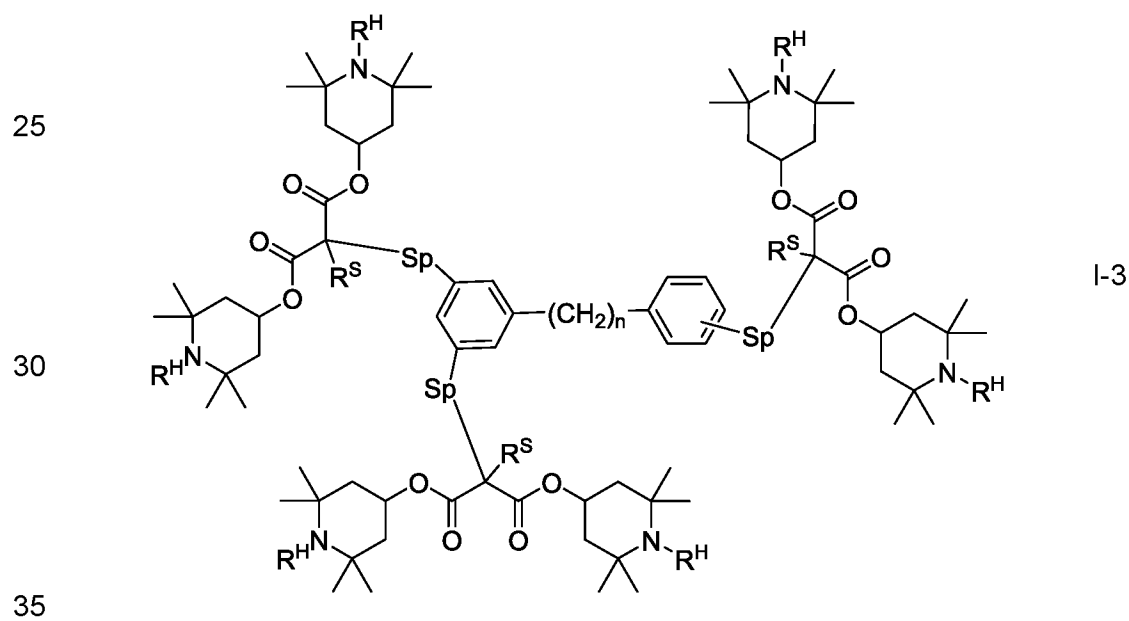
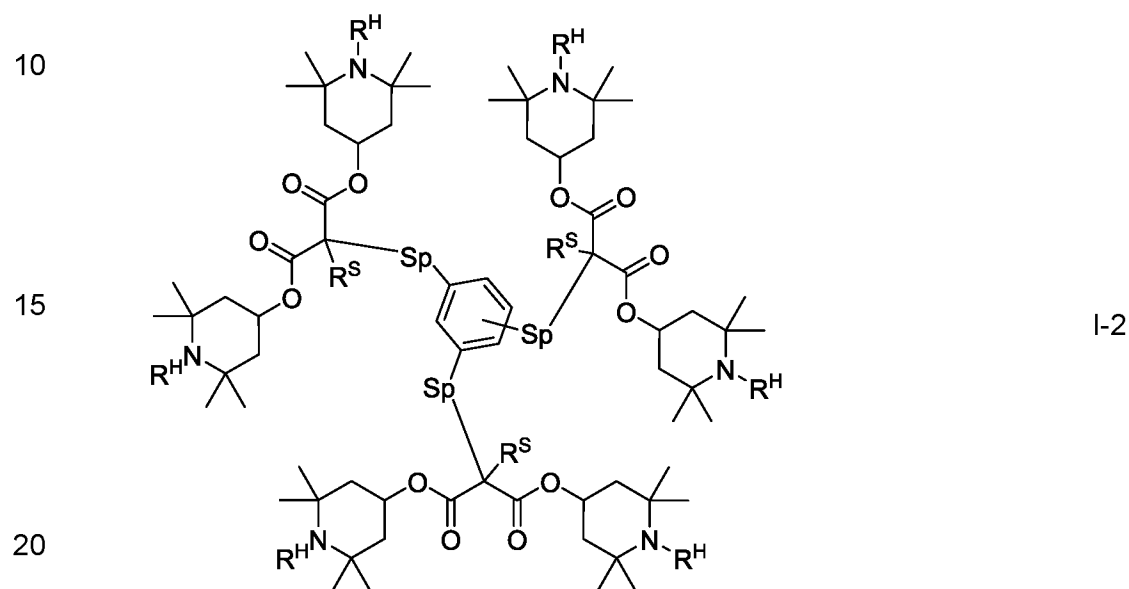
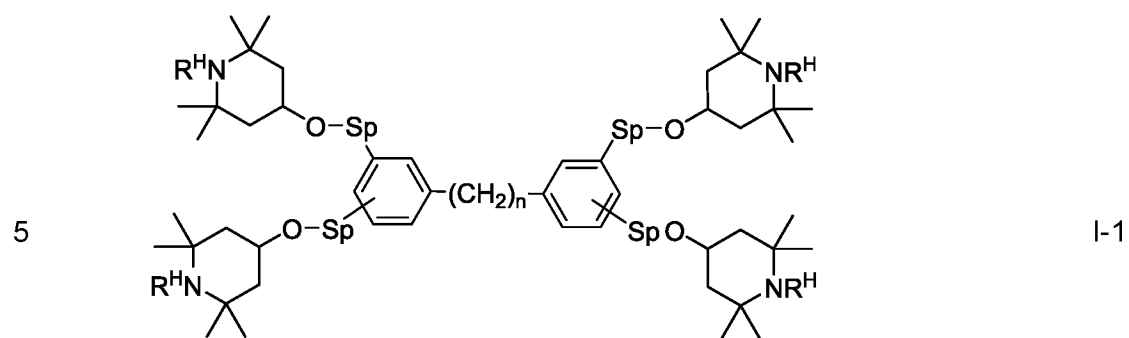
- improved transmission of the display
- a high clearing temperature,
- 5 - a suitable tilt generation which is inside a certain process window,
- fast polymerization leading to minimal residues of RM after the UV-process,
- a high voltage-holding-ratio after the UV-process,
- good tilt stability,
- sufficient stability against heat and/or UV in particular when used outdoors,
- 10 - fast switching.

In formula I, aryl denotes an aromatic or heteroaromatic hydrocarbon group having 4 to 40 C atoms, comprising one, two, three or four aromatic rings including condensed rings that may be linked directly or via an alkylene linking group having 1 to 12 C atoms, in which one or more H atoms are optionally replaced with alkyl or alkoxy having 1 to 6 C atoms or alkenyl having 2 to 6 C atoms, or with CN, CF₃ or halogen, and in which one or more CH₂ groups may each, independently of one another, be replaced by -O-, -S-, -NH-, -N(C₁-C₄-alkyl)-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CH=CH- or -C≡C- in such a way that O or S atoms are not linked directly to one another.

Preferred aryl groups are benzene, naphthalene, anthracene, biphenyl, m-terphenyl, p-terphenyl, and (phenylalkyl)benzene in which alkyl is straight chain alkyl having 1 to 12 C atoms.

The compounds of formula I are described in EP3354710 A1 and EP3354709 A1.

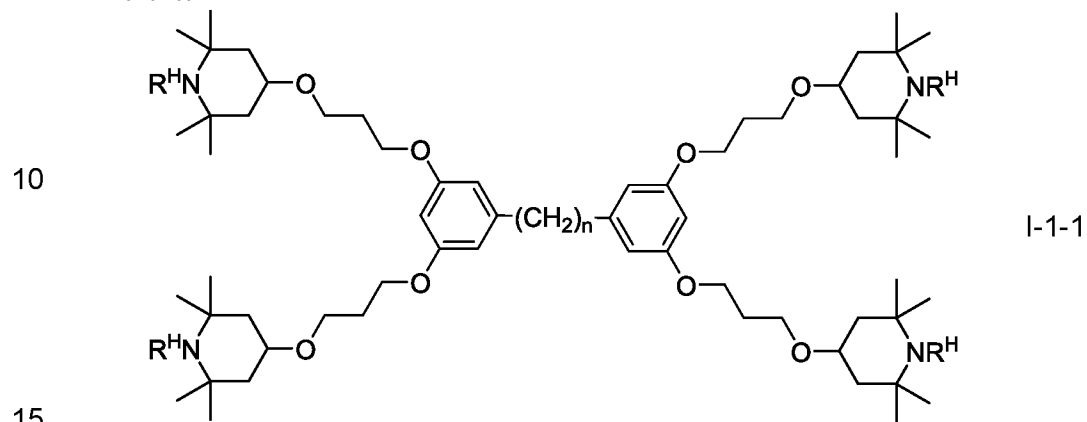
The compounds of formula I are preferably selected from the compounds of the formulae I-1, I-2 and I-3:



in which R^H has the meanings given above and preferably denote H or O^+ , and

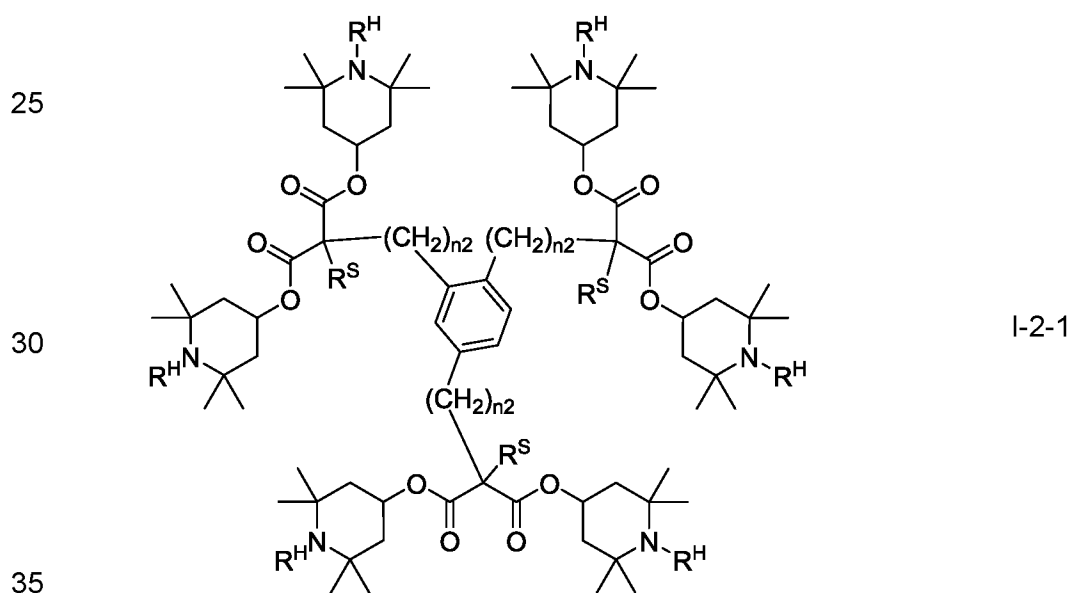
n is an integer from 0 to 12, preferably 5, 6, 7, 8 or 9, very preferably 7, and
 Sp denotes a spacer group, preferably alkylene having 1 to 12 C atoms in which one
 or more non-adjacent -CH₂- groups may be replaced with -O-.

5 Preferred compounds of formula I-1 are selected from the compounds of the formula
 I-1-1:



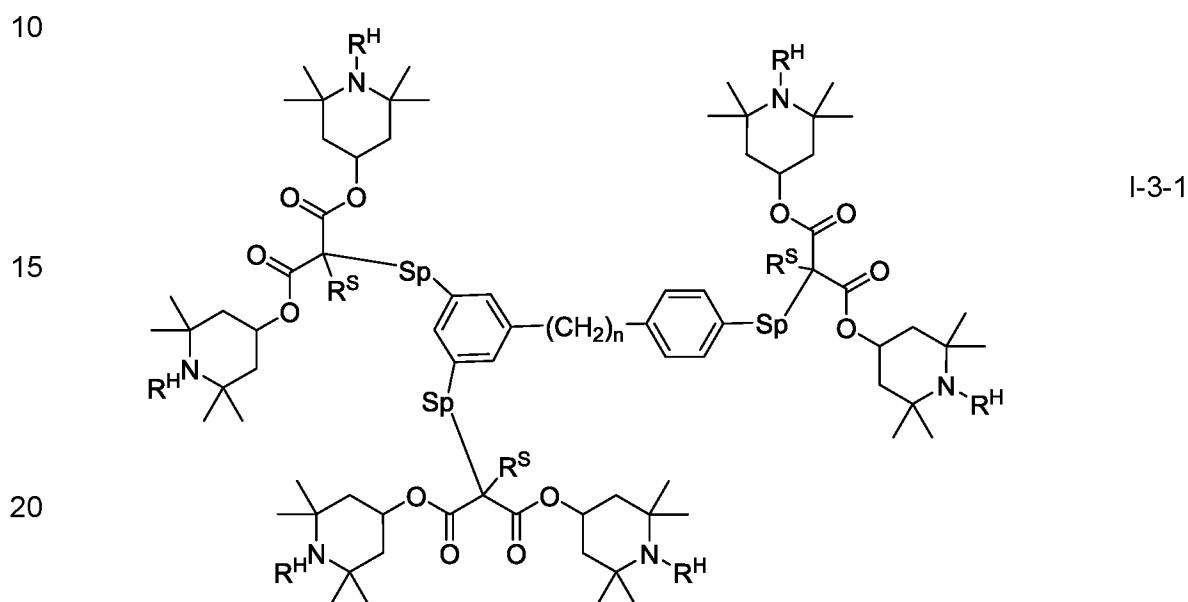
in which R^H has the meanings given above and preferably denotes H or O⁺, and n is
 an integer from 0 to 12, preferably 5, 6, 7, 8 or 9, very preferably 7.

20 Preferred compounds of formula I-2 are selected from the compounds of the formula
 I-2-1:



in which R^H has the meanings given above and preferably denotes H or O^* , and n ,
on each occurrence identically or differently, preferably identically, is an integer from
1 to 12, preferably 2, 3, 4, 5, or 6, very preferably 3, and R^S on each occurrence
identically or differently, preferably identically, denotes alkyl having 1 to 6 C atoms,
preferably *n*-butyl.

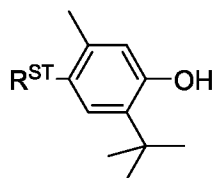
Preferred compounds of formula I-3 are selected from the compounds of the formula
I-3-1:



in which R^H has the meanings given above and preferably denotes H or O^* , and n is
an integer from 0 to 12, preferably 5, 6, 7, 8 or 9, very preferably 7.

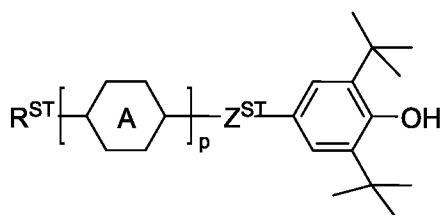
Preferably, the medium according to the invention comprises a compound selected
from the group of compounds of the formulae ST-1 to ST-18:





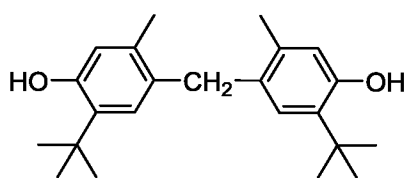
ST-2

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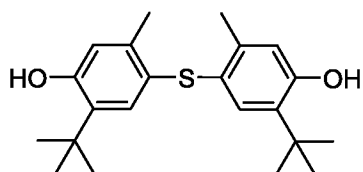
ST-3

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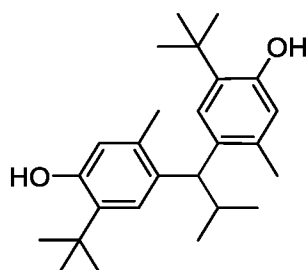
ST-4

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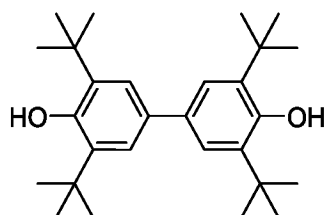
ST-5

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ST-6

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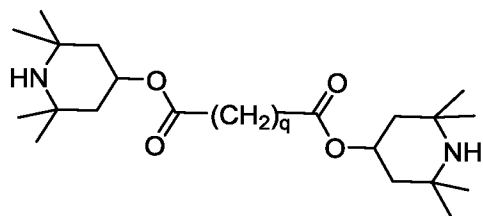


ST-7

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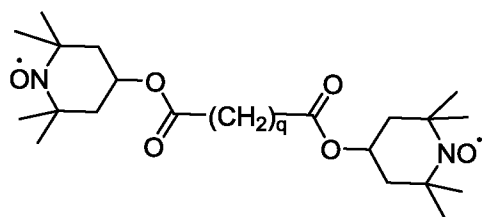
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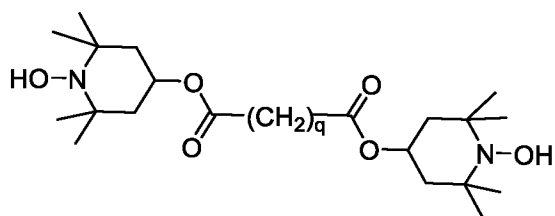
ST-8

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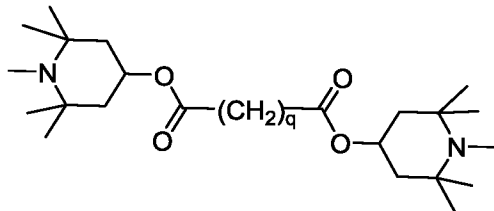
ST-9

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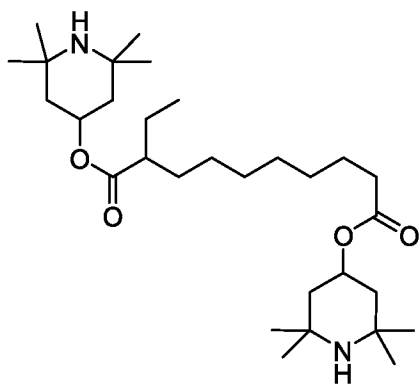
ST-10

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ST-11

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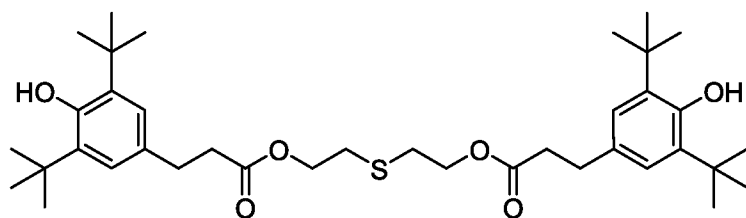


ST-12

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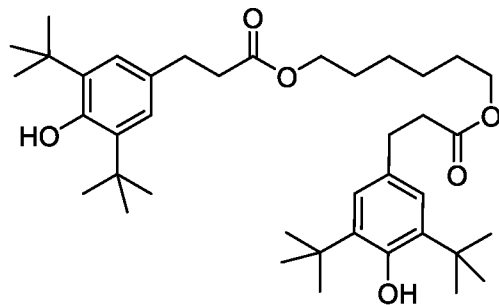
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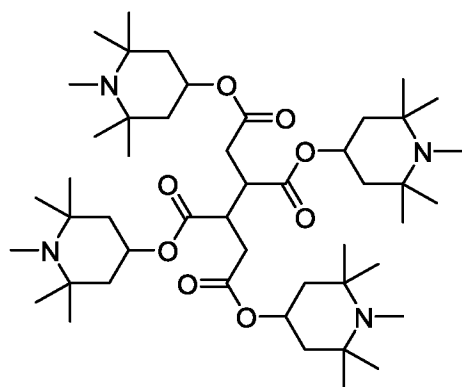
ST-13

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ST-14

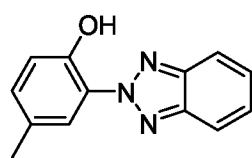
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ST-15

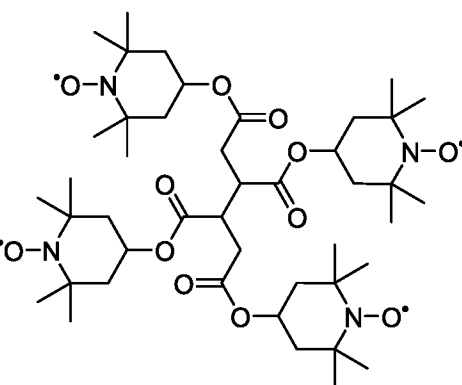
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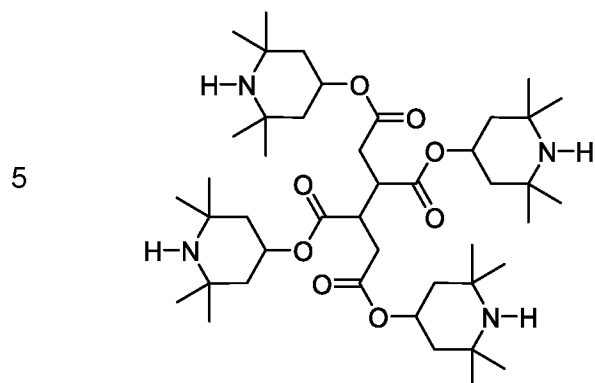
ST-16

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ST-17

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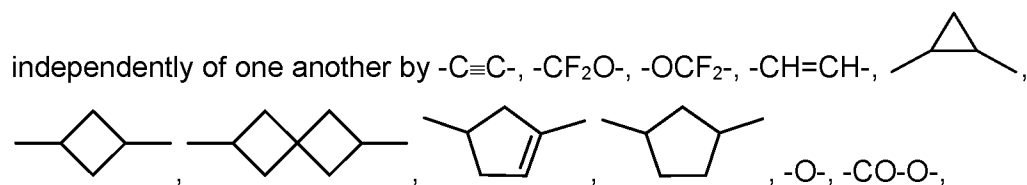
ST-18

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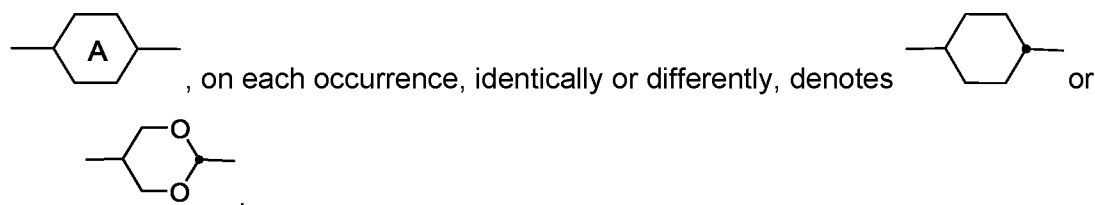
in which

R^{ST} denotes H, an alkyl or alkoxy radical having 1 to 15 C atoms, where, in addition, one or more CH_2 groups in these radicals may each be replaced,

15



20



25

Z^{ST} each, independently of one another, denote $-CO-O-$, $-O-CO-$, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-CH_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-CH=CH-$, $-CH_2O-$, $-C_2F_4-$, $-CH_2CF_2-$, $-CF_2CH_2-$, $-CF=CF-$, $-CH=CF-$, $-CF=CH-$, $-CH=CH-$, $-C\equiv C-$ or a single bond,

30

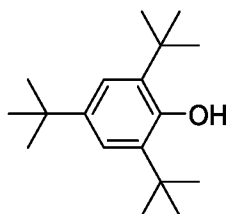
L^1 and L^2 each, independently of one another, denote F, Cl, CH_3 , CF_3 or CHF_2 ,

p denotes 0, 1 or 2,

q denotes 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10.

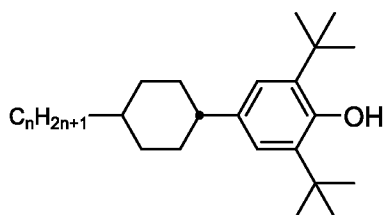
Of the compounds of the formula ST, special preference is given to the compounds of the formulae ST-3 and in particular:

35



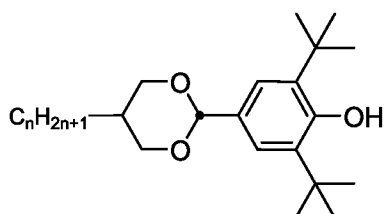
ST-1

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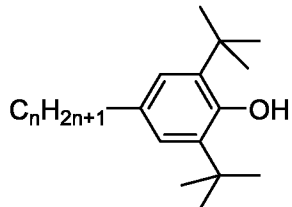
ST-3a

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in which $n = 1, 2, 3, 4, 5, 6$ or 7 , preferably $n = 3$ 

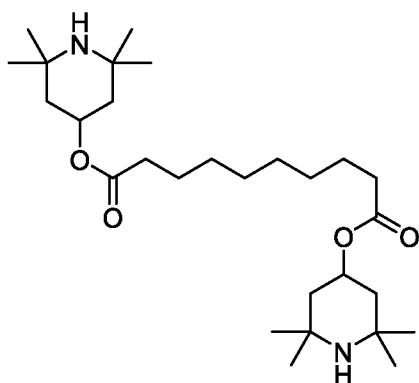
ST-3b

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in which $n = 1, 2, 3, 4, 5, 6$ or 7 , preferably $n = 3$ 

ST-3c

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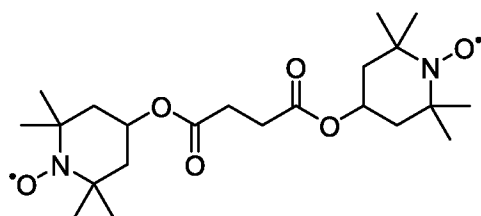
in which $n = 1, 2, 3, 4, 5, 6$ or 7 , preferably $n = 1$ or 7 

ST-8-1

25

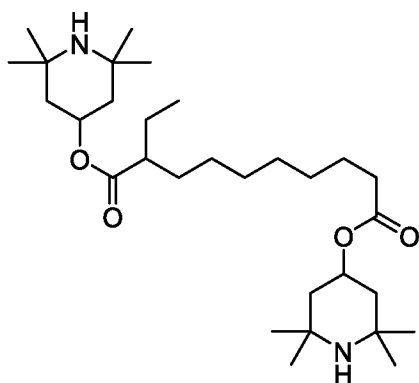
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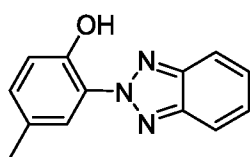
ST-9-1

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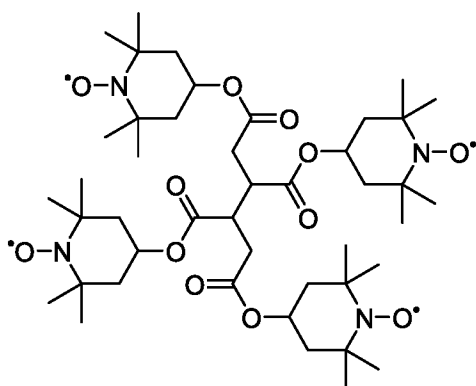
ST-12

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ST-16

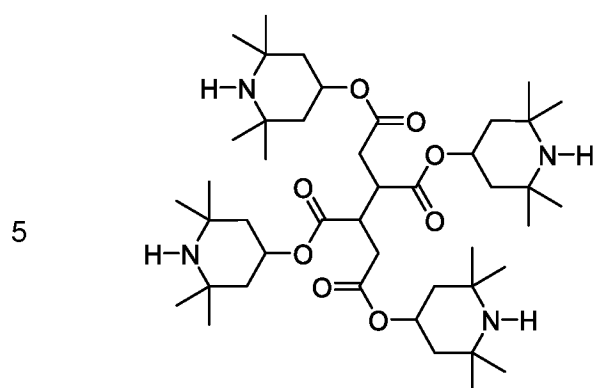
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ST-17

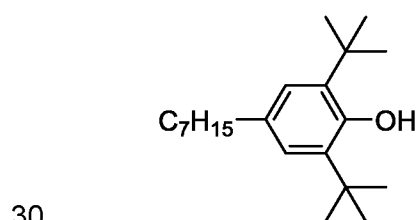
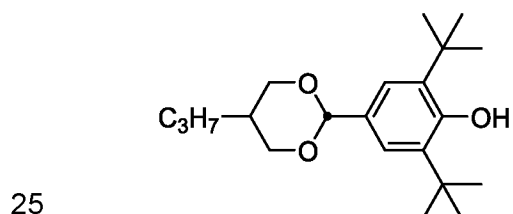
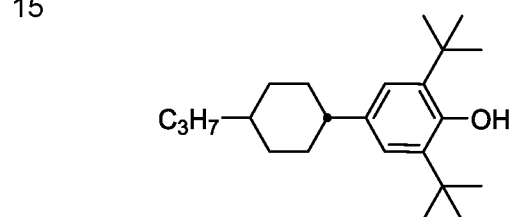
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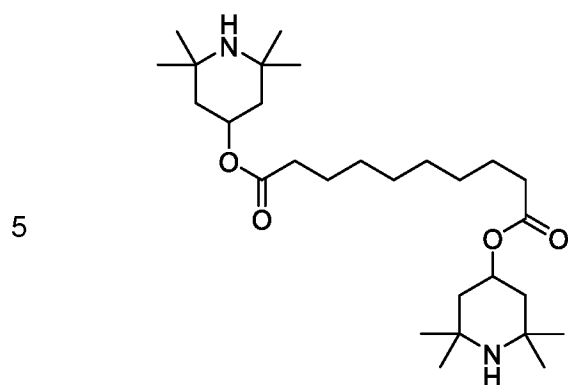


10 In the compounds of the formulae ST-3a and ST-3b, n preferably denotes 3. In the compounds of the formula ST-2a, n preferably denotes 7.

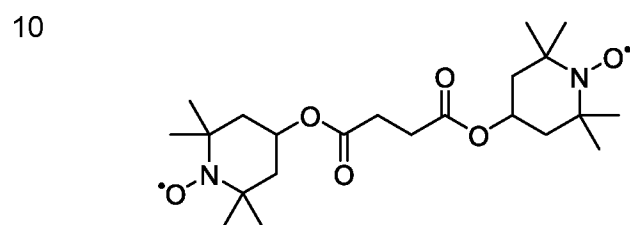
15 Very particularly preferred mixtures according to the invention comprise one or more stabilizers from the group of the compounds of the formulae ST-2a-1, ST-3a-1, ST-3b-1, ST-8-1, ST-9-1 and ST-12:



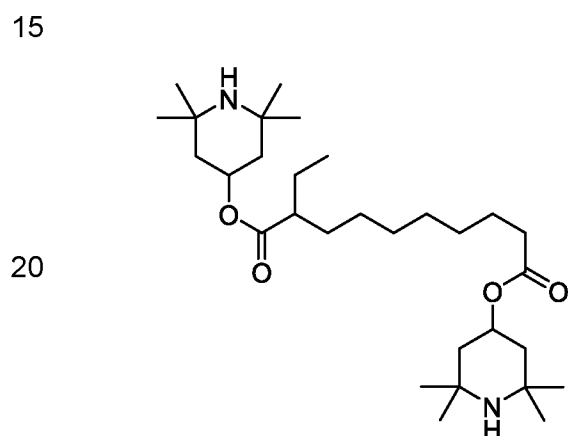
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ST-8-1



ST-9-1



ST-12

25 The compounds of the formulae ST-1 to ST-18 are preferably each present in the liquid-crystal mixtures according to the invention in amounts of 0.005 – 0.5%, based on the mixture.

30 If the mixtures according to the invention comprise two or more compounds from the group of the compounds of the formulae ST-1 to ST-18, the concentration correspondingly increases to 0.01 – 1% in the case of two compounds, based on the mixtures.

35 However, the total proportion of the compounds of the formulae ST-1 to ST-18, based on the mixture according to the invention, should not exceed 2%.

The use of chiral dopants in nematic liquid crystals is known to the skilled person. For a review see e.g. A. Taugerbeck, Ch. Booth, 2013. Design and Synthesis of Chiral Nematic Liquid Crystals. Handbook of Liquid Crystals. 3:III:14:1–63.

5 The media according to the present invention comprise one or more chiral dopants. Preferably these chiral dopants have an absolute value of the helical twisting power (short:HTP) in the range of from $1\ \mu\text{m}^{-1}$ to $150\ \mu\text{m}^{-1}$, preferably in the range of from $10\ \mu\text{m}^{-1}$ to $100\ \mu\text{m}^{-1}$. In case the media comprise two or more chiral dopants, these may have opposite signs of their HTP-values. This condition is preferred for some
10 specific embodiments, as it allows to compensate the chirality of the respective compounds to some degree and, thus, may be used to compensate various temperature dependent properties of the resulting media in the devices. Generally, however, it is preferred that most, preferably all of the chiral compounds present in the media according to the present invention have the same sign of their HTP-values.
15 Preferably the chiral dopants present in the media according to the instant application are mesogenic compounds and most preferably they exhibit a mesophase on their own.

20 In a preferred embodiment of the present invention, the chiral component D) consists of two or more chiral compounds which all have the same algebraic sign of the HTP.

The temperature dependence of the HTP of the individual compounds may be high or low. The temperature dependence of the pitch of the medium can be compensated by mixing compounds having different temperature dependence of the HTP in
25 corresponding ratios.

For the optically active component, a multiplicity of chiral dopants, some of which are commercially available, is available to the person skilled in the art, such as, for example, cholesteryl nonanoate, R- and S-811, R- and S-1011, R- and S-2011, R-
30 and S-3011 R- and S-4011, B(OC)2C*H-C-3 or CB15 (all Merck KGaA, Darmstadt).

Particularly suitable dopants are compounds which contain one or more chiral groups and one or more mesogenic groups, or one or more aromatic or alicyclic groups which form a mesogenic group with the chiral group.
35

Suitable chiral groups are, for example, chiral branched hydrocarbon radicals, chiral ethanediols, binaphthols or dioxolanes, furthermore mono- or polyvalent chiral groups selected from the group consisting of sugar derivatives, sugar alcohols, sugar acids, lactic acids, chiral substituted glycols, steroid derivatives, terpene derivatives, amino acids or sequences of a few, preferably 1-5, amino acids.

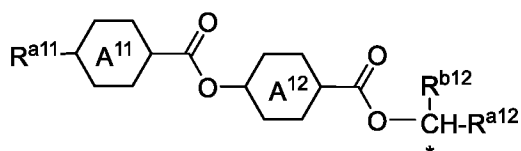
Preferred chiral groups are sugar derivatives, such as glucose, mannose, galactose, fructose, arabinose and dextrose; sugar alcohols, such as, for example, sorbitol, mannitol, iditol, galactitol or anhydro derivatives thereof, in particular dianhydrohexitols, such as dianhydrosorbide (1,4:3,6-dianhydro-D-sorbide, isosorbide), dianhydromannitol (isosorbitol) or dianhydroiditol (isoiditol); sugar acids, such as, for example, gluconic acid, gulonic acid and ketogulonic acid; chiral substituted glycol radicals, such as, for example, mono- or oligoethylene or propylene glycols, in which one or more CH₂ groups are substituted by alkyl or alkoxy; amino acids, such as, for example, alanine, valine, phenylglycine or phenylalanine, or sequences of from 1 to 5 of these amino acids; steroid derivatives, such as, for example, cholesteryl or cholic acid radicals; terpene derivatives, such as, for example, menthyl, neomenthyl, campheyl, pineyl, terpineyl, isolongifolyl, fenchyl, carreyll, myrthenyl, nopyl, geraniyl, linaloyl, neryl, citronellyl or dihydrocitronellyl.

The optically active component D) preferably consists of chiral dopants which are selected from the group of known chiral dopants. Suitable chiral groups and mesogenic chiral compounds are described, for example, in DE 34 25 503, DE 35 34 777, DE 35 34 778, DE 35 34 779 and DE 35 34 780, DE 43 42 280, EP 01 038 941 and DE 195 41 820. Examples are also compounds listed in Table B below.

Chiral compounds preferably used according to the present invention are selected from the group consisting of the formulae shown below.

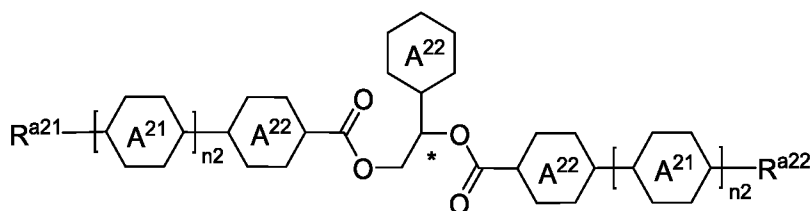
Particular preference is given to chiral dopants selected from the group consisting of compounds of the following formulae A-I to A-III and Ch:

Particular preference is given to chiral dopants selected from the group consisting of compounds of the following formulae A-I to A-III and A-Ch:



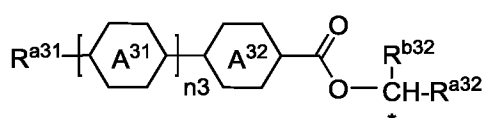
A-I

5



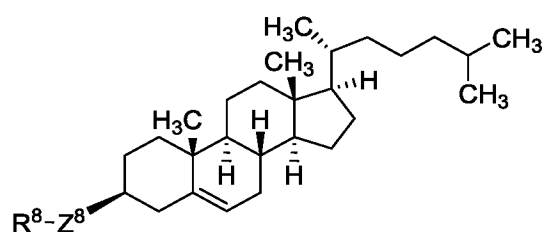
A-II

10



A-III

15



A-Ch

20

in which

R^{a11} , R^{a12} and R^{b12} , independently of one another, denote alkyl having 1 to 15 C atoms, in which, in addition, one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by $-C(R^Z)=C(R^Z)-$, $-C\equiv C-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may each be replaced by F, Cl, Br, I or CN, preferably alkyl, more preferably n-alkyl, with the proviso that R^{a12} is different from R^{b12} ,

25

R^{a21} and R^{a22} , independently of one another, denote alkyl having 1 to 15 C atoms, in which, in addition, one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by $-C(R^Z)=C(R^Z)-$, $-C\equiv C-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by F, Cl, Br, I or CN, preferably both are alkyl, more preferably n-alkyl,

35

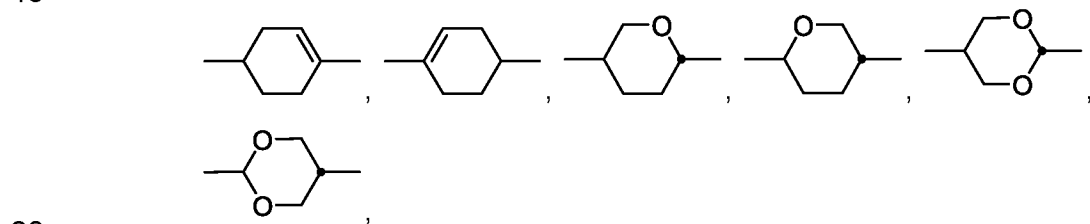
R^{a31} , R^{a32} and R^{b32} , independently of one another, denote straight-chain or branched alkyl having 1 to 15 C atoms, in which, in addition, one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by $-C(R^z)=C(R^z)-$, $-C\equiv C-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by F, Cl, Br, I or CN, preferably alkyl, more preferably n-alkyl, with the proviso that R^{a32} is different from R^{b32} ;

R^z denotes H, CH_3 , F, Cl, or CN, preferably H or F,

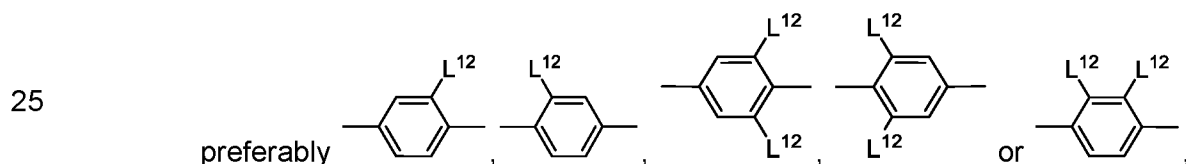
R^8 has one of the meanings of R^{a11} given above, preferably alkyl, more preferably n-alkyl having 1 to 15 C atoms,

Z^8 denotes- $C(O)O-$, CH_2O , CF_2O or a single bond, preferably $-C(O)O-$,

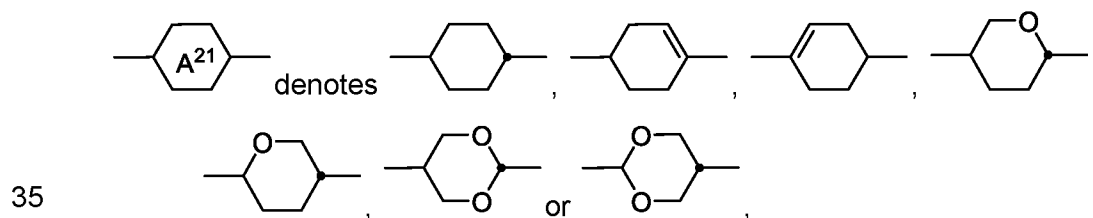
A^{11} is defined as A^{12} below, or alternatively denotes

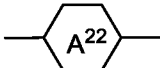
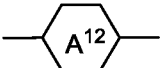
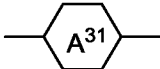
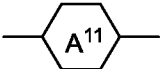


A^{12} denotes



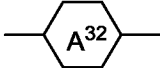
preferably in which L^{12} on each occurrence, independently of one another, denotes halogen, CN, or alkyl, alkenyl, alkoxy or alkenyloxy having up to 12 C atoms and in which one or more H atoms are optionally replaced with halogen, preferably methyl, ethyl, Cl or F, particularly preferably F,



 has the meanings given for ,
 has the meanings given for , or alternatively denotes

5



 has the meanings given for ,

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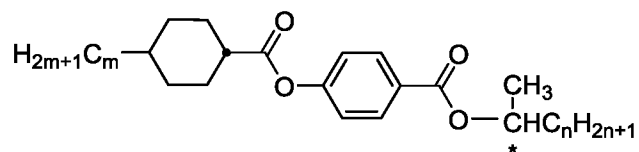
n_2 on each occurrence, identically or differently, is 0, 1 or 2,

n_3 is 1, 2 or 3, and

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

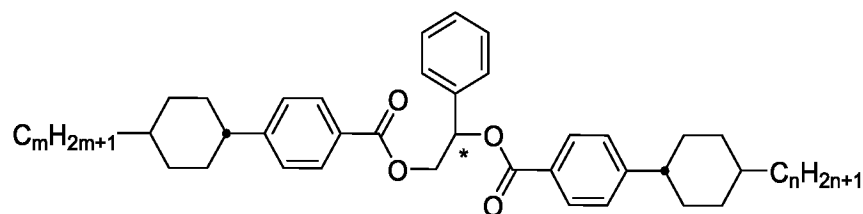
Particular preference is given to dopants selected from the group consisting of the compounds of the following formulae:

15



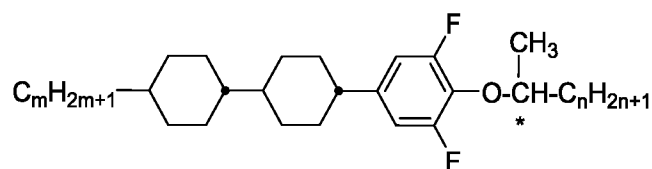
A-I-1

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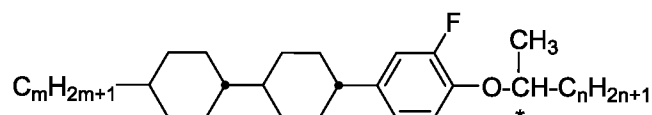
A-II-1

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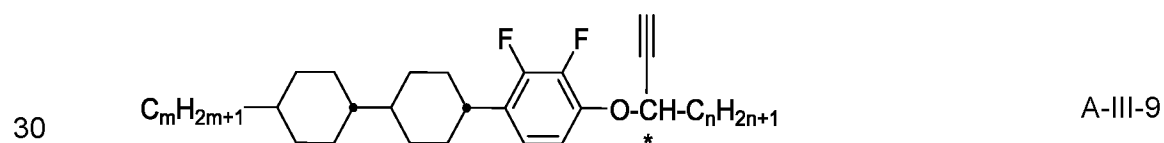
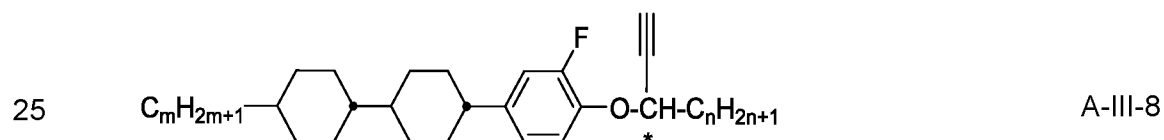
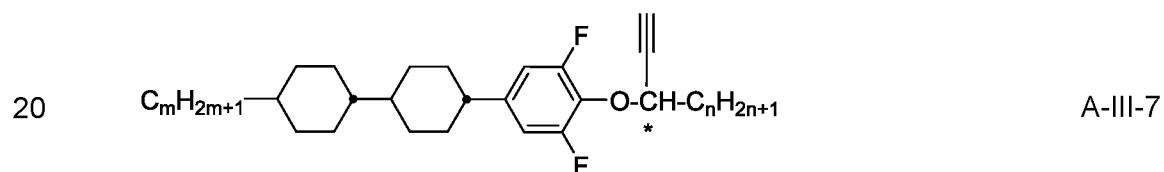
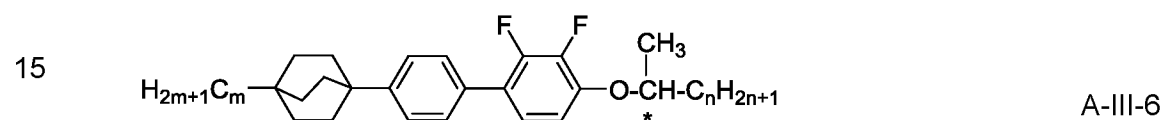
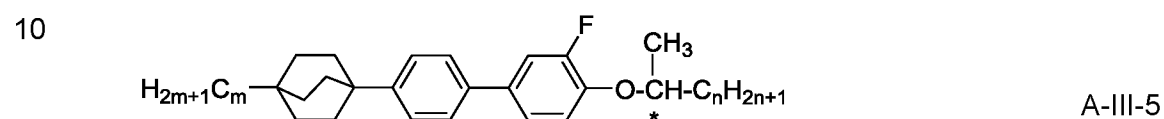
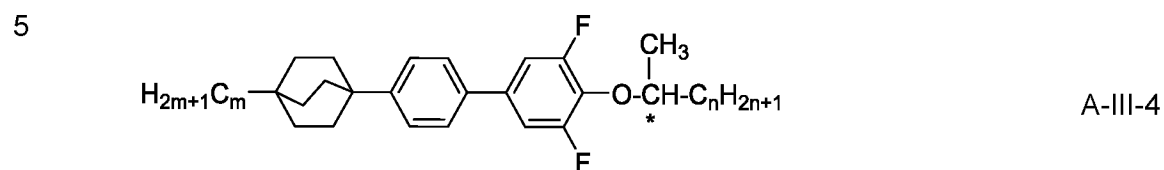
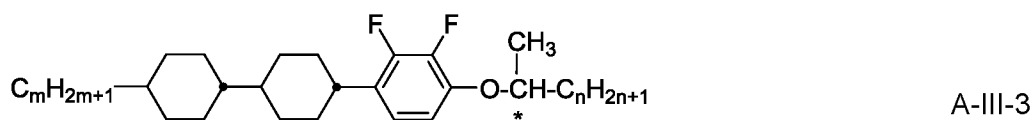
A-III-1

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A-III-2

35



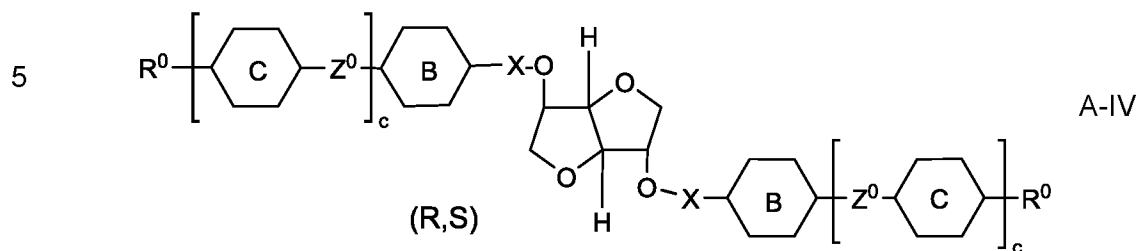
in which

m is, on each occurrence, identically or differently, an integer from 1 to 9
and

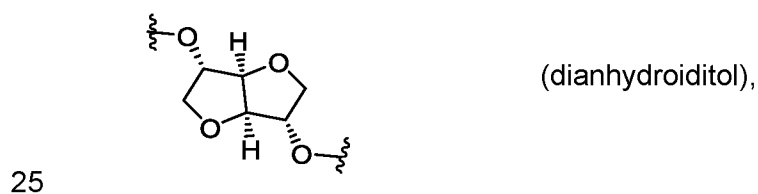
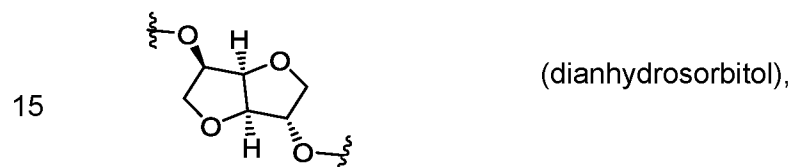
35 n is, on each occurrence, identically or differently, an integer from 2 to 9.

Particularly preferred compounds of formula A are compounds of formula A-III.

