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Description

The invention relates to liquid crystal phases (LC phases) having a particularly low threshold voltage and broad nematic phases.

Liquid crystal display elements (LC display elements) increasingly utilize the properties of nematic or nematic-cholesteric liquid crystal materials of significantly changing their optical properties such as light absorption, light scattering, birefringence, reflectance or colour under the influence of electric fields. The function of such display elements is based for example on the phenomena of dynamic scattering, the deformation of aligned phases, the guest-host effect, the Schadt-Helfrich effect in the twisted cell, or the cholesteric-nematic phase transition.

The industrial application of these effects in electronic components requires liquid crystal phases which must meet a large number of requirements. Of particular importance here are the chemical resistance to moisture, air and physical factors such as heat, radiation in infrared, visible and ultraviolet region and continuous and alternating electric fields. Industrially utilizable liquid crystal phases are also required to have a liquid crystal mesophase within a suitable temperature range, a very low viscosity, a relatively low optical anisotropy, a high steepness of the electro-optical characteristic and adequate dissolving power for pleochroic dyes. Finally, they must not have any self-absorption in the region of visible light, i.e. they must be colourless.

None of the hitherto disclosed series of compounds with a liquid crystal mesophase contain an individual compound which meets all these requirements. For that reason, the rule is to prepare mixtures of two to twenty-five, preferably three to fifteen, compounds in order to obtain substances which are usable as liquid crystal phases. Usually at least one compound having a low melting and clear point is additionally mixed. The result is normally a mixture whose melting point is below that of the lower-melting component, while the clear point is

between the clear points of the components. However, optimal phases cannot be easily prepared in this way, since the components having the high melting and clear points frequently also confer on the mixtures a high viscosity.

- 5 As a result the switching times of the electro-optical display elements prepared therewith are changed in an undesirable manner.

EP-A-0107759 describes liquid crystal dielectrics which, in addition to dioxane compounds (e.g. phenyl-
10 dioxanes), contain cyclohexane derivatives having 1,4-cyclohexylene group axially substituted in the 1- and/or 4-position. However, optimal phases having a low threshold voltage are not preparable in this way.

- To reduce the threshold voltage, hitherto disclosed
15 LC phases have added to them strongly polar nematic compounds having a terminal cyano group. The effective dipole moment of these compounds, however, is distinctly reduced by a more or less strong antiparallel association of these molecules, so that relatively large amounts of
20 polar compounds need to be added. This in turn gives rise to various disadvantages, such as unfavorable elastic properties of the LC phases, and high viscosity. On addition of 4-cyano-3-fluorophenyl p-alkylbenzoates as strongly polar components to ZLI-1957/5 (commercially available mixture from E. Merck, Darmstadt, containing phenylcyclo-
25 hexane, cyclohexylbiphenyl, bis-cyclohexylbiphenyl compounds and phenyl cyclohexylbenzoates), it has been possible to show (Hp. Schad and S.M. Kelly, J. Chem. Phys. 81 (3), 1514 - 15 (1984) that the threshold voltage is
30 reduced, which is explained in terms of a reduced degree of association of the added compounds. However, even these LC phases do not meet all the abovementioned requirements at the same time. In particular, for many applications their threshold voltages are still too high, and, in
35 addition, the steepnesses of the characteristic are not sufficient for highly informative displays owing to the relatively large ratio of the elastic constants for bending (K_3) and spreading (K_1) K_3/K_1 . The hitherto disclosed mixtures therefore have an excessively high threshold

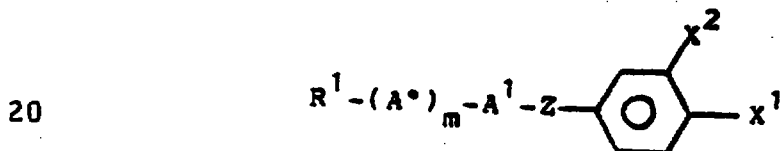
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voltage and/or an unacceptably poor steepness of characteristic (characterized by an excessively high K_3/K_1).

There is thus still a great need for liquid crystal phases having high clear points, low melting points, a low viscosity (and hence short switching times) and a low threshold voltage, which at the same time have favorable elastic properties.

The invention has for its object to prepare liquid crystal phases which have a nematic phase within the required temperature range and are completely or almost completely free from the abovementioned disadvantages.

It has now been found that the liquid crystal phases having particularly favorable combinations of material properties, in particular wide mesophase ranges, and extraordinarily low threshold voltage and favorable elastic properties are obtained when they contain at least one component of the formula I



in which R^1

is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups,

25

A^0 and A^1

are each, independently of each other, Cy, Dio, Pyr or Phe,

Z

is $-\text{CO}-\text{O}-$, $-\text{O}-\text{CO}-$, $-\text{CH}_2-\text{O}-$, $-\text{O}-\text{CH}_2-$ or a single bond,

30

X^1

is F, Cl, $-\text{CN}$ or $-\text{NCS}$,

X^2

is F, Cl and in the case of $X^1 = \text{NCS}$ also H,

m

is 0 or 1,

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Cy

is trans-1,4-cyclohexylene,

Pyr

is pyrimidine-2,5-diyl or pyridine-2,5-diyl,

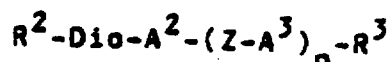
Dio

is trans-1,3-dioxane-2,5-diyl and

Phe

is 1,4-phenylene,

and at least one component of the formula II contains (sic)



- 5 in which R^2 is alkyl of 1 to 12 C atoms, in which
in addition one or two non-adjacent
CH₂ groups can be
replaced by O atoms, -CO-, -O-CO-,
-CO-O- and/or -CH=CH- groups,
10 R^3 is alkyl of 1 to 12 C atoms, in
which in addition one or two non-
adjacent CH₂ groups can be replaced
by O atoms, -CO-, -O-CO-, -CO-O-
and/or -CH=CH- groups, or is F, Cl
or CN,
15 A^2 and A^3 are each Phe or Cy,
 n is 0, 1 or 2 and
Z, Dio, Phe and Cy have the abovementioned meanings.

The invention thus provides the above-described
liquid crystal phases which may also contain one or more
20 pleochroic dyes (guest-host systems), and the use of these
phases in liquid crystal display elements.

The invention further provides liquid crystal display
elements, in particular electro-optical display elements
which contain such phases.

25 The guest-host systems according to the invention
generally contain 0.1 to 15, preferably 0.5 to 10, in particular
1 to 7, percent by weight of pleochroic dyes.

