

Description

The present invention is concerned with novel alkoxy-methyl- and alkenyloxymethylcyclohexanes, their manufacture, liquid crystalline mixtures which contain these compounds as well as their use for electro-optical purposes.

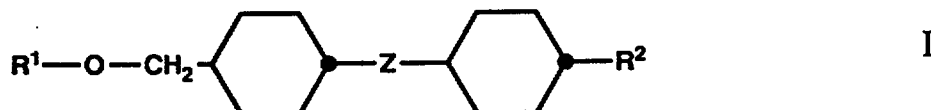
Liquid crystals are used primarily as dielectrics in indicating devices, since the optical properties of such substances can be influenced by an applied voltage. Electro-optical devices based on liquid crystals are well-known to the person skilled in the art and can be based on various effects. Such devices are, for example, cells having dynamic scattering, DAP cells (deformation of aligned phases), guest/host cells, TN cells having a twisted nematic structure, STN cells ("super-twisted nematic"), SBE cells ("super-birefringence effect") and OMI cells ("optical mode interference"). The most common indicating devices are based on the Schadt-Helfrich effect and have a twisted nematic structure.

The liquid crystal materials must have a good chemical and thermal stability and a good stability towards electric fields and electromagnetic radiation. Further, the liquid crystal materials should have a low viscosity and in the cells should give short response times, low threshold potentials and a high contrast. Furthermore, at the usual operating temperatures, i.e. in a widest possible range below and above room temperature, they should have a suitable mesophase, for example a nematic or cholesteric mesophase for the aforementioned cells. Since liquid crystals are generally used as mixtures of several components, it is important that the components have a good miscibility with one another. Other properties such as the electrical conductivity, the dielectric anisotropy and the optical anisotropy must fulfil different requirements depending on the type of cell and field of application. For example, materials for cells having a twisted nematic structure should have a positive dielectric anisotropy and an electrical conductivity which is as low as possible.

There has recently been an increased interest in materials having a low optical anisotropy, especially for actively addressed liquid crystal indicators such as MIM applications (metal-isolator-metal) or TFT applications ("thin film transistor") in television sets. Compounds having low optical anisotropy are, for example, the bicyclohexyl derivatives with alkyl/alkoxyalkyl side-chains which are described in EP-A-0 132 553 and in EP-A-0 090 548. The state of the art according to Article 54(3) EPC also discloses in EP-A-361 532 bicyclohexyl derivatives with alkyl/alkoxy side-

chains. However, the known liquid crystalline compounds having a low optical anisotropy frequently produce smectic tendencies in mixtures and for the most part lead to an undesired increase in the threshold potential, the viscosity and/or the response times.

The object of the present invention comprises the compounds of the general formula



wherein Z represents a single covalent bond or $-\text{CH}_2-\text{CH}_2-$; R^1 denotes alkyl or 2-alkenyl; and R^2 signifies 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl or, when R^1 denotes 2-alkenyl and Z represents $-\text{CH}_2-\text{CH}_2-$, also alkyl or alkoxy-methyl.

The compounds in accordance with the invention are liquid crystals having a very low optical anisotropy, relatively low melting points and for the most part comparatively high clearing points. They have a very good solubility in known liquid crystal materials and produce a good melting behaviour in mixtures.

The compounds in accordance with the invention have low viscosities and produce remarkably short switching times in mixtures. In particular, the switching-on times are generally considerably shorter than those of mixtures of comparable compounds having a low optical anisotropy.

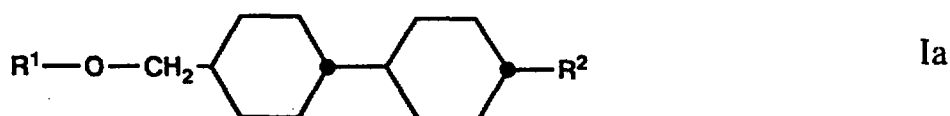
The short response times and the good melting behaviour can also be passed on to complex mixtures so that rapidly switching liquid crystals having high clearing points, low melting points and at the same time low threshold potentials, short response times (especially at low temperatures) and comparatively low optical anisotropies are obtained.

These properties can be varied to a certain extent depending on the significance of R^1 and R^2 . 4-Alkenyl or (2-alkenyl)oxymethyl in R^2 and/or 2-alkenyl in R^1 leads, for example, to particularly low threshold potentials and optical anisotropies. On the other hand, compounds of formula I in which R^2 signifies 1E-alkenyl or 3E-alkenyl generally give higher clearing points and shorter response times.

The compounds of formula I are non-polar compounds having a small absolute value of the electrical anisotropy

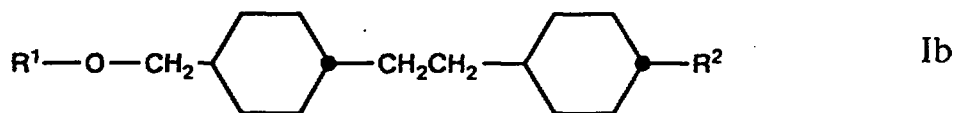
The compounds in accordance with the invention are especially suitable as components of nematic and cholesteric mixtures. They can be used in the usual electro-optical devices, for example in the liquid crystal cells mentioned earlier. Having regard to the low optical anisotropy, they are especially suitable for use in liquid crystal mixtures for OMI cells, for TFT applications, for TN cells, which are operated in the first minimum, and the like.

Formula I embraces the compounds of the general formulae



wherein R¹ denotes alkyl and R² denotes 1E-alkenyl, 3E-alkenyl, 4-alkenyl or (2-alkenyl)oxymethyl or R¹ denotes 2-alkenyl and R² denotes 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl, alkyl or alkoxy-methyl,

and



wherein R¹ denotes alkyl and R² denotes 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl, alkyl or alkoxy-methyl or R¹ denotes 2-alkenyl and R² denotes 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl, alkyl or alkoxy-methyl.

The terms "alkyl", "1E-alkenyl", "2-alkenyl", "3E-alkenyl", "4-alkenyl", "alkoxy-methyl" and "(2-alkenyl)oxymethyl" embrace in the scope of the present invention straight-chain and branched groups. Examples of preferred groups are methyl, ethyl, propyl, butyl (= n-butyl), s-butyl, 2-methylbutyl, pentyl (= n-pentyl), 2-pentyl, hexyl, heptyl, vinyl, 1E-propenyl, 1E-butenyl, 1E-pentenyl, 1E-hexenyl, 1E-heptenyl, allyl, 2E-butenyl, 2Z-butenyl, 2E-pentenyl, 2Z-pentenyl, 3-butenyl, 3E-pentenyl, 3E-hexenyl, 3E-heptenyl, 4-pentenyl, 4E-hexenyl, 4Z-hexenyl, 4E-heptenyl, 4Z-heptenyl, methoxymethyl, ethoxymethyl, propyloxymethyl, butyloxymethyl, s-butyloxymethyl, pentyloxymethyl, (2-pentyl)-oxymethyl, (2-methylbutyl)oxymethyl, allyloxymethyl, (2E-

butenyl)oxymethyl, (2Z-butenyl)oxymethyl, (2E-pentenyl)oxymethyl, (2Z-pentenyl)oxymethyl and the like. 2-Alkenyl and 4-alkenyl groups can be present in the E-configuration or preferably in the Z-configuration.

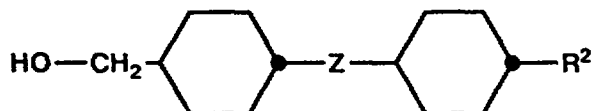
Compounds of formula I having straight-chain residues R^1 and R^2 are generally preferred. However, if desired, R^1 and/or R^2 can be branched, and branched groups can preferably be chiral. Optically active compounds of formula I having chiral R^1 and/or R^2 are suitable, for example, as optically active doping substances for the production of cholesteric mixtures or for avoiding the reversal of the twisting direction (reverse twist) in TN cells.

R^1 in formulae I, Ia and Ib above preferably has a maximum of 10 carbon atoms, particularly a maximum of 5 carbon atoms. Preferred residues R^1 are therefore C_1 - C_{10} -alkyl and C_3 - C_{10} -2-alkenyl, especially C_1 - C_5 -alkyl and C_3 - C_5 -2-alkenyl. Methyl, ethyl, propyl, allyl and 2-butenyl are examples of especially preferred residues R^1 .