Further preferred dopants are derivatives of the isosorbide, isomannitol or isoiditol of the following formula A-IV:

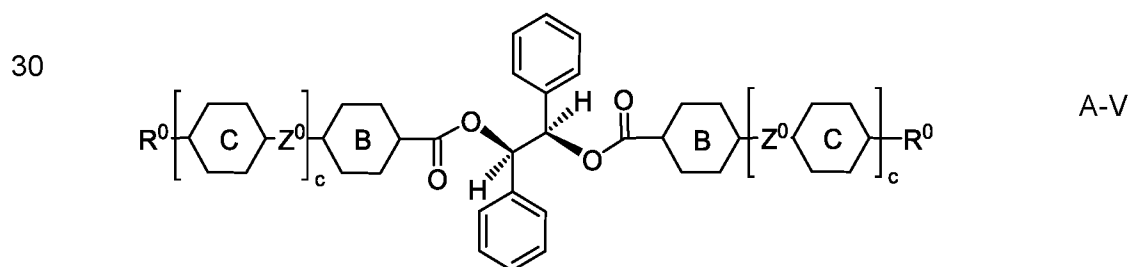


10 in which the group is

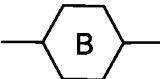
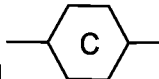


preferably dianhydrosorbitol,

and chiral ethane diols, such as, for example, diphenylethanediol (hydrobenzoin), in particular mesogenic hydrobenzoin derivatives of the following formula A-V:

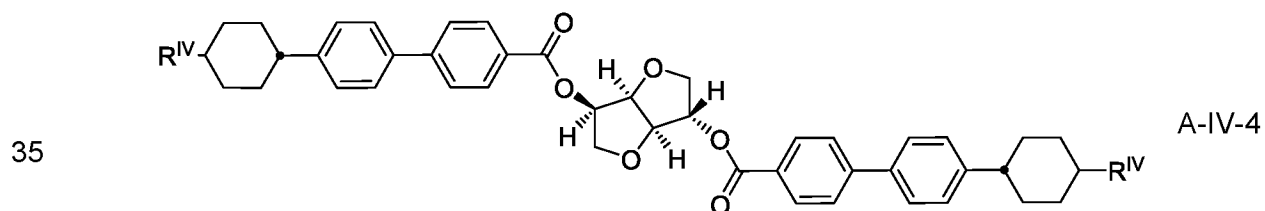
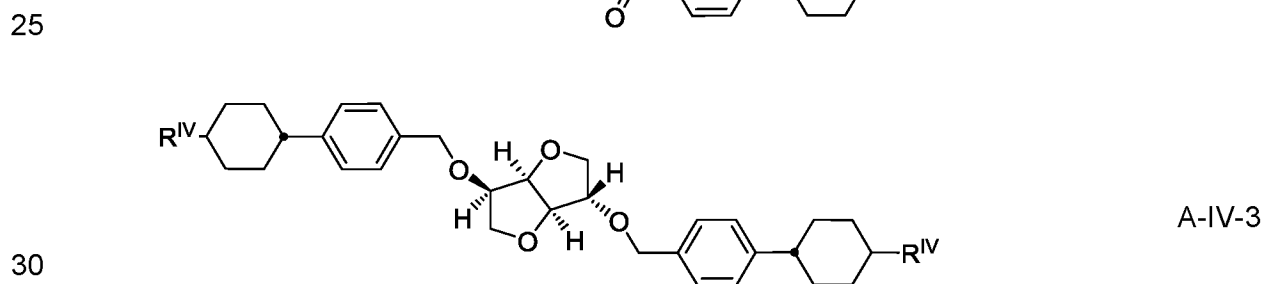
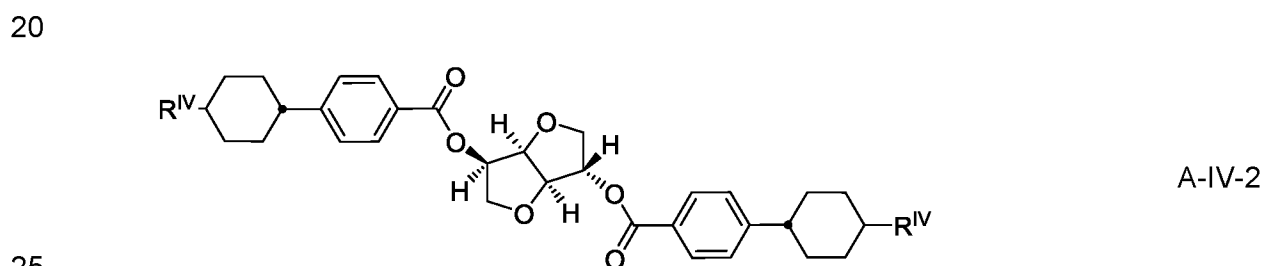
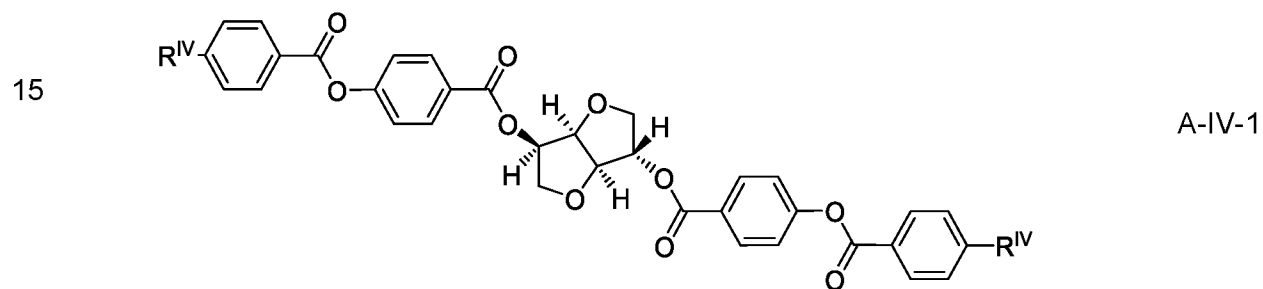


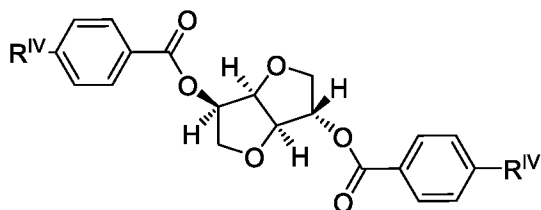
35 including the (S,S) enantiomers, which are not shown,

in which  and  are each, independently of one another, 1,4-phenylene, which may also be mono-, di- or trisubstituted by L, or 1,4-cyclohexylene,

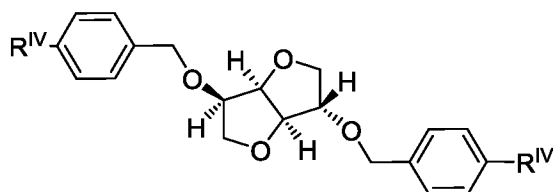
- 5 L is H, F, Cl, CN or optionally halogenated alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl or alkoxy carbonyloxy having 1-7 carbon atoms,
 c is 0 or 1,
 X is CH₂ or -C(O)-,
 10 Z⁰ is -COO-, -OCO-, -CH₂CH₂- or a single bond, and
 R⁰ is alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl or alkylcarbonyloxy having 1-12 carbon atoms.

Examples of compounds of formula IV are:

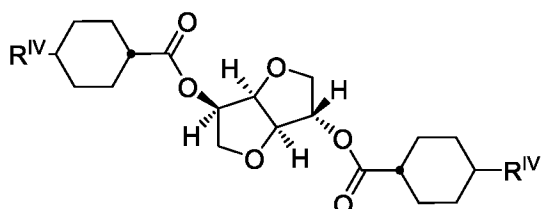




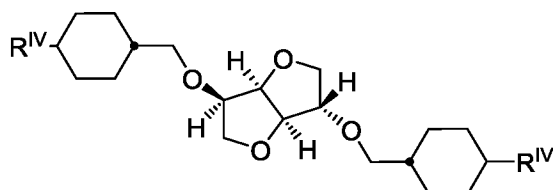
A-IV-5



A-IV-6



A-IV-7



A-IV-8

The compounds of the formula A-IV are described in WO 98/00428. The compounds of the formula A-V are described in GB-A-2,328,207.

Very particularly preferred dopants are chiral binaphthyl derivatives, as described in WO 02/94805, chiral binaphthol acetal derivatives, as described in WO 02/34739, chiral TADDOL derivatives, as described in WO 02/06265, and chiral dopants having at least one fluorinated bridging group and a terminal or central chiral group, as described in WO 02/06196 and WO 02/06195.

Particular preference is given to chiral compounds of the formula A-VI



in which

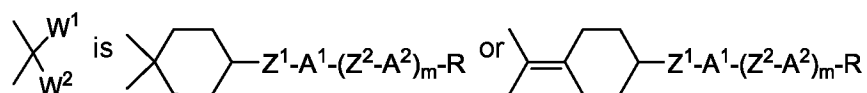
X^1 , X^2 , Y^1 and Y^2 are each, independently of one another, F, Cl, Br, I, CN, SCN, SF₅, straight-chain or branched alkyl having from 1 to 25 carbon atoms, which is unsubstituted or monosubstituted or polysubstituted by F, Cl, Br, I or CN and in which, in addition, one or more non-adjacent CH₂ groups may each, independently of one another, be replaced by -O-, -S-, -NH-, NR^x-, -CO-, -COO-, -OCO-, -OCOO-, -S-CO-, -CO-S-, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not bonded directly to one another, a polymerisable group or cycloalkyl or aryl having up to 20 carbon atoms, which may optionally be monosubstituted or polysubstituted by halogen, preferably F, or by a polymerisable group,

x^1 and x^2 are each, independently of one another, 0, 1 or 2,

y^1 and y^2 are each, independently of one another, 0, 1, 2, 3 or 4,

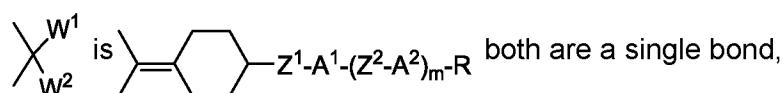
B^1 and B^2 are each, independently of one another, an aromatic or partially or fully saturated aliphatic six-membered ring in which one or more CH groups may each be replaced by N and one or more non-adjacent CH₂ groups may each be replaced by O or S,

W^1 and W^2 are each, independently of one another, $-Z^1-A^1-(Z^2-A^2)_m-R$, and one of the two is alternatively R¹ or A³, but both are not simultaneously H, or



U^1 and U^2 are each, independently of one another, CH₂, O, S, CO or CS,

V^1 and V^2 are each, independently of one another, (CH₂)_n, in which from one to four non-adjacent CH₂ groups may each be replaced by O or S, and one of V^1 and V^2 and, in the case where



n is 1, 2 or 3

Z¹ and Z² are each, independently of one another, -O-, -S-, -CO-, -COO-,
 -OCO-, -O-COO-, -CO-NR^x-, -NR^x-CO-, -O-CH₂-, -CH₂-O-, -S-CH₂-, -CH₂-
 S-, -CF₂-O-, -O-CF₂-, -CF₂-S-, -S-CF₂-, -CH₂-CH₂-, -CF₂-CH₂-, -CH₂-CF₂-, -
 5 CF₂CF₂-, -CH=N-, -N=CH-, -N=N-, -CH=CH-, -CF=CH-, -CH=CF-, -CF=CF-,
 or -C≡C-, or a combination of two of these groups, where no two O and/or S
 and/or N atoms are bonded directly to one another, preferably -CH=CH-COO-,
 or -COO-CH=CH-, or a single bond,

R^x denotes alkyl having 1 to 6 C atoms,

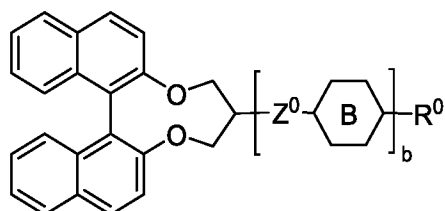
10 A¹, A² and A³ are each, independently of one another, 1,4-phenylene, in which one
 or two non-adjacent CH groups may each be replaced by N, 1,4-
 cyclohexylene, in which one or two non-adjacent CH₂ groups may each be
 replaced by O or S, 1,3-dioxolane-4,5-diyl, 1,4-cyclohexenylylene, 1,4-
 15 bicyclo[2.2.2]octylene, piperidine-1,4-diyl, naphthalene-2,6-diyl,
 decahydronaphthalene-2,6-diyl or 1,2,3,4-tetrahydronaphthalene-2,6-diyl,
 where each of these groups may be monosubstituted or polysubstituted by L,
 and in addition A¹ can be a single bond,

L is a halogen atom, preferably F, CN, NO₂, alkyl, alkoxy, alkylcarbonyl,
 20 alkoxy carbonyl or alkoxy carbonyloxy having 1-7 carbon atoms, in which one or
 more H atoms may each be replaced by F or Cl,

m is in each case, independently, 0, 1, 2 or 3, and

R and R¹ are each, independently of one another, H, F, Cl, Br, I, CN, SCN, SF₅,
 straight-chain or branched alkyl having from 1 or 3 to 25 carbon atoms
 25 respectively, which may optionally be monosubstituted or polysubstituted by F,
 Cl, Br, I or CN, and in which one or more non-adjacent CH₂ groups may each
 be replaced by -O-, -S-, -NH-, -NR^x-, -CO-, -COO-, -OCO-, -O-COO-,
 -S-CO-, -CO-S-, -CH=CH- or -C≡C-, where no two O and/or S atoms are
 30 bonded directly to one another, or a polymerisable group.

Particular preference is given to chiral binaphthyl derivatives of the formula A-VI-1

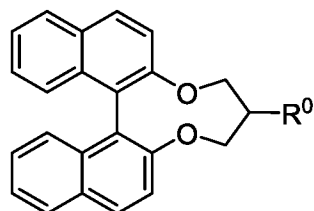


A-VI-1

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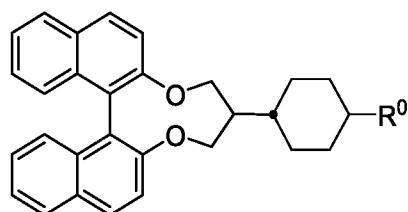
in which ring B and Z^0 have the meanings defined for the formulae A-IV and A-V, R^0 denotes alkyl having 1 to 7 C atoms and b is 0, 1 or 2,

in particular to those selected from the following formulae A-VI-1a to A-VI-1c:



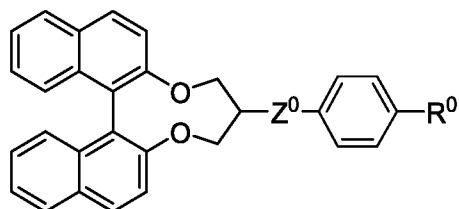
10

A-VI-1a



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A-VI-1b



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A-VI-1c

25

in which R^0 and Z^0 have the meanings defined for the formula A-VI-1, and preferably R^0 denotes H or alkyl having from 2 to 5 carbon atoms, and Z^0 is, in particular, $-OC(O)-$ or a single bond.

30

The concentration of the one or more chiral dopant(s), in the LC medium is preferably in the range from 0.001 % to 20 %, preferably from 0.05 % to 5 %, more preferably from 0.1 % to 2 %, and, most preferably from 0.5 % to 1.5 %. These preferred concentration ranges apply in particular to the chiral dopant S-4011 or R-4011 (both from Merck KGaA) and for chiral dopants having the same or a similar HTP. For Chiral dopants having either a higher or a lower absolute value of the HTP compared to S-4011 these preferred concentrations have to be decreased, or

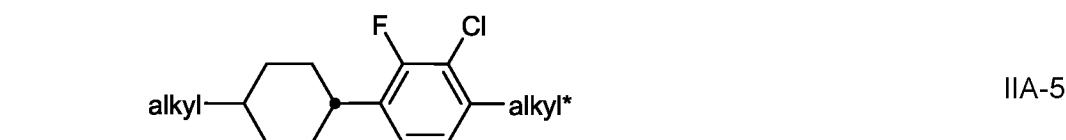
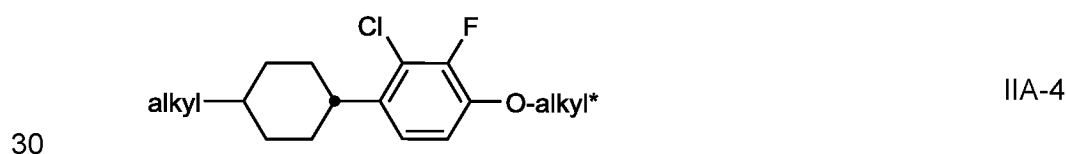
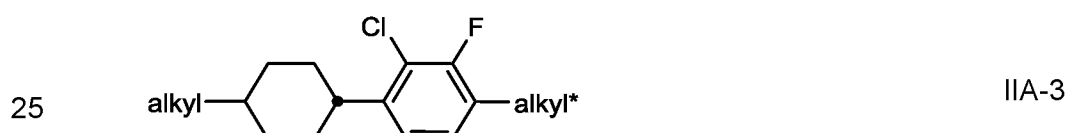
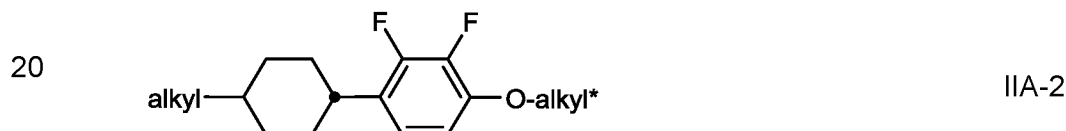
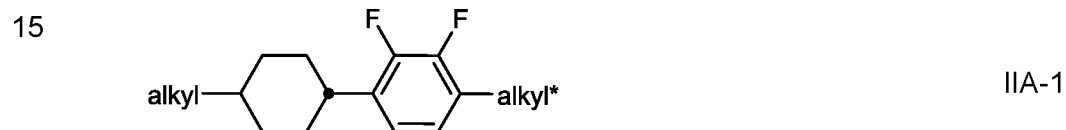
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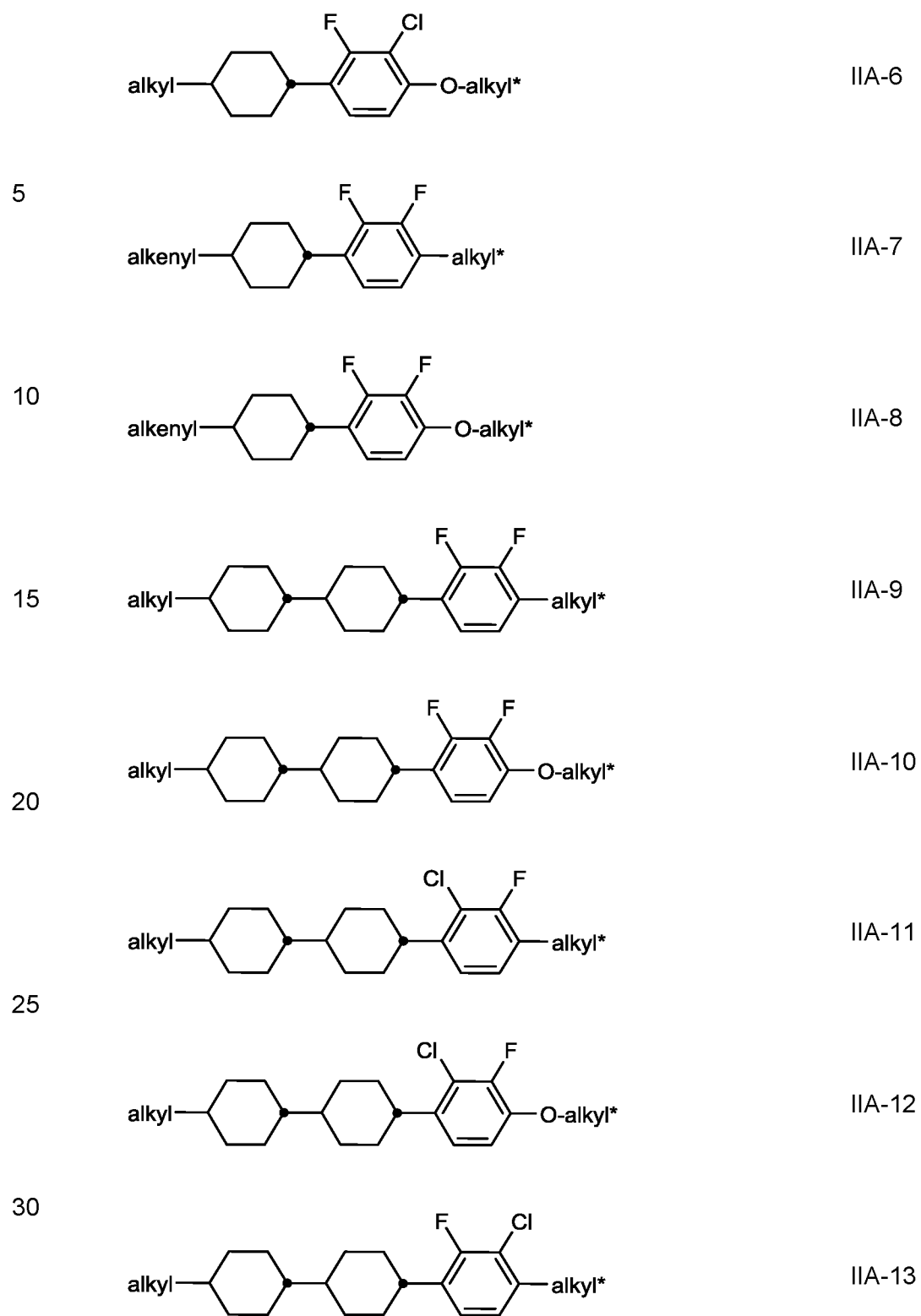
increased proportionally according to the ratio of their HTP values relatively to that of S-4011.

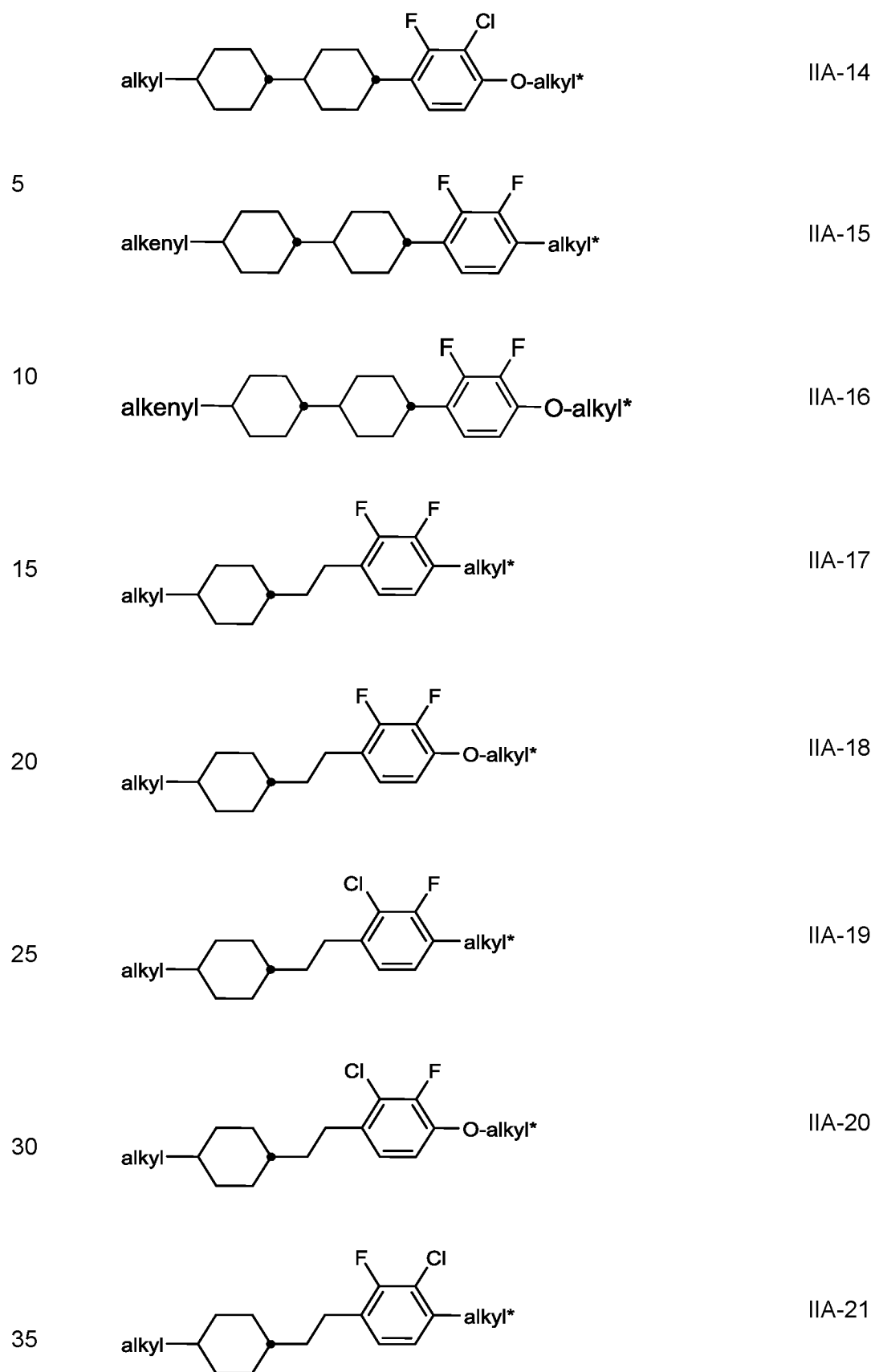
5 The pitch p of the LC media or host mixtures according to the invention is preferably in the range of from 5 to 50 μm , more preferably from 8 to 30 μm and particularly preferably from 10 to 20 μm .

10 The cell gap d , or thickness of the LC layer of the display according to the invention is preferably in the range of from 2 μm to 10 μm , more preferably 3 μm to 5 μm .
Based on this, according to the invention, a preferable range of the ratio d/p between the cell gap d and the chiral pitch p is set to 0.04 to 2, preferably 0.1 to 1, very preferably 0.2 to 0.3.

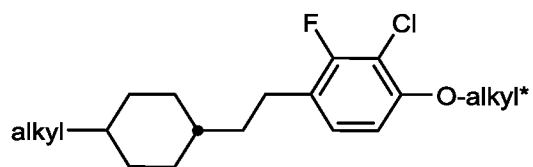
Preferred compounds of the formulae IIA, IIB, IIC and IID are indicated below:





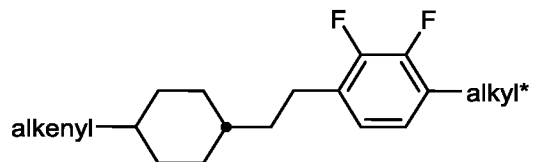


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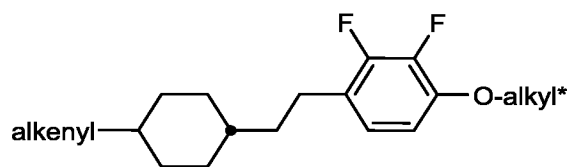
IIA-22

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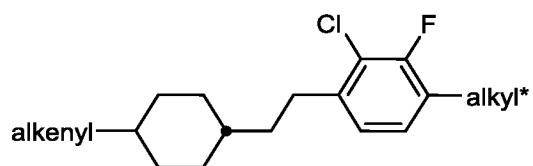
IIA-23

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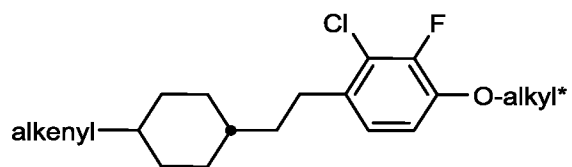
IIA-24

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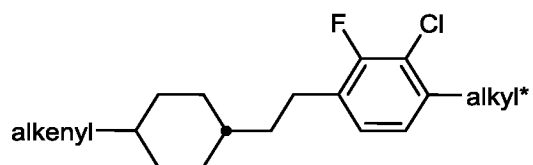
IIA-25

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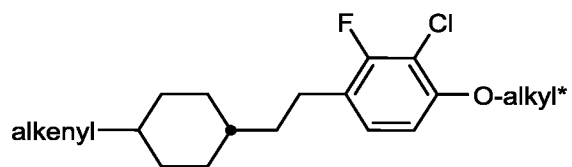
IIA-26

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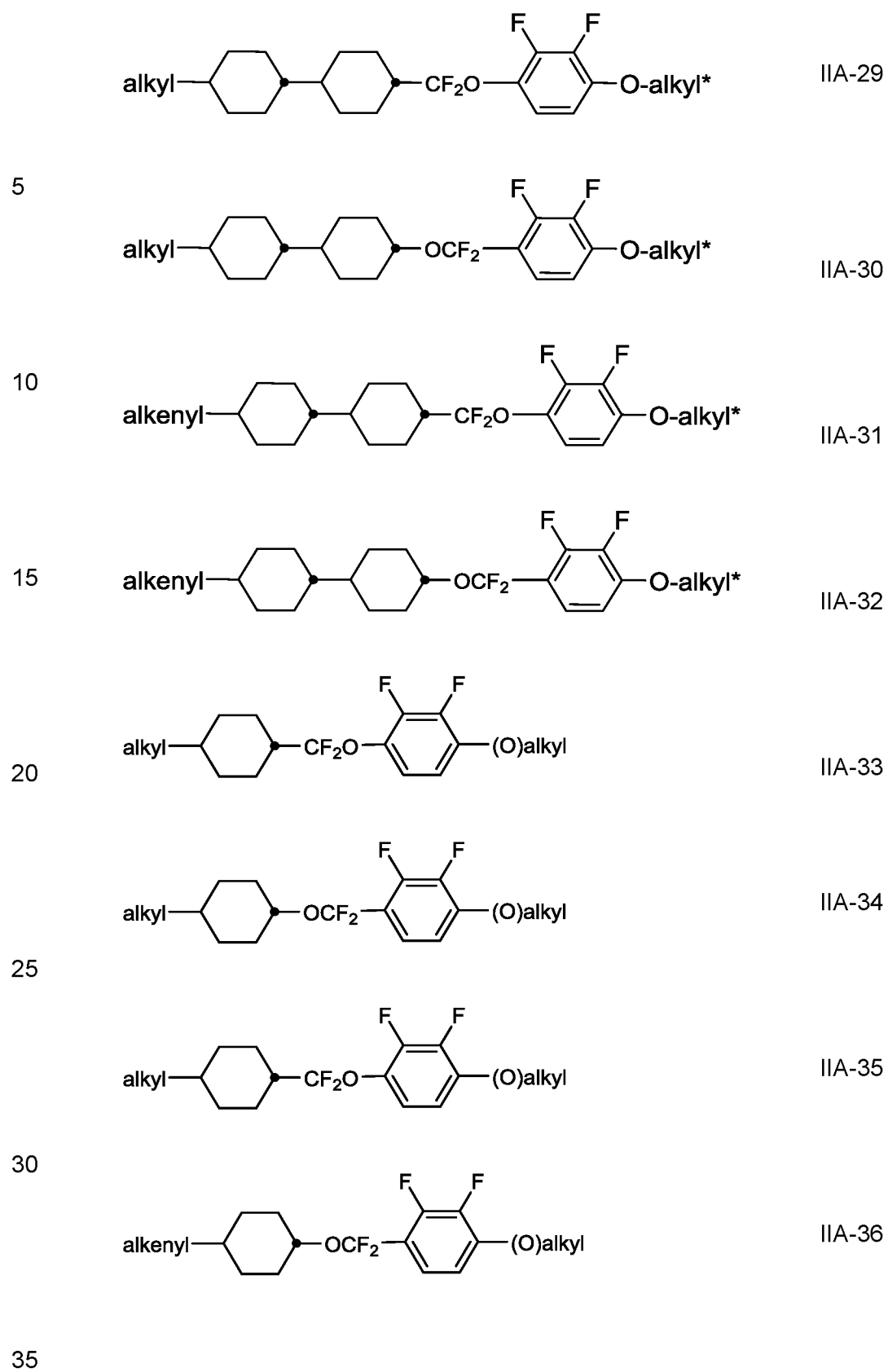


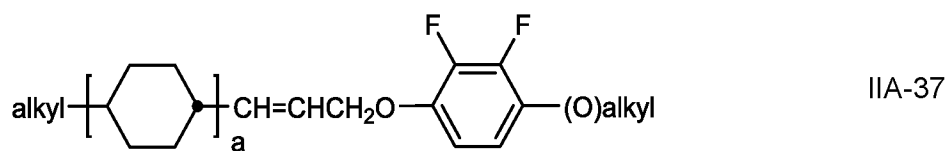
IIA-27

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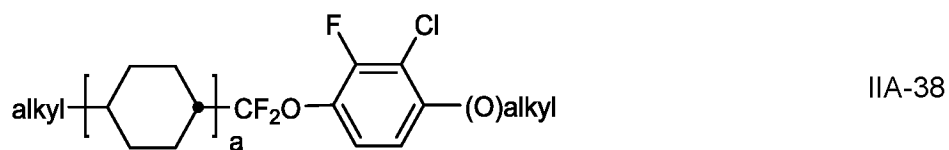


IIA-28

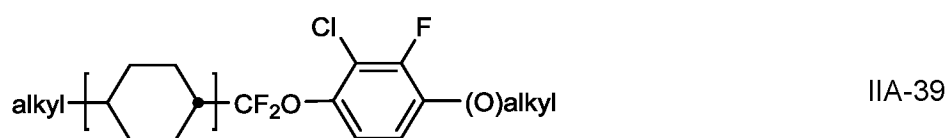




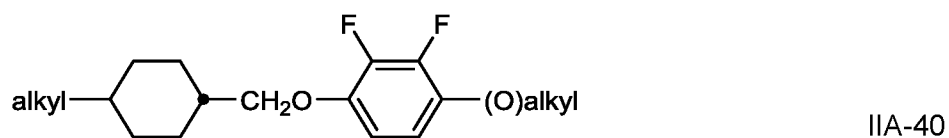
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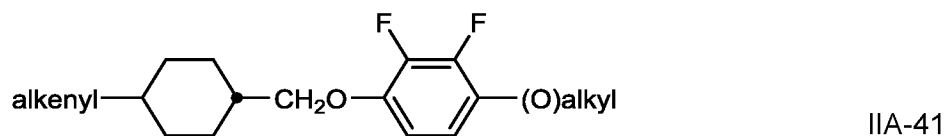
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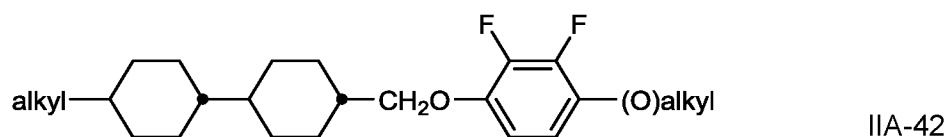
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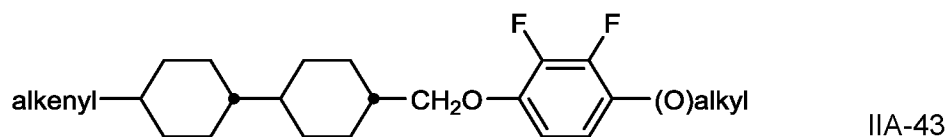
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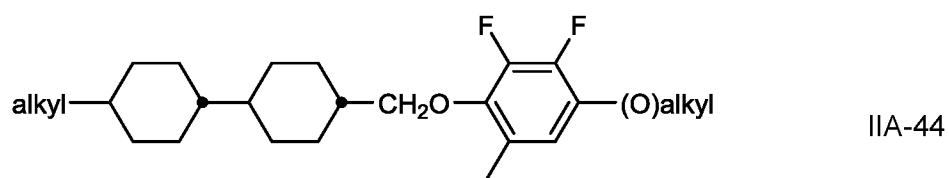
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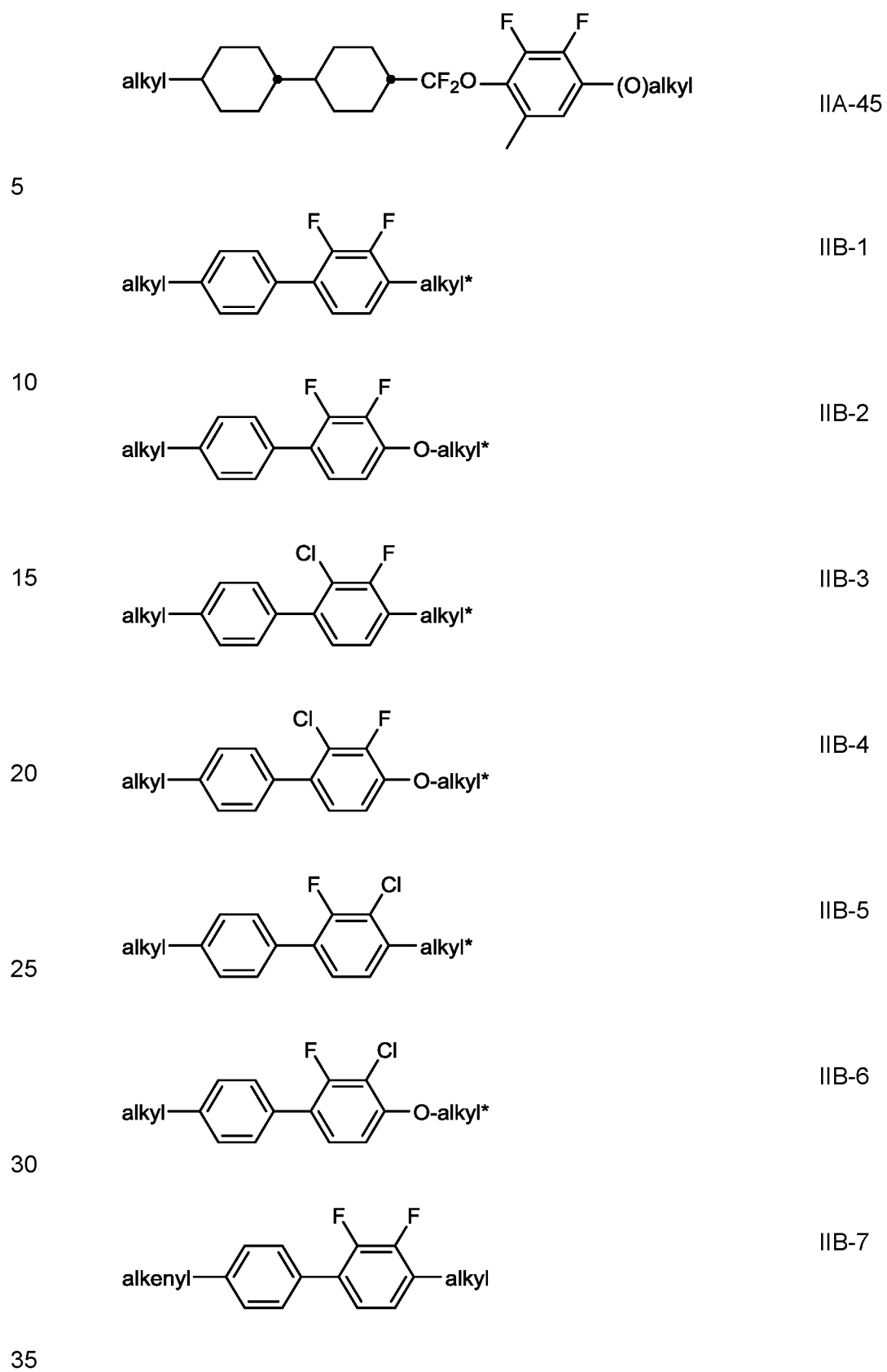


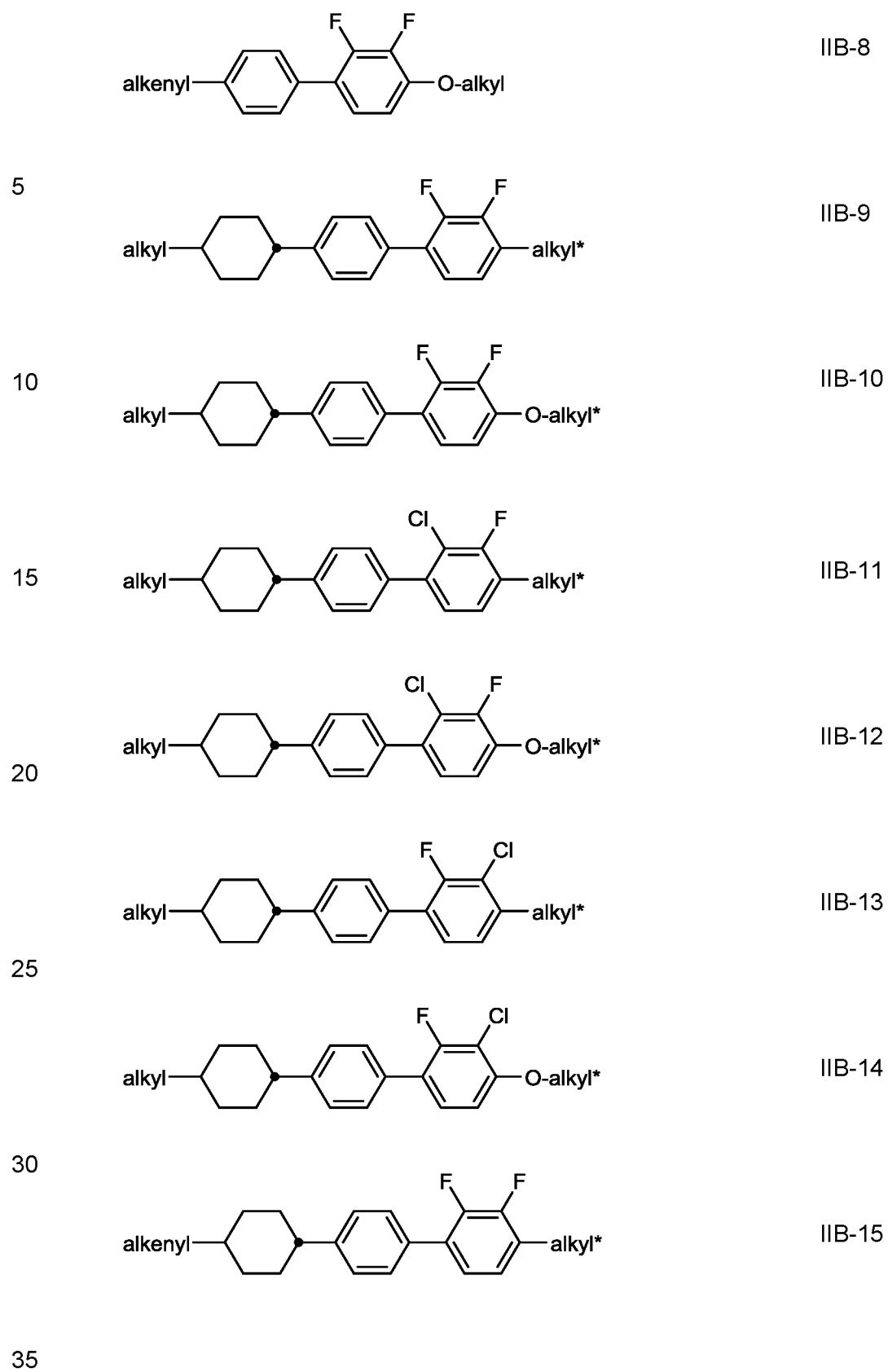
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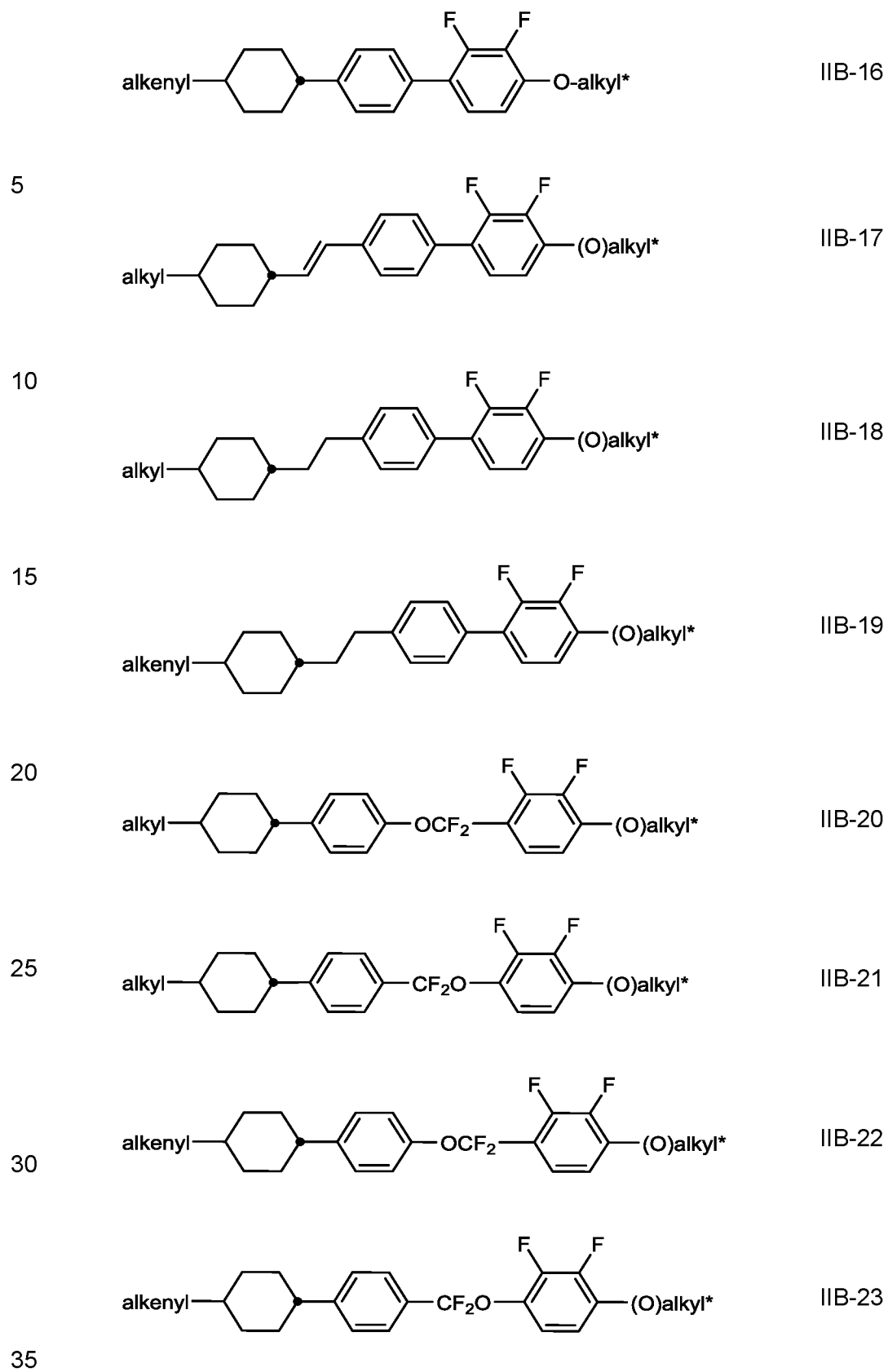


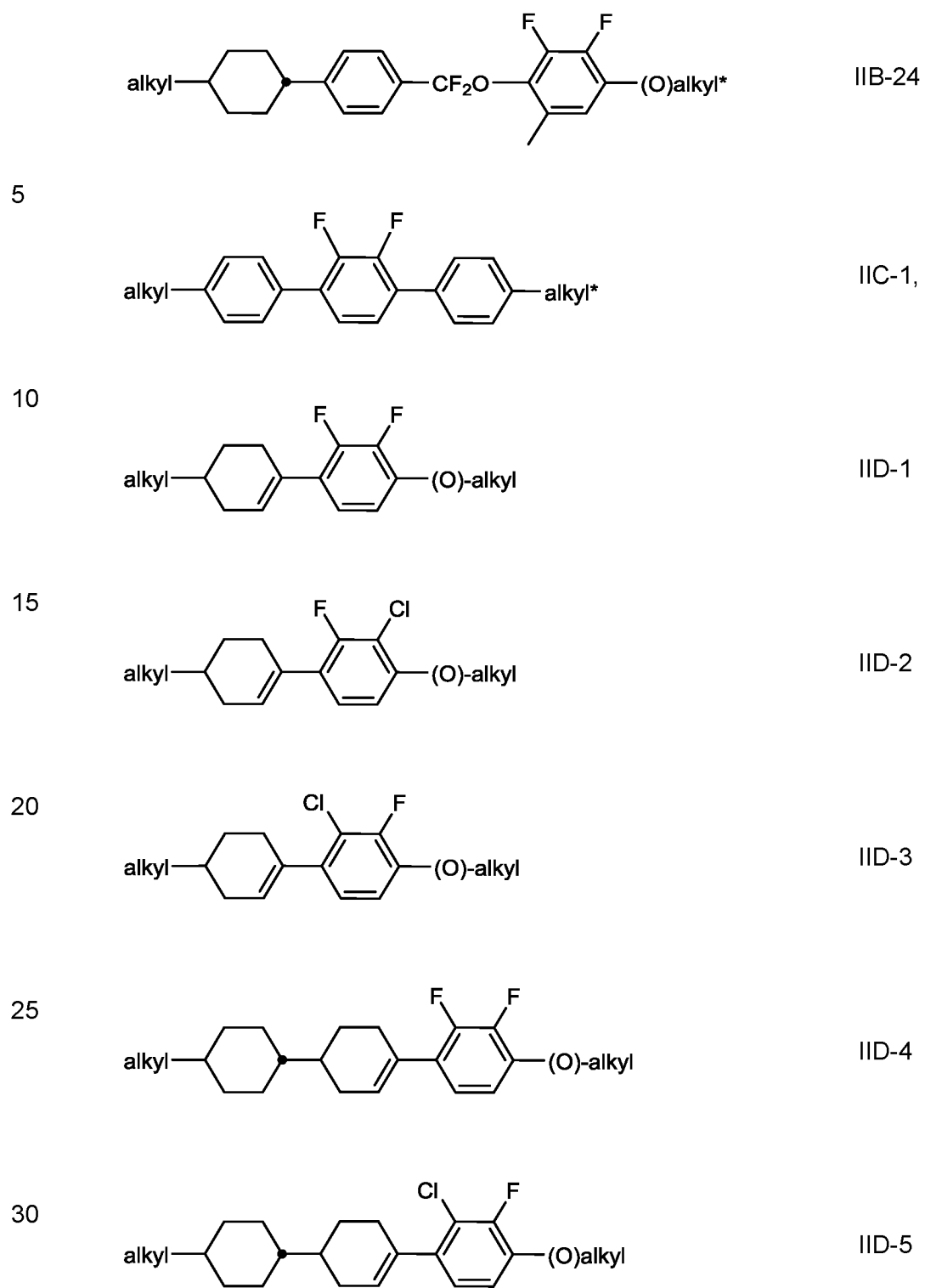
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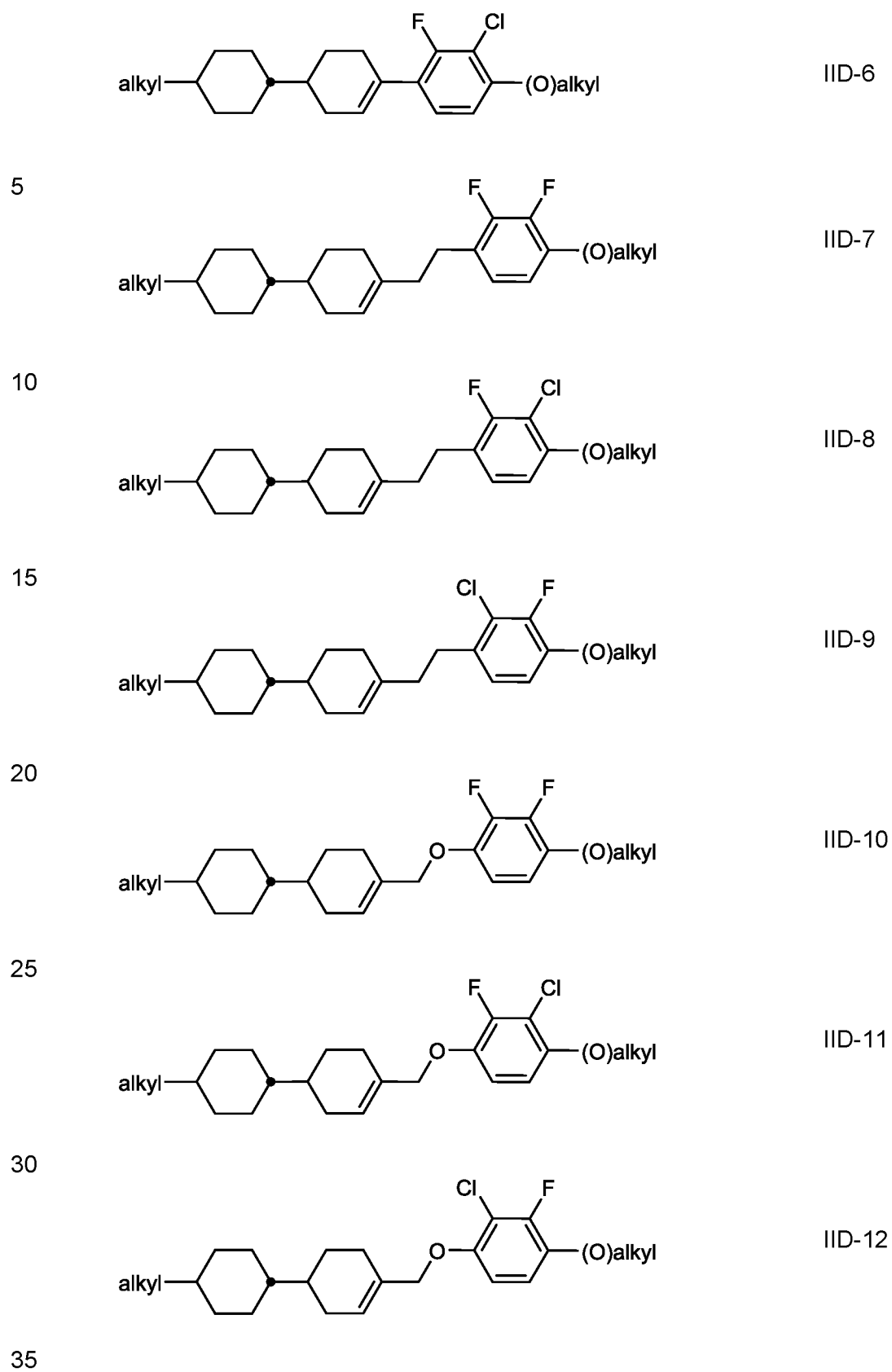


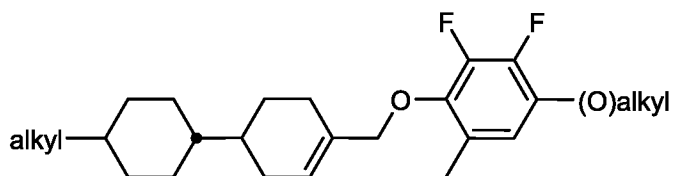








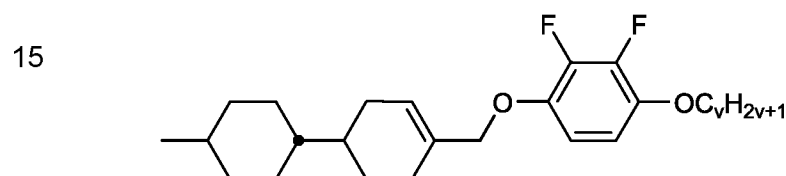




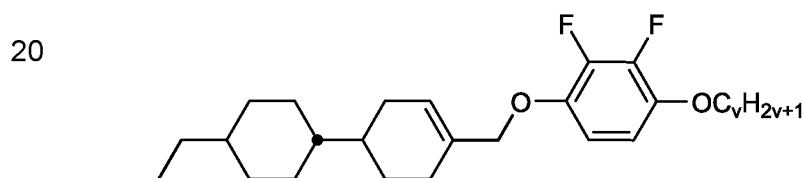
IID-13

- 5 in which the parameter a denotes 1 or 2, alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms, and alkenyl denotes a straight-chain alkenyl radical having 2-6 C atoms, and (O) denotes an oxygen atom or a single bond. Alkenyl preferably denotes $\text{CH}_2=\text{CH}-$, $\text{CH}_2=\text{CHCH}_2\text{CH}_2-$, $\text{CH}_3-\text{CH}=\text{CH}-$, $\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}-$, $\text{CH}_3-(\text{CH}_2)_2-\text{CH}=\text{CH}-$, CH_3-
 10 $(\text{CH}_2)_3-\text{CH}=\text{CH}-$ or $\text{CH}_3-\text{CH}=\text{CH}-(\text{CH}_2)_2-$.

