

Partially hydrogenated oligo-1,4-phenylenes, dielectrics containing these compounds and an electro-optical display element.

- For electro-optical display elements, the properties of nematic or nematic-cholesteric liquid crystal materials of changing significantly their optical properties, such as light absorption, light scattering, double refraction, reflecting power or colour, under the influence of electric fields are utilised to an increasing extent.
- 10 The functioning of such display elements is based, for example, on the phenomena of dynamic scattering, the deformation of oriented phases, the Schadt-Helfrich effect in a twisted cell or the cholesteric-nematic phase transition.
- 15 Industrial application of these effects in electronic components necessitates liquid crystal dielectrics, which must fulfil a large number of requirements. Chemical stability towards moisture, air and physical influences, such as heat, radiation in the infrared,
- 20 visible and ultraviolet range and constant and alternating electrical fields, is particularly important in this context. A liquid crystal mesophase in the temperature range from at least $+10^{\circ}\text{C}$ to $+50^{\circ}\text{C}$, preferably from 0°C to 60°C , and as low as possible a viscosity at room temperature,
- 25 preferably not more than $70 \cdot 10^{-3} \text{ Pa.s}$, are also required of liquid crystal dielectrics which can be used industrially. Finally, these dielectrics must exhibit no characteristic absorption in the range of visible light, that is to say they must be colourless.

(57)

A number of liquid crystal compounds which fulfil the stability requirements demanded of dielectrics for electronic components and also are colourless are already known. These include, in particular, the p,p'-

5 disubstituted phenyl benzoates described in German Offenlegungsschrift 2,139,628 and the p,p'-disubstituted phenylcyclohexane derivatives described in German Offenlegungsschrift 2,636,684. In both the classes of compounds mentioned, and also in other known series

10 of compounds with a liquid crystal mesophase, there are no individual compounds which form a liquid crystal nematic mesophase in the required temperature range of 10°C to 60°C. Mixtures of two or more compounds are thus as a rule prepared in order to obtain substances

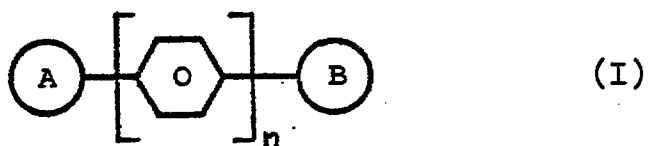
15 which can be used as liquid crystal dielectrics. These are usually obtained by mixing at least one compound with a low melting point and clear point with another compound with a significantly higher melting point and clear point.

20 A mixture which has a melting point below that of the lower-melting component, whilst the clear point is between the clear points of the components, is usually obtained by this procedure. However, optimum dielectrics cannot easily be prepared in this manner,

25 since the components with the high melting points and high clear points frequently also impart a high viscosity to the mixtures. The switching times of the electro-optical display elements produced with these mixtures are thus lengthened in an undesirable manner.

The invention is based on the object of preparing liquid crystal dielectrics which have a nematic phase in the required temperature range and permit sufficiently short switching times in liquid crystal cells at room temperature. Furthermore, for all the types of display elements mentioned above, it is important for the contrast/voltage curve to be as steep as possible in the region of the threshold voltage, that is to say that slightly exceeding the threshold voltage immediately activates the display to as full a contrast as possible; moreover, the threshold voltage itself should be as independent of the temperature as possible, so that, in particular, the threshold voltages necessary for activation of the display at low temperatures are not substantially higher than that which is necessary, for example, at room temperature.

It has now been found that the partially hydrogenated oligo-1,4-phenylenes of the formula (I)

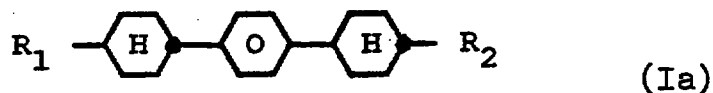


wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms, are outstandingly suitable as components of mixtures for the preparation of liquid crystal dielectrics in which the dependence of the threshold voltage on the temperature is at a low level which has hitherto been unachieved. Moreover,

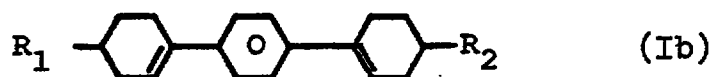
the compounds of the formula (I) in which n is 2, in particular, have very high clear points, in most cases significantly above 200°C; they can therefore advantageously be used for broadening the temperature range of the nematic phase of liquid crystal dielectrics.

The invention thus relates to the partially hydrogenated oligo-1,4-phenylenes of the formula (I) and their use as components of liquid crystal dielectrics. The invention furthermore relates to liquid crystal dielectrics containing at least one partially hydrogenated oligo-1,4-phenylene of the formula (I) and to electro-optical display elements based on a liquid crystal cell containing such a liquid crystal dielectric.

The partially hydrogenated oligo-1,4-phenylenes according to the invention thus include 1,4-bis-(trans-4-alkylcyclohexyl)-benzenes of the formula (Ia)



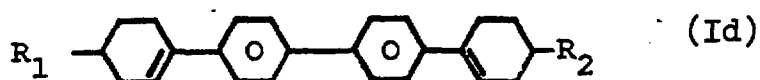
wherein R_1 and R_2 are identical or different and are alkyl groups with up to 10 carbon atoms, 1,4-bis-(4-alkylcyclohex-1-enyl)-benzenes of the formula (Ib)



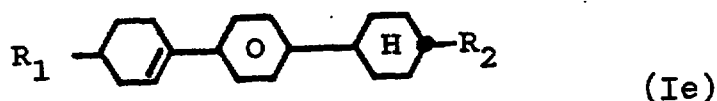
4,4'-bis-(trans-4-alkylcyclohexyl)-biphenyls of the formula (Ic)



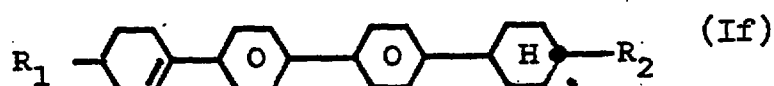
4,4'-bis-(4-alkylcyclohex-1-enyl)-biphenyls of the formula (Id)



1-(trans-4-alkylcyclohexyl)-4-(4-alkylcyclohex-1-enyl)-
5 benzenes of the formula (Ie)



and 4-(trans-4-alkylcyclohexyl)-4'-(4-alkylcyclohex-1-enyl)-biphenyls of the formula (If)



10 wherein R_1 and R_2 in the formulae (Ib) to (If) have the meaning given in the case of formula (Ia).

Where the compounds according to the invention contain cyclohexane rings, these are disubstituted, in the trans-configuration, in the 1,4-position; in the
15 formulae, this is expressed by the black dot on the right-hand side of the cyclohexane rings. The compounds of the formulae (Ia), (Ib) and (Ie) as a rule have melting points and clear points which are lower than the analogously substituted biphenyl derivatives of the
20 formula (Ic), (Id) and (If).

At the same time, however, they also have a considerably lower viscosity and are therefore preferably used as components which lower the viscosity of liquid

crystal dielectrics, in which the remaining constituents have high clear points. In contrast, the biphenyl derivatives (Ic), (Id) and (If) have an extremely wide mesophase range, which as a rule extends over 150 degrees and more. They are therefore preferably used for widening the mesophase range of liquid crystal dielectrics, the derivatives increasing the viscosity significantly less than other known liquid crystal compounds which have a high clear point and have hitherto been employed for this purpose. It has been found, surprisingly, that dielectrics according to the invention which contain one or more compounds of the formula (I) have a particularly steep contrast/voltage curve and a very low dependence of the threshold voltage on the temperature.

The alkyl groups in the compounds of the formula (I) can be straight-chain or branched, compounds with two straight-chain end group substituents being preferred. Compounds of the formula (I) in which one of the radicals R_1 and R_2 is branched can occasionally be used as chiral doping substances if they are optically active as a result of the chain branching. In no case does a branched end group substituent contain more than one chain branching; preferred branched end group substituents are those in which a methyl or ethyl group is in 1- or 2-position of a longer carbon chain, for example 1-methylpropyl, 2-methylpropyl, 2-methylbutyl, 2-methylpentyl, 2-ethylhexyl, 1-methylheptyl or 2-methylheptyl. In the compounds according to the invention, the end group substituents R_1 and R_2 each contain up to 10 carbon

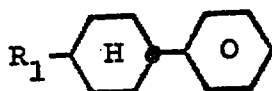
atoms, that is to say 2-20 carbon atoms in total.

