

THIS SHEET HAS BEEN
REPLACED

RAN 6220/120

The present invention is concerned with photo cross-linkable liquid crystalline compounds having a chromophore,
5 liquid crystalline mixtures which contain such compounds and their use in the cross-linked state as optical components.

Photo cross-linkable liquid crystals, which are provided with a suitable amount of a photoinitiator, can be orientated on a
10 substrate or in a cell by suitable orientating layers or in a field and then in this state can be cross-linked by irradiation with light of a suitable wavelength. The structure thereby produced remains even at high temperatures. Thus, optical components such as, for example, wave guides, optical grids and filters,
15 piezoelectric cells and cells having non-linear optical (NLO) properties, etc., can be produced. Such optical components can be used, for example, in frequency doubling (SHG) or in colour filters.

Further properties such as, for example, the birefringence,
20 the refractive index, the transparency, etc. must fulfil different requirements depending on the field of use. For example, materials for optical filters should have a strong absorption in a direction perpendicular to the filter surface.

25 The photo cross-linkable liquid crystals must have a good chemical and thermal stability, good solubility in common solvents and a good stability towards electric fields and electromagnetic radiation. They should possess a suitable mesophase in a temperature range from about 25°C to about +100°C, especially
30 from about 25°C to about +80°C. Moreover, they should have a strong absorption in the desired wavelength range for the uses set forth above.

Since liquid crystals are usually used as mixtures of
35 several components, it is important that the components have a good miscibility with one another.

This Sheet Has Been Replaced



Liquid crystalline mixtures, which are used for frequency doubling or as optical filters having a strong absorption at a particular wavelength, contain dichroic dyes, which for the most part are themselves not liquid crystalline. Mixtures containing
5 such dyes can be based on various principles. Thus, for example, dyes can be admixed with the liquid crystals, but in this case the phase transition temperatures are severely reduced, so that only very limited amounts of dye can be added. A further method
10 comprises adding dyes to mixtures of photo cross-linkable liquid crystals, but in this case there is the danger that the non-cross-linked component (dye) relaxes and thus the absorption decreases with time; moreover, the solubility of such dyes in photo cross-linked liquid crystals is usually limited by phase separation and/or aggregate formation.

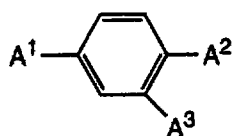
15

There is accordingly the need, especially for SHG uses, to produce mixtures which are distinguished not only by a high chromophore concentration, but also by a good orientation stability.

20

By incorporating chromophores into networks high concentrations of the active additives are achieved without phase separation or aggregate formation occurring and without the long-term stability of the photo cross-linked liquid crystals
25 being influenced. Moreover, the chromophores can orientate in an electric field perpendicular to the optical axis of the prepolymerized polymers; this leads to a high SHG efficiency.

The present invention now provides compounds which are
30 suitable in an outstanding manner as single components or as components of such liquid crystal mixtures. These compounds have the general formula



35

wherein

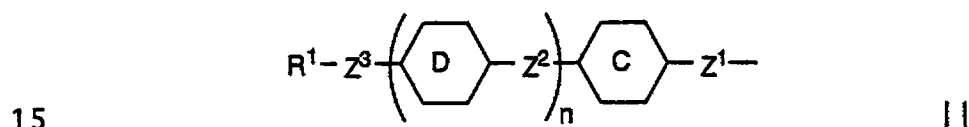
A¹ and A² each represent a cross-linkable, meso-
genic group; and

A³ represents a dichroic group.

5

Since the compounds of formula I in accordance with the
invention or their mixtures often have a mesophase, they can be
orientated by the application of an electric or magnetic field
prior to the cross-linking. A uniform layer can be produced in
10 this manner.

Preferably, the mesogenic groups A¹ and A² each signify a
group of the general formula



wherein

rings C and D each independently signify 1,4-phenylene,
which is optionally substituted with
20 halogen, methyl and/or cyano, or pyridine-
2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-
cyclohexylene or trans-1,3-dioxane-2,5-
diyl;

Z¹ signifies -CH₂CH₂-, -CH₂O-, -COO-, -OOC-,
25 -(CH₂)₄- or -(CH₂)₃O-;

Z² signifies a single bond; -CH₂CH₂-, -CH₂O-,
-OCH₂-, -COO-, -OOC-, -(CH₂)₄-, -O(CH₂)₃-
or -(CH₂)₃O-;

30 Z³ signifies -(CY₂)_m-, -O(CY₂)_m-, -(CY₂)_mO-,
-(CY₂)_mCOO-, -(CY₂)_mOOC-,
-(Si[(CH₃)₂]O)_m-, -OCH₂(Si[(CH₃)₂]O)_m-,
Si[(CH₃)₂]CH₂O- or -NHCH₂(Si[(CH₃)₂]O)_m-
Si[(CH₃)₂]CH₂NH-;

Y signifies hydrogen or fluorine;

35 n signifies 0 or 1;

m signifies a whole number of 1 to 16; and

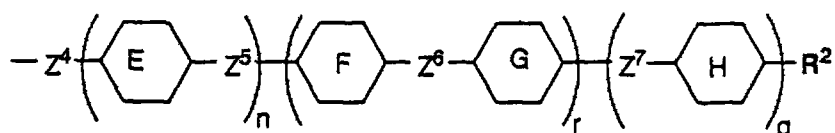
R¹ signifies a cross-linkable group such as

ethylene, acrylate, methacrylate,
 2-chloroacrylate, 2-phenylacrylate,
 acryloylphenylene, acrylamide,
 methacrylamide, 2-chloroacrylamide,
 5 2-phenylacrylamide, epoxy, itaconic acid
 ester, vinyl ether, vinyl ester, styrene
 derivative, siloxane, ethyleneimine
 derivative, maleic acid derivative, fumaric
 acid derivative or a cinnamic acid
 10 derivative, which is optionally substituted
 with methyl, methoxy, cyano and/or
 halogen.

Compounds of formula I in which the two mesogenic groups
 15 A¹ and A² have the same significance are especially preferred.
 Groups A¹ and A² of formula II in which rings C and D each
 independently signify 1,4-phenylene, which is unsubstituted or
 substituted with fluorine, pyridine-2,5-diyl or pyrimidine-2,5-
 diyl are particularly preferred. Z¹ in groups of formula II
 20 preferably signifies -CH₂O-, -COO- or -OOC-; Z² preferably
 signifies a single bond, -CH₂CH₂-, -CH₂O-, OCH₂-, -COO- or -OOC-;
 Z³ preferably signifies -(CY₂)_m-, -(CY₂)_mO-, -(CY₂)_mCOO- or
 -(CY₂)_mOOC-; and Y preferably signifies hydrogen.

25 The cross-linkable group R¹ preferably signifies acrylate,
 methacrylate, 2-chloroacrylate, 2-phenylacrylate, acryloyl-
 phenylene, acrylamide, methacrylamide, 2-phenylacrylamide,
 epoxy, vinyl ether, vinyl ester, styrene derivative, maleic acid
 derivative or fumaric acid derivative. These are the groups which
 30 can be cross-linked photochemically after orientation of the
 compounds of formula I in a field. Acrylate, methacrylate, vinyl
 ether and epoxy are especially preferred groups R¹.