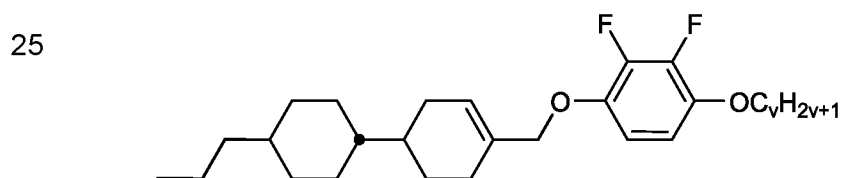
Very preferred compounds of the formula IID are selected from the following sub-formulae:



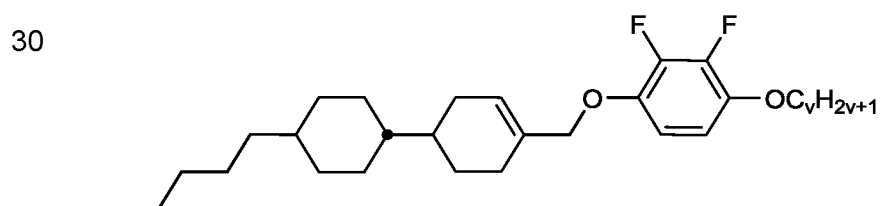
IID-10-1



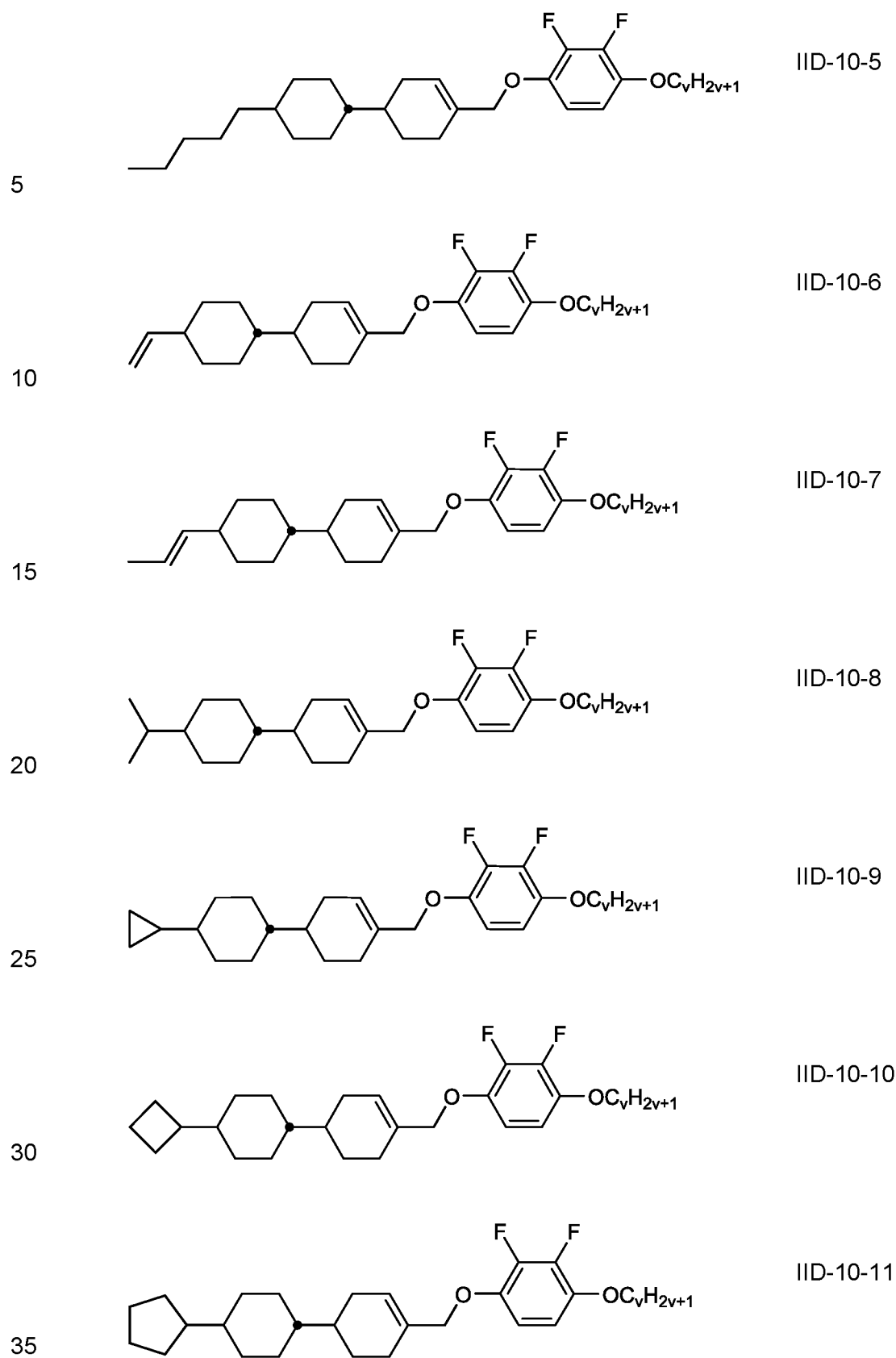
IID-10-2



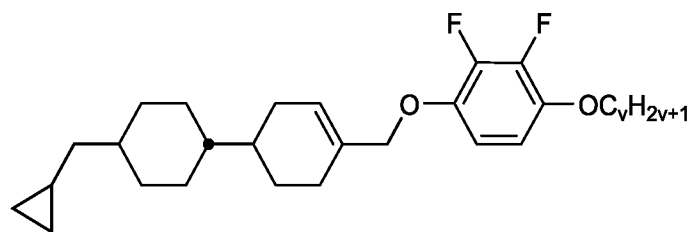
IID-10-3



IID-10-4

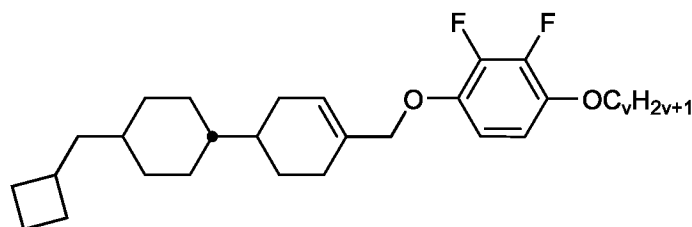


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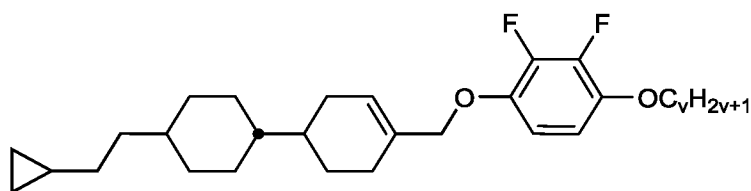
IID-10-12

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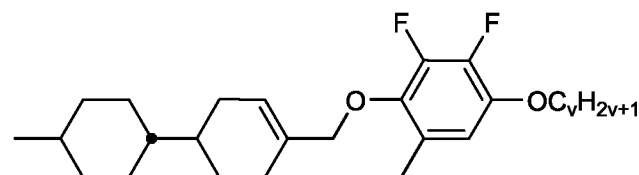
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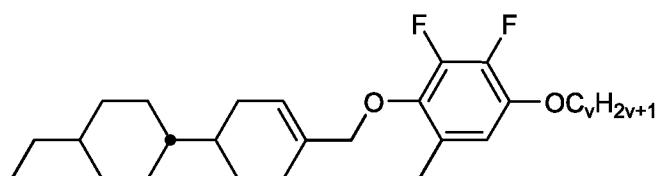
IID-10-14

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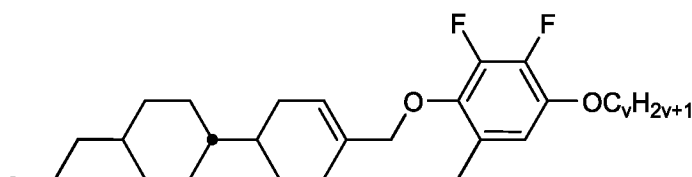
IID-10-15

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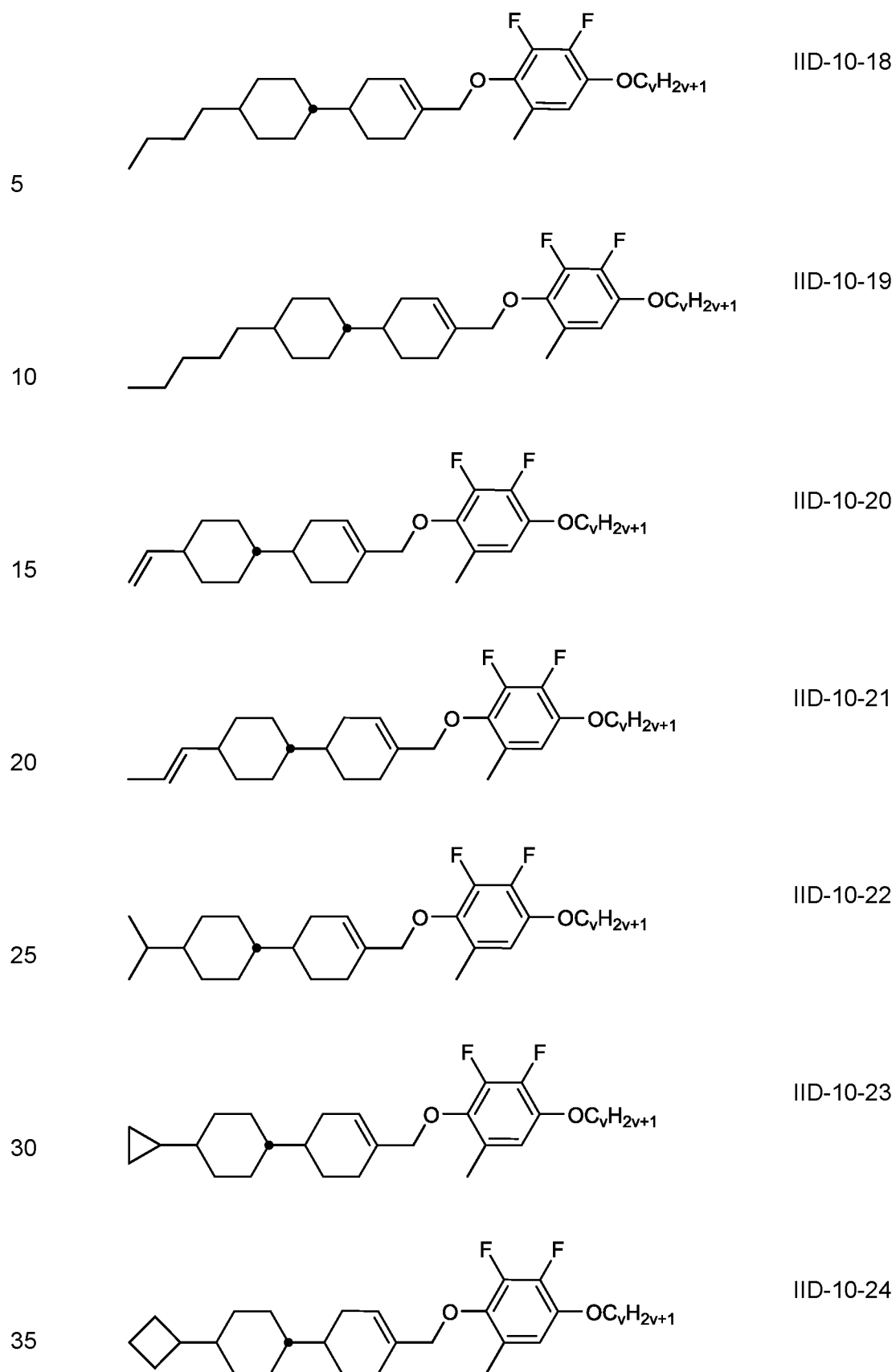
IID-10-16

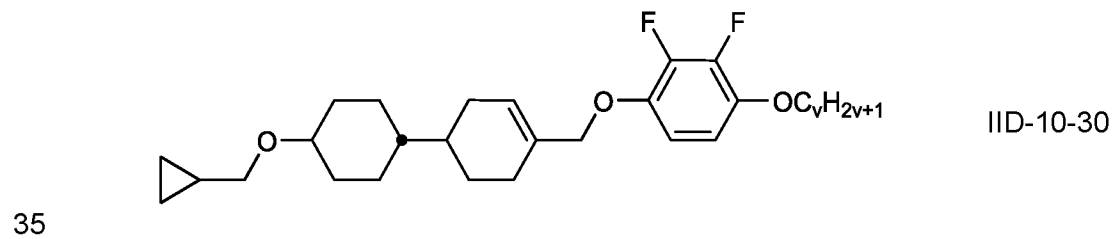
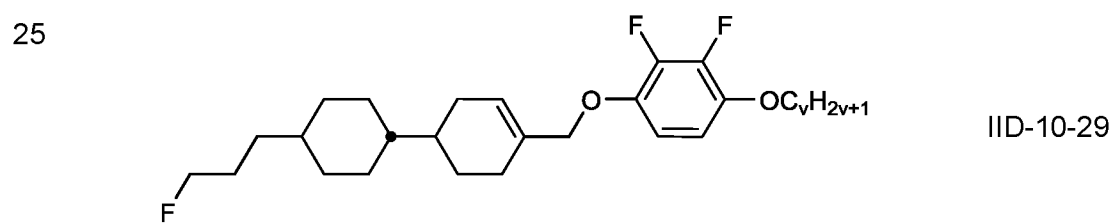
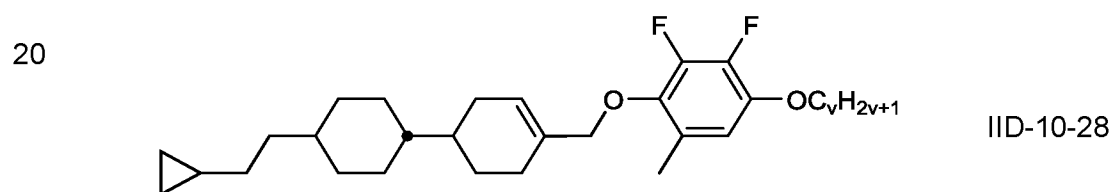
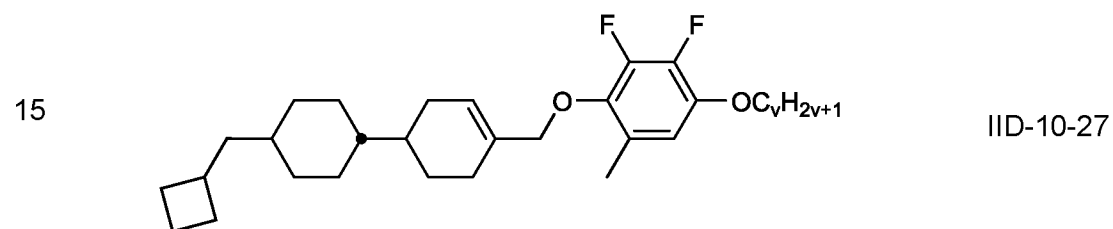
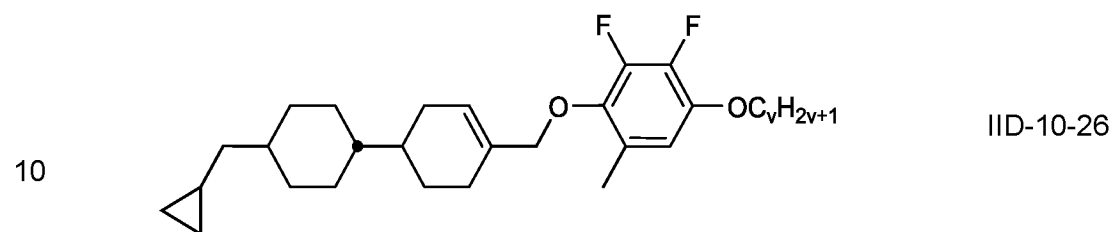
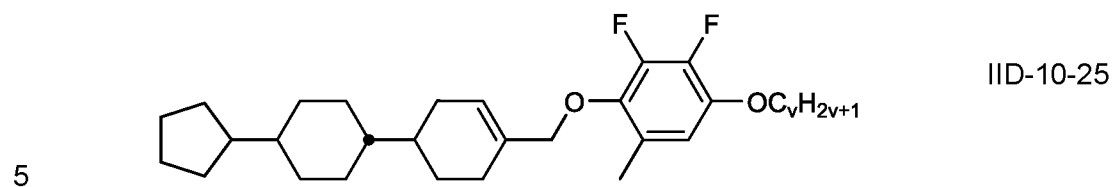
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IID-10-17

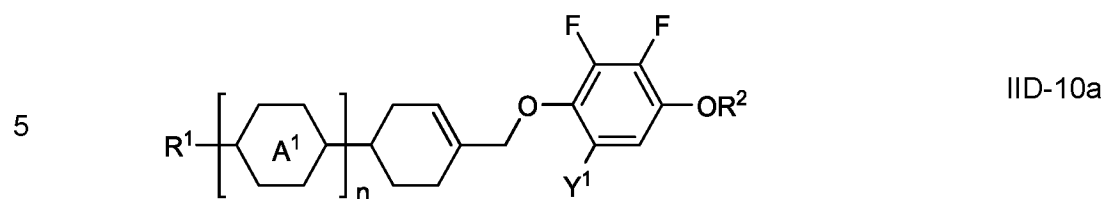
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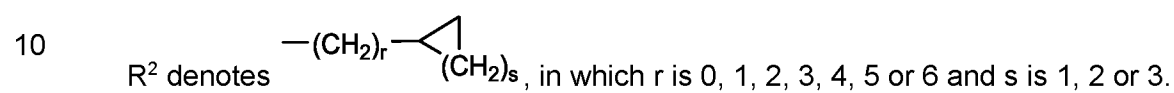


Very preferred compounds of formula I are the compounds I-1 to I-14.

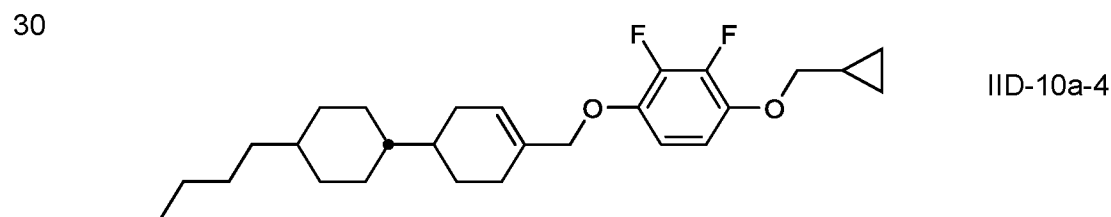
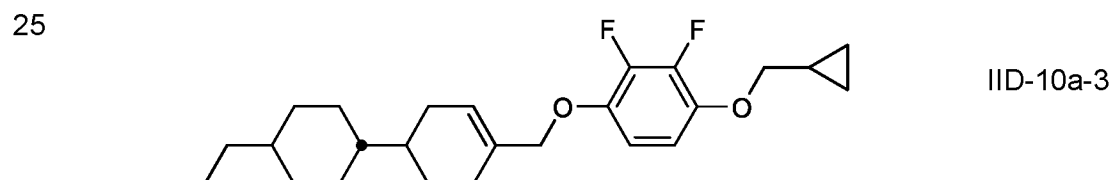
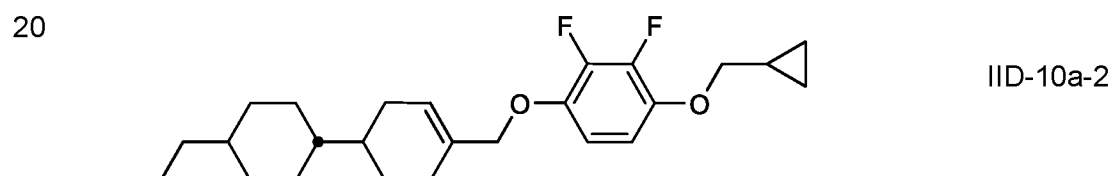
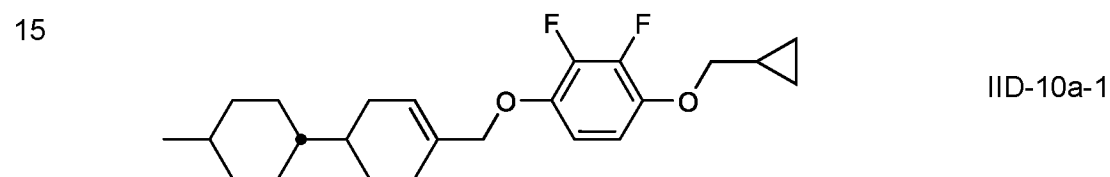
In a preferred embodiment, the medium comprises one or more compounds of formula IID-10a

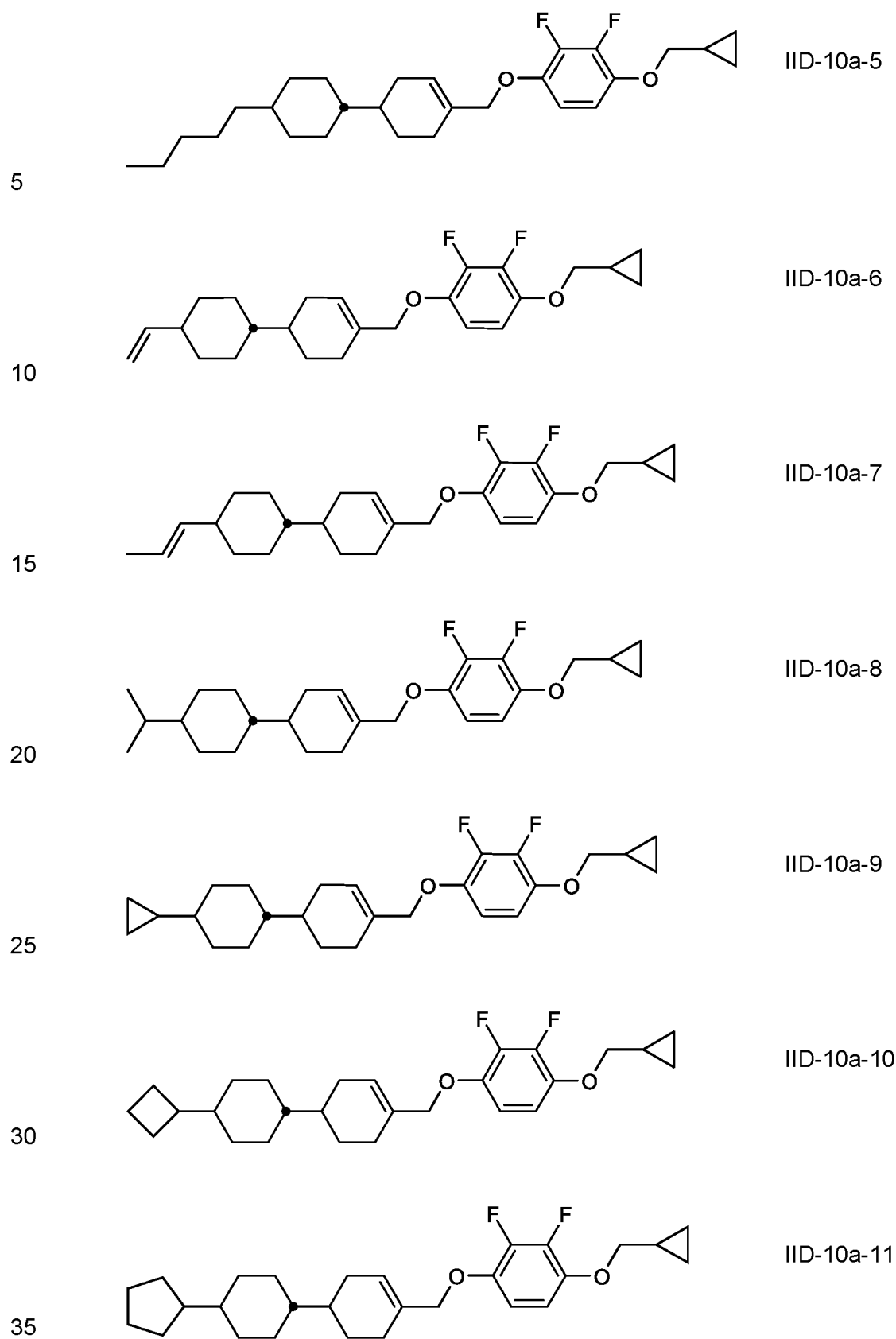


in which the occurring groups and parameters have the meanings given above under formula IID, and

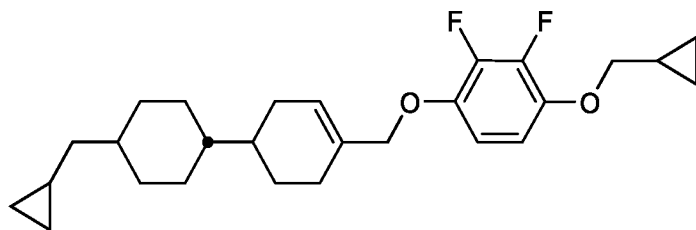


Preferred compounds of formula IID-10a are the compounds IID-10a-1 to IID-10a-14.



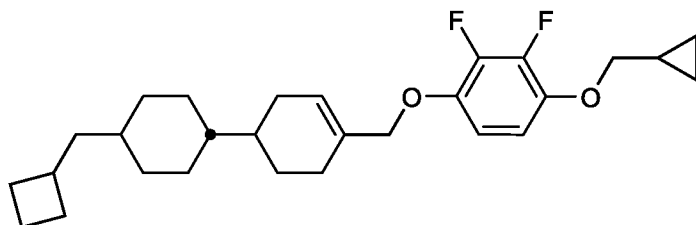


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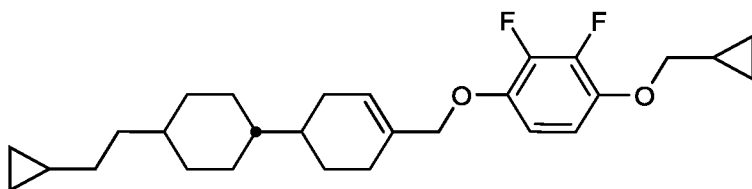
IID-10a-12

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IID-10a-13

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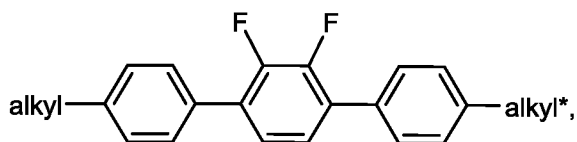
IID-10a-14

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Particularly preferred mixtures according to the invention comprise one or more compounds of the formulae IIA-2, IIA-8, IIA-10, IIA-16, IIA-18, IIA-40, IIA-41, IIA-42, IIA-43, IIB-2, IIB-10, IIB-16, IIC-1, IID-4 and IID-10.

Preferred media according to the invention comprise at least one compound of the formula IIC-1,

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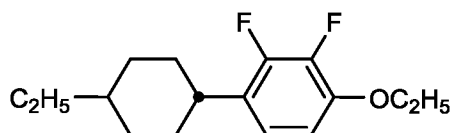
IIC-1

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in which alkyl and alkyl* have the meanings indicated above, preferably in amounts of 0.5% to 5 % by weight, in particular 1% to 3 % by weight.

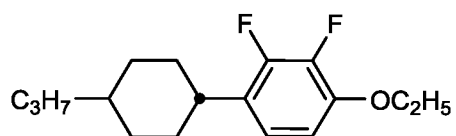
In particular, the medium comprises one or more compounds of the formula IIA-2 selected from the following sub-formulae:

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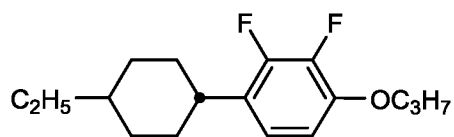
IIA-2-1

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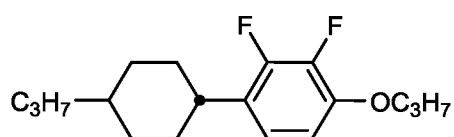
IIA-2-2

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IIA-2-3

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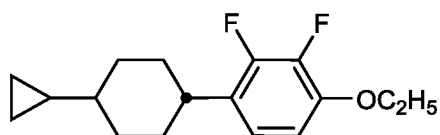


IIA-2-4

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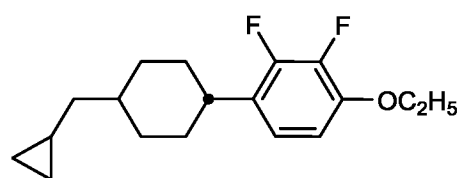
Alternatively, preferably in addition to the compounds of the formulae IIA-2-1 to IIA-2-5, the medium comprises one or more compounds of the formulae IIA-2a-1 to IIA-2a-5:

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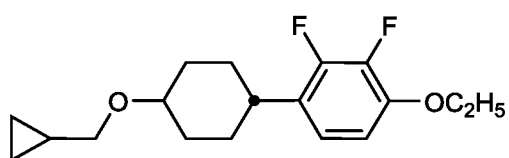
IIA-2a-1

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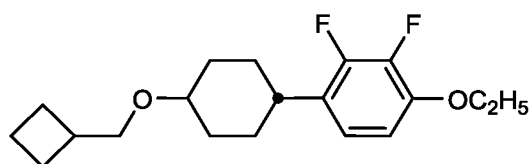


IIA-2a-2

35

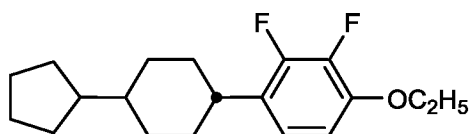


IIA-2a-3



IIA-2a-4

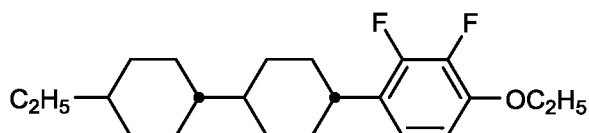
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IIA-2a-5

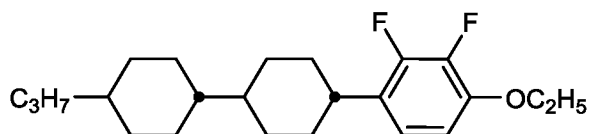
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In particular, the medium comprises one or more compounds of the formula IIA-10 selected from the following sub-formulae:



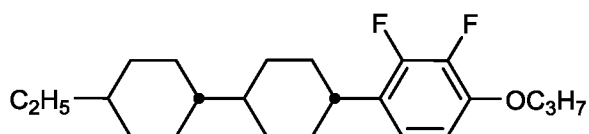
IIA-10-1

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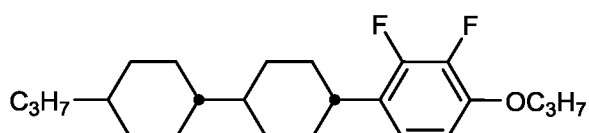
IIA-10-2

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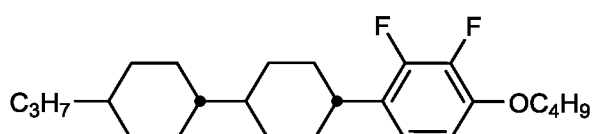
IIA-10-3

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IIA-10-4

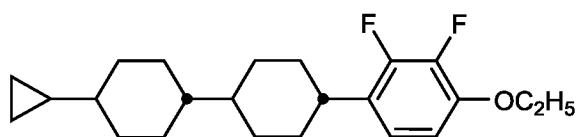
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IIA-10-5

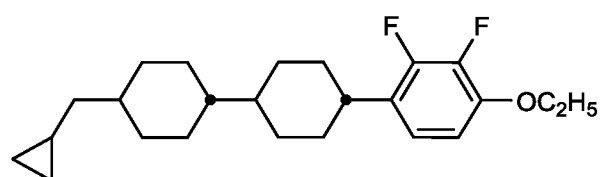
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Alternatively, preferably in addition to the compounds of the formulae IIA-10-1 to IIA-10-5, the medium comprises one or more compounds of the formulae IIA-10a-1 to IIA-10a-5:



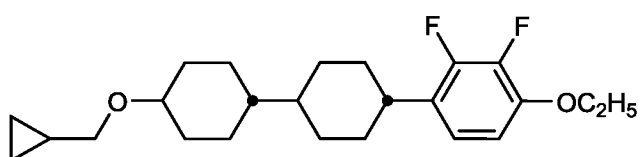
IIA-10a-1

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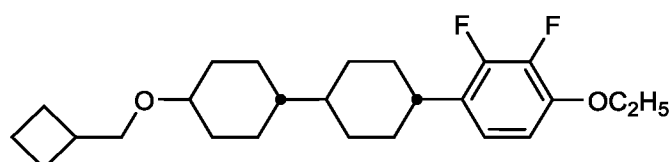
IIA-10a-2

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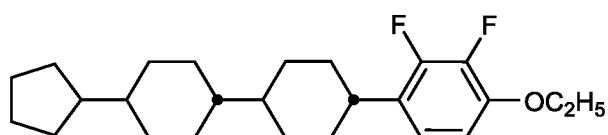
IIA-10a-3

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IIA-10a-4

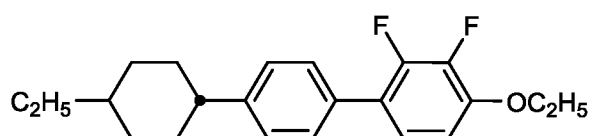
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IIA-10a-5

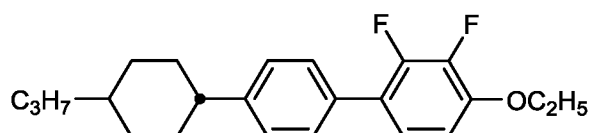
In particular, the medium comprises one or more compounds of the formula IIB-10
selected from the following sub-formulae:

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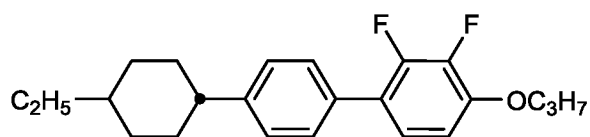
IIB-10-1

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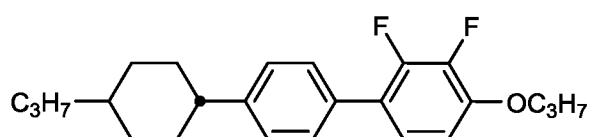
IIB-10-2

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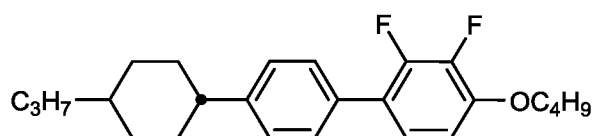
IIB-10-3

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IIB-10-4

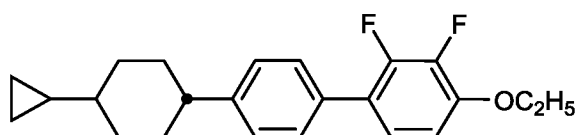
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IIB-10-5

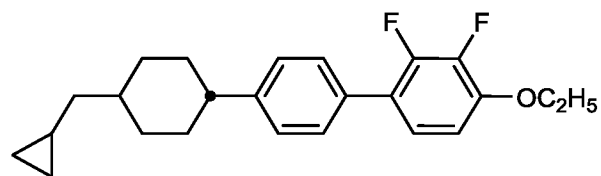
Alternatively, preferably in addition to the compounds of the formulae IIB-10-1 to IIB-10-5, the medium comprises one or more compounds of the formulae IIB-10a-1 to IIB-10a-5:

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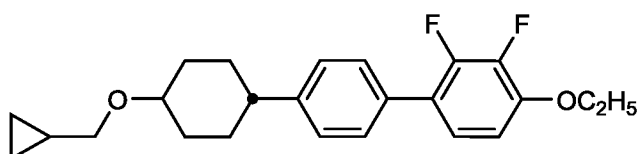
IIB-10a-1

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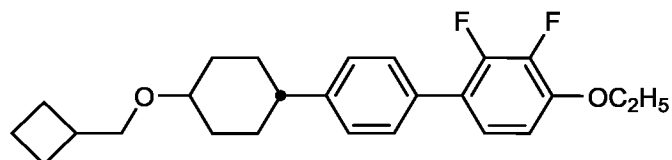
IIB-10a-2

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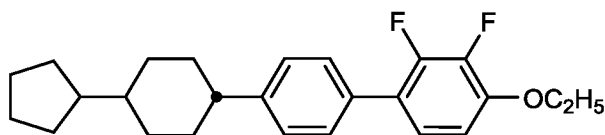
IIB-10a-3

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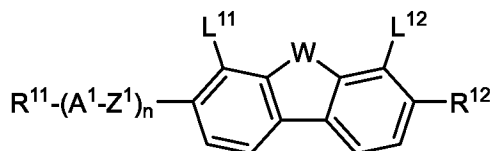
IIB-10a-4

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IIB-10a-5

5 The medium according to the invention optionally comprises one or more compounds of formula III



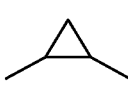
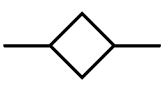
III

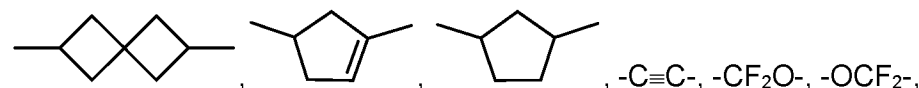
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in which

R^{11} and R^{12} each, independently of one another, denote H, an alkyl or alkoxy radical having 1 to 15 C atoms, where one or more CH_2 groups in these radicals may

15

each be replaced, independently of one another, by , ,



20

A^1 on each occurrence, independently of one another, denotes

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a) 1,4-cyclohexenylene or 1,4-cyclohexylene radical, in which one or two non-adjacent CH_2 groups may be replaced by -O- or -S-,

b) a 1,4-phenylene radical, in which one or two CH groups may be replaced by N, or

30

c) a radical from the group spiro[3.3]heptane-2,6-diyl, 1,4-bicyclo[2.2.2]octylene, naphthalene-2,6-diyl, decahydronaphthalene-2,6-diyl, 1,2,3,4-tetrahydronaphthalene-2,6-diyl, phenanthrene-2,7-diyl and fluorene-2,7-diyl, where the radicals a), b) and c) may be mono- or polysubstituted by halogen atoms,

n denotes 0, 1 or 2, preferably 0 or 1,

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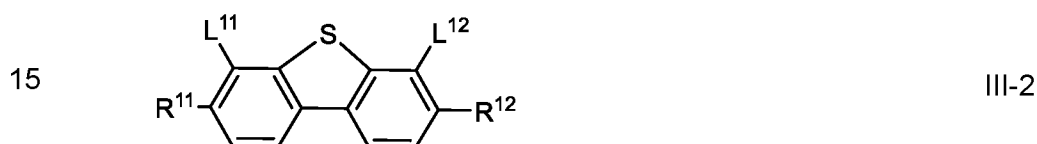
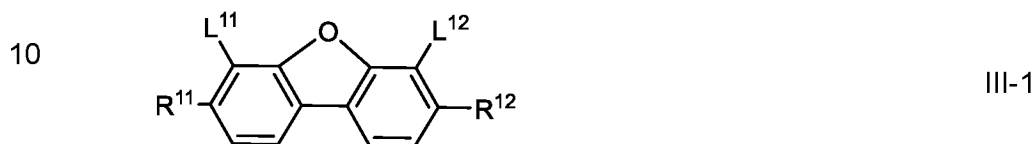
Z^1 on each occurrence independently of one another denotes -CO-O-, -O-CO-, -CF₂O-, -OCF₂-, -CH₂O-, -OCH₂-, -CH₂-, -CH₂CH₂-, -(CH₂)₄-,

-CH=CH-CH₂O-, -C₂F₄-, -CH₂CF₂-, -CF₂CH₂-, -CF=CF-, -CH=CF-,
-CF=CH-, -CH=CH-, -C≡C- or a single bond, and

L¹¹ and L¹² each, independently of one another, denote F, Cl, CF₃ or CHF₂,
preferably H or F, most preferably F, and

5 W denotes O or S.

The compounds of formula III are preferably selected from the compounds of the
formula III-1 and/or III-2

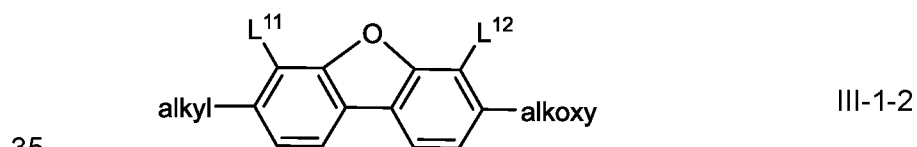
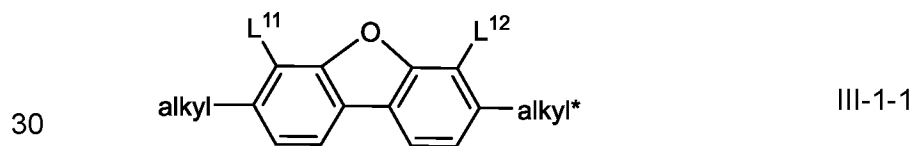


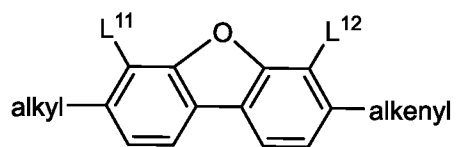
in which the occurring groups have the same meanings as given under formula III
above and preferably

20 R¹¹ and R¹² each, independently of one another, an alkyl, alkenyl or alkoxy radical
having up to 15 C atoms, more preferably one or both of them denote an
alkoxy radical and

L¹¹ and L¹² each preferably denote F.

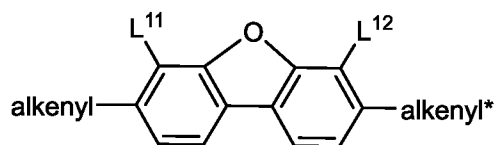
25 Preferably, the compounds of the formula III-1 selected from the group of
compounds of formulae III-1-1 to III-1-11, preferably of formula III-1-6,





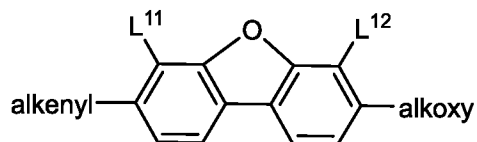
III-1-3

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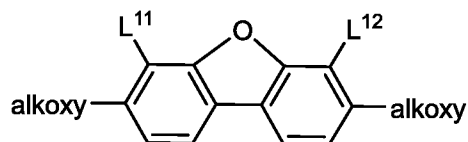
III-1-4

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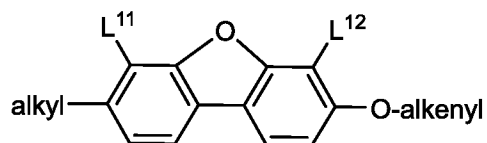
III-1-5

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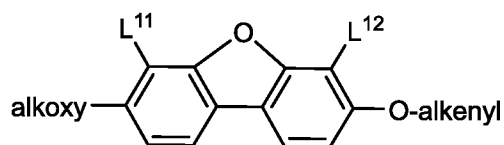
III-1-6

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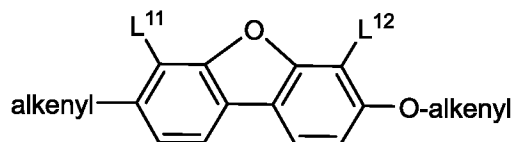
III-1-7

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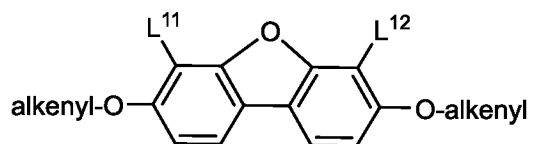
III-1-8

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III-1-9

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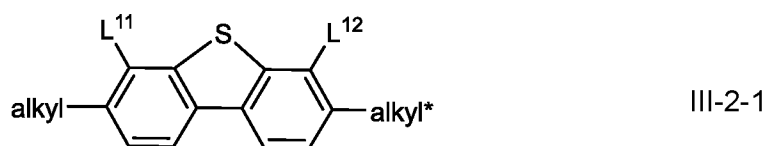
III-1-10,

in which

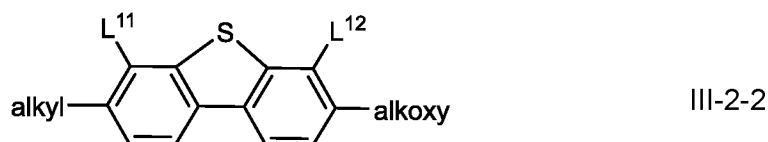
alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms, alkenyl and alkenyl* each, independently of one another, denote a straight-chain alkenyl radical having 2-6 C atoms, alkoxy and alkoxy* each, independently of one another, denote a straight-chain alkoxy radical having 1-6 C atoms, and L¹¹ and L¹² each, independently of one another, denote F or Cl, preferably both F.

Preferably, the compounds of the formula III-2 are selected from the group of compounds of formulae III-2-1 to III-2-10, preferably of formula III-2-6,

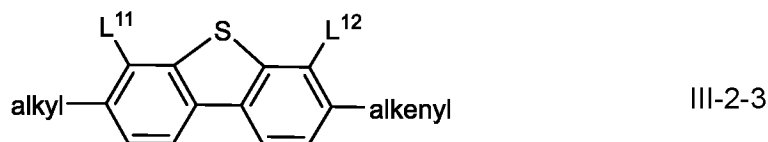
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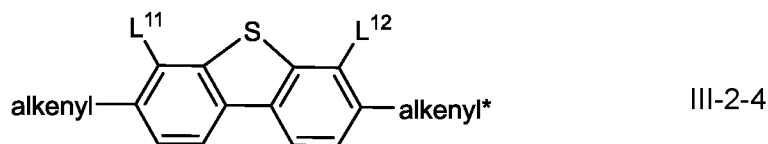
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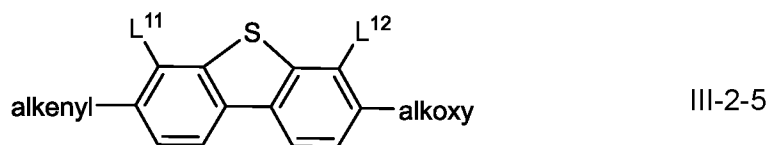
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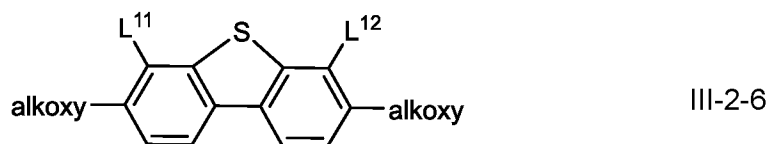
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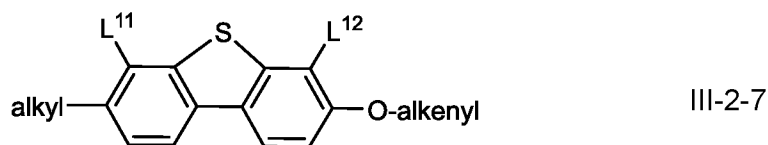


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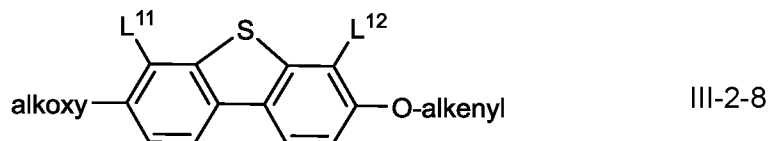


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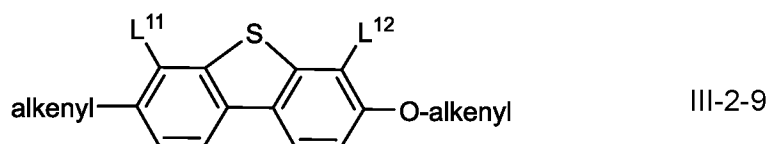




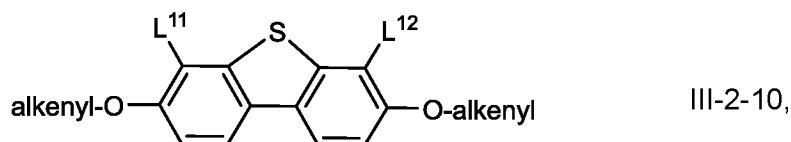
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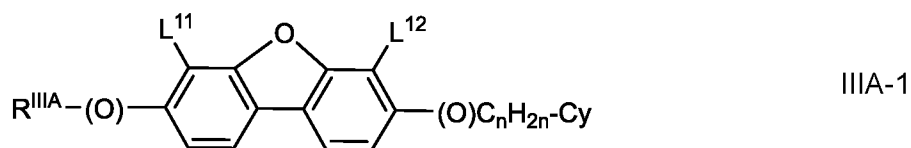
in which

alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms, alkenyl and alkenyl* each, independently of one another, denote a straight-chain alkenyl radical having 2-6 C atoms, alkoxy and alkoxy* each, independently of one another, denote a straight-chain alkoxy radical having 1-6 C atoms, and L^1 and L^2 each, independently of one another, denote F or Cl, preferably both F.