The pleochroic dyes of the guest-host system according
to the invention are preferably chosen in such a way
30 that they cover a suitable part of the visible spectrum and
that the absorption in this range is more or less constant.

The preparation of the guest-host systems according
to the invention is effected in conventional manner.
In general, the desired amounts of the various pleochroic
35 dyes are dissolved in the host material, preferably at
elevated temperature.

However, it is also possible to mix solutions of
the pleochroic dye and of the host material in a suitable
organic solvent, for example acetone, chloroform or

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methanol, and to remove the solvent after thorough mixing, for example by distillation under reduced pressure. It is self-evident that with this method it is necessary to ensure that the solvent does not introduce any contaminants or undesirable dopants.

The individual compounds of the formula I and II of the liquid crystal phases according to the invention are either known or preparable by methods which are easily derivable by those skilled in the art from the prior art, since they are based on standard methods described in the literature.

Corresponding compounds of the formula I are described for example in German Patent Applications P 34 05 914 and P 35 15 633; in European Patent Specification 0,019,665; in S.M. Kelly and Hp. Schad, Helvetica Chimica Acta, 67, 1580-1587 (1984); in S.M. Kelly, ibid 67, 1572-1579 (1984); in Japanese Offenlegungsschrift 59-191,789 and European Offenlegungsschriften 0,099,099 and 0,119,756. Compounds of the formula II are described for example in German Offenlegungsschriften 29 44 905, 31 12 185, 31 46 249, 31 50 761 31 50 763, 32 07 114, 32 27 916, 33 02 218, 33 34 054, in European Offenlegungsschrift 0,122,389, in U.S. Patent 4,322,354 and in Japanese Offenlegungsschrift 56-164,179.

It was found, surprisingly, that the combination according to the invention of compounds of the formulae I and II gives LC phases which on the one hand have wide mesophase ranges with low melting points and low smectic-nematic transition temperatures and on the other are characterized, combined with remarkably low threshold voltages, by favorable ratios of the elastic constants for bending (K_3) and spreading (K_1).

The LC phases according to the invention preferably contain at least two components, in particular at least three components, of the formula I and at least two components, in particular at least four components, of the formula II.

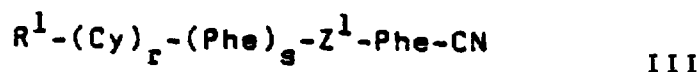
The total proportion of the compounds of the formulae I and II in the LC phases according to the invention

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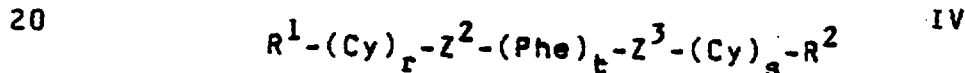
is preferably more than 50%, in particular more than 58%. Particularly preferably the LC phases according to the invention have a total proportion of compounds of the formulae I and II of 80 to 100%.

5 The proportion of the compounds of the formula I is preferably 13 to 79%, particularly preferably 18 to 55%. The proportion of the compound of the formula II is preferably 29 to 69%, particularly preferably 32 to 59%.

10 Suitable further components of the LC phases according to the invention, in addition to compounds of the formulae I and II, are compounds of the formula III



in which r is 0, 1 or 2,
 15 s is 0 or 1,
 $r + s$ is 1 or 2,
 Z^1 is $-CO-O-$ or a single bond,
 and R^1 , Cy and Phe have the abovementioned meanings,
 and/or compounds of the formula IV



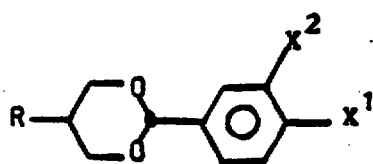
in which t is 0, 1 or 2,
 $r + s + t$ is 2, 3 or 4,
 Z^2 and Z^3 are each $-CO-O-$, $-O-CO-$, $-CH_2CH_2-$
 25 or a single bond

and R^1 , R^2 , Cy , Phe , r and s have the abovementioned meanings. Preferably the phases according to the invention contain at least one compound of the formula III or IV. Particular preference is given to LC phases which
 30 simultaneously contain at least one compound each of the formula III and IV.

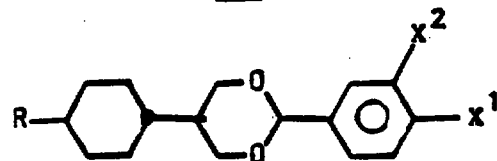
Preferred compounds of the formula I are those of the partial formulae Ia to Is:

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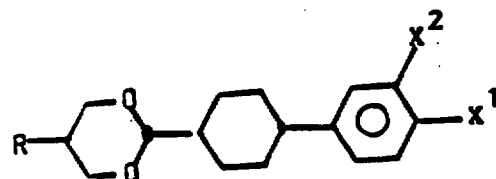
Ia



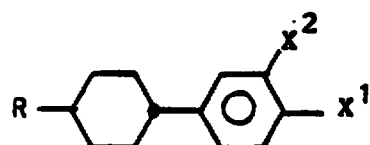
Ib



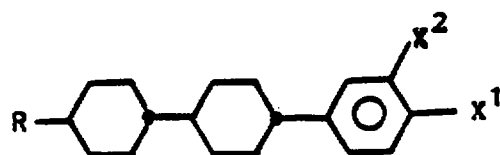
Ic



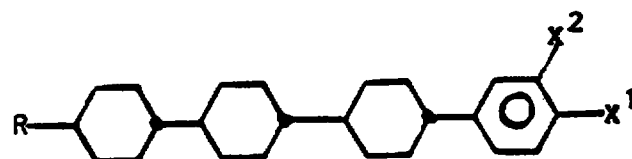
Id



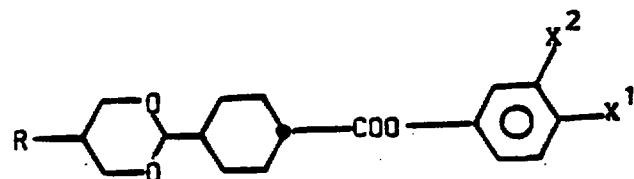
Ie



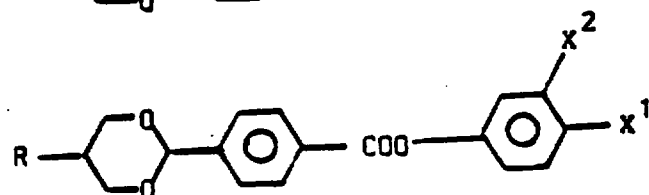
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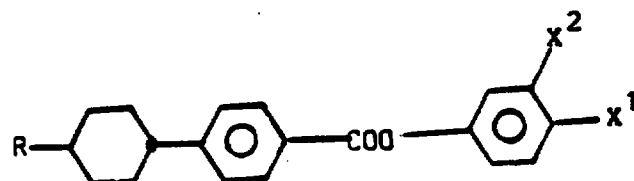
Ig



