

Description

The invention relates to a liquid crystal display element (LC display element) having a low multiplex ratio and low operating voltage.

5 For LC display elements, the properties of nematic or nematic-cholesteric liquid crystal materials are utilized to modify their optical properties, such as absorption of light, light scattering, birefringence, reflectance or colour, under the influence of electrical fields. Func-
10 tioning of such display elements is based here, for example, on the phenomenon 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.

15 LC phases which must meet a number of requirements are required for technical use of these effects in electronic components. Mechanical stability towards moisture, air and physical influences, such as heat, radiation in the infrared, visible and ultraviolet range and constant and
20 alternating electrical fields, are particularly important here. Technically usable LC phases are also required to have a liquid crystal mesophase in a suitable temperature range, a low viscosity, a low optical anisotropy, a high gradient of the electrooptical characteristic line and an
25 adequate dissolving power for pleochroic dyestuffs.

In none of the series of compounds so far known with a liquid crystal mesophase is there a single compound which meets all these requirements. Mixtures of two to 25, preferably three to 18, compounds are therefore prepared
30 in order to obtain substances which can be used as LC phases. However, optimum phases cannot easily be prepared in this manner, since components with high melting and clearing points frequently also impart to the mixtures a high viscosity. The switching times of the electrooptical
35 display elements produced with these components are thereby modified in an undesirable manner.

There is therefore still a great need for LC phases with a wider operating temperature range, a low viscosity (and therefore short switching times) and a low threshold voltage.

5 Most LC display elements produced today are addressed in multiplex operation with multiplex ratios of about 1:2 to 1:4 and with operating voltages of about 3 volts. The operating temperature range of such display elements is in general between about -10 and +50°.

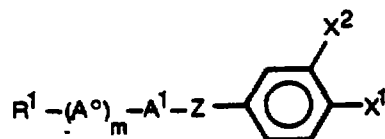
10 However, a wider operating temperature range is desirable for outdoor applications, for example including those in cars.

The invention is based on the object of providing LC display elements which have a wide operating temperature range and display the abovementioned disadvantages to
15 only a small extent, if at all.

It has been found that this object can be achieved if liquid crystal dielectrics which have operating temperature ranges of between -30 and +80°C and viscosities of
20 less than 40 mPa.s at 20° are used in these display elements.

The invention relates to LC display element with static or multiplex drive, having a low multiplex ratio and an operating voltage below 3.3 volts, containing a liquid
25 crystal dielectric, characterized in that the operating temperature range extends from -30°C to +80°C, the viscosity of the dielectric at 20°C is less than 40 mPa.s and the dielectric contains at least one component of the formula I:

30



I

wherein R^1 is alkyl of 1 to 12 C atoms, wherein one or two non-adjacent CH_2 groups can also be replaced by O atoms, $-CO-$, $-O-CO-$, $-CO-O-$ and/or $-CH=CH-$ groups,

5 A^0 and A^1 each independently of one another are Cy, Dio or Phe,

Z is $-CO-O-$, $-O-CO-$, $-CH_2-O-$, $-O-CH_2-$ or a single bond,

X_1 is F, Cl or $-CN$,

10 X^2 is F or Cl,

m is 0 or 1,

Cy is trans-1,4-cyclohexylene,

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

Phe is 1,4-phenylene which is unsubstituted or substituted by fluorine, with the proviso

15 that the dielectric does not contain any component of the formula II



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

R^3 is alkyl of 1 to 12 C atoms, in which one or two non-adjacent CH_2 groups can also be

25 replaced by O atoms, $-CO-$, $-O-CO-$, $-CO-O-$ and/or $-CH=CH$ groups, F, Cl or CN, A^2 and A^3 are each 1,4-phenylene or Cy,

n is 0, 1 or 2 and

Z , Dio and Cy have the meanings given.