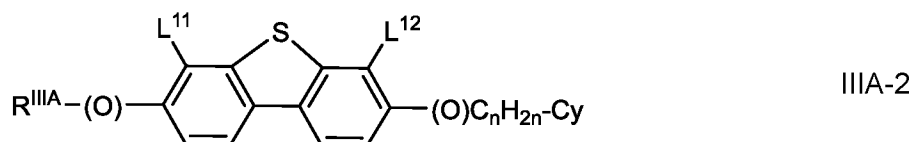
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Optionally the medium comprises one or more compounds of the formula IIIA-1 and/or IIIA-2

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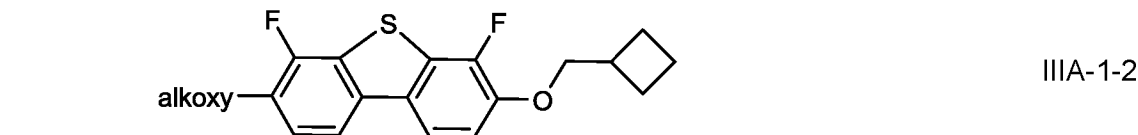
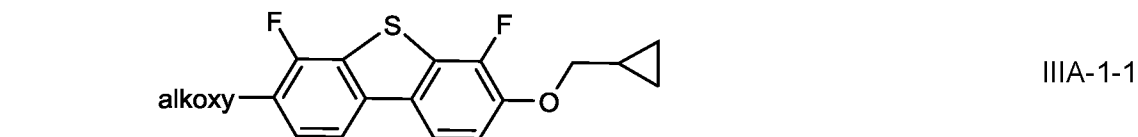
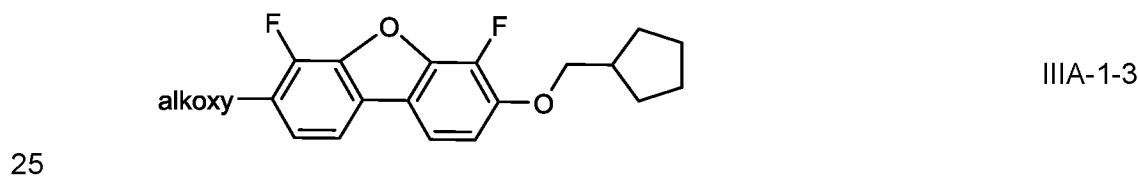
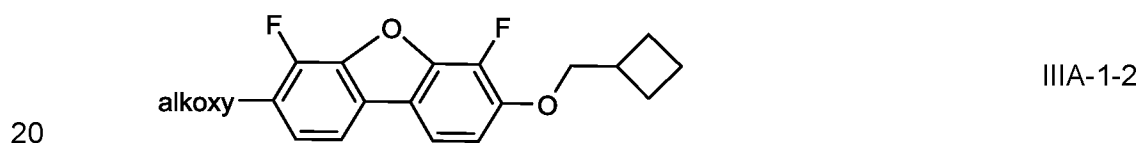
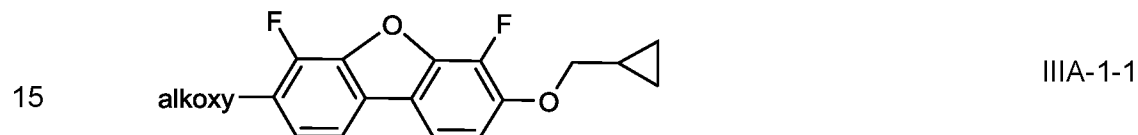
in which L^{11} and L^{12} have the same meanings as given under formula III, (O) denotes O or a single bond,

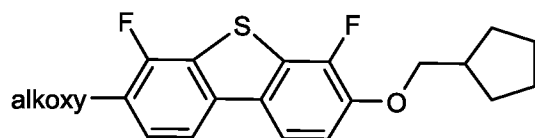
R^{IIIA} denotes alkyl or alkenyl having up to 7 C atoms or a group $Cy-C_mH_{2m+1}-$,
 m and n are, identically or differently, 0, 1, 2, 3, 4, 5 or 6, preferably 1, 2 or 3, very
 preferably 1,

- 5 Cy denotes a cycloaliphatic group having 3, 4 or 5 ring atoms, which is optionally
 substituted with alkyl or alkenyl each having up to 3 C atoms, or with halogen
 or CN, and preferably denotes cyclopropyl, cyclobutyl or cyclopentyl.

10 The compounds of formula IIIA-1 and/or IIIA-2 are contained in the medium either
 alternatively or in addition to the compounds of formula III, preferably additionally.

Very preferred compounds of the formulae IIIA-1 and IIIA-2 are the following:

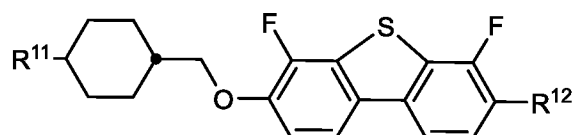




IIIA-1-3

in which alkoxy denotes a straight-chain alkoxy radical having 1-6 C atoms or alternatively $-(CH_2)_nF$ in which n is 2,3,4, or 5, preferably C_2H_4F .

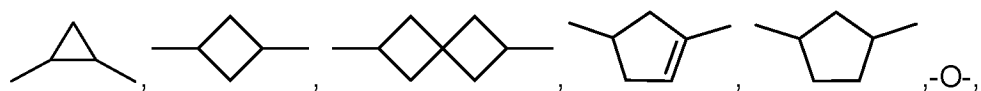
In a preferred embodiment of the present invention, the medium comprises one or more compounds of formula III-3



III-3

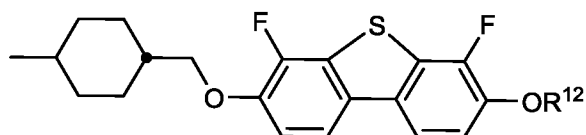
in which

R^{11} , R^{12} identically or differently, denote H, an alkyl or alkoxy radical having 1 to 15 C atoms, in which one or more CH_2 groups in these radicals are optionally replaced, independently of one another, by $-C\equiv C-$, $-CF_2O-$, $-OCF_2-$, $-CH=CH-$,

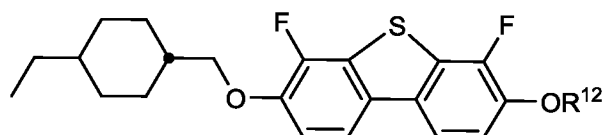


$-CO-O-$ or $-O-CO-$ in such a way that O atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by halogen.

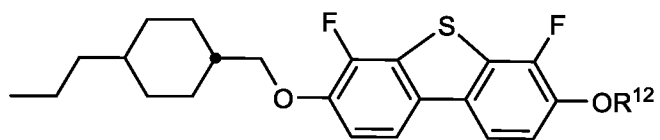
The compounds of formula III-3 are preferably selected from the group of compounds of the formulae III-3-1 to III-3-10:



III-3-1

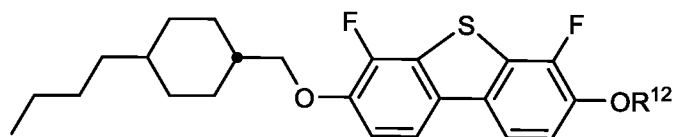


III-3-2



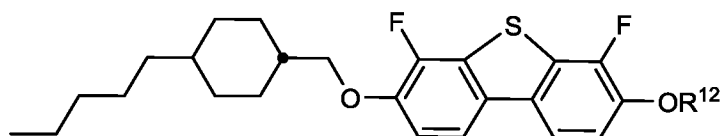
III-3-3

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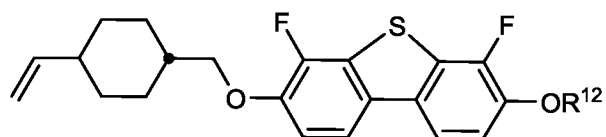
III-3-4

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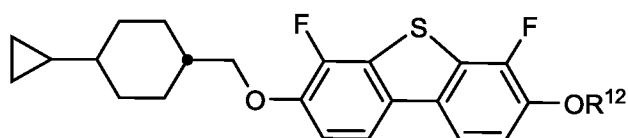
III-3-5

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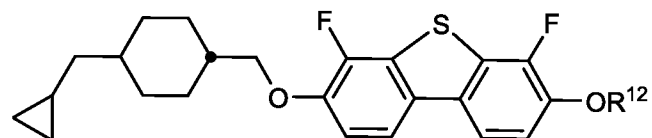
III-3-6

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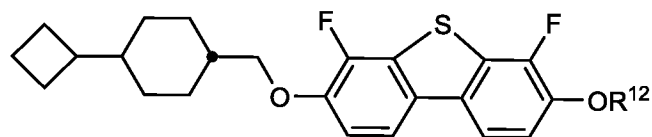
III-3-7

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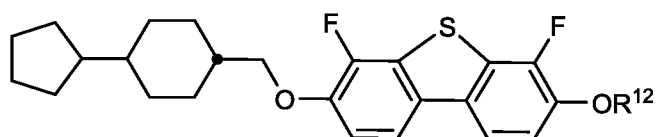
III-3-8

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III-3-9

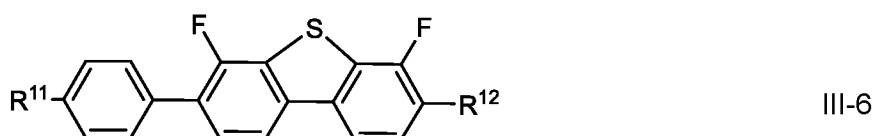
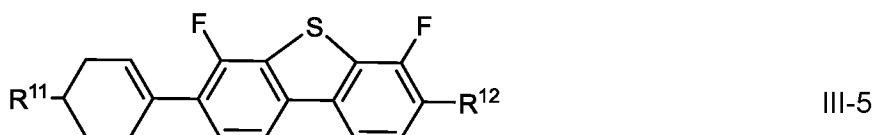
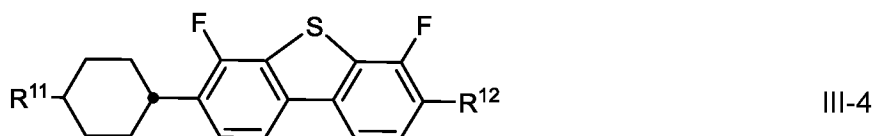
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III-3-10

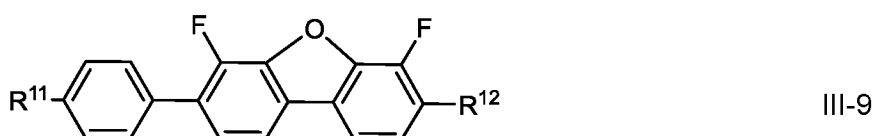
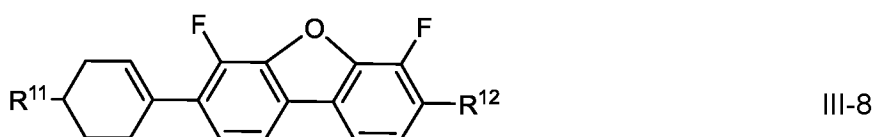
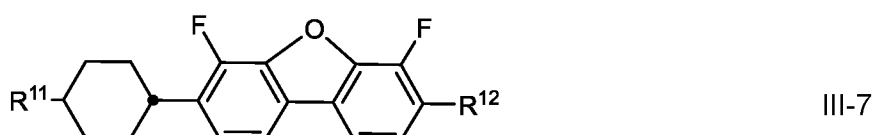
in which R¹² denotes alkyl having 1 to 7 C-atoms, preferably ethyl, n-propyl or n-butyl, or alternatively cyclopropylmethyl, cyclobutylmethyl or cyclopentylmethyl or alternatively $-(CH_2)_nF$ in which n is 2,3,4, or 5, preferably C₂H₄F.

- 5 In a preferred embodiment of the present invention, the medium comprises one or more compounds of the formulae III-4 to III-6, preferably of formula III-5,



in which the parameters have the meanings given above, R¹¹ preferably denotes straight-chain alkyl and R¹² preferably denotes alkoxy, each having 1 to 7 C atoms.

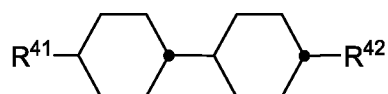
In a preferred embodiment the media comprise one or more compounds of the formula I selected from the group of compounds of formulae III-7 to III-9, preferably of formula III-8,



in which the parameters have the meanings given above, R¹¹ preferably denotes straight-chain alkyl and R¹² preferably denotes alkoxy each having 1 to 7 C atoms.

In a preferred embodiment, the medium comprises one or more compounds of the formula IV,

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IV

in which

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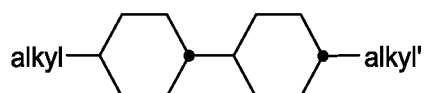
R⁴¹ denotes an unsubstituted alkyl radical having 1 to 7 C atoms or an unsubstituted alkenyl radical having 2 to 7 C atoms, preferably an *n*-alkyl radical, particularly preferably having 2, 3, 4 or 5 C atoms, and

15

R⁴² denotes an unsubstituted alkyl radical having 1 to 7 C atoms or an unsubstituted alkoxy radical having 1 to 6 C atoms, both preferably having 2 to 5 C atoms, an unsubstituted alkenyl radical having 2 to 7 C atoms, preferably having 2, 3 or 4 C atoms, more preferably a vinyl radical or a 1-propenyl radical and in particular a vinyl radical.

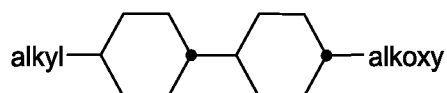
The compounds of the formula IV are preferably selected from the group of the compounds of the formulae IV-1 to IV-4,

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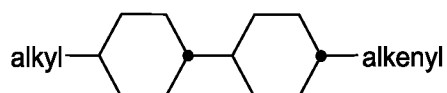
IV-1

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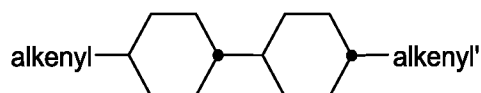


IV-2

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IV-3



IV-4

in which

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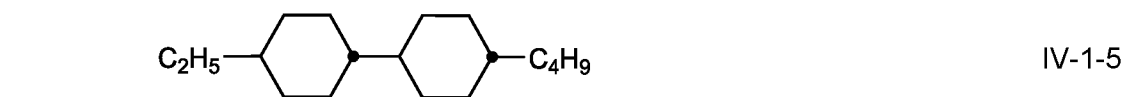
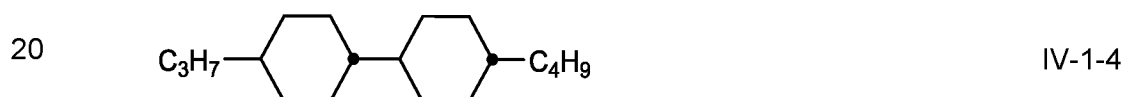
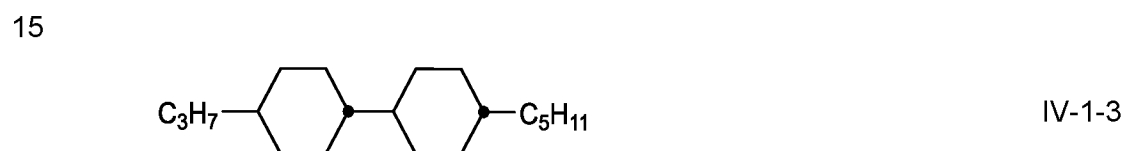
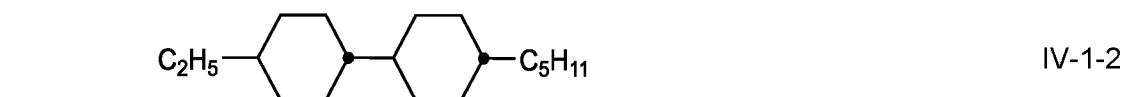
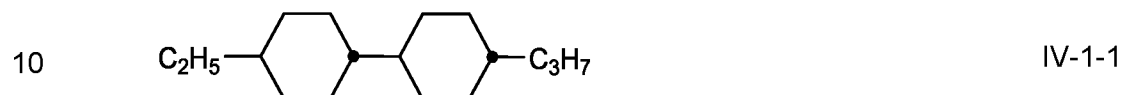
alkyl and alkyl', independently of one another, denote alkyl having 1 to 7 C atoms, preferably having 2 to 5 C atoms,

alkenyl denotes an alkenyl radical having 2 to 5 C atoms, preferably having 2 to 4 C atoms, particularly preferably 2 C atoms,

alkenyl' denotes an alkenyl radical having 2 to 5 C atoms, preferably having 2 to 4 C atoms, particularly preferably having 2 to 3 C atoms, and

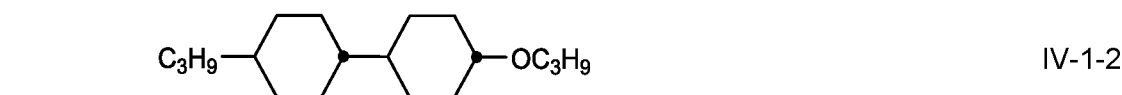
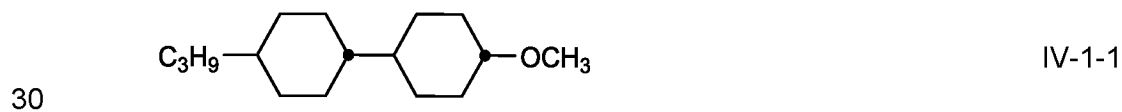
5 alkoxy denotes alkoxy having 1 to 5 C atoms, preferably having 2 to 4 C atoms.

Preferably, the medium comprises one or more compounds selected from the compounds of the formulae IV-1-1 to IV-1-4



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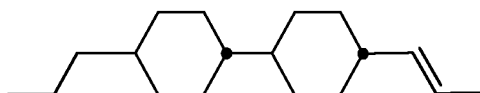
Very preferably, the medium according to the invention comprises one or more compounds of the formulae IV-2-1 and/or IV-2-2



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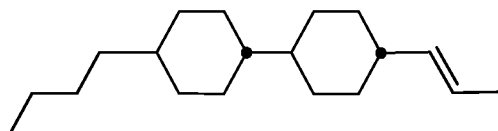
Very preferably, the medium according to the invention comprises a compound of formula IV-3, in particular selected from the compounds of the formulae IV-3-1 to IV-3-5

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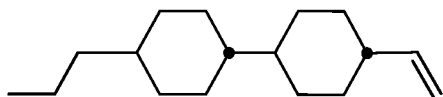
IV-3-1

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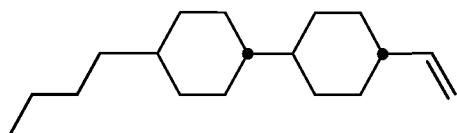
IV-3-2

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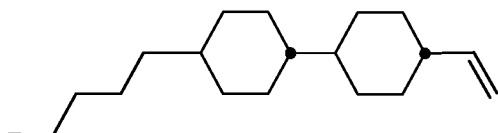
IV-3-3

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IV-3-4

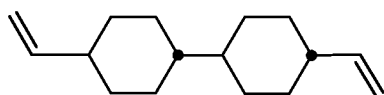
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IV-3-5

Very preferably, the medium according to the invention comprises a compound of formula IV-4, in particular selected from the compounds of the formulae IV-4-1 and IV-4-2

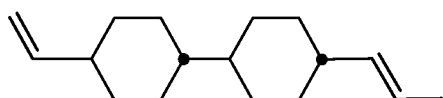
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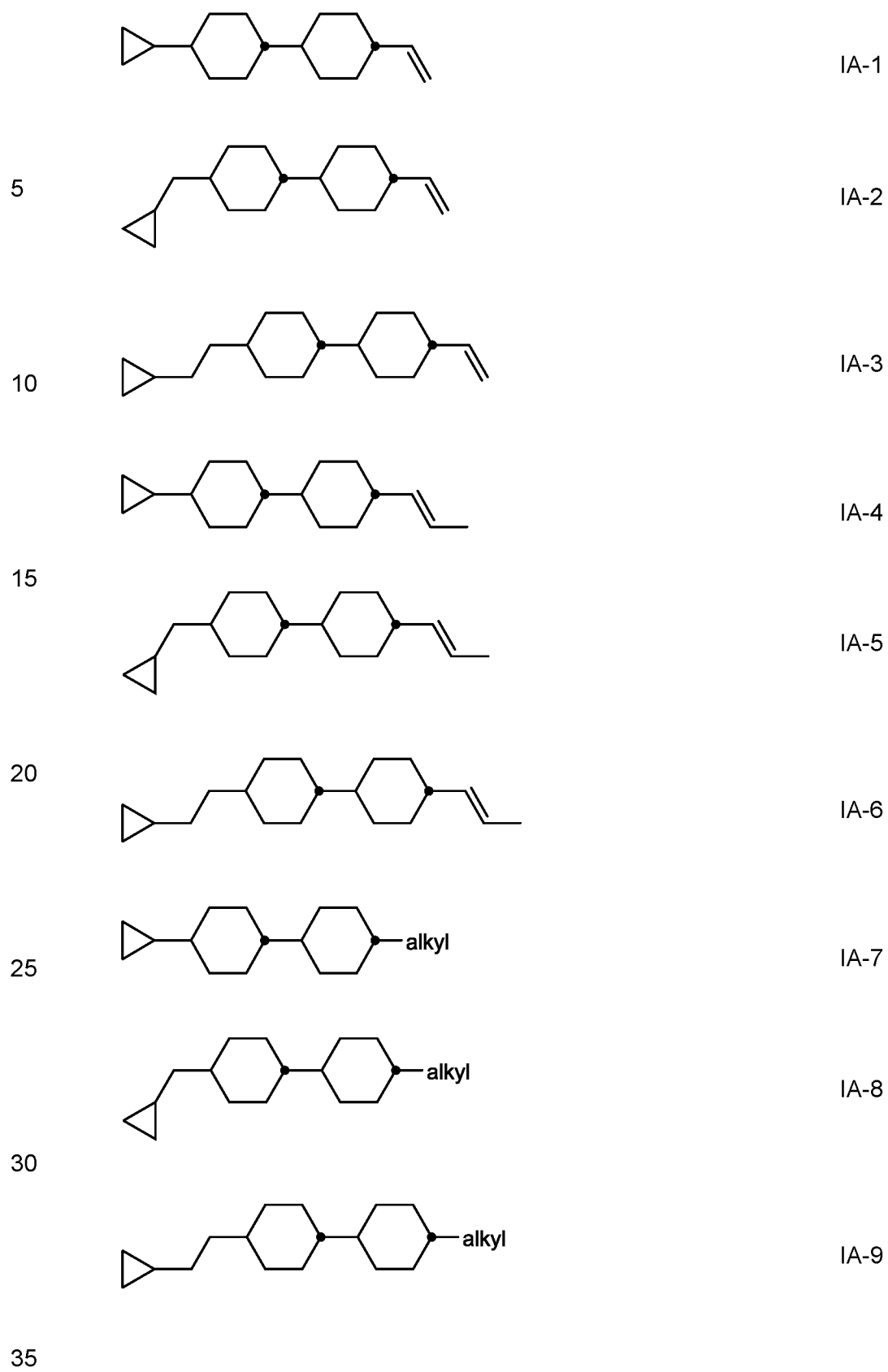
IV-4-1

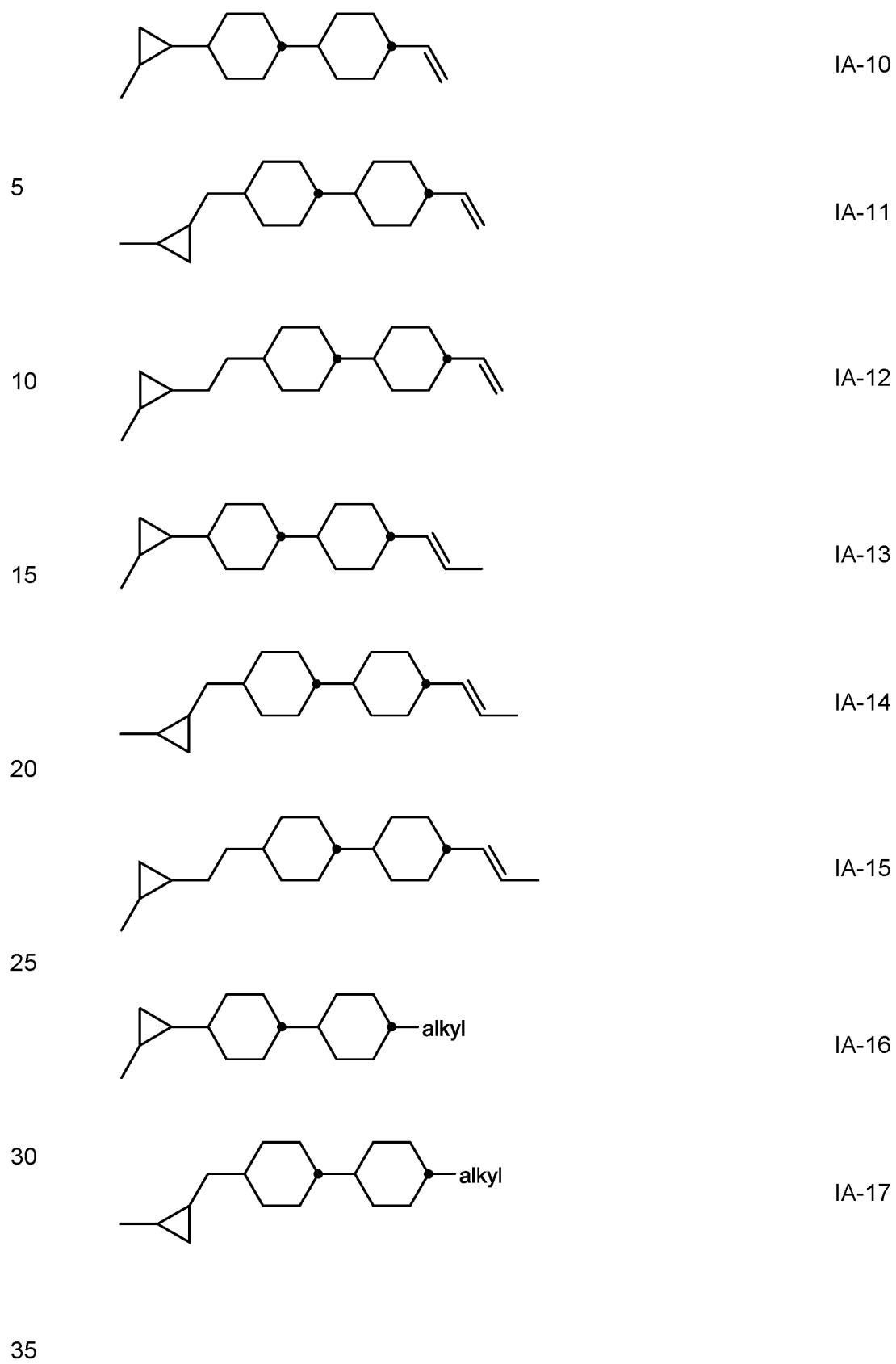
In an embodiment, the medium according to the invention comprises one or more compounds of formula I selected from the compounds of the formulae I-1 to I-4 in combination with one or more compounds selected from the group of compounds of the formulae IA-1 to IA-18:

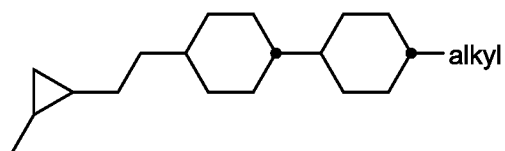
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IV-4-2



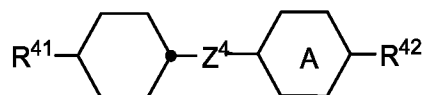




IA-18

in which alkyl denotes methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, or n-pentyl.

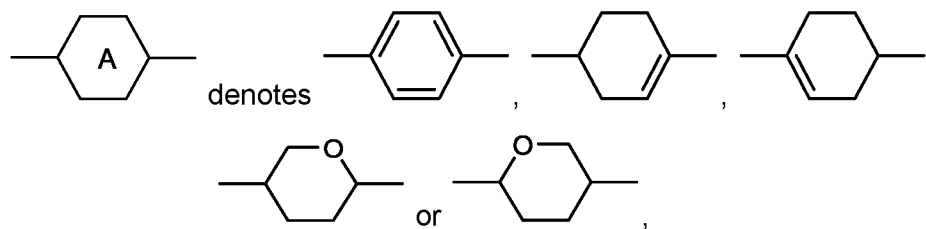
The liquid-crystalline medium preferably additionally comprises one or more compounds of the formula IVa,



IVa

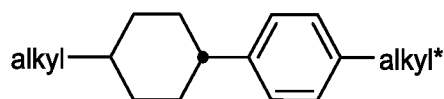
in which

R^{41} and R^{42} each, independently of one another, denote a straight-chain alkyl, alkoxy, alkenyl, alkoxyalkyl or alkoxy radical having up to 12 C atoms, and

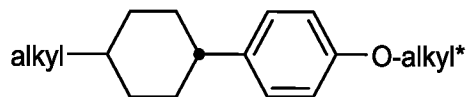


Z^4 denotes a single bond, $-\text{CH}_2\text{CH}_2-$, $-\text{CH}=\text{CH}-$, $-\text{CF}_2\text{O}-$, $-\text{OCF}_2-$, $-\text{CH}_2\text{O}-$, $-\text{OCH}_2-$, $-\text{COO}-$, $-\text{OCO}-$, $-\text{C}_2\text{F}_4-$, $-\text{C}_4\text{H}_8-$, $-\text{CF}=\text{CF}-$.

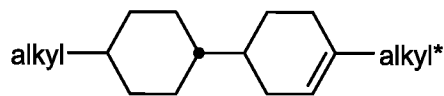
Preferred compounds of the formula IVa are indicated below:



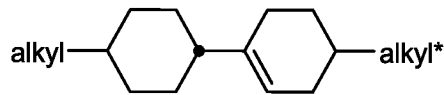
IVa-1



IVa-2



IVa-3



IVa-4

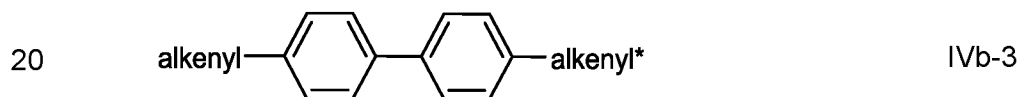
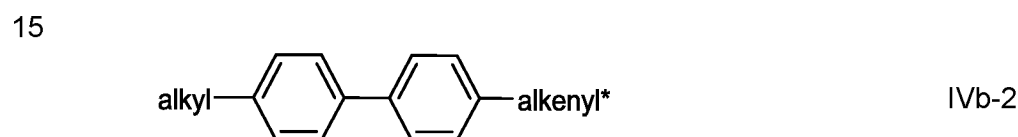
in which

alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1 to 6 C atoms.

5 The medium according to the invention preferably comprises at least one compound of the formula IVa-1 and/or formula IVa-2.

The proportion of compounds of the formula IVa in the mixture as a whole is preferably less than 5 % by weight, very preferably less than 2% by weight.

10 Preferably, the medium comprises one or more compounds of formula IVb-1 to IVb-3



in which

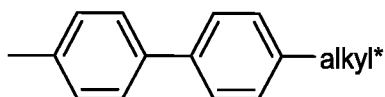
alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1 to 6 C atoms, and

25 alkenyl and alkenyl* each, independently of one another, denote a straight-chain alkenyl radical having 2 to 6 C atoms.

The proportion of the biphenyls of the formulae IV-1 to IV-3 in the mixture as a whole is preferably less than 3 % by weight, in particular less than 2 % by weight.

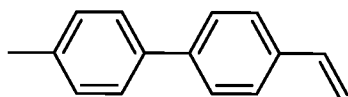
30 Of the compounds of the formulae IVb-1 to IVb-3, the compounds of the formula IVb-2 are particularly preferred.

35 Particularly preferred biphenyls are



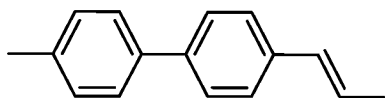
IVb-1-1

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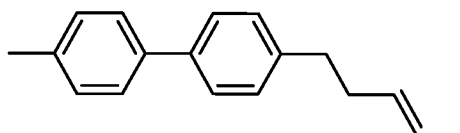


IVb-2-1

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IVb-2-2



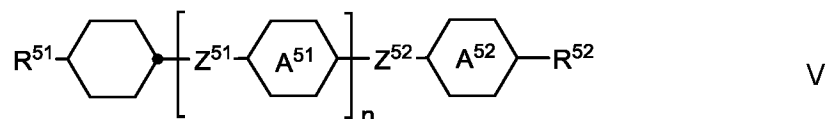
IVb-2-3

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in which alkyl* denotes an alkyl radical having 1 to 6 C atoms and preferably denotes n-propyl. The medium according to the invention particularly preferably comprises one or more compounds of the formulae IVb-1-1 and/or IVb-2-3.

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In a preferred embodiment, the medium according to the invention comprises one or more compounds of formula V



V

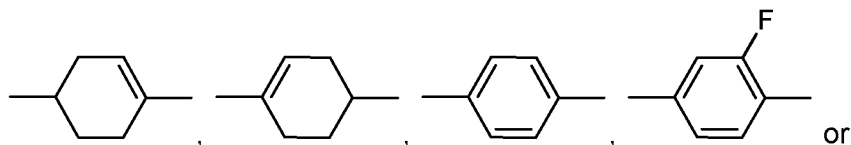
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in which

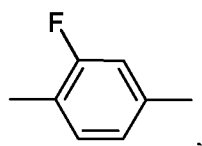
R^{51} , R^{52} denote alkyl having 1 to 7 C atoms, alkoxy having 1 to 7 C atoms, or alkoxyalkyl, alkenyl or alkenyloxy having 2 to 7 C atoms,



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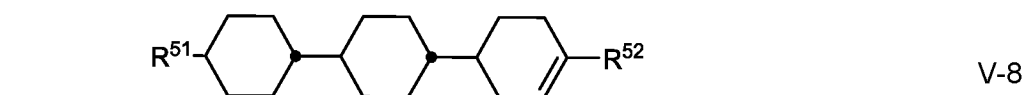
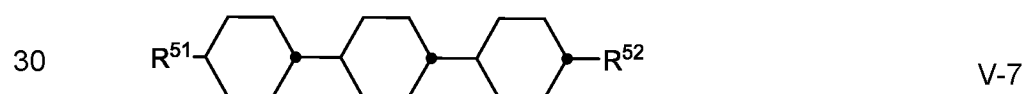
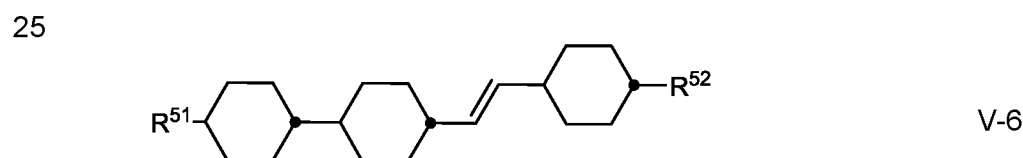
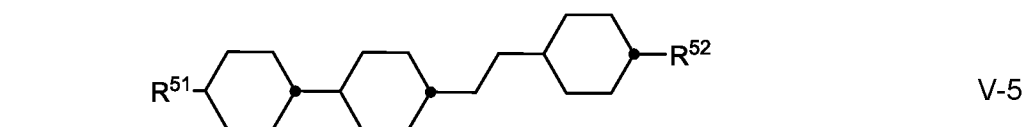
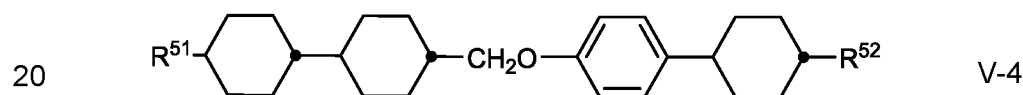
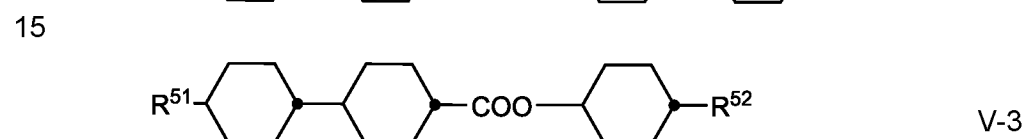
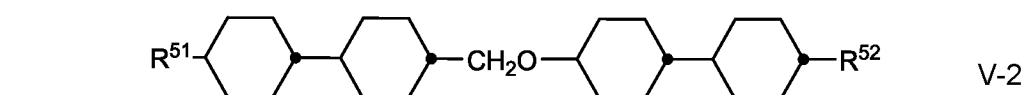
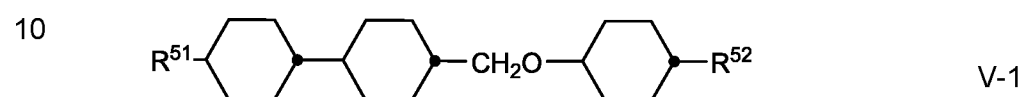
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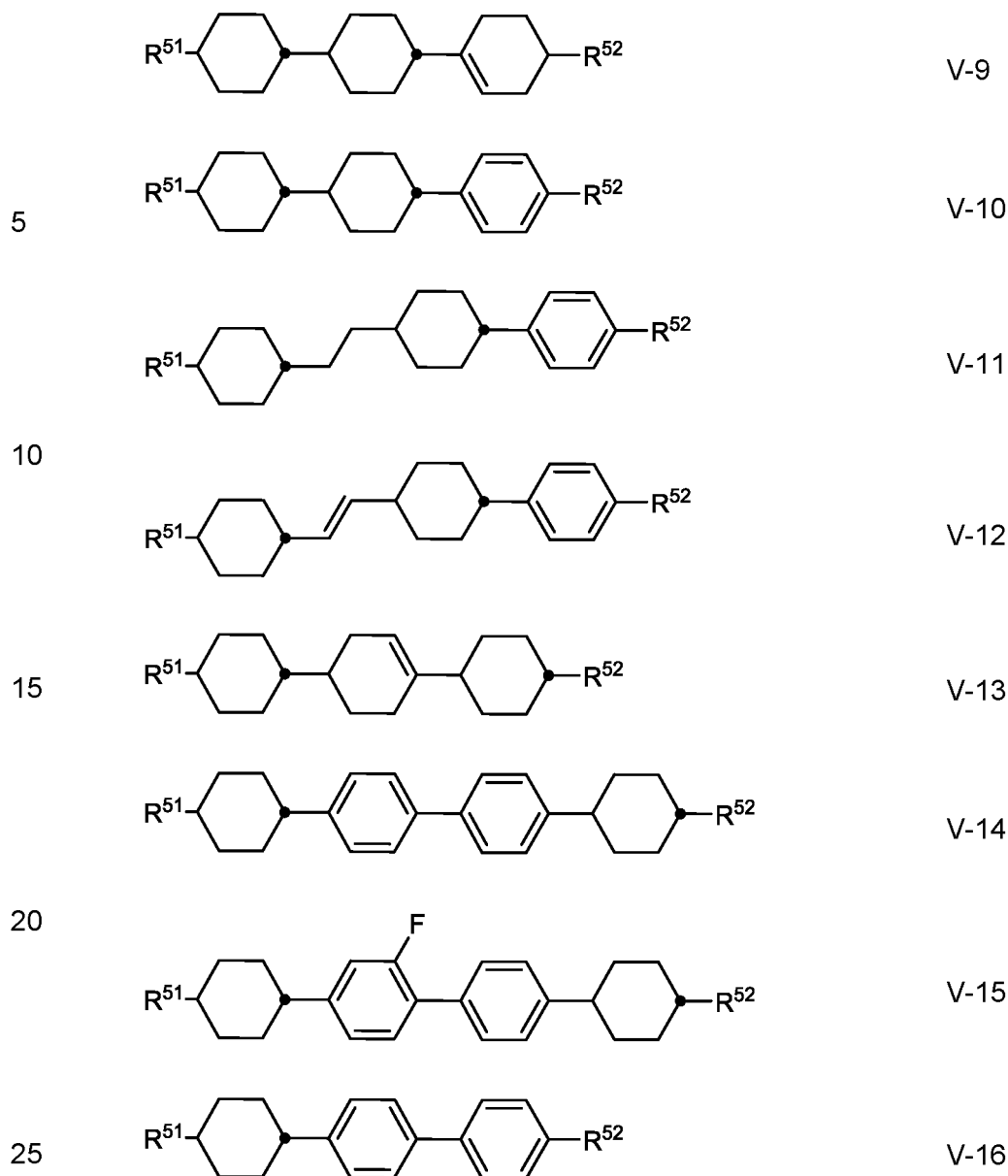
Z^{51} , Z^{52} each, independently of one another, denote $-\text{CH}_2-\text{CH}_2-$, $-\text{CH}_2-\text{O}-$, $-\text{CH}=\text{CH}-$, $-\text{C}\equiv\text{C}-$, $-\text{COO}-$ or a single bond, and n is 1 or 2.

5 Preferably, the compounds of the formula V are selected from the group consisting of the formulae

The compounds of formula V are preferably selected from the compounds of the formulae V-1 to V-16:



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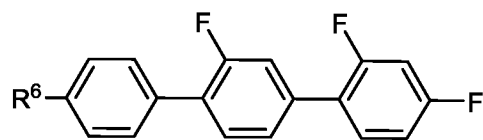


in which R^{51} and R^{52} have the meanings indicated for Formula V above.

R^{51} and R^{52} preferably each, independently of one another, denote straight-chain alkyl having 1 to 7 C atoms or alkenyl having 2 to 7 C atoms.

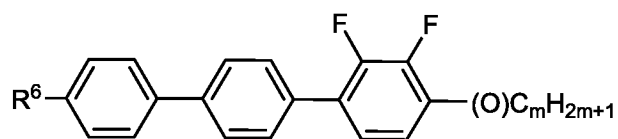
Preferred media comprise one or more compounds of the formulae V-1, V-3, V-4, V-6, V-7, V-10, V-11, V-12, V-14, V-15, and/or V-16, very preferably V-3.

In a preferred embodiment of the present invention the medium additionally comprises one or more compounds of the formulae VI-1 to VI-21,



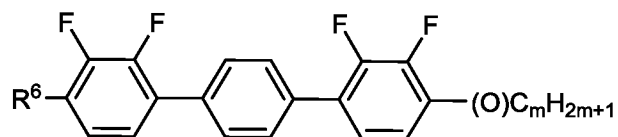
VI-1

5



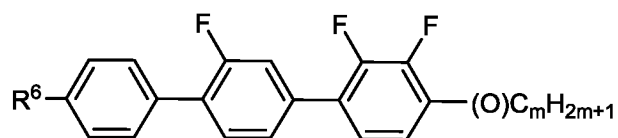
VI-2

10



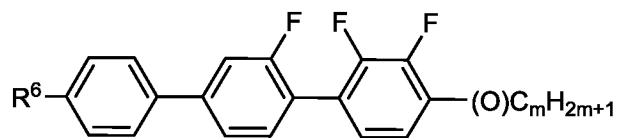
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15



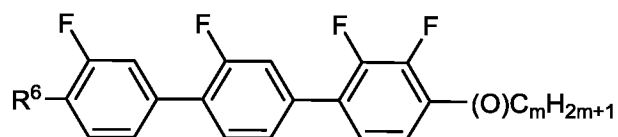
VI-4

20



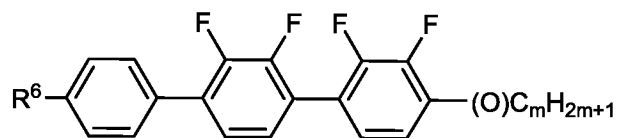
VI-5

25



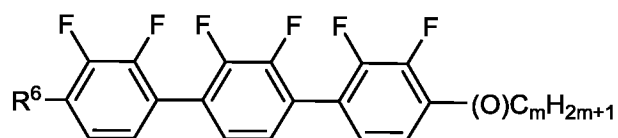
VI-6

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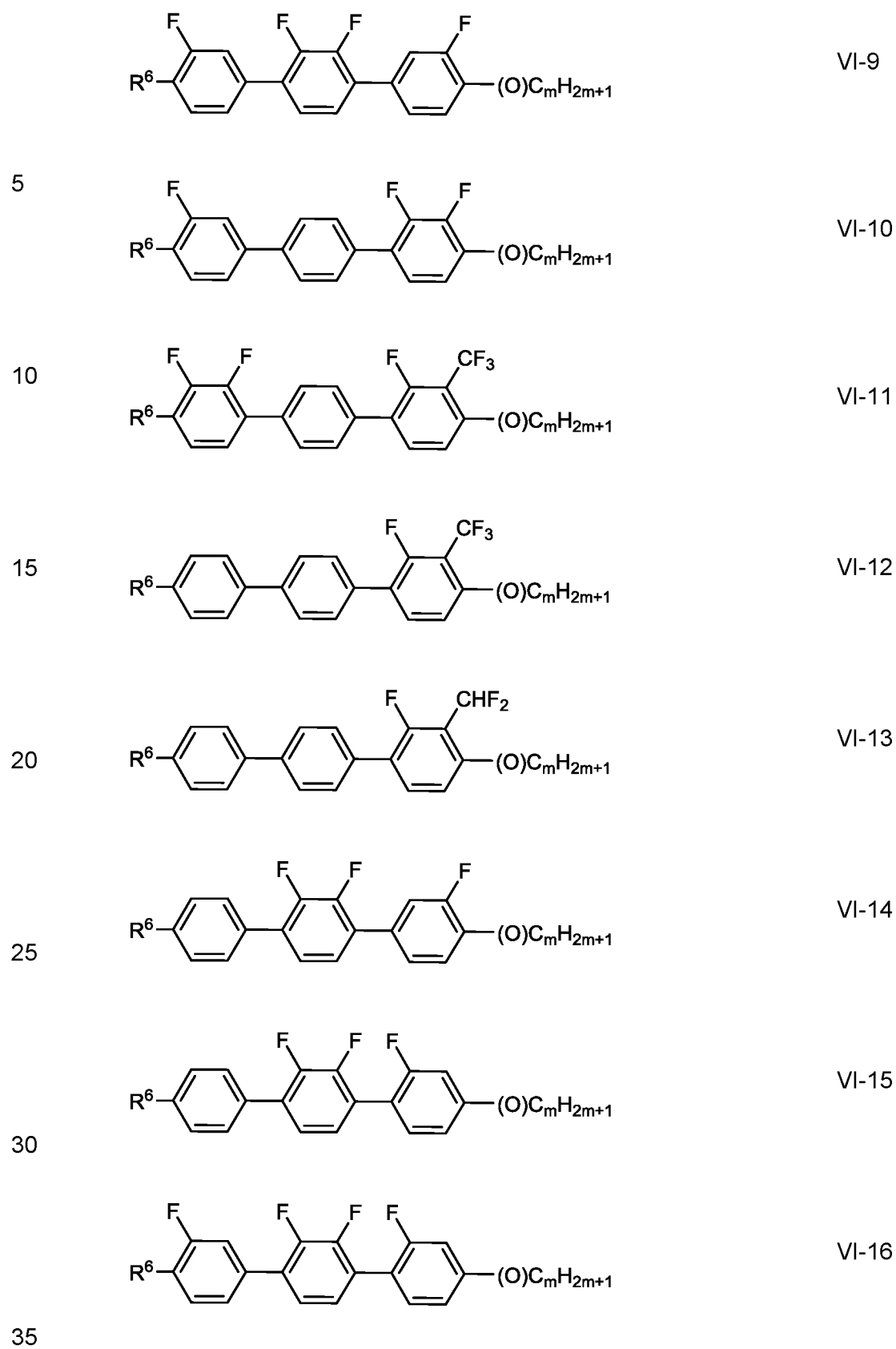


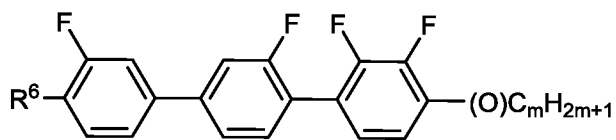
VI-7

35



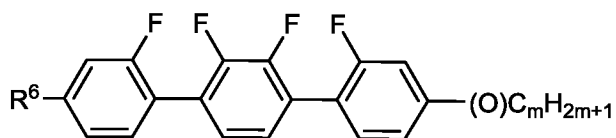
VI-8





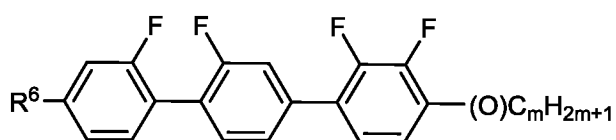
VI-17

5



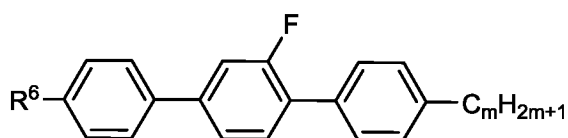
VI-18

10



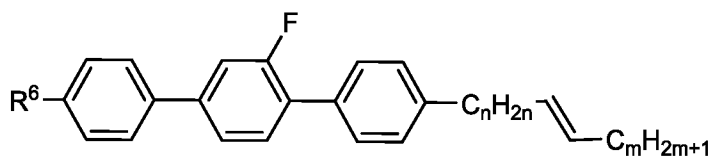
VI-19

15



VI-20

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VI-21

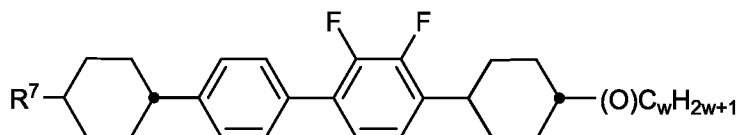
in which R denotes a straight-chain alkyl or alkoxy radical having 1 to 6 C atoms, (O) denotes -O- or a single bond, and m is 0, 1, 2, 3, 4, 5 or 6 and n is 0, 1, 2, 3 or 4.

25

R preferably denotes methyl, ethyl, propyl, butyl, pentyl, hexyl, methoxy, ethoxy, propoxy, butoxy, pentoxy.