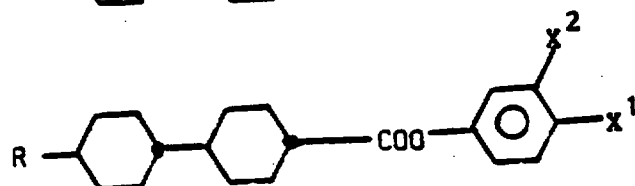
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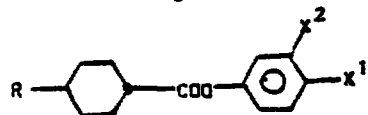
Ii



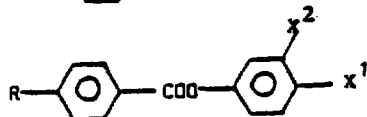
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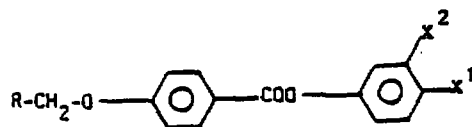
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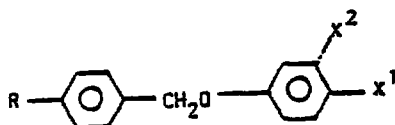
Ik



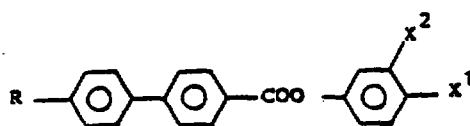
Il



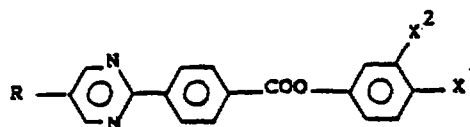
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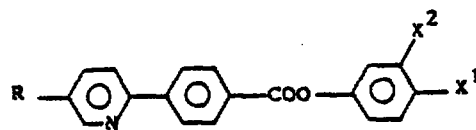
In



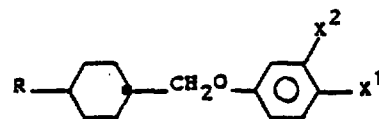
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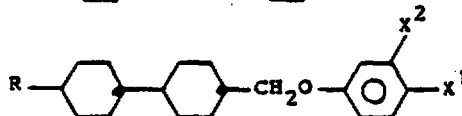
Ip



Iq

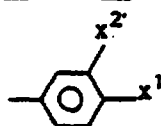


Ir

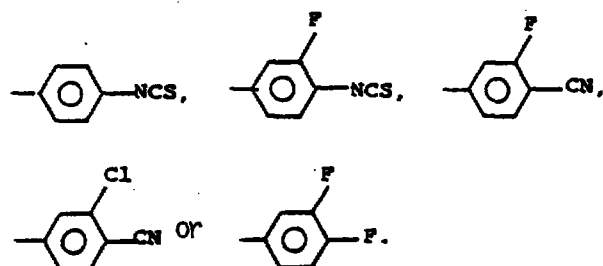


Is

The group



is preferably



R^1 is preferably straight-chain alkyl of 2 to 7 C atoms. Z is in the case of compounds of the formula I preferably -CO-O-, CH₂-O- or a single bond. X^2 is preferably fluorine.

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Of the foregoing partial formulae, those of the formulae Ia, Ib, Ic, Id, Ie, Ig, Ih, Ii, Ij, Ik, Il, Im, Io, Ip, Ir and Is are preferred. Particular preference is given to those of the partial formulae Ia-Ic, Ig, Ih, Im and Ip.

Preferred compounds of the formula II are those of the partial formulae IIa to IIac:

R-Dio-Phe-CN	IIa
R-Dio-Phe-R	IIb
R-Dio-Phe-OCH ₂ R	IIc
R-Dio-Phe-OCOCH ₂ R	IIId
R-Dio-Cy-R	IIe
R-Dio-Cy-OCH ₂ R	IIIf
R-Dio-Cy-CN	IIg
R-Dio-Cy-COOCH ₂ R	IIh
RCH ₂ O-Dio-Cy-R	IIi
R-Dio-Cy-COO-Cy-R	IIj
R-Dio-Phe-COO-Phe-CN	IIk
R-Dio-Phe-COO-Phe-R	IIl
R-Dio-Phe-COO-Phe-OCH ₂ R	IIIm
R-Dio-Phe-COO-Cy-R	IIIn
R-Dio-Cy-COO-Phe-CN	IIo
R-Dio-Phe-Cy-R	IIp
R-Dio-Cy-Cy-R	IIq
R-Dio-Phe-Phe-Cy-R	IIr
R-Dio-Cy-Phe-CN	IIs
R-Dio-Cy-Phe-R	IIIt
R-Dio-Cy-Phe-OCH ₂ R	IIu
R-Phe-OCO-Dio-R	IIv
R-CH ₂ O-Phe-OCO-Dio-R	IIw
NC-Phe-OCO-Dio-R	IIx

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NC-Phe-OCO-Dio-Phe-R	IIy
NC-Phe-OCO-Dio-Phe-OCH ₂ R	IIz
R-Cy-OCO-Dio-R	IIaa
R-Cy-Cy-OCO-Dio-R	IIab
R-Cy-Ph-OCO-Dio-R	IIac

Of the foregoing partial formulae, those of the formulae IIa, IIb, IIc, IId, IIe, IIf, IIg, IIj, IIk, III, IIm and IIr are preferred. Particular preference is given to those of the partial formulae IIa, IIb, IIc, IId, 5 IIe, IIf, IIg and III.
m is preferably 0 or 1.

Z is in the case of compounds of the formula II preferably a single bond. R² is preferably straight-chain alkyl of 2 to 7 C atoms. R³ is preferably straight-chain 10 alkyl or alkoxy of 2 to 7 C atoms in each case, or is F, Cl or CN, particularly preferably CN.

