

# PATENT SPECIFICATION

(11) 1 531 405

1 531 405

- (21) Application No. 33929/77 (22) Filed 12 Aug. 1977  
 (31) Convention Application No. 2636684  
 (32) Filed 14 Aug. 1976 in  
 (33) Federal Republic of Germany (DE)  
 (44) Complete Specification published 8 Nov. 1978  
 (51) INT CL<sup>2</sup> C07C 121/60 121/75 C09K 3/34  
 (52) Index at acceptance



C2C 220 221 225 226 227 22Y 234 240 26X 270 280 295 304 30Y  
 313 316 31Y 326 339 342 34Y 351 353 358 35Y 360 363  
 364 366 367 368 36Y 37X 386 401 409 40Y 43X 440 46Y  
 490 491 496 500 506 509 50Y 573 579 623 624 625 628  
 62X 62Y 658 662 665 666 668 66X 68Y 73Y 776 792 79Y  
 BT BY KF MB MC MD NR UE UP WS  
 C4X 12

## (54) LIQUID CRYSTALLINE CYCLOHEXANE DERIVATIVES

(71) We, MERCK PATENT GESELLSCHAFT MIT BESCHRANKTER HAFTUNG, of 250, Frankfurter Strasse, 61 Darmstadt, Federal Republic of Germany, a Joint-Stock Company organised under the laws of the Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with liquid crystalline cyclohexane derivatives and with dielectrics containing them.

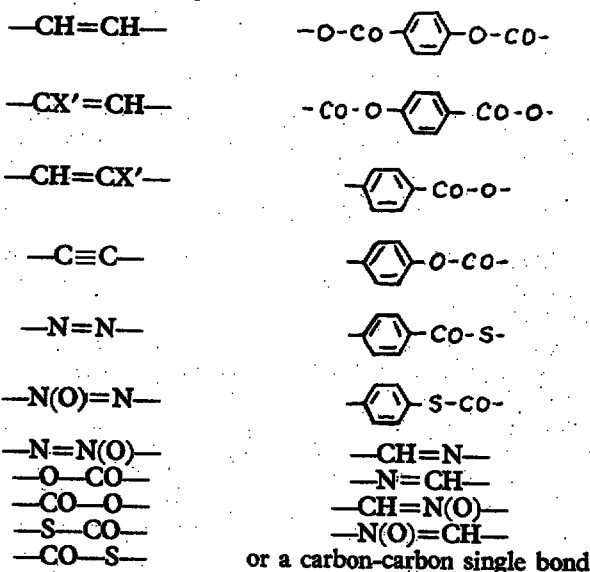
For electro-optical indicating elements, there are utilised, to an increasing extent, the properties of nematic or nematic-cholesteric liquid crystalline materials significantly to change their optical properties, such as light scattering, birefringence, reflecting power or colour, under the influence of electric fields. The function of such indicator elements thereby depends, for example, upon the phenomenon of dynamic scattering, the deformation of aligned phases, the Schadt-Helfrich effect in the twisted cell or the cholesteric-nematic phase transition.

For the technical use of these effects in electronic constructional elements, liquid crystalline materials are needed which must satisfy a plurality of requirements. Especially important are the chemical stability to moisture, air and physical influences, such as heat, radiation in the infra-red, visible and ultra-violet range and direct and alternating electric fields. Furthermore, there is required of technically usable liquid crystalline materials a liquid crystalline mesophase in the temperature range of at least +10°C. to +60°C. and preferably of 0°C. to 60°C., and a low viscosity at ambient temperature, which should preferably be not more than 70 cP. Finally, in the range of visible light, they should not exhibit an inherent absorption, i.e. they must be colourless.

A number of liquid crystalline compounds is already known which satisfy the stability requirements demanded of dielectrics for electronic constructional elements and are also colourless. These include, in particular, the *p,p'*-disubstituted benzoic acid phenyl esters described in German Patent Specification No. 2,139,628 and the *p,p'*-disubstituted biphenyl derivatives described in German Patent Specification No. 2,356,085. In both of these classes of compounds, as well as in other known series of compounds with liquid crystalline mesophase, there are no individual compounds which form a liquid crystalline nematic mesophase in the required temperature range of 10°C. to 60°C. Therefore, as a rule, mixtures of two or more compounds are produced in order to obtain materials which can be used as liquid crystalline dielectrics. For this purpose, it is usual to mix at least two compounds, one having a low melting and clear point and the other one having a distinctly higher melting and clear point. A mixture is thus normally obtained, the melting point of which is below that of the lower melting component, whereas the clear point lies between the clear points of the components. However, optimal dielectrics cannot be produced in this way since the components with the high melting and clear points also almost always impart a high viscosity to the mixtures. The switch times of the electro-optical indicator elements produced therewith are thus prolonged in an undesirable manner.