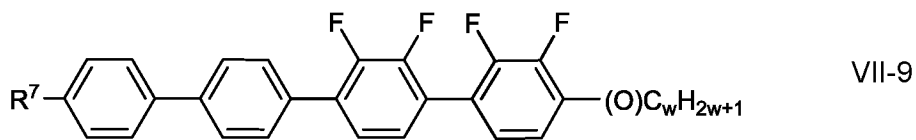
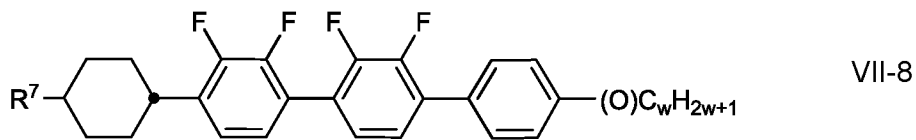
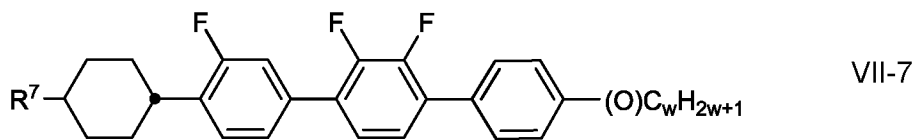
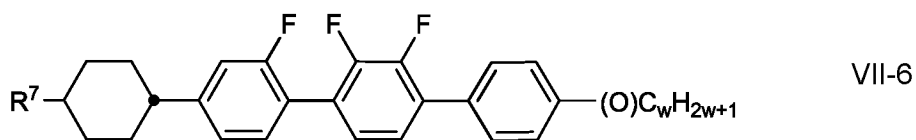
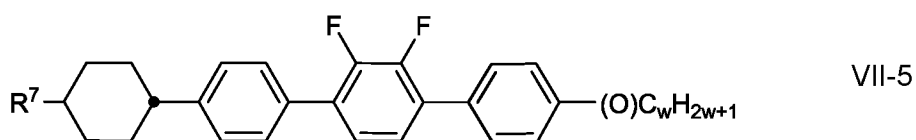
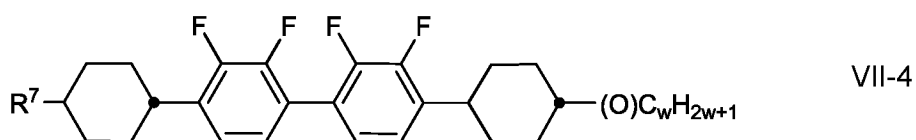
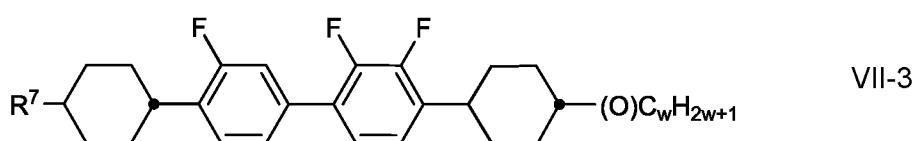
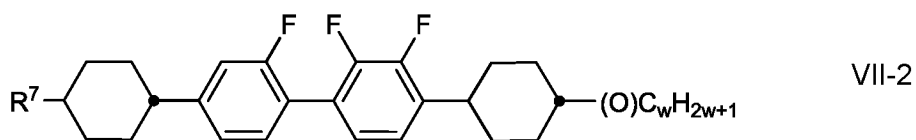
In a preferred embodiment of the present invention the medium additionally comprises one or more compounds of the formulae VII-1 to VII-9

30



VII-1

35



in which

R^7 denotes a straight-chain alkyl or alkoxy radical having 1 to 6 C atoms, or a straight chain alkenyl radical having 2 to 6 C atoms, and

w is an integer from 1 to 6.

Particular preference is given to mixtures comprising at least one compound of the formula V-9.

5

Particular preference is given to compounds of the formulae VI-1, VI-2, VI-4, VI-20 and VI-21. In these compounds, R preferably denotes alkyl, furthermore alkoxy, each having 1 to 5 C atoms. In the compounds of the formula VI-20, R preferably denotes alkyl or alkenyl, in particular alkyl. In the compound of the formula VI-21, R preferably denotes alkyl.

10

Further preferred embodiments are listed below:

- a) Liquid-crystalline medium comprising at least one compound of the formulae Z-1 to Z-7,

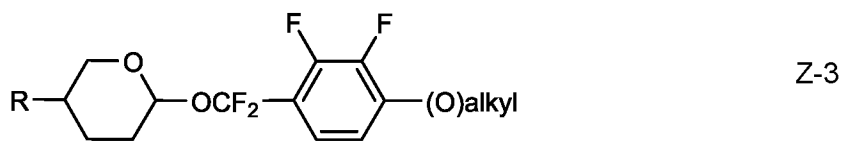
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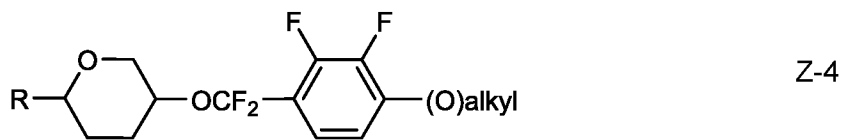
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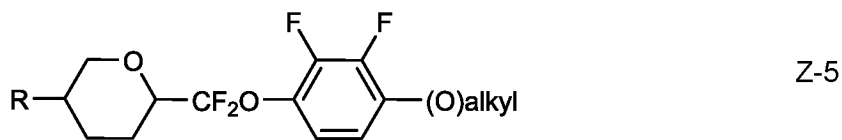
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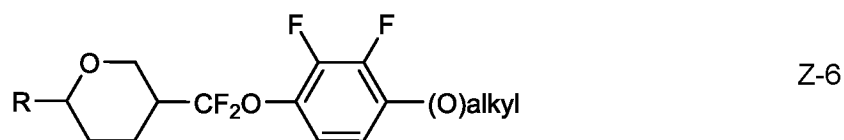


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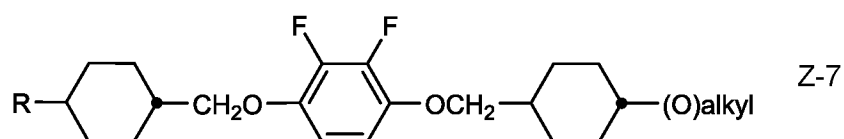


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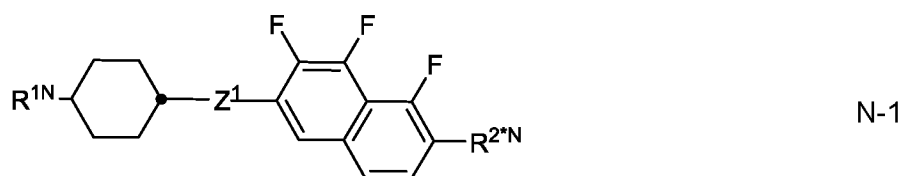


in which R and alkyl have the meanings indicated above for formula III.

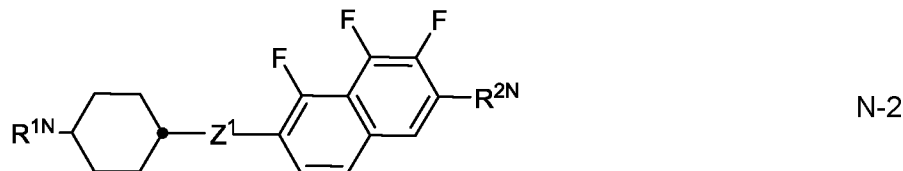
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- b) Preferred liquid-crystalline media according to the invention comprise one or more substances which contain a tetrahydronaphthyl or naphthyl unit, such as, for example, the compounds of the formulae N-1 to N-5,

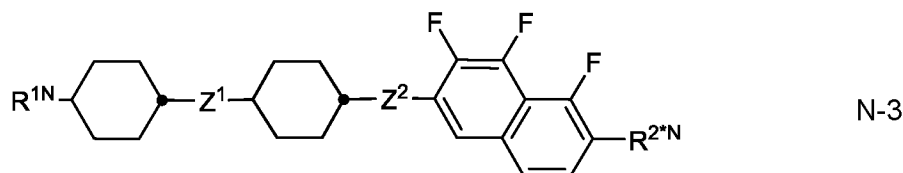
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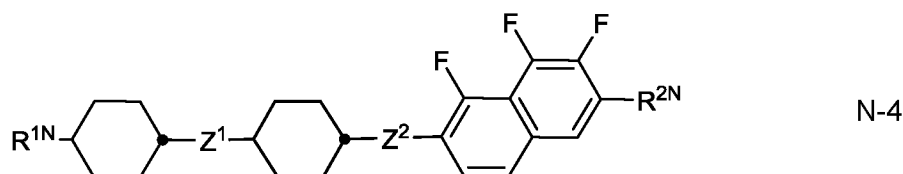
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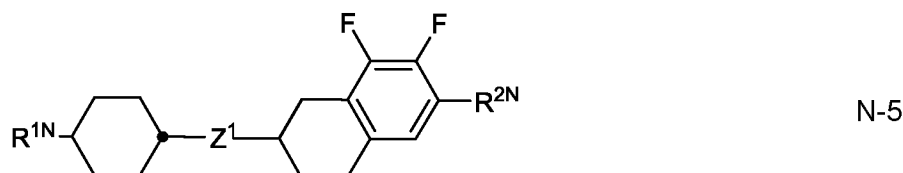
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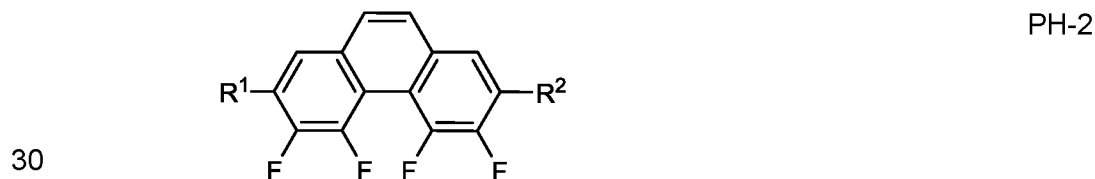
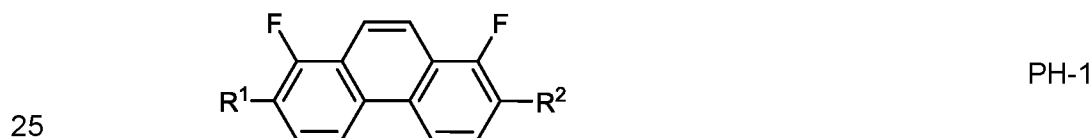
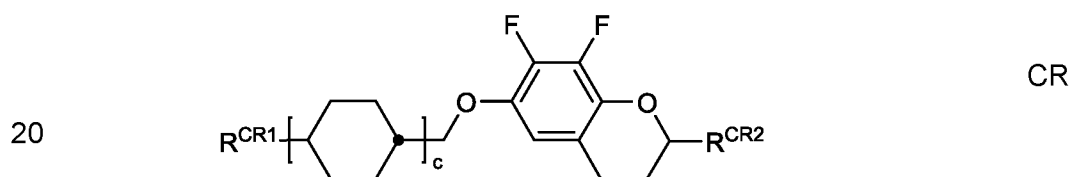
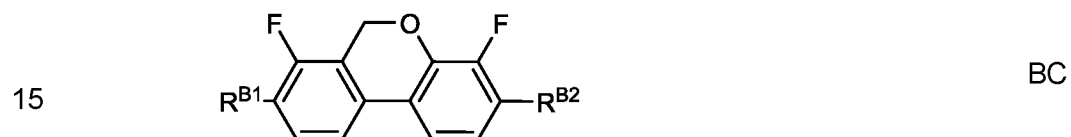


in which R^{1N} and R^{2N} each, independently of one another, have the meanings indicated for R^{2A} , preferably denote straight-chain alkyl, straight-chain alkoxy or straight-chain alkenyl, and

Z^1 and Z^2 each, independently of one another,

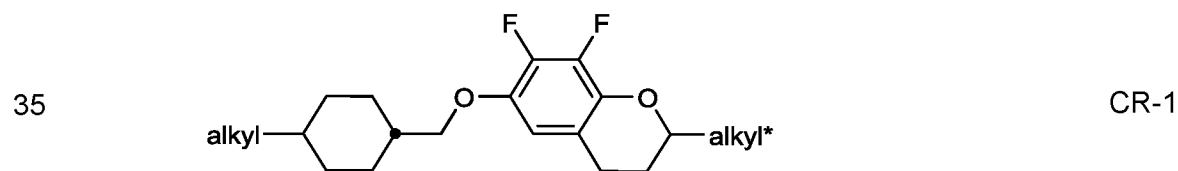
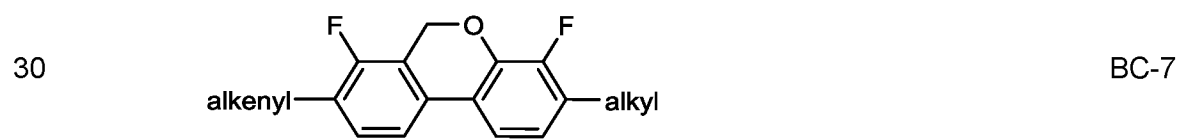
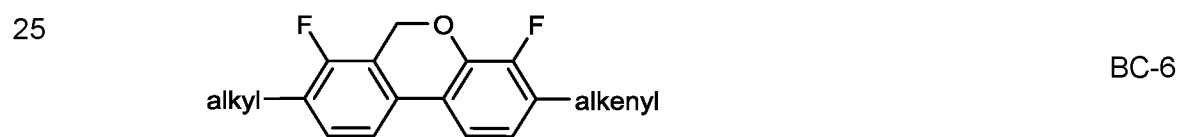
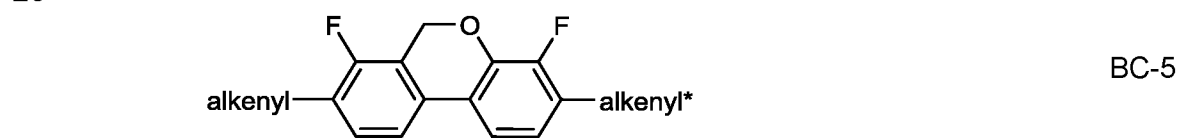
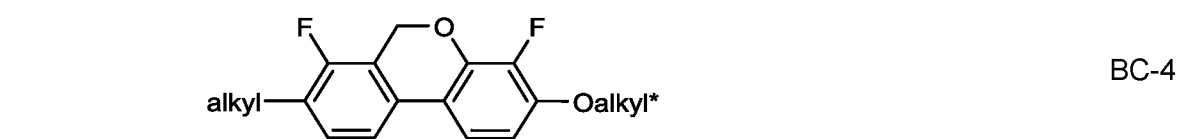
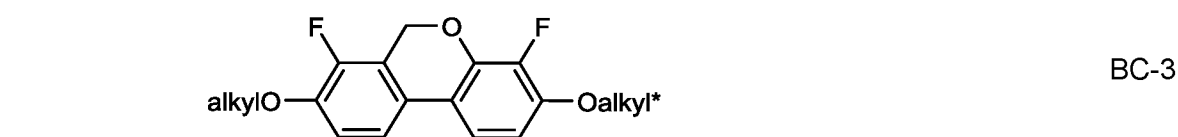
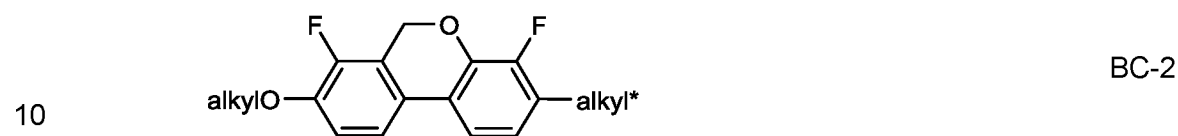
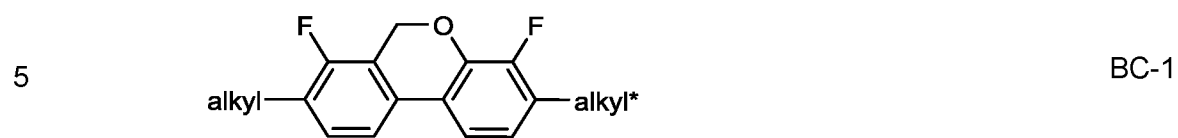
5 denote $-C_2H_4-$, $-CH=CH-$, $-(CH_2)_4-$, $-(CH_2)_3O-$, $-O(CH_2)_3-$, $-CH=CHCH_2CH_2-$, $-CH_2CH_2CH=CH-$, $-CH_2O-$, $-OCH_2-$, $-COO-$, $-OCO-$, $-C_2F_4-$, $-CF=CF-$, $-CF=CH-$, $-CH=CF-$, $-CF_2O-$, $-OCF_2-$, $-CH_2-$ or a single bond.

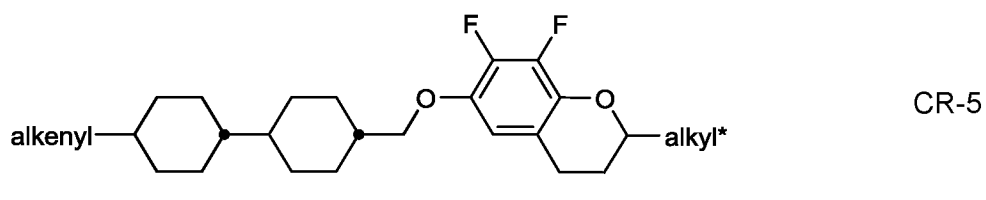
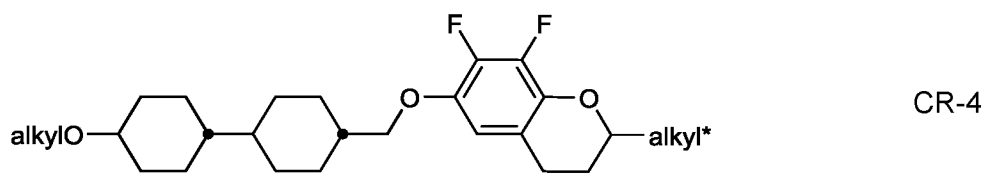
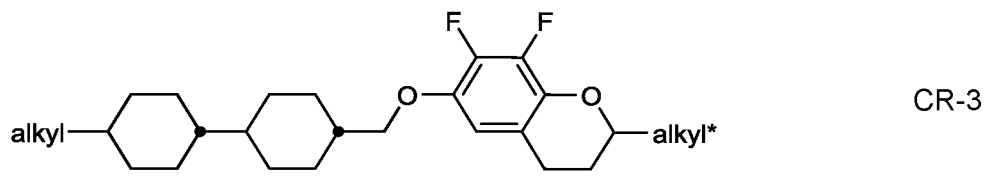
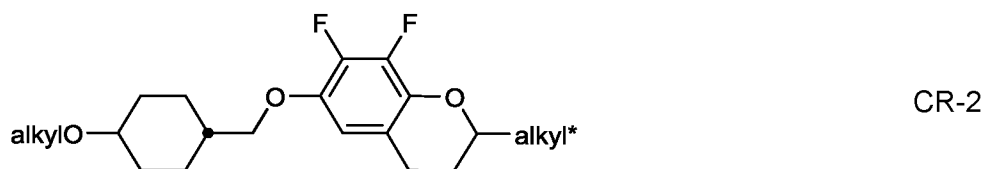
10 c) Preferred mixtures comprise one or more compounds selected from the group of the difluorodibenzochroman compounds of the formula BC, chromans of the formula CR, and fluorinated phenanthrenes of the formulae PH-1 and PH-2,



in which R^{B1} , R^{B2} , R^{CR1} , R^{CR2} , R^1 , R^2 each, independently of one another, have the meaning of R^{2A} . c is 0, 1 or 2. R^1 and R^2 preferably, independently of one another, denote alkyl or alkoxy having 1 to 6 C atoms.

Particularly preferred compounds of the formulae BC and CR are the compounds BC-1 to BC-7 and CR-1 to CR-5,





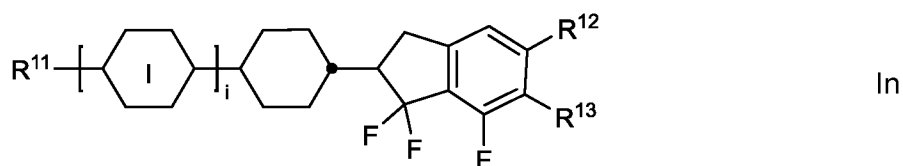
in which

alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1 to 6 C atoms, and

alkenyl and alkenyl* each, independently of one another, denote a straight-chain alkenyl radical having 2 to 6 C atoms.

Very particular preference is given to mixtures comprising one, two or three compounds of the formula BC-2, BF-1 and/or BF-2.

d) Preferred mixtures comprise one or more indane compounds of the formula In,

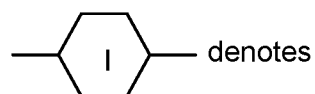


in which

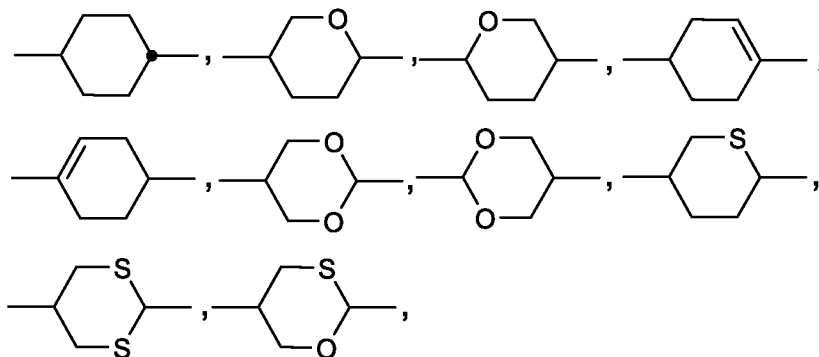
R^{11} , R^{12} , and R^{13} each, independently of one another, denote a straight-chain alkyl, alkoxy, alkoxyalkyl or alkenyl radical having 1 to 6 C atoms,

R^{12} and R^{13} alternatively denote halogen, preferably F,

5



10



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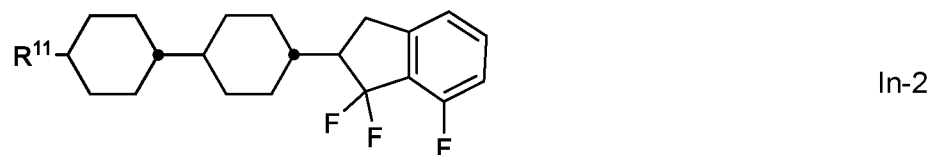
i denotes 0, 1 or 2.

Preferred compounds of the formula In are the compounds of the formulae In-1 to In-16 indicated below:

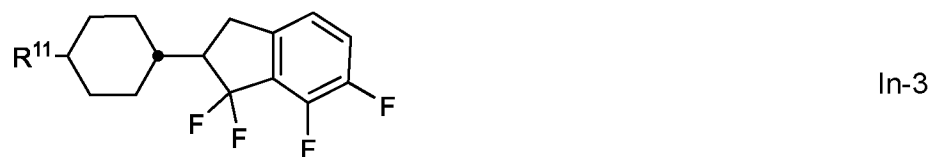
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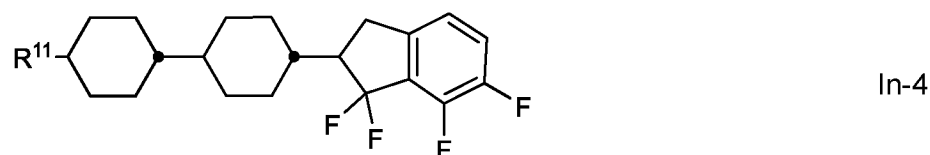
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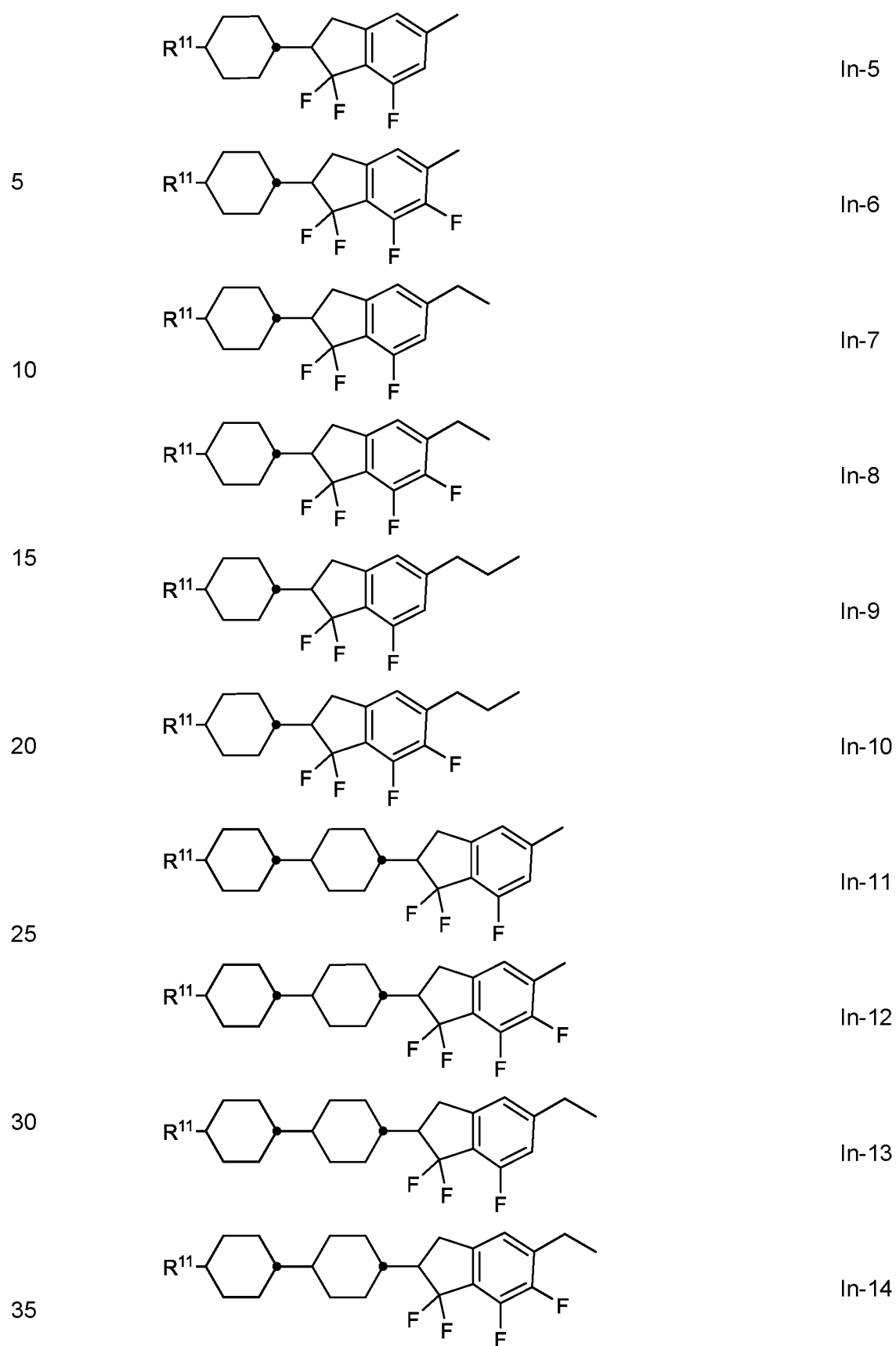


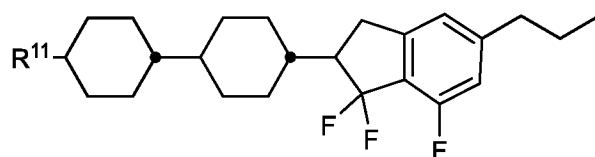
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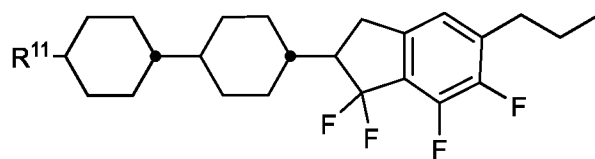






In-15

5



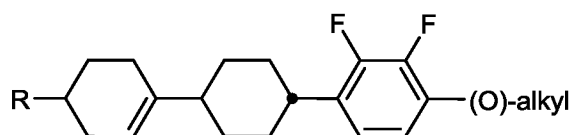
In-16.

Particular preference is given to the compounds of the formulae In-1, In-2, In-3 and In-4.

10

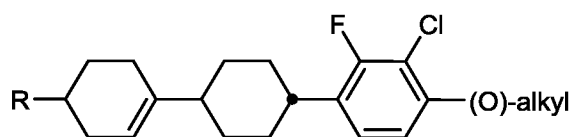
- e) Preferred mixtures additionally comprise one or more compounds of the formulae L-1 to L-5,

15

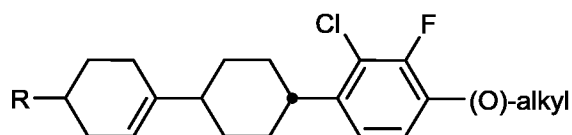


L-1

20

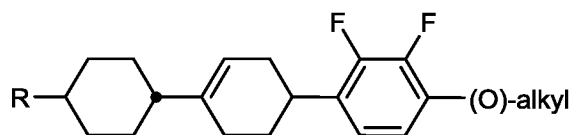


L-2



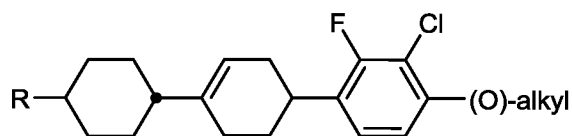
L-3

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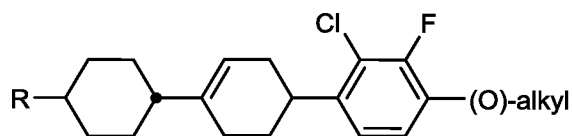


L-4

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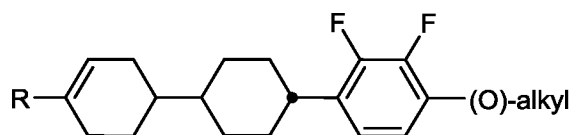


L-5

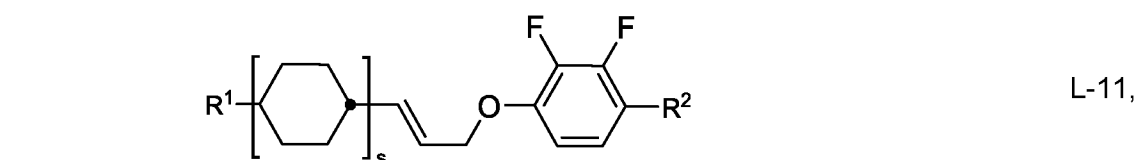
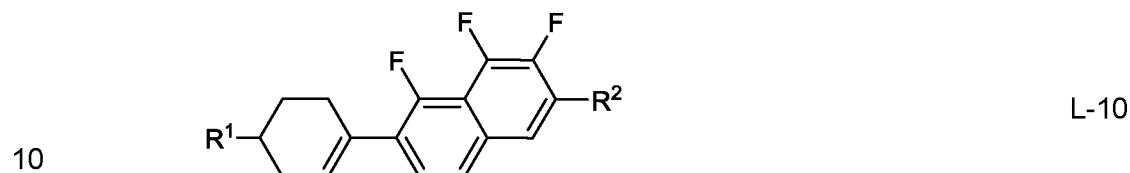
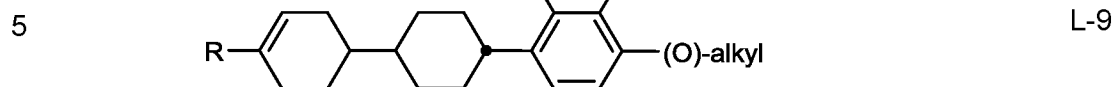
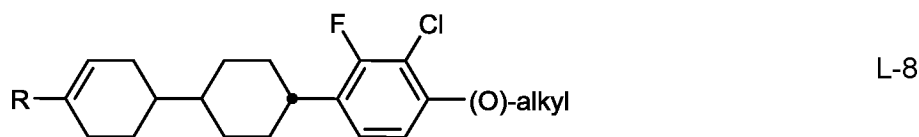


L-6

35



L-7



in which

R, R¹ and R² each, independently of one another, have the meanings indicated for R^{2A} in formula IIA above, and alkyl denotes an alkyl radical having 1 to 6 C atoms. The parameter s denotes 1 or 2.

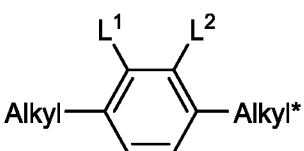
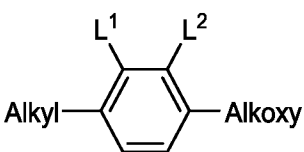
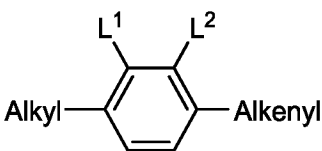
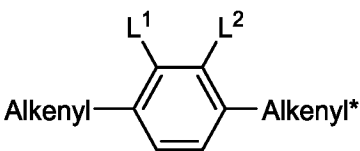
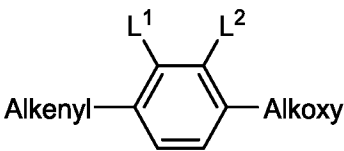
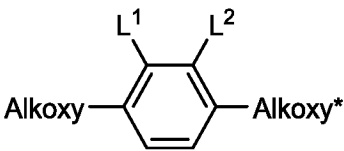
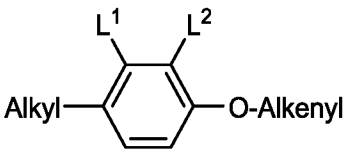
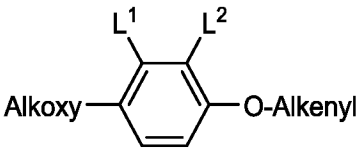
20 The compounds of the formulae L-1 to L-9 are preferably employed in concentrations of 5 to 15 % by weight, in particular 5 to 12 % by weight and very particularly preferably 8 to 10 % by weight.

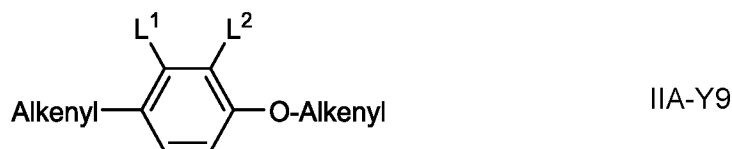
25 f) Preferred mixtures additionally comprise one or more compounds of formula IIA-Y



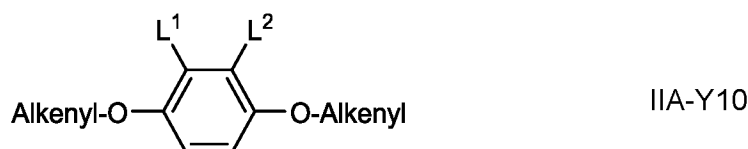
30 in which R¹¹ and R¹² have one of the meanings given for R^{2A} in formula IIA above, and L¹ and L², identically or differently, denote F or Cl.

35 Preferred compounds of the formula IIA-Y are selected from the group consisting of the following sub-formulae

		IIA-Y1
5		IIA-Y2
10		IIA-Y3
15		IIA-Y4
20		IIA-Y5
25		IIA-Y6
30		IIA-Y7
35		IIA-Y8



5



10

in which, Alkyl and Alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms, Alkoxy denotes a straight-chain alkoxy radical having 1-6 C atoms, Alkenyl and Alkenyl* each, independently of one another, denote a straight-chain alkenyl radical having 2-6 C atoms, and O denotes an oxygen atom or a single bond. Alkenyl and Alkenyl* preferably denote $\text{CH}_2=\text{CH}-$, $\text{CH}_2=\text{CHCH}_2\text{CH}_2-$, $\text{CH}_3-\text{CH}=\text{CH}-$, $\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}-$, $\text{CH}_3-(\text{CH}_2)_2-\text{CH}=\text{CH}-$, $\text{CH}_3-(\text{CH}_2)_3-\text{CH}=\text{CH}-$ or $\text{CH}_3-\text{CH}=\text{CH}-(\text{CH}_2)_2-$.

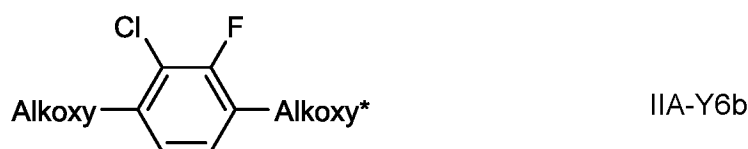
15

Particularly preferred compounds of the formula IIA-Y are selected from the group consisting of following sub-formulae:

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25



30

in which Alkoxy and Alkoxy* have the meanings defined above and preferably denote methoxy, ethoxy, n-propyloxy, n-butyloxy or n-pentyloxy.

35

The term "reliability" as used herein means the quality of the performance of the display during time and with different stress loads, such as light load, temperature, humidity, voltage, and comprises display effects such as image sticking (area and

line image sticking), mura, yogore etc. which are known to the skilled person in the field of LC displays. As a standard parameter for categorising the reliability usually the voltage holding ration (VHR) value is used, which is a measure for maintaining a constant electrical voltage in a test display. Among other factors, a high VHR is a prerequisite for a high reliability of the LC medium.

Unless indicated otherwise, the term "PSA" is used hereinafter when referring to displays of the polymer sustained alignment type in general, and the term "PS" is used when referring to specific display modes, like PS-VA, PS-TN and the like.

Also, unless indicated otherwise, the term "RM" is used hereinafter when referring to a polymerisable mesogenic or liquid-crystalline compound.

As used herein, the terms "active layer" and "switchable layer" mean a layer in an electrooptical display, for example an LC display, that comprises one or more molecules having structural and optical anisotropy, like for example LC molecules, which change their orientation upon an external stimulus like an electric or magnetic field, resulting in a change of the transmission of the layer for polarized or unpolarized light.

As used herein, the terms "tilt" and "tilt angle" will be understood to mean a tilted alignment of the LC molecules of an LC medium relative to the surfaces of the cell in an LC display (here preferably a PSA display). The tilt angle here denotes the average angle ($< 90^\circ$) between the longitudinal molecular axes of the LC molecules (LC director) and the surface of the plane-parallel outer plates which form the LC cell. A low value for the tilt angle (i.e. a large deviation from the 90° angle) corresponds to a large tilt here. A suitable method for measurement of the tilt angle is given in the examples. Unless indicated otherwise, tilt angle values disclosed above and below relate to this measurement method.

As used herein, the terms "reactive mesogen" and "RM" will be understood to mean a compound containing a mesogenic or liquid crystalline skeleton, and one or more functional groups attached thereto which are suitable for polymerisation and are also referred to as "polymerisable group" or "P".

Unless stated otherwise, the term "polymerisable compound" as used herein will be understood to mean a polymerisable monomeric compound.

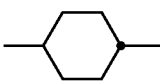
5 As used herein, the term "low-molecular-weight compound" will be understood to mean to a compound that is monomeric and/or is not prepared by a polymerisation reaction, as opposed to a "polymeric compound" or a "polymer".

10 As used herein, the term "unpolymerisable compound" will be understood to mean a compound that does not contain a functional group that is suitable for polymerisation under the conditions usually applied for the polymerisation of the RMs.

15 The term "mesogenic group" as used herein is known to the person skilled in the art and described in the literature, and means a group which, due to the anisotropy of its attracting and repelling interactions, essentially contributes to causing a liquid-crystal (LC) phase in low-molecular-weight or polymeric substances. Compounds containing mesogenic groups (mesogenic compounds) do not necessarily have to have an LC phase themselves. It is also possible for mesogenic compounds to exhibit LC phase behaviour only after mixing with other compounds and/or after
20 polymerisation. Typical mesogenic groups are, for example, rigid rod- or disc-shaped units. An overview of the terms and definitions used in connection with mesogenic or LC compounds is given in *Pure Appl. Chem.* 2001, 73(5), 888 and C. Tschierske, G. Pelzl, S. Diele, *Angew. Chem.* **2004**, 116, 6340-6368.

25 As used herein, the terms "optically active" and "chiral" are synonyms for materials that are able to induce a helical pitch in a nematic host material, also referred to as "chiral dopants".

30 The term "spacer group", hereinafter also referred to as "Sp", as used herein is known to the person skilled in the art and is described in the literature, see, for example, *Pure Appl. Chem.* 2001, 73(5), 888 and C. Tschierske, G. Pelzl, S. Diele, *Angew. Chem.* **2004**, 116, 6340-6368. As used herein, the terms "spacer group" or "spacer" mean a flexible group, for example an alkylene group, which connects the
35 mesogenic group and the polymerisable group(s) in a polymerisable mesogenic compound.

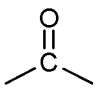
Above and below,  denotes a trans-1,4-cyclohexylene ring.

5 In a group  the single bond shown between the two ring atoms can be attached to any free position of the benzene ring.

Above and below "organic group" denotes a carbon or hydrocarbon group.

10 "Carbon group" denotes a mono- or polyvalent organic group containing at least one carbon atom, where this either contains no further atoms (such as, for example, $-\text{C}\equiv\text{C}-$) or optionally contains one or more further atoms, such as, for example, N, O, S, B, P, Si, Se, As, Te or Ge (for example carbonyl, etc.). The term "hydrocarbon group" denotes a carbon group which additionally contains one or
15 more H atoms and optionally one or more heteroatoms, such as, for example, N, O, S, B, P, Si, Se, As, Te or Ge.

"Halogen" denotes F, Cl, Br or I, preferably F or Cl.

20 $-\text{CO}-$, $-\text{C}(=\text{O})-$ and $-\text{C}(\text{O})-$ denote a carbonyl group, i.e. .

A carbon or hydrocarbon group can be a saturated or unsaturated group.

25 Unsaturated groups are, for example, aryl, alkenyl or alkynyl groups. A carbon or hydrocarbon radical having more than 3 C atoms can be straight-chain, branched and/or cyclic and may also contain spiro links or condensed rings.

30 The terms "alkyl", "aryl", "heteroaryl", etc., also encompass polyvalent groups, for example alkylene, arylene, heteroarylene, etc.

The term "aryl" denotes an aromatic carbon group or a group derived therefrom. The term "heteroaryl" denotes "aryl" as defined above, containing one or more heteroatoms, preferably selected from N, O, S, Se, Te, Si and Ge.

35 Preferred carbon and hydrocarbon groups are optionally substituted, straight-chain, branched or cyclic, alkyl, alkenyl, alkynyl, alkoxy, alkylcarbonyl, alkoxy carbonyl,

alkylcarbonyloxy and alkoxycarbonyloxy having 1 to 40, preferably 1 to 20, very preferably 1 to 12, C atoms, optionally substituted aryl or aryloxy having 5 to 30, preferably 6 to 25, C atoms, or optionally substituted alkylaryl, arylalkyl, alkylaryloxy, arylalkyloxy, arylcarbonyl, aryloxy carbonyl, arylcarbonyloxy and aryloxy carbonyloxy having 5 to 30, preferably 6 to 25, C atoms, wherein one or more C atoms may also be replaced by hetero atoms, preferably selected from N, O, S, Se, Te, Si and Ge.

Further preferred carbon and hydrocarbon groups are C₁-C₂₀ alkyl, C₂-C₂₀ alkenyl, C₂-C₂₀ alkynyl, C₃-C₂₀ allyl, C₄-C₂₀ alkyldienyl, C₄-C₂₀ polyenyl, C₆-C₂₀ cycloalkyl, C₄-C₁₅ cycloalkenyl, C₆-C₃₀ aryl, C₆-C₃₀ alkylaryl, C₆-C₃₀ arylalkyl, C₆-C₃₀ alkylaryloxy, C₆-C₃₀ arylalkyloxy, C₂-C₃₀ heteroaryl, C₂-C₃₀ heteroaryloxy.

Particular preference is given to C₁-C₁₂ alkyl, C₂-C₁₂ alkenyl, C₂-C₁₂ alkynyl, C₆-C₂₅ aryl and C₂-C₂₅ heteroaryl.

Further preferred carbon and hydrocarbon groups are straight-chain, branched or cyclic alkyl having 1 to 20, preferably 1 to 12, C atoms, which are unsubstituted or mono- or polysubstituted by F, Cl, Br, I or CN and in which one or more non-adjacent CH₂ groups may each be replaced, independently of one another, by -C(R^x)=C(R^x)-, -C≡-, -N(R^x)-, -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a way that O and/or S atoms are not linked directly to one another.

R^x preferably denotes H, F, Cl, CN, a straight-chain, branched or cyclic alkyl chain having 1 to 25 C atoms, in which, in addition, one or more non-adjacent C atoms may be replaced by -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- and in which one or more H atoms may be replaced by F or Cl, or denotes an optionally substituted aryl or aryloxy group with 6 to 30 C atoms, or an optionally substituted heteroaryl or heteroaryloxy group with 2 to 30 C atoms.

Preferred alkyl groups are, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, s-butyl, t-butyl, 2-methylbutyl, n-pentyl, s-pentyl, cyclopentyl, n-hexyl, cyclohexyl, 2-ethylhexyl, n-heptyl, cycloheptyl, n-octyl, cyclooctyl, n-nonyl, n-decyl,

n-undecyl, n-dodecyl, dodecanyl, trifluoromethyl, perfluoro-n-butyl, 2,2,2-trifluoroethyl, perfluorooctyl, perfluorohexyl, etc.

5 Preferred alkenyl groups are, for example, ethenyl, propenyl, butenyl, pentenyl, cyclopentenyl, hexenyl, cyclohexenyl, heptenyl, cycloheptenyl, octenyl, cyclooctenyl, etc.

10 Preferred alkynyl groups are, for example, ethynyl, propynyl, butynyl, pentynyl, hexynyl, octynyl, etc.

15 Preferred alkoxy groups are, for example, methoxy, ethoxy, 2-methoxyethoxy, n-propoxy, i-propoxy, n-butoxy, i-butoxy, s-butoxy, t-butoxy, 2-methylbutoxy, n-pentoxy, n-hexoxy, n-heptoxy, n-octoxy, n-nonoxo, n-decoxy, n-undecoxy, n-dodecoxy, etc.

Preferred amino groups are, for example, dimethylamino, methylamino, methylphenylamino, phenylamino, etc.

20 Aryl and heteroaryl groups can be monocyclic or polycyclic, i.e. they can contain one ring (such as, for example, phenyl) or two or more rings, which may also be fused (such as, for example, naphthyl) or covalently bonded (such as, for example, biphenyl), or contain a combination of fused and linked rings. Heteroaryl groups contain one or more heteroatoms, preferably selected from O, N, S and Se.

25 Particular preference is given to mono-, bi- or tricyclic aryl groups having 6 to 25 C atoms and mono-, bi- or tricyclic heteroaryl groups having 5 to 25 ring atoms, which optionally contain fused rings and are optionally substituted. Preference is furthermore given to 5-, 6- or 7-membered aryl and heteroaryl groups, in which, in
30 addition, one or more CH groups may be replaced by N, S or O in such a way that O atoms and/or S atoms are not linked directly to one another.

Preferred aryl groups are, for example, phenyl, biphenyl, terphenyl,
35 [1,1':3',1'']terphenyl-2'-yl, naphthyl, anthracene, binaphthyl, phenanthrene, 9,10-

dihydro-phenanthrene, pyrene, dihydropyrene, chrysene, perylene, tetracene, pentacene, benzopyrene, fluorene, indene, indenofluorene, spirobifluorene, etc.

Preferred heteroaryl groups are, for example, 5-membered rings, such as pyrrole,
5 pyrazole, imidazole, 1,2,3-triazole, 1,2,4-triazole, tetrazole, furan, thiophene,
selenophene, oxazole, isoxazole, 1,2-thiazole, 1,3-thiazole, 1,2,3-oxadiazole,
1,2,4-oxadiazole, 1,2,5-oxadiazole, 1,3,4-oxadiazole, 1,2,3-thiadiazole, 1,2,4-
thiadiazole, 1,2,5-thiadiazole, 1,3,4-thiadiazole, 6-membered rings, such as pyridine,
10 pyridazine, pyrimidine, pyrazine, 1,3,5-triazine, 1,2,4-triazine, 1,2,3-triazine, 1,2,4,5-
tetrazine, 1,2,3,4-tetrazine, 1,2,3,5-tetrazine, or condensed groups, such as indole,
isoindole, indolizine, indazole, benzimidazole, benzotriazole, purine,
naphthimidazole, phenanthrimidazole, pyridimidazole, pyrazinimidazole,
quinoxalinimidazole, benzoxazole, naphthoxazole, anthroxazole, phenanthroxazole,
15 isoxazole, benzothiazole, benzofuran, isobenzofuran, dibenzofuran, quinoline,
isoquinoline, pteridine, benzo-5,6-quinoline, benzo-6,7-quinoline, benzo-7,8-
quinoline, benzoisoquinoline, acridine, phenothiazine, phenoxazine,
benzopyridazine, benzopyrimidine, quinoxaline, phenazine, naphthyridine, aza-
carbazole, benzocarboline, phenanthridine, phenanthroline, thieno[2,3b]thiophene,
20 thieno[3,2b]thiophene, dithienothiophene, isobenzothiophene, dibenzothiophene,
benzothiophene, benzothiadiazo thiophene, or combinations of these groups.

The aryl and heteroaryl groups mentioned above and below may also be substituted
25 by alkyl, alkoxy, thioalkyl, fluorine, fluoroalkyl or further aryl or heteroaryl groups.

The (non-aromatic) alicyclic and heterocyclic groups encompass both saturated
rings, i.e. those containing exclusively single bonds, and also partially unsaturated
rings, i.e. those which may also contain multiple bonds. Heterocyclic rings contain
30 one or more heteroatoms, preferably selected from Si, O, N, S and Se.

The (non-aromatic) alicyclic and heterocyclic groups can be monocyclic, i.e. contain
only one ring (such as, for example, cyclohexane), or polycyclic, i.e. contain a
plurality of rings (such as, for example, decahydronaphthalene or bicyclooctane).
35 Particular preference is given to saturated groups. Preference is furthermore given
to mono-, bi- or tricyclic groups having 5 to 25 ring atoms, which optionally contain

fused rings and are optionally substituted. Preference is furthermore given to 5-, 6-, 7- or 8-membered carbocyclic groups, in which, in addition, one or more C atoms may be replaced by Si and/or one or more CH groups may be replaced by N and/or one or more non-adjacent CH₂ groups may be replaced by -O- and/or -S-.

5

Preferred alicyclic and heterocyclic groups are, for example, 5-membered groups, such as cyclopentane, tetrahydrofuran, tetrahydrothiofuran, pyrrolidine, 6-membered groups, such as cyclohexane, silinane, cyclohexene, tetrahydropyran, tetrahydrothiopyran, 1,3-dioxane, 1,3-dithiane, piperidine, 7-membered groups, such as cycloheptane, and fused groups, such as tetrahydronaphthalene, decahydronaphthalene, indane, bicyclo[1.1.1]pentane-1,3-diyl, bicyclo[2.2.2]octane-1,4-diyl, spiro[3.3]heptane-2,6-diyl, octahydro-4,7-methanoindane-2,5-diyl.

10

15

Preferred substituents are, for example, solubility-promoting groups, such as alkyl or alkoxy, electron-withdrawing groups, such as fluorine, nitro or nitrile, or substituents for increasing the glass transition temperature (T_g) in the polymer, in particular bulky groups, such as, for example, t-butyl or optionally substituted aryl groups.

20

Preferred substituents, hereinafter also referred to as "L^S", are, for example, F, Cl, Br, I, -CN, -NO₂, -NCO, -NCS, -OCN, -SCN, -C(=O)N(R^x)₂, -C(=O)Y¹, -C(=O)R^x, -N(R^x)₂, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy each having 1 to 25 C atoms, in which one or more H atoms may optionally be replaced by F or Cl, optionally substituted silyl having 1 to 20 Si atoms, or optionally substituted aryl having 6 to 25, preferably 6 to 15, C atoms,

25

30

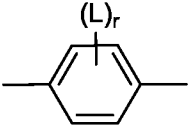
wherein R^x denotes H, F, Cl, CN, or straight chain, branched or cyclic alkyl having 1 to 25 C atoms, wherein one or more non-adjacent CH₂-groups are optionally replaced by -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a manner that O- and/or S-atoms are not directly connected with each other, and wherein one or more H atoms are each optionally replaced by F, Cl, P- or P-Sp-, and

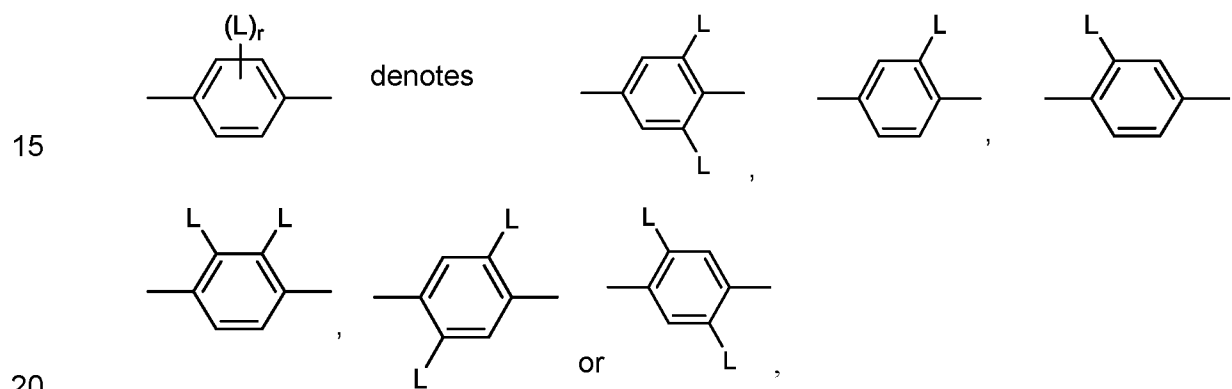
Y¹ denotes halogen.

