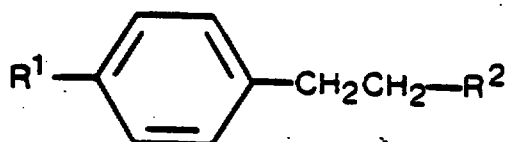


5

"PHENYLETHANES"

The present invention is concerned with novel tri-, tetra- and pentacyclic phenylethanes of the general formula

10



I

15

wherein R¹ signifies trans-4-alkylcyclohexyl, 4'-alkyl-4-biphenyl, p-(trans-4-alkylcyclohexyl)phenyl, 2-(trans-4-alkylcyclohexyl)ethyl or p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl and

20

R² signifies trans-4-alkylcyclohexyl, or R¹ signifies trans-4-alkylcyclohexyl and R² signifies p-(trans-4-alkylcyclohexyl)phenyl, p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl or 4'-(trans-4-alkyl-

25

cyclohexyl)-4-biphenyl, or R¹ signifies p-alkylphenyl and R² signifies p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl, and the alkyl groups in the substituents R¹ and R² are straight-chain groups containing 1 to 7

30

carbon atoms.

(11)

5 The invention is also concerned with the manufacture of the compounds of formula I above, liquid crystalline mixtures which contain compounds of formula I above as well as their use for electro-optical purposes.

10 The compounds in accordance with the invention contain one or two terminal trans-4-alkylcyclohexyl groups as well as 1-3 p-phenylene groups and one or two ethylene groups. The term "alkyl" in the aforementioned substituents R^1 and R^2 embraces the groups methyl, ethyl, propyl, butyl, pentyl, hexyl and heptyl.

15

Liquid crystals have recently gained considerable importance primarily as dielectrics in indicating devices, since the optical properties of such substances can be influenced by an applied voltage. Electro-optical devices
20 based on liquid crystals are well known to the person skilled in the art and can be based on various effects such as, for example, dynamic scattering, deformation of aligned phases (DAP type), the Schadt-Helfrich effect (rotation cell), the "guest-host effect" or a cholesteric-
25 -nematic phase transition.

The liquid crystals must satisfy a number of requirements in order to be suitable as dielectrics for electro-optical indicating devices. For example, they

must have a high chemical stability towards environmental factors (e.g. heat, air, moisture and the like), must be photochemically stable and colourless, must have short response times and not too high a viscosity, must have a nematic or cholesteric mesophase in all temperature ranges in which the liquid crystal cell is to be operated, and must give a good contrast. Other properties such as, for example, the threshold potential, the dielectric anisotropy and the electrical conductivity must fulfil different conditions depending on the type of cell which is used.

Since, in general, it is not possible to achieve all desired and to some extent contradictory properties with a single compound, attempts have mainly been made to optimize the properties for the particular applications by mixing several components. In this case it is, however, important that the components undergo no chemical reactions with one another and can be mixed well. Further, the mixtures formed should have no smectic mesophases.

The object of the present invention is therefore to provide novel compounds which permit the further improvement of the properties of liquid crystalline dielectrics.

It has now been found that the compounds provided

by the invention are very well suited as components of
5 liquid crystalline mixtures, since they surprisingly at the
same time have large mesophase ranges with high clearing
points as well as low viscosities and accordingly short res-
ponse times. Moreover, the melting points are often
very considerably super-coolable. Further, the compounds
10 provided by the invention have small absolute values of
the dielectric anisotropies and generally a nematic and/or
smectic mesophase. Furthermore, they have an excellent
chemical and photochemical stability and are colourless.
The compounds provided by the invention can be widely
15 used, since they have a good miscibility with other liquid
crystals and since liquid crystals having nematic or chole-
steric mesophases can be manufactured readily by mixing
the present compounds with other liquid crystalline and/or
non-liquid crystalline compounds. On the basis of the
20 aforementioned properties they are especially suitable for
increasing the clearing points of mixtures having low
viscosities, since in this case the viscosity is not
increased or is increased only insignificantly.

25 Those compounds of formula I in which the sum of
the carbon atoms in the two terminal alkyl groups of the
substituents R^1 and R^2 is 5 to 10 are preferred. Those

compounds of formula I in which R^1 signifies trans-4-alkylcyclohexyl, 4'-alkyl-4-biphenyl or p-(trans-4-alkylcyclohexyl)phenyl and R^2 signifies trans-4-alkylcyclohexyl, or R^1 signifies trans-4-alkylcyclohexyl and R^2 signifies 4'-(trans-4-alkylcyclohexyl)-4-biphenyl are also preferred.

The following are examples of preferred compounds of formula I:

1-[2-(Trans-4-propylcyclohexyl)ethyl]-4-(trans-4-ethylcyclohexyl)benzene,

1-[2-(trans-4-propylcyclohexyl)ethyl]-4-(trans-4-propylcyclohexyl)benzene,

1-[2-(trans-4-propylcyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,

1-[2-(trans-4-propylcyclohexyl)ethyl]-4-(trans-4-heptylcyclohexyl)benzene,

1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,

1-[2-(trans-4-pentylcyclohexyl)ethyl]-4-(trans-4-propylcyclohexyl)benzene,

1-[2-(trans-4-pentylcyclohexyl)ethyl]-4-(trans-4-butylcyclohexyl)benzene,

1-[2-(trans-4-pentylcyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,

4-(trans-4-ethylcyclohexyl)-4'-[2-(trans-4-propylcyclohexyl)ethyl]biphenyl,

- 5 4-(trans-4-propylcyclohexyl)-4'-[2-(trans-4-propyl-
cyclohexyl)ethyl]biphenyl,
- 4-(trans-4-butylcyclohexyl)-4'-[2-(trans-4-pentyl-
cyclohexyl)ethyl]biphenyl,
- 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-propyl-
cyclohexyl)ethyl]biphenyl,
- 10 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-butyl-
cyclohexyl)ethyl]biphenyl,
- 4-(trans-4-pentylcyclohexyl)-4'-[2-trans-4-pentyl-
cyclohexyl)ethyl]biphenyl,
- 4-(trans-4-heptylcyclohexyl)-4'-[2-(trans-4-propyl-
15 cyclohexyl)ethyl]biphenyl,
- 1-[2-(trans-4-ethylcyclohexyl)ethyl]-4-[2-(trans-
-4-propylcyclohexyl)ethyl]benzene,
- 1,4-bis[2-(trans-4-propylcyclohexyl)ethyl]benzene,
- 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-[2-(trans-4-
20 -pentylcyclohexyl)ethyl]benzene,
- 1-[2-(trans-4-pentylcyclohexyl)ethyl]-4-[2-(trans-4-
-propylcyclohexyl)ethyl]benzene,
- 1,4-bis[2-(trans-4-pentylcyclohexyl)ethyl]benzene,
- 1-[2-(trans-4-heptylcyclohexyl)ethyl]-4-[2-(trans-4-
25 -propylcyclohexyl)ethyl]benzene,
- 4-[2-(trans-4-ethylcyclohexyl)ethyl]-4'-[2-(trans-4-
-propylcyclohexyl)ethyl]biphenyl,
- 4,4'-bis[2-(trans-4-propylcyclohexyl)ethyl]biphenyl,
- 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-[2-(trans-4-
30 -pentylcyclohexyl)ethyl]biphenyl,

16

- 4-[2-(trans-4-pentylcyclohexyl)ethyl]-4'-[2-(trans-4-
5 -propylcyclohexyl)ethyl]biphenyl,
4,4'-bis[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl,
4-[2-(trans-4-heptylcyclohexyl)ethyl]-4'-[2-(trans-4-
-propylcyclohexyl)ethyl]biphenyl,
4-(trans-4-ethylcyclohexyl)-4'-(trans-4-propyl-
10 cyclohexyl)-1,1'-ethylenedibenzene,
4,4'-bis(trans-4-propylcyclohexyl)-1,1'-ethylene-
dibenzene,
4-(trans-4-butylcyclohexyl)-4'-(trans-4-pentyl-
cyclohexyl)-1,1'-ethylenedibenzene,
15 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propyl-
cyclohexyl)-1,1'-ethylenedibenzene,
4,4'-bis(trans-4-pentylcyclohexyl)-1,1'-ethylene-
dibenzene,
4-(trans-4-heptylcyclohexyl)-4'-trans-4-propylcyclo-
20 hexyl)-1,1'-ethylenedibenzene,
4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(trans-4-
-ethylcyclohexyl)-1,1'-ethylenedibenzene,
4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(trans-4-
-propylcyclohexyl)-1,1'-ethylenedibenzene,
25 4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(trans-4-
-pentylcyclohexyl)-1,1'-ethylenedibenzene,
4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(trans-4-
-heptylcyclohexyl)-1,1'-ethylenedibenzene,
4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-
30 -propylcyclohexyl)-1,1'-ethylenedibenzene,