However, preferred compounds of the formula (I) are those in which R_1 and R_2 together contain 3-16 carbon atoms, in particular 4-13 carbon atoms.

5 The compounds according to the invention are prepared in the manner customary for such substances.

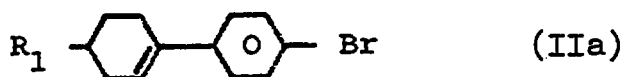
Thus, the compounds of the formula (Ia) are obtained by a process in which a trans-(4-alkylcyclohexyl)-benzene of the formula (II)

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(II)

is reacted with bromine in carbon tetrachloride in the presence of iron powder to give the 4-(trans-4-alkylcyclohexyl)-bromobenzene and this compound is converted into a 1,4-bis-(trans-4-alkylcyclohexyl)-benzene (Ia) in
15 a Grignard reaction, by reaction with magnesium in the presence of an ether, addition of a 4-alkylcyclohexanone, hydrolysis, hydrogenation and, if appropriate, cis/trans-isomerisation and separation of the isomers. Compounds of the formula (Ie) are prepared by splitting off
20 water by treatment with an acid, for example p-toluenesulfonic acid, instead of the hydrogenation and the subsequent steps in the abovementioned sequence for the preparation of the compounds (Ia). The compounds of the formula (Ib) are obtained analogously to those of
25 the formula (Ie) if a 4-(4-alkylcyclohex-1-enyl)-bromobenzene of the formula (IIa)

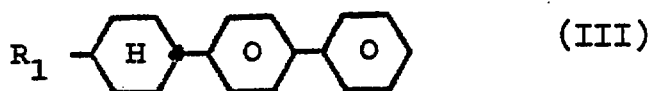


is employed as the starting material.

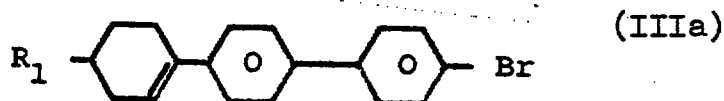
The compounds of the formula (IIa) are known from the laid-open European Patent Application No. 2136.

5 For the preparation of those compounds of the formula (Ib) in which R_1 and R_2 are identical, it is also possible to use 1,4-dibromobenzene as the starting material, which is reacted with twice the molar amount of magne-
 10 sium and then with twice the molar amount of a 4-alkyl-cyclohexanone. The steps of hydrolysis and splitting off of water are then carried out in the customary manner.

The biphenyl derivatives (Ic), (Id) and (If) are prepared analogously to the benzene derivatives (Ia), (Ib) and (Ie), 4-(trans-4-alkylcyclohexyl)-biphenyls of
 15 the formula (III)



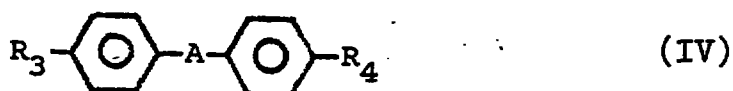
4-(4-alkylcyclohex-1-enyl)-4'-bromobiphenyls of the formula (IIIa)



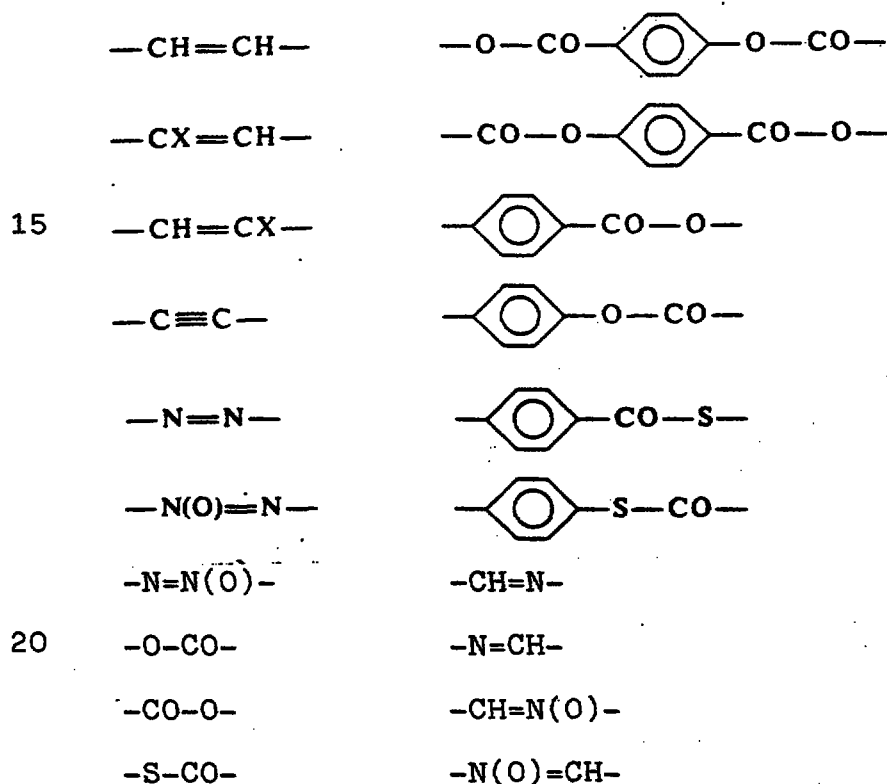
20 and 4,4'-dibromobiphenyl being respectively used as starting material.

The liquid crystal dielectrics according to the invention consist of two or more components, of which at least one is a component of the formula (I). Other

components which are optionally used are preferably nematic or nematogenic substances from the classes of azobenzenes, azoxybenzenes, biphenyls, Schiff's bases, in particular benzylidene derivatives, phenyl benzoates, 5 phenylpyrimidines, phenylcyclohexanes, optionally halogenated stilbenes, diphenylacetylene derivatives, diphenyl nitrones and substituted cinnamic acids. The most important compounds which can be used as other components of this type can be characterised by the formula 10 (IV):



wherein A is



-CO-S-



or a C-C single bond. Other possible components of the dielectrics according to the invention are those compounds of the formula (IV) in which one or more phenyl rings are replaced by a corresponding number of trans-cyclohexyl rings; it is also possible for one of these rings to be a 2,5-disubstituted pyrimidine ring.

X is halogen, preferably Cl, or -CN. R_3 and R_4 are identical or different and can be alkyl, alkoxy, alkanoyl, alkanoyloxy or alkoxy-carbonyloxy radicals with up to 18, preferably up to 8, C atoms; furthermore, it is also possible for one of these radicals to be -CN, -NC, NO_2 , CF_3 or halogen.

In most of these compounds, R_3 and R_4 are preferably different, one of the radicals usually being an alkyl or alkoxy group. However, a large number of other variants of the substituents envisaged are also customary. Many such substances are commercially available.

The dielectrics according to the invention as a rule contain at least 30, preferably 50 - 99 and in particular 60 - 98, parts by weight of the compounds of the formula (I) and (IV). Of this amount, one or more compounds of the formula (I) preferably make up 3 to 50 parts by weight, in particular 5 to 25 parts by weight. The invention also comprises those liquid crystal dielectrics to which only less than 3 parts

by weight, for example 0.1 to 2 parts by weight, of one or more compounds of the formula (I) have been added, for example for doping purposes. On the other hand, it is also possible for up to 80 per cent by weight of the dielectrics according to the invention to be made up by the compounds of the formula (I).

The dielectrics according to the invention are prepared in a manner which is customary per se. As a rule, the desired amount of the components used in a smaller amount is dissolved in the component comprising the main constituent, preferably at elevated temperature. The completeness of the dissolving operation can be observed particularly easily if a temperature above the clear point of the main constituent is chosen.

However, it is also possible to mix solutions of the components of the formula (I) and (IV) in a suitable organic solvent, for example acetone, chloroform or methanol, and, after thorough mixing, to remove the solvent again, for example by distillation under reduced pressure. In this procedure, of course, care must be taken that no impurities or undesired doping substances are incorporated through the solvent.

The liquid crystal dielectrics according to the invention can be modified by suitable additives so that they can be used in all types of liquid crystal display elements hitherto disclosed. Such additives are known to the expert and are described in detail in the relevant literature. For example, it is possible to add substances to alter the dielectric anisotropy, the

viscosity, the conductivity and/or the orientation of the nematic phases. Such substances are described, for example, in German Offenlegungsschriften 2,209,127, 2,240,864, 2,321,632, 2,338,281 and 2,450,088.