R^2 in formulae I, Ia and Ib above preferably has a maximum of 12 carbon atoms, particularly a maximum of 7 carbon atoms. Preferred residues R^2 are therefore C_2 - C_{12} -1E-alkenyl, C_4 - C_{12} -3E-alkenyl, C_5 - C_{12} -4-alkenyl, C_4 - C_{12} -(2-alkenyl)oxymethyl, C_1 - C_{12} -alkyl and C_2 - C_{12} -alkoxymethyl, especially C_2 - C_7 -1E-alkenyl, C_4 - C_7 -3E-alkenyl, C_5 - C_7 -4-alkenyl, C_4 - C_7 -(2-alkenyl)-oxymethyl, C_1 - C_7 -alkyl and C_2 - C_7 -alkoxymethyl. Vinyl, 1E-propenyl, 1E-butenyl, 1E-pentenyl, 3-butenyl, 3E-pentenyl, 4-pentenyl, allyloxymethyl, (2-butenyl)oxymethyl, methyl, ethyl, propyl, butyl, pentyl, methoxymethyl, ethoxymethyl, propyloxymethyl and butyloxymethyl are examples of especially preferred residues R^2 .

Compounds of formula I which have a C-C double bond in R^1 and/or R^2 are generally preferred. Accordingly, in formulae I, Ia and Ib above R^1 preferably stands for 2-alkenyl and/or R^2 preferably stands for 1E-alkenyl, 3E-alkenyl, 4-alkenyl or (2-alkenyl)-oxymethyl.

The compounds of formula I can be manufactured in accordance with the invention by etherifying a compound of the general formula



II

with a compound of the general formula

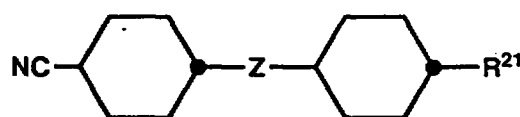


III

wherein X denotes chlorine, bromine or iodine and R^1 and R^2 have the above significances.

The etherification can be effected in a manner known per se using usual bases. The etherification is preferably effected with the bromide or iodide of formula III.

The compounds of formula II can be prepared in a manner known per se from the nitriles of the general formula



IV

wherein Z represents a single covalent bond or $-CH_2CH_2-$ and R^{21} signifies 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)-oxymethyl, alkyl or alkoxyethyl, for example by hydrolyzing the cyano group and subsequently reducing the carboxy group to the hydroxymethyl group. Preferably, the hydrolysis and reduction can be effected according to the methods described in the detailed Examples hereinafter.

The compounds of formula IV in which Z signifies a single covalent bond and R^{21} signifies (2-alkenyl)oxymethyl or Z signifies $-CH_2CH_2-$ and R^{21} signifies alkoxyethyl or (2-alkenyl)-oxymethyl are novel intermediates and can be prepared in a manner known per se.

The compounds of formula I can be used in the form of mixtures with one another and/or with other liquid crystal components such as e.g. with substances from the classes of Schiff's bases, azobenzenes, azoxybenzenes, phenylbenzoates, cyclohexanecarboxylic acid phenyl esters, cyclohexanecarboxylic acid cyclohexyl esters, biphenyls, phenylcyclohexanes, cyclohexylcyclohexanes, phenylpyrimidines, cyclohexylpyrimidines, phenyldioxanes, 2-cyclohexyl-1-phenylethanes, terphenyls, cyclohexylbiphenyls, cyclohexylphenylpyrimidines and the like. Such substances are known to the person skilled in the art and many of them are, moreover, commercially obtainable.

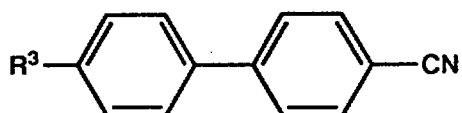
The liquid crystalline mixtures in accordance with the invention contain at least two components, of which at least one

component is a compound of formula I. A second component and optionally additional components can be further compounds of formula I and/or other liquid crystal components.

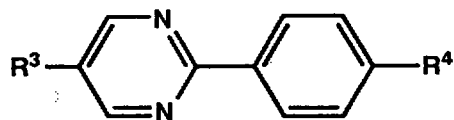
The compounds of formula I are especially suitable for nematic mixtures or, insofar as at least one component of the mixture is optically active, also for cholesteric mixtures. A preferred field of application is their use as dielectrics in liquid crystal indicating devices having a twisted nematic liquid crystal structure such as TN cells, STN cells, SBE cells and OMI cells. Preferred mixtures are therefore those which contain one or more compounds of formula I and one or more compounds having positive dielectric anisotropy.

Having regard to the good solubility of the compounds of formula I in other liquid crystal materials and having regard to their good miscibility with one another, the content of compounds of formula I in the mixtures in accordance with the invention can be relatively high and can amount to, for example, about 1-70 wt.%. A content of about 3-40 wt.%, especially about 5-30 wt.%, of compounds of formula I is generally preferred.

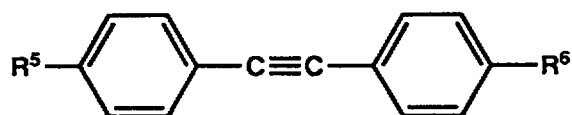
The mixtures in accordance with the invention preferably contain, in addition to one or more compounds of formula I, one or more compounds from the group of compounds of the general formulae



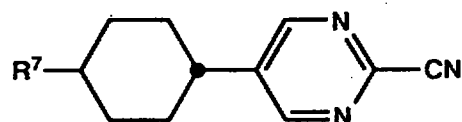
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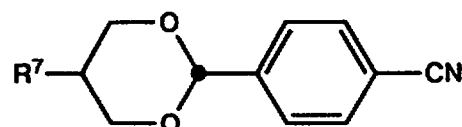
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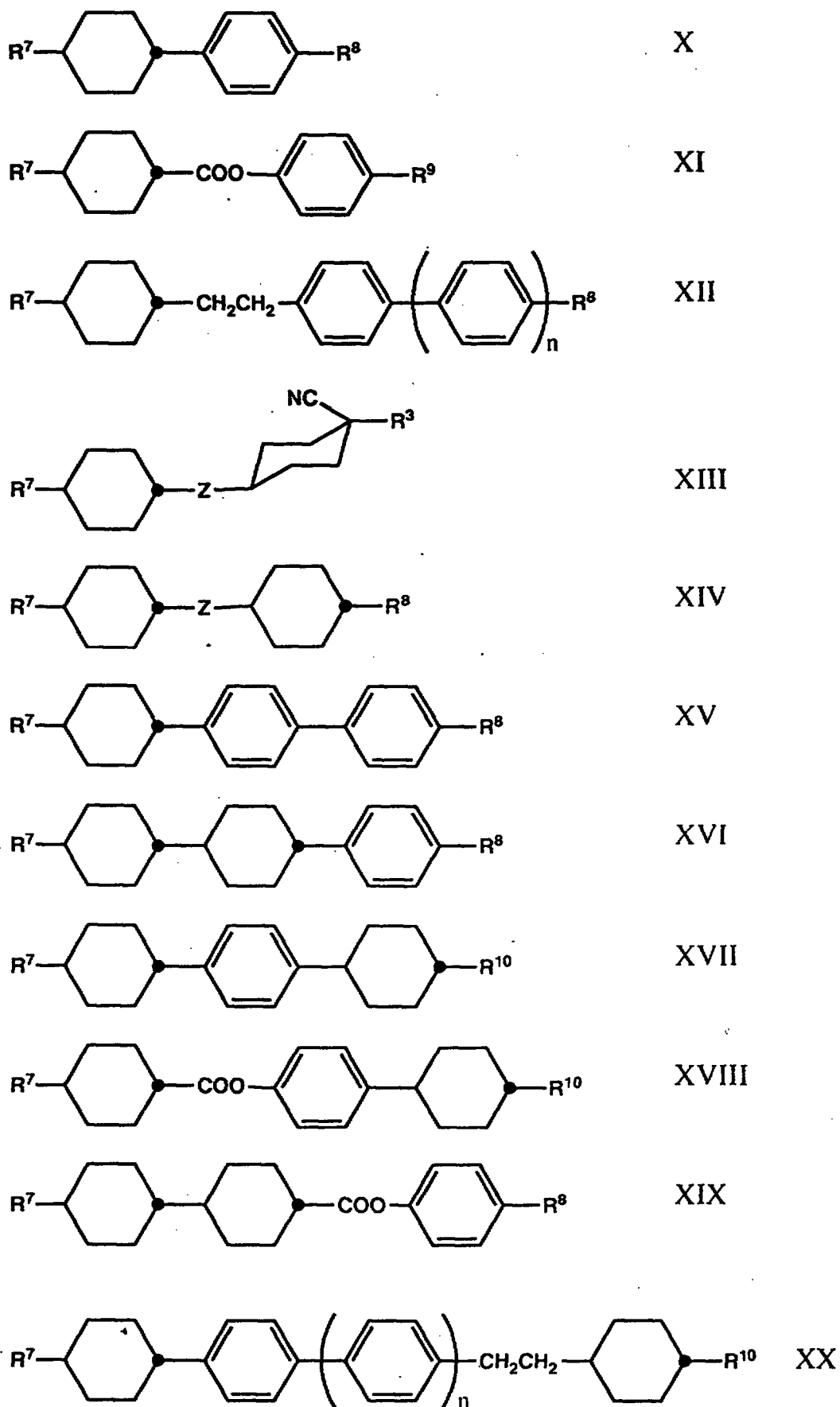
VII