30 In EP-A-0,168,012, liquid-crystalline compositions having C-N transitions of $0^\circ C$ or below and N-I transitions between 59.5 and $66.1^\circ C$ and the corresponding operating temperature ranges are described. In WO-A -8,603,769, liquid-crystalline phases are given which contain not

35 only compounds of the formula I but also compounds of the formula II.

In WO-A -8,605,799, liquid crystal phases are described which contain compounds of a definite formula which overlaps with the present formula I; however, it contains no reference to the 3-X²-4-X¹-phenyl group which is present in the compound of the formula I as a requirement. The two last-mentioned publications were only published after the present priority date.

Preferred compounds of the formula I correspond to the following subformulae (wherein FCP is the 3-fluoro-4-cyanophenyl radical):

R ¹ -Phe-COO-FCP	Ia
R ¹ -Cy-Phe-COO-FCP	Ib
R ¹ -Dio-Phe-COO-FCP	Ic

Other preferred compounds correspond to the following subformulae:

R ¹ -Cy-FCP	Ic
R ¹ -Dio-FCP	Id
R ¹ -Phe-FCP	Ie
R ¹ -Cy-Dio-FCP	If
R ¹ -Dio-Cy-FCP	Ig
R ¹ -Cy-Cy-FCP	Ih
R ¹ -Cy-Phe-FCP	Ii
R ¹ -Phe-Cy-FCP	Ij
R ¹ -Phe-Dio-FCP	Ik
R ¹ -Dio-Phe-FCP	Il
R ¹ -Cy-COO-FCP	Im
R ¹ -Dio-COO-FCP	In
R ¹ -Dio-Cy-COO-FCP	Io
R ¹ -Cy-Cy-COO-FCP	Ip
R ¹ -Phe-CH ₂ O-FCP	Iq

The radical R¹ is preferably straight-chain alkyl of 1-9 C atoms, such as methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl or nonyl, or furthermore straight-chain alkoxy of 1-9 C atoms, with (sic) methoxy, ethoxy,

propoxy, butoxy, pentoxy, hexoxy, heptoxy, octoxy or nonoxy, or furthermore alkoxyalkyl of 2-9 C atoms such methoxymethyl or ethoxymethyl.

5 Phe is preferably an unsubstituted 1,4-phenylene group, or furthermore preferably a 2-fluoro-1,4-phenylene group.

The individual compounds of the formula I which can be used in the LC display elements according to the invention are known or can be prepared analogously to known compounds.

10 Preferred dielectrics which can be used according to the invention contain, for example, over 7-20% of I. They contain in total preferably 10-20, in particular 12-18 components.

15 The operating temperature range of these dielectrics is between -30 and +80°, preferably between -40 and +85°. Their viscosity at 20° is less than 40, preferably less than 30 mPa.s and their threshold voltage is preferably not more than 1.7, in particular not more than 1.5 volts.

20 The dielectrics which can be used according to the invention are prepared in a manner which is customary per se. As a rule, the desired amount of the components used in the smaller amount is dissolved in the component which makes up the main constituent, advantageously at elevated temperature. It is also possible for solutions of the
25 components in an organic solvent, for example in acetone, chloroform or methanol, to be mixed and, after thorough mixings for the solvent to be removed again, for example by distillation.

30 The dielectrics can also contain other additives which are known to the expert and are described in the literature. For example, 0-15% of pleochroic dyestuffs can be added, as well as conductive salts, preferably ethyldimethyldodecylammonium 4-hexoxybenzoate,

5 tetrabutylammonium tetraphenylboranate or complex salts of crown ethers (compare, for example, 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 2,209,127, 2,240,864, 2,321,632, 2,338,281, 2,450,088, 2,637,430 and 2,853,728.

10 The following examples are intended to illustrate the invention without limiting it.

The symbols have the following meanings:

S-N Smectic-nematic phase transition temperature,
c.p. Clearing point,
15 visc. Viscosity at 20° (mPa.s),
t.v. Threshold voltage of a TN cell at 20°, observation angle 0° (perpendicular) and 10% contrast.

All the temperatures above and below are given in °C. The percentage figures are percentages by weight.