5 The following examples are intended to illustrate the invention, without limiting it. In the examples, m. denotes the melting point and c. denotes the clear point of a liquid crystal substance in degrees Centigrade; boiling points are designated by b.p. Unless other-
10 wise indicated, data relating to parts or percentages are parts by weight or percentages by weight.

Example 1

a) 160 g of bromine are added dropwise, with stirring, to a solution of 230 g of (trans-4-n-pentylcyclohexyl)-
15 benzene in 750 ml of carbon tetrachloride in the presence of 15 g of iron filings at a rate such that the temperature does not rise above 30°. The reaction mixture is then heated for a further 10 minutes to the boiling point and subsequently filtered and subjected to frac-
20 tional distillation. After distilling off the solvent, 163 g of 4-(trans-4-n-pentylcyclohexyl)-bromobenzene are distilled off under reduced pressure; b.p. 130 - 135°/0.1 mm Hg.

b) A solution of 18 g of 4-n-pentylcyclohexanone
25 in 30 ml of tetrahydrofuran is added dropwise, with stirring and at room temperature, to a Grignard solution prepared from 31 g of 4-(trans-4-n-pentylcyclohexyl)-bromobenzene and 3 g of magnesium filings in 100 ml of tetrahydrofuran. Hydrolysis is then carried out with

a 10% aqueous solution of ammonium chloride and the organic phase is separated off, washed twice with 50 ml of water each time, dried over sodium sulfate and evaporated. The residue is dissolved in 300 ml of ethanol and the solution is hydrogenated at room temperature in the presence of 4 g of palladium-on-charcoal (5% of Pd) for 48 hours. The catalyst is then filtered off, the solvent is distilled off, the residue is taken up in 50 ml of dimethylsulfoxide and the mixture is warmed to 100° in the absence of moisture and in the presence of 7 g of potassium tert.-butylate for 16 hours. After cooling, the reaction mixture is poured into 300 ml of ice-water and the aqueous phase is extracted twice with 100 ml of methylene chloride each time. The extracts are washed with 100 ml of water, dried over calcium chloride and evaporated. The 1,4-bis-(trans-4-n-pentylcyclohexyl)-benzene which remains is recrystallised from ethanol; yield: 19 g, m. 50°, c. 196°.

The following compounds are prepared analogously:

- 1,4-bis-(4-trans-methylcyclohexyl)-benzene,
1-(trans-4-ethylcyclohexyl)-4-(trans-4-methylcyclohexyl)-benzene,
1-(trans-4-n-propylcyclohexyl)-4-(trans-4-methylcyclohexyl)-benzene,
1-(trans-4-n-butylcyclohexyl)-4-(trans-4-methylcyclohexyl)-benzene,
1-(trans-4-n-pentylcyclohexyl)-4-(trans-4-methylcyclohexyl)-benzene,
1-(trans-4-n-hexylcyclohexyl)-4-(trans-4-methylcyclohexyl)-benzene.

- hexyl)-benzene,
1-(trans-4-n-heptylcyclohexyl)-4-(trans-4-methylcyclo-
hexyl)-benzene,
1-(trans-4-n-octylcyclohexyl)-4-(trans-4-methylcyclo-
5 hexyl)-benzene,
1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-methyl-
cyclohexyl)-benzene,
1,4-bis-(trans-4-ethylcyclohexyl)-benzene,
1-(trans-4-n-propylcyclohexyl)-4-(trans-4-ethylcyclohexyl)-
10 benzene,
1-(trans-4-n-butylcyclohexyl)-4-(trans-4-ethylcyclo-
hexyl)-benzene,
1-(trans-4-n-pentylcyclohexyl)-4-(trans-4-ethylcyclo-
hexyl)-benzene,
15 1-(trans-4-n-hexylcyclohexyl)-4-(trans-4-ethylcyclo-
hexyl)-benzene,
1-(trans-4-n-heptylcyclohexyl)-4-(trans-4-ethylcyclo-
hexyl)-benzene,
1-(trans-4-n-octylcyclohexyl)-4-(trans-4-ethylcyclohexyl)-
20 benzene,
1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-ethyl-
cyclohexyl)-benzene,
1-[trans-4-(2-ethylhexyl)-cyclohexyl]-4-(trans-4-ethyl-
cyclohexyl)-benzene,
25 1,4-bis-(trans-4-n-propylcyclohexyl)-benzene, m. 77°, c. 194°,
1-(trans-4-n-butylcyclohexyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,
1-(trans-4-n-pentylcyclohexyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,

- 1-(trans-4-n-hexylcyclohexyl)-4-(trans-4-n-propylcyclohexyl)-benzene,
1-(trans-4-n-heptylcyclohexyl)-4-(trans-4-n-propylcyclohexyl)-benzene,
5 1-(trans-4-n-octylcyclohexyl)-4-(trans-4-n-propylcyclohexyl)-benzene,
1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-n-(trans-4-n-propyl-cyclohexyl)-benzene,
1-[trans-4-(2-ethylhexyl)-cyclohexyl]-4-(trans-4-n-propylcyclohexyl)-benzene,
10 1,4-bis-(trans-4-n-butylcyclohexyl)-benzene,
1-(trans-4-n-pentylcyclohexyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(trans-4-n-hexylcyclohexyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
15 1-(trans-4-n-heptylcyclohexyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(trans-4-n-octylcyclohexyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
20 1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-n-butylcyclohexyl)-benzene,
1-[trans-4-(2-ethylhexyl)-cyclohexyl]-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(trans-4-n-hexylcyclohexyl)-4-(trans-4-n-pentylcyclohexyl)-benzene,
25 1-(trans-4-n-heptylcyclohexyl)-4-(trans-4-n-pentylcyclohexyl)-benzene,
1-(trans-4-n-octylcyclohexyl)-4-trans-4-n-pentylcyclohexyl)-benzene,

- 1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-n-pentylcyclohexyl)-benzene,
1-[trans-4-(2-ethylhexyl)-cyclohexyl]-4-(trans-4-n-pentylcyclohexyl)-benzene,
5 1,4-bis-(trans-4-n-hexylcyclohexyl)-benzene,
1-(trans-4-n-heptylcyclohexyl)-4-(trans-4-n-hexylcyclohexyl)-benzene,
1-(trans-4-n-octylcyclohexyl)-4-(trans-4-n-hexylcyclohexyl)-benzene,
10 1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-n-hexylcyclohexyl)-benzene,
1-[trans-4-(2-ethylhexyl)-cyclohexyl]-4-(trans-4-n-hexylcyclohexyl)-benzene,
1,4-bis-(trans-4-n-heptylcyclohexyl)-benzene,
15 1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-n-heptylcyclohexyl)-benzene and
1-[trans-4-(2-methylbutyl)-cyclohexyl]-4-(trans-4-n-octylcyclohexyl)-benzene.

Example 2

- 20 a) 4-(Trans-4-n-pentylcyclohexyl)-biphenyl is brominated in a manner analogous to that in Example 1 (a); after distilling off the carbon tetrachloride, however, the 4-(trans-4-n-pentylcyclohexyl)-4'-bromobiphenyl which remains as a crystalline mass is recrystallised
25 from ethanol; m. 148°, c. 185°.
- b) A Grignard solution prepared from 38.5 g of 4-(trans-4-n-pentylcyclohexyl)-4'-bromobiphenyl and 3 g of magnesium in 200 ml of tetrahydrofuran is reacted with 4-methylcyclohexanone in a manner analogous to that in

Example 1 (b). After hydrolysis, hydrogenation and isomerisation in the manner described in Example 1 (b), and after recrystallisation of the product from ethanol, 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-methylcyclo-
5 hexyl)-biphenyl is obtained; m. 96°, c. 284°.