The dichroic group A³ preferably signifies a group of the
 35 general formula

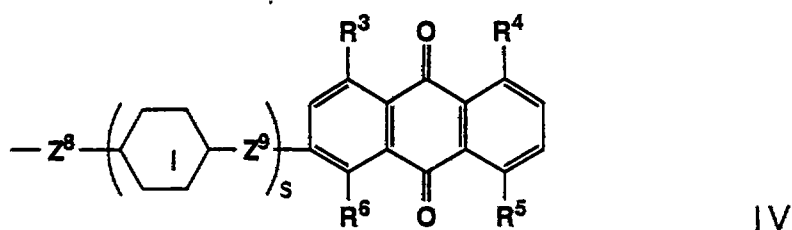


|||

wherein

5	rings E and H	each independently signify 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;
10	ring F	signifies 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl or pyrimidine-2,5-diyl;
15	ring G	signifies 1,4-phenylene, which is optionally mono- or multiply-substituted with halogen, methyl, dimethylamino, amino, nitro and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, 1,4-naphthylene, 2,6-naphthylene, 2,5-pyrazolediyl, 2,5-thiazolediyl, 2,5-benzthiazolediyl, 2,5-imidazolediyl, 2,5-pyrrolediyl or 2,5-thiophenediyl;
20	Z ⁴	signifies -CH ₂ CH ₂ -, -CH ₂ O-, -COO-, -OOC-, -(CH ₂) ₄ -, -(CH ₂) ₃ O-, -COO(CH ₂) _p - or -COO(CH ₂) _p O-;
25	Z ⁵ and Z ⁷	each independently signify a single bond, -CH ₂ CH ₂ -, -CH ₂ O-, -OCH ₂ -, -COO-, -OOC-, -(CH ₂) ₄ -, -O(CH ₂) ₃ - or -(CH ₂) ₃ O-;
30	Z ⁶	signifies -N=N-, -N(O)=N-, -CH=CH- or -CH=N-;
	n and q	each signify 0 or 1;
	p	signifies a whole number of 1 to 16;
	r	signifies 0, 1 or 2; and
35	R ²	signifies hydrogen, halogen, cyano, -CH=CHNO ₂ , -CH=CHCN, -CH=C(CN) ₂ , nitro, a dialkylamino or cyclobutylamino group or

an alkyl, alkoxy or alkanoyloxy group, which is optionally substituted with methoxy, cyano and/or halogen, with the proviso that, when $r = 0$, R^2 signifies a substituted anthraquinone group of the general formula



10 wherein
ring I

signifies 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;

15

Z^8

signifies $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{COO}-$, $-\text{OOC}-$, $-(\text{CH}_2)_4-$, $-(\text{CH}_2)_3\text{O}-$, $-\text{COO}(\text{CH}_2)_p-$ or $-\text{COO}(\text{CH}_2)_p\text{O}-$;

Z^9

signifies a single bond, $-\text{COO}(\text{CH}_2)_p\text{N}(\text{CH}_3)-$, $-\text{COO}(\text{CH}_2)_p\text{NH}-$, $-\text{CH}_2\text{O}-$, $-\text{OCH}_2-$, $-\text{COO}-$, $-\text{OOC}-$ or $-\text{NH}-$;

20

s

signifies 0 or 1;

p

signifies a whole number of 1 to 16; and

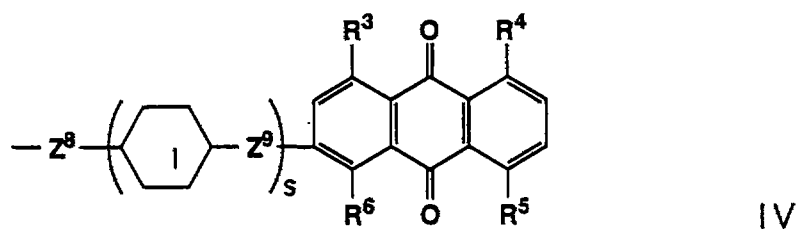
R^3, R^4, R^5 and R^6

each independently signify hydrogen, halogen, cyano, $-\text{CH}=\text{CHNO}_2$, $-\text{CH}=\text{CHCN}$, $-\text{CH}=\text{C}(\text{CN})_2$, nitro, hydroxy, a dialkylamino or cyclobutylamino group or an alkyl, alkoxy or alkanoyloxy group, which is optionally substituted with methyl, methoxy, cyano and/or halogen.

25

30

The dichroic residue A^3 also preferably signifies a residue of the general formula



wherein
ring I

5

10

 Z^8 Z^9

15

s

p

 R^3, R^4, R^5 and R^6

20

25

signifies 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;

signifies $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{COO}-$, $-\text{OOC}-$, $-(\text{CH}_2)_4-$, $-(\text{CH}_2)_3\text{O}-$, $-\text{COO}(\text{CH}_2)_p-$ or $-\text{COO}(\text{CH}_2)_p\text{O}-$;

signifies a single bond, $-\text{COO}(\text{CH}_2)_p\text{N}(\text{CH}_3)-$, $-\text{COO}(\text{CH}_2)_p\text{NH}-$, $-\text{CH}_2\text{O}-$, $-\text{OCH}_2-$, $-\text{COO}-$, $-\text{OOC}-$ or $-\text{NH}-$;

signifies 0 or 1;

signifies a whole number of 1 to 16; and

each independently signify hydrogen, halogen, cyano, $-\text{CH}=\text{CHNO}_2$, $-\text{CH}=\text{CHCN}$, $-\text{CH}=\text{C}(\text{CN})_2$, nitro, hydroxy, a dialkylamino or cyclobutylamino group or an alkyl, alkoxy or alkanoyloxy group, which is optionally substituted with methyl, methoxy, cyano and/or halogen.

The terms used above will be explained hereinafter:

"halogen" signifies fluorine, chlorine or bromine, especially fluorine;

30

"1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano," embraces in the scope of the present invention 1,4-phenylene or substituted 1,4-phenylene such as, for example, 2- or 3-fluoro-1,4-phenylene, 2,3-difluoro-1,4-phenylene, 2,6- or 3,5-difluoro-1,4-phenylene, 2- or 3-

35

chloro-1,4-phenylene, 2,3-dichloro-1,4-phenylene, 2,6- or 3,5-dichloro-1,4-phenylene, 2- or 3-bromo-1,4-phenylene, 2- or 3-methyl-1,4-phenylene, 2- or 3-cyano-1,4-phenylene and the like;

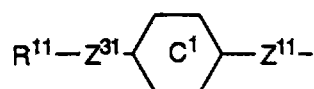
5

"1,4-phenylene, which is optionally substituted with halogen, methyl, dimethylamino, amino, nitro and/or cyano," embraces in the scope of the present invention in addition to the rings enumerated above also 2- or 3-nitro-1,4-phenylene, 2- or
10 3-dialkylamino-1,4-phenylene and the like;

"dialkylamino" groups embrace dimethylamino, diethylamino, dipropylamino and diisopropylamino groups;

15 "alkyl, alkoxy or alkanoyloxy groups, which are optionally substituted with methoxy, cyano and/or halogen," embrace in the scope of the present invention groups in which the alkyl group can be straight-chain or branched and which preferably has 1 to 12 carbon atoms. The groups can be mono- or multiply- substituted
20 with methoxy, cyano and/or fluorine, chlorine or bromine. Methyl, ethyl, propyl, butyl, pentyl, methoxy, ethoxy, propyloxy, butoxy, acyloxy, propanoyloxy, butanoyloxy and the like are particularly preferred groups.