20 Example 1

A mixture of

5	% of p-trans-4-ethylcyclohexyl-benzonitrile
12	% of p-trans-4-propylcyclohexyl-benzonitrile
8	% of p-trans-4-butylcyclohexyl-benzonitrile
25 10	% of p-trans-4-pentylcyclohexyl-benzonitrile
6	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
8	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
5	% of 3-fluoro-4-cyanophenyl p-(trans-5-pentyl-1,3-dioxan-2-yl)-benzoate
30 16	% of trans,trans-4-propylcyclohexyl-4'-propoxycyclohexane
9	% of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
8	% of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
3	% of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
35 3	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-

propylcyclohexyl)-biphenyl

3 % of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl and

4 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl

exhibits an S-N of less than -30° , a c.p. of $+87^{\circ}$, a visc. of 27 and a t.v. of 1.4 V.

Example 2

A mixture of

- | | | |
|----|----|--|
| 10 | 15 | % of p-trans-4-propylcyclohexyl-benzonitrile |
| | 6 | % of 3-fluoro-4-cyanophenyl p-ethylbenzoate |
| | 8 | % of 3-fluoro-4-cyanophenyl p-propylbenzoate |
| | 5 | % of 3-fluoro-4-cyanophenyl p-(trans-5-pentyl-1,3-dioxan-2-yl)-benzoate |
| 15 | 13 | % of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane |
| | 13 | % of trans,trans-4-methoxy-4'-pentylcyclohexyl-cyclohexane |
| | 12 | % of trans,trans-4-ethoxy-4'-pentylcyclohexyl-cyclohexane |
| 20 | 4 | % of trans-4-propylcyclohexyl trans,trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate |
| | 4 | % of trans-4-pentylcyclohexyl trans,trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate |
| 25 | 4 | % of trans-4-propylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate |
| | 4 | % of trans-4-pentylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate |
| | 3 | % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl |
| 30 | 3 | % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl |
| | 3 | % of 2-fluoro-4,4'-(trans-4-propylcyclohexyl)-biphenyl |
| | 3 | % of trans-4-propylcyclohexyl-2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-biphenyl |
| 35 | | |

exhibits an S-N of less than -30° , a c.p. of $+89^{\circ}$, a visc. of 25 and a t.v. of 1.4 V.

Example 3

A mixture of

- 15 % of p-trans-4-propylcyclohexyl-benzonitrile
6 % of trans-1-p-ethoxyphenyl-4-propylcyclohexane
5 3.6 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
4.8 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
5 % of 3-fluoro-4-cyanophenyl p-(trans-5-pentyl-1,3-dioxan-2-yl)-benzoate
10 13.8 % of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
13.4 % of trans,trans-4-methoxy-4'-pentylcyclohexyl-cyclohexane
12.4 % of trans,trans-4-ethoxy-4'-pentylcyclohexyl-cyclohexane
15 2.4 % of trans-4-propylcyclohexyl trans,trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate
2.4 % of trans-4-pentylcyclohexyl trans,trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate
2.4 % of trans-4-propylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate
20 2.4 % of trans-4-pentylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate
3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
4.2 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
25 1.6 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-biphenyl
3.4 % of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
4.2 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
30 exhibits an S-N of less than -40°, a c.p. of +90°, a visc. of 21 and a t.v. of 1.6 V.

Example 4

A mixture of

- 35 5 % of p-trans-4-ethylcyclohexyl-benzonitrile
17 % of p-trans-4-propylcyclohexyl-benzonitrile
8 % of p-trans-4-butylcyclohexyl-benzonitrile
10 % of p-trans-4-pentylcyclohexyl-benzonitrile

- 3 % of 4-ethyl-4'-cyanobiphenyl
6 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
8 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
5 % of 4-cyano-4'-(trans-4-pentylcyclohexyl)-biphenyl
5 9 % of trans-1-p-ethoxyphenyl-4-propylcyclohexane
11 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
9 % 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
10 3 % of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
4 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
15 exhibits an S-N of less than -30° , a c.p. of $+95^{\circ}$, a visc. of 28 and a t.v. of 1.5 V.