- 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-
5 -pentylcyclohexyl)-1,1'-ethylenedibenzene,
4-[2-(trans-4-pentylcyclohexyl)ethyl]-4'-(trans-4-
-butylcyclohexyl)-1,1'-ethylenedibenzene,
4-[2-(trans-4-pentylcyclohexyl)ethyl]-4'-(trans-4-
-pentylcyclohexyl)-1,1'-ethylenedibenzene,
10 4-ethyl-4"-[2-(trans-4-propylcyclohexyl)ethyl]-p-
-terphenyl,
4-propyl-4"-[2-(trans-4-propylcyclohexyl)ethyl]-p-
-terphenyl,
4-butyl-4"-[2-(trans-4-pentylcyclohexyl)ethyl]-p-
15 -terphenyl,
4-pentyl-4"-[2-(trans-4-propylcyclohexyl)ethyl]-p-
-terphenyl,
4-pentyl-4"-[2-(trans-4-butylcyclohexyl)ethyl]-p-
-terphenyl,
20 4-pentyl-4"-[2-trans-4-pentylcyclohexyl)ethyl]-p-
-terphenyl,
4-heptyl-4"-[2-(trans-4-propylcyclohexyl)ethyl]-p-
-terphenyl,
4-(trans-4-ethylcyclohexyl)-4'-[2-(p-(trans-4-propyl-
25 cyclohexyl)phenyl)ethyl]biphenyl,
4-(trans-4-propylcyclohexyl)-4'-[2-(p-(trans-4-propyl-
cyclohexyl)phenyl)ethyl]biphenyl,
4-(trans-4-butylcyclohexyl)-4'-[2-(p-(trans-4-pentyl-
cyclohexyl)phenyl)ethyl]biphenyl,

4-(trans-4-pentylcyclohexyl)-4'-[2-(p-(trans-4-propyl-
cyclohexyl)phenyl)ethyl]biphenyl,

5 4-(trans-4-pentylcyclohexyl)-4'-[2-(p-(trans-4-butyl-
cyclohexyl)phenyl)ethyl]biphenyl,

4-(trans-4-pentylcyclohexyl)-4'-[2-(p-(trans-4-pentyl-
cyclohexyl)phenyl)ethyl]biphenyl,

10 4-(trans-4-heptylcyclohexyl)-4'-[2-(p-(trans-4-propyl-
cyclohexyl)phenyl)ethyl]biphenyl,

4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(p-ethyl-
phenyl)-1,1'-ethylenedibenzene,

4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(p-propyl-
phenyl)-1,1'-ethylenedibenzene,

15 4-[2-(trans-4-propylcyclohexyl)ethyl]-4'-(p-pentyl-
phenyl)-1,1'-ethylenedibenzene,

4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(p-pentyl-
phenyl)-1,1'-ethylenedibenzene,

20 4-[2-(trans-4-pentylcyclohexyl)ethyl]-4'-(p-butyl-
phenyl)-1,1'-ethylenedibenzene and

4-[2-(trans-4-pentylcyclohexyl)ethyl]-4'-(p-pentyl-
phenyl)-1,1'-ethylenedibenzene.

Especially preferred compounds of formula I are:

25 1-[2-(Trans-4-butylcyclohexyl)ethyl]-4-(trans-4-pentyl-
cyclohexyl)benzene,

4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentyl-
cyclohexyl)-1,1'-ethylenedibenzene and

(19)

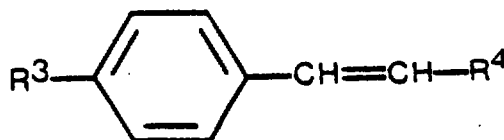
4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-butylcyclohexyl)ethyl]biphenyl.

5

The compounds of formula I can be manufactured in accordance with the invention by

(a) for the manufacture of the compounds of formula I
10 in which R^1 signifies trans-4-alkylcyclohexyl, 4'-alkyl-4-biphenyl, p-(trans-4-alkylcyclohexyl)phenyl or 2-(trans-4-alkylcyclohexyl)ethyl and R^2 signifies trans-4-alkylcyclohexyl, or R^1 signifies trans-4-alkylcyclohexyl and R^2 signifies p-(trans-4-alkylcyclohexyl)phenyl, p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl or 4'-(trans-4-alkylcyclohexyl)-4-biphenyl, or R^1 signifies p-alkylphenyl and R^2 signifies p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl,
15 catalytically hydrogenating a compound of the general formula

20



VII

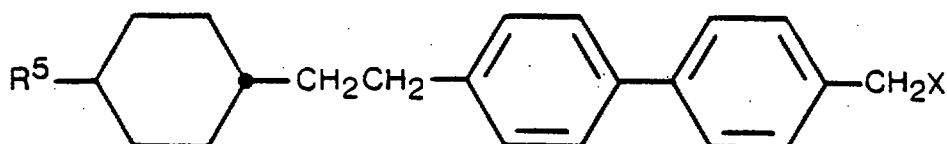
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wherein R^3 signifies trans-4-alkylcyclohexyl, 4'-alkyl-4-biphenyl, p-(trans-4-alkylcyclohexyl)phenyl or 2-(trans-4-alkylcyclohexyl)-

ethyl and R^4 signifies trans-4-alkyl-
 5 cyclohexyl, or R^3 signifies trans-4-
 -alkylcyclohexyl and R^4 signifies p-
 -(trans-4-alkylcyclohexyl)phenyl,
 p-[2-(trans-4-alkylcyclohexyl)ethyl]-
 phenyl or 4'-(trans-4-alkylcyclohexyl)-
 10 -4-biphenyl, or R^3 signifies p-alkyl-
 phenyl and R^4 signifies p-[2-(trans-4-
 -alkylcyclohexyl)ethyl]phenyl, and the
 alkyl groups in the substituents R^3
 and R^4 are straight-chain groups con-
 15 taining 1 to 7 carbon atoms,

or

(b) for the manufacture of the compounds of formula I
 in which R^1 signifies p-[2-(trans-4-alkylcyclohexyl)ethyl]-
 20 phenyl and R^2 signifies trans-4-alkylcyclohexyl, reacting
 a compound of the general formula

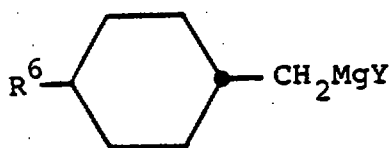


XI

(21)

wherein R^5 signifies a straight-chain
alkyl group containing 1 to 7 carbon
atoms and X signifies a leaving group,
with a compound of the general formula

10



XX

wherein R^6 signifies a straight-chain
alkyl group containing 1 to 7 carbon
atoms and Y signifies chlorine or
bromine,
in the presence of dilithium tetrachlorocuprate.

20

The catalytic hydrogenation of a compound of
formula VII can be carried out according to methods known
per se. Palladium is the preferred catalyst.