25 The mesophase type of the compounds in accordance with the invention can be influenced by varying the rings in the mesogenic side chains A¹ and A². Thus, aromatic rings such as phenylene have the tendency to produce smectic phases, while saturated rings such as trans-1,4-cyclohexylene or trans-1,3-dioxane-
30 2,5-diyl promote nematic tendencies. Preferably, the mesogenic groups A¹ and A² signify a group of formula II in which n = 0 such as, for example



II-a

35

wherein

ring C¹

signifies phenylene, which is optionally substituted with fluorine;

Z¹¹

signifies -CH₂CH₂-, -CH₂O-, -COO-, -OOC-,
-(CH₂)₄- or -(CH₂)₃O-;

Z³¹

signifies -(CH₂)_{m'}-, -(CH₂)_{m'}O-,
-(CH₂)_{m'}COO- or -(CH₂)_{m'}OOC-;

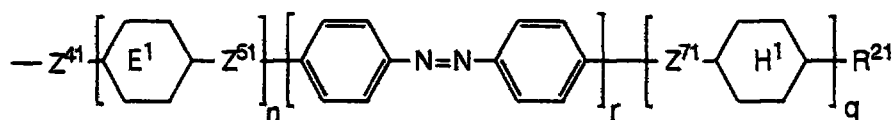
m'

signifies a whole number of 4 to 12; and

R¹¹

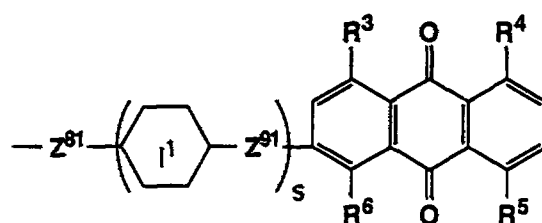
signifies acrylate, methacrylate, vinyl
ether or epoxy.

Preferably the dichroic group A³ signifies a group of the
general formula



III-a

or



IV-a

wherein

rings E¹ and H¹

signify 1,4-phenylene, which is optionally
substituted with fluorine;

Z⁴¹

signifies -COO(CH₂)_{p'}- or -COO(CH₂)_{p'}O-;

Z⁵¹ and Z⁷¹

each independently signify a single bond,
-CH₂CH₂-, -CH₂O-, -COO- or -OOC-;

n, q

signify 0 or 1;

r

signifies 1;

p'

signifies a whole number of 4 to 12;

R²¹

signifies nitro or dimethylamino;

ring I¹

signifies phenylene, which is optionally
substituted with fluorine, or trans-1,4-
cyclohexylene;

$$\text{CH}_2=\text{CH}-\text{C}(=\text{O})-\text{O}-(\text{CH}_2)_m-\text{O}-\text{C}_6\text{H}_4-\text{COO}-\text{C}_6\text{H}_4-\text{OOC}-\text{C}_6\text{H}_4-\text{O}-(\text{CH}_2)_m-\text{O}-\text{C}(=\text{O})-\text{CH}=\text{CH}_2$$

$$\text{Z}^{41} \left[\text{E}^1 \right] \text{Z}^{51} \left[\text{C}_6\text{H}_4-\text{N}=\text{N}-\text{C}_6\text{H}_4 \right] \text{Z}^{71} \left[\text{H}^1 \right] \text{Z}^{21} \quad \text{q}$$

10

15 are particularly preferred. Especially preferred compounds of formula I-a are those in which q signifies 0.

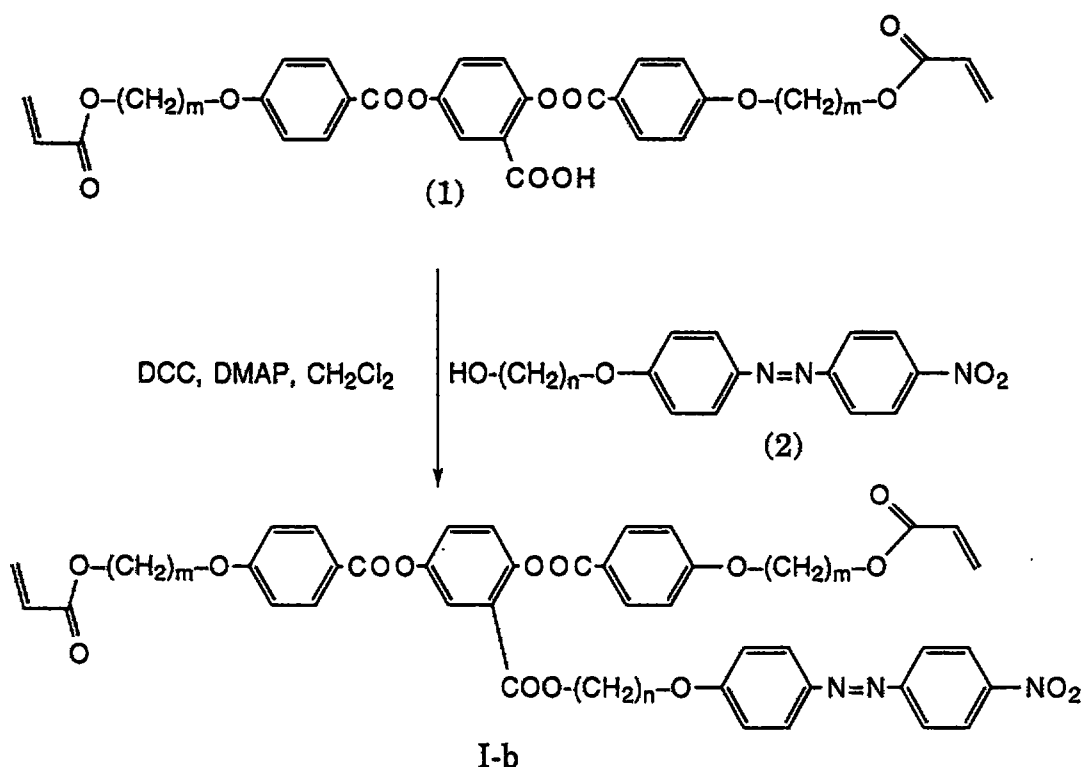
The compounds of formula I in which A¹ and A² have the same significance are very readily accessible synthetically and can be produced, for example, analogously to the methods illustrated in Schemes 1 and 2. Thus, dichroic alcohols (2) and, respectively, (6) can be reacted with bis[2,5-bis[4-(ω -acryloyloxyalkyloxy)]phenylcarboxy]benzoic acids (1) and, respectively, (7). This esterification can be effected, for example, in the presence of N,N'-dicyclohexylcarbodiimide and 4-(dimethylamino)pyridine in dichloromethane or another suitable solvent such as e.g. chloroform. The dichroic alcohols are known or can be prepared, for example, from the esterification product of 4-hydroxybenzaldehyde (3) and a chromophore-containing benzoic acid (4) by reducing the aldehyde (5) with sodium borohydride.