The following compounds are prepared analogously:

- 4,4'-bis-(trans-4-methylcyclohexyl)-biphenyl,
4-(trans-4-ethylcyclohexyl)-4'-(trans-4-methylcyclohexyl)-
biphenyl,
10 4-(trans-4-n-propylcyclohexyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(trans-4-n-butylcyclohexyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(trans-4-n-hexylcyclohexyl)-4'-(trans-4-methylcyclohexyl)-
15 hexyl)-biphenyl,
4-(trans-4-n-heptylcyclohexyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(trans-4-n-octylcyclohexyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
20 4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-[trans-4-(2-ethylhexyl)-cyclohexyl]-4'-(trans-4-methylcyclohexyl)-biphenyl,
4,4'-bis-(trans-4-ethylcyclohexyl)-biphenyl,
25 4-(trans-4-n-propylcyclohexyl)-4'-(trans-4-ethylcyclohexyl)-biphenyl,
4-(trans-4-n-butylcyclohexyl)-4'-(trans-4-ethylcyclohexyl)-biphenyl,
4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-ethylcyclo-

- hexyl)-biphenyl,
4-(trans-4-n-hexylcyclohexyl)-4'-(trans-4-ethylcyclo-
hexyl)-biphenyl,
4-(trans-4-n-heptylcyclohexyl)-4'-(trans-4-ethylcyclo-
5 hexyl)-biphenyl,
4-(trans-4-n-octylcyclohexyl)-4'-(trans-4-ethylcyclo-
hexyl)-biphenyl,
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-ethyl-
cyclohexyl)-biphenyl,
10 4-[trans-4-(2-ethylhexyl)-cyclohexyl]-4'-(trans-4-ethyl-
cyclohexyl)-biphenyl,
4,4'-bis-(trans-4-n-propylcyclohexyl)-biphenyl, m. 63°, c. 308°,
4-(trans-4-n-butylcyclohexyl)-4'-(trans-4-n-propyl-
cyclohexyl)-biphenyl,
15 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-propyl-
cyclohexyl)-biphenyl,
4-(trans-4-n-hexylcyclohexyl)-4'-(trans-4-n-propyl-
cyclohexyl)-biphenyl,
4-(trans-4-n-heptylcyclohexyl)-4'-(trans-4-n-propylcyclo-
20 hexyl)-biphenyl,
4-(trans-4-n-octylcyclohexyl)-4'-(trans-4-n-propylcyclo-
hexyl)-biphenyl,
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-n-
propylcyclohexyl)-biphenyl,
25 4-[trans-4-(2-ethylhexyl)-cyclohexyl]-4'-(trans-4-n-
propylcyclohexyl)-biphenyl,
4,4'-bis-(trans-4-n-butylcyclohexyl)-biphenyl,
4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-butylcyclo-
hexyl)-biphenyl,

- 4-(trans-4-n-hexylcyclohexyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
4-(trans-4-n-heptylcyclohexyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
5 4-(trans-4-n-octylcyclohexyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
4-[trans-4-(2-ethylhexyl)-cyclohexyl]-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
10 4,4'-bis-(trans-4-n-pentylcyclohexyl)-biphenyl, m. 43°, c. 300°,
4-(trans-4-n-hexylcyclohexyl)-4'-(trans-4-n-pentylcyclohexyl)-biphenyl, m. 84°, c. 240°,
15 4-(trans-4-n-heptylcyclohexyl)-4'-(trans-4-n-pentylcyclohexyl)-biphenyl,
4-(trans-4-n-octylcyclohexyl)-4'-(trans-4-n-pentylcyclohexyl)-biphenyl,
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-n-pentylcyclohexyl)-biphenyl,
20 4-[trans-4-(2-ethylhexyl)-cyclohexyl]-4'-(trans-4-n-pentylcyclohexyl)-biphenyl,
4,4'-bis-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(trans-4-n-heptylcyclohexyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
25 hexyl)-biphenyl,
4-(trans-4-n-octylcyclohexyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,

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4-[trans-4-(2-ethylhexyl)-cyclohexyl]-4'-(trans-4-n-
hexylcyclohexyl)-biphenyl,
4,4'-bis-(trans-4-n-heptylcyclohexyl)-biphenyl,
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-n-
5 heptylcyclohexyl)-biphenyl and
4-[trans-4-(2-methylbutyl)-cyclohexyl]-4'-(trans-4-n-
octylcyclohexyl)-biphenyl.

Example 3

A solution of 24 g of 1,4-dibromobenzene in
10 30 ml of tetrahydrofuran is slowly added dropwise to
48 g of magnesium filings in 50 ml of tetrahydrofuran,
whilst stirring. The reaction mixture is then heated
to the boiling point for 2 hours and, after cooling, a
solution of 28 g of 4-n-propylcyclohexanone in 40 ml of
15 tetrahydrofuran is added dropwise. The mixture is
subsequently stirred for a further 2 hours at 60° and
hydrolysis is then carried out by dropwise addition of
1 l of 5% aqueous hydrochloric acid. The hydrolysed
reaction mixture is extracted three times with a total
20 of 600 ml of diethyl ether and the extracts are washed
with water and evaporated, under reduced pressure in the
final stages. The syrupy residue is taken up in
90 ml of acetone, 5 g of p-toluene-sulfonic acid are
added and the mixture is heated to the boiling point
25 under reflux for 4 hours. The reaction mixture is
then cooled to -5° and the 1,4-bis-(4-n-propylcyclo-
hex-1-enyl)-benzene which has crystallised out is fil-
tered off and recrystallised from isopropyl alcohol;
yield: 17.6 g, m. 42°, c. 212°.

The following compounds are prepared analogously:

- 1,4-bis-(4-methylcyclohex-1-enyl)-benzene,
1,4-bis-(4-ethylcyclohex-1-enyl)-benzene,
1,4-bis-(4-n-butylcyclohex-1-enyl)-benzene,
5 1,4-bis-(4-n-pentylcyclohex-1-enyl)-benzene,
1,4-bis-(4-n-hexylcyclohex-1-enyl)-benzene,
1,4-bis-(4-n-heptylcyclohex-1-enyl)-benzene and
1,4-bis-(4-n-octylcyclohex-1-enyl)-benzene.

If equivalent amounts of 4,4'-dibromobiphenyl
10 are used instead of 1,4-dibromobenzene, the following
compounds are prepared:

- 4,4'-bis-(4-methylcyclohex-1-enyl)-biphenyl,
4,4'-bis-(4-ethylcyclohex-1-enyl)-biphenyl,
4,4'-bis-(4-n-propylcyclohex-1-enyl)-biphenyl,
15 4,4'-bis-(4-n-butylcyclohex-1-enyl)-biphenyl,
4,4'-bis-(4-n-pentylcyclohex-1-enyl)-biphenyl,
4,4'-bis-(4-n-hexylcyclohex-1-enyl)-biphenyl and
4,4'-bis-(4-n-heptylcyclohex-1-enyl)-biphenyl.

Example 4:

- 20 A solution of 31 g of 4-(4-n-pentylcyclohex-1-enyl)-bromobenzene in 50 ml of tetrahydrofuran is slowly added dropwise to 24 g of magnesium filings in 50 ml of tetrahydrofuran, whilst stirring. The reaction mixture is then heated to the boiling point for 2
25 hours and, after cooling, a solution of 14 g of 4-n-propylcyclohexanone in 20 ml of tetrahydrofuran is added dropwise. The mixture is subsequently stirred for a further 2 hours at 60° and hydrolysis is then carried out by dropwise addition of 500 ml of 5% aqueous

hydrochloric acid. The hydrolysed reaction mixture is extracted four times with a total of 800 ml of diethyl ether and the extracts are washed with water and evaporated, under reduced pressure in the final stages. The
5 syrupy residue is dissolved in 90 ml of acetone and this solution is heated to the boiling point under reflux with 5 g of p-toluenesulfonic acid for 4 hours. The reaction mixture is then cooled to -5° and the 1-(4-n-pentylcyclohex-1-enyl)-4-(4-n-propylcyclohex-1-enyl)-benzene
10 which has crystallised out is filtered off and recrystallised from isopropyl alcohol; yield: 23.6 g of colourless crystals, m. 35° , c. 141° .

