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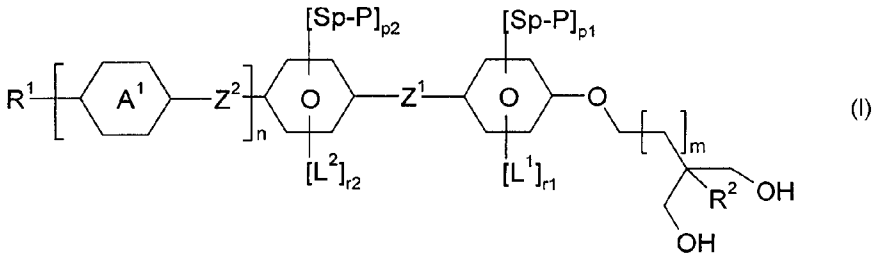
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(54) Title: LIQUID-CRYSTALLINE MEDIUM




(I)

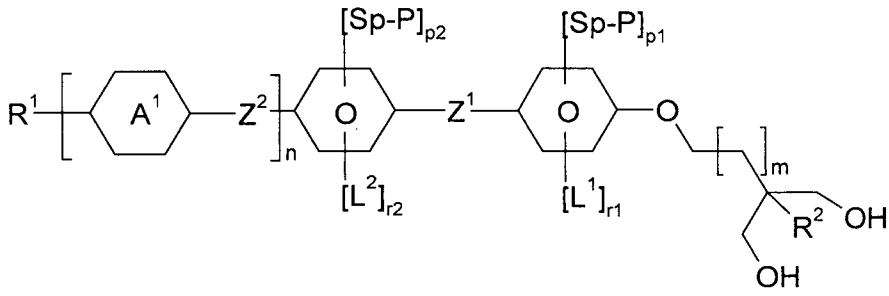
(57) Abstract: The invention relates to the compounds of the formula I and to a liquid-crystalline medium based on a mixture of polar compounds which contains at least one compound of the formula I (I) in which in which $R^1$, $R^2$, ring $A^1$, $Z^1$, $Z^2$, Sp, P, $L^1$, $L^2$, r1, r2, r3, m, n, p1 and p2 have the meanings indicated in Claim 1 and to the use of the LC mixtures in electro-optical displays, especially for the self-aligning VA, PSA, PS-VA, PVA, MVA, PM-VA, HT-VA or VA-IPS mode.

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# Liquid-crystalline medium

The invention relates to a liquid-crystalline medium which comprises at least one self-aligning additive, especially for VA, PVA, MVA, PS-VA, PM-VA, HT-VA and VA-IPS applications.

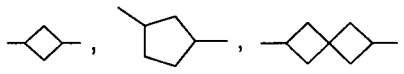
The self-aligning additives are selected from the compounds of the formula I



I

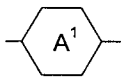
in which

$R^1$ 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 -CH=CH-, -C≡C-, $-CF_2O-$, -CH=CH-,

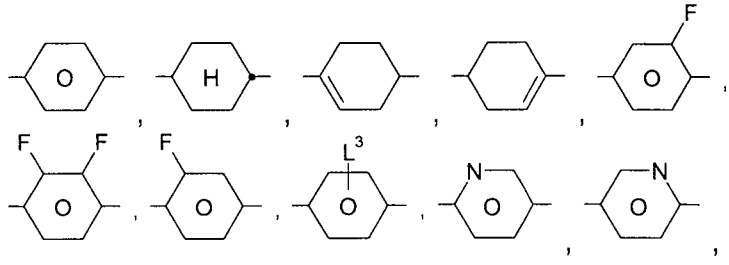


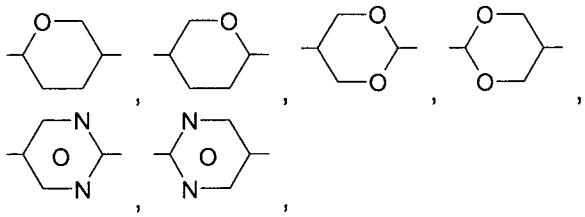
, -O-, -CO-O-, -O-CO- in such a way that O atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by halogen,

$R^2$ denotes H or an alkyl radical having 1 to 8 C atoms, in particular H, $CH_3$, $C_2H_5$, $C_3H_7$, $C_4H_9$,



denotes





| | | |
|---|---|---|
| $L^1$ and $L^2$ | | in each case, independently of one another, denotes F, Cl, Br, I, -CN, -$NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl, |
| $L^3$ | | in each case, independently of one another, denotes H, F, Cl, Br, I, -CN, -$NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl, |
| m | | denotes 0, 1 or 2, |
| n | | denotes 0, 1 or 2, |
| P | | denotes a polymerisable group, |
| Sp | | denotes a spacer group (also called spacer) or a single bond, |
| $Z^1$ and $Z^2$ | | in each case, independently of one another, denotes a single bond, -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-, -$OCH_2$-, -$CH_2$-, -$CH_2O$-, -$CF_2O$-, -$OCF_2$-, -$CH_2CH_2$-, -$(CH_2)_4$-, -$CF_2CH_2$-, -$CH_2CF_2$-, -$CF_2CF_2$-, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-COO- or -OCO-CH=CH-, |
| p1 | | denotes 1, 2 or 3, preferably 2 or 3, |
| r1 | | 0, 1, 2 or 3, whereas p1+r1 ≤ 4, |

p2 denotes 0, 1, 2 or 3

r2 denotes 0, 1, 2 or 3, whereas $p2+r2 \leq 4$.

Media of this type can be used, in particular, for electro-optical displays having active-matrix addressing based on the ECB effect.

The principle of electrically controlled birefringence, the ECB effect or also DAP (deformation of aligned phases) effect, was described for the first time in 1971 (M.F. Schieckel and K. Fahrenschon, "Deformation of nematic liquid crystals with vertical orientation in electrical fields", Appl. Phys. Lett. 19 (1971), 3912). This was followed by papers by J.F. Kahn (Appl. Phys. Lett. 20 (1972), 1193) and G. Labrunie and J. Robert (J. Appl. Phys. 44 (1973), 4869).

The papers by J. Robert and F. Clerc (SID 80 Digest Techn. Papers (1980), 30), J. Duchene (Displays 7 (1986), 3) and H. Schad (SID 82 Digest Techn. Papers (1982), 244) showed that liquid-crystalline phases must have high values for the ratio of the elastic constants $K_3/K_1$, high values for the optical anisotropy $\Delta n$ and values for the dielectric anisotropy of $\Delta\varepsilon \leq -0.5$ in order to be suitable for use in high-information display elements based on the ECB effect. Electro-optical display elements based on the ECB effect have a homeotropic edge alignment (VA technology = vertically aligned).

Displays which use the ECB effect, as so-called VAN (vertically aligned nematic) displays, for example in the MVA (multi-domain vertical alignment, for example: Yoshide, H. et al., paper 3.1: "MVA LCD for Notebook or Mobile PCs ...", SID 2004 International Symposium, Digest of Technical Papers, XXXV, Book I, pp. 6 to 9, and Liu, C.T. et al., paper 15.1: "A 46-inch TFT-LCD HDTV Technology ...", SID 2004 International Symposium, Digest of Technical Papers, XXXV, Book II, pp. 750 to 753), PVA (patterned vertical alignment, for example: Kim, Sang Soo, paper 15.4: "Super PVA Sets New State-of-the-Art for LCD-TV", SID 2004 International Symposium, Digest of Technical Papers, XXXV, Book II, pp. 760 to 763), ASV (advanced super view, for example: Shigeta, Mitzuhiro and Fukuoka,

Hirofumi, paper 15.2: "Development of High Quality LCDTV", SID 2004 International Symposium, Digest of Technical Papers, XXXV, Book II, pp. 754 to 757) modes, have established themselves as one of the three more recent types of liquid-crystal display that are currently the most important, in particular for television applications, besides IPS (in-plane switching) displays (for example: Yeo, S.D., paper 15.3: "An LC Display for the TV Application", SID 2004 International Symposium, Digest of Technical Papers, XXXV, Book II, pp. 758 & 759) and the long-known TN (twisted nematic) displays. The technologies are compared in general form, for example, in Souk, Jun, SID Seminar 2004, seminar M-6: "Recent Advances in LCD Technology", Seminar Lecture Notes, M-6/1 to M-6/26, and Miller, Ian, SID Seminar 2004, seminar M-7: "LCD-Television", Seminar Lecture Notes, M-7/1 to M-7/32. Although the response times of modern ECB displays have already been significantly improved by addressing methods with overdrive, for example: Kim, Hyeon Kyeong et al., paper 9.1: "A 57-in. Wide UXGA TFT-LCD for HDTV Application", SID 2004 International Symposium, Digest of Technical Papers, XXXV, Book I, pp. 106 to 109, the achievement of video-compatible response times, in particular on switching of grey shades, is still a problem which has not yet been satisfactorily solved.

Industrial application of this effect in electro-optical display elements requires LC phases, which have to satisfy a multiplicity of requirements. Particularly important here are chemical resistance to moisture, air and physical influences, such as heat, infrared, visible and ultraviolet radiation and direct and alternating electric fields.

Furthermore, industrially usable LC phases are required to have a liquid-crystalline mesophase in a suitable temperature range and low viscosity.

None of the hitherto-disclosed series of compounds having a liquid-crystalline mesophase includes a single compound which meets all these requirements. Mixtures of two to 25, preferably three to 18, compounds are therefore generally prepared in order to obtain substances which can be used as LC phases. However, it has not been possible to prepare optimum phases easily in this way since no liquid-crystal materials having signifi-

cantly negative dielectric anisotropy and adequate long-term stability were hitherto available.

Matrix liquid-crystal displays (MLC displays) are known. Non-linear elements which can be used for individual switching of the individual pixels are, for example, active elements (i.e. transistors). The term "active matrix" is then used, where a distinction can be made between two types:

1. MOS (metal oxide semiconductor) transistors on a silicon wafer as substrate
2. thin-film transistors (TFTs) on a glass plate as substrate.

In the case of type 1, the electro-optical effect used is usually dynamic scattering or the guest-host effect. The use of single-crystal silicon as substrate material restricts the display size, since even modular assembly of various part-displays results in problems at the joints.

In the case of the more promising type 2, which is preferred, the electro-optical effect used is usually the TN effect.

A distinction is made between two technologies: TFTs comprising compound semiconductors, such as, for example, CdSe, or TFTs based on polycrystalline or amorphous silicon. The latter technology is being worked on intensively worldwide.

The TFT matrix is applied to the inside of one glass plate of the display, while the other glass plate carries the transparent counterelectrode on its inside. Compared with the size of the pixel electrode, the TFT is very small and has virtually no adverse effect on the image. This technology can also be extended to fully colour-capable displays, in which a mosaic of red, green and blue filters is arranged in such a way that a filter element is opposite each switchable pixel.

The term MLC displays here covers any matrix display with integrated non-linear elements, i.e. besides the active matrix, also displays with passive matrix (PM displays).

MLC displays of this type are particularly suitable for TV applications (for example pocket TVs) or for high-information displays in automobile or aircraft construction. Besides problems regarding the angle dependence of the contrast and the response times, difficulties also arise in MLC displays due to insufficiently high specific resistance of the liquid-crystal mixtures [TOGASHI, S., SEKIGUCHI, K., TANABE, H., YAMAMOTO, E., SORIMACHI, K., TAJIMA, E., WATANABE, H., SHIMIZU, H., Proc. Eurodisplay 84, Sept. 1984: A 210-288 Matrix LCD Controlled by Double Stage Diode Rings, pp. 141 ff., Paris; STROMER, M., Proc. Eurodisplay 84, Sept. 1984: Design of Thin Film Transistors for Matrix Addressing of Television Liquid Crystal Displays, pp. 145 ff., Paris]. With decreasing resistance, the contrast of an MLC display deteriorates. Since the specific resistance of the liquid-crystal mixture generally drops over the life of an MLC display owing to interaction with the inside surfaces of the display, a high (initial) resistance is very important for displays that have to have acceptable resistance values over a long operating period.

VA displays have significantly better viewing-angle dependencies and are therefore principally used for televisions and monitors. However, there continues to be a need here to improve the response times, in particular with respect to the use of televisions having frame rates (image change frequency/repetition rates) of greater than 60 Hz. At the same time, however, the properties, such as, for example, the low-temperature stability, must not be impaired.

The reliability of liquid crystal (LC) mixtures is one of the major issues in today's LCD industry. A main aspect is the stability of the liquid crystal molecules towards the light emitted from the backlight unit of the LCD. Light induced reactions of the LC material can cause display defects known as image sticking. This strongly reduces the lifetime of the LCD and is one of the main reliability criterions in LCD industry.

In conventional VA-displays a polyimide (PI) layer is needed for inducing the required homeotropic orientation of the LC. Besides of the significant costs due to its production, unfavourable interaction between PI and LC often leads to a reduction of the electric resistance of the VA-display. The

number of suitable LC molecules is thus significantly reduced, at the expenses of the overall switching performances (e.g. higher switching times) of the display. Getting rid of PI is thus desirable, while providing for the required homeotropic orientation.

Thus, there is a demand to find LC mixtures which do not require a polyimide layer for the homeotropic orientation but still show a high performance and reliability.

The invention thus has an object of providing self-aligning additives and liquid-crystal mixtures, in particular for monitor and TV applications, which are based on the ECB effect especially for VA, PSA, PS-VA, PVA, MVA, PM-VA, HT-VA and VA-IPS applications, which do not have the above-mentioned disadvantages or only do so to a reduced extent. In particular, it must be ensured for monitors and televisions that they also operate at extremely high and extremely low temperatures and have short response times and at the same time have improved reliability behaviour, in particular have no or significantly reduced image sticking after long operating times.

It has now been found that these and other objects can be achieved if LC media according to the invention are used in LC displays, especially in displays without any orientation layer (polyimide layer).

The invention thus relates to a liquid crystalline medium, preferably having a negative dielectrically anisotropy ($\Delta\varepsilon$), with improved degradation which contains at least one compound of the formula I.

Such kind of mixtures are highly suitable for the use in displays which do not contain any orientation layer. Liquid crystal display devices, in general have a structure in which a liquid crystal mixture is sealed between a pair of insulating substrates, such as glass substrates, in such a manner that the liquid crystal molecules thereof are orientated in a predetermined direction, and an orientation film is formed on the respective substrates on the side of the liquid crystal mixture. As a material of an orientation film there is usually used a polyimide (PI). Homeotropic orientation of the LC

molecules is especially necessary for LC modes like PVA, PS-VA, VA, etc., and can be achieved by the use of self-aligning additives, without the need of an orientation film. The mixtures according to the invention show an improved light and temperature stability compared to LC mixtures without any self-aligning additives.

In a preferred embodiment, the LC mixture according to the invention contains at least one self-aligning additive of the formula I and optionally at least one polymerisable compound (also called reactive mesogen (RM)). Such kind of LC mixtures are highly suitable for PI-free PS (polymer stabilised)-VA displays or PSA (polymer sustained alignment) displays. The alignment of the LC molecules is induced by the self-aligning additives and the induced orientation (pre-tilt) may be additionally tuned or stabilized by the polymerization of the reactive mesogens (RMs), under conditions suitable for a multidomain switching. By the tuning of the UV-curing conditions it is possible in one single step to improve simultaneously SWT and contrast ratio. Reliability of the mixture (VHR) after light stress (both UV-curing and Backlight (BLT)) is improved compared to LC mixtures without any self-aligning additive filled in a "classic" PI-coated test cell. Furthermore, the UV-curing may be performed by using cut-filters at a wavelength by which the polymerization of the RMs is still reasonably fast and the VHR values are on an acceptable level.

The mixtures according to the invention preferably exhibit very broad nematic phase ranges having clearing points ≥ 70°C, preferably ≥ 75°C, in particular ≥ 80°C, very favourable values for the capacitive threshold, relatively high values for the holding ratio and at the same time very good low-temperature stabilities at -20°C and -30°C, as well as very low rotational viscosities and short response times. The mixtures according to the invention are furthermore distinguished by the fact that, in addition to the improvement in the rotational viscosity $\gamma_1$, relatively high values of the elastic constant $K_{33}$ for improving the response times can be observed.

Some preferred embodiments of the mixtures according to the invention are indicated below.

In the compounds of the formulae I $R^1$ preferably denotes straight-chain or branched alkyl, in particular $CH_3$, $C_2H_5$, n-$C_3H_7$, n-$C_4H_9$, n-$C_5H_{11}$, n-$C_6H_{13}$ or $CH_2C(C_2H_5)C_4H_9$, furthermore alkenyloxy, in particular $OCH_2CH=CH_2$, $OCH_2CH=CHCH_3$, $OCH_2CH=CHC_2H_5$, alkoxy, in particular $OC_2H_5$, $OC_3H_7$, $OC_4H_9$, $OC_5H_{11}$ and $OC_6H_{13}$. In particular $R^1$ denotes a straight chain alkyl residue, preferably $C_5H_{11}$.

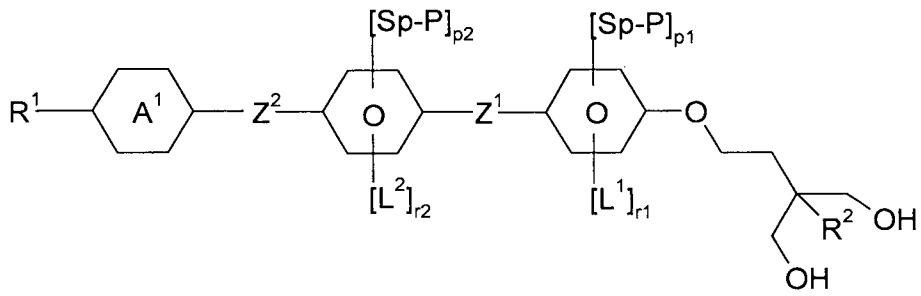
In the compounds of the formulae I $Z^1$ and $Z^2$ preferably denote a single bond, $-C_2H_4-$, $-CF_2O-$ or $-CH_2O-$. In a specifically preferred embodiment $Z^1$ and $Z^2$ each independently denote a single bond.

In the compounds of the formula I $L^1$ and $L^2$ each independently preferably denote F or alkyl, preferably $CH_3$, $C_2H_5$ or $C_3H_7$. In a preferred embodiment, r2 denotes 1 or r1 denotes 0. $L^3$ preferably denotes H, F or straight chain alkyl mit up to 5, preferably 3, carbon atoms.

In the compounds of formula I the index m preferably denotes 1 or 2, more preferably 1. The index n preferably denotes 1 or 2, more preferably 1.

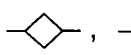
The term "spacer group" or "spacer", generally denoted by "Sp" herein, is known to the person skilled in the art and is described in the literature, for example in Pure Appl. Chem. 73(5), 888 (2001) and C. Tschierske, G. Pelzl, S. Diele, Angew. Chem. (2004), 116, 6340-6368. In the present disclosure, the term "spacer group" or "spacer" denotes a connecting group, for example an alkylene group, which connects a mesogenic group to a polymerisable group. Whereas the mesogenic group generally contains rings, the spacer group is generally without ring systems, i.e. is in chain form, where the chain may also be branched. The term chain is applied, for example, to an alkylene group. Substitutions on and in the chain, for example by -O- or -COO-, are generally included. In functional terms, the spacer (the spacer group) is a bridge between linked functional structural parts which facilitates a certain spatial flexibility to one another. In a preferred embodiment Sp denotes an alkylene group, preferably with 2 to 5 carbon atoms.

Preferred three ring compounds of the formula I are selected from the compounds of the formula I*,

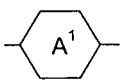
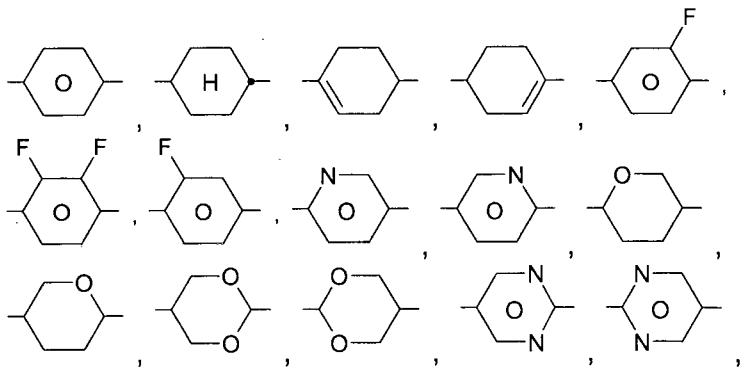


I*

in which

$R^1$ 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 -CH=CH-, -C≡C-, $-CF_2O-$, -CH=CH-,  ,  , -O-, -CO-O-, -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,

$R^2$ denotes H or an alkyl radical having 1 to 8 C atoms,

 denotes 

$L^1$ and $L^2$ in each case, independently of one another, denotes F, Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms,

in which, in addition, one or more H atoms may be replaced by F or Cl,

P denotes a polymerisable group,

Sp denotes a spacer group (also called spacer) or a single bond,

$Z^1$ and $Z^2$ in each case, independently of one another, denotes a single bond, -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-, $-OCH_2-$, $-CH_2-$, $-CH_2O-$, $-CF_2O-$, $-OCF_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-CF_2CH_2-$, $-CH_2CF_2-$, $-CF_2CF_2-$, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-COO- or -OCO-CH=CH-,

p1 denotes 1, 2 or 3, preferably 2 or 3,

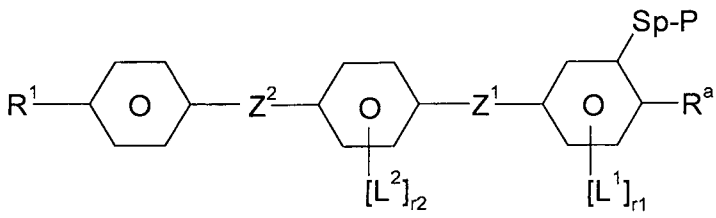
r1 denotes 0, 1, 2 or 3, whereas $p1+r1 \leq 4$,

p2 denotes 0, 1, 2 or 3

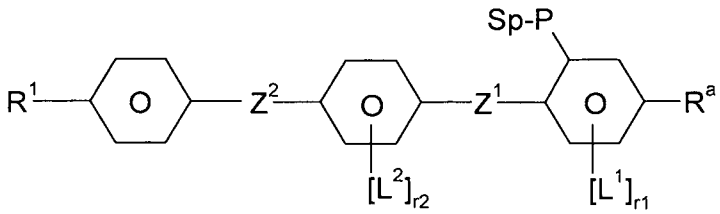
r2 denotes 1, 2 or 3, whereas $p2+r2 \leq 4$.

Preferred liquid-crystalline mixtures are based on a mixture of polar compounds which contain at least one compound of the formula I*,

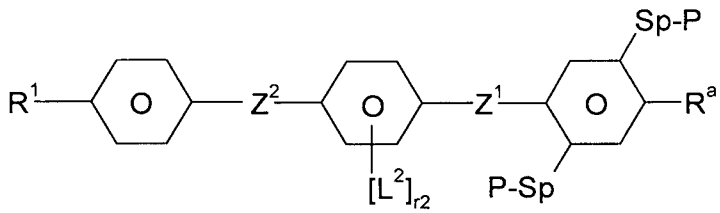
Preferred compounds of the formula I are illustrated by the following sub-formulae I-A to I-H



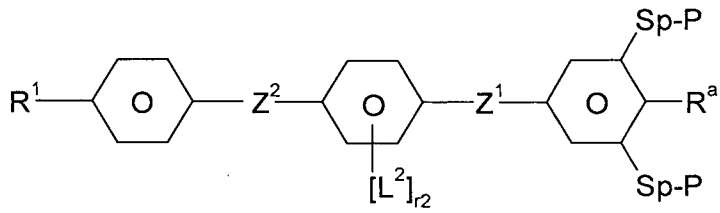

I-A



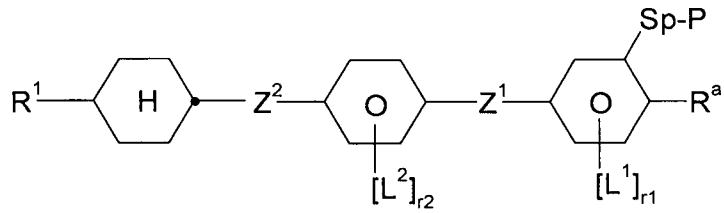

I-B



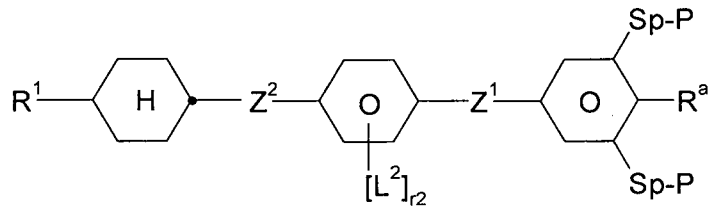

I-C



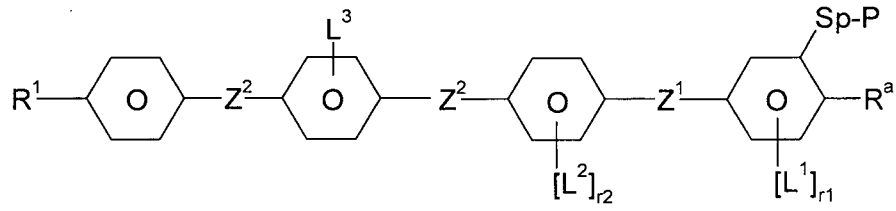

I-D



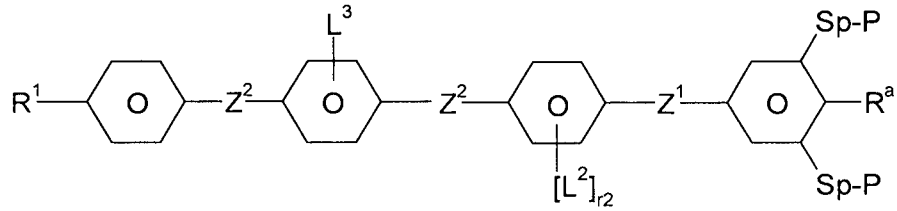

I-E




I-F



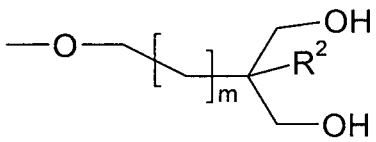

I-G



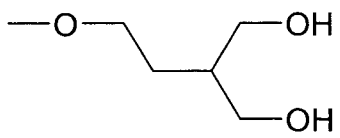

I-H

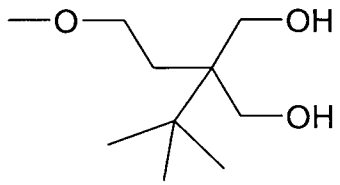
in which $R^1$, $L^1$, $L^2$, $L^3$, $Z^1$, $Z^2$, Sp, P, r1, r2 have the meanings as defined for formula I in Claim 1. $L^3$ preferably denotes H, F or alkyl. $Z^1$ and $Z^2$ preferably denote a single bond or $-CH_2CH_2-$ and very particularly a single bond.

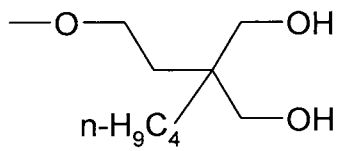
$R^a$ denotes



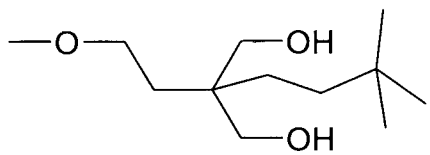
wherein m denotes 0, 1 or 2,
in particular



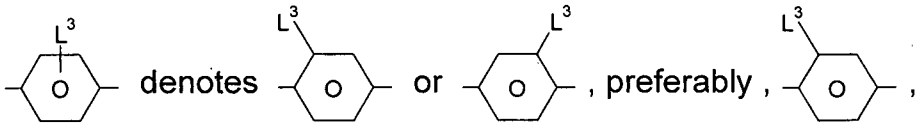




or

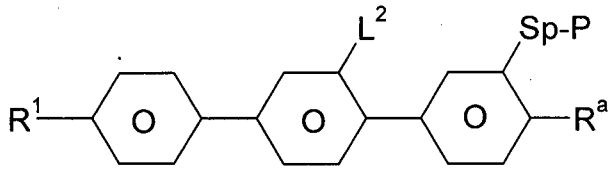


In the formulae above and below,

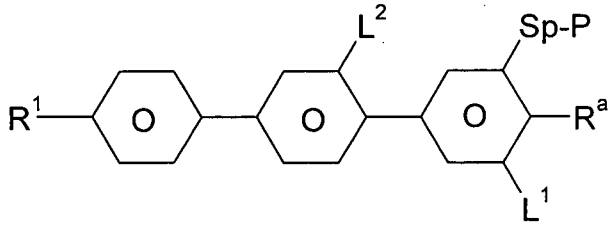


wherein $L^3$ is defined independently as above, and denotes preferably H, methyl, ethyl, n-propyl or F.

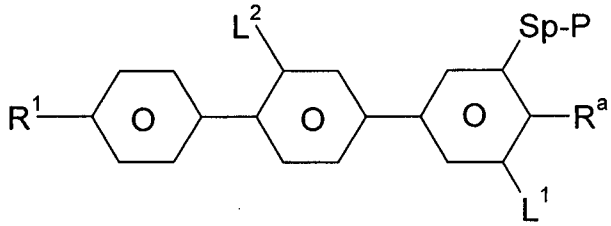
In particular preferred compounds of the formula I are selected from the compounds of the sub-formulae I-1 to I-79,



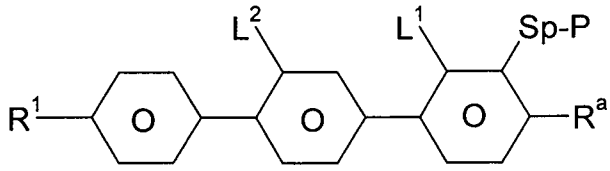
I-1



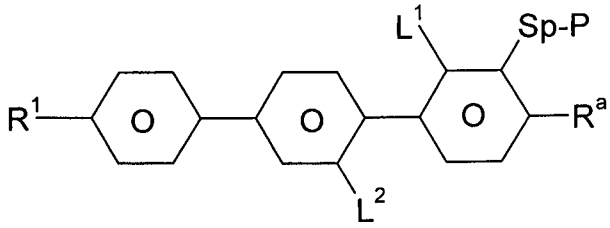
I-2



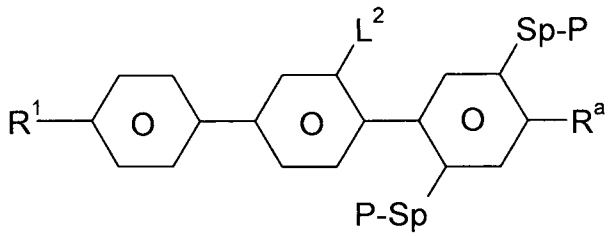
I-3



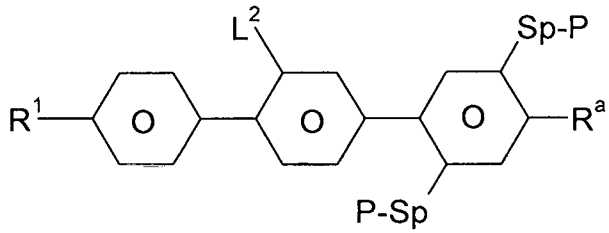
I-4



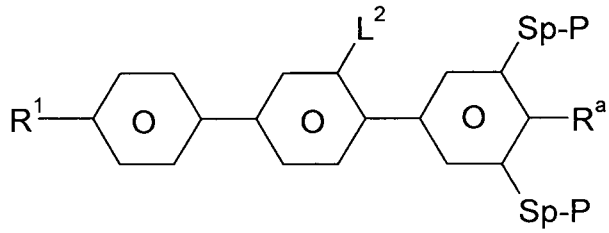
I-5



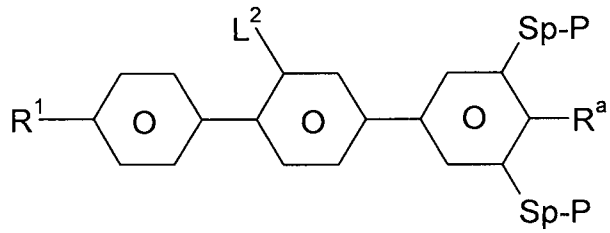

I-6



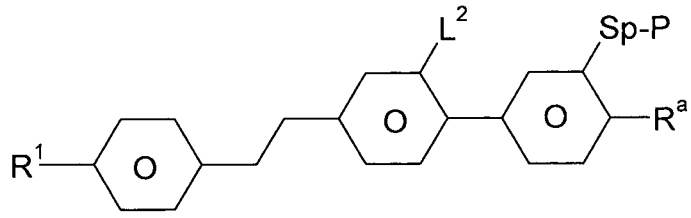

I-7



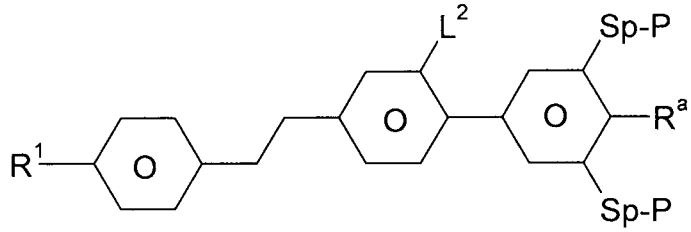

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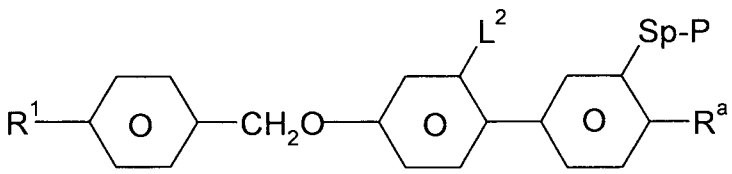

I-9



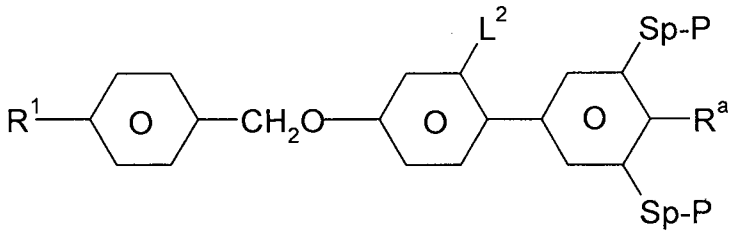

I-10



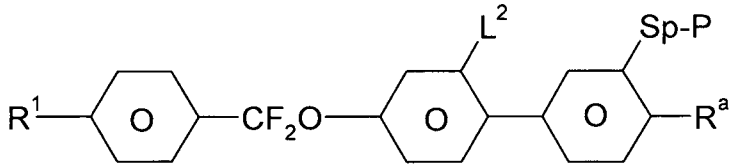

I-11



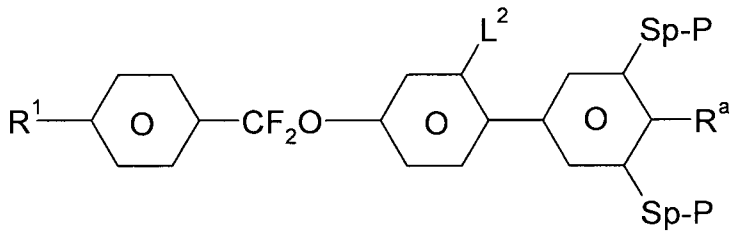

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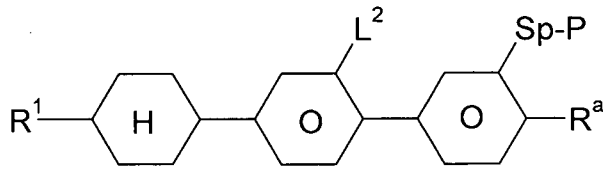

I-13



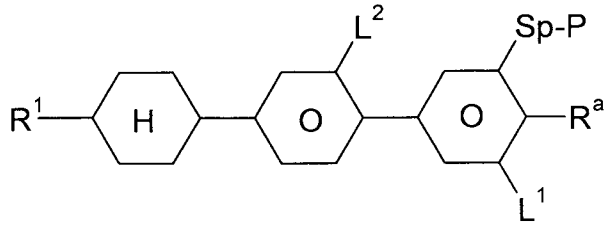

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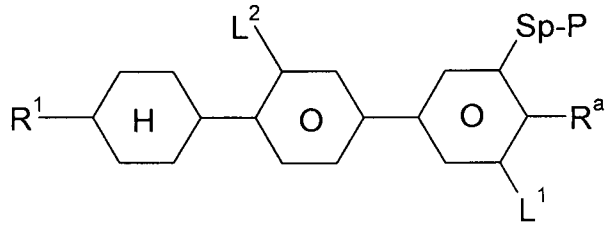

I-15



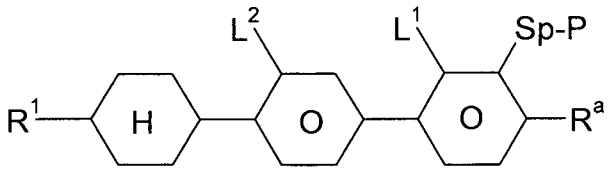

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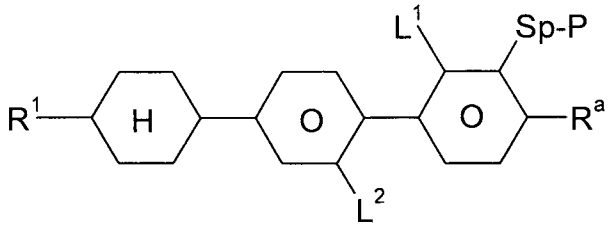

I-17



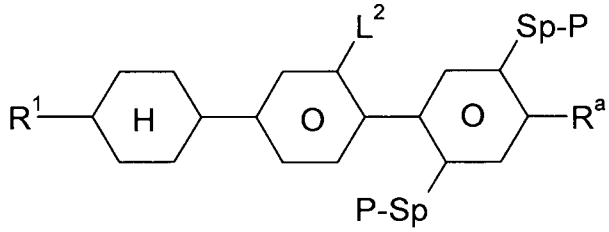

I-18



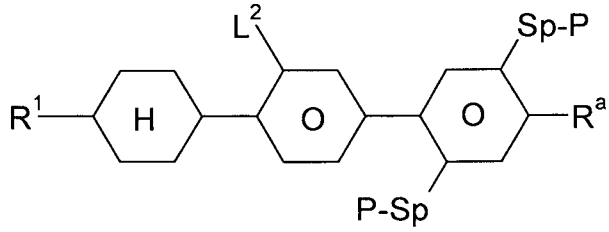

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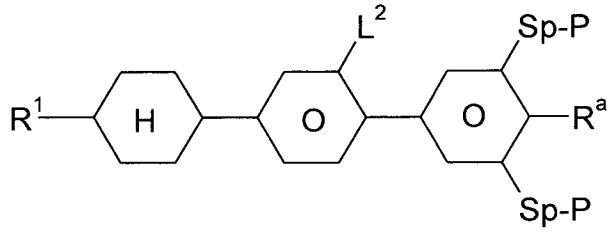

I-20



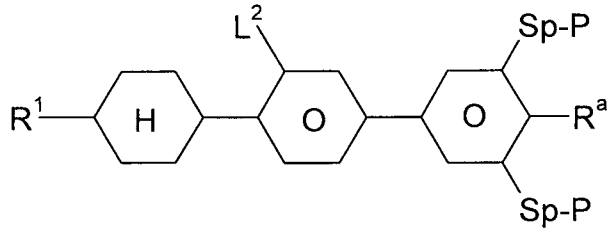

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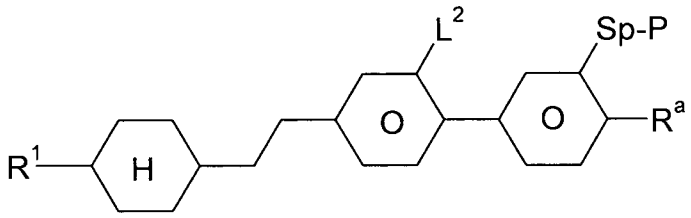

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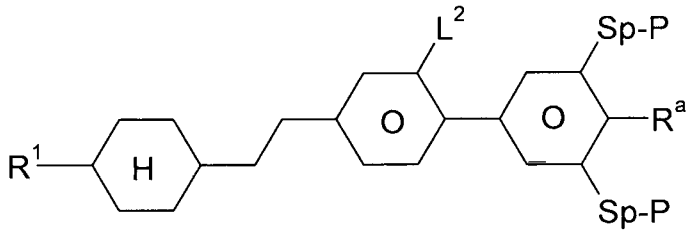

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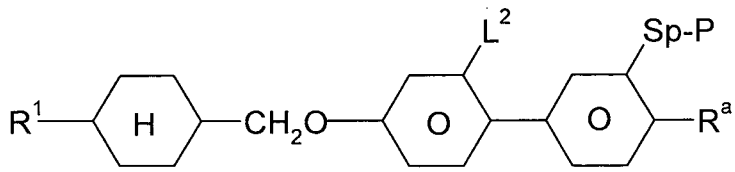

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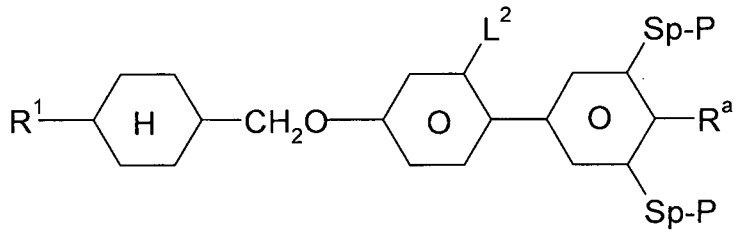

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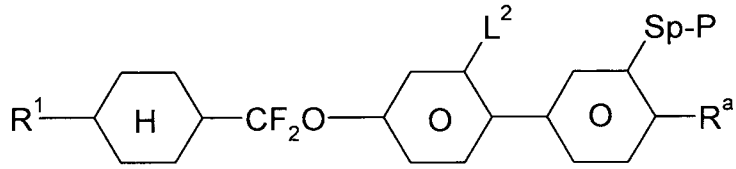

I-26



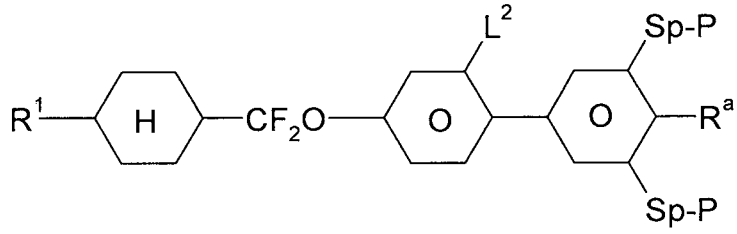

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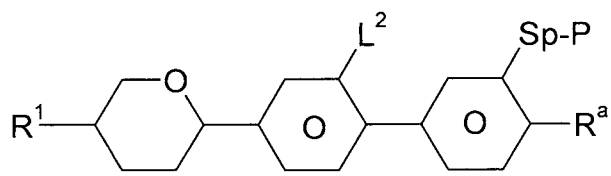

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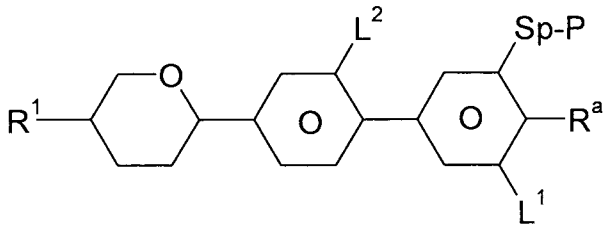

I-29



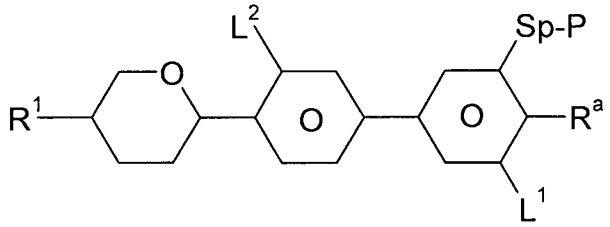

I-30



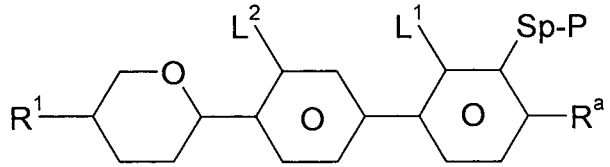

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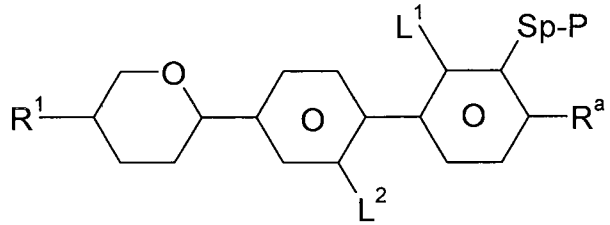

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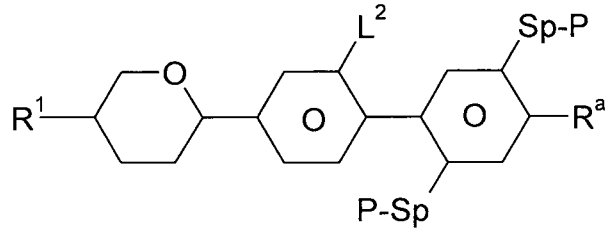

I-33



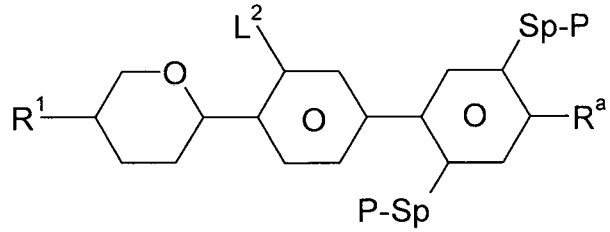

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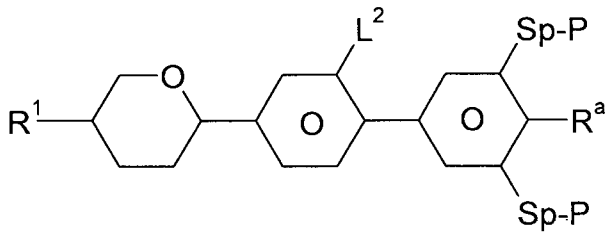

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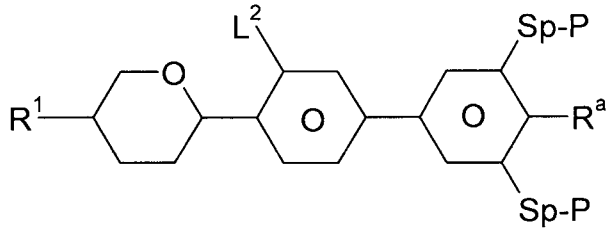

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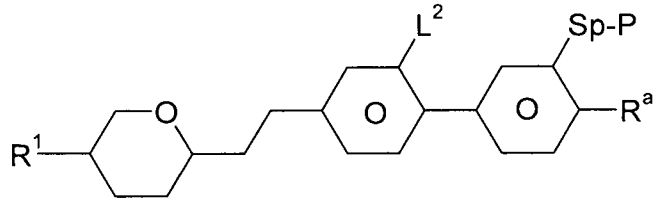

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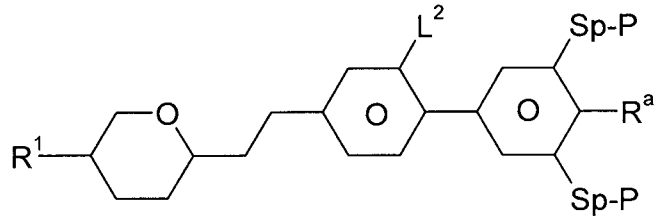
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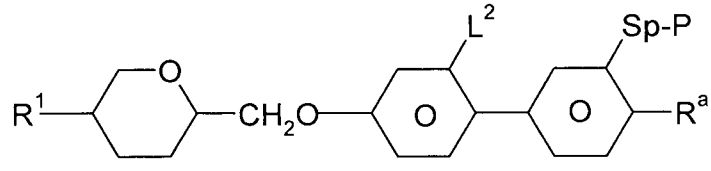
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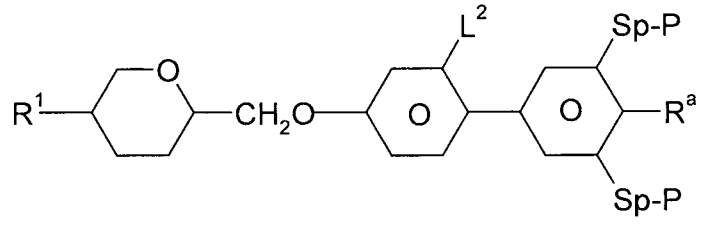
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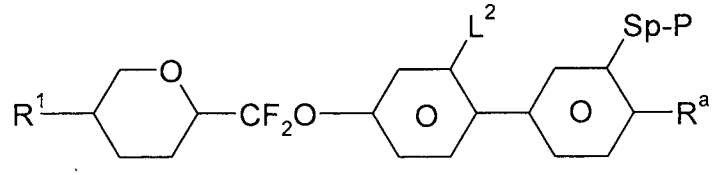
I-41



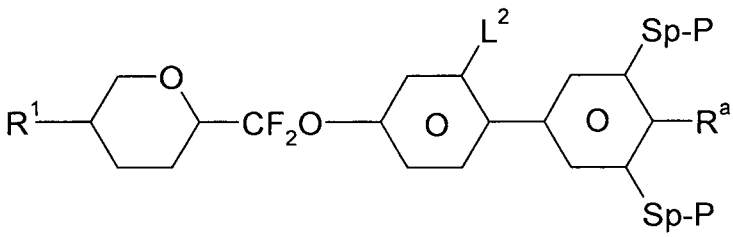
I-42



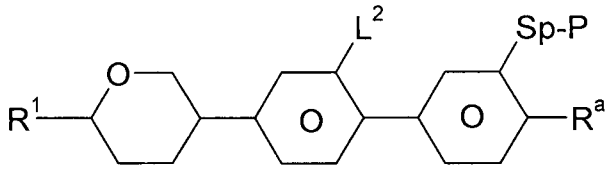
I-43



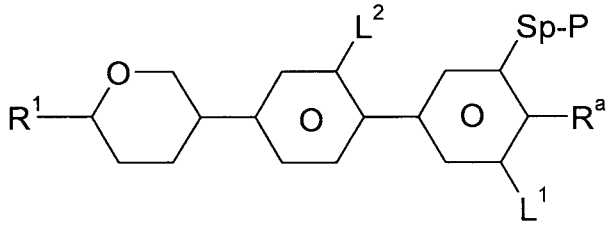
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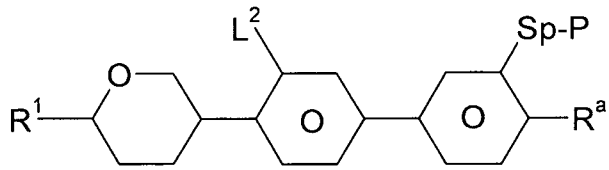
I-45



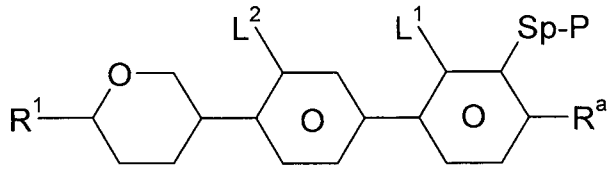
I-46



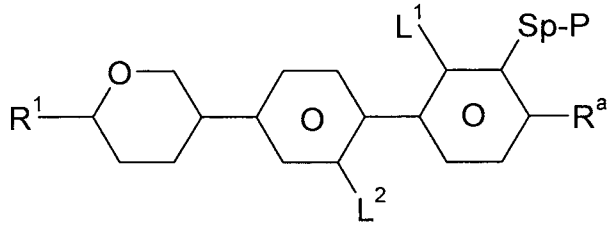
I-47



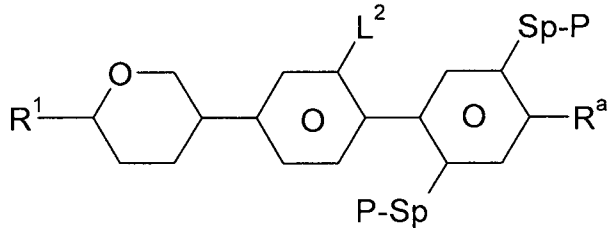
I-48



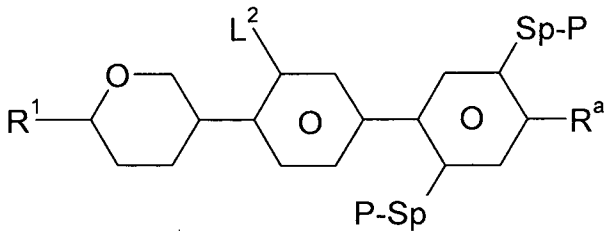
I-49



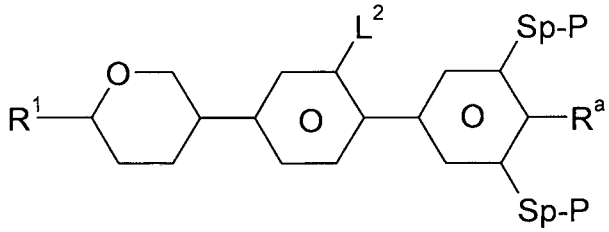
I-50



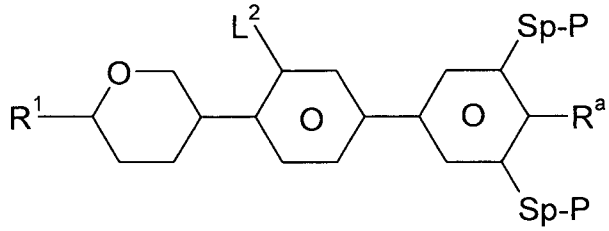
I-51



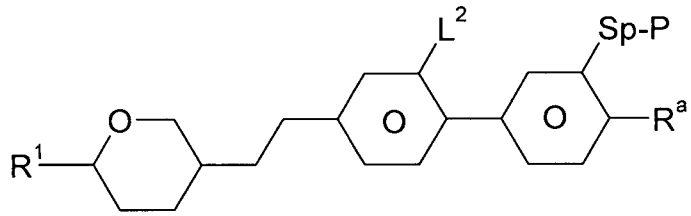

I-52



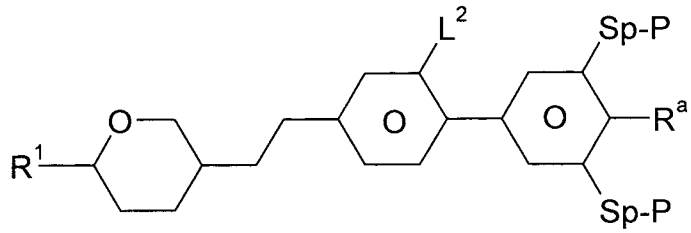

I-53



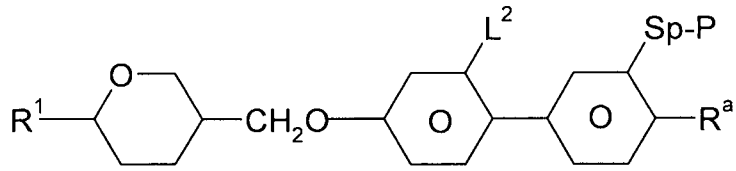

I-54



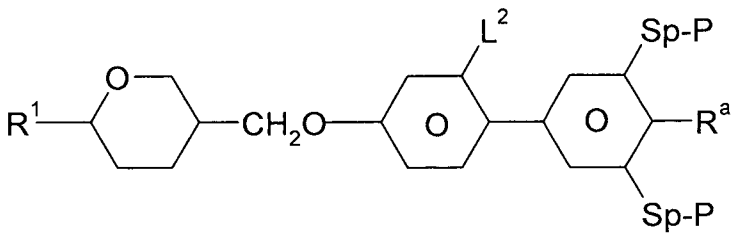

I-55



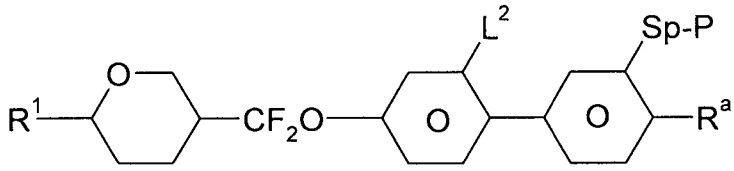

I-56



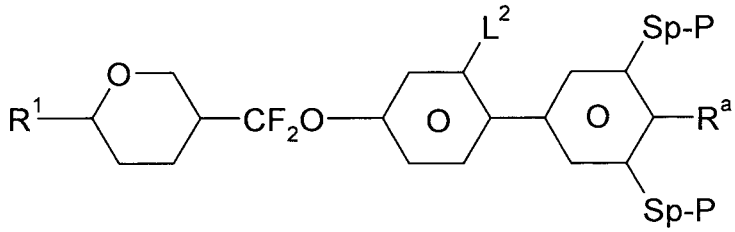

I-57



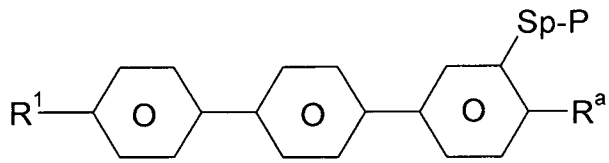
I-58



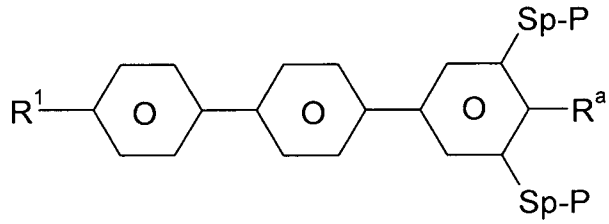
I-59



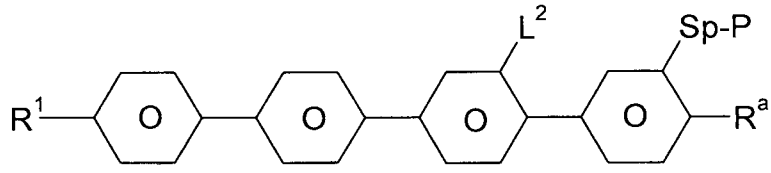
I-60



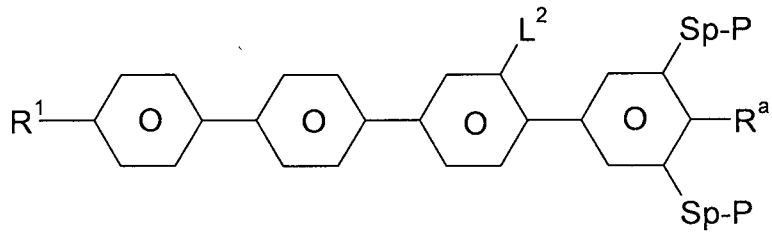
I-61



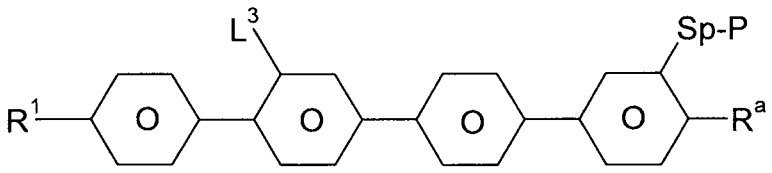
I-62



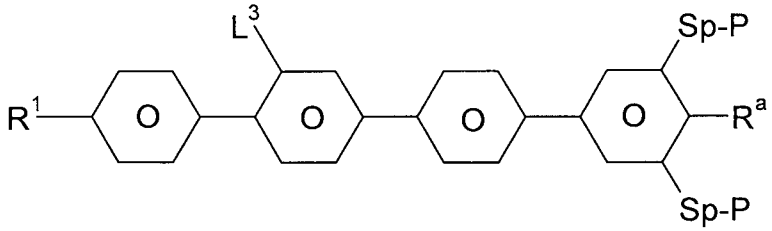
I-63



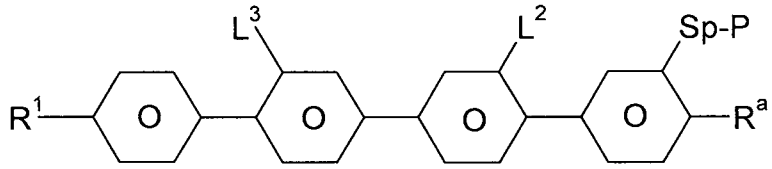
I-64



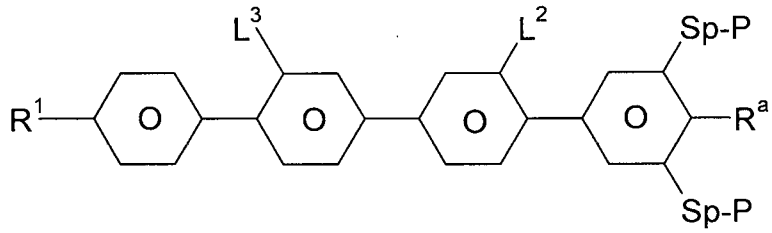

I-65



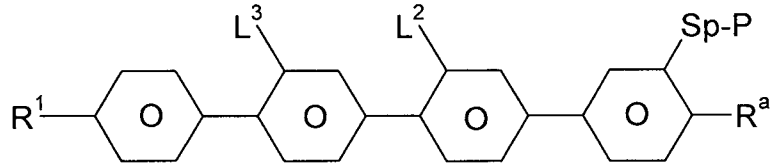

I-66



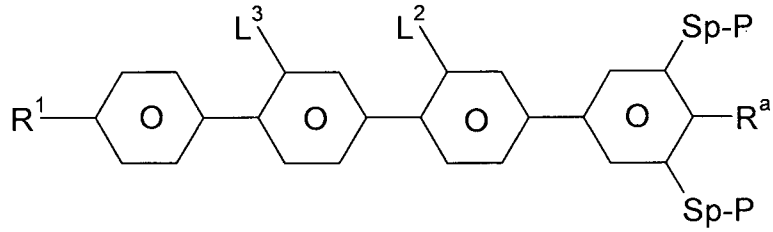

I-67



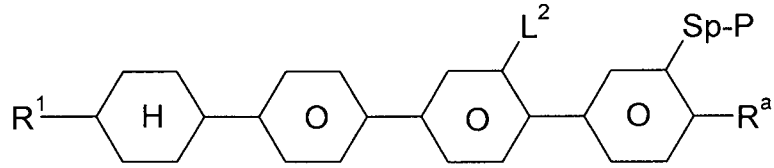

I-68



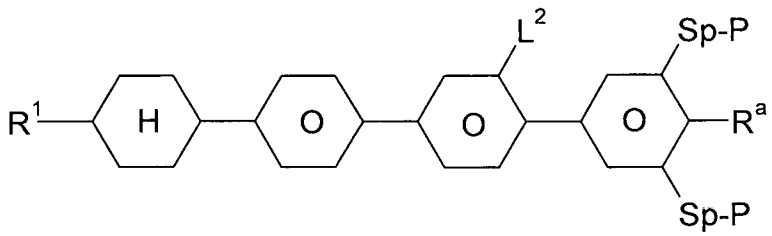

I-69



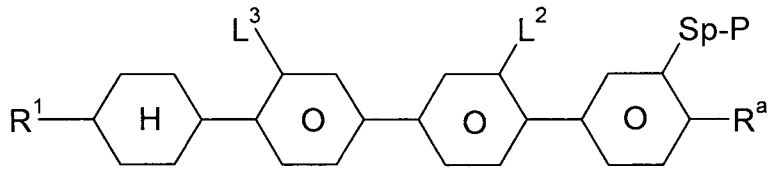

I-70



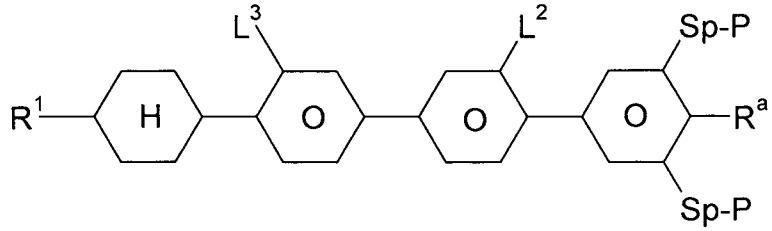

I-71



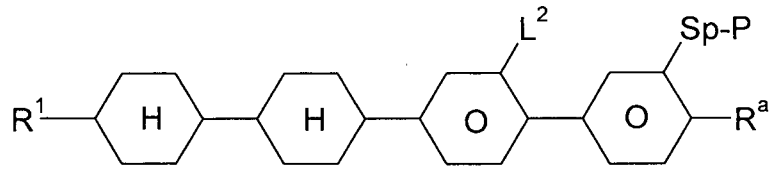

I-72



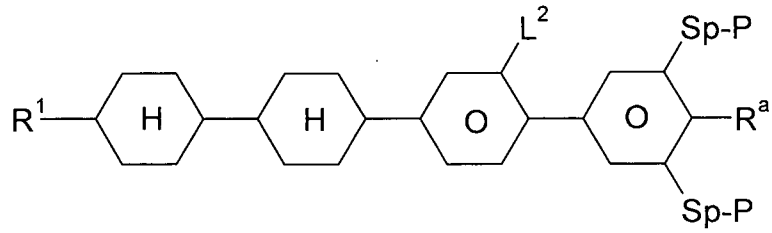

I-73



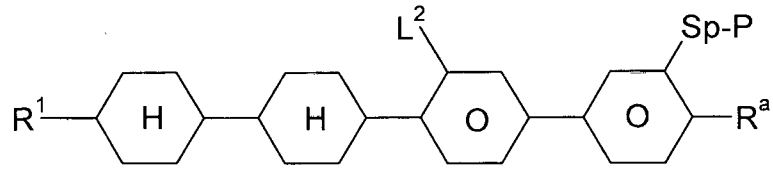

I-74



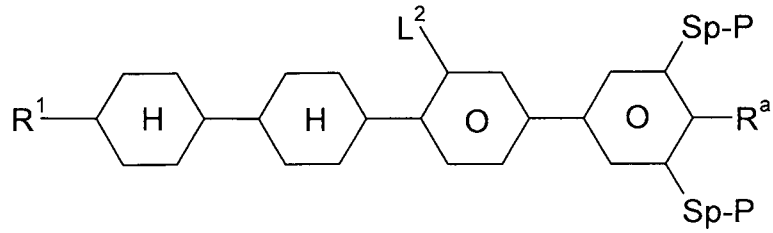

I-75



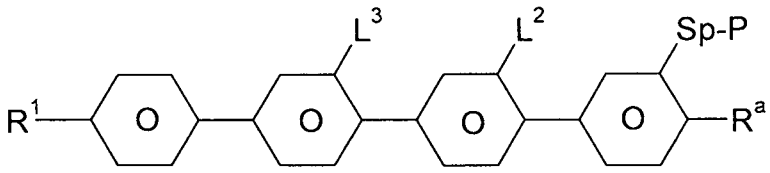

I-76




I-77




I-78

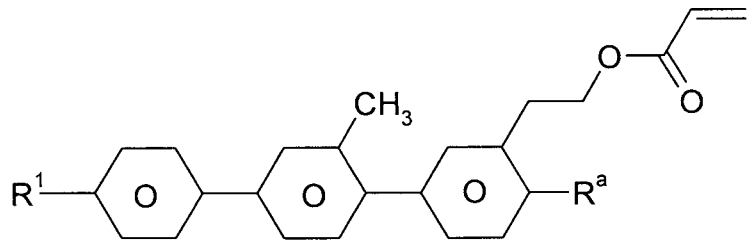



I-79

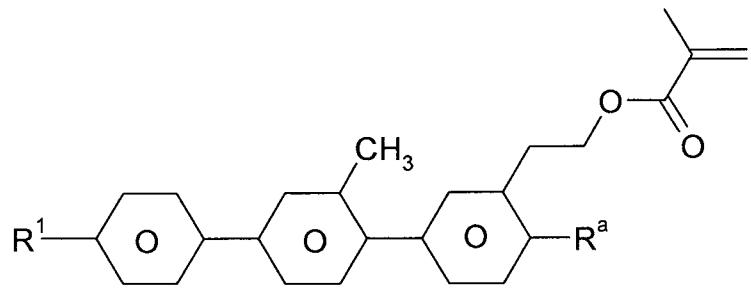
in which $R^1$, $L^1$, $L^2$, $L^3$, Sp, P and $R^a$ have the meanings as given in Claim 1 and/or above.

In the formula I and in the sub-formulae of the formula I $R^1$ preferably denotes a straight-chain alkyl or branched alkyl radical having 1-8 C atoms, preferably a straight-chain alkyl radical.

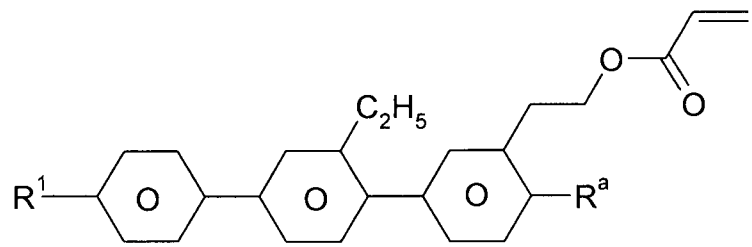
The mixtures according to the invention very particularly contain at least one self-aligning additive selected from the following group of compounds of the sub-formulae I-1a to I-1h, I-8a to I8h, I-16a to I-16h, I-23a to I-23h,



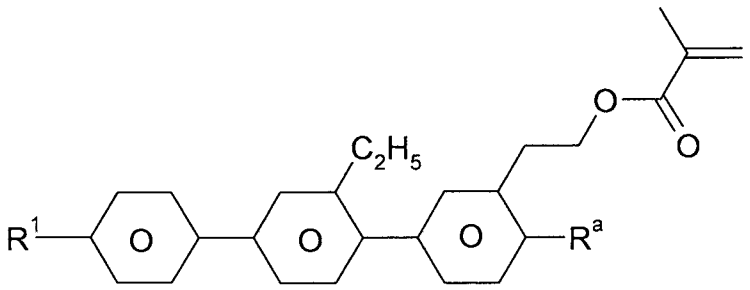

I-1a



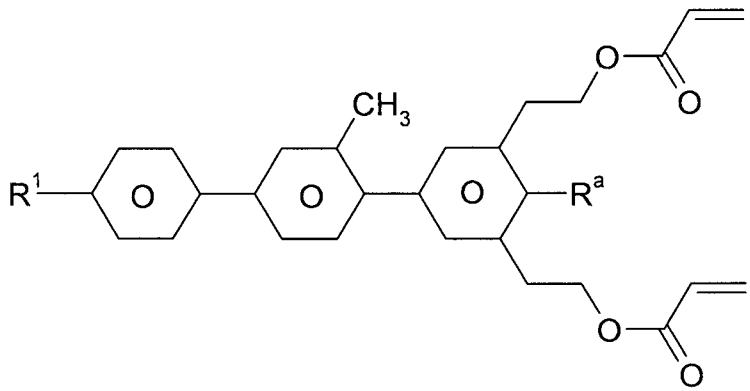

I-1b



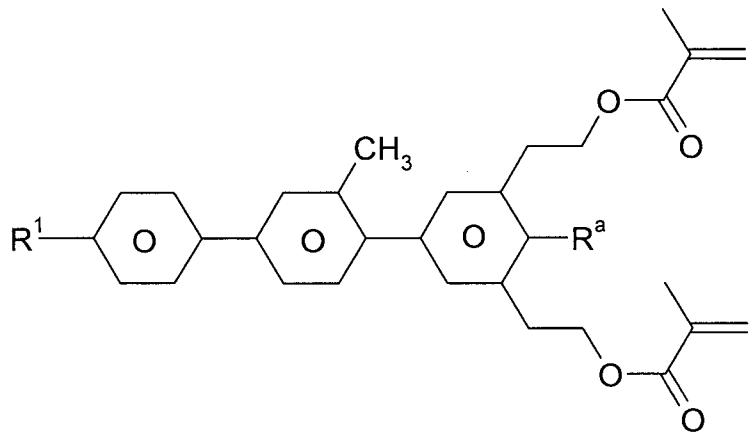

I-1c



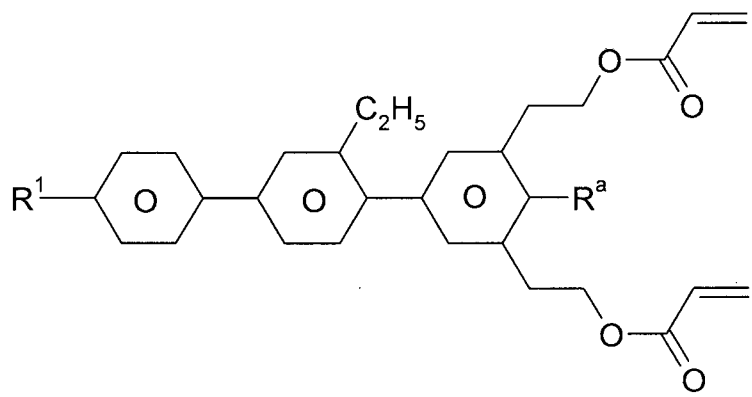
I-1d



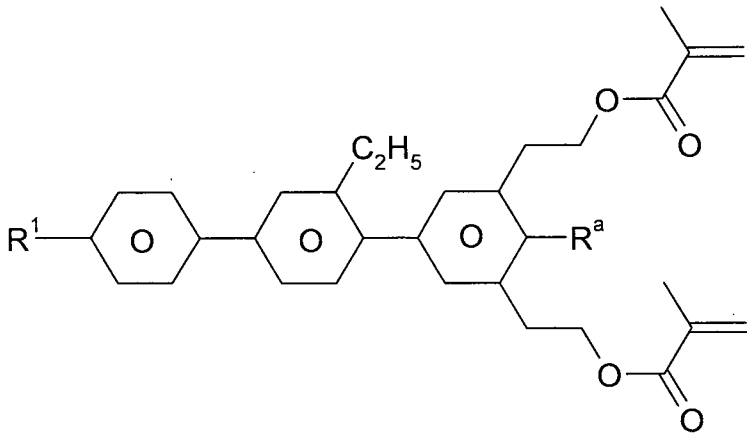
I-8a



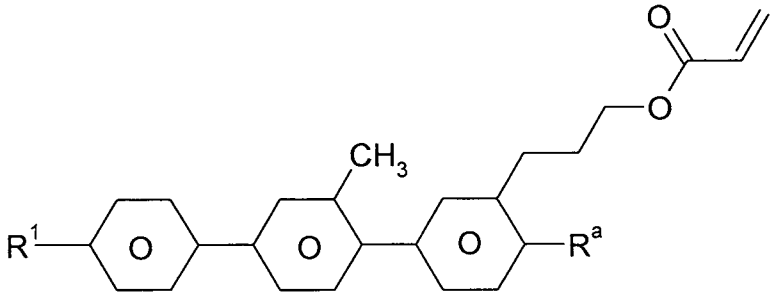
I-8b



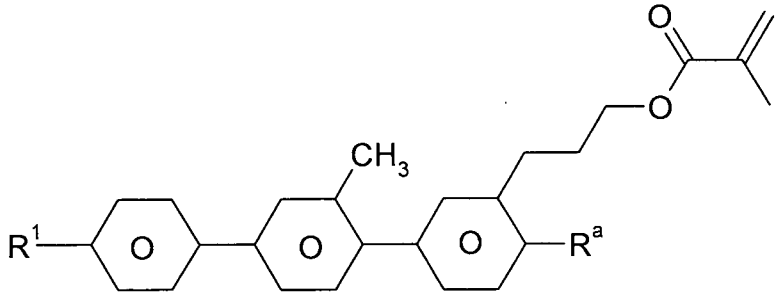
I-8c



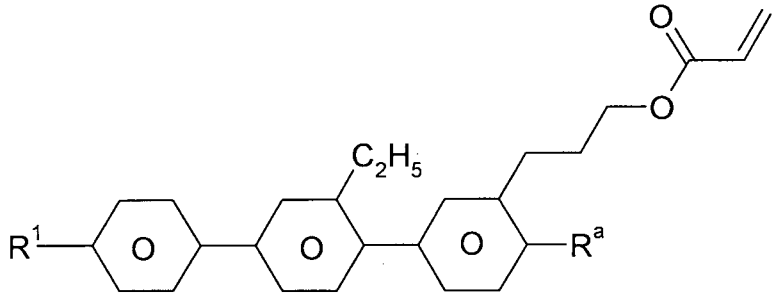
I-8d



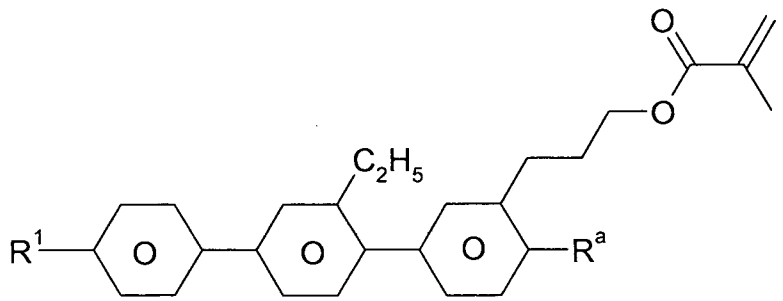
I-1e



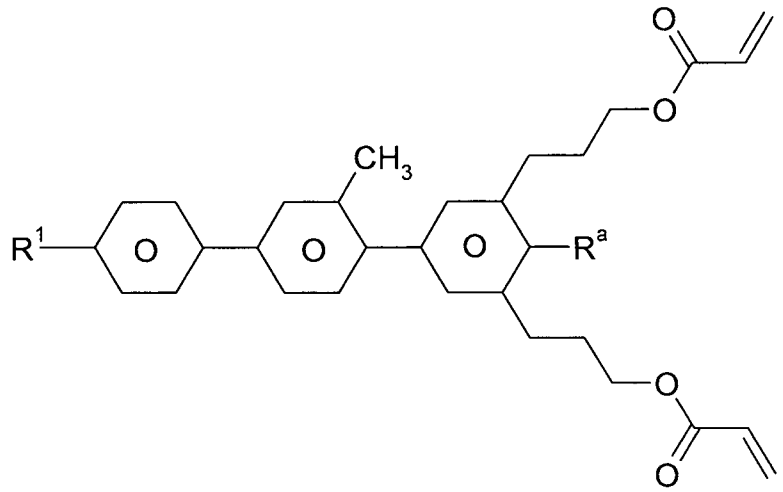
I-1f



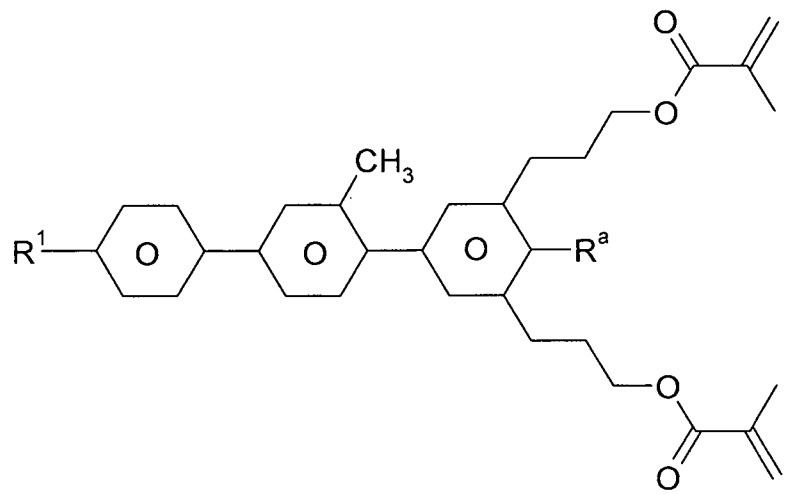
I-1g



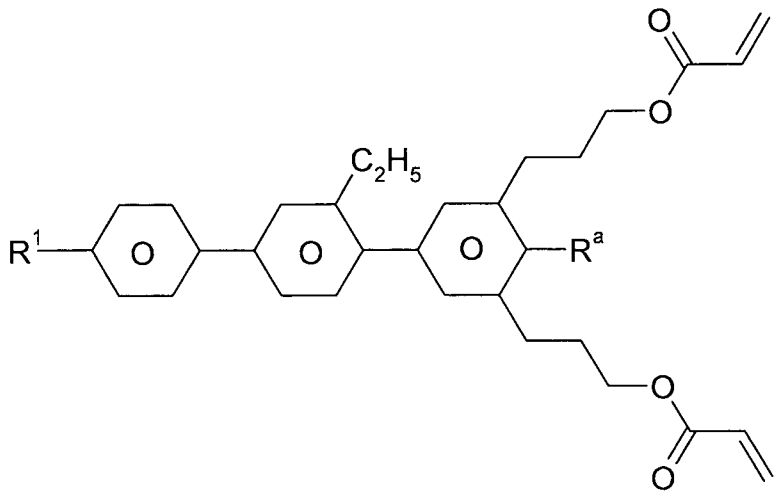
I-1h



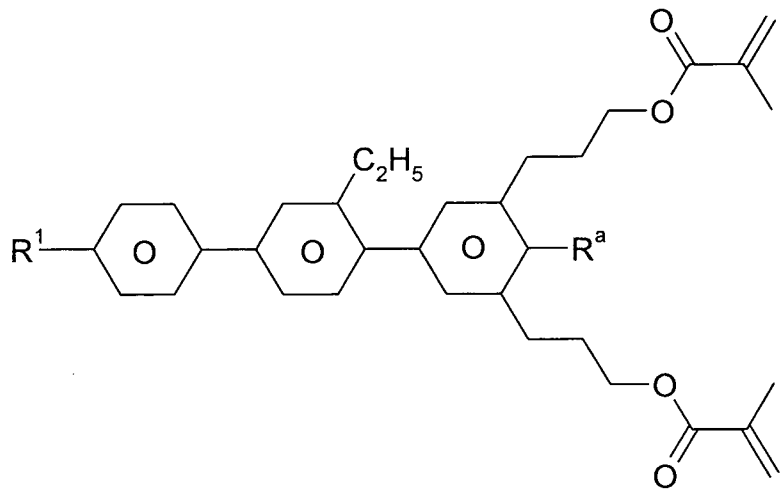
I-8e



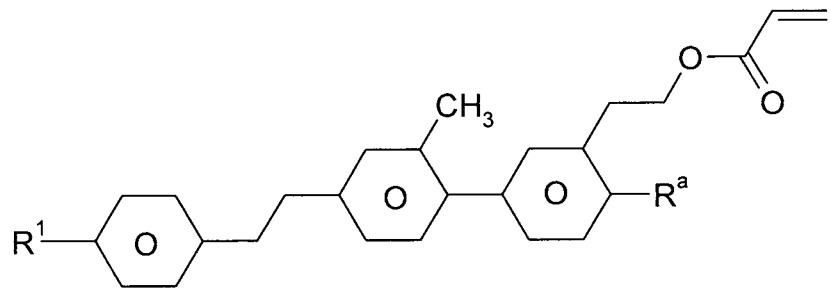
I-8f



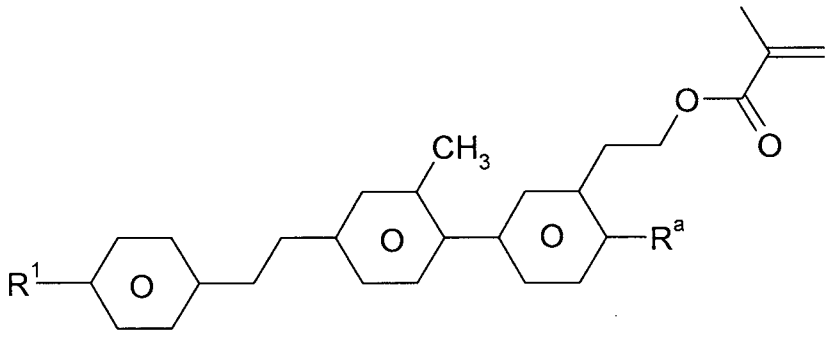
I-8g



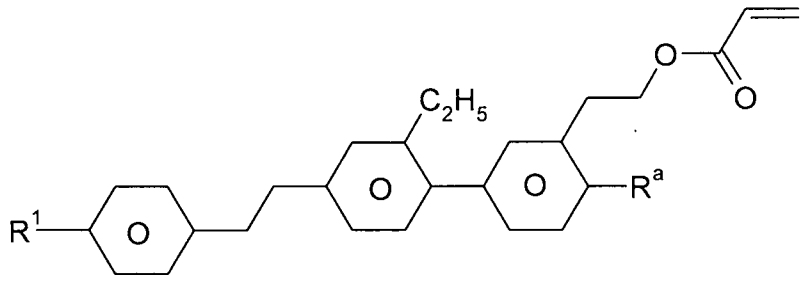
I-8h



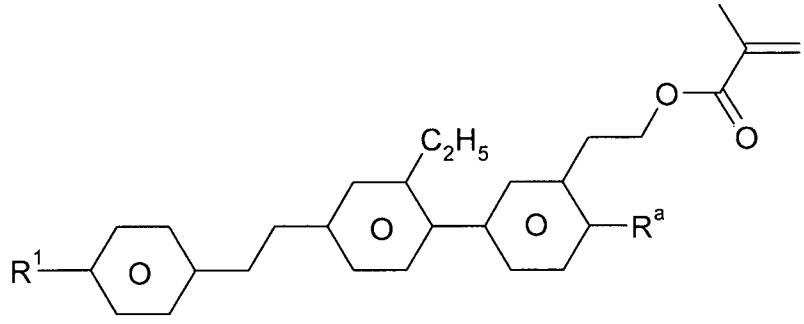
I-10a



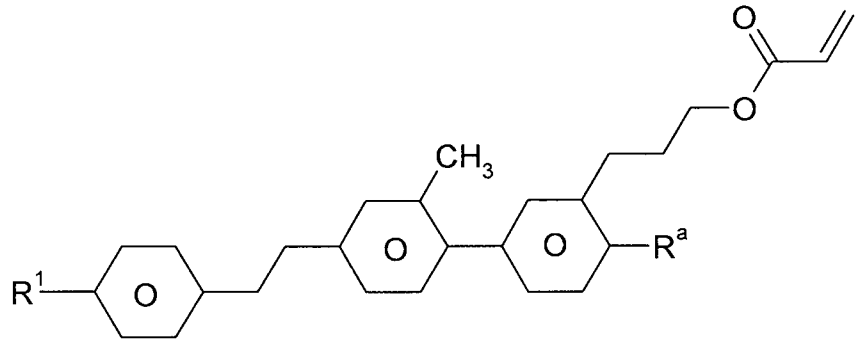
I-10b



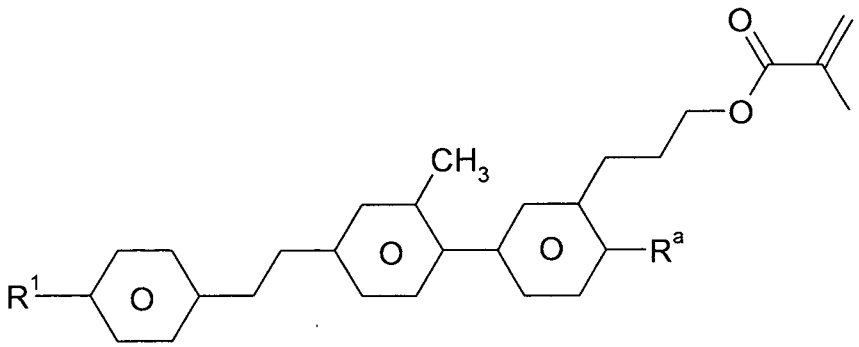
I-10c



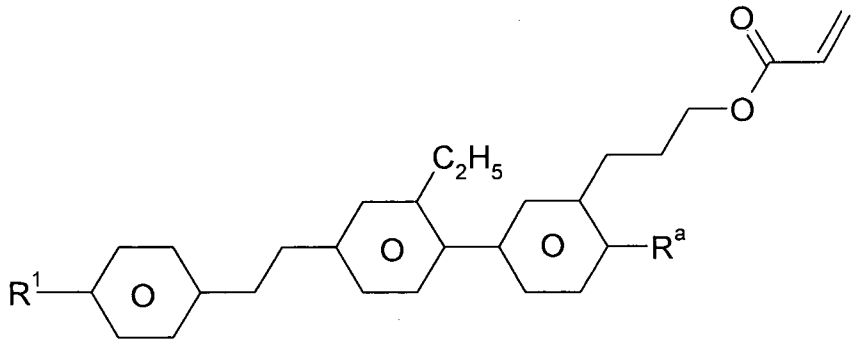
I-10d



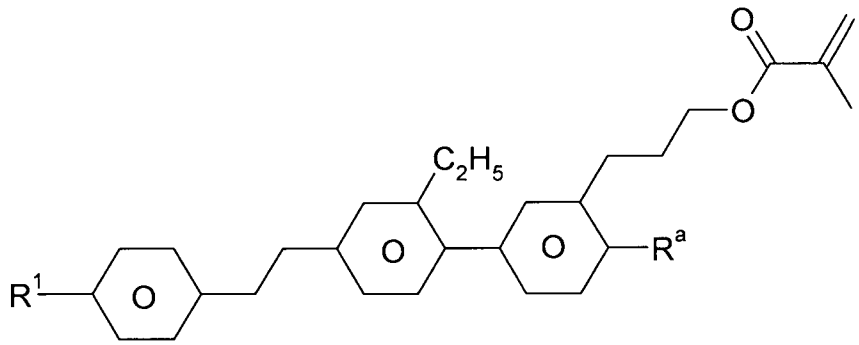
I-10e



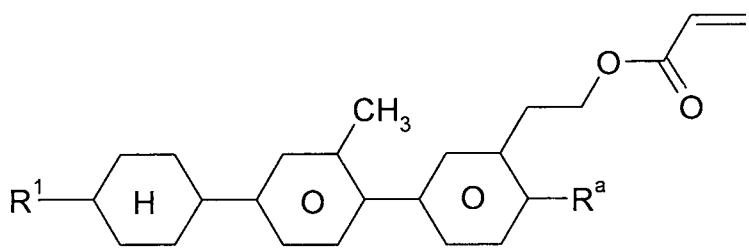
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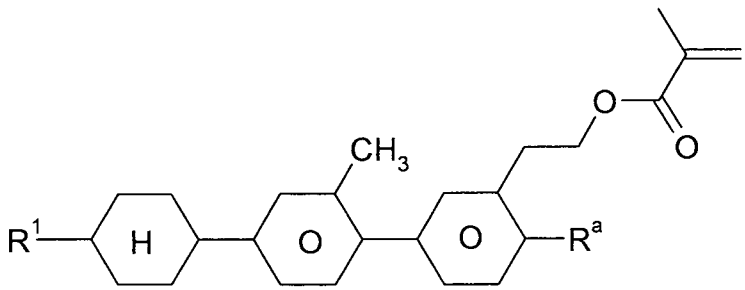
I-10g



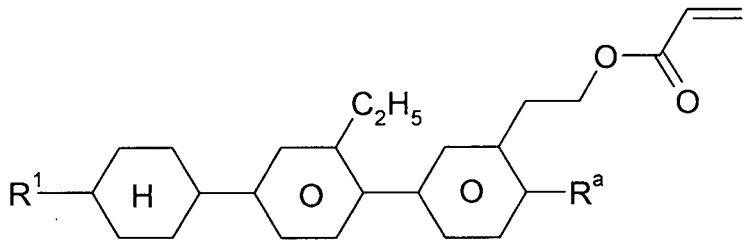
I-10h



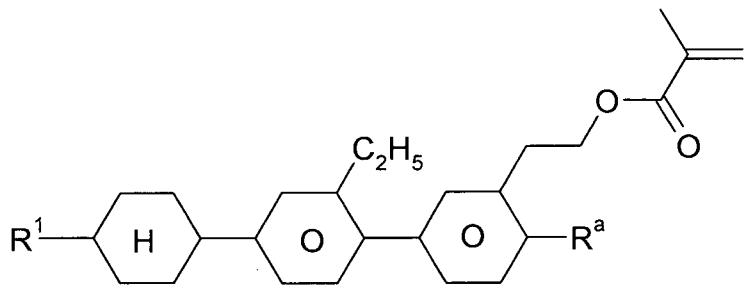
I-16a



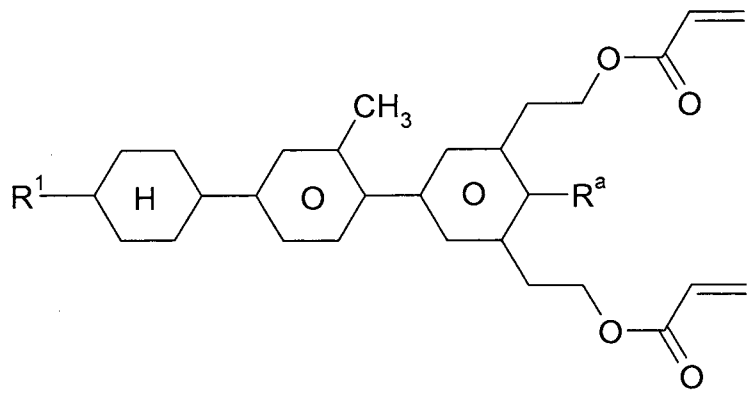
I-16b



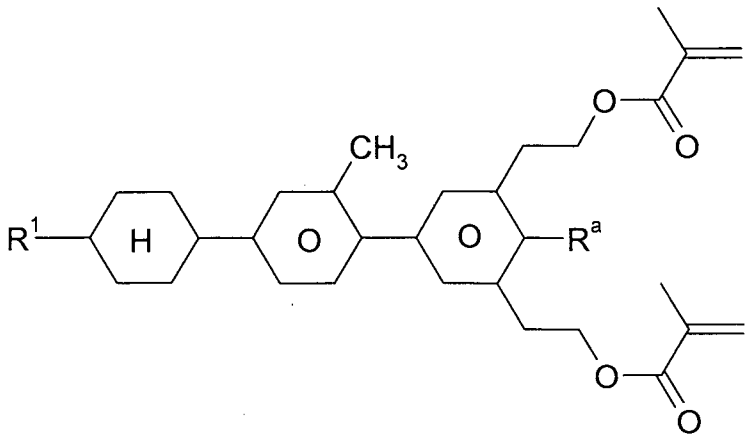
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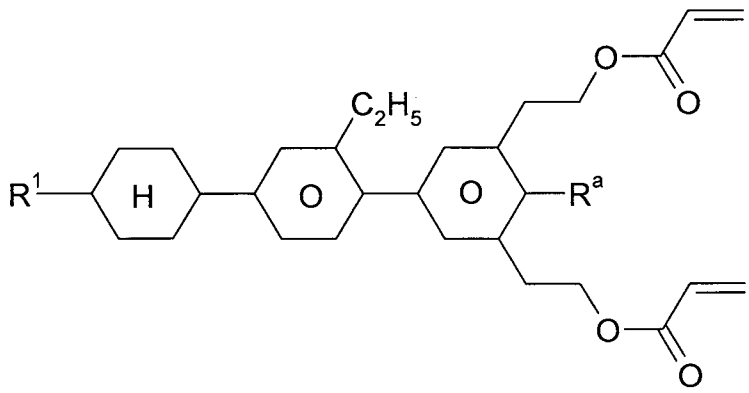
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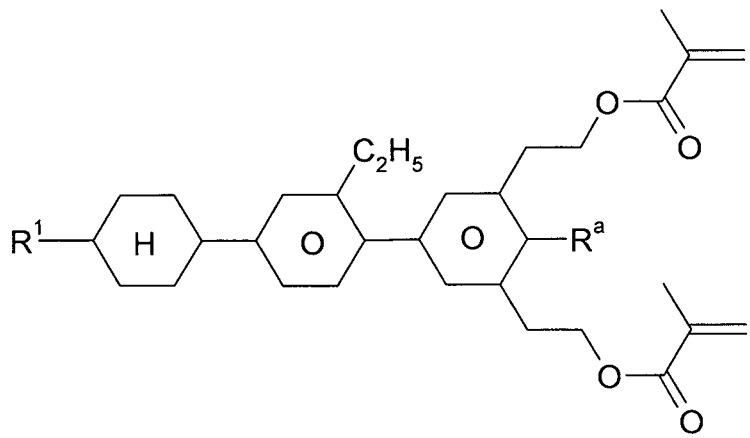
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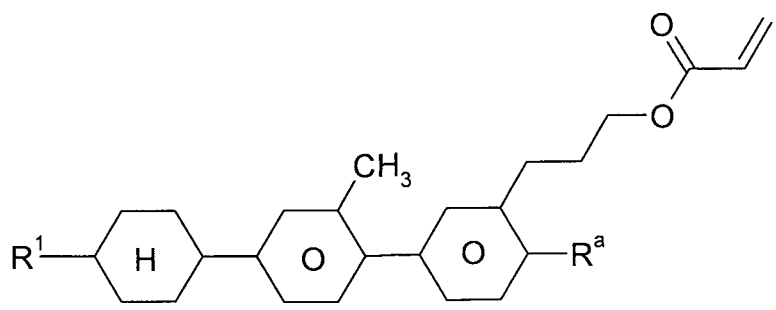
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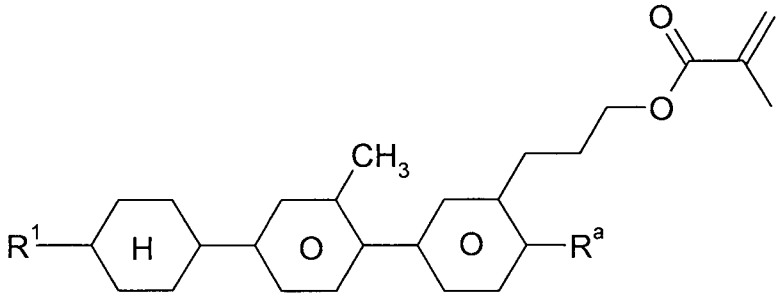
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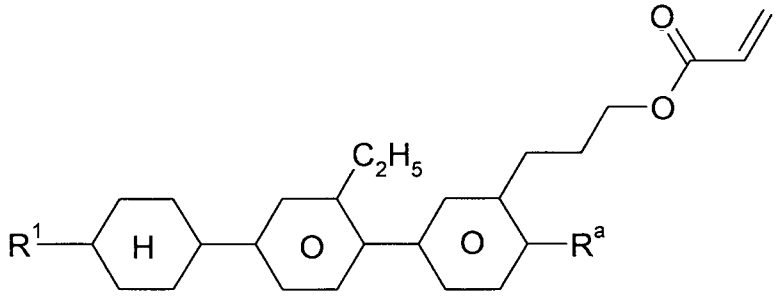
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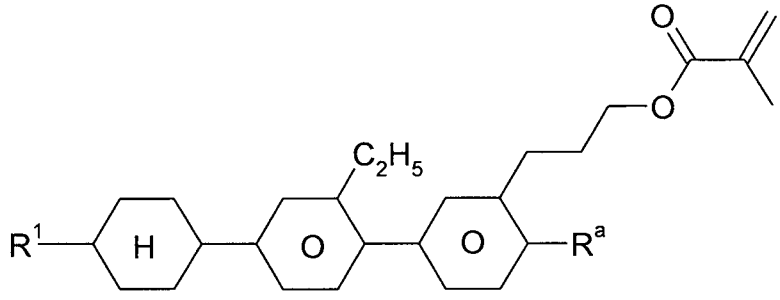
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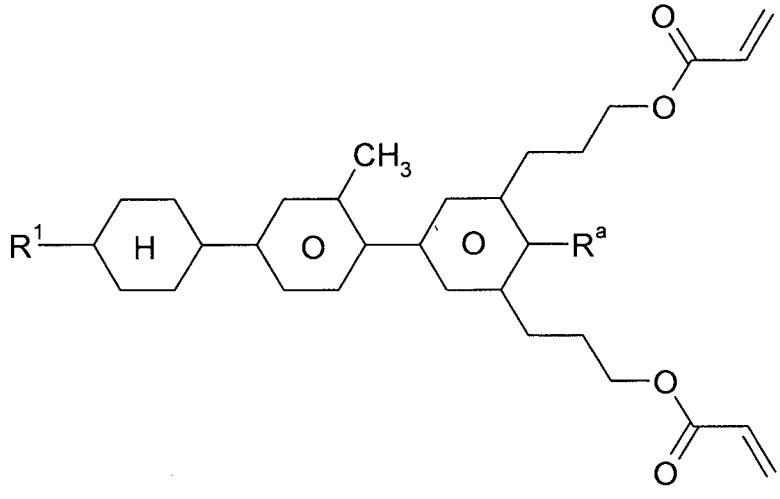
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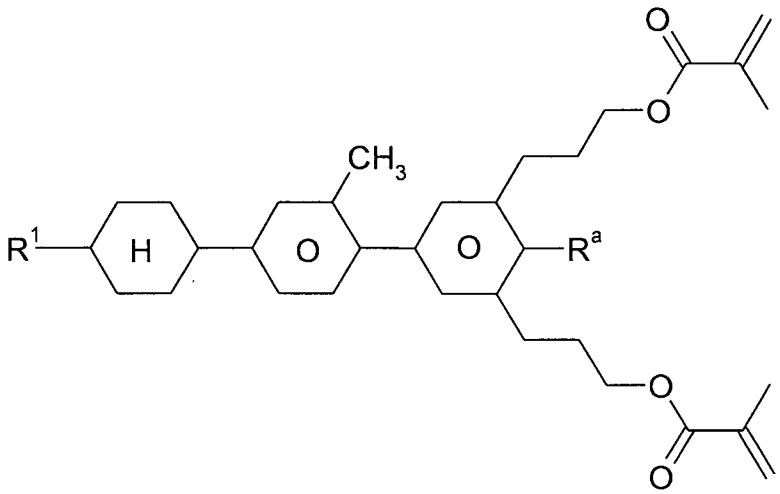
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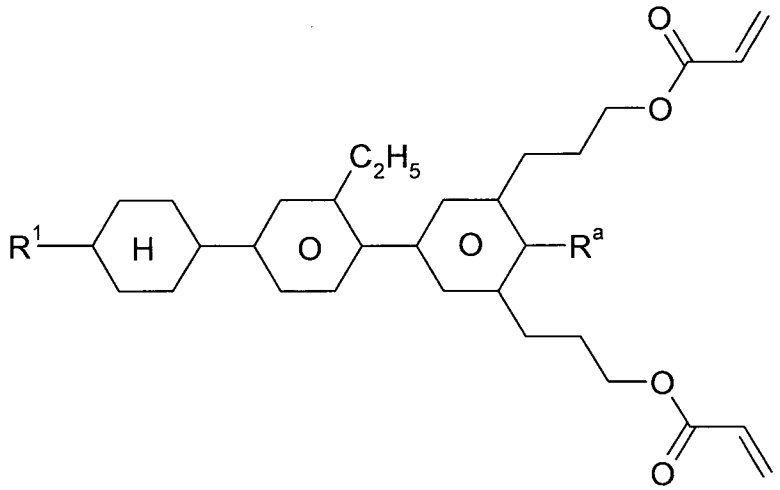
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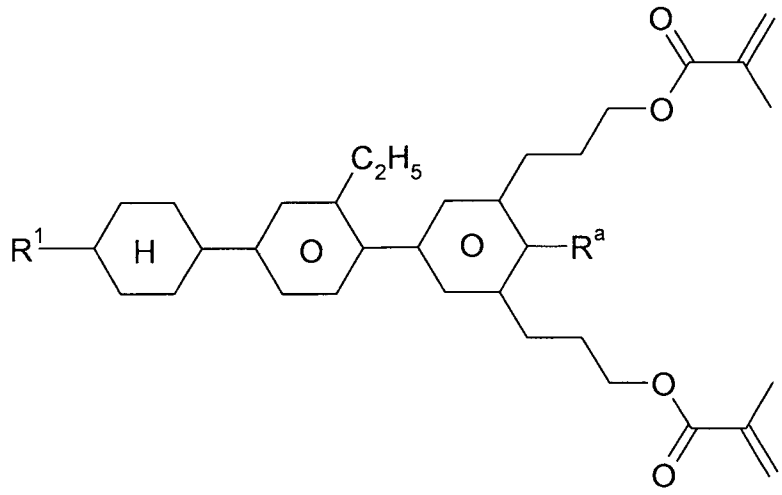
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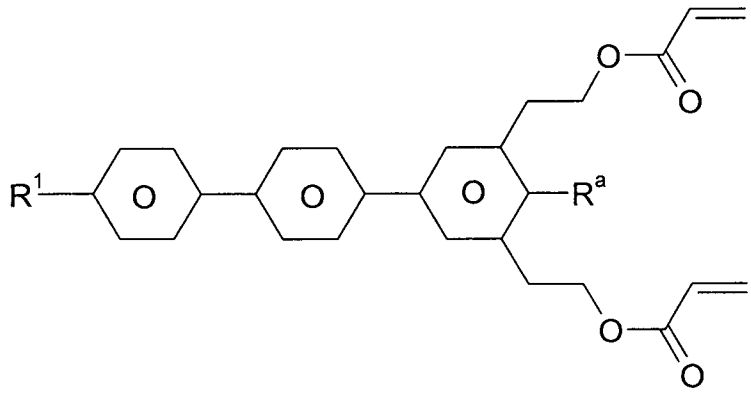
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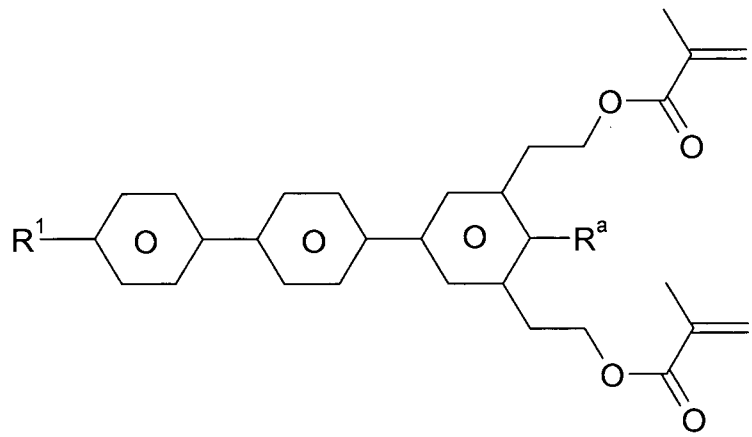
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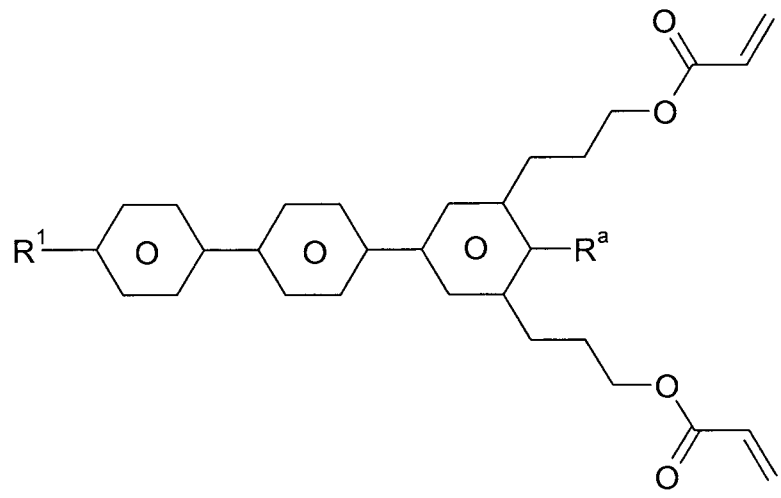
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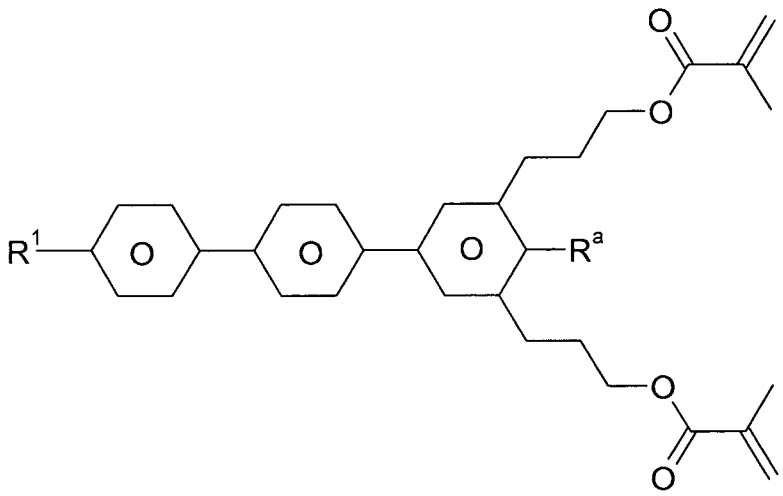
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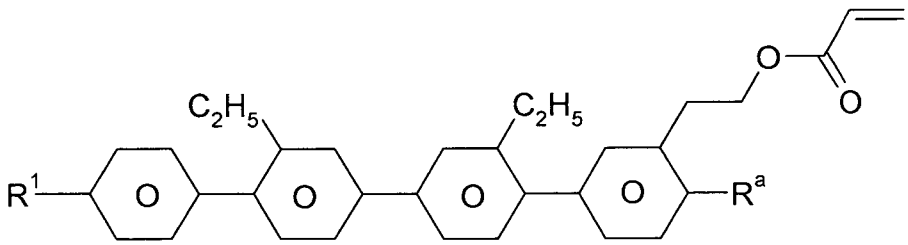
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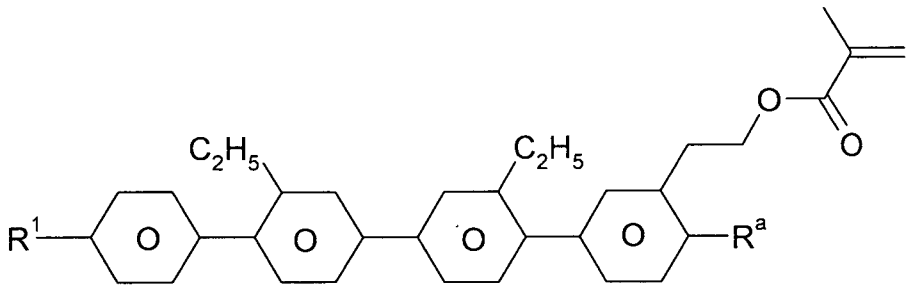
I-62c