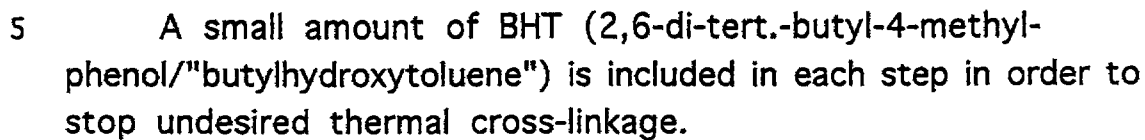
Compounds of formula I in which A¹ and A² are different can be produced starting from asymmetric 2-[4-(ω-acryloyloxy-

alkyloxy)phenylcarboxy]-5-[4-(ω -acryloyloxyalkyloxy)phenylcarboxy]benzoic acids. These can be prepared, for example, by the mono-esterification of 2,5-dihydroxybenzaldehyde with a 4-(ω -acryloyloxyalkyloxy)benzoic acid to the monoester and subsequent
 5 esterification with another 4-(ω -acryloyloxyalkyloxy)benzoic acid to the diester. Oxidation with Jones' reagent gives the corresponding asymmetric 2-[4-(ω -acryloyloxyalkyloxy)phenylcarboxy]-5-[4-(ω -acryloyloxyalkyloxy)]phenylcarboxy]benzoic acid. The starting materials are known and are in part
 10 commercially available.

The symbols in the Schemes have the aforementioned significances.

15 Scheme 1





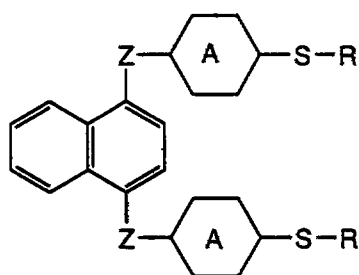
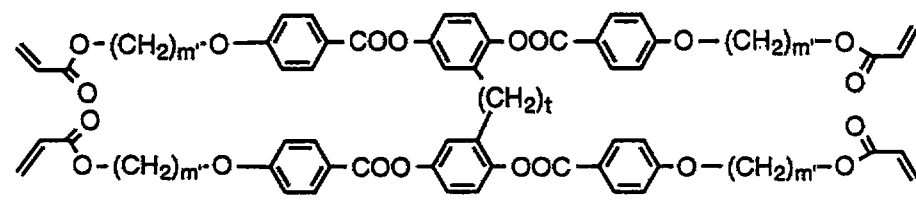
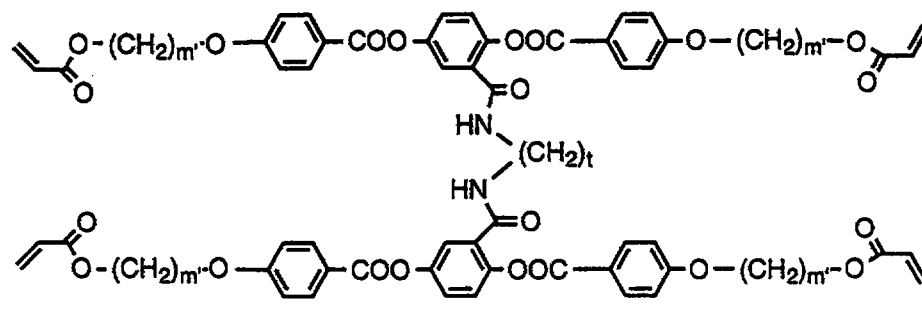
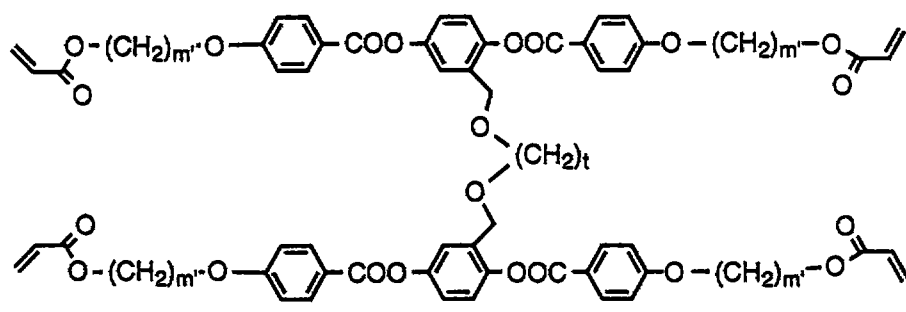
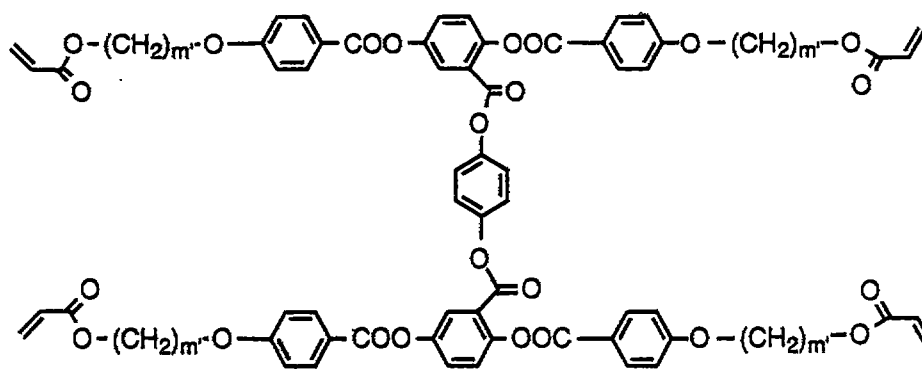
5 The liquid crystalline mixtures in accordance with the invention contain at least 2 components, of which at least one component is a compound of formula I. A second component and any other components can be additional compounds of formula I or other known liquid crystalline compounds having a photo cross-
10 linkable group. One or more chiral components can also be present in the mixture.

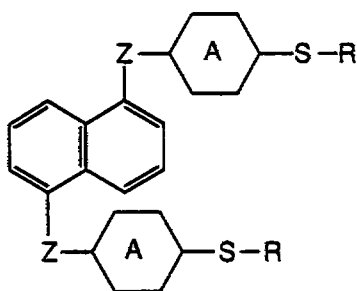
Having regard to the good solubility of the compounds of formula I and having regard to their good miscibility with one another, the content of compounds of formula I in the mixtures in accordance with the invention can be high and can amount to up to 100 wt. %.

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



25





XII

wherein

5	X	signifies hydrogen, fluorine, chlorine, bromine or methyl;
	m'	signifies a whole number of 4 to 12;
	t	signifies a whole number of 1 to 12;
	Z	signifies $-\text{OCH}_2-$ or $-\text{OOC}-$;
10	A	signifies 1,4-phenylene or 2- or 3-fluoro-1,4-phenylene;
	S	signifies $-(\text{CH}_2)_{m'}-$ or $-(\text{CH}_2)_{m'}\text{O}-$; and
	R	signifies acrylate, methacrylate, vinyl ether or epoxy.

15 The production of the compounds of formula I and of liquid crystalline mixtures containing these compounds is illustrated in more detail by the following Examples. C signifies a crystalline phase, S signifies a smectic phase, N signifies a nematic phase and I signifies the isotropic phase.

