



RAN 6220/130

The present invention is concerned with novel liquid crystalline compounds having a terminal cyclopentyl group, liquid
5 crystalline mixture containing such compounds and the use of such compounds and mixtures in optical devices.

Liquid crystals are used primarily as dielectrics in display devices, since the optical properties of such substances can be
10 influenced by an applied voltage. Electro-optical devices based on liquid crystals will be well-known to a person skilled in the art and can be based on various effects. Such devices are, for example, cells having dynamic scattering, DAP cells (deformation of aligned phases), guest/host cells, TN cells having a "twisted
15 nematic" structure, STN cells ("super twisted nematic"), SBE cells ("super birefringence effect") and OMI cells ("optical mode interference"). For displays having a high content of information, actively controlled cells, e.g. TFT cells ("thin film transistor"), have, in particular, recently become important in addition to
20 passively controlled, multiplexed cells. The most common display devices are based on the Schadt-Helfrich effect and have a twisted nematic structure.

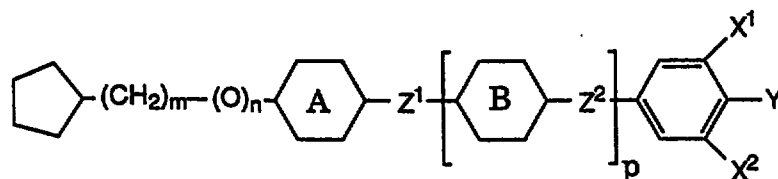
The liquid crystal materials must have a good chemical,
25 photochemical and thermal stability and a good stability towards electric fields. Further, they should have a suitable mesophase over a range which is as broad as possible (for example, a nematic or a cholesteric phase for the cells referred to above), but nevertheless should have a sufficiently low viscosity in order
30 to permit short response times, low threshold potentials and a high contrast in the cells. Further properties such as the electrical conductivity, the dielectric anisotropy and the optical anisotropy must fulfil different requirements depending on the field of application and type of cell. For example, materials for
35 cells having a twisted nematic structure should have a positive dielectric anisotropy which is as high as possible and at the same time should have a conductivity which is as low as possible. This latter property is of particular importance primarily for actively



addressed liquid crystal displays having a high density of information, e.g. TFT cells. Unfortunately, however, components having a high dielectric anisotropy mainly lead to an increased conductivity in mixtures because of their improved capacity to dissolve ionic impurities. Accordingly, components which are distinguished by a dielectric anisotropy which is as high as possible with simultaneously a conductivity which is as low as possible are sought after.

It has surprisingly been found that liquid crystalline compounds having a cyclopentyl group at the end of a side-chain or in place of a side-chain are distinguished by an increased clearing point or also an improved solubility. Moreover, the positive properties such as chemical stability, viscosity, dielectric and optical anisotropy etc. are scarcely influenced by the cyclopentyl group.

The present invention accordingly provides compounds of the general formula



wherein

rings A and B

each independently signify trans-1,4-cyclohexylene or 1,4-phenylene, which is optionally mono- or multiply-substituted with fluorine, or one of rings A and B also signifies trans-1,3-dioxane-5,2-diyl, pyridine-5,2-diyl or pyrimidine-5,2-diyl; Z¹ and Z² signify a single bond or one of groups Z¹ and Z² also signifies -(CH₂)₂-, -CH₂O-, -COO- or -C≡C-;

X¹ and X²

each independently signify hydrogen or fluorine;

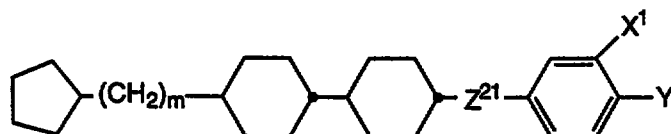


- Y signifies fluorine, chlorine, cyano, $-OCHF_2$,
 $-CHF_2$, $-OCF_3$ or $-CF_3$;
 m signifies a whole number of 0 to 7;
 n signifies 0 or, where A is an aromatic
 ring, also 1; and
 p signifies 0 or 1.

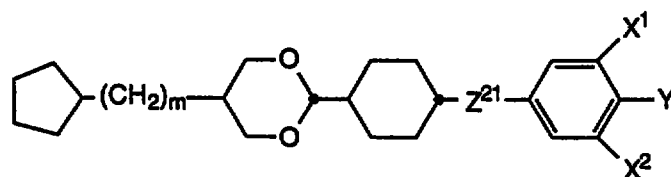
The compounds in accordance with the invention in which
 $m + n = 0$ or an even number are distinguished by a comparatively
 high clearing point without at the same the solubility of these
 compounds in liquid crystalline mixtures being lowered, with
 compounds of formula I in which $m = 0, 2$ or 4 and $n = 0$ being
 especially preferred. In the case of compounds of formula I in
 which $m + n =$ an odd number, especially the solubility in liquid
 crystalline mixtures is very much improved in comparison to
 conventional liquid crystalline compounds.

Especially preferred compounds of formula I are those in
 which ring A signifies trans-1,4-cyclohexylene, 1,4-phenylene,
 which is optionally mono- or multiply-substituted with fluorine,
 trans-1,3-dioxane-5,2-diyl or pyrimidine-5,2-diyl; and ring B
 signifies trans-1,4-cyclohexylene or 1,4-phenylene, which is
 optionally mono- or multiply-substituted with fluorine. The term
 "1,4-phenylene, which is optionally mono- or multiply-
 substituted with fluorine," signifies 1,4-phenylene, 2- or 3-
 fluoro-1,4-phenylene or 2,6- or 3,5-difluoro-1,4-phenylene.

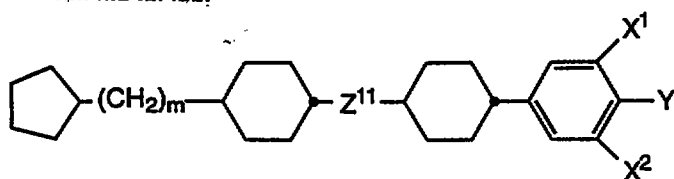
Other preferred compounds of formula I are those in which
 $p = 1$, especially compounds of the general formulae



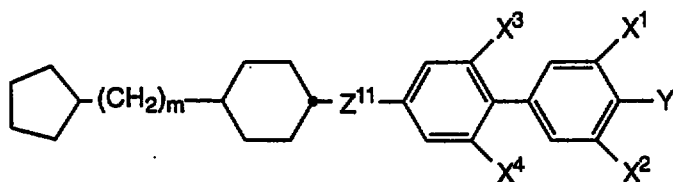
IA-1



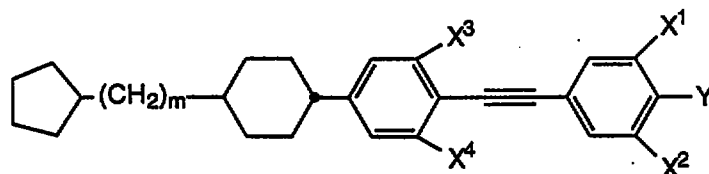
IA-2



IA-3



IA-4



IA-5

5

wherein

Z¹¹ and Z²¹signify a single bond or -(CH₂)₂-;X³ and X⁴

each independently signify hydrogen or fluorine; and

m, Y, X¹ and X² have the aforementioned significances.

10

The compounds of formulae IA-1 to IA-5 in which m signifies a whole number of 0 to 4, especially 0, 2 or 4, are particularly preferred.

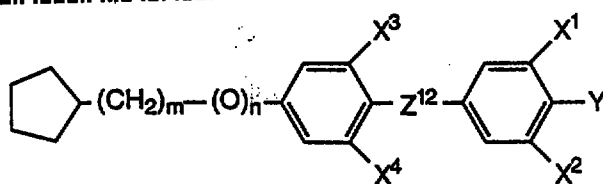
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The compounds of formulae 1A-1 to 1A-5 are suitable for passively addressed display devices, especially when Y signifies cyano. On the other hand, compounds of formulae 1A-1 to 1A-4 in which Y signifies fluorine, -CF₃, -OCHF₂ or -OCF₃ are distinguished by outstanding properties which qualify them mainly for use in actively addressed display devices. Y signifies fluorine in quite particularly preferred compounds of formulae IA-1 to IA-5.