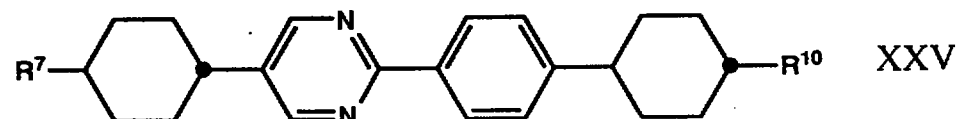
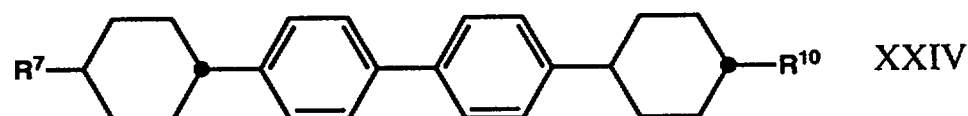
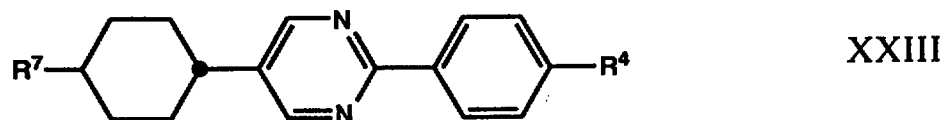
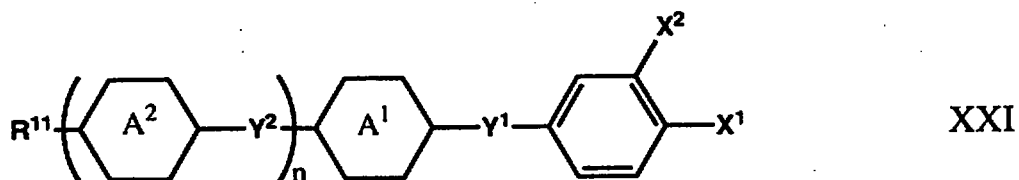


VIII



IX





wherein R^3 signifies alkyl, 3E-alkenyl or 4-alkenyl; R^4 represents alkyl, cyano or fluorine; R^5 and R^6 denote alkyl or alkoxy; R^7 and R^{10} each independently signify alkyl, 1E-alkenyl, 3E-alkenyl or 4-alkenyl; R^8 denotes cyano, alkyl, 1E-alkenyl, 3E-alkenyl, 4-alkenyl, alkoxy, 2E-alkenyloxy or 3-alkenyloxy; R^9 signifies alkoxy, 2E-alkenyloxy or 3-alkenyloxy; n stands for the number 0 or 1; Z represents a single covalent bond or $-\text{CH}_2\text{CH}_2-$; X^1 denotes fluorine or chlorine and X^2 denotes hydrogen, fluorine or chlorine; R^{11} signifies alkyl, 3E-alkenyl, 4-alkenyl, alkoxy, 2E-alkenyloxy or 3-alkenyloxy; one of the groups Y^1 and Y^2 signifies a single covalent bond, $-\text{COO}-$, $-\text{OOC}-$, $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$ or $-\text{OCH}_2-$ and the other of the groups Y^1 and Y^2 signifies a single covalent bond; and rings A^1 and A^2 each independently represent substituted or unsubstituted trans-1,4-cyclohexylene, in which optionally 2 non-adjacent CH_2 groups are replaced by oxygen, or substituted or unsubstituted 1,4-phenylene, in which optionally 1 or 2 CH groups is/are replaced by nitrogen.

The term "substituted or unsubstituted trans-1,4-cyclohexylene, in which optionally 2 non-adjacent CH_2 groups are replaced by oxygen" embraces especially trans-1,4-cyclohexylene and trans-m-dioxane-2,5-diyl as well as rings which are substituted with substituents which are usual in liquid crystals, such as

cyano, methyl, fluorine or chlorine, for example 1-cyano-trans-1,4-cyclohexylene or 2-methyl-trans-1,4-cyclohexylene.

The term "substituted or unsubstituted 1,4-phenylene, in which optionally 1 or 2 CH groups is/are replaced by nitrogen" embraces especially 1,4-phenylene, pyridine-2,5-diyl, pyrazine-2,5-diyl and pyrimidine-2,5-diyl as well as rings which are substituted with substituents which are usual in liquid crystals, such as cyano, methyl, fluorine or chlorine, for example 2-cyano-1,4-phenylene, 2-fluoro-1,4-phenylene, 2-chloro-1,4-phenylene or 2-methyl-1,4-phenylene.

The cyano and halo compounds of formulae V, VI, VIII, IX, X, XII, XIV, XV, XIX, XXI and XXIII as well as the isothiocyanates of formula XXII are preferred mixture components having positive dielectric anisotropy. Preferably, the final mixture contains about 20-70 wt.%, especially about 25-50 wt.%, of one or more of these compounds.

The compounds of formulae VIII-XXI, especially the compounds of formulae XIII, XIV, XVI, XVII, XVIII, XIX and XX as well as the compounds of formula XXI in which rings A¹ and A² signify trans-1,4-cyclohexylene, are preferred mixture components for the production of a low optical anisotropy in the final mixture.

Those mixtures which contain, in addition to one or more compounds of formula I, one or more compounds of formula VIII, X, XIV, XVI, XVII and/or XXI are generally especially preferred.

The mixtures in accordance with the invention can also contain optically active compounds (e.g. optically active 4'-alkyl- or 4'-alkoxy-4-biphenylcarbonitriles) and/or dichroic colouring substances (e.g. azo, azoxy or anthraquinone colouring substances). The amount of such compounds is determined by the solubility, the desired pitch, colour, extinction and the like. In general, the amount of optically active compounds and dichroic colouring substances amounts to a maximum of in each case about 10 wt.% in the final mixture.

The manufacture of the mixtures in accordance with the invention and the manufacture of the electro-optical devices can be effected in a manner known per se.

The manufacture of the compounds of formula I and of liquid crystalline mixtures containing these compounds are illustrated in more detail by the following Examples. C signifies a crystalline

phase, S signifies a smectic phase, S_B signifies a smectic B phase, N signifies a nematic phase and I signifies the isotropic phase. V₁₀ denotes the voltage for 10% transmission (direction of view perpendicular to the plate surface). t_{on} and t_{off} denote the switching-on time and the switching-off time, respectively, and Δn denotes the optical anisotropy.

Example 1

a) A solution of 1.04 g of trans-4-[trans-4-(3-butenyl)-cyclohexyl]cyclohexanecarbonitrile in 10 ml of diethylene glycol was treated with a solution of 2 g of potassium hydroxide in 10 ml of diethylene glycol and then stirred at 180°C (oil bath temperature) for 2.5 hours. Subsequently, the reaction mixture was poured on to ice/water, acidified with 8 ml of 25 percent hydrochloric acid and extracted with diethyl ether. The organic phase was dried over magnesium sulphate, filtered and evaporated. Crystallization of the resulting beige crude product (1.06 g) from 50 ml of hexane gave 588 mg. of trans-4-[trans-4-(3-butenyl)-cyclohexyl]cyclohexanecarboxylic acid as colourless crystals.

b) A suspension of 1.55 g of lithium aluminium hydride in 30 ml of diethyl ether was treated dropwise at room temperature within 10 minutes with a solution of 2.7 g of trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexanecarboxylic acid in 40 ml of diethyl ether. Subsequently, the reaction mixture was stirred under reflux (bath temperature 45°C) for 1 hour, then treated at 0-10°C with 20 ml of 2N hydrochloric acid and extracted three times with diethyl ether. The organic phase was washed with 2N hydrochloric acid and twice with water, dried over magnesium sulphate, filtered and evaporated. There were thus obtained 2.5 g of [trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methanol as colourless crystals.