20

Example 1

0.2 g of N, N'-dicyclohexyldicarbodiimide (DCC) was added at room temperature while stirring to a solution of 0.5 g of 2,5-
 25 bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoic acid, 0.25 g of 6-[4-(4-nitrophenylazo)phenoxy]hexanol and 0.04 g of 4-dimethylaminopyridine (DMAP) in 25 ml of dichloromethane. The reaction mixture was stirred at room temperature overnight, poured into 100 ml of water and then extracted three times with
 30 50 ml of dichloromethane each time. The organic phases were combined, washed twice with 100 ml of water each time, dried over magnesium sulphate, filtered and the filtrate was concen-

trated. Chromatographic purification of the residue on silica gel with hexane/ethyl acetate (vol. 1:1) and two-fold recrystallization from acetone of the fractions which were pure according to thin-layer chromatography gave 0.4 g of 6-[4-(4-nitrophenylazo)phenoxy]hexyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 72°C, cl.p. (N-I) 127°C.

The following compounds can be produced in an analogous manner:

2-[4-(4-Nitrophenylazo)phenoxy]ethyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 122°C, cl.p. (N-I) 162°C.

3-[4-(4-Nitrophenylazo)phenoxy]propyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

4-[4-(4-Nitrophenylazo)phenoxy]butyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 113°C, cl.p. (N-I) 142°C.

5-[4-(4-Nitrophenylazo)phenoxy]pentyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 98°C, cl.p. (N-I) 104°C.

7-[4-(4-Nitrophenylazo)phenoxy]heptyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

8-[4-(4-Nitrophenylazo)phenoxy]octyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 86°C, cl.p. (N-I) 119°C.

9-[4-(4-Nitrophenylazo)phenoxy]nonyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

10-[4-(4-Nitrophenylazo)phenoxy]decyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

11-[4-(4-Nitrophenylazo)phenoxy]undecyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

12-[4-(4-Nitrophenylazo)phenoxy]dodecyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

2-[4-(4-Dimethylaminophenylazo)phenoxy]ethyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 124°C, cl.p. (N-I) 166°C.

3-[4-(4-Dimethylaminophenylazo)phenoxy]propyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

4-[4-(4-Dimethylaminophenylazo)phenoxy]butyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 100°C,
5 cl.p. (N-I) 149°C.

5-[4-(4-Dimethylaminophenylazo)phenoxy]pentyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 80°C,
cl.p. (N-I) 113°C.

6-[4-(4-Dimethylaminophenylazo)phenoxy]hexyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 90°C,
10 cl.p. (N-I) 137°C.

7-[4-(4-Dimethylaminophenylazo)phenoxy]heptyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

8-[4-(4-Dimethylaminophenylazo)phenoxy]octyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate; m.p. (C-N) 98°C,
15 cl.p. (N-I) 131°C.

9-[4-(4-Dimethylaminophenylazo)phenoxy]nonyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

10-[4-(4-Dimethylaminophenylazo)phenoxy]decyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.
20

11-[4-(4-Dimethylaminophenylazo)phenoxy]undecyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

12-[4-(4-Dimethylaminophenylazo)phenoxy]dodecyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

25 6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(3-acryloyloxypropyloxy)phenylcarboxy]benzoate.

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(4-acryloyloxybutyloxy)phenylcarboxy]benzoate.

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(5-acryloyloxypropyloxy)phenylcarboxy]benzoate.
30

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(7-acryloyloxyheptyloxy)phenylcarboxy]benzoate.

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(8-acryloyloxyoctyloxy)phenylcarboxy]benzoate.

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(9-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(10-acryloyloxydecyloxy)phenylcarboxy]benzoate.

- 5 6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(11-acryloyloxyundecyloxy)phenylcarboxy]benzoate; m.p. (C-SA) 65°C, SA-N, 98°C, cl.p. (N-I) 121°C.

6-[4-(4-Nitrophenylazoxy)phenoxy]hexyl 2,5-bis[4-(12-acryloyloxydodecyloxy)phenylcarboxy]benzoate.

- 10 6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(3-acryloyloxypropyloxy)phenylcarboxy]benzoate.

6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(4-acryloyloxybutyloxy)phenylcarboxy]benzoate.

- 15 6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(5-acryloyloxyptyloxy)phenylcarboxy]benzoate.

6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(7-acryloyloxyheptyloxy)phenylcarboxy]benzoate.

6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(8-acryloyloxyoctyloxy)phenylcarboxy]benzoate.

- 20 6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(9-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(10-acryloyloxydecyloxy)phenylcarboxy]benzoate.

- 25 6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(11-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

6-[4-(4-Dimethylaminophenylazoxy)phenoxy]hexyl 2,5-bis[4-(12-acryloyloxydodecyloxy)phenylcarboxy]benzoate.

Example 2

- 30 0.2 g of N,N'-dicyclohexylcarbodiimide is added at room temperature while stirring to a solution of 0.6 g of 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoic acid, 0.4 g of (4-[4-(4-nitrophenylazo)benzoyloxy]phenyl)methanol and 0.04 g of 4-dimethylaminopyridine in 20 ml of dichloromethane. The reaction
35 mixture is stirred at room temperature overnight, poured into

100 ml of water and then extracted three times with 50 ml of dichloromethane each time. The organic phases are combined, washed twice with 100 ml of water each time, dried over magnesium sulphate, filtered and the filtrate is concentrated.

5 Chromatographic purification of the residue on silica gel with hexane/ethyl acetate (vol. 1:1) and two-fold recrystallization from acetone of the fractions which are pure according to thin-layer chromatography gives 0.4 g of (4-[4-(4-nitrophenylazo)-benzoyloxy]phenyl)methyl 2,5-bis[4-(6-acryloyloxyhexyloxy)-phenylcarboxy]benzoate.

The (4-[4-(4-nitrophenylazo)benzoyloxy]phenyl)methanol used as the starting material is prepared as follows:

(a). A mixture of 0.13 g of sodium borohydride and 15 ml
15 of water is treated dropwise at 0°C with a solution of 0.8 g of 4-[4-(4-nitrophenylazo)benzoyloxy]benzaldehyde in 100 ml of dioxan. The reaction mixture is stirred at 0°C for 60 minutes and then at room temperature for 10 minutes, poured into 100 ml of dichloromethane and washed twice with 100 ml of water each
20 time. The aqueous phases are combined and extracted twice with 50 ml of dichloromethane each time. The organic phases are combined, washed twice with 100 ml of water each time, dried over magnesium sulphate, the suspension is filtered and the filtrate is concentrated. The residue is used in the next step
25 without further purification.

(b). 0.6 g of N,N'-dicyclohexylcarbodiimide is added at room temperature while stirring to a solution of 1.0 g of 4-(4-nitrophenylazo)benzoic acid, 0.3 g of 4-hydroxybenzaldehyde and
30 0.04 g of 4-dimethylaminopyridine in 20 ml of dichloromethane. The reaction mixture is stirred at room temperature overnight, poured into 100 ml of water and then extracted three times with 50 ml of dichloromethane each time. The organic phases are combined, washed twice with 100 ml of water each time, dried
35 over magnesium sulphate, filtered and the filtrate is concentrated. Chromatographic purification of the residue on silica gel with hexane/ethyl acetate (vol. 1:1) and two-fold recrystallization from ethanol of the fractions which are pure according to

thin-layer chromatography gives 0.9 g of 4-[4-(4-nitrophenyl-azo)benzoyloxy]benzaldehyde.