25

The reaction of a compound of formula XI with a
compound of formula XX can be carried out according to
methods known per se for the Fouquet-Schlosser coupling
reaction. As leaving groups X there come into considera-
tion all leaving groups which are usually used in such
reactions. Preferred leaving groups are chlorine, bromine,

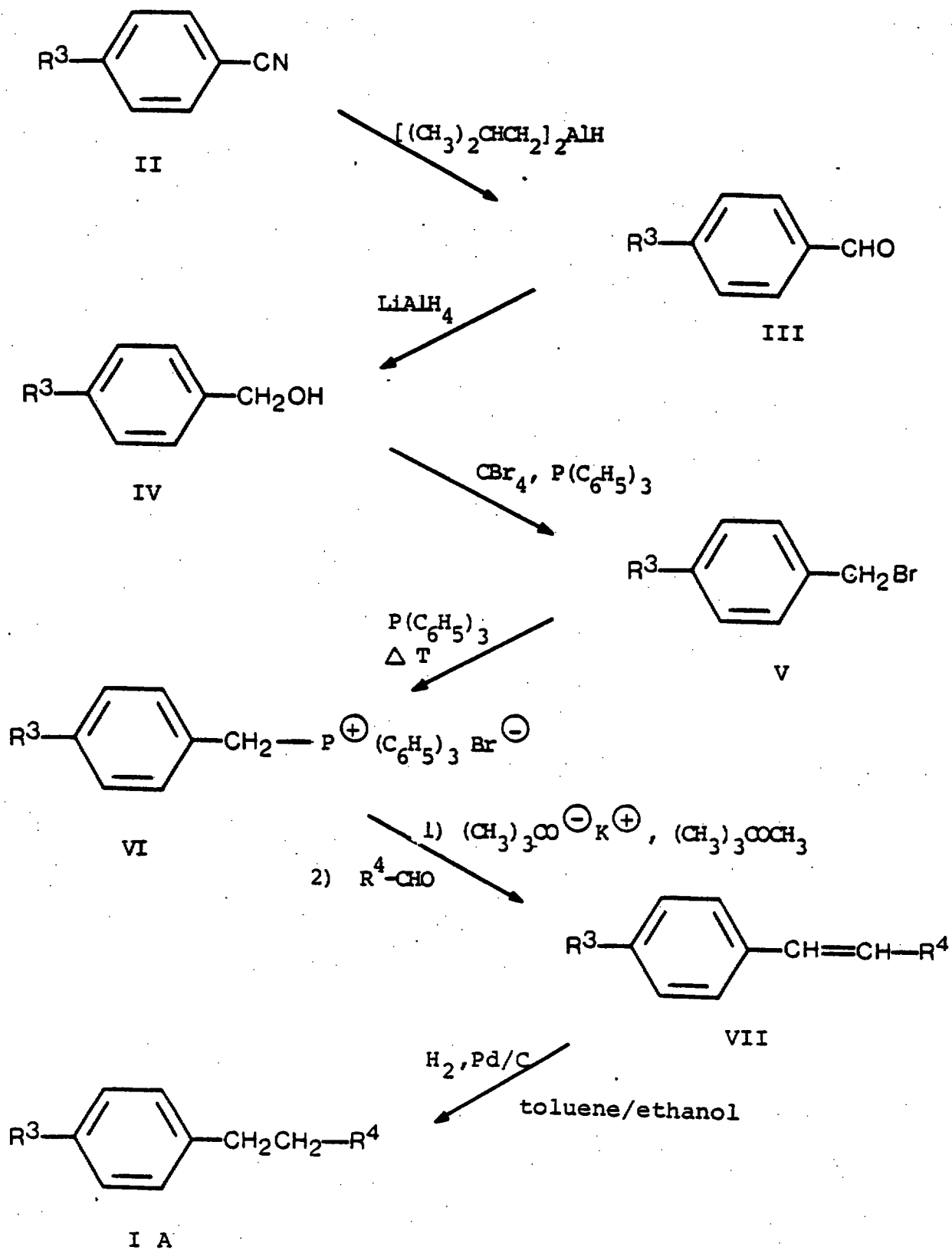
iodine and the p-tosyloxy group, especially bromine. Y preferably signifies bromine.

5

The preparation of the starting materials of formulae VII and XI and preferred methods for the manufacture of the compounds of formula I are illustrated hereinafter in Reaction Schemes 1 and 2 in which R^3 , R^4 ,
10 R^5 and R^6 have the significances given above.

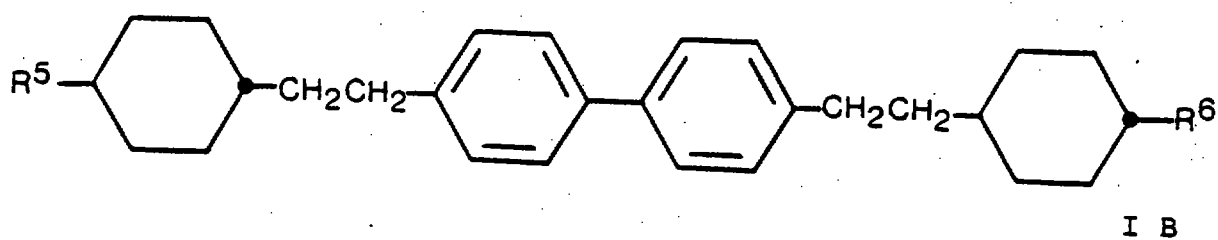
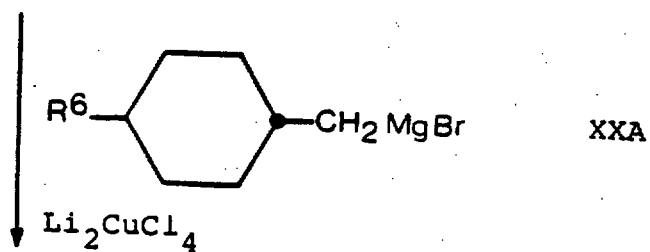
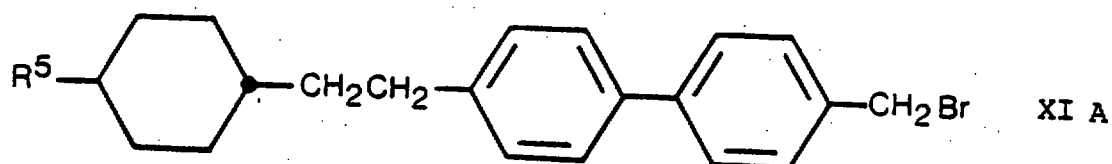
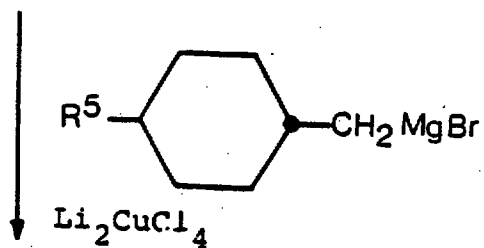
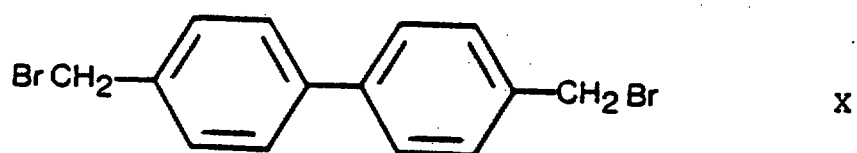
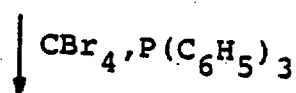
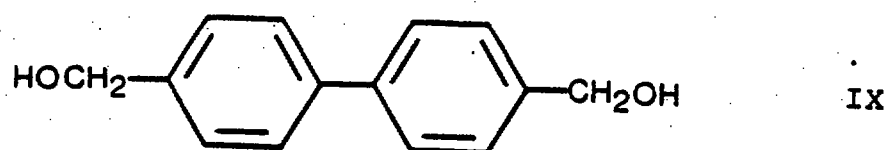
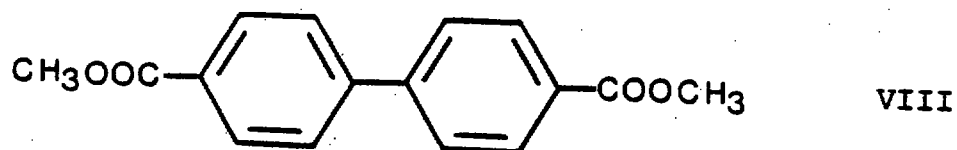
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Scheme 1



24

Scheme 2



25

The compounds of the formula R^4 -CHO in Scheme 1 can
5 be obtained in a simple manner from known compounds; for
example, the trans-4-alkylcyclohexanecarboxaldehydes can
be obtained by Rosenmund reduction of the corresponding acid
chlorides and the remaining compounds can be obtained by
reduction of the corresponding cyano compounds (in an
10 analogous manner to the preparation of the compounds of
formula III).

By reacting the compound of formula X with Grignard
reagents in accordance with Scheme 2 there can be obtained
15 compounds of formula XI or directly compounds of formula IB
in which R^5 and R^6 have the same significance. When at
least about 2 mol of Grignard reagent are used per mol of
the compound of formula X a compound of formula IB is
generally predominantly formed directly.