Example 5

A mixture of

- 10 % of p-trans-4-ethylcyclohexyl-benzonitrile
20 18 % of p-trans-4-propylcyclohexyl-benzonitrile
10 % of p-trans-4-pentylcyclohexyl-benzonitrile
5 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
7 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
13 % of trans-1-p-ethoxyphenyl-4-propylcyclohexane
25 9 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
8 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
5 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
30 4 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-biphenyl
3 % of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
4 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
35 exhibits an S-N of less than -30° , a c.p. of $+95^{\circ}$, a visc. of 25 and a t.v. of 1.7 V.

Example 6

A mixture of

	6	% of p-trans-4-ethylcyclohexyl-benzonitrile
	16	% of p-trans-4-propylcyclohexyl-benzonitrile
5	4	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
	4	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
	6	% of 3-fluoro-4-cyanophenyl p-pentylbenzoate
	3	% of p-cyanophenyl p-ethylbenzoate
	2	% of p-cyanophenyl p-pentylbenzoate
10	11	% of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
	10	% of trans,trans-4-methoxy-4'-pentylcyclohexyl-cyclohexane
	10	% of trans,trans-4-ethoxy-4'-pentylcyclohexyl-cyclohexane
15	4	% of trans-4-propylcyclohexyl trans,trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate
	4	% of trans-4-pentylcyclohexyl trans,trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate
20	4	% of trans-4-propylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate
	3	% of trans-4-pentylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate
	4	% of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
25	5	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
	4	% of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
30	exhibits an S-N of less than -40° , a c.p. of $+89^{\circ}$, a visc. of 25 and a t.v. of 1.3 V.	

Example 7

A mixture of

	5	% of p-trans-4-ethylcyclohexyl-benzonitrile
	12	% of p-trans-4-propylcyclohexyl-benzonitrile
35	8	% of p-trans-4-butylcyclohexyl-benzonitrile
	10	% of p-trans-4-pentylcyclohexyl-benzonitrile
	6	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
	8	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
	5	% of 3-fluoro-4-cyanophenyl p-(trans-4-pentylcyclo-

hexyl)-benzoate

- 16 % of trans,trans-4-propylcyclohexyl-4'-propoxy-cyclohexane
- 5 9 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
- 8 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
- 3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 3 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
- 10 3 % of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 4 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
- exhibits an S-N of less than -30° , a c.p. of $+89^{\circ}$, a visc. of 26 and a t.v. of 1.4 V.

15 Example 8

A mixture of

- 15 % of p-trans-4-propylcyclohexyl-benzonitrile
- 6 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
- 8 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
- 20 5 % of o-fluoro-p-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-ethylbenzonitrile
- 13 % of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
- 13 % of trans,trans-4-methoxy-4'-pentylcyclohexyl-cyclohexane
- 25 12 % of trans,trans-4-ethoxy-4'-pentylcyclohexyl-cyclohexane
- 4 % of trans-4-propylcyclohexyl trans-trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate
- 30 4 % of trans-4-pentylcyclohexyl trans,-trans-4-propyl-cyclohexyl-cyclohexane-4'-carboxylate
- 4 % of trans-4-propylcyclohexyl trans,trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate
- 4 % of trans-4-pentylcyclohexyl trans-trans-4-butyl-cyclohexyl-cyclohexane-4'-carboxylate
- 35 3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 3 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl

- 3 % of 2-fluoro-4,4'-(trans-4-propylcyclohexyl)-
biphenyl
- 3 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-
(trans-4-propylcyclohexyl)-biphenyl
- 5 exhibits an S-N of less than -30° , a c.p. of $+84^{\circ}$, a
visc. of 23 and a t.v. of 1.5 V.