Preferred compounds of the formula III are those of the partial formulae IIIa to IIIh:

R-Phe-Phe-CN	IIIa
RCH ₂ O-Phe-Phe-CN	IIIb
R-Cy-Phe-CN	IIIc
R-Cy-Phe-Phe-CN	IIId
R-Cy-Cy-Phe-CN	IIIe
R-Phe-COO-Phe-CN	IIIf
R-Cy-COO-Phe-CN	IIIg
R-Cy-Phe-COO-Phe-CN	IIIh

Preferred compounds of the formula IV are those 15 of the partial formulae IVa to IVj:

(401)

R-Cy-Ph-R	IVa
R-Cy-Ph-OCH ₂ R	IVb
R-Cy-Ph-Ph-R	IVc
R-Cy-Ph-Ph-OCH ₂ R	IVd
R-Cy-Ph- $\overset{\text{F}}{\text{C}}\text{-Ph-R}$	IVe
R-Cy-Ph-Ph-Cy-R	IVf
R-Cy-Ph- $\overset{\text{F}}{\text{C}}\text{-Ph-Cy-R}$	IVg
R-Cy-Cy-COO-Cy-R	IVh
R-Cy-Cy-CH ₂ CH ₂ -Cy-R	IVi
R-Cy-Ph-Ph-CH ₂ CH ₂ -Cy-R	IVj

Of the foregoing partial formulae those of the formulae IVb, IVe, IVf, IVg, IVh and IVi are preferred. Particular preference is given to those of the partial formulae IVe, IVf, IVg, IVh and IVi.

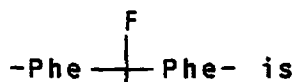
5 In the case of the compounds of the foregoing partial formulae, R is a straight-chain alkyl group, preferably of 1 to 7 C atoms, in which in addition a CH₂ group can also be replaced by -O- or -CH=CH-. Particularly preferred groups R are methyl, ethyl, n-propyl, n-butyl, n-
10 pentyl and n-heptyl.

In the case of compounds of the foregoing partial formulae with two groups R, both groups R each have independently of each other one of the abovementioned meanings.

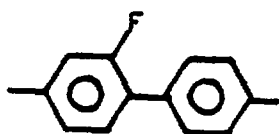
When the alkyl groups contain 3 or more carbon
15 atoms, these can be arranged in a straight or branched chain. However, the phases according to the invention did not use any components which contain more than one branched alkyl group. Such branched alkyl groups for the purposes of the present invention contain not more than
20 one chain branching; preferably this is a methyl or ethyl group in the 1- or 2-position of carbon skeleton, so that suitable branched alkyl groups are in particular: 2-methylpropyl, 2-methylbutyl, 1-methylpentyl, 2-methylpentyl, 1-methylhexyl. Generally the liquid crystal di-
25 electrics according to the invention contain only one

component having a branched-chain alkyl radical in order to induce, if desired, optical activity. For this purpose, normally not more than 10 percent by weight, preferably 0.5 to 3 percent by weight, of a component having a
5 branched alkyl radical are added.

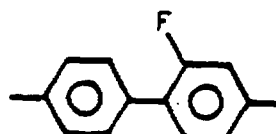
In the compounds of the foregoing partial formulae,



10



or



The LC phases according to the invention preferably do not contain compounds of the formulae III and IV at the
15 same time.

Preferred phases according to the invention contain compounds of the formula III in which R^2 is n-alkyl and R^3 is n-alkyl, n-alkoxy or n-alkanoyloxy and/or compounds of the formula I in which A^1 is Dio. R^1 and R^2
20 are preferably n-alkyl or n-alkoxy of in each case 2 to 7 C atoms. R^3 is preferably n-alkyl, n-alkoxy, n-alkanoyloxy of in each case 2 to 7 C atoms, or CN. Particularly preferably R^2 is n-alkyl and R^3 n-alkoxy.

The preparation of the phases according to the invention is effected in the conventional manner. In general,
25 the desired amount of the components which is used in the smaller amount is dissolved in the components which constitutes the main constituent, preferably at elevated temperature. If this temperature is chosen to be above the clear
30 point of the main constituent, the completeness of the process of dissolving can be observed particularly easily.

However, it is also possible to mix solutions of the components in a suitable organic solvent, for example acetone, chloroform or methanol, and to remove the solvent
35 after thorough mixing, for example by distillation under reduced pressure. It is self-evident that with this method it must be ensured that the solvent does not introduce any contaminants or undesirable dopants.

By means of suitable additives the liquid crystal

(C3)

phases according to the invention can be modified in such a way that they can be used in any hitherto disclosed kind of liquid crystal display element.

Such additives are known to those skilled in the art and are exhaustively described in the literature. It is possible to add for example conducting salts, preferably ethyldimethyldodecylammonium 4-hexyloxybenzoate, tetrabutylammonium tetraphenylboranate or complex salts of crown ethers (cf. for example I. Haller et al., Mol. Cryst. Liq. Cryst. volume 24, pages 249 - 258, (1973)) for improving the conductivity or substances for modifying the dielectric anisotropy, the viscosity and/or the orientation of the nematic phases. Such substances are described for example in German Offenlegungsschriften 22 09 127, 22 40 864, 23 21 632, 23 38 281, 24 50 088, 26 37 430, 28 53 728 and 29 02 177.

The examples below serve to illustrate the invention. In the examples, the melting point and clear point of a liquid crystal substance are given in degrees Celsius. The percentages are by weight. The values of the threshold voltages relate to an angle of observation of 0°, 10% contrast and 20°C.

Example 1

A liquid crystal phase consisting of

25 7 % of trans-4-propylcyclohexyl trans,trans-4-butylcyclohexylcyclohexane-4'-carboxylate,

7 % of trans-4-pentylcyclohexyl trans,trans-4-butylcyclohexylcyclohexane-4'-carboxylate,

7 % of trans-4-propylcyclohexyl trans,trans-4-propylcyclohexylcyclohexane-4'-carboxylate,

30 7 % of trans-4-pentylcyclohexyl trans,trans-4-propylcyclohexylcyclohexane-4'-carboxylate,

19 % of trans-4-(trans-5-propyl-1,3-dioxan-2-yl)-cyclohexanecarbonitrile,

35 20 % of trans-4-(trans-5-butyl-1,3-dioxan-2-yl)-cyclohexanecarbonitrile,

17 % of trans-4-(trans-5-pentyl-1,3-dioxan-2-yl)-cyclohexanecarbonitrile,

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7 % of 4-cyano-3-fluorophenyl p-ethylbenzoate and
9 % of 4-cyano-3-fluorophenyl p-propylbenzoate
has a threshold voltage of 1.2 volt.