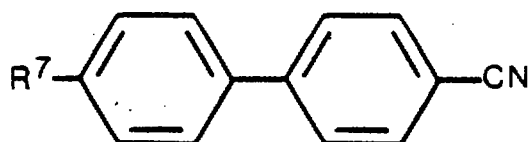
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The compounds of formula I can be used in the form
of mixtures with one or more other liquid crystalline and/or non-liquid
crystalline substances such as, for example, with substances
from the classes of the Schiff's bases, azobenzenes, azoxy-
25 benzenes, phenylbenzoates, cyclohexanecarboxylic acid phenyl
esters, cyclohexanecarboxylic acid cyclohexyl esters, bi-
phenyls, terphenyls, phenylcyclohexanes, cinnamic acid
derivatives, phenylpyrimidines, diphenylpyrimidines,
cyclohexylphenylpyrimidines, phenyldioxanes, 2-cyclohexyl-
30 -1-phenylethanes and the like. Such substances are known

to the person skilled in the art and many of them are,
5 moreover, commercially available.

The liquid crystal mixtures in accordance with the
invention contain, in addition to one or more compounds of
formula I, preferably one or more of the following compounds:

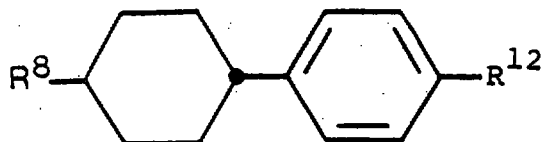
10 4-Cyanobiphenyls of the general formula



XII

15 wherein R^7 signifies a straight-chain
alkyl or alkoxy group containing 2 to
7 carbon atoms,

20 p-(trans-4-alkylcyclohexyl)benzonitriles or p-(trans-4-
-alkylcyclohexyl)alkylbenzenes of the general formula



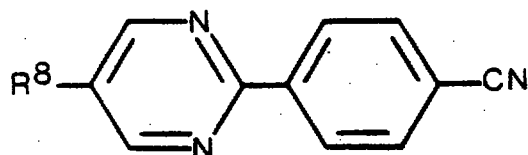
XIII

25 wherein R^8 signifies a straight-chain
alkyl group containing 2 to 7 carbon

27

atoms and R^{12} signifies the cyano group
 5 or a straight-chain alkyl group con-
 taining 1 to 7 carbon atoms,
 p-(5-alkyl-2-pyrimidinyl)benzonitriles of the general
 formula

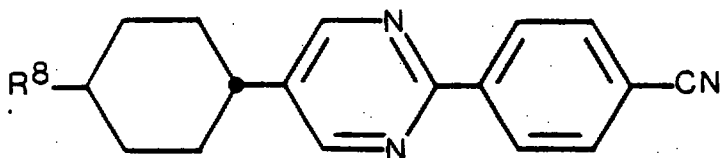
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XIV

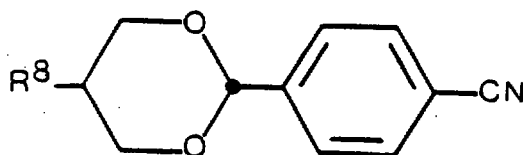
wherein R^8 has the above significance,
 15 p-[5-(trans-4-alkylcyclohexyl)-2-pyrimidinyl]benzonitriles
 of the general formula

20



XV

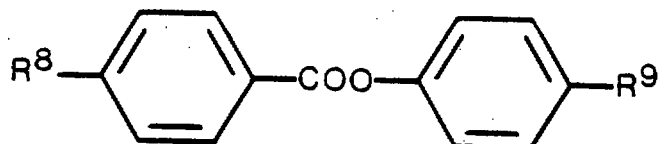
wherein R^8 has the above significance,
 p-(trans-5-alkyl-m-dioxan-2-yl)benzonitriles of the general
 25 formula



XVI

wherein R^8 has the above significance,

5 p-alkylbenzoic acid phenyl esters of the general formula



XVII

10

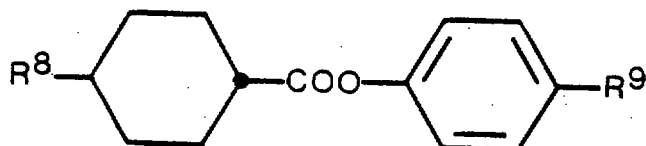
wherein R^9 signifies the cyano group

or a straight-chain alkoxy group

containing 1 to 6 carbon atoms and

15 R^8 has the above significance,

trans-4-alkylcyclohexanecarboxylic acid phenyl esters of
the general formula



XVIII

20

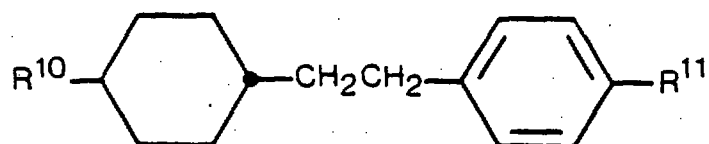
wherein R^8 and R^9 have the above sig-

25 nificances,

2-(trans-4-alkylcyclohexyl)-1-phenylethanes of the general
formula

29

5



XIX

10

wherein R^{10} signifies a straight-chain alkyl group containing 3 to 7 carbon atoms and R^{11} signifies the cyano group or a straight-chain alkyl or alkoxy group containing 1 to 7 carbon atoms, 4''-alkyl-4-cyano-p-terphenyls of the general formula

15

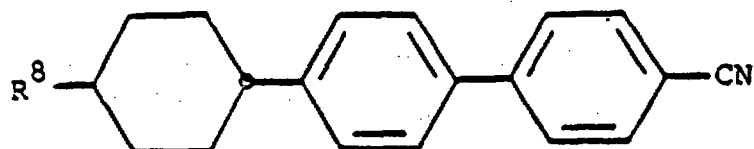


XXI

20

wherein R^8 has the above significance, or 4'-(trans-4-alkylcyclohexyl)-4-cyanobiphenyls of the general formula

25



XXII

wherein R^8 has the above significance.

5 The mixtures provided by the invention can contain one or more compounds of formula I. Mixtures which contain one or more compounds of formula I in an amount of about 1 weight % to about 50 weight % and one or more other suitable liquid crystalline and/or non-liquid crystalline
10 substances are preferred. Mixtures which contain about 3 weight % to about 30 weight % of compounds of formula I are especially preferred.

 The mixtures provided by the invention can contain
15 other suitable optically active compounds (e.g. optically active biphenyls) and/or dichroic colouring substances (e.g. azo, azoxy and anthraquinone colouring substances). The amount of such compounds is determined by the solubility and the desired pitch, colour, extinction and the like.
20 Preferably, the amount of optically active compounds is at most about 4 weight % and the amount of dichroic colouring substance is at most about 10 weight %.

 The manufacture of the liquid crystalline mixtures
25 and of the electro-optical devices can be carried out in a manner known per se and therefore need not be described herein in more detail.

The invention is also concerned with all novel

compounds, mixtures, processes, uses and devices as described herein.

The following Mixture Examples 1-11 are examples of preferred mixtures. The mixtures of Mixture Examples 5-8 are especially preferred. η signifies the viscosity (bulk viscosity), $\Delta\epsilon$ signifies the dielectric anisotropy, Δn signifies the optical anisotropy, t_{on} signifies the switching-on time (0-50% transmission), t_{off} signifies the switching-off time (100-10% transmission), V_{10} and V_{50} signify the threshold potential for 10% or 50% transmission (tilt angle 0°), N_{max} signifies the maximum number of multiplexible lines. k_{11} (splay) and k_{33} (bend) are elastic constants.

Mixture Example 1

20

Basic mixture A:

5.2 weight % of p-(5-pentyl-2-pyrimidinyl)benzonitrile,
11.5 weight % of p-(5-heptyl-2-pyrimidinyl)benzonitrile,
5.8 weight % of p-butylbenzoic acid p'-cyanophenyl ester,
25 12.2 weight % of trans-4-propylcyclohexanecarboxylic acid
p-cyanophenyl ester,
12.4 weight % of trans-4-pentylcyclohexanecarboxylic acid
p-cyanophenyl ester,
22.0 weight % of trans-4-butylcyclohexanecarboxylic acid p-
30 -ethoxyphenyl ester,

- 19.9 weight % of trans-4-pentylcyclohexanecarboxylic acid
5 p-methoxyphenyl ester,
11.0 weight % of p-[5-(trans-4-ethylcyclohexyl)-2-pyrimidinyl]benzonitrile,
cl.p. 72.5°C, η = 42 cp, nematic.
- 10 92 weight % of basic mixture A + 8 weight % of
4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl; cl.p. 91°C, η = 43 cp, nematic.
- 90 weight % of basic mixture A + 10 weight % of
15 4,4'-bis[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl; cl.p.
90.2°C, η = 43 cp, nematic.