Example 9

A mixture of

- 15 % of p-trans-4-propylcyclohexyl-benzonitrile
- 10 6 % of trans-1-p-ethoxyphenyl-4-propylcyclohexane
- 3.6 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
- 4.8 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
- 5 % of o-fluoro-p-[trans-4-(trans-4-propylcyclohexyl)-
cyclohexyl]-benzonitrile
- 15 13.8 % of trans,trans-4-propyl-4'-propoxycyclohexyl-
cyclohexane
- 13.4 % of trans,trans-4-methoxy-4'-pentylcyclohexyl-
cyclohexane
- 12.4 % of trans,trans-4-ethoxy-4'-pentylcyclohexyl-
cyclohexane
- 20 2.4 % of trans-4-propylcyclohexyl trans,trans-4-propyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 2.4 % of trans-4-pentylcyclohexyl trans,trans-4-propyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 25 2.4 % of trans-4-propylcyclohexyl trans,trans-4-butyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 2.4 % of trans-4-pentylcyclohexyl trans,trans-4-butyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 3 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 30 4.2 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-
propylcyclohexyl)-biphenyl
- 1.6 % of 4,4'-bis-(trans-4-pentylcyclohexyl)-biphenyl
- 3.4 % of 2-fluoro-4,4'- bis (trans-4-propylcyclohexyl)-
biphenyl
- 35 4.2 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-
(trans-4-propylcyclohexyl)-biphenyl
- exhibits an S-N of less than -40° , a c.p. of $+88^{\circ}$, a
visc. of 19 and a t.v. of 1.7 V.

Example 10

A mixture of

	5	% of p-trans-4-ethylcyclohexyl-benzonitrile
	17	% of p-trans-4-propylcyclohexyl-benzonitrile
5	8	% of p-trans-4-butylcyclohexyl-benzonitrile
	10	% of p-trans-4-pentylcyclohexyl-benzonitrile
	3	% of 4-ethyl-4'-cyanobiphenyl
	6	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
	8	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
10	5	% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-ethyl-isothiocyanatobenzene
	9	% of trans-1-p-ethoxyphenyl-4-propylcyclohexane
	11	% of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
	9	% of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
15	3	% of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
	4	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
	3	% of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
20	4	% of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl

exhibits an S-N of less than -30° , a c.p. of $+91^{\circ}$, a visc. of 25 and a t.v. of 1.55 V.

Example 11

25 A mixture of

	10	% of p-trans-4-ethylcyclohexyl-benzonitrile
	18	% of p-trans-4-propylcyclohexyl-benzonitrile
	10	% of p-[trans-4-(trans-4-propylcyclohexyl)-cyclohexyl]-isothiocyanatobenzene
30	5	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
	7	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
	13	% of trans-1-p-ethoxyphenyl-4-propylcyclohexane
	9	% of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
	8	% of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
35	4	% of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
	5	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
	4	% of 4,4'-bis-(trans-4-pentylcyclohexyl)-biphenyl

- 3 % of 2-fluoro-4,4'-bis-(trans-4-propylcyclohexyl)-
biphenyl
- 4 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-
(trans-4-propylcyclohexyl)-biphenyl
- 5 exhibits an S-N of less than -30° , a c.p. of $+102^{\circ}$, a
visc. of 26 and a t.v. of 1.8 V.