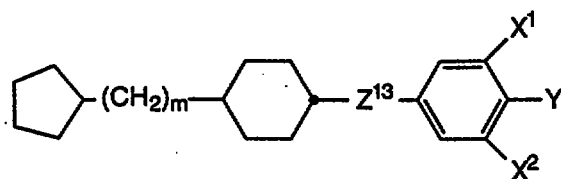
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A further aspect of the invention is concerned with compounds of general formula I in which p = 0; especially the compounds of the general formulae

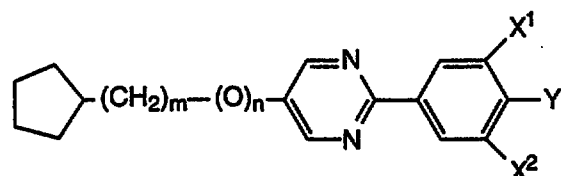
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IB-1



IB-2



IB-3

5 wherein

m is a whole number of 0 to 7;

n is 0 or 1;

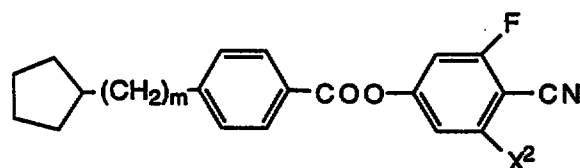
X³ and X⁴ each independently signify hydrogen or fluorine;

10 Z¹² signifies a single bond, -COO- or -C≡C-;

Z¹³ signifies a single bond, -(CH₂)₂-, -CH₂O- or -COO-; and

Y, X¹ and X² have the aforementioned significances.

15 Quite particularly preferred are the compounds of formula IB-1 in which Z¹² signifies -COO-, Y signifies cyano and X¹ signifies fluorine, especially the compounds of the general formula



20

IB-4

wherein m and X² have the aforementioned significances.

25 The compounds of formulae IB-1 to IB-3 and especially compounds of formula IB-4 are distinguished by a high dielectric anisotropy and are accordingly very well suited for use in



passively addressed display devices. The compounds IB-2 in which Z^{13} signifies a single bond or $-(CH_2)_2-$ and Y signifies fluorine, $-CF_3$, $-OCHF_2$ or $-OCF_3$ are especially suitable for actively addressed display devices.

5

The compounds of formula I in accordance with the invention can be produced in a manner known per se. Thus, compounds in which A = trans-1,4-cyclohexylene and m = 0 or 1 are preferably obtained via a Wittig reaction of a 4-substituted
10 cyclohexanone with a Wittig salt of a halo- or halomethyl-cyclopentane with triphenylphosphine with the addition of an equivalent of a suitable base such as e.g. potassium tert.butylate in an inert solvent, preferably between -20°C and room temperature, and subsequently catalytic hydrogenation,
15 preferably with platinum/charcoal in ethanol, ethanol/toluene mixtures and the like.

Compounds in which n = 0, m signifies a whole number of 2 to 6 and ring A signifies trans-1,4-cyclohexylene, optionally
20 substituted 1,4-phenylene, pyrimidine-5,2-diyl or pyridine-5,2-diyl are preferably produced by a Wittig reaction of a formyl compound with the corresponding cyclopentylalkyl Wittig salts and subsequent catalytic hydrogenation with palladium/charcoal e.g. in toluene.

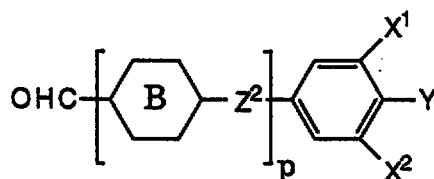
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Compounds in which ring A is optionally substituted 1,4-phenylene, p = 0 and m = 1 are preferably produced by a Friedel-Crafts acylation of the corresponding phenyl derivative with a cyclopentanoyl chloride and aluminium chloride, e.g. in dichloro-
30 methane, with reduction of the cyclopentanoylbenzene, e.g. according to Huang-Minlon.

Compounds in which ring A signifies optionally substituted 1,4-phenylene and p and m = 0 are preferably produced starting
35 from the cyclopentylbenzene obtainable by Friedel-Crafts alkylation of benzene with bromocyclopentane in the presence of aluminium chloride.



Compounds in which ring A signifies trans-1,3-dioxane-5,2-ylene are preferably produced by reaction of a sodium malonate (prepared in situ from an unsubstituted malonic ester with a sodium alkylate such as sodium methylate or sodium ethylate) with a corresponding bromo- or (ω -bromoalkyl)-cyclopentane, reduction of the resulting alkylated malonic ester with lithium aluminium hydride to the 2-alkylated 1,3-propanediol and acid-catalyzed reaction of the diol with an aldehyde of the formula



wherein the symbols have the aforementioned significances, in an inert solvent such as benzene or toluene, preferably at the boiling temperature.

These aforementioned processes are standard procedures of liquid crystal chemistry and will be known to a person skilled in the art.

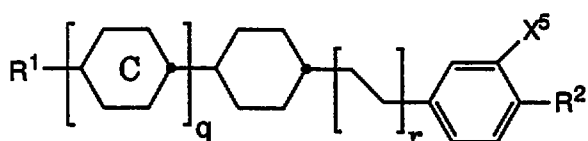
The compounds of formula I can be used in the form of mixtures with one another and/or with other liquid crystal components. Suitable liquid crystal components will be known to a person skilled in the art in large numbers, e.g. from D. Demus et al., *Flüssige Kristalle in Tabellen*, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig, volumes I and II, and, moreover, many of them are commercially available.

The invention is also concerned with liquid crystalline mixtures having at least two components, of which at least one component is a compound of formula I. A second component and further components which may be present can be other compounds of general formula I or other suitable liquid crystal components.

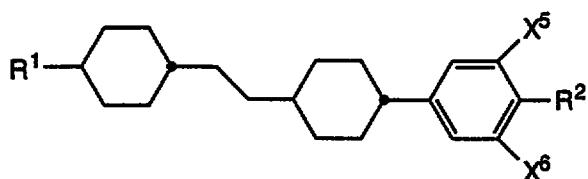


Having regard to the good solubility of the compounds of formula I in accordance with the invention in other liquid crystal materials and having regard to their good miscibility with one another, the content of compounds of formula I in the mixtures in accordance with the invention can be relatively high and can be, for example, 1-40 wt.%. In general, a content of about 2-30 wt.%, especially of about 3-25 wt.%, of compounds of formula I is preferred.

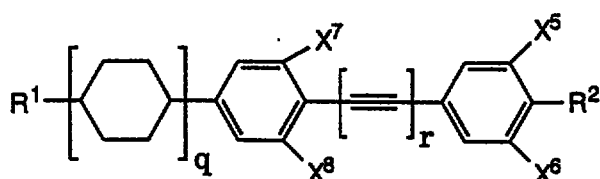
Preferably, the mixtures in accordance with the invention contain, in addition to one or more compounds of formula I, one or more compounds from the group of compounds of the formulae:



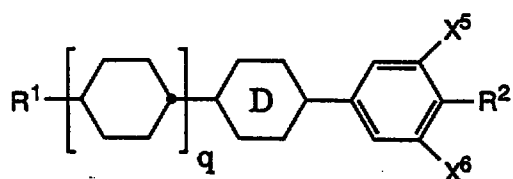
II



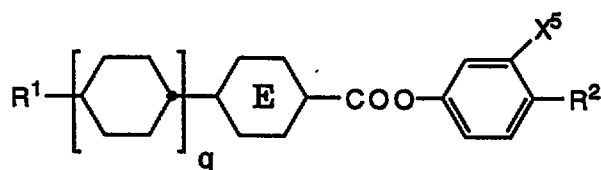
III



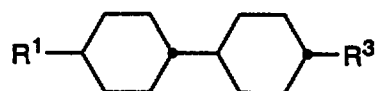
IV



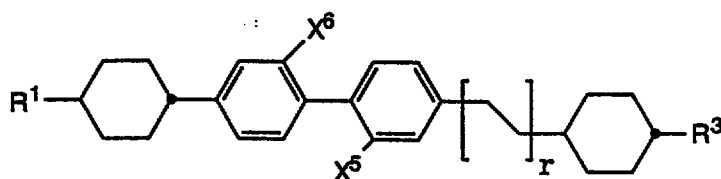
V



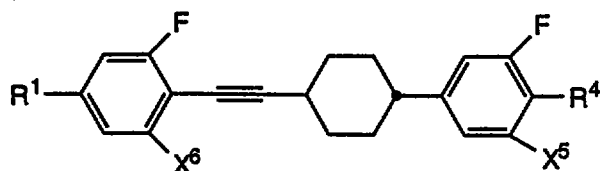
VI



VII



VIII



IX

wherein

- 5 R¹ and R³ signify alkyl, alkoxyalkyl, 3E-alkenyl, alkenyl having a terminal double bond, as well as on a saturated ring also 1E-alkenyl, with in each case a maximum of 7 carbon atoms;
- 10 R² signifies halogen, cyano, -OCF₃, -OCHF₂, -CF₃, alkyl, alkoxy, alkoxyalkyl, 2E-alkenyloxy, 3E-alkenyl or alkenyl or alkenyloxy having a terminal double bond with in each case a maximum of 5 carbon
- 15 R⁴ signifies halogen, cyano, -OCF₃, -OCHF₂ or -CF₃,
- X⁵-X⁸ each independently signify hydrogen or fluorine;
- 20 ring C signifies trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl;
- ring D signifies trans-1,3-dioxane-5,2-diyl, pyridine-5,2-diyl or pyrimidine-5,2-diyl;
- ring E signifies trans-1,4-cyclohexylene or 1,4-phenylene optionally mono- or di-
- 25 q and r substituted with fluorine; and each independently signify 0 or 1.