Mixture Example 2

- 20 Basic mixture B:
4.1 weight % of p-(5-pentyl-2-pyrimidinyl)benzonitrile,
7.3 weight % of p-(5-heptyl-2-pyrimidinyl)benzonitrile,
14.0 weight % of trans-4-pentylcyclohexanecarboxylic acid
p-methoxyphenyl ester,
25 22.9 weight % of trans-4-pentylcyclohexanecarboxylic acid
p-propyloxyphenyl ester,
8.6 weight % of p-[5-(trans-4-ethylcyclohexyl)-2-pyrimidinyl benzonitrile,

6.5 weight % of p-[5-(trans-4-pentylcyclohexyl)-2-pyrimidinyl]benzonitrile,

36.6 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxyphenyl)ethane; cl.p. 69.9°C, η = 26.3 cp, nematic.

90 weight % of basic mixture B + 10 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl; cl.p. 87°C, η = 27 cp, nematic.

Mixture Example 3

Basic mixture C:

6.3 weight % of p-(5-pentyl-2-pyrimidinyl)benzonitrile,

12.3 weight % of p-(5-heptyl-2-pyrimidinyl)benzonitrile,

22.0 weight % of trans-4-pentylcyclohexanecarboxylic acid p-methoxyphenyl ester,

30.2 weight % of trans-4-pentylcyclohexanecarboxylic acid p-propyloxyphenyl ester,

15.5 weight % of 2-(trans-4-heptylcyclohexyl)-1-(p-ethoxyphenyl)ethane,

13.7 weight % of trans-4-(p-pentylphenyl)cyclohexanecarboxylic acid trans-4-propylcyclohexyl ester; cl.p. 60.3°C, η = 30.0 cp, nematic.

90 weight % of basic mixture C + 10 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl; cl.p. 79°C, η = 30.6 cp, nematic.

Mixture Example 4

5

Basic mixture D:

- 4.1 weight % of p-(5-pentyl-2-pyrimidinyl)benzonitrile,
8.2 weight % of p-(5-heptyl-2-pyrimidinyl)benzonitrile,
15.9 weight % of trans-4-pentylcyclohexanecarboxylic acid
10 p-methoxyphenyl ester,
27.1 weight % of trans-4-pentylcyclohexanecarboxylic acid
p-propyloxyphenyl ester,
24.7 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
15 6.5 weight % of p-[5-(trans-4-pentylcyclohexyl)-2-pyrimi-
dinyl]benzonitrile,
7.4 weight % of p-[(4 α H,8 α H)-decahydro-6 β -propyl-2 α -
-naphthyl]benzonitrile (racemate),
6.1 weight % of p-[(4 α H,8 α H)-decahydro-6 β -pentyl-2 α -
20 -naphthyl]benzonitrile (racemate); cl.p. 68.9°C, η = 28.2
cp, nematic.

- 90 weight % of basic mixture D + 10 weight % of 4-
-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-pentylcyclo-
25 hexyl)ethyl]biphenyl; cl.p. 87°C, η = 29 cp, nematic.

Mixture Example 5

- 3.89 weight % of 4'-propyl-4-cyanobiphenyl,
30 19.00 weight % of 4'-pentyl-4-cyanobiphenyl,

- 16.08 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
5 phenyl)ethane,
22.16 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
5.72 weight % of 4"-pentyl-4-cyano-p-terphenyl,
5.83 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyano-
10 biphenyl,
12.79 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-
-(trans-4-pentylcyclohexyl)benzene,
8.55 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
15 5.98 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-
-4-butylcyclohexyl)ethyl]biphenyl; m.p. < -30°C, cl.p.
91.2°C, nematic; $\eta = 24.8$ cp; $\Delta\epsilon = 6.19$; $\Delta n = 0.142$;
 $t_{on} = 25$ ms, $t_{off} = 40$ ms; $V_{10} = 2.76$ V, $V_{50} = 3.10$ V;
 $N_{max} = 76$; $k_{33}/k_{11} = 1.17$.

20

Mixture Example 6

- 3.70 weight % of 4'-propyl-4-cyanobiphenyl,
18.09 weight % of 4'-pentyl-4-cyanobiphenyl,
25 15.32 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
21.10 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,

- 5.45 weight % of 4"-pentyl-4-cyano-p-terphenyl,
5 5.55 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyanobi-
phenyl,
12.18 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-
(trans-4-pentylcyclohexyl)benzene,
8.14 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
10 -(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
5.70 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-
-4-butylcyclohexyl)ethyl]biphenyl,
4.77 weight % of 1-propyl-4-(trans-4-pentylcyclohexyl)ben-
zene; m.p. <-30°C, cl.p. 88.2°C, nematic; $\eta = 21.0$ cp;
15 $\Delta\epsilon = 5.84$, $\Delta n = 0.140$; $t_{on} = 24$ ms, $t_{off} = 38$ ms; $V_{10} =$
2.75V, $V_{50} = 3.08$ V; $N_{max} = 78$; $k_{33}/k_{11} = 1.05$.

Mixture Example 7

- 20 3.23 weight % of 4'-propyl-4-cyanobiphenyl,
16.75 weight % of 4'-pentyl-4-cyanobiphenyl,
16.03 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
9.72 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-butyl-
25 oxyphenyl)ethane,
18.56 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
4.75 weight % of 4"-pentyl-4-cyano-p-terphenyl,
4.84 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyanobi-
30 phenyl,

11.59 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-
5 -(trans-4-pentylcyclohexyl)benzene,
8.55 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
5.98 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-
-4-butylcyclohexyl)ethyl]biphenyl; m.p. <-30°C, cl.p. 85.7,
10 nematic; $\eta = 21.5$ cp; $\Delta\epsilon = 5.40$; $\Delta n = 0.133$; $t_{on} = 23$ ms,
 $t_{off} = 37$ ms; $V_{10} = 2.84V$, $V_{50} = 3.20V$; $N_{max} = 73$; $k_{33}/k_{11} =$
1.07.

Mixture Example 8

15
4.36 weight % of 4'-ethyl-4-cyanobiphenyl,
3.33 weight % of 4'-propyl-4-cyanobiphenyl,
16.49 weight % of 4'-pentyl-4-cyanobiphenyl,
15.67 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
20 phenyl)ethane.
6.36 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-butyl-
oxyphenyl)ethane,
18.19 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
25 4.90 weight % of 4"-pentyl-4-cyano-p-terphenyl,
4.98 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyano-
biphenyl,
11.92 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-
-(trans-4-pentylcyclohexyl)benzene,
30 6.90 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-

-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,

- 5 6.90 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-butylcyclohexyl)ethyl]biphenyl; m.p. $<-30^{\circ}\text{C}$, cl.p. 87.0°C , nematic; $\eta = 24.0$ cp; $\Delta\epsilon = 6.10$; $\Delta n = 0.143$; $t_{\text{on}} = 26$ ms, $t_{\text{off}} = 43$ ms; $V_{10} = 2.63\text{V}$, $V_{50} = 2.94$ V; $N_{\text{max}} = 78$; $k_{33}/k_{11} = 1.10$.

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Mixture Example 9

14.62 weight % of 4'-pentyl-4-cyanobiphenyl,

12.35 weight % of 4-hexyl-4-cyanobiphenyl,

- 15 14.48 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxyphenyl)ethane,

7.98 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-butyloxyphenyl)ethane,

- 20 15.96 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxyphenyl)ethane,

4.77 weight % of 4"-pentyl-4-cyano-p-terphenyl,

4.85 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyanobiphenyl,

10.46 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-

- 25 -(trans-4-pentylcyclohexyl)benzene,

8.55 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene;

5.98 weight % of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-butylcyclohexyl)ethyl]biphenyl; cl.p. 86.1°C , nematic.