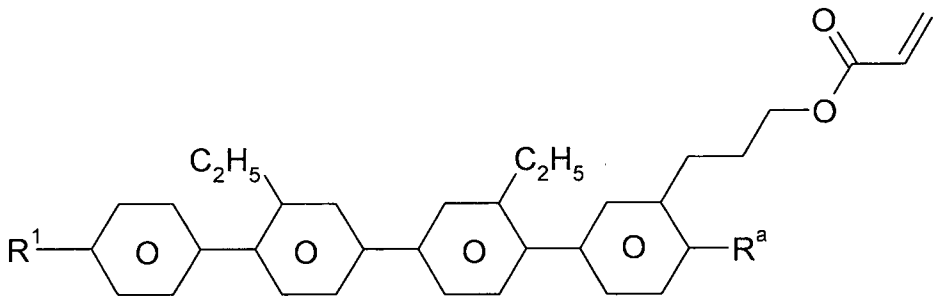
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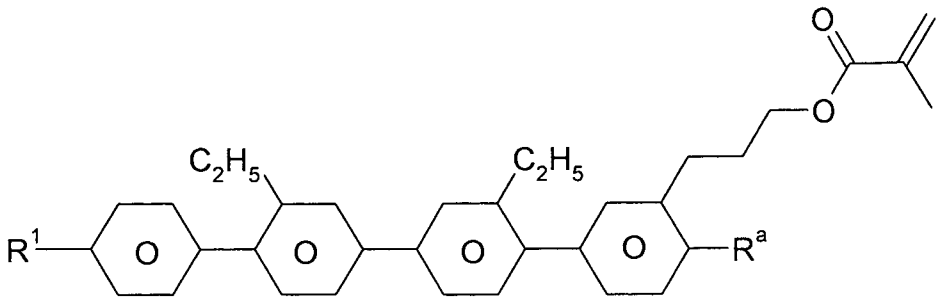
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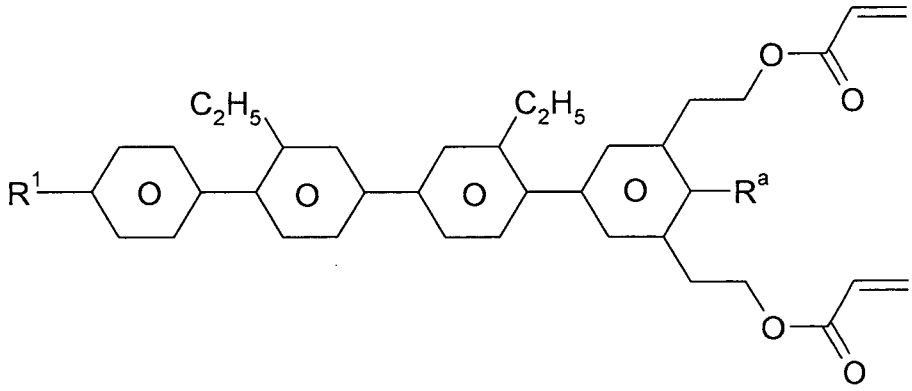
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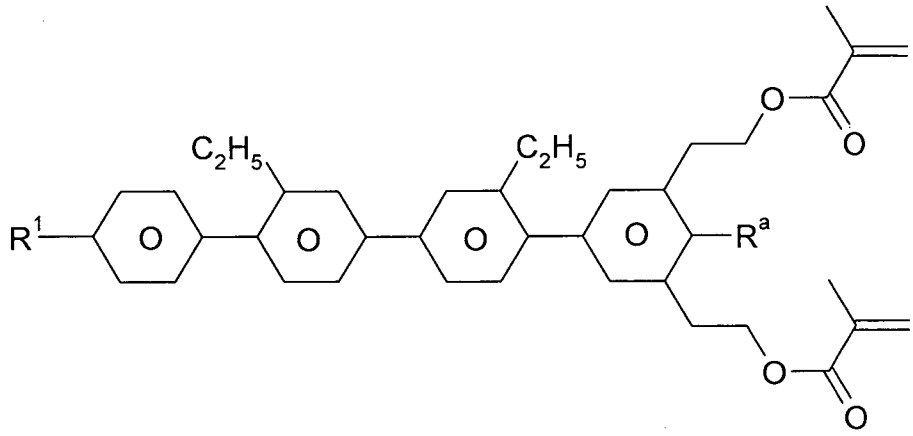
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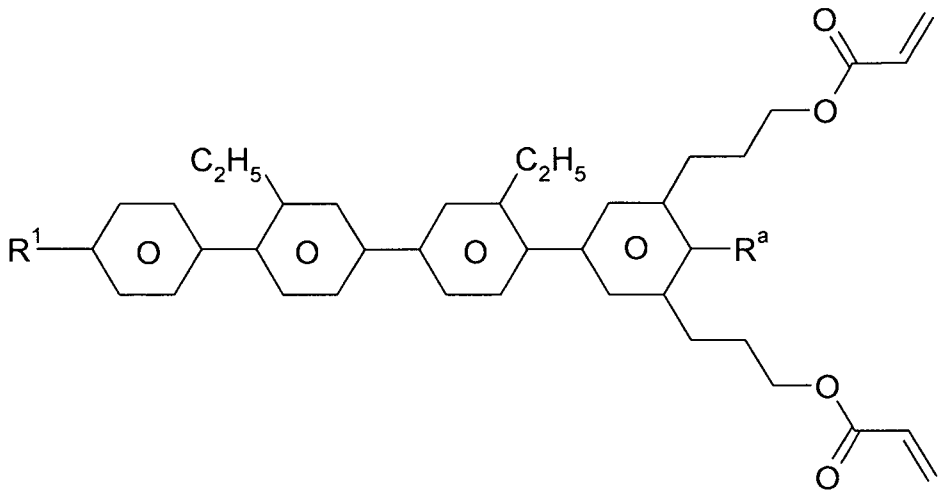
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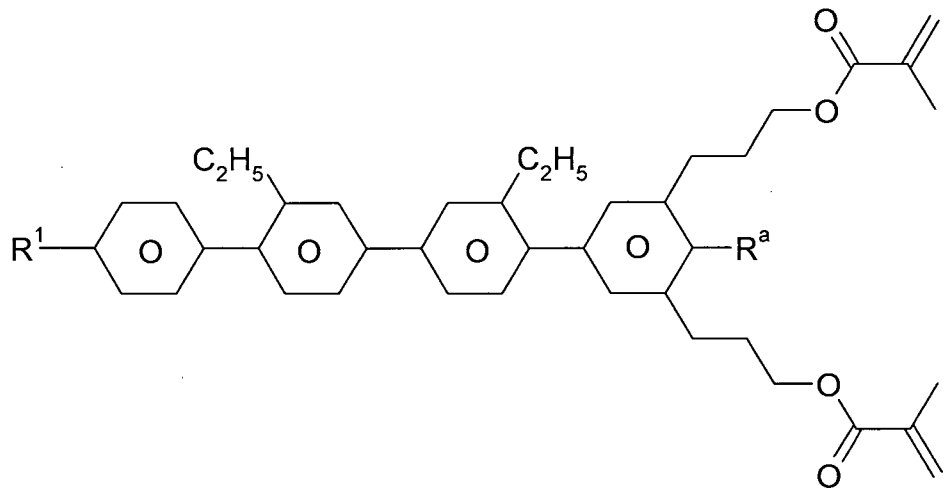
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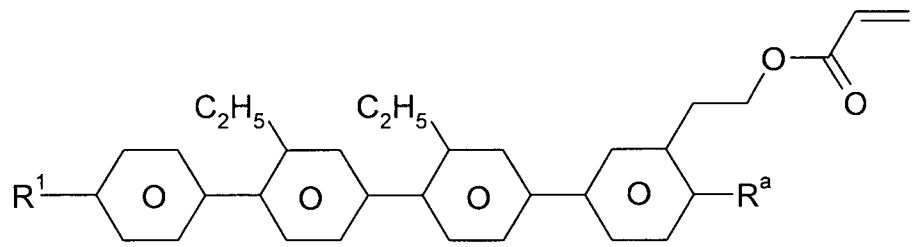
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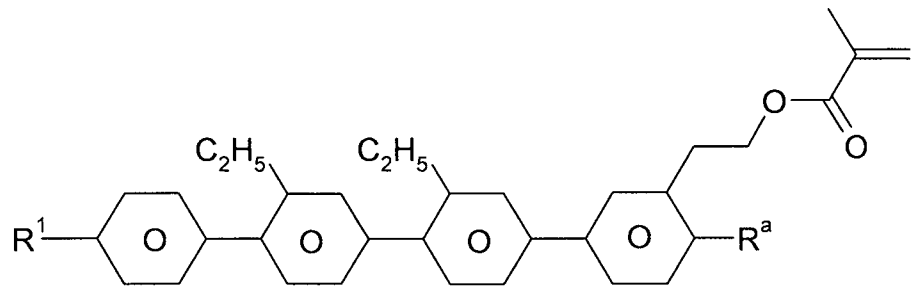
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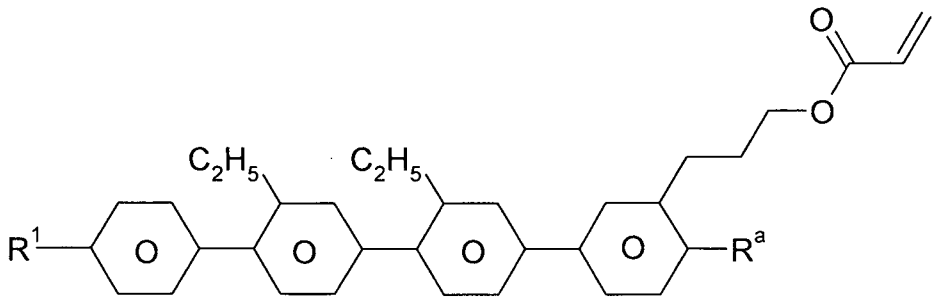
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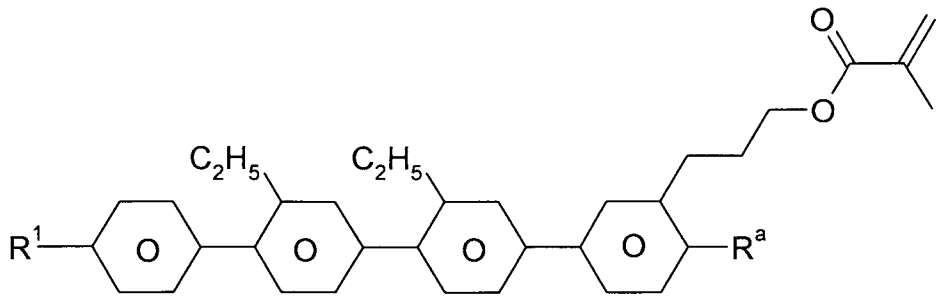
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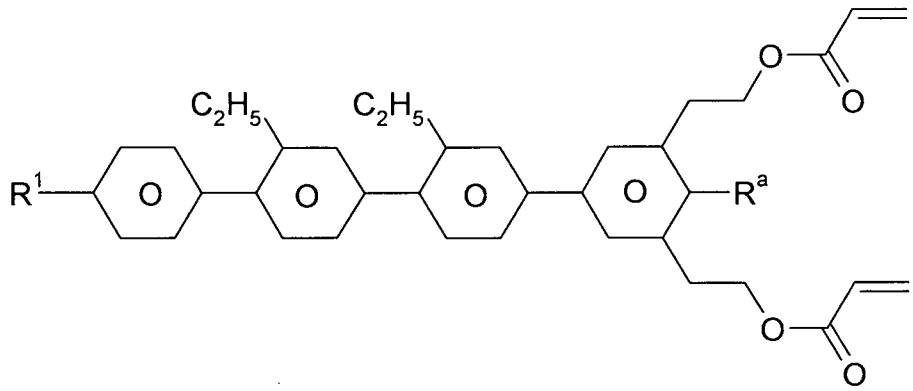
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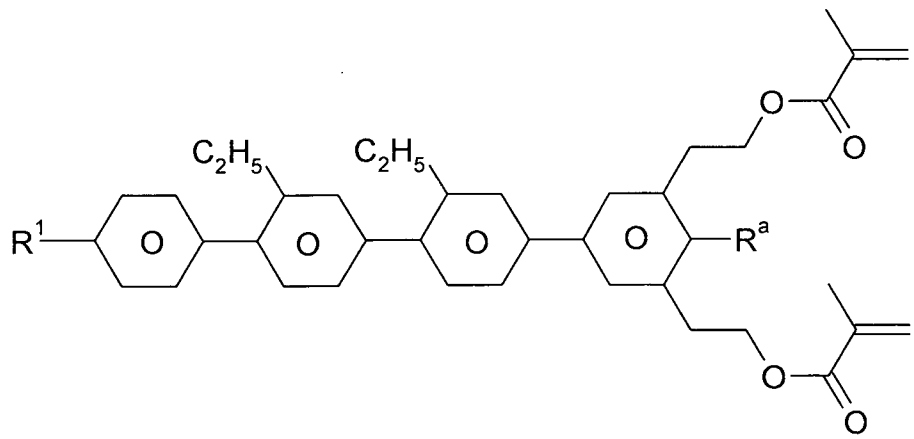
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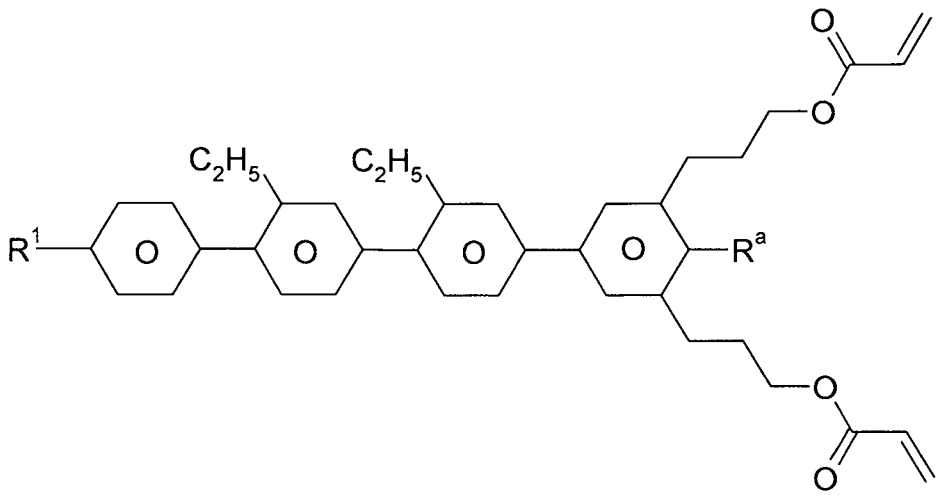
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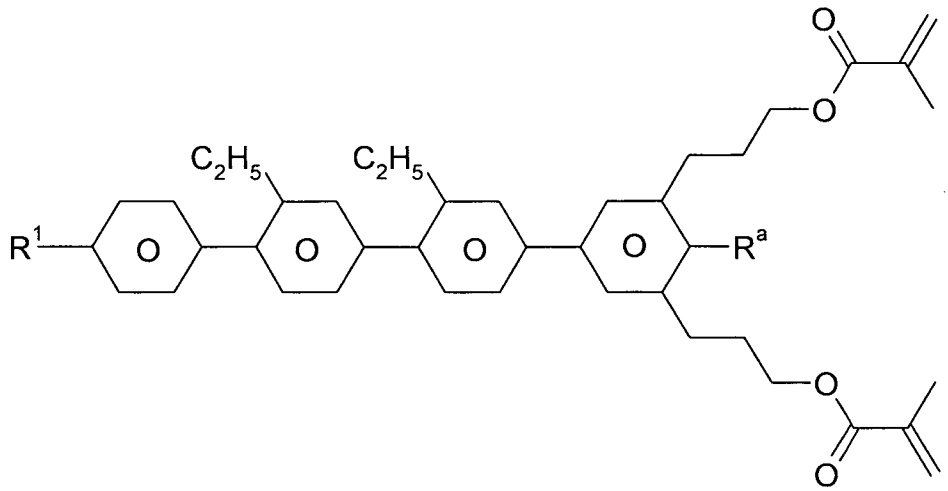
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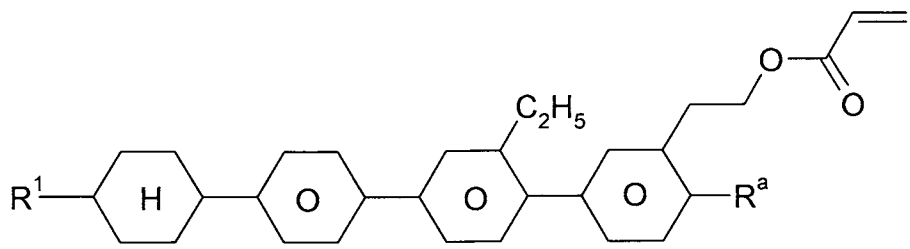
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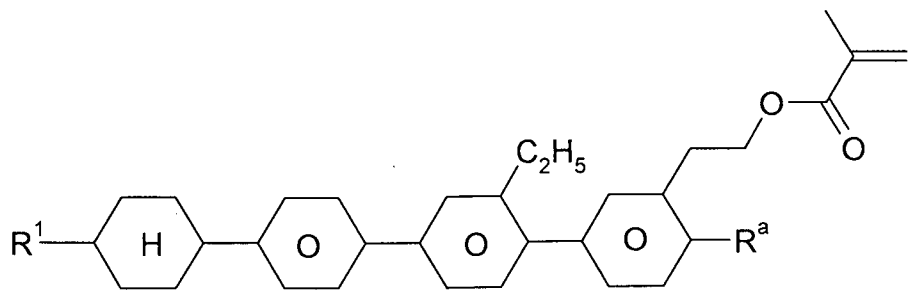
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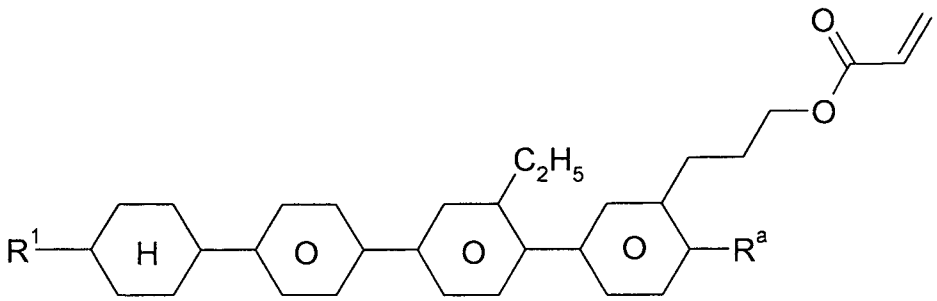
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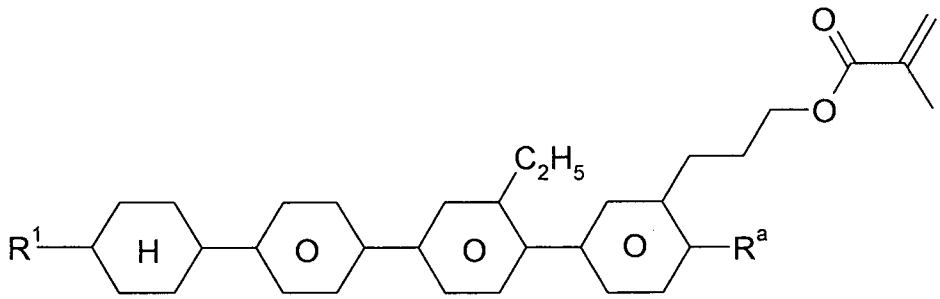
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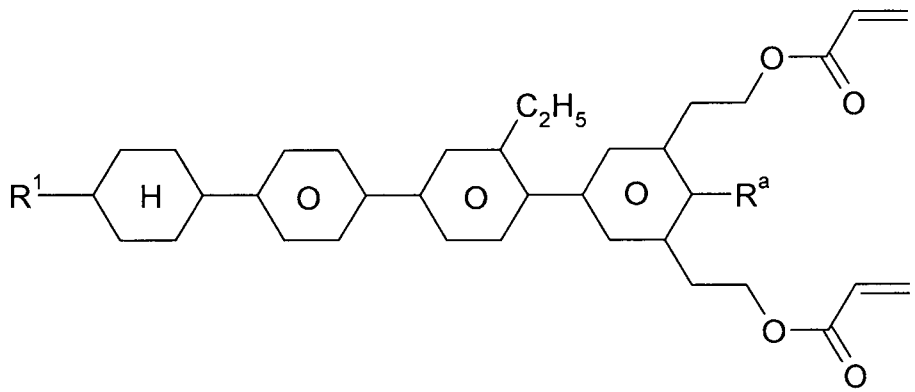
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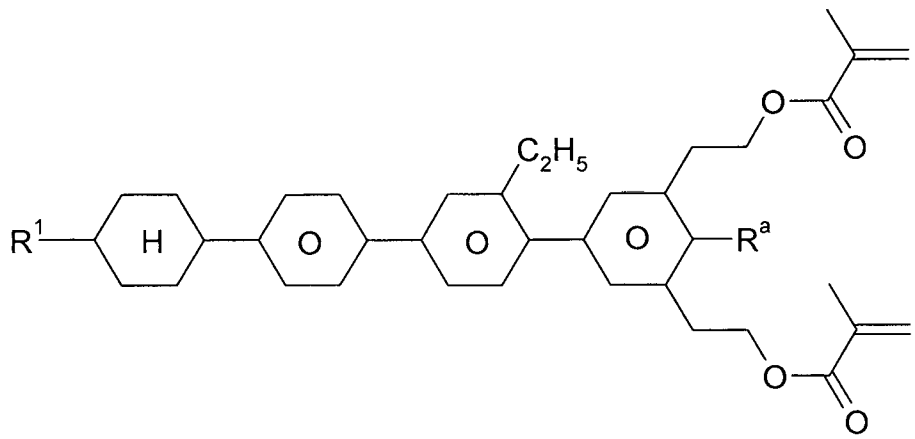
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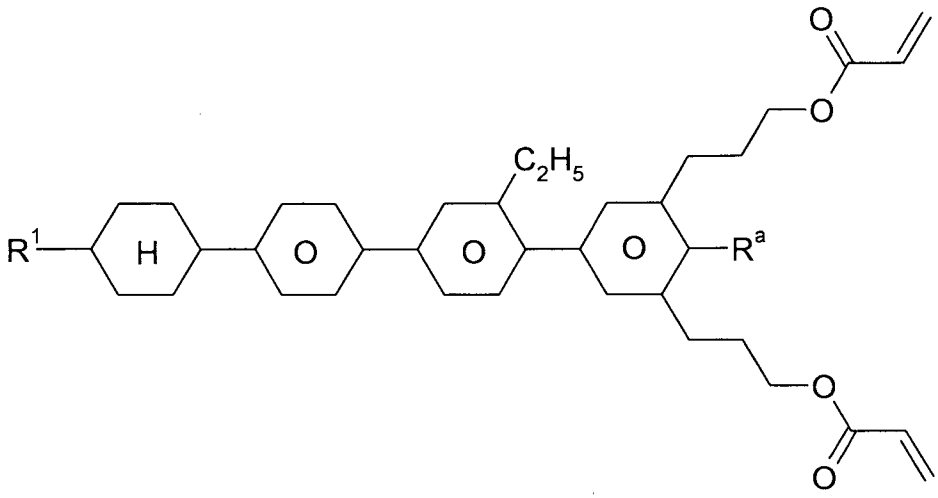
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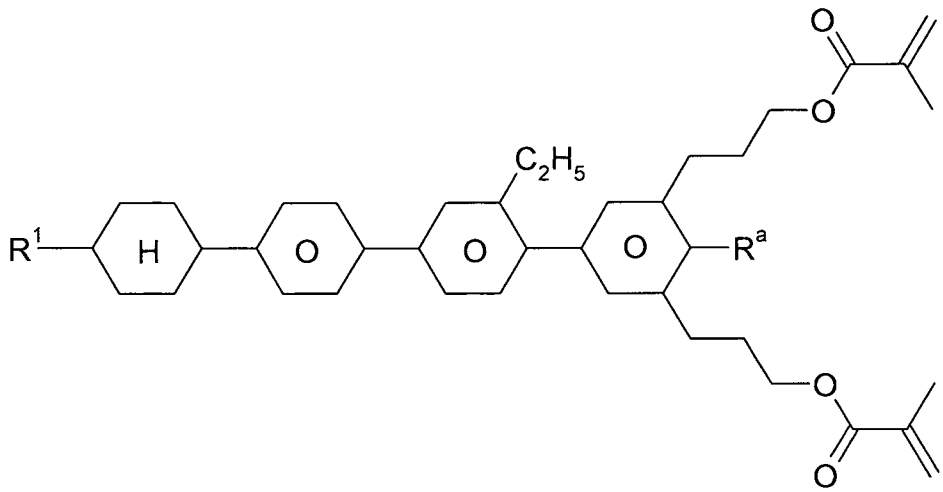
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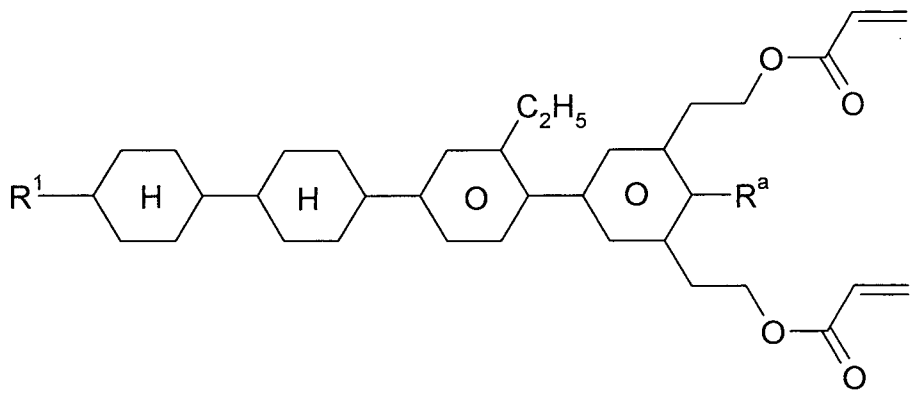
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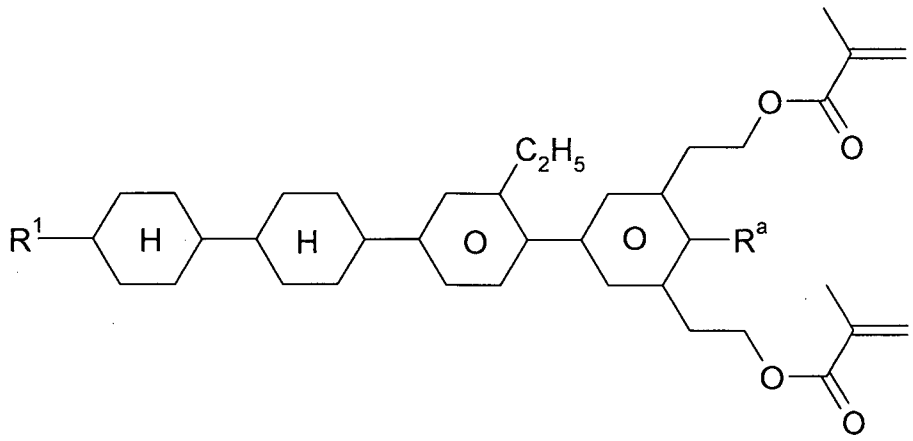
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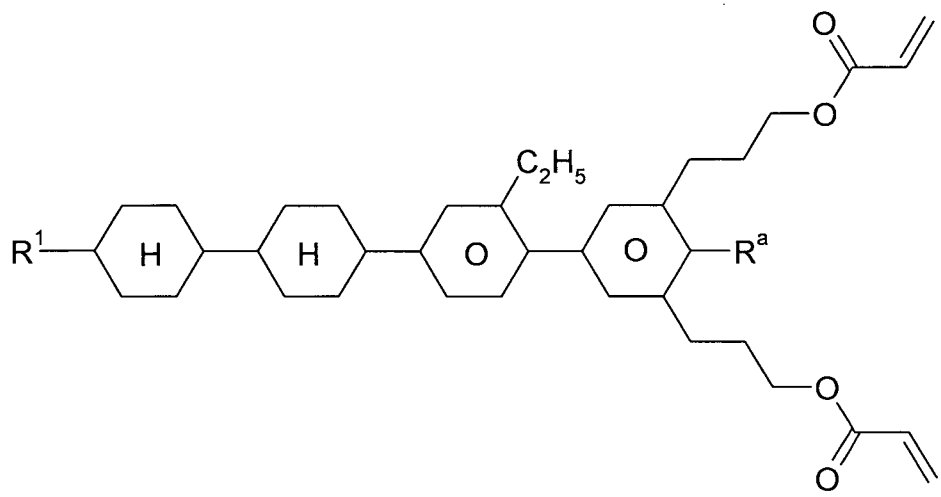
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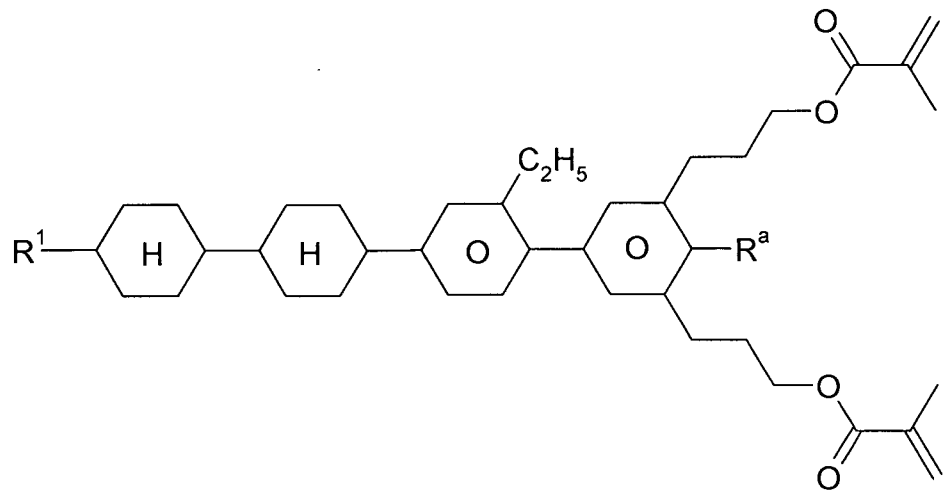
I-76a



I-76b



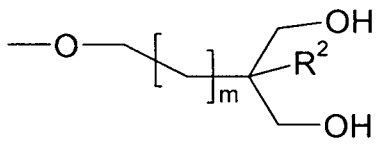
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I-76d

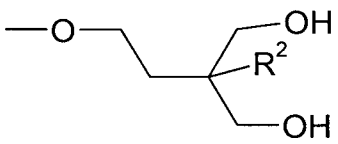
in which

$R^a$ denotes

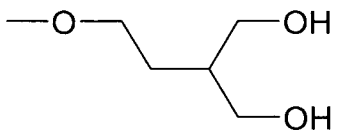


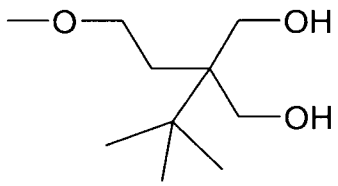
wherein m denotes 0, 1 or 2,

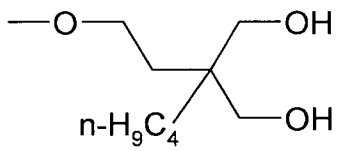
preferably



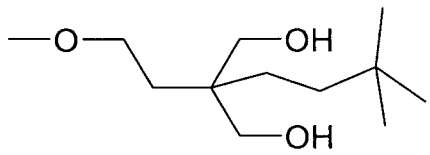
and in particular







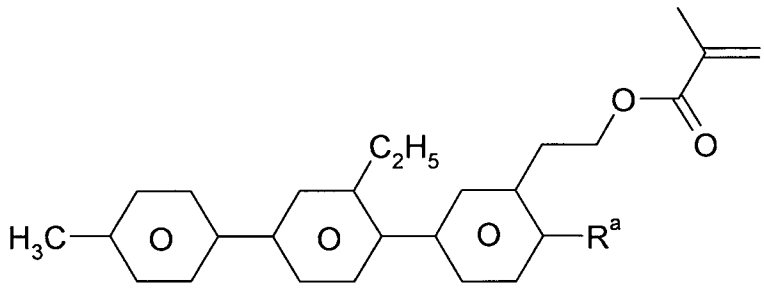
or



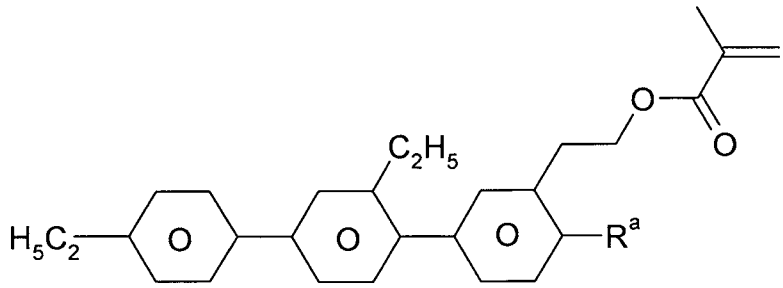
and $R^1$ has the meanings given in Claim 1, preferably denotes a straight-chain alkyl radical having 1 to 8 carbon atoms, preferably $C_2H_5$, n-$C_3H_7$, n-$C_4H_9$, n-$C_5H_{11}$, n-$C_6H_{13}$ or n-$C_7H_{15}$, most preferably n-$C_5H_{11}$.

Preferred LC mixtures according to the present invention contain at least one compound of the formula I-8 or I-23, in particular a compound of the formula I-8h or I23h.

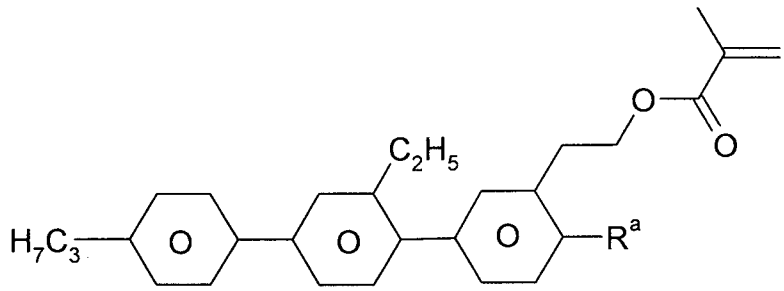
Particular preferred mixtures contain at least one compound selected from the following group of compounds



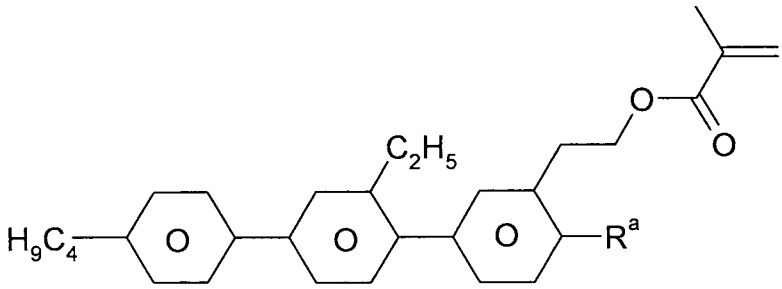
I-1d-1



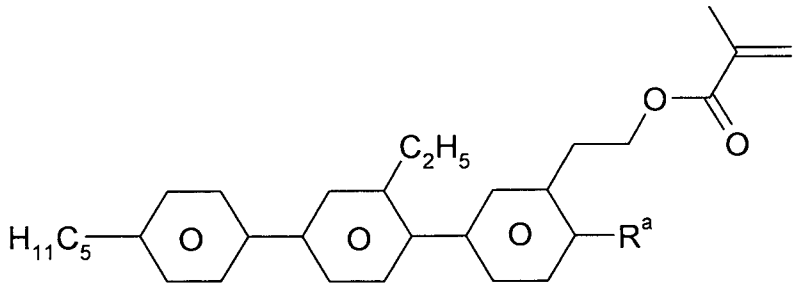
I-1d-2



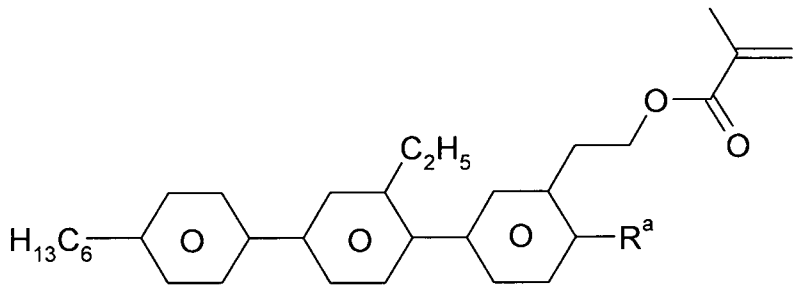
I-1d-3



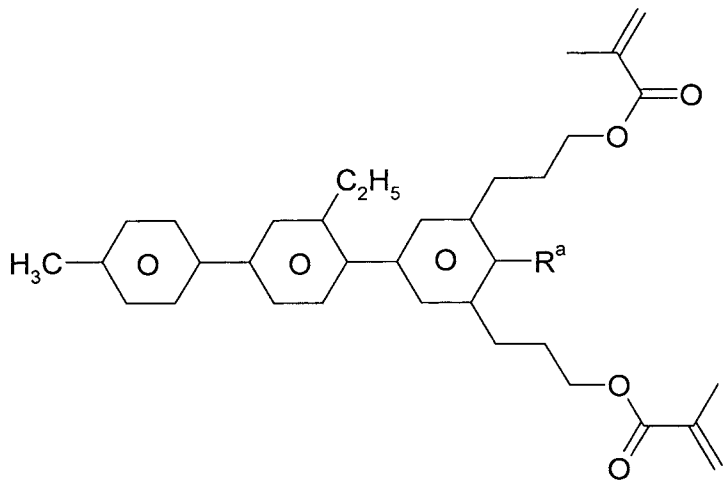
I-1d-4



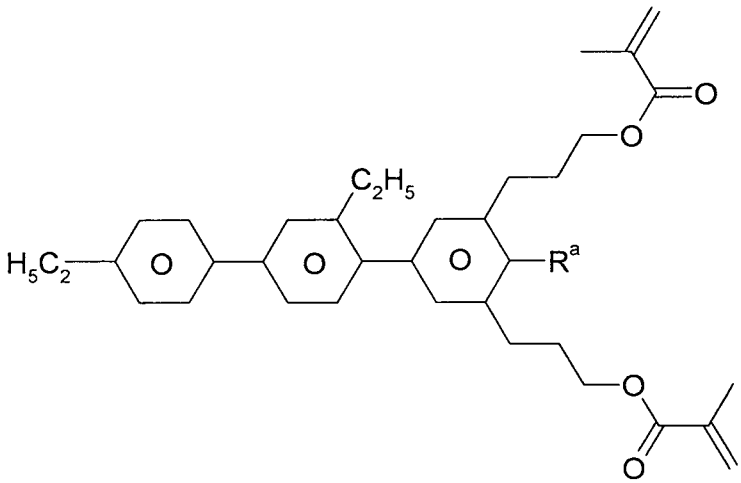
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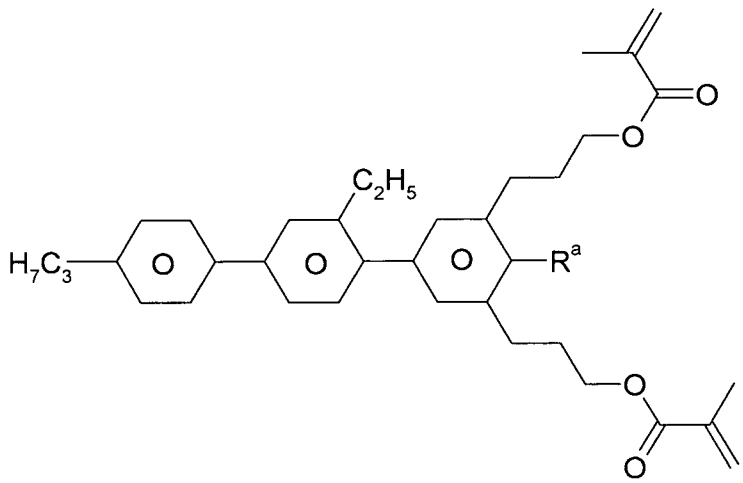
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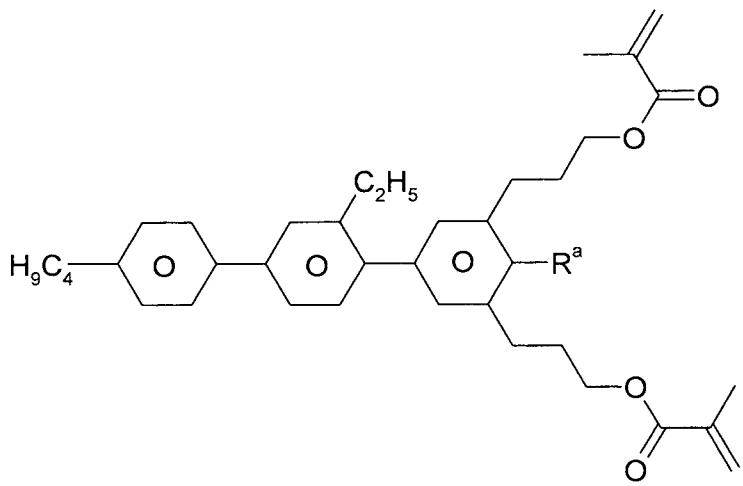
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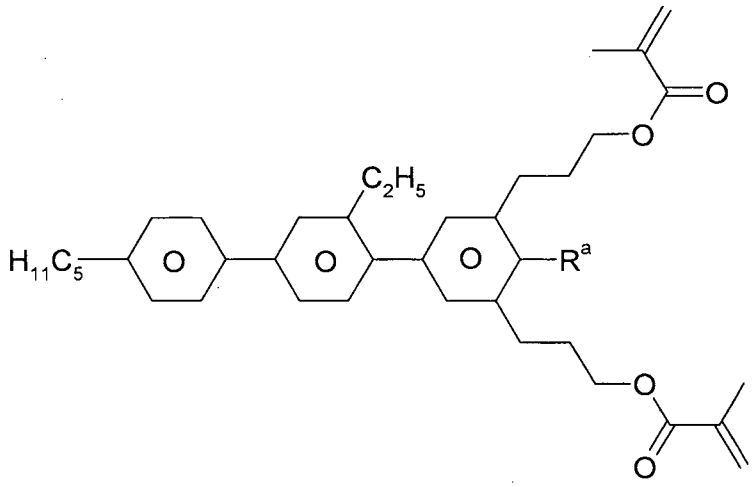
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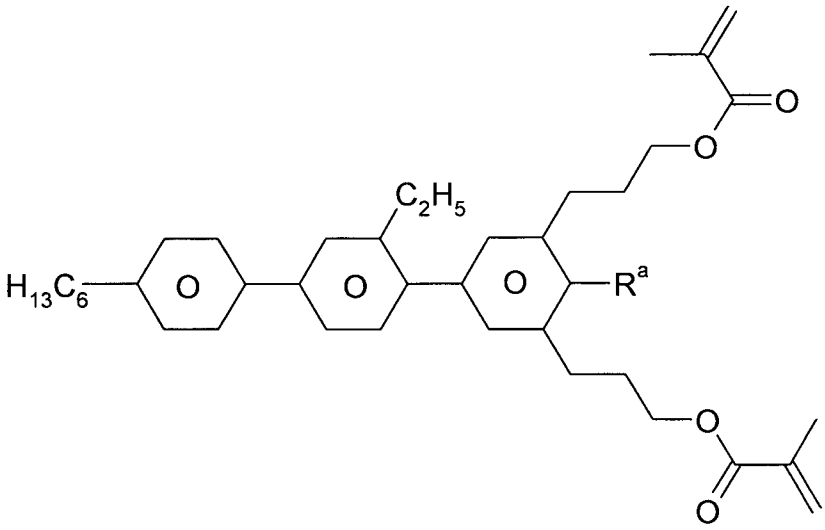
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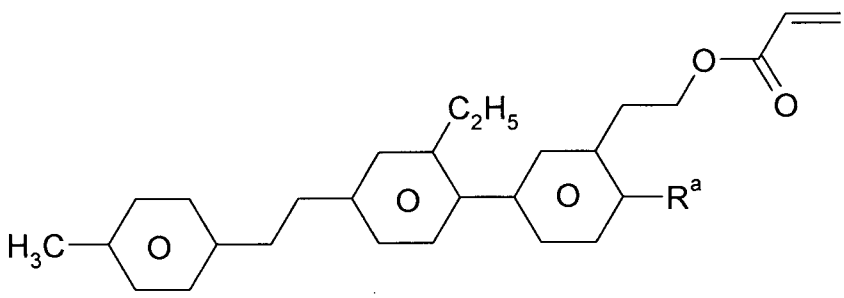
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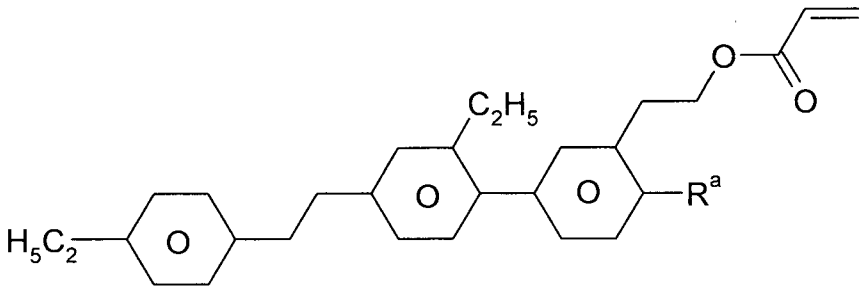
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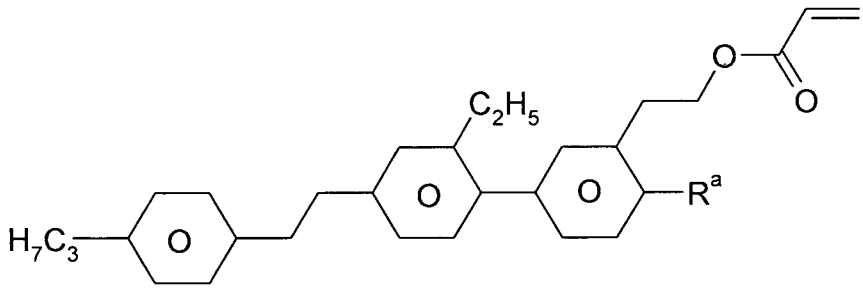
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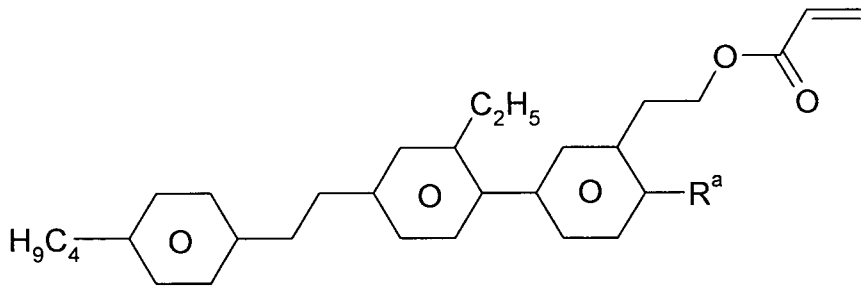
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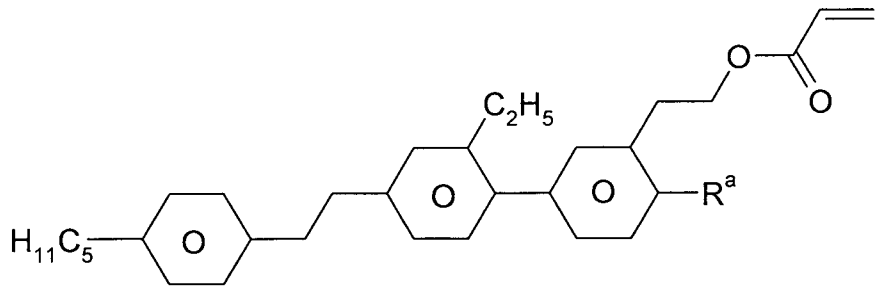
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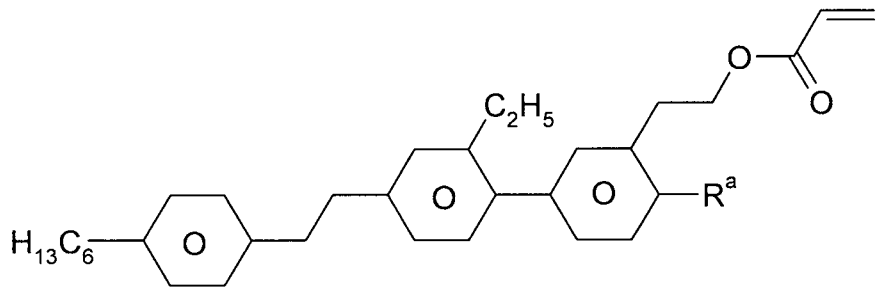
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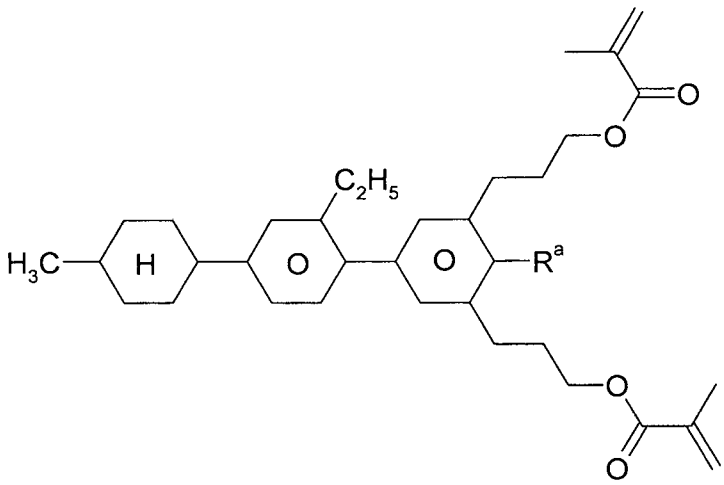
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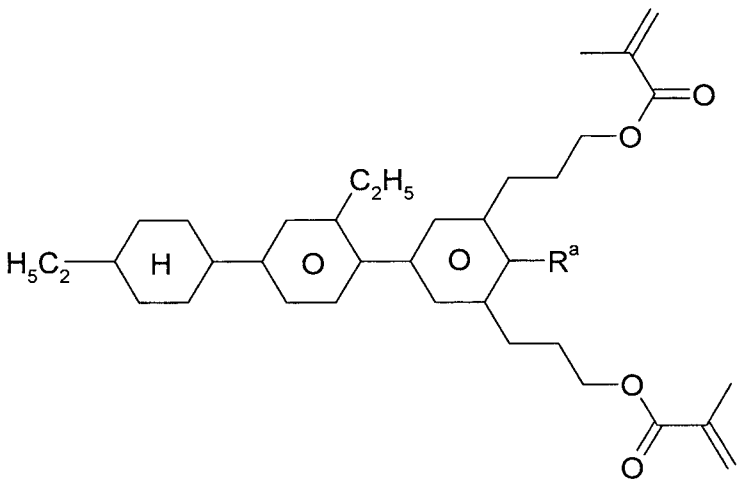
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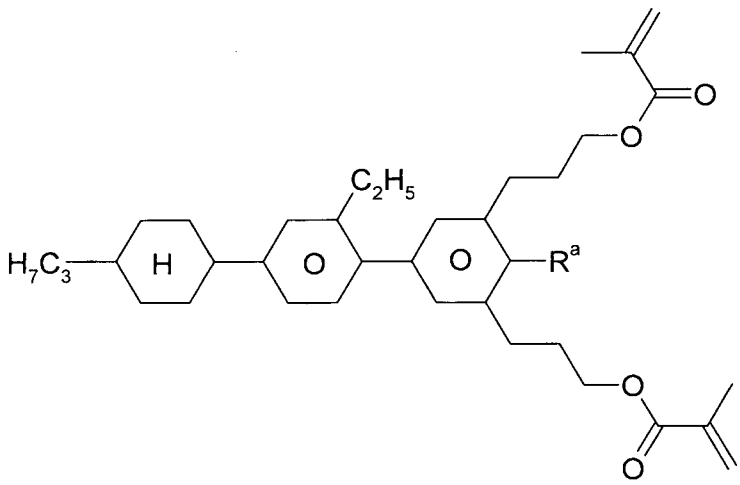
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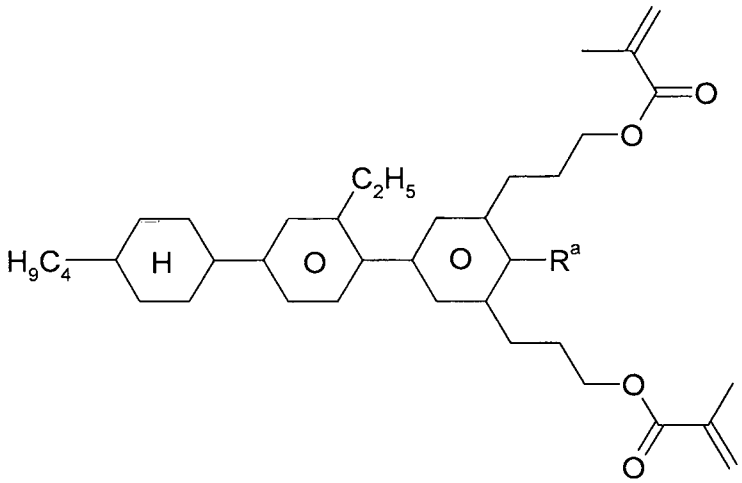
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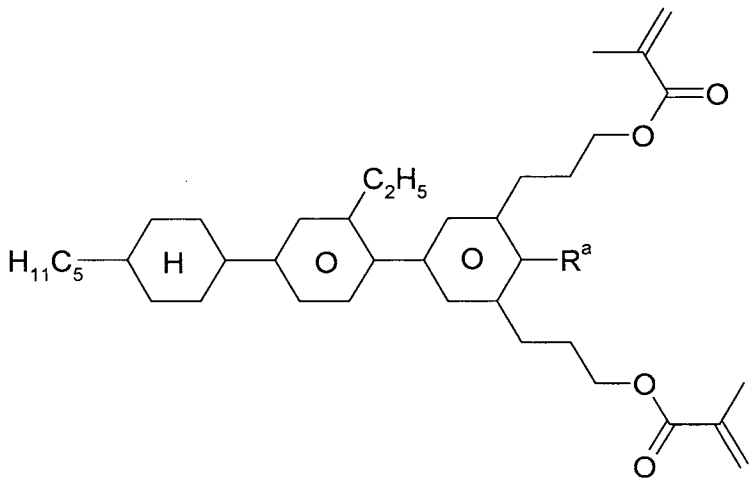
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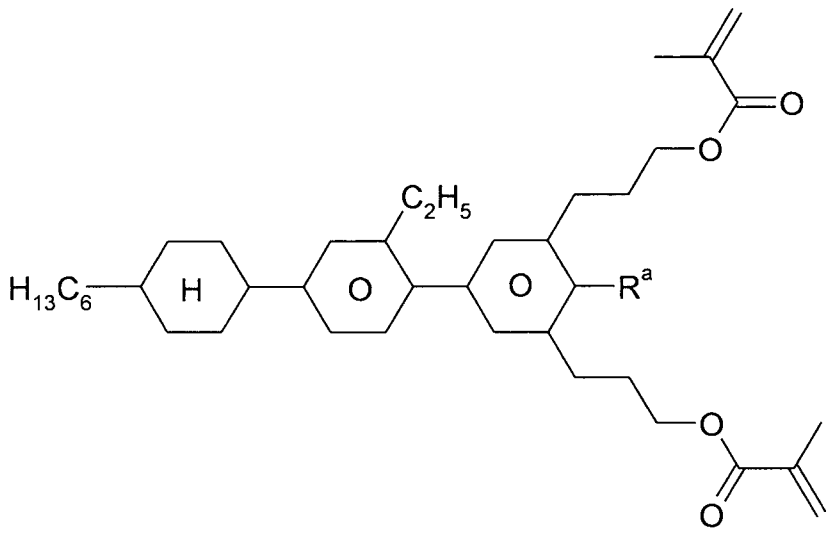
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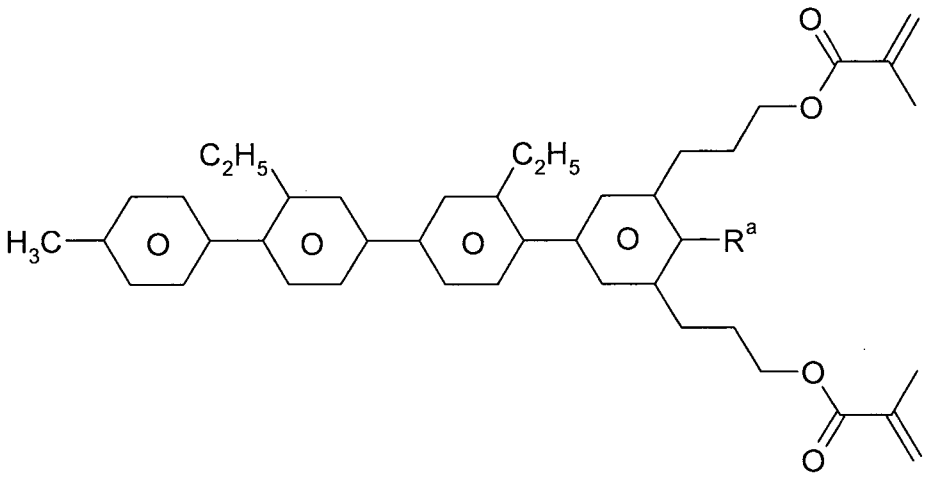
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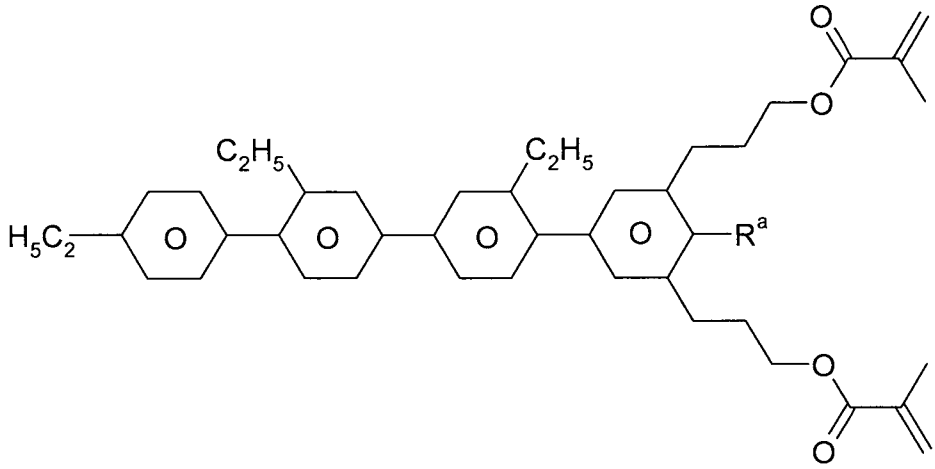
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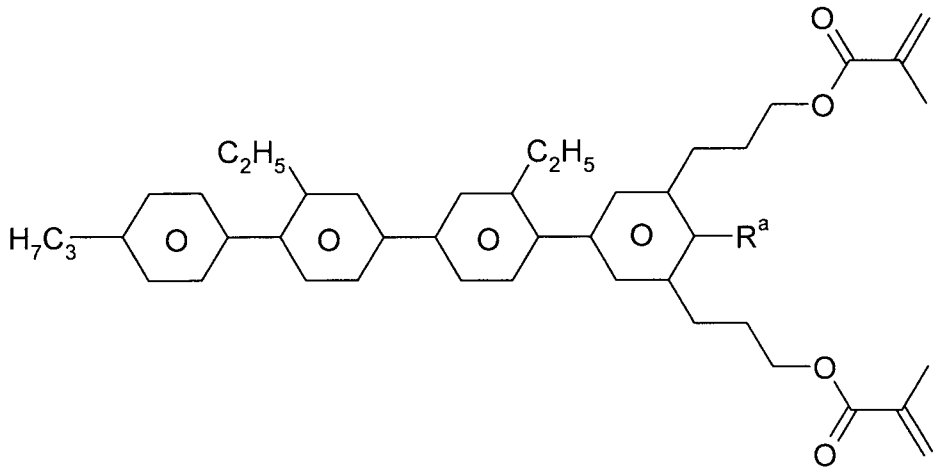
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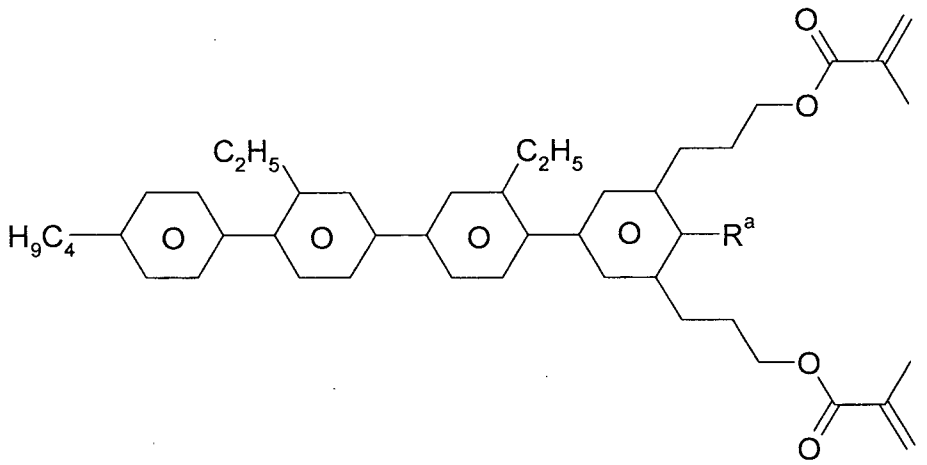
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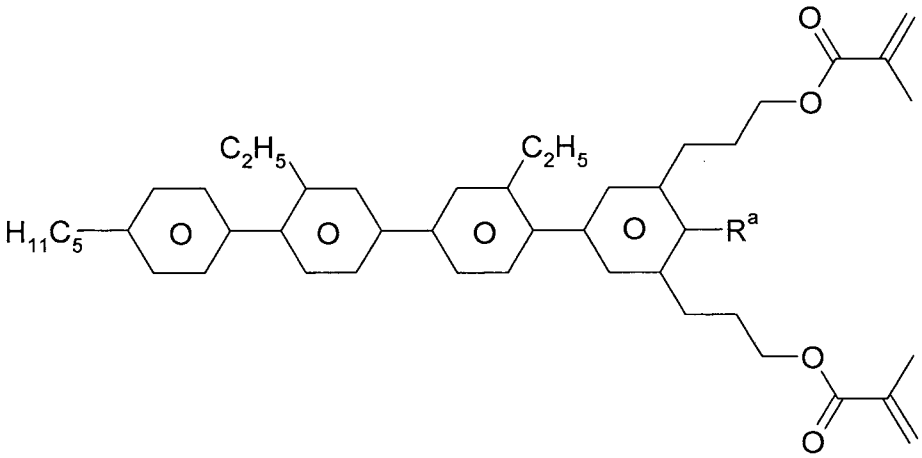
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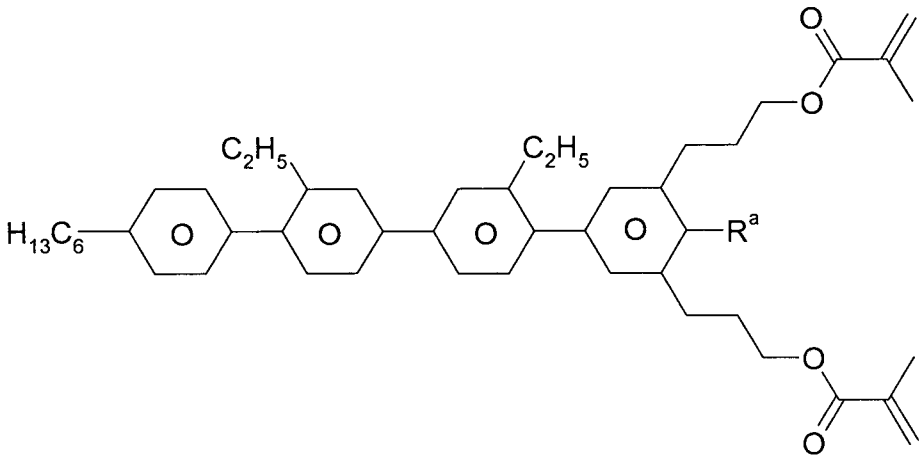
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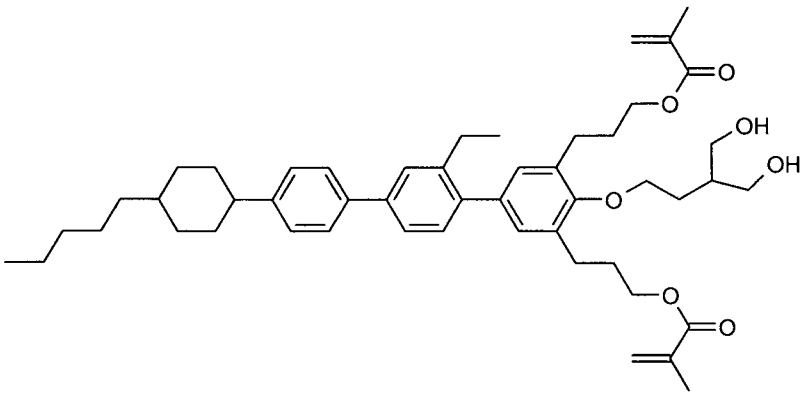
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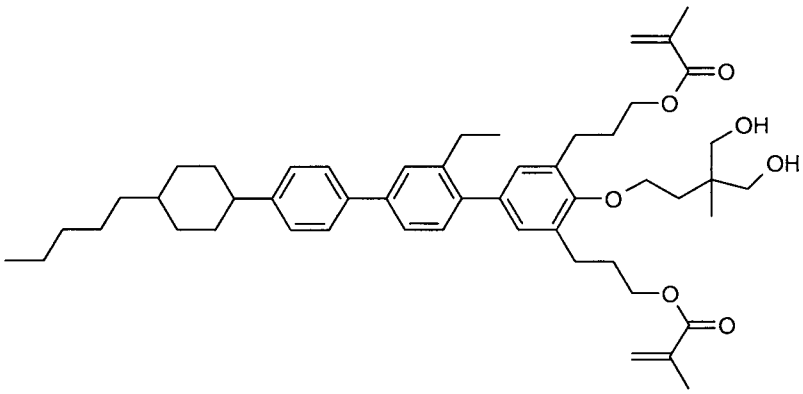
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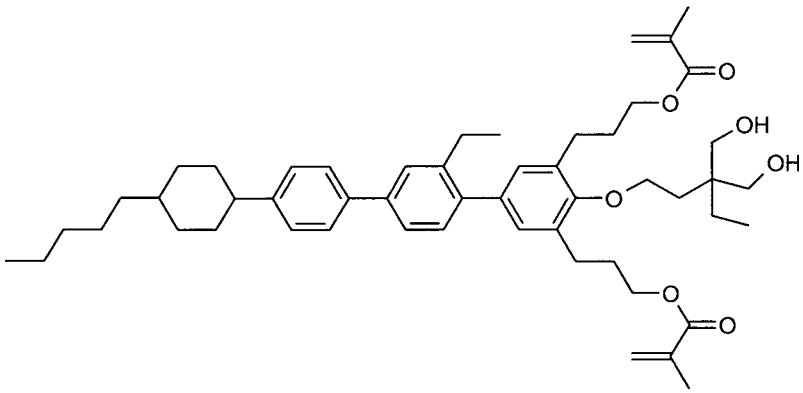
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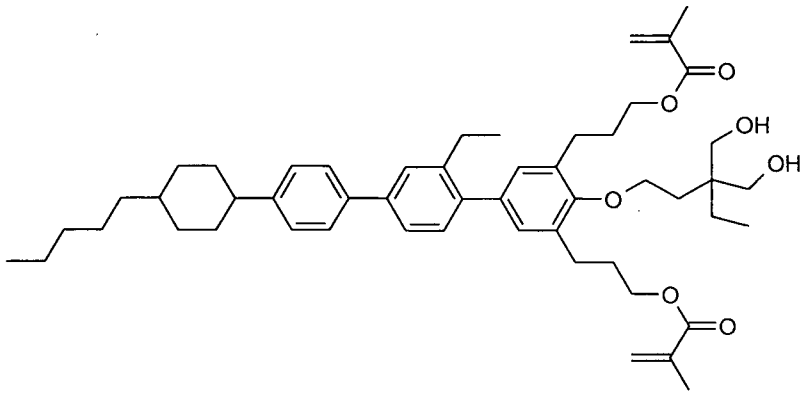
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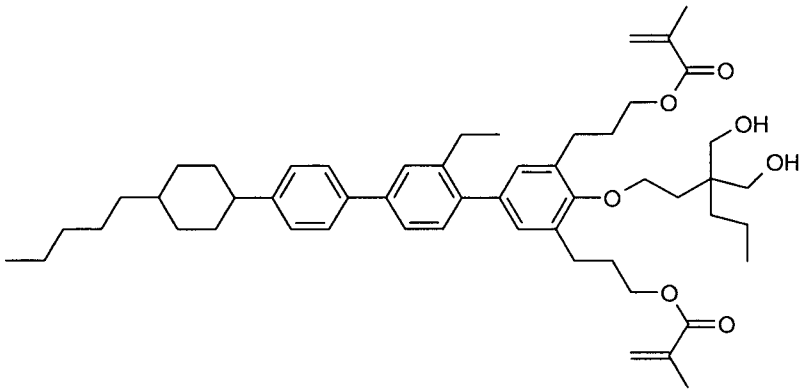
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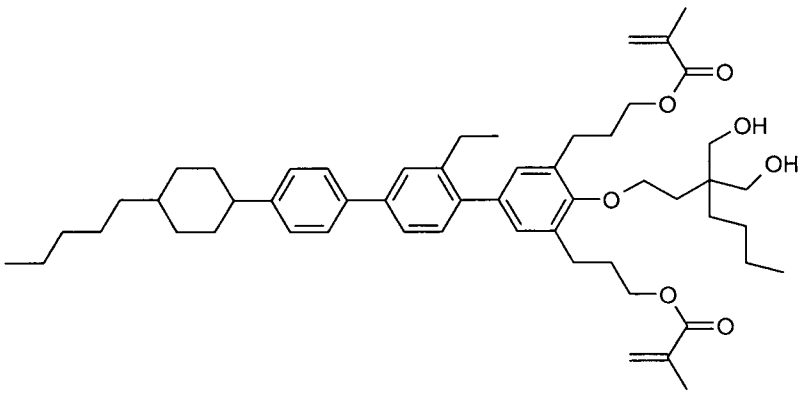
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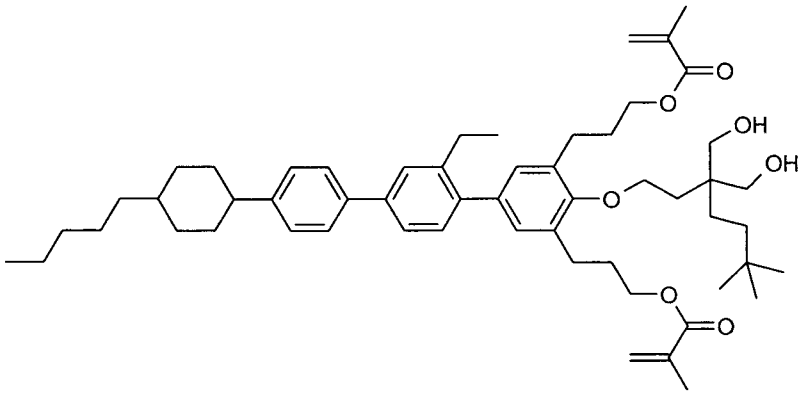
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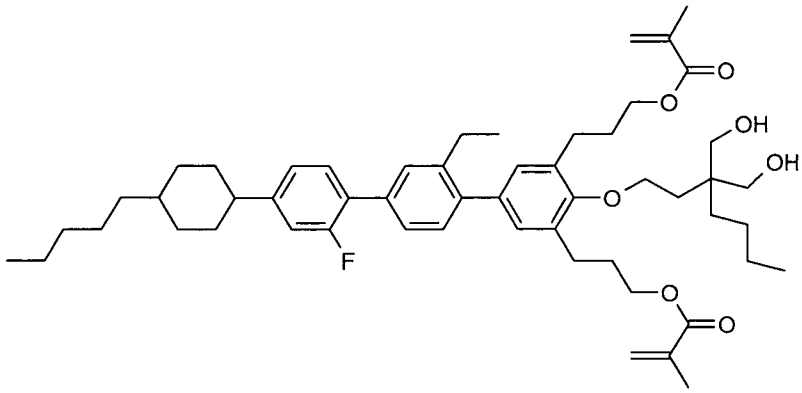
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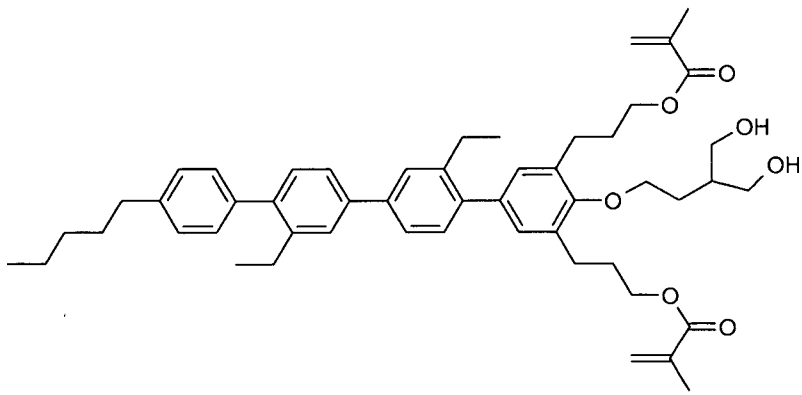
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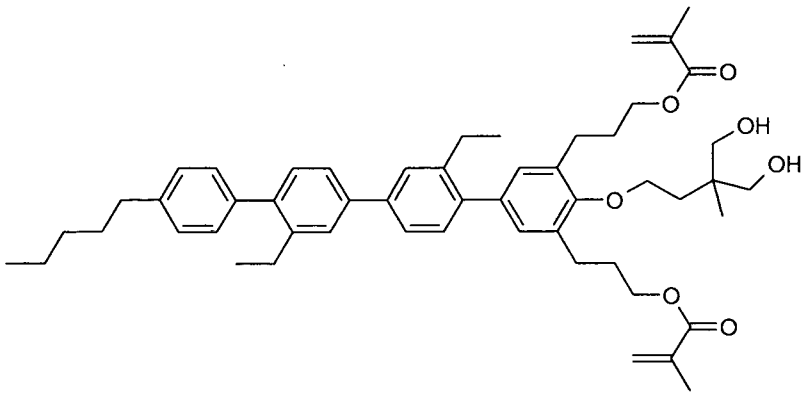
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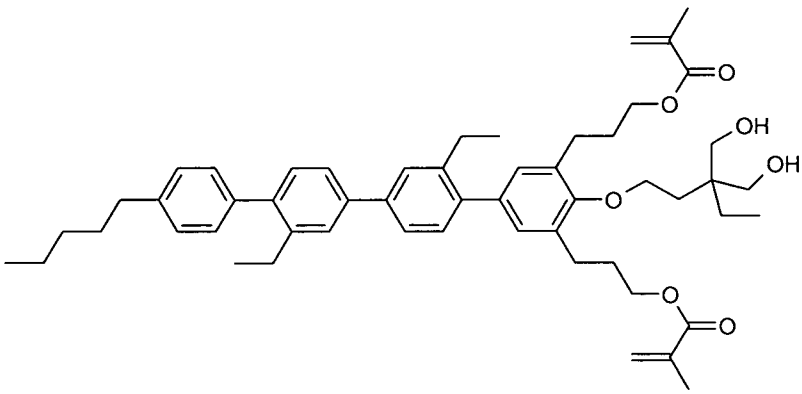
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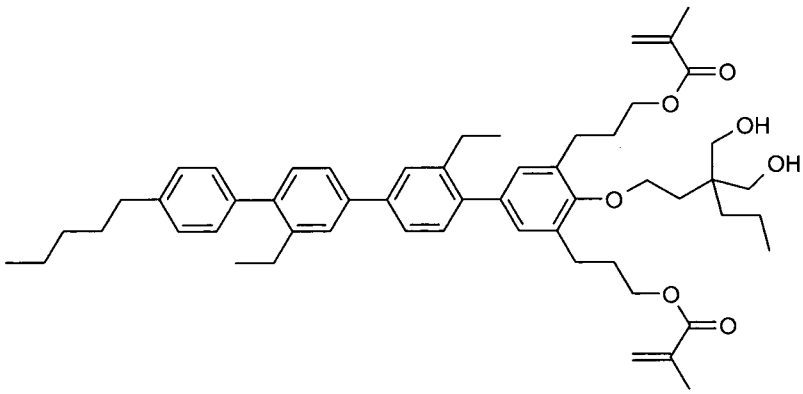
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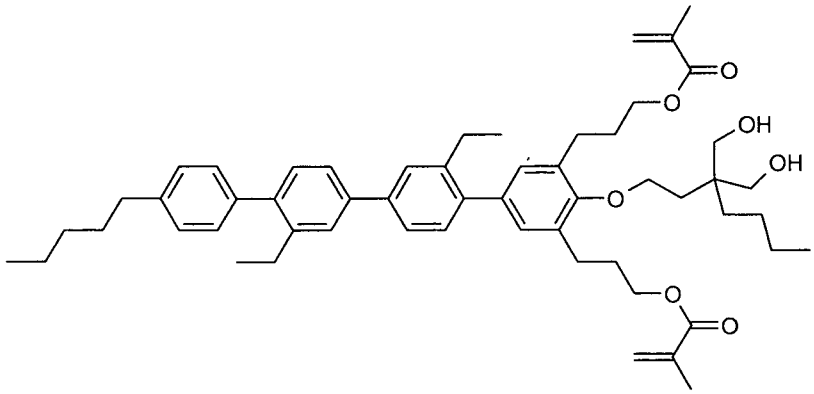
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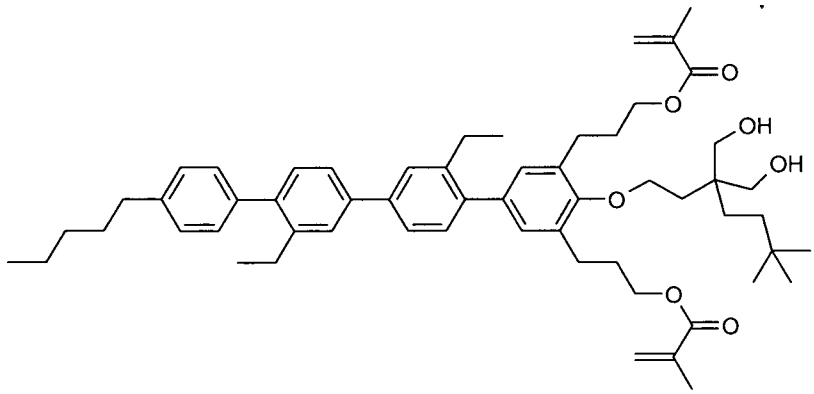
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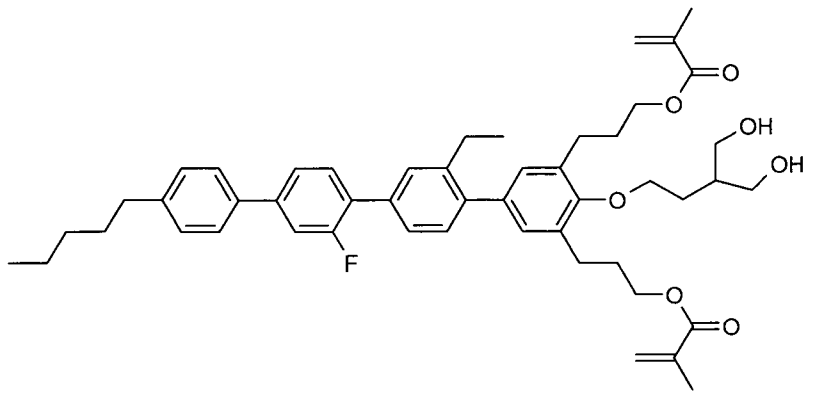
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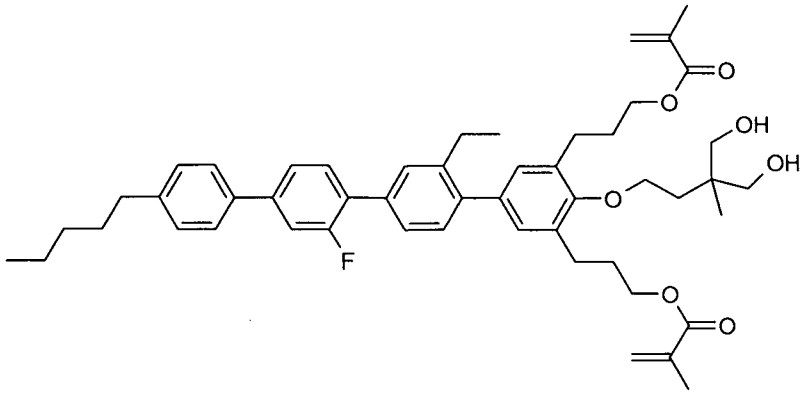
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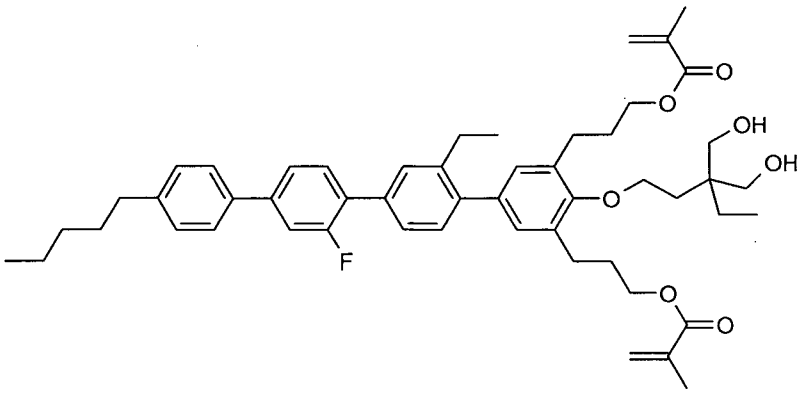
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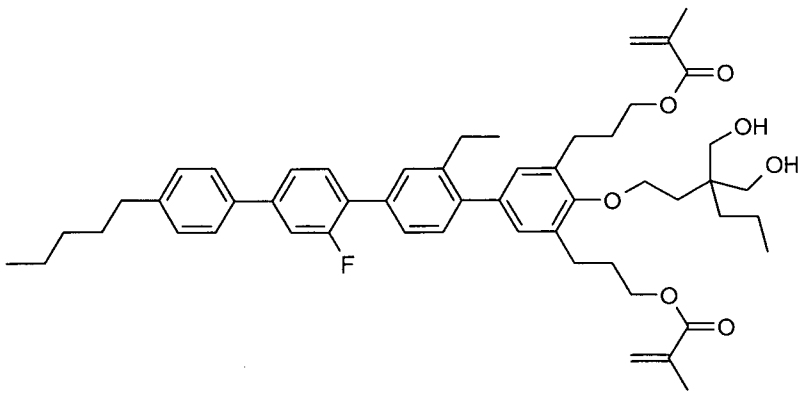
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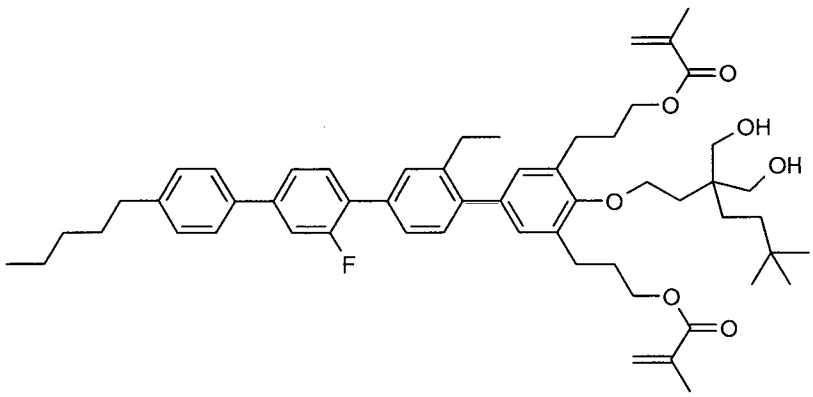
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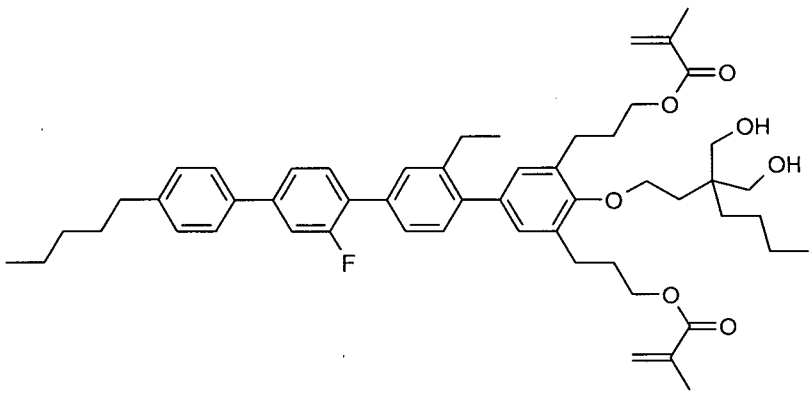
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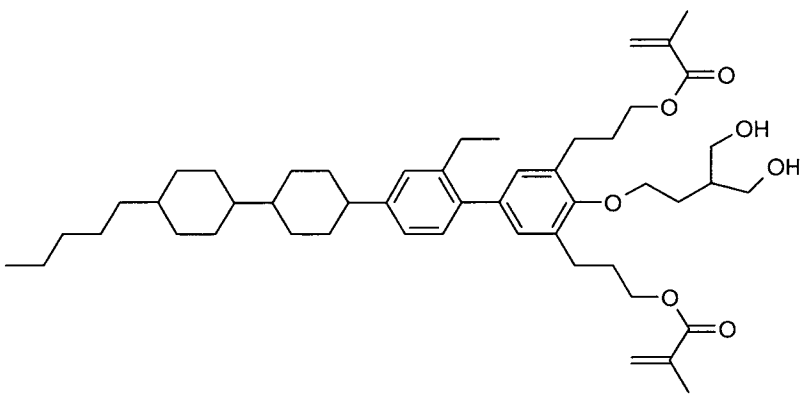
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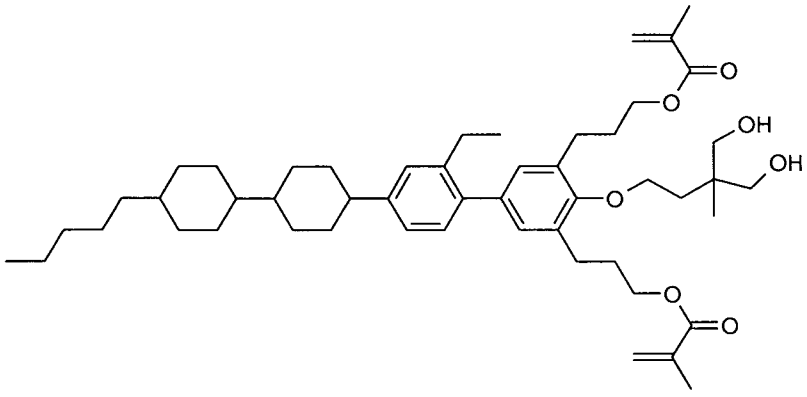
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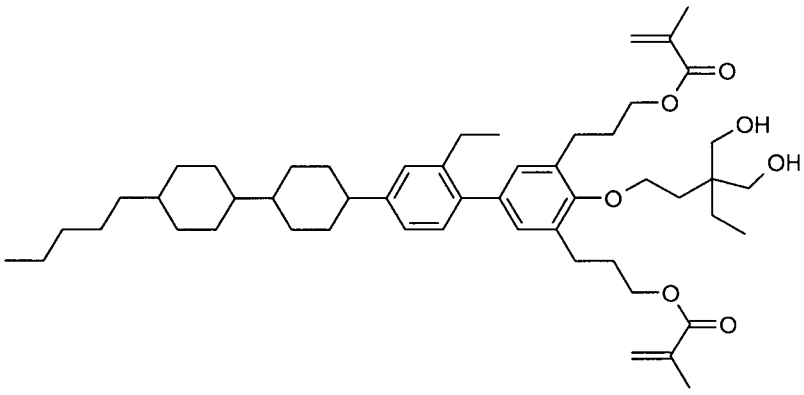
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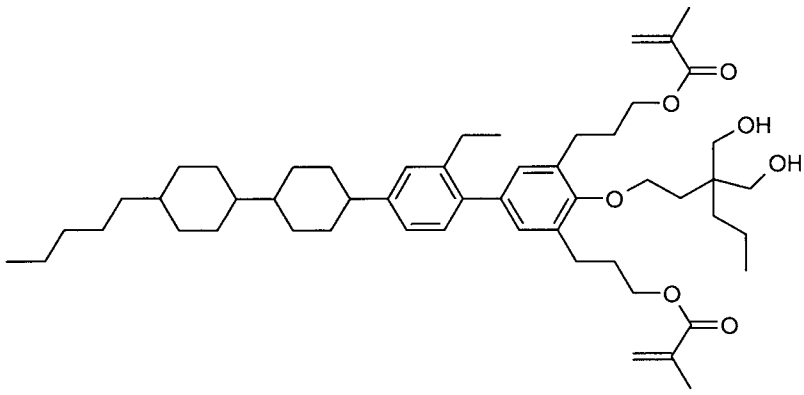
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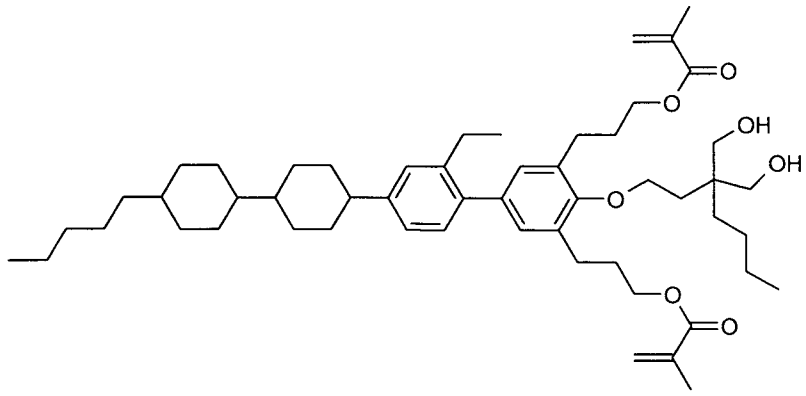
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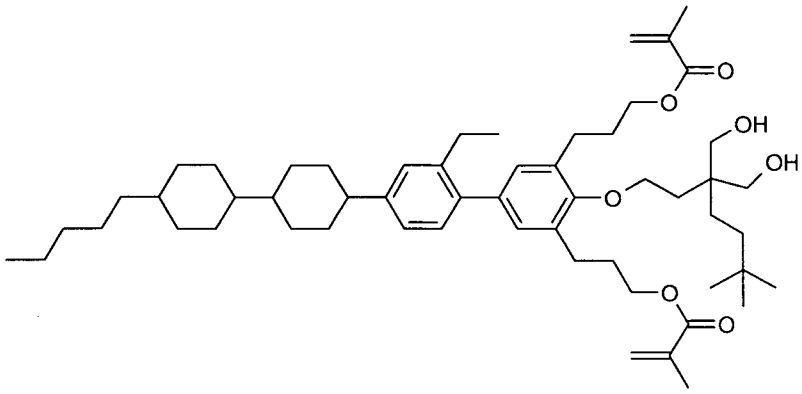
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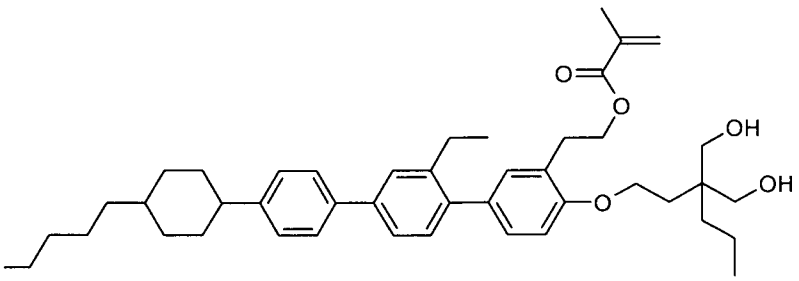
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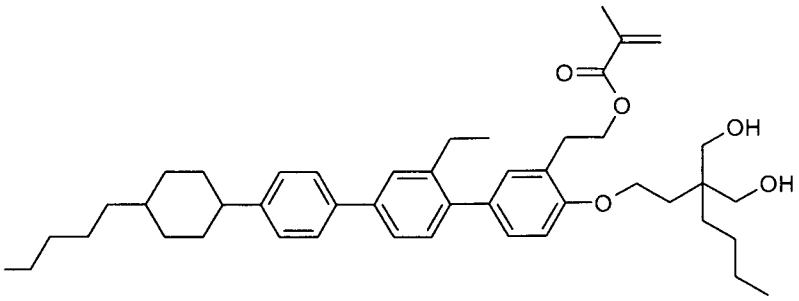
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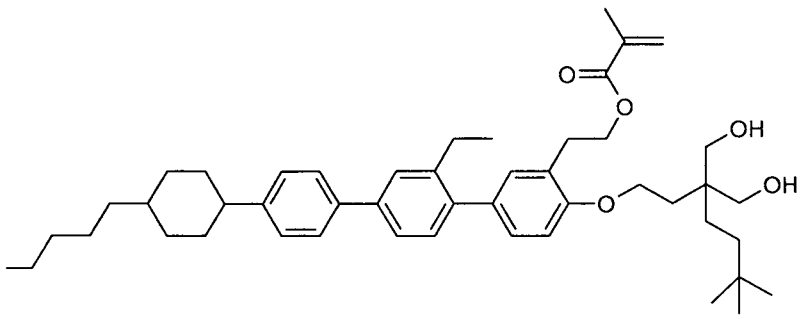
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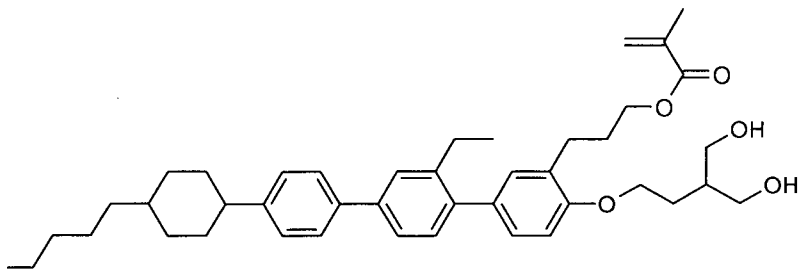
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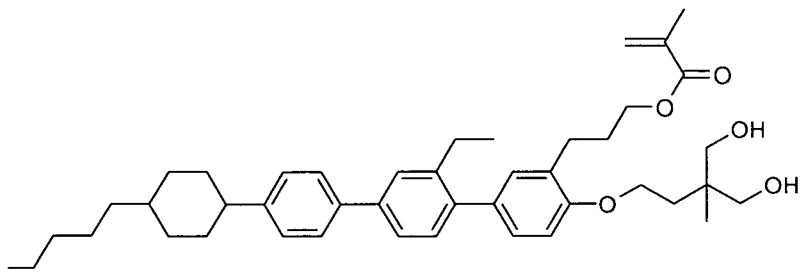
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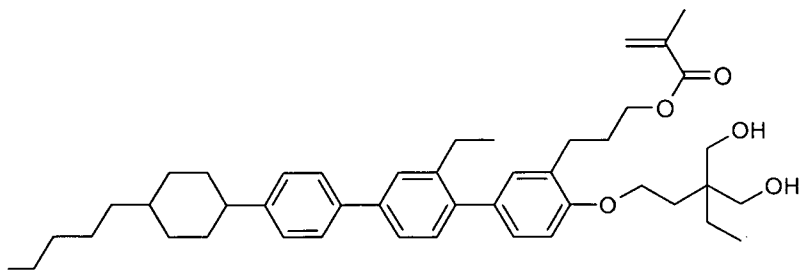
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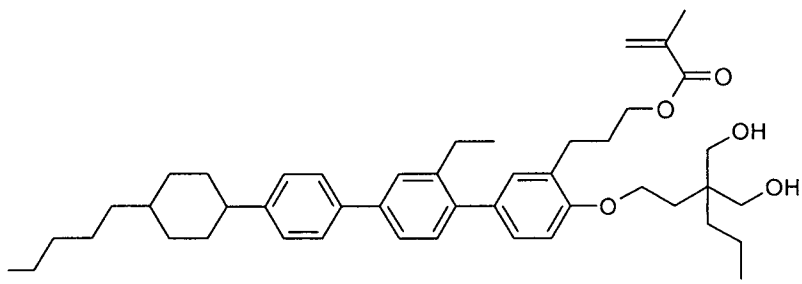
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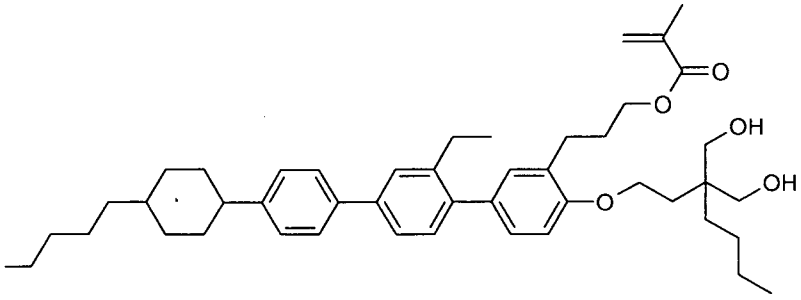
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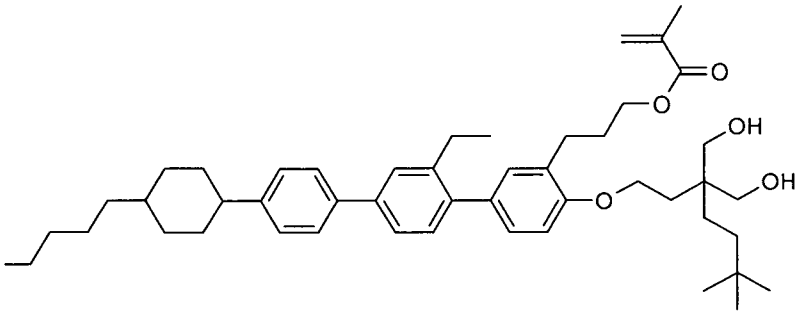
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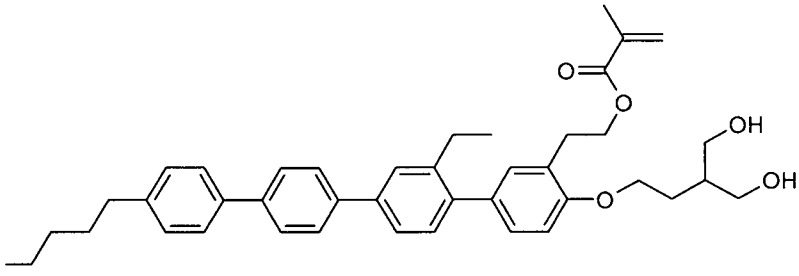
I-71c-4