Example 2

- 5 An LC phase consisting of
- 12 % of trans-4-(trans-5-propyl-1,3-dioxan-2-yl)-cyclo-
hexanecarbonitrile,
- 12 % of trans-4-(trans-5-pentyl-1,3-dioxan-2-yl)-cyclo-
hexanecarbonitrile,
- 10 22 % of trans-4-(trans-5-ethyl-1,3-dioxan-2-yl)-1-pentyl-
cyclohexane,
- 23 % of trans-4-(trans-5-propyl-1,3-dioxan-2-yl)-1-propyl-
cyclohexane
- 6 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluorobiphenyl,
- 15 6 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-2-fluoro-
biphenyl,
- 6 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-2-fluoro-biphenyl,
- 6 % of 4-cyano-3-fluorophenyl p-ethylbenzoate and
- 20 7 % of 4-cyano-3-fluorophenyl p-propylbenzoate
has a threshold voltage of 1.3 volt.

Example 3

- An LC phase consisting of
- 7 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-
25 biphenyl,
- 7 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-2-fluoro-
biphenyl,
- 7 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-2-fluoro-biphenyl,
- 30 10 % of 4-ethyl-2'-fluoro-4'-(trans-4-pentylcyclohexyl)-
biphenyl,
- 18 % of trans-4-(trans-5-propyl-1,3-dioxan-2-yl)-1-ethoxy-
cyclohexane,
- 18 % of trans-4-(trans-5-propyl-1,3-dioxan-2-yl)-1-butoxy-
35 cyclohexane,
- 7 % of 2-p-butyryloxyphenyl-5-propyl-1,3-dioxane,
- 12 % of 2-p-butyryloxyphenyl-5-pentyl-1,3-dioxane,
- 5 % of 4-cyano-3-fluorophenyl p-trans-4-propylcyclohexyl-
benzoate,

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4 % of 4-cyano-3-fluorophenyl p-ethylbenzoate and
5 % of 4-cyano-3-fluorophenyl p-propylbenzoate
has a melting point of -11° and a clear point of 85° .

Example 4

- 5 An LC phase consisting of
- 12 % of p-propylphenyl p-(trans-5-propyl-1,3-dioxan-2-yl)-benzoate,
- 10 % of p-pentylphenyl p-(trans-5-propyl-1,3-dioxan-2-yl)-benzoate,
- 10 12 % of p-pentylphenyl p-(trans-5-pentyl-1,3-dioxan-2-yl)-benzoate,
- 11 % of p-propylphenyl p-(trans-5-pentyl-1,3-dioxan-2-yl)-benzoate,
- 6 % of 4-cyano-3-(fluorophenyl p-ethylbenzoate,
- 15 8 % of 4-cyano-3-fluorophenyl p-propylbenzoate,
- 9 % of 4-cyano-3-fluorophenyl p-butylbenzoate,
- 12 % of 4-cyano-3-fluorophenyl p-pentylbenzoate,
- 11 % of 4-cyano-3-fluorophenyl p-hexylbenzoate and
- 9 % of 4-cyano-3-fluorophenyl p-heptylbenzoate
- 20 has a threshold voltage of 1.3 volt.

Example 5

- An LC phase consisting of
- 11 % of 2-p-ethoxyphenyl-5-propyl-1,3-dioxane,
- 7 % of 2-p-butoxyphenyl-5-propyl-1,3-dioxane,
- 25 8 % of 2-p-butoxyphenyl-5-pentyl-1,3-dioxane,
- 5 % of 2-p-hexylphenyl-5-propyl-1,3-dioxane,
- 9 % of 2-p-hexylphenyl-5-pentyl-1,3-dioxane,
- 7 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-biphenyl,
- 30 7 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-2-fluoro-biphenyl
- 7 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluoro-biphenyl,
- 11 % of propyl trans-4-(trans-5-propyl-1,3-dioxan-2-yl)-cyclohexanecarboxylate,
- 35 7 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
- 9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
- 12 % of 4-cyano-3-fluorophenyl p-pentylbenzoate
- has a threshold voltage of 1.4 volt.

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Example 6

An LC phase consisting of

- 13 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane
- 19 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
- 5 13 % of 4-ethyl-4'-cyanobiphenyl,
- 22 % of 4-butyl-4'-cyanobiphenyl,
- 8 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
- 3 % of p-cyanophenyl p-(trans-4-ethylcyclohexyl)-benzoate,
- 4 % of p-cyanophenyl p-(trans-4-pentylcyclohexyl)-benzoate,
- 10 8 % of 4-cyano-3-fluorophenyl p-(trans-4-propylcyclohexyl)-benzoate,
- 5 % of 4-cyano-3-fluorophenyl p-ethylbenzoate and
- 5 % of 4-cyano-3-fluorophenyl p-propylbenzoate

has a threshold voltage of 1.00 volt, an optical anisotropy of 0.17, a smectic/nematic phase transition $> -20^{\circ}$, a melting point of -6° and a clear point of 62° .

Example 7

An LC phase consisting of

- 14 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
- 20 18 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
- 11 % of 4-ethyl-4'-cyanobiphenyl,
- 19 % of 4-butyl-4'-cyanobiphenyl,
- 6 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
- 3 % of p-cyanophenyl p-(trans-4-ethylcyclohexyl)-benzoate,
- 25 3 % of p-cyanophenyl p-(trans-4-pentylcyclohexyl)-benzoate,
- 11 % of 4-cyano-3-fluorophenyl p-(trans-4-propylcyclohexyl)-benzoate,
- 7 % of 4-cyano-3-fluorophenyl p-ethylbenzoate and
- 8 % of 4-cyano-3-fluorophenyl p-propylbenzoate

30 has a threshold voltage of 0.93 volt, an optical anisotropy of 0.17, a smectic/nematic phase transition $< -20^{\circ}$, a melting point of -5° and a clear point of 61° .

Example 8

An LC phase consisting of

- 35 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
- 12 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
- 17 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
- 6 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-biphenyl,

- 6 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-2-fluoro-biphenyl,
6 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-cyclohexyl)-2-fluoro-biphenyl,
5 15 % of 4-(trans-4-propylcyclohexyl)-2-fluorobenzonitrile,
10 % of 4-(trans-4-butylcyclohexyl)-2-fluorobenzonitrile
and
20 % of 4-(trans-4-pentylcyclohexyl)-2-fluorobenzonitrile
has a threshold voltage of 1.3 volt.