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Mixture Example 10

5. 14.02 weight % of 4'-pentyl-4-cyanobiphenyl,
11.84 weight % of 4'-hexyl-4-cyanobiphenyl,
13.89 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
7.66 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-butyloxy-
10 phenyl)ethane,
15.30 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
4.57 weight % of 4"-pentyl-4-cyano-p-terphenyl,
4.66 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyanobiphe-
15 nyl,
10.03 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-
-(trans-4-pentylcyclohexyl)benzene,
9.83 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
20 8.20 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-propylcyclohexyl)-1,1'-ethylenedibenzene; nematic.

Mixture Example 11

- 25 4.29 weight % of 4'-ethyl-4-cyanobiphenyl,
3.27 weight % of 4'-propyl-4-cyanobiphenyl,
16.21 weight % of 4'-pentyl-4-cyanobiphenyl,
15.41 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,

- 6.26 weight % of 2-(trans-4-propylcyclohexyl)-1-(p-butyloxy-
5 phenyl)ethane,
17.88 weight % of 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane,
4.81 weight % of 4"-pentyl-4-cyano-p-terphenyl,
4.90 weight % of 4'-(trans-4-pentylcyclohexyl)-4-cyano-
10 biphenyl,
11.72 weight % of 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-
-(trans-4-pentylcyclohexyl)benzene,
8.47 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-
-4'-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene,
15 6.78 weight % of 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-
-(trans-4-propylcyclohexyl)-1,1'-ethylenedibenzene; nematic.

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The following Examples illustrate in more detail
5 the manufacture of the compounds provided by the invention.
C denotes a crystalline phase, S denotes a smectic phase,
N denotes a nematic phase and I denotes the isotropic phase.

Example 1

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2.20 g of 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-
-4-pentylcyclohexyl)vinyl]biphenyl were suspended in a
toluene/ethanol mixture (3:2) in a sulphonation flask,
treated with 200 mg of palladium/carbon (10%) and hydro-
15 genated at normal pressure and 50°C until the hydrogen
uptake came to a standstill. Filtration of the mixture
and concentration of the filtrate gave a white, semi-
-crystalline residue which, after recrystallization from
100 ml of hexane, yielded 1.55 g of 4-(trans-4-pentylcyclo-
20 hexyl)-4'-[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl as
colourless needles; transition (presumably S-S) 219.5°C,
transition S-N 243.2°C, cl.p. (N-I) 256.1°C. This sub-
stance showed itself to be very considerably super-coolable;
it did not crystallize upon cooling to room temperature.
25 Rf value (hexane): 0.32.

The 4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-
-pentylcyclohexyl)vinyl]biphenyl used as the starting
material was prepared as follows:

(a) A solution of 10.0 g of 4'-(trans-4-pentylcyclohexyl)-
5 -4-biphenylcarbonitrile in 150 ml of methylene chloride was
placed at -35°C in a sulphonation flask while gassing with
argon and treated within 8 minutes with 40 ml of an about
1.5N solution of diisobutylaluminium hydride in toluene.
After completion of the addition, the mixture was stirred
10 for 2 hours at -35°C and then for a further 1.5 hours with
gradual warming to 0°C, before it was treated cautiously
with 100 ml of 1N sulphuric acid and extracted three times
with 150 ml of diethyl ether each time. The organic phases
were washed with 100 ml of 1N sulphuric acid, twice with
15 100 ml of water each time and once with 100 ml of saturated
sodium chloride solution, dried over magnesium sulphate and
concentrated. There were obtained 9.5 g (95%) of 4'-(trans-
-4-pentylcyclohexyl)-4-biphenylcarboxaldehyde as a colour-
less, crystalline mass (m.p. 115-116°C) which was used in
20 the following step without further purification. R_f
value [toluene/ethyl acetate (19:1)]: educt 0.65, product
0.52.

(b) - A mixture of 930 mg of lithium aluminium hydride in
25 100 ml of absolute tetrahydrofuran was placed at 0°C in a
sulphonation flask and treated within 20 minutes with a
solution of 8.2 g of 4'-(trans-4-pentylcyclohexyl)-4-
-biphenylcarboxaldehyde in 100 ml of absolute tetrahydro-
furan. After completion of the addition, the mixture

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was stirred for a further 2 hours while warming to room
5 temperature, subsequently cautiously quenched with 100 ml of
1N sulphuric acid and extracted three times with 200 ml of
methylene chloride each time. The organic phases were
washed twice with 100 ml of water each time, dried over
magnesium sulphate and concentrated. There were obtained
10 7.90 g (96%) of 4'-(trans-4-pentylcyclohexyl)-4-biphenyl-
methanol as a colourless, crystalline mass (purity 99.4% in
accordance with gas chromatography) which was used in the
following step without further purification. M.p. 180.4°C;
Rf value [petroleum ether/ethyl acetate (9:1)]: educt 0.70,
15 product 0.30.

(c) A mixture of 3.5 g of 4'-(trans-4-pentylcyclohexyl)-
-4-biphenylmethanol and 2.9 g of triphenylphosphine in 150
ml of absolute methylene chloride was placed at -20°C in a
20 sulphonation flask while gassing with argon and treated
portionwise within 10 minutes with 3.8 g of solid tetra-
bromomethane. Partially undissolved educt thereby dis-
solved slowly. The mixture was stirred for a further 2
hours while warming to room temperature. The mixture
25 was subsequently concentrated on a rotary evaporator and
the crystalline residue was suspended in 300 ml of warm
hexane, freed by filtration from precipitated triphenyl-
phosphine oxide (rinsing with hexane) and the filtrate was

concentrated. Low-pressure chromatography (0.7 bar) of the
5 residue on silica gel with toluene as the eluant gave 3.39 g
(82%) of 4-(bromomethyl)-4'-(trans-4-pentylcyclohexyl)biphe-
nyl as colourless crystals. This material was used in the
following step without further purification. R_f value of
the product [petroleum ether/ethyl acetate (97:3)]: 0.47.

10

(d) A mixture of 2.63 g of 4-(bromomethyl)-4'-(trans-4-
-pentylcyclohexyl)biphenyl and 2.2 g of triphenylphosphine
in 150 ml of o-xylene was heated to reflux (bath temperature
160°C) for 15 hours in a sulphonation flask while gassing
15 with argon. After cooling, the white precipitate formed
was filtered off, washed several times with benzene and
dried in a high vacuum (0.1 mmHg) at 80°C for 1 hour. There
were obtained 3.48 g (80%) of [[4'-(trans-4-pentylcyclohexyl)-
-4-biphenyl]methyl]triphenylphosphonium bromide as a
20 white powder (m.p. 263-265°C) which was used in the follow-
ing Wittig reaction without further purification.

(e) A mixture of 3.31 g of [[4'-(trans-4-pentylcyclohe-
xyl)-4-biphenyl]methyl]triphenylphosphonium bromide in
25 50 ml of t-butyl methyl ether was placed at 0°C in a sul-
phonation flask while gassing with argon and treated with
617 mg of solid potassium 5-butylate. After completion
of the addition, the mixture was stirred at 0°C for a

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further 15 minutes (a deep orange coloration resulting)
5 and then treated within 10 minutes at 0°C with a solution
of 912 mg of trans-4-pentylcyclohexanecarboxaldehyde in
20 ml of t-butyl methyl ether. The mixture was subse-
quently stirred at 0°C for a further 30 minutes and at
room temperature for 90 minutes and then the yellow mix-
10 ture was poured into 150 ml of water and extracted three
times with 150 ml of diethyl ether each time. The organic
phases were washed twice with 100 ml of water each time,
dried over magnesium sulphate and concentrated. Low-
-pressure chromatography (0.7 bar) of the residue on silica
15 gel with toluene as the eluant gave 2.43 g (100%) of
4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-pentylcyclo-
hexyl)vinyl]biphenyl as a colourless, crystalline mass.
This material was used without further purification in the
hydrogenation described in the first paragraph of this
20 Example. Rf values of the product (hexane): 0.20 and
0.32 (cis/trans mixture).