The following compounds can be prepared in an analogous manner:

[trans-4-(trans-4-Methylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-ethylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-propylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-butylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-pentylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-hexylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-heptylcyclohexyl)cyclohexyl]methanol;
 [trans-4-(trans-4-vinylcyclohexyl)cyclohexyl]methanol;

[trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(1E-butenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(1E-pentenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(1E-hexenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(1E-heptenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(3E-pentenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(3E-hexenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(3E-heptenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(4Z-hexenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[trans-4-(4Z-heptenyl)cyclohexyl]cyclohexyl]-methanol;

[trans-4-[2-(trans-4-methylcyclohexyl)ethyl]cyclohexyl]-methanol;

[trans-4-[2-(trans-4-ethylcyclohexyl)ethyl]cyclohexyl]-methanol;

[trans-4-[2-(trans-4-propylcyclohexyl)ethyl]cyclohexyl]-methanol;

[trans-4-[2-(trans-4-butylcyclohexyl)ethyl]cyclohexyl]-methanol;

[trans-4-[2-(trans-4-pentylcyclohexyl)ethyl]cyclohexyl]-methanol;

[trans-4-[2-(trans-4-(1E-propenyl)cyclohexyl)ethyl]cyclohexyl]methanol;

[trans-4-[2-(trans-4-(1E-butenyl)cyclohexyl)ethyl]cyclohexyl]methanol;

[trans-4-[2-(trans-4-(1E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methanol;

[trans-4-[2-(trans-4-(3-butenyl)cyclohexyl)ethyl]cyclohexyl]methanol;

[trans-4-[2-(trans-4-(3E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methanol;

[trans-4-[2-(trans-4-(4-pentenyl)cyclohexyl)ethyl]cyclohexyl]methanol.

Example 2

a) 1.5 g of [trans-4-(trans-4-cyanocyclohexyl)cyclohexyl]-methyl methyl ether were suspended in 30 ml of glacial acetic acid and 15 ml of 50 percent sulphuric acid and the suspension was heated to reflux (bath temperature 130°C) for 20 hours while stirring. Subsequently, the reaction mixture was partitioned in methylene chloride/water and extracted three times with methylene chloride. The organic phases were washed three times with water, dried over magnesium sulphate, filtered and evaporated. There were thus obtained 1.33 g of brown, oily trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexanecarboxylic acid which was used without purification.

b) A suspension of 390 mg of lithium aluminium hydride in 20 ml of diethyl ether was treated dropwise at room temperature within 5 minutes with a solution of 1.3 g of trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexanecarboxylic acid in 40 ml of methylene chloride. The reaction mixture was stirred at 50°C bath temperature for 1 hour, then treated with 100 mg of lithium aluminium hydride and stirred for a further 1 hour. Subsequently, the reaction mixture was treated dropwise at about 15°C with 40 ml of water and extracted three times with methylene chloride. The organic phases were washed with dilute hydrochloric acid (pH about 1) and twice with water, dried over magnesium sulphate, filtered and evaporated. Chromatographic purification of the yellow crude product (0.96 g) on silica gel with toluene/ethyl acetate (vol. 5:1) gave yellowish, solid [trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]methanol.

c) 150 mg of sodium hydride (as a 50 percent suspension in oil) is suspended in 10 ml of absolute tetrahydrofuran and then treated dropwise at room temperature within 3 minutes with a solution of 0.5 g of [trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]methanol in 8 ml of absolute tetrahydrofuran. The mixture is stirred for a further 5 minutes, then treated with 0.755 g of allyl bromide and stirred under reflux (bath temperature 70°C) for 16 hours. Thereafter, the reaction mixture is partitioned in diethyl ether/water and extracted three times with diethyl ether. The organic phases are washed twice with water, dried over magnesium sulphate, filtered and evaporated. Chromatographic purification of the resulting crude product on silica gel with ethyl acetate/ petroleum ether (vol. 3:97) gives [trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]methyl allyl ether.

The following compounds can be manufactured in an analogous manner:

[trans-4-[trans-4-(Methoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-pentenyl ether;

[trans-4-[trans-4-(ethoxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(ethoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(ethoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-pentenyl ether;

[trans-4-[trans-4-(propyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(propyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(butyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(butyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(pentyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(allyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(allyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(allyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-pentenyl ether;

[trans-4-[trans-4-(2Z-butenyloxymethyl)cyclohexyl]cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(methoxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(methoxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(ethoxymethyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(ethoxymethyl)cyclohexyl)ethyl]cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(propyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(butyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(pentyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(allyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(allyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(2Z-butenyloxymethyl)cyclohexyl)-ethyl]cyclohexyl]methyl 2Z-butenyl ether.

Example 3

290 mg of sodium hydride as a 50 percent suspension in oil were placed in a sulphonation flask and rinsed with 10 ml of pentane. The supernatant solution was then sucked off and the sodium hydride slurry was treated dropwise with a solution of 1.0 g of [trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]-methanol in 15 ml of tetrahydrofuran. The reaction mixture was stirred at room temperature, treated after 5 minutes with 0.745 ml of methyl iodide and stirred at 70°C bath temperature for a further 3 hours. Subsequently, the reaction mixture was partitioned in diethyl ether/water and extracted three times with diethyl ether. The organic phases were washed twice with water, dried over magnesium sulphate, filtered and evaporated. The colourless crude product (1.1 g) was purified by chromatography on silica gel with ethyl acetate/petroleum ether (vol. 3:97) and crystallized from 40 ml at -20°C. There were thus obtained 727 mg of colourless, crystalline [trans-4-[trans-4-(3-butenyl)-cyclohexyl]cyclohexyl]methyl methyl ether; m.p. (C-S_B) -9.4°C, phase transition (S_B-N) 50.3°C, cl.p. (N-I) 53.0°C.

The following compounds can be manufactured in an analogous manner:

[trans-4-(trans-4-Vinylcyclohexyl)cyclohexyl]methyl methyl ether, m.p. (C-S_B) 5.6°C, cl.p. (S_B-I) 17.1°C;

[trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]-methyl methyl ether, m.p. (C-S_B) 12.3°C, phase transition (S_B-N) 22.4°C, cl.p. (N-I) 62.2°C;

[trans-4-[trans-4-(1E-butenyl)cyclohexyl]cyclohexyl]methyl methyl ether, m.p. (C-S_B) 6.3°C, phase transition (S_B-N) 46.8°C, cl.p. (N-I) 49.0°C;

[trans-4-[trans-4-(1E-pentenyl)cyclohexyl]cyclohexyl]-methyl methyl ether;

[trans-4-[trans-4-(1E-hexenyl)cyclohexyl]cyclohexyl]methyl methyl ether;

[trans-4-[trans-4-(1E-heptenyl)cyclohexyl]cyclohexyl]-methyl methyl ether;

[trans-4-[trans-4-(3E-pentenyl)cyclohexyl]cyclohexyl]-
methyl methyl ether, m.p. (C-N) 41°C, cl.p. (N-I) 74.3°C;

[trans-4-[trans-4-(3E-hexenyl)cyclohexyl]cyclohexyl]methyl
methyl ether;

[trans-4-[trans-4-(3E-heptenyl)cyclohexyl]cyclohexyl]-
methyl methyl ether;

[trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]methyl
methyl ether, cl.p. 70.8°C;

[trans-4-[trans-4-(4Z-hexenyl)cyclohexyl]cyclohexyl]methyl
methyl ether;

[trans-4-[trans-4-(4Z-heptenyl)cyclohexyl]cyclohexyl]-
methyl methyl ether;

[trans-4-[trans-4-vinylcyclohexyl]cyclohexyl]methyl ethyl
ether, m.p. (C-S_B) -19.6°C, cl.p. (S_B-I) 9.9°C;

[trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]-
methyl ethyl ether, m.p. (C-N) 20.8°C, transition (S_B-N) 13.3°C, cl.p.
(N-I) 34.1°C;

[trans-4-[trans-4-(1E-butenyl)cyclohexyl]cyclohexyl]methyl
ethyl ether;

[trans-4-[trans-4-(1E-pentenyl)cyclohexyl]cyclohexyl]-
methyl ethyl ether;

[trans-4-[trans-4-(1E-hexenyl)cyclohexyl]cyclohexyl]methyl
ethyl ether;

[trans-4-[trans-4-(1E-heptenyl)cyclohexyl]cyclohexyl]-
methyl ethyl ether;

[trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methyl
ethyl ether;