30 The terms used in connection with the compounds of formulae II to IX are as defined in more detail earlier.



The term "saturated rings" denotes trans-1,4-cyclohexylene or trans-1,3-dioxane-2,5-diyl.

The term "halogen" signifies fluorine or chlorine in connection with formulae II-XI.

- 5 The term "alkyl with a maximum of 7 carbon atoms" embraces straight-chain residues such as methyl, ethyl, propyl, butyl, pentyl, hexyl and heptyl and the like.

The term "alkoxyalkyl with a maximum of 7 carbon atoms" embraces straight-chain residues such as methoxymethyl, methoxyethyl, methoxypropyl, methoxybutyl, methoxypentyl, methoxyhexyl, ethoxymethyl, ethoxyethyl, ethoxypropyl and the like.

- 10 The term "3E-alkenyl with a maximum of 7 carbon atoms" embraces 3E-pentenyl, 3E-hexenyl and 3E-heptenyl.
- 15 The term "alkenyl having a terminal double bond with a maximum of 7 carbon atoms" embraces 2-propenyl, 3-butenyl, 4-pentenyl, 5-hexenyl, 6-heptenyl and on a saturated ring also vinyl.

The term "1E-alkenyl with a maximum of 7 carbon atoms" embraces 1E-propenyl, 1E-butenyl, 1E-pentenyl, 1E-hexenyl and 1E-heptenyl.

20 The term "alkoxy" embraces straight-chain residues in which alkyl is as defined above.

The term "alkenyloxy" having a terminal double bond embraces residues in which alkenyl is as defined above.

25

Residues R¹ and R³ with in each case a maximum of 5 carbon atoms are preferred.

- 30 The mixtures in accordance with the invention can also contain optically active compounds (e.g. optically active 4'-alkyl- or 4'-alkoxy-4-biphenylcarbonitriles). The content of such compounds is determined by the solubility, the desired helical pitch, and the like. In general, the content of optically active compounds is a maximum of about 5 wt.% in the final mixture.

35

Electro-optical display devices containing the aforementioned liquid crystalline mixtures in accordance with the invention are also an object of the present invention.

The production of the liquid crystalline mixtures and of the electro-optical display devices can be effected in a manner known per se.

5

The production of the compounds of formula I and of liquid crystalline mixtures containing these compounds are illustrated in more detail by the following Examples. C signifies a crystalline phase, S signifies a smectic phase, N signifies the nematic phase and I signifies the isotropic phase. V_{10} denotes the voltage for 10% transmission (viewing direction perpendicular to the plate surface). t_{on} and t_{off} denote, respectively, the switching-on time and the switching-off time, Δn denotes the optical anisotropy, and GC signifies gas chromatography.

10

15

Example 1

A solution of 0.40 g of 4-cyclopentylidene-trans-4'-(3,4-difluorophenyl)-bicyclohexyl in 15 ml of toluene/ethanol 1:2 (v/v) was hydrogenated with 50 mg of platinum(IV) oxide at room temperature and normal pressure until the hydrogen uptake came to a standstill. The crude product obtained after filtration and concentration of the filtrate was recrystallized three times from ethanol. There was obtained 0.184 g of pure trans-4-cyclopentyl-trans-4'-(3,4-difluorophenyl)-bicyclohexyl; m.p. (C-S_B) 97.8°C, S_B-N 101.4°C, cl.p. (N-I) 145°C.

20

25

The 4-cyclopentylidene-trans-4'-(3,4-difluorophenyl)-bicyclohexyl used as the starting material was prepared as follows:

30

A suspension of 5.6 g of cyclopentyl-triphenyl-phosphonium bromide in 50 ml of t-butyl methyl ether was treated with 1.4 g of potassium t-butyrate. The resulting red suspension was stirred at room temperature for 45 minutes and then treated dropwise at 3°C with a solution of 0.80 g of 4-[trans-4-(3,4-difluorophenyl)-cyclohexyl]-cyclohexanone in 20 ml of t-butyl

35



methyl ether. The reaction mixture was stirred at 3°C for a further 15 minutes and at room temperature for 6 hours, then stirred with 25 ml of saturated sodium hydrogen carbonate solution and diluted with diethyl ether. The aqueous phase was
5 separated and extracted with diethyl ether. The organic phase was combined, washed neutral with water, dried over sodium sulphate, filtered and the filtrate was concentrated. The residue was dissolved in 30 ml of methanol/water 4:1 (v/v) and hexane. The methanol phase was separated and the hexane phase was
10 washed three times with 15 ml of methanol/water 4:1 and concentrated. The residue (1.9 g) was flash chromatographed on 40 g of silica gel with hexane. A readily volatile byproduct (0.17 g) was distilled off from the product-containing fractions (0.80 g; GC purity 77%) in a bulb-tube at 180-200°/about
15 0.5 Torr.

The distillation residue (0.49 g, GC purity 99%) was recrystallized twice from 10 ml of ethanol each time. There was obtained 0.43 g of pure 4-cyclopentylidene-trans-4'-(3,4-
20 difluorophenyl)-bicyclohexane; m.p. 104.4°C.

In an analogous manner there can be produced:

trans-4-Cyclopentyl-trans-4'-(3,4,5-trifluorophenyl)-
25 bicyclohexyl;
trans-4-cyclopentyl-trans-4'-(4-trifluoromethoxy-phenyl)-
bicyclohexyl;
trans-4-cyclopentyl-trans-4'-(4-trifluoromethoxy-3-
fluorophenyl)-bicyclohexyl;
30 trans-4-cyclopentyl-trans-4'-(4-difluoromethoxy-phenyl)-
bicyclohexyl;
trans-4-cyclopentyl-trans-4'-(4-difluoromethoxy-3-
fluorophenyl)-bicyclohexyl;
trans-4-cyclopentyl-trans-4'-(4-difluoromethoxy-3,5-
35 difluorophenyl)-bicyclohexyl;
trans-4-cyclopentyl-trans-4'-(3,4-difluorophenethyl)-
bicyclohexyl;



trans-4-cyclopentyl-trans-4'-(3,4,5-trifluorophenethyl)-
bicyclohexyl;

trans-4-cyclopentyl-trans-4'-(4-trifluoromethoxy-
phenethyl)-bicyclohexyl;

5 trans-4-cyclopentyl-trans-4'-(4-difluoromethoxy-3-
fluorophenethyl)-bicyclohexyl;

trans-4-cyclopentyl-trans-4'-(4-difluoromethoxy-3,5-
difluorophenethyl)-bicyclohexyl;

10 1-[trans-4-[2-(trans-4-cyclopentyl-cyclohexyl)-ethyl]-
cyclohexyl]-3,4-difluorobenzene;

1-[trans-4-[2-(trans-4-cyclopentyl-cyclohexyl)-ethyl]-
cyclohexyl]-3,4,5-trifluorobenzene;

1-[trans-4-[2-(trans-4-cyclopentyl-cyclohexyl)-ethyl]-
cyclohexyl]-4-trifluoromethoxybenzene;

15 1-[trans-4-[2-(trans-4-cyclopentyl-cyclohexyl)-ethyl]-
cyclohexyl]-4-difluoromethoxy-3-fluorobenzene;

1-[trans-4-[2-(trans-4-cyclopentyl-cyclohexyl)-ethyl]-
cyclohexyl]-4-difluoromethoxy-3,5-difluorobenzene;

trans-4'-(4-cyclopentyl-cyclohexyl)-3,4-difluorobiphenyl;