The following compounds can be manufactured in an
analogous manner:

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4-(Trans-4-pentylcyclohexyl)-4'-[2-(trans-4-propyl-
cyclohexyl)ethyl]biphenyl; transition S-S 208.1°C, tran-
sition S-N 234.0°C, cl.p. (N-I) 263.5°C;

4-(trans-4-pentylcyclohexyl)-4'-[2-(trans-4-butyl-
30 cyclohexyl)ethyl]biphenyl; transition S-S 215.9°C,

transition S-N 240°C, cl.p. (N-I) 259°C;

5 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-
-propylcyclohexyl)-1,1'-ethylenedibenzene; m.p. (C-S)
68.9°C, transition S-S 117.5°C, transition S-N 171.5°C,
cl.p. (N-I) 187.3°C;

10 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-
-pentylcyclohexyl)-1,1'-ethylenedibenzene; m.p. (C-S)
48.0°C, cl.p. (S-I) 188.0°C;

 4-(trans-4-pentylcyclohexyl)-4'-[2-(p-(trans-4-butyl-
cyclohexyl)phenyl)ethyl]biphenyl; m.p. 65°C, cl.p. 331.6°C;

15 4-(trans-4-pentylcyclohexyl)-4'-[2-(p-(trans-4-pen-
tylcyclohexyl)phenyl)ethyl]biphenyl; cl.p. 323.5°C;

 4-(trans-4-pentylcyclohexyl)-4'-(trans-4-propylcyclo-
hexyl)-1,1'-ethylenedibenzene; m.p. (C-S) 116.8°C, tran-
sition S-N 198.5°C, cl.p. (N-I) 221.9°C;

20 4-pentyl-4"-[2-(trans-4-butylcyclohexyl)ethyl]-p-
-terphenyl; m.p. (C-S) 149.8°C, transition S-S 215.5°C,
transition S-N 263°C, cl.p. (N-I) 267°C;

 4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(p-pentyl-
phenyl)-1,1'-ethylenedibenzene; m.p. (C-S) 0°C, transition
S-S 76.5°C, cl.p. (S-I) 194°C;

25 1-[2-(trans-4-butylcyclohexyl)ethyl]-4-(trans-4-
-pentylcyclohexyl)benzene; m.p. (C-S) 28.1°C, cl.p. (S-I)
138.4°C;

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1-[2-(trans-4-pentylcyclohexyl)ethyl]-4-(trans-4-
5 -propylcyclohexyl)benzene; m.p. (C-S) 40.2°C, transition
S-N 126°C, cl.p. (N-I) 132.7°C; and

1-[2-(trans-4-butylcyclohexyl)ethyl]-4-[2-(trans-4-
-pentylcyclohexyl)ethyl]benzene; m.p. (C-S) 10.4 or
21.6°C (2 modifications), cl.p. (S-I) 125.8°C.

10

Example 2

(a) A suspension of 2.14 g of 4,4'-bis(hydroxymethyl)bi-
phenyl (prepared by reducing dimethyl biphenyl-4,4'-dicar-
15 boxylate with lithium aluminium hydride) and 5.5 g of
triphenylphosphine in 60 ml of methylene chloride was
placed at -10°C in a sulphonation flask while gassing with
argon and treated within 3 minutes with 7.3 g of tetra-
bromoethane. After completion of the addition, the mixture
20 was stirred for a further 16 hours with gradual warming to
+10°C and then, after concentration on a rotary evaporator,
trituated with hot benzene. Filtration and concentration
gave 12.67 g of crude product which, after low-pressure
chromatography (0.5 bar) with toluene on silica gel, yielded
25 2.60 g (76%) of 4,4'-bis(bromomethyl)biphenyl. A recryst-
tallization from 50 ml of acetone gave 1.78 g of the di-
bromide as colourless crystals of melting point 172.8°C.
Rf value [hexane/toluene (2:1)]: 0.41.

(b) 122 mg of magnesium shavings were covered with 3 ml
5 of absolute tetrahydrofuran in a sulphonation flask while
gassing with argon and, after the addition of a crystal of
iodine, treated with a solution of 1.24 g of trans-1-
-(bromomethyl)-4-pentylcyclohexane in 7 ml of absolute
tetrahydrofuran. After completion of the addition the
10 mixture was heated to reflux for a further 30 minutes and
then the mixture, cooled to -78°C , was treated in sequence
with 0.7 ml of a 0.1N solution of dilithium tetrachloro-
cuprate in tetrahydrofuran and with a solution of 670 mg
of 4,4'-bis(bromomethyl)biphenyl in 10 ml of absolute
15 tetrahydrofuran. The yellow colouration which initially
appeared disappeared again after a few minutes. The
mixture, warmed to -15°C , was subsequently stirred for a
further 17 hours, then treated with 25 ml of 2N hydrochlo-
ric acid and extracted three times with 50 ml of diethyl
20 ether each time. The organic phases were washed with 50
ml of saturated sodium chloride solution, dried over mag-
nesium sulphate and concentrated. Low-pressure chroma-
tography (0.5 bar) of the residue (1.06 g) on silica gel
with hexane and subsequently hexane/diethyl ether (19:1)
25 as the eluant gave in succession 1,1'-ethylene-bis(trans-
4-pentylcyclohexane), 228 mg (22%) of 4,4'-bis[2-(trans-
4-pentylcyclohexyl)ethyl]biphenyl, 78 mg (9%) of 4-(bromo-
methyl)-4'-[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl and
4,4'-bis(bromomethyl)biphenyl. A single crystallization
30 of the 228 mg of 4,4'-bis[2-(trans-4-pentylcyclohexyl)ethyl]-

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biphenyl from hexane yielded 194 mg of colourless needles
5 of clearing point $>300^{\circ}\text{C}$ (further phase transitions at 68°C ,
 84°C , 161°C , 203°C , 221°C and 224°C). Rf values (hexane):
4,4,-bis(bromomethyl)biphenyl 0.14; 4-(bromomethyl)-4'-
-[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl 0.24; 4,4'-
-bis[2-(trans-4-pentylcyclohexyl)ethyl]biphenyl 0.40.

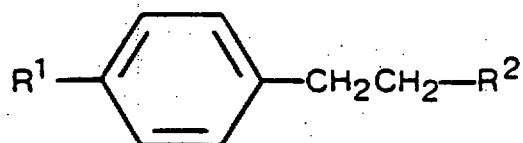
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CLAIMS:

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1. Compounds of the general formula



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wherein R^1 signifies trans-4-alkylcyclohexyl, 4'-alkyl-4-biphenyl, p-(trans-4-alkylcyclohexyl)phenyl, 2-(trans-4-alkylcyclohexyl)ethyl or p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl and R^2 signifies trans-4-alkylcyclohexyl, or R^1 signifies trans-4-alkylcyclohexyl and R^2 signifies p-(trans-4-alkylcyclohexyl)phenyl, p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl or 4'-(trans-4-alkylcyclohexyl)-4-biphenyl, or R^1 signifies p-alkylphenyl and R^2 signifies p-[2-(trans-4-alkylcyclohexyl)ethyl]phenyl, and the alkyl groups in the substituents R^1 and R^2 are straight-chain groups containing 1 to 7 carbon atoms.



- 42 -

2. Compounds according to claim 1,
25 wherein the sum of the carbon atoms in the alkyl groups of
the substituents R^1 and R^2 is 5 to 10.

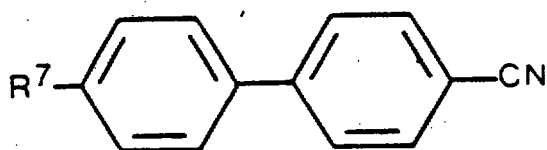
3. 1-[2-(Trans-4-butylcyclohexyl)ethyl]-4-(trans-4-
-pentylcyclohexyl)benzene.