Example 12

A mixture of

- 6 % of p-trans-4-ethylcyclohexyl-benzonitrile
- 10 16 % of p-trans-4-propylcyclohexyl-benzonitrile
- 4 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
- 4 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
- 6 % of 3-fluoro-4-cyanophenyl p-pentylbenzoate
- 15 5 % of p-[trans-4-(5-hexenyl)-cyclohexyl]-isothio-
cyanatobenzene
- 11 % of trans,trans-4-propyl-4'-propoxycyclohexyl-
cyclohexane
- 10 % of trans,trans-4-methoxy-4'-pentylcyclohexyl-
cyclohexane
- 20 10 % of trans,trans-4-ethoxy-4'-pentylcyclohexyl-
cyclohexane
- 4 % of trans-4-propylcyclohexyl trans,trans-4-propyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 4 % of trans-4-pentylcyclohexyl trans,trans-4-propyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 25 4 % of trans-4-propylcyclohexyl trans,trans-4-butyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 3 % of trans-4-pentylcyclohexyl trans,trans-4-butyl-
cyclohexyl-cyclohexane-4'-carboxylate
- 30 4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 5 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-
propylcyclohexyl)-biphenyl
- 4 % of 2-fluoro-4-(trans-4-pentylcyclohexyl)-4'-
(trans-4-propylcyclohexyl)-biphenyl
- 35 exhibits an S-N of less than -40° , a c.p. of $+91^{\circ}$, a
visc. of 23 and a t.v. of 1.4 V.

Example 13

A mixture of

	4	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
	4	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
5	8	% of 3-fluoro-4-cyanophenyl p-pentylbenzoate
	6	% of 3-fluoro-4-cyanophenyl p-heptylbenzoate
	5	% of 3-fluoro-4-cyanophenyl p-(trans-4-propylcyclohexyl)-benzoate
10	5	% of 3-fluoro-4-cyanophenyl p-(trans-4-butylcyclohexyl)-benzoate
	4	% of 3-fluoro-4-cyanophenyl p-(trans-4-pentylcyclohexyl)-benzoate
	19	% of trans-1-p-methoxyphenyl-4-propylcyclohexane
	17	% of trans-1-p-methoxyphenyl-4-pentylcyclohexane
15	7	% of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
	4	% of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
	4	% of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
20	4	% of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluorobiphenyl
	5	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
	4	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluorobiphenyl
25	exhibits an S-N of less than -40°, a c.p. of +85°, a visc. of 30 and a t.v. of 1.4 V.	

Example 14

A mixture of

	4	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
30	6	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
	12	% of 3-fluoro-4-cyanophenyl p-pentylbenzoate
	6	% of 3-fluoro-4-cyanophenyl p-heptylbenzoate
	5	% of 3-fluoro-4-cyanophenyl p-(trans-4-propylcyclohexyl)-benzoate
35	7	% of 3-fluoro-4-cyanophenyl p-(trans-4-butylcyclohexyl)-benzoate
	4	% of 3-fluoro-4-cyanophenyl p-(trans-4-pentylcyclohexyl)-benzoate

- 18 % of trans-1-p-methoxyphenyl-4-propylcyclohexane
- 14 % of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
- 4 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
- 5 3 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
- 4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-biphenyl
- 5 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-cyclohexyl)-biphenyl
- 10 4 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluorobiphenyl
- exhibits an S-N of less than -30° , a c.p. of $+94^{\circ}$, a visc. of 38 and a t.v. of 1.2 V.

15 Example 15

A mixture of

- 3 % of 3-fluoro-4-cyanophenyl p-ethylbenzoate
- 4 % of 3-fluoro-4-cyanophenyl p-propylbenzoate
- 10 % of 3-fluoro-4-cyanophenyl p-pentylbenzoate
- 20 5 % of 3-fluoro-4-cyanophenyl p-heptylbenzoate
- 5 % of 3-fluoro-4-cyanophenyl p-(trans-4-propylcyclohexyl)-benzoate
- 6 % of 3-fluoro-4-cyanophenyl p-(trans-4-butylcyclohexyl)-benzoate
- 25 4 % of 3-fluoro-4-cyanophenyl p-(trans-4-pentylcyclohexyl)-benzoate
- 24 % of trans-1-p-methoxyphenyl-4-propylcyclohexane
- 14 % of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
- 30 4 % of 4-ethyl-4'-(trans-4-propylcyclohexyl)-biphenyl
- 4 % of 4-ethyl-4'-(trans-4-pentylcyclohexyl)-biphenyl
- 4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-biphenyl
- 4 % of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluoro-biphenyl
- 35 5 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-biphenyl
- 4 % of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluorobiphenyl

exhibits an S-N of less than -40° , a c.p. of $+93^{\circ}$, a visc. of 31 and a t.v. of 1.5 V.