20 trans-4'-(4-cyclopentyl-cyclohexyl)-3,4,5-trifluoro-
biphenyl;

trans-4'-(4-cyclopentyl-cyclohexyl)-3,4',2'-trifluoro-
biphenyl;

trans-4'-(4-cyclopentyl-cyclohexyl)-4-trifluoromethoxy-
25 biphenyl;

trans-4'-(4-cyclopentyl-cyclohexyl)-2'-fluoro-4-
trifluoromethoxy-biphenyl;

trans-4'-(4-cyclopentyl-cyclohexyl)-4-difluoromethoxy-3-
fluorobiphenyl;

30 trans-4'-(4-cyclopentyl-cyclohexyl)-4-difluoromethoxy-
3,5-difluorobiphenyl;

trans-4'-[2-(4-cyclopentyl-cyclohexyl)-ethyl]-3,4-
difluorobiphenyl;

trans-4'-[2-(4-cyclopentyl-cyclohexyl)-ethyl]-4-
35 trifluoromethoxy-biphenyl;

trans-4'-[2-(4-cyclopentyl-cyclohexyl)-ethyl]-4-
difluoromethoxy-3-fluorobiphenyl;



4-(trans-4'-cyclopentyl-bicyclohexyl-trans-4-yl)-
benzonitrile;

4-(trans-4'-cyclopentyl-bicyclohexyl-trans-4-yl)-2-
fluorobenzonitrile;

5 4-[2-(trans-4'-cyclopentyl-bicyclohexyl-trans-4-yl)-
ethyl]-2-fluorobenzonitrile;

4'-(trans-4-cyclopentyl-cyclohexyl)-biphenyl-4-
carbonitrile;

trans-4-(cyclopentyl-methyl)-trans-4'-(3,4-difluoro-
10 phenyl)-bicyclohexyl, m.p. (C-N) 76.4°C, S_B-N 40.5°C, cl.p. (N-I)
95.5°C;

trans-4-(cyclopentyl-methyl)-trans-4'-(3,4,5-trifluoro-
phenyl)-bicyclohexyl;

trans-4-(cyclopentyl-methyl)-trans-4'-(4-trifluoro-
15 methoxy-phenyl)-bicyclohexyl;

trans-4-(cyclopentyl-methyl)-trans-4'-(4-difluoro-
methoxy-3-fluorophenyl)-bicyclohexyl;

trans-4-(cyclopentyl-methyl)-trans-4'-(4-difluoro-
methoxy-3,5-difluorophenyl)-bicyclohexyl;

20 trans-4-(cyclopentyl-methyl)-trans-4'-(3,4-difluoro-
phenethyl)-bicyclohexyl;

trans-4-(cyclopentyl-methyl)-trans-4'-(3,4,5-trifluoro-
phenethyl)-bicyclohexyl;

trans-4-(cyclopentyl-methyl)-trans-4'-(4-trifluoro-
25 methoxy-phenethyl)-bicyclohexyl;

trans-4-(cyclopentyl-methyl)-trans-4'-(4-difluoro-
methoxy-3-fluorophenethyl)-bicyclohexyl;

1-[trans-4-[2-[trans-4-(cyclopentyl-methyl)-cyclohexyl]-
ethyl]-cyclohexyl]-3,4,5-trifluorobenzene;

30 trans-4'-[4-(cyclopentyl-methyl)-cyclohexyl]-3,4-difluoro-
biphenyl;

trans-4'-[4-(cyclopentyl-methyl)-cyclohexyl]-3,4,5-
trifluorobiphenyl;

trans-4'-[2-[4-(cyclopentyl-methyl)-cyclohexyl]-ethyl]-
35 3,4,5-trifluorobiphenyl.

Example 2

A solution of 0.54 g of trans-4-(2-cyclopentyl-vinyl)-trans-4'-(3,4,5-trifluorophenyl)-bicyclohexyl in 12 ml of toluene
5 was hydrogenated to a standstill using 80 mg of 5% palladium-on-charcoal at room temperature and normal pressure. The crude product obtained after filtration and concentration of the filtrate was recrystallized several times from ethanol. There was
10 obtained pure trans-4-(2-cyclopentylethyl)-trans-4'-(3,4,5-trifluorophenyl)-bicyclohexyl; m.p. (C-N) 91.6°C, cl.p. (N-I) 99.6°C.

The trans-4-(2-cyclopentyl-vinyl)-trans-4'-(3,4,5-trifluorophenyl)-bicyclohexyl used as the starting material was prepared as follows:

15

A suspension of 2.3 g of (cyclopentyl-ethyl)-triphenylphosphonium bromide in 15 ml of t-butyl-methyl ether was treated with 0.59 g of potassium t-butyrate. The resulting orange suspension was stirred at room temperature for 45 minutes and
20 then treated dropwise at 3°C with a solution of 0.85 g of trans-4'-(3,4,5-trifluorophenyl)-trans-4-bicyclohexyl-carboxaldehyde in 15 ml of t-butyl methyl ether. The reaction mixture was stirred at 3°C for a further 15 minutes and at room temperature for 2 hrs., and then stirred with 30 ml of saturated sodium
25 hydrogen carbonate solution. The aqueous phase was separated and extracted with diethyl ether. The organic phases were combined, washed neutral with water, dried over sodium sulphate, filtered and the filtrate was concentrated. The residue was taken up in methanol/water 4:1 and hexane. The methanol
30 phase was separated and the hexane phase was washed twice with 20 ml of methanol/water 4:1 each time and subsequently concentrated. Flash chromatography of the residue on 35 g of silica gel with hexane gave 0.74 g of trans-4-(2-cyclopentyl-vinyl)-trans-4'-(3,4,5-trifluorophenyl)-bicyclohexyl.

35

The following compounds can be produced in an analogous manner:



trans-4-(3-Cyclopentyl-propyl)-trans-4'-(3,4,5-trifluoro-phenyl)-bicyclohexyl;

trans-4-(4-cyclopentyl-butyl)-trans-4'-(3,4,5-trifluoro-phenyl)-bicyclohexyl;

5 trans-4-(5-cyclopentyl-pentyl)-trans-4'-(3,4,5-trifluoro-phenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(3,5-difluoro-4-difluoromethoxyphenyl)-bicyclohexyl;

10 trans-4-(3-cyclopentyl-propyl)-trans-4'-(3,5-difluoro-4-difluoromethoxyphenyl)-bicyclohexyl;

trans-4-(4-cyclopentyl-butyl)-trans-4'-(3,5-difluoro-4-difluoromethoxyphenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-cyano-3,5-difluorophenyl)-bicyclohexyl;

15 trans-4-(3-cyclopentyl-propyl)-trans-4'-(4-cyano-3,5-difluorophenyl)-bicyclohexyl;

trans-4-(4-cyclopentyl-butyl)-trans-4'-(4-cyano-3,5-difluorophenyl)-bicyclohexyl;

20 trans-4-(2-cyclopentyl-ethyl)-trans-4'-[3,5-difluoro-4-(2,2,2-trifluoroethoxy)phenyl]-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(3,4-difluoro-phenyl)-bicyclohexyl, m.p. (C-S_B) 57°C, S_B-N 74.8°C, cl.p. (N-I) 126.3°C;

25 trans-4-(3-cyclopentyl-propyl)-trans-4'-(3,4-difluoro-phenyl)-bicyclohexyl, m.p. (C-N) 54.0°C, S_B-N 19.1°C, cl.p. (N-I) 99.5°C;

trans-4-(4-cyclopentyl-butyl)-trans-4'-(3,4-difluoro-phenyl)-bicyclohexyl, m.p. (C-N) 61.1°C, S_B-N 59.8°C, cl.p. (N-I) 116.0°C;

30 trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-chloro-3-fluoro-phenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-(difluoro-methoxy)-3-fluoro-phenyl)-bicyclohexyl;

35 trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-(difluoro-methoxyphenyl)-bicyclohexyl;

trans-4-(4-cyclopentyl-butyl)-trans-4'-(4-difluoro-methoxyphenyl)-bicyclohexyl;



trans-4-(2-cyclopentyl-ethyl)-trans-4'-(3-fluoro-4-trifluoromethoxy-phenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-butyl)-trans-4'-(3-fluoro-4-trifluoromethoxy-phenyl)-bicyclohexyl;

5 trans-4-(2-cyclopentylethyl)-trans-4'-(4-cyano-3-fluorophenyl)-bicyclohexyl;

trans-4-(3-cyclopentyl-propyl)-trans-4'-(4-cyano-3-fluoro-phenyl)-bicyclohexyl;