It is an object of the present invention to provide liquid crystalline dielectrics

wherein A is



X' is a halogen atom and preferably a chlorine atom and R<sub>1</sub> and R<sub>2</sub>, which can be the same or different, are alkyl, alkoxy, alkanoyl, alkanoyloxy or alkoxy-carbonyloxy radicals, which contain up to 18 and preferably up to 8 carbon atoms; furthermore, one of the symbols R<sub>1</sub> and R<sub>2</sub> can represent a cyano, nitro or isonitrile group. In the case of most of these compounds, R<sub>1</sub> and R<sub>2</sub> are preferably different, one of the radicals usually being an alkyl or alkoxy radical. However, a large number of other variants of the mentioned substituents is also conventional. Many such nematic substances are commercially available.

The dielectrics according to the present invention usually contain at least 40, preferably 50—99 and especially 60—98 parts by weight of the compounds of general formula (I) and possibly of general formula (V). Of these, preferably at least 15 parts by weight but usually 20 or more parts by weight are constituted by one or more compounds of general formula (I). However, according to the present invention, dielectrics can also be produced which consist exclusively of two or more compounds of general formula (I).

By appropriate additions, the liquid crystalline dielectrics according to the present invention can be so modified that they can be used in all previously known kinds of liquid crystal indicator elements. Such additions are known and are described in detail in the appropriate literature. For example, there can be added substances for the alteration of the dielectric anisotropy, of the viscosity, of the conductivity and/or of the orientation of the nematic phases. Such substances are described, for example, in German Patent Specifications Nos. 2,209,127; 2,240,864; 2,321,632; 2,338,281 and 2,450,088.

The following Examples are given for the purpose of illustrating the present invention. In the Examples, m.p. means the melting point and c.p. the clear point of a liquid crystalline substance in degrees Celsius; boiling temperatures are indicated by b.p. If not otherwise stated, the parts or percentages are by weight.

#### Example 1.

(a) A solution of 280 g. 4-*n*-pentylphenol in 1.5 litres glacial acetic acid is mixed with 12 g. platinum dioxide and hydrogenated at ambient temperature under a hydrogen pressure of 6 ats. Subsequently, the catalyst is filtered off, the solvent is distilled off and the remaining 4-*n*-pentyl-cyclohexanol is distilled under reduced pressure. 86.4 g. of the distillate are dissolved in 250 ml. diethyl ether and mixed, with vigorous stirring, with a solution of 52 g. sodium dichromate dihydrate in 25 ml. water and 39 ml. concentrated sulphuric acid. The reaction mixture is further stirred for 2.5 hours, whereafter the organic phase is separated off, washed twice with 200 ml. amounts of water, dried over anhydrous sodium sulphate and evaporated. The remaining 4-*n*-pentyl-cyclohexanone is distilled under reduced pressure; b.p. 101°C./0.1 mm.Hg.

12-13

5

1,531,405

5

The following compounds are prepared analogously:

4-methylcyclohexanone  
 4-ethylcyclohexanone  
 4-*n*-propylcyclohexanone; b.p. 49°C./0.2 mm.Hg.  
 4-isopropylcyclohexanone  
 4-*n*-butylcyclohexanone; b.p. 71°C./0.2 mm.Hg.  
 4-(1-methylpropyl)-cyclohexanone  
 4-(2-methylpropyl)-cyclohexanone  
 4-(1-methylbutyl)-cyclohexanone  
 4-(2-methylbutyl)-cyclohexanone  
 4-(3-methylbutyl)-cyclohexanone  
 4-*n*-hexylcyclohexanone; b.p. 102°C./0.4 mm.Hg.  
 4-(1-methylpentyl)-cyclohexanone  
 4-(2-methylpentyl)-cyclohexanone  
 4-*n*-heptylcyclohexanone; b.p. 110°C./0.4 mm.Hg.  
 4-(1-methylhexyl)-cyclohexanone  
 4-*n*-octylcyclohexanone  
 4-(2-ethylhexyl)-cyclohexanone  
 4-(1-methylheptyl)-cyclohexanone  
 4-*n*-nonylcyclohexanone  
 4-*n*-decylcyclohexanone  
 4-*n*-dodecylcyclohexanone.