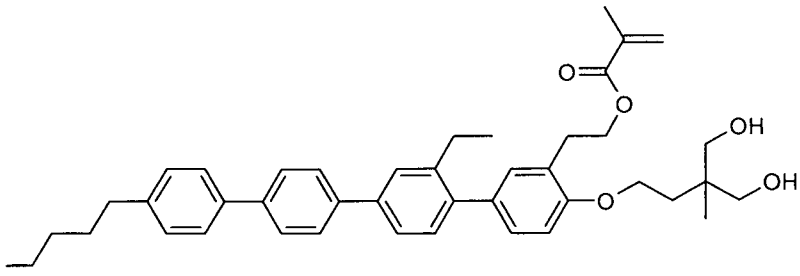
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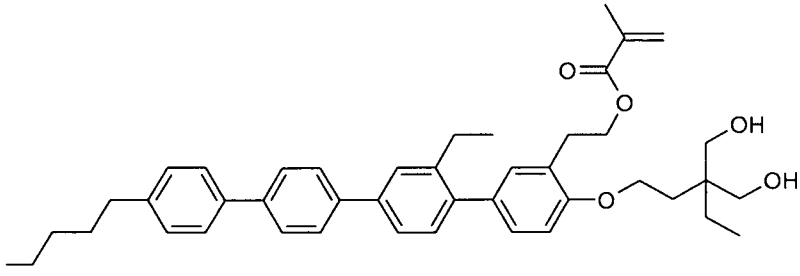
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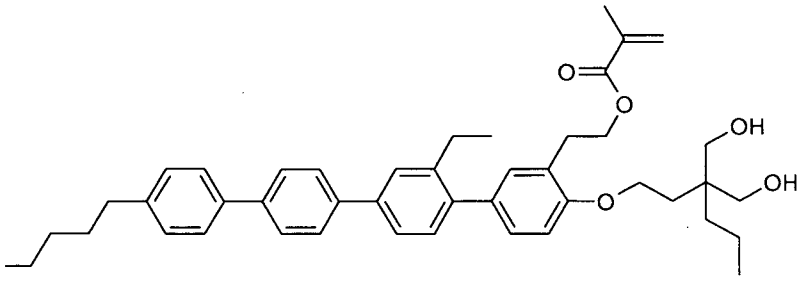
I-63a-1



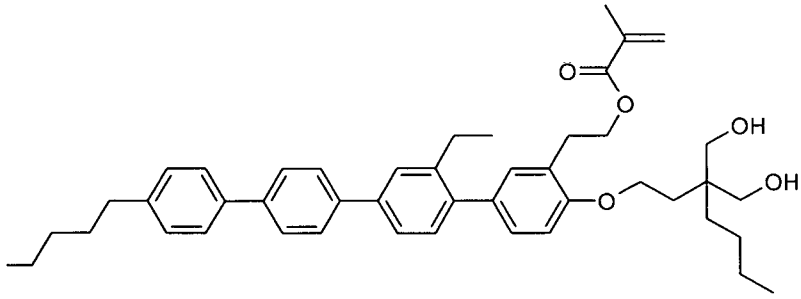
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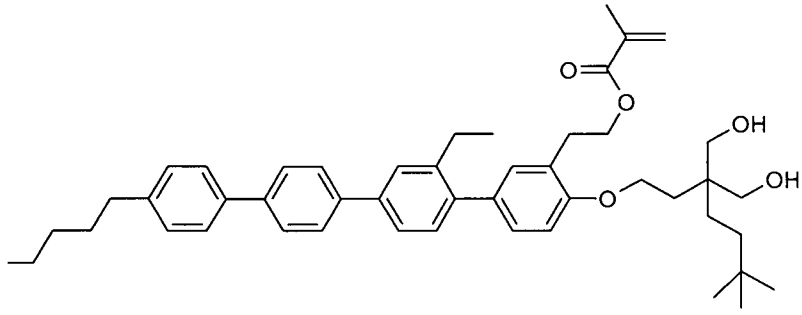
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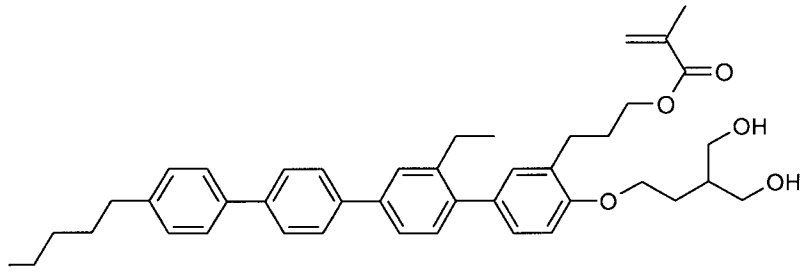
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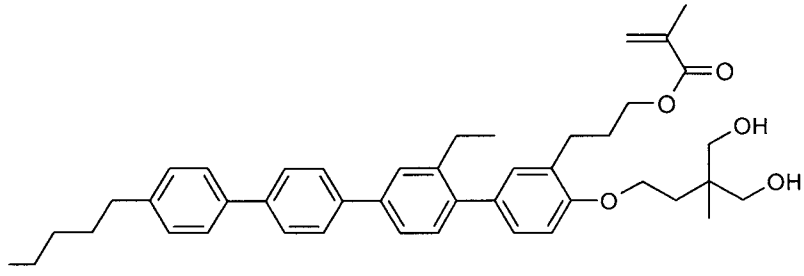
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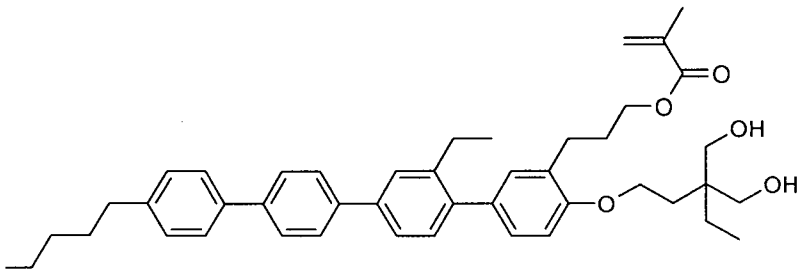
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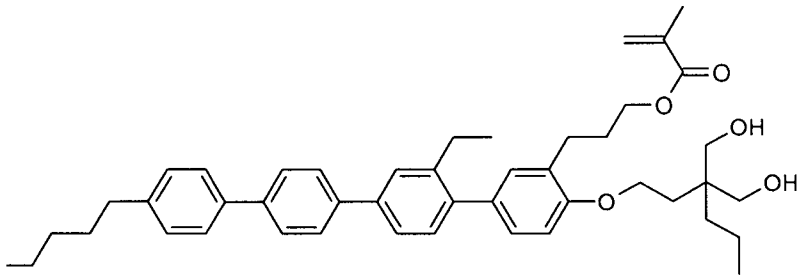
I-63a-7



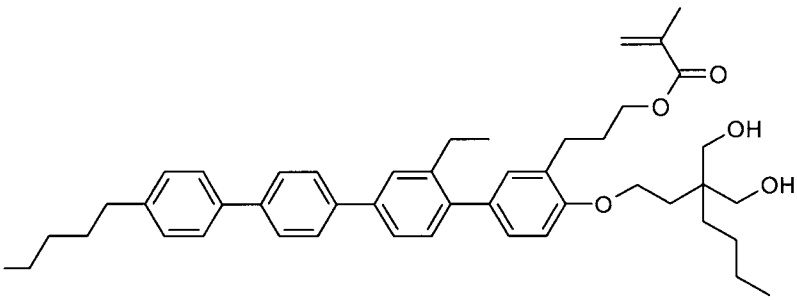
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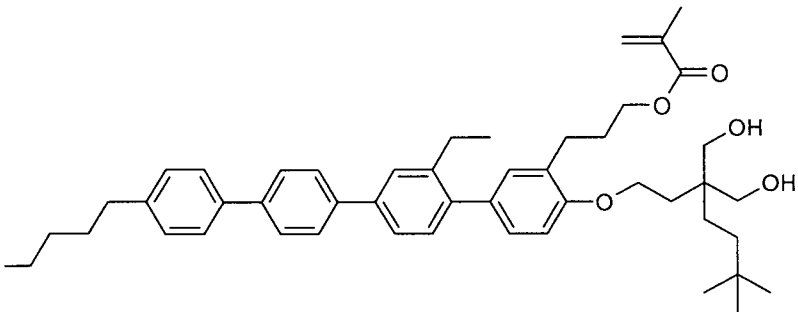
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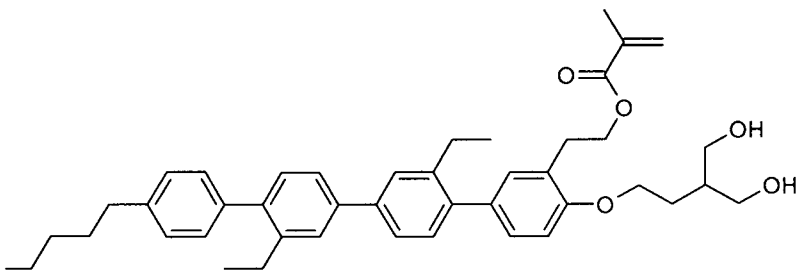
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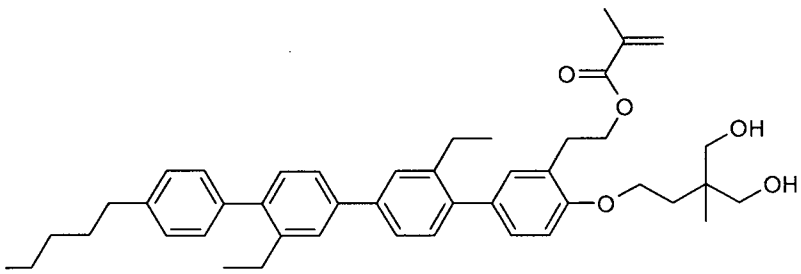
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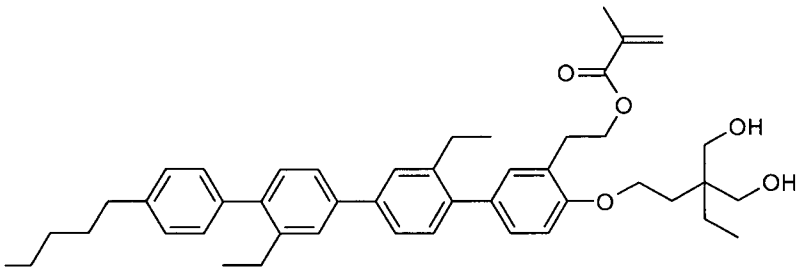
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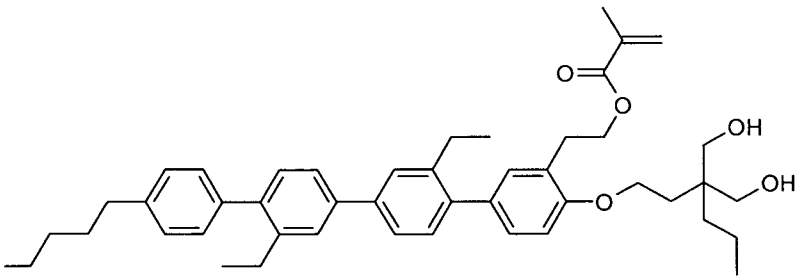
I-67b-1



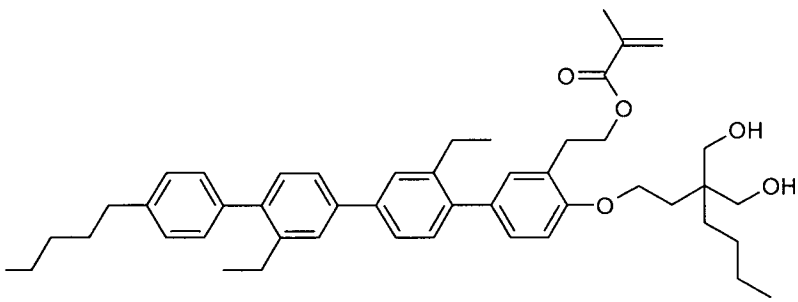
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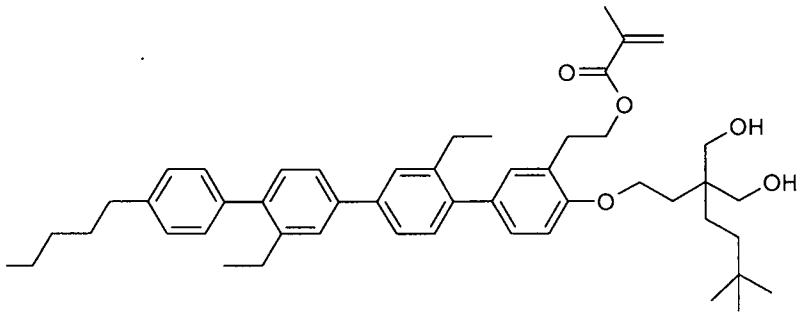
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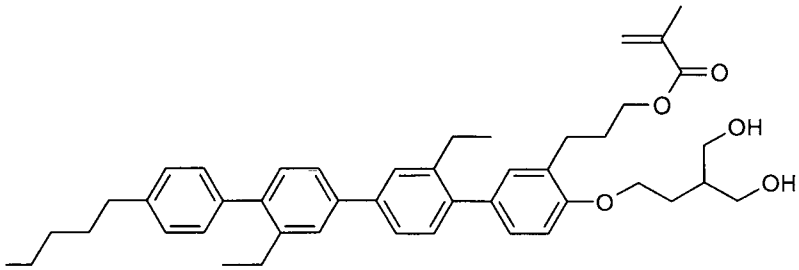
I-67b-4



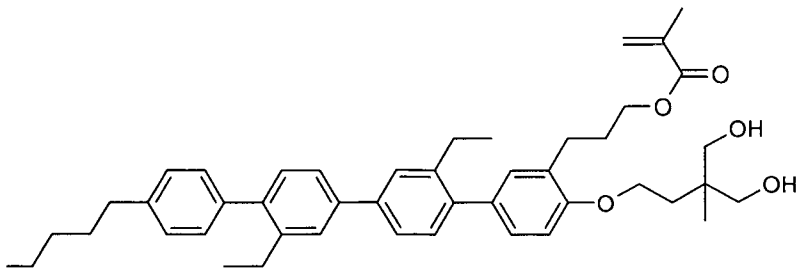
I-67b-5



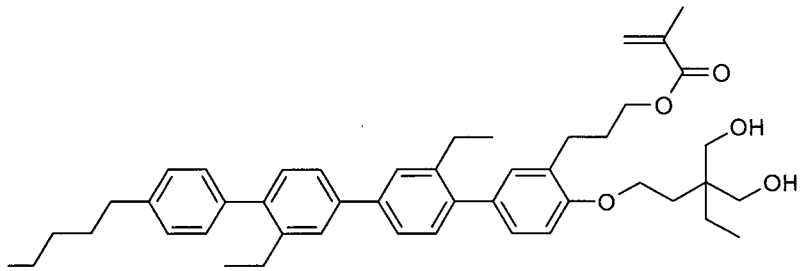
I-67b-6



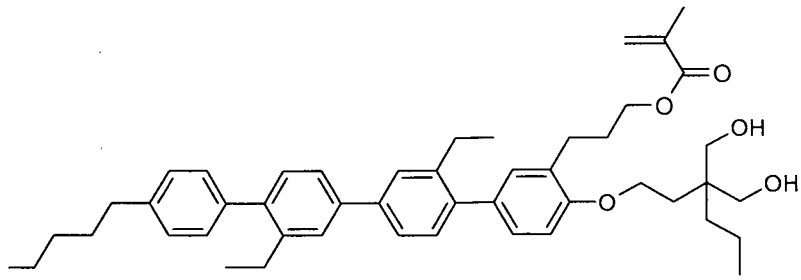
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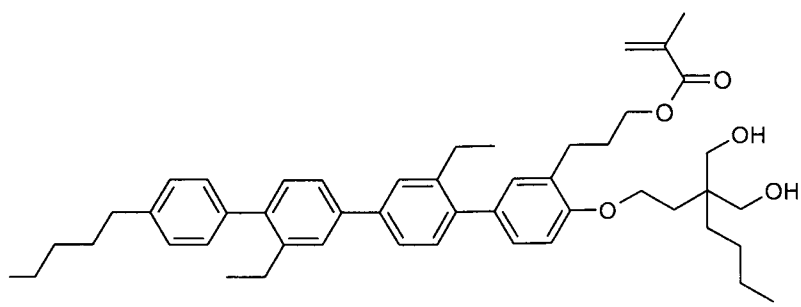
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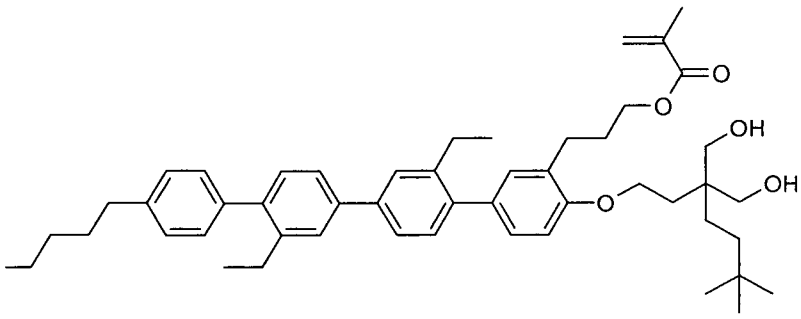
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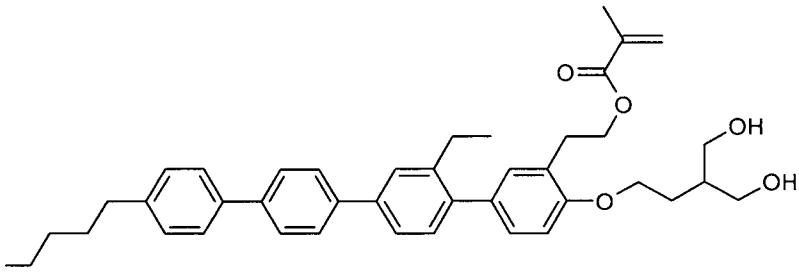
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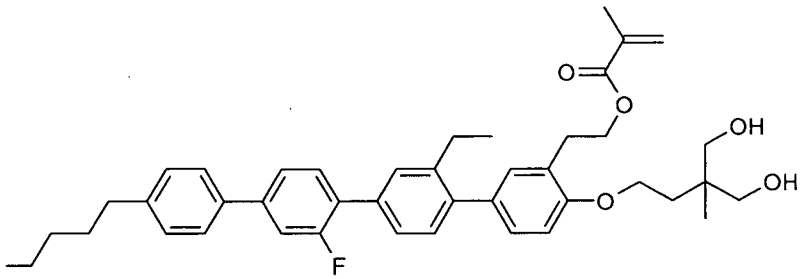
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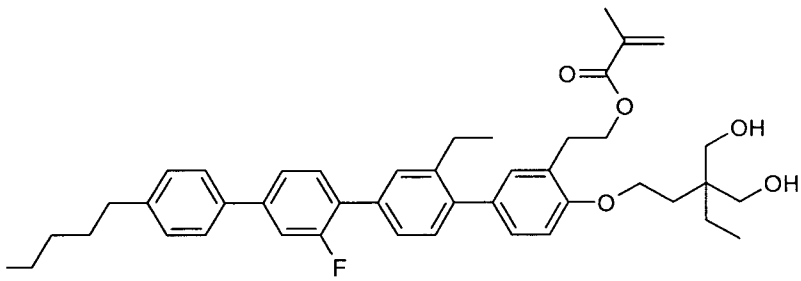
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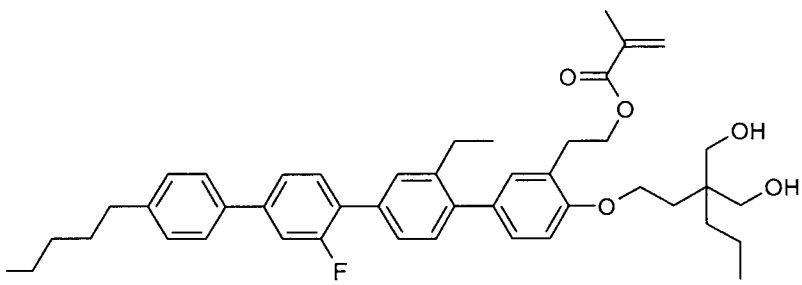
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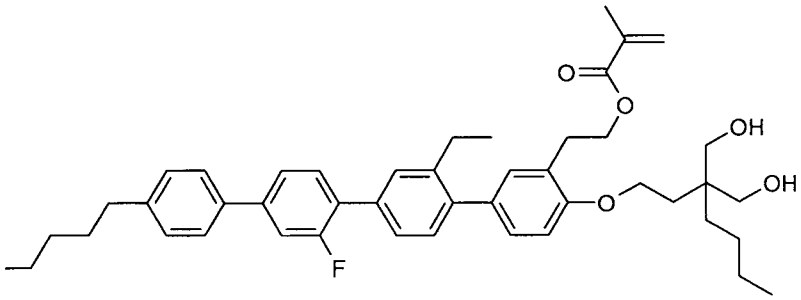
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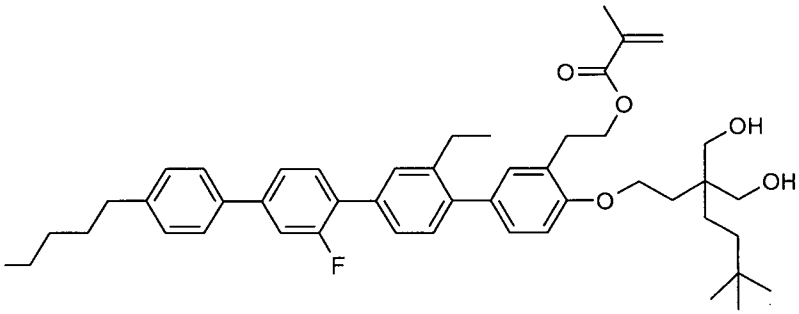
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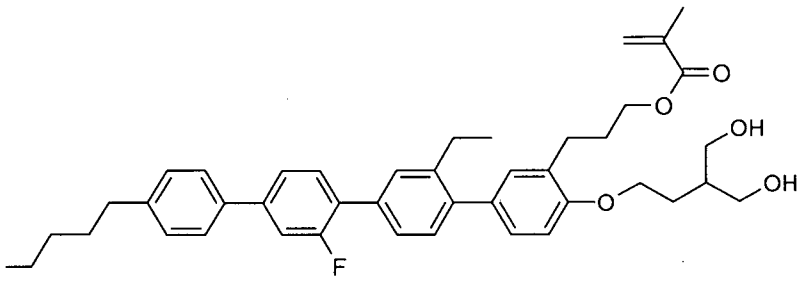
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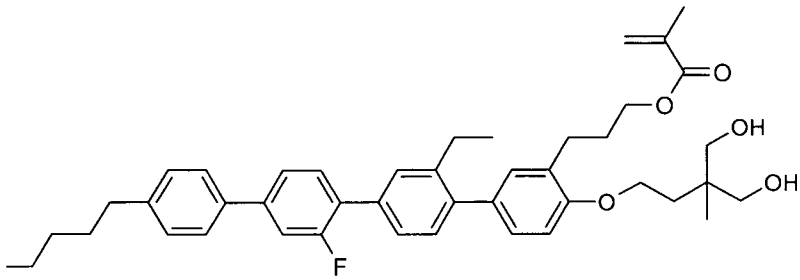
I-79a-4



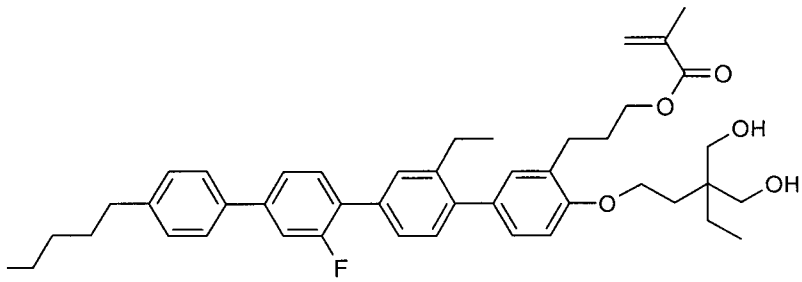
I-79a-5



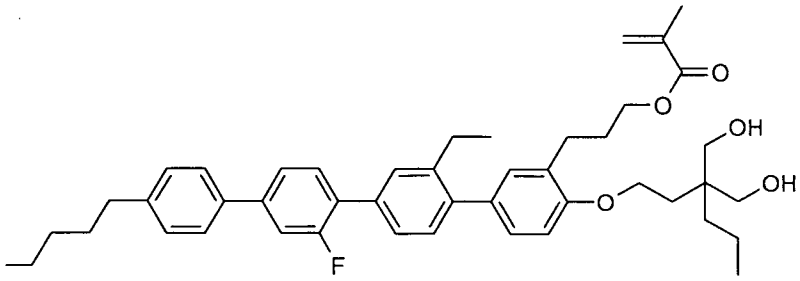
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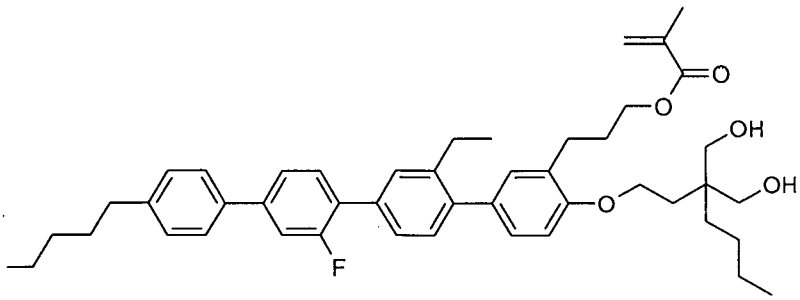
I-79a-7



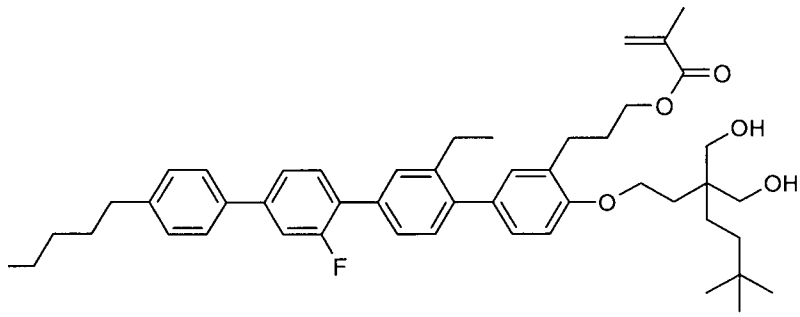
I-79a-8



I-79a-9

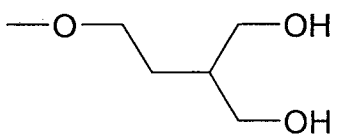


I-79a-10

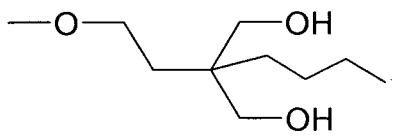


I-79a-11

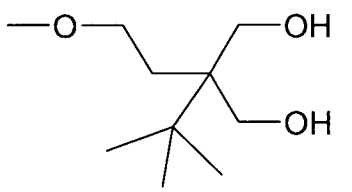
In the compounds of the formula I and the sub-formulae of the compounds of the formula I $R^a$ preferably denotes



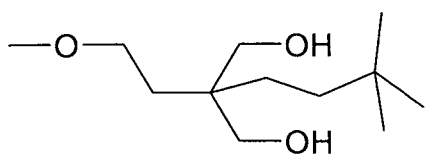
,



,



or

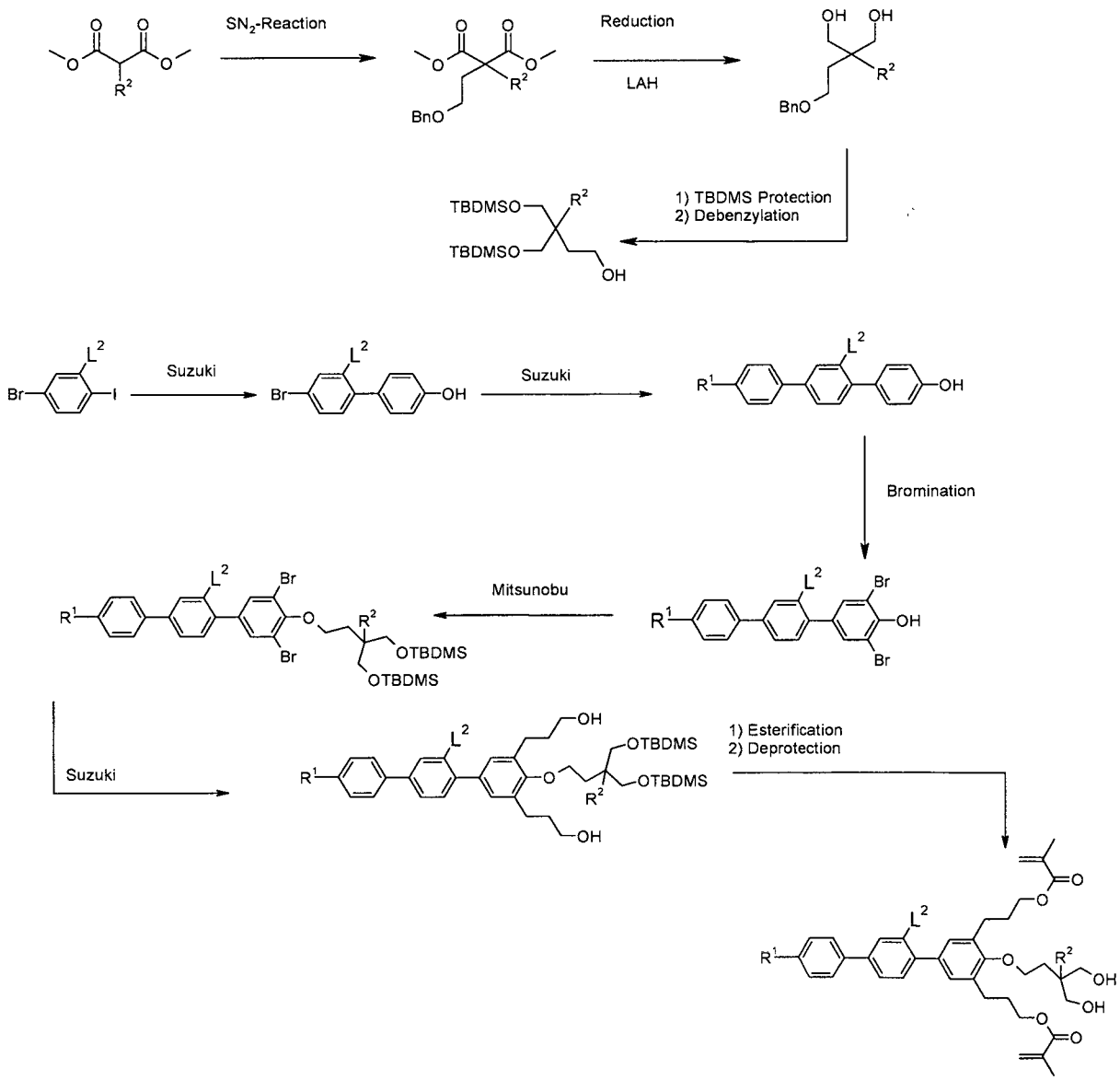


The compounds of the formula I can be prepared by methods known per se, which are described in standard works for organic chemistry as such,

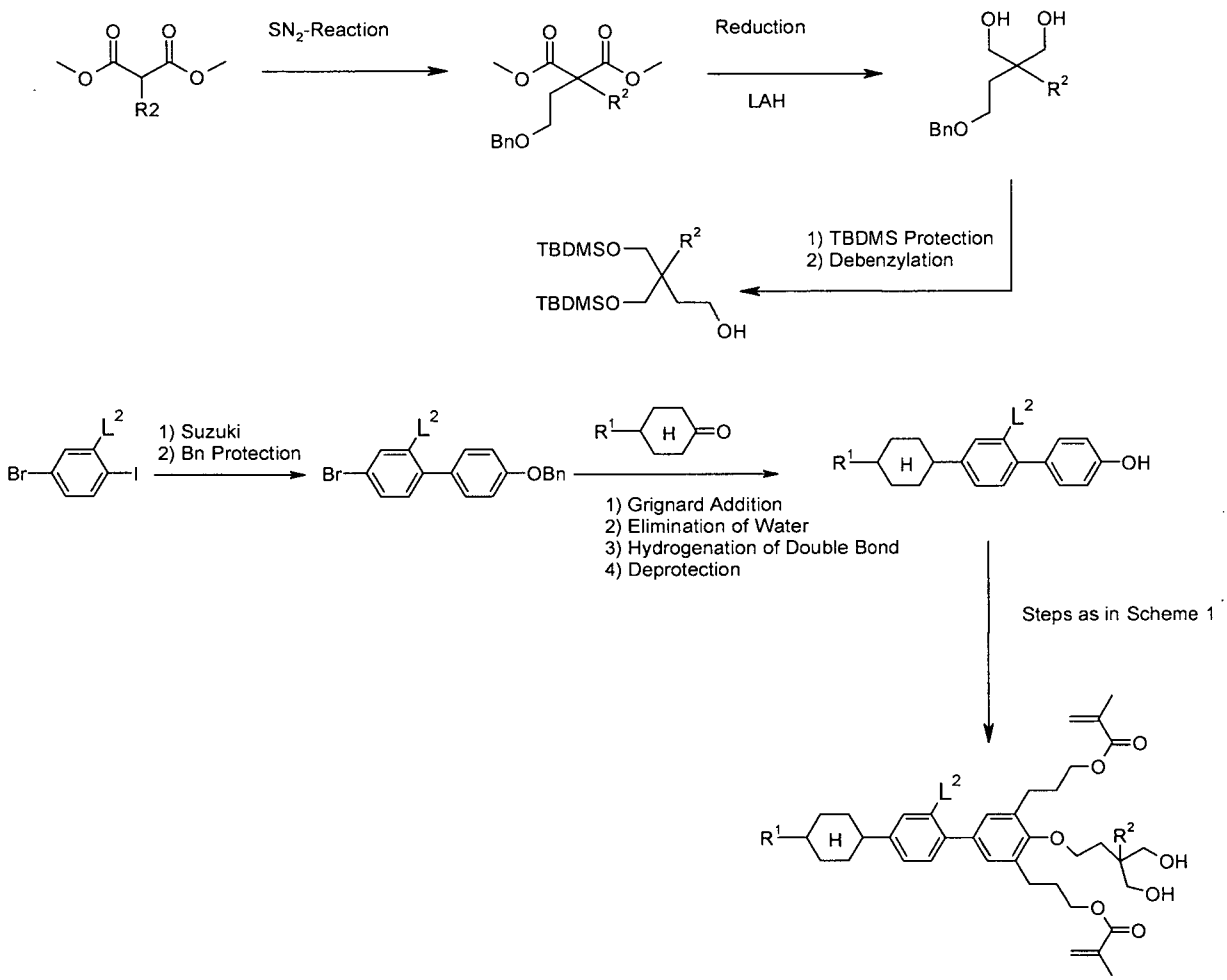
for example, Houben-Weyl, Methoden der organischen Chemie, Thieme-Verlag, Stuttgart.

The compounds of the formula I can be prepared for example as follows:

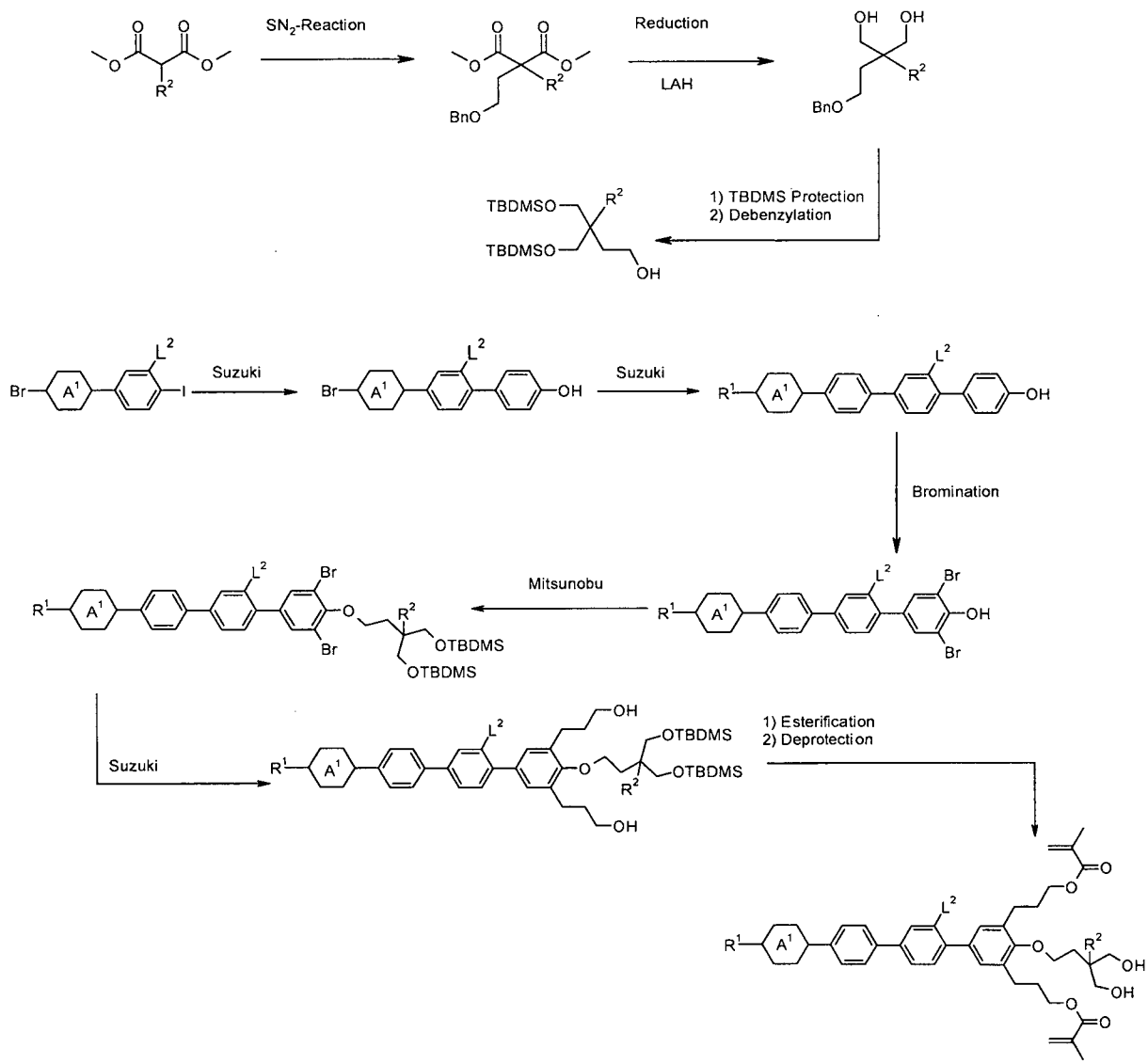
Scheme 1



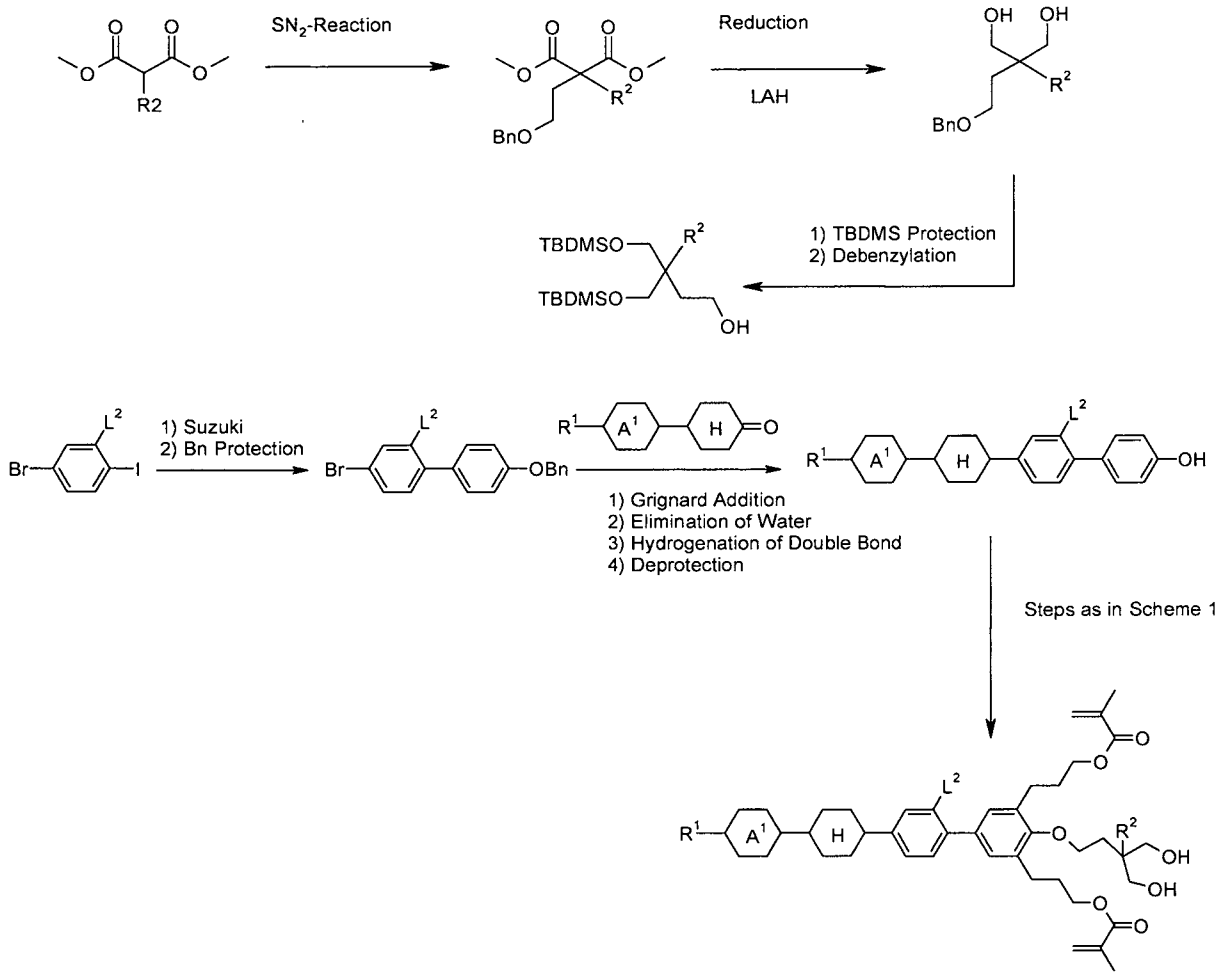
Scheme 2


SN2-Reaction
Reduction
LAH
1) TBDMS Protection
2) Debenzylation
1) Suzuki
2) Bn Protection
1) Grignard Addition
2) Elimination of Water
3) Hydrogenation of Double Bond
4) Deprotection
Steps as in Scheme 1

Scheme 3


SN2-Reaction
Reduction
LAH
BnO
OH
OH
R2
TBDMSO
TBDMSO
1) TBDMS Protection
2) Debenzylation
Br
A1
L2
I
Suzuki
OH
Suzuki
R1
Bromination
Mitsunobu
OTBDMS
OTBDMS
Suzuki
1) Esterification
2) Deprotection
O

Scheme 4


SN2-Reaction
Reduction
LAH
1) TBDMS Protection
2) Debenzylation
1) Suzuki
2) Bn Protection
1) Grignard Addition
2) Elimination of Water
3) Hydrogenation of Double Bond
4) Deprotection
Steps as in Scheme 1

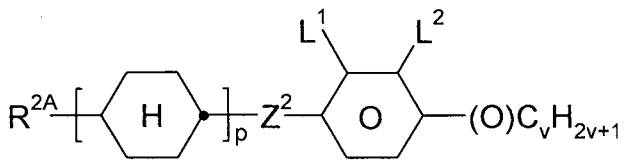
The media according to the invention preferably contain one, two, three, four or more, preferably one, self-aligning additive, preferably selected from the compounds of the formulae I-1 to I-79.

The self-aligning additives of the formula I are preferably employed in the liquid-crystalline medium in amounts of ≥ 0.01 % by weight, preferably 0.1-10 % by weight, based on the mixture as a whole. Particular preference is given to liquid-crystalline media which contain 0.1-5 %, preferably 1.0-3 %, by weight of one or more self-aligning additives, based on the total mixture, especially additives which are selected from the group of compounds of the formula I-1 to I-78.

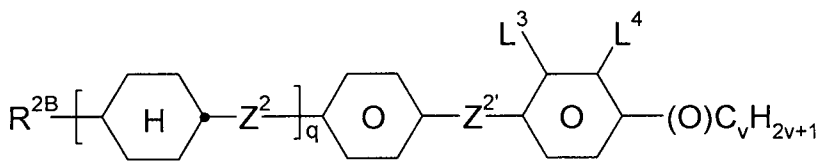
The use of preferably 1.0 to 3 % by weight of one or more compounds of the formula I results in a complete homeotropic alignment of the LC layer for conventional LC thickness (3 to 4 µm) and for the substrate materials used in the display industrie. Special surface treatment may allow to significantly reduce the amount of the compound(s) of the formula I which means less than 1.0 % by weight.

Preferred embodiments of the liquid-crystalline medium according to the invention are indicated below:

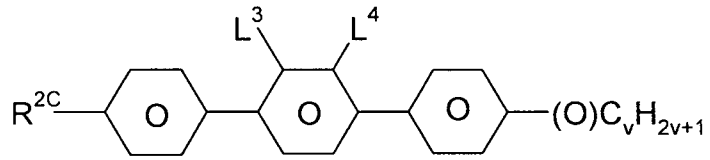
a) Liquid-crystalline medium which additionally comprises one or more compounds selected from the group of the compounds of the formulae IIA, IIB and IIC:




IIA




IIB



IIC

in which

| | |
|---|---|
| $R^{2A}$, $R^{2B}$ and $R^{2C}$ | 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, in addition, one or more $CH_2$ groups in these radicals may be replaced by -O-, -S-,  , -C≡C-, $-CF_2O-$, $-OCF_2-$, -OC-O- or -O-CO- in such a way that O atoms are not linked directly to one another, |
| $L^{1-4}$ | each, independently of one another, denote F, Cl, $CF_3$ or $CHF_2$, |
| $Z^2$ and $Z^{2'}$ | 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-, $-CH=CHCH_2O-$, |
| p | denotes 0, 1 or 2, |
| q | denotes 0 or 1, and |
| v | denotes 1 to 6. |

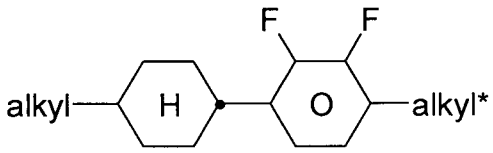
In the compounds of the formulae IIA and IIB, $Z^2$ may have identical or different meanings. In the compounds of the formula IIB, $Z^2$ and $Z^{2'}$ may have identical or different meanings.

In the compounds of the formulae IIA, IIB and IIC, $R^{2A}$, $R^{2B}$ and $R^{2C}$ each preferably denote alkyl having 1-6 C atoms, in particular $CH_3$, $C_2H_5$, n-$C_3H_7$, n-$C_4H_9$, n-$C_5H_{11}$.

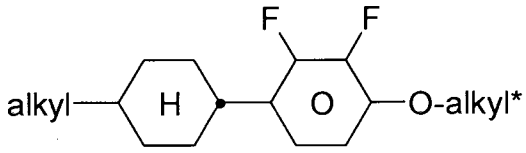
In the compounds of the formulae IIA and IIB, $L^1$, $L^2$, $L^3$ and $L^4$ preferably denote $L^1 = L^2 = F$ and $L^3 = L^4 = F$, furthermore $L^1 = F$ and $L^2 = Cl$, $L^1 = Cl$ and $L^2 = F$, $L^3 = F$ and $L^4 = Cl$, $L^3 = Cl$ and $L^4 = F$. $Z^2$ and $Z^{2'}$ in the formulae IIA and IIB preferably each, independently of one another, denote a single bond, furthermore a -$C_2H_4$- or -$CH_2O$- bridge.

If in the formula IIB $Z^2$ = -$C_2H_4$- or -$CH_2O$-, $Z^{2'}$ is preferably a single bond or, if $Z^{2'}$ = -$C_2H_4$- or -$CH_2O$-, $Z^2$ is preferably a single bond. In the compounds of the formulae IIA and IIB, (O)$C_vH_{2v+1}$ preferably denotes $OC_vH_{2v+1}$, furthermore $C_vH_{2v+1}$. In the compounds of the formula IIC, (O)$C_vH_{2v+1}$ preferably denotes $C_vH_{2v+1}$. In the compounds of the formula IIC, $L^3$ and $L^4$ preferably each denote F.

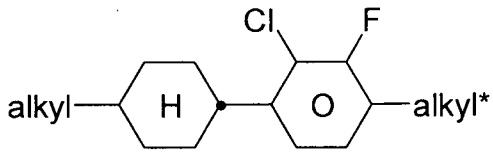
Preferred compounds of the formulae IIA, IIB and IIC are indicated below:



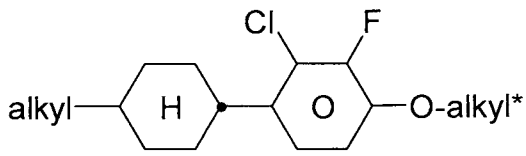

IIA-1



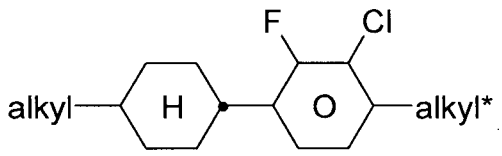

IIA-2



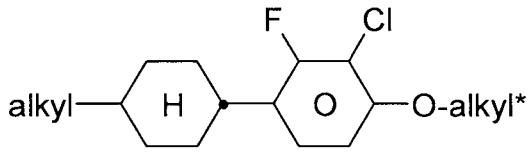

IIA-3



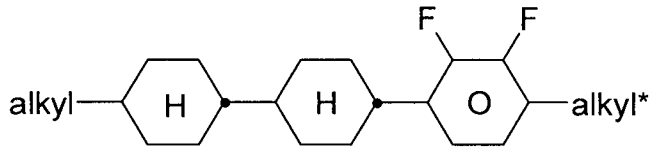

IIA-4



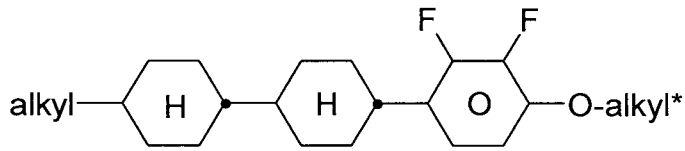

IIA-5



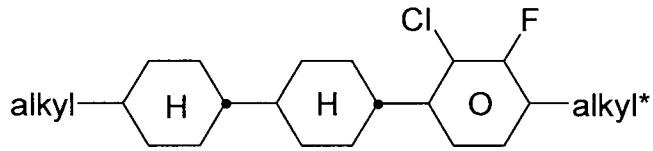

IIA-6



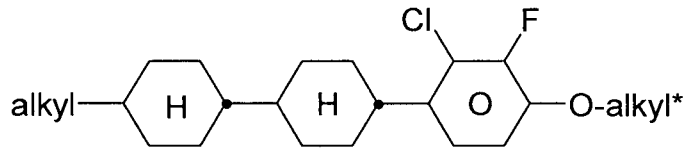

IIA-7



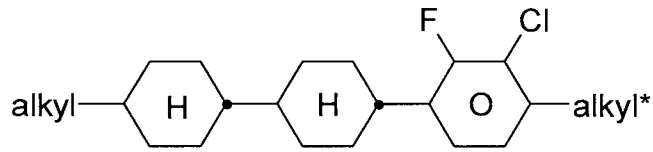

IIA-8



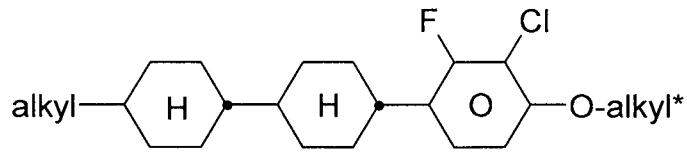

IIA-9



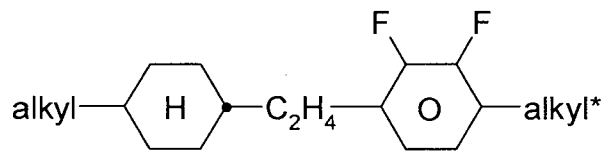

IIA-10



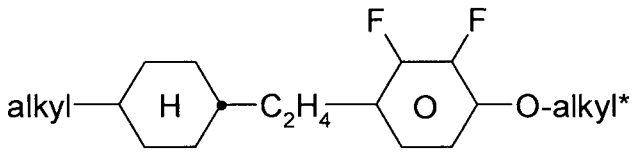

IIA-11



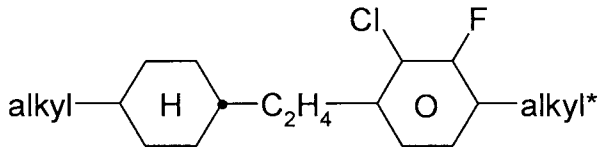

IIA-12



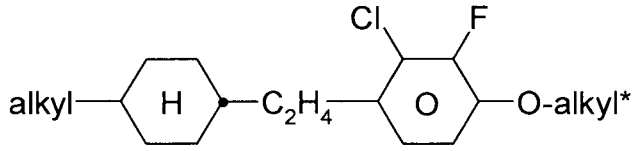

IIA-13



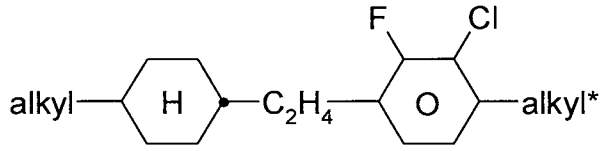

IIA-14



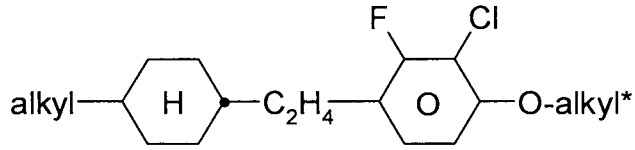

IIA-15



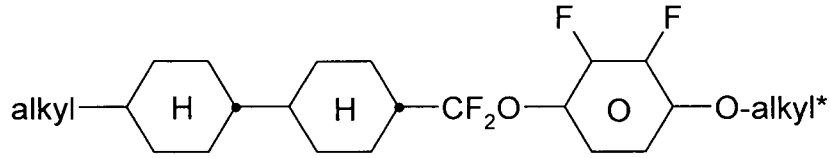

IIA-16



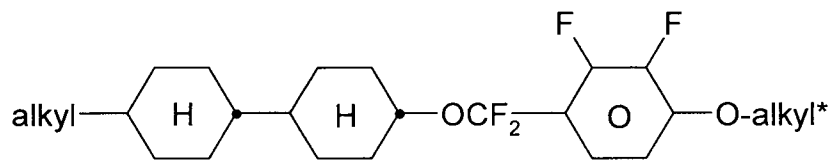

IIA-17



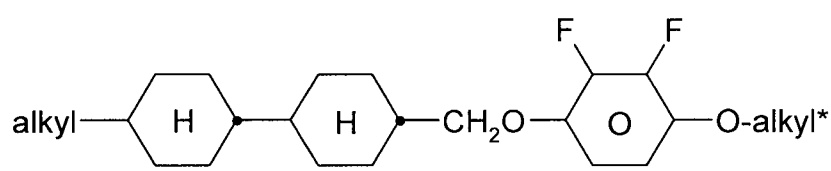

IIA-18



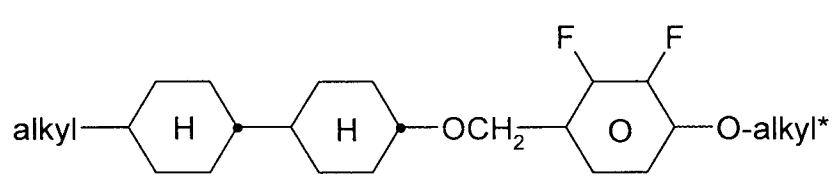

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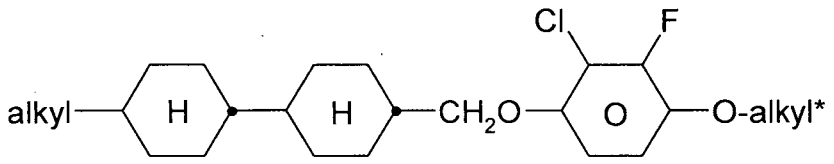

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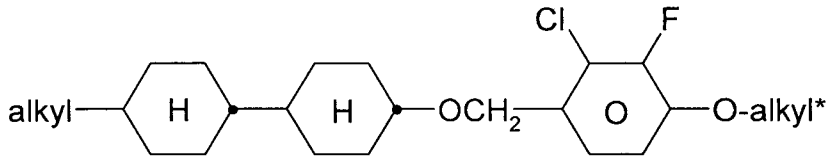

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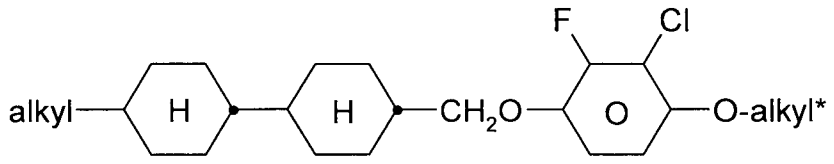

IIA-22



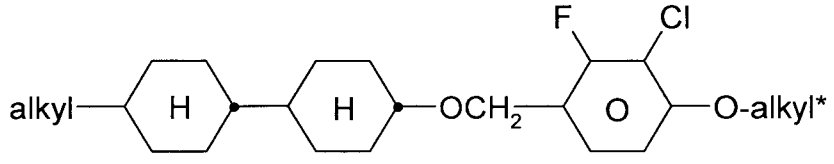

IIA-23



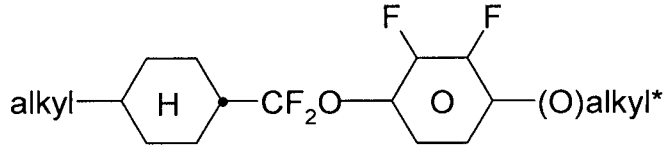

IIA-24



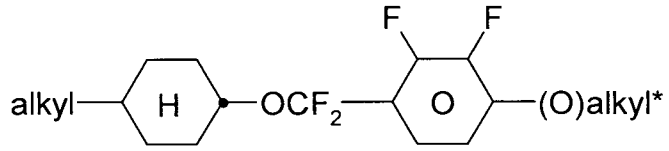

IIA-25



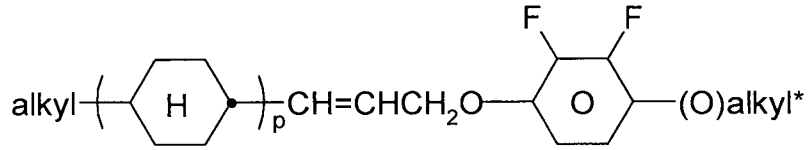

IIA-26



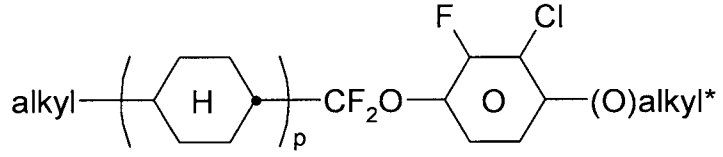

IIA-27



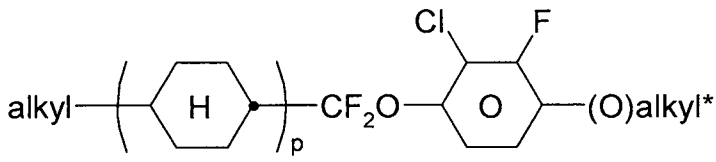

IIA-28



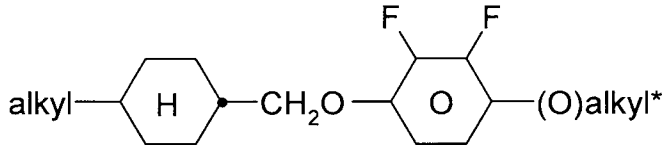

IIA-29



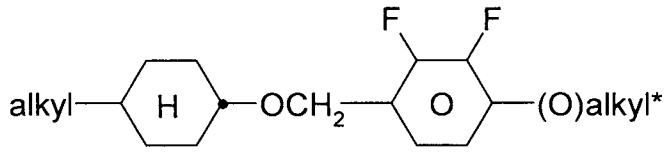

IIA-30



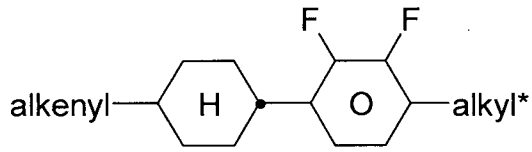

IIA-31



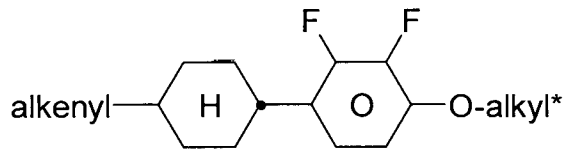

IIA-32



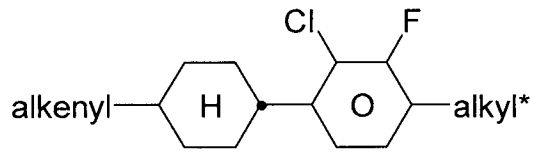

IIA-33



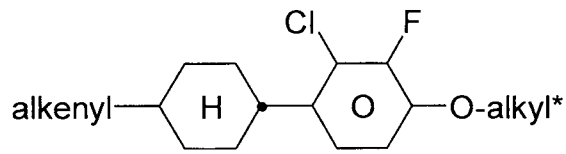

IIA-34



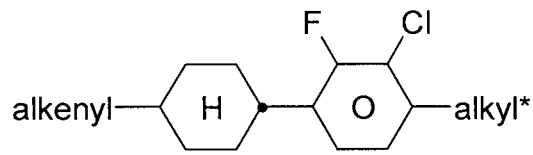

IIA-35



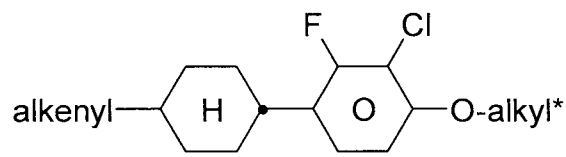

IIA-36



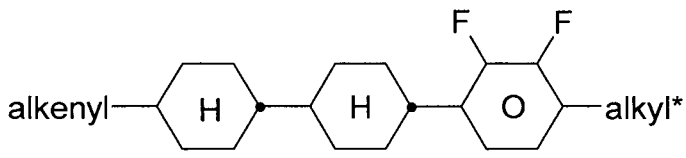

IIA-37



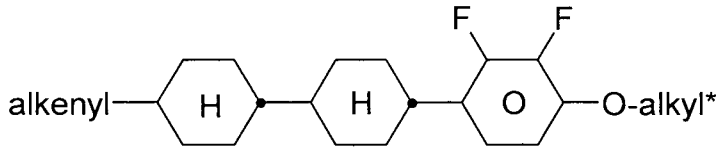

IIA-38



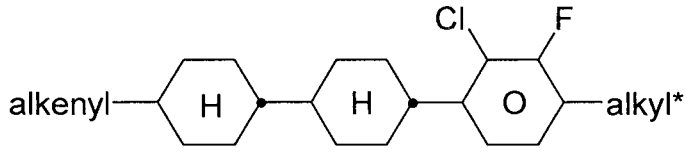

IIA-39



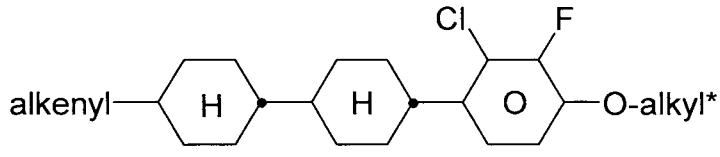

IIA-40



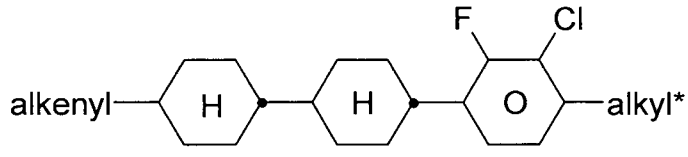

IIA-41



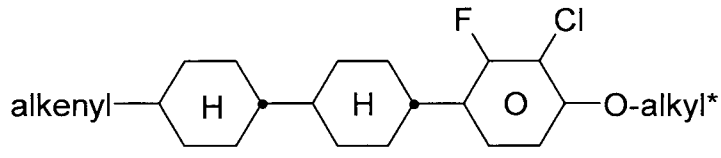

IIA-42



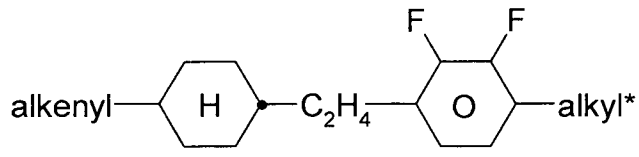

IIA-43



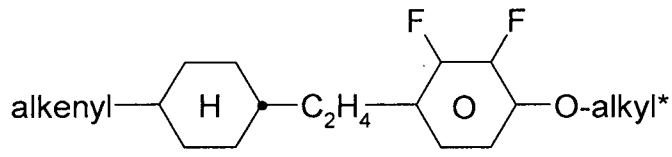

IIA-44



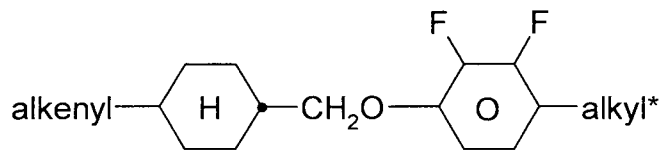

IIA-45



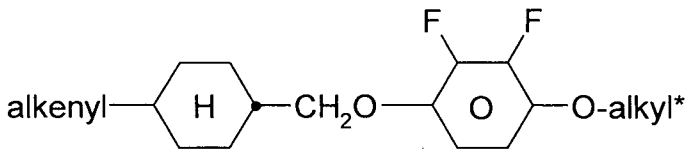

IIA-46



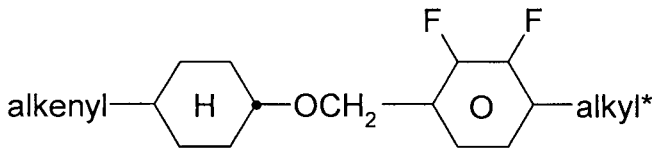

IIA-47



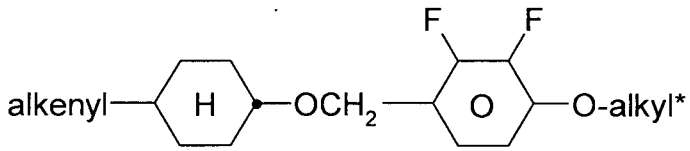

IIA-48



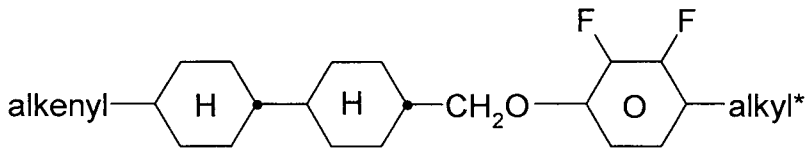

IIA-49



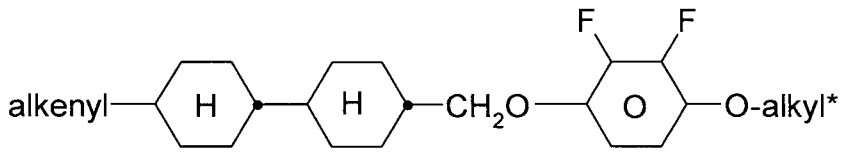

IIA-50



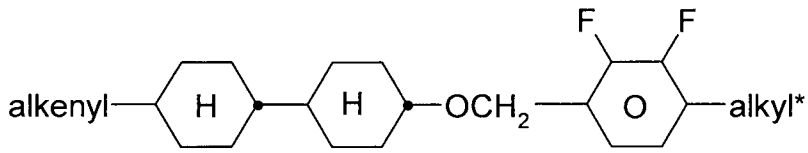

IIA-51



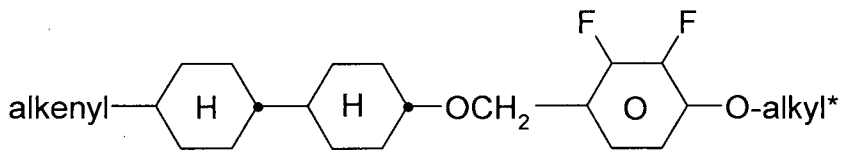

IIA-52



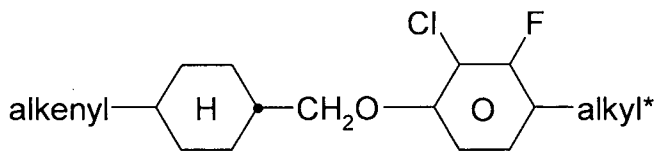

IIA-53



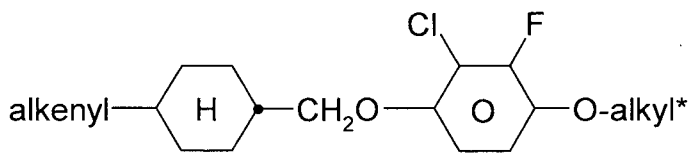

IIA-54



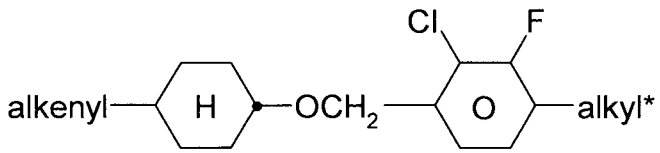

IIA-55



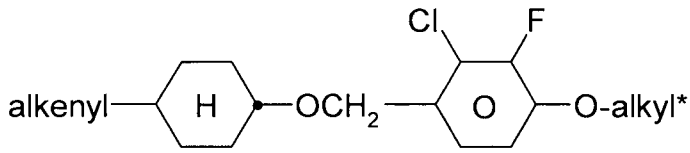

IIA-56



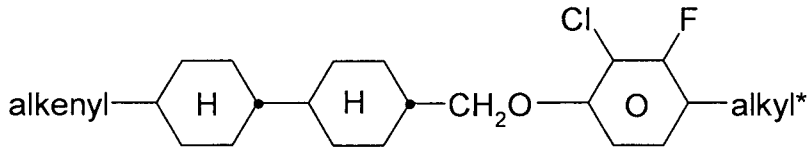

IIA-57



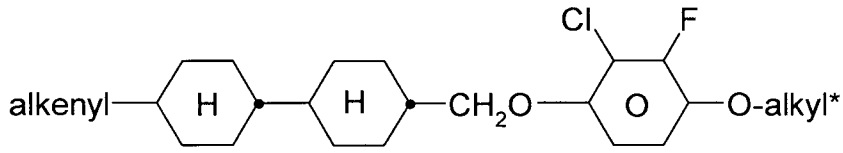

IIA-58



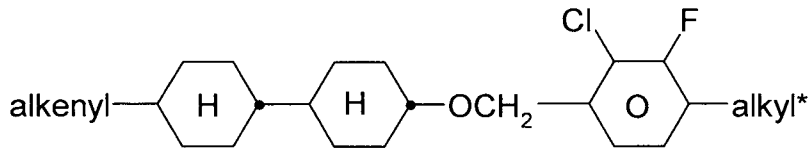

IIA-59



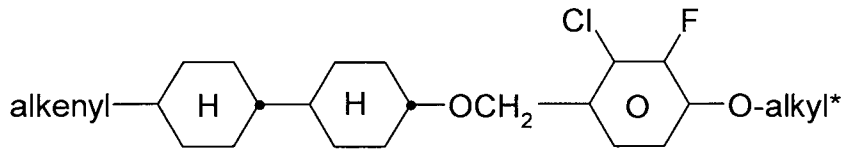

IIA-60



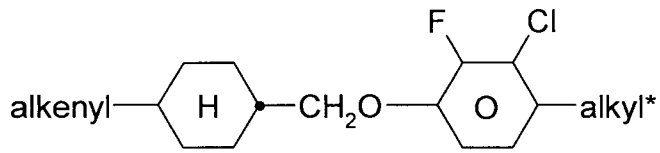

IIA-61



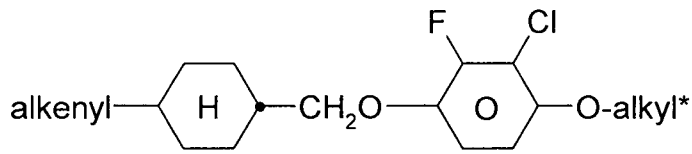

IIA-62



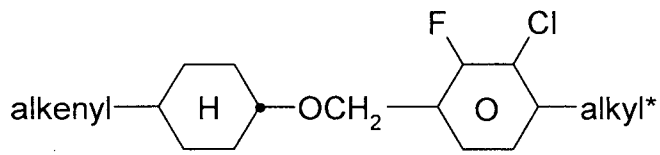

IIA-63



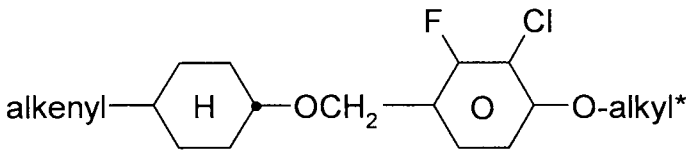

IIA-64



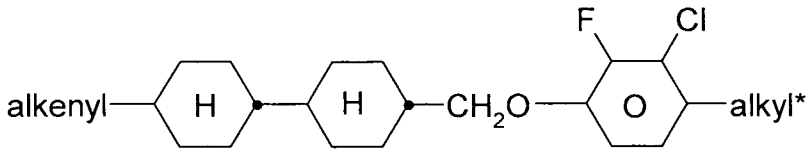

IIA-65



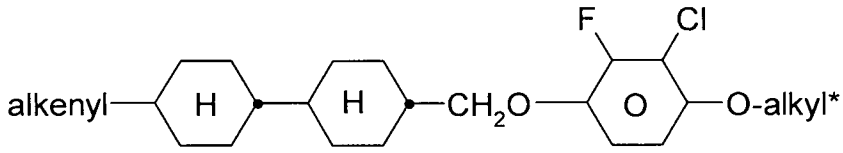

IIA-66



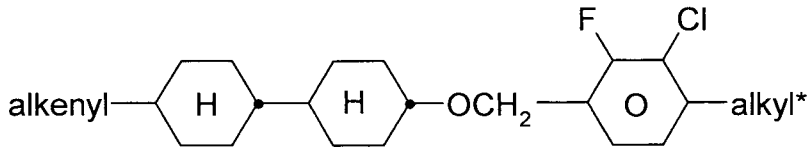

IIA-67



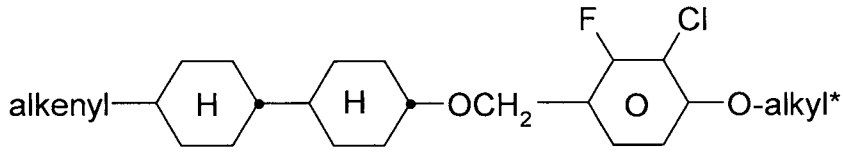

IIA-68



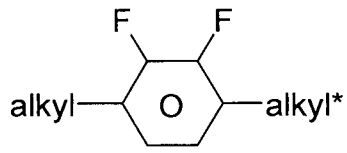

IIA-69



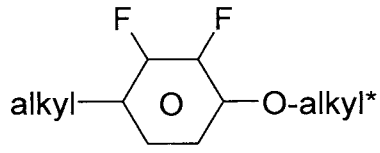

IIA-70



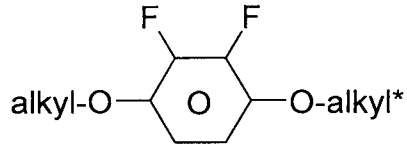

IIA-71



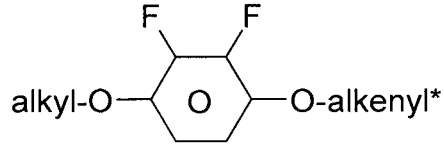

IIA-72



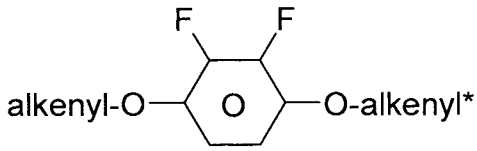

IIA-73



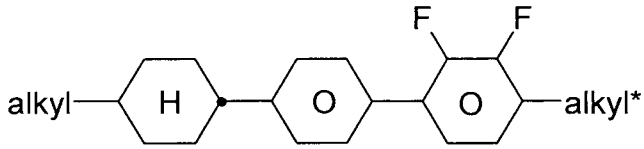

IIA-74



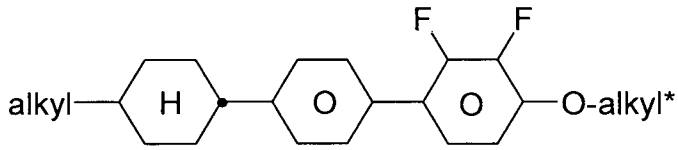

IIA-75



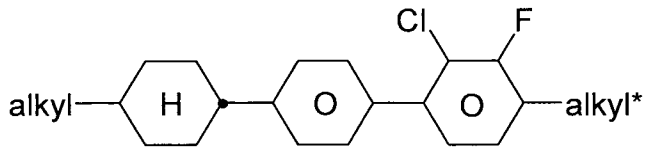

IIA-76



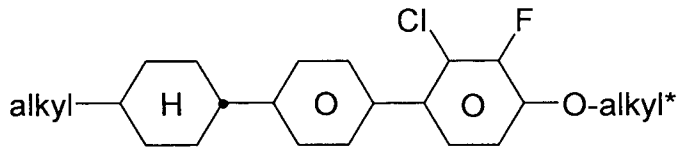

IIB-1



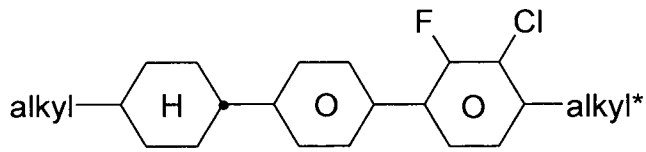

IIB-2



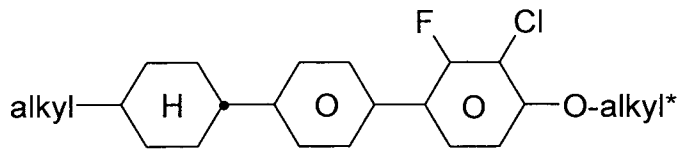

IIB-3



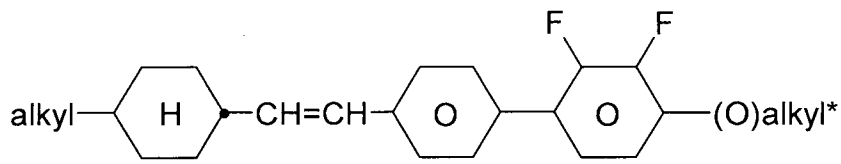

IIB-4



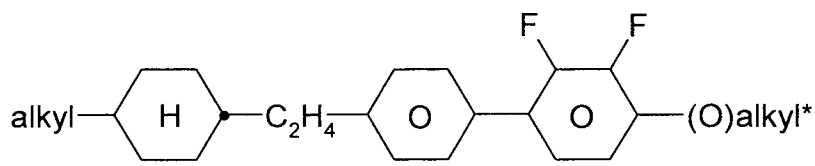

IIB-5



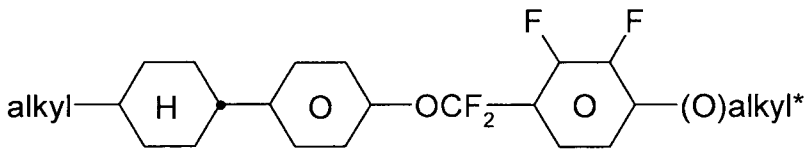

IIB-6



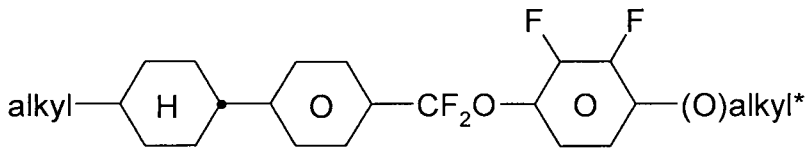

IIB-7



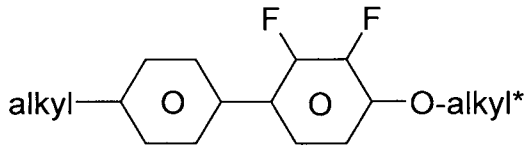

IIB-8



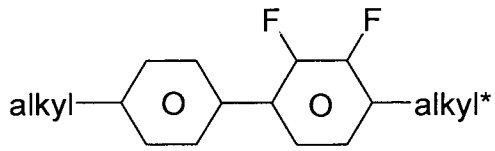

IIB-9



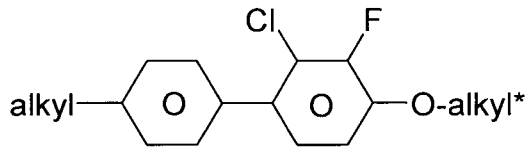

IIB-10



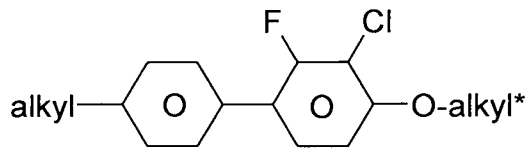

IIB-11



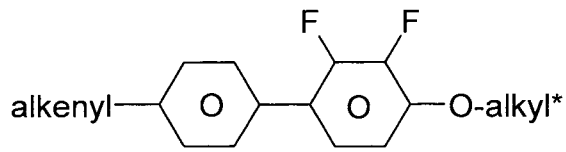

IIB-12



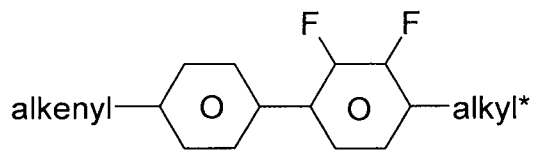

IIB-13



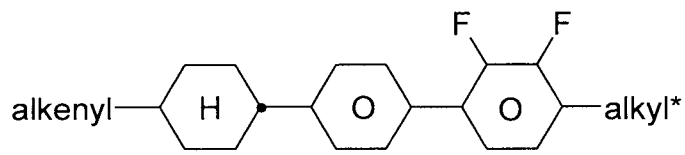

IIB-14



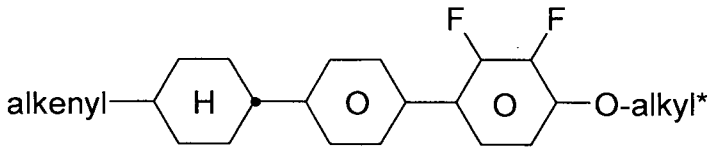

IIB-15



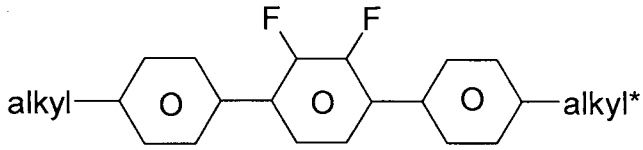

IIB-16




IIB-17




IIB-18



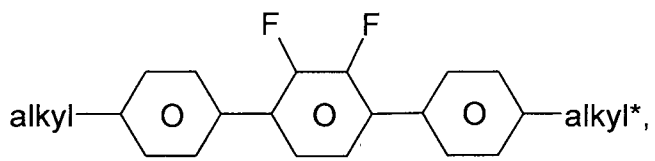

IIC-1,

in which alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms and in which alkenyl and alkenyl* each, independently of one another, denote a straight-chain alkenyl radical having 2-6 C atoms.

Particularly preferred mixtures according to the invention comprise one or more compounds of the formulae IIA-2, IIA-8, IIA-14, IIA-29, IIA-35, IIA-74, IIB-2, IIB-11, IIB-16 and IIC-1.

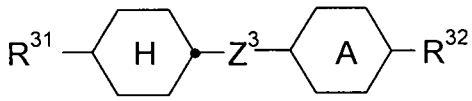
The proportion of compounds of the formulae IIA and/or IIB in the mixture as a whole is preferably at least 10 % by weight.

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




in which alkyl and alkyl* have the meanings indicated above, preferably in amounts of ≥ 3 % by weight, in particular ≥ 5 % by weight and particularly preferably 5-25 % by weight.

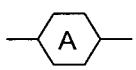
b) Liquid-crystalline medium which additionally comprises one or more compounds of the formula III,

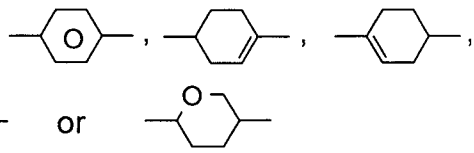



III

in which

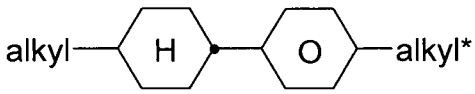
$R^{31}$ and $R^{32}$ each, independently of one another, denote a straight-chain alkyl, alkoxyalkyl, alkenyl or alkoxy radical having up to 12 C atoms, and



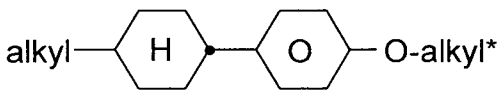

denotes 


$Z^3$ denotes a single bond, $-CH_2CH_2-$, $-CH=CH-$, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-COO-$, $-OCO-$, $-C_2F_4-$, $-C_4H_8-$, $-CF=CF-$.

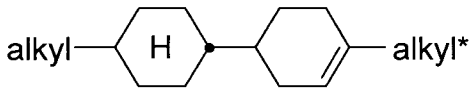
Preferred compounds of the formula III are indicated below:



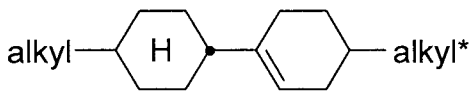

IIIa




IIIb




IIIc




IIId

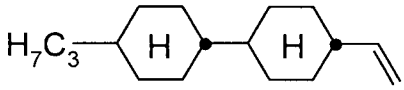
in which

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

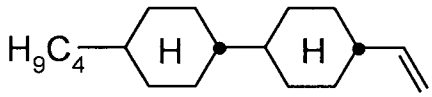
The medium according to the invention preferably comprises at least one compound of the formula IIIa and/or formula IIIb.

The proportion of compounds of the formula III in the mixture as a whole is preferably at least 5% by weight.

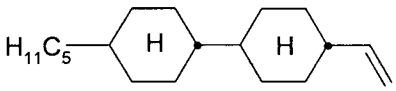
c) Liquid-crystalline medium additionally comprising a compound of the formula



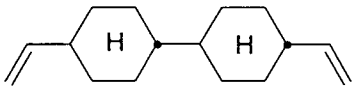

and / or



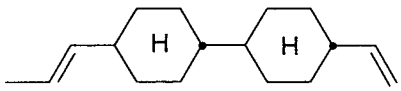

and / or



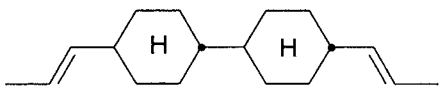

and / or




and / or



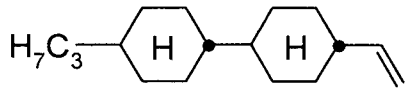

and / or



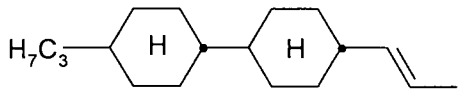

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preferably in total amounts of ≥ 5% by weight, in particular ≥ 10% by weight.

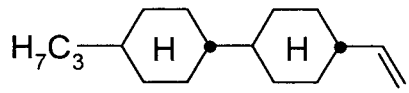
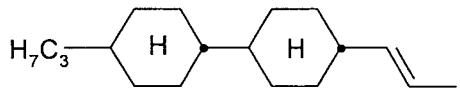
Preference is given to mixtures according to the invention comprising the compound



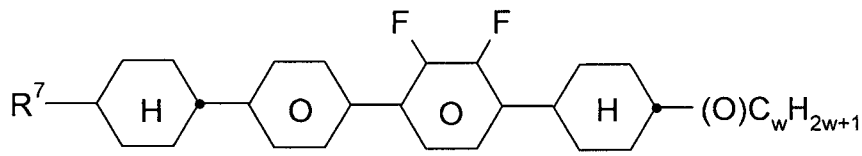
Preference is furthermore given to mixtures according to the invention comprising the compound

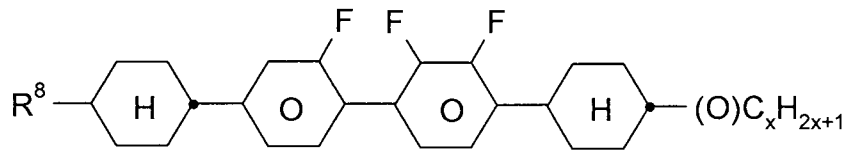


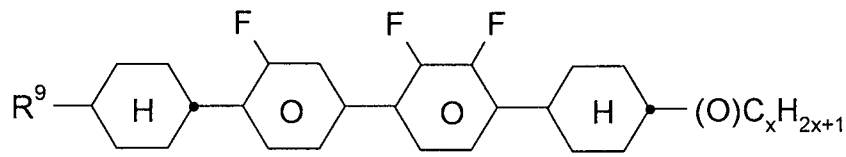
or

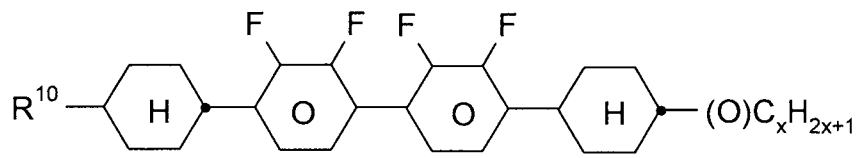

and

.

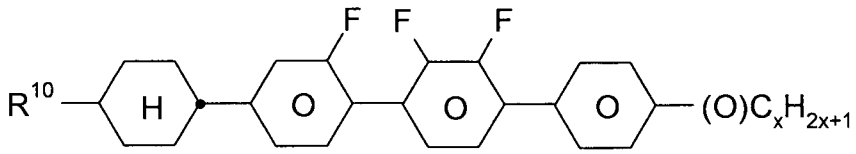
d) Liquid-crystalline medium which additionally comprises one or more tetracyclic compounds of the formulae


V-1

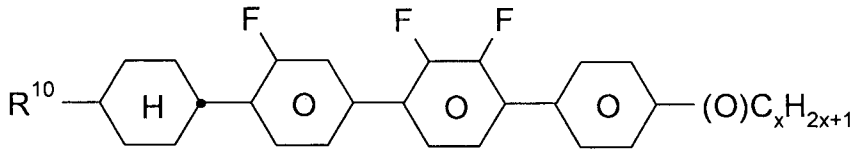

V-2


V-3

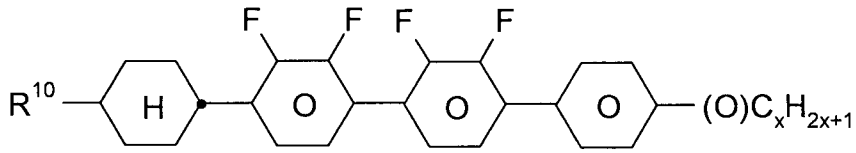

V-4



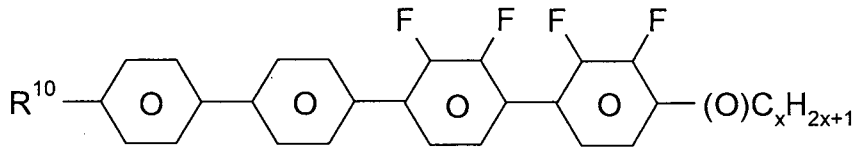
V-5



V-6



V-7



V-8

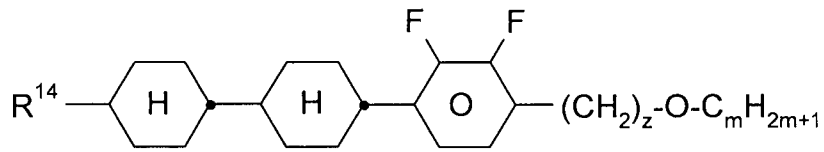
in which

$R^{7-10}$ each, independently of one another, have one of the meanings indicated for $R^{2A}$ in Claim 10, and

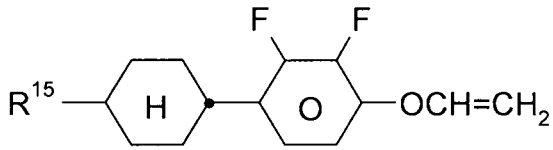
w and x each, independently of one another, denote 1 to 6.

Particular preference is given to mixtures comprising at least one compound of the formula V-8.

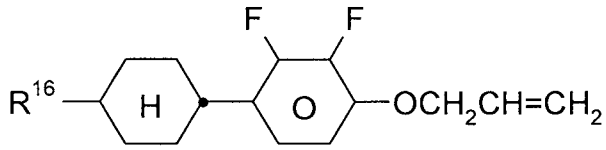
e) Liquid-crystalline medium which additionally comprises one or more compounds of the formulae Y-1 to Y-6,



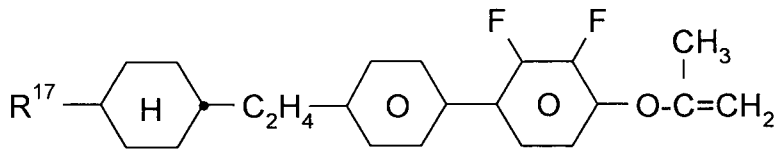
Y-1



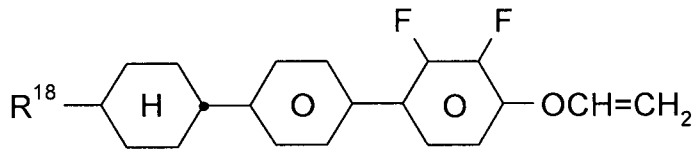

Y-2



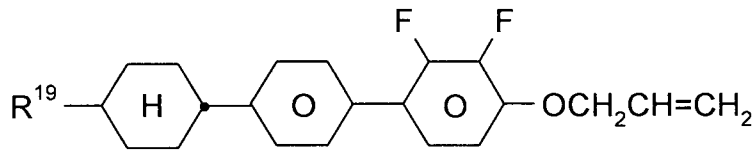

Y-3




Y-4




Y-5

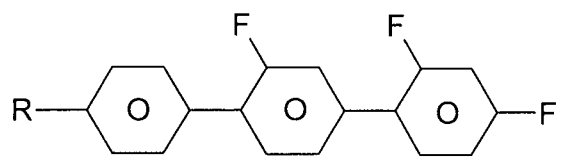



Y-6

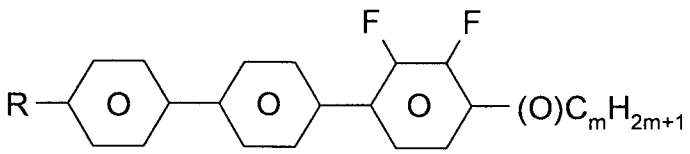
in which $R^{14}$-$R^{19}$ each, independently of one another, denote an alkyl or alkoxy radical having 1-6 C atoms; z and m each, independently of one another, denote 1-6; x denotes 0, 1, 2 or 3.

The medium according to the invention particularly preferably comprises one or more compounds of the formulae Y-1 to Y-6, preferably in amounts of ≥ 5% by weight.

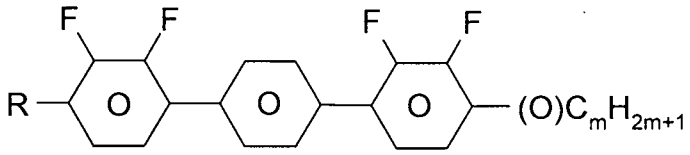
f) Liquid-crystalline medium additionally comprising one or more fluorinated terphenyls of the formulae T-1 to T-21,



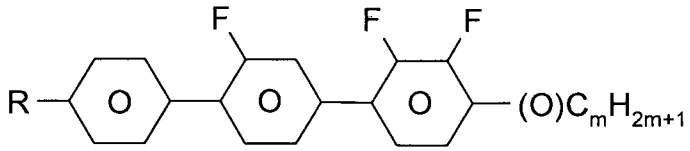

T-1



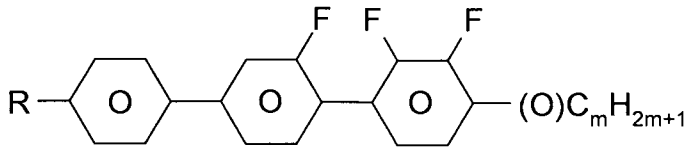

T-2



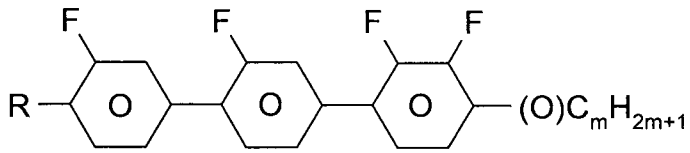

T-3



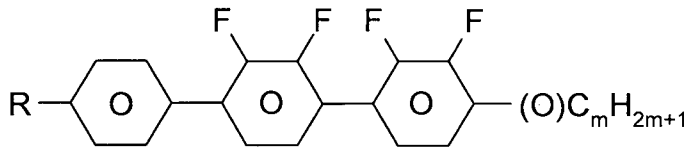

T-4



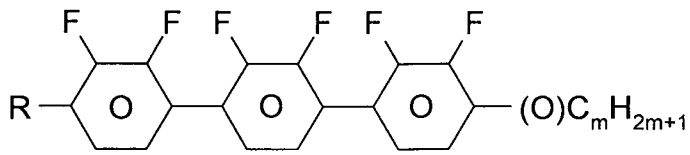

T-5



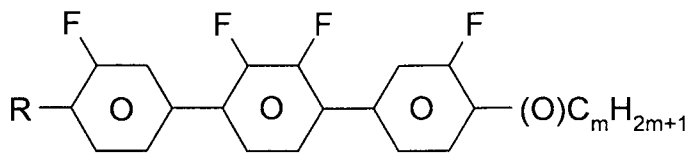

T-6



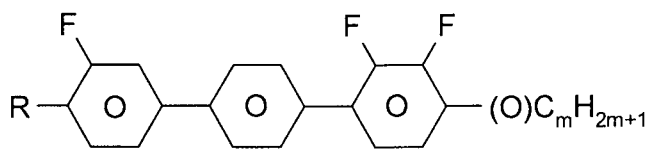

T-7



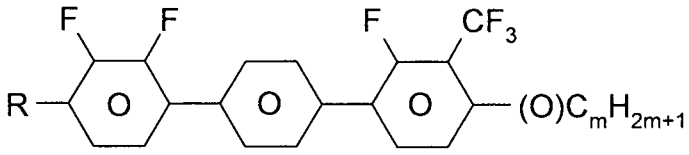

T-8



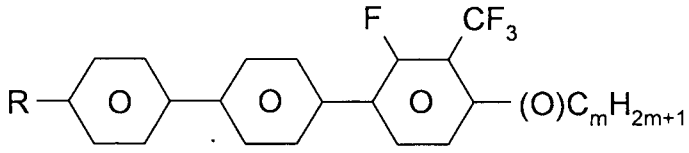

T-9



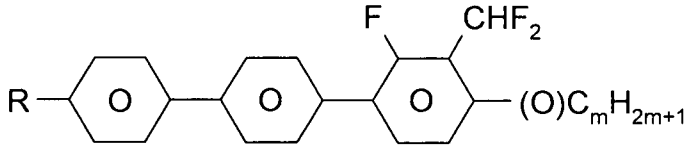

T-10



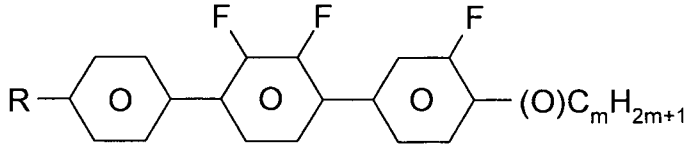

T-11



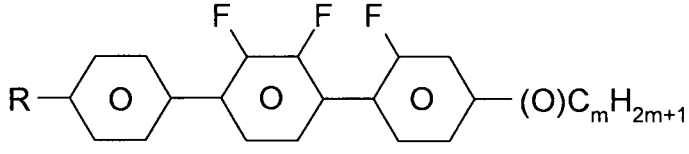

T-12



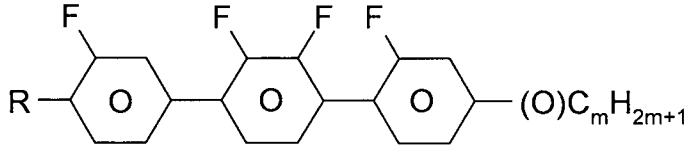

T-13



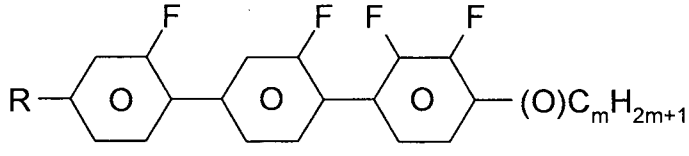

T-14



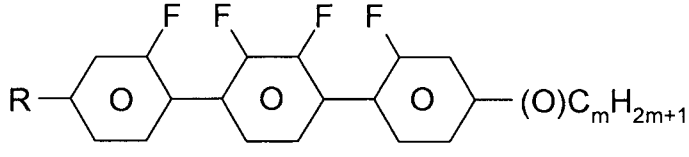

T-15



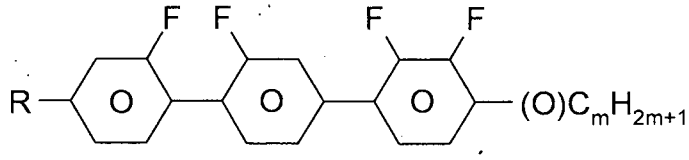

T-16



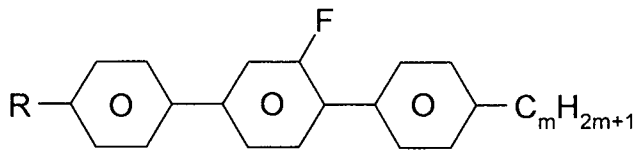

T-17



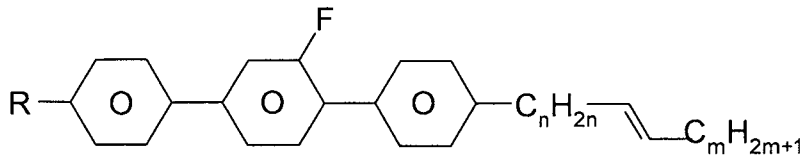

T-18




T-19




T-20




T-21

in which

R denotes a straight-chain alkyl or alkoxy radical having 1-7 C atoms, and m = 0, 1, 2, 3, 4, 5 or 6 and n denotes 0, 1, 2, 3 or 4.