10 trans-4-(4-cyclopentyl-butyl)-trans-4'-(4-cyano-3-fluorophenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-trifluoromethoxy-phenyl)-bicyclohexyl;

trans-4-(3-cyclopentyl-propyl)-trans-4'-(4-trifluoromethoxyphenyl)-bicyclohexyl;

15 trans-4-(4-cyclopentyl-butyl)-trans-4'-(4-trifluoromethoxyphenyl)-bicyclohexyl;

trans-4-(5-cyclopentyl-pentyl)-trans-4'-(4-trifluoromethoxyphenyl)-bicyclohexyl;

20 trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-difluoromethoxy-phenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-trifluoromethyl-phenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-fluorophenyl)-bicyclohexyl;

25 trans-4-(3-cyclopentyl-propyl)-trans-4'-(4-fluorophenyl)-bicyclohexyl;

trans-4-(4-cyclopentyl-pentyl)-trans-4'-(4-fluorophenyl)-bicyclohexyl;

30 trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-chlorophenyl)-bicyclohexyl;

trans-4-(2-cyclopentyl-ethyl)-trans-4'-(4-cyano-phenyl)-bicyclohexyl;

4'-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-3,4,5-trifluoro-biphenyl;

35 4'-[trans-4-(3-cyclopentyl-propyl)-cyclohexyl]-3,4,5-trifluoro-biphenyl;

4'-[trans-4-(4-cyclopentyl-butyl)-cyclohexyl]-3,4,5-trifluoro-biphenyl;



4'-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-3,4,2'-
trifluoro-biphenyl;

4'-[trans-4-(3-cyclopentyl-propyl)-cyclohexyl]-3,4,2'-
trifluoro-biphenyl;

5 4'-[trans-4-(4-cyclopentyl-butyl)-cyclohexyl]-3,4,2'-
trifluoro-biphenyl;

4'-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-4,2',6'-
trifluoro-biphenyl;

10 4-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-3,4,2',6'-
tetrafluoro-biphenyl;

4-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-4-difluoro-
methoxy-3,5-difluoro-biphenyl;

4-[trans-4-(3-cyclopentyl-propyl)-cyclohexyl]-4-difluoro-
methoxy-3,5-difluoro-biphenyl;

15 4-[trans-4-(4-cyclopentyl-butyl)-cyclohexyl]-4-difluoro-
methoxy-3,5-difluoro-biphenyl;

4-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-4-difluoro-
methoxy-3,2'-difluoro-biphenyl;

20 4'-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-4-trifluoro-
methoxy-3,2'-difluoro-biphenyl;

4'-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-4-trifluoro-
methoxy-2',6'-difluoro-biphenyl;

4'-[trans-4-(3-cyclopentyl-propyl)-cyclohexyl]-4-
trifluoromethoxy-2',6'-difluoro-biphenyl;

25 4'-[trans-4-(4-cyclopentyl-butyl)-cyclohexyl]-4-trifluoro-
methoxy-2',6'-difluoro-biphenyl;

4'-[trans-4-(2-cyclopentyl-ethyl)-cyclohexyl]-4-trifluoro-
methoxy-2',6'-difluoro-biphenyl;

30 4'-(4-cyclopentyl-butyl)-3,4-difluorobiphenyl;

4'-(5-cyclopentyl-pentyl)-3,4-difluorobiphenyl;

4'-(2-cyclopentyl-ethyl)-3,4-difluorotolane;

4'-(4-cyclopentyl-butyl)-3,4-difluorotolane;

4'-(4-cyclopentyl-butyl)-4-trifluoromethoxy-tolane;

5-(4-cyclopentyl-butyl)-2-(3,4-difluorophenyl)-pyridine;

35 5-(4-cyclopentyl-butyl)-2-(3,4-difluorophenyl)-pyrimidine;

5-(5-cyclopentyl-pentyl)-2-(3,4-difluorophenyl)-
pyrimidine;



5-(6-cyclopentyl-hexyl)-2-(3,4-difluorophenyl)-
pyrimidine;

5-(7-cyclopentyl-heptyl)-2-(3,4-difluorophenyl)-
pyrimidine;

5 5-(4-cyclopentyl-butyl)-2-(4-trifluoromethoxy-phenyl)-
pyrimidine;

5-(6-cyclopentyl-hexyl)-2-(4-trifluoromethoxy-phenyl)-
pyrimidine;

10 5-(4-cyclopentyl-butyl)-2-(3-fluoro-4-cyanophenyl)-
pyrimidine;

5-(5-cyclopentyl-pentyl)-2-(3-fluoro-4-cyanophenyl)-
pyrimidine;

5-(6-cyclopentyl-hexyl)-2-(3-fluoro-4-cyanophenyl)-
pyrimidine;

15 trans-1-(4-cyclopentyl-butyl)-4-(4-trifluoromethoxy-
phenyl)-cyclohexane;

trans-1-(6-cyclopentyl-hexyl)-4-(4-trifluoromethoxy-
phenyl)-cyclohexane;

20 trans-1-(2-cyclopentyl-ethyl)-4-(3,4-difluorophenyl)-
cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(3,4-difluorophenyl)-
cyclohexane;

trans-1-(6-cyclopentyl-hexyl)-4-(3,4-difluorophenyl)-
cyclohexane;

25 trans-1-(6-cyclopentyl-hexyl)-4-(4-chloro-3-fluoro-
phenyl)-cyclohexane;

trans-1-(2-cyclopentyl-ethyl)-4-(3-fluoro-4-trifluoro-
methoxy-phenyl)-cyclohexane;

30 trans-1-(4-cyclopentyl-butyl)-4-(3-fluoro-4-trifluoro-
methoxy-phenyl)-cyclohexane;

trans-1-(6-cyclopentyl-hexyl)-4-(3-fluoro-4-trifluoro-
methoxy-phenyl)-cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(4-difluoromethyl-3-
fluorophenyl)-cyclohexane;

35 trans-1-(6-cyclopentyl-hexyl)-4-(4-difluoromethyl-3-
fluorophenyl)-cyclohexane;

trans-1-(2-cyclopentyl-ethyl)-4-(3,4,5-trifluorophenyl)-
cyclohexane;



trans-1-(4-cyclopentyl-butyl)-4-(3,4,5-trifluorophenyl)-
cyclohexane;

trans-1-(5-cyclopentyl-pentyl)-4-(3,4,5-trifluorophenyl)-
cyclohexane;

5 trans-1-(6-cyclopentyl-hexyl)-4-(3,4,5-trifluorophenyl)-
cyclohexane;

trans-1-(7-cyclopentyl-heptyl)-4-(3,4,5-trifluorophenyl)-
cyclohexane;

10 trans-1-(4-cyclopentyl-butyl)-4-(3,5-difluoro-4-
trifluoromethoxy-phenyl)-cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(3,5-difluoro-4-
difluoromethoxy-phenyl)-cyclohexane;

trans-1-(6-cyclopentyl-hexyl)-4-(3,5-difluoro-4-
difluoromethoxy-phenyl)-cyclohexane;

15 trans-1-(4-cyclopentyl-butyl)-4-(4-trifluoromethoxy-
phenethyl)-cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(3,4-difluoro-phenethyl)-
cyclohexane;

20 trans-1-(6-cyclopentyl-hexyl)-4-(3,4-difluoro-phenethyl)-
cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(4-trifluoromethoxy-3-
fluoro-phenethyl)-cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(4-difluoromethoxy-3-
fluoro-phenethyl)-cyclohexane;

25 trans-1-(6-cyclopentyl-hexyl)-4-(4-difluoromethoxy-3-
fluoro-phenethyl)-cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(3,4,5-trifluoro-
phenethyl)-cyclohexane;

30 trans-1-(5-cyclopentyl-pentyl)-4-(3,4,5-trifluoro-
phenethyl)-cyclohexane;

trans-1-(6-cyclopentyl-hexyl)-4-(3,4,5-trifluoro-
phenethyl)-cyclohexane;

trans-1-(4-cyclopentyl-butyl)-4-(4-trifluoromethoxy-3,5-
difluoro-phenethyl)-cyclohexane;

35 trans-1-(4-cyclopentyl-butyl)-4-(4-difluoromethoxy-3,5-
difluoro-phenethyl)-cyclohexane;

trans-1-(6-cyclopentyl-hexyl)-4-(4-difluoromethoxy-3,5-
difluoro-phenethyl)-cyclohexane.