5

5

10

10

15

15

20

20

25

25

30

30

35

35

40

40

45

45

50

50

55

55

60

60

(b) To a solution of phenyl magnesium bromide prepared from 80 g. bromobenzene and 13 g. magnesium turnings in 400 ml. diethyl ether, there is added dropwise, with stirring and cooling, in the course of an hour, a solution of 65 g. 4-*n*-pentylcyclohexanone in 200 ml. diethyl ether. The reaction mixture is heated to the boil for a further hour and then poured into a solution of 50 ml. concentrated hydrochloric acid in 1 litre ice water. The ethereal phase is separated off and the aqueous phase is further shaken out twice with 100 ml. amounts of diethyl ether. The combined ethereal phases are washed neutral with 5% aqueous sodium bicarbonate solution, dried over anhydrous sodium sulphate and evaporated. The residue is subjected to a separation over a column filled with silica gel. The 1-phenyl-*cis*-4-*n*-pentyl-*r*-cyclohexanol eluted with petroleum ether (boiling range 40–60°C.) is dissolved in 1 litre ethanol and hydrogenated in the presence of 75 g. moist Raney nickel at ambient temperature and atmospheric pressure for 72 hours. After filtering off the catalyst and distilling off the ethanol from the filtrate, the remaining 4-*n*-pentyl-1-phenylcyclohexane is distilled under reduced pressure; b.p. 105–110°C./0.02 mm.Hg.

(c) A suspension of 16 g. aluminium chloride in 100 ml. dichloromethane is successively mixed, while cooling with ice, with 7.9 g. acetyl chloride and a solution of 23 g. 4-*n*-pentyl-1-phenylcyclohexane. The reaction mixture is further stirred for 2 hours, poured on to 300 g. ice and mixed with sufficient concentrated hydrochloric acid to redissolve the precipitated aluminium hydroxide. The organic phase is separated off and the aqueous phase is washed twice with 100 ml. amounts of dichloromethane. The combined organic phases are dried over anhydrous calcium chloride and evaporated. The remaining 4-(4-*n*-pentylcyclohexyl)-acetophenone is distilled under reduced pressure; b.p. 153°C./0.02 mm.Hg.

(d) To a solution of 28 g. sodium hydroxide and 33.6 g. bromine in 160 ml. water, there is added dropwise at ambient temperature, while stirring, a solution of 19 g. 4-(4-*n*-pentylcyclohexyl)-acetophenone in 70 ml. dioxan. The reaction mixture is subsequently stirred for 1 hour, mixed with a solution of 10 g. sodium bisulphite in 100 ml. water and adjusted to a pH value of about 5 with hydrochloric acid, 4-(4-*n*-Pentylcyclohexyl)benzoic acid is isolated from the aqueous solution by extracting twice with 100 ml. amounts of dichloromethane, the extracts then being washed with water and evaporated. The 4-(4-*n*-pentylcyclohexyl)-benzoic acid thus obtained is heated to the boil for 2.5 hours with 40 ml. thionyl chloride. After distilling off excess thionyl chloride, the remaining 4-(4-*n*-pentylcyclohexyl)-benzoyl chloride is dissolved in 300 ml. anhydrous dioxan and this solution is mixed with 140 ml. 25% aqueous ammonia solution. The reaction mixture is poured into 2 litres ice water and the precipitated 4-(4-*n*-pentylcyclohexyl)-benzamide is filtered off and dried. 12.6 g. of this benzamide are dissolved at 40°C. in 200 ml. dimethyl formamide. To this solution are added dropwise at 50°C., in the course of 30 minutes, 26 g. phosphorus oxychloride. After 1 hour, the reaction mixture is poured into 600 ml. ice water; by extracting four times with 200 ml. amounts of dichloromethane, washing the extracts

with water, drying over anhydrous sodium sulphate and evaporating, there is obtained therefrom 4-*n*-pentyl-1-(4-cyanophenyl)-cyclohexane, which is purified by distillation under reduced pressure; b.p. 168°C./0.05 mm.Hg.; m.p. 30°C.; c.p. 56°C.; viscosity 21 cP at 20°C.