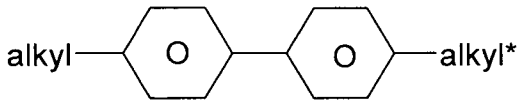
R preferably denotes methyl, ethyl, propyl, butyl, pentyl, hexyl, methoxy, ethoxy, propoxy, butoxy, pentoxy.

The medium according to the invention preferably comprises the terphenyls of the formulae T-1 to T-21 in amounts of 2-30 % by weight, in particular 5-20 % by weight.

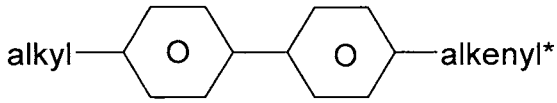
Particular preference is given to compounds of the formulae T-1, T-2, T-20 and T-21. In these compounds, R preferably denotes alkyl, furthermore alkoxy, each having 1-5 C atoms. In the compounds of the formula T-20, R preferably denotes alkyl or alkenyl, in particular alkyl. In the compound of the formula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

The terphenyls are preferably employed in the mixtures according to the invention if the $\Delta n$ value of the mixture is to be $\geq 0.1$. Preferred mixtures comprise 2-20 % by weight of one or more terphenyl compounds selected from the group of the compounds T-1 to T-21.

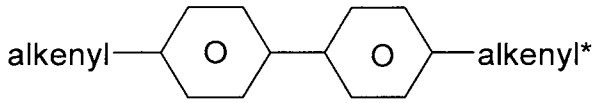
g) Liquid-crystalline medium additionally comprising one or more biphenyls of the formulae B-1 to B-3,




B-1




B-2




B-3

in which

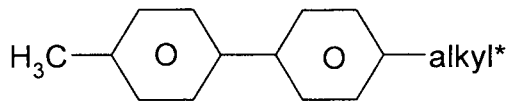
alkyl and alkyl* each, independently of one another, denote a straight-chain alkyl radical having 1-6 C atoms, and

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

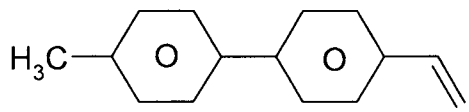
The proportion of the biphenyls of the formulae B-1 to B-3 in the mixture as a whole is preferably at least 3% by weight, in particular ≥ 5% by weight.

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

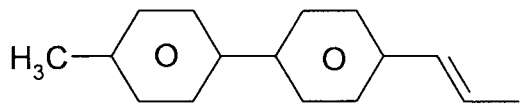
Particularly preferred biphenyls are



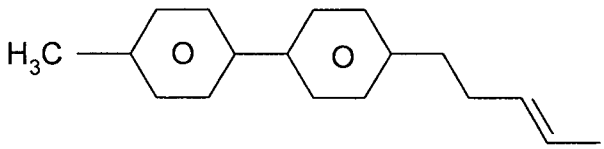

B-1a




B-2a



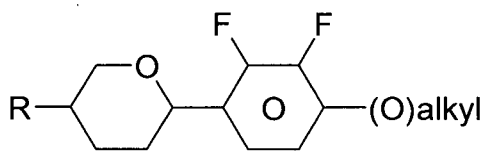

B-2b



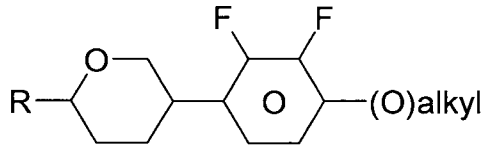
B-2c,

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

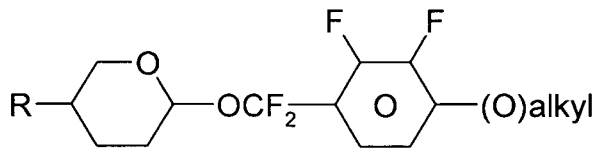
h) Liquid-crystalline medium comprising at least one compound of the formulae Z-1 to Z-7,



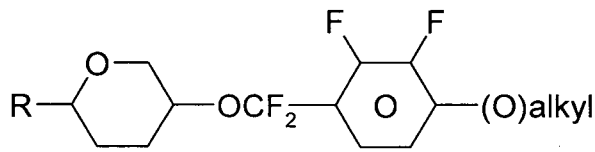
Z-1



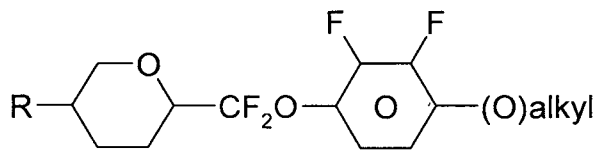
Z-2



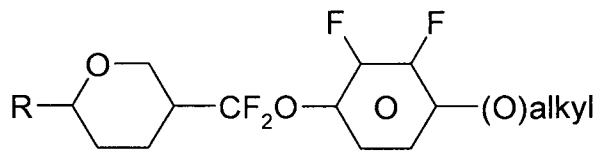
Z-3



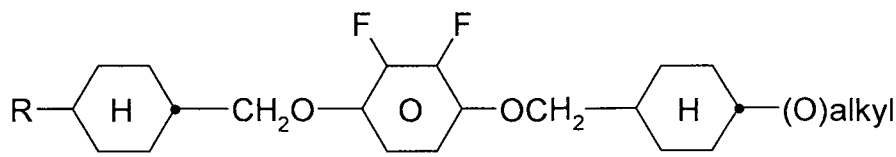
Z-4



Z-5



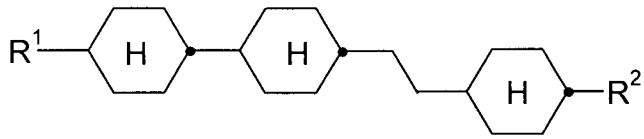
Z-6



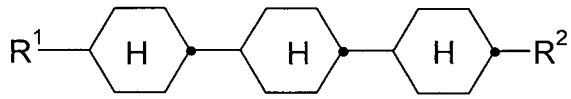
Z-7

in which R and alkyl have the meanings indicated above.

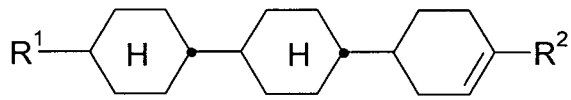
i) Liquid-crystalline medium comprising at least one compound of the formulae O-1 to O-11,



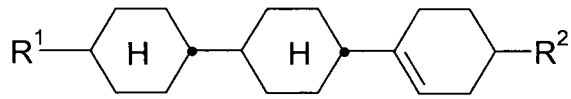

O-1



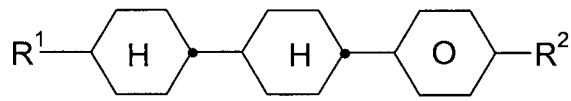

O-2



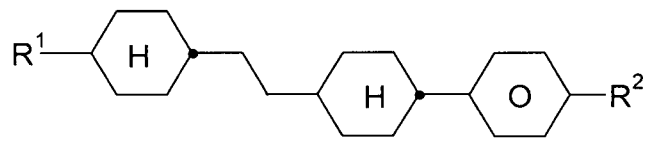

O-3



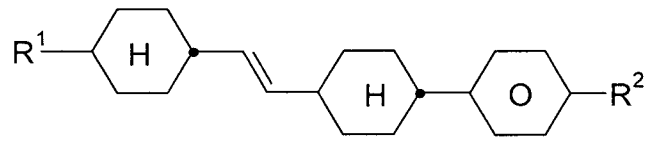

O-4



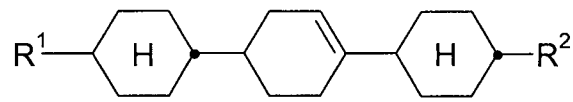

O-5



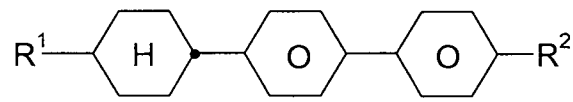

O-6



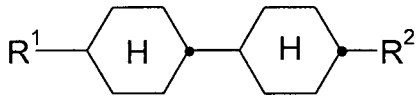

O-7



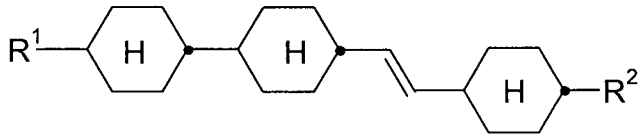

O-8




O-9



O-10

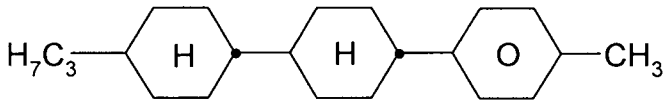


O-11

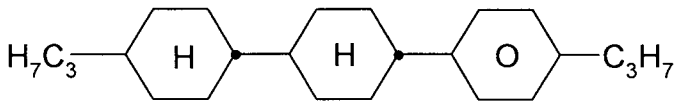
in which $R^1$ and $R^2$ have the meanings indicated for $R^{2A}$. $R^1$ and $R^2$ preferably each, independently of one another, denote straight-chain alkyl or Alkenyl having up to 6 carbon atoms.

Mixtures according to the invention very particularly preferably comprise the compounds of the formula O-5, O-7, O-9, O-10 and/or O-11, in particular in amounts of 5-30 %.

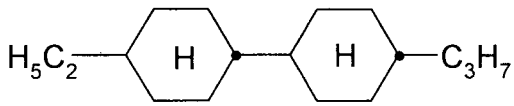
Preferred compounds of the formulae O-5 and O-10 are indicated below:



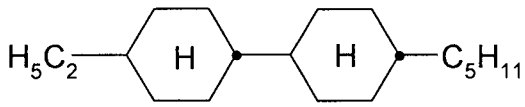
O-5a



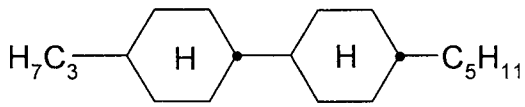
O-5b



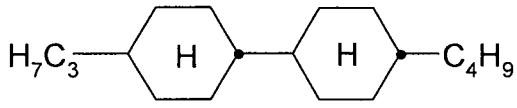
O-10a



O-10b



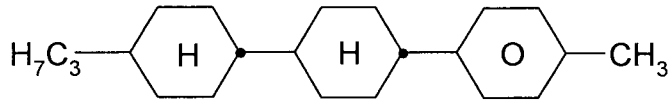
O-10c



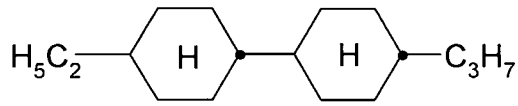

O-10d.

The medium according to the invention particularly preferably comprises the tricyclic compounds of the formula O-10a and/or of the formula O-10b in combination with one or more bicyclic compounds of the formulae O-10a to O-10d. The total proportion of the compounds of the formulae O-5a and/or O-5b in combination with one or more compounds selected from the bicyclic compounds of the formulae O-10a to O-10d is 5-40 %, very particularly preferably 15-35 %.

Very particularly preferred mixtures comprise compounds O-5a and O-10a:



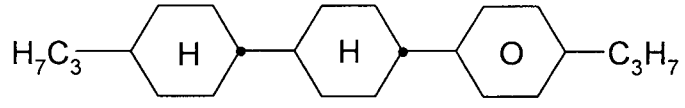

O-5a



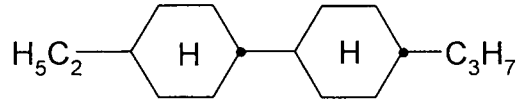

O-10a.

Compounds O-5a and O-10a are preferably present in the mixture in a concentration of 15-35 %, particularly preferably 15-25 % and especially preferably 18-22 %, based on the mixture as a whole.

Very particularly preferred mixtures comprise compounds O-5b and O-10a:



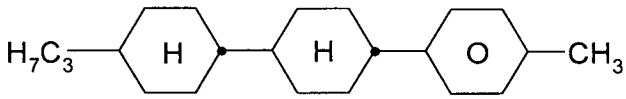

O-5b



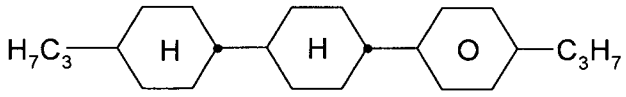

O-10a.

Compounds O-5b and O-10a are preferably present in the mixture in a concentration of 15-35 %, particularly preferably 15-25 % and especially preferably 18-22 %, based on the mixture as a whole.

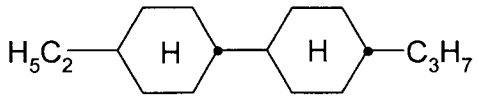
Very particularly preferred mixtures comprise the following three compounds:



O-5a



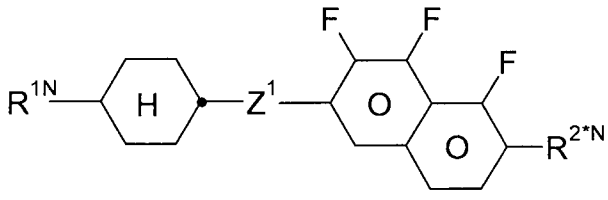
O-5b



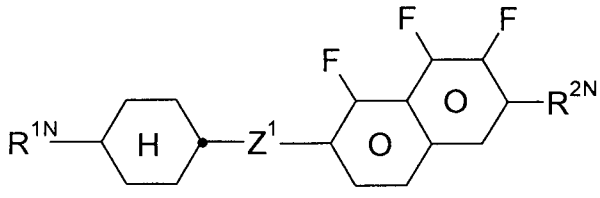
O-10a.

Compounds O-5a, O-5b and O-10a are preferably present in the mixture in a concentration of 15-35 %, particularly preferably 15-25 % and especially preferably 18-22 %, based on the mixture as a whole.

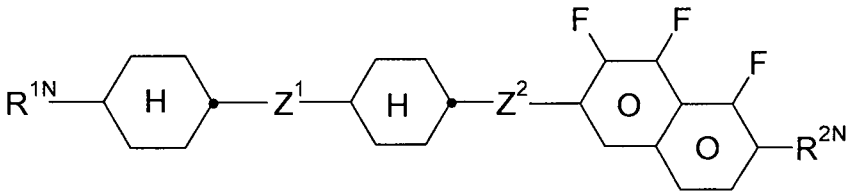
j) Preferred liquid-crystalline media according to the invention comprise one or more substances which contain a tetrahydronaphthyl or naphthyl unit, such as, for example, the compounds of the formulae N-1 to N-5,

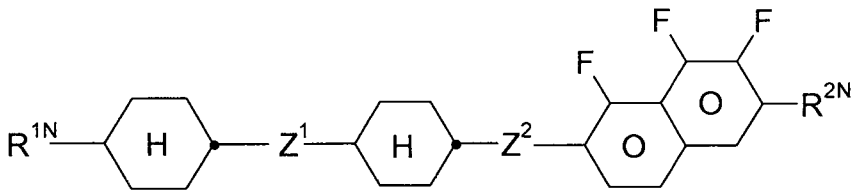


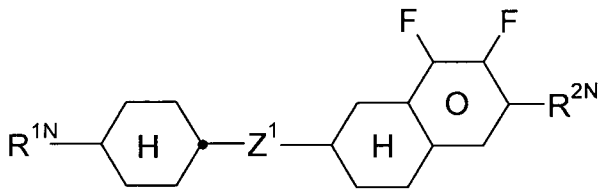
N-1



N-2


N-3

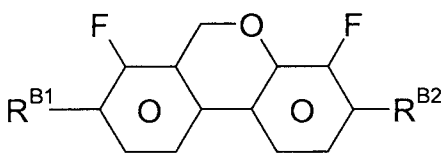

N-4

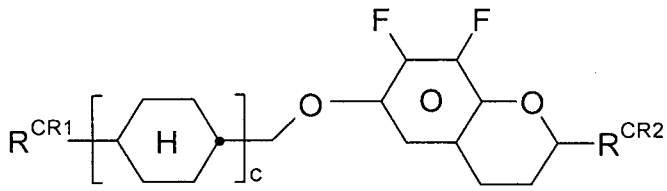

N-5

in which $R^{1N}$ and $R^{2N}$ each, independently of one another, have the meanings indicated for $R^{2A}$ in Claim 10, preferably denote straight-chain alkyl, straight-chain alkoxy or straight-chain alkenyl, and

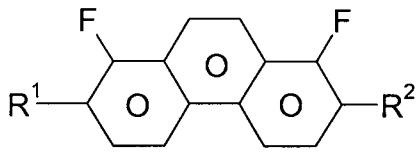
$Z^1$ and $Z^2$ each, independently of one another, denote $-C_2H_4-$, $-CH=CH-$, $-(CH_2)_4-$, $-(CH_2)_3O-$, $-O(CH_2)_3-$, $-CH=CHCH_2CH_2-$, $-CH_2CH_2CH=CH-$, $-CH_2O-$, $-OCH_2-$, $-COO-$, $-OCO-$, $-C_2F_4-$, $-CF=CF-$, $-CF=CH-$, $-CH=CF-$, $-CF_2O-$, $-OCF_2-$, $-CH_2-$ or a single bond.

k) Preferred mixtures comprise one or more compounds selected from the group of the difluorodibenzochromane compounds of the formula BC, chromans of the formula CR, fluorinated phenanthrenes of the formulae PH-1 and PH-2, fluorinated dibenzofurans of the formula BF-1 and BF-2 and fluorinated dibenzothiophene compounds of the formula BS-1 and BS-2,

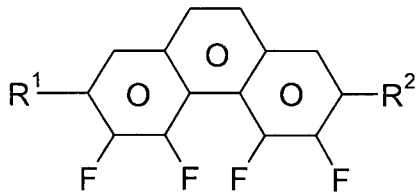

BC



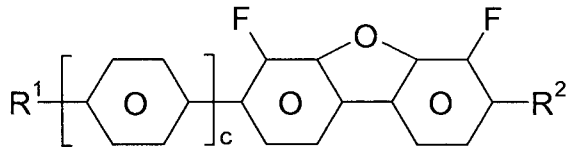
CR



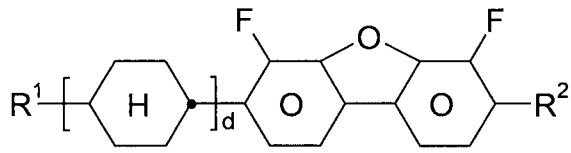
PH-1



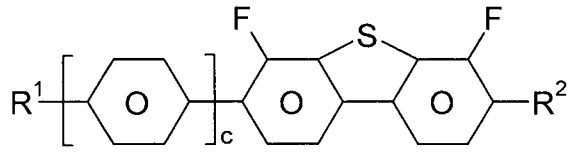
PH-2



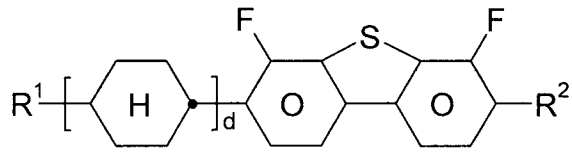
BF-1



BF-2



BS-1



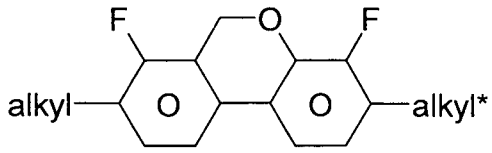
BS-2

in which

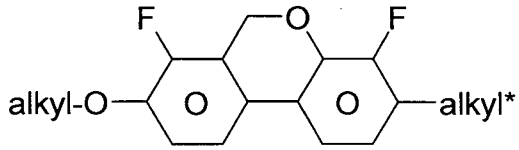
$R^{B1}$, $R^{B2}$, $R^{CR1}$, $R^{CR2}$, $R^1$, $R^2$ each, independently of one another, have the meaning of $R^{2A}$. c denotes 0, 1 or 2 and d denotes 1 or 2.

The mixtures according to the invention preferably comprise the compounds of the formulae BC, CR, PH-1, PH-2, BF-1, BF-2, BS-1 and/or BS-2 in amounts of 3 to 20 % by weight, in particular in amounts of 3 to 15 % by weight.

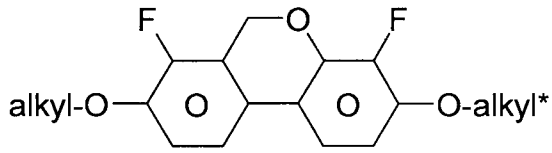
Particularly preferred compounds of the formulae BC, CR, BF-1 are the compounds BC-1 to BC-7 and CR-1 to CR-5,



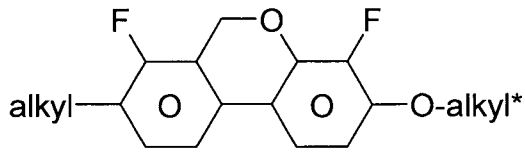

BC-1



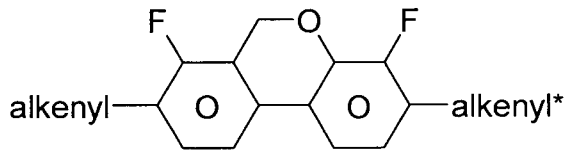

BC-2



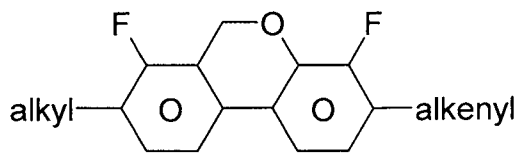

BC-3



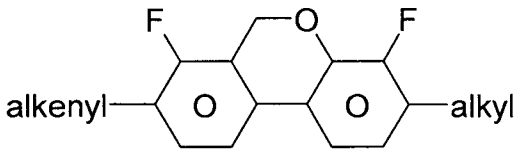

BC-4



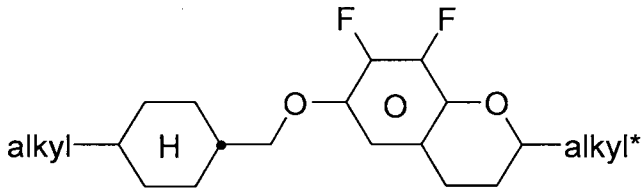

BC-5



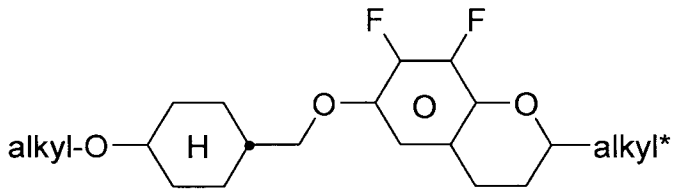

BC-6



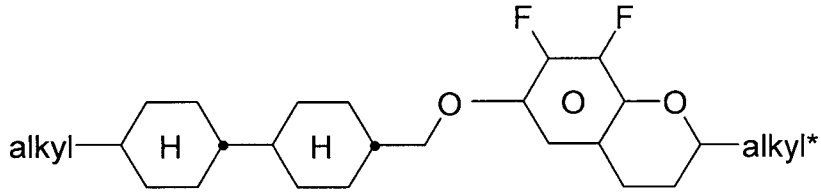

BC-7



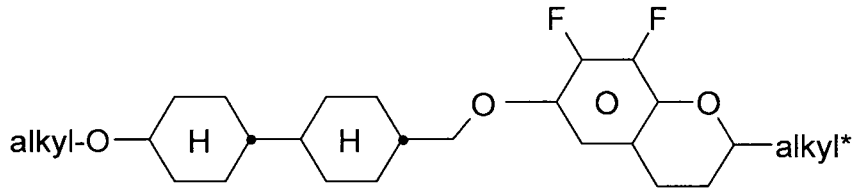

CR-1



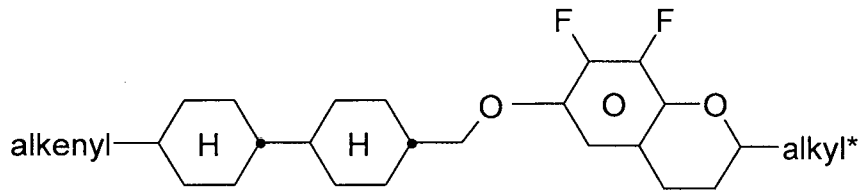

CR-2



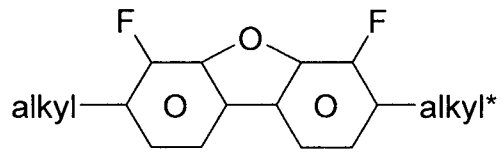

CR-3



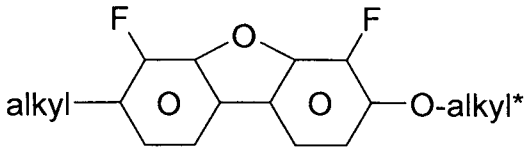

CR-4



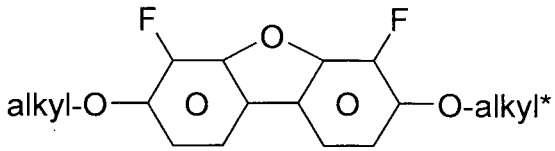

CR-5



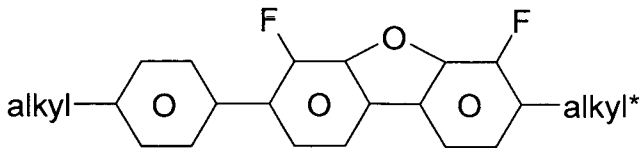

BF-1a



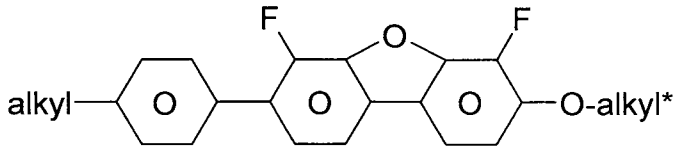

BF-1b



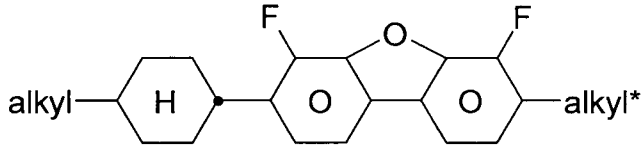

BF-1c



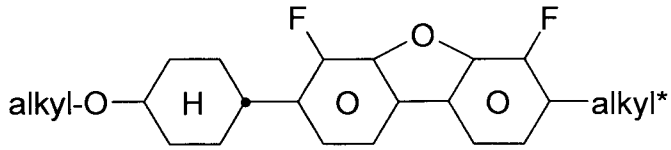

BF-1d



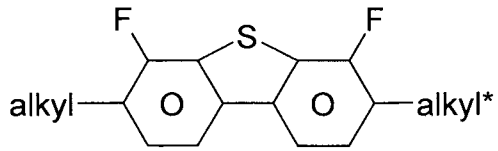

BF-1e



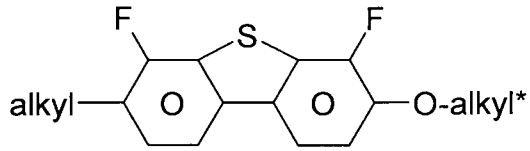

BF-1f



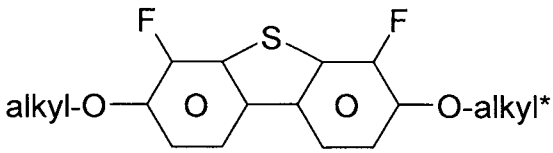

BF-1g



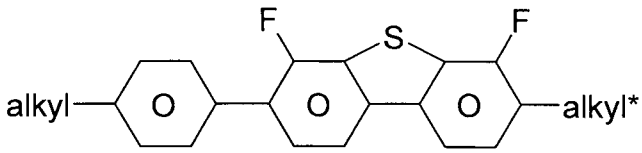

BS-1a



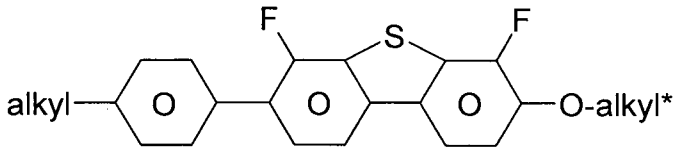

BS-1b



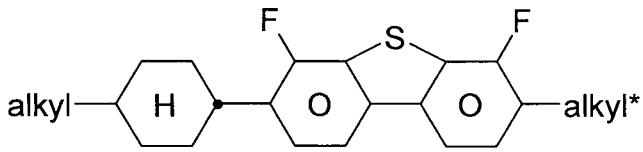

BS-1c



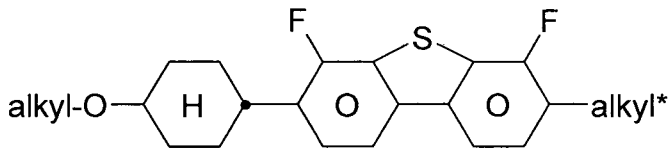

BS-1d




BS-1e




BS-1f



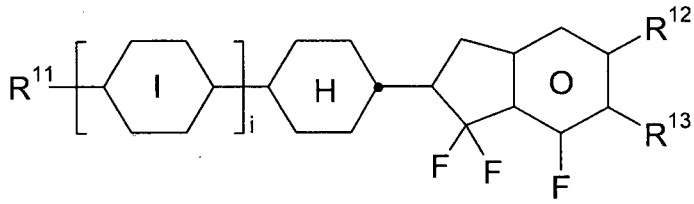

BS-1g

in which

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

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

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



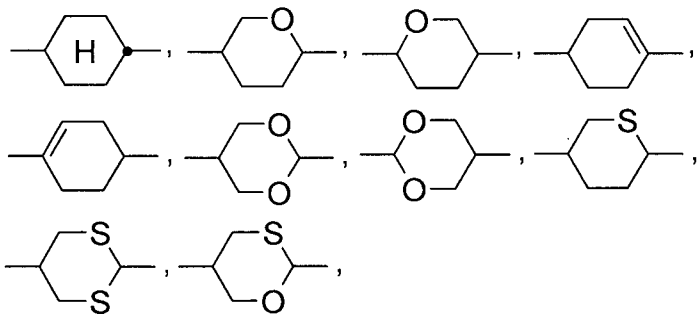
In

in which

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

$R^{12}$ and $R^{13}$ additionally denote H or halogen,

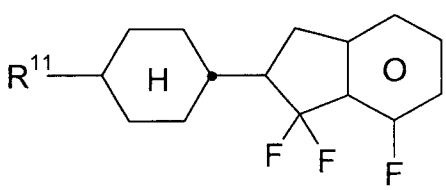
 denotes



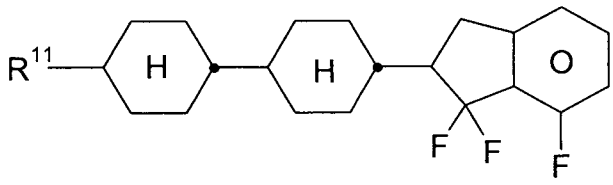
i denotes 0, 1 or 2.

In the case that $R^{12}$ and/or $R^{13}$ denote halogen, halogen is preferably F.

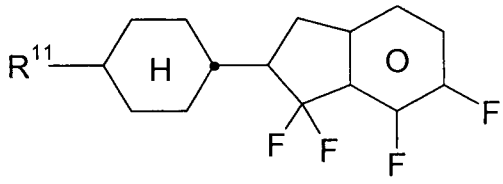
Preferred compounds of the formula In are the compounds of the formulae In-1 to In-16 indicated below:



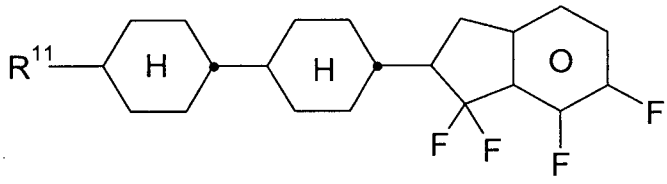
In-1



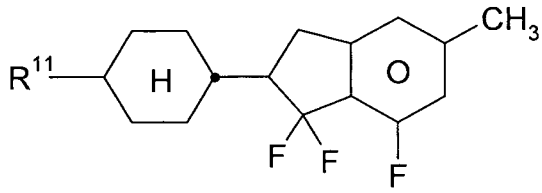
In-2



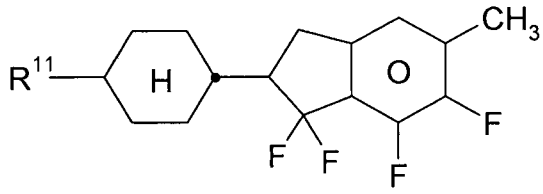
In-3



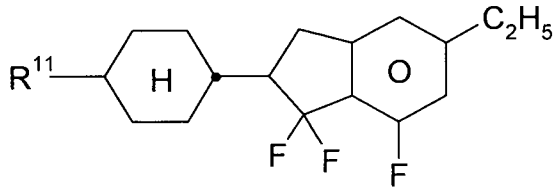
In-4



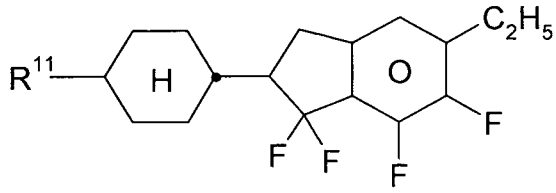
In-5



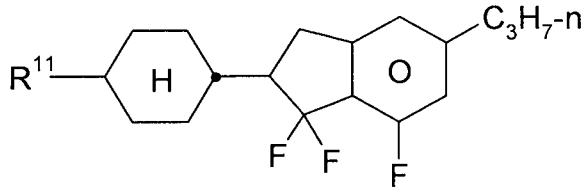
In-6



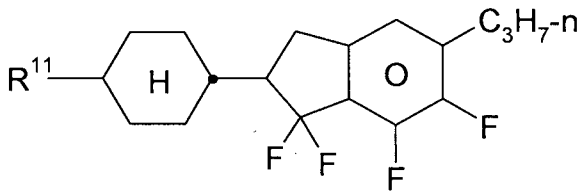
In-7



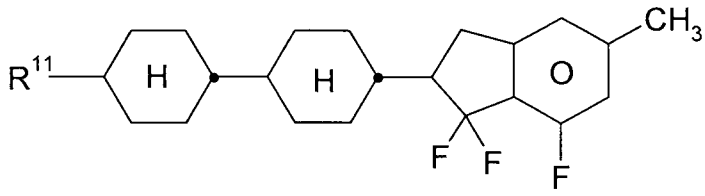
In-8



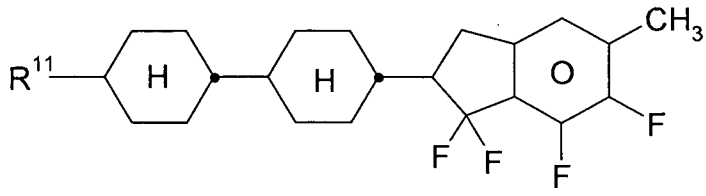
In-9



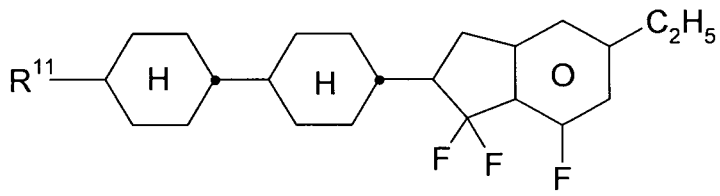

In-10



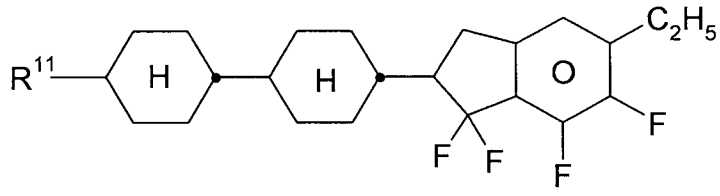

In-11



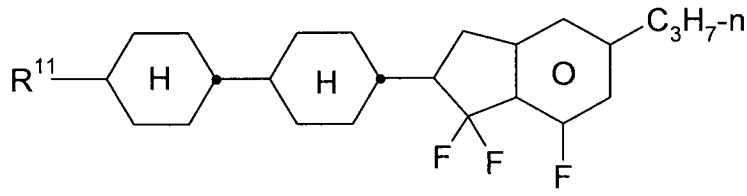

In-12



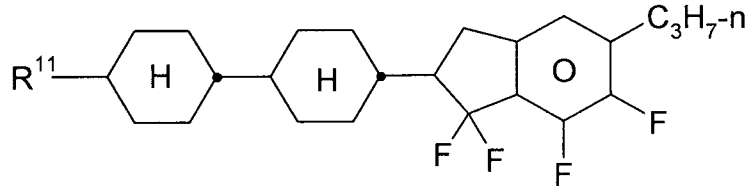

In-13




In-14




In-15



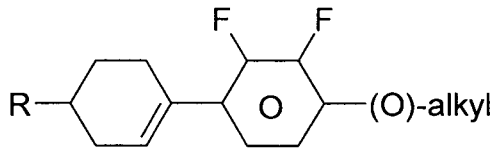

In-16

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

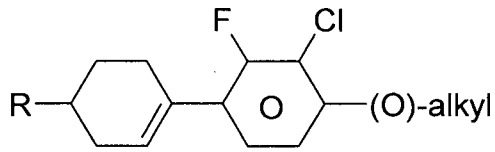
The compounds of the formula In and the sub-formulae In-1 to In-16 are preferably employed in the mixtures according to the invention in

concentrations ≥ 5 % by weight, in particular 5 - 30 % by weight and very particularly preferably 5 - 25 % by weight.

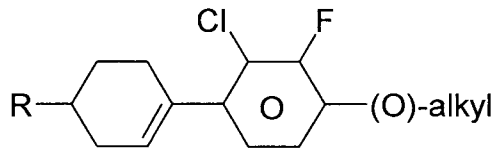
m) Preferred mixtures additionally comprise one or more compounds of the formulae L-1 to L-11,



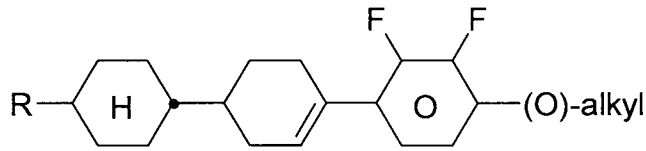

L-1



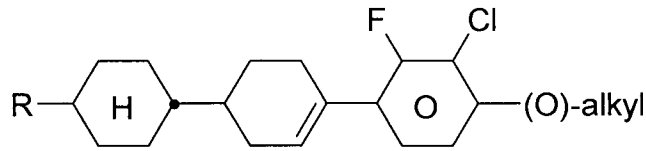

L-2



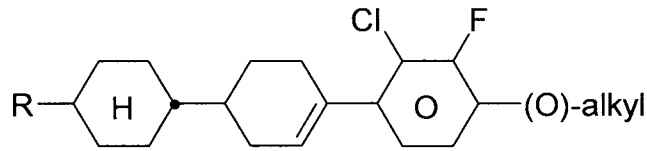

L-3



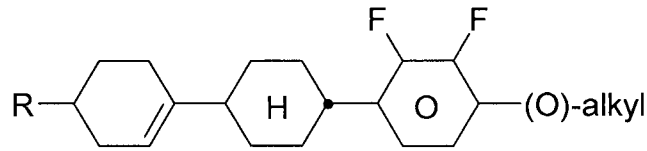

L-4



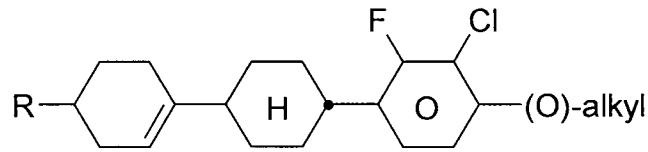

L-5



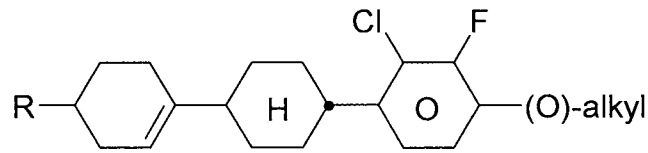

L-6



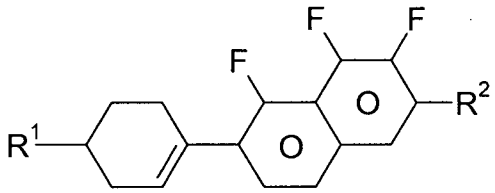

L-7



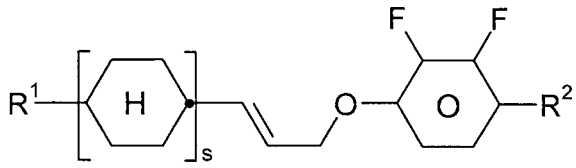

L-8




L-9



L-10



L-11

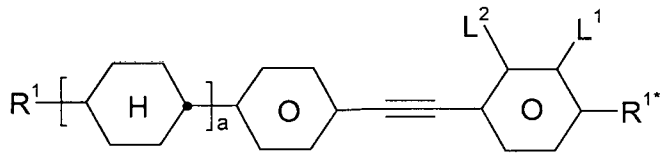
in which

R, $R^1$ and $R^2$ each, independently of one another, have the meanings indicated for $R^{2A}$ in Claim 10, and alkyl denotes an alkyl radical having 1-6 C atoms. s denotes 1 or 2.

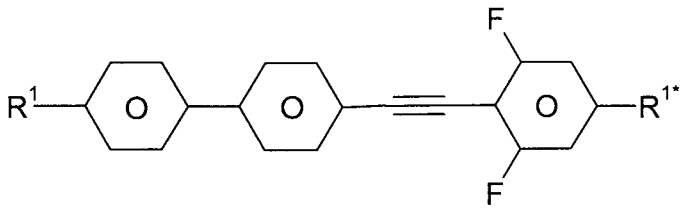
Particular preference is given to the compounds of the formulae L-1 and L-4, in particular L-4.

The compounds of the formulae L-1 to L-11 are preferably employed in concentrations of 5 - 50 % by weight, in particular 5 - 40 % by weight and very particularly preferably 10 - 40 % by weight.

n) Preferred mixtures additionally comprise one or more tolan compounds of the formula To-1 and To-2,

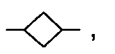
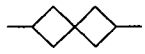


To-1

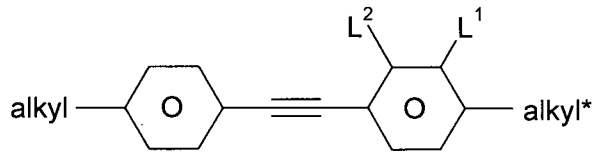


To-2

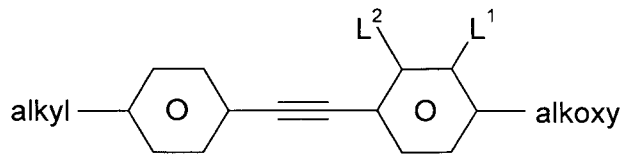
in which

| | |
|---|---|
| $R^1$ and $R^{1*}$ | each, independently of one another, denote 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≡C-, $-CF_2O-$, -CH=CH-,  ,  , -O-, -CO-O-, -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, |
| a | 0 or 1, |
| $L^1$ and $L^2$ | each, independently of one another, denote H, F, Cl, $CF_3$ or $CHF_2$, preferably H or F. |

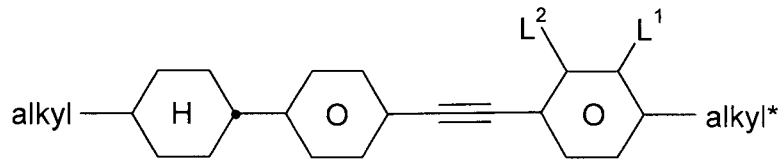
Preferred compounds of the formulae To-1 and To-2 are the compounds of the formula



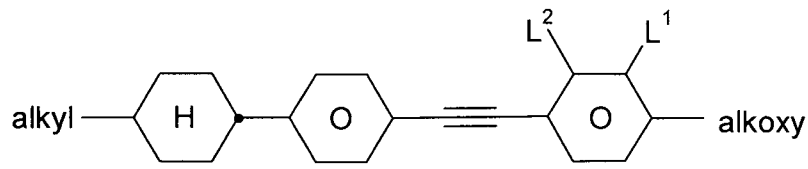

To-1a



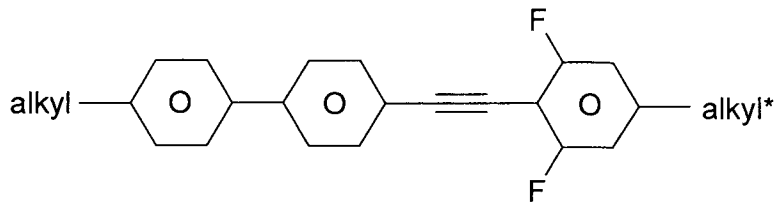

To-1b




To-1c




To-1d




To-2a

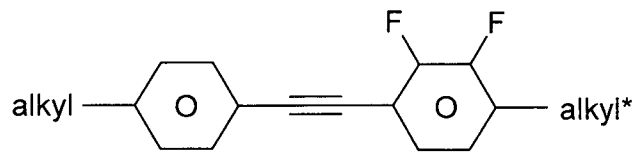
in which

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

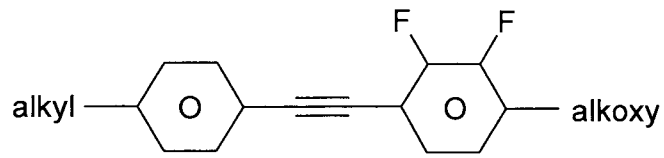
alkoxy or O-alkyl denotes a straight-chain alkoxy radical having 1-6 C atoms, and

$L^1$ and $L^2$ each, independently of one another, denote H, F, Cl, $CF_3$ or $CHF_2$, preferably H or F.

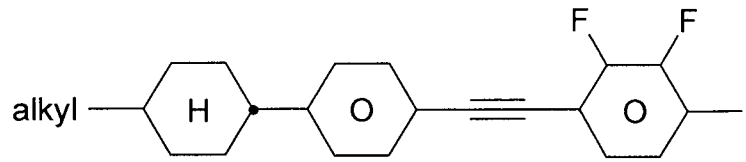
In particular, the following compounds of the formula To-1 are preferred:



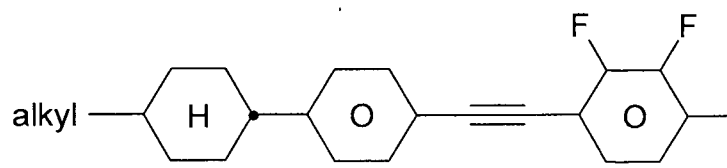

To-1a-1



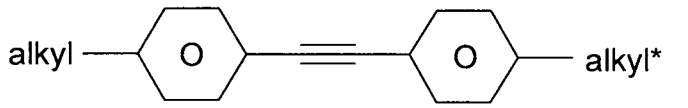

To-1b-1



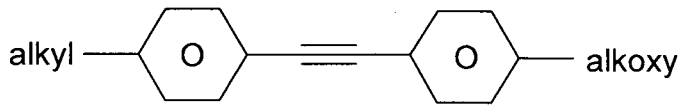

To-1c-1



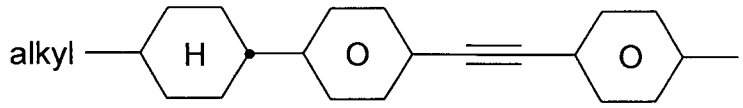

To-1d-1



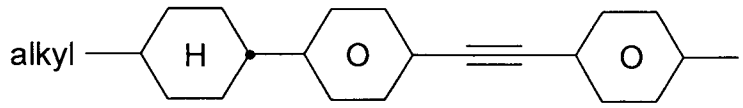

To-1a-2




T-1b-2




To-1c-2

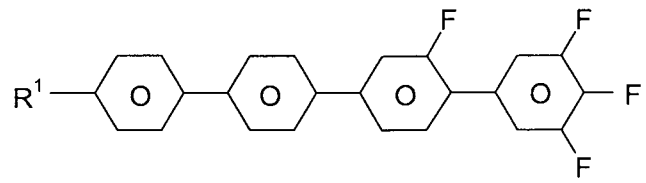



To-1d-2

where

alkyl, alkyl* and alkoxy have the meanings indicated above.

o) Preferred mixtures contain at least one compound of the formula P,

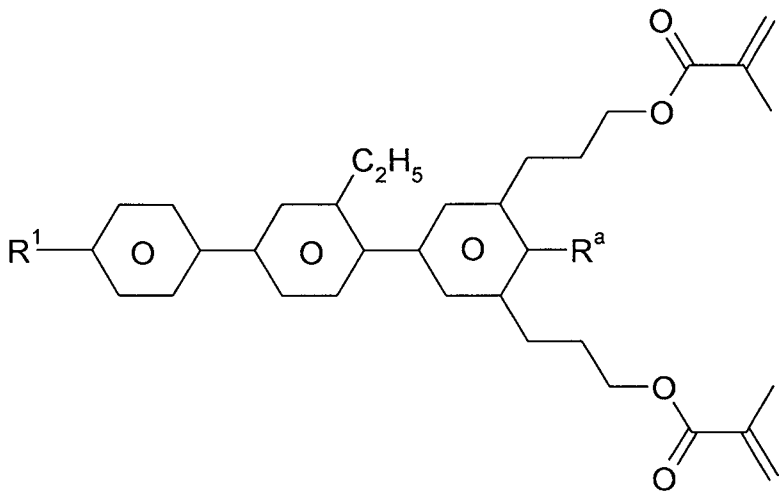



P

wherein $R^1$ has the meanings given for formula I in Claim 1. In a preferred embodiment $R^1$ denotes alkyl, in particular n-$C_3H_7$. The compound P is preferably used in amounts of 0.01-10 %, in particular 0.01-5 %, by weight.

Particularly preferred mixture concepts are indicated below: (the acronyms used are explained in Table A. n and m here each denote, independently of one another, 1-6). The preferred mixtures contain

- at least one self-aligning additive selected from the compounds of the formula I-8h



I-8h

preferably in amounts of 0.1-10 wt.%, in particular 1-3 wt.%.

- CPY-n-Om, in particular CPY-2-O2, CPY-3-O2 and/or CPY-5-O2, preferably in concentrations > 5 %, in particular 10-30 %, based on the mixture as a whole,

and/or

- CY-n-Om, preferably CY-3-O2, CY-3-O4, CY-5-O2 and/or CY-5-O4, preferably in concentrations > 5 %, in particular 15-50 %, based on the mixture as a whole,

and/or

- CCY-n-Om, preferably CCY-4-O2, CCY-3-O2, CCY-3-O3, CCY-3-O1 and/or CCY-5-O2, preferably in concentrations > 5 %, in particular 10-30 %, based on the mixture as a whole,

and/or

- CLY-n-Om, preferably CLY-2-O4, CLY-3-O2 and/or CLY-3-O3, preferably in concentrations > 5 %, in particular 10-30 %, based on the mixture as a whole,

and/or

- CK-n-F, preferably CK-3-F, CK-4-F and/or CK-5-F, preferably in concentrations of > 5 %, in particular 5-25 %, based on the mixture as a whole.

Preference is furthermore given to mixtures according to the invention which comprise the following mixture concepts:
(n and m each denote, independently of one another, 1-6.)

- CPY-n-Om and CY-n-Om, preferably in concentrations of 10-80%, based on the mixture as a whole,

and/or

- CCOY-n-Om and CCH-nm, preferably in concentrations of 10-80%, based on the mixture as a whole,

and/or

- CPY-n-Om and CK-n-F, preferably in concentrations of 10-70 %, based on the mixture as a whole,

and/or

- CPY-n-Om and CLY-n-Om, preferably in concentrations of 10-80 %, based on the mixture as a whole.

and/or

- PYP-n-m, preferably one, two or three compounds, preferably in concentrations of 1-20 % of the mixture as a whole,

and/or

- PY-n-Om, preferably one, two or three compounds, preferably in concentrations of 1-20 % of the mixture as a whole.

The invention furthermore relates to an electro-optical display, preferably a PI-free display, having either passive- or active-matrix addressing (based on the ECB, VA, PS-VA, PSA, IPS, HT-VA, PM (passive matrix)-VA characterised in that it contains, as dielectric, a liquid-crystalline medium according to one or more of Claims 1 to 16.

The liquid-crystalline medium according to the invention preferably has a nematic phase from ≤ -20 °C to ≥ 70 °C, particularly preferably from ≤ -30 °C to ≥ 80 °C, very particularly preferably from ≤ -40°C to ≥ 90 °C.

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 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, 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.

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

The values of the birefringence $\Delta n$ in the liquid-crystal mixture are generally between 0.07 and 0.16, preferably between 0.08 and 0.13.

The liquid-crystal mixture according to the invention has a $\Delta\varepsilon$ of -0.5 to -8.0, in particular -2.5 to -6.0, where $\Delta\varepsilon$ denotes the dielectric anisotropy. The rotational viscosity $\gamma_1$ at 20 °C is preferably ≤ 165 mPa·s, in particular ≤ 140 mPa·s.

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 ≤ 2.5 V and very particularly preferably ≤ 2.3 V.

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

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

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 $\Delta\varepsilon > 1.5$, the term "dielectrically neutral compounds" denotes those having $-1.5 \leq \Delta\varepsilon \leq 1.5$ and the term "dielectrically negative compounds" denotes those having $\Delta\varepsilon < -1.5$. 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 homogeneous surface alignment at 1 kHz. The measurement voltage is typically 0.5 V to 1.0 V, but is always lower than the capacitive threshold of the respective liquid-crystal mixture investigated.

All temperature values indicated for the present invention are in °C.

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), as well as for PM-VA, HT (high transmission)-VA and VA-IPS applications, for example for car navigation and white market.

The nematic liquid-crystal mixtures in the displays according to the invention generally comprise two components A and B, which themselves consist of one or more individual compounds.

Component A has significantly negative dielectric anisotropy and gives the nematic phase a dielectric anisotropy of ≤ -0.5. Preferably component A comprises the compounds of the formulae IIA, IIB and/or IIC, furthermore compounds of the formula III.

The proportion of component A is preferably between 45 and 100 %, in particular between 60 and 100 %.

For component A, one (or more) individual compound(s) which has (have) a value of $\Delta\varepsilon \leq -0.8$ is (are) preferably selected. This value must be more negative, the smaller the proportion A in the mixture as a whole.

Component B has pronounced nematogeneity and a flow viscosity of not greater than 30 $mm^2 \cdot s^{-1}$, preferably not greater than 25 $mm^2 \cdot s^{-1}$, at 20 °C.

Particularly preferred individual compounds in component B are extremely low-viscosity nematic liquid crystals having a flow viscosity of not greater than 18 $mm^2 \cdot s^{-1}$, preferably not greater than 12 $mm^2 \cdot s^{-1}$, at 20 °C.

Component B is monotropically or enantiotropically nematic, has no smectic phases and is able to prevent the occurrence of smectic phases down to very low temperatures in liquid-crystal mixtures. For example, if various materials of high nematogeneity are added to a smectic liquid-crystal mixture, the nematogeneity of these materials can be compared through the degree of suppression of smectic phases that is achieved.

The mixture may optionally also comprise a component C, comprising compounds having a dielectric anisotropy of $\Delta\varepsilon \geq 1.5$. These so-called positive compounds are generally present in a mixture of negative dielectric anisotropy in amounts of ≤ 20 % by weight, based on the mixture as a whole.

A multiplicity of suitable materials is known to the person skilled in the art from the literature. Particular preference is given to compounds of the formula III.

In addition, these liquid-crystal phases may also comprise more than 18 components, preferably 18 to 25 components.

The mixtures according to the invention contain one or more compounds of the formula I and preferably comprise 4 to 15, in particular 5 to 12, and particularly preferably < 10, compounds of the formulae IIA, IIB and/or IIC and optionally III.

Besides compounds of the formula I and the compounds of the formulae IIA, IIB and/or IIC and optionally III, other constituents may also be present, for example in an amount of up to 45 % of the mixture as a whole, but preferably up to 35 %, in particular up to 10 %.

The other constituents are preferably selected from nematic or nematogenic substances, in particular known substances, from the classes of the azoxybenzenes, benzylideneanilines, biphenyls, terphenyls, phenyl or cyclohexyl benzoates, phenyl or cyclohexyl cyclohexanecarboxylates, phenylcyclohexanes, cyclohexylbiphenyls, cyclohexylcyclohexanes, cyclohexylnaphthalenes, 1,4-biscyclohexylbiphenyls or cyclohexylpyrimidines, phenyl- or cyclohexyldioxanes, optionally halogenated stilbenes, benzyl phenyl ethers, tolans and substituted cinnamic acid esters.

The most important compounds which are suitable as constituents of liquid-crystal phases of this type can be characterised by the formula IV

$R^{20}$-L-G-E-$R^{21}$ IV

in which L and E each denote a carbo- or heterocyclic ring system from the group formed by 1,4-disubstituted benzene and cyclohexane rings, 4,4'-disubstituted biphenyl, phenylcyclohexane and cyclohexylcyclohexane systems, 2,5-disubstituted pyrimidine and 1,3-dioxane rings, 2,6-disubsti-

tuted naphthalene, di- and tetrahydronaphthalene, quinazoline and tetrahydroquinazoline,

| G denotes | | |
|---|---|---|
| | -CH=CH- | -N(O)=N- |
| | -CH=CQ- | -CH=N(O)- |
| | -C≡C- | $-CH_2-CH_2-$ |
| | -CO-O- | $-CH_2-O-$ |
| | -CO-S- | $-CH_2-S-$ |
| | -CH=N- | -COO-Phe-COO- |
| | $-CF_2O-$ | -CF=CF- |
| | $-OCF_2-$ | $-OCH_2-$ |
| | $-(CH_2)_4-$ | $-(CH_2)_3O-$ |

or a C-C single bond, Q denotes halogen, preferably chlorine, or -CN, and $R^{20}$ and $R^{21}$ each denote alkyl, alkenyl, alkoxy, alkoxyalkyl or alkoxycarbonyloxy having up to 18, preferably up to 8, carbon atoms, or one of these radicals alternatively denotes CN, NC, $NO_2$, NCS, $CF_3$, $SF_5$, $OCF_3$, F, Cl or Br.

In most of these compounds, $R^{20}$ and $R^{21}$ are different from one another, one of these radicals usually being an alkyl or alkoxy group. Other variants of the proposed substituents are also common. Many such substances or also mixtures thereof are commercially available. All these substances can be prepared by methods known from the literature.

It goes without saying for the person skilled in the art that the VA 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.

Polymerisable compounds, so-called reactive mesogens (RMs), for example as disclosed in U.S. 6,861,107, may furthermore be added to the mixtures according to the invention in concentrations of preferably 0.1 - 5% by weight, particularly preferably 0.2 - 2 % by weight, based on the mixture. These mixtures may optionally also comprise an initiator, as described, for example, in U.S. 6,781,665. The initiator, for example Irganox-1076 from

Ciba, is preferably added to the mixture comprising polymerisable compounds in amounts of 0-1 %. Mixtures of this type can be used for so-called polymer-stabilised VA modes (PS-VA) or PSA (polymer sustained VA), in which polymerisation of the reactive mesogens is intended to take place in the liquid-crystalline mixture. The prerequisite for this is that the liquid-crystal mixture does not itself comprise any polymerisable components.

In a preferred embodiment of the invention, the polymerisable compounds (monomers) are selected from the compounds of the formula M,

$$R^{Ma}\text{-}A^{M1}\text{-}(Z^{M1}\text{-}A^{M2})_{m1}\text{-}R^{Mb} \qquad M$$

in which the individual radicals have the following meanings:

| | |
|---|---|
| $R^{Ma}$ and $R^{Mb}$ | each, independently of one another, denote P, P-Sp-, H, halogen, $SF_5$, $NO_2$, an alkyl, alkenyl or alkynyl group, where at least one of the radicals $R^{Ma}$ and $R^{Mb}$ preferably denotes or contains a group P or P-Sp-, |
| P | denotes a polymerisable group, |
| Sp | denotes a spacer group or a single bond, |
| $A^{M1}$ and $A^{M2}$ | each, independently of one another, denote an aromatic, heteroaromatic, alicyclic or heterocyclic group, preferably having 4 to 25 ring atoms, preferably C atoms, which may also encompass or contain fused rings, and which may optionally be mono- or polysubstituted by L, |
| L | denotes P, P-Sp, F, Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, $-C(=O)N(R^x)_2$, $-C(=O)Y^1$, $-C(=O)R^x$, $-N(R^x)_2$, optionally substituted silyl, optionally substituted aryl having 6 to 20 C atoms, or straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 25 C atoms, in which, in addition, one or more H atoms may be replaced by F, Cl, P or |

P-Sp-, preferably P, P-Sp-, H, halogen, $SF_5$, $NO_2$, an alkyl, alkenyl or alkynyl group,

$Y^1$ denotes halogen,

$Z^{M1}$ denotes -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-, $-OCH_2-$, $-CH_2O-$, $-SCH_2-$, $-CH_2S-$, $-CF_2O-$, $-OCF_2-$, $-CF_2S-$, $-SCF_2-$, $-(CH_2)_{n1}-$, $-CF_2CH_2-$, $-CH_2CF_2-$, $-(CF_2)_{n1}-$, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-, -COO-, -OCO-CH=CH-, $CR^0R^{00}$ or a single bond,

$R^0$ and $R^{00}$ each, independently of one another, denote H or alkyl having 1 to 12 C atoms,

$R^x$ denotes P, P-Sp-, H, halogen, straight-chain, branched or cyclic alkyl having 1 to 25 C atoms, in which, in addition, one or more non-adjacent $CH_2$ groups may be replaced by -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, P or P-Sp-, an optionally substituted aryl or aryloxy group having 6 to 40 C atoms, or an optionally substituted heteroaryl or heteroaryloxy group having 2 to 40 C atoms,

m1 denotes 0, 1, 2, 3 or 4, and

n1 denotes 1, 2, 3 or 4,

where at least one, preferably one, two or three, particularly preferably one or two, from the group $R^{Ma}$, $R^{Mb}$ and the substituents L present denotes a group P or P-Sp- or contains at least one group P or P-Sp-.

Particularly preferred compounds of the formula M are those in which

$R^{Ma}$ and $R^{Mb}$ each, independently of one another, denote P, P-Sp-, H, F, Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, $SF_5$ or

straight-chain or branched alkyl having 1 to 25 C atoms, in which, in addition, one or more non-adjacent $CH_2$ groups may each be replaced, independently of one another, by $-C(R^0)=C(R^{00})-$, $-C\equiv C-$, $-N(R^{00})-$, -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, Br, I, CN, P or P-Sp-, where at least one of the radicals $R^{Ma}$ and $R^{Mb}$ preferably denotes or contains a group P or P-Sp-,

$A^{M1}$ and $A^{M2}$ each, independently of one another, denote 1,4-phenylene, naphthalene-1,4-diyl, naphthalene-2,6-diyl, phenanthrene-2,7-diyl, anthracene-2,7-diyl, fluorene-2,7-diyl, coumarine, flavone, where, in addition, one or more CH groups in these groups may be replaced by N, cyclohexane-1,4-diyl, in which, in addition, one or more non-adjacent $CH_2$ groups may be replaced by O and/or S, 1,4-cyclohexenylene, bicyclo[1.1.1]-pentane-1,3-diyl, bicyclo[2.2.2]octane-1,4-diyl, spiro[3.3]heptane-2,6-diyl, piperidine-1,4-diyl, decahydronaphthalene-2,6-diyl, 1,2,3,4-tetrahydronaphthalene-2,6-diyl, indane-2,5-diyl or octahydro-4,7-methanoindane-2,5-diyl, where all these groups may be unsubstituted or mono- or polysubstituted by L,

L denotes P, P-Sp-, F, Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, $-C(=O)N(R^x)_2$, $-C(=O)Y^1$, $-C(=O)R^x$, $-N(R^x)_2$, optionally substituted silyl, optionally substituted aryl having 6 to 20 C atoms, or straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 25 C atoms, in which, in addition, one or more H atoms may be replaced by F, Cl, P or P-Sp-,

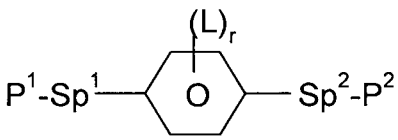
P denotes a polymerisable group,

$Y^1$ denotes halogen,

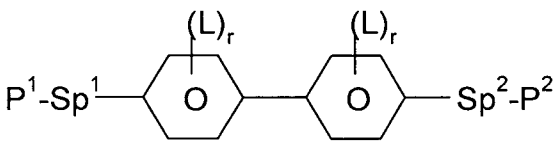
$R^x$ denotes P, P-Sp-, H, halogen, straight-chain, branched or cyclic alkyl having 1 to 25 C atoms, in which, in addition, one or more non-adjacent $CH_2$ groups may be replaced by -O-, -S-, -CO-, -CO-O-, -O-CO-, -O-CO-O- in such a way that O and/or S atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by F, Cl, P or P-Sp-, an optionally substituted aryl or aryloxy group having 6 to 40 C atoms, or an optionally substituted heteroaryl or heteroaryloxy group having 2 to 40 C atoms.

Very particular preference is given to compounds of the formula M in which one of $R^{Ma}$ and $R^{Mb}$ or both denote(s) P or P-Sp-.

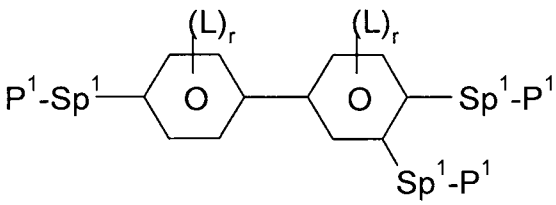
Suitable and preferred mesogenic comonomers, particularly for use in PSA displays, are selected, for example, from the following formulae:



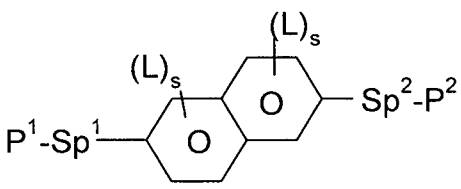

M1



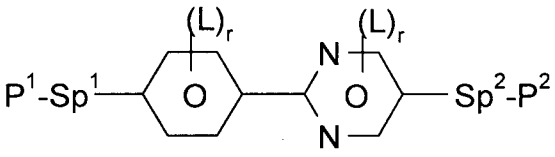

M2



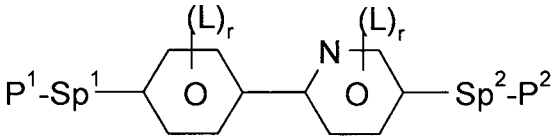

M3



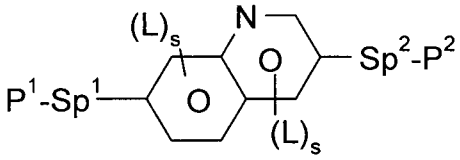

M4



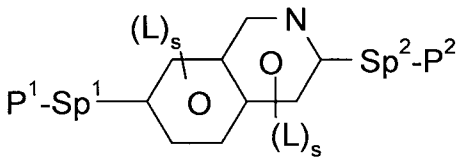

M5



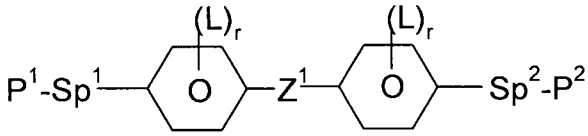

M6



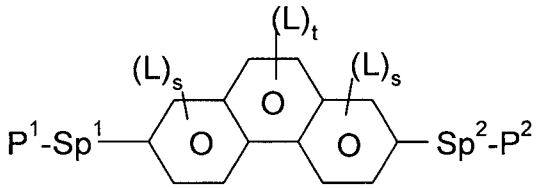

M7



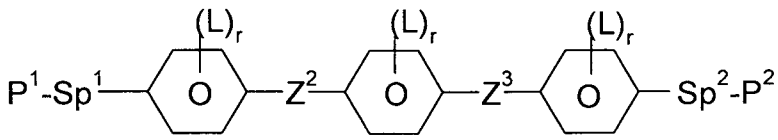

M8



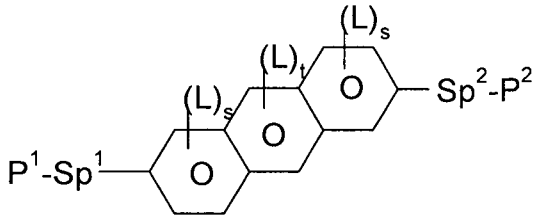

M9



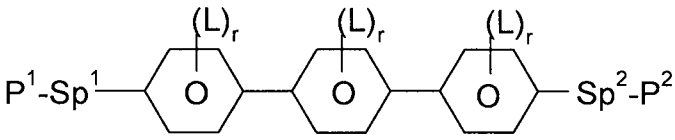

M10



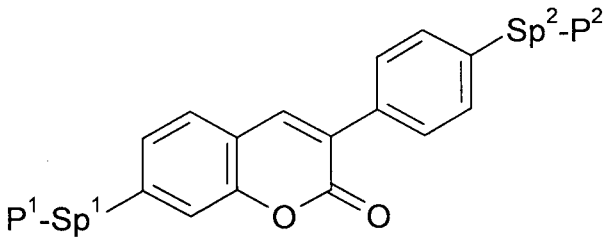

M11



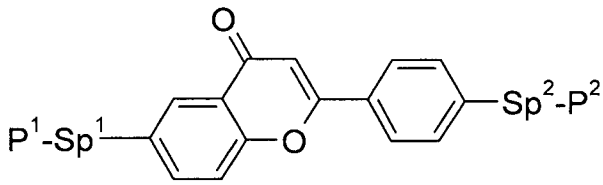

M12



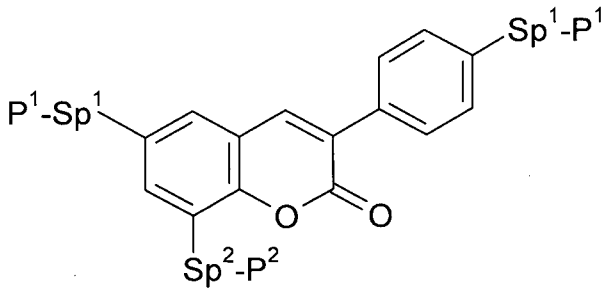
M13



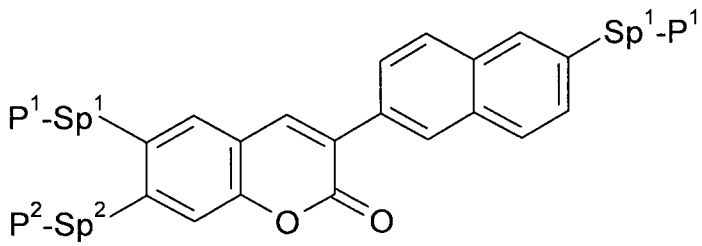
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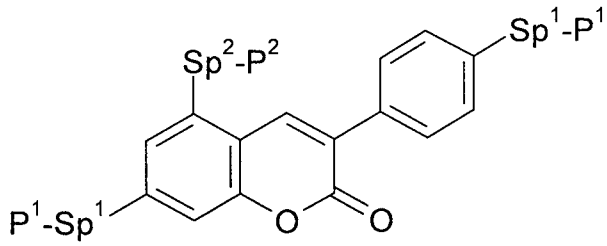
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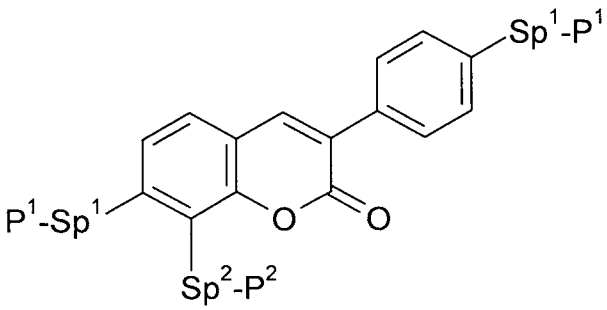
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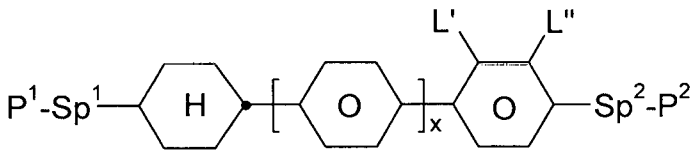
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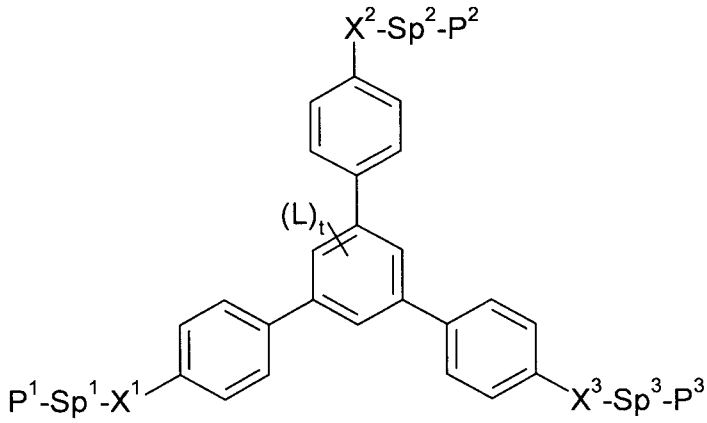
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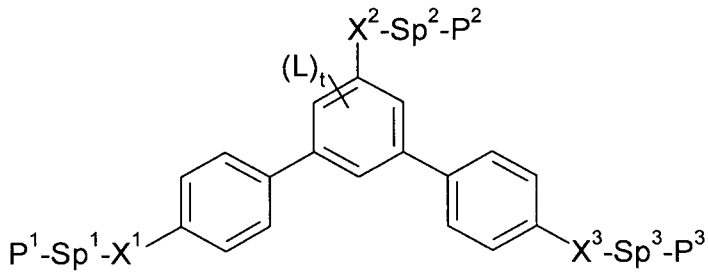

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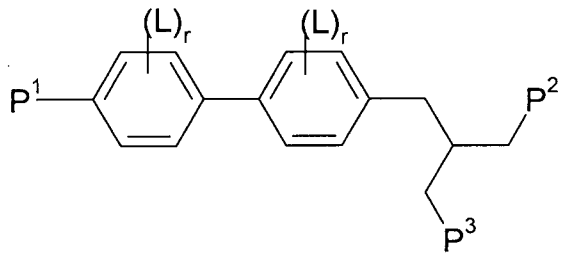

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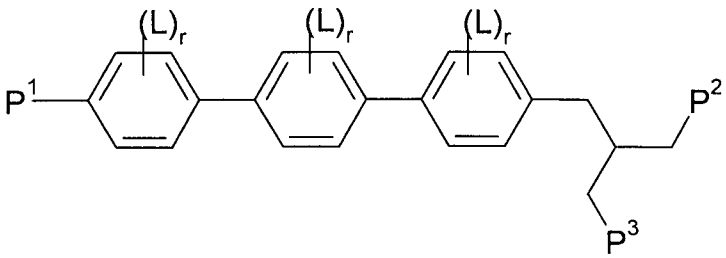

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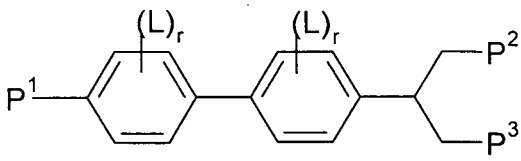

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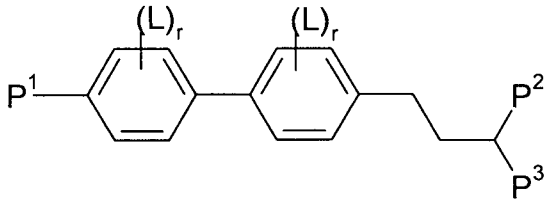

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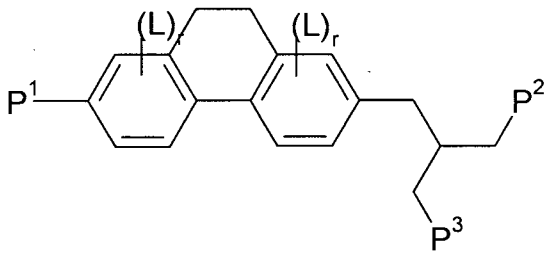
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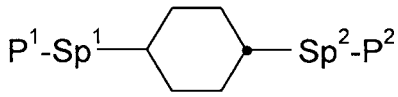
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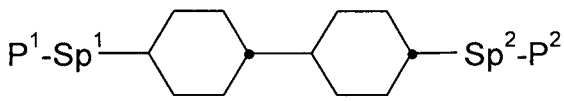
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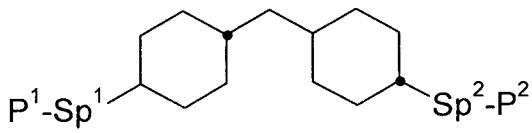
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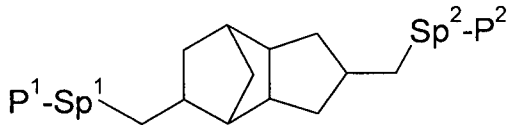
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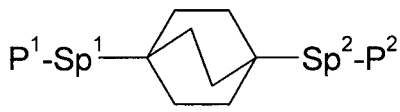
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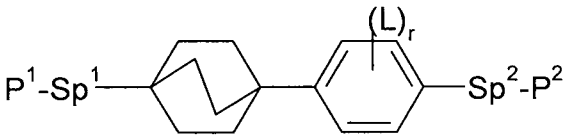
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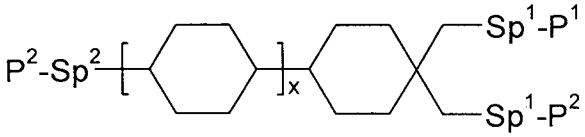
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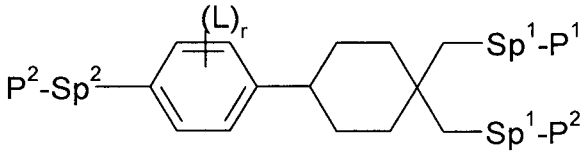
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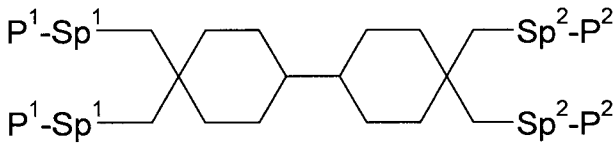

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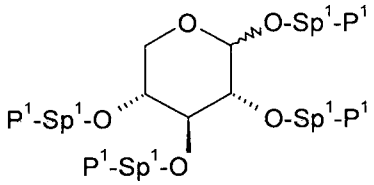

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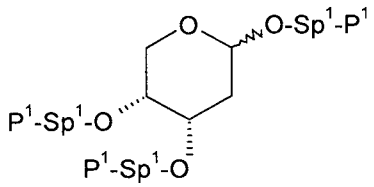

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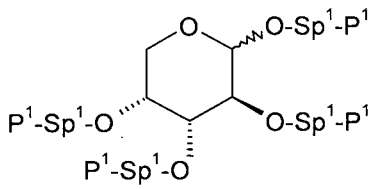

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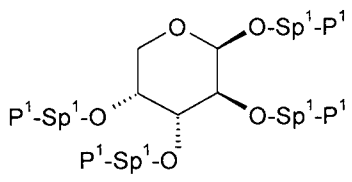

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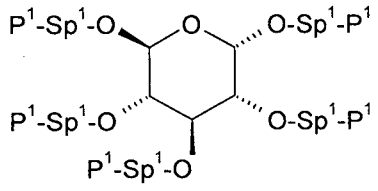

M38




M39




M40



M41

in which the individual radicals have the following meanings:

$P^1$, $P^2$ and $P^3$ each, independently of one another, denote a polymerisable group, preferably having one of the meanings indicated above and below for P, particularly preferably an acrylate, methacrylate, fluoroacrylate, oxetane, vinyl, vinyloxy or epoxide group,

$Sp^1$,$Sp^2$ and $Sp^3$ each, independently of one another, denote a single bond or a spacer group, preferably having one of the meanings indicated above and below for Sp, and particularly preferably denote $-(CH_2)_{p1}-$, $-(CH_2)_{p1}-O-$, $-(CH_2)_{p1}-CO-O-$ or $-(CH_2)_{p1}-O-CO-O-$, in which p1 is an integer from 1 to 12, and where the linking to the adjacent ring in the last-mentioned groups takes place via the O atom,

where, in addition, one or more of the radicals $P^1-Sp^1-$, $P^2-Sp^2-$ and $P^3-Sp^3-$ may denote $R^{aa}$, with the proviso that at least one of the radicals $P^1-Sp^1-$, $P^2-Sp^2-$ and $P^3-Sp^3-$ present does not denote $R^{aa}$,

$R^{aa}$ 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 $CH_2$ groups may each be replaced, independently of one another, by $C(R^0)=C(R^{00})-$, $-C\equiv C-$, $-N(R^0)-$, -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 $P^1-Sp^1-$, 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),

$R^0$, $R^{00}$ 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, $CH_3$ or $CF_3$,

$X^1$, $X^2$ and $X^3$ each, independently of one another, denote -CO-O-, -O-CO- or a single bond,

$Z^1$ denotes -O-, -CO-, $-C(R^yR^z)-$ or $-CF_2CF_2-$,

$Z^2$ and $Z^3$ each, independently of one another, denote -CO-O-, -O-CO-, $-CH_2O-$, $-OCH_2-$, $-CF_2O-$, $-OCF_2-$ or $-(CH_2)_n-$, 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 poly-fluorinated 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,

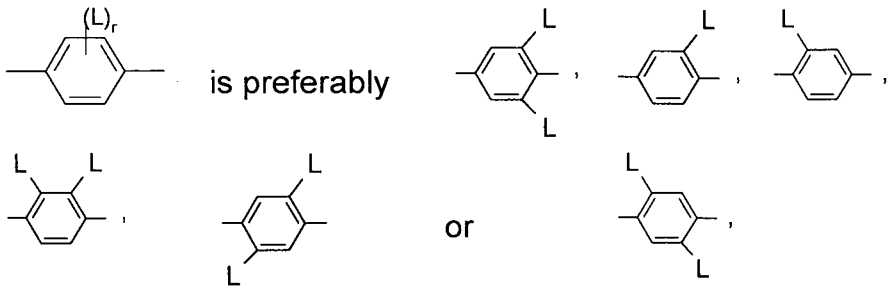
r denotes 0, 1, 2, 3 or 4,

s denotes 0, 1, 2 or 3,

t denotes 0, 1 or 2,

x denotes 0 or 1.

In the compounds of formulae M1 to M41



is preferably



wherein L on each occurrence, identically or differently, has one of the meanings given above or below, and is preferably F, Cl, CN, $NO_2$, $CH_3$, $C_2H_5$, $C(CH_3)_3$, $CH(CH_3)_2$, $CH_2CH(CH_3)C_2H_5$, $OCH_3$, $OC_2H_5$, $COCH_3$, $COC_2H_5$, $COOCH_3$, $COOC_2H_5$, $CF_3$, $OCF_3$, $OCHF_2$, $OC_2F_5$ or P-Sp-, very preferably F, Cl, CN, $CH_3$, $C_2H_5$, $OCH_3$, $COCH_3$, $OCF_3$ or P-Sp-, more preferably F, Cl, $CH_3$, $OCH_3$, $COCH_3$ or $OCF_3$ , especially F or $CH_3$.

Suitable polymerisable compounds are furthermore listed, for example, in Table D. LC mixtures containing at least one polymerisable compound listed in Table D are especially preferred.

The liquid-crystalline media in accordance with the present application preferably comprise in total 0.1 to 10 %, preferably 0.2 to 4.0 %, particularly preferably 0.2 to 2.0 %, of polymerisable compounds.

Particular preference is given to the polymerisable compounds of the formula M.

The polymerisable compounds are preferably polymerised by photopolymerisation, for example by UV irradiation, often in the presence of at least one suitable initiator. The polymerisation takes place under conditions where the single components of the liquid crystalline mixture as such containing for example single compounds containing an alkenyl side chain like CC-n-V or an alkenyloxy side chain do not polymerize. Suitable conditions for the polymerisation and suitable types and amounts of initiator(s) are known to a person skilled in the art and are described in the literature. Suitable for free-radical polymerisation are, for example,

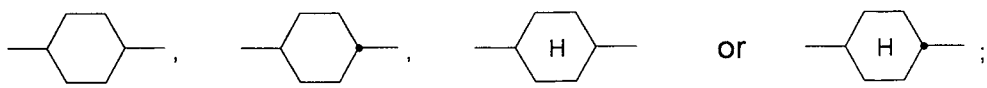
commercially available photoinitiators, for example Irgacure® 651, Irgacure® 184 or Darocure® 1173 (BASF). The polymerisable compound(s) preferably comprise from 0 to 5 % by weight, particularly preferably 0.1 to 3 % by weight of one or more photoinitiators.

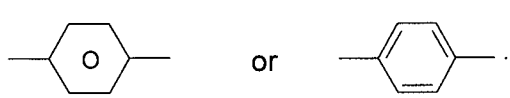
The combination of at least two liquid crystalline compounds, at least one self-aligning additive and preferably with at least one polymerisable compound, in particular one selected from the formula M and/or the formulae M1 to M41, produces low threshold voltages, low rotational viscosities, very good low temperature stabilities (LTS) in the media but at the same time high clearing points and high HR values, and enables the setting or a pretilt angle in VA displays without the need of any alignment layer, e.g., a polyimide layer.

The mixtures according to the invention may furthermore comprise conventional additives, such as, for example, stabilisers, antioxidants, UV absorbers, nanoparticles, microparticles, etc.

The structure of the liquid-crystal displays according to the invention corresponds to the usual geometry, as described, for example, in EP 0 240 379. The following examples are intended to explain the invention without limiting it. Above and below, per cent data denote per cent by weight; all temperatures are indicated in degrees Celsius.

Throughout the patent application, 1,4-cyclohexylene rings and 1,4-phenylene rings are depicted as follows:

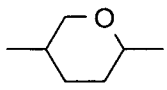


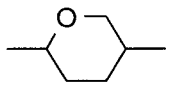

Throughout the patent application and in the working examples, the structures of the liquid-crystalline compounds are indicated by means of acronyms. Unless indicated otherwise, the transformation into chemical formulae is carried out in accordance with Tables 1-3. All radicals $C_nH_{2n+1}$,

$C_mH_{2m+1}$ and $C_{m'}H_{2m'+1}$ or $C_nH_{2n}$ and $C_mH_{2m}$ are straight-chain alkyl radicals or alkylene radicals in each case having n, m, m' or z C atoms respectively. n, m, m', z each denote, independently of one another, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 or 12, preferably 1, 2, 3, 4, 5 or 6. In Table 1 the ring elements of the respective compound are coded, in Table 2 the bridging members are listed and in Table 3 the meanings of the symbols for the left-hand or right-hand side chains of the compounds are indicated.

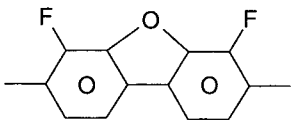
Table 1: Ring elements



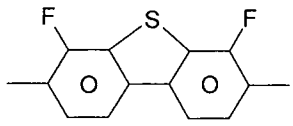
**A**



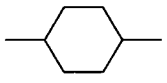
**AI**



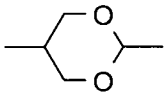
**B**



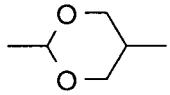
**B(S)**



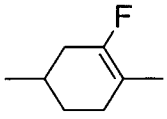
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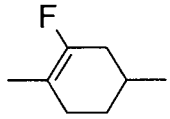
**D**



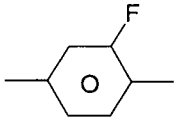
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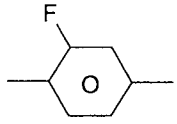
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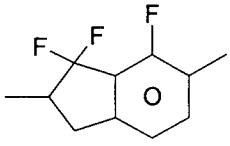
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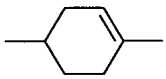
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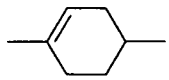
**GI**



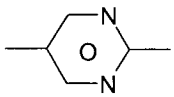
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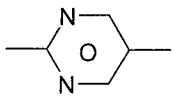
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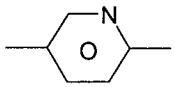
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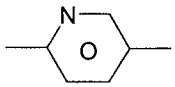

M



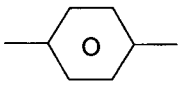

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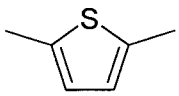

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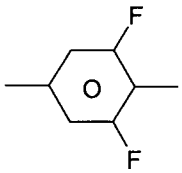

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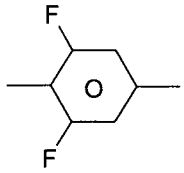

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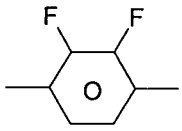

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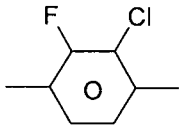

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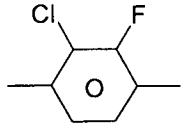

UI




Y




Y(F,Cl)




Y(Cl,F)

Table 2: Bridging members

| | | | |
|---|---|---|---|
| **E** | $-CH_2CH_2-$ | | |
| **V** | -CH=CH- | | |
| **T** | -C≡C- | | |
| **W** | $-CF_2CF_2-$ | | |
| **Z** | -COO- | **ZI** | -OCO- |
| **O** | $-CH_2O-$ | **OI** | $-OCH_2-$ |
| **Q** | $-CF_2O-$ | **QI** | $-OCF_2-$ |

Table 3: Side chains

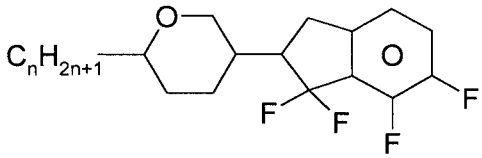
| Left-hand side chain | | Right-hand side chain | |
|---|---|---|---|
| **n-** | $C_nH_{2n+1}-$ | **-n** | $-C_nH_{2n+1}$ |
| **nO-** | $C_nH_{2n+1}-O-$ | **-On** | $-O-C_nH_{2n+1}$ |
| **V-** | $CH_2=CH-$ | **-V** | $-CH=CH_2$ |
| **nV-** | $C_nH_{2n+1}-CH=CH-$ | **-nV** | $-C_nH_{2n}-CH=CH_2$ |
| **Vn-** | $CH_2=CH-\ C_nH_{2n}-$ | **-Vn** | $-CH=CH-C_nH_{2n+1}$ |
| **nVm-** | $C_nH_{2n+1}-CH=CH-C_mH_{2m}-$ | **-nVm** | $-C_nH_{2n}-CH=CH-C_mH_{2m+1}$ |
| **N-** | N≡C- | **-N** | -C≡N |
| **F-** | F- | **-F** | -F |
| **Cl-** | Cl- | **-Cl** | -Cl |
| **M-** | $CFH_2-$ | **-M** | $-CFH_2$ |
| **D-** | $CF_2H-$ | **-D** | $-CF_2H$ |
| **T-** | $CF_3-$ | **-T** | $-CF_3$ |
| **MO-** | $CFH_2O-$ | **-OM** | $-OCFH_2$ |
| **DO-** | $CF_2HO-$ | **-OD** | $-OCF_2H$ |
| **TO-** | $CF_3O-$ | **-OT** | $-OCF_3$ |
| **T-** | $CF_3-$ | **-T** | $-CF_3$ |
| **A-** | H-C≡C- | **-A** | -C≡C-H |

In a preferred embodiment the mixtures according to the invention contain at least one compound of the of the formula I and at least two compounds selected from the compounds listed in Table A.