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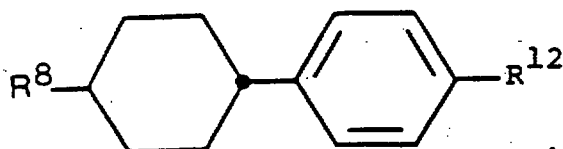
4. 4-[2-(Trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentylcyclohexyl)-1,1'-ethylenedibenzene.
5. 4-(Trans-4-pentylcyclohexyl)-4'-[2-(trans-4-butylcyclohexyl)ethyl]biphenyl.
- 10 6. A liquid crystalline mixture containing one or more compounds of formula I defined in claim 1 and one or more other suitable liquid crystalline and/or non-liquid crystalline substances.
- 15 7. A liquid crystalline mixture according to claim 6 containing one or more compounds of formula I and one or more compounds of the general formulae

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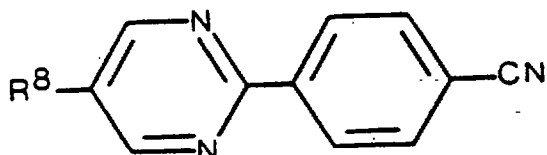


XII

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XIII

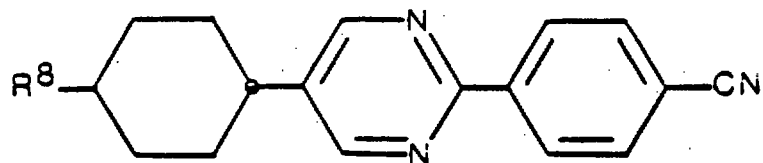


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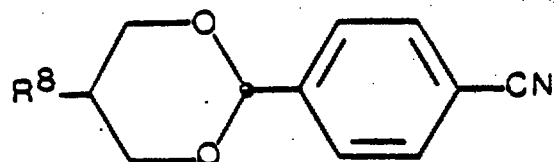
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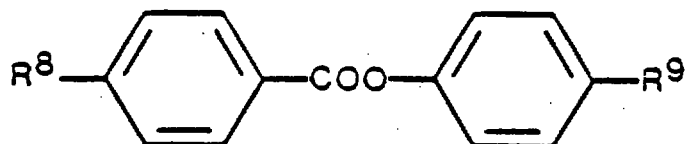
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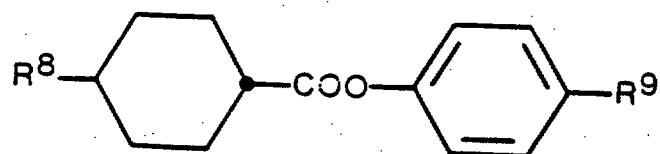
XVI

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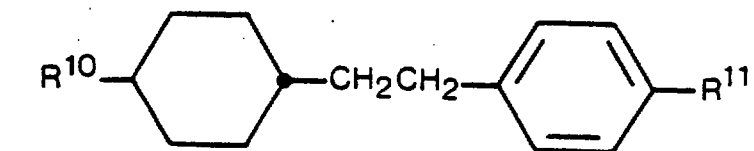
XVII

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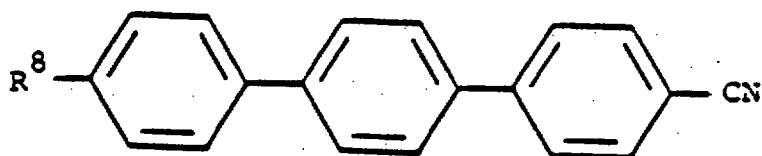


XVIII

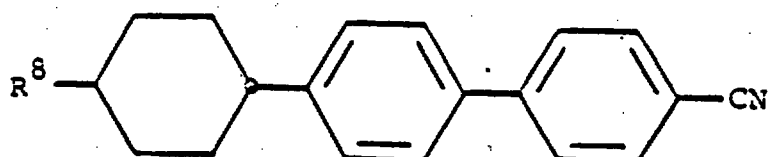
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XIX



XXI



XXII

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wherein R^7 signifies a straight-chain
alkyl or alkoxy group containing 2 to
7 carbon atoms, R^8 signifies a straight-
chain alkyl group containing 2 to 7
carbon atoms, R^9 signifies the cyano
group or a straight-chain alkoxy group
containing 1 to 6 carbon atoms, R^{10}
signifies a straight-chain alkyl group
containing 3 to 7 carbon atoms, R^{11}
signifies the cyano group or a straight-
chain alkyl or alkoxy group containing
1 to 7 carbon atoms and R^{12} signifies
the cyano group or a straight-chain
alkyl group containing 1 to 7 carbon
atoms.

8. A liquid crystalline mixture according to claim 6
or 7 containing 4'-propyl-4-cyanobiphenyl, 4'-pentyl-4-
-cyanobiphenyl, 2-(trans-4-propylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane, 2-(trans-4-pentylcyclohexyl)-1-(p-ethoxy-
phenyl)ethane, 4"-pentyl-4-cyano-p-terphenyl, 4'-(trans-4-
-pentylcyclohexyl)-4-cyanobiphenyl, 1-[2-(trans-4-butyl-
cyclohexyl)ethyl]-4-(trans-4-pentylcyclohexyl)benzene,
4-[2-(trans-4-butylcyclohexyl)ethyl]-4'-(trans-4-pentyl-
cyclohexyl)-1,1'-ethylenedibenzene and 4-(trans-4-pentyl-
cyclohexyl)-4'-[2-(trans-4-butylcyclohexyl)ethyl]biphenyl.

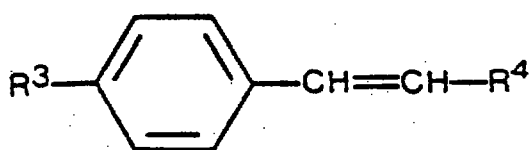


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9. A process for the manufacture of the compounds of
5 formula I defined in claim 1, which process comprises

(a) for the manufacture of the compounds of formula I
in which R^1 signifies trans-4-alkylcyclohexyl, 4'-alkyl-4-
-biphenyl, p-(trans-4-alkylcyclohexyl)phenyl or 2-(trans-
10 -4-alkylcyclohexyl)ethyl and R^2 signifies trans-4-alkyl-
cyclohexyl, or R^1 signifies trans-4-alkylcyclohexyl and
 R^2 signifies p-(trans-4-alkylcyclohexyl)phenyl, p-[2-
(trans-4-alkylcyclohexyl)ethyl]phenyl or 4'-(trans-4-alkyl-
cyclohexyl)-4-biphenyl, or R^1 signifies p-alkylphenyl
15 and R^2 signifies p-[2-(trans-4-alkylcyclohexyl)ethyl]-
phenyl, catalytically hydrogenating a compound of the
general formula

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VII

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wherein R^3 signifies trans-4-alkyl-
cyclohexyl, 4'-alkyl-4-biphenyl, p-(trans-4-alkylcyclohexyl)phenyl or
2-(trans-4-alkylcyclohexyl)ethyl and
 R^4 signifies trans-4-alkylcyclohexyl,
or R^3 signifies trans-4-alkylcyclo-
30 hexyl and R^4 signifies p-(trans-4-

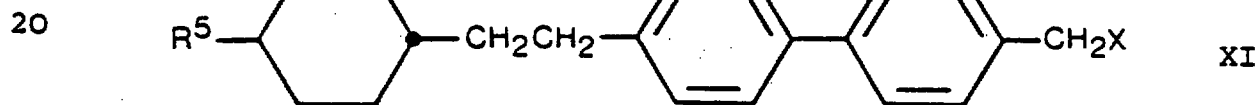
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-alkylcyclohexyl)phenyl, p-[2-(trans-
5 -4-alkylcyclohexyl)ethyl]phenyl or
4'-(trans-4-alkylcyclohexyl)-4-biphenyl,
or R^3 signifies p-alkylphenyl and R^4 sig-
nifies p-[2-(trans-4-alkylcyclohexyl)ethyl]-
phenyl, and the alkyl groups in the substi-
10 tuents R^3 and R^4 are straight-chain groups
containing 1 to 7 carbon atoms,

or

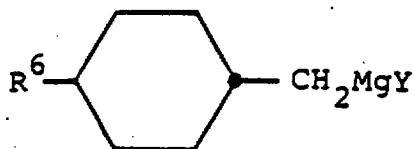
(b) for the manufacture of the compounds of formula I
15 in which R^1 signifies p-[2-(trans-4-alkylcyclohexyl)ethyl]-
phenyl and R^2 signifies trans-4-alkylcyclohexyl, reacting
a compound of the general formula



25 wherein R^5 signifies a straight-chain
alkyl group containing 1 to 7 carbon
atoms and X signifies a leaving group,
with a compound of the general formula



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XX

wherein R⁶ signifies a straight-chain
alkyl group containing 1 to 7 carbon
atoms and Y signifies chlorine or
10 bromine,
in the presence of dilithium tetrachlorocuprate.

10. Compounds of formula I according to any one of
claims 1 to 5 when manufactured by the process claimed
15 in claim 9 ~~or by an obvious chemical equivalent thereof.~~

11. The use of the compounds of formula I defined in
claim 1 for electro-optical purposes.