The following compounds are prepared analogously:

4-methyl-1-(4-cyanophenyl)-cyclohexane,  
4-ethyl-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-propyl-1-(4-cyanophenyl)-cyclohexane; m.p. 42°C.; c.p. 45°C.,  
4-*n*-butyl-1-(4-cyanophenyl)-cyclohexane; m.p. 41°C.; c.p. 41°C.,  
4-*n*-hexyl-1-(4-cyanophenyl)-cyclohexane; m.p. 42°C.; c.p. 47°C.,  
4-*n*-heptyl-1-(4-cyanophenyl)-cyclohexane; m.p. 30°C.; c.p. 59°C.,  
4-*n*-octyl-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-nonyl-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-decyl-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-undecyl-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-dodecyl-1-(4-cyanophenyl)-cyclohexane,  
4-isopropyl-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylpropyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylbutyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(2-methylbutyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylpentyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(2-methylpentyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(3-methylpentyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(2-ethylhexyl)-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylheptyl)-1-(4-cyanophenyl)-cyclohexane.

#### Example 2.

(a) A suspension of 48 g. silver (I) oxide and 35.2 g. *trans*-4-phenylcyclohexanol in 100 ml. *n*-butyl iodide is boiled for 72 hours and then filtered. After distilling off excess *n*-butyl iodide, the remaining 4-*n*-butyloxy-1-phenylcyclohexane is purified by distillation under reduced pressure.

(b) 23.2 g. 4-*n*-Butyloxy-1-phenylcyclohexane and 54.3 g. thallium tris-trifluoroacetate are boiled for 24 hours in 300 ml. acetonitrile. Subsequently, the acetonitrile is distilled off and the remaining 4-*n*-butyloxy-1-[4-(bis-trifluoroacetate-thallium)-phenyl]-cyclohexane is suspended in a solution of 80 g. potassium cyanide in 1 litre water. The suspension is irradiated in an immersed lamp apparatus, with vigorous stirring, for 2.5 hours with a low pressure mercury lamp. Subsequently, the reaction mixture is extracted four times with 200 ml. amounts of hexane, the extracts are dried over anhydrous sodium sulphate and evaporated and the remaining 4-*n*-butyloxy-1-(4-cyanophenyl)-cyclohexane is purified by distillation under reduced pressure.

The following compounds are prepared analogously:

4-methoxy-1-(4-cyanophenyl)-cyclohexane,  
4-ethoxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-propyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-pentyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-hexyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-heptyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-octyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-nonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-decyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-undecyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-*n*-dodecyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-isopropyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylpropyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylbutyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(2-methylbutyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylpentyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(2-methylpentyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(3-methylpentyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(2-ethylhexyloxy)-1-(4-cyanophenyl)-cyclohexane,  
4-(1-methylheptyloxy)-1-(4-cyanophenyl)-cyclohexane.

## Example 3.

A solution of 35.2 g. *trans*-4-phenylcyclohexanol in 200 ml. toluene is boiled for 1 hour with 24 g. *n*-pentanoyl chloride and 30 ml. pyridine. After cooling, the reaction mixture is washed with 100 ml. water, dried over anhydrous sodium sulphate and distilled. After stripping off the toluene and residual pyridine, there are distilled off under reduced pressure 42.7 g. 4-*n*-pentanoyloxy-1-phenylcyclohexane. From 26 g. of this distillate there are obtained, analogously to Example 2 (b), by reaction with thallium tris-trifluoroacetate in acetonitrile and subsequent irradiation in aqueous potassium cyanide solution, 12.3 g. 4-*n*-pentanoyloxy-1-(4-cyanophenyl)-cyclohexane.