Example 3

A mixture of 1.902 g of 4-cyclopentyl-benzoic acid, 1.371 g
5 of 2-fluoro-4-hydroxy-benzonitrile, 0.122 g of 4-dimethylamino-
pyridine and 50 ml of dichloromethane was treated portionwise
within 3 minutes with 2.37 g of N,N'-dicyclohexyl-carbodiimide.
The resulting suspension was stirred at room temperature for 75
minutes and filtered. The filtrate was diluted with 150 ml of
10 diethyl ether. The solution was washed with 45 ml of 2M
hydrochloric acid, 20 ml of water, 15 ml of 1M soda solution and
twice with 20 ml of water each time, dried over sodium
sulphate, filtered and the filtrate was concentrated. The crude
product was chromatographed on 23 g of silica gel with
15 hexane/ethyl acetate 23:2 (v/v). Two-fold recrystallization of
the product-containing fractions (2.254 g) gave 1.982 g of pure
cyclopentyl-benzoic acid 4-cyano-3-fluoro-phenyl ester; m.p. (C-
I) 77.2°C, cl.p. (N-I) 27.3°C.

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

4-Cyclopentylmethyl-benzoic acid 4-cyano-3-fluorophenyl
ester, m.p. (C-I) 54.2°C;

25 4-(2-cyclopentyl-ethyl)-benzoic acid 4-cyano-3-fluoro-
phenyl ester, m.p. (C-I) 43.2°C, cl.p. (N-I) 24.1°C;

4-(3-cyclopentyl-propyl)-benzoic acid 4-cyano-3-fluoro-
phenyl ester, m.p. (C-I) 50.6°C, cl.p. (N-I) -4.9°C;

4-(4-cyclopentyl-butyl)-benzoic acid 4-cyano-3-fluoro-
30 phenyl ester, m.p. (C-I) 50.1°C, cl.p. (N-I) 24.9°C;

4-(5-cyclopentyl-pentyl)-benzoic acid 4-cyano-3-fluoro-
phenyl ester;

4-(cyclopentyl-methoxy)-benzoic acid 4-cyano-3-fluoro-
phenyl ester, m.p. (C-I) 63.3°C, cl.p. (N-I) 20.7°C;

35 4-(3-cyclopentyl-propyloxy)-benzoic acid 4-cyano-3-
fluorophenyl ester;

4-cyclopentyl-2-fluorobenzoic acid 4-cyano-3-fluorophenyl
ester;



4-(2-cyclopentyl-ethyl)-2-fluorobenzoic acid 4-cyano-3-fluorophenyl ester;

4-cyclopentyl-benzoic acid 4-cyano-3,5-difluorophenyl ester;

5 4-(2-cyclopentyl-ethyl)-benzoic acid 4-cyano-3,5-difluorophenyl ester;

4-cyclopentyl-benzoic acid 3,4-difluorophenyl ester.

Example 4

10

A mixture of 340 mg of 1-cyclopentyl-4-ethynylbenzene, 430 mg of 5-bromo-1,2,3-trifluorobenzene, 47 mg of tetrakis-(triphenylphosphine)palladium, 17 mg of copper(I) bromide and 12 ml of triethylamine is heated to boiling overnight. The
15 reaction mixture is evaporated in a vacuum. The residue is taken up in 30 ml of diethyl ether and 10 ml of water. The ether phase is washed with water, dried over sodium sulphate, filtered and the filtrate is concentrated. Chromatography of the residue on 10 g of silica gel with hexane yields pure 4'-cyclopentyl-3,4,5-
20 trifluorotolane.

The 1-cyclopentyl-4-ethynylbenzene used as the starting material can be prepared as follows:

25 a) A solution of 13.1 g of triphenylphosphine in 30 ml of dichloromethane is added dropwise within 5 minutes at 5-10°C to a solution of 8.3 g of tetrabromomethane in 30 ml of dichloromethane. The orange solution is stirred at 5°C for a further 10 min., then a solution of 8.7 g of 4-cyclopentylbenzaldehyde in
30 20 ml of dichloromethane is added dropwise at the same temperature within 10 minutes. The solution is stirred at 5°C for a further 30 min., then extracted carefully with 2 x 30 ml of saturated sodium hydrogen carbonate solution until the CO₂ evolution has finished, washed with 50 ml of water, dried over
35 sodium sulphate, filtered and the filtrate is concentrated. The residue is taken up in 50 ml of hexane and 50 ml of 80% aqueous methanol. The hexane phase is washed with 20 ml of 80% methanol and then concentrated. The resulting 1-cyclopentyl-4-



(2,2-dibromovinyl)-benzene is dissolved in 50 ml of tetrahydrofuran. About 10 ml of this solution are added to 0.42 g of magnesium shavings. The magnesium is activated by the addition of a small amount of bromine and the solution is heated until the reaction begins, then the remaining solution is added dropwise in such a manner that the mixture boils slightly. Thereafter, the mixture is heated to boiling for a further 1 hour, treated with 50 ml of hexane and washed with 30 ml of semi-saturated sodium hydrogen carbonate solution and 30 ml of water. The organic phase is dried over sodium sulphate, filtered and the filtrate is concentrated. Distillation of the residue yields 1-cyclopentyl-4-ethynyl-benzene.

The following compounds can be produced analogously:

15

4'-Cyclopentyl-4-trifluoromethyl-tolane

4'-cyclopentyl-4-trifluoromethoxy-tolane

4'-cyclopentyl-3,4-difluorotolane

4'-cyclopentyl-4-difluoromethoxy-3-fluorotolane

20

4'-(2-cyclopentyl-ethyl)-3,4-difluorotolane

4'-(trans-4-cyclopentyl-cyclohexyl)-3,4-difluoro-tolane

4'-(trans-4-cyclopentyl-cyclohexyl)-4-trifluoromethoxy-tolane

4'-(trans-4-cyclopentyl-cyclohexyl)-3,4,5-trifluorotolane

25

4'-(trans-4-cyclopentyl-cyclohexyl)-3,4,2'-trifluorotolane

4'-(trans-4-cyclopentyl-cyclohexyl)-3,4,2',6'-tetrafluorotolane

4'[trans-4-(2-cyclopentyl-ethyl)cyclohexyl]-3,4-difluorotolane

30

4'[trans-4-(2-cyclopentyl-ethyl)cyclohexyl]-3,4,5-trifluorotolane

4'[trans-4-(2-cyclopentyl-ethyl)cyclohexyl]-3,4,2'-trifluorotolane

35

4'[trans-4-(2-cyclopentyl-ethyl)cyclohexyl]-3,4,2',6'-tetrafluorotolane

4'[trans-4-(2-cyclopentyl-ethyl)cyclohexyl]-3,4,5,2',6'-pentafluorotolane

Example 5

A mixture of 0.67 g of trans-4-(3,4-difluorophenyl)-cyclohexanecarboxaldehyde, 0.46 g of 2-cyclopentyl-1,3-propanediol, 20 ml of toluene and 3 drops of 10% sulphuric acid is heated to boiling for one hour, with moist toluene being distilled off and being replaced by fresh toluene. The reaction mixture is neutralized with 2 drops of triethylamine and, after cooling, washed with 5 ml of sodium chloride solution, dried over sodium sulphate, filtered and concentrated. The residue is chromatographed on 15 g of silica gel with hexane/ethyl acetate vol. 97:3. Two-fold recrystallization of the product-containing fractions from ethanol yields pure trans-5-cyclopentyl-2-[trans-4-(3,4-difluorophenyl)-cyclohexyl]-1,3-dioxane.

15

The following compounds can be produced analogously:

- trans-5-Cyclopentyl-2-[trans-4-(3,4,5-trifluorophenyl)-cyclohexyl]-1,3-dioxane,
- 20 trans-5-cyclopentyl-2-[trans-4-(4-difluoromethoxy-3,5-difluorophenyl)-cyclohexyl]-1,3-dioxane,
- trans-5-cyclopentyl-2-[trans-4-(4-trifluoromethoxyphenyl)-cyclohexyl]-1,3-dioxane,
- trans-5-cyclopentyl-2-[trans-4-(3-fluoro-4-trifluoromethoxy-phenyl)-cyclohexyl]-1,3-dioxane,
- 25 trans-5-cyclopentyl-2-[trans-4-(3,4-difluorophenethyl)-cyclohexyl]-1,3-dioxane,
- trans-5-cyclopentyl-2-[trans-4-(3,4,5-trifluorophenethyl)-cyclohexyl]-1,3-dioxane,
- 30 trans-5-cyclopentyl-2-[trans-4-(4-difluoromethoxy-3-fluorophenethyl)-cyclohexyl]-1,3-dioxane,
- trans-5-cyclopentyl-2-[trans-4-(4-difluoromethoxy-3,5-difluorophenethyl)-cyclohexyl]-1,3-dioxane,
- trans-5-(2-cyclopentyl-ethyl)-2-[trans-4-(3,4,5-trifluorophenyl)-cyclohexyl]-1,3-dioxane,
- 35 trans-5-(2-cyclopentyl-ethyl)-2-[trans-4-(3,4,5-trifluorophenethyl)-cyclohexyl]-1,3-dioxane.