The following compounds can be produced in an analogous
5 manner:

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(7-acryloyloxyheptyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-
10 (8-acryloyloxyoctyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(9-acryloyloxynonyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(10-acryloyloxydecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-
15 (11-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(12-acryloyloxydodecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-
20 bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(7-acryloyloxyheptyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(8-acryloyloxyoctyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-
25 bis[4-(9-acryloyloxynonyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(10-acryloyloxydecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-
30 bis[4-(11-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenyl)methyl 2,5-bis[4-(12-acryloyloxydodecyloxy)phenylcarboxy]benzoate.

Example 3

A solution of 0.6 g of 2,5-bis[4-(6-acryloyloxyhexyloxy)-phenylcarboxy]benzoic acid, 0.4 g of (4-[4-(4-nitrophenylazo)-benzoyloxy]phenoxy)ethanol and 0.04 g of 4-dimethylamino-pyridine is reacted with 0.2 g of N,N'-dicyclohexyldicarbodiimide and 20 ml of dichloromethane in an analogous manner to Example 1 to give (4-[4-(4-nitrophenylazo)benzoyloxy]-phenoxy)ethyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]-benzoate.

The (4-[4-(4-nitrophenylazo)benzoyloxy]phenoxy)ethanol used as the starting material is prepared as follows:

(a) A solution of 0.35 g of 4-(4-nitrophenylazo)benzoic acid, 0.2 g of (4-hydroxyphenoxy)ethanol and 0.04 g of 4-dimethylaminopyridine is reacted with 0.4 g of N,N'-dicyclohexyldicarbodiimide and 50 ml of dichloromethane in an analogous manner to Example 1 to give 0.4 g of (4-[4-(4-nitrophenylazo)-benzoyloxy]phenoxy)ethanol.

The following compounds can be prepared in an analogous manner:

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(7-acryloyloxyheptyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(8-acryloyloxyoctyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(9-acryloyloxynonyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(10-acryloyloxydecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(11-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Nitrophenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(12-acryloyloxydodecyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(7-acryloyloxyheptyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(8-acryloyloxyoctyloxy)phenylcarboxy]benzoate.

5 (4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(9-acryloyloxynonyloxy)phenylcarboxy]benzoate.

(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(10-acryloyloxydecyloxy)phenylcarboxy]benzoate.

10 (4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(11-acryloyloxyundecyloxy)phenylcarboxy]benzoate.

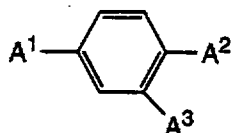
(4-[4-(4-Dimethylphenylazo)benzoyloxy]phenoxy)ethyl 2,5-bis[4-(12-acryloyloxydodecyloxy)phenylcarboxy]benzoate.

Example 4

15 A mixture of 95 wt.% pentyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]benzoate and 5 wt.% 6-[4-(4-nitrophenylazo)-phenoxy]hexyl 2,5-bis[4-(6-acryloyloxyhexyloxy)phenylcarboxy]-benzoate was provided, treated with 1 wt.% of a photoinitiator (IRGACURE, Ciba Geigy), dissolved in anisole (20 wt.%) and then
20 spun on to a glass plate at 2000 revolutions per minute. The glass plate had previously been coated with poly[methacryloyloxyethyl 3-(E)-[4-cyano-4'-biphenyl]acrylate] and irradiated with linear polarized light. Thereby, a predetermined structure was inscribed photolithographically by means of a mask in the (PPN)
25 layer. The new layer (on the PPN layer) was dried at 90°C on a heating block and then irradiated with xenon light in a vacuum oven under a vacuum and 90°C. The inscribed original structure remained and was copied faithfully by the new network. A clear dichroic absorption (orange) was recognizable. This layer can be
30 used as a structured absorption filter.

Claims

1. Compounds of the general formula



wherein

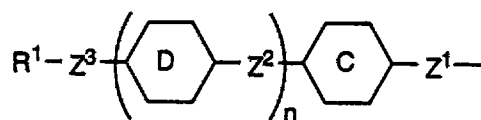
A¹ and A²

each represent a cross-linkable, meso-
genic group; and

A³

represents a dichroic group.

2. Compounds according to claim 1, wherein the
mesogenic groups A¹ and A² signify a group of the general
formula



wherein

rings C and D

each independently signify 1,4-phenylene,
which is optionally substituted with
halogen, methyl and/or cyano, or pyridine-
2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-
cyclohexylene or trans-1,3-dioxane-2,5-
diyl;

Z¹

signifies -CH₂CH₂-, -CH₂O-, -COO-, -OOC-,
-(CH₂)₄- or -(CH₂)₃O-;

Z²

signifies a single bond; -CH₂CH₂-, -CH₂O-,
-OCH₂-, -COO-, -OOC-, -(CH₂)₄-, -O(CH₂)₃-
or -(CH₂)₃O-;

Z³

signifies -(CY₂)_m-, -O(CY₂)_m-, -(CY₂)_mO-,
-(CY₂)_mCOO-, -(CY₂)_mOOC-,
-Si[(CH₃)₂]O)_m-, -OCH₂(Si[(CH₃)₂]O)_m-,
Si[(CH₃)₂]CH₂O- or -NHCH₂(Si[(CH₃)₂]O)_m-,
Si[(CH₃)₂]CH₂NH-;

Y

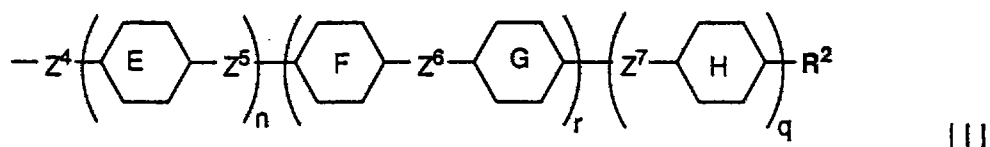
signifies hydrogen or fluorine;



n signifies 0 or 1;
 m signifies a whole number of 1 to 16; and
 R¹ signifies a cross-linkable group such as ethylene, acrylate, methacrylate, 2-chloroacrylate, 2-phenylacrylate, acryloylphenylene, acrylamide, methacrylamide, 2-chloroacrylamide, 2-phenylacrylamide, epoxy, itaconic acid ester, vinyl ether, vinyl ester, styrene derivative, siloxane, ethyleneimine derivative, maleic acid derivative, fumaric acid derivative or a cinnamic acid derivative, which is optionally substituted with methyl, methoxy, cyano and/or halogen.