The following compounds are prepared analogously:

4-acetoxy-1-(4-cyanophenyl)-cyclohexane,  
4-propionyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-butyryloxy-1-(4-cyanophenyl)-cyclohexane,  
4-hexanoyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-heptanoyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-octanoyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-ethoxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-propyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-butyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-pentyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-hexyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-heptyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-octyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-nonyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane,  
4-decyloxycarbonyloxy-1-(4-cyanophenyl)-cyclohexane.

## Example 4.

(a) To a suspension of 66.6 g. anhydrous aluminium chloride in 200 ml. carbon disulphide there are added at  $-15^{\circ}\text{C.}$ , with stirring, 39 g. acetyl chloride and thereafter 41 g. cyclohexene. The reaction mixture is stirred for 30 minutes at  $-15^{\circ}\text{C.}$  and then the upper carbon disulphide layer is removed and replaced by 400 ml. *n*-pentylbenzene. After the addition of a further 33 g. aluminium chloride, the reaction mixture is warmed up, while stirring, to ambient temperature and further stirred until the evolution of hydrogen chloride ceases. Thereafter, the reaction mixture is poured on to ice water, the separated aluminium hydroxide is brought into solution with hydrochloric acid and the organic phase is separated off, dried and distilled. After stripping off excess *n*-pentylbenzene, the 4-acetyl-1-(4-pentylphenyl)-cyclohexane thus obtained is distilled off under reduced pressure; yield 48 g.

(b) Analogously to Example 1 (d), from 27 g. 4-acetyl-1-(4-pentylphenyl)-cyclohexane, there are obtained, by successive reaction with sodium hypobromite, thionyl chloride, ammonia solution and phosphorus oxychloride, 14.9 g. 4-cyano-1-(4-pentylphenyl)-cyclohexane.

The following compounds are prepared analogously:

4-cyano-1-(4-methylphenyl)-cyclohexane,  
4-cyano-1-(4-ethylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-propylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-butylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-hexylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-heptylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-octylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-nonylphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-decylphenyl)-cyclohexane,  
4-cyano-1-(4-isopropylphenyl)-cyclohexane,  
4-cyano-1-[4-(1-methylpropyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(1-methylbutyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(2-methylbutyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(1-methylpentyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(2-methylpentyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(3-methylpentyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(2-ethylhexyl)-phenyl]-cyclohexane,  
4-cyano-1-[4-(1-methylheptyl)-phenyl]-cyclohexane,  
4-cyano-1-(4-methoxyphenyl)-cyclohexane,  
4-cyano-1-(4-ethoxyphenyl)-cyclohexane,

- 5 4-cyano-1-(4-*n*-propyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-butyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-pentyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-hexyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-heptyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-octyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-nonyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-*n*-decyloxyphenyl)-cyclohexane,  
10 4-cyano-1-(4-*n*-dodecyloxyphenyl)-cyclohexane,  
4-cyano-1-(4-isopropylloxyphenyl)-cyclohexane,  
4-cyano-1-[4-(1-methylpropyloxy)-phenyl]-cyclohexane,  
4-cyano-1-[4-(1-methylbutyloxy)-phenyl]-cyclohexane,  
4-cyano-1-[4-(2-methylbutyloxy)-phenyl]-cyclohexane,  
15 4-cyano-1-[4-(1-methylpentyloxy)-phenyl]-cyclohexane,  
4-cyano-1-[4-(2-methylpentyloxy)-phenyl]-cyclohexane,  
4-cyano-1-[4-(3-methylpentyloxy)-phenyl]-cyclohexane,  
4-cyano-1-[4-(2-ethylhexyloxy)-phenyl]-cyclohexane,  
4-cyano-1-[4-(1-methylheptyloxy)-phenyl]-cyclohexane.

20 The following Examples describe liquid crystalline dielectrics according to the present invention:

Example 5.

A mixture of:

- 25 40 parts by weight 4-*n*-pentyl-1-(4-cyanophenyl)-cyclohexane,  
25 parts by weight 4-*n*-heptyl-1-(4-cyanophenyl)-cyclohexane, and  
35 parts by weight 4-*n*-butyloxy-1-(4-cyanophenyl)-cyclohexane,

has a positive dielectric anisotropy of  $\Delta\epsilon \sim 10$ . The dielectric in a twisted nematic cell with 10 micron plate distance is light permeable between crossed polarisers. Upon applying a voltage of 1.5 V, the area between the electrodes appears to be dark.