Example 6

A mixture of 412 mg of 3',4'-difluoro-biphenyl-4-ol, 420 mg of (3-bromopropyl)-cyclopentane, 5 ml of dimethyl-
5 formamide and 550 mg of finely powdered potassium carbonate is stirred at 50°C for 4 hours. The suspension is treated with 15 ml of toluene and 15 ml of water. The aqueous phase is separated. The toluene phase is washed several times with water, dried over sodium sulphate, filtered and the filtrate is
10 concentrated. The crude product is chromatographed on 10 g of silica gel with hexane/ethyl acetate vol. 49:1. Recrystallization from ethanol yields pure 4'-(3-cyclopentyl-propoxy)-3,4-difluorobiphenyl.

15 In an analogous manner there can be produced:

4'-(5-Cyclopentyl-pentoxy)-3,4-difluorobiphenyl,
4'-(5-cyclopentyl-pentoxy)-3,4,5-trifluorobiphenyl,
4'-(5-cyclopentyl-pentoxy)-4-trifluoromethoxy-biphenyl,
20 5-(5-cyclopentyl-pentoxy)-2-(3,4-difluorophenyl)-pyridine,
5-(5-cyclopentyl-pentoxy)-2-(3,4-difluorophenyl)-pyrimidine,
5-(6-cyclopentyl-hexyloxy)-2-(3,4-difluorophenyl)-pyrimidine,
25 5-(7-cyclopentyl-heptyloxy)-2-(3,4-difluorophenyl)-pyrimidine,
5-(5-cyclopentyl-pentoxy)-2-(3,4,5-trifluorophenyl)-pyrimidine,
5-(5-cyclopentyl-pentoxy)-2-(4-trifluoromethoxy-phenyl)-
30 pyrimidine,
5-(5-cyclopentyl-pentoxy)-2-(4-difluoromethoxy-3-fluorophenyl)-pyrimidine,
5-(5-cyclopentyl-pentoxy)-2-(4-difluoromethoxy-3,5-difluorophenyl)-pyrimidine,
35 4'-(cyclopentyl-methoxy)-3,4-difluorotolane,
4'-(cyclopentyl-methoxy)-4-chloro-3-fluorotolane,
4'-(cyclopentyl-methoxy)-4-trifluoromethoxy-tolane,



4'-(cyclopentyl-methoxy)-4-difluoromethoxy-3-fluoro-
tolane,
4'-(3-cyclopropyl-propoxy)-3,4-difluorotolane,
4'-(3-cyclopropyl-propoxy)-4-chloro-3-fluoro-tolane,
5 4'-(3-cyclopropyl-propoxy)-4-trifluoromethoxy-tolane,
4'-(3-cyclopropyl-propoxy)-4-difluoromethoxy-3-fluoro-
tolane,
4'-(3-cyclopropyl-propoxy)-3,4,5-trifluoro-tolane.

10

Example 7

Binary mixtures (BM) with 4-(trans-4-pentylcyclohexyl)-
benzonitrile were prepared in order to investigate the properties
of the compounds of formula I in mixtures. The threshold
15 potential (V_{10}) and the response times (t_{on} and t_{off}) were
measured at 22°C in a TN cell (low bias tilt) having a plate
separation of 8 μm ; the 2.5-fold value of the threshold potential
was chosen as the operating voltage. The corresponding data for
4-(trans-4-pentylcyclohexyl)-benzonitrile are: cl.p. (N-I) 54.6°C,
20 $V_{10} = 1.62\text{V}$, $t_{on} = 22\text{ ms}$, $t_{off} = 42\text{ ms}$, $\Delta n = 0.120$.

BM-1

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
25 10 wt.% of trans-4-(4-cyclopentyl-butyl)-trans-4'-(3,4-
difluorophenyl)-bicyclohexyl
cl.p. (N-I) 57.9°C, $V_{10} = 1.62\text{V}$, $t_{on} = 30\text{ ms}$, $t_{off} = 49\text{ ms}$, $\Delta n =$
0.118.

30 BM-2

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
20 wt.% of trans-4-(4-cyclopentyl-butyl)-trans-4'-(3,4-
difluorophenyl)-bicyclohexyl
35 cl.p. (N-I) 62.3°C, $V_{10} = 1.64\text{V}$, $t_{on} = 34\text{ ms}$, $t_{off} = 56\text{ ms}$, $\Delta n =$
0.113.

BM-3

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

10 wt.% of trans-4-(2-cyclopentyl-ethyl)-trans-4'-(3,4,5-
trifluorophenyl)-bicyclohexyl

cl.p. (N-I) 56.6°C, $V_{10} = 1.51V$, $t_{on} = 31$ ms, $t_{off} = 47$ ms, $\Delta n = 0.117$.

BM-4

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

20 wt.% of trans-4-(2-cyclopentyl-ethyl)-trans-4'-(3,4,5-
trifluorophenyl)-bicyclohexyl

cl.p. (N-I) 58.7°C, $V_{10} = 1.40V$, $t_{on} = 41$ ms, $t_{off} = 55$ ms, $\Delta n = 0.114$.

BM-5

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

10 wt.% of 4-cyclopentyl-benzoic acid 4-cyano-3-fluoro-phenyl
ester

cl.p. (N-I) 50.1°C, $V_{10} = 1.35V$, $t_{on} = 33$ ms, $t_{off} = 52$ ms, $\Delta n = 0.125$.

BM-6

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

20 wt.% of 4-cyclopentyl-benzoic acid 4-cyano-3-fluoro-phenyl
ester

cl.p. (N-I) 46.2°C, $V_{10} = 1.14V$, $t_{on} = 45$ ms, $t_{off} = 67$ ms, $\Delta n = 0.126$.

BM-7

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

10 wt.% of 4-(cyclopentyl-methyl)-benzoic acid 4-cyano-3-
fluorophenyl ester



cl.p. (N-I) 46.3°C, $V_{10} = 1.31V$, $t_{on} = 34$ ms, $t_{off} = 56$ ms, $\Delta n = 0.120$.

BM-8

5

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

20 wt.% of 4-(cyclopentyl-methyl)-benzoic acid 4-cyano-3-fluorophenyl ester

10 cl.p. (N-I) 37.9°C, $V_{10} = 1.06V$, $t_{on} = 50.2$ ms, $t_{off} = 82$ ms, $\Delta n = 0.114$.

BM-9

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

15 10 wt.% of 4-(2-cyclopentyl-ethyl)-benzoic acid 4-cyano-3-fluorophenyl ester

cl.p. (N-I) 49.9°C, $V_{10} = 1.42V$, $t_{on} = 31$ ms, $t_{off} = 52$ ms, $\Delta n = 0.123$.

20 BM-10

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

20 wt.% of 4-(2-cyclopentyl-ethyl)-benzoic acid 4-cyano-3-fluorophenyl ester

25 cl.p. (N-I) 45.6°C, $V_{10} = 1.23V$, $t_{on} = 42$ ms, $t_{off} = 68$ ms, $\Delta n = 0.124$.

BM-11

30 90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile

10 wt.% of 4-(3-cyclopentyl-propyl)-benzoic acid 4-cyano-3-fluorophenyl ester

cl.p. (N-I) 47.8°C, $V_{10} = 1.31V$, $t_{on} = 36$ ms, $t_{off} = 57$ ms, $\Delta n = 0.120$.

35

**BM-12**

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
20 wt.% of 4-(3-cyclopentyl-propyl)-benzoic acid 4-cyano-3-
5 fluorophenyl ester
cl.p. (N-I) 41.0°C, $V_{10} = 1.11\text{V}$, $t_{\text{on}} = 50\text{ ms}$, $t_{\text{off}} = 81\text{ ms}$, $\Delta n =$
0.116.