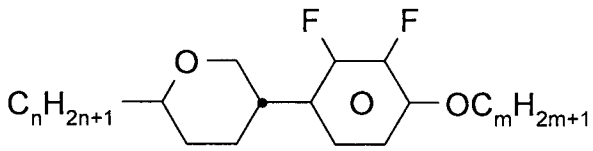
**Table A**

The following abbreviations are used:

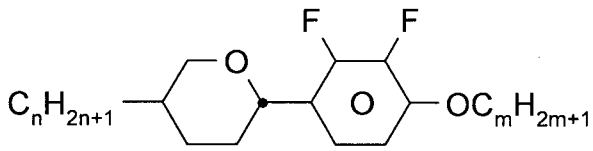
(n, m, m', z: each, independently of one another, 1, 2, 3, 4, 5 or 6;
$(O)C_mH_{2m+1}$ denotes $OC_mH_{2m+1}$ or $C_mH_{2m+1}$)



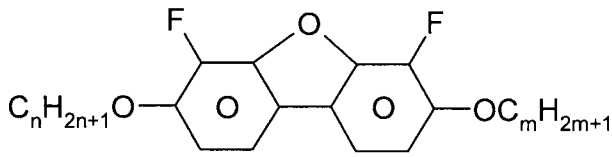
**AIK-n-F**



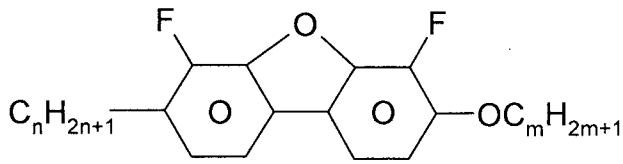
**AIY-n-Om**



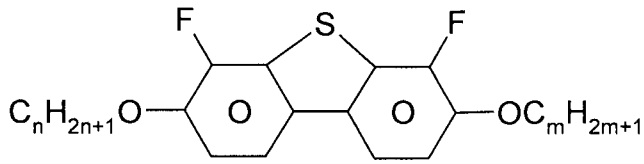
**AY-n-Om**



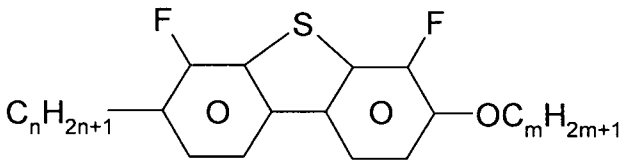
**B-nO-Om**



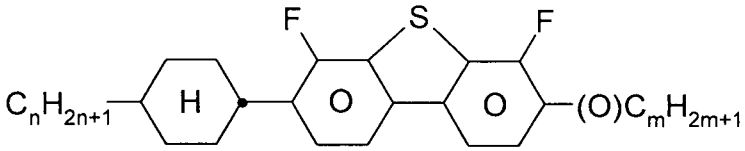
**B-n-Om**



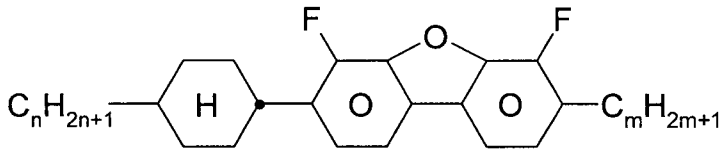
**B(S)-nO-Om**



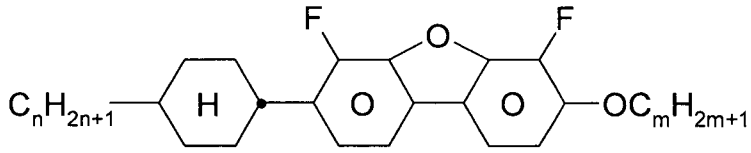

**B(S)-n-Om**



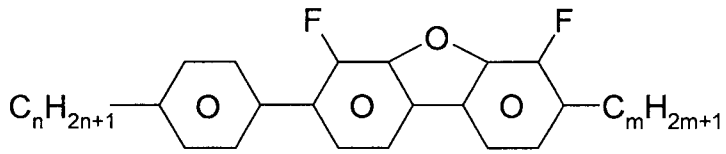

**CB(S)-n-(O)m**



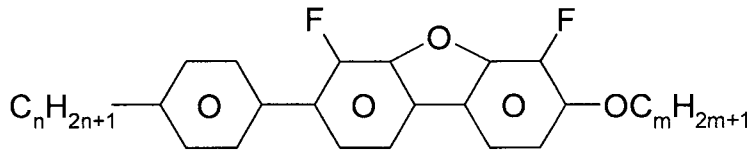

**CB-n-m**



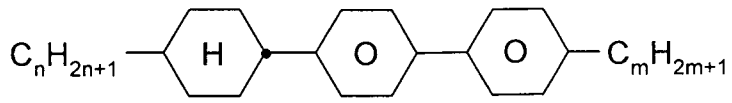

**CB-n-Om**



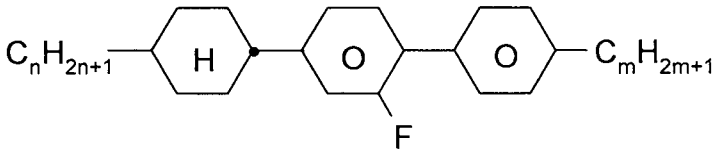

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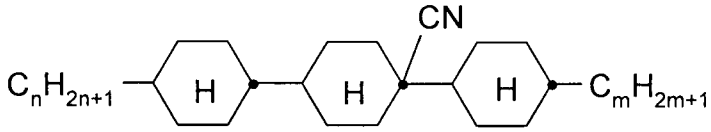

**PB-n-Om**



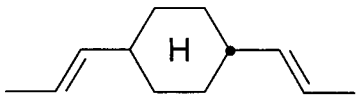

**BCH-nm**



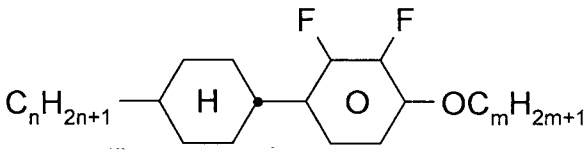

**BCH-nmF**



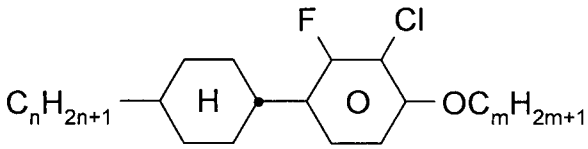

**BCN-nm**



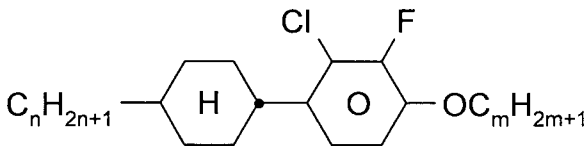

**C-1V-V1**



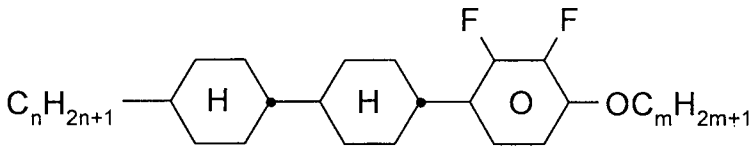

**CY-n-Om**



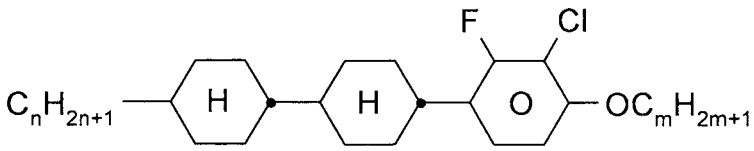

**CY(F,Cl)-n-Om**



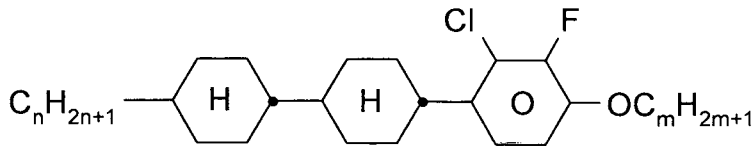

**CY(Cl,F)-n-Om**



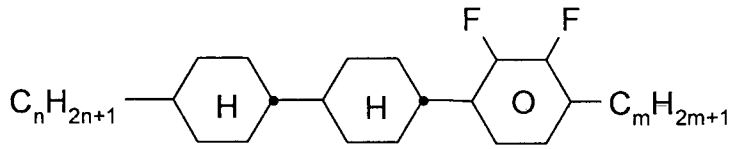

**CCY-n-Om**



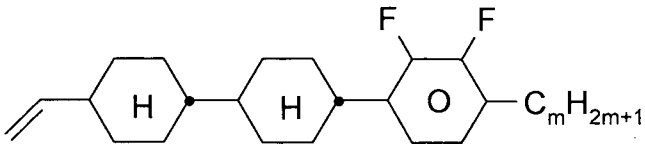
**CCY(F,Cl)-n-Om**



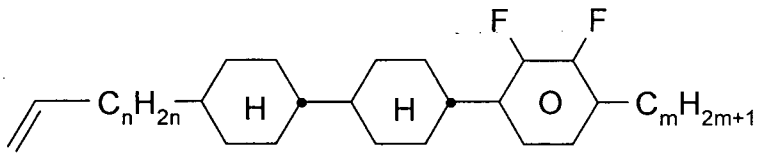

**CCY(Cl,F)-n-Om**



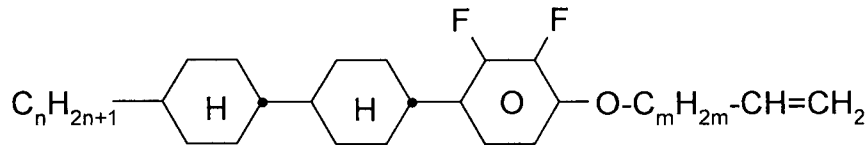

**CCY-n-m**



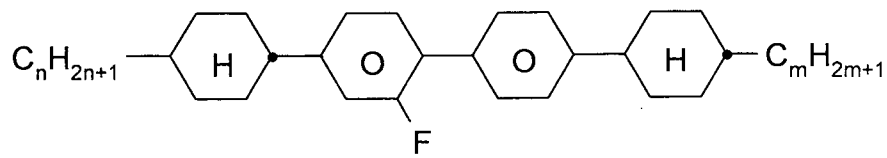

**CCY-V-m**



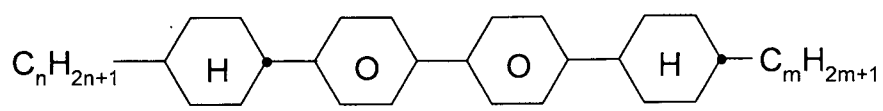

**CCY-Vn-m**



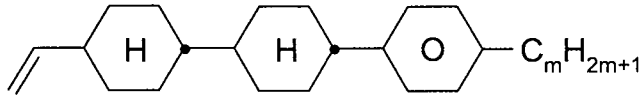

**CCY-n-OmV**



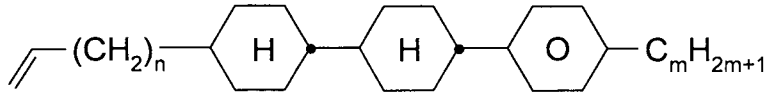

**CBC-nmF**



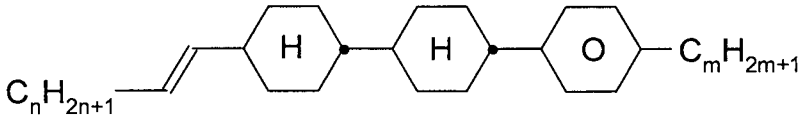

**CBC-nm**



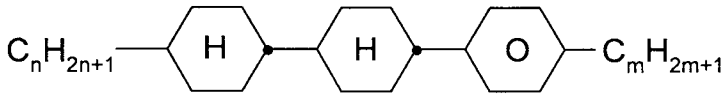
**CCP-V-m**



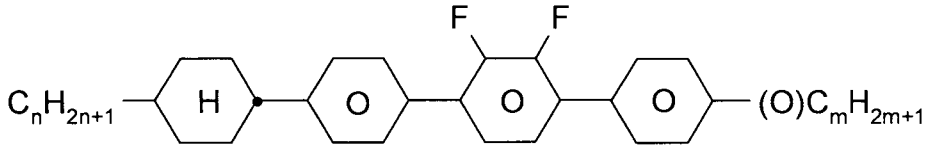
**CCP-Vn-m**



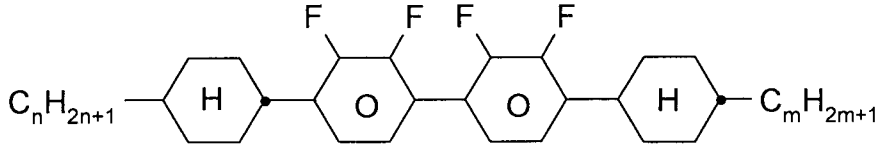
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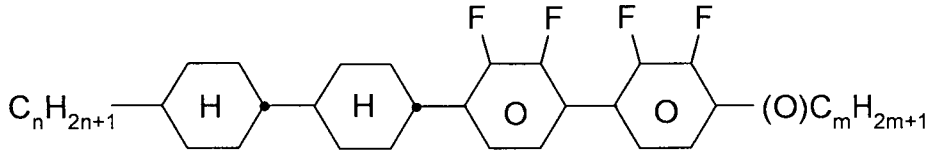
**CCP-n-m**



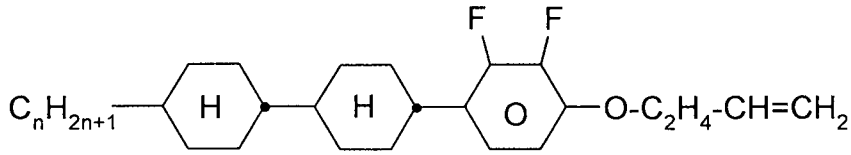
**CPYP-n-(O)m**



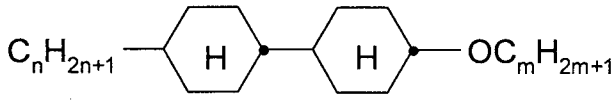
**CYYC-n-m**



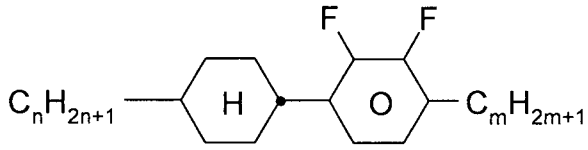
**CCYY-n-(O)m**



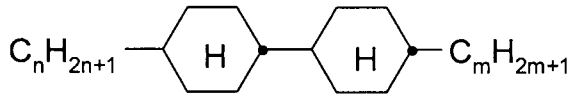
**CCY-n-O2V**



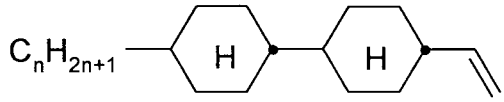

**CCH-nOm**



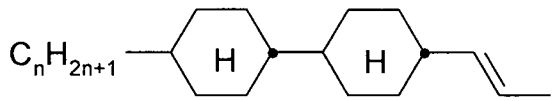

**CY-n-m**



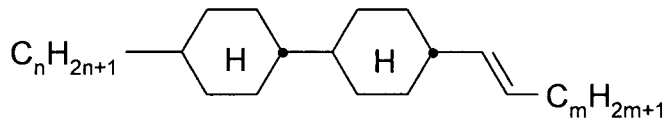

**CCH-nm**



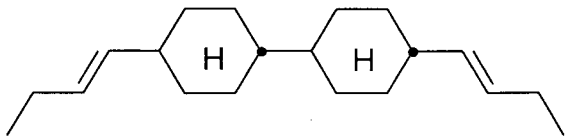

**CC-n-V**



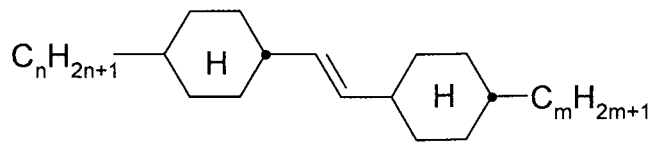

**CC-n-V1**



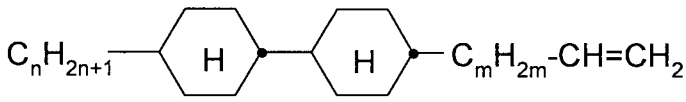

**CC-n-Vm**



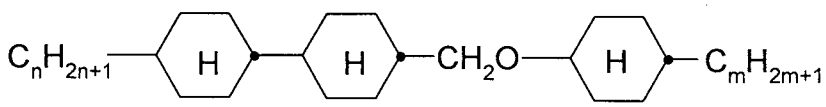

**CC-2V-V2**



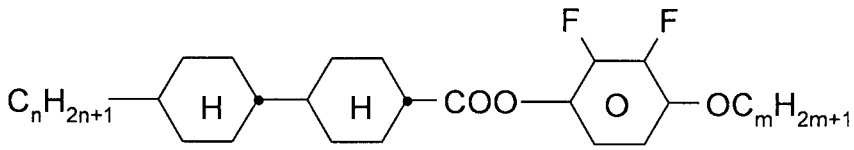

**CVC-n-m**



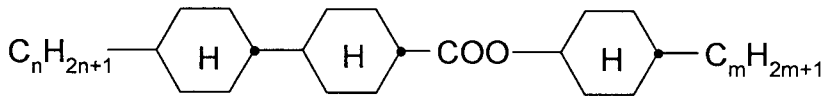
**CC-n-mV**



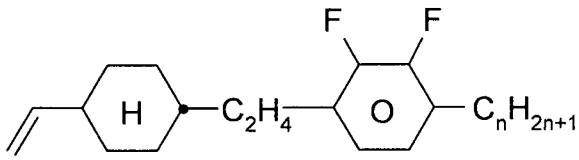
**CCOC-n-m**



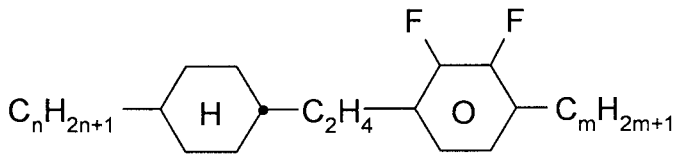
**CP-nOmFF**



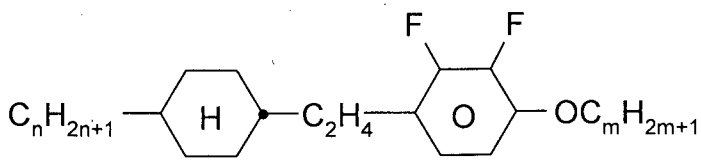
**CH-nm**



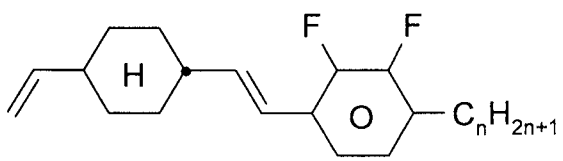
**CEY-V-n**



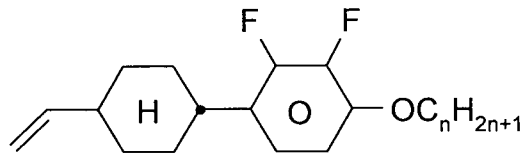
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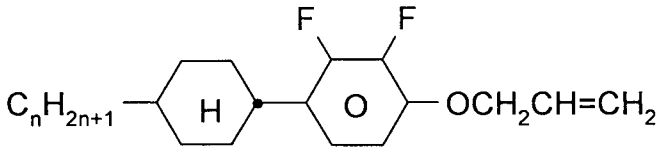
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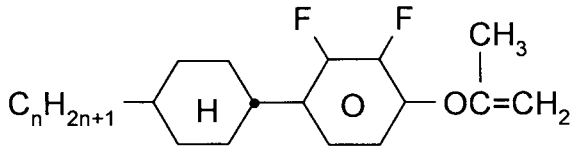
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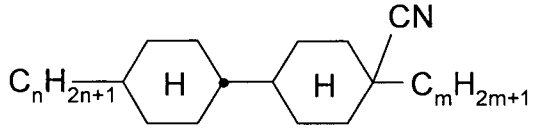

**CY-V-On**



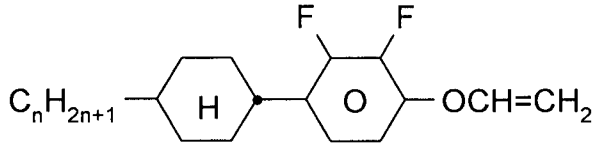

**CY-n-O1V**



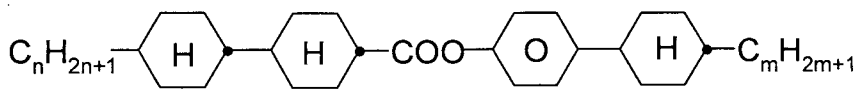

**CY-n-OC(CH$_3$)=CH$_2$**



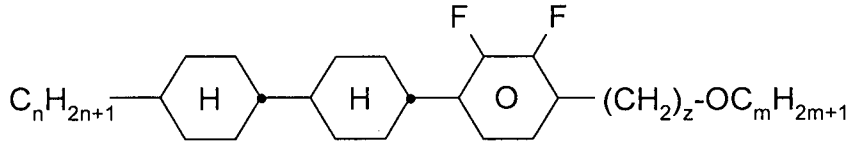

**CCN-nm**



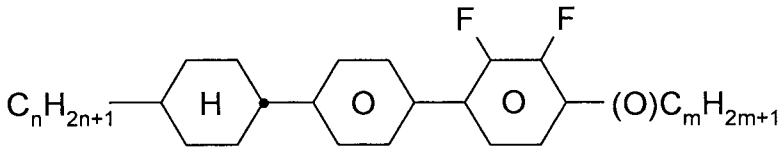

**CY-n-OV**



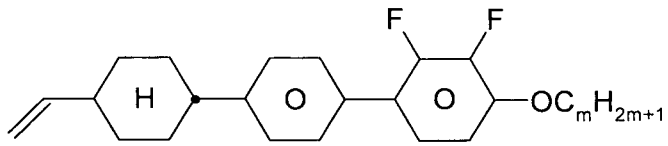

**CCPC-nm**



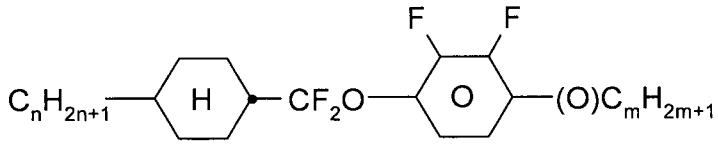

**CCY-n-zOm**



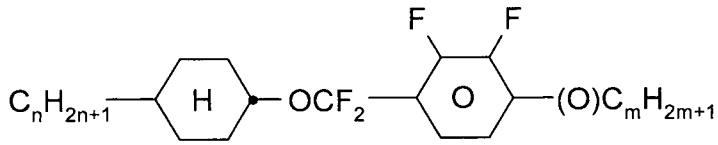

**CPY-n-(O)m**



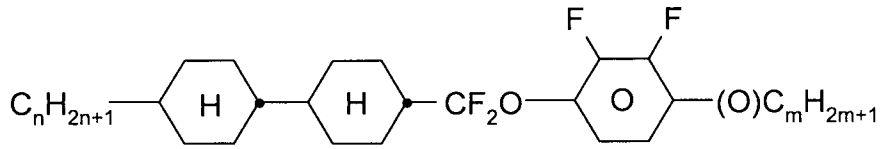

**CPY-V-Om**



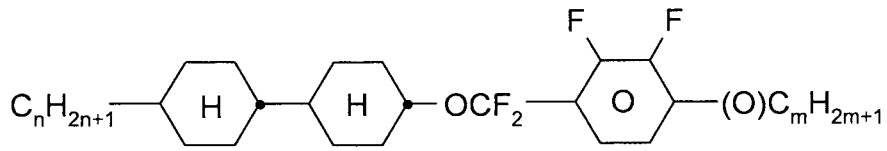

**CQY-n-(O)m**



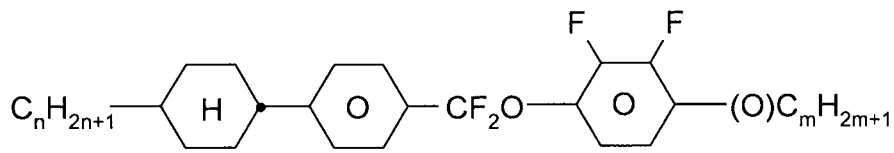

**CQIY-n-(O)m**



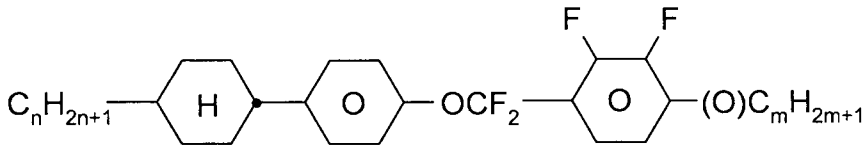

**CCQY-n-(O)m**



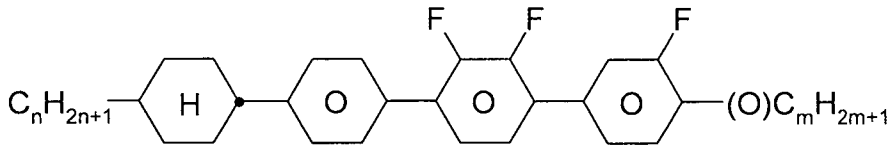

**CCQIY-n-(O)m**



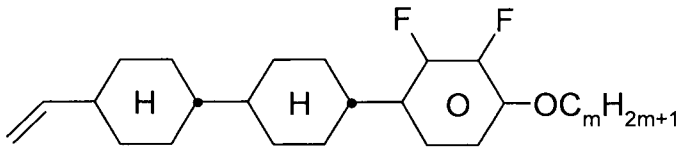

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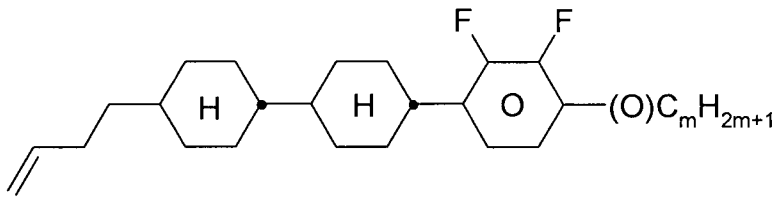
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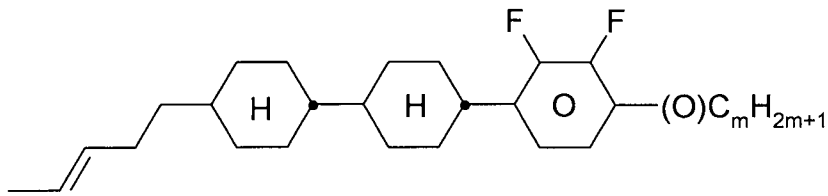
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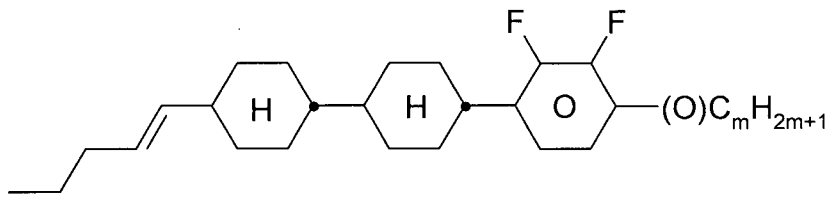
**CCY-V-Om**



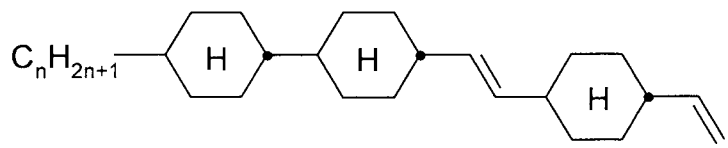
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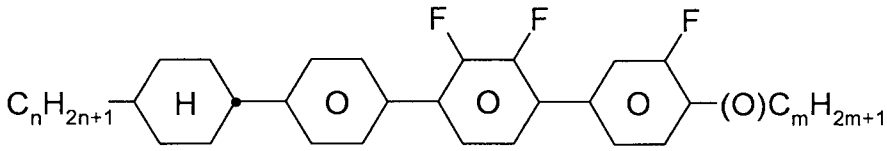
**CCY-1V2-(O)m**



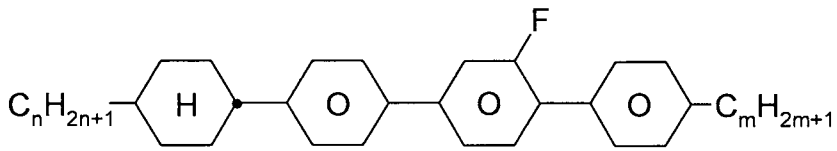
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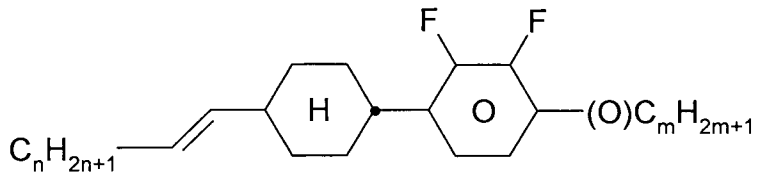
**CCVC-n-V**



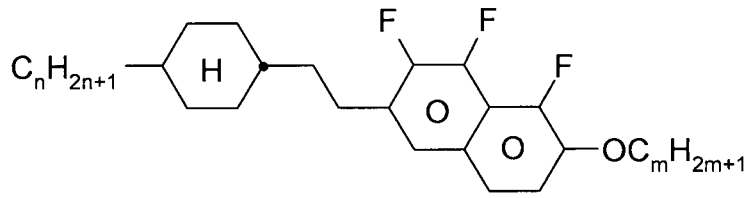

**CPYG-n-(O)m**



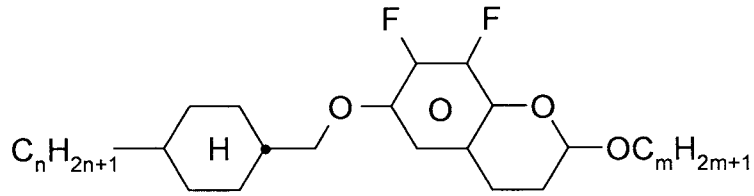

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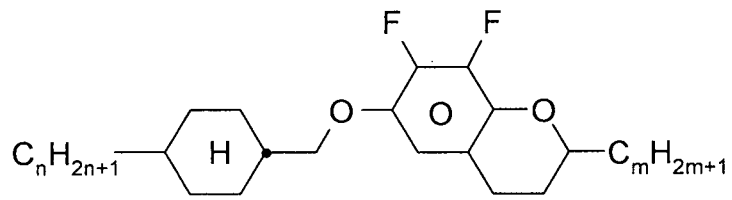

**CY-nV-(O)m**



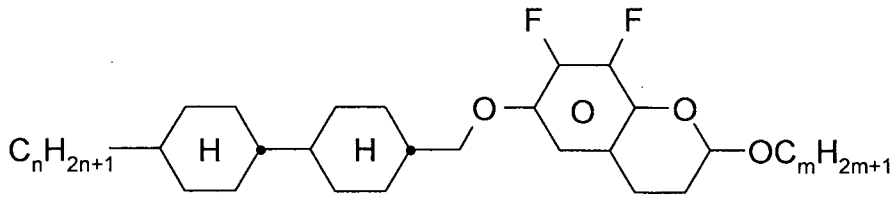

**CENaph-n-Om**



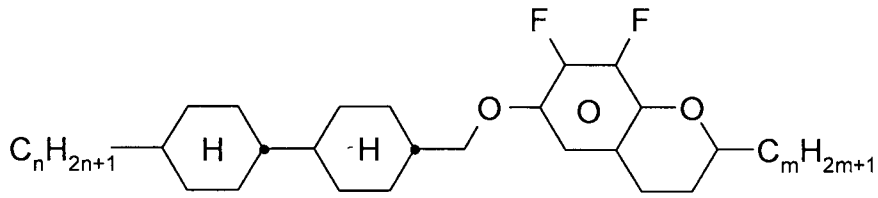

**COChrom-n-Om**



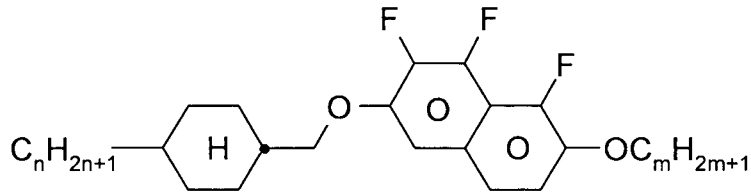

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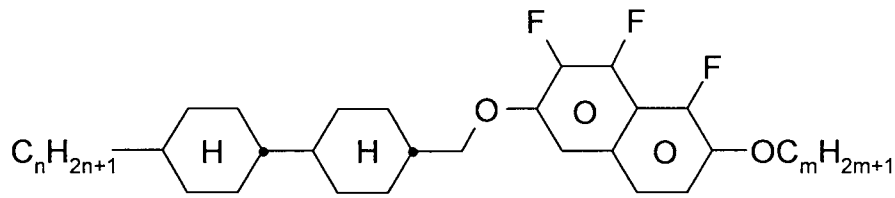
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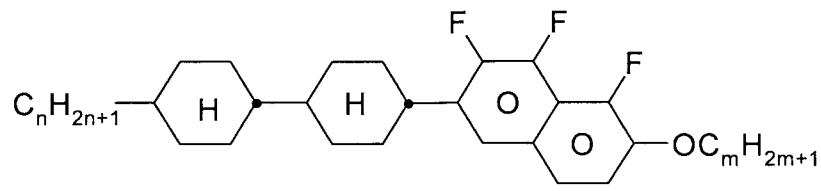
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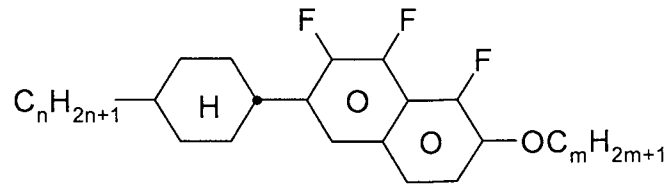
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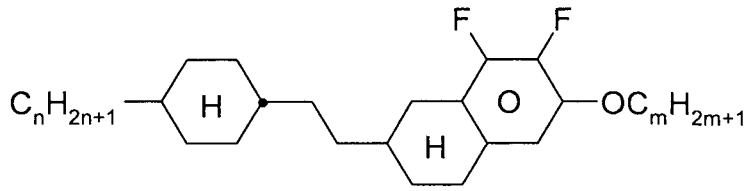
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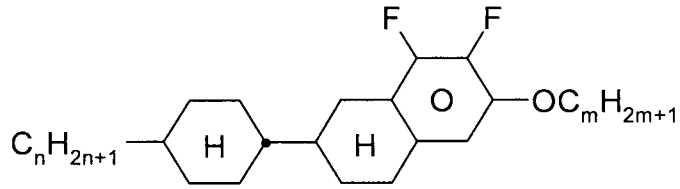
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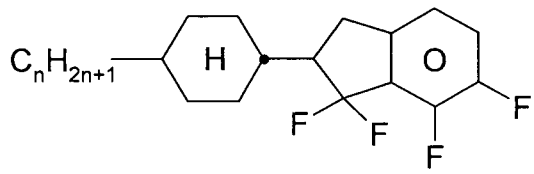
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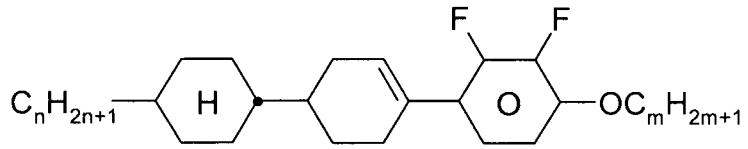

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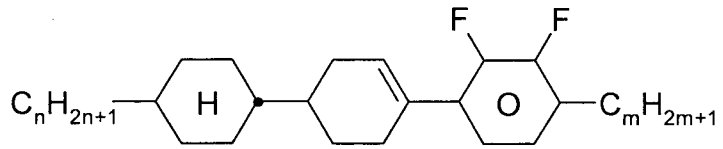

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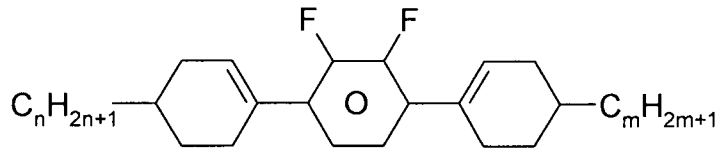

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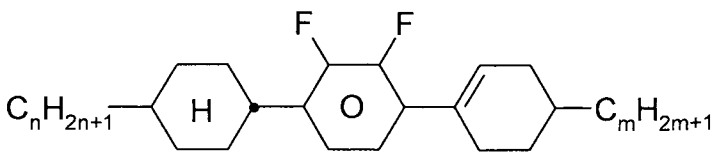

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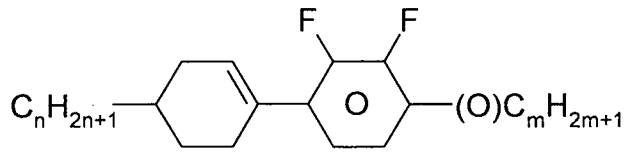

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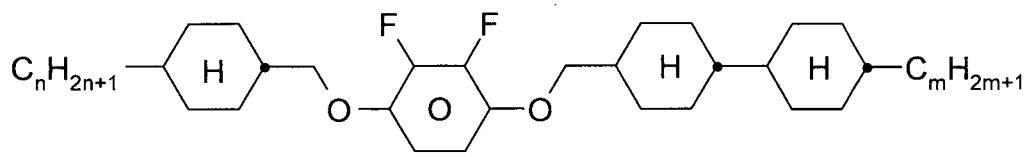

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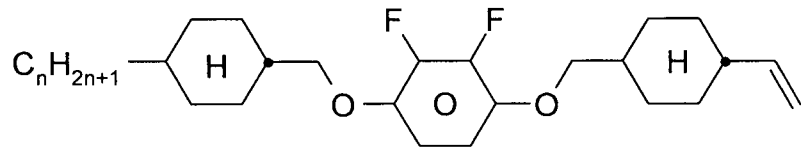
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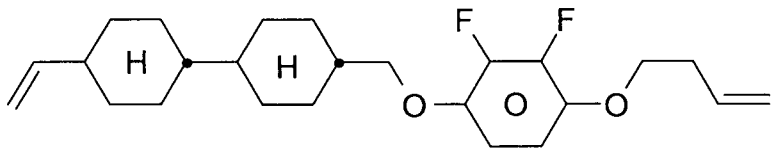
**LY-n-(O)m**



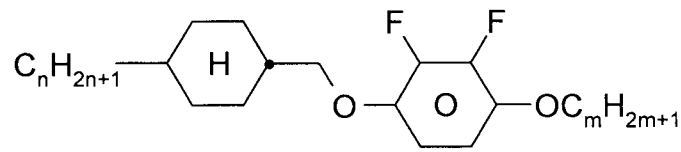
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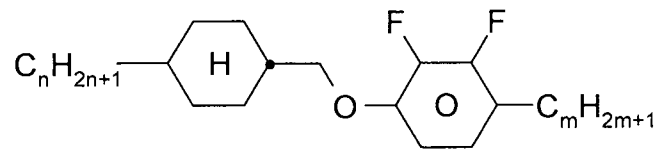
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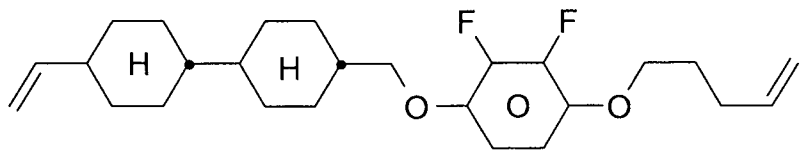
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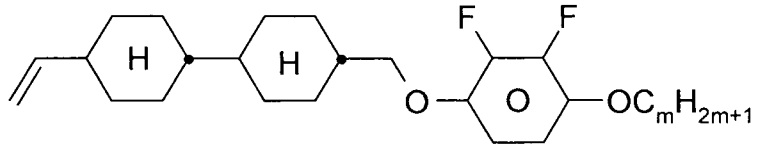
**COY-n-Om**



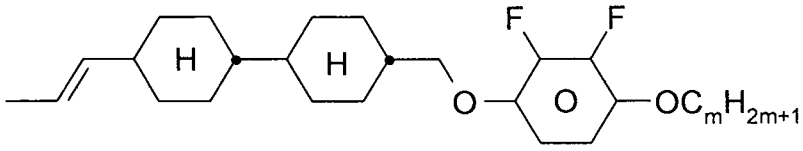
**COY-n-m**



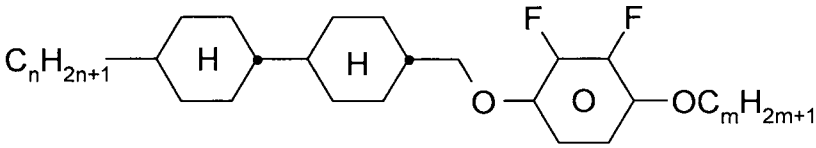
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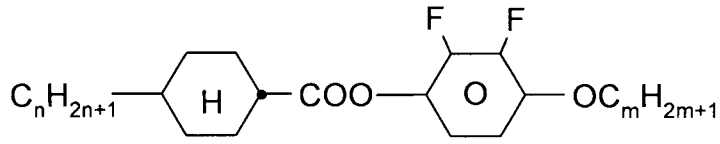
**CCOY-V-Om**



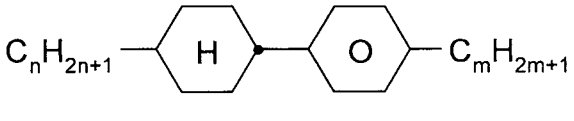
**CCOY-1V-Om**



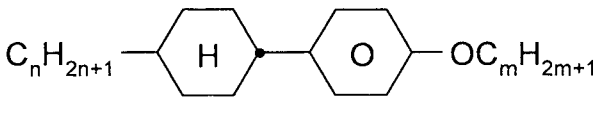
**CCOY-n-Om**



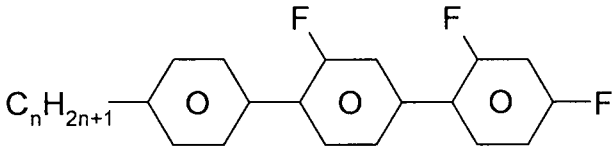
**D-nOmFF**



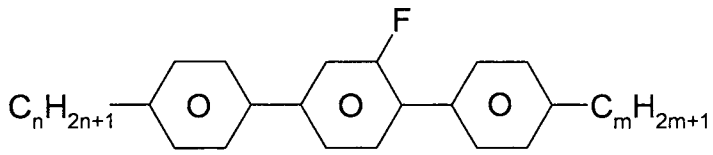
**PCH-nm**



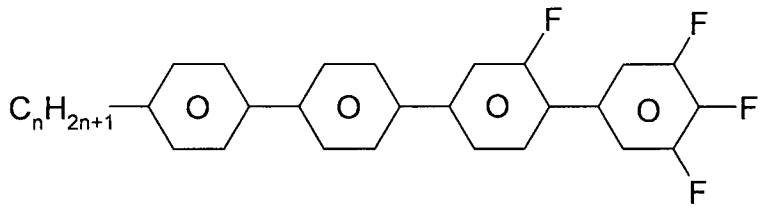
**PCH-nOm**



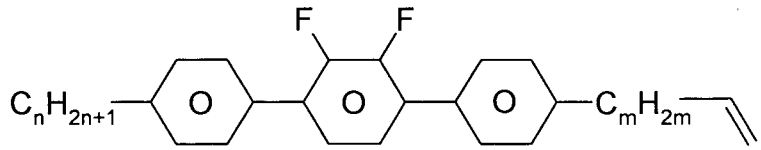
**PGIGI-n-F**



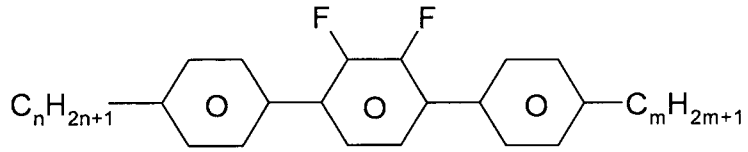
**PGP-n-m**



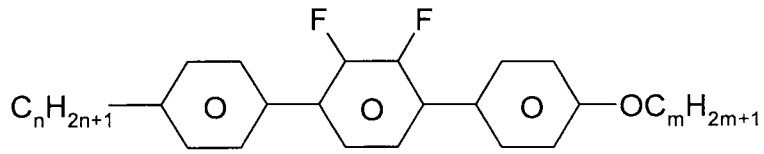
**PPGU-n-F**



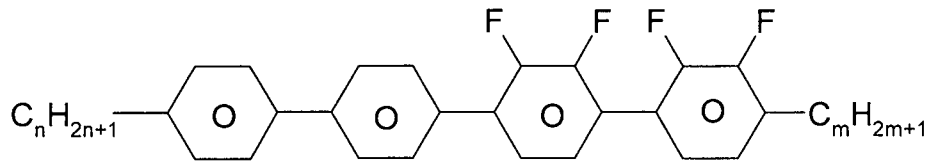
**PYP-n-mV**



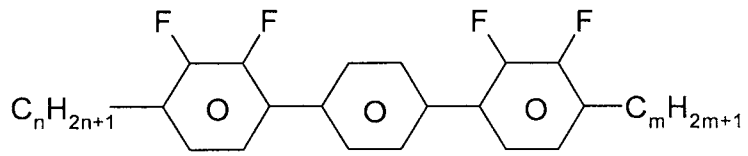
**PYP-n-m**



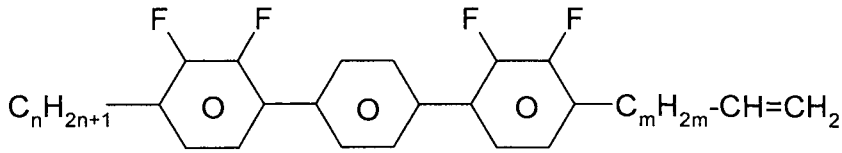
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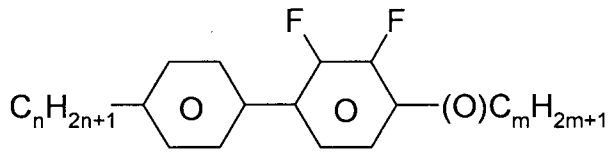
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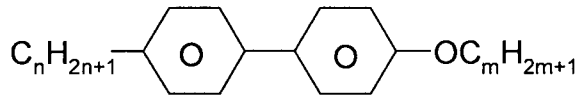
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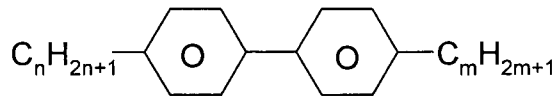
**YPY-n-mV**



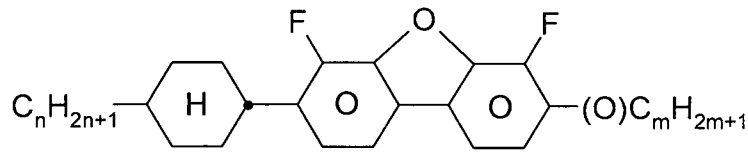
**PY-n-(O)m**



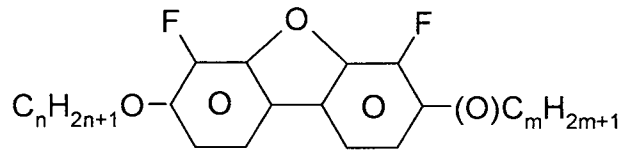
**PP-n-Om**



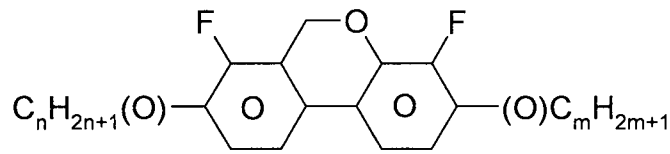
**PP-n-m**



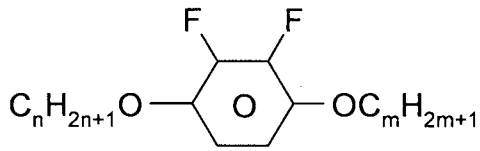
**CB-n-(O)m**



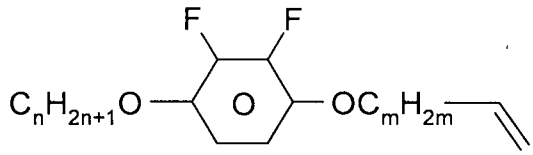
**B-nO-(O)m**



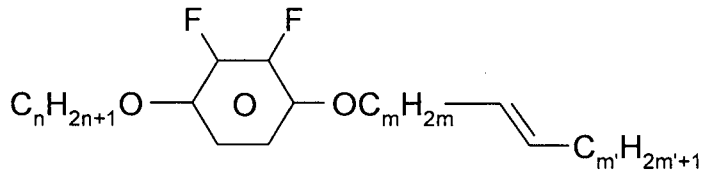
**DFDBC-n(O)-(O)m**



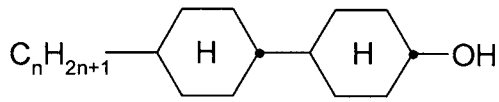
**Y-nO-Om**



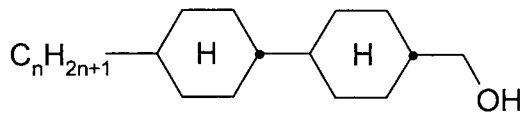
**Y-nO-OmV**



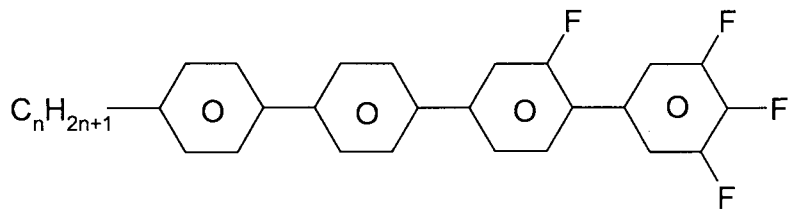
**Y-nO-OmVm'**



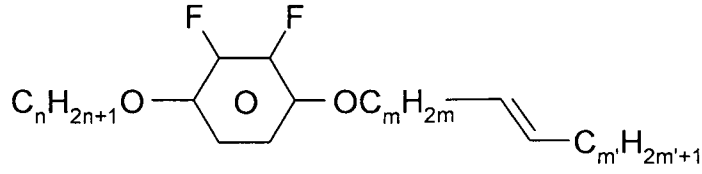
**CC-n-O**



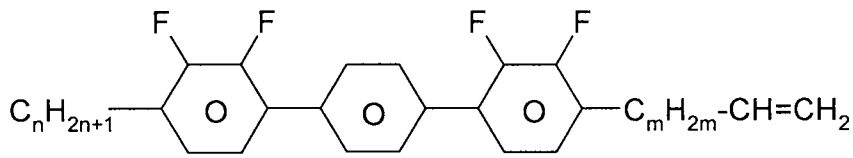
**CC-n-1O**



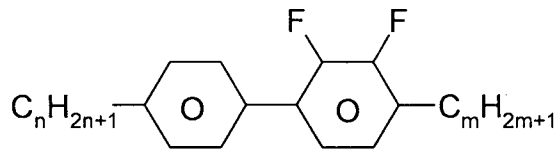
**PPGU-n-F**



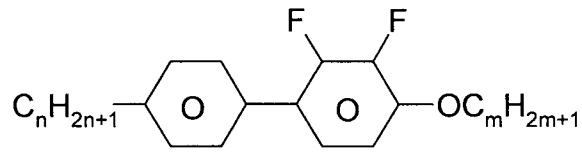
**Y-nO-OmVm'**



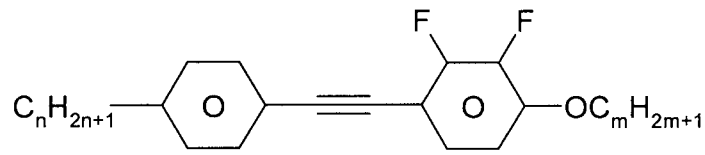

**YPY-n-mV**



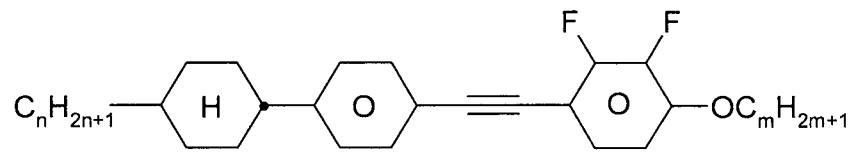

**PY-n-m**



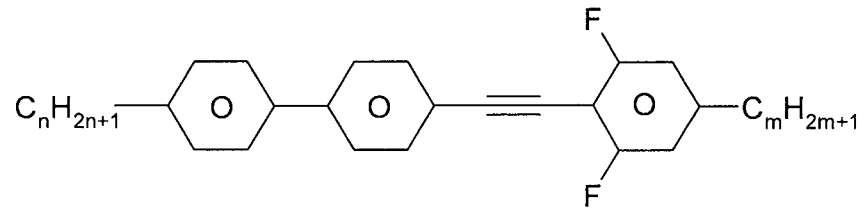

**PY-n-Om**



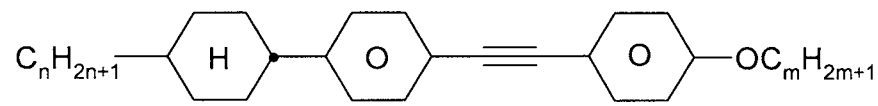

**PTP-nOmFF**



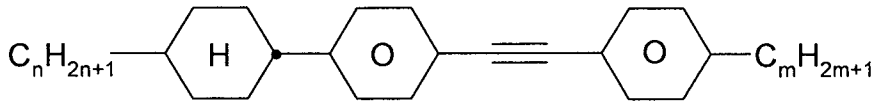

**CPTP-nOmFF**



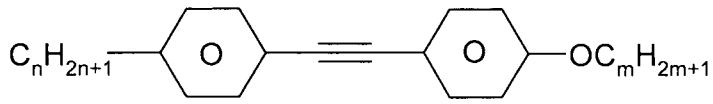

**PPTUI-n-m**



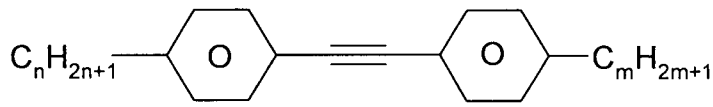

**CPTP-nOm**



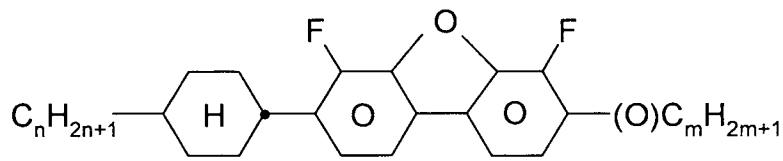
**CPTP-nm**



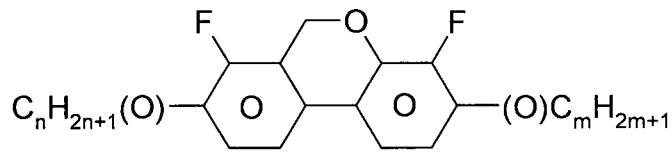
**PTP-nOm**



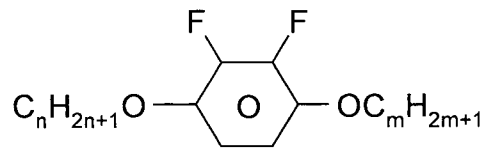
**PTP-nm**



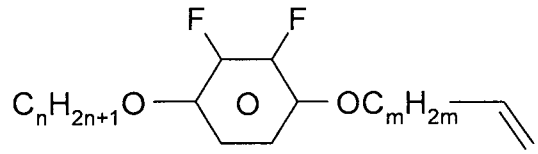
**C-DFDBC-n-(O)m**



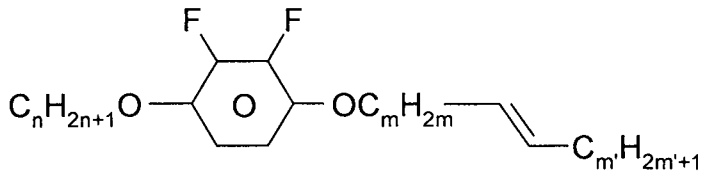
**DFDBC-n(O)-(O)m**



**Y-nO-Om**



**Y-nO-OmV**



**Y-nO-OmVm'**

The liquid-crystal mixtures which can be used in accordance with the invention are prepared in a manner which is conventional per se. In general, the desired amount of the components used in lesser amount is dissolved in the components making up the principal constituent, advantageously at elevated temperature. It is also possible to mix solutions of the components in an organic solvent, for example in acetone, chloroform or methanol, and to remove the solvent again, for example by distillation, after thorough mixing.

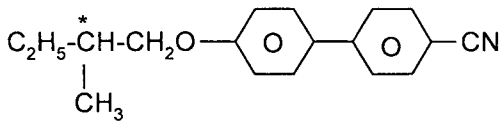
By means of suitable additives, the liquid-crystal phases according to the invention can be modified in such a way that they can be employed in any type of, for example, ECB, VAN, GH or ASM-VA, PS-VA, PM-VA, HT-VA, VA-IPS LCD display that has been disclosed to date.

The dielectrics may also comprise further additives known to the person skilled in the art and described in the literature, such as, for example, UV absorbers, antioxidants, nanoparticles and free-radical scavengers. For example, 0-15% of pleochroic dyes, stabilisers or chiral dopants may be added. Suitable stabilisers for the mixtures according to the invention are, in particular, those listed in Table C.

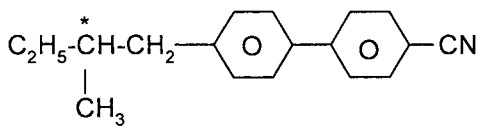
For example, 0-15 % of pleochroic dyes may be added, furthermore conductive salts, preferably ethyldimethyldodecylammonium 4-hexoxybenzoate, tetrabutylammonium tetraphenylboranate or complex salts of crown ethers (cf., for example, Haller et al., Mol. Cryst. Liq. Cryst. Volume 24, pages 249-258 (1973)), may be added in order to improve the conductivity or substances may be added in order to modify the dielectric anisotropy, the viscosity and/or the alignment of the nematic phases. Substances of this type are described, for example, in DE-A 22 09 127, 22 40 864, 23 21 632, 23 38 281, 24 50 088, 26 37 430 and 28 53 728.

Table B shows possible dopants which can be added to the mixtures according to the invention. If the mixtures comprise a dopant, it is employed in amounts of 0.01-4% by weight, preferably 0.1-1.0% by weight.

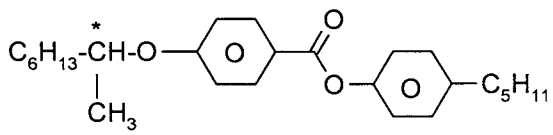
**Table B**



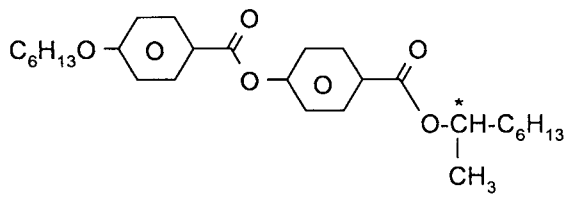
**C 15**



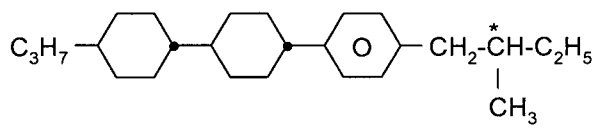
**CB 15**



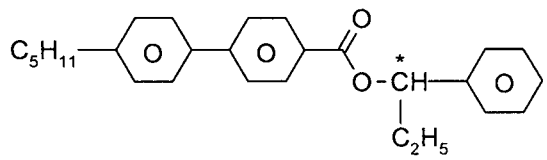
**CM 21**



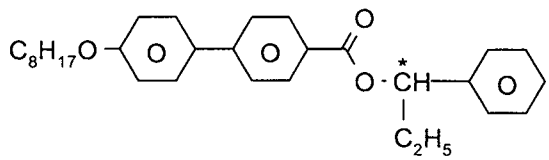
**R/S-811**



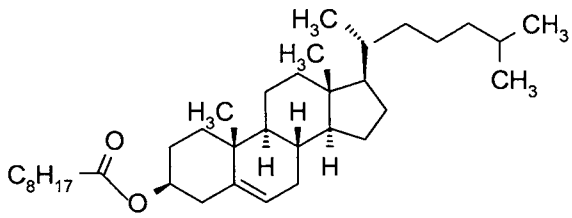
**CM 44**



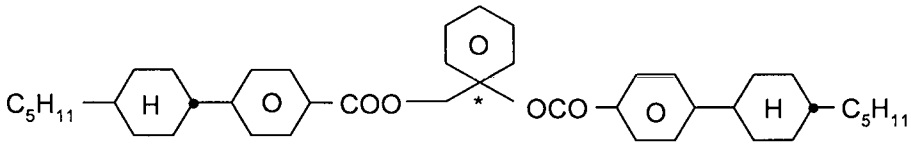
**CM 45**



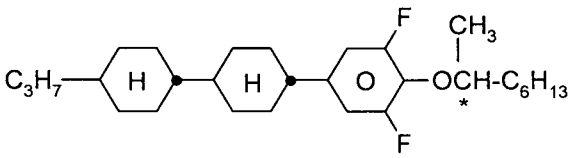
**CM 47**



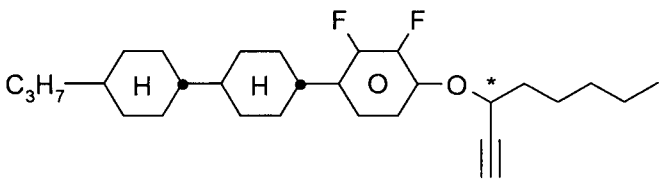
**CN**



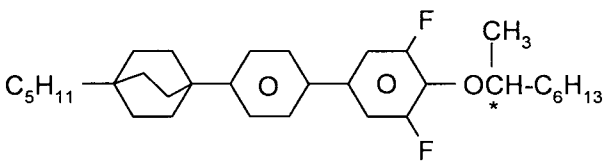
**R/S-1011**



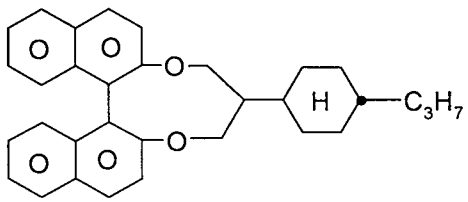
**R/S-2011**



**R/S-3011**



**R/S-4011**

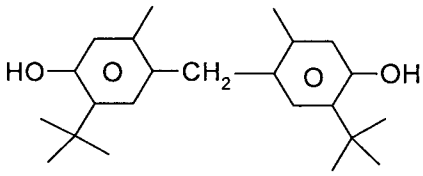


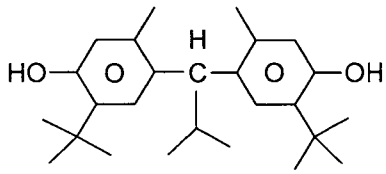
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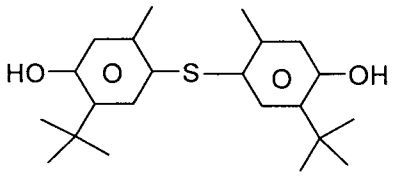
Stabilisers which can be added, for example, to the mixtures according to the invention in amounts of up to 10% by weight, based on the total amount of the mixture, preferably 0.01 to 6% by weight, in particular 0.1 to 3% by weight, are shown below in Table C. Preferred stabilisers are, in particular, BHT derivatives, for example 2,6-di-tert-butyl-4-alkylphenols, and Tinuvin 770, as well as Tunivin P and Tempol.

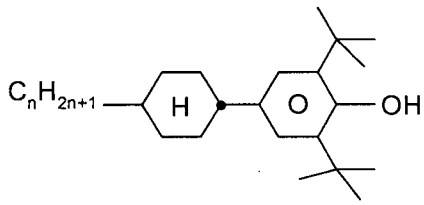
**Table C**

(n = 1-12)

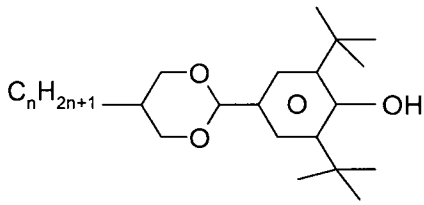




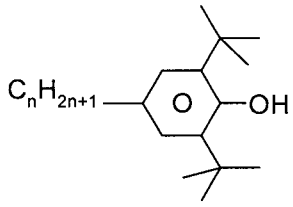


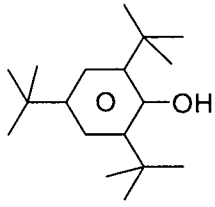


n = 1, 2, 3, 4, 5, 6 or 7

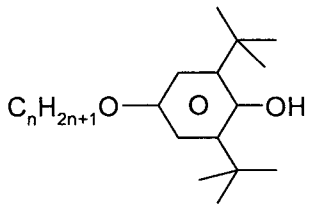


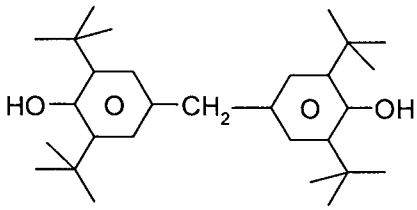
n = 1, 2, 3, 4, 5, 6 or 7

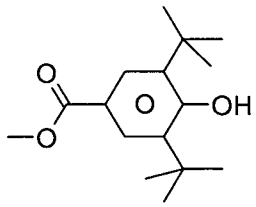


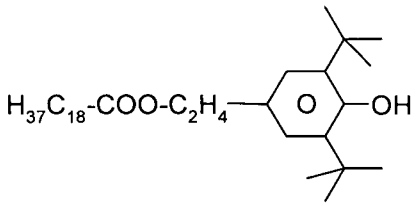


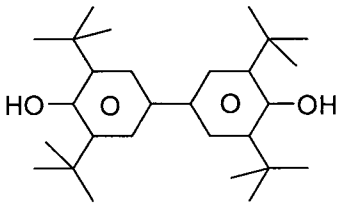
n = 1, 2, 3, 4, 5, 6 or 7

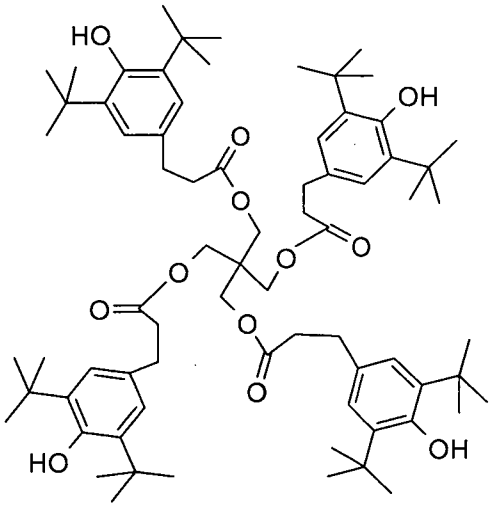

CnH2n+1O
O
OH

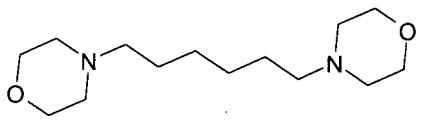

HO
O
CH2
O
OH

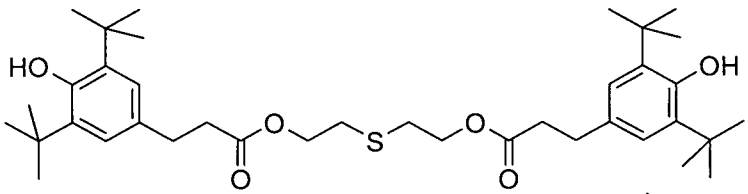

O
O
OH
O

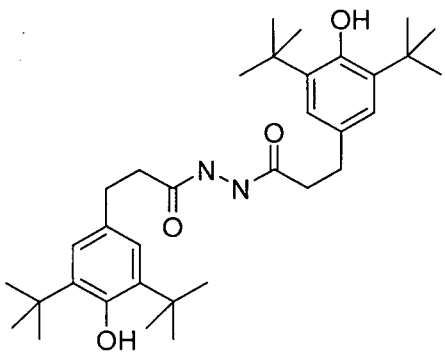

H37C18-COO-C2H4
O
OH

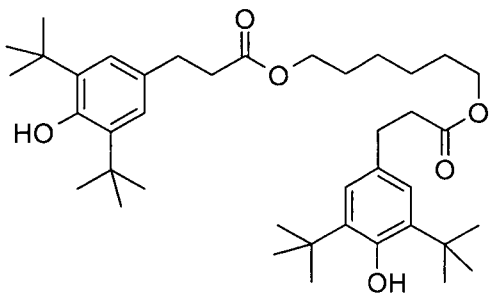

HO
O
O
OH

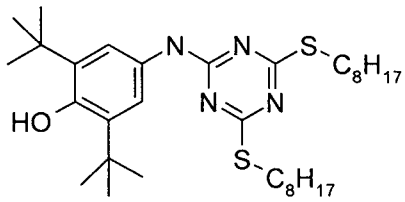

HO
OH
O
O
O
O
O
O
O
HO
OH

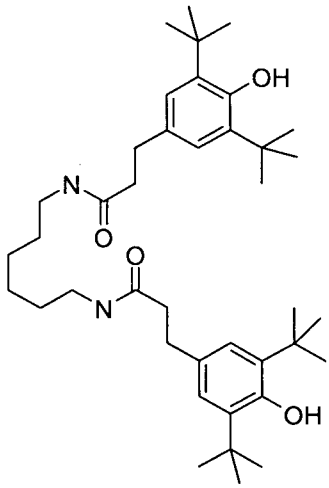

N
O
N
O

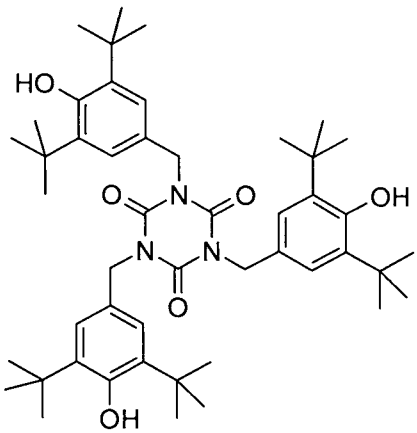

HO
OH
O
S
O
O
O

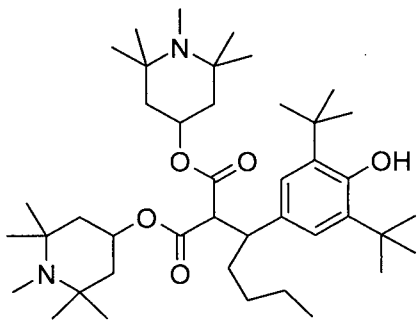

OH
O
N
N
O
OH

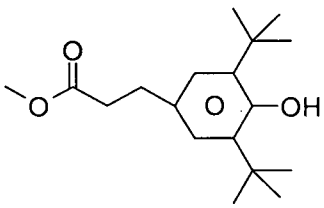

O
O
HO
O
O
OH

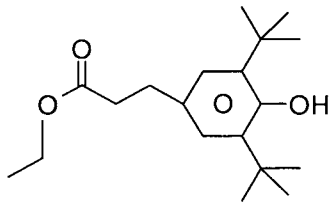


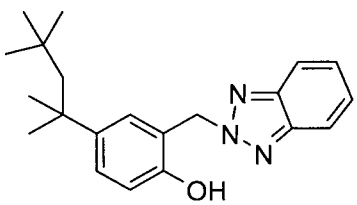


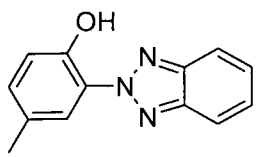


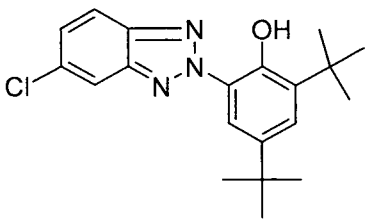


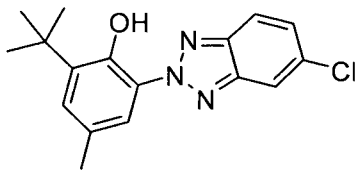


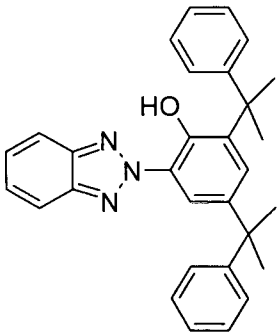


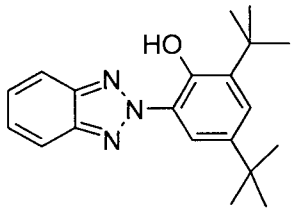


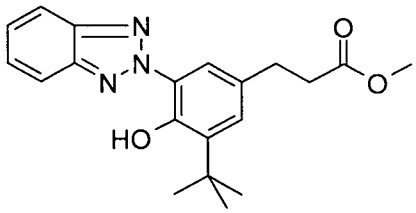


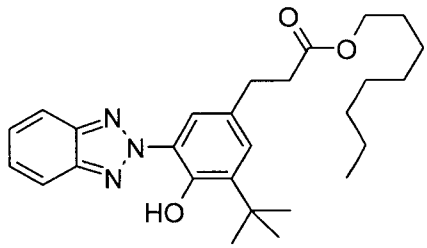


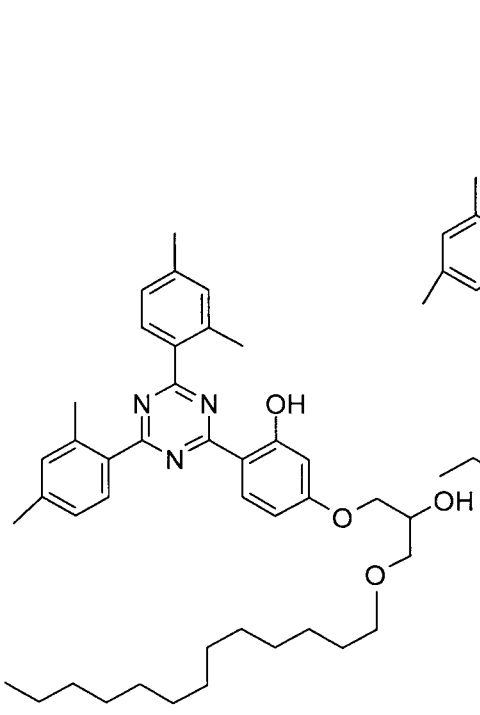


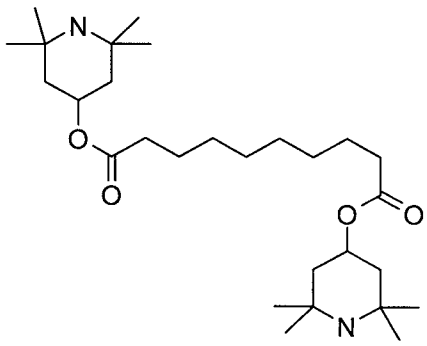


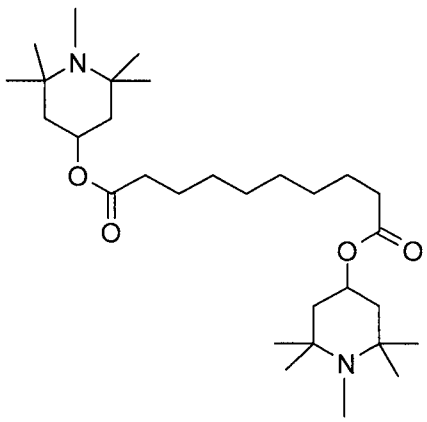


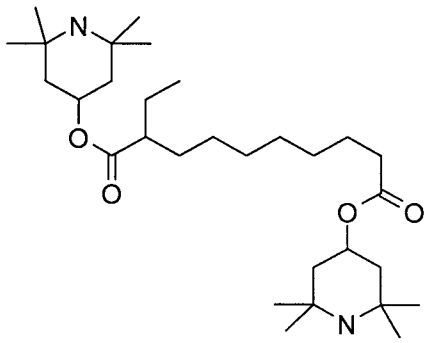


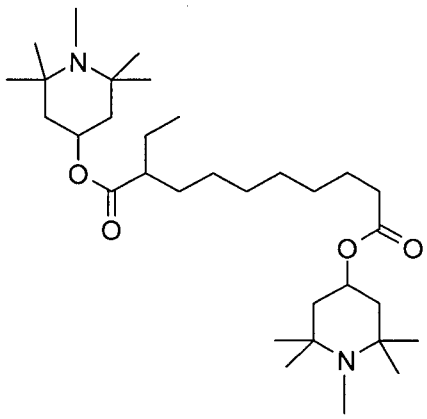


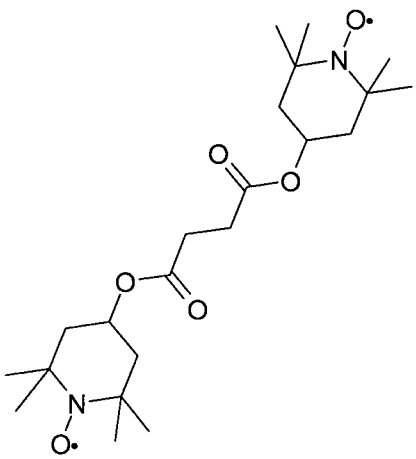


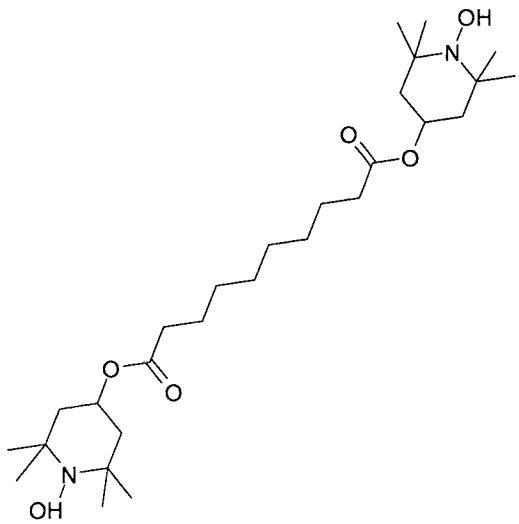






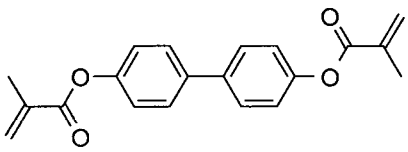
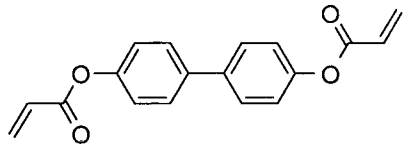
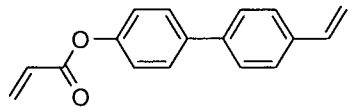
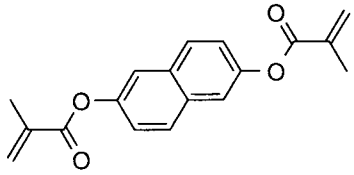
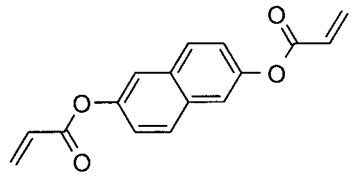
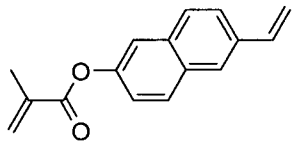
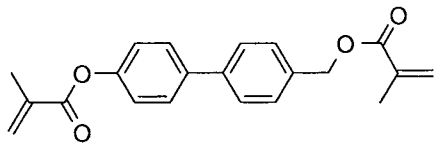
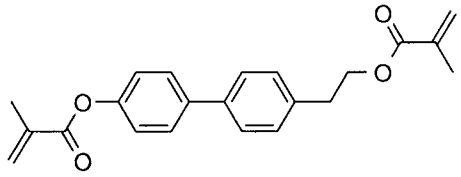
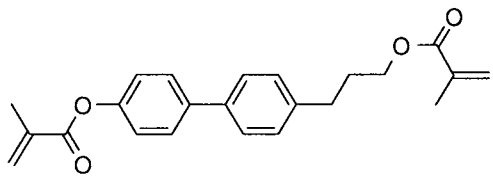


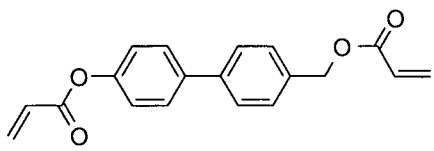




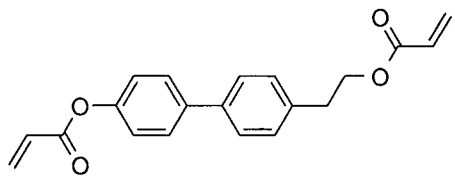
Preferred reactive mesogens (polymerisable compounds) for use in the mixtures according to the invention, preferably in PSA and PS-VA applications are shown in Table D below:

**Table D**

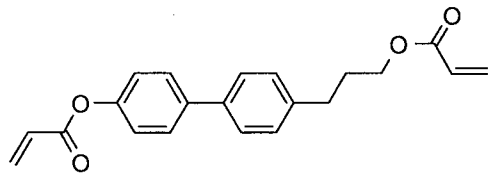
| | |
|---|---|
|  | RM-1 |
|  | RM-2 |
|  | RM-3 |
|  | RM-4 |
|  | RM-5 |
|  | RM-6 |
|  | RM-7 |
|  | RM-8 |
|  | RM-9 |



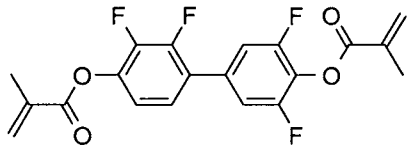
RM-10



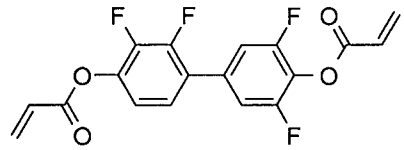
RM-11



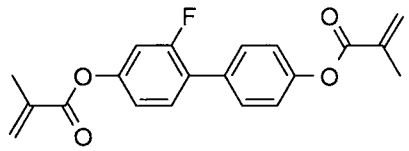
RM-12



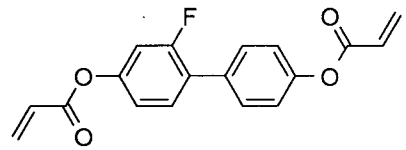
RM-13



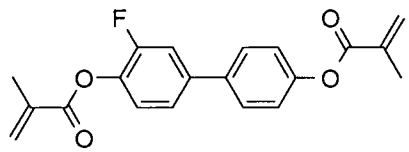
RM-14



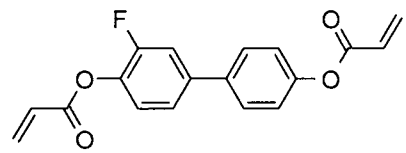
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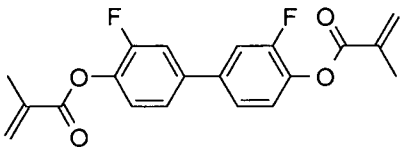
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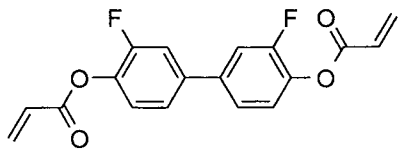
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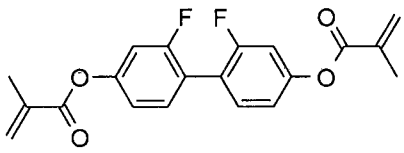
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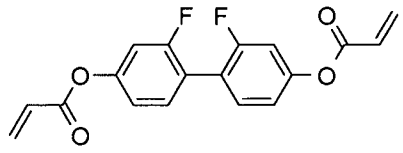
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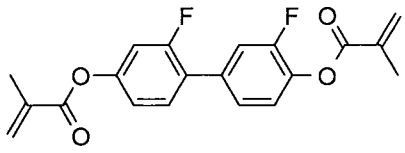
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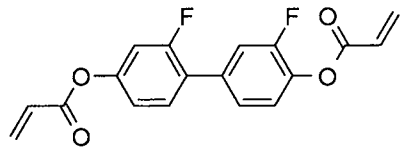
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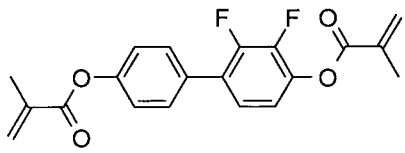
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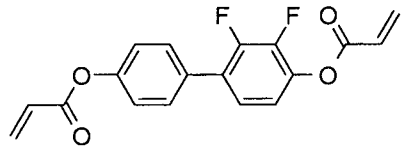
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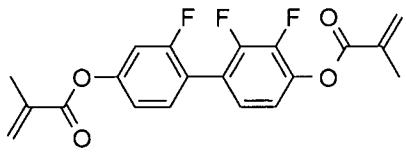
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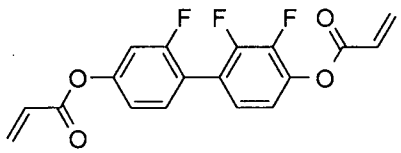
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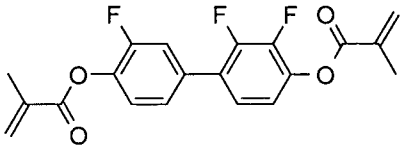
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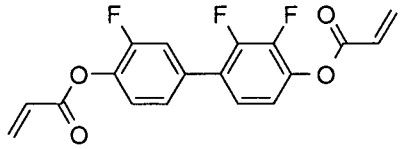
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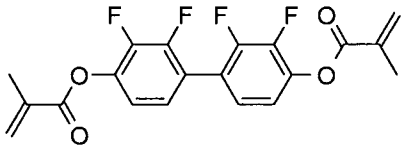
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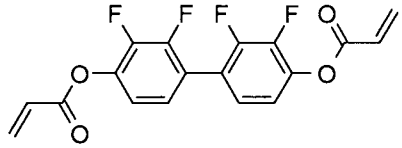
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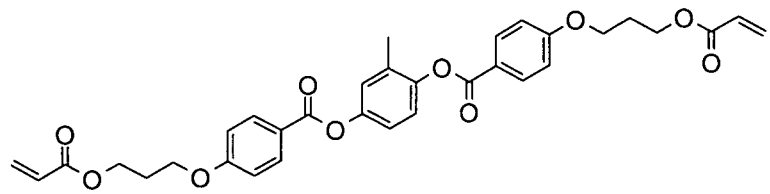
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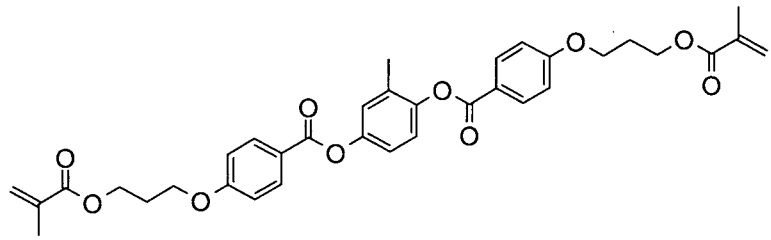
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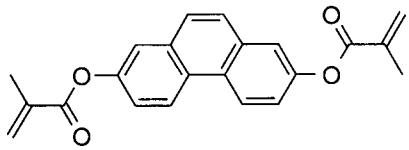
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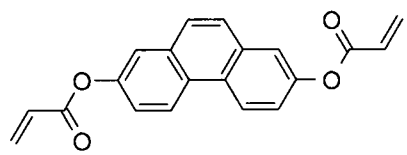
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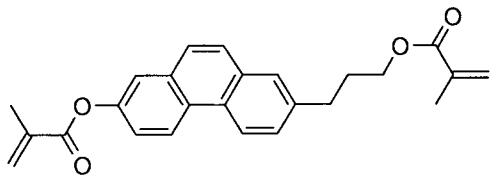
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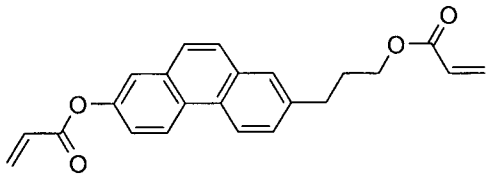
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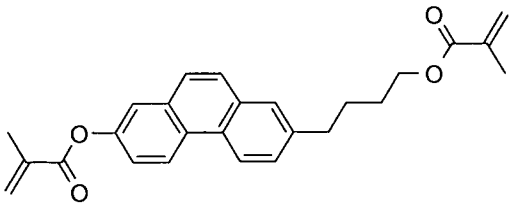
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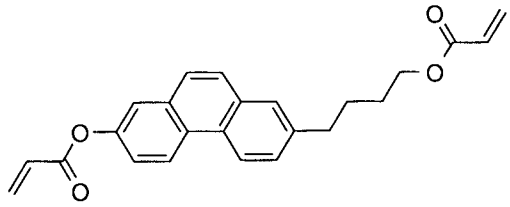
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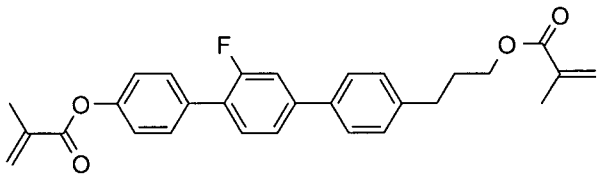
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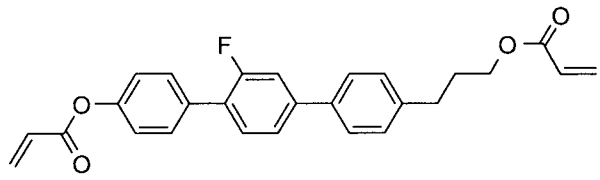
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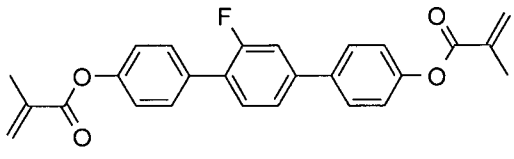
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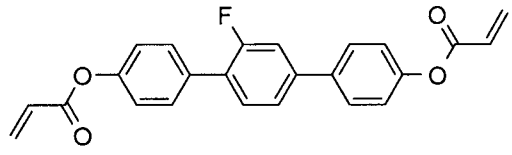
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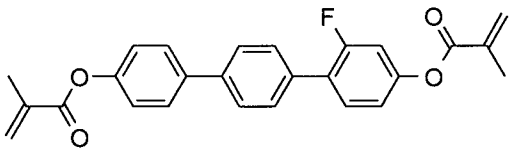
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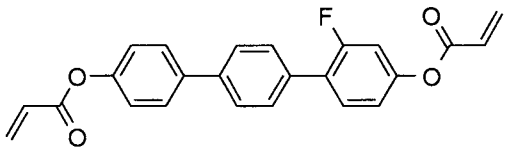
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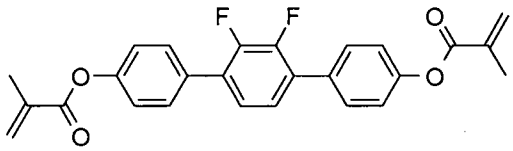
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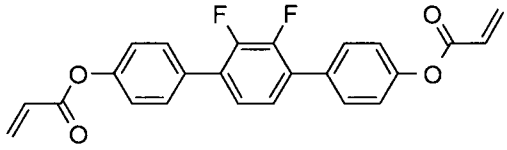
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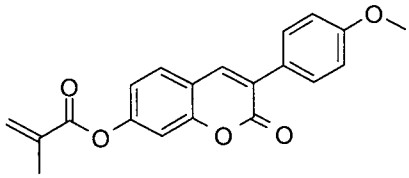
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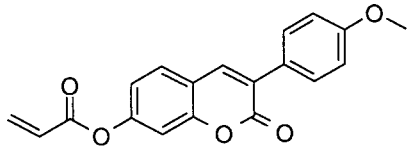
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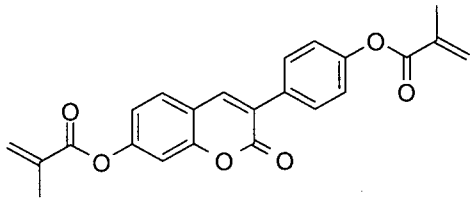
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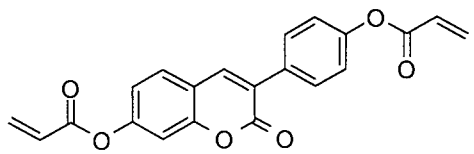
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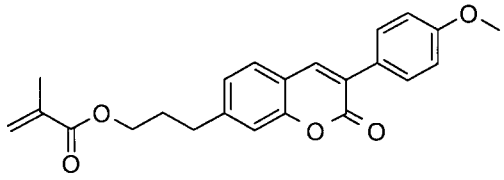
RM-50



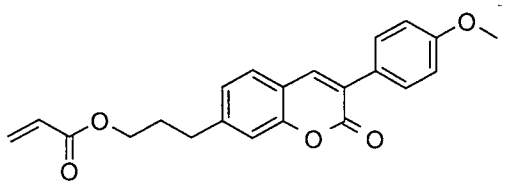
RM-51



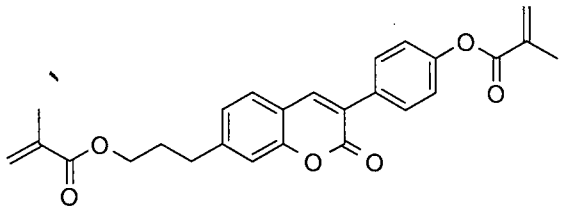
RM-52



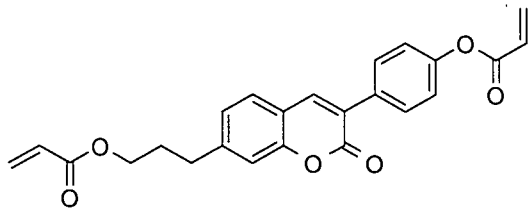
RM-53



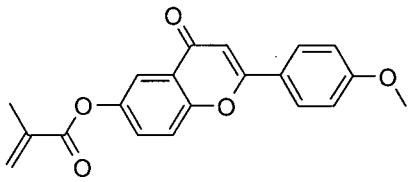
RM-54



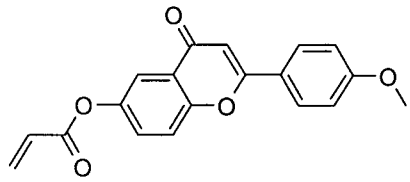
RM-55



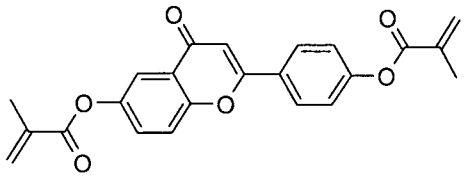
RM-56



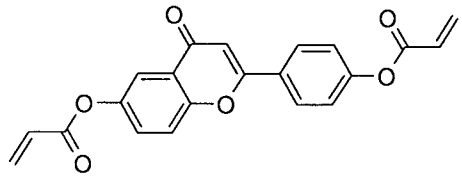
RM-57



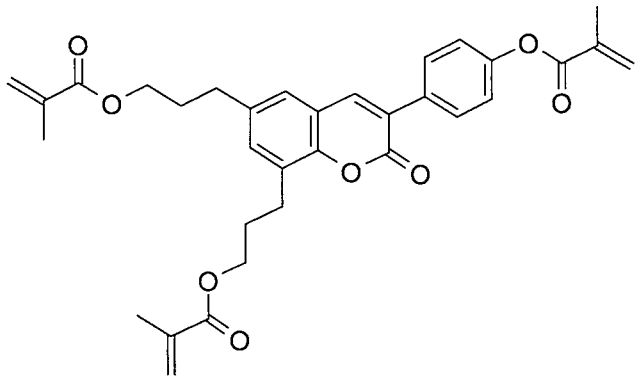
RM-58



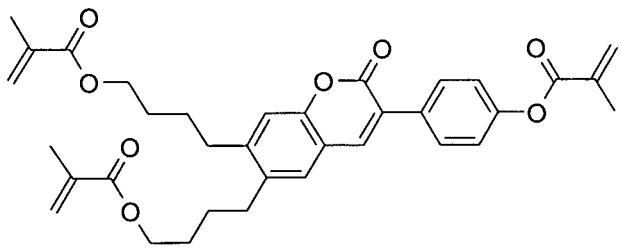
RM-59



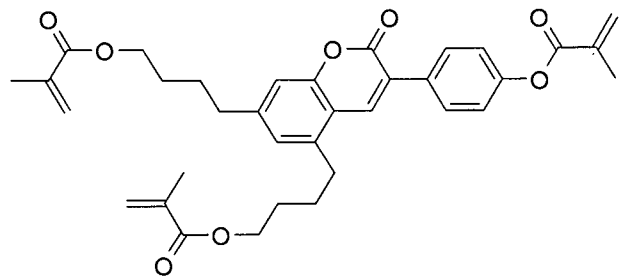
RM-60



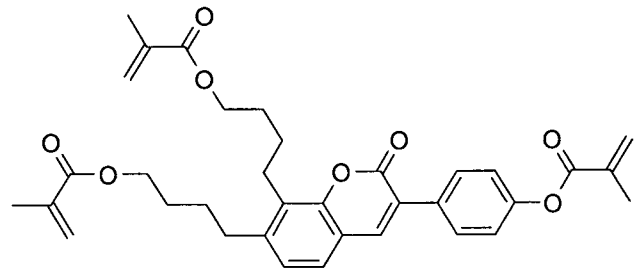
RM-61



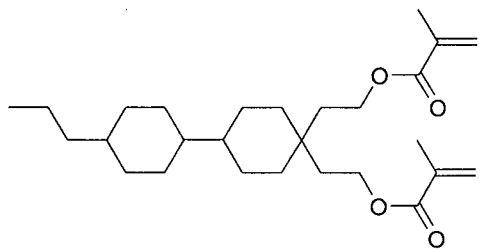
RM-62



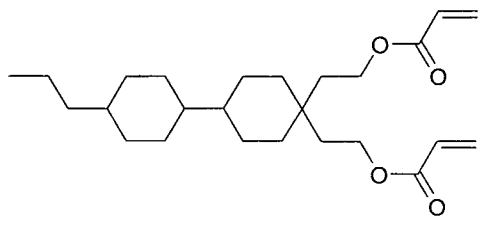
RM-63



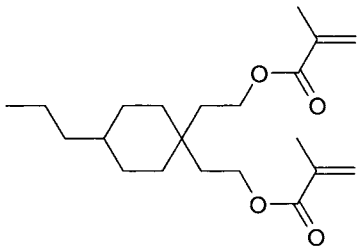
RM-64



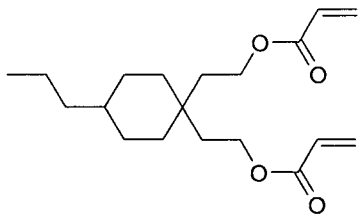
RM-65



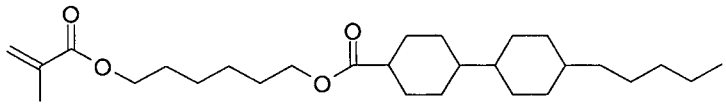
RM-66



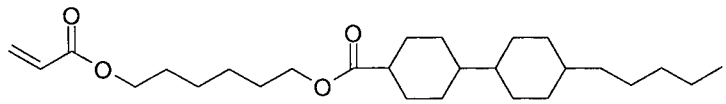
RM-67



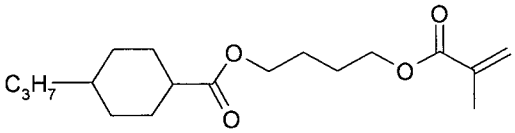
RM-68



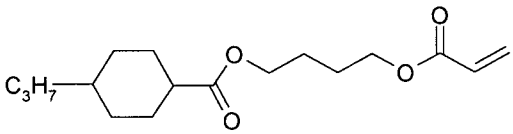
RM-69



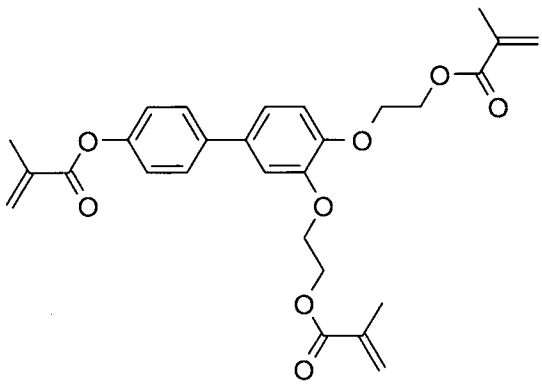
RM-70



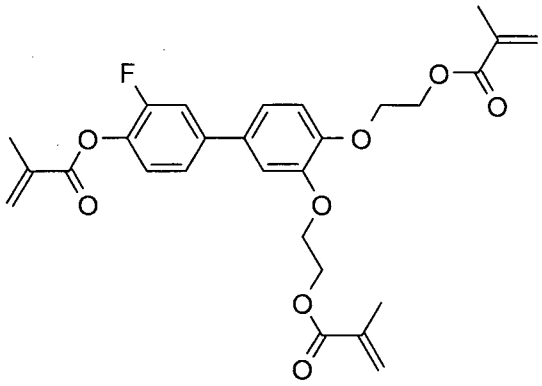
RM-71



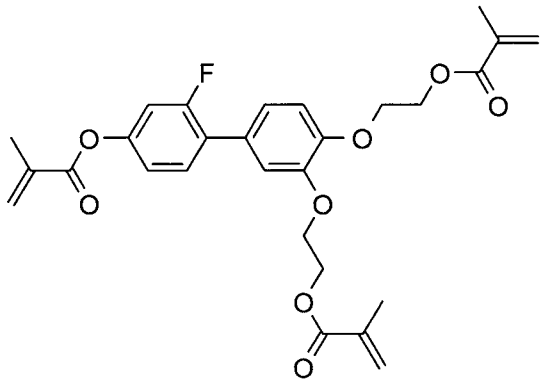
RM-72



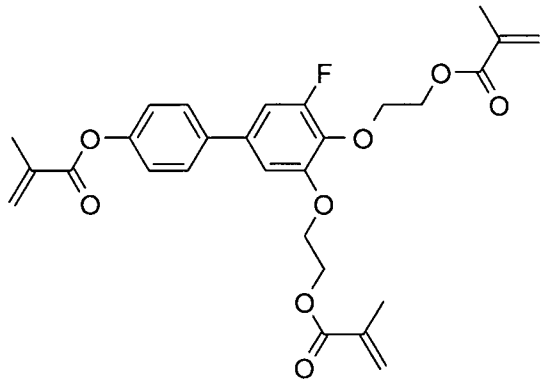
RM-73



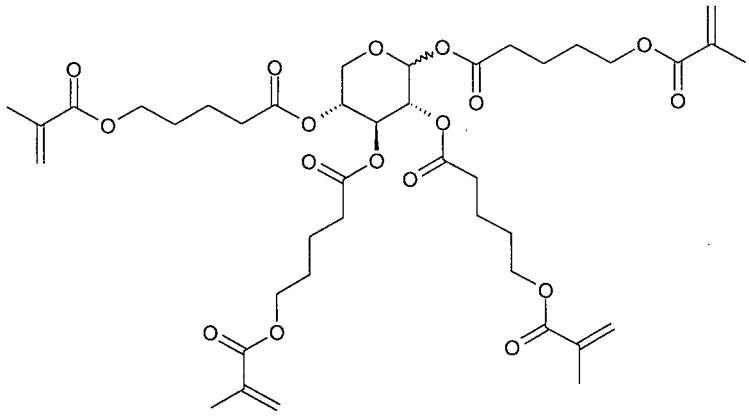
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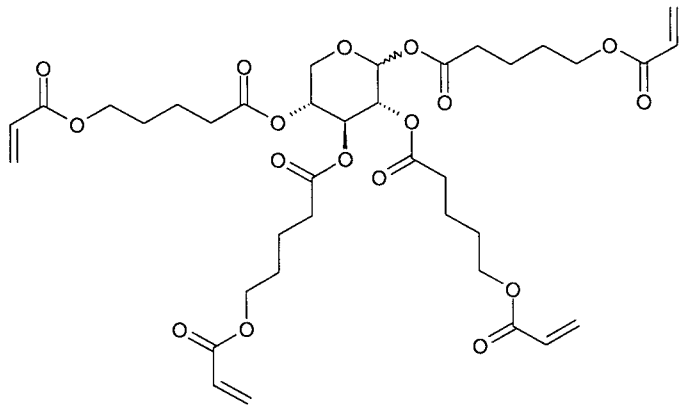
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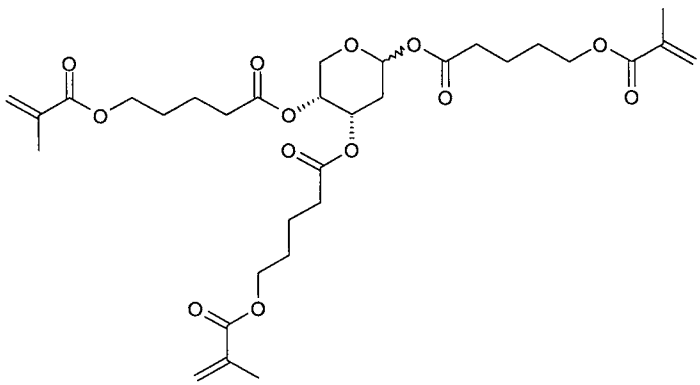
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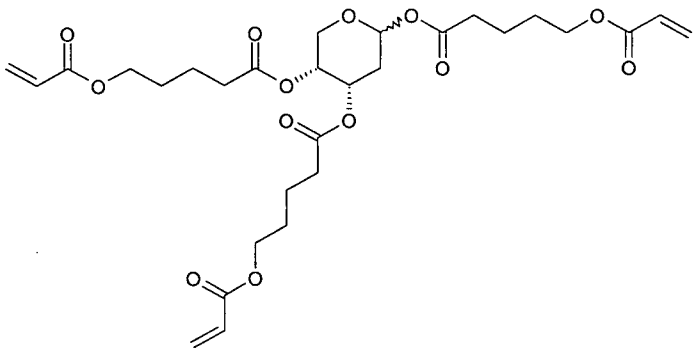
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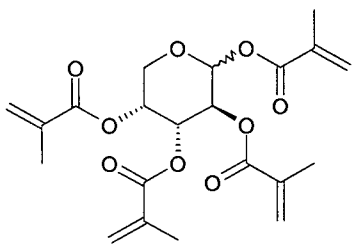
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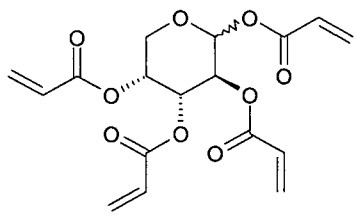
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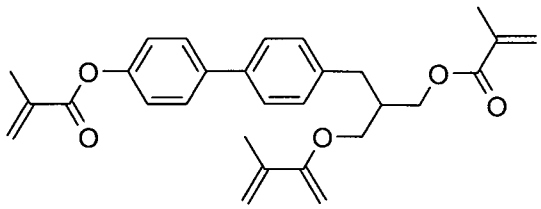
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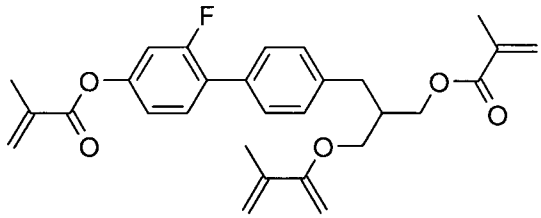
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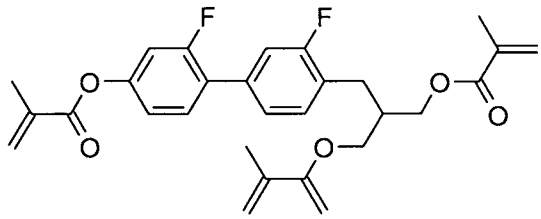
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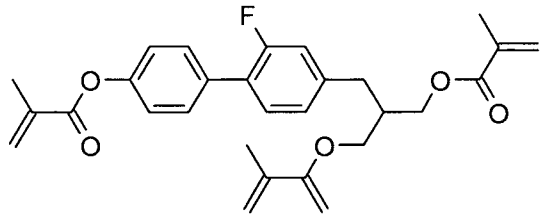
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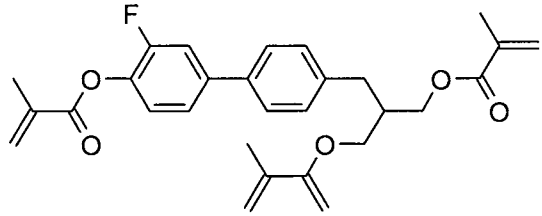
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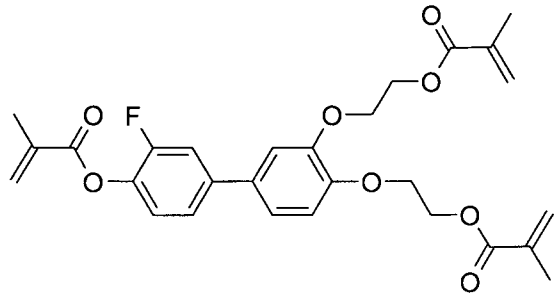
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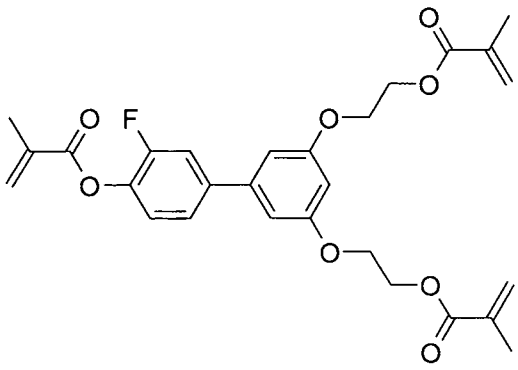
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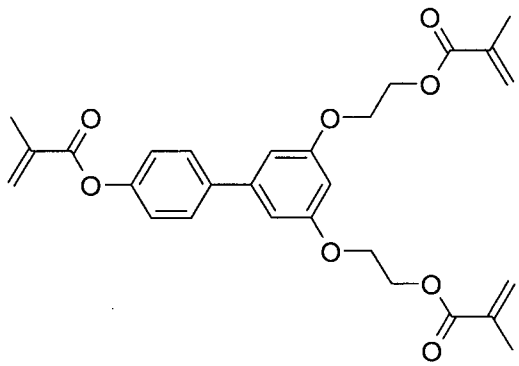
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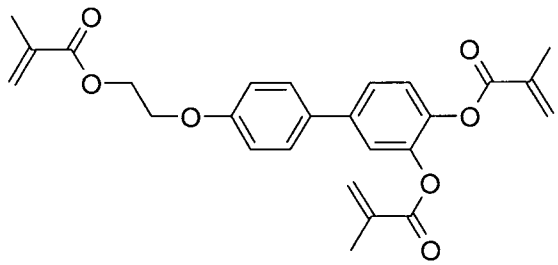
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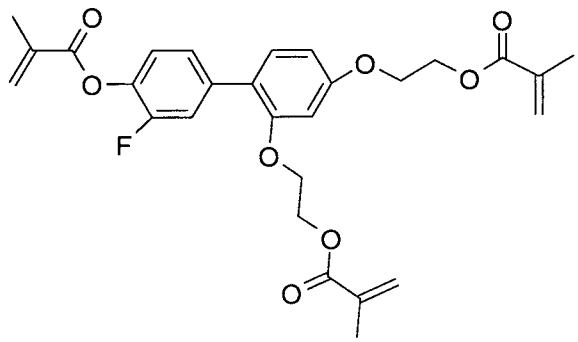
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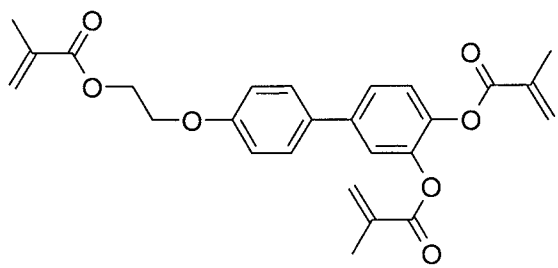
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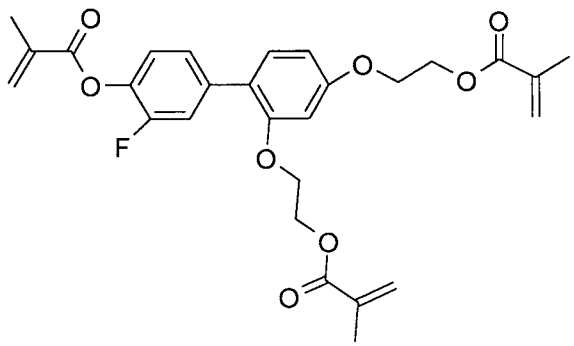
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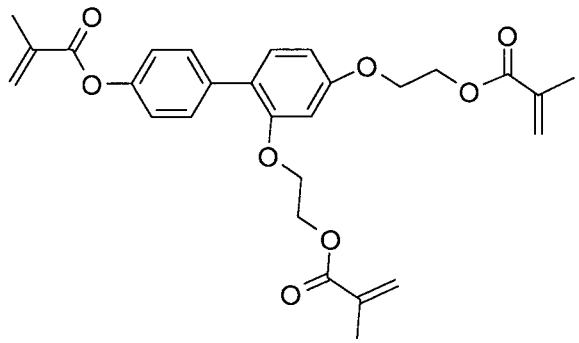
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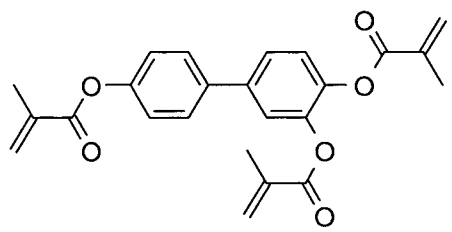
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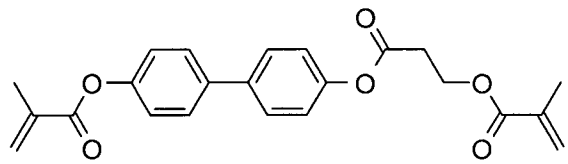
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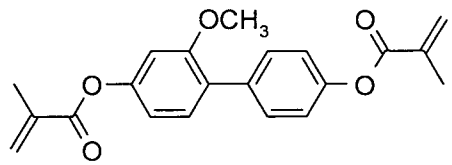
RM-95



RM-96



RM-97



RM-98

## Examples

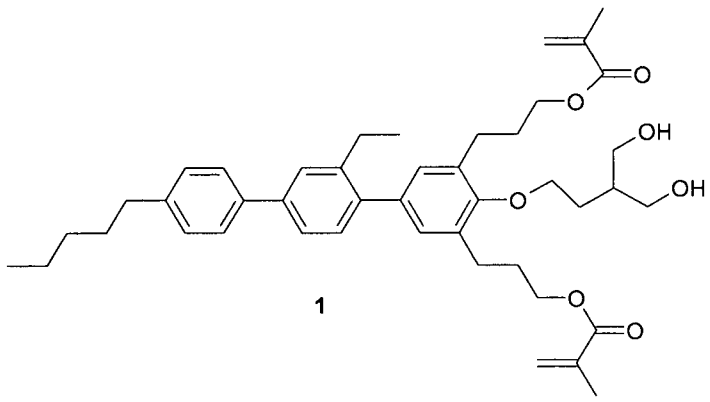
The following examples are intended to explain the invention without restricting it. In the examples, m.p. denotes the melting point and C denotes the clearing point of a liquid-crystalline substance in degrees Celsius; boiling points are denoted by b.p. Furthermore:

C denotes crystalline solid state, S denotes smectic phase (the index denotes the phase type), N denotes nematic state, Ch denotes cholesteric phase, I denotes isotropic phase, $T_g$ denotes glass transition temperature. The number between two symbols indicates the conversion temperature in degrees Celsius.