The following compounds are prepared analogously:
1-(4-ethylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-
15 benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,
20 1-(4-n-pentylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-
25 benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,

- 1-(4-n-decylcyclohex-1-enyl)-4-(4-methylcyclohex-1-enyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(4-methylcyclohex-1-enyl)-benzene,
- 5 1-(4-n-propylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-
- 10 benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-benzene,
- 15 1-(4-n-octylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(4-ethylcyclohex-1-enyl)-
- 20 benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(4-ethylcyclohex-1-enyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(4-propylcyclohex-1-enyl)-benzene,
- 25 1-(4-n-hexylcyclohex-1-enyl)-4-(4-propylcyclohex-1-enyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(4-propylcyclohex-1-enyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(4-propylcyclohex-1-enyl)-

- benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(4-propylcyclohex-1-enyl)-
benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(4-propylcyclohex-1-enyl)-
5 benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(4-propylcyclo-
hex-1-enyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(4-n-butylcyclohex-1-
enyl)-benzene,
10 1-(4-n-hexylcyclohex-1-enyl)-4-(4-n-butylcyclohex-1-enyl)-
benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(4-n-butylcyclohex-1-
enyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(4-n-butylcyclohex-1-
15 enyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(4-n-butylcyclohex-1-
enyl)-benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(4-n-butylcyclohex-1-
enyl)-benzene,
20 1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(4-n-butylcyclo-
hex-1-enyl)-benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(4-n-pentylcyclohex-1-
enyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(4-n-pentylcyclohex-1-
25 enyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(4-n-pentylcyclohex-1-
enyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(4-n-pentylcyclohex-1-
enyl)-benzene,

- 1-(4-n-decylcyclohex-1-enyl)-4-(4-n-pentylcyclohex-1-enyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(4-n-pentylcyclohex-1-enyl)-benzene,
- 5 1-(4-n-heptylcyclohex-1-enyl)-4-(4-n-hexylcyclohex-1-enyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(4-n-hexylcyclohex-1-enyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(4-n-hexylcyclohex-1-enyl)-benzene,
- 10 1-(4-n-decylcyclohex-1-enyl)-4-(4-n-hexylcyclohex-1-enyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(4-n-hexylcyclohex-1-enyl)-benzene,
- 15 4-(4-ethylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
- 20 4-(4-n-pentylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
- 25 4-(4-n-heptylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,

- enyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(4-methylcyclohex-1-enyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(4-methylcyclohex-1-enyl)-biphenyl,
5 4-(4-n-propylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
10 4-(4-n-pentylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
15 4-(4-n-octylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
20 4-(4-n-decylcyclohex-1-enyl)-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(4-ethylcyclohex-1-enyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,
25 4-(4-n-pentylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,

- 4-(4-n-heptylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,
5 4-(4-n-nonylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(4-n-propylcyclohex-1-enyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(4-n-propylcyclo-
10 hex-1-enyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(4-n-butylcyclohex-1-enyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(4-n-butylcyclohex-1-enyl)-biphenyl,
15 4-(4-n-heptylcyclohex-1-enyl)-4'-(4-n-butylcyclohex-1-enyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(4-n-butylcyclohex-1-enyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(4-n-butylcyclohex-1-
20 enyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(4-n-butylcyclohex-1-enyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(4-n-butylcyclo-
hex-1-enyl)-biphenyl,
25 4-(4-n-hexylcyclohex-1-enyl)-4'-(4-n-pentylcyclohex-1-enyl)-biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(4-n-pentylcyclohex-1-enyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(4-n-pentylcyclohex-1-

- enyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(4-n-pentylcyclohex-1-enyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(4-n-pentylcyclohex-1-enyl)-biphenyl,
5 4-(4-n-octylcyclohex-1-enyl)-4'-(4-n-pentylcyclohex-1-enyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(4-n-pentylcyclohex-1-enyl)-biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(4-n-hexylcyclohex-1-enyl)-biphenyl,
10 4-(4-n-octylcyclohex-1-enyl)-4'-(4-n-hexylcyclohex-1-enyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(4-n-hexylcyclohex-1-enyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(4-n-hexylcyclohex-1-enyl)-biphenyl, and
15 4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(4-n-hexylcyclohex-1-enyl)-biphenyl.

Example 5

- The following compounds according to the invention are prepared in a manner analogous to that in Example 4, starting from the corresponding 4-(trans-4-alkylcyclohexyl)-bromobenzenes or 4-(trans-4-alkylcyclohexyl)-4'-bromobiphenyls:
- 1-(4-methylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
25 1-(4-ethylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,

- 1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
- 1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene.
- 5 1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
- 1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
- 1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-
- 10 benzene,
- 1-(4-n-nonylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
- 1-(4-n-decylcyclohex-1-enyl)-4-(trans-4-methylcyclohexyl)-benzene,
- 15 1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-methylcyclohexyl)-benzene,
- 1-(4-methylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-benzene,
- 1-(4-ethylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-
- 20 benzene,
- 1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-benzene,
- 1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-benzene,
- 25 1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-benzene,
- 1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-benzene,
- 1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-

- benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-
benzene.
1-(4-n-nonylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-
5 benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(trans-4-ethylcyclohexyl)-
benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-ethyl-
cyclohexyl)-benzene,
10 1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-propylcyclohexyl)-
benzene,
1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-propylcyclohexyl)-
benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
15 hexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,
20 1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
25 hexyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(trans-4-n-propylcyclo-
hexyl)-benzene,

- 1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-n-propylcyclohexyl)-benzene,
1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
5 1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
10 1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
15 1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
20 1-(4-n-decylcyclohex-1-enyl)-4-(trans-4-n-butylcyclohexyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-n-butylcyclohexyl)-benzene,
25 1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclohexyl)-benzene,
1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclohexyl)-benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclohexyl)-benzene,

- hexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
hexyl)-benzene.
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
5 hexyl)-benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
hexyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
hexyl)-benzene,
10 1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
hexyl)-benzene,
1-(4-n-nonylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
hexyl)-benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(trans-4-n-pentylcyclo-
15 hexyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-n-pentyl-
cyclohexyl)-benzene,
1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclohexyl)-
benzene,
20 1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclohexyl)-
benzene.
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclo-
hexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclo-
25 hexyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclo-
hexyl)-benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclo-
hexyl)-benzene,

- 1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclohexyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclohexyl)-benzene,
5 1-(4-n-nonylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclohexyl)-benzene,
1-(4-n-decylcyclohex-1-enyl)-4-(trans-4-n-hexylcyclohexyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-n-hexylcyclohexyl)-benzene,
10 1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
15 1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
20 1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
25 1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-n-heptylcyclohexyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-n-heptylcyclohexyl)-benzene,
1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-octylcyclohexyl)-

- benzene,
1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-octylcyclohexyl)-
benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-octylcyclo-
5 hexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-octylcyclo-
hexyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-octylcyclo-
hexyl)-benzene,
10 1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-octylcyclo-
hexyl)-benzene,
1-(4-n-heptylcyclohex-1-enyl)-4-(trans-4-n-octylcyclo-
hexyl)-benzene,
1-(4-n-octylcyclohex-1-enyl)-4-(trans-4-n-octylcyclo-
15 hexyl)-benzene,
1-[4-(2-methylbutyl)-cyclohex-1-enyl]-4-(trans-4-n-octyl-
cyclohexyl)-benzene,
1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-nonylcyclo-
hexyl)-benzene,
20 1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-nonylcyclohexyl)-
benzene,
1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-nonylcyclo-
hexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-nonylcyclo-
25 hexyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-nonylcyclo-
hexyl)-benzene,
1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-nonylcyclo-
hexyl)-benzene,

- 1-(4-methylcyclohex-1-enyl)-4-(trans-4-n-decylcyclohexyl)-benzene,
1-(4-ethylcyclohex-1-enyl)-4-(trans-4-n-decylcyclohexyl)-benzene,
5 1-(4-n-propylcyclohex-1-enyl)-4-(trans-4-n-decylcyclohexyl)-benzene,
1-(4-n-butylcyclohex-1-enyl)-4-(trans-4-n-decylcyclohexyl)-benzene,
1-(4-n-pentylcyclohex-1-enyl)-4-(trans-4-n-decylcyclohexyl)-benzene,
10 1-(4-n-hexylcyclohex-1-enyl)-4-(trans-4-n-decylcyclohexyl)-benzene,
4-(4-methylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
15 4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
20 4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
25 4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(trans-4-methylcyclohexyl)-biphenyl,

- hexyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(trans-4-methylcyclo-
hexyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-methyl-
5 cyclohexyl)-biphenyl,
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biphenyl,
4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-ethylcyclohexyl)-
biphenyl,
10 4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-ethylcyclo-
hexyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-ethylcyclohexyl)-
biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-ethylcyclo-
15 hexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-ethylcyclohexyl)-
biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-ethylcyclo-
hexyl)-biphenyl,
20 4-(4-n-octylcyclohex-1-enyl)-4'-(trans-4-ethylcyclohexyl)-
biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(trans-4-ethylcyclohexyl)-
biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(trans-4-ethylcyclohexyl)-
25 biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-ethyl-
cyclohexyl)-biphenyl,
4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclo-
hexyl)-biphenyl,