35

"Substituted silyl or aryl" preferably means substituted by halogen, -CN, R^0 , -OR⁰, -CO-R⁰, -CO-O-R⁰, -O-CO-R⁰ or -O-CO-O-R⁰, wherein R⁰ denotes H or alkyl with 1 to 20 C atoms.

- 5 Particularly preferred substituents L are, for example, F, Cl, CN, NO₂, CH₃, C₂H₅, OCH₃, OC₂H₅, COCH₃, COC₂H₅, COOCH₃, COOC₂H₅, CF₃, OCF₃, OCHF₂, OC₂F₅, furthermore phenyl.

10 A¹ and A² very preferably denote  in which L has one of the meanings indicated above and r denotes 0, 1, 2, 3 or 4, in particular



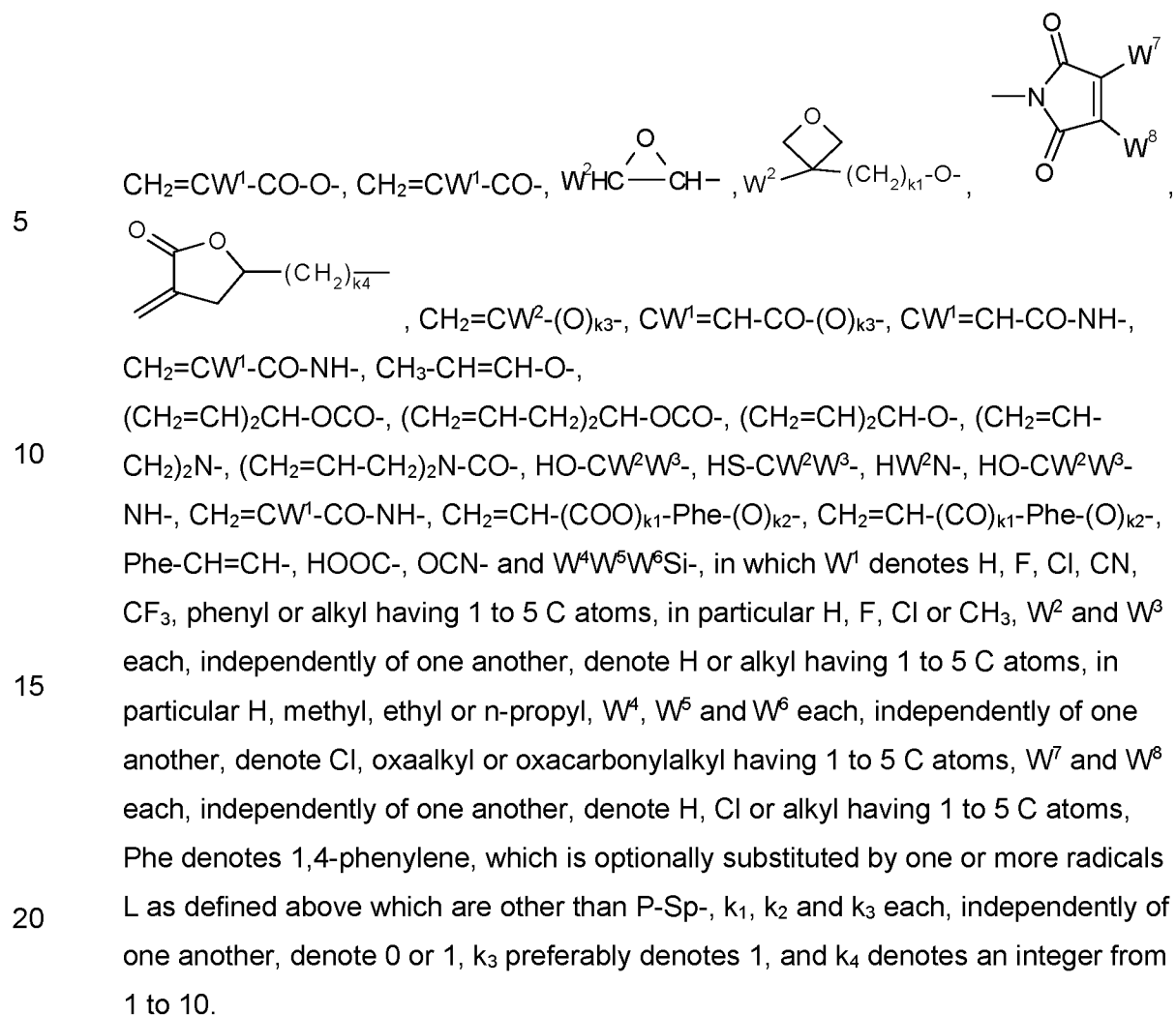
The polymerisable group P is a group which is suitable for a polymerisation reaction, such as, for example, free-radical or ionic chain polymerisation, polyaddition or polycondensation, or for a polymer-analogous reaction, for example addition or

25 condensation onto a main polymer chain. Particular preference is given to groups for chain polymerisation, in particular those containing a C=C double bond or -C≡C- triple bond, and groups which are suitable for polymerisation with ring opening, such as, for example, oxetane or epoxide groups.

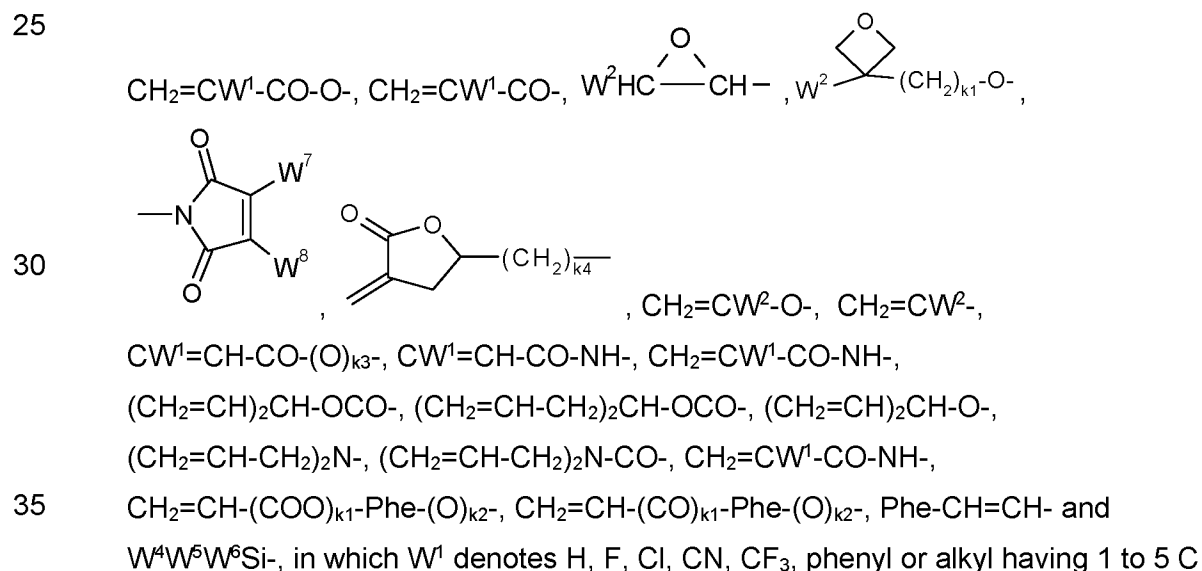
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Preferred groups P are selected from the group consisting of

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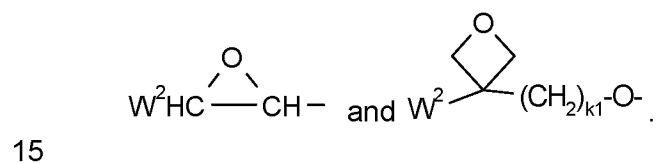


Very preferred groups P are selected from the group consisting of



atoms, in particular H, F, Cl or CH₃, W² and W³ each, independently of one another, denote H or alkyl having 1 to 5 C atoms, in particular H, methyl, ethyl or n-propyl, W⁴, W⁵ and W⁶ each, independently of one another, denote Cl, oxaalkyl or oxa-carbonylalkyl having 1 to 5 C atoms, W⁷ and W⁸ each, independently of one
 5 another, denote H, Cl or alkyl having 1 to 5 C atoms, Phe denotes 1,4-phenylene, k₁, k₂ and k₃ each, independently of one another, denote 0 or 1, k₃ preferably denotes 1, and k₄ denotes an integer from 1 to 10.

Very particularly preferred groups P are selected from the group consisting of
 10 CH₂=CW¹-CO-O-, in particular CH₂=CH-CO-O-, CH₂=C(CH₃)-CO-O- and CH₂=CF-CO-O-, furthermore CH₂=CH-O-, (CH₂=CH)₂CH-O-CO-, (CH₂=CH)₂CH-O-,



Further preferred polymerisable groups P are selected from the group consisting of vinyloxy, acrylate, methacrylate, fluoroacrylate, chloroacrylate, oxetane and epoxide, most preferably from acrylate and methacrylate.

20 If the spacer group Sp is different from a single bond, it is preferably of the formula Sp"-X", so that the respective radical P-Sp- conforms to the formula R-Sp"-X"-, wherein

25 Sp" denotes linear or branched alkylene having 1 to 20, preferably 1 to 12, 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 each be replaced, independently of one another, by -O-, -S-,
 -NH-, -N(R⁰)-, -Si(R⁰R⁰⁰)-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -S-CO-,
 30 -CO-S-, -N(R⁰⁰)-CO-O-, -O-CO-N(R⁰)-, -N(R⁰)-CO-N(R⁰⁰)-, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not linked directly to one another,

X" denotes -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O-, -CO-N(R⁰)-,
 -N(R⁰)-CO-, -N(R⁰)-CO-N(R⁰⁰)-, -OCH₂-, -CH₂O-, -SCH₂-, -CH₂S-,
 35 -CF₂O-, -OCF₂-, -CF₂S-, -SCF₂-, -CF₂CH₂-, -CH₂CF₂-, -CF₂CF₂-,

-CH=N-, -N=CH-, -N=N-, -CH=CR⁰-, -CY²=CY³-, -C≡C-,
 -CH=CH-CO-O-, -O-CO-CH=CH- or a single bond,

5 R⁰ and R⁰⁰ each, independently of one another, denote H or alkyl having 1 to 20 C atoms, and

Y² and Y³ each, independently of one another, denote H, F, Cl or CN.

10 X" is preferably -O-, -S-, -CO-, -COO-, -OCO-, -O-COO-, -CO-NR⁰-,
 -NR⁰-CO-, -NR⁰-CO-NR⁰⁰- or a single bond.

15 Typical spacer groups Sp and -Sp"-X"- are, for example, -(CH₂)_{p1}-, -(CH₂)_{p1}-O-, -(CH₂)_{p1}-O-CO-, -(CH₂)_{p1}-CO-O-, -(CH₂)_{p1}-O-CO-O-, -(CH₂CH₂O)_{q1}-CH₂CH₂-, -CH₂CH₂-S-CH₂CH₂-, -CH₂CH₂-NH-CH₂CH₂- or -(SiR⁰R⁰⁰-O)_{p1}-, in which p₁ is an integer from 1 to 12, q₁ is an integer from 1 to 3, and R⁰ and R⁰⁰ have the meanings indicated above.

20 Particularly preferred groups Sp and -Sp"-X"- are -(CH₂)_{p1}-, -(CH₂)_{p1}-O-, -(CH₂)_{p1}-O-CO-, -(CH₂)_{p1}-CO-O-, -(CH₂)_{p1}-O-CO-O-, in which p₁ and q₁ have the meanings indicated above.

25 Particularly preferred groups Sp" are, in each case straight-chain, ethylene, propylene, butylene, pentylene, hexylene, heptylene, octylene, nonylene, decylene, undecylene, dodecylene, octadecylene, ethyleneoxyethylene, methyleneoxybutylene, ethylenethioethylene, ethylene-N-methyliminoethylene, 1-methylalkylene, ethenylene, propenylene and butenylene.

30 In a preferred embodiment of the invention the compounds of formula P and its subformulae contain a spacer group Sp that is substituted by one or more polymerisable groups P, so that the group Sp-P corresponds to Sp(P)_s, with s being ≥2 (branched polymerisable groups).

35 Preferred compounds of formula P according to this preferred embodiment are those wherein s is 2, i.e. compounds which contain a group Sp(P)₂. Very preferred

compounds of formula P according to this preferred embodiment contain a group selected from the following formulae:

5	-X-alkyl-CHPP	S1
	-X-alkyl-CH((CH ₂) _{aa} P)((CH ₂) _{bb} P)	S2
	-X-N((CH ₂) _{aa} P)((CH ₂) _{bb} P)	S3
10	-X-alkyl-CHP-CH ₂ -CH ₂ P	S4
	-X-alkyl-C(CH ₂ P)(CH ₂ P)-C _{aa} H _{2aa+1}	S5
15	-X-alkyl-CHP-CH ₂ P	S6
	-X-alkyl-CPP-C _{aa} H _{2aa+1}	S7
	-X-alkyl-CHPCHP-C _{aa} H _{2aa+1}	S8

20

in which P is as defined in formula P,

alkyl denotes a single bond or straight-chain or branched alkylene having 1 to 12 C atoms which is unsubstituted or mono- or polysubstituted by F, Cl or CN and in which one or more non-adjacent CH₂ groups may each, independently of one another, be replaced by -C(R⁰)=C(R⁰)-, -C≡C-, -N(R⁰)-, -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a way that O and/or S atoms are not linked directly to one another, where R⁰ has the meaning indicated above,

30

aa and bb each, independently of one another, denote 0, 1, 2, 3, 4, 5 or 6,

X has one of the meanings indicated for X", and is preferably O, CO, SO₂, O-CO-, CO-O or a single bond.

35

Preferred spacer groups Sp(P)₂ are selected from formulae S1, S2 and S3.

Very preferred spacer groups $\text{Sp}(\text{P})_2$ are selected from the following subformulae:

5	-CHPP	S1a
	-O-CHPP	S1b
	-CH ₂ -CHPP	S1c
10	-OCH ₂ -CHPP	S1d
	-CH(CH ₂ -P)(CH ₂ -P)	S2a
15	-OCH(CH ₂ -P)(CH ₂ -P)	S2b
	-CH ₂ -CH(CH ₂ -P)(CH ₂ -P)	S2c
	-OCH ₂ -CH(CH ₂ -P)(CH ₂ -P)	S2d
20	-CO-NH((CH ₂) ₂ P)((CH ₂) ₂ P)	S3a

In the compounds of formula P and its subformulae as described above and below, P is preferably selected from the group consisting of vinyloxy, acrylate, methacrylate, fluoroacrylate, chloroacrylate, oxetane and epoxide, most preferably from acrylate and methacrylate.

Further preferred are compounds of formula P and its subformulae as described above and below, wherein all polymerisable groups P that are present in the compound have the same meaning, and very preferably denote acrylate or methacrylate, most preferably methacrylate.

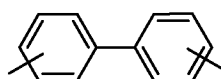
In the compounds of formula P and its subformulae as described above and below, R preferably denotes P-Sp-.

Further preferred are compounds of formula P and its subformulae as described above and below, wherein Sp denotes a single bond or $-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-$, $-O-CO-(CH_2)_{p1}$, or $-CO-O-(CH_2)_{p1}$, wherein p1 is 2, 3, 4, 5 or 6, and, if Sp is $-O-(CH_2)_{p1}-$, $-O-CO-(CH_2)_{p1}$ or $-CO-O-(CH_2)_{p1}$ the O-atom or CO-group, respectively, is linked to the benzene ring.

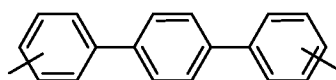
Further preferred are compounds of formula P and its subformulae as described above and below, wherein at least one group Sp is a single bond.

Further preferred are compounds of formula P and its subformulae as described above and below, wherein at least one group Sp is different from a single bond, and is preferably selected from $-(CH_2)_{p1}-$, $-O-(CH_2)_{p1}-$, $-O-CO-(CH_2)_{p1}$, or $-CO-O-(CH_2)_{p1}$, wherein p1 is 2, 3, 4, 5 or 6, and, if Sp is $-O-(CH_2)_{p1}-$, $-O-CO-(CH_2)_{p1}$ or $-CO-O-(CH_2)_{p1}$ the O-atom or CO-group, respectively, is linked to the benzene ring.

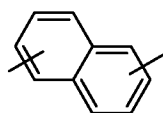
Very preferred groups $-A^1-(Z-A^2)_z-$ in formula P are selected from the following formulae



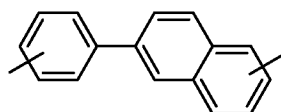
A1



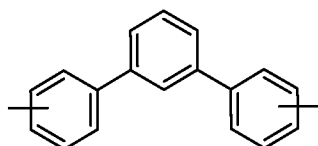
A2



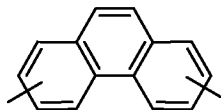
A3



A4



A5



A6

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wherein at least one benzene ring is substituted by at least one group L and the benzene rings are optionally further substituted by one or more groups L or P-Sp-.

10

Preferred compounds of formula P and their subformulae are selected from the following preferred embodiments, including any combination thereof:

15

- All groups P in the compound have the same meaning,
- $-A^1-(Z-A^2)_z-$ is selected from formulae A1, A2 and A5,
- the compounds contain exactly two polymerizable groups (represented by the groups P),
- the compounds contain exactly three polymerizable groups (represented by the groups P),
- P is selected from the group consisting of acrylate, methacrylate and oxetane, very preferably acrylate or methacrylate,
- P is methacrylate,
- all groups Sp are a single bond,
- at least one of the groups Sp is a single bond and at least one of the groups Sp is different from a single bond,
- Sp, when being different from a single bond, is $-(CH_2)_{p2}-$, $-(CH_2)_{p2}-O-$, $-(CH_2)_{p2}-CO-O-$, $-(CH_2)_{p2}-O-CO-$, wherein p2 is 2, 3, 4, 5 or 6, and the O-atom or the CO-group, respectively, is connected to the benzene ring,
- Sp is a single bond or denotes $-(CH_2)_{p2}-$, $-(CH_2)_{p2}-O-$, $-(CH_2)_{p2}-CO-O-$, $-(CH_2)_{p2}-O-CO-$, wherein p2 is 2, 3, 4, 5 or 6, and the O-atom or the CO-group, respectively, is connected to the benzene ring,
- R denotes P-Sp-,
- R does not denote or contain a polymerizable group,
- R does not denote or contain a polymerizable group and denotes straight chain, branched or cyclic alkyl having 1 to 25 C atoms, wherein one or more non-adjacent CH₂-groups are optionally replaced by -O-,

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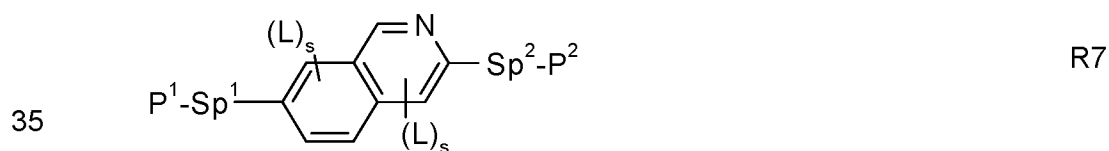
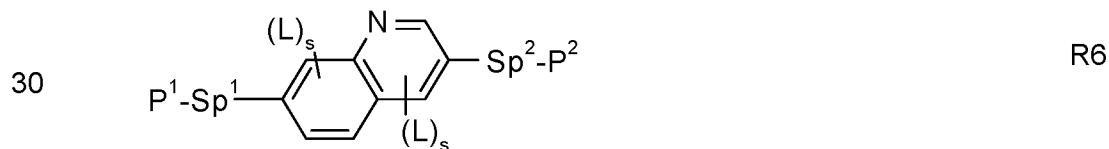
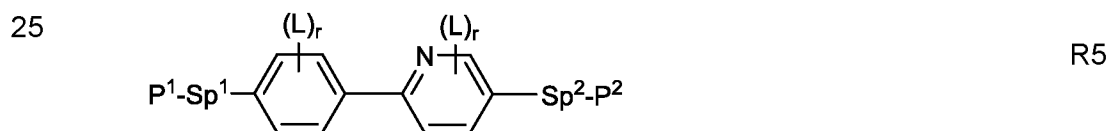
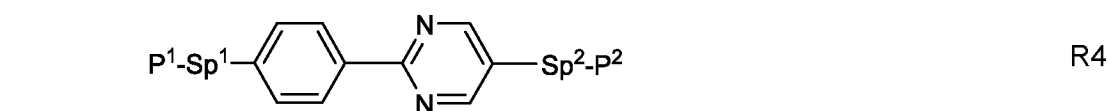
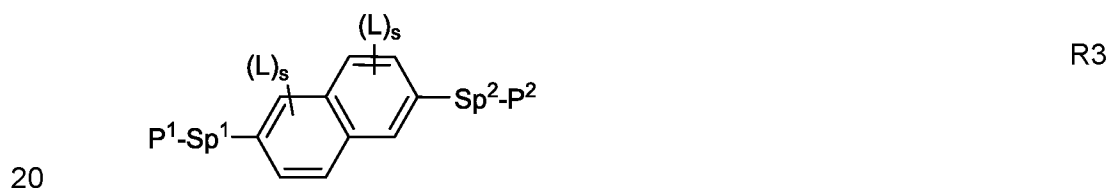
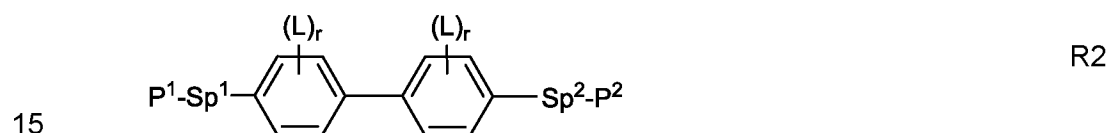
-S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a manner that O- and/or S-atoms are not directly connected with each other, and wherein one or more H atoms are each optionally replaced by F, Cl or L^a,

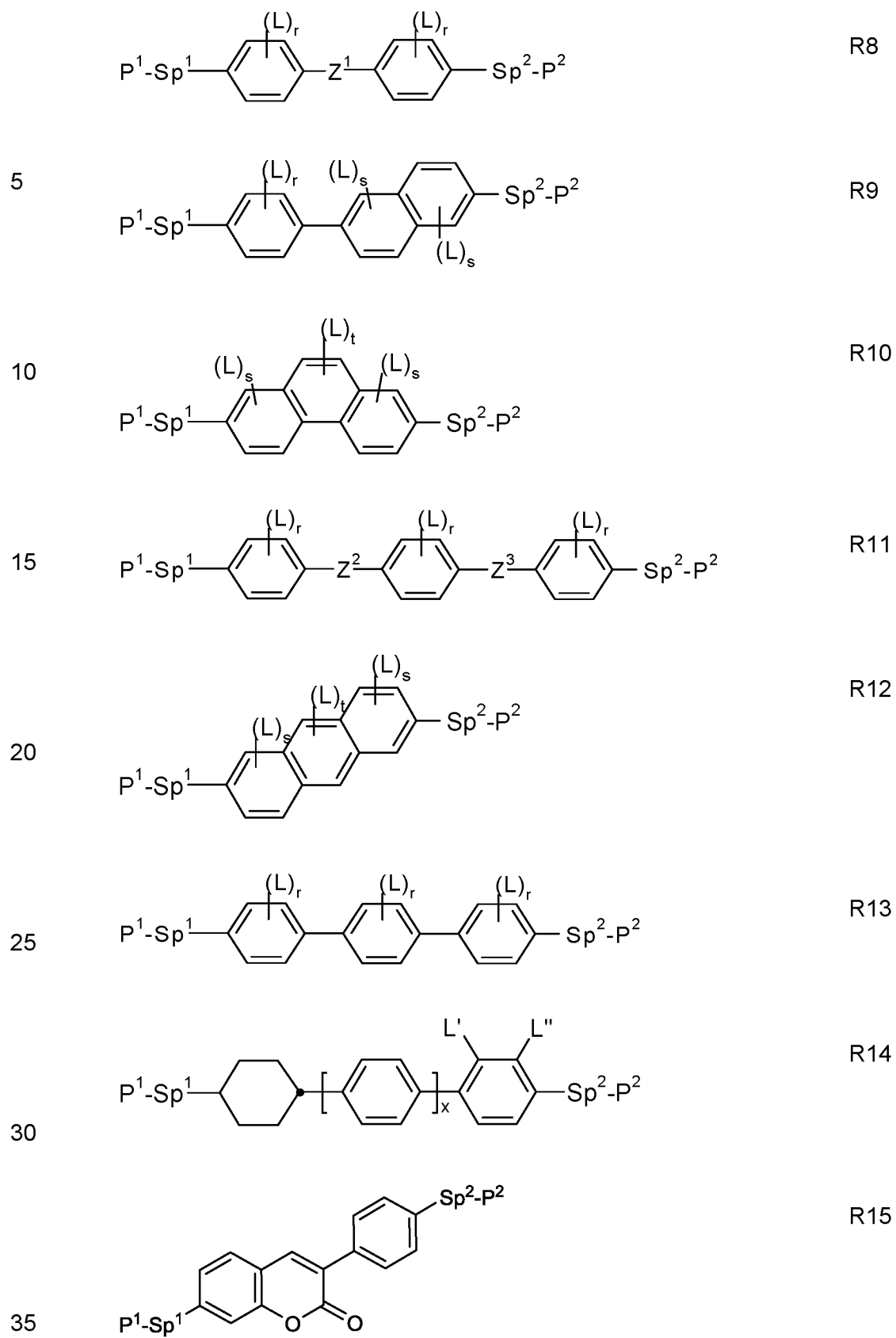
- L or L' denote F, Cl or CN,

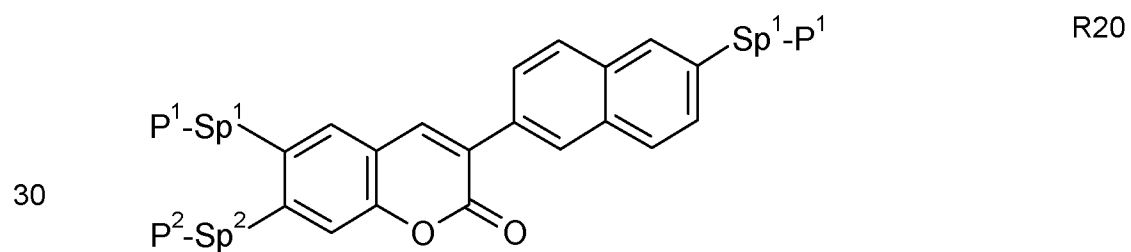
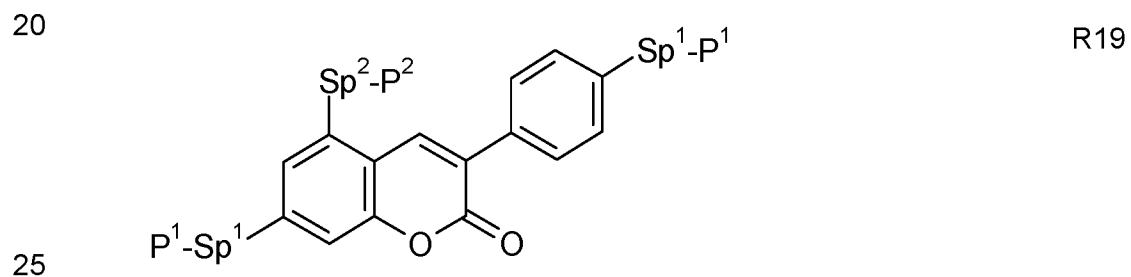
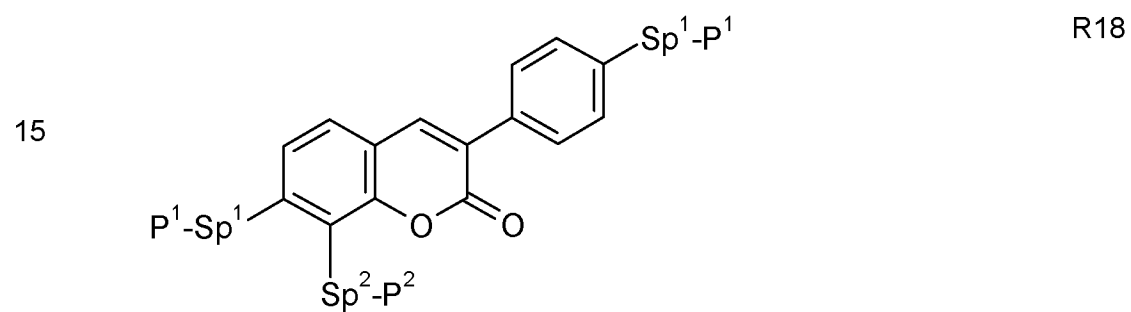
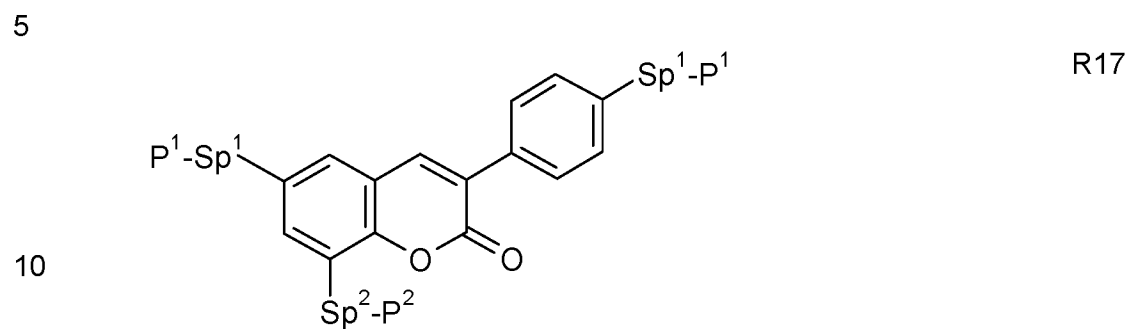
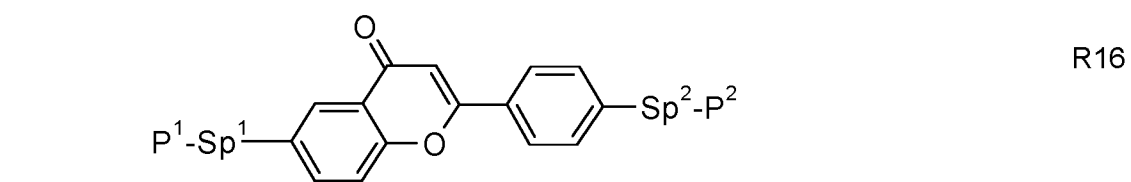
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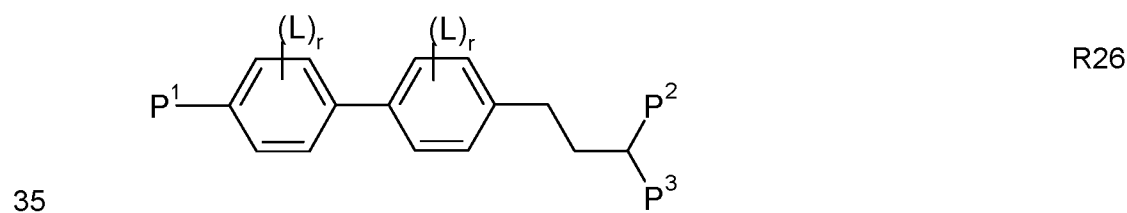
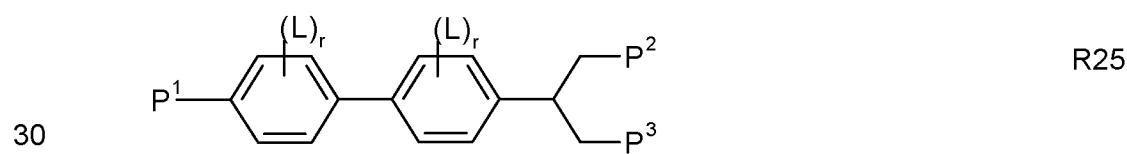
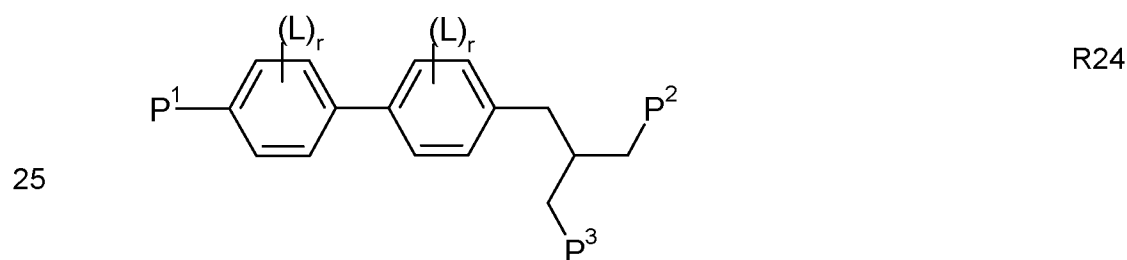
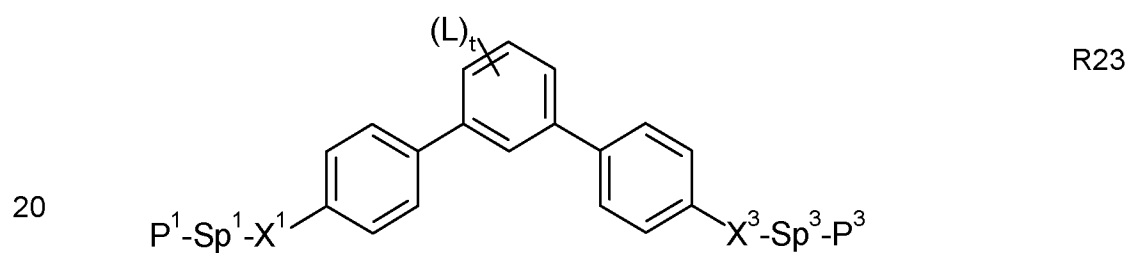
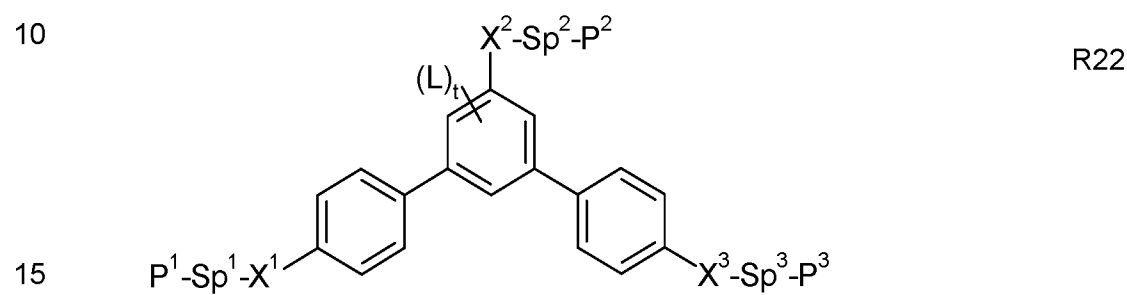
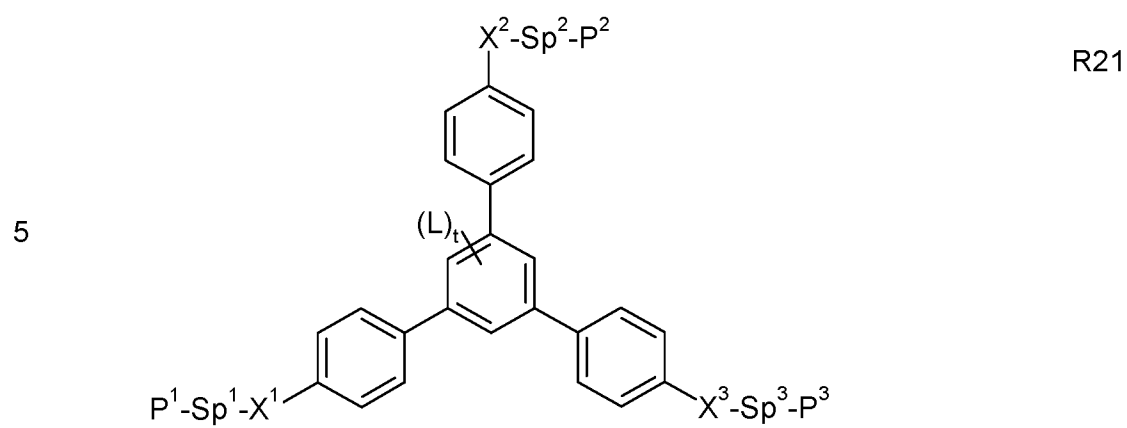
- L is F.

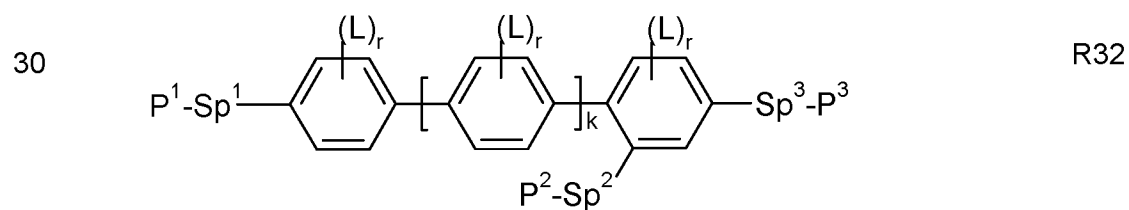
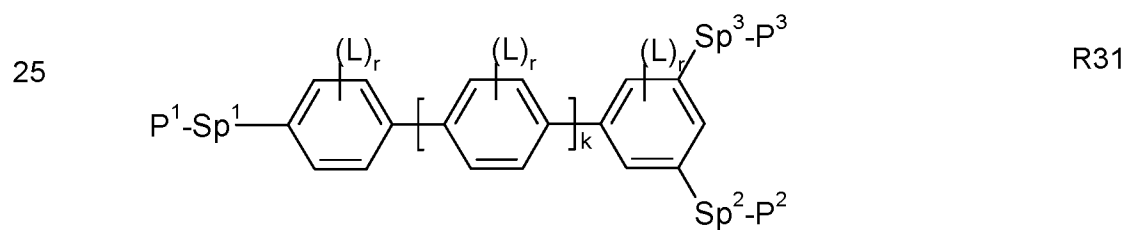
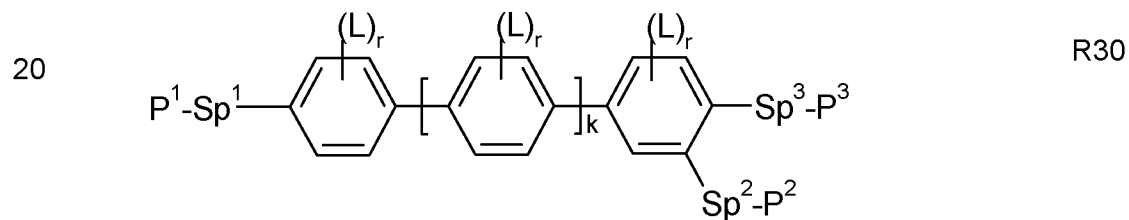
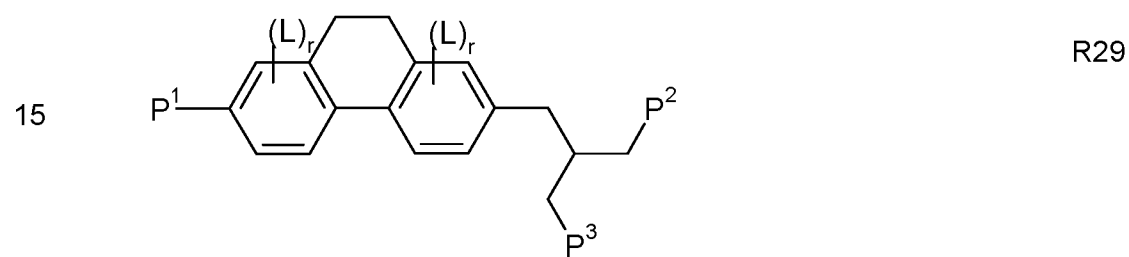
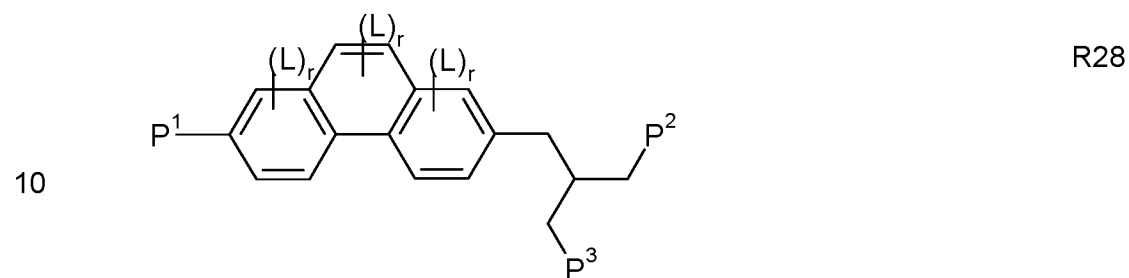
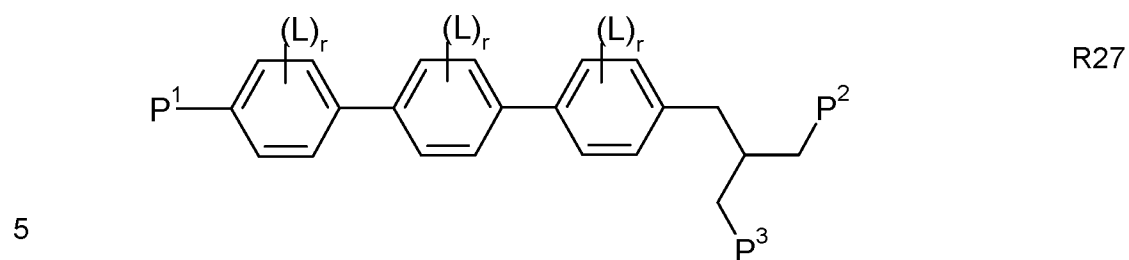
Suitable and preferred compounds of formula P are selected from the following formulae:











35 in which the individual radicals have the following meanings:

P¹, P² and P³ each, independently of one another, denote an acrylate or methacrylate group,

Sp¹, Sp² and Sp³ each, independently of one another, denote a single bond or a spacer group having one of the meanings indicated above and below for Sp, and particularly preferably denote -(CH₂)_{p1}-, -(CH₂)_{p1}-O-, -(CH₂)_{p1}-CO-O-, -(CH₂)_{p1}-O-CO- or -(CH₂)_{p1}-O-CO-O-, in which p1 is an integer from 1 to 12, where, in addition, one or more of the radicals P¹-Sp¹-, P²-Sp²- and P³-Sp³- may denote R^{aa}, with the proviso that at least one of the radicals P¹-Sp¹-, P²-Sp²- and P³-Sp³- present is different from R^{aa},

R^{aa} denotes H, F, Cl, CN or straight-chain or branched alkyl having 1 to 25 C atoms, in which, in addition, one or more non-adjacent CH₂ groups may each be replaced, independently of one another, by -C(R⁰)=C(R⁰⁰)-, -C≡C-, -N(R⁰)-, -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by F, Cl, CN or P¹-Sp¹-, particularly preferably straight-chain or branched, optionally mono- or polyfluorinated alkyl, alkoxy, alkenyl, alkynyl, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 12 C atoms (where the alkenyl and alkynyl radicals have at least two C atoms and the branched radicals have at least three C atoms),

R⁰, R⁰⁰ each, independently of one another and identically or differently on each occurrence, denote H or alkyl having 1 to 12 C atoms,

R^y and R^z each, independently of one another, denote H, F, CH₃ or CF₃,

X¹, X² and X³ each, independently of one another, denote -CO-O-, -O-CO- or a single bond,

Z¹ denotes -O-, -CO-, -C(R^yR^z)- or -CF₂CF₂-,

Z² and Z³ each, independently of one another, denote -CO-O-, -O-CO-, -CH₂O-, -OCH₂-, -CF₂O-, -OCF₂- or -(CH₂)_n-, where n is 2, 3 or 4,

L on each occurrence, identically or differently, denotes F, Cl, CN or straight-chain or branched, optionally mono- or polyfluorinated alkyl, alkoxy, alkenyl, alkynyl, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 12 C atoms, preferably F,

L' and L'' each, independently of one another, denote H, F or Cl,

k denotes 0 or 1,

r denotes 0, 1, 2, 3 or 4,
 s denotes 0, 1, 2 or 3,
 t denotes 0, 1 or 2,
 x denotes 0 or 1.

5

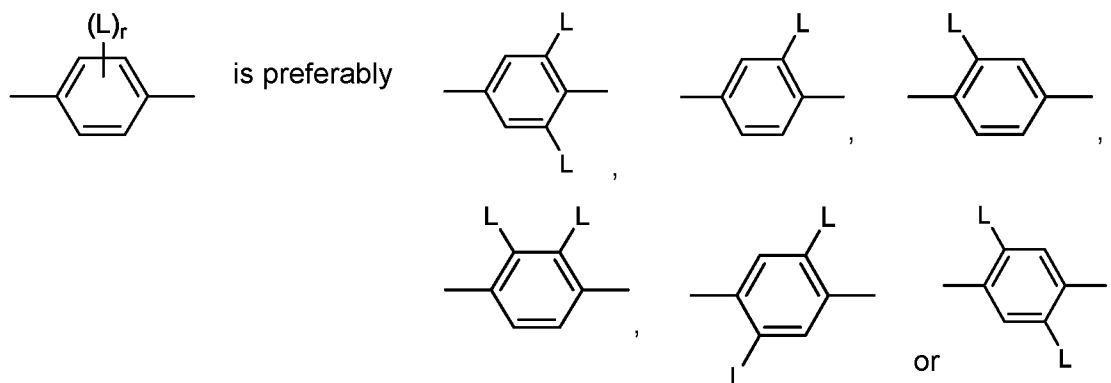
Especially preferred are compounds of the formulae R2, R13, R17, R22, R23, R24, R30, R31 and R32.

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Further preferred are trireactive compounds R15 to R30, in particular R17, R18, R19, R22, R23, R24, R25, R26, R30, R31 and R32.

In the compounds of formulae P1 to P32 the group

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wherein L on each occurrence, identically or differently, has one of the meanings given above or below, and is preferably F, Cl, CN, NO₂, CH₃, C₂H₅, C(CH₃)₃, CH(CH₃)₂, CH₂CH(CH₃)C₂H₅, OCH₃, OC₂H₅, COCH₃, COC₂H₅, COOCH₃, COOC₂H₅,
 25 CF₃, OCF₃, OCHF₂, OC₂F₅ or P-Sp-, very preferably F, Cl, CN, CH₃, C₂H₅, OCH₃, COCH₃, OCF₃ or P-Sp-, more preferably F, Cl, CH₃, OCH₃, COCH₃ oder OCF₃, especially F or CH₃.

30

For the production of PSA displays, the polymerisable compounds contained in the LC medium are polymerised or crosslinked (if one compound contains two or more polymerisable groups) by in-situ polymerisation in the LC medium between the substrates of the LC display, optionally while a voltage is applied to the electrodes.

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The structure of the PSA displays according to the invention corresponds to the usual geometry for PSA displays, as described in the prior art cited at the outset. Geometries without protrusions are preferred, in particular those in which, in

addition, the electrode on the colour filter side is unstructured and only the electrode on the TFT side has slots. Particularly suitable and preferred electrode structures for PS-VA displays are described, for example, in US 2006/0066793 A1.

- 5 A preferred PSA type LC display of the present invention comprises:
- a first substrate including a pixel electrode defining pixel areas, the pixel electrode being connected to a switching element disposed in each pixel area and optionally including a micro-slit pattern, and optionally a first alignment layer disposed on the pixel electrode,
 - 10 - a second substrate including a common electrode layer, which may be disposed on the entire portion of the second substrate facing the first substrate, and optionally a second alignment layer,
 - an LC layer disposed between the first and second substrates and including an LC medium comprising a polymerisable component comprising one or
15 more compounds of formula R and a chiral nematic liquid crystal host including as described above and below, wherein the polymerisable component may also be polymerised.

20 The first and/or second alignment layer controls the alignment direction of the LC molecules of the LC layer. For example, in PS-VA displays the alignment layer is selected such that it imparts to the LC molecules homeotropic (or vertical) alignment (i.e. perpendicular to the surface) or tilted alignment. Such an alignment layer may for example comprise a polyimide, which may also be rubbed, or may be prepared
25 by a photoalignment method.

The LC layer with the LC medium can be deposited between the substrates of the display by methods that are conventionally used by display manufacturers, for example the so-called one-drop-filling (ODF) method. The polymerisable component
30 of the LC medium is then polymerised for example by UV photopolymerisation. The polymerisation can be carried out in one step or in two or more steps.

The PSA display may comprise further elements, like a colour filter, a black matrix, a passivation layer, optical retardation layers, transistor elements for addressing the individual pixels, etc., all of which are well known to the person skilled in the art and
35 can be employed without inventive skill.

The electrode structure can be designed by the skilled person depending on the individual display type. For example for PS-VA displays a multi-domain orientation of the LC molecules can be induced by providing electrodes having slits and/or bumps or protrusions in order to create two, four or more different tilt alignment directions.

5

Upon polymerisation the polymerisable compounds form a crosslinked polymer, which causes a certain pretilt of the LC molecules in the LC medium. Without wishing to be bound to a specific theory, it is believed that at least a part of the crosslinked polymer, which is formed by the polymerisable compounds, will phase-separate or precipitate from the LC medium and form a polymer layer on the substrates or electrodes, or the alignment layer provided thereon. Microscopic measurement data (like SEM and AFM) have confirmed that at least a part of the formed polymer accumulates at the LC/substrate interface.

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The polymerisation can be carried out in one step. It is also possible firstly to carry out the polymerisation, optionally while applying a voltage, in a first step in order to produce a pretilt angle, and subsequently, in a second polymerisation step without an applied voltage, to polymerise or crosslink the compounds which have not reacted in the first step ("end curing").

15

Suitable and preferred polymerisation methods are, for example, thermal or photopolymerisation, preferably photopolymerisation, in particular UV induced photopolymerisation, which can be achieved by exposure of the polymerisable compounds to UV radiation.

20

Optionally one or more polymerisation initiators are added to the LC medium. Suitable conditions for the polymerisation and suitable types and amounts of initiators are known to the person skilled in the art and are described in the literature. Suitable for free-radical polymerisation are, for example, the commercially available photoinitiators Irgacure651®, Irgacure184®, Irgacure907®, Irgacure369® or Darocure1173® (Ciba AG). If a polymerisation initiator is employed, its proportion is preferably 0.001 to 5% by weight, particularly preferably 0.001 to 1% by weight.

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The polymerisable compounds according to the invention are also suitable for polymerisation without an initiator, which is accompanied by considerable advantages, such, for example, lower material costs and in particular less contamination of the LC medium by possible residual amounts of the initiator or

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degradation products thereof. The polymerisation can thus also be carried out without the addition of an initiator. In a preferred embodiment, the LC medium thus does not contain a polymerisation initiator.

- 5 The the LC medium may also comprise one or more stabilisers in order to prevent undesired spontaneous polymerisation of the RMs, for example during storage or transport. Suitable types and amounts of stabilisers are known to the person skilled in the art and are described in the literature. Particularly suitable are, for example, the commercially available stabilisers from the Irganox® series (Ciba AG), such as, 10 for example, Irganox® 1076. If stabilisers are employed, their proportion, based on the total amount of RMs or the polymerisable component (component P), is preferably 10-500,000 ppm, particularly preferably 50-50,000 ppm.