[trans-4-[trans-4-(3E-pentenyl)cyclohexyl]cyclohexyl]-
methyl ethyl ether, m.p. (C-S_B) 14.3°C, cl.p. (S_B-I) 57.5°C;

[trans-4-[trans-4-(3E-hexenyl)cyclohexyl]cyclohexyl]methyl
ethyl ether;

[trans-4-[trans-4-(3E-heptenyl)cyclohexyl]cyclohexyl]-
methyl ethyl ether;

[trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]methyl
ethyl ether;

[trans-4-[trans-4-(4Z-hexenyl)cyclohexyl]cyclohexyl]methyl
ethyl ether;

[trans-4-[trans-4-(4Z-heptenyl)cyclohexyl]cyclohexyl]-
methyl ethyl ether;

[trans-4-[trans-4-vinylcyclohexyl]cyclohexyl]methyl propyl
ether;

[trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]-
methyl propyl ether;

[trans-4-[trans-4-(1E-butenyl)cyclohexyl]cyclohexyl]methyl
propyl ether;

[trans-4-[trans-4-(1E-pentenyl)cyclohexyl]cyclohexyl]-
 methyl propyl ether;
 [trans-4-[trans-4-(1E-hexenyl)cyclohexyl]cyclohexyl]methyl
 propyl ether;
 [trans-4-[trans-4-(1E-heptenyl)cyclohexyl]cyclohexyl]-
 methyl propyl ether;
 [trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methyl
 propyl ether;
 [trans-4-[trans-4-(3E-pentenyl)cyclohexyl]cyclohexyl]-
 methyl propyl ether;
 [trans-4-[trans-4-(3E-hexenyl)cyclohexyl]cyclohexyl]methyl
 propyl ether;
 [trans-4-[trans-4-(3E-heptenyl)cyclohexyl]cyclohexyl]-
 methyl propyl ether;
 [trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]methyl
 propyl ether;
 [trans-4-[trans-4-(4Z-hexenyl)cyclohexyl]cyclohexyl]methyl
 propyl ether;
 [trans-4-[trans-4-(4Z-heptenyl)cyclohexyl]cyclohexyl]-
 methyl propyl ether;
 [trans-4-(trans-4-methylcyclohexyl)cyclohexyl]methyl allyl
 ether;
 [trans-4-(trans-4-ethylcyclohexyl)cyclohexyl]methyl allyl
 ether;
 [trans-4-(trans-4-propylcyclohexyl)cyclohexyl]methyl allyl
 ether, cl.p. (S_B-I) 54°C;
 [trans-4-(trans-4-butylcyclohexyl)cyclohexyl]methyl allyl
 ether, m.p. (C-S_B) -1.4°C, cl.p. (S_B-I) 72.9°C;
 [trans-4-(trans-4-pentylcyclohexyl)cyclohexyl]methyl allyl
 ether;
 [trans-4-(trans-4-hexylcyclohexyl)cyclohexyl]methyl allyl
 ether;
 [trans-4-(trans-4-heptylcyclohexyl)cyclohexyl]methyl allyl
 ether;
 [trans-4-[trans-4-vinylcyclohexyl]cyclohexyl]methyl allyl
 ether;
 [trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]-
 methyl allyl ether;
 [trans-4-[trans-4-(1E-butenyl)cyclohexyl]cyclohexyl]methyl
 allyl ether;
 [trans-4-[trans-4-(1E-pentenyl)cyclohexyl]cyclohexyl]-
 methyl allyl ether;
 [trans-4-[trans-4-(1E-hexenyl)cyclohexyl]cyclohexyl]methyl
 allyl ether;
 [trans-4-[trans-4-(1E-heptenyl)cyclohexyl]cyclohexyl]-
 methyl allyl ether;

[trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methyl
 allyl ether;
 [trans-4-[trans-4-(3E-pentenyl)cyclohexyl]cyclohexyl]-
 methyl allyl ether;
 [trans-4-[trans-4-(3E-hexenyl)cyclohexyl]cyclohexyl]methyl
 allyl ether;
 [trans-4-[trans-4-(3E-heptenyl)cyclohexyl]cyclohexyl]-
 methyl allyl ether;
 [trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]methyl
 allyl ether;
 [trans-4-[trans-4-(4Z-hexenyl)cyclohexyl]cyclohexyl]methyl
 allyl ether;
 [trans-4-[trans-4-(4Z-heptenyl)cyclohexyl]cyclohexyl]-
 methyl allyl ether;
 [trans-4-(trans-4-methylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-(trans-4-ethylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-(trans-4-propylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-(trans-4-butylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-(trans-4-pentylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-(trans-4-hexylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-(trans-4-heptylcyclohexyl)cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-[trans-4-vinylcyclohexyl]cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]-
 methyl 2Z-butenyl ether;
 [trans-4-[trans-4-(1E-butenyl)cyclohexyl]cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-[trans-4-(1E-pentenyl)cyclohexyl]cyclohexyl]-
 methyl 2Z-butenyl ether;
 [trans-4-[trans-4-(1E-hexenyl)cyclohexyl]cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-[trans-4-(1E-heptenyl)cyclohexyl]cyclohexyl]-
 methyl 2Z-butenyl ether;
 [trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methyl
 2Z-butenyl ether;
 [trans-4-[trans-4-(3E-pentenyl)cyclohexyl]cyclohexyl]-
 methyl 2Z-butenyl ether;
 [trans-4-[trans-4-(3E-hexenyl)cyclohexyl]cyclohexyl]methyl
 2Z-butenyl ether;

[trans-4-[trans-4-(3E-heptenyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[trans-4-(4Z-hexenyl)cyclohexyl]cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[trans-4-(4Z-heptenyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-vinylcyclohexyl)ethyl]cyclohexyl]-methyl methyl ether;

[trans-4-[2-(trans-4-(1E-propenyl)cyclohexyl)ethyl]cyclohexyl]methyl methyl ether;

[trans-4-[2-(trans-4-(1E-butenyl)cyclohexyl)ethyl]cyclohexyl]methyl methyl ether;

[trans-4-[2-(trans-4-(1E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl methyl ether;

[trans-4-[2-(trans-4-(3-butenyl)cyclohexyl)ethyl]cyclohexyl]methyl methyl ether;

[trans-4-[2-(trans-4-(3E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl methyl ether;

[trans-4-[2-(trans-4-(4-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl methyl ether;

[trans-4-[2-(trans-4-vinylcyclohexyl)ethyl]cyclohexyl]-methyl ethyl ether;

[trans-4-[2-(trans-4-(1E-propenyl)cyclohexyl)ethyl]cyclohexyl]methyl ethyl ether;

[trans-4-[2-(trans-4-(1E-butenyl)cyclohexyl)ethyl]cyclohexyl]methyl ethyl ether;

[trans-4-[2-(trans-4-(1E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl ethyl ether;

[trans-4-[2-(trans-4-(3-butenyl)cyclohexyl)ethyl]cyclohexyl]methyl ethyl ether;

[trans-4-[2-(trans-4-(3E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl ethyl ether;

[trans-4-[2-(trans-4-(4-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl ethyl ether;

[trans-4-[2-(trans-4-methylcyclohexyl)ethyl]cyclohexyl]-methyl allyl ether;

[trans-4-[2-(trans-4-ethylcyclohexyl)ethyl]cyclohexyl]-methyl allyl ether;

[trans-4-[2-(trans-4-propylcyclohexyl)ethyl]cyclohexyl]-methyl allyl ether, m.p. (C-S_B) -6.5°C, cl.p. (S_B-I) 62.4°C;

[trans-4-[2-(trans-4-butylcyclohexyl)ethyl]cyclohexyl]-methyl allyl ether, m.p. (C-S_B) -4.1°C, cl.p. (S_B-I) 76.5°C;

[trans-4-[2-(trans-4-pentylcyclohexyl)ethyl]cyclohexyl]-methyl allyl ether, m.p. (C-S_B) -15.9°C, cl.p. (S_B-I) 83.6°C;

[trans-4-[2-(trans-4-vinylcyclohexyl)ethyl]cyclohexyl]-methyl allyl ether;

[trans-4-[2-(trans-4-(1E-propenyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(1E-butenyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(1E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(3-butenyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(3E-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(4-pentenyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(methoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-pentenyl ether;

[trans-4-[trans-4-(ethoxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(ethoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(ethoxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-pentenyl ether;

[trans-4-[trans-4-(propyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(propyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(butyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(butyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(pentyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(allyloxymethyl)cyclohexyl]cyclohexyl]-methyl allyl ether;

[trans-4-[trans-4-(allyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-butenyl ether;

[trans-4-[trans-4-(allyloxymethyl)cyclohexyl]cyclohexyl]-methyl 2Z-pentenyl ether;

[trans-4-[trans-4-(2Z-butenyloxymethyl)cyclohexyl]cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(methoxymethyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(methoxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(ethoxymethyl)cyclohexyl)ethyl]cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(ethoxymethyl)cyclohexyl)ethyl]cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(propyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(butyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(pentyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(allyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl allyl ether;

[trans-4-[2-(trans-4-(allyloxymethyl)cyclohexyl)ethyl]-cyclohexyl]methyl 2Z-butenyl ether;

[trans-4-[2-(trans-4-(2Z-butenyloxymethyl)cyclohexyl)-ethyl]cyclohexyl]methyl 2Z-butenyl ether.