- 4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
5 4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
10 4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
15 4-(4-n-nonylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-n-propylcyclohexyl)-biphenyl,
20 4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
25 4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclohexyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclohexyl)-

- hexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclo-
hexyl)-biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclo-
5 hexyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclo-
hexyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclo-
hexyl)-biphenyl,
10 4-(4-n-decylcyclohex-1-enyl)-4'-(trans-4-n-butylcyclo-
hexyl)-biphenyl,
4-[4-(3-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-n-
butylcyclohexyl)-biphenyl,
4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
15 hexyl)-biphenyl,
4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
hexyl)-biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
hexyl)-biphenyl,
20 4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
hexyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
hexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
25 hexyl)-biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
hexyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclo-
hexyl)-biphenyl,

- 4-(4-n-nonylcyclohex-1-enyl)-4'-(trans-4-n-pentylcyclohexyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-n-pentylcyclohexyl)-biphenyl,
- 5 4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclo-
- 10 hexyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
- 15 4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-n-octylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclo-
- 20 hexyl)-biphenyl,
4-(4-n-nonylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-n-decylcyclohex-1-enyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
- 25 4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-n-hexylcyclohexyl)-biphenyl,
4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclohexyl)-biphenyl,
4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclo-

- hexyl)-biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclo-
hexyl)-biphenyl,
4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclo-
5 hexyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclo-
hexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclo-
hexyl)-biphenyl,
10 4-(4-n-heptylcyclohex-1-enyl)-4'-(trans-4-n-heptylcyclo-
hexyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-n-
heptylcyclohexyl)-benzene,
4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-octylcyclo-
15 hexyl)-biphenyl,
4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-octylcyclohexyl)-
biphenyl,
4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-octylcyclo-
hexyl)-biphenyl,
20 4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-octylcyclo-
hexyl)-biphenyl,
4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-octylcyclo-
hexyl)-biphenyl,
4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-octylcyclo-
25 hexyl)-biphenyl,
4-[4-(2-methylbutyl)-cyclohex-1-enyl]-4'-(trans-4-n-octyl-
cyclohexyl)-biphenyl,
4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-nonylcyclo-
hexyl)-biphenyl,

- 4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-nonylcyclohexyl)-biphenyl,
- 4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-nonylcyclohexyl)-biphenyl,
- 5 4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-nonylcyclohexyl)-biphenyl,
- 4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-nonylcyclohexyl)-biphenyl,
- 4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-nonylcyclohexyl)-biphenyl,
- 10 4-(4-methylcyclohex-1-enyl)-4'-(trans-4-n-decylcyclohexyl)-biphenyl,
- 4-(4-ethylcyclohex-1-enyl)-4'-(trans-4-n-decylcyclohexyl)-biphenyl,
- 15 4-(4-n-propylcyclohex-1-enyl)-4'-(trans-4-n-decylcyclohexyl)-biphenyl,
- 4-(4-n-butylcyclohex-1-enyl)-4'-(trans-4-n-decylcyclohexyl)-biphenyl,
- 4-(4-n-pentylcyclohex-1-enyl)-4'-(trans-4-n-decylcyclohexyl)-biphenyl and
- 20 4-(4-n-hexylcyclohex-1-enyl)-4'-(trans-4-n-decylcyclohexyl)-biphenyl.

The following examples relate to the use of the partially hydrogenated oligo-1,4-phenylenes according to the invention as components of liquid crystal dielectrics.

Example 6

- a) A dielectric consisting of 33.3% of 4-n-butyl-4'-methoxy-azoxybenzene, 16.7% of 4-ethyl-4'-methoxy-azoxy-

benzene and 50.0% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile has a clear point of 64° , a threshold voltage in a twisted nematic cell of 1.7 V at 40° and a temperature dependence of the threshold voltage of 10.5 mV per degree Centigrade.

b) In contrast, a dielectric of 86% of the mixture described above and 14% of the compound 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl according to the invention has a clear point of 80° , a threshold voltage in a twisted nematic cell of 1.9 V at 40° and a temperature dependence of the threshold voltage of only 4.7 mV per degree Centigrade.

Example 7

a) A dielectric consisting of 12% of 4-(trans-4-ethylcyclohexyl)-benzonitrile, 23% of 4-(trans-4-n-butylcyclohexyl)-benzonitrile, 14% of 4-ethyl-4'-cyanobiphenyl, 10% of 4-n-propyloxy-4'-cyanobiphenyl, 20% of 4-(trans-4-ethylcyclohexyl)-benzoic acid (trans-4-n-propylcyclohexyl) ester and 21% of 4-(trans-4-n-butylcyclohexyl)-benzoic acid (trans-4-n-propylcyclohexyl) ester has a m. of -5° , a c. of 68° , a threshold voltage in a twisted nematic cell of 1.52 V at 40° and a temperature dependence of the threshold voltage of 6.0 mV per degree Centigrade.

b) In contrast, a dielectric consisting of 90% of the mixture described above and 10% of the compound 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-hexylcyclohexyl)-biphenyl according to the invention has a m. of -6° , a c. of 81° , a threshold voltage in a twisted

nematic cell of 1.74 V at 40° and a temperature dependence of the threshold voltage of only 3.0 mV per degree Centigrade.

Example 8

- 5 a) A dielectric consisting of 24% of 4-(trans-4-n-propylcyclohexyl)-benzonitrile, 36% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile, 25% of 4-(trans-4-n-heptylcyclohexyl)-benzonitrile and 15% of 4-(trans-4-n-pentylcyclohexyl)-4'-cyanobiphenyl has a m. of -6°, a c.
10 of 72°, a threshold voltage in a twisted nematic cell of 1.7 V at 40° and a temperature dependence of the threshold voltage of 10.0 mV per degree Centigrade.
- b) In contrast, a dielectric consisting of 90% of the mixture described above and 10% of the compound 4,4-
15 bis-(trans-4-n-pentylcyclohexyl)-biphenyl according to the invention has a m. of -7°, a c. of 88°, a threshold voltage in a twisted nematic cell of 2.0 V at 40° and a temperature dependence of the threshold voltage of only 7.5 mV per degree Centigrade.

20 Example 9

A dielectric consisting of 28% of 4-n-pentylphenyl anisate, 22% of 4-n-propylphenyl 4-n-hexanoyloxybenzoate, 20% of 4-n-propylcyclohexyl 4-(trans-4-n-butylcyclohexyl)-benzoate, 19% of 4-(trans-4-n-propylcyclohexyl)-ethylbenz-
25 ene and 11% of 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl has a m. of -7°, a c. of +70°, a viscosity of 35×10^{-3} Pa.s at 20° and a dielectric anisotropy of -0.2. It is thus outstandingly suitable for display elements which operate by the principle

of dynamic scattering.

Example 10

A dielectric consisting of 23% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile, 17% of 4-(trans-4-n-propylcyclohexyl)-benzonitrile, 16% of 4-(trans-4-n-propylcyclohexyl)-phenetol, 12% of 4-(trans-4-n-propylcyclohexyl)-1-n-butoxybenzene, 22% of 4-(trans-4-n-pentylcyclohexyl)-4'-ethylbiphenyl and 10% of 4-(trans-4-n-propylcyclohexyl)-4'-(trans-4-n-pentylcyclohexyl)-biphenyl has a m. of -20° , a c. of $+85^{\circ}$, a viscosity of 19×10^{-3} Pa.s at 20° , a dielectric anisotropy of +6.0, a threshold voltage in a twisted nematic cell of 2.3 V at 20° and a temperature dependence of the threshold voltage of only 8 mV per degree centigrade. Due to its low viscosity and the wide temperature range of the nematic phase, it is particularly well suited for display elements in motor vehicles.

Example 11

A dielectric consisting of 49% of 4-(trans-4-n-propylcyclohexyl)-1-n-butyryloxybenzene, 21% of 4-(trans-4-n-propylcyclohexyl)-phenetol, 18% of 4-(trans-4-n-propylcyclohexyl)-1-n-butoxybenzene and 12% of 4-(trans-4-n-propylcyclohexyl)-4'-(trans-4-n-pentylcyclohexyl)-biphenyl has a nematic phase in the temperature range from -10° to $+59^{\circ}$, a viscosity of only 13×10^{-3} Pa.s at 20° and a dielectric anisotropy of -0.59. It is therefore particularly well suited for fast-switching display elements which are run at relatively low control voltages and which operate by the principle of dynamic scattering.