Conventional work-up means: water is added, the mixture is extracted with methylene chloride, the phases are separated, the organic phase is dried and evaporated, and the product is purified by crystallisation and/or chromatography.

Example 1

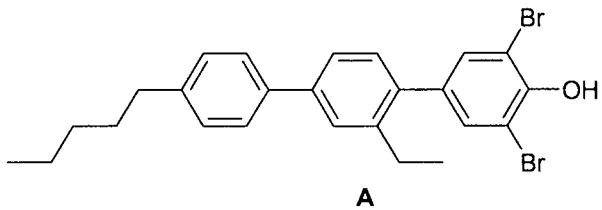
Synthesis of 3-{5-[2-ethyl-4-(4-pentylphenyl)phenyl]-2-[4-hydroxy-3-(hydroxymethyl)butoxy]-3-{3-[(2-methylprop-2-enoyl)oxy]propyl}phenyl}-propyl 2-methylprop-2-enoate **1**




**1**

Step 1.1

Synthesis of 2,6-dibromo-4-[2-ethyl-4-(4-pentylphenyl)-phenyl]phenol **A**

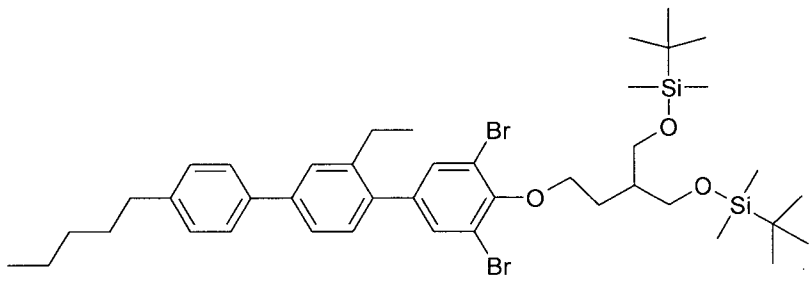



**A**

20.6 g (59.8 mmol) 4-[2-ethyl-4-(4-pentylphenyl)phenyl]phenol are solved in 150 mL dichloromethane (DCM) and 1.50 mL (10.7 mmol) diisoproplyamine are added dropwise. The reaction mixture is cooled with dry ice / acetone to -5°C and a solution of 21.6 g (121 mmol) N-bromosuccinimide in 300 mL DCM is added dropwise. The reaction mixture is then stirred for 18 h at room temperature, washed successively with water. The water layers are extracted with dichloromethane and the combined organic layers are dried over $Na_2SO_4$, filtered and evaporated under vacuum. The crude product is purified with column filtration over 600g silica gel with toluene / heptane (1:1 + 1% triethylamine). The product is combined, evaporated under vacuum and crystallized at -30°C in heptane to give the product as a slightly yellow powder with a purity of >99 % (gas chromatography).

Step 1.2

Synthesis of 6-[2-2,6-dibromo-4-[2-ethyl-4-[4-pentylphenyl] phenyl]-phenoxy}ethyl)-2,2,3,3,9,9,10,10-octamethyl-4,8-dioxa-3,9-disilaundecane **B**



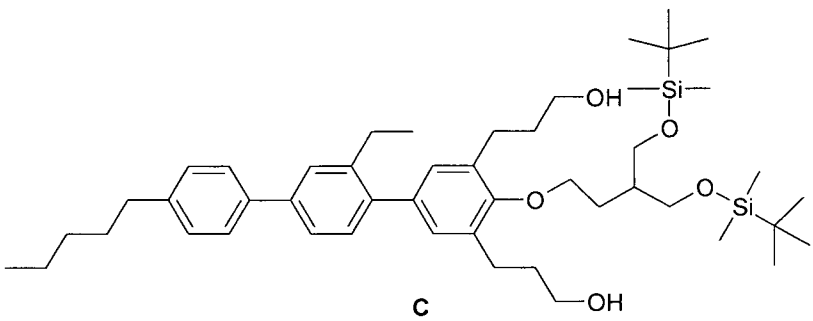

**B**

23.8 g (47.0 mmol) 2,6-dibromo-4-[2-ethyl-4-(4-pentylphenyl)phenyl]-phenol A, 20.7 g (59.0 mmol) 4-(tert-butyl-dimethylsilanyloxy)-3-(tert.-butyl-dimethyl-silanyloxymethyl]-butane-1-ol and 15.7 g (59.9 mmol) triphenylphosphine are solved in 155 mL tetrahydrofuran (THF) and 12.6 ml (64.2 mmol) diisopropyl azodicarboxylate are added dropwise and the reaction mixture is stirred for 16 h at room temperature. The reaction mixture is evaporated under vacuum and filtered with a mixture of heptane

(H) / dichlormethane (DCM) (3:1) over 200 ml silica gel. The product is a colourless oil.

Step 1.3

Synthesis of 3-(2-{4-[(tert-butyldimethylsilyl)oxy]-3-{[(tert.-butyl-dimethylsilyl)oxy]methyl}butoxy}-5-[2-ethyl-4-(4-pentyl-phenyl)-phenyl]-3-(3-hydroxypropyl)phenyl)propan-1-ol **C**

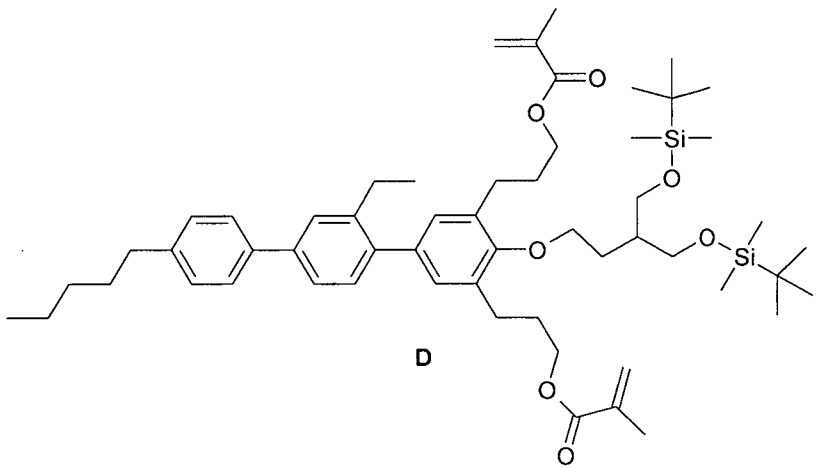



C

20.1 g (190 mmol) $Na_2CO_3$, 39.0 g (47.0 mmol) bromide **B** and 26.5 g (187 mmol) 2-butoxy-1,2-oxaborolane and 0.45 ml (3.28 mmol) triethylamine are solved in a mixture of 110 ml water and 570 ml tetrahydrofuran (THF). The reaction mixture is degassed for 45 min and 655 mg (1.40 mmol) 2-dicyclohexylphosphino-2´-6´-di-isopropoxy-1-1´-biphenyl and 415 mg (2.34 mmol) palladium (II)-chloride are added. The reaction mixture is then stirred at 80 °C for 16 h, cooled to room temperature, water is added and the mixture is extracted with methyl-tertiary-butylether (MTBE). The organic layer is separated, the water layer is extracted with MTBE and the combined organic layers are washed with brine, dried over $Na_2SO_4$, filtered and evaporated under vacuum. The crude product is purified with column filtration over 1.1 l silica gel with a mixture of toluene / ethyl acetate (EE) (4:1). The obtained product is a colourless oil.

Step 1.4

Synthesis of 3-(2-{4-[(tert-butyldimethylsilyl)oxy]-3-{[(tert-butyl-dimethylsilyl)oxy]methyl}butoxy}-5-[2-ethyl-4-(4-pentylphenyl)-phenyl]-3-{3-[(2-methylprop-2-enoyl)oxy]propyl}phenyl)propyl 2-methylprop-2-enoate **D**

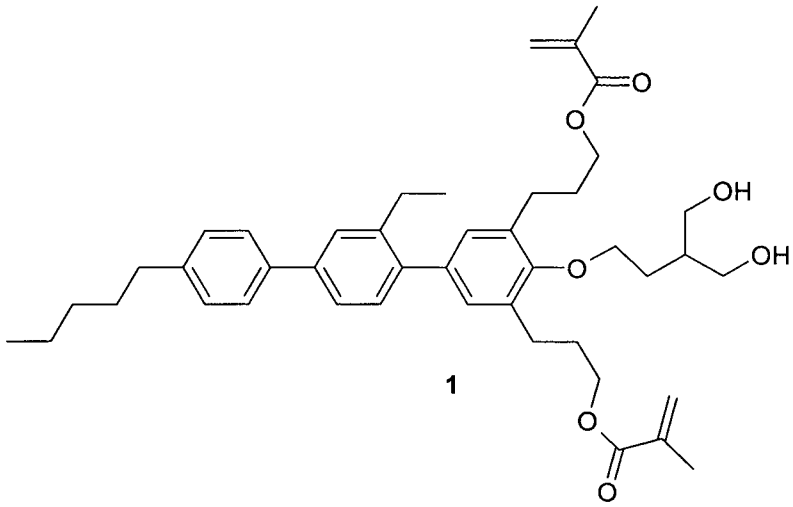


**D**

25.3 g (32.0 mmol) alcohol C, 11.7 ml (138 mmol) methacrylic acid and 430.0 mg (3.52 mmol) 4-(dimethylamino)-pyridine are solved in 320 ml dichloromethane and cooled to 0 °C. 23.4 ml (136 mmol) 1-(-3-dimethylaminopropyl)-3-ethylcarbodiimide in 110 ml dichloro-methane (DCM) are added dropwise and the reaction mixture is stirred for 16 hours (h) at room temperature (RT). The mixture is evaporated under vacuum and filtered over 900 g silica gel with a mixture of DCM / MTBE (9:1). The obtained product is a colourless oil.

Step 1.5

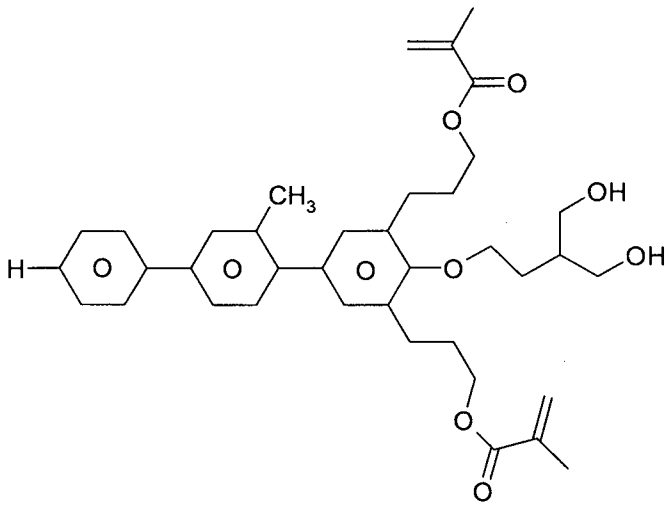
Synthesis of 3-{5-[2-ethyl-4-(4-pentylphenyl)phenyl]-2-[4-hydroxy-3-(hydroxymethyl)butoxy]-3-{3-[(2-methylprop-2-enoyl)oxy]propyl}-phenyl}propyl 2-methylprop-2-enoate **1**

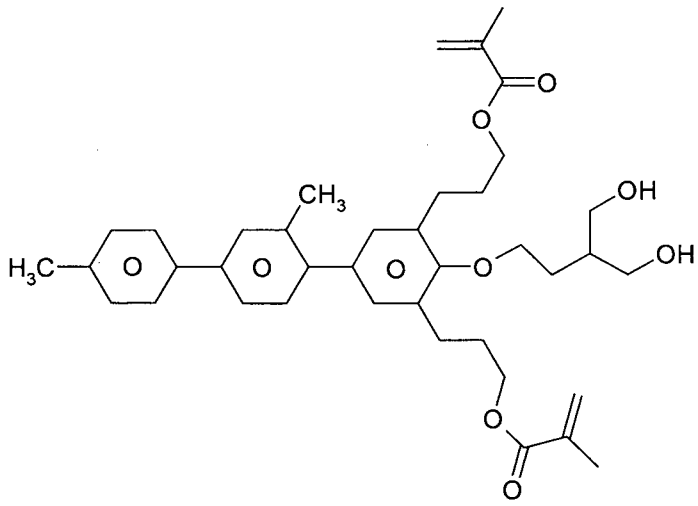


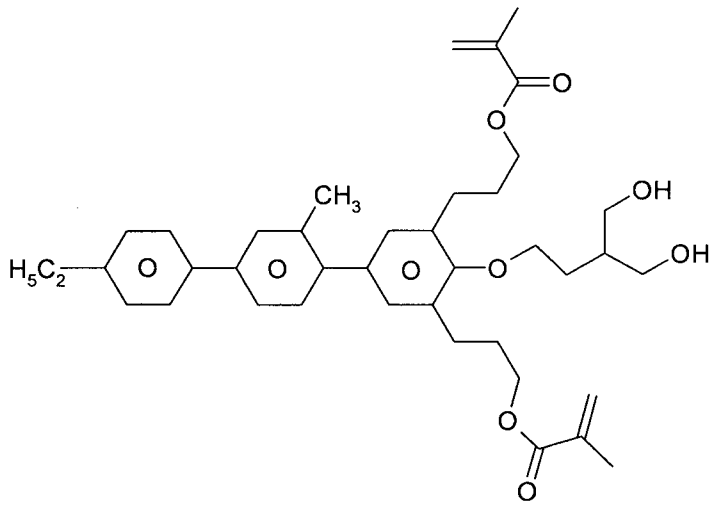
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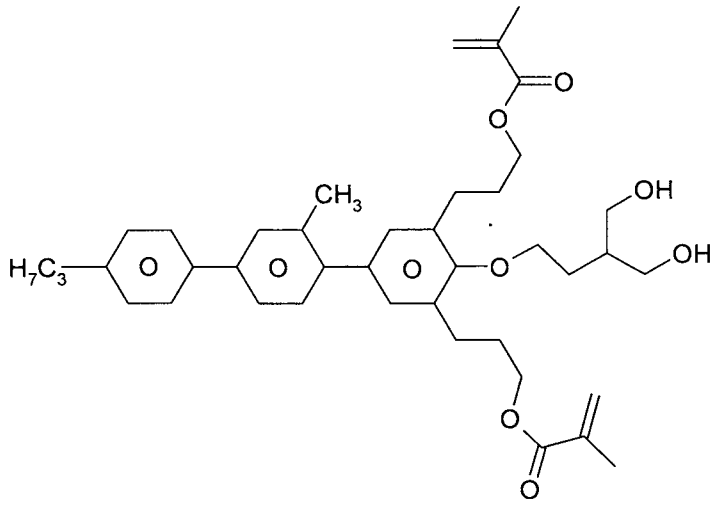
23.2 g (25.0 mmol) **D** are solved in 225 ml THF, cooled to 2 °C and 30.0 ml (60.0 mmol) HCl (2N) are added slowly dropwise and the reaction mixture is then stirred for 16 h at room temperature. The mixture is cautiously neutralized with $Na_2CO_3$ solution and the mixture is extracted with MTB-ether. The layers are separated, the water layer is extracted with MTB-ether and the combined organic layers are washed with brine, dried over $Na_2SO_4$ and evaporated under vacuum. The crude product is filtered over 300 g silica gel with a mixture of H/EE (1:1 - 1:4). After evaporation the product is obtained as an oil which is dried at 50°C and 0.01 mbar for 6 h.
Phases: $T_g$ -33 K 26 I

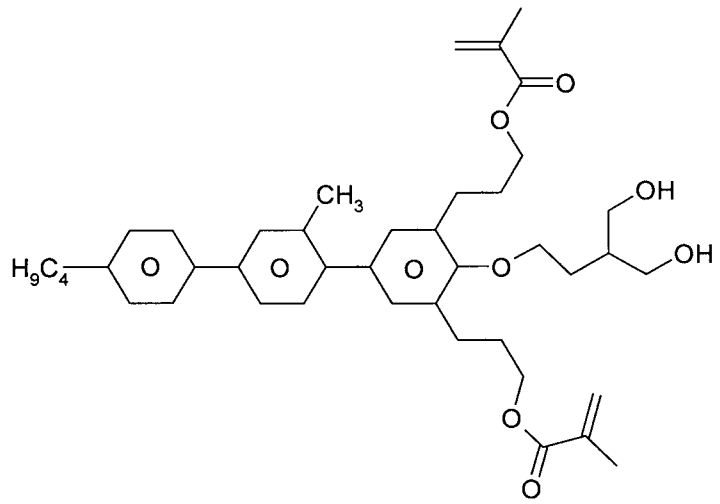
The following compounds are synthesized acordingly to the above mentioned examples:

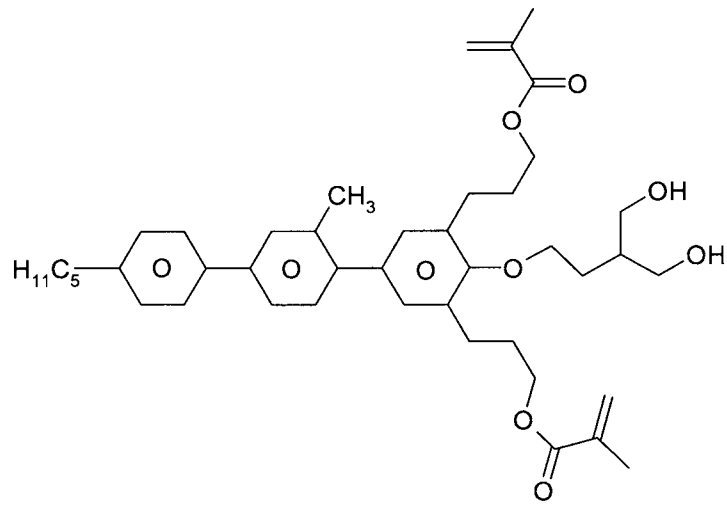


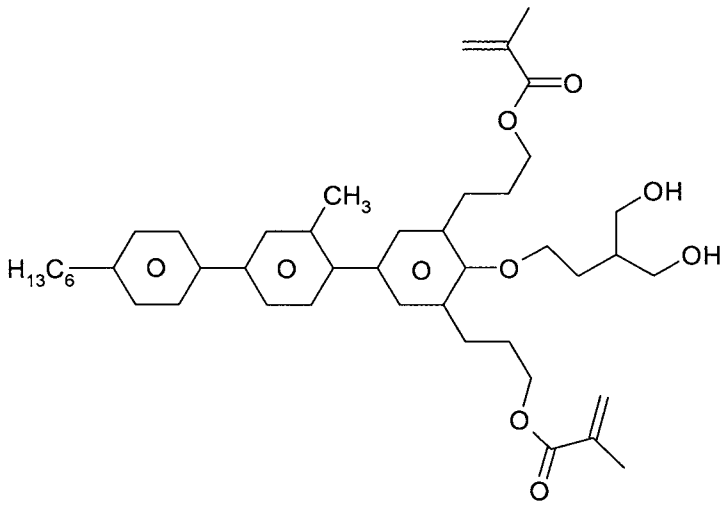


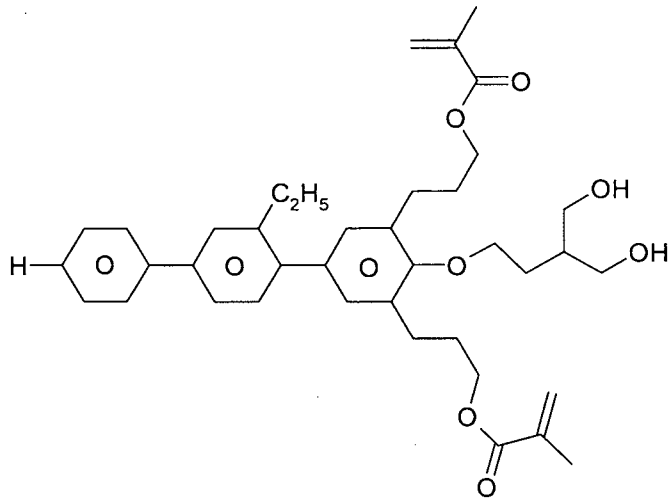


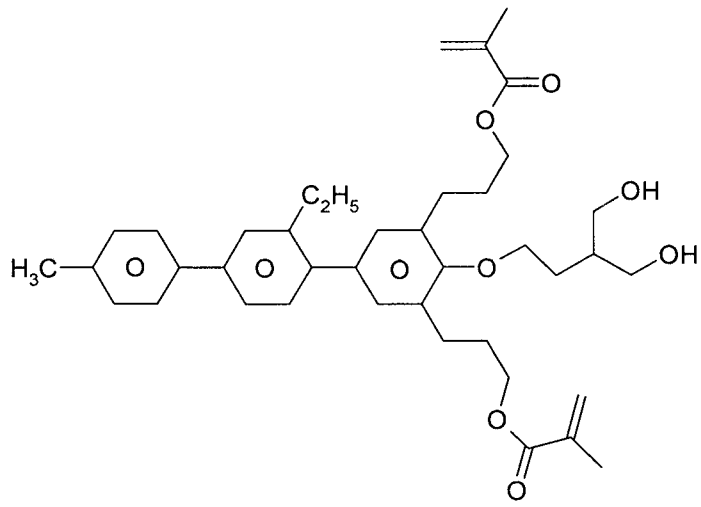


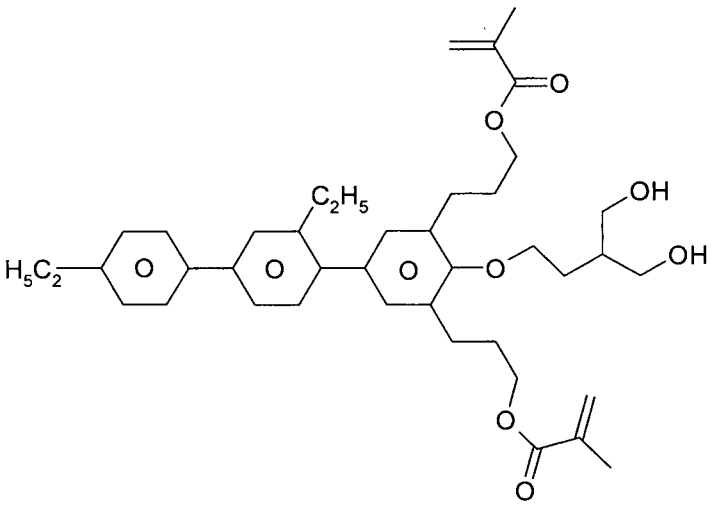


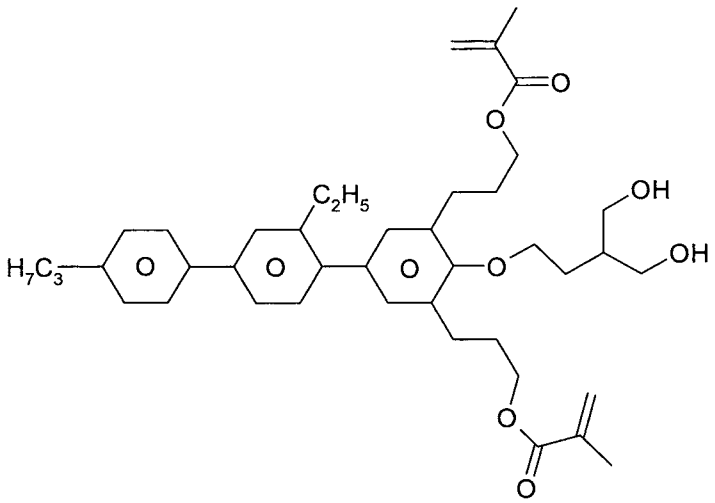


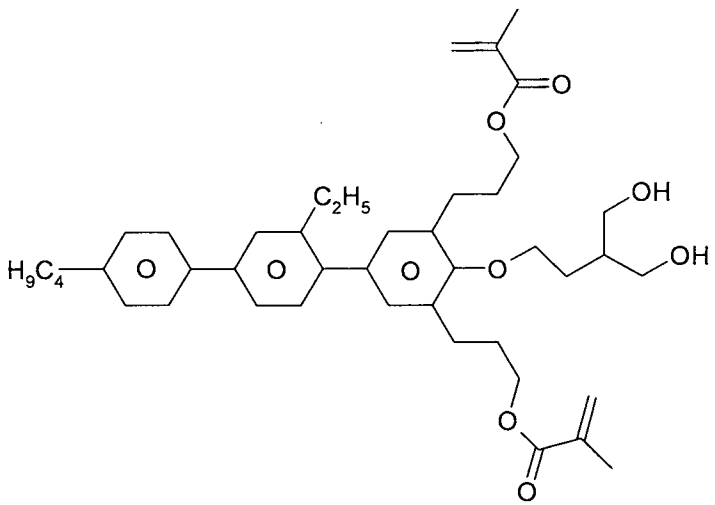


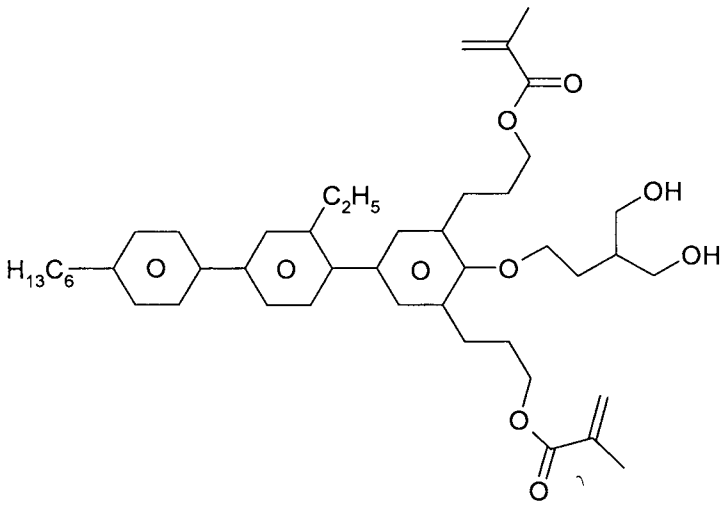


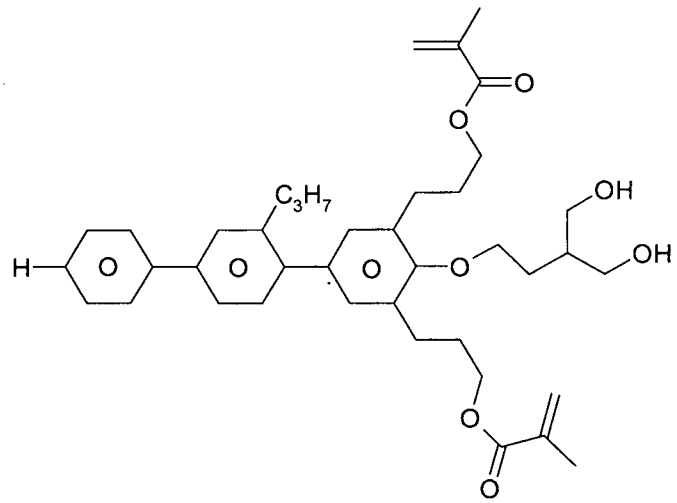


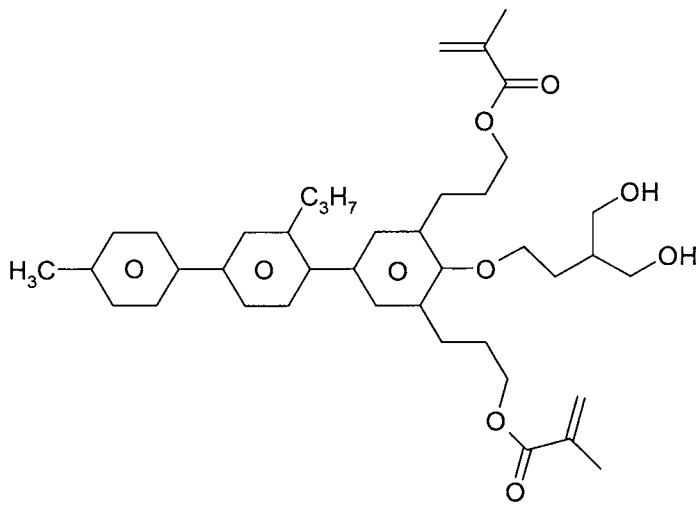


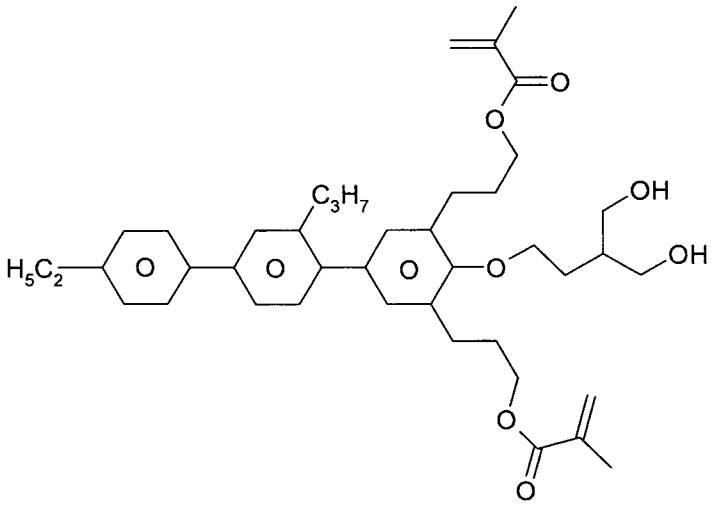


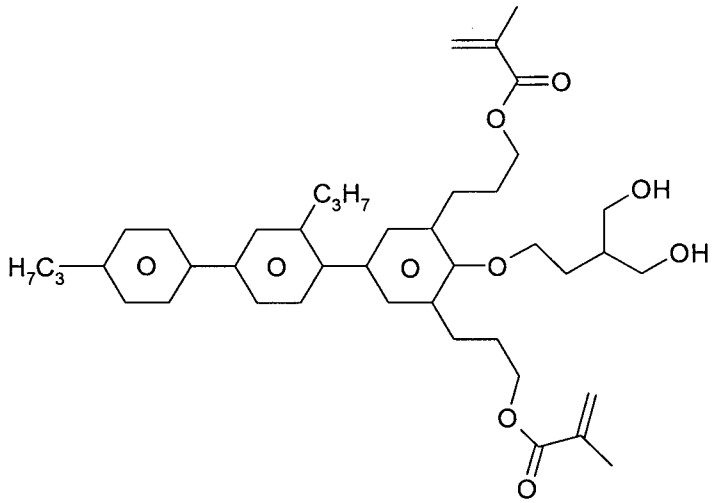


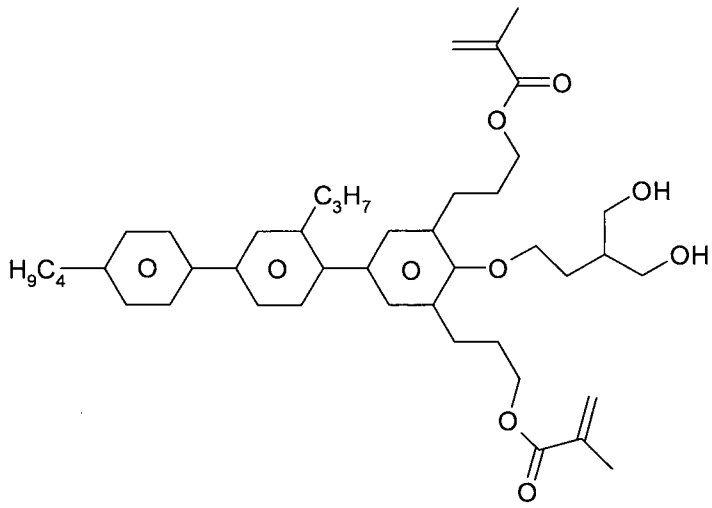


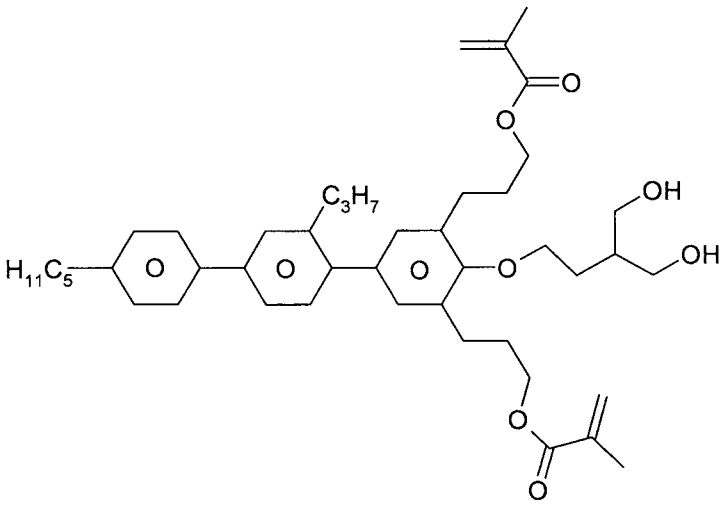


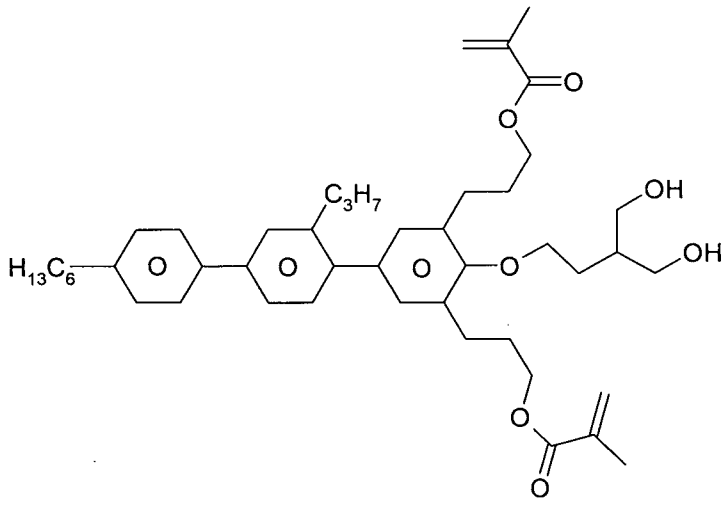


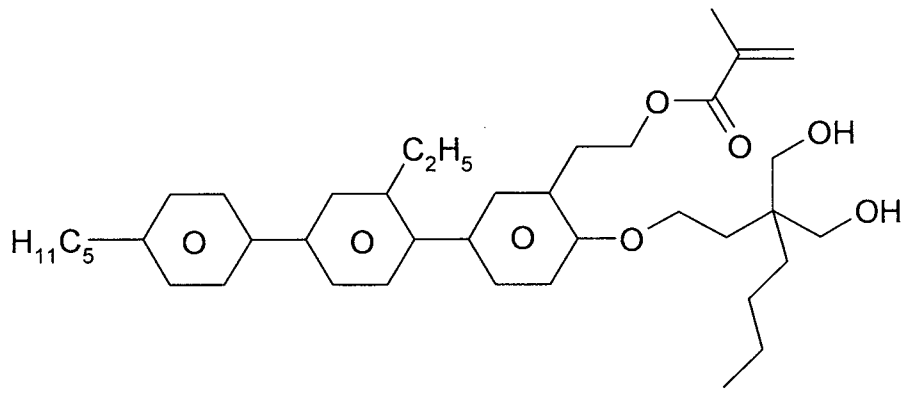


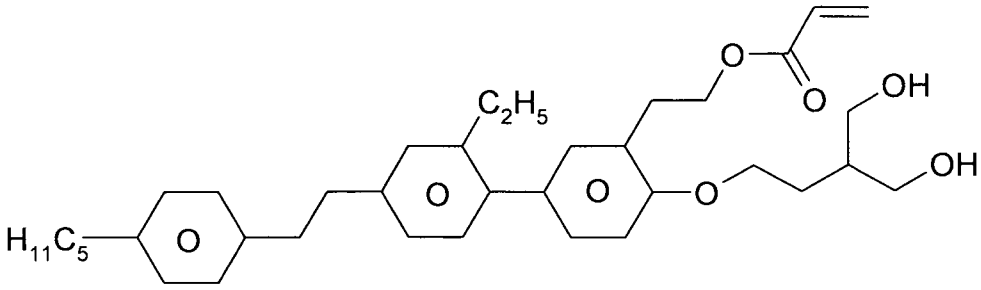


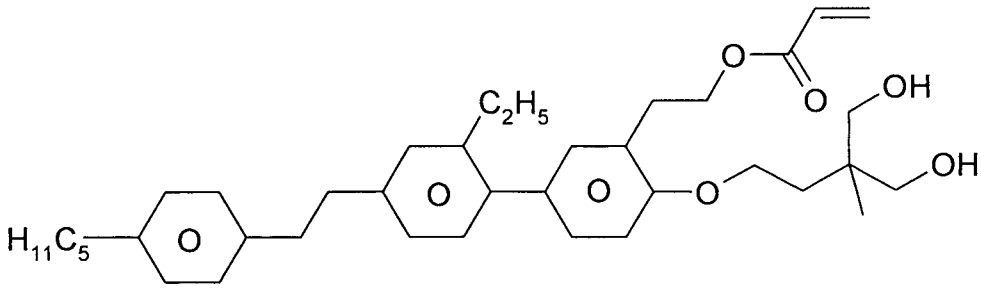


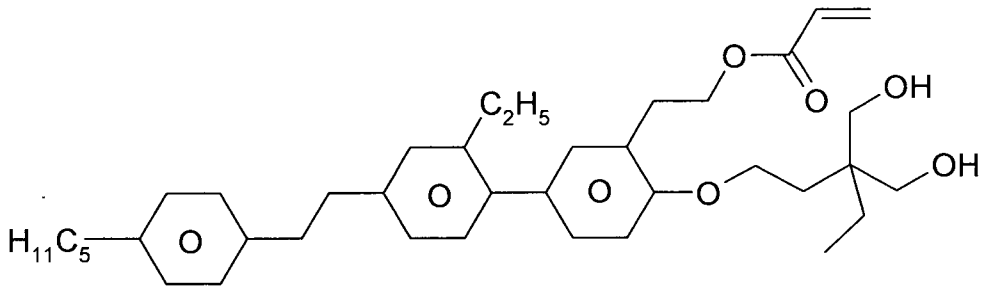


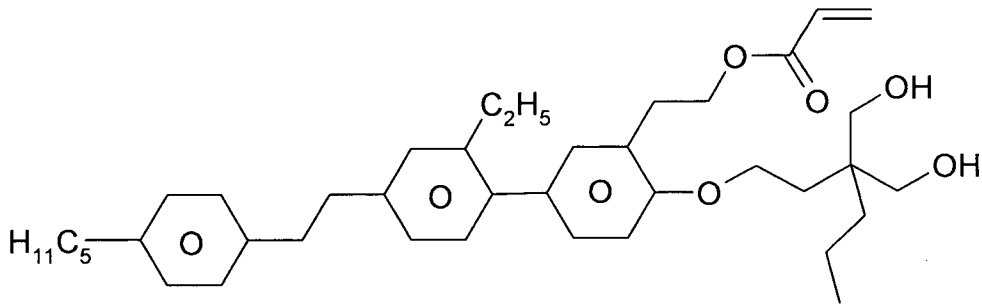


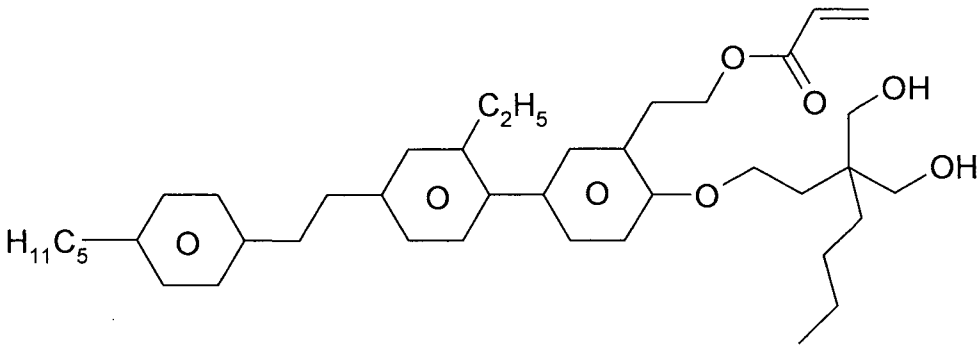


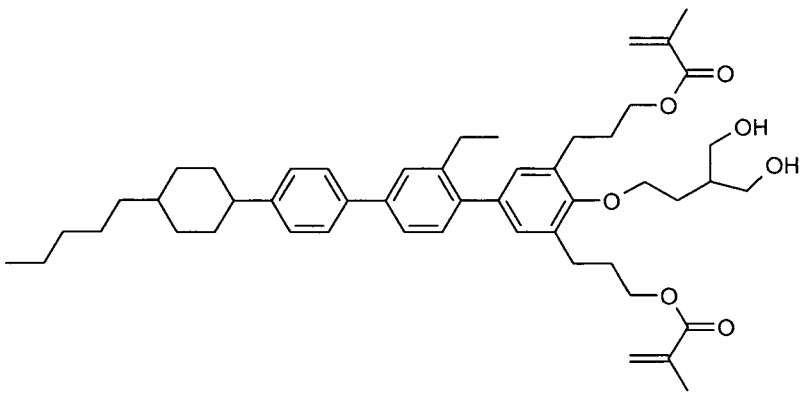


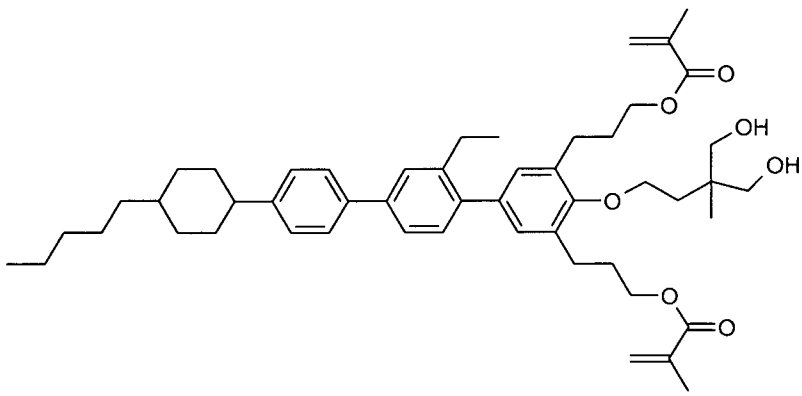


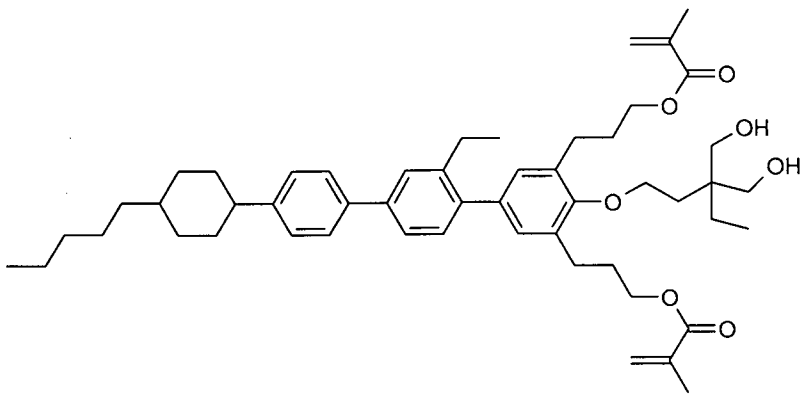


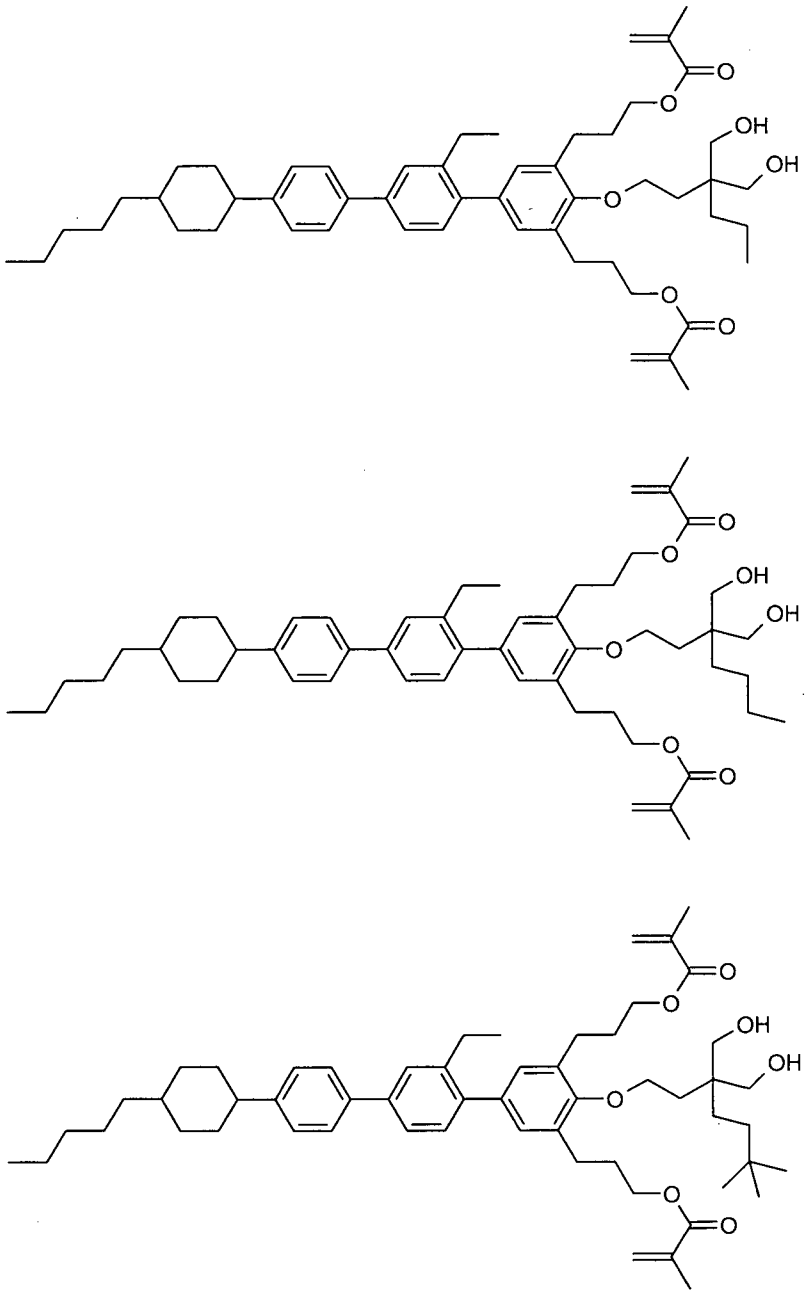


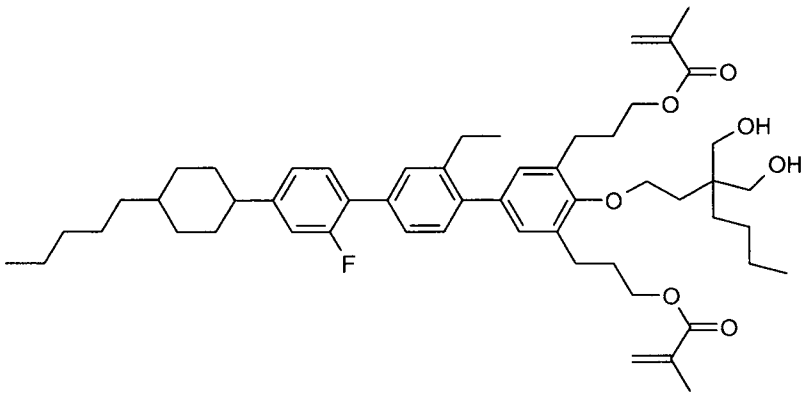


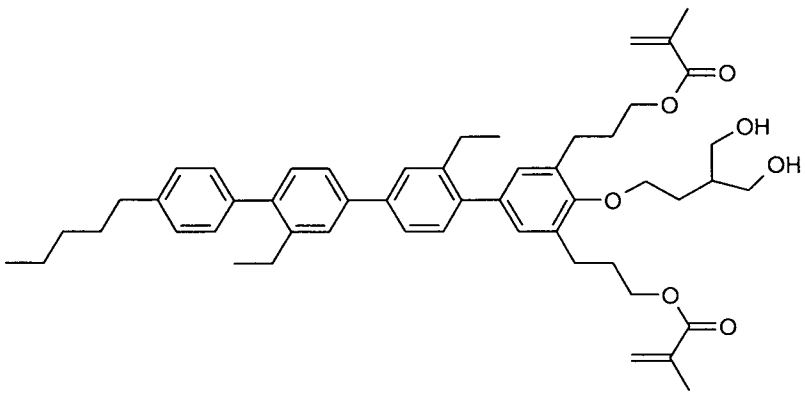


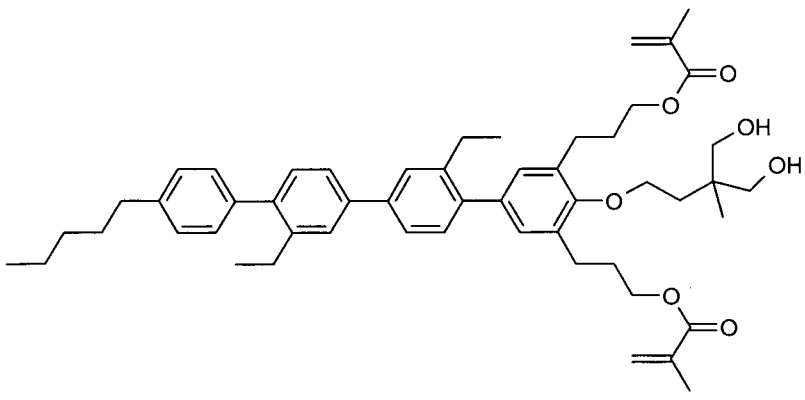


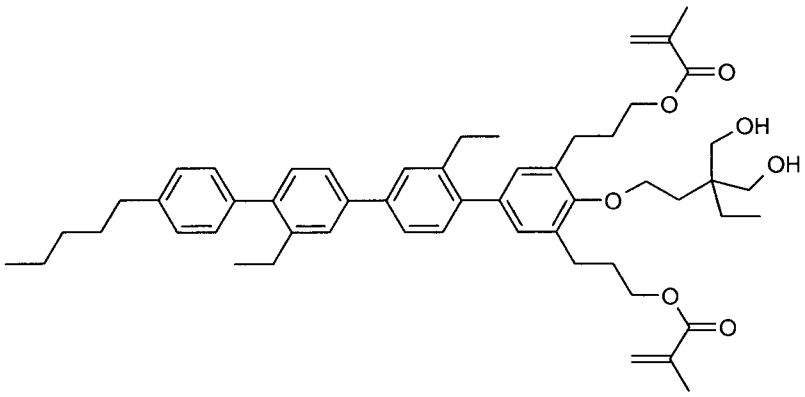


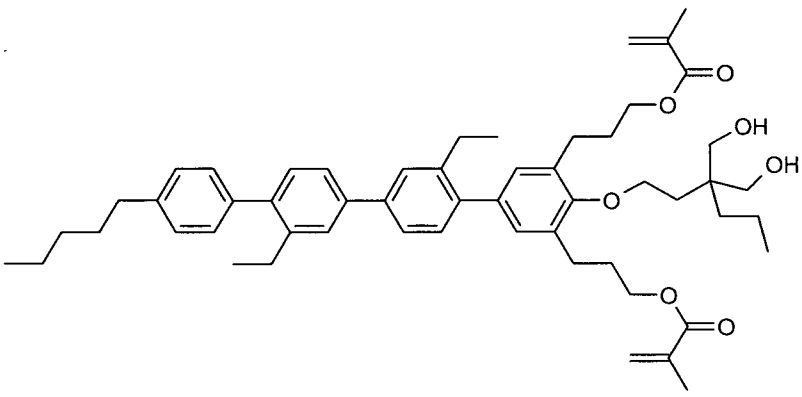


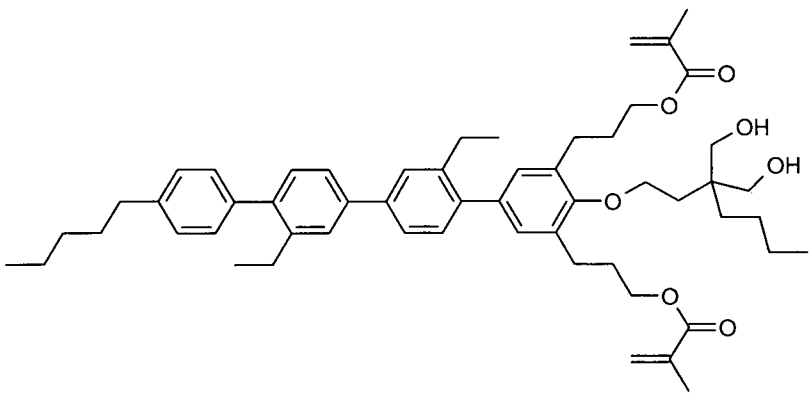


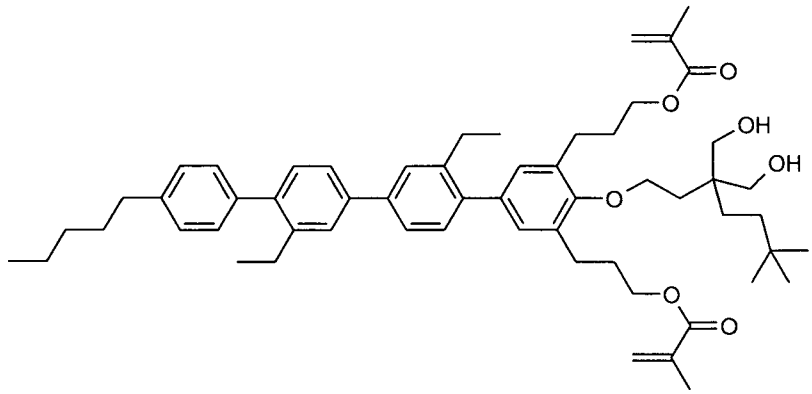


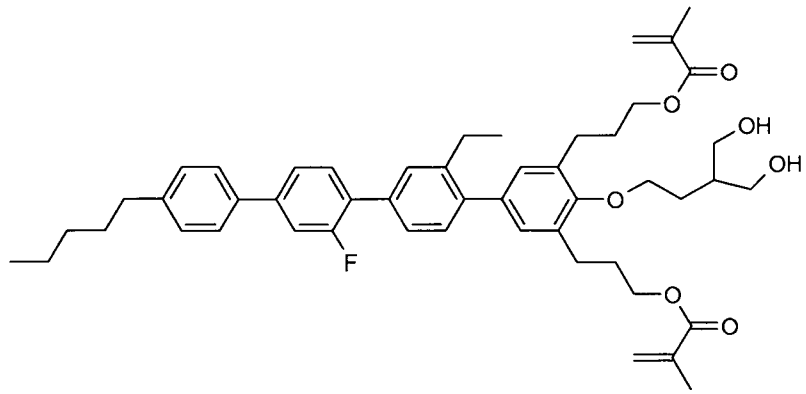


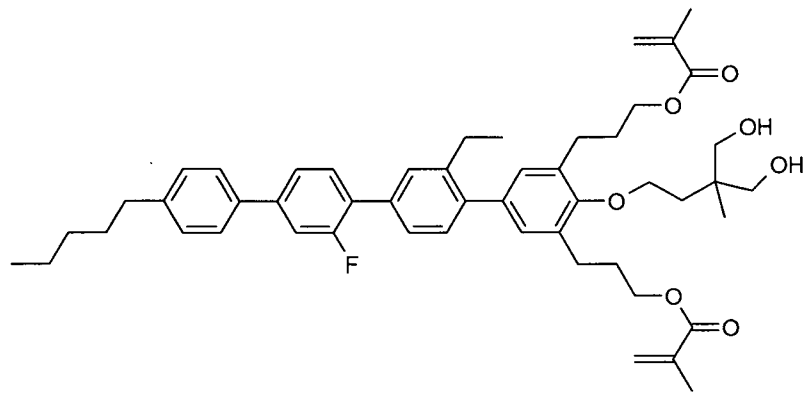


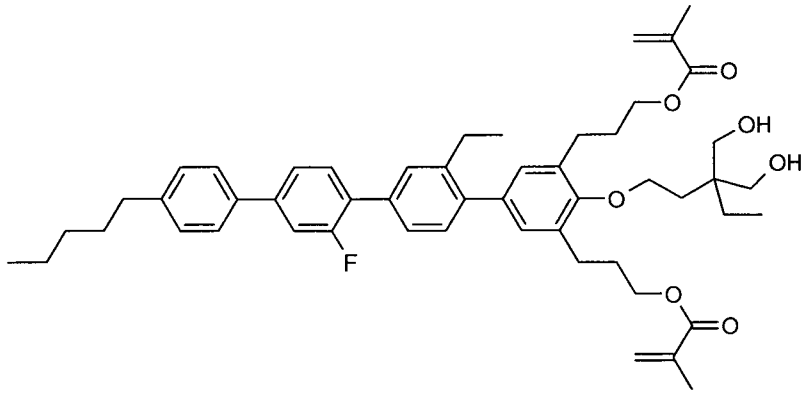


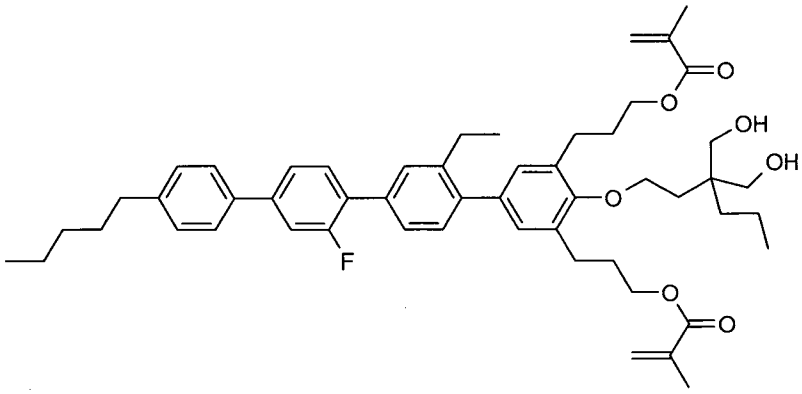


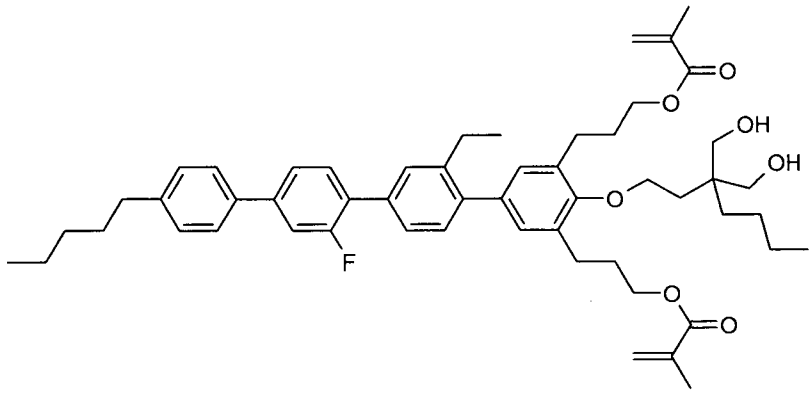


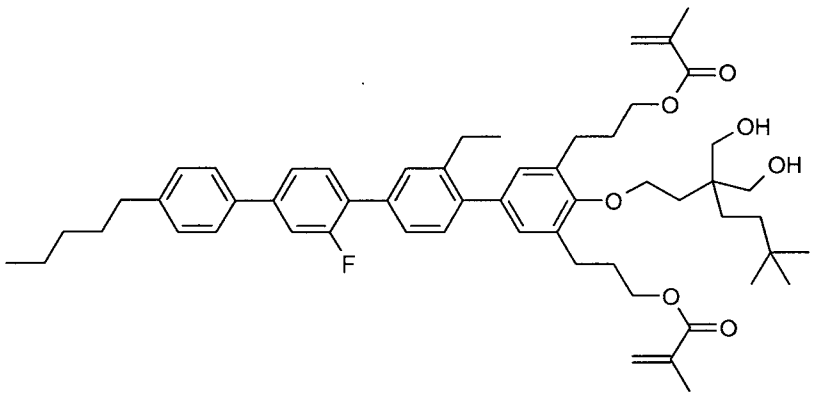


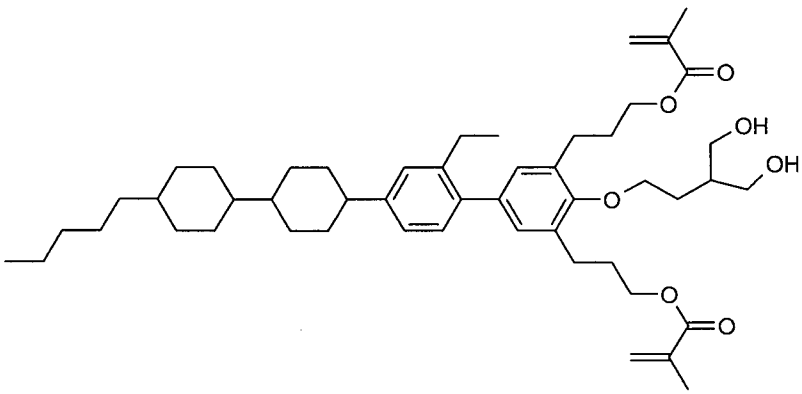


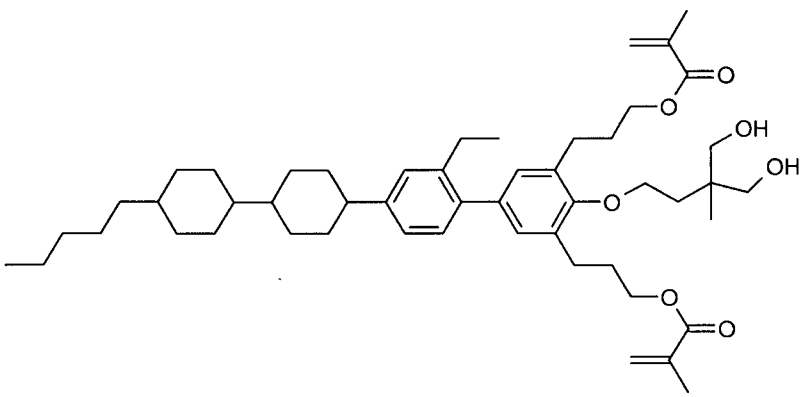


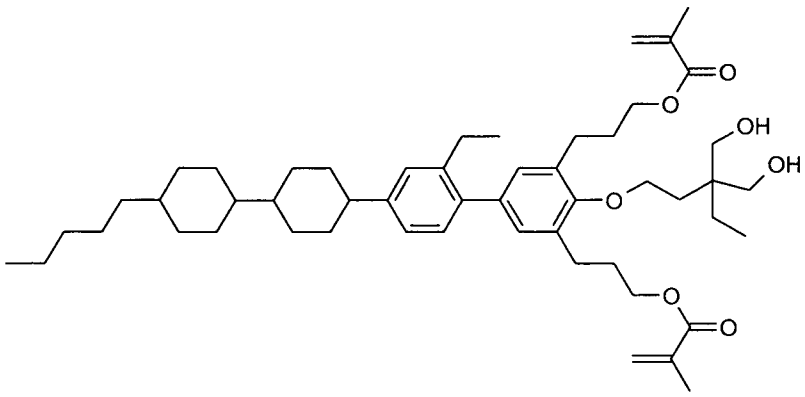


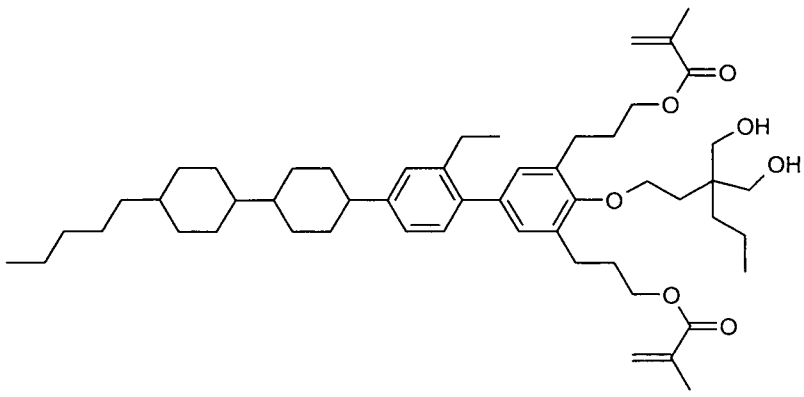


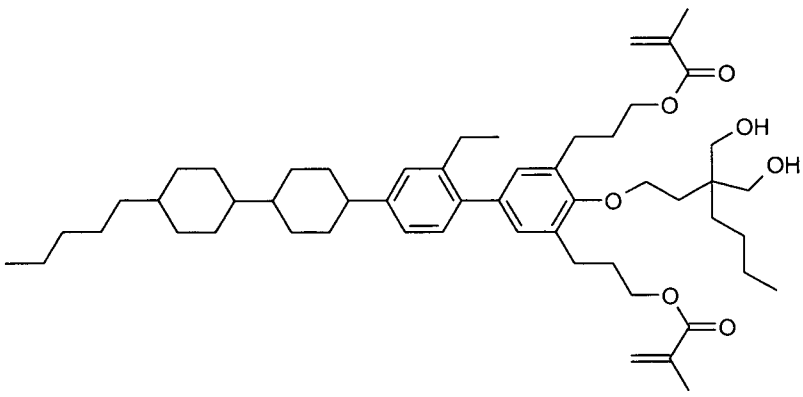


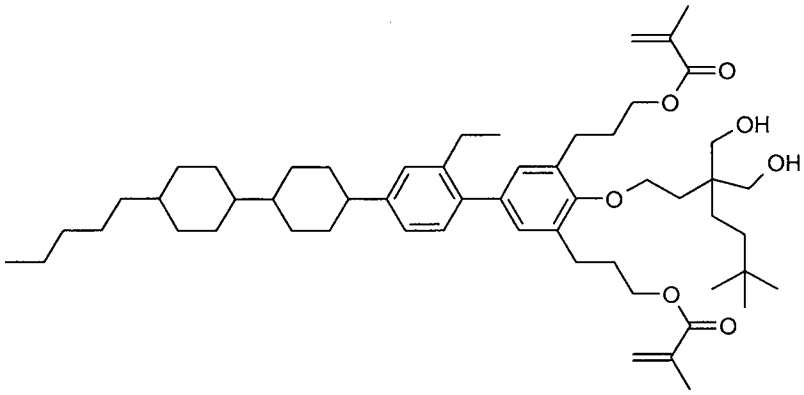


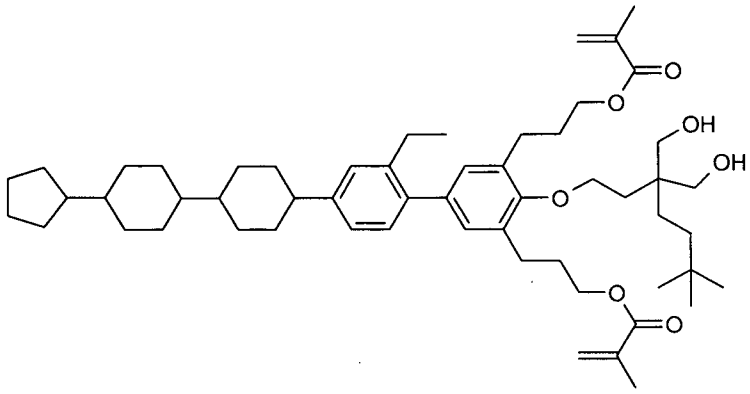


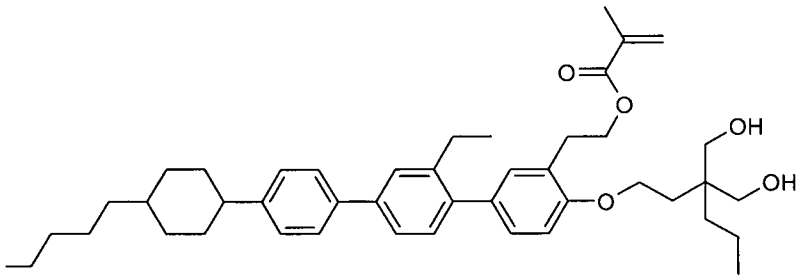


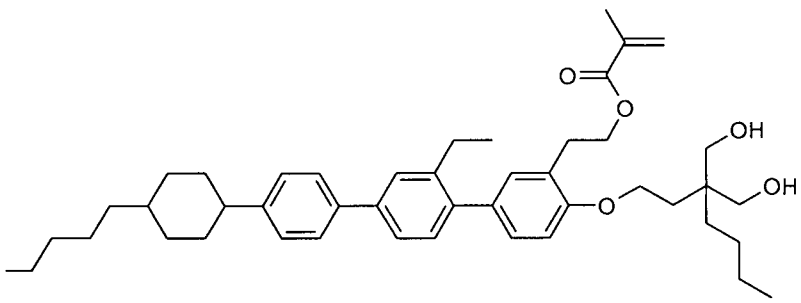


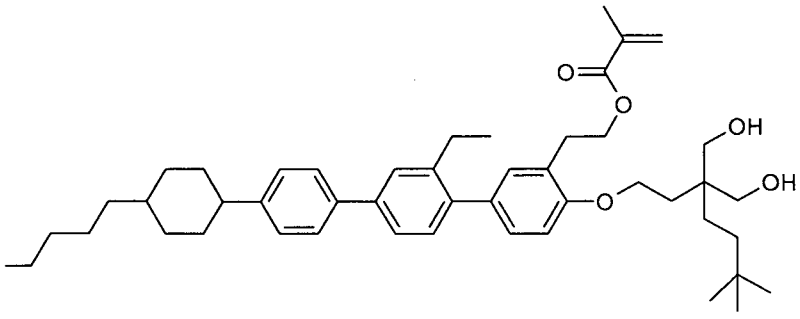


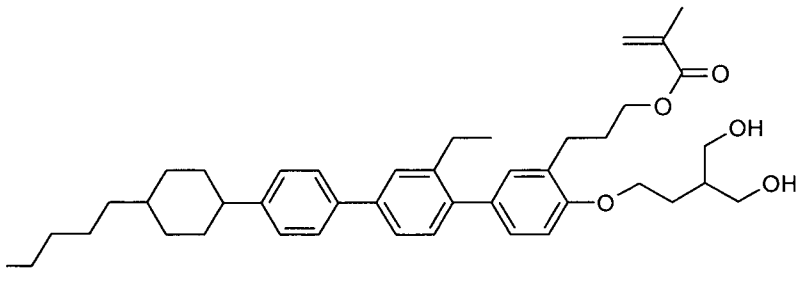


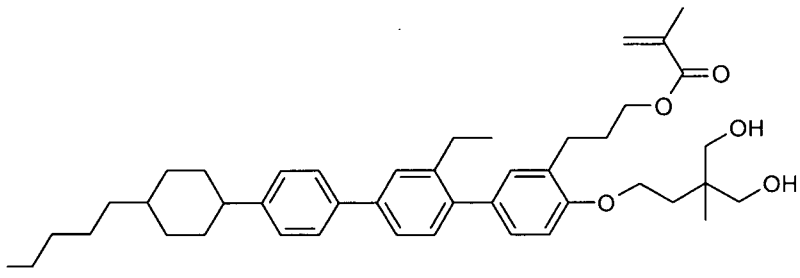


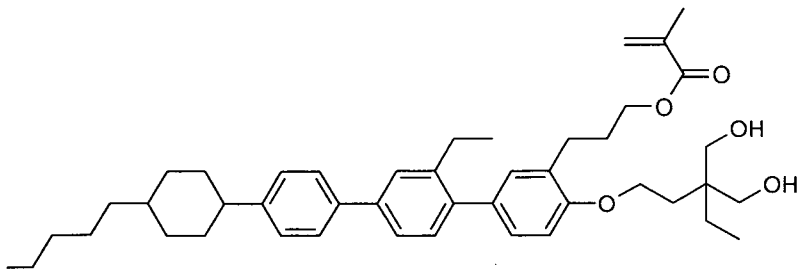


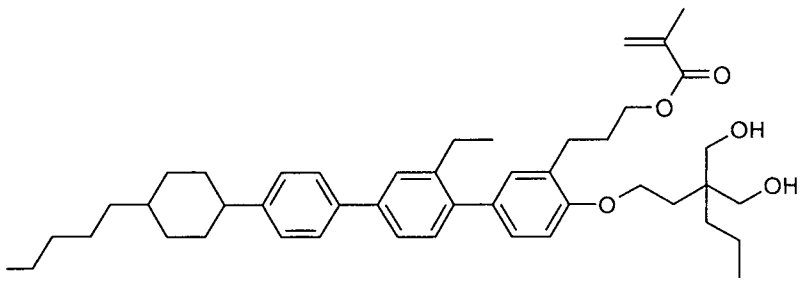


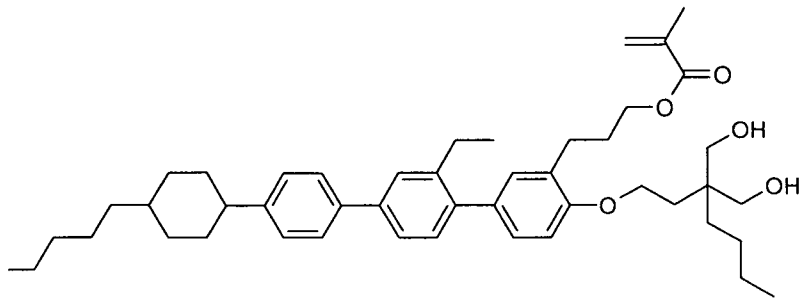


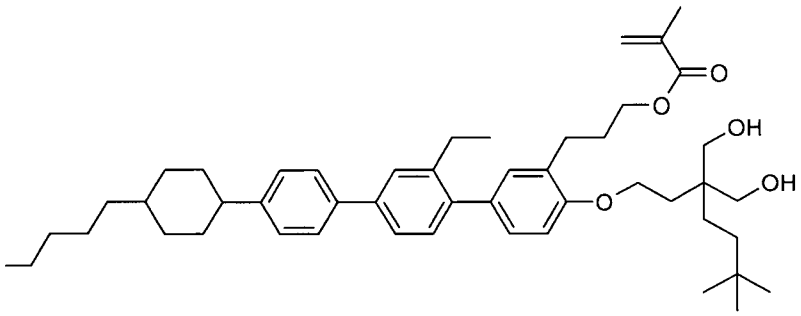


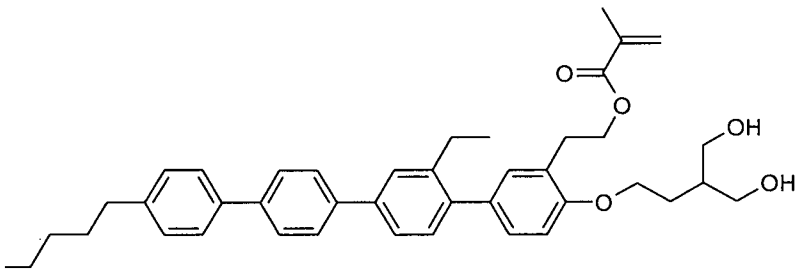


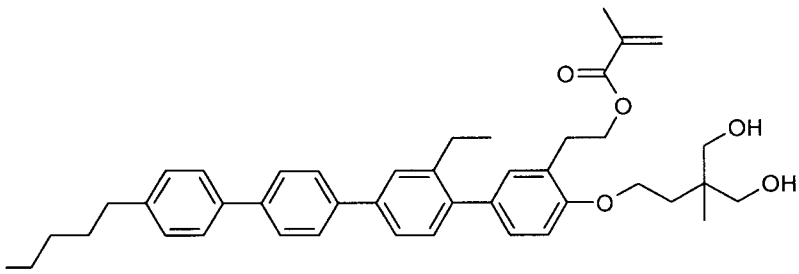


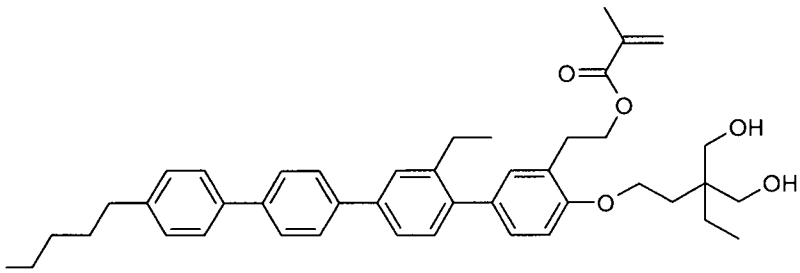


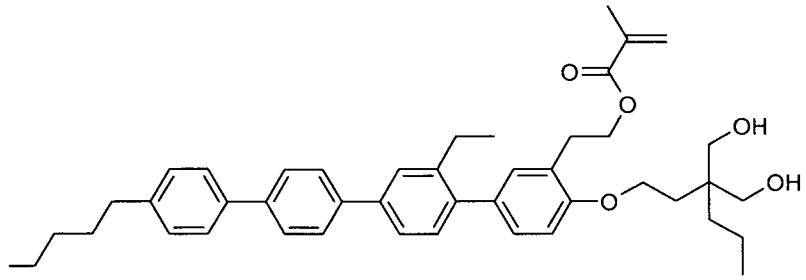


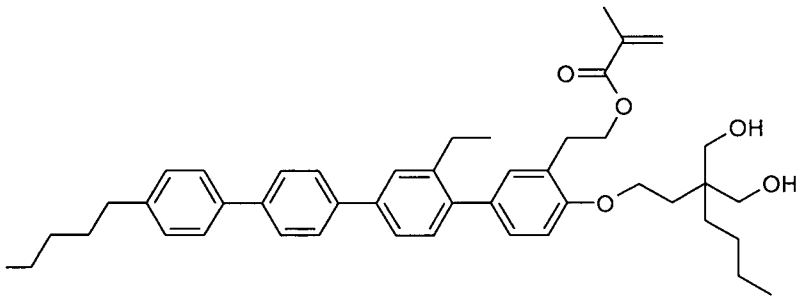


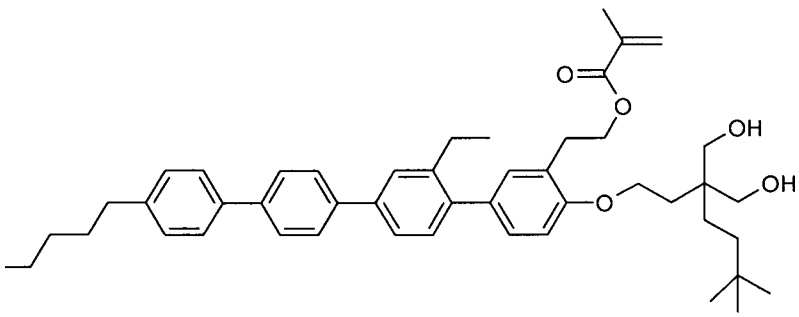


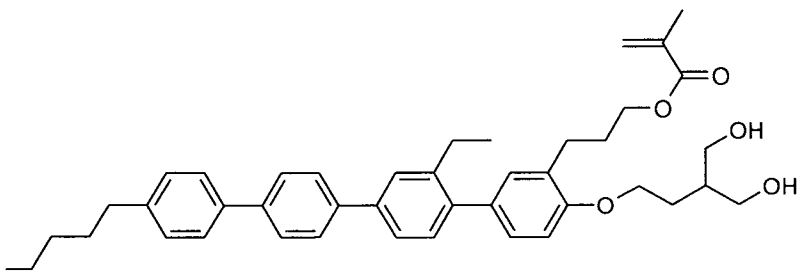


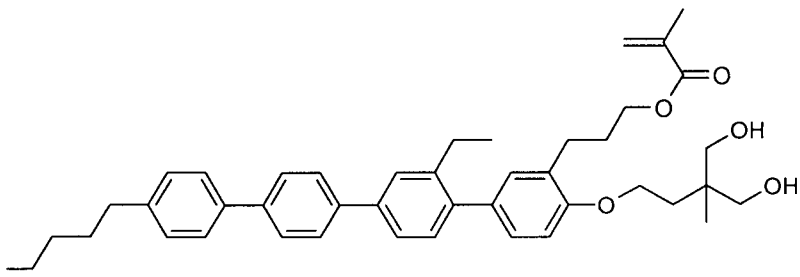


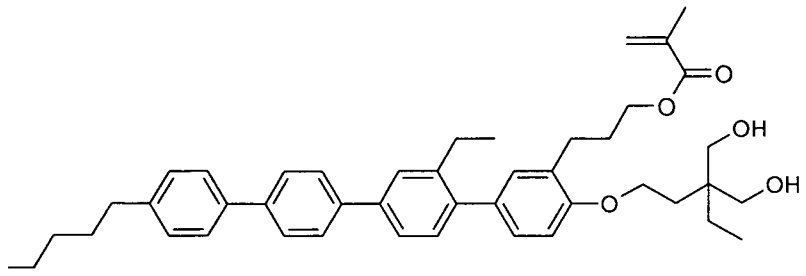


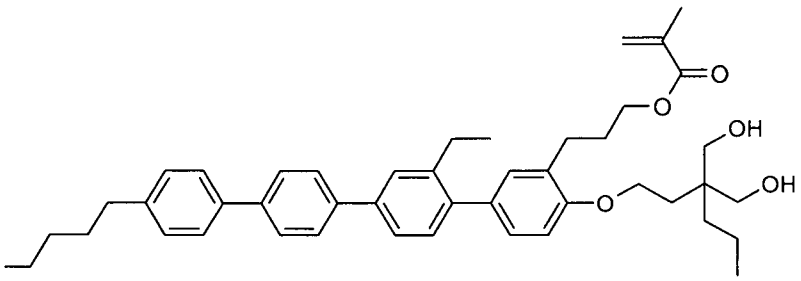


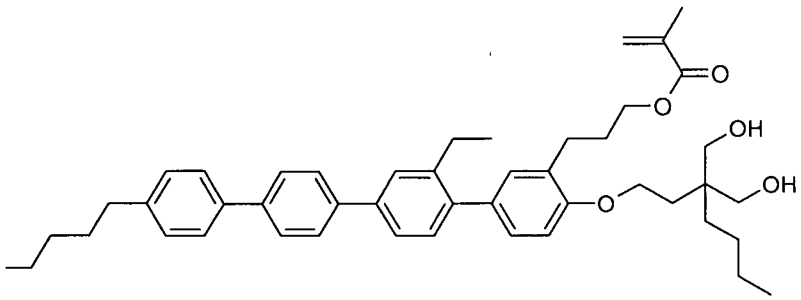


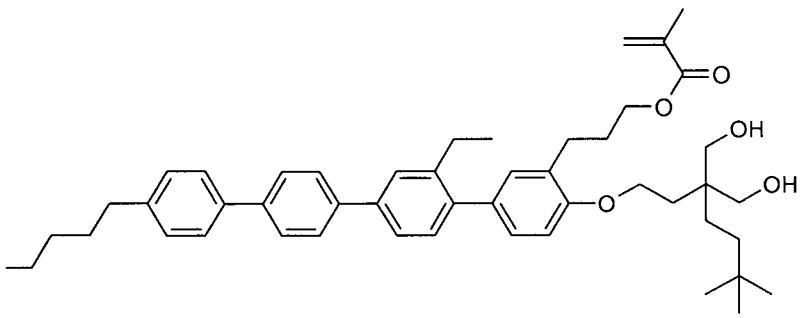


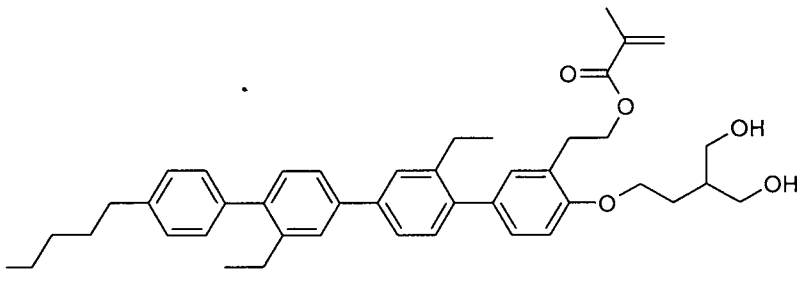


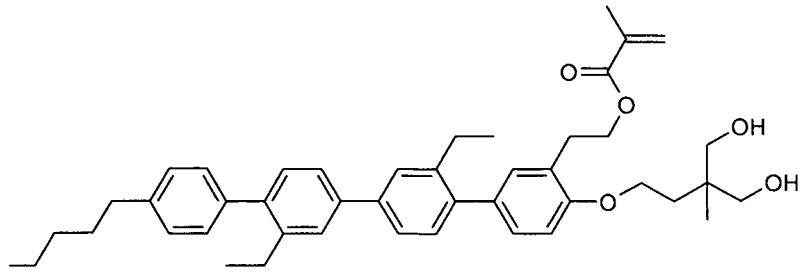


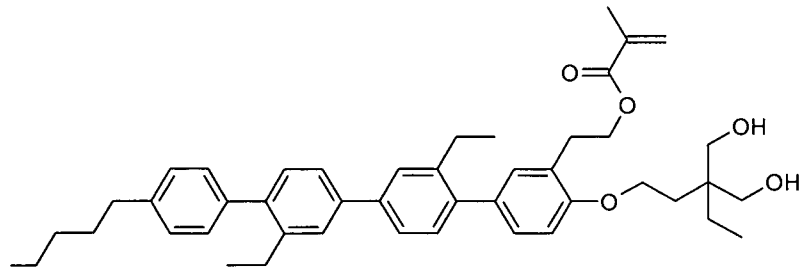


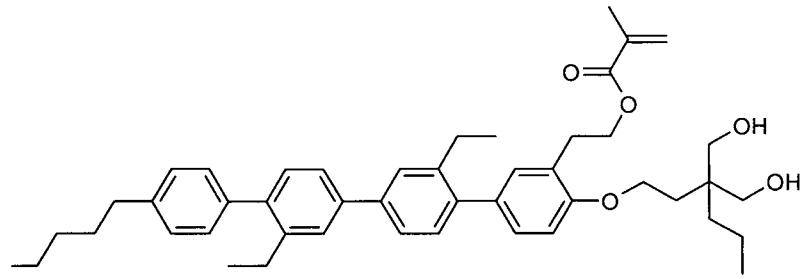


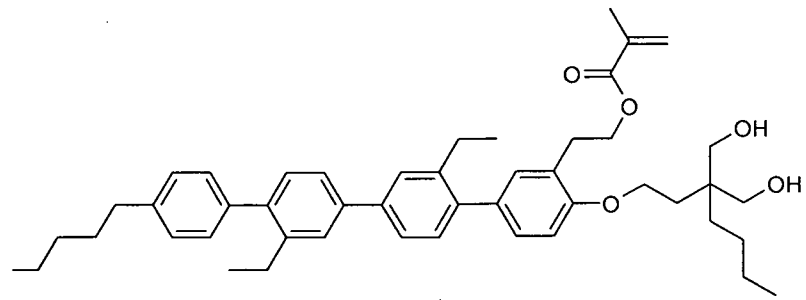


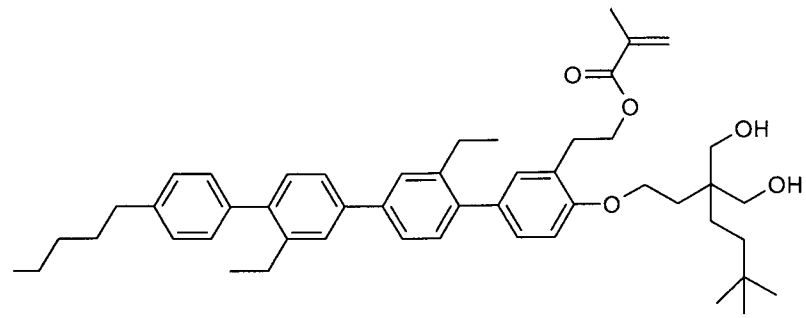


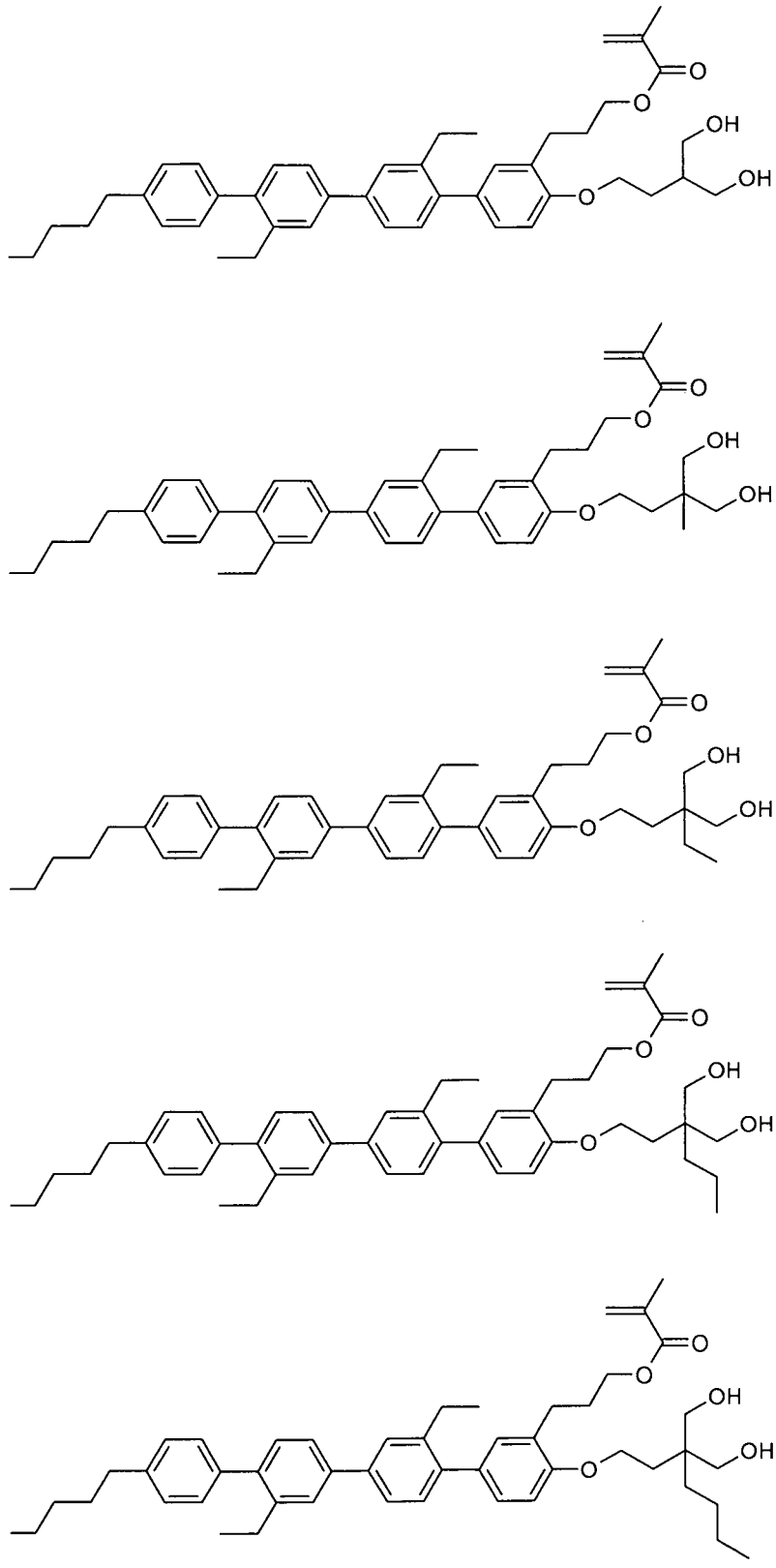


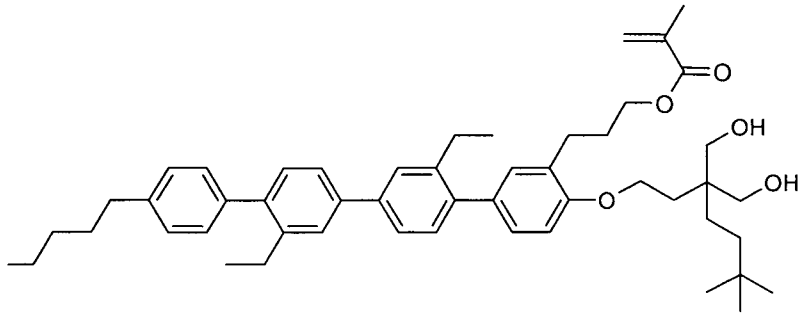


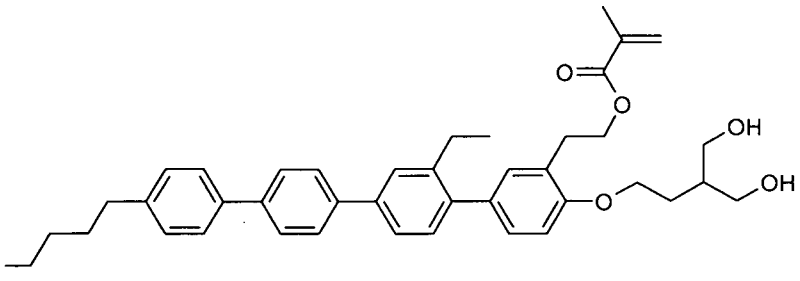


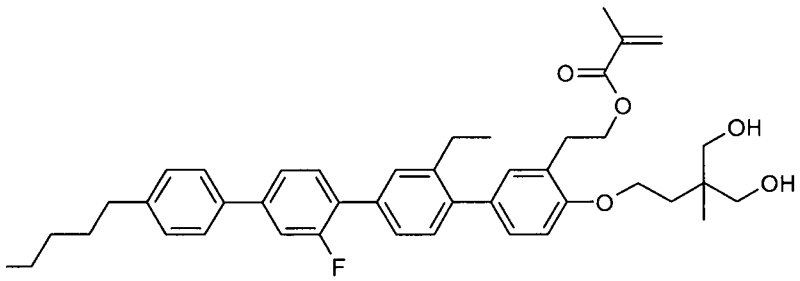


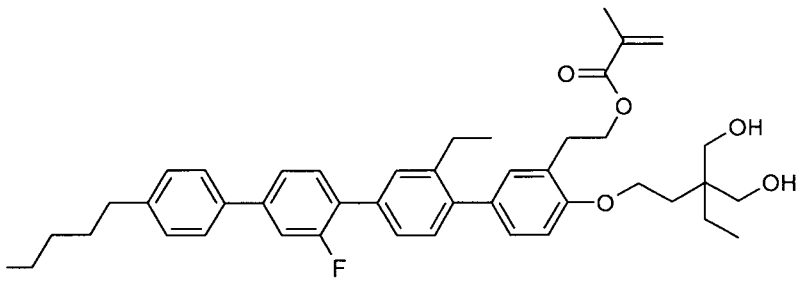


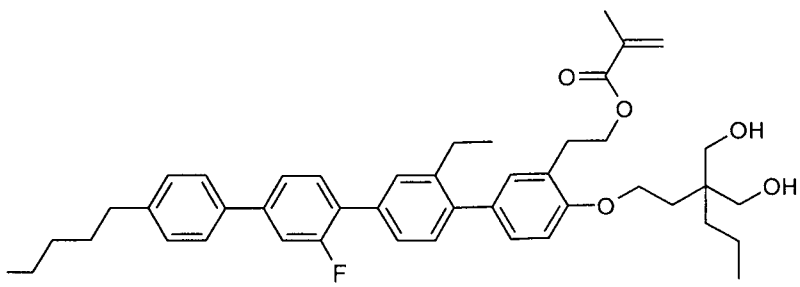


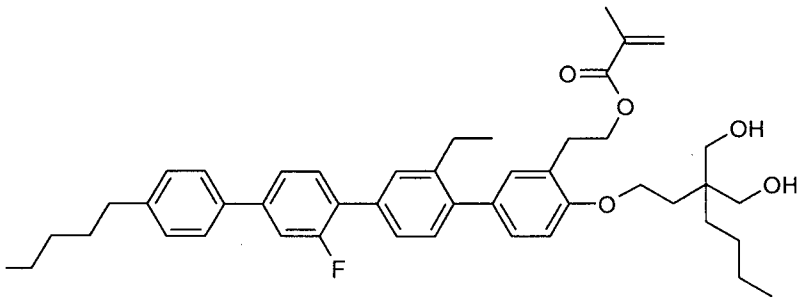


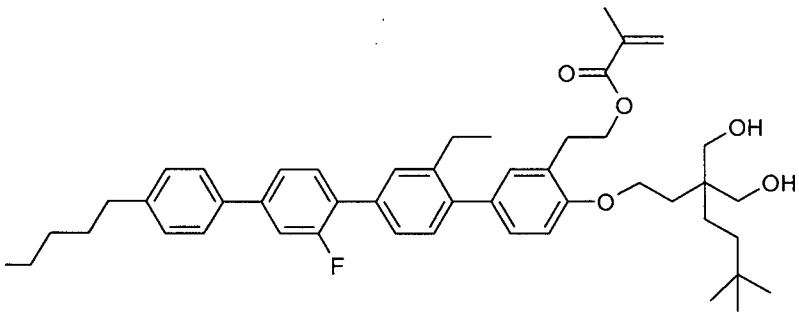


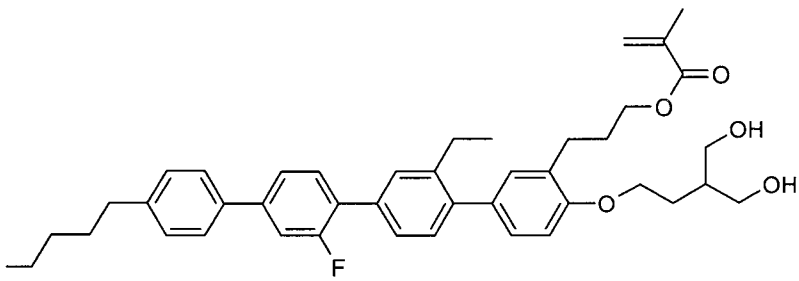


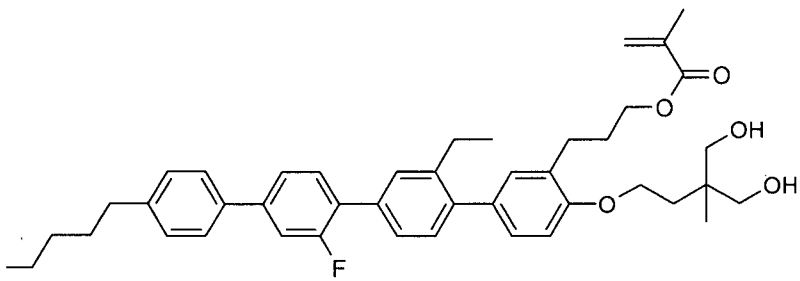


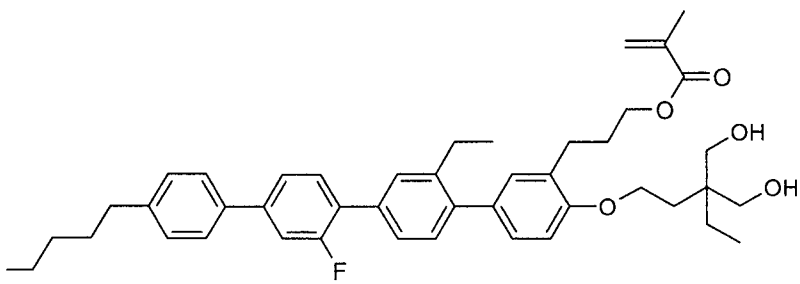


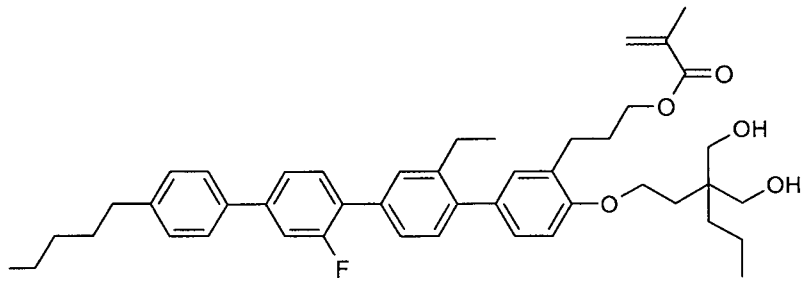


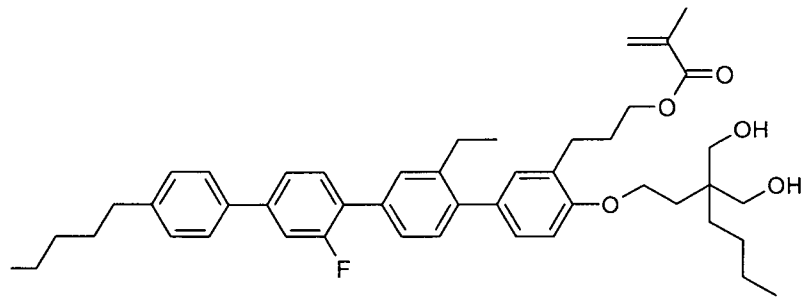


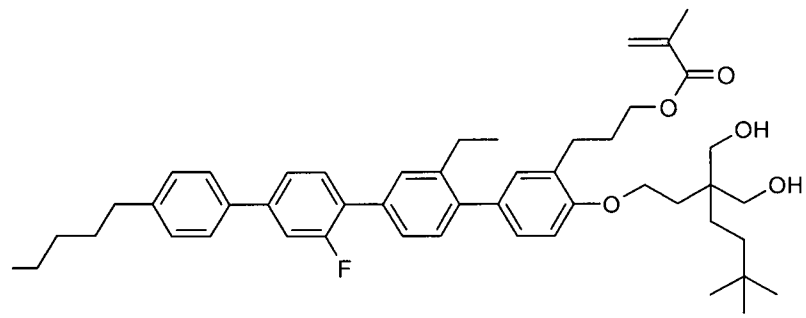












In the following examples

| | |
|---|---|
| $V_0$ | denotes the threshold voltage, capacitive [V] at 20°C |
| $\Delta n$ | denotes the optical anisotropy measured at 20°C and 589 nm |
| $\Delta\varepsilon$ | denotes the dielectric anisotropy at 20°C and 1 kHz |
| cl.p. | denotes the clearing point [°C] |
| $K_1$ | denotes the elastic constant, "splay" deformation at 20°C [pN] |
| $K_3$ | denotes the elastic constant, "bend" deformation at 20°C [pN] |
| $\gamma_1$ | denotes the rotational viscosity measured at 20°C [mPa·s], determined by the rotation method in a magnetic field |
| LTS | denotes the low-temperature stability (nematic phase), determined in test cells. |

The display used for measurement of the threshold voltage has two plane-parallel outer plates at a separation of 20 µm and electrode layers with overlying alignment layers of JALS-2096 on the insides of the outer plates, which effect a homeotropic alignment of the liquid crystals.