Example 4

In order to investigate the influence of the compounds in accordance with the invention on the electro-optical properties of liquid crystalline mixtures, the following binary mixtures (BM) with 4-(trans-4-pentylcyclohexyl)benzonitrile were prepared and compared with corresponding mixtures of alkoxy- or alkenyloxy-cyclohexanes. The electro-optical data were measured at 22°C in a TN cell having a plate separation of 8 μm ; the response times were determined at the 2.5-fold value of V_{10} . The corresponding values for pure 4-(trans-4-pentylcyclohexyl)benzonitrile are: cl.p. (N-I) 54.6°C, $V_{10} = 1.62\text{V}$, $t_{on} = 30\text{ms}$, $t_{off} = 42\text{ms}$, $\Delta n = 0.120$.

BM-1

50 wt.% of [trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methyl methyl ether,

50 wt.% of 4-(trans-4-pentylcyclohexyl)benzonitrile;

cl.p. (N-I) 52.6°C, $V_{10} = 1.73\text{V}$, $t_{on} = 14\text{ms}$, $t_{off} = 29\text{ms}$, $\Delta n = 0.085$.

BM-2

50 wt.% of [trans-4-(trans-4-vinylcyclohexyl)cyclohexyl]methyl methyl ether,

50 wt.% of 4-(trans-4-pentylcyclohexyl)benzonitrile;

cl.p. (N-I) 38.3°C, $V_{10} = 1.41V$, $t_{on} = 14ms$, $t_{off} = 29ms$,

$\Delta n = 0.067$.

BM-3

50 wt.% of [trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]methyl methyl ether,

50 wt.% of 4-(trans-4-pentylcyclohexyl)benzonitrile;

cl.p. (N-I) 55.9°C, $V_{10} = 1.87V$, $t_{on} = 13ms$, $t_{off} = 25ms$, $\Delta n = 0.092$.

BM-4

50 wt.% of [trans-4-[trans-4-(4-pentenyl)cyclohexyl]cyclohexyl]methyl methyl ether,

50 wt.% of 4-(trans-4-pentylcyclohexyl)benzonitrile;

cl.p. (N-I) 42.4°C, $V_{10} = 1.41V$, $t_{on} = 20ms$, $t_{off} = 45ms$, $\Delta n = 0.074$.

Comparative mixture 1

50 wt.% of trans-4-allyloxy-1-(trans-4-ethylcyclohexyl)cyclohexane,

50 wt.% of 4-(trans-4-pentylcyclohexyl)benzonitrile;

cl.p. (N-I) 49.9°C, $V_{10} = 1.38V$, $t_{on} = 26ms$, $t_{off} = 42ms$, $\Delta n = 0.114$.

Comparative mixture 2

50 wt.% of trans-4-ethoxy-1-[trans-4-(3-butenyl)cyclohexyl]cyclohexane,

50 wt.% of 4-(trans-4-pentylcyclohexyl)benzonitrile;

cl.p. (N-I) 44.4°C, $V_{10} = 1.66V$, $t_{on} = 21ms$, $t_{off} = 31ms$, $\Delta n = 0.082$.

Example 5

The nematic mixtures of the compositions given in Tables 1 and 3 illustrate the use of the compounds in accordance with the invention in complex liquid crystal mixtures. The concentration data in Tables 1 and 3 are given in weight percent. The physical data of the mixtures are given in Tables 2 and 4. The electro-optical data were measured at 22°C in a TN cell having a plate separation of 6 μm (for mixtures M-1 to M-4 in Table 2) and 8 μm (for mixtures M-5 to M-8 in Table 4), with the response times

being determined at a voltage corresponding to the 2.5-fold value of V_{10} . M-8 is a comparative mixture to M-7 without the compound of formula I. The abbreviations used for the components in Tables 1 and 3 have the following significances:

2P(1)P2 =	5-ethyl-2-(4-ethylphenyl)pyrimidine,
0(3)P(1)P2 =	5-(3-butenyl)-2-(4-ethylphenyl)pyrimidine,
0(4)P(1)P2 =	5-(4-pentenyl)-2-(4-ethylphenyl)pyrimidine,
0(3)P(1)PF =	5-(3-butenyl)-2-(4-fluorophenyl)pyrimidine,
3CPO2 =	4-ethoxy-1-(trans-4-propylcyclohexyl)benzene,
3CP =	4-(trans-4-propylcyclohexyl)benzonitrile,
0d(1)CP =	4-(trans-4-vinylcyclohexyl)benzonitrile,
1d(1)CP =	4-[trans-4-(1E-propenyl)cyclohexyl]benzonitrile,
2d(1)CP =	4-[trans-4-(1E-butenyl)cyclohexyl]benzonitrile,
0(3)CP =	4-[trans-4-(3-butenyl)cyclohexyl]benzonitrile,
3CPS =	4-(trans-4-propylcyclohexyl)phenylisothio- cyanate,
1d(3)CCO1 =	trans-4-methoxy-1-[trans-4-(3E-pentenyl)cyclo- hexyl]cyclohexane,
0d(3)CCO2 =	trans-4-ethoxy-1-[trans-4-(3-butenyl)cyclo- hexyl]cyclohexane,
1d(3)CCO2 =	trans-4-ethoxy-1-[trans-4-(3E-pentenyl)cyclo- hexyl]cyclohexane,
0d(4)CCO2 =	trans-4-ethoxy-1-[trans-4-(4-pentenyl)cyclo- hexyl]cyclohexane,
3CAPO2 =	4-ethoxy-1-[2-(trans-4-propylcyclohexyl)ethyl]- benzene,
2CP(1)P5 =	5-(trans-4-ethylcyclohexyl)-2-(4-pentylphenyl)- pyrimidine,
1d(3)CPP2 =	4'-ethyl-4-[trans-4-(3E-pentenyl)cyclohexyl]- biphenyl,
1d(3)CPP3 =	4'-propyl-4-[trans-4-(3E-pentenyl)cyclohexyl]- biphenyl,
1d(1)CCP1 =	4-methyl-1-[trans-4-(trans-4-(1E-propenyl)- cyclohexyl)cyclohexyl]benzene,
3CCPF =	4-fluoro-1-[trans-4-(trans-4-propylcyclohexyl)- cyclohexyl]benzene,
0d(1)CCPF =	4-fluoro-1-[trans-4-(trans-4-vinylcyclohexyl)- cyclohexyl]benzene,
1d(1)CCPF =	4-fluoro-1-[trans-4-(trans-4-(1E-propenyl)- cyclohexyl)cyclohexyl]benzene,
0d(3)CCPF =	4-fluoro-1-[trans-4-(trans-4-(3-butenyl)cyclo- hexyl)cyclohexyl]benzene,
3d(1)CPC3 =	4-(trans-4-propylcyclohexyl)-1-[trans-4-(1E- pentenyl)cyclohexyl]benzene,

5CPAC4 =	4-(trans-5-pentylcyclohexyl)-1-[2-(trans-4-butylcyclohexyl)ethyl]benzene,
0d(3)CCEPF =	trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexanecarboxylic acid 4-fluorophenyl ester,
3CEPCd(3)1 =	trans-4-propylcyclohexanecarboxylic acid 4-[trans-4-(3E-pentenyl)cyclohexyl]phenyl ester,
3CPPC3 =	4,4'-bis(trans-4-propylcyclohexyl)biphenyl,
5CP(1)PC3 =	5-(trans-4-pentylcyclohexyl)-2-[4-(trans-4-propylcyclohexyl)phenyl]pyrimidine,
5CPPAC4 =	4'-(trans-4-pentylcyclohexyl)-4-[2-(trans-4-butylcyclohexyl)ethyl]biphenyl,
0d(1)CC101 =	[trans-4-(trans-4-vinylcyclohexyl)cyclohexyl]-methyl methyl ether,
1d(1)CC101 =	[trans-4-[trans-4-(1E-propenyl)cyclohexyl]cyclohexyl]methyl methyl ether,
0d(3)CC101 =	[trans-4-[trans-4-(3-butenyl)cyclohexyl]cyclohexyl]methyl methyl ether,
3CC1Od(4)0 =	[trans-4-(trans-4-propylcyclohexyl)cyclohexyl]-methyl allyl ether.