BM-13

10

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
10 wt.% of 4-(4-cyclopentyl-butyl)-benzoic acid 4-cyano-3-
fluorophenyl ester
cl.p. (N-I) 50.4°C, $V_{10} = 1.41\text{V}$, $t_{\text{on}} = 32\text{ ms}$, $t_{\text{off}} = 54\text{ ms}$, $\Delta n =$
15 0.123.

BM-14

20

80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
20 wt.% of 4-(4-cyclopentyl-butyl)-benzoic acid 4-cyano-3-
fluorophenyl ester
cl.p. (N-I) 46.6°C, $V_{10} = 1.25\text{V}$, $t_{\text{on}} = 45\text{ ms}$, $t_{\text{off}} = 74\text{ ms}$, $\Delta n =$
0.123.

25 **BM-15**

90 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
10 wt.% of 4-(cyclopentyl-methoxy)-benzoic acid 4-cyano-3-
fluorophenyl ester
30 cl.p. (N-I) 51.4°C, $V_{10} = 1.39\text{V}$, $t_{\text{on}} = 36\text{ ms}$, $t_{\text{off}} = 58\text{ ms}$, $\Delta n =$
0.125.

BM-16

35 80 wt.% of 4-(trans-4-pentylcyclohexyl)-benzonitrile
20 wt.% of 4-(cyclopentyl-methoxy)-benzoic acid 4-cyano-3-
fluorophenyl ester

cl.p. (N-I) 47.9°C, $V_{10} = 1.20\text{V}$, $t_{\text{on}} = 51\text{ ms}$, $t_{\text{off}} = 84\text{ ms}$, $\Delta\eta = 0.126$.

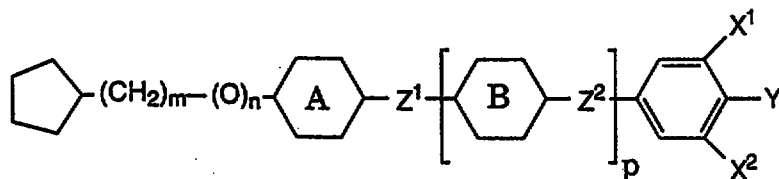
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Claims

1. Compounds of the general formula



wherein

rings A and B

each independently signify trans-1,4-cyclohexylene or 1,4-phenylene, which is optionally mono- or multiply-substituted with fluorine, or one of rings A and B also signifies trans-1,3-dioxane-5,2-diyl, pyridine-5,2-diyl or pyrimidine-5,2-diyl;

Z¹ and Z²

signify a single bond or one of groups Z¹ and Z² also signifies -(CH₂)₂-, -CH₂O-, -COO- or -C≡C-;

X¹ and X²

each independently signify hydrogen or fluorine;

Y

signifies fluorine, chlorine, cyano, -OCHF₂, -CHF₂, -OCF₃ or -CF₃;

m

signifies a whole number of 0 to 7;

n

signifies 0 or, where A is an aromatic ring, also 1; and

p

signifies 0 or 1.

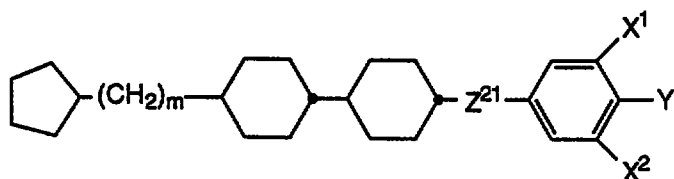
2. Compounds according to claim 1, wherein ring A signifies trans-1,4-cyclohexylene, 1,4-phenylene, which is optionally mono- or multiply-substituted with fluorine, trans-1,3-dioxane-5,2-diyl, pyridine-5,2-diyl or pyrimidine-5,2-diyl; and ring B signifies trans-1,4-cyclohexylene or 1,4-phenylene, which is optionally mono- or multiply-substituted with fluorine.

3. Compounds according to claim 1 or 2, wherein p = 1.

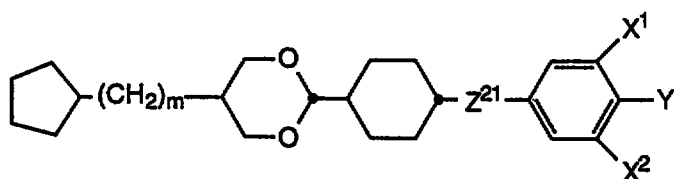




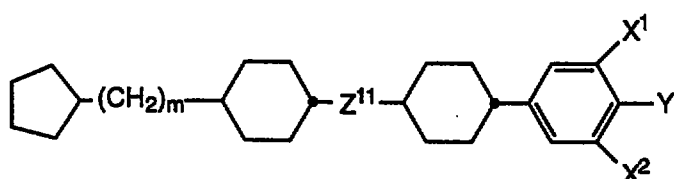
4. Compounds according to any one of claims 1 to 3 of the general formulae



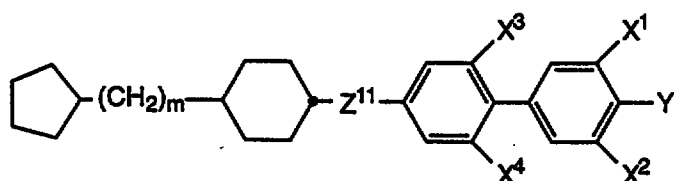
IA-1



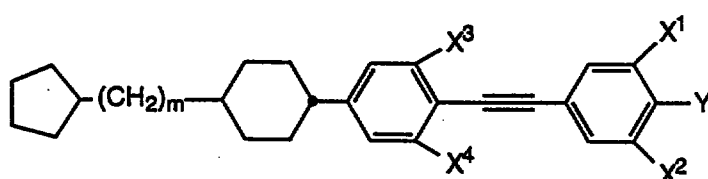
IA-2



IA-3



IA-4



IA-5

wherein

Z11 and Z21

signify a single bond or $-(CH_2)_2-$;

X3 and X4

each independently signify hydrogen or fluorine; and

m, Y, X1 and X2

have the significances given in claim 1.

5. Compounds according to any one of claims 1 to 4, wherein m is a whole number of 0 to 4.

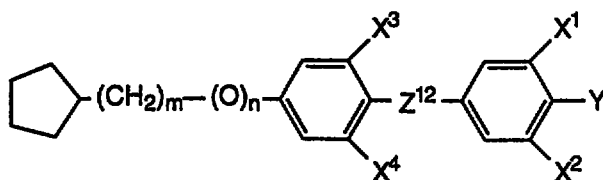
6. Compounds according to claim 1 or 2, wherein p = 0.

7. Compounds according to claim 1, 2 or 6 of the general formulae

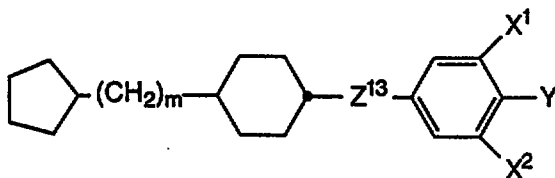




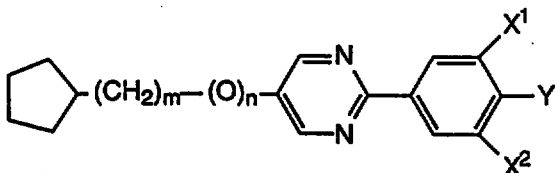
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IB-1



IB-2

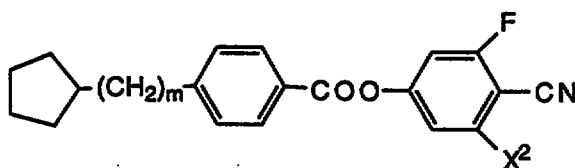


IB-3

- 5 wherein
 m is a whole number of 0 to 7;
 n is 0 or 1;
 X³ and X⁴ each independently signify hydrogen or
 fluorine;
10 Z¹² signifies a single bond, -COO- or -C≡C-
 and
 Z¹³ signifies a single bond, -(CH₂)₂-, -CH₂O-
 or -COO-; and
 Y, X¹ and X² have the significances given in claim 1.

15

8. Compounds of the formula



IB-4

- 20 wherein m and X² have the significances given in claim 1.

9. A liquid crystalline mixture having at least two
 components, wherein at least one component is a compound of
 formula I defined in claim 1.

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10. A liquid crystalline mixture according to claim 9,
wherein the content of compounds of formula I is 1-40 wt.%.
5

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

12. The use of liquid crystalline mixtures according to
claim 9 or 10 for electro-optical devices.

10 13. An electro-optical display device containing a liquid
crystalline mixture according to claim 9.

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