10 Example 9

- An LC phase consisting of
14 % of 2-p-butoxyphenyl-5-propyl-1,3-dioxane,
15 % of 2-p-butoxyphenyl-5-pentyl-1,3-dioxane
18 % of 4-(trans-4-propylcyclohexyl)-2-fluorobenzonitrile,
15 15 % of 4-(trans-4-butylcyclohexyl)-2-fluorobenzonitrile,
27 % of 4-(trans-4-pentylcyclohexyl)-2-fluorobenzonitrile
and
11 % of trans-4-(trans-4-pentylcyclohexyl)-1-(4-cyano-3-fluorophenyl)-cyclohexane
20 has a threshold voltage of 1.2 volt.

Example 10

- An LC phase consisting of
19 % of p-trans-4-propylcyclohexyl-benzonitrile,
15 % of 2-p-butoxyphenyl-5-propyl-1,3-dioxane,
25 15 % of 2-p-butoxyphenyl-5-pentyl-1,3-dioxane,
11 % of p-propylphenyl p-(5-propyl-1,3-dioxan-2-yl)-benzoate,
9 % of p-pentylphenyl p-(5-propyl-1,3-dioxan-2-yl)-benzoate,
30 9 % of p-propylphenyl p-(5-pentyl-1,3-dioxan-2-yl)-benzoate,
11 % of 2-(4-cyano-3-fluorophenyl)-5-propyl-1,3-dioxane
and
11 % of 2-(4-cyano-3-fluorophenyl)-5-pentyl-1,3-dioxane.
35 has a threshold voltage of 1.4 volt.

Example 11

- An LC phase consisting of
20 % of p-trans-4-propylcyclohexylbenzonitrile,



- 12 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
14 % of 2-p-butoxyphenyl-5-propyl-1,3-dioxane,
13 % of 2-p-butoxyphenyl-5-pentyl-1,3-dioxane,
17 % of 4-(trans-4-propylcyclohexyl)-2-fluorobenzonitrile,
5 8 % of 2-(4-cyano-3-fluorophenyl)-5-propyl-1,3-dioxane,
9 % of 2-(4-cyano-3-fluorophenyl)-5-(trans-4-propylcyclohexyl)-1,3-dioxane and
7 % of 2-(4-cyano-3-fluorophenyl)-5-(trans-4-pentylcyclohexyl)-1,3-dioxane
10 has a threshold voltage of 1.2 volt.

Example 12

An LC phase consisting of

- 13.5 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
24.3 % of trans-1-p-ethylphenyl-4-propylcyclohexane,
15 9.0 % of trans-1-p-ethoxyphenyl-4-propylcyclohexane,
6.3 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
8.1 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl,
7.2 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl,
9.0 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl
20 cyclohexyl)-biphenyl,
7.2 % of p-propylphenyl p-trans-4-propylcyclohexylbenzoate,
5.4 % of p-propylphenyl p-trans-4-pentylcyclohexylbenzoate
and
10.0 % of 4-cyano-3-fluorophenyl p-propylbenzoate
25 has a clear point of 77°, no smectic phase up to -20°, a
viscosity of 23 (72; 383) mPa.s at 20° (0°; -20°) and
a threshold voltage of 1.8 volt.

Example 13

A liquid crystal phase consisting of

- 30 18 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
24 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
30 % of 4-(trans-4-propylcyclohexyl)-phenyl isothiocyanate,
10 % of 4-(trans-4-pentylcyclohexyl)-phenyl isothiocyanate,
7 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
35 7 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate
and
4 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-biphenyl

has a clear point of 64° , a viscosity of 28 mPa.s at 20° , an optical anisotropy of 0.14 and a threshold voltage of 1.5 volt (2nd minimum according to Gooch-Tarry).

Example 14

- 5 A liquid crystal phase consisting of
- 15 % of 2-(trans-4-cyanocyclohexyl)-5-propyl-1,3-dioxane
- 18 % of 2-(trans-4-cyanocyclohexyl)-5-pentyl-1,3-dioxane
- 12 % of 2-(trans-4-cyanocyclohexyl)-5-heptyl-1,3-dioxane
- 21 % of 4-(trans-5-pentyl-1,3-dioxan-2-yl)-phenylisothio-
- 10 cyanate,
- 6 % of 4-(trans-5-heptyl-1,3-dioxan-2-yl)-phenylisothio-
- cyanate,
- 11 % of p-propylphenyl p-trans-4-propylcyclohexylbenzoate,
- 7 % of p-pentylphenyl p-trans-4-propylcyclohexylbenzoate
- 15 and
- 10 % of p-propylphenyl p-trans-4-propylcyclohexylbenzoate
- has a melting point of 75° , a viscosity of 36 mPa.s at
- 20° , an optical anisotropy of 0.11 and a threshold volt-
- age of 1.5 volt (1st minimum according to Gooch-Tarry).

20 Example 15

- A liquid crystal phase consisting of
- 19 % of 4-(trans-5-pentyl-1,3-dioxan-2-yl)-phenyl isothio-
- cyanate,
- 25 % of 4-(trans-5-heptyl-1,3-dioxan-2-yl)-phenyl isothio-
- 25 cyanate,
- 4 % of 4-(trans-4-pentylcyclohexyl)-phenyl isothiocyanate,
- 22 % of 4-(trans-4-propylcyclohexyl)-phenyl isothiocyanate,
- 9 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
- 9 % of 2-p-cyanophenyl-5-pentyl-1,3-dioxane,
- 30 5 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl and
- 7 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
- cyclohexyl)-biphenyl
- has a clear point of 63° , a viscosity of 23 mPa.s at 20° ,
- an optical anisotropy of 0.17 and a threshold voltage of
- 35 1.4 volt (2nd minimum).

Example 16

- A liquid crystal phase consisting of
- 12 % of 2-(trans-4-cyanocyclohexyl)-5-butyl-1,3-dioxane,

- 8 % of 2-(trans-4-cyanocyclohexyl)-5-pentyl-1,3-dioxane,
6 % of 2-(p-cyanophenyl)-5-butyl-1,3-dioxane,
5 % of 2-(p-cyanophenyl)-5-pentyl-1,3-dioxane,
11 % of 2-(trans-4-pentylcyclohexyl)-5-ethyl-1,3-dioxane,
5 12 % of 4-(trans-4-propylcyclohexyl)-phenyl isothiocyanate,
10 % of 4-(trans-5-pentyl-1,3-dioxan-2-yl)-phenyl iso-
thiocyanate,
10 % of p-trans-4-propylcyclohexylbenzonitrile,
10 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl,
10 8 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl,
3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl and
5 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-biphenyl
has a clear point of 74° , a viscosity of 23 mPa.s at 20° ,
15 an optical anisotropy of 0.12 and a threshold voltage of
1.7 volt (2nd minimum).