- 15 The polymerisable compounds of formula R do in particular show good UV absorption in, and are therefore especially suitable for, a process of preparing a PSA display including one or more of the following features:
- the polymerisable medium is exposed to UV light in the display in a 2-step process, including a first UV exposure step ("UV-1 step") to generate the tilt angle, and a second UV exposure step ("UV-2 step") to finish polymerization,
 - 20 - the polymerisable medium is exposed to UV light in the display generated by an energy-saving UV lamp (also known as "green UV lamps"). These lamps are characterized by a relative low intensity (1/100-1/10 of a conventional UV1 lamp) in their absorption spectra from 300-380nm, and are preferably used in the UV2 step, but are optionally also used in the UV1 step when avoiding high intensity is 25 necessary for the process.
 - the polymerisable medium is exposed to UV light in the display generated by a UV lamp with a radiation spectrum that is shifted to longer wavelengths, preferably 340nm or more, to avoid short UV light exposure in the PS-VA process.
- 30 Both using lower intensity and a UV shift to longer wavelengths protect the organic layer against damage that may be caused by the UV light.

- 35 A preferred embodiment of the present invention relates to a process for preparing a PSA display as described above and below, comprising one or more of the following features:

- the polymerisable LC medium is exposed to UV light in a 2-step process, including a first UV exposure step ("UV-1 step") to generate the tilt angle, and a second UV exposure step ("UV-2 step") to finish polymerization,
- the polymerisable LC medium is exposed to UV light generated by a UV lamp having an intensity of from 0.5 mW/cm² to 10 mW/cm² in the wavelength range from 300-380nm, preferably used in the UV2 step, and optionally also in the UV1 step,
- the polymerisable LC medium is exposed to UV light having a wavelength of 340 nm or more, and preferably 400 nm or less.

10 This preferred process can be carried out for example by using the desired UV lamps or by using a band pass filter and/or a cut-off filter, which are substantially transmissive for UV light with the respective desired wavelength(s) and are substantially blocking light with the respective undesired wavelengths. For example, when irradiation with UV light of wavelengths λ of 300-400nm is desired, UV exposure can be carried out using a wide band pass filter being substantially transmissive for wavelengths $300\text{nm} < \lambda < 400\text{nm}$. When irradiation with UV light of wavelength λ of more than 340 nm is desired, UV exposure can be carried out using a cut-off filter being substantially transmissive for wavelengths $\lambda > 340 \text{ nm}$.

20 "Substantially transmissive" means that the filter transmits a substantial part, preferably at least 50% of the intensity, of incident light of the desired wavelength(s). "Substantially blocking" means that the filter does not transmit a substantial part, preferably at least 50% of the intensity, of incident light of the undesired wavelengths. "Desired (undesired) wavelength" e.g. in case of a band pass filter means the wavelengths inside (outside) the given range of λ , and in case of a cut-off filter means the wavelengths above (below) the given value of λ .

30 This preferred process enables the manufacture of displays by using longer UV wavelengths, thereby reducing or even avoiding the hazardous and damaging effects of short UV light components.

UV radiation energy is in general from 6 to 100 J, depending on the production process conditions.

35 Preferably the LC medium according to the present invention essentially consist of a polymerisable component P) comprising or one or more polymerisable compounds of

formula R, and an LC host mixture, and an optically active component comprising one or more chiral dopants, as described above and below. However, the LC medium may additionally comprise one or more further components or additives, preferably selected from the list including but not limited to co-monomers, polymerisation
5 initiators, inhibitors, stabilizers, surfactants, wetting agents, lubricating agents, dispersing agents, hydrophobing agents, adhesive agents, flow improvers, defoaming agents, deaerators, diluents, reactive diluents, auxiliaries, colourants, dyes, pigments and nanoparticles.

10 The LC media according to the invention comprise one, two or three chiral dopants, very preferably one chiral dopant.

Particular preference is given to LC media comprising one, two or three polymerisable compounds of formula R.

15 Preference is furthermore given to LC media that have a chiral nematic LC phase.

Preferably the proportion of compounds of formula R in the LC medium is from >0 to $< 5\%$, very preferably from >0 to $< 1\%$, most preferably from 0.01 to 0.5% .

20 In preferred embodiments, taken alone or in combination with one another the medium according to the invention comprises

- one or more compounds of the formula IIA in a total concentration in the range of from 25% to 50% , more preferably from 30% to 45% and very preferably from 32% to 40% ;

25 - one or more compounds of the formula IIA-2 in a total concentration in the range of from 5% to 20% , more preferably from 8% to 18% and very preferably from 10% to 15% ;

- one or more compounds of the formula IIA-10 in a total concentration in the range of from 17% to 38% , more preferably from 19% to 30% and very preferably from
30 20% to 26% ;

- one or more compounds of the formula IIB, preferably of the formula IIB-10, in a total concentration in the range of from 5% to 25% , more preferably from 9% to 22% and very preferably from 12% to 20% ;

35 - one or more compounds of formula IIA and one or more compounds of formula IIB in a total concentration of 50% or more, more preferably of 55% or more, and very preferably of 60% or more;

- one or more compounds of formula IIA and one or more compounds of formula IIB and one or more compounds of formula V in a total concentration of 60% or more, more preferably of 65% or more, very preferably of 70% or more and in particular of 73% or 74% or more;
- 5 - one or more compounds of the formula IV in a total concentration of less than 30%, preferably less than 29%, more preferably less than 28% or 27% or 26%;
- one or more compounds of the formula IV in a total concentration in the range of from 15% to 45%, more preferably from 18% to 38%, still more preferably from 21% to 30% and very preferably from 22% to 28% or from 22% to 26%;
- 10 - one or more compounds of the formula IV-2 in a total concentration in the range of from 1% to 8%, more preferably from 2% to 7%, still more preferably from 3% to 6% and very preferably from 4% to 5%;
- one or more compounds of the formula IV-3, preferably IV-3-4 and IV-3-1, in a total concentration in the range of from 10% to 35%, more preferably from 12% to 32%,
15 still more preferably from 16% to 28% and very preferably from 18% to 22%;
- the compound of the formula IV-3-4 in a total concentration in the range of from 5% to 25%, more preferably from 10% to 22% and very preferably from 13% to 17%;
- the compound of the formula IV-3-1 in a total concentration in the range of from 1% to 12%, more preferably from 2% to 10%, and very preferably from 3% to 7%;
- 20 - one or more compounds of the formula V in a total concentration in the range of from 15% to 40%, more preferably from 17% to 38%, still more preferably from 19% to 30% and very preferably from 20% to 26%;
- one or more compounds of the formula V-3 in a total concentration in the range of from 1% to 12%, more preferably from 2% to 10%, still more preferably from 3% to
25 9% and very preferably from 4% to 8%;
- one or more compounds of the formula V-10 in a total concentration in the range of from 5% to 30%, more preferably from 10% to 25% and very preferably from 12% to 18%.
- 30 It is advantageous for the liquid-crystalline medium according to the invention to preferably have a nematic phase from $\leq -20^{\circ}\text{C}$ to $\geq 100^{\circ}\text{C}$, particularly preferably from $\leq -30^{\circ}\text{C}$ to $\geq 110^{\circ}\text{C}$, very particularly preferably from $\leq -40^{\circ}\text{C}$ to $\geq 120^{\circ}\text{C}$.
- 35 The medium according to the invention has a clearing temperature of 90°C or more, preferably of 100°C or more, more preferably of 105°C or more and in particular of 110°C or more.

5 The expression "have a nematic phase" here means on the one hand that no smectic phase and no crystallisation are observed at low temperatures at the corresponding temperature and on the other hand that clearing (phase transition to the isotropic phase) still does not occur on heating from the nematic phase. The investigation at low temperatures is carried out in a flow viscometer at the corresponding temperature and checked by storage in test cells having a layer thickness corresponding to the electro-optical use for at least 100 hours. If the storage stability at a temperature of -20°C in a corresponding test cell is 1000 h or more, 10 the medium is referred to as stable at this temperature. At temperatures of -30°C and -40°C, the corresponding times are 500 h and 250 h respectively. At high temperatures, the clearing point is measured by conventional methods in capillaries.

15 The liquid-crystal mixture preferably has a nematic phase range of at least 60 K and a flow viscosity η_{20} of at most $30 \text{ mm}^2 \cdot \text{s}^{-1}$ at 20°C.

The mixture is nematic at a temperature of -20°C or less, preferably at -30°C or less, very preferably at -40°C or less.

20 In a preferred embodiment of the present invention, the medium has a birefringence in the range of from 0.085 to 0.110, preferably from 0.090 to 0.105, in particular from 0.095 to 0.100.

25 The liquid-crystal mixture according to the invention has a dielectric anisotropy $\Delta\epsilon$ of -2.5 to -5.0, preferably of -2.8 to -4.0, in particular -3.0 to -3.5,

The rotational viscosity γ_1 at 20°C is preferably in the range of from 150 to 250 mPas, more preferably from 170 to 210 mPa s.

30 The liquid-crystal media according to the invention have relatively low values for the threshold voltage (V_0). They are preferably in the range from 1.7 V to 3.0 V, particularly preferably $\leq 2.8 \text{ V}$ and very particularly preferably $\leq 2.6 \text{ V}$.

35

For the present invention, the term "threshold voltage" relates to the capacitive threshold (V_0), also called the Freedericks threshold, unless explicitly indicated otherwise.

5 In addition, the liquid-crystal media according to the invention have high values for the voltage holding ratio in liquid-crystal cells.

10 In general, liquid-crystal media having a low addressing voltage or threshold voltage exhibit a lower voltage holding ratio than those having a higher addressing voltage or threshold voltage and vice versa.

For the present invention, the term "dielectrically positive compounds" denotes compounds having a $\Delta\epsilon > 1.5$, the term "dielectrically neutral compounds" denotes
15 those having $-1.5 \leq \Delta\epsilon \leq 1.5$ and the term "dielectrically negative compounds" denotes those having $\Delta\epsilon < -1.5$. The dielectric anisotropy of the compounds is determined here by dissolving 10 % of the compounds in a liquid-crystalline host and determining the capacitance of the resultant mixture in at least one test cell in each case having a layer thickness of 20 μm with homeotropic and with
20 homogeneous surface alignment at 1 kHz. The measurement voltage is typically 0.5 V to 1.0 V but it is always lower than the capacitive threshold of the respective liquid-crystal mixture investigated.

25 All temperature values indicated for the present invention are in $^{\circ}\text{C}$.

Preferably, the liquid crystal medium according to the invention has negative dielectric anisotropy ($\Delta\epsilon$).

30 The mixtures according to the invention are suitable for all VA-TFT applications, such as, for example, VAN, MVA, (S)-PVA, ASV, PSA (polymer sustained VA) and PS-VA (polymer stabilized VA). They are furthermore suitable for IPS (in-plane switching) and FFS (fringe field switching) applications having negative $\Delta\epsilon$.

35

It goes without saying for the person skilled in the art that the VA, IPS or FFS mixture according to the invention may also comprise compounds in which, for example, H, N, O, Cl and F have been replaced by the corresponding isotopes.

5 The compounds according to the present invention can be synthesized by or in analogy to known methods described in the literature (for example in the standard works such as Houben-Weyl, Methoden der Organischen Chemie [Methods of Organic Chemistry], Georg-Thieme-Verlag, Stuttgart), under reaction conditions
10 which are known and suitable for said reactions. Use may also be made here of variants which are known per se, but are not mentioned here. In particular, they can be prepared as described in or in analogy to the following reaction schemes. Further methods for preparing the inventive compounds can be taken from the examples.

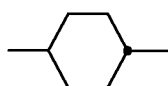
15 Other mesogenic compounds which are not explicitly mentioned above can optionally and advantageously also be used in the media in accordance with the present invention. Such compounds are known to the person skilled in the art.

For the present invention and in the following examples, the structures of the liquid-crystal compounds are indicated by means of acronyms, with the transformation into
20 chemical formulae taking place in accordance with Tables A to C below. All radicals C_mH_{2m+1} , C_nH_{2n+1} , and C_lH_{2l+1} or C_mH_{2m-1} , C_nH_{2n-1} and C_lH_{2l-1} are straight-chain alkyl radicals or alkylene radicals, in each case having n, m and l C atoms respectively. Preferably n, m and l are independently of each other 1, 2, 3, 4, 5, 6, or 7. Table A
25 shows the codes for the ring elements of the nuclei of the compound, Table B lists the bridging units, and Table C lists the meanings of the symbols for the left- and right-hand end groups of the molecules. The acronyms are composed of the codes for the ring elements with optional linking groups, followed by a first hyphen and the codes for the left-hand end group, and a second hyphen and the codes for the right-hand end group. Table D shows illustrative structures of compounds together with
30 their respective abbreviations.

Table A: Ring elements

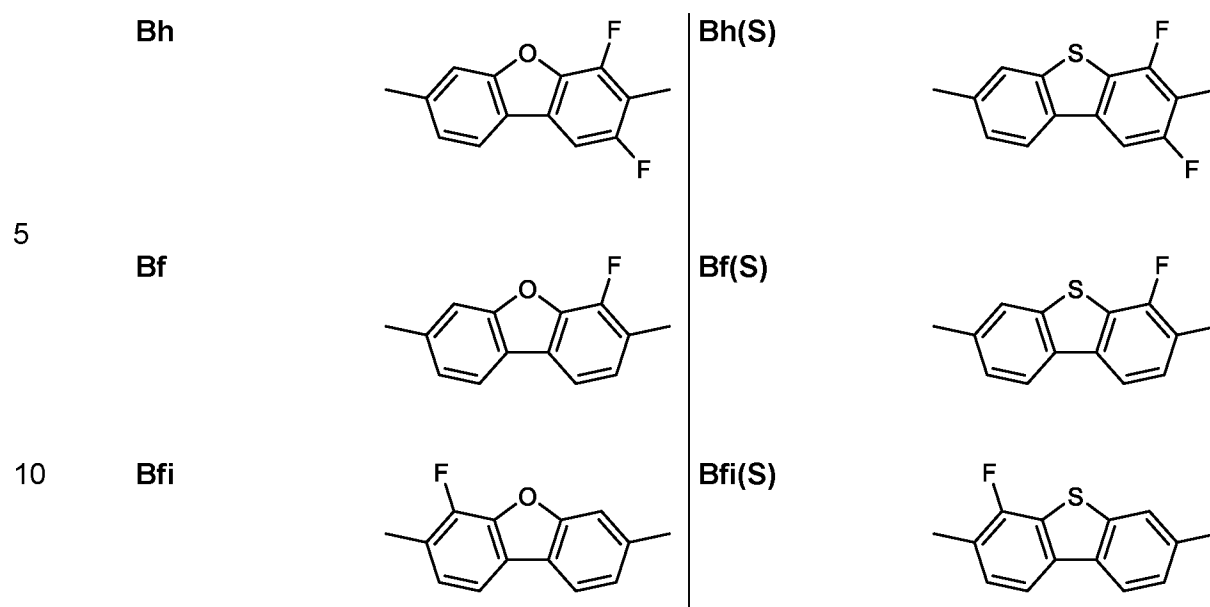
35

C



5	D		DI	
	A		AI	
10	P			
	G		GI	
15	U		UI	
20	Y			
25	P(F, Cl)Y		P(Cl,F)Y	
30	np			
35	n3f		nN3fl	

	th		thl	
5	tH2f		tH2fl	
10	o2f		o2fl	
15	dh			
20	B		B(S)	
	O		S	
25	K		KI	
30	L		LI	
35	F		FI	

**Table B: Bridging units**

15	E	-CH ₂ -CH ₂ -		
	V	-CH=CH-		
	T	-C≡C-		
	W	-CF ₂ -CF ₂ -		
	B	-CF=CF-		
20	Z	-CO-O-	ZI	-O-CO-
	X	-CF=CH-	XI	-CH=CF-
	O	-CH ₂ -O-	OI	-O-CH ₂ -
	Q	-CF ₂ -O-	QI	-O-CF ₂ -
25				

Table C: End groups

	On the left individually or in combination		On the right individually or in combination	
30	-n-	C _n H _{2n+1} -	-n	-C _n H _{2n+1}
	-nO-	C _n H _{2n+1} -O-	-On	-O- C _n H _{2n+1}
	-v-	CH ₂ =CH-	-v	-CH=CH ₂
	-nV-	C _n H _{2n+1} -CH=CH-	-nV	-C _n H _{2n} -CH=CH ₂
	-Vn-	CH ₂ =CH- C _n H _{2n} -	-Vn	-CH=CH- C _n H _{2n+1}
35	-nVm-	C _n H _{2n+1} -CH=CH-C _m H _{2m} -	-nVm	- C _n H _{2n} -CH=CH-C _m H _{2m+1}

5	-N-	$\text{N}\equiv\text{C}-$		-N	$-\text{C}\equiv\text{N}$
	-S-	$\text{S}=\text{C}=\text{N}-$		-S	$-\text{N}=\text{C}=\text{S}$
	-F-	$\text{F}-$		-F	$-\text{F}$
	-CL-	$\text{Cl}-$		-CL	$-\text{Cl}$
	-M-	CFH_2-		-M	$-\text{CFH}_2$
	-D-	$\text{CF}_2\text{H}-$		-D	$-\text{CF}_2\text{H}$
	-T-	CF_3-		-T	$-\text{CF}_3$
	-MO-	$\text{CFH}_2\text{O}-$		-OM	$-\text{OCFH}_2$
	-DO-	$\text{CF}_2\text{HO}-$		-OD	$-\text{OCF}_2\text{H}$
	-TO-	$\text{CF}_3\text{O}-$		-OT	$-\text{OCF}_3$
10	-A-	$\text{H}-\text{C}\equiv\text{C}-$		-A	$-\text{C}\equiv\text{C}-\text{H}$
	-nA-	$\text{C}_n\text{H}_{2n+1}-\text{C}\equiv\text{C}-$		-An	$-\text{C}\equiv\text{C}-\text{C}_n\text{H}_{2n+1}$
	-NA-	$\text{N}\equiv\text{C}-\text{C}\equiv\text{C}-$		-AN	$-\text{C}\equiv\text{C}-\text{C}\equiv\text{N}$
	-(cn)-	$(\text{CH}_2)_{n-2}$ 		-(cn)	 $(\text{CH}_2)_{n-2}$
	-(cn)m-	$(\text{CH}_2)_{n-2}$  $(\text{CH}_2)_m-$		-m(cn)	$-(\text{CH}_2)_m-$  $(\text{CH}_2)_{n-2}$
15					
20					
25					
30					

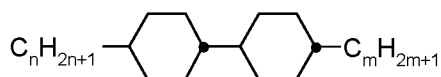
in which n and m are each integers, and the three dots "..." are placeholders for other abbreviations from this table.

Apart from the compounds of formula I, IIA, IIB, IIC and/or IID, IVa, IVb and V, the mixtures according to the invention optionally comprise one or more compounds of the compounds mentioned below.

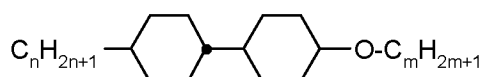
The following abbreviations are used:

(n, m, k and l are, independently of one another, each an integer, preferably 1 to 9 preferably 1 to 7, k and l possibly may be also 0 and preferably are 0 to 4, more preferably 0 or 2 and most preferably 2, n preferably is 1, 2, 3, 4 or 5, in the combination “-nO-” it preferably is 1, 2, 3 or 4, preferably 2 or 4, m preferably is 1, 2, 3, 4 or 5, in the combination “-Om” it preferably is 1, 2, 3 or 4, more preferably 2 or 4. The combination “-IVm” preferably is “2V1”.)

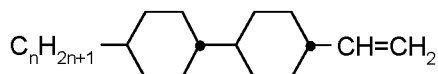
Table D



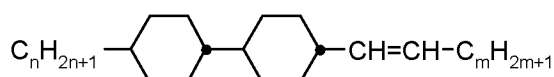
CC-n-m



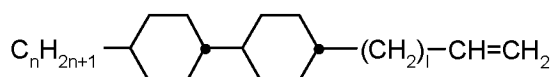
CC-n-Om



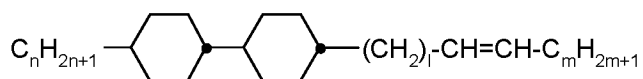
CC-n-V



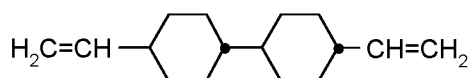
CC-n-Vm



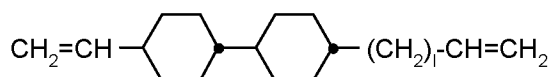
CC-n-IV

**CC-n-IVm**

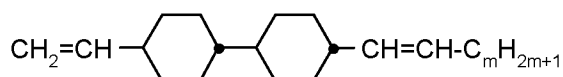
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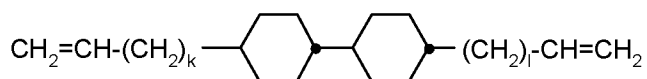
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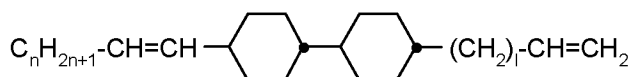
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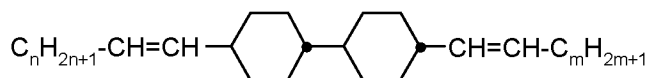
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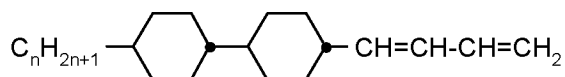
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**CC-nV-IV**

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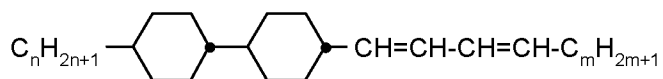
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35

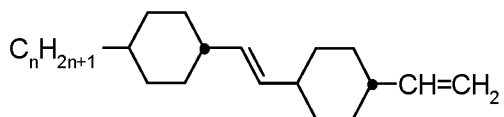


CC-n-VV

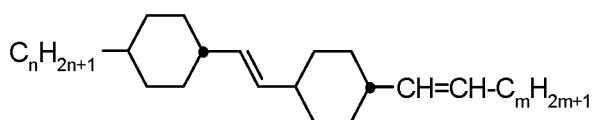
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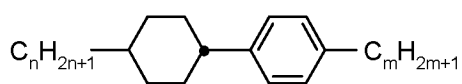
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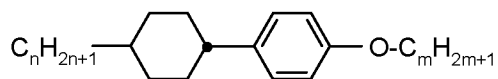
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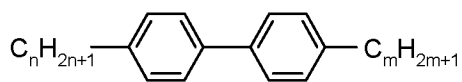
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**CP-n-m**

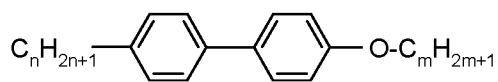
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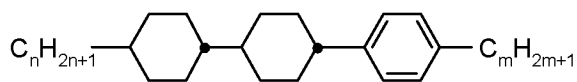
**CP-n-Om**

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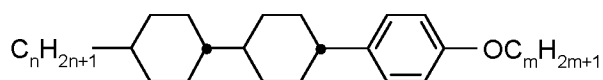
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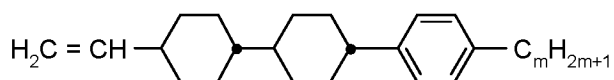
**PP-n-Om**

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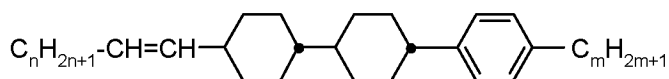
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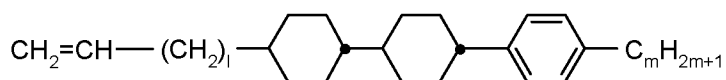
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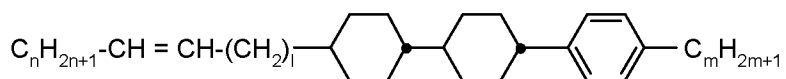
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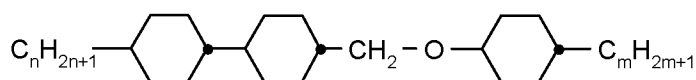
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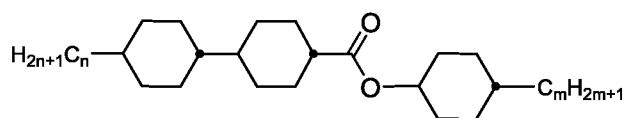
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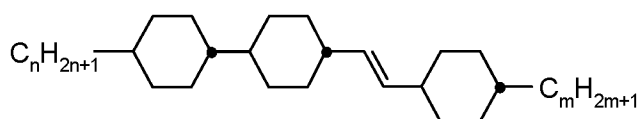
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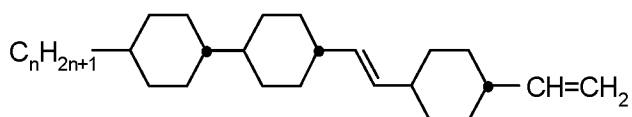
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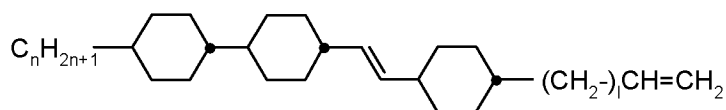
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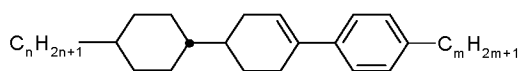
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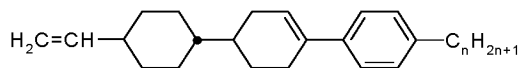
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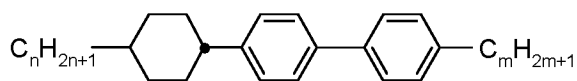
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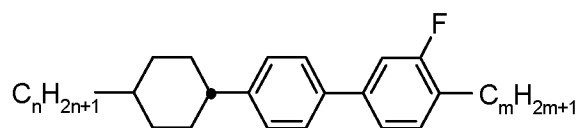
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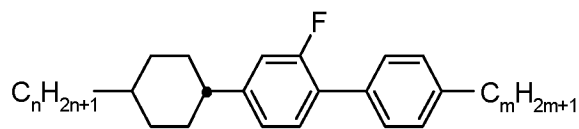
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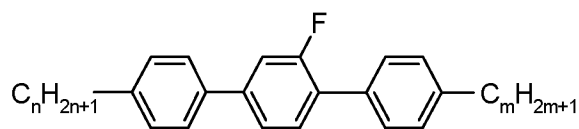
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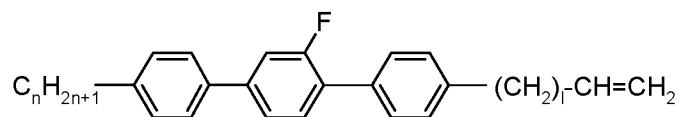
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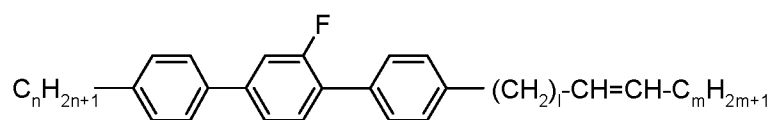
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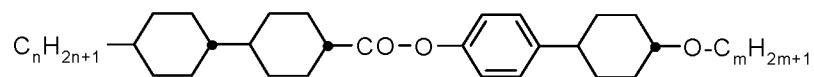
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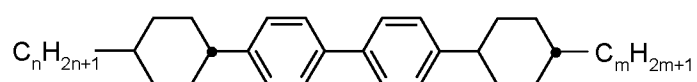
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**PGP-n-IVm**

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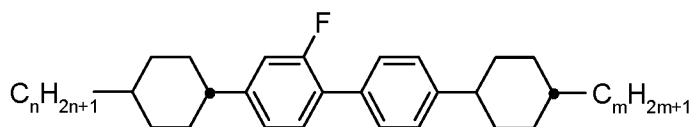
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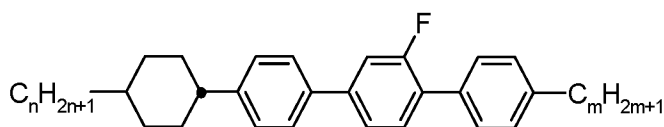
CPPC-n-m

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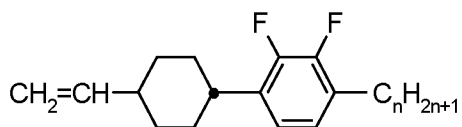
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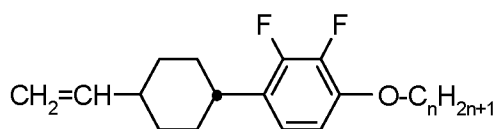
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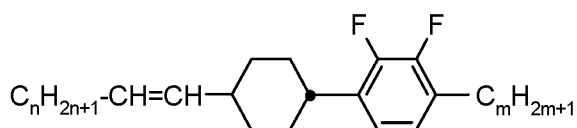
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CY-V-n



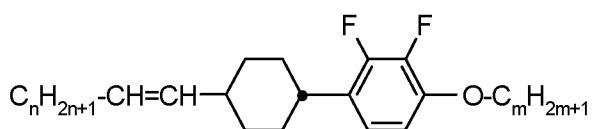
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CY-V-On



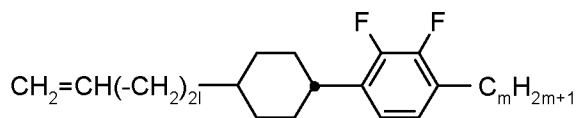
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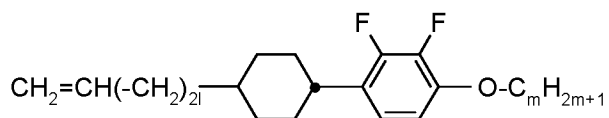


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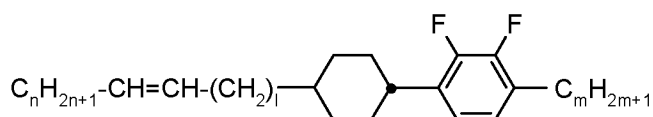
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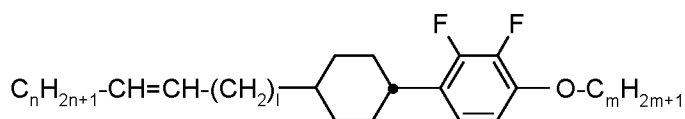
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CY-VI-m

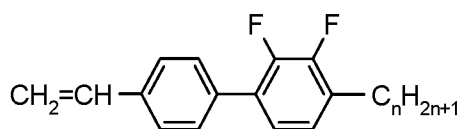
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CY-VI-Om

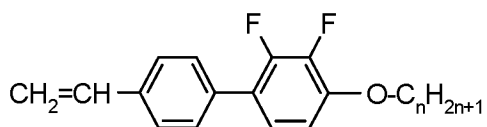
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CY-nVI-m

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CY-nVI-Om

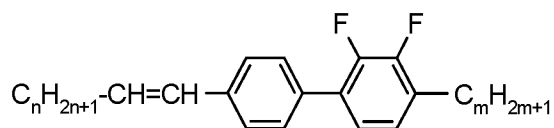
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PY-V-n

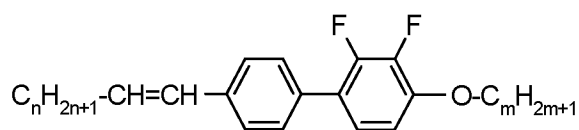
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PY-V-On

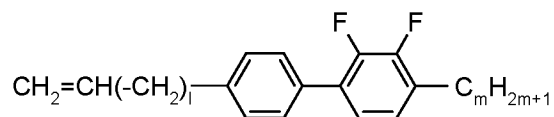
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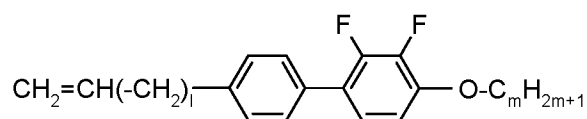
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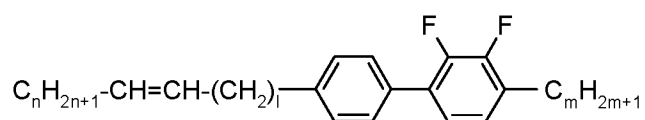
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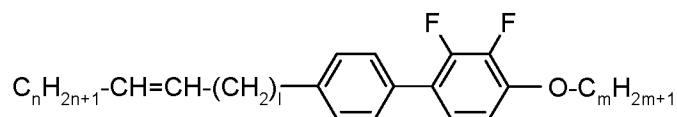
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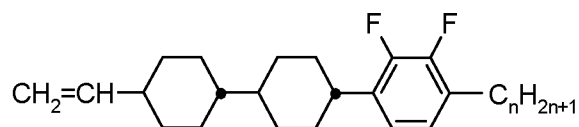
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**PY-nVI-m**

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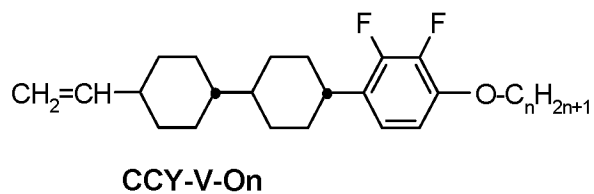
**PY-nVI-Om**

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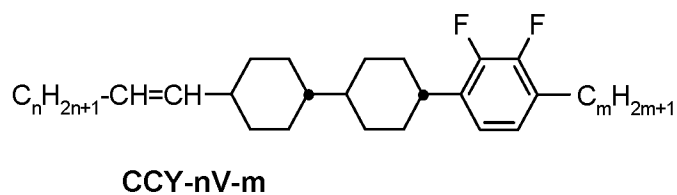
**CCY-V-n**

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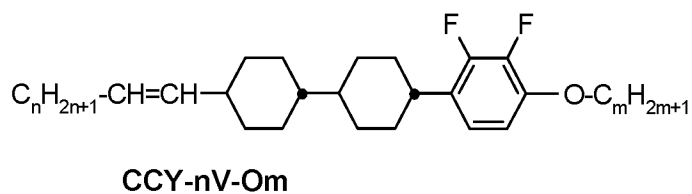
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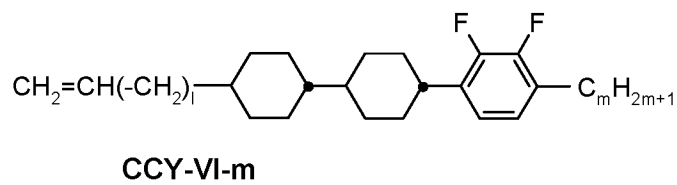
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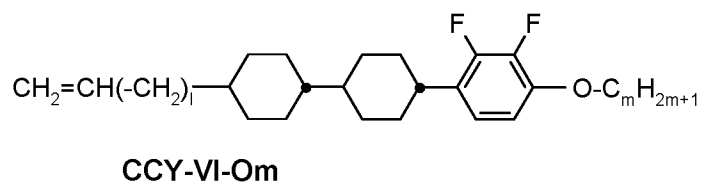
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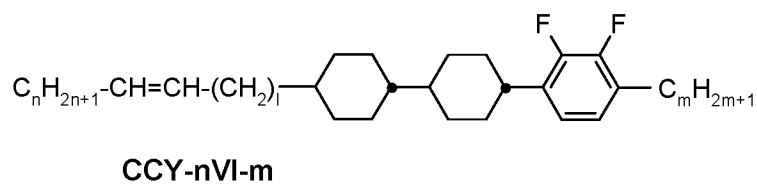
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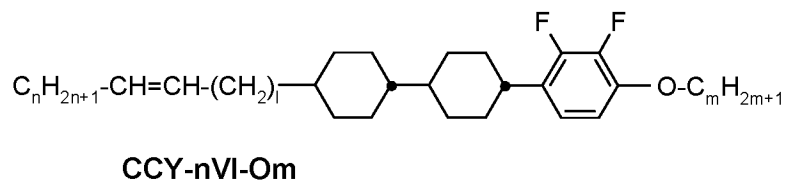
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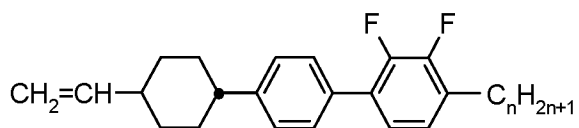


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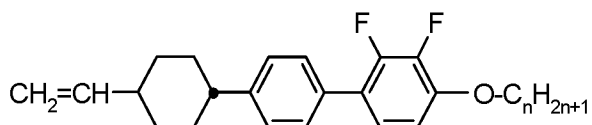


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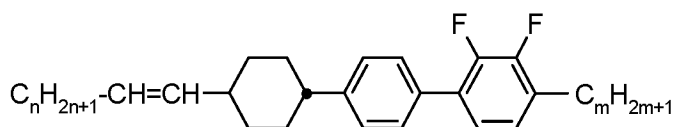


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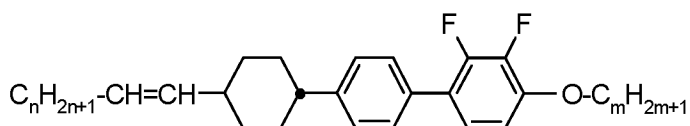
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**CPY-V-On**

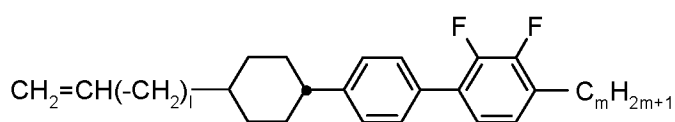
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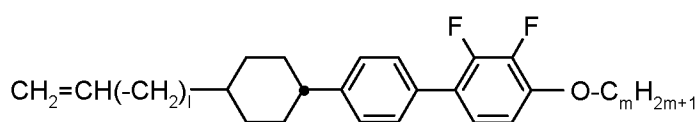
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**CPY-nV-Om**

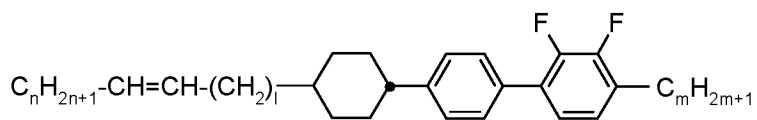
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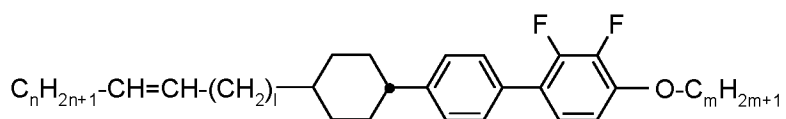
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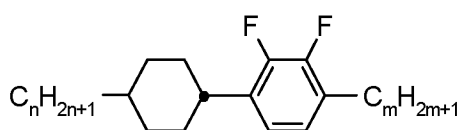
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**CPY-nVI-k**

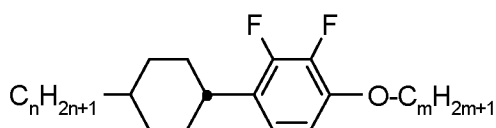
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**CPY-nVI-Om**

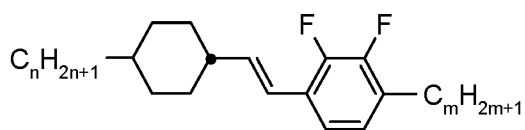
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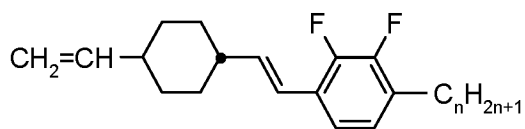
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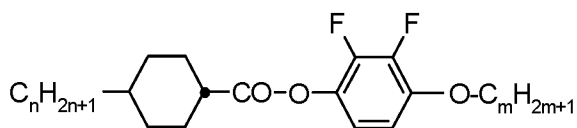
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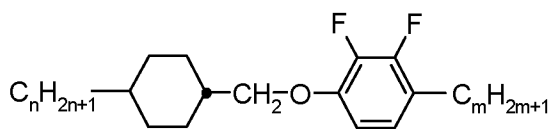
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**CVY-V-n**

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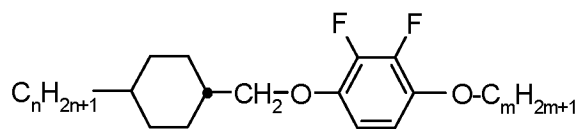
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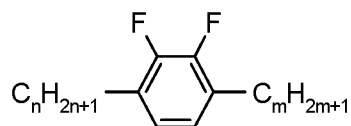
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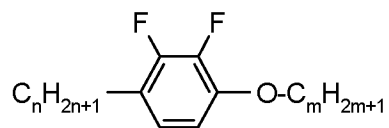
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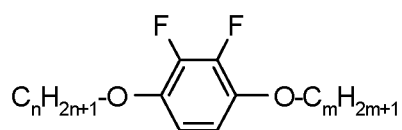
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**Y-n-m**

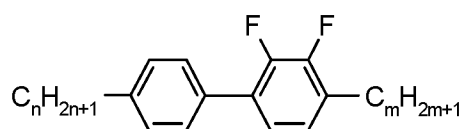
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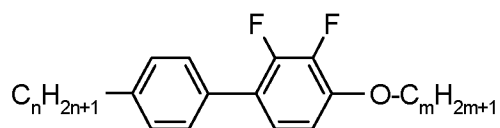
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**Y-nO-Om**

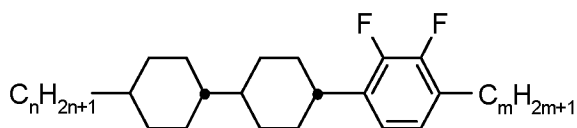
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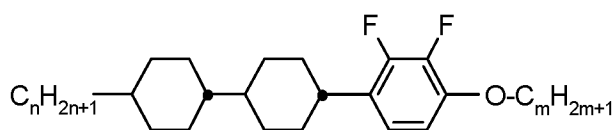
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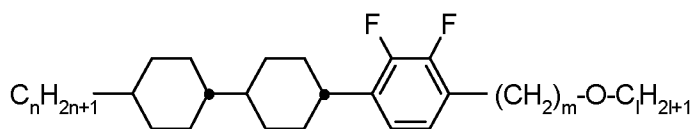
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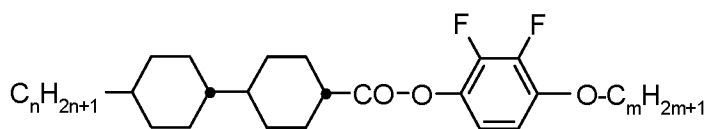
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**CCY-n-*Om***

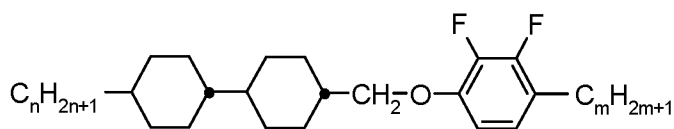
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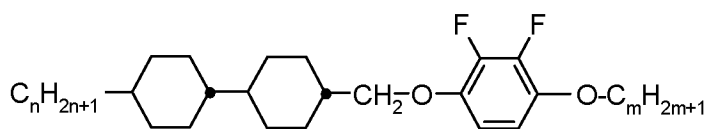
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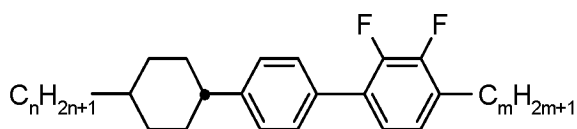
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**CCOY-n-m**

25

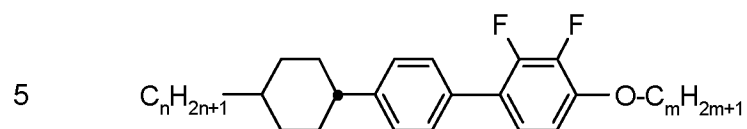
**CCOY-n-*Om***

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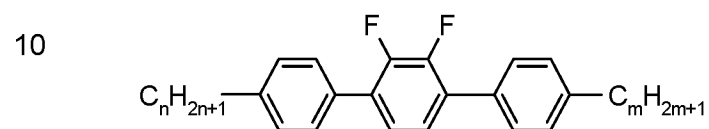


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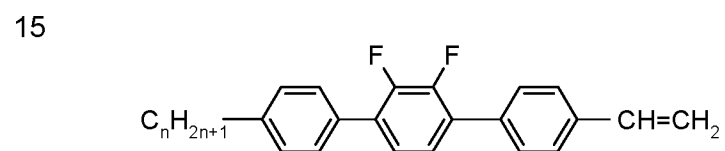
CPY-n-m



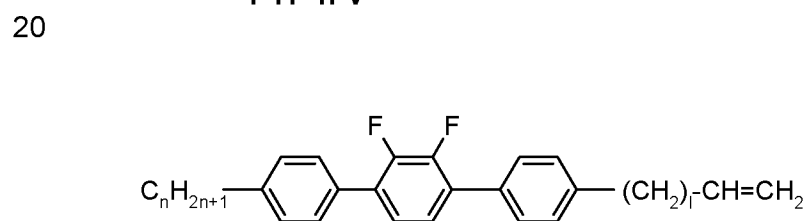
CPY-n-Om



PYP-n-m

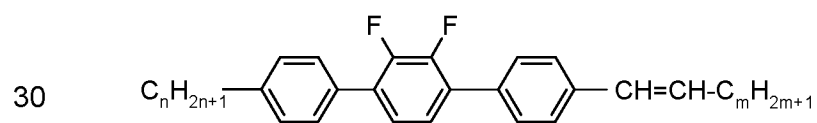


PYP-n-V



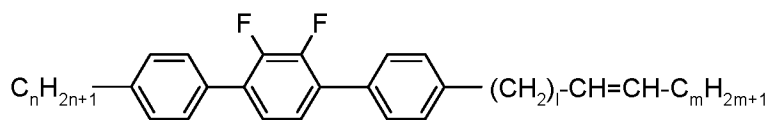
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PYP-n-IV

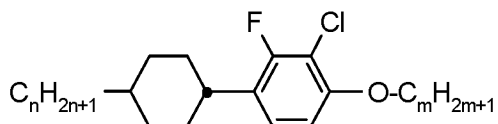


PYP-n-Vm

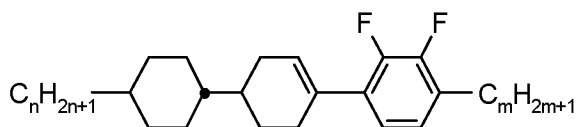
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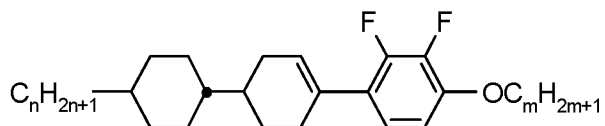
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PYP-n-IVm

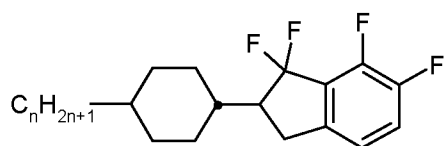
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CP(F,Cl)-n-Om

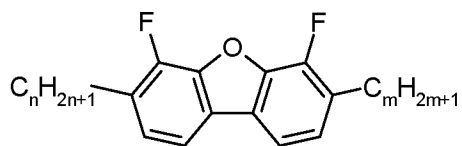
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CLY-n-m

20

CLY-n-Om

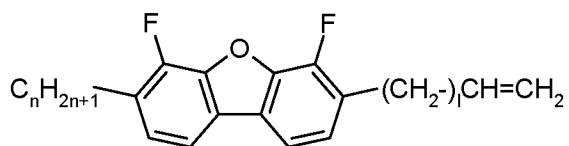
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CK-n-F

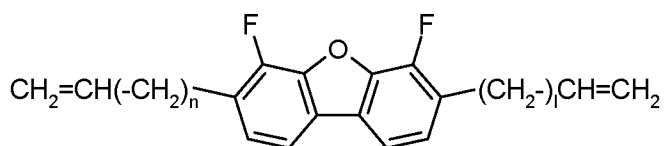
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35

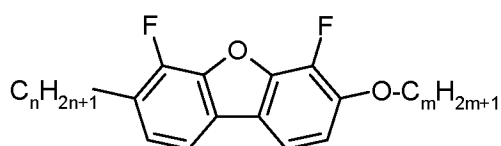
B-n-m

**B-n-IV**

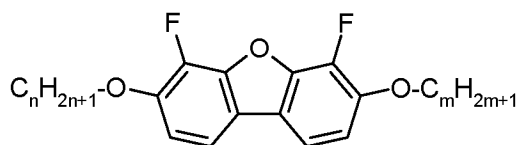
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**B-Vn-IV**

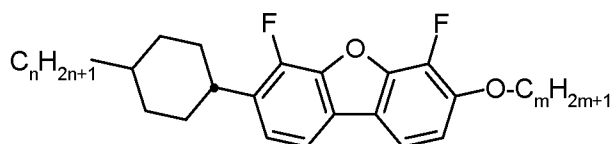
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**B-n-Om**

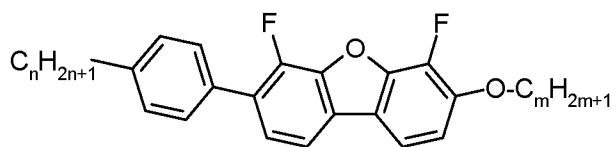
15

**B-nO-Om**

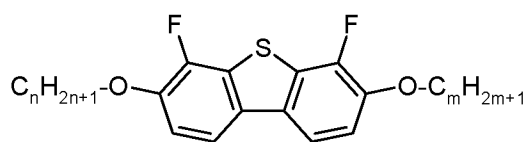
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**CB-n-Om**

25

**PB-n-Om**

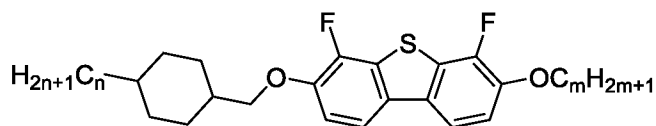
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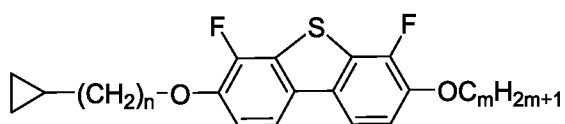
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B(S)-nO-Om

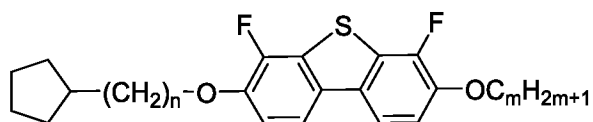
5

**COB(S)-n-Om**

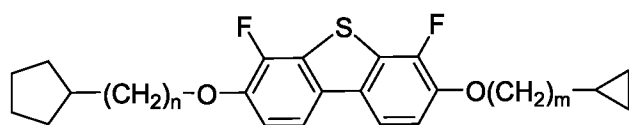
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**B(S)-(c3)nO-Om**

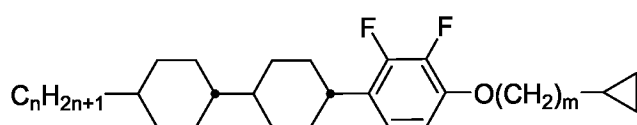
15

**B(S)-(c5)nO-Om**

20

**B(S)-(c5)nO-Om(c3)**

25

**CCY-n-Om(c3)**

30

Examples

The present invention is illustrated in detail by the following non-restrictive working examples.

The following abbreviations and symbols are used:

35

V_0 threshold voltage, capacitive [V] at 20°C,
 n_e extraordinary refractive index at 20°C and 589 nm,

	n_o	ordinary refractive index at 20°C and 589 nm,
	Δn	optical anisotropy at 20°C and 589 nm,
	$\epsilon_{\perp}$	dielectric permittivity perpendicular to the director at 20°C and 1 kHz,
	$\epsilon_{ }$	dielectric permittivity parallel to the director at 20°C and 1 kHz,
5	$\Delta\epsilon$	dielectric anisotropy at 20°C and 1 kHz,
	cl.p., T(N,I)	clearing point [°C],
	γ_1	rotational viscosity at 20°C [mPa·s],
	K_1	elastic constant, "splay" deformation at 20°C [pN],
	K_2	elastic constant, "twist" deformation at 20°C [pN],
10	K_3	elastic constant, "bend" deformation at 20°C [pN].