All concentrations in this application relate to the corresponding mixture or mixture component, unless explicitly indicated otherwise. All physical properties are determined as described in "Merck Liquid Crystals, Physical Properties of Liquid Crystals", status November 1997, Merck KGaA, Germany, and apply for a temperature of 20 °C, unless explicitly indicated otherwise.

Unless indicated otherwise, parts or per cent data denote parts by weight or per cent by weight.

**Mixture examples**

For the production of the examples according to the present invention the following host mixtures **H1** to **H48** are used:

**H1**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.50 % | Clearing point [°C]: | 75.1 |
| CCY-3-O3 | 8.00 % | $\Delta n$ [589 nm, 20°C]: | 0.098 |
| CCY-4-O2 | 10.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.0 |
| CPY-2-O2 | 5.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.4 |
| CPY-3-O2 | 11.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.4 |
| CCH-34 | 9.25 % | $K_1$ [pN, 20°C]: | 13.1 |
| CCH-23 | 24.50 % | $K_3$ [pN, 20°C]: | 13.3 |
| PYP-2-3 | 8.75 % | $\gamma_1$ [mPa·s, 20°C]: | 113 |
| PCH-301 | 7.00 % | $V_0$ [20°C, V]: | 2.22 |

**H2**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O4 | 14.00 % | Clearing point [°C]: | 80.0 |
| CCY-3-O2 | 9.00 % | Δn [589 nm, 20°C]: | 0.090 |
| CCY-3-O3 | 9.00 % | Δε [1 kHz, 20°C]: | -3.3 |
| CPY-2-O2 | 10.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.4 |
| CPY-3-O2 | 10.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.7 |
| CCY-3-1 | 8.00 % | $K_1$ [pN, 20°C]: | 15.1 |
| CCH-34 | 9.00 % | $K_3$ [pN, 20°C]: | 14.6 |
| CCH-35 | 6.00 % | $\gamma_1$ [mPa·s, 20°C]: | 140 |
| PCH-53 | 10.00 % | $V_0$ [20°C, V]: | 2.23 |
| CCH-301 | 6.00 % | | |
| CCH-303 | 9.00 % | | |

**H3**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CC-3-V1 | 9.00 % | Clearing point [°C]: | 74.7 |
| CCH-23 | 18.00 % | Δn [589 nm, 20°C]: | 0.098 |
| CCH-34 | 3.00 % | Δε [1 kHz, 20°C]: | -3.4 |
| CCH-35 | 7.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.5 |
| CCP-3-1 | 5.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.9 |
| CCY-3-O2 | 11.50 % | $K_1$ [pN, 20°C]: | 14.9 |
| CPY-2-O2 | 8.00 % | $K_3$ [pN, 20°C]: | 15.9 |
| CPY-3-O2 | 11.00 % | $\gamma_1$ [mPa·s, 20°C]: | 108 |
| CY-3-O2 | 15.50 % | $V_0$ [20°C, V]: | 2.28 |
| PY-3-O2 | 11.50 % | | |

**H4:** Nematic host-mixture

| | | | |
|---|---|---|---|
| CC-3-V | 37.50 % | Clearing point [°C]: | 74.8 |
| CC-3-V1 | 2.00 % | Δn [589 nm, 20°C]: | 0.099 |
| CCY-4-O2 | 14.50 % | Δε [1 kHz, 20°C]: | -2.9 |
| CPY-2-O2 | 10.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| CPY-3-O2 | 9.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.6 |

| | | | | |
|---|---|---|---|---|
| | CY-3-O2 | 15.00 % | $K_1$ [pN, 20°C]: | 12.2 |
| | CY-3-O4 | 4.50 % | $K_3$ [pN, 20°C]: | 13.4 |
| | PYP-2-4 | 5.50 % | $\gamma_1$ [mPa·s, 20°C]: | 92 |
| 5 | PPGU-3-F | 1.00 % | $V_0$ [20°C, V]: | 2.28 |

**H5**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| 10 | CCH-23 | 20.00 % | Clearing point [°C]: | 74.8 |
| | CCH-301 | 6.00 % | $\Delta n$ [589 nm, 20°C]: | 0.105 |
| | CCH-34 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.2 |
| | CCP-3-1 | 3.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.5 |
| | CCY-3-O2 | 11.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.8 |
| 15 | CPY-2-O2 | 12.00 % | $K_1$ [pN, 20°C]: | 12.7 |
| | CPY-3-O2 | 11.00 % | $K_3$ [pN, 20°C]: | 13.6 |
| | CY-3-O2 | 14.00 % | $\gamma_1$ [mPa·s, 20°C]: | 120 |
| | CY-3-O4 | 4.00 % | $V_0$ [20°C, V]: | 2.16 |
| | PCH-301 | 4.00 % | | |
| 20 | PYP-2-3 | 9.00 % | | |

**H6**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| 25 | CC-4-V | 17.00 % | Clearing point [°C]: | 106.1 |
| | CCP-V-1 | 15.00 % | $\Delta n$ [589 nm, 20°C]: | 0.120 |
| | CCPC-33 | 2.50 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.6 |
| | CCY-3-O2 | 4.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.5 |
| | CCY-3-O3 | 5.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.0 |
| 30 | CCY-4-O2 | 5.00 % | $K_1$ [pN, 20°C]: | 16.8 |
| | CLY-3-O2 | 3.50 % | $K_3$ [pN, 20°C]: | 17.3 |
| | CLY-3-O3 | 2.00 % | $\gamma_1$ [mPa·s, 20°C]: | 207 |
| | CPY-2-O2 | 8.00 % | $V_0$ [20°C, V]: | 2.33 |
| | CPY-3-O2 | 10.00 % | | |
| 35 | CY-3-O4 | 17.00 % | | |
| | PYP-2-3 | 11.00 % | | |

**H7**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 75.5 |
| CCY-4-O2 | 9.50 % | Δn [589 nm, 20°C]: | 0.108 |
| CCY-5-O2 | 5.00 % | Δε [1 kHz, 20°C]: | -3.0 |
| CPY-2-O2 | 9.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.5 |
| CPY-3-O2 | 9.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.5 |
| CCH-34 | 9.00 % | $K_1$ [pN, 20°C]: | 12.9 |
| CCH-23 | 22.00 % | $K_3$ [pN, 20°C]: | 13.0 |
| PYP-2-3 | 7.00 % | $\gamma_1$ [mPa·s, 20°C]: | 115 |
| PYP-2-4 | 7.50 % | $V_0$ [20°C, V]: | 2.20 |
| PCH-301 | 7.00 % | | |

**H8**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 74.7 |
| CY-5-O2 | 6.50 % | Δn [589 nm, 20°C]: | 0.108 |
| CCY-3-O2 | 11.00 % | Δε [1 kHz, 20°C]: | -3.0 |
| CPY-2-O2 | 5.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.6 |
| CPY-3-O2 | 10.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.6 |
| CC-3-V | 28.50 % | $K_1$ [pN, 20°C]: | 12.9 |
| CC-3-V1 | 10.00 % | $K_3$ [pN, 20°C]: | 15.7 |
| PYP-2-3 | 12.50 % | $\gamma_1$ [mPa·s, 20°C]: | 97 |
| PPGU-3-F | 0.50 % | $V_0$ [20°C, V]: | 2.42 |

**H9**: Nematic host-mixture

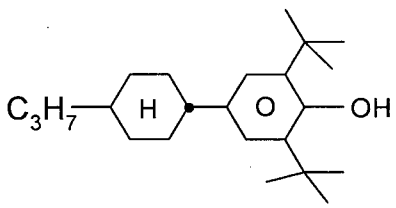
| | | | |
|---|---|---|---|
| CCH-35 | 9.50 % | Clearing point [°C]: | 79.1 |
| CCH-501 | 5.00 % | Δn [589 nm, 20°C]: | 0.091 |
| CCY-2-1 | 9.50 % | Δε [1 kHz, 20°C]: | -3.6 |
| CCY-3-1 | 10.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.5 |
| CCY-3-O2 | 10.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.1 |
| CCY-5-O2 | 9.50 % | $K_1$ [pN, 20°C]: | 14.6 |
| CPY-2-O2 | 12.00 % | $K_3$ [pN, 20°C]: | 14.5 |

| | | | |
|---|---|---|---|
| CY-3-O4 | 9.00 % | $\gamma_1$ [mPa·s, 20°C]: | 178 |
| CY-5-O4 | 11.00 % | $V_0$ [20°C, V]: | 2.12 |
| PCH-53 | 13.50 % | | |

**H10**: Nematic host-mixture

| | | | |
|---|---|---|---|
| Y-4O-O4 | 3.00% | Clearing point [°C]: | 100 |
| PYP-2-3 | 10.00% | Δn [589 nm, 20°C]: | 0.1603 |
| PYP-2-4 | 10.00% | Δε [1 kHz, 20°C]: | -0.7 |
| CC-3-V | 25.00% | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.1 |
| CCP-V-1 | 11.00% | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 3.8 |
| CCP-V2-1 | 10.00% | | |
| BCH-32 | 5.00% | | |
| CVCP-1V-O1 | 5.00% | | |
| PTP-3O2FF | 3.00% | | |
| CPTP-3O2FF | 2.50% | | |
| PTP-101 | 5.00% | | |
| PTP-201 | 5.00% | | |
| CPTP-301 | 5.00% | | |
| PPTUI-3-2 | 0.50% | | |

stabilized with 0.01 % of the compound of the formula




**H11**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 91 |
| CY-3-O4 | 20.00 % | Δn [589 nm, 20°C]: | 0.0909 |
| CY-5-O2 | 10.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.1 |
| CY-5-O4 | 7.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 10.1 |
| CCY-3-O2 | 6.50 % | Δε [1 kHz, 20°C]: | -6.0 |

| | | | |
|---|---|---|---|
| CCY-3-O3 | 6.50 % | $\gamma_1$ [mPa·s, 20°C]: | 310 |
| CCY-4-O2 | 6.50 % | | |
| CCY-5-O2 | 6.50 % | | |
| CPY-2-O2 | 3.00 % | | |
| CH-33 | 3.00 % | | |
| CH-35 | 3.00 % | | |
| CH-43 | 3.00 % | | |
| CCPC-33 | 5.00 % | | |
| CCPC-34 | 5.00 % | | |

**H12**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 91 |
| CY-3-O4 | 20.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1099 |
| CY-5-O2 | 10.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.2 |
| CCY-3-O2 | 6.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 10.3 |
| CCY-3-O3 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -6.1 |
| CCY-4-O2 | 6.00 % | $\gamma_1$ [mPa·s, 20°C]: | 297 |
| CCY-5-O2 | 6.00 % | | |
| CPY-2-O2 | 8.00 % | | |
| CPY-3-O2 | 8.00 % | | |
| CC-4-V | 2.50 % | | |
| CCP-V-1 | 3.50 % | | |
| CPTP-3-1 | 2.50 % | | |
| CCPC-33 | 4.00 % | | |
| CCPC-34 | 2.00 % | | |

**H13**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 91 |
| CY-3-O4 | 20.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0897 |
| CY-5-O2 | 6.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| CCY-3-O2 | 6.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.0 |
| CCY-3-O3 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -4.3 |
| CCY-4-O2 | 6.00 % | $\gamma_1$ [mPa·s, 20°C]: | 204 |
| CPY-2-O2 | 6.00 % | | |

| | |
|---|---|
| CC-4-V | 15.00 % |
| CCP-V2-1 | 6.50 % |
| CCPC-33 | 4.50 % |
| CCPC-34 | 4.50 % |
| CCPC-35 | 4.50 % |

**H14**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 91 |
| CY-3-O4 | 20.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1106 |
| CCY-3-O2 | 6.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.9 |
| CCY-3-O3 | 6.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.4 |
| CCY-4-O2 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -4.5 |
| CCY-5-O2 | 2.00 % | $\gamma_1$ [mPa·s, 20°C]: | 202 |
| CPY-2-O2 | 8.00 % | | |
| CPY-3-O2 | 8.00 % | | |
| CC-4-V | 8.00 % | | |
| CCP-V-1 | 12.00 % | | |
| CCP-V2-1 | 5.00 % | | |
| CPTP-3-1 | 4.00 % | | |

**H15**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 15.00 % | Clearing point [°C]: | 95 |
| CY-3-O4 | 20.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0974 |
| CY-5-O2 | 8.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.1 |
| CCY-3-O2 | 6.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.9 |
| CCY-3-O3 | 6.50 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.8 |
| CCY-4-O2 | 6.50 % | $K_1$ [pN, 20°C]: | 14.3 |
| CCY-5-O2 | 6.50 % | $K_3$ [pN, 20°C]: | 16.8 |
| CPY-2-O2 | 7.50 % | $V_0$ [pN, 20°C]: | 1.79 |
| CPY-3-O2 | 3.50 % | $\gamma_1$ [mPa·s, 20°C]: | 292 |
| CC-4-V | 6.00 % | | |
| CH-33 | 3.50 % | | |
| CCPC-33 | 5.00 % | | |
| CCPC-34 | 5.00 % | | |

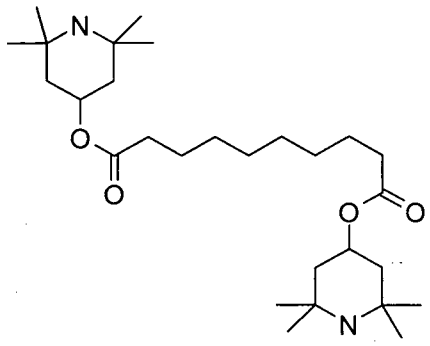
**H16**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 15.00 | % | Clearing point [°C]: | 95 |
| CY-3-O4 | 20.00 | % | Δn [589 nm, 20°C]: | 0.1126 |
| CY-5-O2 | 2.00 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.0 |
| CCY-3-O2 | 6.50 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.8 |
| CCY-3-O3 | 6.50 | % | Δε [1 kHz, 20°C]: | -5.8 |
| CCY-4-O2 | 6.50 | % | $K_1$ [pN, 20°C]: | 15.1 |
| CCY-5-O2 | 6.50 | % | $K_3$ [pN, 20°C]: | 17.8 |
| CPY-2-O2 | 8.00 | % | $V_0$ [pN, 20°C]: | 1.84 |
| CPY-3-O2 | 8.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 270 |
| CPTP-3O2FF | 4.00 | % | | |
| CC-4-V | 5.00 | % | | |
| CCP-V-1 | 10.50 | % | | |
| CCPC-33 | 1.50 | % | | |

**H17**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 12.00 | % | Clearing point [°C]: | 95 |
| CY-3-O4 | 16.00 | % | Δn [589 nm, 20°C]: | 0.0972 |
| CCY-3-O2 | 6.50 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.6 |
| CCY-3-O3 | 6.50 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.6 |
| CCY-4-O2 | 6.50 | % | Δε [1 kHz, 20°C]: | -4.0 |
| CCY-5-O2 | 6.00 | % | $K_1$ [pN, 20°C]: | 14.9 |
| CPY-2-O2 | 6.00 | % | $K_3$ [pN, 20°C]: | 17.0 |
| CPY-3-O2 | 5.50 | % | $V_0$ [pN, 20°C]: | 2.17 |
| CC-4-V | 15.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 180 |
| CCP-V-1 | 10.00 | % | | |
| CCP-V2-1 | 10.00 | % | | |

stabilized with 0.03 % of



**H18**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 11.00 | % | Clearing point [°C]: | 95 |
| CY-3-O4 | 16.00 | % | Δn [589 nm, 20°C]: | 0.1121 |
| CCY-3-O2 | 6.50 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| CCY-3-O3 | 6.00 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.7 |
| CCY-4-O2 | 6.00 | % | Δε [1 kHz, 20°C]: | -4.0 |
| CPY-2-O2 | 8.00 | % | $K_1$ [pN, 20°C]: | 14.8 |
| CPY-3-O2 | 8.00 | % | $K_3$ [pN, 20°C]: | 16.2 |
| CPTP-3O2FF | 5.00 | % | $V_0$ [pN, 20°C]: | 2.13 |
| CC-4-V | 16.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 179 |
| CCP-V-1 | 12.00 | % | | |
| BCH-32 | 5.50 | % | | |

**H19**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 3.50 | % | Clearing point [°C]: | 102.5 |
| CY-3-O4 | 16.00 | % | Δn [589 nm, 20°C]: | 0.1112 |
| CY-5-O2 | 8.75 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.8 |
| CCY-3-O2 | 6.00 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.8 |
| CCY-3-O3 | 6.00 | % | Δε [1 kHz, 20°C]: | -5.0 |
| CCY-4-O2 | 6.00 | % | $K_1$ [pN, 20°C]: | 15.0 |
| CCY-5-O2 | 6.00 | % | $K_3$ [pN, 20°C]: | 18.7 |
| CPY-2-O2 | 8.00 | % | $V_0$ [pN, 20°C]: | 2.04 |
| CPY-3-O2 | 8.50 | % | $\gamma_1$ [mPa·s, 20°C]: | 280 |
| CC-4-V | 3.00 | % | | |
| CCP-V-1 | 7.25 | % | | |

| | | |
|---|---|---|
| CCP-V2-1 | 3.25 | % |
| CCPC-33 | 2.75 | % |
| CY-5-O4 | 6.50 | % |
| CC-5-V | 3.50 | % |
| CCPC-34 | 2.00 | % |
| CPTP-301 | 1.75 | % |
| PTP-102 | 1.25 | % |

**H20**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CCY-5-O2 | 5.25 | % | Clearing point [°C]: | 102 |
| CPY-2-O2 | 11.75 | % | $\Delta n$ [589 nm, 20°C]: | 0.1133 |
| CPY-3-O2 | 11.75 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.1 |
| CC-5-V | 3.00 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 10.5 |
| CCPC-33 | 1.50 | % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -6.4 |
| CCPC-34 | 1.50 | % | $K_1$ [pN, 20°C]: | 15.4 |
| CCPC-35 | 1.00 | % | $K_3$ [pN, 20°C]: | 18.8 |
| CY-3-O2 | 8.50 | % | $V_0$ [pN, 20°C]: | 1.81 |
| CY-3-O4 | 23.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 367 |
| CCY-3-O2 | 7.25 | % | | |
| CCY-3-O3 | 6.75 | % | | |
| CCY-4-O2 | 6.75 | % | | |
| CY-5-O4 | 4.50 | % | | |
| CCY-3-1 | 4.00 | % | | |
| CCP-V-1 | 2.00 | % | | |
| CBC-33F | 1.50 | % | | |

**H21**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 6.00 | % | Clearing point [°C]: | 102 |
| CY-3-O4 | 14.00 | % | $\Delta n$ [589 nm, 20°C]: | 0.0898 |
| CCY-3-O2 | 4.00 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.1 |
| CCY-3-O3 | 4.00 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 5.3 |
| CPY-2-O2 | 9.00 | % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -2.1 |
| CCH-301 | 5.00 | % | $K_1$ [pN, 20°C]: | 16.7 |
| CC-3-V1 | 8.00 | % | $K_3$ [pN, 20°C]: | 18.3 |

| | | | | |
|---|---|---|---|---|
| CC-5-V | 13.00 % | $V_0$ [pN, 20°C]: | 3.11 |
| CCP-V-1 | 13.00 % | $\gamma_1$ [mPa·s, 20°C]: | 133 |
| CCP-V2-1 | 13.00 % | | |
| CH-33 | 3.00 % | | |
| CH-35 | 3.00 % | | |
| CP-43 | 3.00 % | | |
| CCPC-33 | 2.00 % | | |

**H22**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 8.00 % | Clearing point [°C]: | 102 |
| CY-3-O4 | 4.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1501 |
| CY-5-O2 | 12.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.1 |
| CY-5-O4 | 6.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 10.2 |
| CCY-3-O2 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -6.1 |
| CCY-4-O2 | 6.00 % | $K_1$ [pN, 20°C]: | 15.9 |
| CCY-5-O2 | 6.00 % | $K_3$ [pN, 20°C]: | 18.3 |
| CCY-3-O3 | 6.00 % | $V_0$ [pN, 20°C]: | 1.83 |
| CPY-2-O2 | 12.00 % | $\gamma_1$ [mPa·s, 20°C]: | 404 |
| CPY-3-O2 | 12.00 % | | |
| PYP-2-3 | 10.00 % | | |
| PYP-2-4 | 10.00 % | | |
| CPTP-301 | 2.00 % | | |

**H23**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 2.00 % | Clearing point [°C]: | 100 |
| CY-3-O4 | 6.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1508 |
| CY-5-O4 | 2.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.3 |
| CCY-3-O2 | 1.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 5.3 |
| CPY-2-O2 | 9.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -1.9 |
| CPY-3-O2 | 9.00 % | $K_1$ [pN, 20°C]: | 15.7 |
| PYP-2-3 | 10.00 % | $K_3$ [pN, 20°C]: | 16.4 |
| PYP-2-4 | 10.00 % | $V_0$ [pN, 20°C]: | 3.06 |
| PTP-102 | 1.50 % | $\gamma_1$ [mPa·s, 20°C]: | 122 |
| CPTP-301 | 5.00 % | | |

| | | |
|---|---|---|
| CPTP-302 | 4.00 | % |
| PCH-301 | 5.50 | % |
| CC-4-V | 14.00 | % |
| CC-5-V | 8.00 | % |
| CCP-V-1 | 7.50 | % |
| BCH-32 | 5.00 | % |

**H24**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 17.00 | % | Clearing point [°C]: | 101 |
| CY-3-O4 | 20.00 | % | Δn [589 nm, 20°C]: | 0.0969 |
| CY-5-O2 | 5.50 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.0 |
| CCY-3-O2 | 6.50 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 10.0 |
| CCY-3-O3 | 6.50 | % | Δε [1 kHz, 20°C]: | -6.0 |
| CCY-4-O2 | 6.50 | % | $K_1$ [pN, 20°C]: | 14.5 |
| CCY-5-O2 | 6.50 | % | $K_3$ [pN, 20°C]: | 17.3 |
| CPY-2-O2 | 10.50 | % | $V_0$ [pN, 20°C]: | 1.80 |
| CCH-34 | 3.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 322 |
| CH-33 | 3.00 | % | | |
| CH-35 | 3.00 | % | | |
| CH-43 | 3.00 | % | | |
| CCPC-33 | 3.00 | % | | |
| CCPC-34 | 3.00 | % | | |
| CCPC-35 | 3.00 | % | | |

**H25**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 2.40 | % | Clearing point [°C]: | 101 |
| CY-3-O4 | 18.80 | % | Δn [589 nm, 20°C]: | 0.0970 |
| CY-5-O2 | 2.40 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| CCY-3-O2 | 7.00 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.2 |
| CCY-5-O2 | 7.90 | % | Δε [1 kHz, 20°C]: | -4.5 |
| CCY-2-1 | 4.90 | % | $K_1$ [pN, 20°C]: | 14.8 |
| CCY-3-1 | 5.30 | % | $K_3$ [pN, 20°C]: | 17.6 |
| CPY-2-O2 | 5.70 | % | $V_0$ [pN, 20°C]: | 2.09 |
| CCH-301 | 8.50 | % | $\gamma_1$ [mPa·s, 20°C]: | 244 |

| | | |
|---|---|---|
| CH-33 | 0.90 | % |
| CH-35 | 0.90 | % |
| CP-33 | 1.20 | % |
| CP-35 | 1.20 | % |
| CCPC-33 | 3.00 | % |
| CCPC-34 | 2.70 | % |
| CCPC-35 | 0.60 | % |
| CCY-3-O3 | 4.90 | % |
| CCY-4-O2 | 4.90 | % |
| CPY-3-O2 | 4.20 | % |
| PYP-2-3 | 3.50 | % |
| CCH-303 | 4.20 | % |
| CCH-501 | 4.90 | % |

**H26**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 17.00 % | Clearing point [°C]: | 101 |
| CY-3-O4 | 20.00 % | Δn [589 nm, 20°C]: | 0.0969 |
| CY-5-O2 | 5.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.0 |
| CCY-3-O2 | 6.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 10.0 |
| CCY-3-O3 | 6.50 % | Δε [1 kHz, 20°C]: | -6.0 |
| CCY-4-O2 | 6.50 % | $K_1$ [pN, 20°C]: | 14.5 |
| CCY-5-O2 | 6.50 % | $K_3$ [pN, 20°C]: | 17.3 |
| CPY-2-O2 | 10.50 % | $V_0$ [pN, 20°C]: | 1.80 |
| CCH-34 | 3.00 % | $\gamma_1$ [mPa·s, 20°C]: | 322 |
| CH-33 | 3.00 % | | |
| CH-35 | 3.00 % | | |
| CH-43 | 3.00 % | | |
| CCPC-33 | 3.00 % | | |
| CCPC-34 | 3.00 % | | |
| CCPC-35 | 3.00 % | | |

**H27**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 16.00 % | Clearing point [°C]: | 101 |
| CY-3-O4 | 20.00 % | Δn [589 nm, 20°C]: | 0.0953 |

| | | | | |
|---|---|---|---|---|
| | CCY-3-O2 | 5.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.9 |
| | CCY-3-O3 | 5.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.4 |
| | CCY-4-O2 | 5.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.5 |
| | CCY-5-O2 | 5.00 % | $K_1$ [pN, 20°C]: | 16.2 |
| | CLY-2-O4 | 5.00 % | $K_3$ [pN, 20°C]: | 17.2 |
| | CLY-3-O2 | 5.00 % | $V_0$ [pN, 20°C]: | 1.85 |
| | CLY-3-O3 | 5.00 % | $\gamma_1$ [mPa·s, 20°C]: | 276 |
| | CPY-2-O2 | 5.00 % | | |
| | CC-5-V | 9.00 % | | |
| | CH-33 | 3.00 % | | |
| | CH-35 | 3.00 % | | |
| | CP-33 | 3.00 % | | |
| | CCPC-33 | 3.00 % | | |
| | CCPC-34 | 3.00 % | | |

**H28**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| | CY-3-O2 | 8.00 % | Clearing point [°C]: | 100 |
| | CY-3-O4 | 15.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0948 |
| | CY-5-O2 | 8.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.9 |
| | CY-5-O4 | 10.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.2 |
| | CCY-3-O2 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.3 |
| | CCY-3-O3 | 6.00 % | $K_1$ [pN, 20°C]: | 14.6 |
| | CCY-4-O2 | 6.00 % | $K_3$ [pN, 20°C]: | 17.3 |
| | CCY-5-O2 | 6.00 % | $V_0$ [pN, 20°C]: | 1.90 |
| | CPY-2-O2 | 10.00 % | $\gamma_1$ [mPa·s, 20°C]: | 298 |
| | CC-5-V | 7.00 % | | |
| | CH-33 | 3.00 % | | |
| | CH-35 | 3.00 % | | |
| | CP-33 | 3.00 % | | |
| | CCPC-33 | 3.00 % | | |
| | CCPC-34 | 3.00 % | | |
| | CCPC-35 | 3.00 % | | |

**H29**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 9.00 % | Clearing point [°C]: | 106 |
| CY-3-O4 | 9.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1077 |
| CY-5-O2 | 12.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.9 |
| CY-5-O4 | 11.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.5 |
| CCY-3-O2 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.6 |
| CCY-3-O3 | 6.00 % | $K_1$ [pN, 20°C]: | 15.8 |
| CCY-4-O2 | 6.00 % | $K_3$ [pN, 20°C]: | 19.4 |
| CCY-5-O2 | 6.00 % | $V_0$ [pN, 20°C]: | 1.96 |
| CPY-2-O2 | 8.00 % | $\gamma_1$ [mPa·s, 20°C]: | 341 |
| CPY-3-O2 | 7.00 % | | |
| CCP-V-1 | 11.00 % | | |
| CCPC-33 | 3.00 % | | |
| CCPC-34 | 3.00 % | | |
| CCPC-35 | 3.00 % | | |

**H30**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 8.00 % | Clearing point [°C]: | 98 |
| CY-3-O4 | 17.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0914 |
| CY-5-O2 | 8.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.8 |
| CCY-3-O2 | 8.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.9 |
| CCY-3-O3 | 8.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.1 |
| CCY-4-O2 | 8.00 % | $K_1$ [pN, 20°C]: | 15.5 |
| CCY-5-O2 | 8.00 % | $K_3$ [pN, 20°C]: | 16.8 |
| CPY-2-O2 | 8.00 % | $V_0$ [pN, 20°C]: | 1.92 |
| CCH-301 | 3.00 % | $\gamma_1$ [mPa·s, 20°C]: | 256 |
| CC-5-V | 10.00 % | | |
| CH-33 | 3.00 % | | |
| CH-35 | 3.00 % | | |
| CP-33 | 3.00 % | | |
| CP-35 | 2.00 % | | |
| CCPC-33 | 3.00 % | | |

**H31**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 7.00 % | Clearing point [°C]: | 105 |
| CY-3-O4 | 16.00 % | Δn [589 nm, 20°C]: | 0.1024 |
| CCY-3-O2 | 6.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.4 |
| CCY-3-O3 | 6.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.6 |
| CCY-4-O2 | 6.00 % | Δε [1 kHz, 20°C]: | -3.2 |
| CPY-2-O2 | 7.50 % | $K_1$ [pN, 20°C]: | 18.4 |
| CPY-3-O2 | 7.50 % | $K_3$ [pN, 20°C]: | 21.2 |
| CC-3-V1 | 8.00 % | $V_0$ [pN, 20°C]: | 2.79 |
| CC-5-V | 9.00 % | $\gamma_1$ [mPa·s, 20°C]: | 171 |
| CCP-V-1 | 13.50 % | | |
| CCP-V2-1 | 13.50 % | | |

**H32**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 9.00 % | Clearing point [°C]: | 106 |
| CY-3-O4 | 9.00 % | Δn [589 nm, 20°C]: | 0.1077 |
| CY-5-O2 | 12.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.9 |
| CY-5-O4 | 11.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.5 |
| CCY-3-O2 | 6.00 % | Δε [1 kHz, 20°C]: | -5.6 |
| CCY-3-O3 | 6.00 % | $K_1$ [pN, 20°C]: | 15.8 |
| CCY-4-O2 | 6.00 % | $K_3$ [pN, 20°C]: | 19.4 |
| CCY-5-O2 | 6.00 % | $V_0$ [pN, 20°C]: | 1.96 |
| CPY-2-O2 | 8.00 % | $\gamma_1$ [mPa·s, 20°C]: | 341 |
| CPY-3-O2 | 7.00 % | | |
| CCP-V-1 | 11.00 % | | |
| CCPC-33 | 3.00 % | | |
| CCPC-34 | 3.00 % | | |
| CCPC-35 | 3.00 % | | |

**H33**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 4.00 % | Clearing point [°C]: | 100 |
| CY-3-O4 | 12.50 % | $\Delta n$ [589 nm, 20°C]: | 0.1566 |
| CCY-3-O2 | 3.50 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.6 |
| CPY-2-O2 | 12.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.6 |
| CPY-3-O2 | 12.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.0 |
| PYP-2-3 | 11.00 % | $K_1$ [pN, 20°C]: | 15.5 |
| PYP-2-4 | 11.00 % | $K_3$ [pN, 20°C]: | 17.1 |
| CPTP-301 | 5.00 % | $V_0$ [pN, 20°C]: | 2.50 |
| CPTP-302 | 5.00 % | $\gamma_1$ [mPa·s, 20°C]: | 202 |
| CC-4-V | 14.00 % | | |
| CC-5-V | 7.00 % | | |
| BCH-32 | 3.00 % | | |

**H34**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 8.00 % | Clearing point [°C]: | 98 |
| CY-3-O4 | 17.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0914 |
| CY-5-O2 | 8.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.8 |
| CCY-3-O2 | 8.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.9 |
| CCY-3-O3 | 8.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.1 |
| CCY-4-O2 | 8.00 % | $K_1$ [pN, 20°C]: | 15.5 |
| CCY-5-O2 | 8.00 % | $K_3$ [pN, 20°C]: | 16.8 |
| CPY-2-O2 | 8.00 % | $V_0$ [pN, 20°C]: | 1.92 |
| CCH-301 | 3.00 % | $\gamma_1$ [mPa·s, 20°C]: | 256 |
| CC-5-V | 10.00 % | | |
| CH-33 | 3.00 % | | |
| CH-35 | 3.00 % | | |
| CP-33 | 3.00 % | | |
| CP-35 | 2.00 % | | |
| CCPC-33 | 3.00 % | | |

**H35**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 2.40 % | Clearing point [°C]: | 101 |
| CY-3-O4 | 18.80 % | Δn [589 nm, 20°C]: | 0.0970 |
| CY-5-O2 | 2.40 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| CCY-3-O2 | 7.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.2 |
| CCY-5-O2 | 7.90 % | Δε [1 kHz, 20°C]: | -4.5 |
| CCY-2-1 | 4.90 % | $K_1$ [pN, 20°C]: | 14.8 |
| CCY-3-1 | 5.30 % | $K_3$ [pN, 20°C]: | 17.6 |
| CPY-2-O2 | 5.70 % | $V_0$ [pN, 20°C]: | 2.09 |
| CCH-301 | 8.50 % | $\gamma_1$ [mPa·s, 20°C]: | 244 |
| CH-33 | 0.90 % | | |
| CH-35 | 0.90 % | | |
| CP-33 | 1.20 % | | |
| CP-35 | 1.20 % | | |
| CCPC-33 | 3.00 % | | |
| CCPC-34 | 2.70 % | | |
| CCPC-35 | 0.60 % | | |
| CCY-3-O3 | 4.90 % | | |
| CCY-4-O2 | 4.90 % | | |
| CPY-3-O2 | 4.20 % | | |
| PYP-2-3 | 3.50 % | | |
| CCH-303 | 4.20 % | | |
| CCH-501 | 4.90 % | | |

**H36**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 6.00 % | Clearing point [°C]: | 101 |
| CY-3-O4 | 13.00 % | Δn [589 nm, 20°C]: | 0.1483 |
| CCY-3-O2 | 6.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.6 |
| CCY-3-O3 | 5.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.0 |
| CPY-2-O2 | 4.00 % | Δε [1 kHz, 20°C]: | -3.4 |
| CC-4-V | 14.00 % | $K_1$ [pN, 20°C]: | 16.6 |
| CCP-V-1 | 10.00 % | $K_3$ [pN, 20°C]: | 18.8 |
| CCP-V2-1 | 11.00 % | $V_0$ [pN, 20°C]: | 2.47 |
| CPTP-3-1 | 5.00 % | $\gamma_1$ [mPa·s, 20°C]: | |
| PTP-3O2FF | 8.00 % | | |

| | |
|---|---|
| PTP-5O2FF | 8.00 % |
| CPTP-3O2FF | 5.00 % |
| CPTP-5O2FF | 5.00 % |

**H37**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 10.00 % | Clearing point [°C]: | 100 |
| CY-3-O4 | 20.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0865 |
| CY-5-O4 | 20.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.9 |
| CCY-3-O2 | 6.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 9.3 |
| CCY-3-O3 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.4 |
| CCY-4-O2 | 6.00 % | $K_1$ [pN, 20°C]: | 15.6 |
| CCY-5-O2 | 6.00 % | $K_3$ [pN, 20°C]: | 16.6 |
| CH-33 | 3.00 % | $V_0$ [pN, 20°C]: | 1.84 |
| CH-35 | 3.50 % | $\gamma_1$ [mPa·s, 20°C]: | 347 |
| CH-43 | 3.50 % | | |
| CH-45 | 3.50 % | | |
| CCPC-33 | 4.00 % | | |
| CCPC-34 | 4.50 % | | |
| CCPC-35 | 4.00 % | | |

**H38**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O2 | 3.00 % | Clearing point [°C]: | 102 |
| CY-3-O4 | 10.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1602 |
| CCY-3-O2 | 6.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.8 |
| CCY-3-O3 | 6.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.8 |
| CCY-4-O2 | 6.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -4.0 |
| CPY-2-O2 | 5.00 % | $K_1$ [pN, 20°C]: | 16.8 |
| CC-4-V | 14.00 % | $K_3$ [pN, 20°C]: | 19.3 |
| CCP-V-1 | 5.00 % | $V_0$ [pN, 20°C]: | 2.32 |
| CCP-V2-1 | 10.00 % | $\gamma_1$ [mPa·s, 20°C]: | 216 |
| PPTUI-3-2 | 3.00 % | | |
| PTP-3O2FF | 11.00 % | | |
| PTP-5O2FF | 11.00 % | | |
| CPTP-3O2FF | 5.00 % | | |

| | | |
|---|---|---|
| CPTP-5O2FF | 5.00 | % |

**H39**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O2 | 5.00 | % | Clearing point [°C]: | 102 |
| CY-3-O4 | 15.00 | % | Δn [589 nm, 20°C]: | 0.2503 |
| CCY-3-O2 | 6.00 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.3 |
| CCY-3-O3 | 6.00 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 8.3 |
| CPY-2-O2 | 3.00 | % | Δε [1 kHz, 20°C]: | -4.0 |
| PTP-102 | 5.00 | % | $K_1$ [pN, 20°C]: | 19.5 |
| PPTUI-3-2 | 15.00 | % | $K_3$ [pN, 20°C]: | 24.0 |
| PPTUI-3-4 | 11.00 | % | $V_0$ [pN, 20°C]: | 2.57 |
| PTP-3O2FF | 12.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 392 |
| PTP-5O2FF | 12.00 | % | | |
| CPTP-3O2FF | 5.00 | % | | |
| CPTP-5O2FF | 5.00 | % | | |

**H40**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-3-O4 | 12.00 | % | Clearing point [°C]: | 91 |
| PY-3-O2 | 6.50 | % | Δn [589 nm, 20°C]: | 0.2100 |
| CCY-3-O2 | 2.00 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.0 |
| CPY-2-O2 | 3.50 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.1 |
| CC-4-V | 13.50 | % | Δε [1 kHz, 20°C]: | -3.1 |
| CC-5-V | 4.00 | % | $K_1$ [pN, 20°C]: | 15.3 |
| PPTUI-3-2 | 15.00 | % | $K_3$ [pN, 20°C]: | 19.3 |
| PPTUI-3-4 | 5.50 | % | $V_0$ [pN, 20°C]: | 2.64 |
| PTP-3O2FF | 12.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 211 |
| PTP-5O2FF | 12.00 | % | | |
| CPTP-3O2FF | 5.00 | % | | |
| CPTP-5O2FF | 5.00 | % | | |
| CCPC-33 | 4.00 | % | | |

**H41**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| D-302FF | 8.00 % | Clearing point [°C]: | 102 |
| D-402FF | 8.00 % | Δn [589 nm, 20°C]: | 0.14780 |
| D-502FF | 8.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.4 |
| PCH-301 | 18.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 5.1 |
| PCH-302 | 15.00 % | Δε [1 kHz, 20°C]: | -1.7 |
| PCH-304 | 4.00 % | | |
| PTP-102 | 4.00 % | | |
| PTP-201 | 4.00 % | | |
| CPTP-301 | 6.00 % | | |
| CPTP-302 | 6.00 % | | |
| CPTP-303 | 7.00 % | | |
| CCPC-33 | 4.00 % | | |
| CCPC-34 | 4.00 % | | |
| CCPC-35 | 4.00 % | | |

**H42**: Nematic host-mixture

| | | | |
|---|---|---|---|
| D-302FF | 15.00 % | Clearing point [°C]: | 109 |
| D-402FF | 15.00 % | Δn [589 nm, 20°C]: | 0.1727 |
| D-502FF | 15.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 5.2 |
| CP-302FF | 5.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 13.2 |
| CP-402FF | 5.00 % | Δε [1 kHz, 20°C]: | -8.0 |
| CP-502FF | 5.00 % | $K_1$ [pN, 20°C]: | 15.6 |
| PTP-3O2FF | 10.00 % | $K_3$ [pN, 20°C]: | 22.8 |
| PTP-5O2FF | 10.00 % | | |
| CPTP-3O2FF | 10.00 % | | |
| CPTP-5O2FF | 10.00 % | | |

**H43**: Nematic host-mixture

| | | | |
|---|---|---|---|
| D-302FF | 7.00 % | Clearing point [°C]: | 85 |
| D-402FF | 7.00 % | Δn [589 nm, 20°C]: | 0.1640 |
| D-502FF | 7.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| PTP-3O2FF | 10.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 6.4 |

| | | | | |
|---|---|---|---|---|
| PTP-5O2FF | 10.00 | % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -2.7 |
| CPTP-301 | 5.00 | % | | |
| CPTP-302 | 5.00 | % | | |
| CPTP-303 | 5.00 | % | | |
| PCH-301 | 19.00 | % | | |
| PCH-302 | 17.00 | % | | |
| CBC-33F | 5.00 | % | | |
| CBC-53F | 3.00 | % | | |

**H44**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CCPC-33 | 1.50 | % | Clearing point [°C]: | 91 |
| CCPC-34 | 1.50 | % | $\Delta n$ [589 nm, 20°C]: | 0.1029 |
| CCPC-35 | 1.50 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.5 |
| CCY-2-1 | 4.50 | % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.2 |
| CCY-3-1 | 3.50 | % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.7 |
| CCY-3-O2 | 7.00 | % | $K_1$ [pN, 20°C]: | 15.5 |
| CCY-3-O3 | 8.00 | % | $K_3$ [pN, 20°C]: | 15.2 |
| CCY-4-O2 | 7.00 | % | $V_0$ [pN, 20°C]: | 2.21 |
| CPY-2-O2 | 6.00 | % | $\gamma_1$ [mPa·s, 20°C]: | 231 |
| CPY-3-O2 | 6.00 | % | | |
| CY-3-O4 | 12.00 | % | | |
| CY-5-O4 | 12.00 | % | | |
| PCH-53 | 10.50 | % | | |
| CCH-34 | 5.50 | % | | |
| CCOC-3-3 | 2.00 | % | | |
| CCOC-4-3 | 2.00 | % | | |
| CCOC-3-5 | 2.00 | % | | |
| CBC-33 | 1.50 | % | | |
| PP-1-2V1 | 6.00 | % | | |

**H45**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CY-5-O2 | 7.00 | % | Clearing point [°C]: | 95 |
| CPY-2-O2 | 11.00 | % | $\Delta n$ [589 nm, 20°C]: | 0.1268 |
| CPY-3-O2 | 10.00 | % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 4.0 |

| | | | | |
|---|---|---|---|---|
| PYP-2-3 | 6.00 % | $\varepsilon_\perp$ [1 kHz, 20°C]: | 7.7 |
| PYP-2-4 | 7.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.7 |
| CC-4-V | 17.00 % | $K_1$ [pN, 20°C]: | 15.5 |
| CC-3-V1 | 9.00 % | $K_3$ [pN, 20°C]: | 15.2.0 |
| CCH-34 | 5.00 % | $V_0$ [pN, 20°C]: | 2.15 |
| CPYP-3-2 | 5.00 % | $\gamma_1$ [mPa·s, 20°C]: | 155 |
| CPYP-2-1 | 5.00 % | | |
| CK-3-F | 9.00 % | | |
| CK-5-F | 9.00 % | | |

**H46**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CY-3-O4 | 18.00 % | Clearing point [°C]: | 96 |
| CY-5-O2 | 10.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1275 |
| CCY-4-O2 | 10.00 % | $\varepsilon_\parallel$ [1 kHz, 20°C]: | 4.0 |
| CCY-3-O3 | 10.00 % | $\varepsilon_\perp$ [1 kHz, 20°C]: | 9.1 |
| CPY-2-O2 | 11.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -5.1 |
| CPY-3-O2 | 12.00 % | $K_1$ [pN, 20°C]: | 14.4 |
| PYP-2-3 | 5.00 % | $K_3$ [pN, 20°C]: | 15.6 |
| PYP-2-4 | 4.00 % | $V_0$ [pN, 20°C]: | 1.84 |
| CC-4-V | 13.00 % | $\gamma_1$ [mPa·s, 20°C]: | 253 |
| CPYP-3-2 | 7.00 % | | |

**H47**: Nematic host-mixture

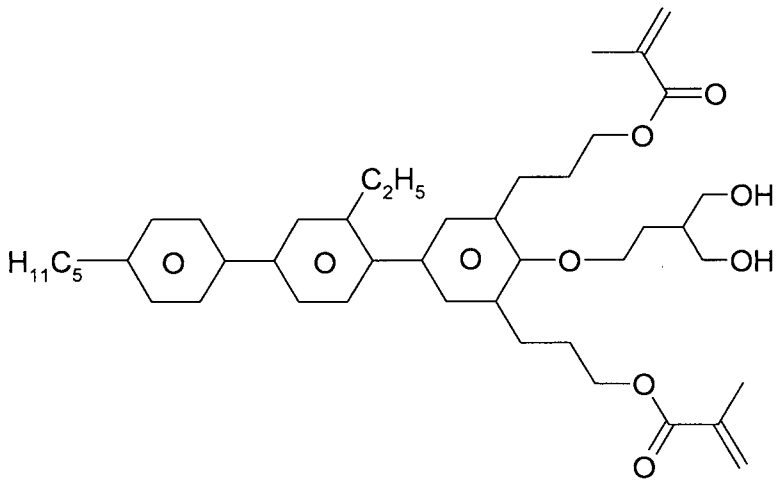
| | | | |
|---|---|---|---|
| CC-3-V | 34.00 % | Clearing point [°C]: | 74.6 |
| CC-3-V1 | 10.00 % | $\Delta n$ [589 nm, 20°C]: | 0.1089 |
| CCY-3-O1 | 8.50 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.2 |
| CCY-3-O2 | 3.50 % | $\varepsilon_\perp$ [1 kHz, 20°C]: | 6.8 |
| CLY-3-O2 | 10.00 % | $\varepsilon_\parallel$ [1 kHz, 20°C]: | 3.6 |
| CPY-3-O2 | 6.50 % | K1 [pN, 20°C]: | 14.4 |
| PY-1-O4 | 9.00 % | $K_3$ [pN, 20°C]: | 15.7 |
| PY-3-O2 | 10.50 % | $V_0$ [pN, 20°C]: | 2.33 |
| PGIY-2-O4 | 8.00 % | $\gamma_1$ [mPa·s, 20°C]: | 89 |

**H48**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CC-3-V | 34.00 % | Clearing point [°C]: | 75.1 |
| CC-3-V1 | 10.00 % | Δn [589 nm, 20°C]: | 0.1087 |
| CCY-3-O1 | 8.50 % | Δε [1 kHz, 20°C]: | -3.8 |
| CCY-3-O2 | 3.50 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.5 |
| CLY-3-O2 | 10.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.7 |
| CPY-3-O2 | 6.50 % | $\gamma_1$ [mPa·s, 20°C]: | 100 |
| PY-1-O4 | 9.00 % | | |
| PY-3-O2 | 10.50 % | | |
| PGIY-2-O4 | 8.00 % | | |

Example **M1**

The compound of the formula I-8h-5a



I-8h-5a

(0.3 %) is added to the nematic host mixture **H1**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).
The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-8h-5a, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, PS-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and orientation.

Example 1P a): Polymer stabilization of the LC mixture of Example **M1**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M1**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

Additives like Irganox 1076 (BASF) may be added (e.g. 0.001 %) for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-8h-5 in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 1P b): Polymer stabilization of the LC mixture of Example **M1**

The polymerizable derivative **RM-41** (0.3 %) is added to the nematic LC-mixture of Example **M1**. The resulting mixture is homogenised and filled

into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to Example 1P a) and similar results are obtained.

By using additives like the compound of the formula I-8h-5 in combination with **RM-41**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Examples **M2** to **M48** and 2P a) to 48P b)

The compound of the formula I-8h-5a (0.3 %) is added to the nematic host mixtures **H2 – H48**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixtures show a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

The polymerizable derivative **RM-1** (0.3 %) or **RM-41** (0.3 %) is added to the nematic LC mixtures of Examples **M2-M48**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to example 1P a). Equivalent results are obtained.

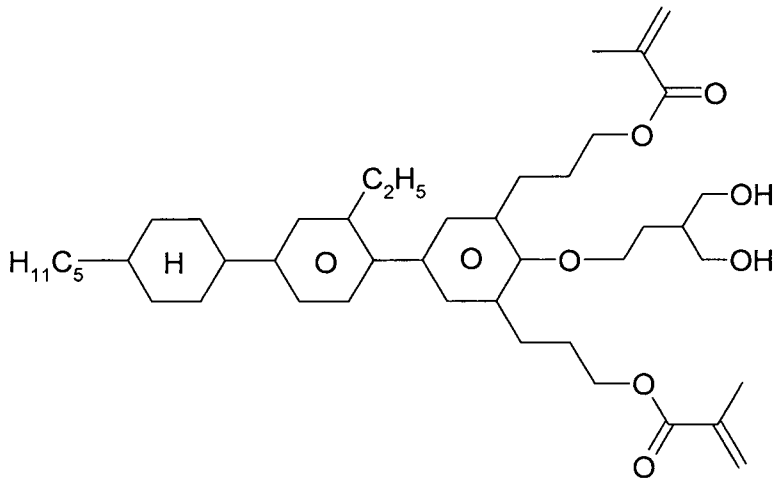
Examples 1P c) to 48P f)

Analogues mixtures like 1P a) to 48P b) are obtained by mixing the nematic LC mixtures **M1** to **M9** with **RM-37** (0.3 %), **RM-61** (0.3 %), **RM-80**

(0.3 %), **RM-84** (0.3 %) or **RM-98** (0.3 %),, obtaining mixtures 1P c) to 48P f). These mixtures are treated according to Example 1P a). In all cases an improvement of the switching times is found.

Example **M49**

The compound of the formula I-23h-5a



I-23h-5a

(0.3 %) is added to the nematic host mixture **H1**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-23h-5, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 49P a): Polymer stabilization of the LC mixture of Example **M49**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M49**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

Additives like Irganox 1076 (BASF) may be added (e.g. 0.001 %) for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-23h-5 in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 49P b): Polymer stabilization of the LC mixture of Example **M49**

The polymerizable derivative **RM-41** (0.3 %) is added to the nematic LC-mixture of Example **M49**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to Example 2P a) and similar results are obtained.

By using additives like the compound of the formula I-23h-5a in combination with **RM-41**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Examples **M50** to **M96** and 50P a) to 96P b)

The compound of the formula I-23h-5a (0.3 %) is added to the nematic host mixtures **H2 – H48**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixtures show a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

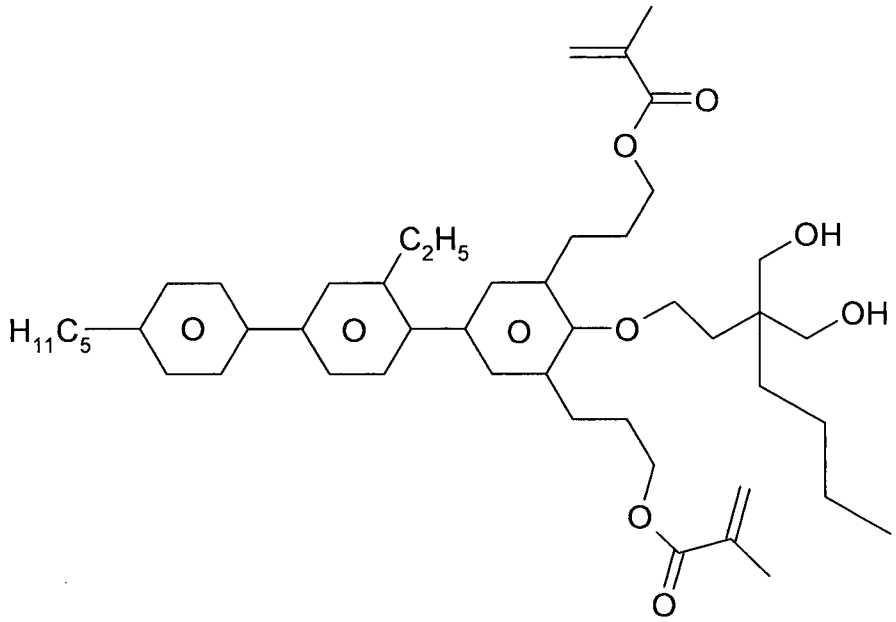
The polymerizable derivative **RM-1** (0.3 %) or **RM-41** (0.3 %) is added to the nematic LC mixtures of Examples **M50-M96**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to example 1P a). Equivalent results are obtained.

Examples 50P c) to 96P f)

Analogues mixtures like 1P a) to 9 P b) are obtained by mixing the nematic LC mixtures **M50** to **M96** with **RM-37** (0.3 %), **RM-61** (0.3 %), **RM-80** (0.3 %), **RM-84** (0.3 %) or **RM-98** (0.3 %), obtaining mixtures 50P c) to 96P f). These mixtures are treated according to Example 1P a). In all cases an improvement of the switching times is found.

Example **M97**

The compound of the formula I-8h-5b



I-8h-5b

(0.7 %) is added to the nematic host mixture **H47**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-8h-5b, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 97P a): Polymer stabilization of the LC mixture of Example **M97**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M97**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

Additives like Irganox 1076 (BASF) may be added (e.g. 0.001 %) for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-8h-5b in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 97P b): Polymer stabilization of the LC mixture of Example **M97**

The polymerizable derivative **RM-41** (0.3 %) is added to the nematic LC-mixture of Example **M19**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to Example 1P a) and similar results are obtained.

By using additives like the compound of the formula I-8h-7 in combination with **RM-41**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Examples **M98** to **M144** and 98P a) to 144P b)

The compound of the formula I-8h-b (0.7 %) is added to the nematic host mixtures **H2 - H48**. The resulting 8 mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixtures show a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

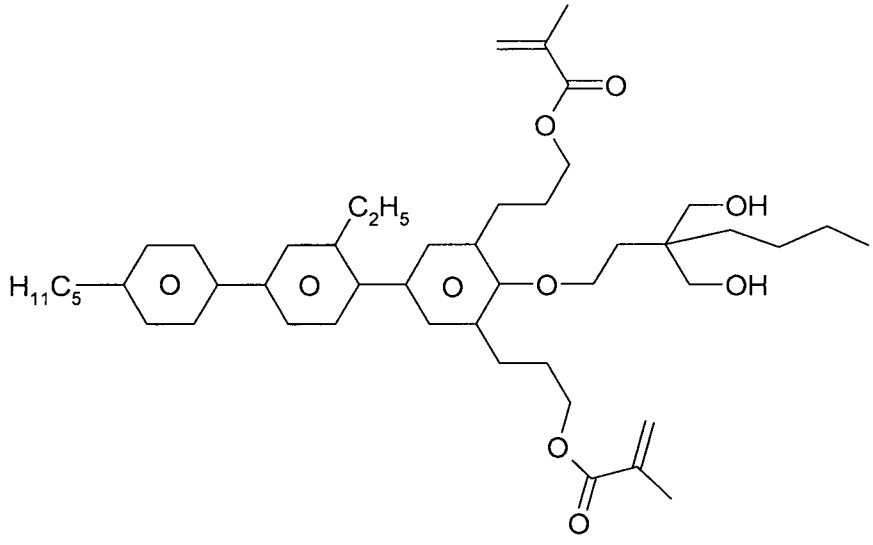
The polymerizable derivative **RM-1** (0.3 %) or **RM-41** (0.3 %) is added to the nematic LC mixtures of Examples **M98-M144**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to example 1P a). Equivalent results are obtained.

Examples 98P c) to 144P f)

Analogues mixtures like 1P a) to 9 P b) are obtained by mixing the nematic LC mixtures **M98** to **M144** with **RM-37** (0.3 %), **RM-61** (0.3 %), **RM-80** (0.3 %), **RM-84** (0.3 %) or **RM-98** (0.3 %), obtaining mixtures 98P c) to 144P f). These mixtures are treated according to Example 1P a). In all cases an improvement of the switching times is found.

Example **M145**

The compound of the formula I-8h-5c



I-8h-5c

(0.7 %) is added to the nematic host mixture **H1**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-8h-5c, no alignment layer (e.g. no PI coating) is required anymore for PM-VA, PVA, MVA, HT-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 145P a): Polymer stabilization of the LC mixture of Example **M145**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M145**. The resulting mixture is homogenised and filled

into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

Additives like Irganox 1076 (BASF) may be added (e.g. 0.001 %) for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-8h-5c in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example 145P b): Polymer stabilization of the LC mixture of Example **M145**

The polymerizable derivative **RM-41** (0.3 %) is added to the nematic LC-mixture of Example **M101**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to Example 1P a) and similar results are obtained.

By using additives like the compound of the formula I-8h-5c in combination with **RM-41**, no alignment layer is required anymore for PSA, PS-VA, and

other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Examples **M146** to **M192** and 146P a) to 192P b)

The compound of the formula I-8h-5c (0.7 %) is added to the nematic host mixtures **H2 – H48**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixtures show a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

The polymerizable derivative **RM-1** (0.3 %) or **RM-41** (0.3 %) is added to the nematic LC mixtures of Examples **M146 – M192**. The resulting mixtures are homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to example 1P a). Equivalent results are obtained.

Examples 145P c) to 192P f)

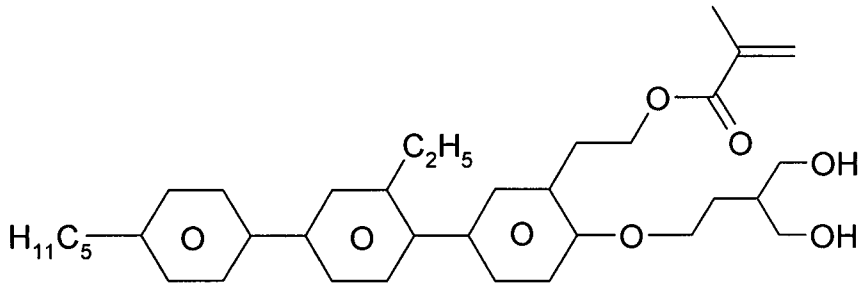
Analogues mixtures like 1P a) to 48P b) are obtained by mixing the nematic LC mixtures **M145** to **M192** with **RM-37** (0.3 %), **RM-61** (0.3 %), **RM-80** (0.3 %), **RM-84** (0.3 %) or **RM-98** (0.3 %), obtaining mixtures 145P c) to 192P f). These mixtures are treated according to Example 1P a). In all cases an improvement of the switching times is found.

**H49**: Nematic host-mixture

| | | | | |
|---|---|---|---|---|
| CC-3-V1 | 9.00 % | Clearing point [°C]: | 74.6 |
| CCH-301 | 3.50 % | Δn [589 nm, 20°C]: | 0.0984 |
| CCH-34 | 8.00 % | Δε [1 kHz, 20°C]: | -3.6 |
| CCH-35 | 8.00 % | $\varepsilon_{\perp}$ [1 kHz, 20°C]: | 7.2 |
| CCP-3-1 | 6.00 % | $\varepsilon_{\parallel}$ [1 kHz, 20°C]: | 3.6 |
| CCY-3-O1 | 6.50 % | $K_1$ [pN, 20°C]: | 14.1 |
| CCY-3-O2 | 12.50 % | $K_3$ [pN, 20°C]: | 17.0 |
| CPY-3-O2 | 10.00 % | $V_0$ [pN, 20°C]: | 2.31 |
| CY-3-O2 | 15.50 % | $\gamma_1$ [mPa·s, 20°C]: | 119 |
| PCH-301 | 8.50 % | | |
| PY-3-O2 | 12.50 % | | |

Example **M193**

The compound of the formula I-1d-5a



I-1d-5a

(0.3 %) is added to the nematic host mixture **H49**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-1d-5a, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, PS-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and orientation.

Example 193P a): Polymer stabilization of the LC mixture of Example **M193**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M193**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

Additives like Irganox 1076 (BASF) may be added (e.g. 0.001 %) for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-8h-5a in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

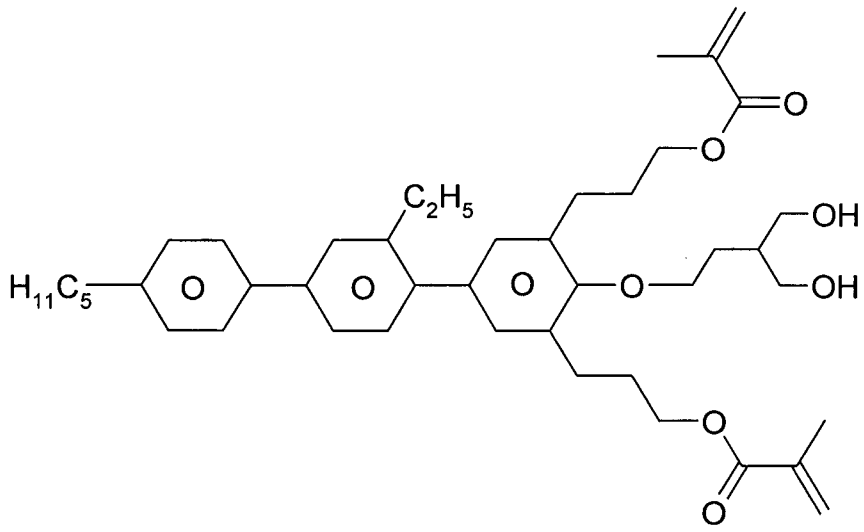
**H50**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CC-3-V1 | 9.00 % | Clearing point [°C]: | 74.7 |
| CCH-23 | 18.00 % | $\Delta n$ [589 nm, 20°C]: | 0.0982 |
| CCH-34 | 3.00 % | $\Delta\varepsilon$ [1 kHz, 20°C]: | -3.4 |
| CCH-35 | 7.00 % | $\varepsilon_\perp$ [1 kHz, 20°C]: | 7.2 |
| CCP-3-1 | 5.50 % | $\varepsilon_\parallel$ [1 kHz, 20°C]: | 3.6 |

| | | | | |
|---|---|---|---|---|
| CCY-3-O2 | 11.50 % | $K_1$ [pN, 20°C]: | 14.9 |
| CPY-2-O2 | 8.50 % | $K_3$ [pN, 20°C]: | 15.9 |
| CPY-3-O2 | 11.00 % | $V_0$ [pN, 20°C]: | 2.28 |
| CY-3-O2 | 15.50 % | $\gamma_1$ [mPa·s, 20°C]: | 108 |
| PY-3-O2 | 11.50 % | | |

Example **M194**

The compound of the formula I-8h-5a



I-8h-5a

(0.25 %) is added to the nematic host mixture **H50**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).
The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.
By using additives like the compound of the formula I-8h-5a, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, PS-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and orientation.

Example 194P a): Polymer stabilization of the LC mixture of Example **M194**

The polymerizable derivative **RM-1** (0.4 %) is added to the nematic LC-mixture of Example **M194**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

The additive Irganox 1076 (BASF) is added in amounts of 0.01 % for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-8h-5a in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

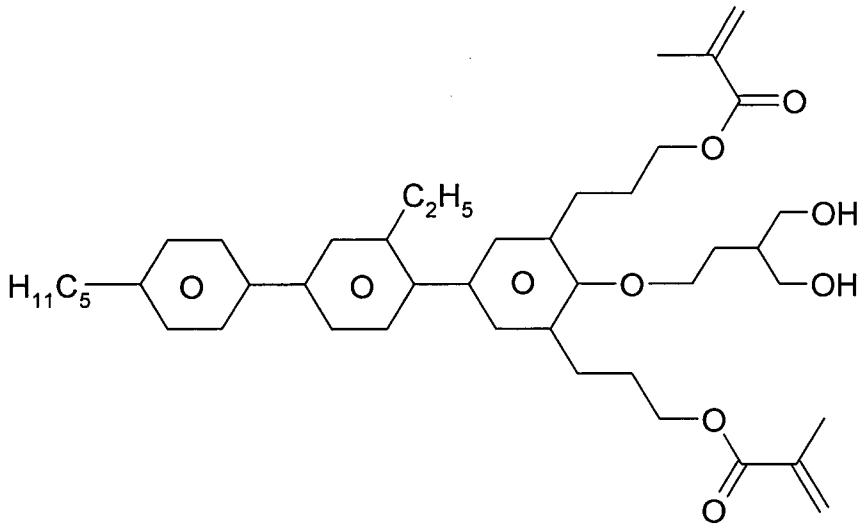
**H51**: Nematic host-mixture

| | | | |
|---|---|---|---|
| CC-3-V1 | 10.25 % | Clearing point [°C]: | 74.7 |
| CCH-23 | 18.50 % | Δn [589 nm, 20°C]: | 0.1027 |
| CCH-35 | 6.75 % | Δε [1 kHz, 20°C]: | -3.1 |
| CCP-3-1 | 6.00 % | $\varepsilon_\perp$ [1 kHz, 20°C]: | 7.2 |
| CCY-3-1 | 2.50 % | $\varepsilon_\parallel$ [1 kHz, 20°C]: | 3.6 |

| | | | | |
|---|---|---|---|---|
| CCY-3-O2 | 12.00 % | $K_1$ [pN, 20°C]: | 15.4 |
| CPY-2-O2 | 6.00 % | $K_3$ [pN, 20°C]: | 16.8 |
| CPY-3-O2 | 9.75 % | $V_0$ [pN, 20°C]: | 2.46 |
| CY-3-O2 | 11.50 % | $\gamma_1$ [mPa·s, 20°C]: | 104 |
| PP-1-2V1 | 3.75 % | | |
| PY-3-O2 | 13.00 % | | |

Example **M195**

The compound of the formula I-8h-5a



I-8h-5a

(0.2 %) is added to the nematic host mixture **H51**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-8h-5a, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, PS-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and orientation.

Example 195P a): Polymer stabilization of the LC mixture of Example **M195**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M195**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

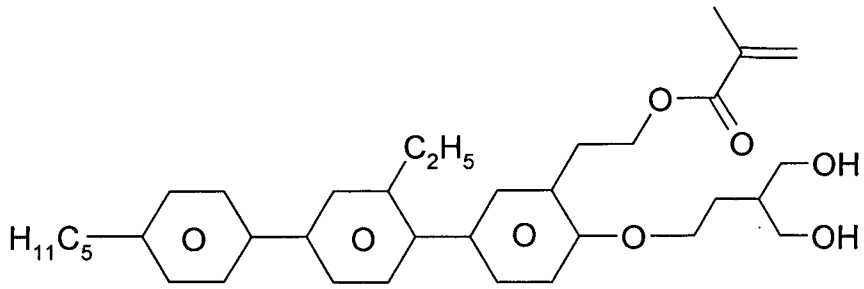
The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

The additive Irganox 1076 (BASF) is added in amounts of 0.01 % for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-8h-5a in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example **M196**

The compound of the formula I-1d-5a



I-1d-5a

(0.3 %) is added to the nematic host mixture **H51**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).
The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.
By using additives like the compound of the formula I-1d-5a, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, PS-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and orientation.

Example 196P a): Polymer stabilization of the LC mixture of Example **M196**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M196**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can

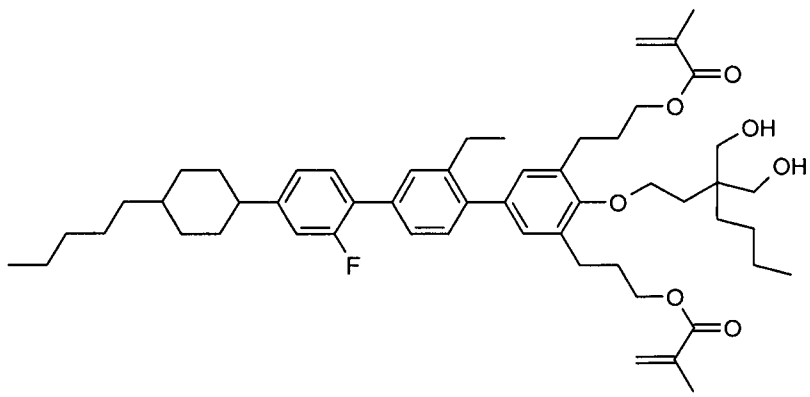
be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

The additive Irganox 1076 (BASF) is added in amounts of 0.01 % for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-1d-5a in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

Example **M197**

The compound of the formula I-74a-1




I-74a-1

(0.3 %) is added to the nematic host mixture **H51**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).
The LC-mixture shows a spontaneous homeotropic (vertical) orientation with respect to the surface of the substrates. The orientation is stable until the clearing point and the resulting VA-cell can be reversibly switched. Crossed polarizers are needed to display the switching.

By using additives like the compound of the formula I-74a-1, no alignment layer (e.g. no PI coating) is required anymore for VA, PM-VA, PVA, MVA, HT-VA, PS-VA, VA-IPS and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and orientation.

Example 197P a): Polymer stabilization of the LC mixture of Example **M197**

The polymerizable derivative **RM-1** (0.3 %) is added to the nematic LC-mixture of Example **M197**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer).

The LC-mixture shows a spontaneous homeotropic (vertical) orientation, with respect to the surface of the substrates. The resulting VA-cell is treated with UV-light (15 min, 100 mW/cm$^2$) after having applied to the cell a voltage higher than the optical threshold. The polymerizable derivative polymerizes and, as a consequence, the homeotropic self-orientation is stabilized and the tilt of the mixture is tuned. The resulting PSA-VA-cell can be reversibly switched even at high temperatures. The switching times are reduced, compared to the not polymerized system.

The additive Irganox 1076 (BASF) is added in amounts of 0.01 % for preventing spontaneous polymerization. UV-cut filter may be used during polymerization for preventing damage of the mixtures (e.g. 340 nm cut-filter).

By using additives like the compound of the formula I-74a-1 in combination with **RM-1**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

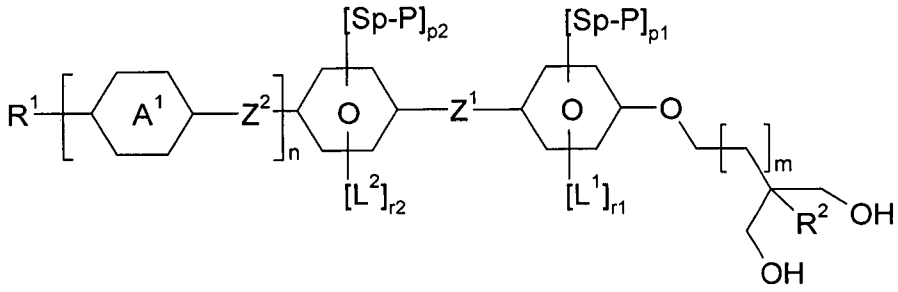
Example 197P b): Polymer stabilization of the LC mixture of Example **M197**

The polymerizable derivative **RM-17** (0.3 %) is added to the nematic LC-mixture of Example **M197**. The resulting mixture is homogenised and filled into an "alignment-free" test cell (cell thickness d ~ 4.0 µm, ITO coating on both sides (structured ITO in case of a multi-domain switching), no alignment layer and no passivation layer). The resulting cell is treated according to Example 2P a) and similar results are obtained.

By using additives like the compound of the formula I-74a-1 in combination with **RM-17**, no alignment layer is required anymore for PSA, PS-VA, and other analogue display technologies based on the combination $\Delta\varepsilon < 0$ and homeotropic orientation.

## Patent Claims

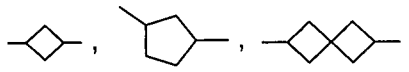
1. Liquid-crystalline medium based on a mixture of polar compounds characterized in that it contains at least one compound of the formula I,



I

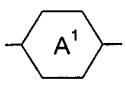
in which

$R^1$ 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 -CH=CH-, -C≡C-, $-CF_2O-$, -CH=CH-,

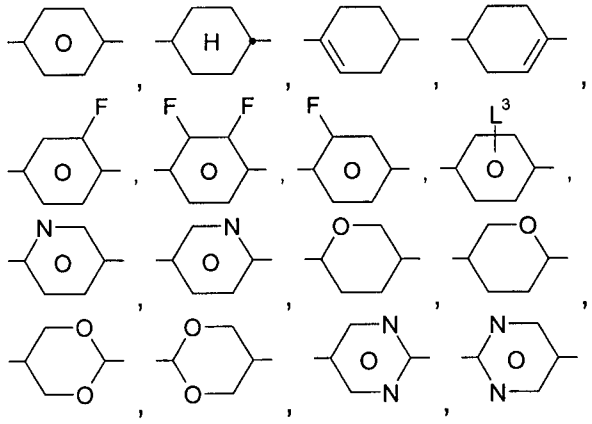


-O-, -CO-O-, -O-CO- in such a way that O atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by halogen,

$R^2$ denotes H or an alkyl radical having 1 to 8 C atoms,

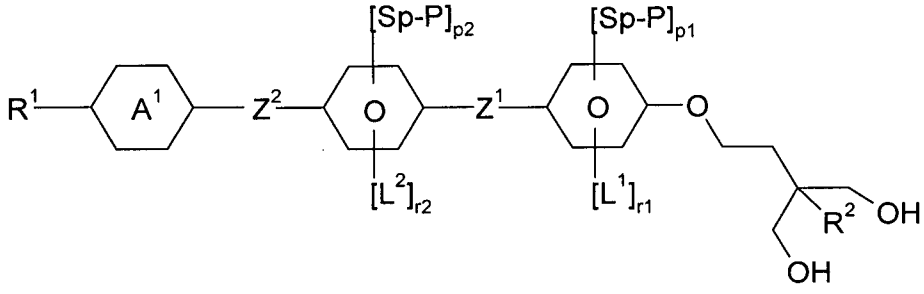


denotes



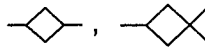
| | | |
|---|---|---|
| | $L^1$ and $L^2$ | in each case, independently of one another, denotes F, Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl, |
| | $L^3$ | in each case, independently of one another, denotes Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl, |
| | m | denotes 0, 1 or 2, |
| | n | denotes 0, 1 or 2, |
| | P | denotes a polymerisable group, |
| | Sp | denotes a spacer group (also called spacer) or a single bond, |
| | $Z^1$ and $Z^2$ | in each case, independently of one another, denotes a single bond, -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-, $-OCH_2-$, $-CH_2-$, $-CH_2O-$, $-CF_2O-$, $-OCF_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-CF_2CH_2-$, $-CH_2CF_2-$, $-CF_2CF_2-$, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-COO- or -OCO-CH=CH-, |
| | p1 | denotes 1, 2 or 3, preferably 2 or 3, |
| | r1 | denotes 0, 1, 2 or 3, whereas $p1+r1 \leq 4$, |
| | p2 | denotes 0, 1, 2 or 3 |
| | r2 | denotes 0, 1, 2 or 3, whereas $p2+r2 \leq 4$. |

2. Liquid-crystalline medium according to Claim 1 characterized in that it contains at least one compound of the formula I*,

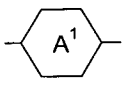
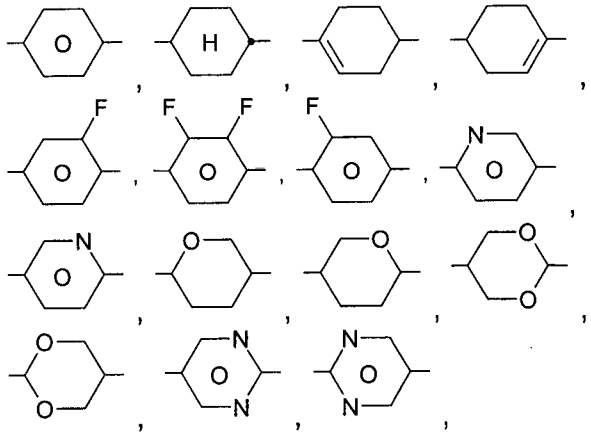


I

in which

$R^1$ 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 -CH=CH-, -C≡C-, $-CF_2O-$, -CH=CH-,  , -O-, -CO-O-, -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,

$R^2$ denotes H or an alkyl radical having 1 to 8 C atoms,

 denotes 

$L^1$ and $L^2$ in each case, independently of one another, denotes F, Cl, Br, I, -CN, $-NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl,

P denotes a polymerisable group,

Sp denotes a spacer group (also called spacer) or a single bond,

$Z^1$ and $Z^2$ in each case, independently of one another, denotes a single bond, -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-, $-OCH_2-$, $-CH_2-$, $-CH_2O-$, $-CF_2O-$, $-OCF_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-CF_2CH_2-$, $-CH_2CF_2-$, $-CF_2CF_2-$, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-COO- or -OCO-CH=CH-,

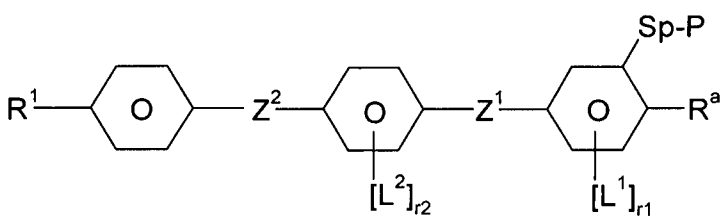
p1 denotes 1, 2 or 3, preferably 2 or 3,

r1 denotes 0, 1, 2 or 3, whereas $p1+r1 \leq 4$,

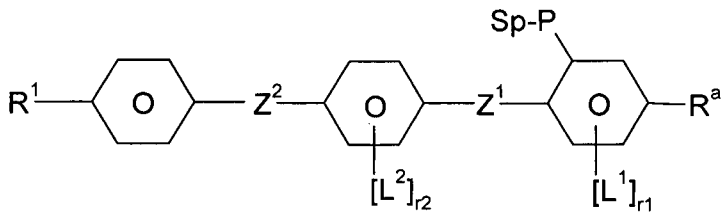
p2 denotes 0, 1, 2 or 3

r2 denotes 1, 2 or 3, whereas $p2+r2 \leq 4$.

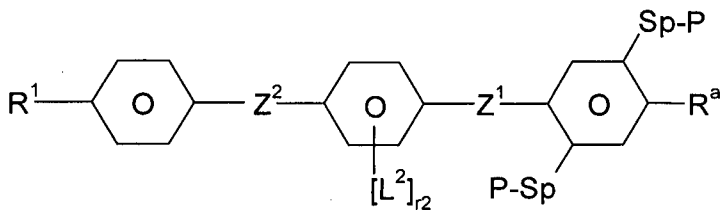
3. Liquid-crystalline medium according to Claim 2 characterized in that the compound of the formula I is selected from the following group of compounds of the formula I-A to I-H,



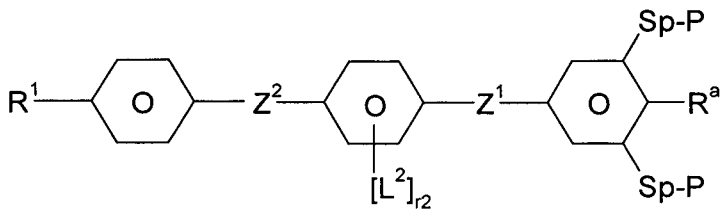

I-A



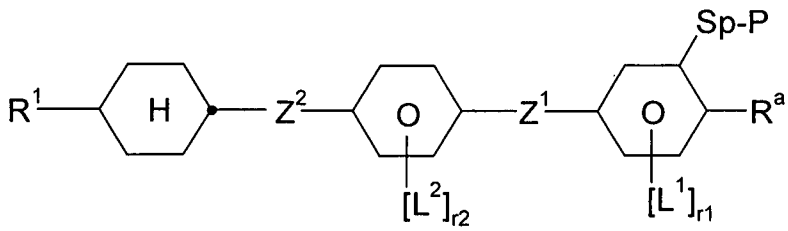

I-B



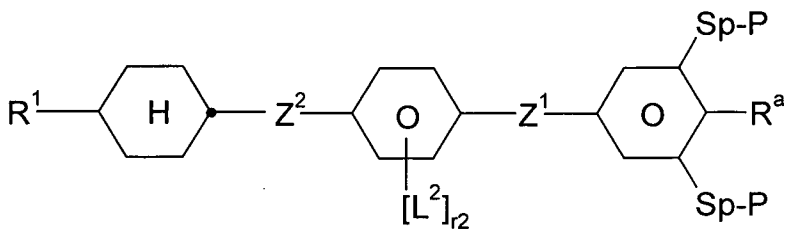

I-C



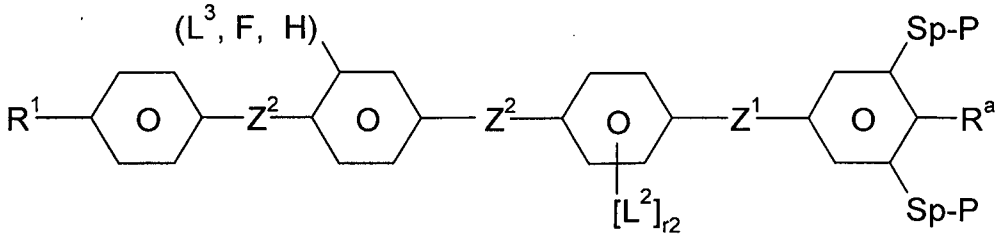

I-D



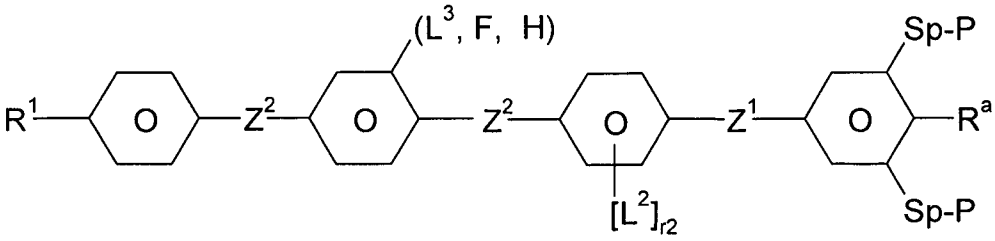

I-E




I-F



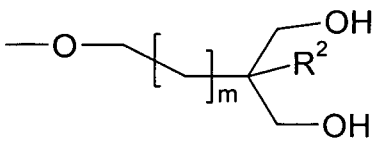

I-G




I-H

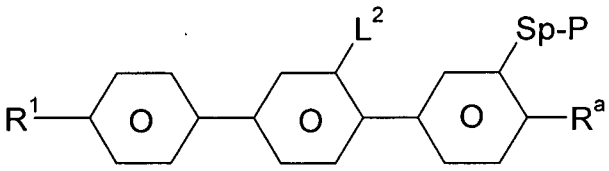
in which $R^1$, $R^2$, $L^1$, $L^2$, $Z^1$, $Z^2$, Sp, P, r1, r2 have the meanings as defined for formula I in Claim 1 and

$R^a$ denotes

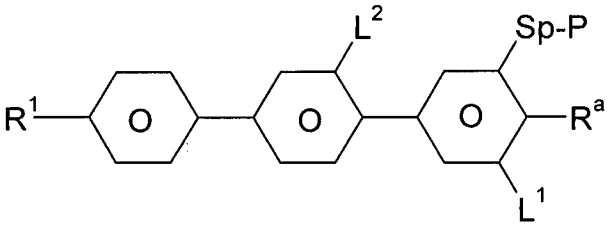



wherein $R^2$ and m having the meanings as defined in Claim 1.

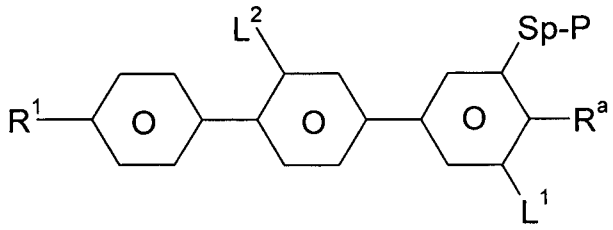
4. Liquid-crystalline medium according to one or more of Claims 1 to 3 characterized in that the medium contains at least one compound selected from the following group of compounds of the formula I-1 to I-79



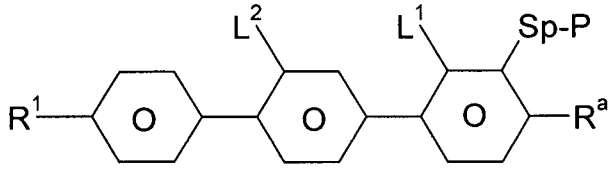

I-1



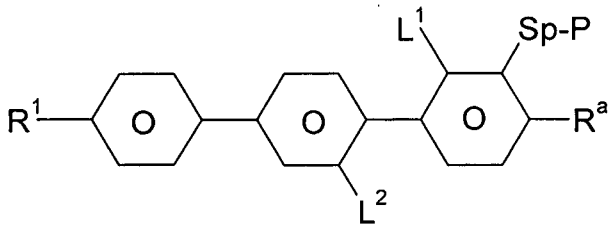

I-2



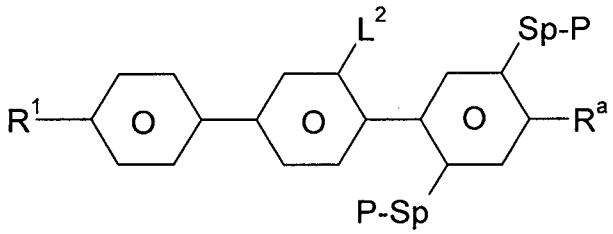

I-3



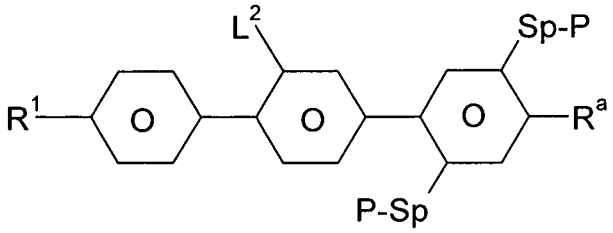

I-4



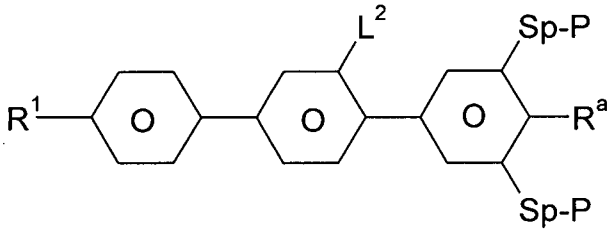

I-5



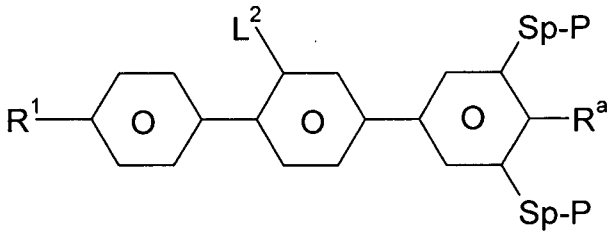

I-6



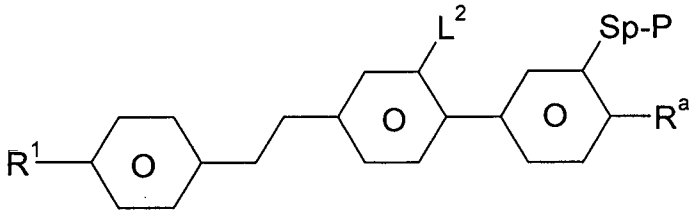

I-7



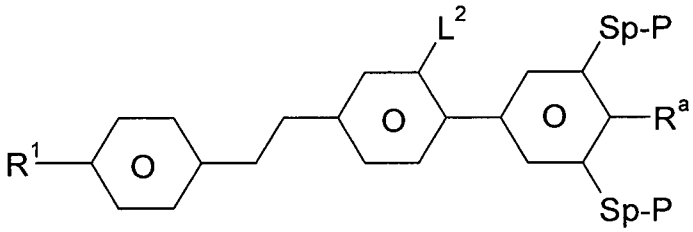

I-8



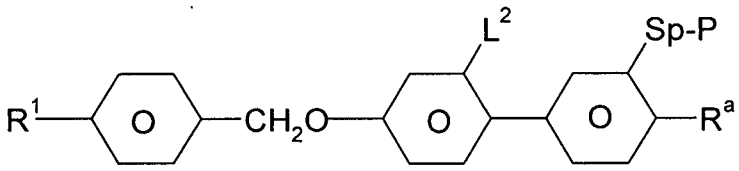

I-9



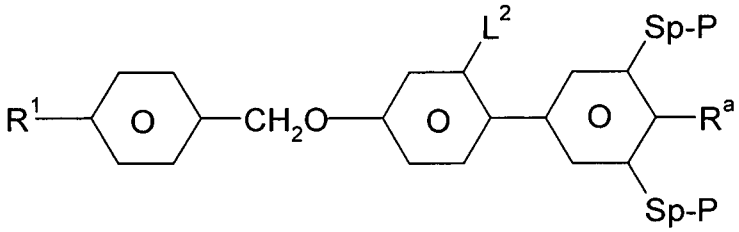

I-10



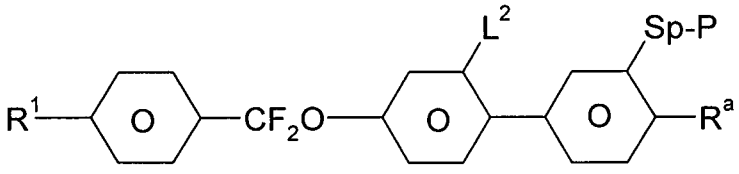

I-11



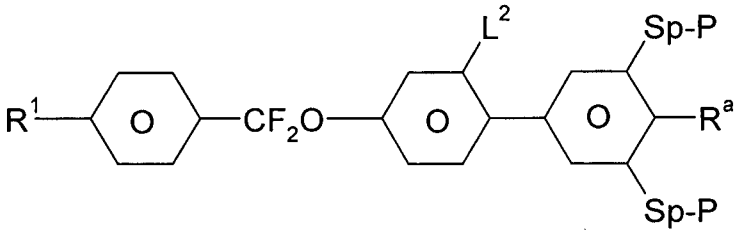

I-12



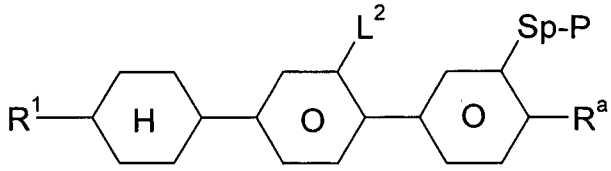

I-13



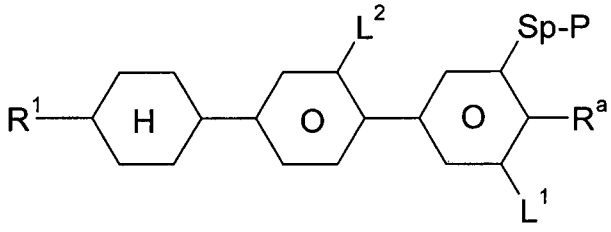

I-14



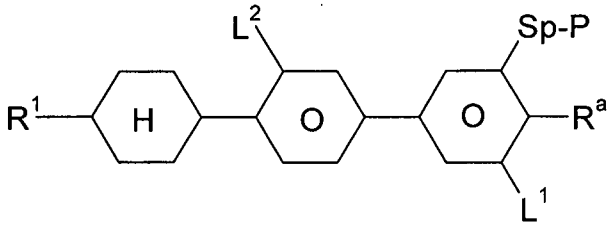

I-15



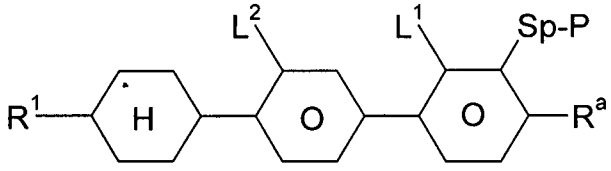

I-16



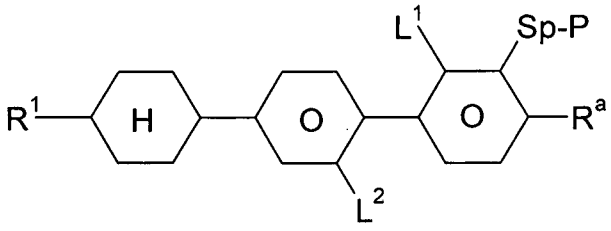

I-17



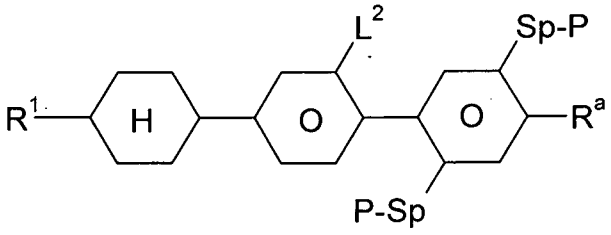

I-18



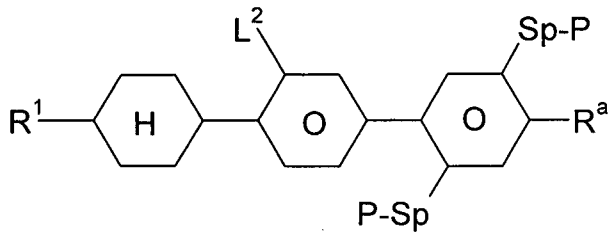

I-19



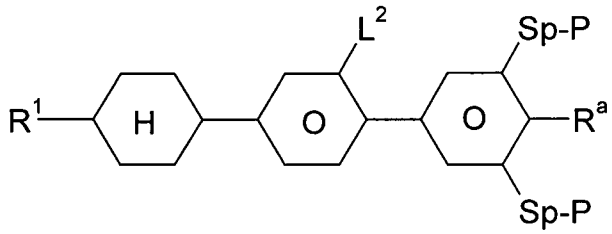

I-20



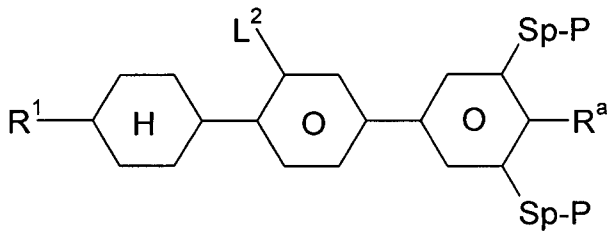

I-21



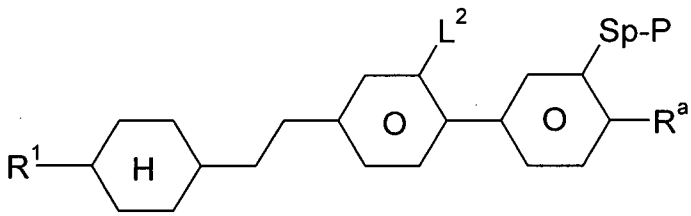

I-22



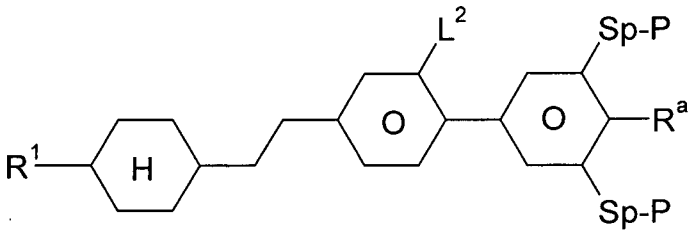

I-23



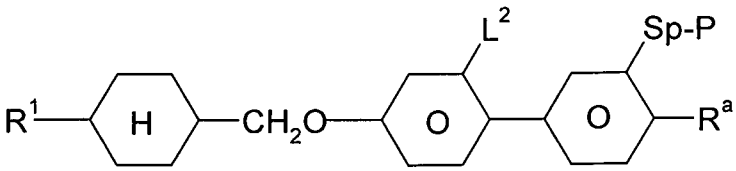

I-24



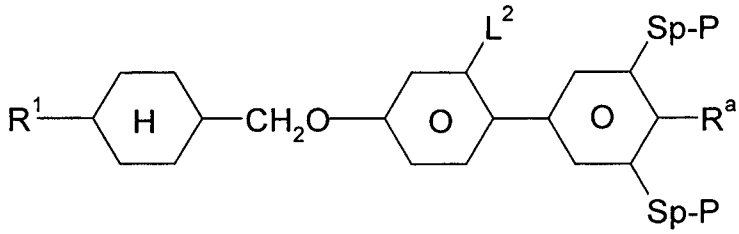

I-25



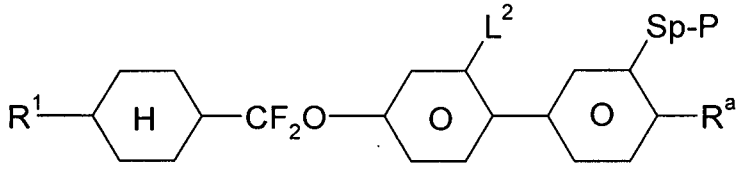

I-26



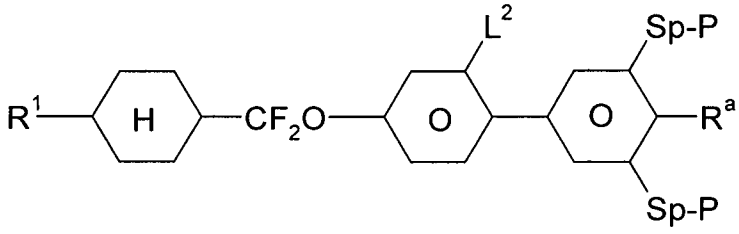

I-27



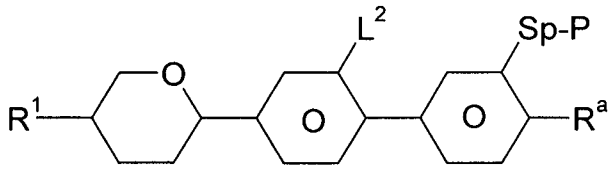

I-28



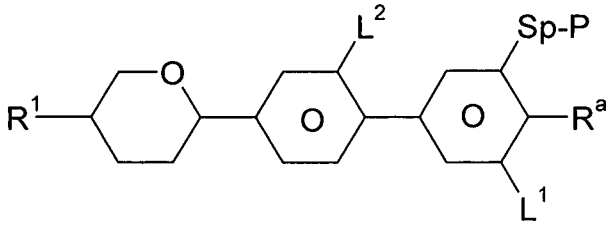

I-29



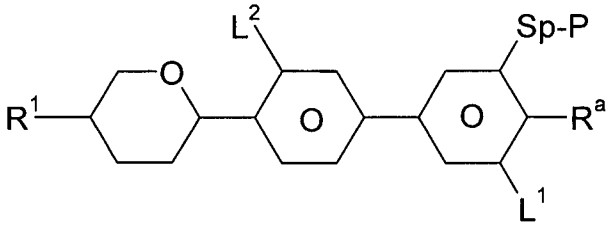

I-30



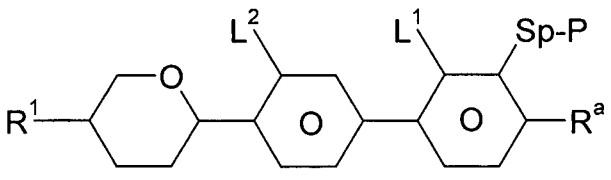

I-31



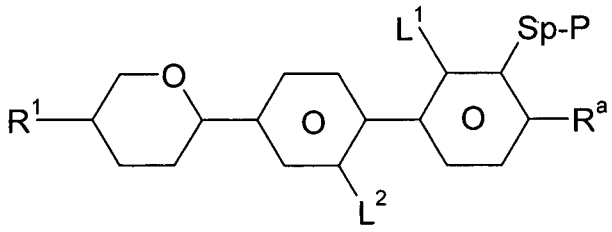

I-32



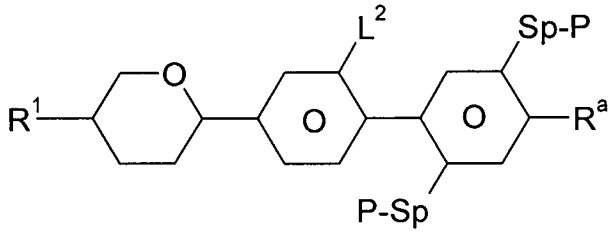

I-33



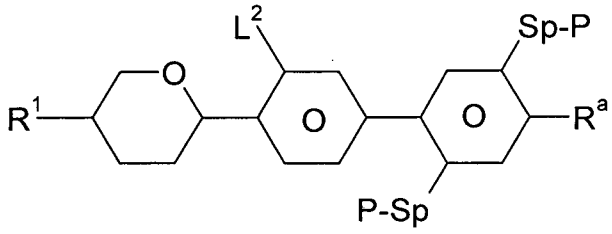

I-34



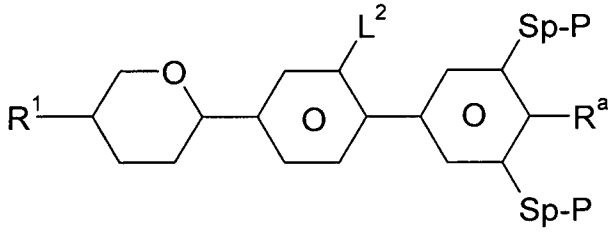

I-35



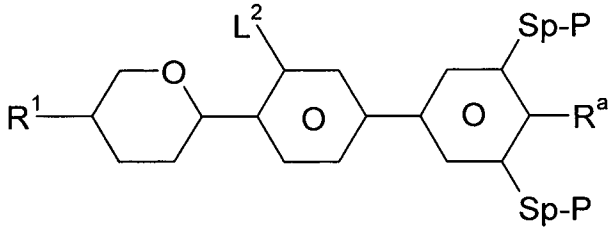

I-36



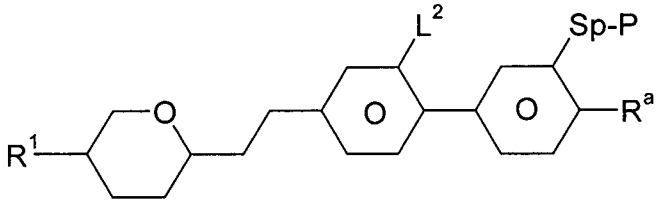

I-37



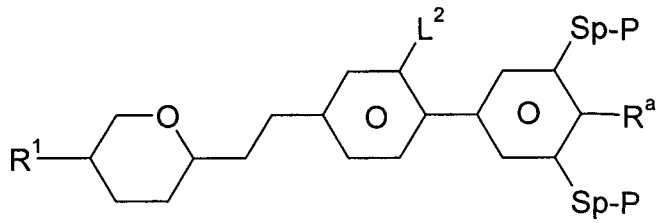

I-38



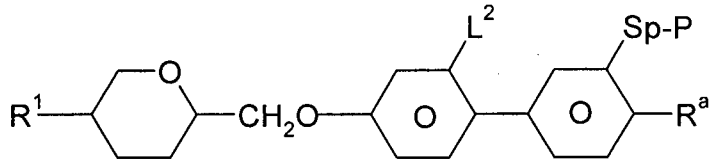

I-39



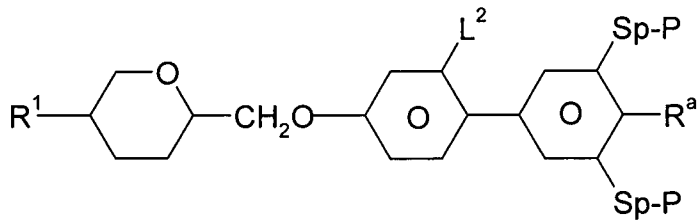

I-40



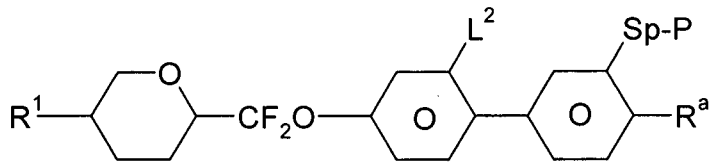
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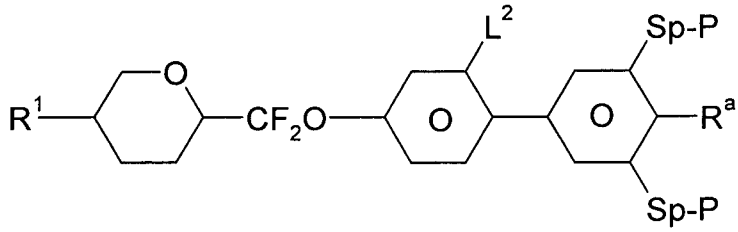
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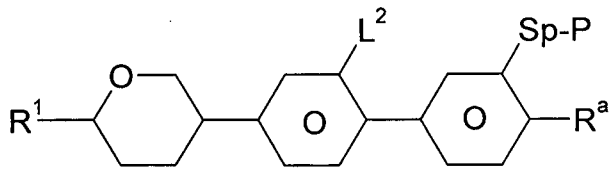
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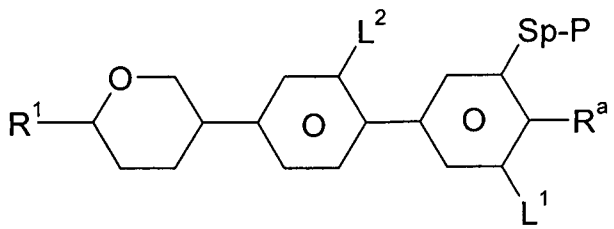
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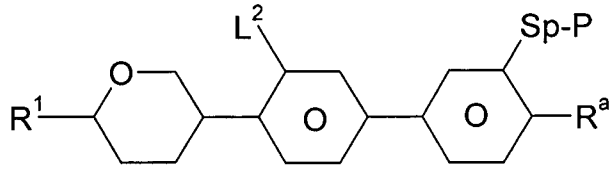
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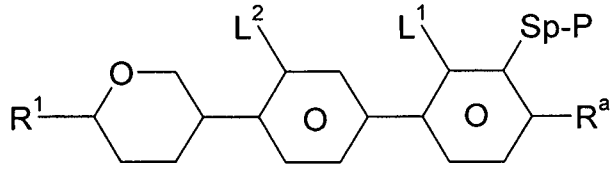
I-46