Example 17

- A liquid crystal phase consisting of
10 % of p-trans-4-ethylcyclohexylbenzonitrile,
20 17 % of p-trans-4-propylcyclohexylbenzonitrile,
9 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
6 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
5 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
7 % of 4-cyano-3-fluorophenyl p-propylbenzoate,
25 4 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
4 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
14 % of trans,trans-4-propoxy-4'-propylcyclohexylcyclo-
hexane,
4 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl,
30 3 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl,
3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl,
4 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-biphenyl,
5 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-
35 biphenyl and
5 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-2-fluorobiphenyl

has a clear point of 84° and no smectic phase up to -30° .
Example 18

A liquid crystal phase consisting of

- 10 % of p-trans-4-ethylcyclohexylbenzonitrile,
- 5 17 % of p-trans-4-propylcyclohexylbenzonitrile,
- 9 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
- 6 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
- 5 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
- 7 % of 4-cyano-3-fluorophenyl p-propylbenzoate,
- 10 4 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
- 4 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
- 14 % of trans,trans-4-propoxy-4'-propylcyclohexylcyclohexane,
- 5 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl,
- 15 4 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl,
- 3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl,
- 4 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl,
- 4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluorobiphenyl and
- 20 4 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluorobiphenyl

has a clear point of 83° , no smectic phase up to -30° and a threshold voltage of 1.36 volt.

25 Example 19

A liquid crystal phase consisting of

- 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
- 16 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
- 18 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
- 30 8 % of 4-ethyl-4'-cyanobiphenyl,
- 9 % of 4-butyl-4'-cyanobiphenyl,
- 6 % of 4-p-cyanophenyl-4'-pentylbiphenyl,
- 5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
- 6 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
- 35 8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
- 9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
- 7 % of 4-cyano-3-fluorophenyl p-(5-heptylpyrimidin-2-yl)-benzoate

has a clear point of 64° , no smectic phase up to -20° and a threshold voltage of 0.92 volt.

Example 20

- A liquid crystal phase consisting of
- 5 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
 - 16 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
 - 18 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
 - 8 % of 4-ethyl-4'-cyanobiphenyl,
 - 9 % of 4-butyl-4'-cyanobiphenyl,
 - 10 7 % of 4-p-cyanophenyl-4'-pentylbiphenyl,
 - 5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
 - 7 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
 - 8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
 - 9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
 - 15 5 % of 4-cyano-3-fluorophenyl p-(5-heptylpyrimidin-2-yl)-benzoate

has a clear point of 65° , no smectic phase up to -20° and a threshold voltage of 0.91 volt.

Example 21

- A liquid crystal phase consisting of
- 20 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
 - 16 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
 - 18 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
 - 8 % of 4-ethyl-4'-cyanobiphenyl,
 - 25 9 % of 4-butyl-4'-cyanobiphenyl,
 - 7 % of 4-p-cyanophenyl-4'-pentylbiphenyl,
 - 5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
 - 7 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
 - 8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
 - 30 9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
 - 5 % of 4-cyano-3-fluorophenyl p-(trans-5-pentyl-1,3-dioxan-2-yl)-benzoate

has a clear point of 65° , no smectic phase up to -20° and a threshold voltage of 0.91 volt.

35 Example 22

- A liquid crystal phase consisting of
- 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
 - 16 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,

(53)

- 18 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
8 % of 4-ethyl-4'-cyanobiphenyl,
9 % of 4-butyl-4'-cyanobiphenyl,
6 % of 4-p-cyanophenyl-4'-pentylbiphenyl,
5 5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
5 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate
9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
8 % of 4-cyano-3-fluorophenyl p-(trans-5-pentyl-1,3-
10 dioxan-2-yl)-benzoate
has a clear point of 64° , no smectic phase up to -20°
and a threshold voltage of 0.86 volt.

Example 23

- A liquid crystal phase consisting of
15 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
15 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
16 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
8 % of 4-ethyl-4'-cyanobiphenyl,
9 % of 4-butyl-4'-cyanobiphenyl,
20 6 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
6 % of 4-p-cyanophenyl-4'-pentylbiphenyl,
5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
5 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
25 9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
5 % of 4-cyano-3-fluorophenyl p-(trans-5-pentyl-1,3-
dioxan-2-yl)-benzoate
has a clear point of 71° , no smectic phase up to -20°
and a threshold voltage of 0.95 volt.

30 Example 24

- A liquid crystal phase consisting of
8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
15 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
16 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
35 8 % of 4-ethyl-4'-cyanobiphenyl,
9 % of 4-butyl-4'-cyanobiphenyl,
6 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
6 % of 4-p-cyanophenyl-4'-pentylbiphenyl,

- 5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
5 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
9 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
5 5 % of 4-cyano-3-fluorophenyl p-hexyloxybenzoate
has a clear point of 65° , no smectic phase up to -20°
and a threshold voltage of 0.90 volt.

Example 25

- A liquid crystal phase consisting of
10 8 % of 2-p-cyanophenyl-5-ethyl-1,3-dioxane,
15 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
15 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
10 % of 4-ethyl-4'-cyanobiphenyl,
12 % of 4-butyl-4'-cyanobiphenyl,
15 7 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
6 % of 4-p-cyanophenyl-4'-pentylbiphenyl,
5 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
5 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
8 % of 4-cyano-3-fluorophenyl p-ethylbenzoate and
20 9 % of 4-cyano-3-fluorophenyl p-propylbenzoate
has a clear point of 65° , no smectic phase up to -20°
and a threshold voltage of 0.98 volt.

Example 26

- A liquid crystal phase consisting of
25 14 % of 2-p-cyanophenyl-5-propyl-1,3-dioxane,
18 % of 2-p-cyanophenyl-5-butyl-1,3-dioxane,
11 % of 4-ethyl-4'-cyanobiphenyl,
19 % of 4-butyl-4'-cyanobiphenyl,
6 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl,
30 3 % of p-cyanophenyl p-trans-4-ethylcyclohexylbenzoate,
3 % of p-cyanophenyl p-trans-4-pentylcyclohexylbenzoate,
7 % of 4-cyano-3-fluorophenyl p-ethylbenzoate,
8 % of 4-cyano-3-fluorophenyl p-propylbenzoate and
11 % of 4-cyano-3-fluorophenyl p-(trans-4-propylcyclohexyl)-
35 benzoate
has a clear point of 61° , no smectic phase up to -20°
and a threshold voltage of 0.93 volt.