Example 12

A dielectric consisting of 21% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile, 14% of 4-(trans-4-n-propylcyclohexyl)-benzonitrile, 16% of 4-(trans-4-n-propylcyclohexyl)-phenetol, 12% of 4-(trans-4-n-propylcyclohexyl)-1-n-butoxybenzene, 22% of 4-(trans-4-n-pentylcyclohexyl)-4'-ethylbiphenyl, 5% of 4-(trans-4-n-pentylcyclohexyl)-4'-cyanobiphenyl and 10% of 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl has a nematic phase in the temperature range from -20° to $+93^{\circ}$, a viscosity of 22×10^{-3} Pa.s at 20° , a dielectric anisotropy of +5.7 and a threshold voltage of 2.3 V. It is particularly well suited for use in display elements for motor vehicles.

Example 13

A dielectric consisting of 20% of 4-(trans-4-n-butylcyclohexyl)-benzonitrile, 18% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile, 17% of 4-n-butyl-4'-cyanobiphenyl, 13% of 4-ethyl-4'-cyanobiphenyl, 12% of 4-n-propylphenyl 4-(trans-4-n-propylcyclohexyl)-benzoate, 10% of 4-(trans-4-n-pentylcyclohexyl)-4'-ethylbiphenyl and 10% of 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl has a nematic phase in the temperature range from -4° to $+84^{\circ}$, a viscosity of 30×10^{-3} Pa.s at 20° , a dielectric anisotropy of +10, a threshold voltage of 1.5 V at 20° and a temperature dependence of the threshold voltage of only 4 mV per degree centigrade. It is very suitable for display elements which have a high information density, are based on a twisted nematic cell

and are constructed as matrix display elements for multiplex operation.

Example 14

A dielectric consisting of 20% of 4-(trans-4-n-propylcyclohexyl)-benzonitrile, 16% of 4-(trans-4-n-butylcyclohexyl)-benzonitrile, 22% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile, 25% of 4-(trans-4-n-pentylcyclohexyl)-4'-ethylbiphenyl, 7% of 4-(trans-4-n-propylcyclohexyl)-ethylbenzene and 10% of 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl has a nematic phase in the temperature range from -15° to $+85^{\circ}$, a viscosity of 21×10^{-3} Pa.s at 20° , a dielectric anisotropy of +7.5 and a threshold voltage of 1.8 V at 20° which changes by 7.0 mV per degree centigrade.

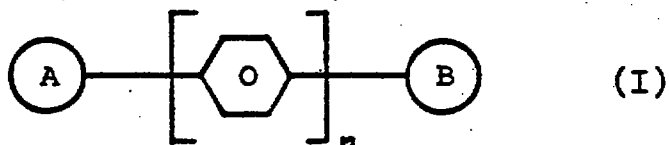
Example 15

A dielectric consisting of 16% of 4-(trans-4-ethylcyclohexyl)-benzonitrile, 22% of 4-(trans-4-n-propylcyclohexyl)-benzonitrile, 17% of 4-(trans-4-n-butylcyclohexyl)-benzonitrile, 27% of 4-(trans-4-n-pentylcyclohexyl)-benzonitrile, 8% of 4-(trans-4-n-pentylcyclohexyl)-4'-ethylbiphenyl and 10% of 4-(trans-4-n-pentylcyclohexyl)-4'-(trans-4-n-propylcyclohexyl)-biphenyl has a nematic phase in the temperature range from -10° to $+66^{\circ}$, a viscosity of 23×10^{-3} Pa.s at 20° and a dielectric anisotropy of +9.7. The threshold voltage in a twisted nematic cell is 1.6 V. Display elements with this dielectric are very suitable, for example, for portable calculators.



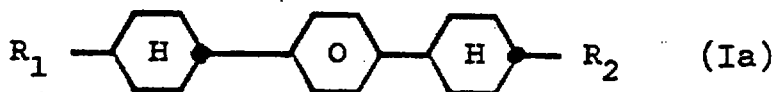
Claims for the contracting states: CH, DE, FR, GB, IT, LI, NL

1. Partially hydrogenated oligo-1,4-phenylenes of the formula I



wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms.

2. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1 of the formula (Ia)



wherein R_1 and R_2 are identical or different and are alkyl groups with up to 10 carbon atoms.

3. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1, of the formula (Ib)

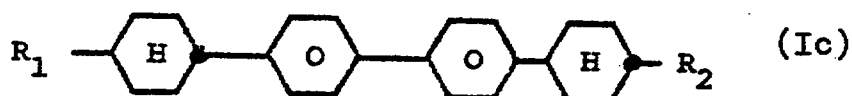


wherein R_1 and R_2 are identical or different and are alkyl groups with up to 10 carbon atoms.

4. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1, of the formula (Ic)



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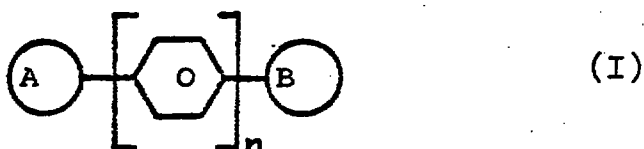
wherein R_1 and R_2 are identical or different and are alkyl groups with up to 10 carbon atoms.

5. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1, of the formula (Id)



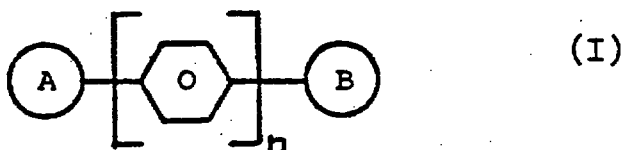
wherein R_1 and R_2 are identical or different and are alkyl groups with up to 10 carbon atoms.

6. Use of the partially hydrogenated oligo-1,4-phenylenes of the formula (I)



wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms, as components of liquid crystal dielectrics.

7. Liquid crystal dielectric for electro-optical display elements, characterised in that it contains at least one partially hydrogenated oligo-1,4-phenylene of the formula (I)





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wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms.

8. Electro-optical display element based on a liquid crystal cell, characterised in that it contains a liquid crystal dielectric according to Claim 7.



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Claims for the contracting state: AT

1. Use of partially hydrogenated oligo-1,4-phenylenes of the formula (I)



(I)

wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms, as components of liquid crystal dielectrics.

2. Liquid crystal dielectric for electro-optical display elements, characterised in that it contains at least one partially hydrogenated oligo-1,4-phenylene of the formula (I)



(I)

wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms.

3. Electro-optical display element based on a liquid crystal cell, characterised in that it contains a liquid crystal dielectric according to Claim 7. (sic).

2. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1 of the formula (Ia)



(Ia)

wherein R₁ and R₂ are identical or different and are alkyl groups with up to 10 carbon atoms.

3. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1, of the formula (Ib)



(Ib)

wherein R₁ and R₂ are identical or different and are alkyl groups with up to 10 carbon atoms.

4. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1, of the formula (Ic)



(Ic)

wherein R₁ and R₂ are identical or different and are alkyl groups with up to 10 carbon atoms.

5. Partially hydrogenated oligo-1,4-phenylenes according to Claim 1, of the formula (Id)



(Id)

wherein R₁ and R₂ are identical or different and are alkyl groups with up to 10 carbon atoms.

6. Use of the partially hydrogenated oligo-1,4-phenylenes of the formula (I)



(I)

wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms, as components of liquid crystal dielectrics.

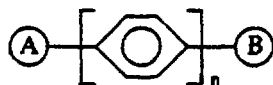
7. Liquid crystal dielectric for electro-optical display elements, characterised in that it contains at least one partially hydrogenated oligo-1,4-phenylene of the formula (I)



(I)

wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms.

8. Electro-optical display element based on a liquid crystal cell, characterised in that it contains a liquid crystal dielectric according to Claim 7.


Patentansprüche für die Vertragsstaaten: CH, DE, FR, GB, IT, LI, NL
1. Partiiell hydrierte Oligo-1,4-phenylene der Formel I


(I)

worin n 1 oder 2 ist und die Ringe A und B, die gleich oder verschieden sind, trans-4-Alkylcyclohexyl oder 4-Alkylcyclohexen-1-yl bedeuten, wobei die Alkylgruppen jeweils bis zu 10 Kohlenstoffatome enthalten.