Table 1

Concentration data in wt.%

Mixture	M-1	M-2	M-3	M-4
3CP02	6%	6%	6%	-
3CP	10%	10%	10%	10%
0d(1)CP	7%	7%	7%	7%
1d(1)CP	8%	8%	8%	8%
1d(3)CC01	10%	10%	10%	10%
0d(3)CC02	10%	10%	10%	10%
0d(4)CC02	-	-	-	6%
1d(1)CCP1	-	-	-	6%
3CCPF	8%	8%	8%	-
0d(1)CCPF	-	-	-	5%
1d(1)CCPF	-	-	-	5%
3d(1)CPC3	8%	8%	8%	-
5CPAC4	8%	8%	8%	8%
3CEPCd(3)1	6%	6%	6%	6%
3CPPC3	4%	4%	4%	-
5CP(1)PC3	3%	3%	3%	3%
5CPPAC4	-	-	-	4%
0d(1)CC101	12%	-	-	-
1d(1)CC101	-	-	-	12%
0d(3)CC101	-	-	12%	-
3CC10d(4)0	-	12%	-	-

Table 2

Mixture		M-1	M-2	M-3	M-4
V ₁₀		2.15V	2.20V	2.28V	2.30V
t _{on}	(22°C)	11ms	13ms	11ms	11ms
	(-20°C)	157ms	174ms	165ms	178ms
	(-30°C)	416ms	425ms	450ms	497ms
t _{off}	(22°C)	22ms	23ms	20ms	20ms
	(-20°C)	229ms	253ms	244ms	256ms
	(-30°C)	565ms	609ms	596ms	657ms
M.p.		<-40°C	<-40°C	<-40°C	<-30°C
Cl.p. (N-I)		85°C	85°C	89°C	93°C
Δn		0.098	0.095	0.099	0.090

Table 3

Concentration data in wt.%

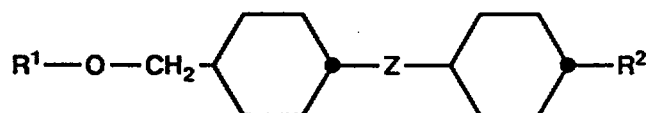
Mixture	M-5	M-6	M-7	M-8
2P(1)P2		8%	8.00%	8.00%
0d(3)P(1)P2	6%			
0d(4)P(1)P2	5%			
0d(3)P(1)PF	5%			
3CP	7%	6%	5.88%	6.44%
1d(1)CP	6%	10%	9.24%	10.12%
2d(1)CP	9%			
0d(3)CP		7%	6.72%	7.36%
3CPS	8%	9%	7.56%	8.28%
1d(3)CCO2			8.40%	9.20%
3CAPO2		7%	8.40%	9.20%
2CP(1)P5	4%			
1d(3)CPP2	5%	5%	4.20%	4.60%
1d(3)CPP3	6%	6%	5.04%	5.52%
1d(1)CCP1	6%			
1d(1)CCPF	5%	4%	3.36%	3.68%
0d(3)CCPF	5%			
0d(3)CCEPF	6%	8%	6.72%	7.36%
3CEPCd(3)1	5%	4%	4.20%	4.60%
5CPAC4		8%	7.56%	8.28%
5CP(1)PC3	2%	3%	2.52%	2.76%
5CPPAC4		5%	4.20%	4.60%
1d(1)CC101	10%	10%	8.00%	

Table 4

Mixture		M-5	M-6	M-7	M-8
V ₁₀		2.18V	2.42V	2.43V	2.4V
t _{on}	(22°C)	16ms	19ms	17ms	18ms
	(-20°C)	287ms	322ms	281ms	301ms
	(-30°C)	888ms	984ms	830ms	931ms
t _{off}	(22°C)	29ms	32ms	30ms	31ms
	(-20°C)	419ms	477ms	397ms	424ms
	(-30°C)	1270ms	1441ms	1120ms	1275ms
M.p.		<-30°C	<-30°C	<-30°C	<-30°C
Cl.p. (N-I)		91°C	96°C	89°C	93°C
Δn		0.139	0.135	0.127	0.133

Claims

1. Compounds of the general formula



wherein Z represents a single covalent bond or -CH₂-CH₂-; R¹ denotes alkyl or 2-alkenyl; and R² signifies 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl or, when R¹ denotes 2-alkenyl and Z represents -CH₂-CH₂-, also alkyl or alkoxyethyl.

2. Compounds according to claim 1, characterized in that R¹ and R² signify straight-chain residues.
3. Compounds according to claim 1 or 2, characterized in that R¹ has a maximum of 10, preferably a maximum of 5, carbon atoms.
4. Compounds according to any one of claims 1 to 3, characterized in that R² has a maximum of 12, preferably a maximum of 7, carbon atoms.

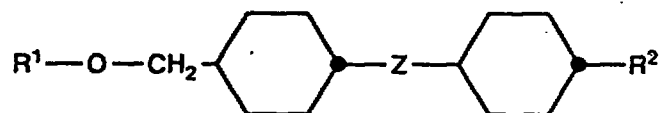


Table 4

Mixture	M-5	M-6	M-7	M-8
V ₁₀	2.18V	2.42V	2.43V	2.4V
t _{on} (22°C)	16ms	19ms	17ms	18ms
(-20°C)	287ms	322ms	281ms	301ms
(-30°C)	888ms	984ms	830ms	931ms
t _{off} (22°C)	29ms	32ms	30ms	31ms
(-20°C)	419ms	477ms	397ms	424ms
(-30°C)	1270ms	1441ms	1120ms	1275ms
M.p.	<-30°C	<-30°C	<-30°C	<-30°C
Cl.p. (N-I)	91°C	96°C	89°C	93°C
Δn	0.139	0.135	0.127	0.133

Claims

- Compounds of the general formula



wherein Z represents a single covalent bond or -CH₂-CH₂-; R¹ denotes alkyl or 2-alkenyl; and R² signifies 1E-alkenyl, 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl or, when R¹ denotes 2-alkenyl and Z represents -CH₂-CH₂-, also alkyl or alkoxyethyl.

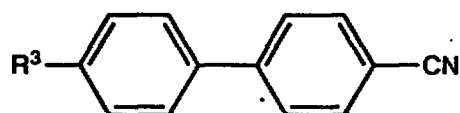
- Compounds according to claim 1, characterized in that R¹ and R² signify straight-chain residues.
- Compounds according to claim 1 or 2, characterized in that R¹ has a maximum of 10, preferably a maximum of 5, carbon atoms.
- Compounds according to any one of claims 1 to 3, characterized in that R² has a maximum of 12, preferably a maximum of 7, carbon atoms.

5. Compounds according to any one of claims 1 to 4, characterized in that R¹ stands for 2-alkenyl and/or R² stands for 1E-alkenyl, 3E-alkenyl, 4-alkenyl or (2-alkenyl)oxymethyl.

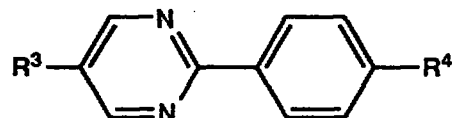
6. A liquid crystalline mixture having at least 2 components, characterized in that at least one component is a compound of formula I defined in claim 1.

7. A liquid crystalline mixture according to claim 6, characterized in that it contains one or more compounds of formula I defined in claim 1 and one or more compounds having positive dielectric anisotropy.