Example 16

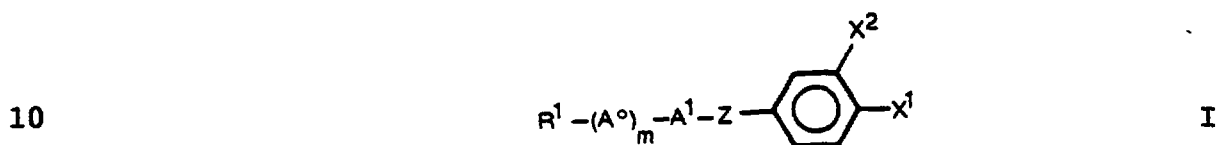
A mixture of

5	5	% of 3-fluoro-4-cyanophenyl p-ethylbenzoate
	5	% of 3-fluoro-4-cyanophenyl p-propylbenzoate
	3	% of 3-fluoro-4-cyanophenyl p-(trans-4-propylcyclohexyl)-benzoate
	7	% of trans-1-p-methoxyphenyl-4-propylcyclohexane
10	21	% of trans,trans-4-propyl-4'-propoxycyclohexyl-cyclohexane
	21	% of trans,trans-4-pentyl-4'-methoxycyclohexyl-cyclohexane
	7	% of trans,trans-4-pentyl-4'-ethoxycyclohexyl-cyclohexane
15	4	% of trans-4-propylcyclohexyl trans,trans-4-propylcyclohexyl-cyclohexane-4'-carboxylate
	5	% of trans-4-pentylcyclohexyl trans,trans-4-propylcyclohexyl-cyclohexane-4'-carboxylate
20	5	% of trans-4-propylcyclohexyl trans,trans-4-butylcyclohexyl-cyclohexane-4'-carboxylate
	4	% of trans-4-pentylcyclohexyl trans,trans-4-butylcyclohexyl-cyclohexane-4'-carboxylate
	4	% of 4,4'-bis-(trans-4-propylcyclohexyl)-2-fluorobiphenyl
25	4	% of 4,4'-bis-(trans-4-pentylcyclohexyl)-2-fluorobiphenyl
	5	% of 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclohexyl)-2-fluorobiphenyl
30		exhibits an S-N of less than -40° , a c.p. of $+89^{\circ}$, a visc. of 30 and a t.v. of 2.0 V.



Patent claim

Liquid crystal display element with static or multiplex drive, having a low multiplex ratio and an operating voltage below 3.3 volts, containing a liquid crystal dielectric, characterized in that the operating temperature range extends from -30°C to $+80^{\circ}\text{C}$, the viscosity of the dielectric at 20°C is less than 40 mPa.s and the dielectric contains at least one component of the formula I



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

15 A^0 and A^1 each independently of one another are Cy, Dio 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 or $-\text{CN}$,

20 X^2 is F or Cl,

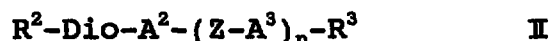
m is 0 or 1,

Cy is trans-1,4-cyclohexylene,

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

Phe is 1,4-phenylene which is unsubstituted or substituted by fluorine, with the proviso

25 that the dielectric does not contain any component of the formula II



30 in which R^2 is alkyl of 1 to 12 C-atoms, in which one or two non-adjacent CH_2 groups can also 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 one or



two non-adjacent CH_2 groups can also be replaced by O atoms, $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}-$ and/or $-\text{CH}=\text{CH}$ groups, F, Cl or CN, A^2 and A^3 are each 1,4-phenylen or Cy,

5

n is 0, 1 or 2 and

Z, Dio and Cy have the meanings given.