Example 6.

A mixture of:

- 30 37.5 parts by weight 4-*n*-pentyl-1-(4-cyanophenyl)-cyclohexane,  
25 parts by weight 4-*n*-heptyl-1-(4-cyanophenyl)-cyclohexane,  
34 parts by weight 4-*n*-butyloxy-1-(4-cyanophenyl)-cyclohexane,  
3 parts by weight cholesterol pelargonate and  
35 0.5 parts by weight 4-*N,N*-diethylaminophenyl-azo-(5-nitro)-thiazole

is, as dielectric in a liquid crystal cell with 15 micron plate distance, planar-cholesteric oriented and exhibits a deep blue colour. When to oppositely-lying transparent electrodes of this cell there is applied an alternating voltage of 20V/50Hz, the places of the dielectric present between these electrodes appear to be transparent.

Example 7.

A mixture of:

- 40 29 parts by weight 4-*n*-propyl-1-(4-cyanophenyl)-cyclohexane,  
41 parts by weight 4-*n*-pentyl-1-(4-cyanophenyl)-cyclohexane and  
30 parts by weight 4-*n*-heptyl-1-(4-cyanophenyl)-cyclohexane,

45 has a nematic phase in the temperature range of from  $-5^{\circ}\text{C.}$  to  $+51^{\circ}\text{C.}$ , a dielectric anisotropy of  $+10.1$  and a viscosity of 21 cP at  $20^{\circ}\text{C.}$

Example 8.

A mixture of:

- 50 30 parts by weight 4-*n*-octyloxy-4'-cyanobiphenyl,  
21 parts by weight 4-*n*-propyl-1-(4-cyanophenyl)-cyclohexane,  
28 parts by weight 4-*n*-pentyl-1-(4-cyanophenyl)-cyclohexane and  
21 parts by weight 4-*n*-heptyl-1-(4-cyanophenyl)-cyclohexane,

has a nematic phase in the temperature range of from  $-7^{\circ}\text{C.}$  to  $+56^{\circ}\text{C.}$ , a dielectric anisotropy of  $+11.3$  and a viscosity of 29 cP at  $20^{\circ}\text{C.}$



\* C L M S \*

1,531,405

9

9

## WHAT WE CLAIM IS:—

1. Compounds of the general formula:—



wherein one of the symbols  $R_1$  and  $R_2$  represents a cyano group and the other represents R, OR, OCOR or OCOOR, in which R is an alkyl radical containing up to 12 carbon atoms.

2. Compounds according to claim 1, wherein R is straight-chained.

3. Compounds according to claim 1, wherein R is a branched alkyl radical with only one chain branching.

4. Compounds according to any of the preceding claims, wherein  $R_1$  is a cyano group.

5. Compounds according to any of claims 1 to 3, wherein  $R_2$  is a cyano group.

6. Compounds according to claim 4 or 5, wherein the other side group is R or OR.

7. 4-n-Pentyl-1-(4-cyanophenyl)-cyclohexane.

8. 4-n-Propyl-1-(4-cyanophenyl)-cyclohexane.

9. 4-n-Butyl-1-(4-cyanophenyl)-cyclohexane.

10. 4-n-Hexyl-1-(4-cyanophenyl)-cyclohexane.

11. 4-n-Heptyl-1-(4-cyanophenyl)-cyclohexane.

12. 4-n-Butyloxy-1-(4-cyanophenyl)-cyclohexane.

13. 4-n-Pentanoyloxy-1-(4-cyanophenyl)-cyclohexane.

14. 4-Cyano-1-(4-pentylphenyl)-cyclohexane.

15. Process for the preparation of compounds of the general formula given in claim 1, substantially as hereinbefore described and exemplified.

16. Compounds according to claim 1, whenever prepared by the process according to claim 15.

17. A liquid crystalline dielectric comprising at least two liquid crystalline components, at least one of said components being a compound of the general formula given in claim 1.

18. Liquid crystalline dielectrics according to claim 17, substantially as hereinbefore described and exemplified.

VENNER, SHIPLEY & CO.,

Chartered Patent Agents,

Rugby Chambers,

2, Rugby Street,

London, WC1N 3QU,

Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978  
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from  
which copies may be obtained.