3. Compounds according to claim 2, wherein the mesogenic groups A¹ and A² have the same significance.

4. Compounds according to claim 1, 2 or 3, wherein the dichroic group A³ signifies a group of the general formula

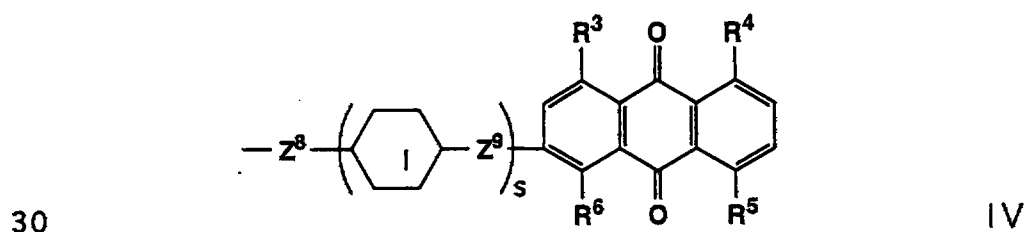


wherein

25 rings E and H each independently signify 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;
 30 ring F signifies 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl or pyrimidine-2,5-diyl;
 35 ring G signifies 1,4-phenylene, which is option-



- ally mono- or multiply-substituted with halogen, methyl, dimethylamino, amino, nitro and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, 1,4-naphthylene, 2,6-naphthylene, 2,5-pyrazolediyl, 2,5-thiazolediyl, 2,5-benzthiazolediyl, 2,5-imidazolediyl, 2,5-pyrrolediyl or 2,5-thiophenediyl;
- 5 Z^4 signifies $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{COO}-$, $-\text{OOC}-$, $-(\text{CH}_2)_4-$, $-(\text{CH}_2)_3\text{O}-$, $-\text{COO}(\text{CH}_2)_p-$ or $-\text{COO}(\text{CH}_2)_p\text{O}-$;
- 10 Z^5 and Z^7 each independently signify a single bond, $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{OCH}_2-$, $-\text{COO}-$, $-\text{OOC}-$, $-(\text{CH}_2)_4-$, $-\text{O}(\text{CH}_2)_3-$ or $-(\text{CH}_2)_3\text{O}-$;
- 15 Z^6 signifies $-\text{N}=\text{N}-$, $-\text{N}(\text{O})=\text{N}-$, $-\text{CH}=\text{CH}-$ or $-\text{CH}=\text{N}-$;
- n and q each signify 0 or 1;
- p signifies a whole number of 1 to 16;
- r signifies 0, 1 or 2; and
- 20 R^2 signifies hydrogen, halogen, cyano, $-\text{CH}=\text{CHNO}_2$, $-\text{CH}=\text{CHCN}$, $-\text{CH}=\text{C}(\text{CN})_2$, nitro, a dialkylamino or cyclobutylamino group or an alkyl, alkoxy or alkanoyloxy group, which is optionally substituted with methoxy, cyano and/or halogen, with the proviso that, when $r = 0$, R^2 signifies a substituted anthraquinone group of the general formula
- 25



wherein
ring I

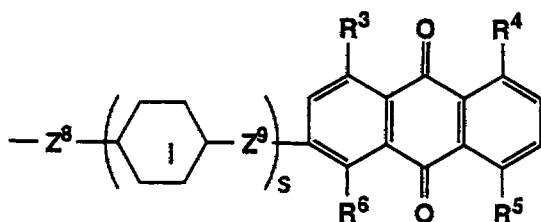
signifies 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl, pyrimidine-

35



- 2,5-diyl, trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;
 5 Z^8 signifies $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{COO}-$, $-\text{OOC}-$, $-(\text{CH}_2)_4-$, $-(\text{CH}_2)_3\text{O}-$, $-\text{COO}(\text{CH}_2)_p-$ or $-\text{COO}(\text{CH}_2)_p\text{O}-$;
 Z^9 signifies a single bond, $-\text{COO}(\text{CH}_2)_p\text{N}(\text{CH}_3)-$, $-\text{COO}(\text{CH}_2)_p\text{NH}-$, $-\text{CH}_2\text{O}-$, $-\text{OCH}_2-$, $-\text{COO}-$, $-\text{OOC}-$ or $-\text{NH}-$;
 10 s signifies 0 or 1;
 p signifies a whole number of 1 to 16; and
 R^3, R^4, R^5 and R^6 each independently signify hydrogen, halogen, cyano, $-\text{CH}=\text{CHNO}_2$, $-\text{CH}=\text{CHCN}$, $-\text{CH}=\text{C}(\text{CN})_2$, nitro, hydroxy, a dialkylamino or cyclobutylamino group or an alkyl, alkoxy or alkanoyloxy group, which is optionally substituted with methyl, methoxy, cyano and/or halogen.

5. Compounds according to claim 1, 2 or 3, wherein the
 20 dichroic group A^3 signifies a group of the general formula



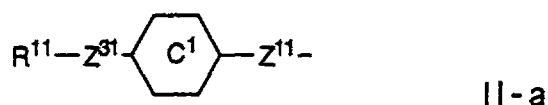
IV

- wherein
 25 ring I signifies 1,4-phenylene, which is optionally substituted with halogen, methyl and/or cyano, or pyridine-2,5-diyl, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;
 30 Z^8 signifies $-\text{CH}_2\text{CH}_2-$, $-\text{CH}_2\text{O}-$, $-\text{COO}-$, $-\text{OOC}-$, $-(\text{CH}_2)_4-$, $-(\text{CH}_2)_3\text{O}-$, $-\text{COO}(\text{CH}_2)_p-$ or $-\text{COO}(\text{CH}_2)_p\text{O}-$;
 Z^9 signifies a single bond, $-\text{COO}(\text{CH}_2)_p\text{N}(\text{CH}_3)-$, $-\text{COO}(\text{CH}_2)_p\text{NH}-$, $-\text{CH}_2\text{O}-$, $-\text{OCH}_2-$, $-\text{COO}-$, $-\text{OOC}-$ or $-\text{NH}-$;
 35



s signifies 0 or 1;
 p signifies a whole number of 1 to 16; and
 R³, R⁴, R⁵ and R⁶ each independently signify hydrogen,
 halogen, cyano, -CH=CHNO₂, -CH=CHCN,
 -CH=C(CN)₂, nitro, hydroxy, a dialkylamino
 or cyclobutylamino group or an alkyl,
 alkoxy or alkanoyloxy group, which is
 optionally substituted with methyl,
 methoxy, cyano and/or halogen.

6. Compounds according to claim 4 or 5, wherein the
 groups A¹ and A² signify a group of the general formula



wherein
 ring C¹

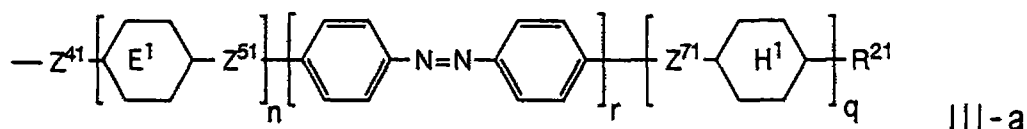
signifies phenylene, which is option-
 ally substituted with fluorine;

Z¹¹ signifies -CH₂CH₂-, -CH₂O-, -COO-, -OOC-,
 -(CH₂)₄- or -(CH₂)₃O-;

Z³¹ signifies -(CH₂)_{m'}-, -(CH₂)_{m'}O-,
 -(CH₂)_{m'}COO- or -(CH₂)_{m'}OOC-;

m' signifies a whole number of 4 to 12; and
 R¹¹ signifies acrylate, methacrylate, vinyl
 ether or epoxy.