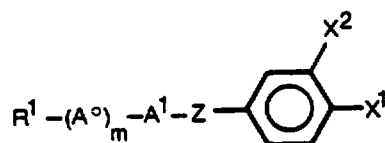


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As printed

Revendication

Elément d'affichage à cristaux liquides avec une commande statique ou multiplex présentant un rapport multiplex faible et une tension de fonctionnement inférieure à 3,3 volts, contenant un diélectrique à cristaux liquides, caractérisé en ce que la gamme de températures de fonctionnement s'étend de -30°C à $+80^{\circ}\text{C}$, en ce que la viscosité du diélectrique à 20°C est inférieure à 40 m Pa·s et en ce que le diélectrique contient au moins un composant de formule I:



où R^1 représente un alkyle ayant 1 à 12 atomes de C dans lequel également un ou deux groupes CH_2 non voisins peuvent être remplacés par des atomes d'O, des groupes $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}$ et/ou $-\text{CH}=\text{CH}-$,

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

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

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

X^2 F ou Cl,

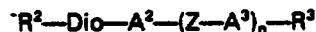
m 0 ou 1,

Cy le trans-1,4-cyclohexylène,

Dio le trans-1,3-dioxanne-2,5-diyle et

Phe le 1,4-phénylène non substitué ou substitué par le fluor,

sous la réserve que le diélectrique ne contienne aucun composant de formule II



II

où R^2 représente un alkyle ayant 1 à 12 atomes de C dans lequel également un ou deux groupes CH_2 non voisins peuvent être remplacés par des atomes d'O, des groupes $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}$ et/ou des groupes $-\text{CH}=\text{CH}-$,

R^3 représente un alkyle ayant 1 à 12 atomes de C dans lequel également un ou deux groupes CH_2 non voisins peuvent être remplacés par des atomes d'O des groupes $-\text{CO}-$, $-\text{O}-\text{CO}-$, $-\text{CO}-\text{O}$ et/ou des groupes $-\text{CH}=\text{CH}-$, F, Cl ou CN,

A^2 et A^3 représentent le 1,4-phénylène ou Cy,

n est égal à 0, 1 ou 2 et,

Z , Dio et Cy ont les significations indiquées.

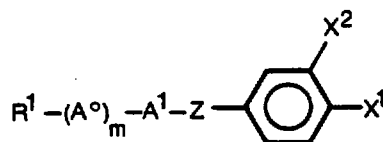
Claim

Liquid crystal display element with static or multiplex drive, having a low multiplex ratio and an operating voltage below 3.3 volts, containing a liquid crystal dielectric, characterized in that the operating temperature range extends from -30°C to $+80^{\circ}\text{C}$, the viscosity of the dielectric at 20°C is less than 40 mPa·s



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and the dielectric contains at least one component of the formula I



wherein R¹ is alkyl of 1 to 12 C atoms, wherein one or two non-adjacent CH₂ groups can also be replaced by O atoms, —CO—, —O—CO—, —CO—O— and/or —CH=CH— groups,

A^o and A¹ each independently of one another are Cy, Dio or Phe,

Z is —CO—O—, —O—CO—, —CH₂—O—, —O—CH₂ or a single bond,

X¹ is F, Cl or —CN,

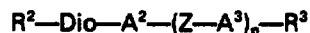
X² is F or Cl,

m is 0 or 1,

CY is trans-1,4-cyclohexylene,

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

Phe is 1,4-phenylene which is unsubstituted or substituted by fluorine, with the proviso that the dielectric does not contain any component of the formula II



in which R² is alkyl of 1 to 12 C-atoms, in which one or two non-adjacent CH₂ groups can also be replaced by O atoms, —CO—, —O—CO—, —CO—O— and/or —CH=CH— groups,

R³ is alkyl of 1 to 12 C atoms, in which one or two non-adjacent CH₂ groups can also be replaced by O atoms, —CO—, —O—CO—, —CO—O— and/or —CH=CH— groups, F, Cl or CN,

A² and A³ are each 1,4-phenylene or Cy,

n is 0, 1 or 2 and

Z, Dio and Cy have the meanings given.