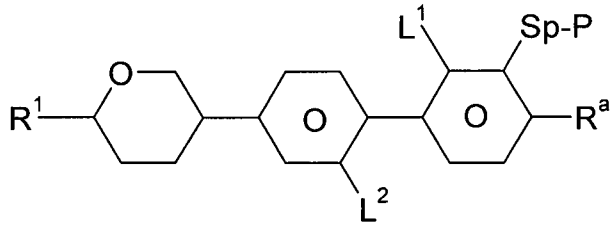
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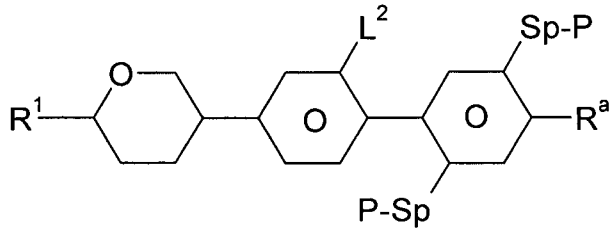

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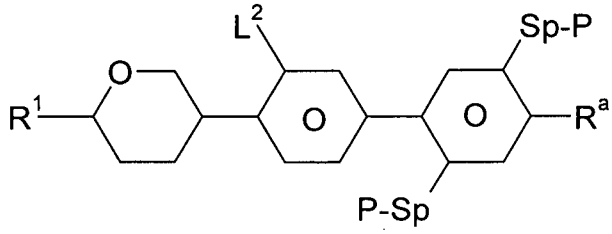

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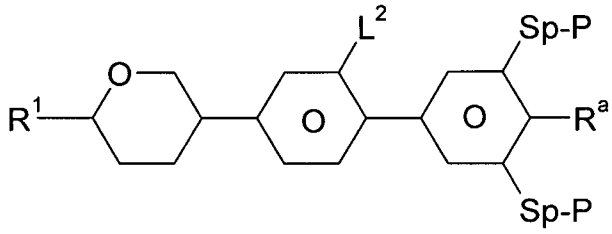

I-50



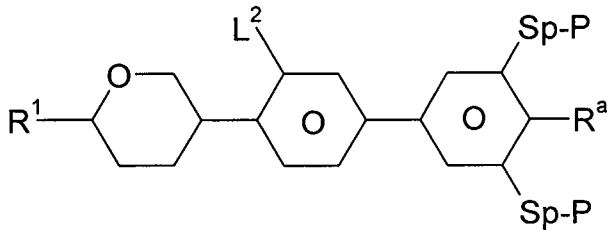

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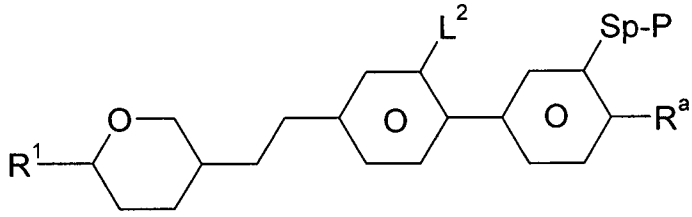

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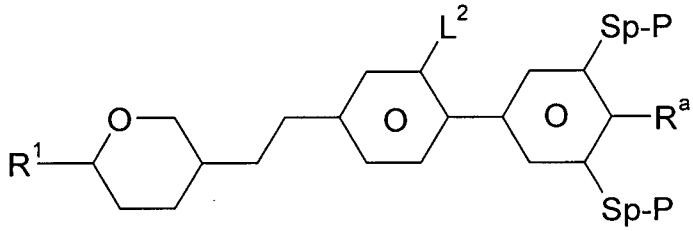

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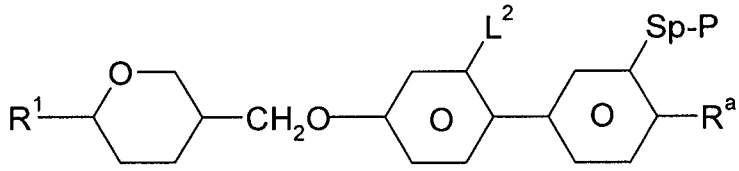
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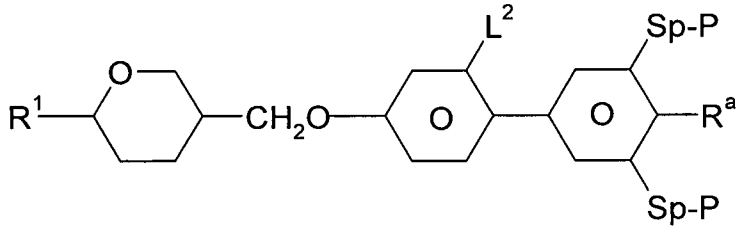
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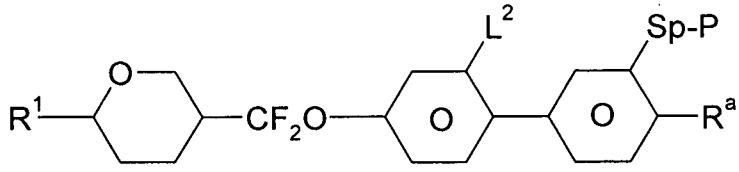
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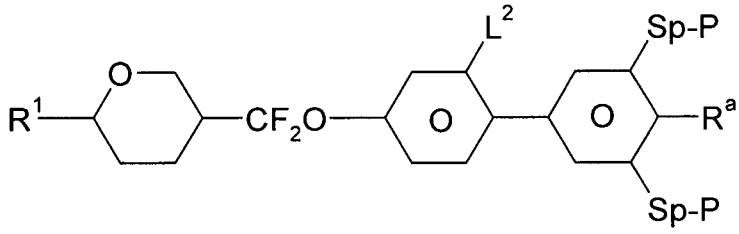
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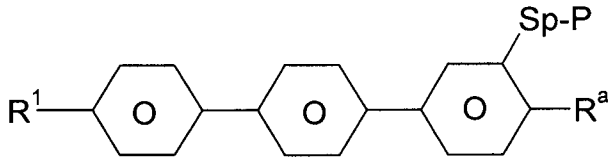
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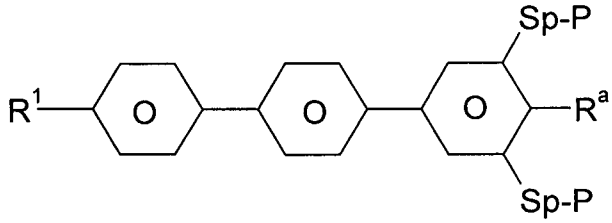
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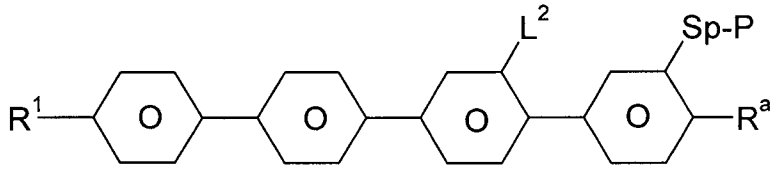
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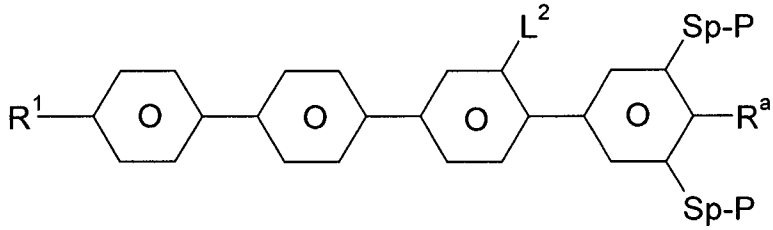

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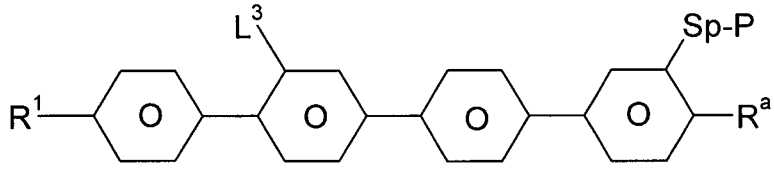

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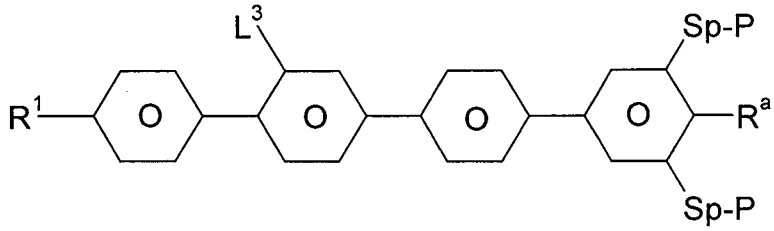

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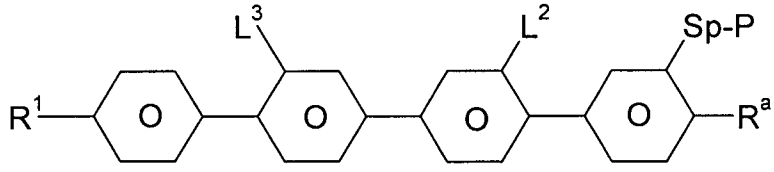

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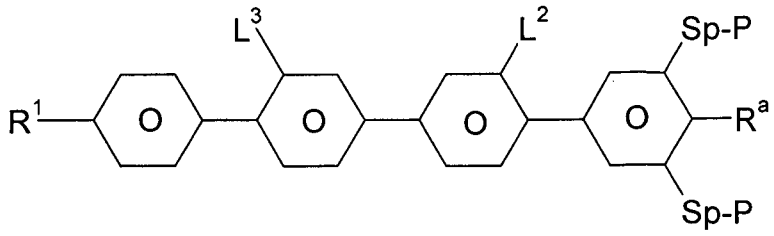

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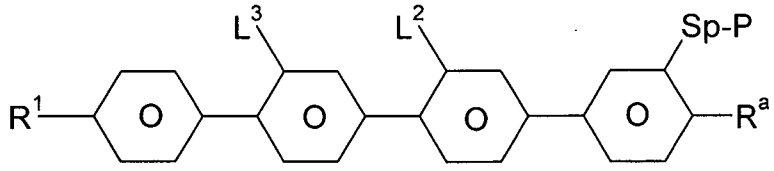

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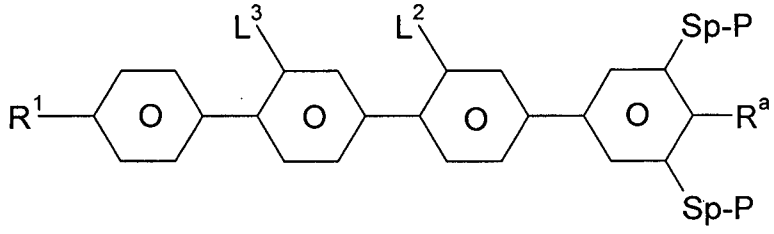

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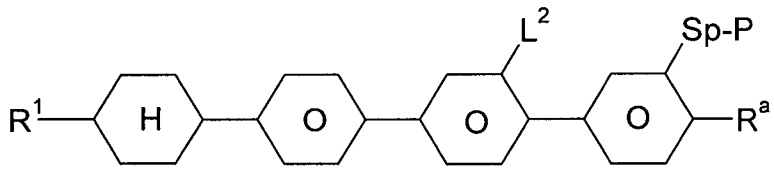

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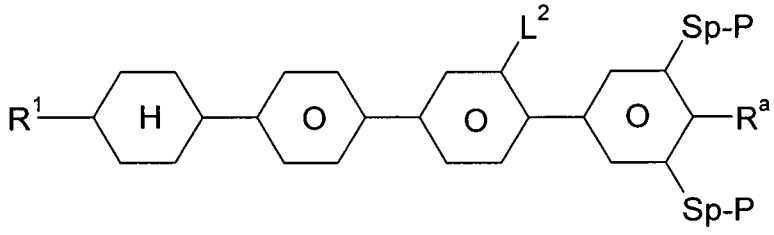

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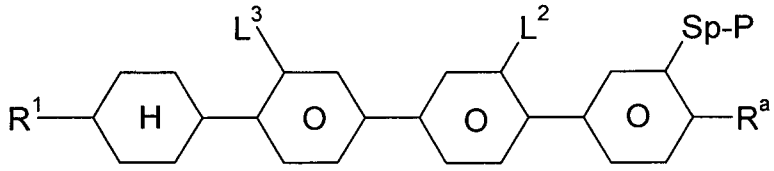

I-70



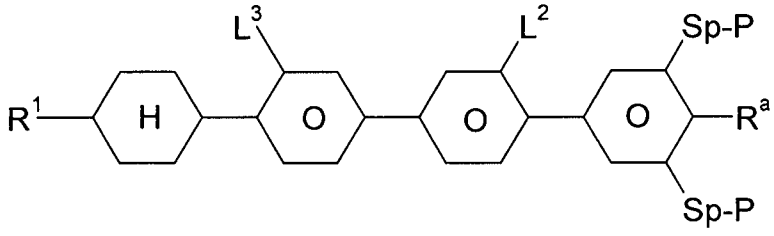

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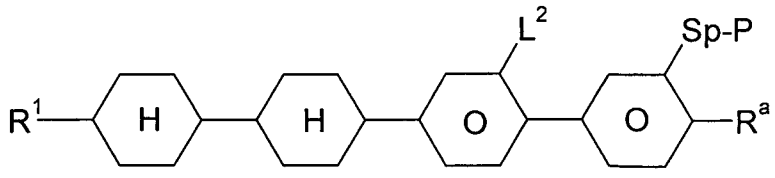

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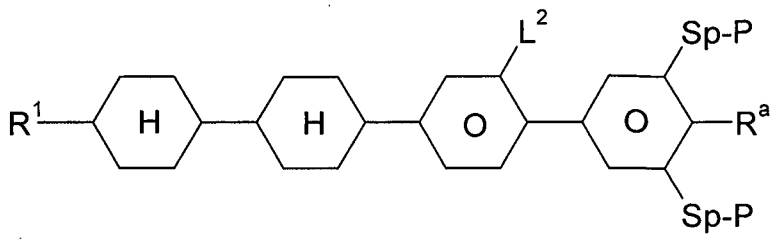

I-73



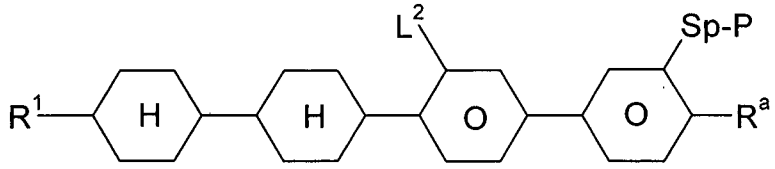

I-74



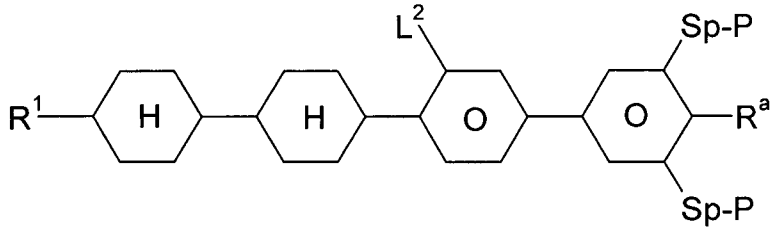

I-75



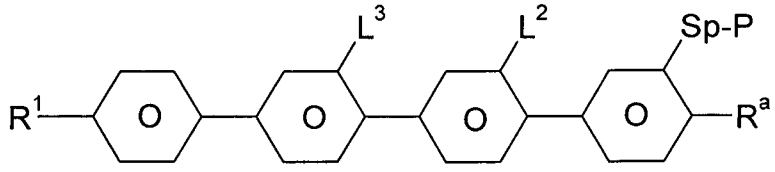

I-76




I-77




I-78



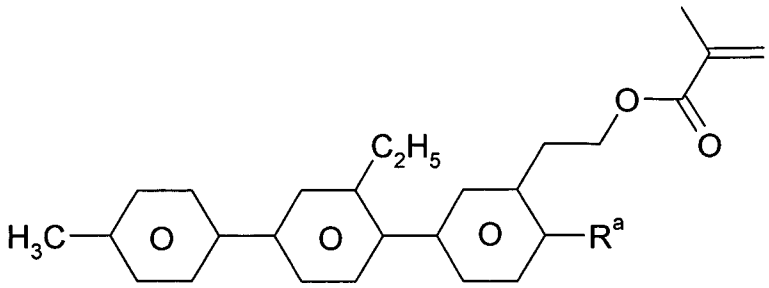

I-79

wherein

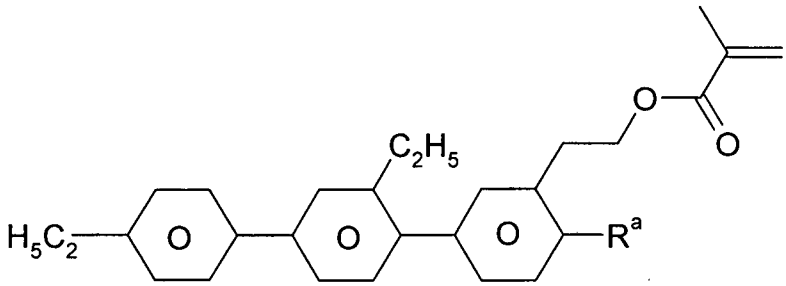
$R^1$, $L^1$, $L^2$, $L^3$, Sp, P have the meanings given in Claim 1 and

$R^a$ has the meanings given in Claim 3.

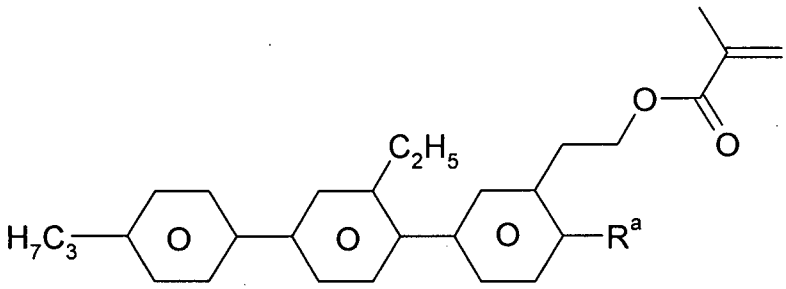
5. Liquid-crystalline medium according to one or more of Claims 1 to 4 characterized in that the medium contains at least one compound selected from the following group of compounds



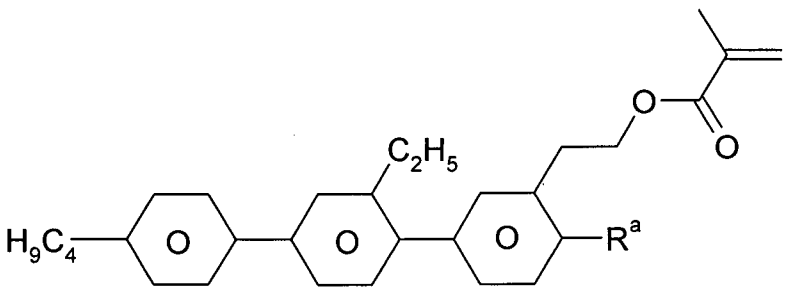
I-1d-1



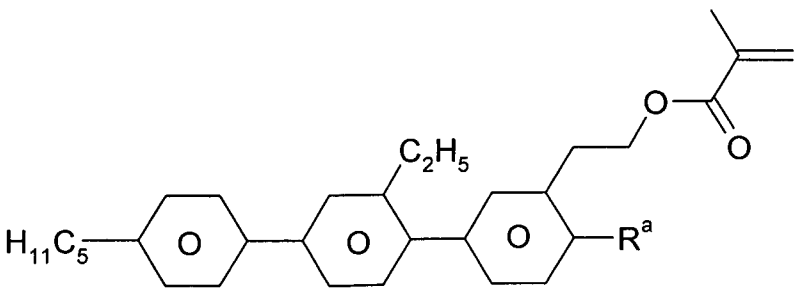
I-1d-2



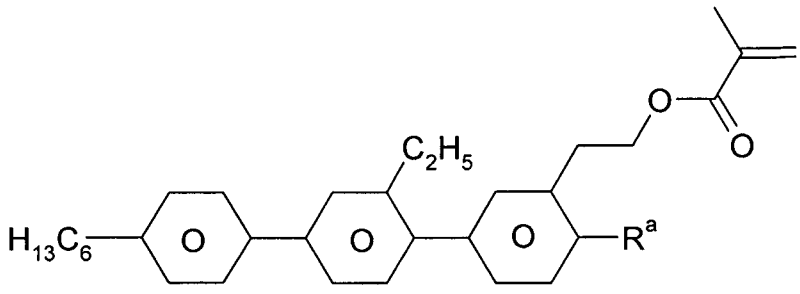
I-1d-3



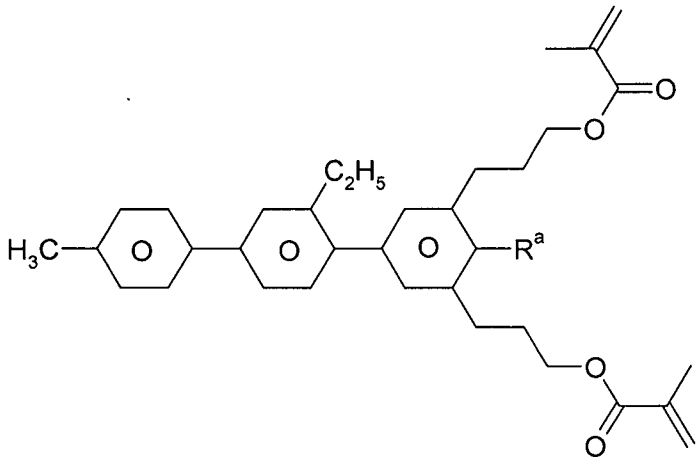
I-1d-4



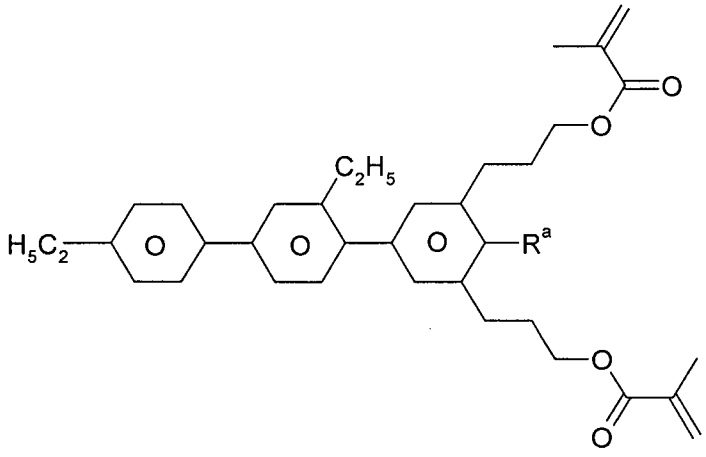
I-1d-5



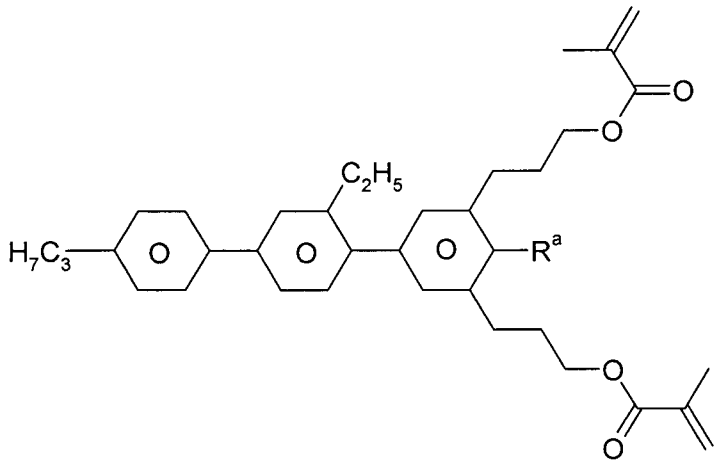
I-1d-6



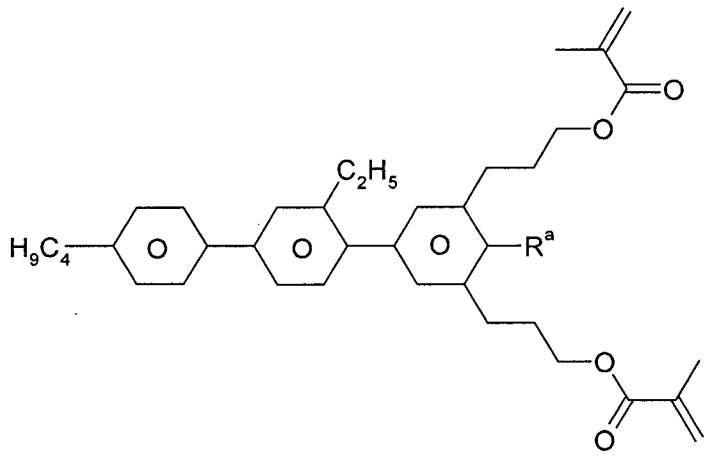
I-8h-1



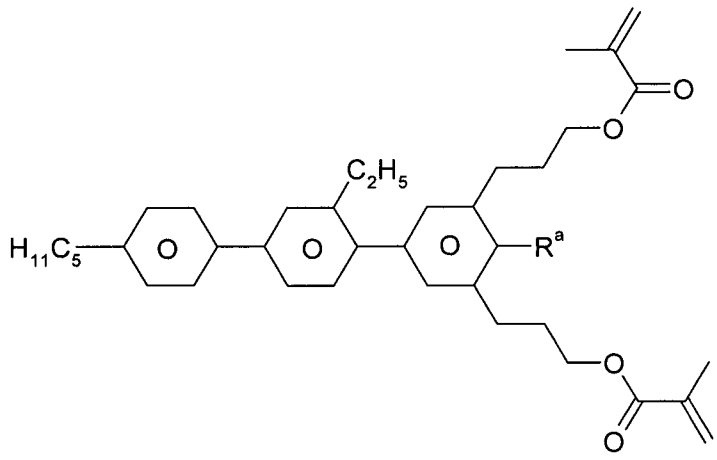
I-8h-2



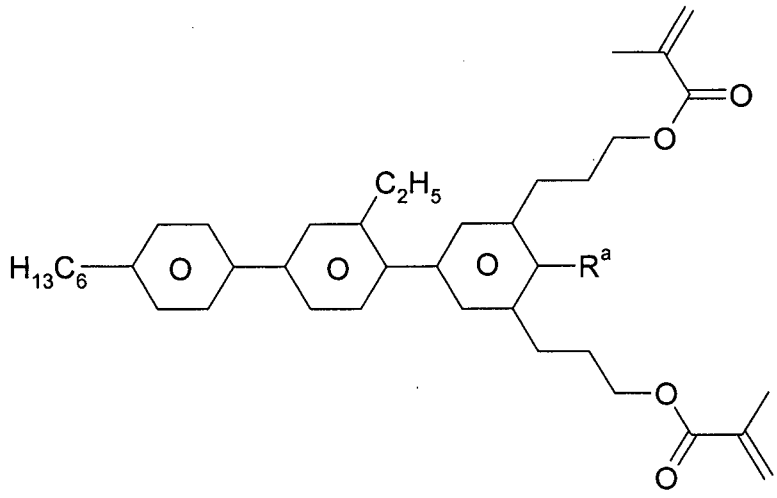
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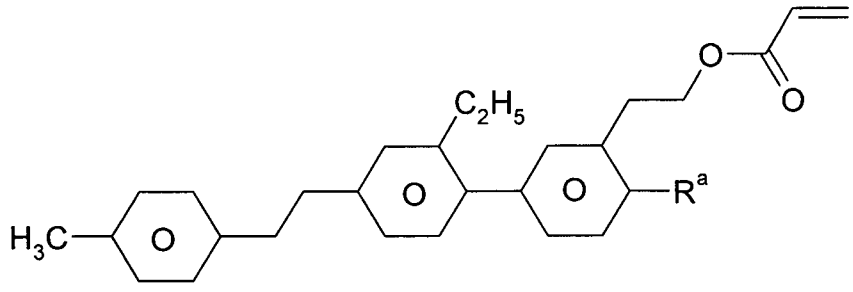
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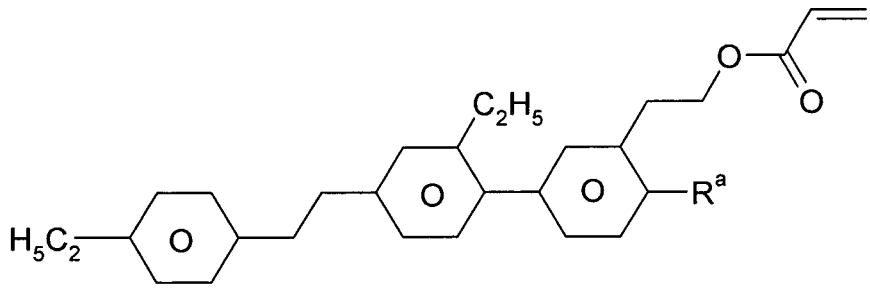
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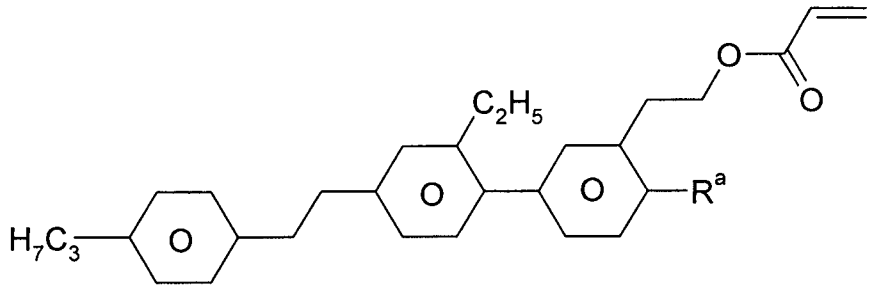
I-8h-6



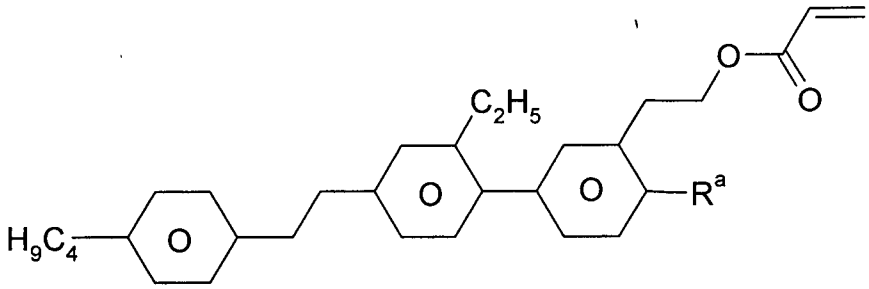
I-10d-1



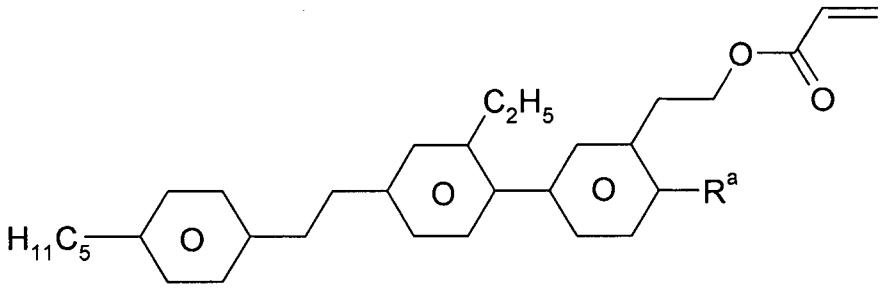
I-10d-2



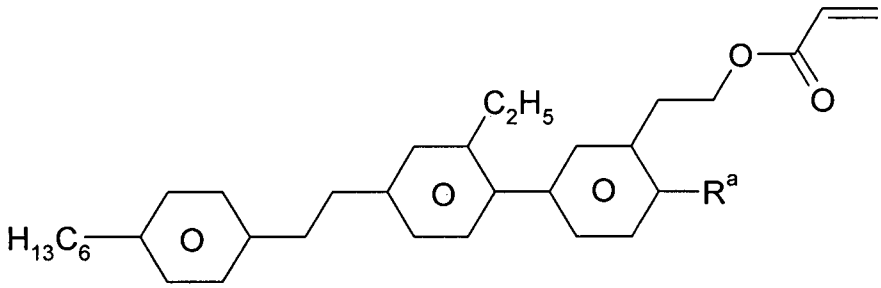
I-10d-3



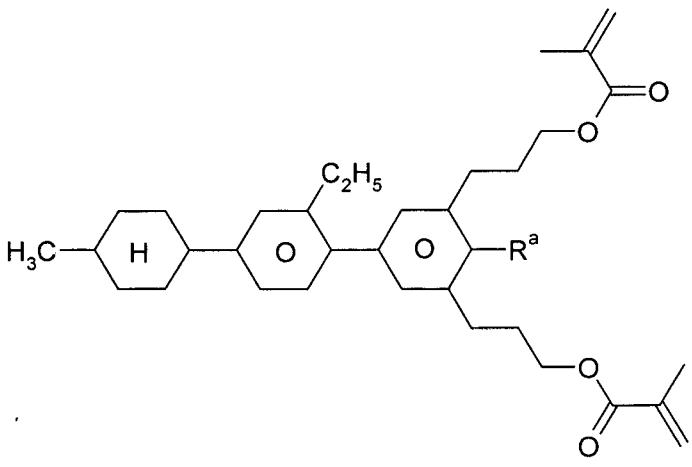
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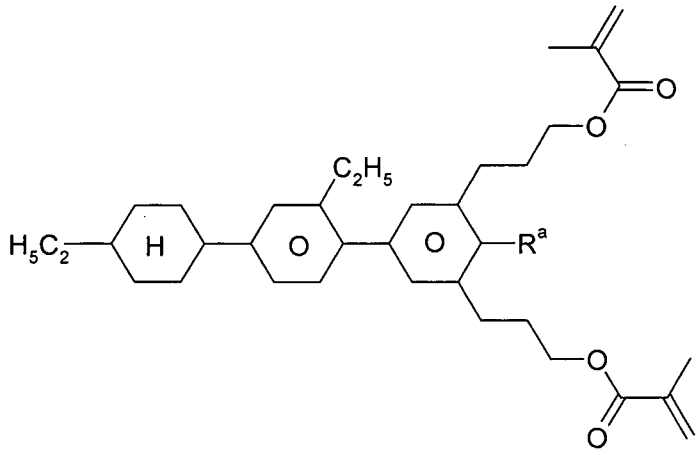
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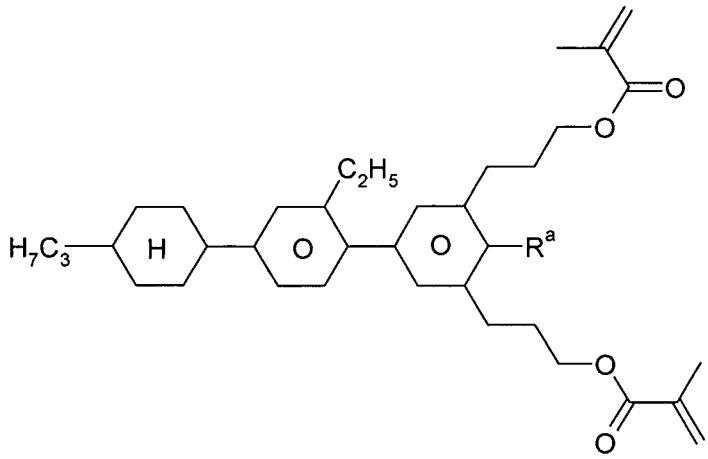
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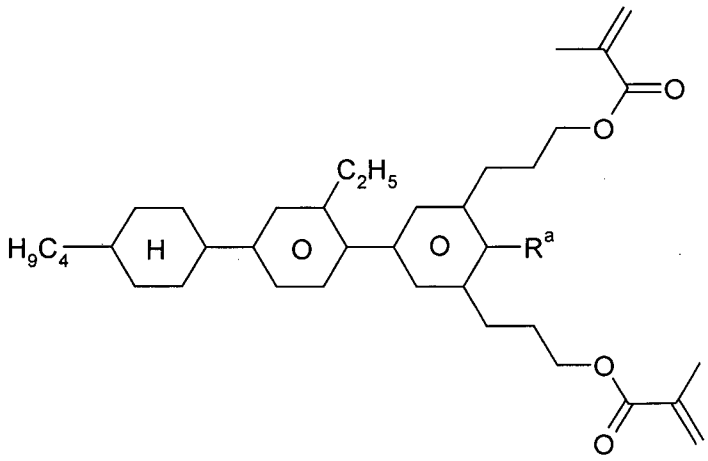
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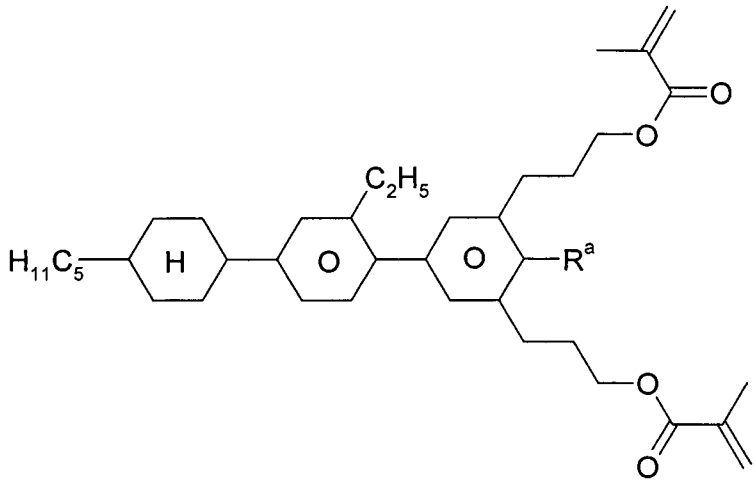
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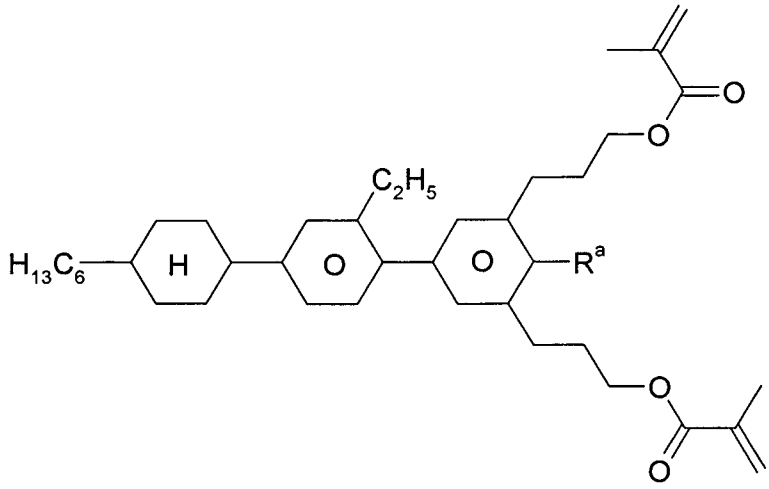
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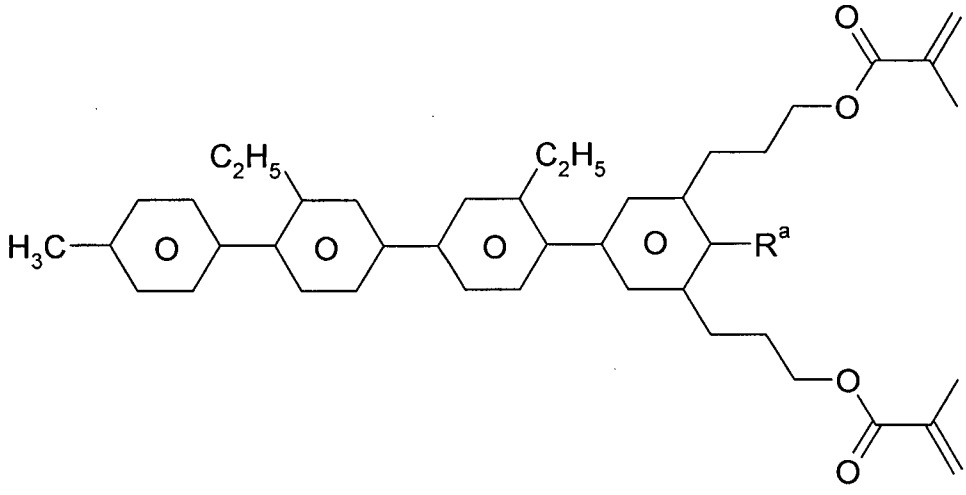
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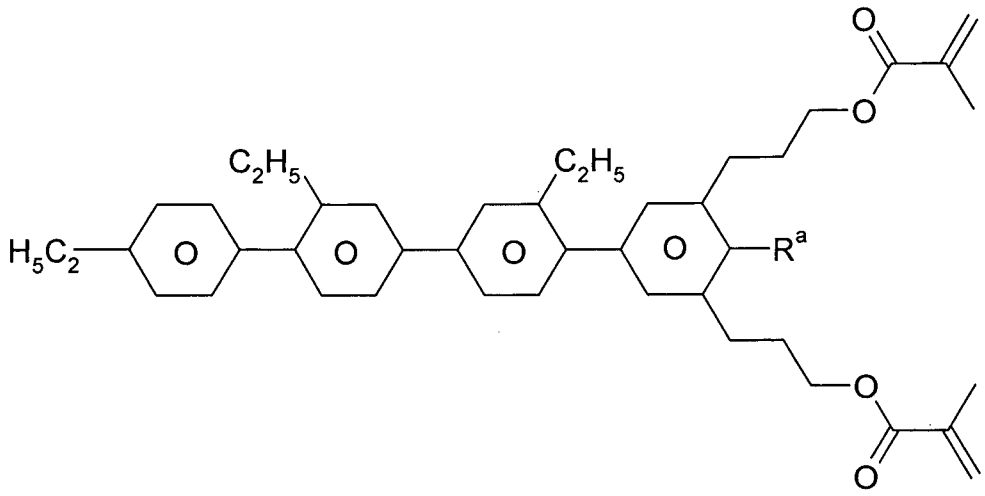
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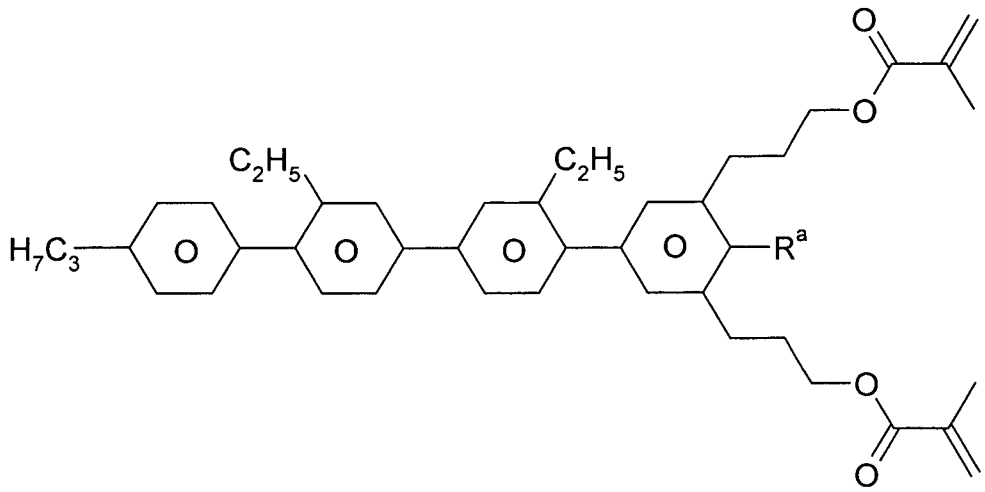
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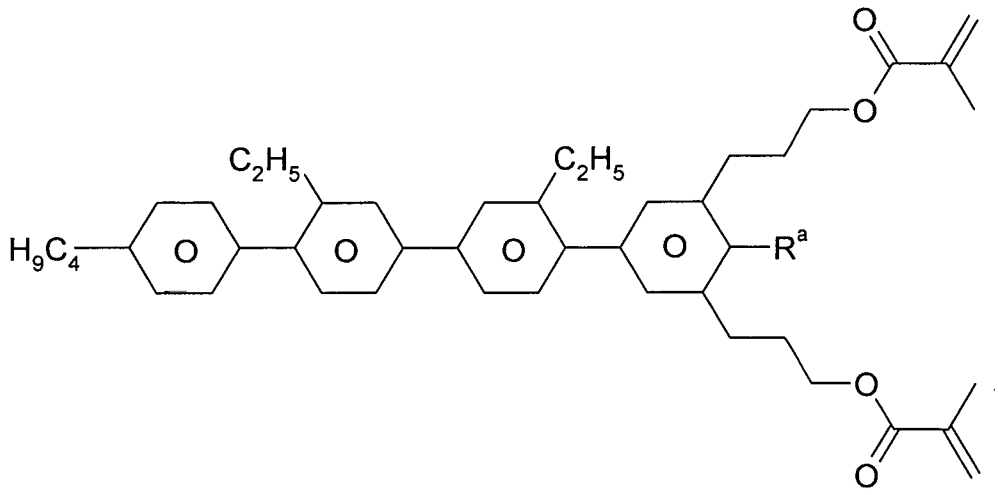
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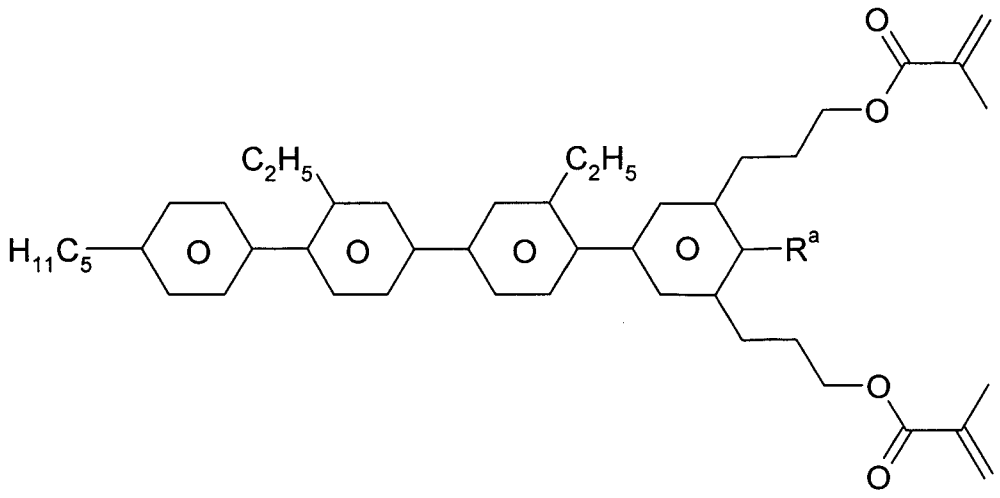
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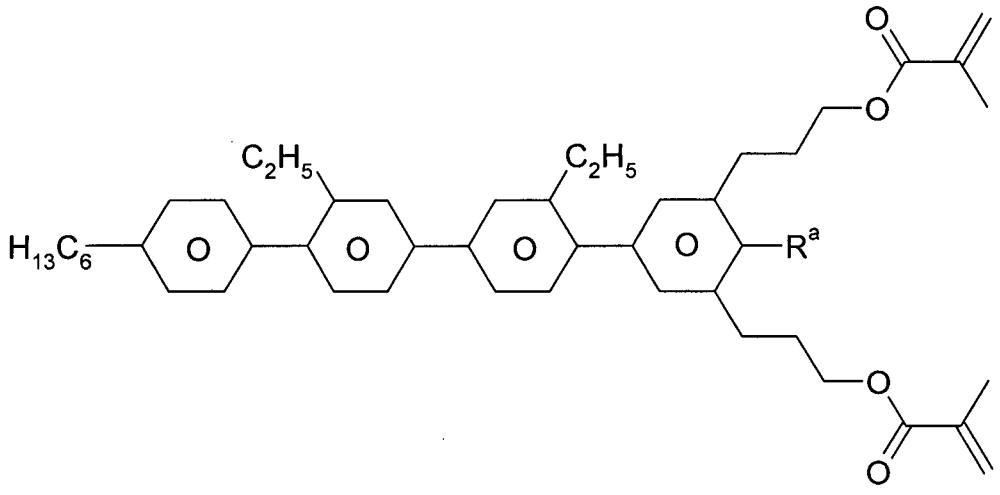
I-68d-3



I-68d-4



I-68d-5



I-68d-6

wherein $R^a$ has the meanings given in Claim 3.

6. Liquid-crystalline medium according to one or more of Claims 1 to 5 characterized in that the medium contains at least one compound selected from the compounds of the formula I wherein $R^2$ denotes H, $CH_3$, $C_2H_5$, $C_3H_7$ or $C_4H_9$.

7. Liquid-crystalline medium according to one or more of Claims 1 to 6 characterized in that it contains at least one compound of the formula I and at least one polymerisable compound.

8. Liquid-crystalline medium according to one or more of Claims 1 to 7 characterized in that the mixture contains 0.01 to 10 % by weight of the compound of the formula I based on the mixture as a whole.

9. Liquid-crystalline medium according to one or more of Claims 1 to 8 characterized in that the the polymerisable compound is selected from the compounds of the formula M

$R^{Ma}$-$A^{M1}$-($Z^{M1}$-$A^{M2}$)$_{m1}$-$R^{Mb}$ M

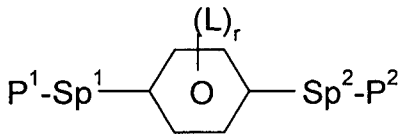
in which the individual radicals have the following meanings:

| | |
|---|---|
| $R^{Ma}$ and $R^{Mb}$ | each, independently of one another, denote P, P-Sp-, H, halogen, $SF_5$, $NO_2$, an alkyl, alkenyl or alkynyl group, where at least one of the radicals $R^{Ma}$ and $R^{Mb}$ preferably denotes or contains a group P or P-Sp-, |
| P | denotes a polymerisable group, |
| Sp | denotes a spacer group or a single bond, |
| $A^{M1}$ and $A^{M2}$ | each, independently of one another, denote an aromatic, heteroaromatic, alicyclic or heterocyclic group, preferably having 4 to 25 ring atoms, preferably C atoms, which may also encompass or contain fused rings, and which may optionally be mono- or polysubstituted by L, |
| L | denotes P, P-Sp-, F, Cl, Br, I, -CN, -$NO_2$, -NCO, -NCS, -OCN, -SCN, -C(=O)N($R^x$)$_2$, -C(=O)$Y^1$, -C(=O)$R^x$, -N($R^x$)$_2$, optionally substituted silyl, optionally substituted aryl having 6 to 20 C atoms, or straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 25 C atoms, in |

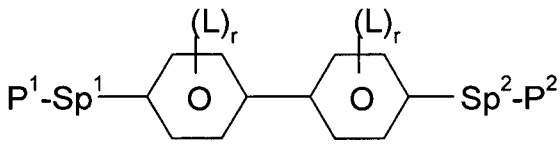
| | | |
|---|---|---|
| | | which, in addition, one or more H atoms may be replaced by F, Cl, P or P-Sp-, preferably P, P-Sp-, H, halogen, $SF_5$, $NO_2$, an alkyl, alkenyl or alkynyl group, |
| | $Y^1$ | denotes halogen, |
| | $Z^{M1}$ | denotes -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-, $-OCH_2-$, $-CH_2O-$, $-SCH_2-$, $-CH_2S-$, $-CF_2O-$, $-OCF_2-$, $-CF_2S-$, $-SCF_2-$, $-(CH_2)_{n1}-$, $-CF_2CH_2-$, $-CH_2CF_2-$, $-(CF_2)_{n1}-$, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-, -COO-, -OCO-CH=CH-, $CR^0R^{00}$ or a single bond, |
| | $R^0$ and $R^{00}$ | each, independently of one another, denote H or alkyl having 1 to 12 C atoms, |
| | $R^x$ | denotes P, P-Sp-, H, halogen, straight-chain, branched or cyclic alkyl having 1 to 25 C atoms, in which, in addition, one or more non-adjacent $CH_2$ groups may be replaced by -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, P or P-Sp-, an optionally substituted aryl or aryloxy group having 6 to 40 C atoms, or an optionally substituted heteroaryl or heteroaryloxy group having 2 to 40 C atoms, |
| | m1 | denotes 0, 1, 2, 3 or 4, and |
| | n1 | denotes 1, 2, 3 or 4, |
| | | where at least one, preferably one, two or three, particularly preferably one or two, from the group $R^{Ma}$, $R^{Mb}$ and the substituents L present denotes a |

group P or P-Sp- or contains at least one group P or P-Sp-.

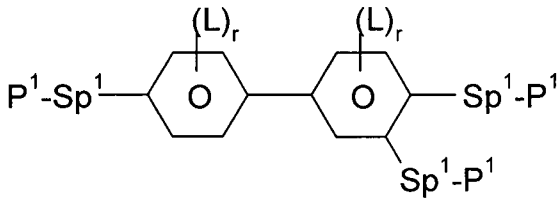
10. Liquid-crystalline medium according to one or more of Claims 1 to 9 characterized in that the polymerisable compound of the formula M is selected from the group of compounds of the formula M1 to M41,



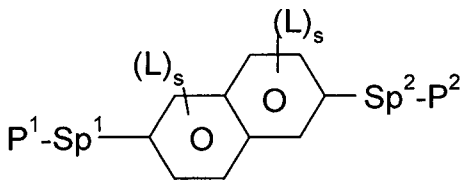
M1



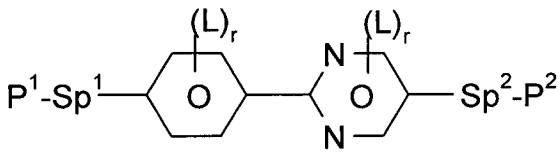
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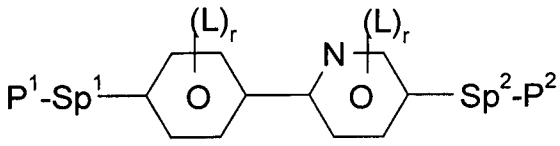
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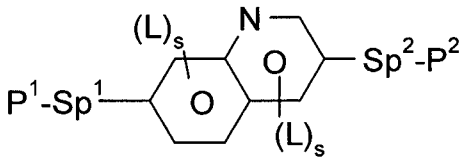
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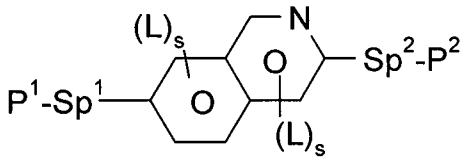
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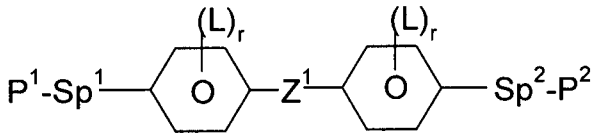
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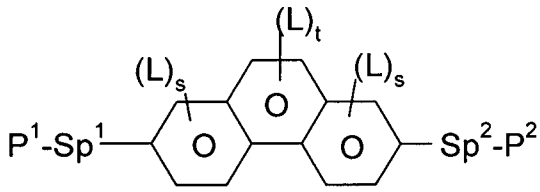
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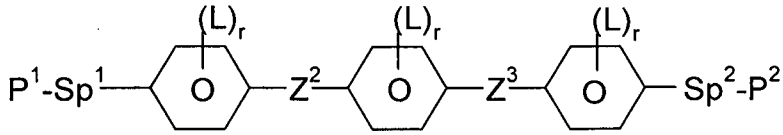
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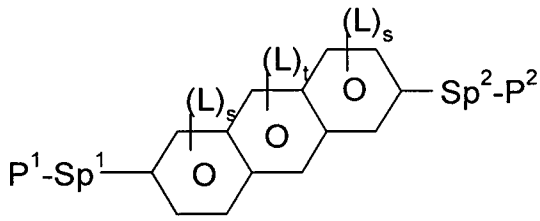
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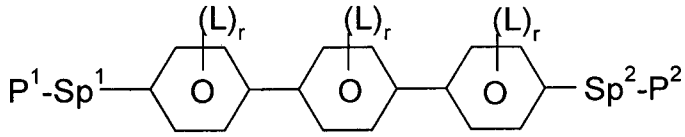
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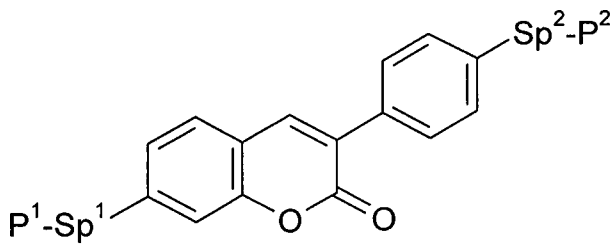
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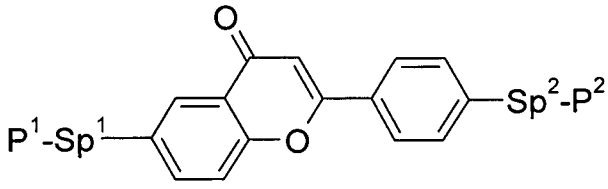
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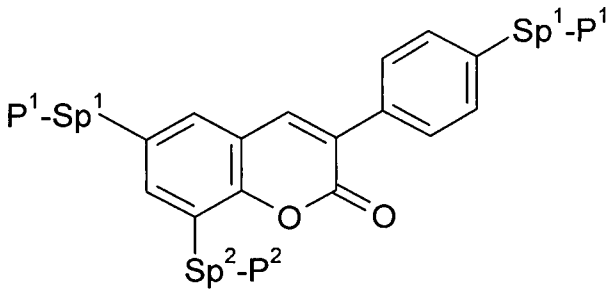
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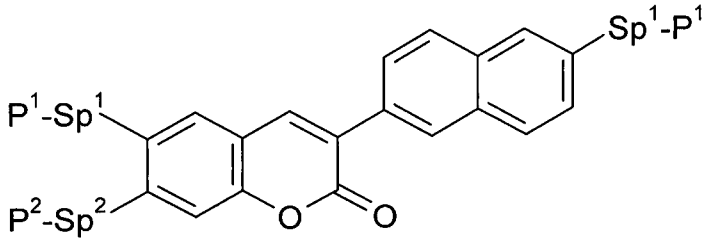
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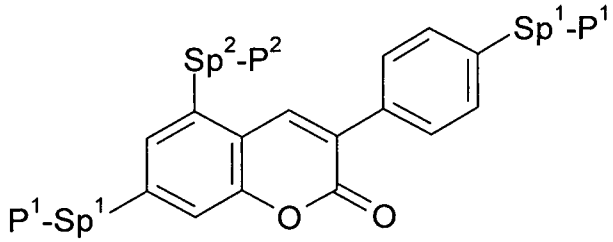

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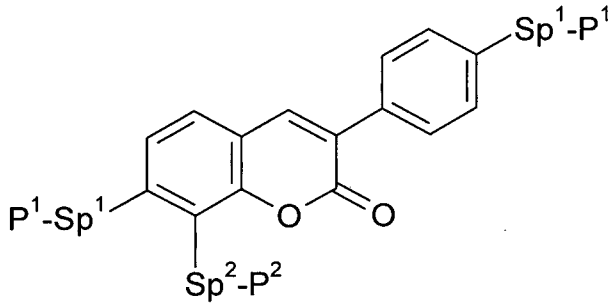

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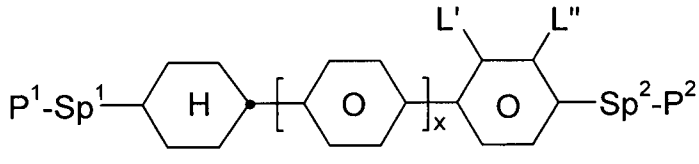

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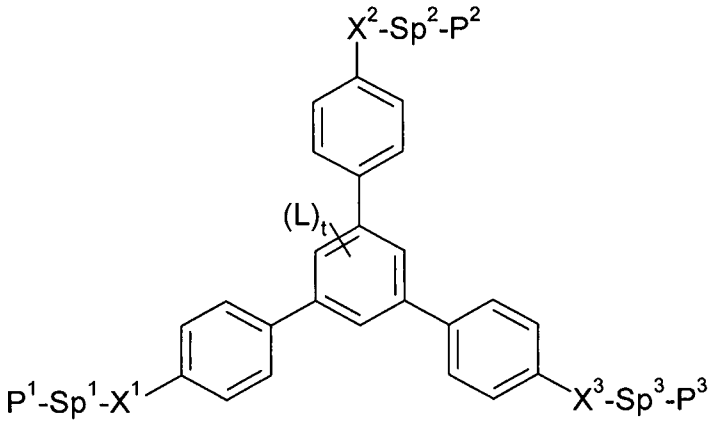

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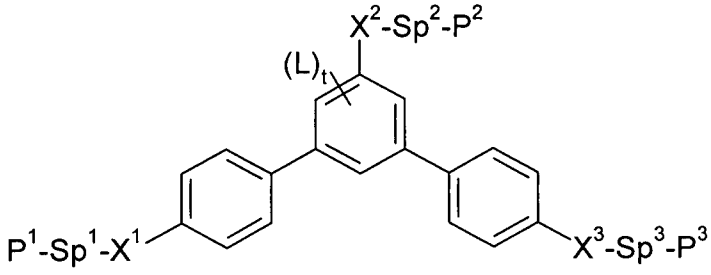

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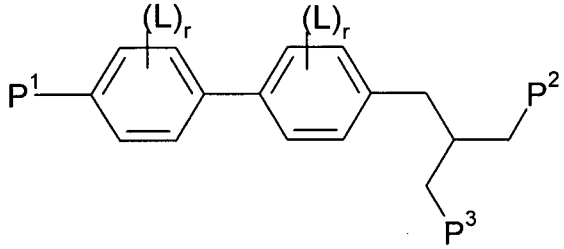

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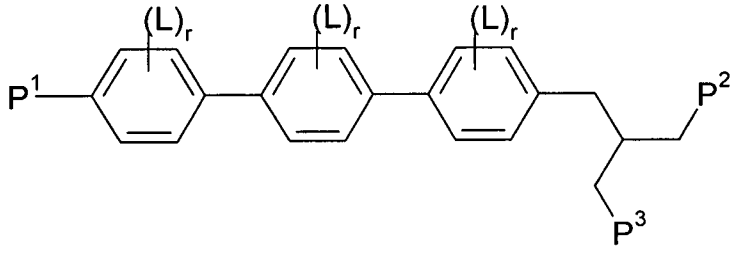

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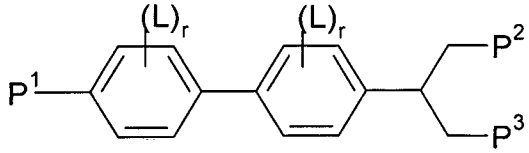

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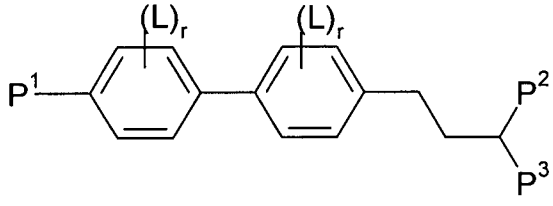

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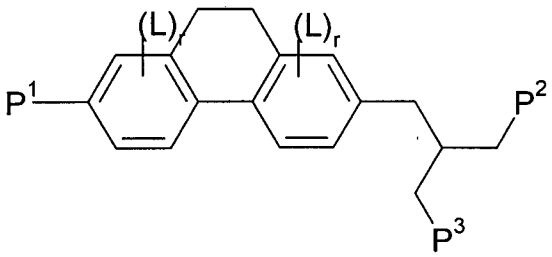

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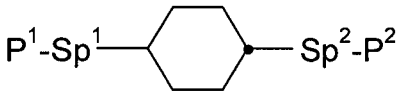

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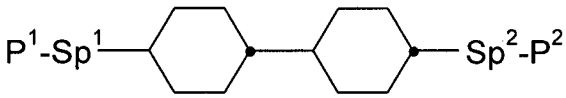

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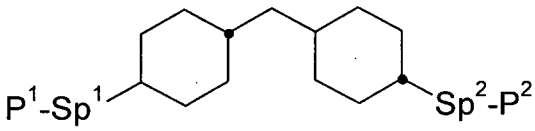

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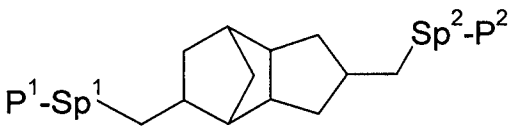

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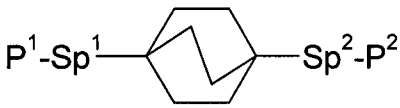

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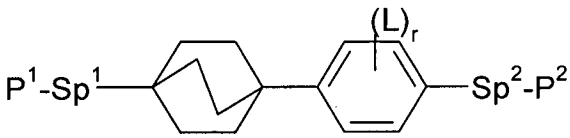

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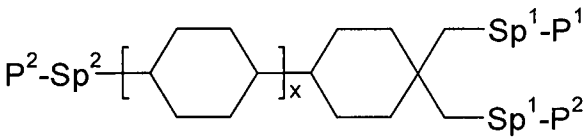

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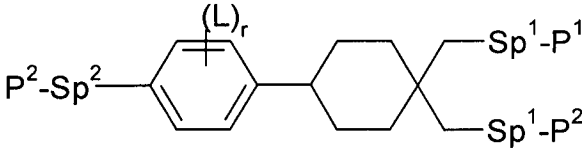

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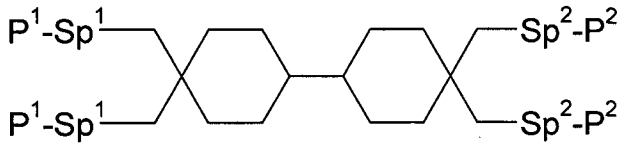

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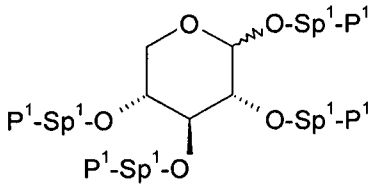

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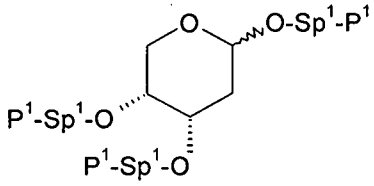

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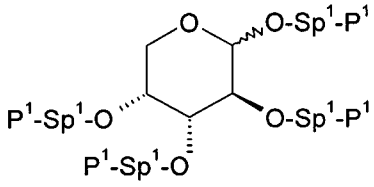
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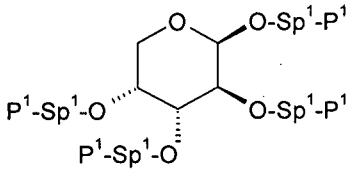
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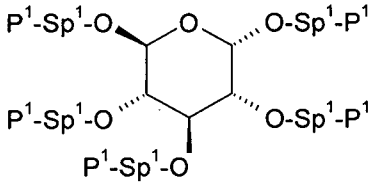
M38



M39



M40



M41

in which the individual radicals have the following meanings:

$P^1$, $P^2$ and $P^3$ each, independently of one another, denote a polymerisable group, preferably having one of the meanings indicated above and below for P, particularly preferably an acrylate, methacrylate, fluoroacrylate, oxetane, vinyl, vinyloxy or epoxide group,

$Sp^1$, $Sp^2$and $Sp^3$ each, independently of one another, denote a single bond or a spacer group, preferably having one of the meanings indicated above and below for Sp, and particularly preferably denote $-(CH_2)_{p1}-$, $-(CH_2)_{p1}-O-$, $-(CH_2)_{p1}-CO-O-$ or $-(CH_2)_{p1}-O-CO-O-$, in which p1 is an integer from 1 to 12, and where the linking to the adjacent ring in the last-mentioned groups takes place via the O atom,
where, in addition, one or more of the radicals $P^1-Sp^1-$, $P^2-Sp^2-$ and $P^3-Sp^3-$ may denote $R^{aa}$, with the proviso that at least one of the radicals $P^1-Sp^1-$, $P^2-Sp^2-$ and $P^3-Sp^3-$ present does not denote $R^{aa}$,

$R^{aa}$ 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 $CH_2$ groups may each be replaced, independently of one another, by $C(R^0)=C(R^{00})-$, $-C\equiv C-$, $-N(R^0)-$, $-O-$, $-S-$, $-CO-$, $-CO-O-$, $-O-CO-$, $-O-CO-O-$ 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 $P^1-Sp^1-$, particularly preferably straight-chain or branched, optionally mono- or polyfluorinated alkyl, alkoxy, alkenyl, alkynyl, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyl-oxy 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),

$R^0$ and $R^{00}$ 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, $CH_3$ or $CF_3$,

$X^1$, $X^2$ and $X^3$ each, independently of one another, denote -CO-O-, -O-CO- or a single bond,

$Z^1$ denotes -O-, -CO-, $-C(R^yR^z)-$ or $-CF_2CF_2-$,

$Z^2$ and $Z^3$ each, independently of one another, denote -CO-O-, -O-CO-, $-CH_2O-$, $-OCH_2-$, $-CF_2O-$, $-OCF_2-$ or $-(CH_2)_n-$, 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,

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

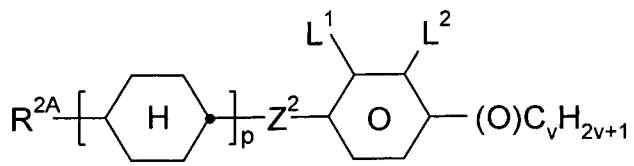
r denotes 0, 1, 2, 3 or 4,

s denotes 0, 1, 2 or 3,

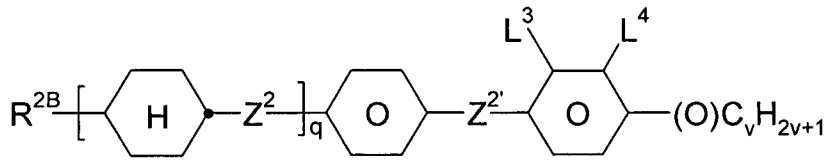
t denotes 0, 1 or 2,

x denotes 0 or 1.

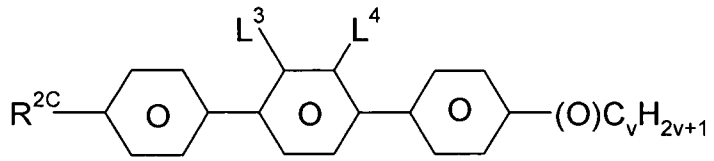
11. Liquid-crystalline medium according to one or more of Claims 1 to 10, characterised in that it additionally contains one or more compounds selected from the group of the compounds of the formulae IIA, IIB and IIC




IIA



IIB



IIC

in which

$R^{2A}$, $R^{2B}$ and $R^{2C}$ 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, in addition, one or more $CH_2$ groups in these radicals may be replaced by -O-, -S-,  , -C≡C-, $-CF_2O-$, $-OCF_2-$, -OC-O- or -O-CO- in such a way that O atoms are not linked directly to one another,

$L^{1-4}$ each, independently of one another, denote F, Cl, $CF_3$ or $OCHF_2$

$Z^2$ and $Z^{2'}$ 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-, $-CH=CHCH_2O-$,

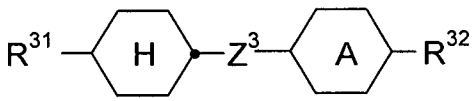
$(O)C_vH_{2v+1}$ denotes $OC_vH_{2v+1}$ or $C_vH_{2v+1}$

p denotes 0, 1 or 2,

q denotes 0 or 1, and

v denotes 1 to 6.

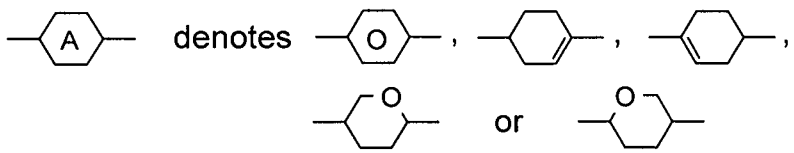
12. Liquid-crystalline medium according to one or more of Claims 1 to 11, characterised in that it additionally contains one or more compounds of the formula III,




III

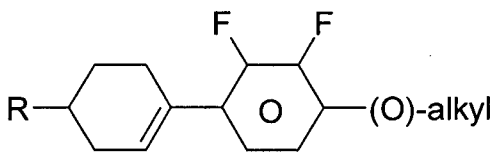
in which

$R^{31}$ and $R^{32}$ each, independently of one another, denote a straight-chain alkyl, alkoxyalkyl or alkoxy radical having up to 12 C atoms,

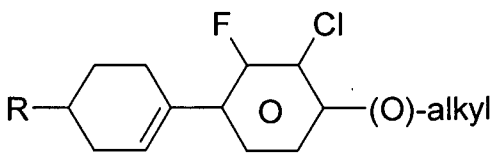



$Z^3$ denotes a single bond, $-CH_2CH_2-$, $-CH=CH-$, $-CF_2O-$, $-OCF_2-$, $-CH_2O-$, $-OCH_2-$, $-COO-$, $-OCO-$, $-C_2F_4-$, $-C_4H_8-$, $-CF=CF-$.

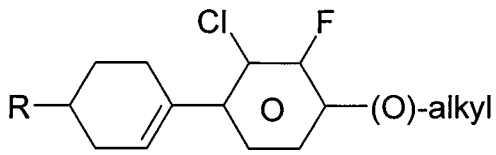
13. Liquid-crystalline medium according to one or more of Claims 1 to 12, characterised in that the medium additionally contains at least one compound of the formulae L-1 to L-11,



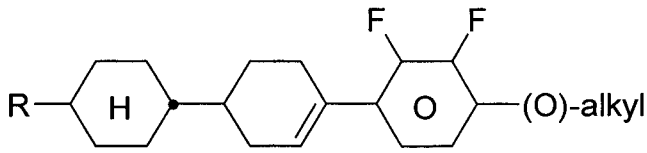

L-1



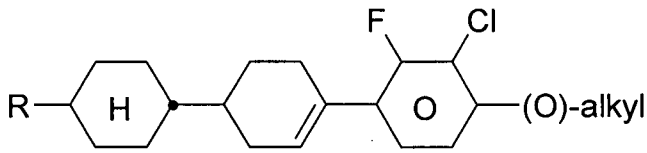

L-2



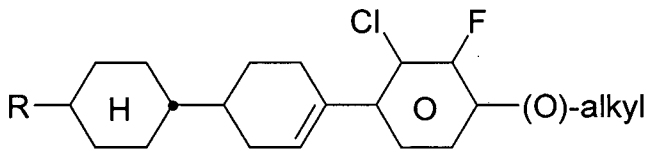

L-3



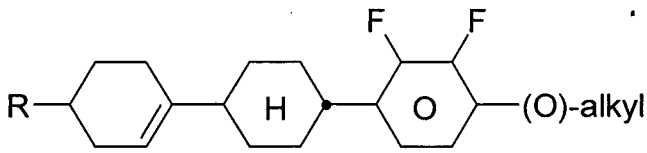

L-4



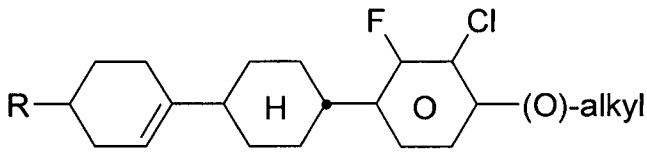

L-5



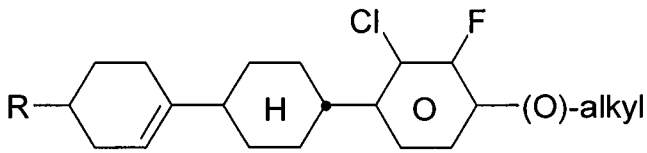

L-6



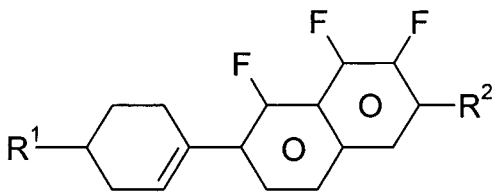

L-7



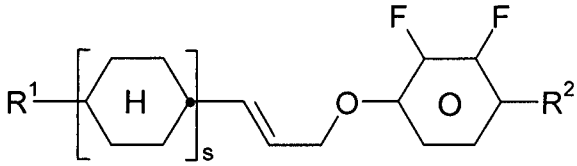

L-8




L-9




L-10

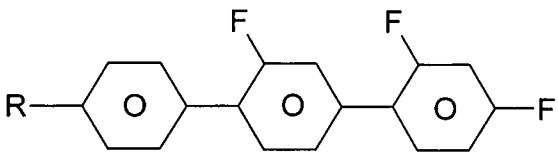



L-11

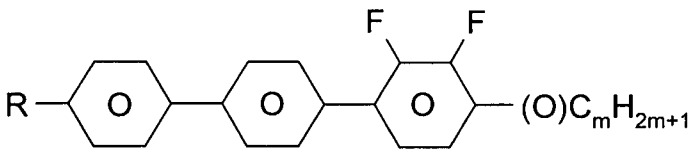
in which

| | |
|---|---|
| R, $R^1$ and $R^2$ | each, independently of one another, have the meanings indicated for $R^{2A}$ in Claim 10, and alkyl denotes an alkyl radical having 1-6 C atoms, |
| (O)-alkyl | denotes O-alkyl or alkyl, and |
| s | denotes 1 or 2. |

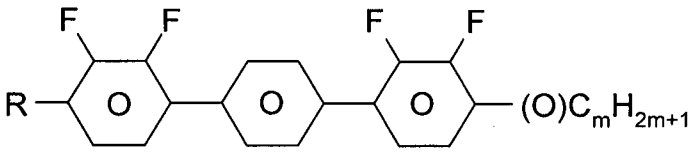
14. Liquid-crystalline medium according to one or more of Claims 1 to 13, characterised in that the medium additionally comprises one or more terphenyls of the formulae T-1 to T-23,



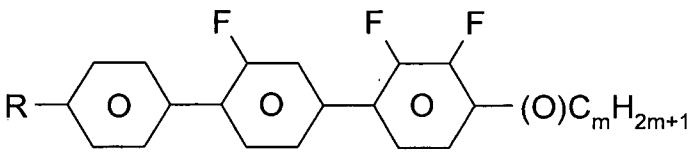

T-1



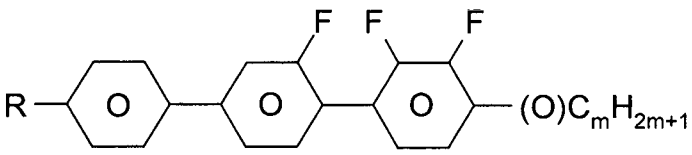

T-2



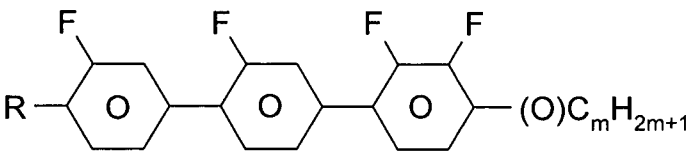

T-3



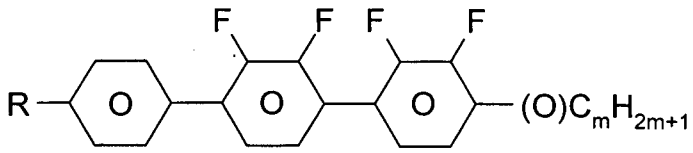

T-4



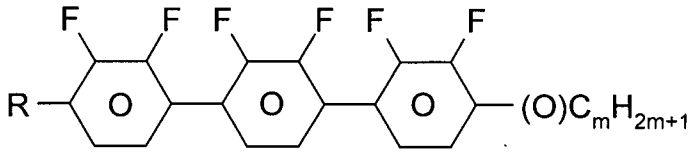

T-5



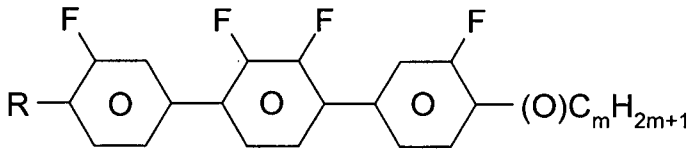

T-6



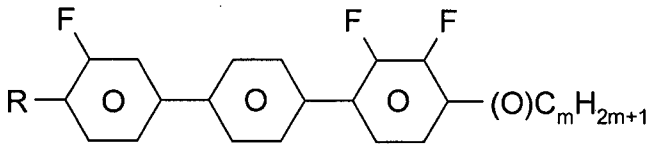

T-7



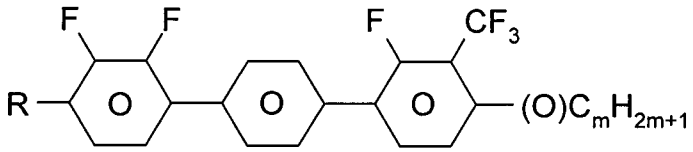

T-8



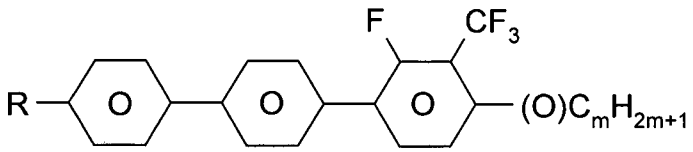

T-9



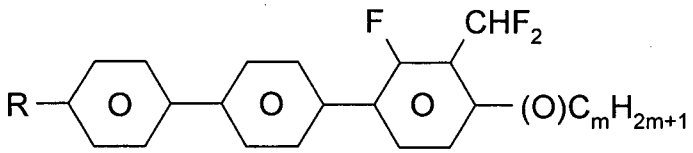

T-10



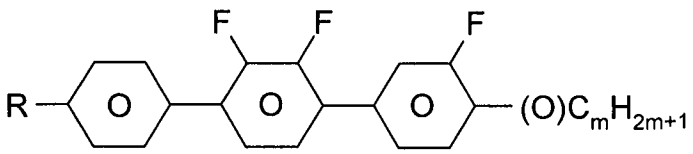

T-11



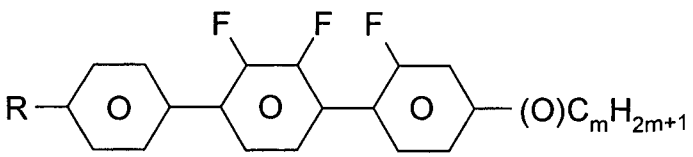

T-12



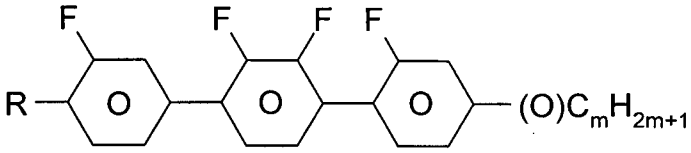

T-13



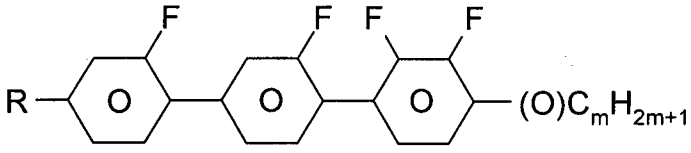

T-14



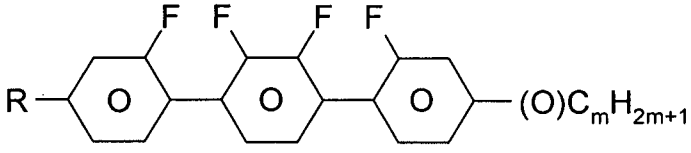

T-15



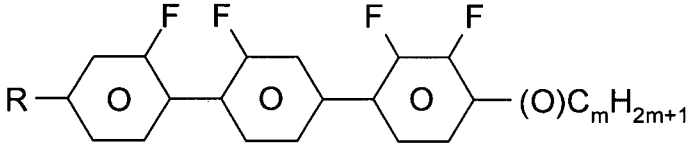

T-16



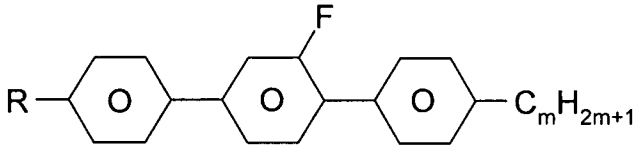

T-17



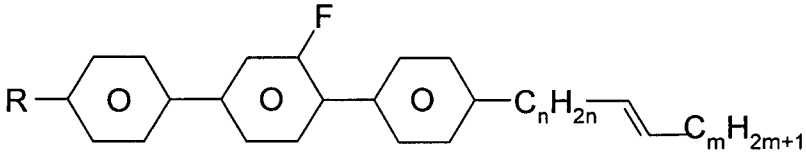

T-18



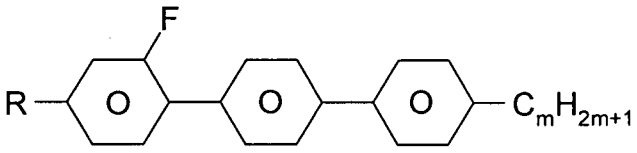

T-19



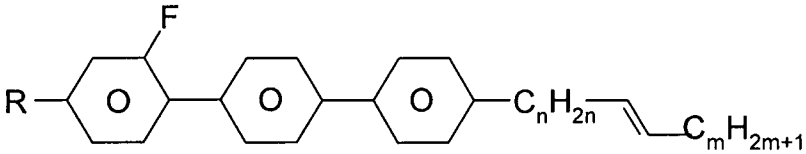

T-20




T-21




T-22

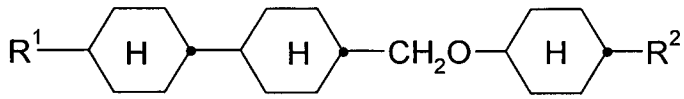



T-23

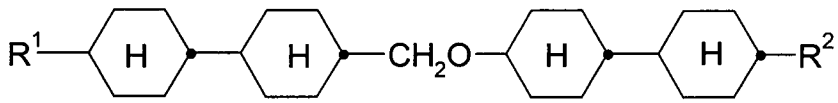
in which

| | | |
|---|---|---|
| R | | denotes a straight-chain alkyl or alkoxy radical having 1-7 C atoms, |
| $(O)C_mH_{2m+1}$ | | denotes $OC_mH_{2m+1}$ or $C_mH_{2m+1}$, |
| m | | denotes 0, 1, 2, 3, 4, 5 or 6, and |
| n | | denotes 0, 1, 2, 3 or 4. |

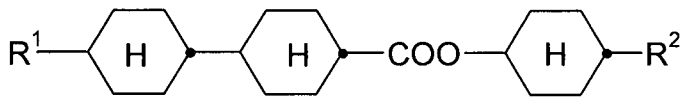
15. Liquid-crystalline medium according to one or more of Claims 1 to 14, characterised in that the medium additionally comprises one or more compounds of the formulae O-1 to O-17,



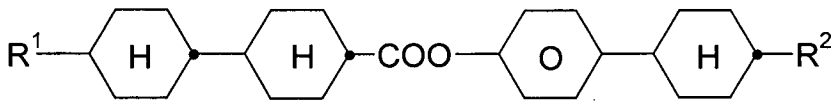
O-1



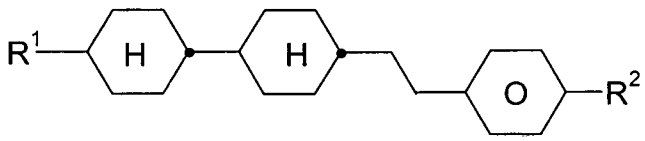
O-2



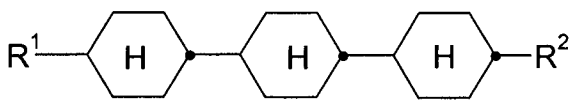
O-3



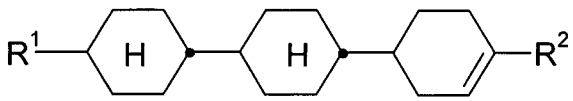
O-4



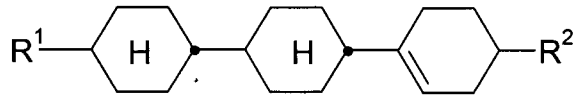
O-5



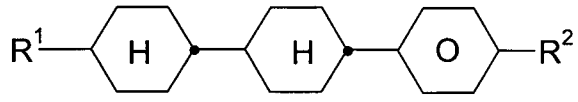
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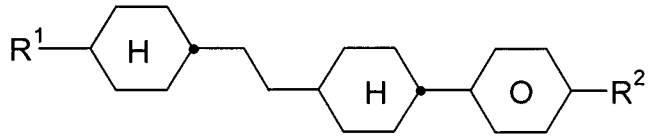
O-7



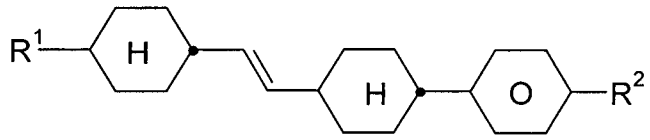

O-8



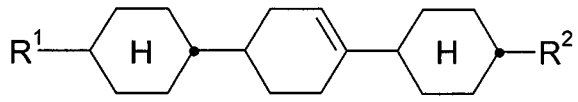

O-9



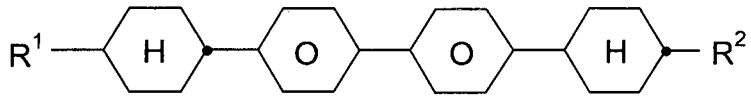

O-10



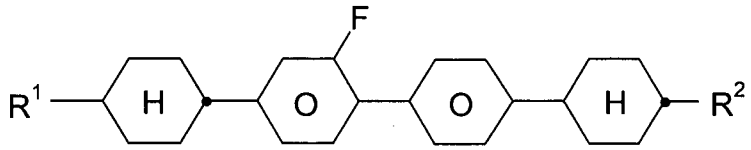

O-11



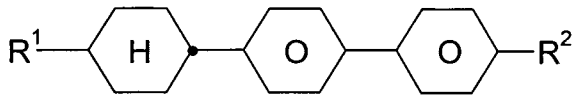

O-12



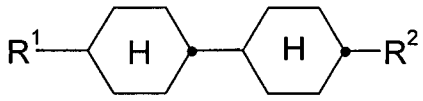

O-13



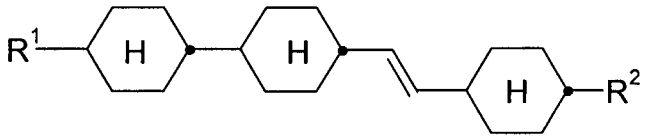

O-14




O-15



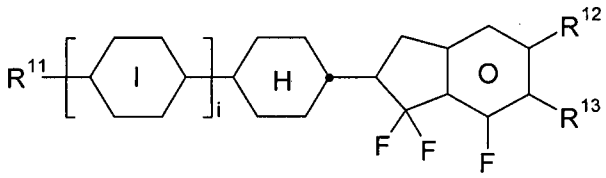

O-16




O-17

in which $R^1$ and $R^2$ each, independently of one another, have the meanings indicated for $R^{2A}$ in Claim 11.

16. Liquid-crystalline medium according to one or more of Claims 1 to 15, characterised in that the medium additionally contains one or more indane compounds of the formula In,

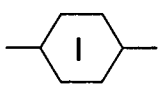



In

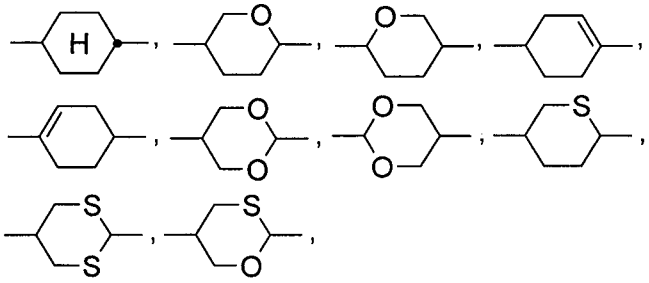
in which

$R^{11}$, $R^{12}$, $R^{13}$ denote a straight-chain alkyl, alkoxy, alkoxyalkyl or alkenyl radical having 1-5 C atoms,

$R^{12}$ and $R^{13}$ additionally also denote H or halogen,




denotes




i denotes 0, 1 or 2.

17. Liquid-crystalline medium according to one or more of Claims 1 to 16, characterised in that the medium additionally contains one or more UV absorbers, antioxidants, nanoparticles and free-radical scavengers.

18. Process for the preparation of a liquid-crystalline medium according to one or more of Claims 1 to 17, characterised in that at least one self-aligning compound of the formula I is mixed with at least two

liquid-crystalline compounds, and optionally with at least one polymerisable compound and optionally one or more additives.

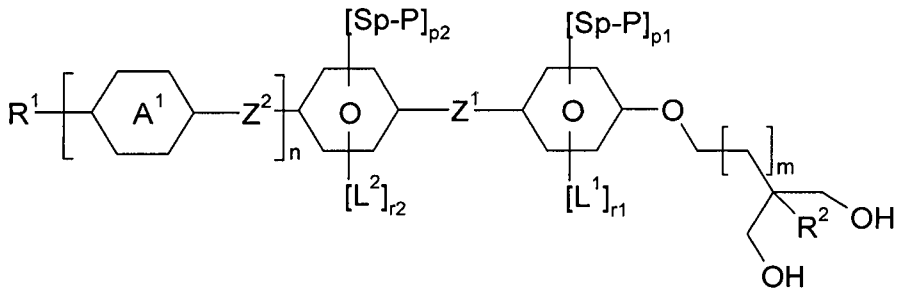
19. Use of the liquid-crystalline medium according to one or more of Claims 1 to 17 in electro-optical displays.

20. Use of the liquid-crystalline medium according to Claim 19 in electro-optical displays for self-aligning VA mode.

21. Electro-optical display having active-matrix or passive-matrix addressing, characterised in that it contains, as dielectric, a liquid-crystalline medium according to one or more of Claims 1 to 17.

22. Electro-optical display according to Claim 21, characterised in that it is a VA, PSA, PS-VA, PVA, MVA, PM-VA, HT-VA or VA-IPS display.

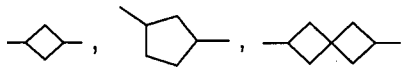
23. Compounds of the formula I



I

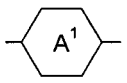
in which

$R^1$ 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 -CH=CH-, -C≡C-, $-CF_2O-$, -CH=CH-,

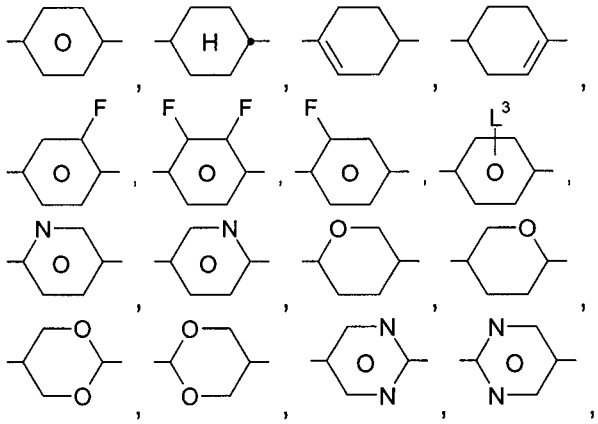


, -O-, -CO-O-, -O-CO- in such a way that O atoms are not linked directly to one another, and in which, in addition, one or more H atoms may be replaced by halogen,

$R^2$ denotes H or an alkyl radical having 1 to 8 C atoms,



denotes



$L^1$ and $L^2$ in each case, independently of one another, denotes F, Cl, Br, I, -CN, -$NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl,

$L^3$ in each case, independently of one another, denotes Cl, Br, I, -CN, -$NO_2$, -NCO, -NCS, -OCN, -SCN, straight-chain or branched alkyl, alkoxy, alkylcarbonyl, alkoxycarbonyl, alkylcarbonyloxy or alkoxycarbonyloxy having 1 to 5 C atoms, in which, in addition, one or more H atoms may be replaced by F or Cl,

m denotes 0, 1 or 2,

n denotes 0, 1 or 2,

P denotes a polymerisable group,

Sp denotes a spacer group (also called spacer) or a single bond,

$Z^1$ and $Z^2$ in each case, independently of one another, denotes a single bond, -O-, -S-, -CO-, -CO-O-, -OCO-, -O-CO-O-,

$-OCH_2-$, $-CH_2-$, $-CH_2O-$, $-CF_2O-$, $-OCF_2-$, $-CH_2CH_2-$, $-(CH_2)_4-$, $-CF_2CH_2-$, $-CH_2CF_2-$, $-CF_2CF_2-$, -CH=CH-, -CF=CF-, -C≡C-, -CH=CH-COO- or -OCO-CH=CH-,

p1 denotes 1, 2 or 3, preferably 2 or 3,

r1 denotes 0, 1, 2 or 3, whereas $p1+r1 \leq 4$,

p2 denotes 0, 1, 2 or 3

r2 denotes 0, 1, 2 or 3, whereas $p2+r2 \leq 4$.

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/001516

A. CLASSIFICATION OF SUBJECT MATTER
INV. C09K19/04 C09K19/30 C09K19/12 C09K19/18
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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | EP 2 883 934 A1 (MERCK PATENT GMBH [DE])<br>17 June 2015 (2015-06-17)<br>paragraphs [0040] - [0042]<br>----- | 1-23 |
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| A | WO 2013/004372 A1 (MERCK PATENT GMBH [DE];<br>ARCHETTI GRAZIANO [DE]; TAUGERBECK ANDREAS<br>[DE) 10 January 2013 (2013-01-10)<br>claims; examples; compounds IA, IB, IC, ID<br>-----<br>-/-- | 1-23 |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 30 November 2016 | 07/12/2016 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Schoenhentz, Jérôme |

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No
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