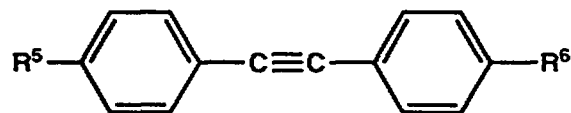
8. A liquid crystalline mixture according to claim 6 or 7, characterized in that it contains one or more compounds of formula I and one or more compounds from the group of compounds of the general formulae



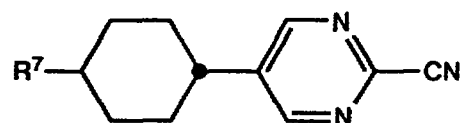
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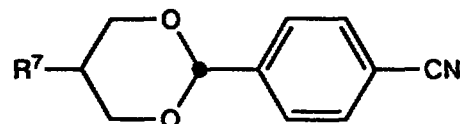
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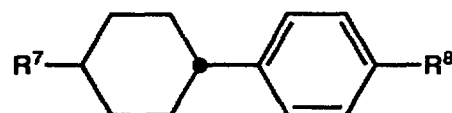
VII



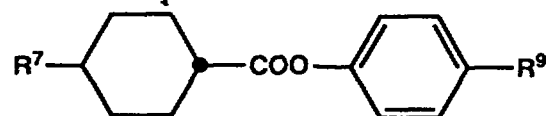
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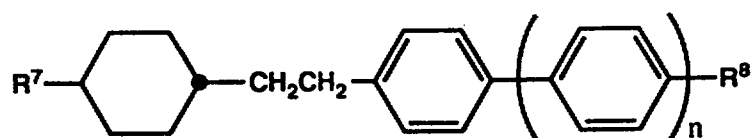
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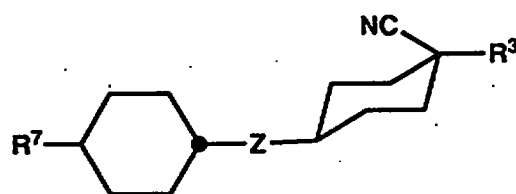
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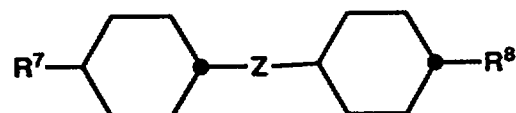
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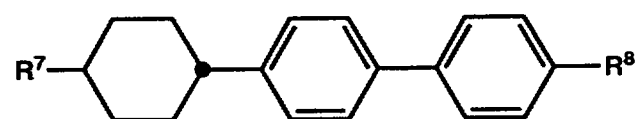
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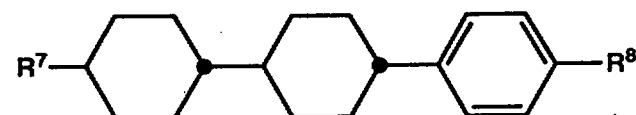
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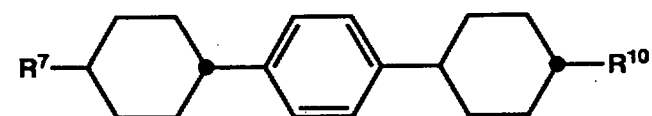
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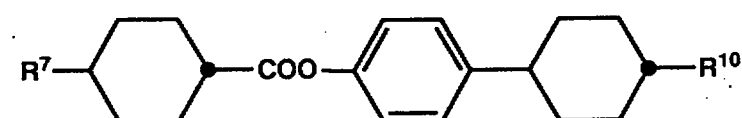
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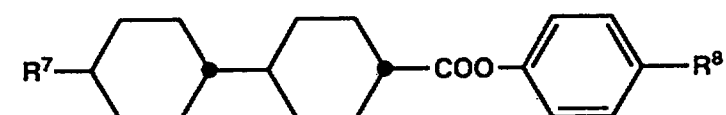
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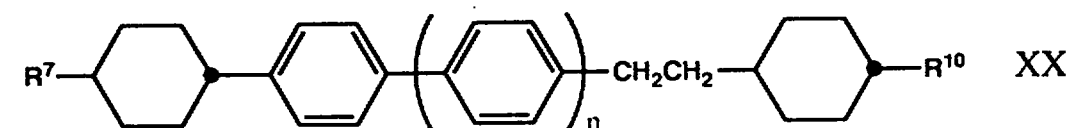
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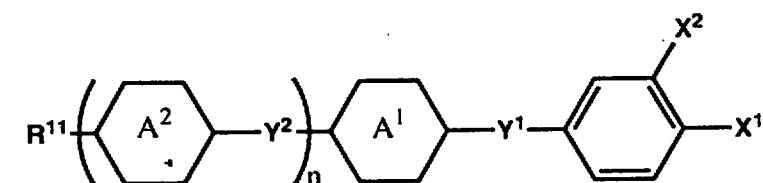
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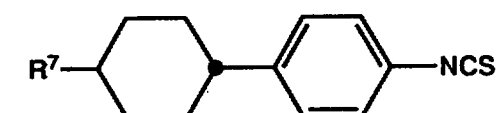
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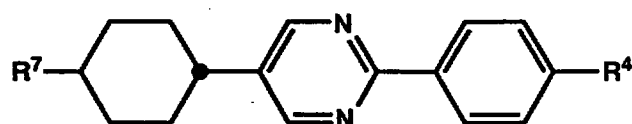
XX



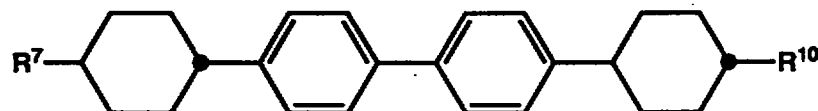
XXI



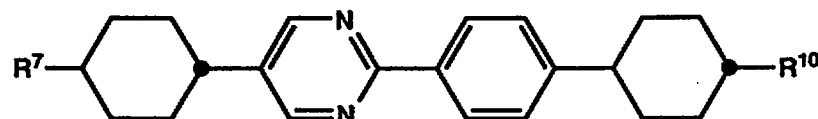
XXII



XXIII



XXIV

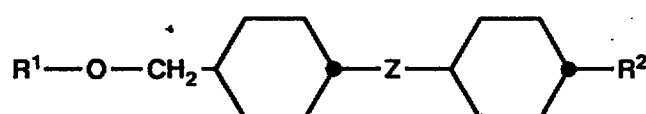


XXV

wherein R^3 signifies alkyl, 3E-alkenyl or 4-alkenyl; R^4 represents alkyl, cyano or fluorine; R^5 and R^6 denote alkyl or alkoxy; R^7 and R^{10} each independently signify alkyl, 1E-alkenyl, 3E-alkenyl or 4-alkenyl; R^8 denotes cyano, alkyl, 1E-alkenyl, 3E-alkenyl, 4-alkenyl, alkoxy, 2E-alkenyloxy or 3-alkenyloxy; R^9 signifies alkoxy, 2E-alkenyloxy or 3-alkenyloxy; n stands for the number 0 or 1; Z represents a single covalent bond or $-\text{CH}_2\text{CH}_2-$; X^1 denotes fluorine or chlorine and X^2 denotes hydrogen, fluorine or chlorine; R^{11} signifies alkyl, 3E-alkenyl, 4-alkenyl, alkoxy, 2E-alkenyloxy or 3-alkenyloxy; one of the groups Y^1 and Y^2 signifies a single covalent bond, $-\text{COO}-$, $-\text{OOC}-$, $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$ or $-\text{OCH}_2-$ and the other of the groups Y^1 and Y^2 signifies a single covalent bond; and rings A^1 and A^2 each independently represent substituted or unsubstituted trans-1,4-cyclohexylene, in which optionally 2 non-adjacent CH_2 groups are replaced by oxygen, or substituted or unsubstituted 1,4-phenylene, in which optionally 1 or 2 CH groups is/are replaced by nitrogen.

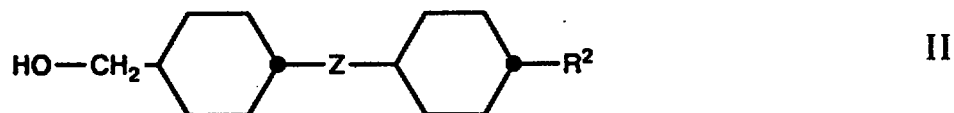
9. A liquid crystalline mixture according to any one of claims 6 to 8, characterized in that the content of compounds of formula I in the final mixture amounts to 1-70 wt.%, preferably 3-40 wt.%.

10. A process for the manufacture of the compounds of the general formula



I

wherein Z represents a single covalent bond or -CH₂-CH₂-;
 R¹ denotes alkyl or 2-alkenyl and R² signifies 1E-alkenyl,
 3E-alkenyl, 4-alkenyl, (2-alkenyl)oxymethyl or, when R¹
 denotes 2-alkenyl and/or Z represents -CH₂-CH₂-, also
 alkyl or alkoxymethyl,
 characterized by etherifying a compound of the general formula



with a compound of the general formula



wherein X denotes chlorine, bromine or iodine and R¹ and R²
 have the above significances.