7. Compounds according to any one of claims 1 to 6,
 wherein the dichroic group A³ signifies group of the general
 formula



or



wherein

5

10

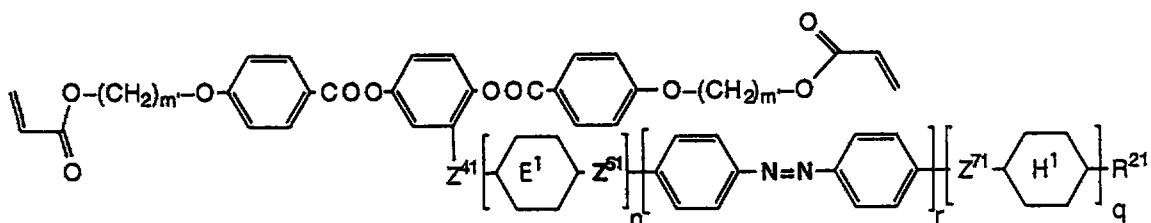
ring 1¹ signifies phenylene, which is optionally substituted with fluorine, or trans-1,4-cyclohexylene;

Z⁹¹ signifies a single bond, -COO(CH₂)_pN(CH₃)- or -COO(CH₂)_pNH-;

20

$R^3, R^4, R^5; R^6$ and p have the significances given above.

8. Compounds of the general formula



25

1 - a

wherein

rings E¹ and N¹ signify 1,4-phenylene, which is optionally



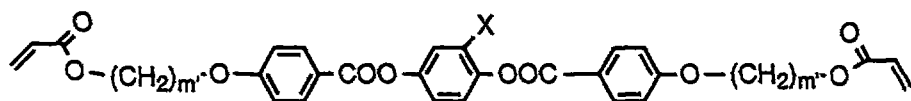
- substituted with fluorine,;
 Z⁴¹ signifies -COO(CH₂)_{p'}- or -COO(CH₂)_{p'}O-;
 Z⁵¹ and Z⁷¹ each independently signify a single bond,
 -CH₂CH₂-, -CH₂O-, -COO- or -OOC-;
 5 n, q signify 0 or 1;
 r signifies 1; and
 R²¹ signifies nitro.

9. Compounds according to claim 8, wherein q
 10 signifies 0.

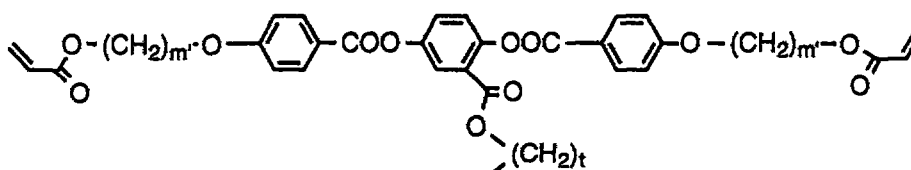
10. A cross-linkable, liquid crystalline mixture
 consisting of at least 2 components, of which at least one
 component is a compound of formula I defined in claim 1.

15 11. A cross-linkable, liquid crystalline mixture according
 to claim 10, characterized in that it contains, in addition to one
 or more compounds of formula I, one or more compounds from the
 group of the formulae

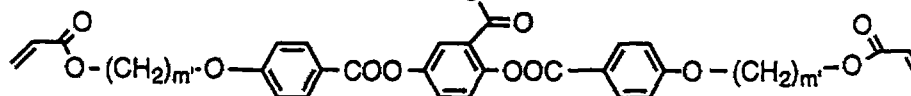
20



V

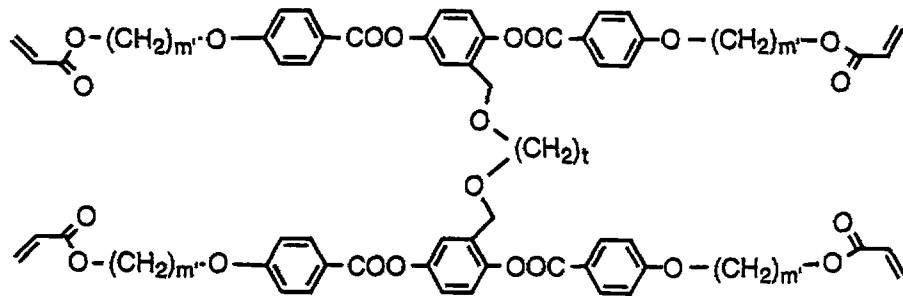


VI

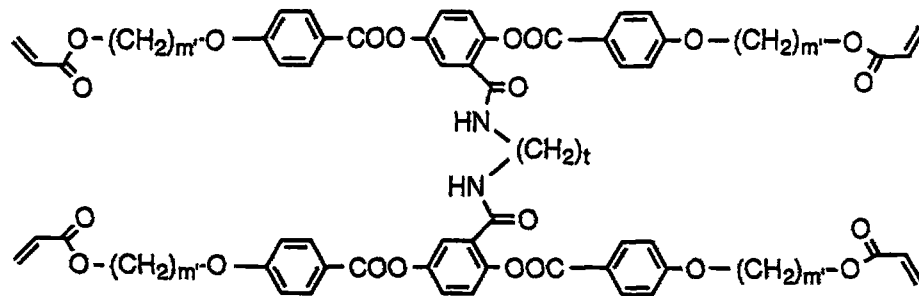


VII

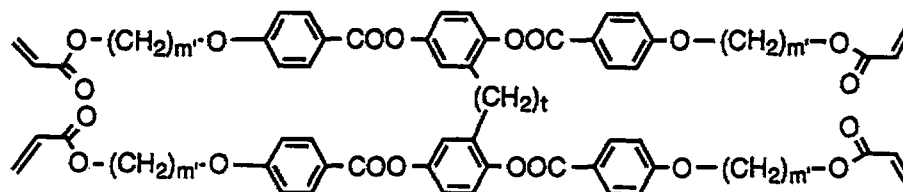




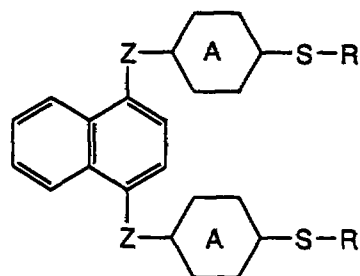
VIII



IX

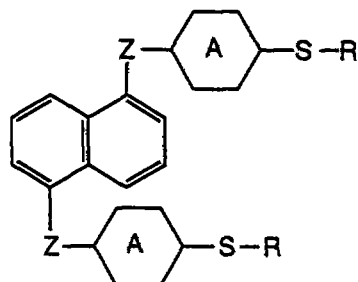


X



XI

5 and



XII

wherein

X

is hydrogen, fluorine, chlorine, bromine



or methyl;
m' is a whole number of 4 to 12; and
t is a whole number of 2 to 12;
Z signifies $-OCH_2-$ or $-OOC-$;
5 A signifies 1,4-phenylene or 2- or 3-fluoro-
1,4-phenylene;
S signifies $-(CH_2)_{m'}-$ or $-(CH_2)_{m'}O-$; and
R signifies acrylate, methacrylate, vinyl
ether or epoxy.

10

12. The use of compounds according to any one of claims 1
to 9 in their cross-linked state for optical components.

13. The use of cross-linkable liquid crystalline mixtures
15 according to claim 10 or 11 in their cross-linked state for
optical components.