Unless explicitly noted otherwise, all concentrations in the present application are quoted in per cent by weight and relate to the corresponding mixture as a whole, comprising all solid or liquid-crystalline components, without solvents.

15

Unless explicitly noted otherwise, all temperature values indicated in the present application, such as, for example, for the melting point T(C,N), the transition from the smectic (S) to the nematic (N) phase T(S,N) and the clearing point T(N,I), are quoted in degrees Celsius (°C). M.p. denotes melting point, cl.p. = clearing point.

20

Furthermore, C = crystalline state, N = nematic phase, S = smectic phase and I = isotropic phase. The data between these symbols represent the transition temperatures.

25

All physical properties are and have been determined in accordance with "Merck Liquid Crystals, Physical Properties of Liquid Crystals", Status Nov. 1997, Merck KGaA, Germany, and apply for a temperature of 20°C, and Δn is determined at 589 nm and $\Delta\epsilon$ at 1 kHz, unless explicitly indicated otherwise in each case.

30

The term "threshold voltage" for the present invention relates to the capacitive threshold (V_0), also known as the Freedericks threshold, unless explicitly indicated otherwise. In the examples, the optical threshold may also, as generally usual, be quoted for 10% relative contrast (V_{10}).

35

Unless stated otherwise, the process of polymerising the polymerisable compounds in the PSA displays as described above and below is carried out at a temperature where

the LC medium exhibits a liquid crystal phase, preferably a nematic phase, and most preferably is carried out at room temperature.

5 Unless stated otherwise, methods of preparing test cells and measuring their electrooptical and other properties are carried out by the methods as described hereinafter or in analogy thereto.

10 The display used for measurement of the capacitive threshold voltage consists of two plane-parallel glass outer plates with a distance of 25 μm , each of which has on the inside an electrode layer and an unrubbed polyimide alignment layer on top, which effect homeotropic alignment of the liquid-crystal molecules.

15 The display or test cell used for measurement of the tilt angles consists of two plane-parallel glass outer plates at a separation of 4 μm , each of which has on the inside an electrode layer and a polyimide alignment layer on top, where the two polyimide layers are rubbed antiparallel to one another and effect a homeotropic edge alignment of the liquid-crystal molecules.

20 The polymerisable compounds are polymerised in the display or test cell by irradiation with UV light of defined intensity for a prespecified time, with a voltage simultaneously being applied to the display (usually 10 V to 30 V alternating current, 1 kHz). In the examples, unless indicated otherwise, a fluorescent lamp and an intensity of 0 to 20 mW/cm^2 is used for polymerisation. The intensity is measured using a standard meter (Ushio Accumulate UV meter with central wavelength of
25 313nm).

30 The transmission measurements are performed in test cells with fishbone electrode layout (from Merck Ltd., Japan; 1 pixel fishbone electrode (ITO, 10x10 mm, 47.7° angle of fishbone with 3 μm line/3 μm space), 3.2 μm cell gap, AF-glass, tilt angle 1°).

Examples

The nematic LC host mixtures H1 to H9 are formulated as follows:

Mixture H1

35

CY-3-O4	13.0 %
CCY-3-O1	5.0 %

	CCY-3-O2	5.0 %
	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
	CCY-5-O2	3.0 %
5	CPY-2-O2	8.5 %
	CPY-3-O2	10.0 %
	CCP-V-1	14.0 %
	CCP-V2-1	2.0 %
10	CC-3-V1	5.0 %
	CC-4-V	14.5 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
	CCZC-4-5	3.0 %
15	<u>Mixture H2</u>	
	CY-3-O4	13.0 %
	CCY-3-O1	5.0 %
	CCY-3-O2	5.0 %
20	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
	CCY-5-O2	3.0 %
	CPY-2-O2	8.5 %
	CPY-3-O2	10.0 %
25	CCP-V-1	14.0 %
	CCP-V2-1	2.0 %
	CC-3-V1	3.0 %
	CC-4-V	12.5 %
30	CC-4-V1	4.0 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
	CCZC-4-5	3.0 %
35	<u>Mixture H3</u>	
	CY-3-O4	13.0 %

	CCY-3-O1	5.0 %
	CCY-3-O2	5.0 %
	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
5	CCY-5-O2	3.0 %
	CPY-2-O2	8.5 %
	CPY-3-O2	10.0 %
	CCP-V-1	12.0 %
	CCP-V2-1	2.0 %
10	CC-3-V1	5.0 %
	CC-4-V	14.5 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
	CCZC-4-5	2.0 %
15	CCC-3-V	3.0 %

Mixture H4

	CY-3-O4	13.0 %
20	CCY-3-O1	5.0 %
	CCY-3-O2	4.0 %
	CCY-3-O3	5.0 %
	CCY-4-O2	4.0 %
	CCY-5-O2	3.0 %
25	CLOY-3-O2	4.0 %
	CPY-2-O2	8.5 %
	CPY-3-O2	8.0 %
	CCP-V-1	14.0 %
	CCP-V2-1	2.0 %
30	CC-3-V1	5.0 %
	CC-4-V	14.5 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
35	CCZC-4-5	3.0 %

	<u>Mixture H5</u>	
	CY-3-O4	13.0 %
	CCY-3-O1	5.0 %
5	CCY-3-O2	5.0 %
	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
	CCY-5-O2	3.0 %
	CPY-2-O2	8.5 %
10	CPY-3-O2	10.0 %
	CLP-3-1	5.0 %
	CCP-V-1	9.0 %
	CCP-V2-1	2.0 %
	CC-3-V1	5.0 %
15	CC-4-V	14.5 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
	CCZC-4-5	3.0 %
20	<u>Mixture H6</u>	
	CY-3-O4	13.0 %
	CCY-3-O1	5.0 %
	CCY-3-O2	5.0 %
25	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
	CCY-5-O2	3.0 %
	CPY-2-O2	8.5 %
	CPY-3-O2	10.0 %
30	CCP-V-1	14.0 %
	CCP-V2-1	2.0 %
	CC-3-2V1	4.0 %
	CC-4-V	14.5 %
	CC-2-3	5.0 %
35	CCZC-3-5	3.0 %
	CCZC-4-5	3.0 %

	<u>Mixture H7</u>	
	CY-3-O4	13.0 %
5	CCY-3-O1	5.0 %
	CCY-3-O2	5.0 %
	CCY-3-O1(c3)	5.0 %
	CCY-4-O2	5.0 %
	CCY-5-O2	3.0 %
10	CPY-2-O2	8.5 %
	CPY-3-O2	10.0 %
	CCP-V-1	14.0 %
	CCP-V2-1	2.0 %
	CC-3-V1	5.0 %
15	CC-4-V	14.5 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
	CCZC-4-5	3.0 %
20	<u>Mixture H8</u>	
	CY-3-O4	13.0 %
	CCY-3-O1	5.0 %
	CCY-3-O2	5.0 %
25	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
	CCY-5-O2	3.0 %
	CPY-2-O2	6.5 %
	CPY-3-O2	10.0 %
30	COB(S)-2-O4	2.0 %
	CCP-V-1	14.0 %
	CCP-V2-1	2.0 %
	CC-3-V1	5.0 %
	CC-4-V	14.5 %
35	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %

CCZC-4-5 3.0 %

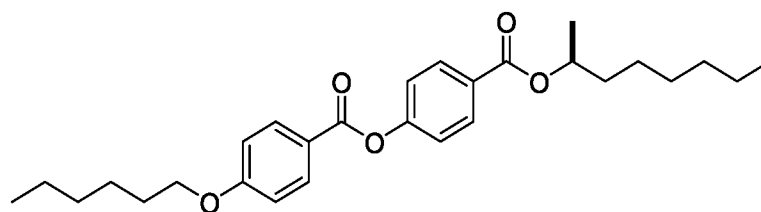
Mixture H9

5	CY-3-O4	13.0 %
	CCY-3-O1	5.0 %
	CCY-3-O2	5.0 %
	CCY-3-O3	5.0 %
	CCY-4-O2	5.0 %
10	CCY-5-O2	3.0 %
	CPY-2-O2	6.5 %
	CPY-3-O2	10.0 %
	B(S)-(c5)1O-O2	2.0 %
	CCP-V-1	14.0 %
15	CCP-V2-1	2.0 %
	CC-3-V1	5.0 %
	CC-4-V	14.5 %
	CC-3-O1	4.0 %
	CCZC-3-5	3.0 %
20	CCZC-4-5	3.0 %

Chiral Nematic Mixtures

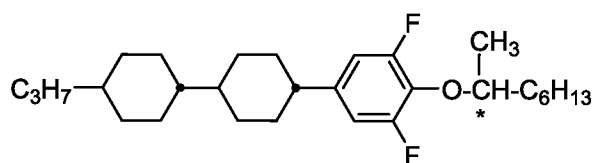
The chiral nematic mixtures are prepared from the nematic host mixture N1 above by adding the chiral dopant S-811, S-2011 or S-4011, resp.

25



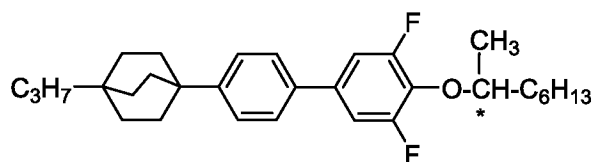
S-811

30



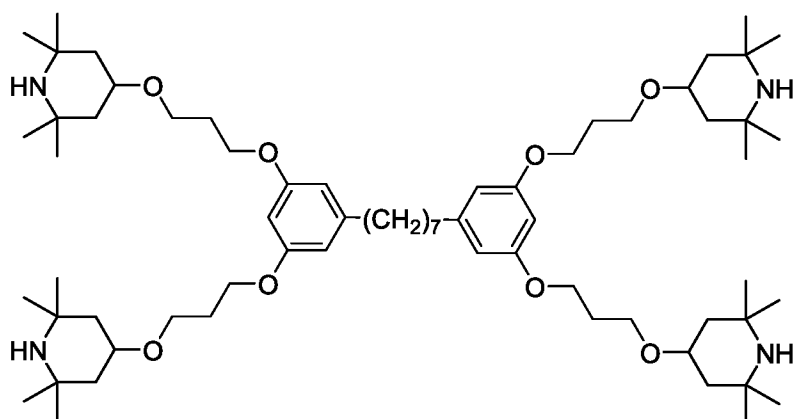
S-2011

35

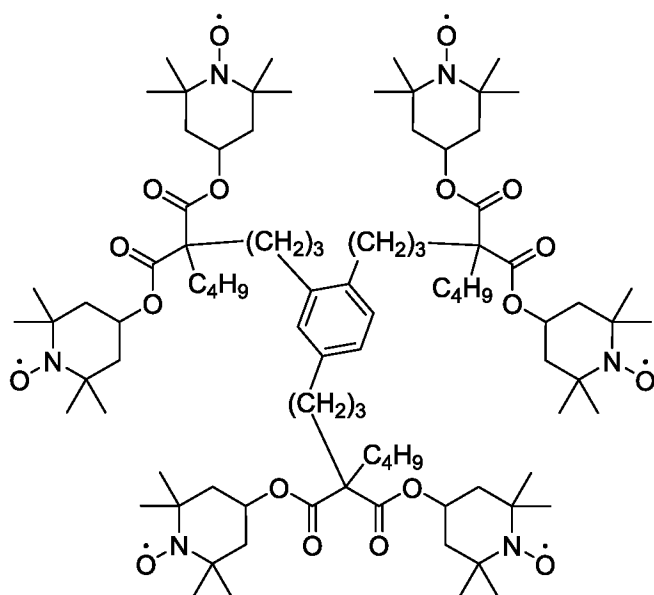


S-4011

The following stabilisers of formula I are used:

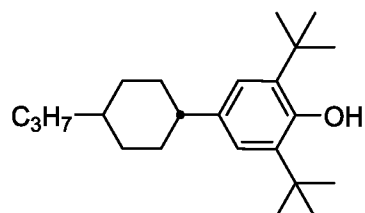


1-1-1a

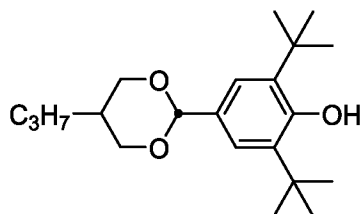


l-2-1a

In addition to the compounds of the formula I, the following stabilisers are used:



ST-3a-1



ST-3b-1

5

Mixture Examples

Using the host mixtures H1 to H9, the following LC mixtures Ch-1 to Ch-10 according to the invention are obtained having the physical properties shown in the following tables.

10

Mixture Ch-1

15	H1	98.915 %	$T_{(N,I)}$, [°C]:	110.5
	ST-3a-1	0.03 %	Δn (589 nm, 20°C):	0.0981
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5827
	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4846
20			$\Delta \varepsilon$ (1 kHz, 20°C):	-3.2
			$\varepsilon_{ }$ (1 kHz, 20°C):	3.3
			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.5
			K_1 [pN], (20°C):	16.7
			K_3 [pN], (20°C):	18.2
			γ_1 [mPa·s], (20°C):	189
			V_0 [V], (20°C):	2.51

25

Mixture Ch-2

30	H1	98.82 %	$T_{(N,I)}$, [°C]:	110.5
	ST-3a-1	0.03 %	Δn (589 nm, 20°C):	0.0981
	1-1-1a	0.10 %	n_e (20°C, 589.3 nm):	1.5827
	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4846
35			$\Delta \varepsilon$ (1 kHz, 20°C):	-3.2
			$\varepsilon_{ }$ (1 kHz, 20°C):	3.3
			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.5
			K_1 [pN], (20°C):	16.7
			K_3 [pN], (20°C):	18.2
			γ_1 [mPa·s], (20°C):	189

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V_0 [V], (20°C): 2.51

Mixture Ch-3

5	H2	98.920 %	$T_{(N,I)}$, [°C]:	111.7
	ST-3b-1	0.025 %	Δn (589 nm, 20°C):	0.0987
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5833
	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4846
10			$\Delta \varepsilon$ (1 kHz, 20°C):	-3.2
			$\varepsilon_{ }$ (1 kHz, 20°C):	3.3
			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.5
			K_1 [pN], (20°C):	17.1
			K_3 [pN], (20°C):	18.4
15			γ_1 [mPa·s], (20°C):	196
			V_0 [V], (20°C):	2.52

Mixture Ch-4

20	H3	98.960 %	$T_{(N,I)}$, [°C]:	112.8
	ST-3a-1	0.035 %	Δn (589 nm, 20°C):	0.0979
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5821
	S-2011	1.00 %	n_o (20°C, 589.3 nm):	1.4841
25			$\Delta \varepsilon$ (1 kHz, 20°C):	-3.2
			$\varepsilon_{ }$ (1 kHz, 20°C):	3.3
			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.5
			γ_1 [mPa·s], (20°C):	188
			V_0 [V], (20°C):	2.39

Mixture Ch-5

30	H4	99.13 %	$T_{(N,I)}$, [°C]:	108
	ST-3a-1	0.02 %	Δn (589 nm, 20°C):	0.0960
	1-1-1a	0.05 %	n_e (20°C, 589.3 nm):	1.5805
	S-4011	0.80 %	n_o (20°C, 589.3 nm):	1.4846
35			$\Delta \varepsilon$ (1 kHz, 20°C):	-3.4
			$\varepsilon_{ }$ (1 kHz, 20°C):	3.3

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5			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.7
			K_1 [pN], (20°C):	16.6
			K_3 [pN], (20°C):	18.2
			γ_1 [mPa·s], (20°C):	193
			V_0 [V], (20°C):	2.46

Mixture Ch-6

10	H5	98.82 %	$T_{(N,I)}$ [°C]:	112.5
	ST-3b-1	0.03 %	Δn (589 nm, 20°C):	0.0969
	1-1-1a	0.10 %	n_e (20°C, 589.3 nm):	1.5845
	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4850
15			$\Delta\varepsilon$ (1 kHz, 20°C):	-3.1
			$\varepsilon_{\parallel}$ (1 kHz, 20°C):	3.4
			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.5
			γ_1 [mPa·s], (20°C):	198
			V_0 [V], (20°C):	2.29

Mixture Ch-7

20	H6	98.960 %	$T_{(N,I)}$ [°C]:	111.0
	ST-3b-1	0.035 %	Δn (589 nm, 20°C):	0.0978
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5822
	S-811	1.0 %	n_o (20°C, 589.3 nm):	1.4845
25			$\Delta\varepsilon$ (1 kHz, 20°C):	-3.1
			$\varepsilon_{\parallel}$ (1 kHz, 20°C):	3.3
			$\varepsilon_{\perp}$ (1 kHz, 20°C):	6.4
			K_1 [pN], (20°C):	17.2
30			K_3 [pN], (20°C):	18.2
			γ_1 [mPa·s], (20°C):	188
			V_0 [V], (20°C):	2.53

Mixture Ch-8

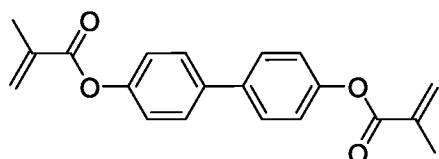
35	H7	98.915 %	$T_{(N,I)}$ [°C]:	111
	ST-3a-1	0.03 %	Δn (589 nm, 20°C):	0.0979
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5824

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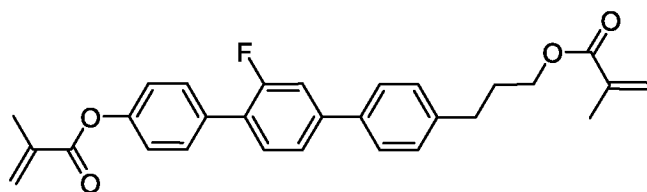
5	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4845
			$\Delta\epsilon$ (1 kHz, 20°C):	-3.2
			$\epsilon_{ }$ (1 kHz, 20°C):	3.2
			$\epsilon_{\perp}$ (1 kHz, 20°C):	6.4
			K_1 [pN], (20°C):	16.6
			K_3 [pN], (20°C):	18.4
			γ_1 [mPa·s], (20°C):	192
			V_0 [V], (20°C):	2.55
10	<u>Mixture Ch-9</u>			
	H8	98.915 %	$T_{(N,I)}$ [°C]:	111
	ST-3a-1	0.03 %	Δn (589 nm, 20°C):	0.0985
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5833
15	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4848
			$\Delta\epsilon$ (1 kHz, 20°C):	-3.3
			$\epsilon_{ }$ (1 kHz, 20°C):	3.3
			$\epsilon_{\perp}$ (1 kHz, 20°C):	6.6
			K_1 [pN], (20°C):	16.7
			K_3 [pN], (20°C):	18.5
			γ_1 [mPa·s], (20°C):	193
			V_0 [V], (20°C):	2.47
20				
25	<u>Mixture Ch-10</u>			
	H9	98.915 %	$T_{(N,I)}$ [°C]:	110
	ST-3a-1	0.03 %	Δn (589 nm, 20°C):	0.0982
	1-2-1a	0.005 %	n_e (20°C, 589.3 nm):	1.5833
30	S-4011	1.05 %	n_o (20°C, 589.3 nm):	1.4851
			$\Delta\epsilon$ (1 kHz, 20°C):	-3.3
			$\epsilon_{ }$ (1 kHz, 20°C):	3.3
			$\epsilon_{\perp}$ (1 kHz, 20°C):	6.6
			γ_1 [mPa·s], (20°C):	185
			V_0 [V], (20°C):	2.49
35				

Polymerisable Chiral Nematic Mixtures

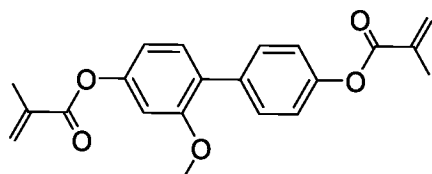
The following polymerisable chiral nematic mixtures are prepared from the chiral nematic mixtures given in Table 1 by adding a reactive mesogen (RM) selected from the group of compounds of the formulae RM1, RM2, RM3 and RM4 in the amount given in Table 4 (% RM).



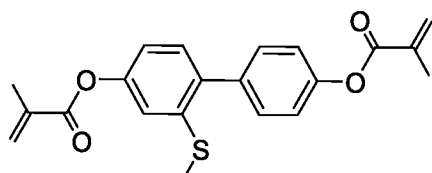
RM1



RM2



RM3



RM4

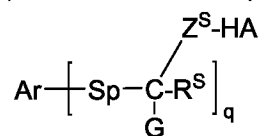
Table 4: Polymerisable Chiral Nematic Mixtures.

Mixture	LC Host	RM	% RM
PCh1	Ch1	RM1	0.3
PCh2	Ch1	RM2	0.3
PCh3	Ch1	RM3	0.4
PCh4	Ch1	RM4	0.3
PCh5	Ch2	RM1	0.2
PCh6	Ch2	RM2	0.25
PCh7	Ch2	RM3	0.25
PCh8	Ch2	RM4	0.25

Patent Claims

1. A liquid crystal medium comprising
a) one or more compounds of the formula I

5



in which

10

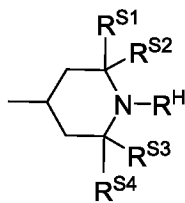
Ar denotes an aromatic or heteroaromatic hydrocarbon group having 4 to 40 C atoms;

Sp denotes a spacer group;

R^S denotes H, alkyl having 1 to 12 C atoms or alkenyl having 2 to 12 C atoms;

Z^S denotes -O-, -C(O)O-, -(CH₂)_z- or -(CH₂)_zO-, or a single bond;

15



HA denotes ;

R^H denotes H, O[•], CH₃, OH or OR^S;

20

R^{S1}, R^{S2}, R^{S3} and R^{S4}, identically or differently, denote alkyl having 1 to 6 C atoms;

G denotes H or R^S or a group Z^S-HA;

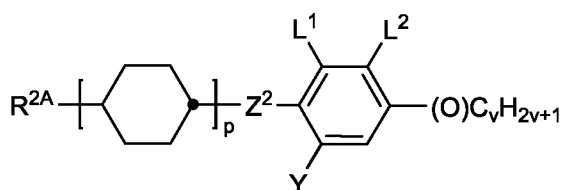
z is an integer from 1 to 6; and

q is 3 or 4;

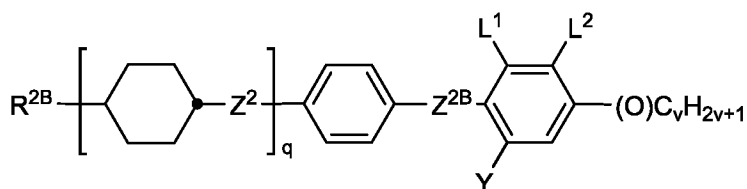
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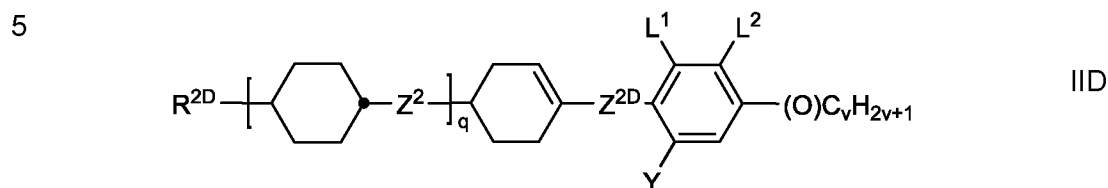
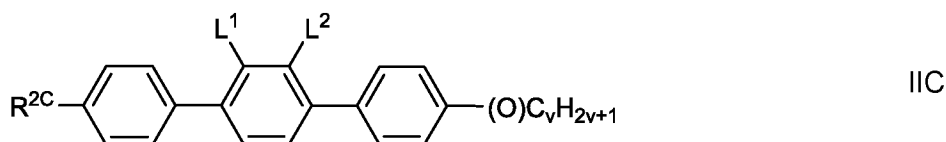
b) one or more compounds selected from the group of compounds of the formulae IIA, IIB, IIC and IID,

30



35





in which

10 R^{2A} , R^{2B} , R^{2C} and R^{2D} each, independently of one another, denote H, an alkyl or alkenyl radical having up to 15 C atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where one or more CH_2 groups in these radicals may be replaced

15 by $-O-$, $-S-$, $-C\equiv C-$, $-CF_2O-$, $-OCF_2-$, $-OC-O-$ or $-O-CO-$ in such a way that O atoms are not linked directly to one another;

L^1 and L^2 each, independently of one another, denote F, Cl, CF_3 or CHF_2 ;

20 Y denotes H, F, Cl, CF_3 , CHF_2 or CH_3 ;

Z^2 , Z^{2B} and Z^{2D} each, independently of one another, denote a single bond, $-CH_2CH_2-$, $-CH=CH-$, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-COO-$, $-OCO-$, $-C_2F_4-$, $-CF=CF-$ or $-CH=CHCH_2O-$;

p denotes 0, 1 or 2;

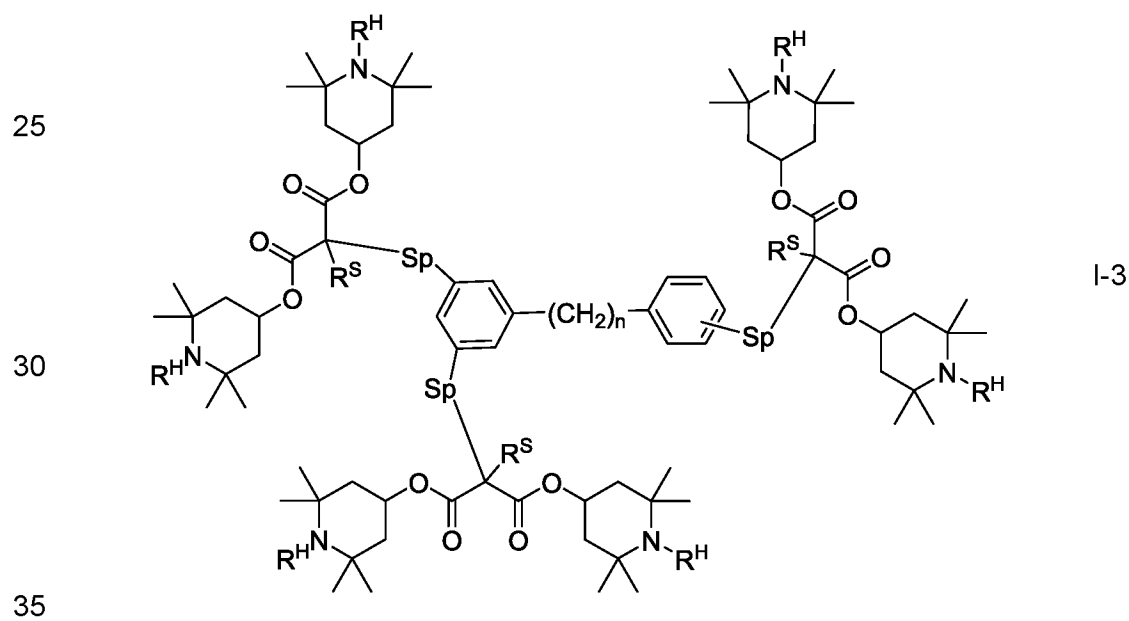
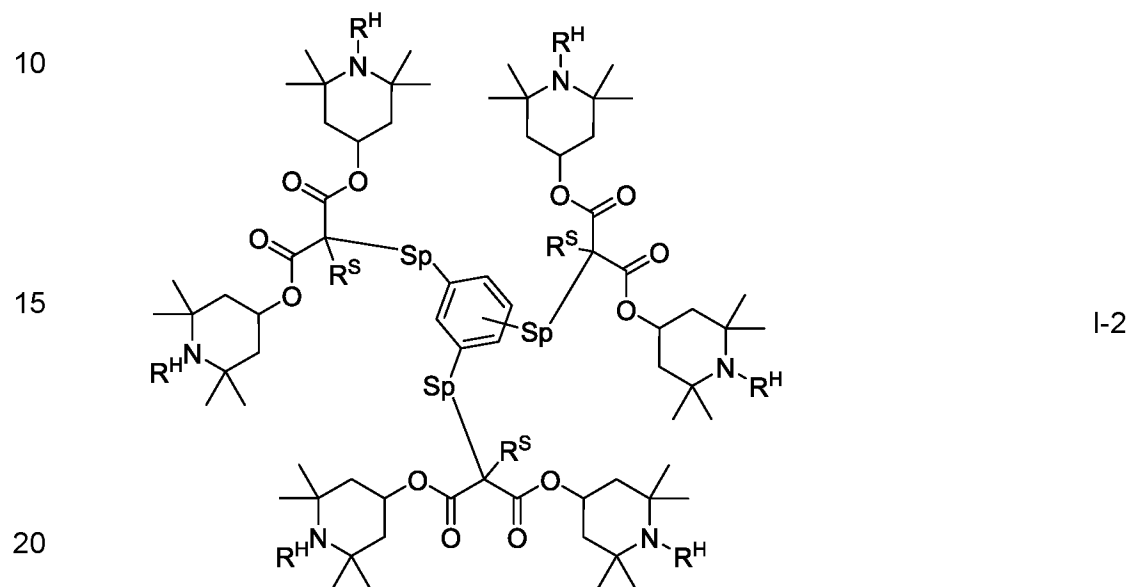
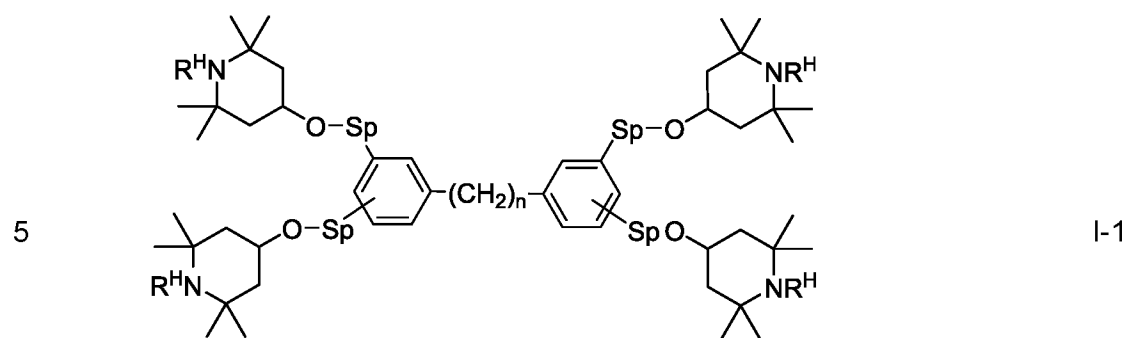
25 q denotes 0 or 1; and

v denotes 1, 2, 3, 4, 5, or 6;

and

c) one or more chiral dopants.

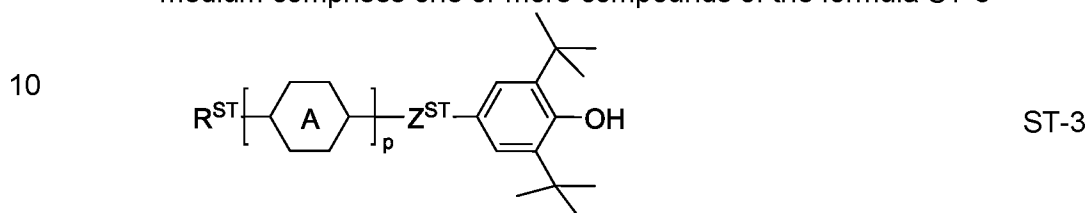
30 2. The liquid crystal medium according to claim 1, wherein the one or more compounds of formula I are selected from the compounds of the formulae I-1, I-2 and I-3:



in which R^H has the meanings given in claim 1, n is an integer from 0 to 12, and Sp denotes a spacer group.

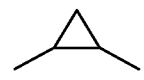
3. The liquid crystal medium according to claim 1 or 2, wherein the radical R^H denotes H or $O^\bullet$.

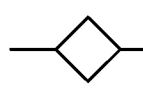
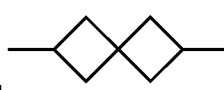
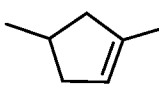
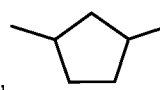
4. The liquid crystal medium according to one or more of claims 1 to 3, wherein the medium comprises one or more compounds of the formula ST-3



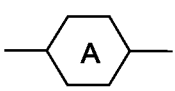
in which

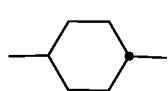
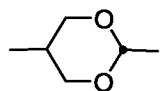
15 R^{ST} denotes H, an alkyl or alkoxy radical having 1 to 15 C atoms, where, in addition, one or more CH_2 groups in these radicals may each be replaced,

independently of one another by $-C\equiv C-$, $-CF_2O-$, $-OCF_2-$, $-CH=CH-$, ,

20 , , , , $-O-$,

$-CO-O-$ or $-O-CO-$ in such a way that O atoms are not linked directly to one another, and in which one or more H atoms may be replaced by halogen,

25 , on each occurrence, identically or differently, denotes

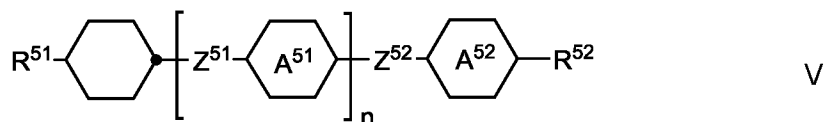
 or ,

30 Z^{ST} denotes $-CO-O-$, $-O-CO-$, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-CH_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-CH=CH-$, $-CH_2O-$, $-C_2F_4-$, $-CH_2CF_2-$, $-CF_2CH_2-$, $-CF=CF-$, $-CH=CF-$, $-CF=CH-$, $-CH=CH-$, $-C\equiv C-$ or a single bond, and

p denotes 0, 1 or 2.

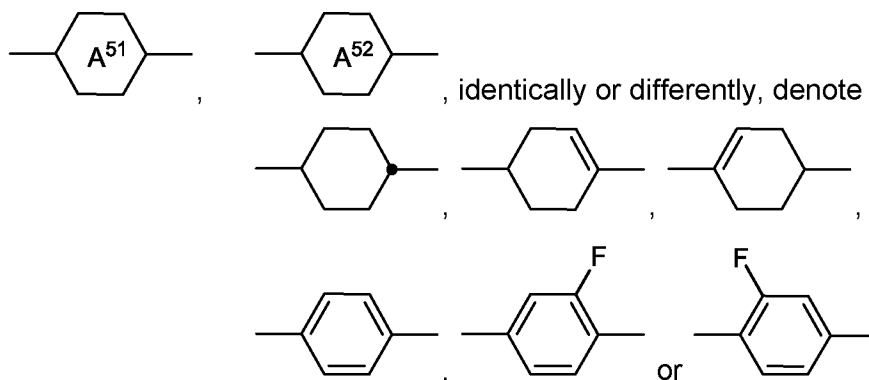
5. The liquid crystal medium according to one or more of claims 1 to 4, wherein the medium comprises one or more compounds of the formula V

35



in which

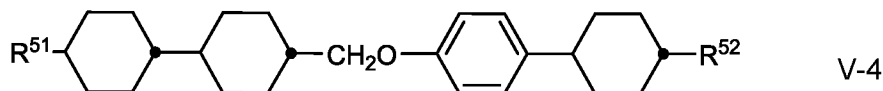
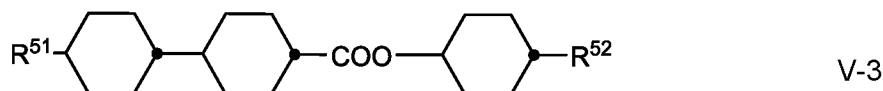
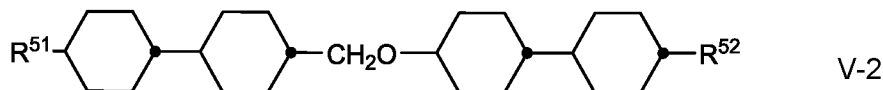
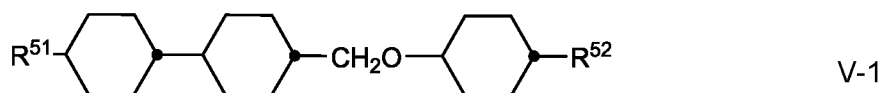
5 R⁵¹ and R⁵², identically or differently, denote alkyl having 1 to 7 C atoms, alkoxy having 1 to 7 C atoms, or alkoxyalkyl, alkenyl or alkenyloxy having 2 to 7 C atoms,

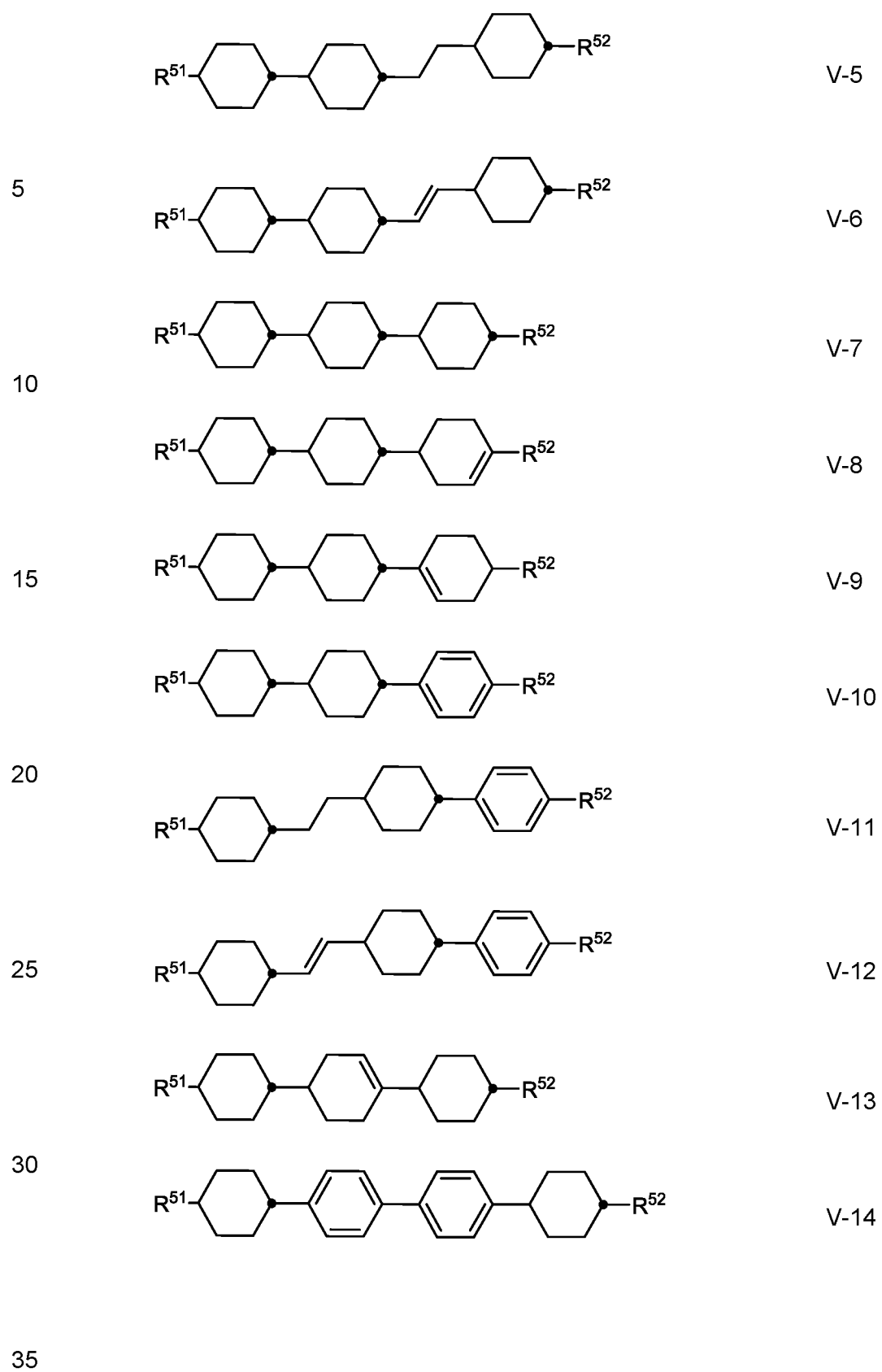


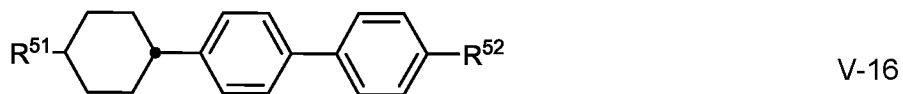
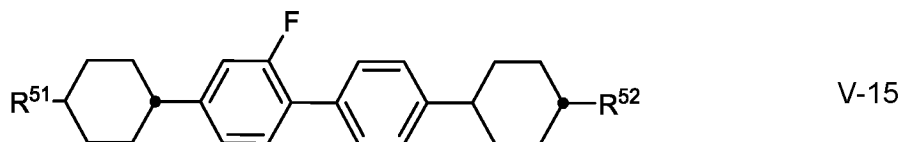
Z⁵¹, Z⁵² each, independently of one another, denote -CH₂CH₂-, -CH₂O-, -CH=CH-, -C≡C-, -COO- or a single bond, and

n is 1 or 2.

6. The liquid crystal medium according to one or more of claims 1 to 5, wherein the medium comprises one or more compounds of the formula V-1 to V-16:

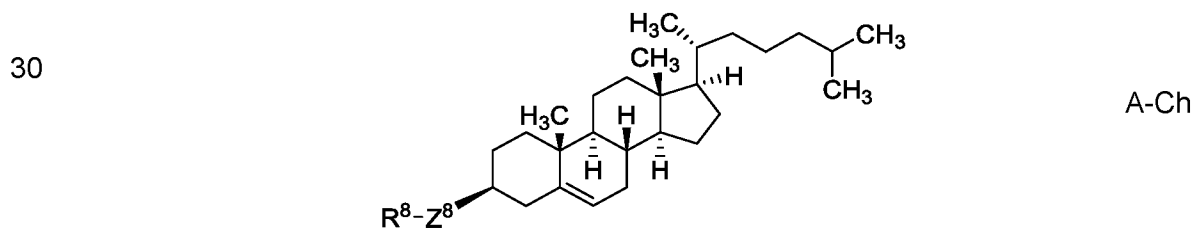
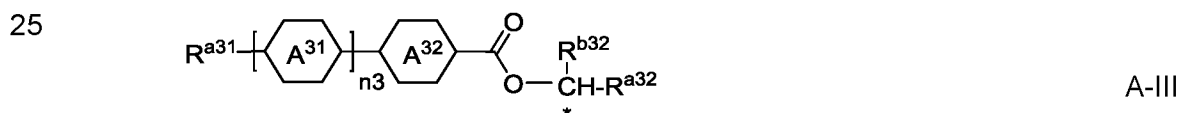
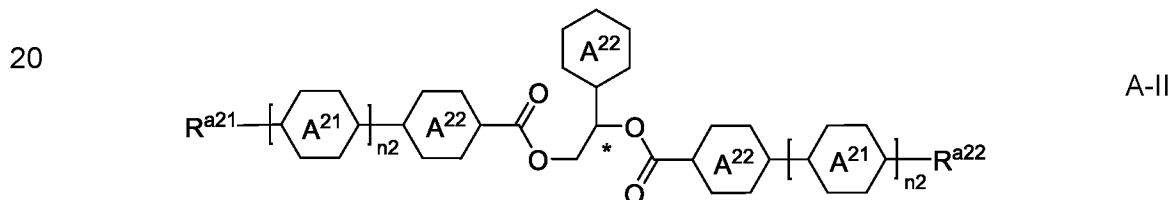
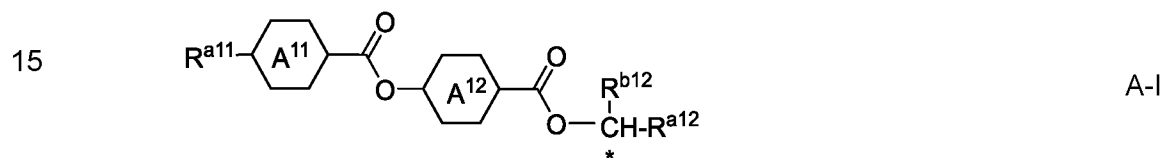






in which R^{51} and R^{52} denote straight-chain alkyl having 1 to 7 C atoms or alkenyl having 2 to 7 C atoms.

7. The liquid crystal medium according to one or more of claims 1 to 6, wherein the medium comprises one or more chiral dopants selected from the group of compounds of the formulae A-I to A-III and A-Ch:



in which

R^{a11} , R^{a12} and R^{b12} , independently of one another, denote alkyl having 1 to 15 C atoms, in which one or more non-adjacent CH_2 groups may each be

replaced, independently of one another, by $-C(R^z)=C(R^z)-$, $-C\equiv C-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may each be replaced by F, Cl, Br, I or CN, with the proviso that

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R^{a12} is different from R^{b12} ,

R^{a21} and R^{a22} , independently of one another, denote alkyl having 1 to 15 C atoms, in which one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by $-C(R^z)=C(R^z)-$, $-C\equiv C-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O and/or S atoms are not

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linked directly to one another, and in which, in addition, one or more H atoms may be replaced by F, Cl, Br, I or CN,

R^{a31} , R^{a32} and R^{b32} , independently of one another, denote straight-chain or branched alkyl having 1 to 15 C atoms, in which, in addition, one or more non-adjacent CH_2 groups may each be replaced, independently of one another, by $-C(R^z)=C(R^z)-$, $-C\equiv C-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by F, Cl, Br, I or CN, with the proviso that R^{a32} is different from

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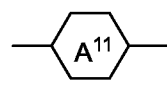
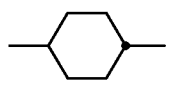
R^{b32} ,

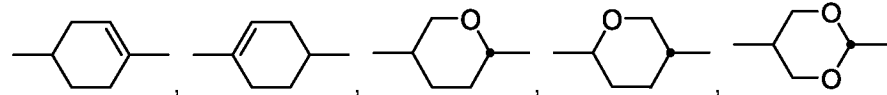
R^z denotes H, CH_3 , F, Cl, or CN,

R^8 has one of the meanings of R^{a11} given above,

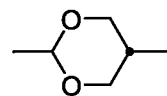
Z^8 denotes $-C(O)O-$, CH_2O , CF_2O or a single bond,

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 is defined as A^{12} below, or alternatively denotes ,

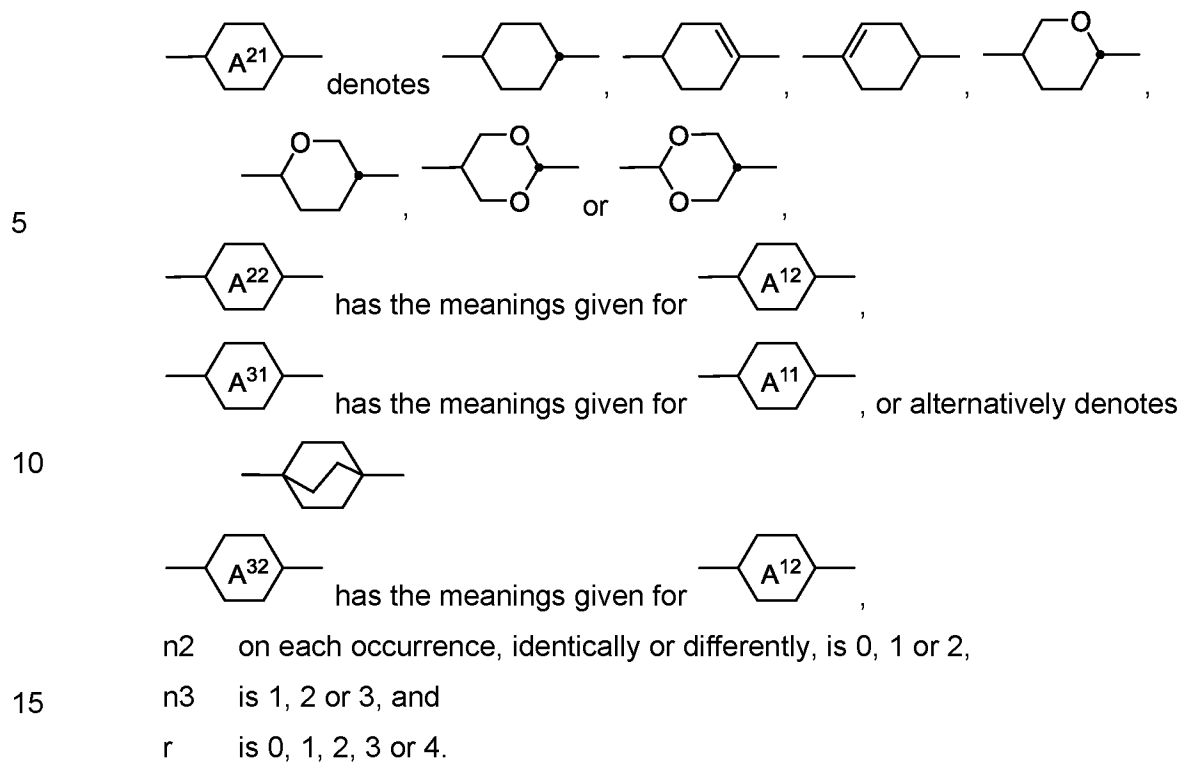


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in which L^{12} on each occurrence, independently of one another, denotes halogen, CN, or alkyl, alkenyl, alkoxy or alkenyloxy having up to 12 C atoms and in which one or more H atoms are optionally replaced with halogen,

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8. The liquid crystal medium according to one or more of claims 5 to 7, wherein the medium comprises one or more compounds of formula IIA and one or more compounds of formula IIB and one or more compounds of formula V in a total concentration of 60% or more.

9. The liquid crystal medium according to one or more of claims 1 to 8, wherein the medium has a helical pitch in the range of from 5 μm to 50 μm .

10. The liquid crystal medium according to one or more of claims 1 to 9, wherein the medium has a clearing temperature of 100°C or more.

11. The liquid crystal medium according to one or more of claims 1 to 10, wherein the medium further comprises a polymerisable compound.

12. A liquid crystal display comprising the liquid crystal medium as defined in any one of claims 1 to 11.

13. The liquid crystal display of claim 12, wherein the display is a VA, IPS or FFS type display.

14. Use of the liquid crystal medium according to one or more of claims 1 to 11 in a VA, IPS, FFS, PS-VA, PS-IPS or PS-FFS display.

5 15. A process of preparing a liquid crystal medium according to any one of claims 1 to 11, comprising the steps of mixing one or more compounds of formula I with one or more compounds selected from the group of compounds of the formulae IIA, IIB, IIC and IID, and with one or more chiral dopants, as defined in claim 1 and optionally
10 with a polymerisable compound or further liquid crystal compounds or additives.

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/074661

A. CLASSIFICATION OF SUBJECT MATTER INV. C09K19/58 C09K19/30 C09K19/04 C09K19/12 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C09K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, CHEM ABS Data, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3 354 710 A1 (MERCK PATENT GMBH [DE]) 1 August 2018 (2018-08-01) examples, especially M6-1 to M6-3; paragraphs [0155], [0157]; claims -----	1-15
X	EP 3 354 709 A1 (MERCK PATENT GMBH [DE]) 1 August 2018 (2018-08-01) examples, especially M1.1 to M1.3; paragraphs [0155], [0157]; claims; example M1.1 to M1.3 -----	1-15
X	US 2015/337202 A1 (FURUSATO YOSHIMASA [JP] ET AL) 26 November 2015 (2015-11-26) paragraphs [0002], [0033], [0078], [0079]; claims; examples -----	1-15
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 21 November 2022		Date of mailing of the international search report 28/11/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Schoenhentz, Jérôme

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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