2. Partiiell hydrierte Oligo-1,4-phenylene nach Anspruch 1 der Formel (Ia)


(Ia)

worin R_1 und R_2 gleich oder verschieden sind und Alkylgruppen mit bis zu 10 Kohlenstoffatomen bedeuten.

3. Partiiell hydrierte Oligo-1,4-phenylene nach Anspruch 1 der Formel (Ib)


(Ib)

worin R_1 und R_2 gleich oder verschieden sind und Alkylgruppen mit bis zu 10 Kohlenstoffatomen bedeuten.

4. Partiiell hydrierte Oligo-1,4-phenylene nach Anspruch 1 der Formel (Ic)

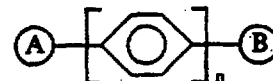

(Ic)

worin R_1 und R_2 gleich oder verschieden sind und Alkylgruppen mit bis zu 10 Kohlenstoffatomen bedeuten.

5. Partiiell hydrierte Oligo-1,4-phenylene nach Anspruch 1 der Formel (Id)


(Id)

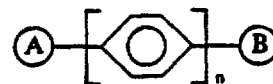
worin R_1 und R_2 gleich oder verschieden sind und Alkylgruppen mit bis zu 10 Kohlenstoffatomen bedeuten.

6. Verwendung der partiiell hydrierten Oligo-1,4-phenylene der Formel (I)


(I)

worin n 1 oder 2 ist und die Ringe A und B, die gleich oder verschieden sind, trans-4-Alkylcyclohexyl oder 4-Alkylcyclohexen-1-yl bedeuten, wobei die Alkylgruppen jeweils bis zu 10 Kohlenstoffatome enthalten, als Komponenten flüssigkristalliner Dielektrika.

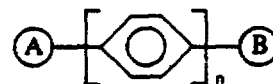
7. Flüssigkristallines Dielektrikum für elektrooptische Anzeigeelemente, dadurch gekennzeichnet, daß es mindestens ein partiiell hydriertes Oligo-1,4-phenylene der Formel (I) enthält.



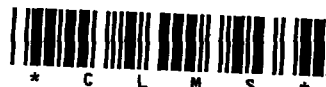
(I)

worin n 1 oder 2 ist und die Ringe A und B, die gleich oder verschieden sind, trans-4-Alkylcyclohexyl oder 4-Alkylcyclohexen-1-yl bedeuten, wobei die Alkylgruppen jeweils bis zu 10 Kohlenstoffatomen enthalten.

8. Elektrooptisches Anzeigeelement auf der Basis einer Flüssigkristallzelle, dadurch gekennzeichnet, daß es ein flüssigkristallines Dielektrikum nach Anspruch 7 enthält.

Patentansprüche für den Vertragsstaat: AT
1. Verwendung partiiell hydrierter Oligo-1,4-phenylene der Formel (I)


(I)



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worin n 1 oder 2 ist und die Ringe A und B, die gleich oder verschieden sind, trans-4-Alkylcyclohexyl oder 4-Alkylcyclohexen-1-yl bedeuten, wobei die Alkylgruppen jeweils bis zu 10 Kohlenstoffatome enthalten, als Komponenten flüssigkristalliner Dielektrika.

2. Flüssigkristallines Dielektrikum für elektrooptische Anzeigeelemente, dadurch gekennzeichnet, daß es mindestens ein partiell hydriertes Oligo-1,4-phenylen der Formel (I) enthält,



(I)

worin n 1 oder 2 ist und die Ringe A und B, die gleich oder verschieden sind, trans-4-Alkylcyclohexyl oder 4-Alkylcyclohexen-1-yl bedeuten, wobei die Alkylgruppen jeweils bis zu 10 Kohlenstoffatome enthalten.

3. Elektrooptisches Anzeigeelement auf der Basis einer Flüssigkristallzelle, dadurch gekennzeichnet, daß es ein flüssigkristallines Dielektrikum nach Anspruch 7 enthält.

Claims for the contracting states: CH, DE, FR, GB, IT, LI, NL

1. Partially hydrogenated oligo-1,4-phenylenes of the formula (I).

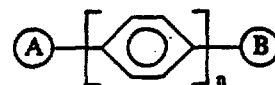


(I)

wherein n is 1 or 2 and the rings A and B, which are identical or different, are trans-4-alkylcyclohexyl or 4-alkylcyclohex-1-enyl, the alkyl groups in each case containing up to 10 carbon atoms.

Revendications pour les Etats contractants: CH, DE, FR, GB, IT, LI, NL

1. Oligo-1,4-phénylènes partiellement hydrogénés de formule I



(I)

dans laquelle n est égal à 1 ou 2 et les cycles A et B, identiques ou différents, sont des cycles trans-4-alkylcyclohexyle ou 4-alkylcyclohexène-1-yle, les groupes alkyle contenant chacun jusqu'à 10 atomes de carbone.

2. Oligo-1,4-phénylènes partiellement hydrogénés selon la revendication 1, de formule Ia



(Ia)

dans laquelle R_1 et R_2 , identiques ou différents, représentent des groupes alkyle contenant jusqu'à 10 atomes de carbone.

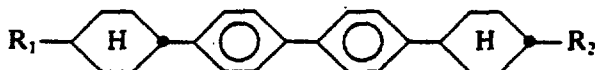
3. Oligo-1,4-phénylènes partiellement hydrogénés selon la revendication 1, de formule Ib



(Ib)

dans laquelle R_1 et R_2 , identiques ou différents, représentent des groupes alkyle contenant jusqu'à 10 atomes de carbone.

4. Oligo-1,4-phénylènes partiellement hydrogénés selon la revendication 1, de formule Ic



(Ic)

dans laquelle R_1 et R_2 , identiques ou différents, représentent des groupes alkyle contenant jusqu'à 10 atomes de carbone.

5. Oligo-1,4-phénylènes partiellement hydrogénés selon la revendication 1, de formule Id

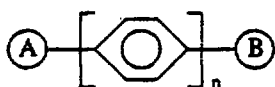


(Id)

dans laquelle R_1 et R_2 , identiques ou différents, représentent des groupes alkyle contenant jusqu'à 10 atomes de carbone.



6. Utilisation des oligo-1,4-phénylènes partiellement hydrogénés de formule I



(I)

dans laquelle n est égal à 1 ou 2 et les cycles A et B, identiques ou différents, sont des cycles trans-4-alkylcyclohexyle ou 4-alkylcyclohexène-1-yle, les groupes alkyle contenant chacun jusqu'à 10 atomes de carbone, en tant que composants de diélectriques liquides cristallins.

7. Diélectrique liquide cristallin pour éléments d'affichage électro-optiques caractérisé en ce qu'il contient au moins un oligo-1,4-phénylène partiellement hydrogéné, de formule I



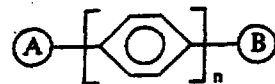
(I)

dans laquelle n est égal à 1 ou 2 et les cycles A et B, identiques ou différents, sont des cycles trans-4-alkylcyclohexyle ou 4-alkylcyclohexène-1-yle, les groupes alkyle contenant chacun jusqu'à 10 atomes de carbone.

8. Élément d'affichage électro-optique à base d'une cellule à cristaux liquides, caractérisé en ce qu'il contient un diélectrique liquide cristallin selon la revendication 7.

Revendications pour l'état contractant: AT

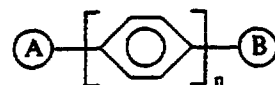
1. Utilisation d'oligo-1,4-phénylènes partiellement hydrogénés de formule I



(I)

dans laquelle n est égal à 1 ou 2 et les cycles A et B, identiques ou différents, sont des cycles trans-4-alkylcyclohexyle ou 4-alkylcyclohexène-1-yle, les groupes alkyle contenant chacun jusqu'à 10 atomes de carbone, en tant que composants de diélectriques liquides cristallins.

2. Diélectrique liquide cristallin pour éléments d'affichage électro-optiques, caractérisé en ce qu'il contient au moins un oligo-1,4-phénylène partiellement hydrogéné de formule I



(I)

dans laquelle n est égal à 1 ou 2 et les cycles A et B, identiques ou différents, sont des cycles trans-4-alkylcyclohexyle ou 4-alkylcyclohexène-1-yle, les groupes alkyle contenant chacun jusqu'à 10 atomes de carbone.

3. Élément d'affichage électro-optique à base d'une cellule à cristaux liquides, caractérisé en ce qu'il contient un diélectrique liquide cristallin selon la revendication 2.