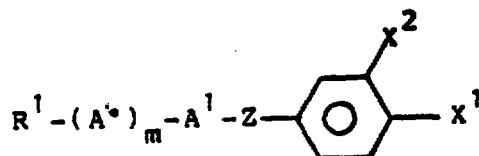
- 25 -

All the LC phases indicated in Examples 1 to 26 have favorable mesophase ranges and advantageous elastic properties.



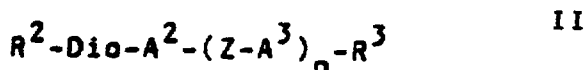
Claims:

1. Liquid crystal phase, characterized in that it contains at least one component of the formula I



- in which R^1 is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups,
- A^0 and A^1 are each, independently of each other, Cy, Dio, Pyr or Phe,
- Z is $-\text{CO}-\text{O}-$, $-\text{O}-\text{CO}-$, $\text{CH}_2-\text{O}-$, $-\text{O}-\text{CH}_2-$ or a single bond,
- X^1 is F, Cl, $-\text{CN}$ or $-\text{NCS}$,
- X^2 is F, Cl and in the case of $X^1 = \text{NCS}$ also H,
- m is 0 or 1,
- Cy is trans-1,4-cyclohexylene,
- Pyr is pyrimidine-2,5-diyl or pyridine-2,5-diyl,
- Dio is trans-1,3-dioxane-2,5-diyl and
- Phe is 1,4-phenylene,

and at least one component of the formula II



- in which R^2 is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups,
- R^3 is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups, or is F, Cl

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A^2 and A^3
n

or CN,
are each Phe or Cy,
is 0, 1 or 2 and

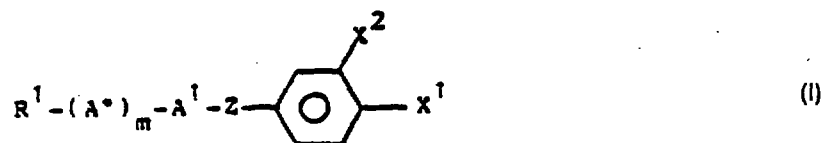
Z, Dio, Phe and Cy have the abovementioned meanings.

2. Use of liquid crystal phases according to Claim 1,
for electro-optical display elements.

3. Electro-optical display element, characterized in
that it contains a phase according to Claim 1.

Claims

1. Liquid crystal phase, characterized in that it contains at least one one component of the formula I



in which

R^1 is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups,

A^0 and A^1 are each, independently of each other, Cy, Dio, Pyr or Phe,

Z is $-\text{CO}-\text{O}-$, $-\text{O}-\text{CO}-$, $\text{CH}_2-\text{O}-$, $-\text{O}-\text{CH}_2-$ or a single bond,

X^1 is F, Cl, $-\text{CN}$ or $-\text{NCS}$,

X^2 is F, Cl and in the case of $X^1 = \text{NCS}$ also H,

m is 0 or 1,

Cy is trans-1,4-cyclohexylene,

Pyr is pyrimidine-2,5-diyl or pyridine-2,5-diyl,

Dio is trans-1,3-dioxane-2,5-diyl and

Phe is 1,4-phenylene,

and at least one component of the formula II



in which

R^2 is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups,

R^3 is alkyl of 1 to 12 C atoms, in which in addition one or two non-adjacent CH_2 groups can be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}-$ groups, or is F, Cl or CN,

A^2 and A^3 are each Phe or Cy,

n is 0, 1 or 2 and

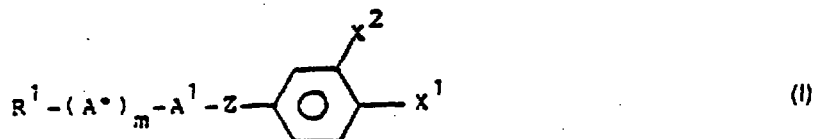
Z, Dio, Phe and Cy have the abovementioned meanings.

2. Use of liquid crystal phases according to Claim 1, for electro-optical display elements.

3. Electro-optical display element, characterized in that it contains a phase according to Claim 1.

Revendications

1. Phase à cristaux liquides caractérisée en ce qu'elle contient au moins un composant de formule I.



dans laquelle

R^1 représente un groupe alkyle en C1-C12 dans lequel un ou deux groupes CH_2 non voisins peuvent également être remplacés par des atomes d'oxygène, des groupes $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ et/ou $-\text{CH}=\text{CH}-$,

A^0 et A^1 représentent chacun, indépendamment l'un de l'autre, Cy, Dio, Pyr ou Phe,

Z représente $-\text{CO}-\text{O}-$, $-\text{O}-\text{CO}-$, $-\text{CH}_2-\text{O}-$, $-\text{O}-\text{CH}_2-$ ou une liaison simple,

X^1 représente F, Cl, $-\text{CN}$ ou $-\text{NCS}$,

X^2 représente F, Cl ou également, lorsque $X^1 = \text{NCS}$, H,

m est égal à 0 ou 1,

Cy représente un groupe trans-1,4-cyclohexylène,

Pyr représente un groupe pyrimidine-2,5-diyle ou pyridine-2,5-diyle,

Dio représente un groupe trans-1,3-dioxane-2,5-diyle et

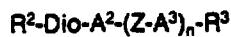
Phe représente un groupe 1,4-phénylène,

et au moins un composant de formule II



as printed

(II)



dans laquelle

R^2 représente un groupe alkyle en C1-C12 dans lequel un ou deux groupes CH_2 non voisins peuvent également être remplacés par des atomes d'oxygène, des groupes —CO— , —O—CO— , —CO—O— et/ou —CH=CH— ,

R^3 représente un groupe alkyle en C1-C12 dans lequel un ou deux groupes CH_2 non voisins peuvent également être remplacés par des atomes d'oxygène, des groupes —CO— , —O—CO— , —CO—O— et/ou —CH=CH— , ou bien F, Cl ou CN,

A^2 et A^3 représentent chacun Phe ou Cy,

n est égal à 0, 1 ou 2, et

Z, Dio, Phe et Cy ont les significations indiquées ci-dessus.

2. Utilisation de phases à cristaux liquides selon la revendication 1 pour des éléments d'affichage électro-optiques.

3. Élément d'affichage électro-optique caractérisé en ce qu'il contient une phase selon la revendication 1.

