

Description

This invention relates to novel phenyl naphthalenes having liquid crystalline properties and to their use in liquid crystal materials and devices.

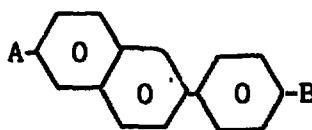
Liquid crystal materials and devices exploit the electro-optical properties of nematic or cholesteric (N or N^{*}), or smectic (S) in particular chiral smectic C (Sc^{*}) or smectic A (SA) phases. The most common type of liquid crystal materials in use are those which show a nematic phase and these are extensively used in, for example, watches, clocks, calculators, electronic displays.

Liquid crystal materials which show a ferro-electric Sc^{*} phase are useful in fast switching displays such as television or VDU screens as the Sc^{*} phase can be switched in a few milliseconds or even microseconds. The principle of Sc^{*} switching is described inter alia by N A Clark and S T Lagerwall in App-Phys Lett 36 (1980) 899.

Materials which show an SA liquid crystal phase may be used in display devices which exploit the electroclinic effect.

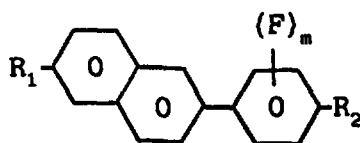
Liquid crystal materials desirably are easy to prepare, show liquid crystal phases which persist over a wide temperature range which preferably includes room temperature and useful physico-chemical properties such as birefringence. For some applications of liquid crystal materials a high birefringence is sought, eg in the so-called "electrically controlled birefringence" (ECB) effect device (see, for example, M F Schieckel and K Fahrenshon App Phys Lett (1971), 19, 2912), in thin film transistors (TFT) or supertwist twisted nematic (STN) devices. It is rare for all the requisite desirable properties to be found in a single liquid crystalline compound and generally liquid crystal materials consist of mixtures of component compounds. Very many liquid crystalline compounds suitable for such uses are known and will be apparent to those skilled in the art.

Some liquid crystalline compounds are known, based upon the phenyl naphthalene system, ie:



For example, Bull Soc Chim Fr (1975) 11-12(2) 2521-6 describes compounds where A is alkoxy and B is alkyl or alkoxy and Helv Chim Acta (1985) 68(5) 1406-26 describes those in which A is alkyl or alkoxy and B is cyano or trifluoromethyl. The present inventors have applied developments in synthetic organic chemistry to investigate the phenyl-naphthalene system further with the object of identifying novel compounds which provide improved or alternative liquid crystalline characteristics. Some examples of fluorinated compounds may be found in Flüssige Kristalle in Tabellen, Leipzig (1976), eg pages 59 and 195.

According to this invention, phenyl-naphthalenes of general formula I are provided:



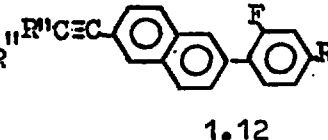
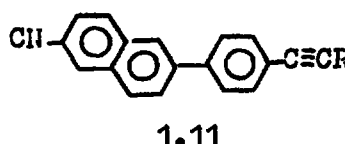
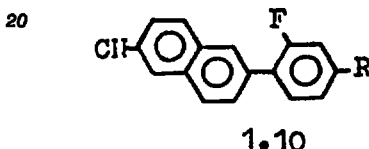
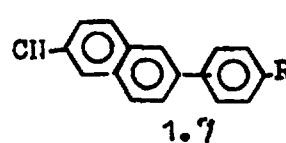
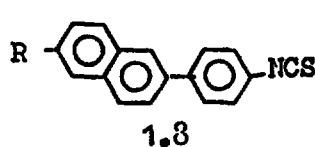
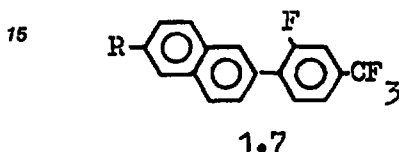
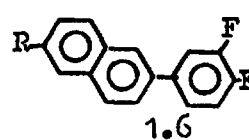
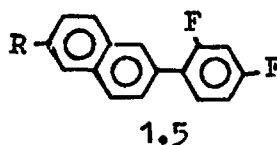
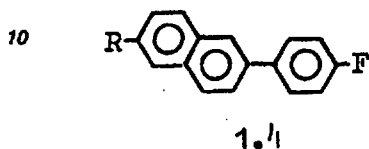
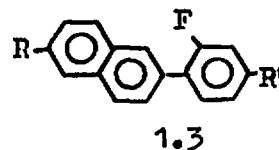
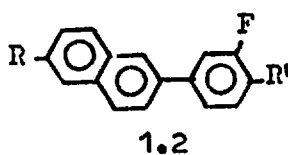
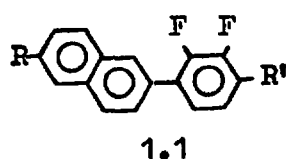
Formula I

wherein R₁ and R₂ are selected from C₁₋₁₅ alkyl, alkoxy, perfluoro-alkyl, perfluoroalkoxy and alkynyl, R₁ may also be CN and R₂ may also be fluorine or NCS; m is 0, 1 or 2 provided that if R₁ is alkyl or alkoxy and R₂ is alkyl, alkoxy or perfluoroalkyl then m is 1 or 2.

The preferred embodiments of the invention discussed below are inter alia chosen with respect to ease of preparation and their liquid crystal properties, particularly with respect to suitability for use in high birefringence nematic or ferro-electric S_c^{*} liquid crystal materials.

Preferably for use in nematic materials alkyl or alkoxy substituents R₁ and/or R₂ contain 1-8 carbon atoms and for use in smectic materials 3-12. For use in nematic materials compounds having R₁ as alkyl or alkoxy and R₂ as fluorine; or R₁ as alkynyl and R₂ as alkyl or alkoxy, or R₁ as CN and R₂ as alkyl, alkoxy or alkynyl are preferred. Preferably for smectic C materials R₁ and R₂ are selected from n-alkyl or n-alkoxy, m is 1 or 2, especially 2, preferably with the fluorines in the 2, 3 positions.

Preferred overall structures for the phenyl naphthalenes of formula I are listed below:

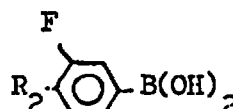
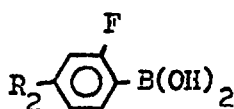
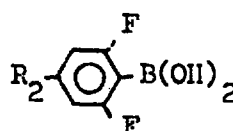
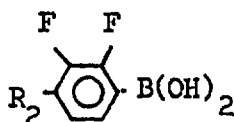


Where R and R' are independently alkyl or alkoxy and R'' is alkyl.

For use in nematic materials structures 1.4, 1.5, 1.6, 1.9, 1.10, 1.11 and 1.12 are preferred. For smectic materials structure 1.1 is preferred.

Phenyl-naphthalenes of formula I may be prepared by generally applicable routes A to D shown in Fig 1 of the accompanying drawings. In these routes the reaction conditions of the individual steps are well known but the overall combination of steps to form the end product is novel. Compounds in which R₂ is NCS, eg 1.8 are preferably prepared by initially incorporating an amino group into the molecule as R₂, for example, coupling the boronic acid of step D1 with para-bromoaniline and then converting the amino group into an isothiocyanate. Ways of doing this will be apparent to those skilled in the art.

Preparative routes to intermediates of formula:

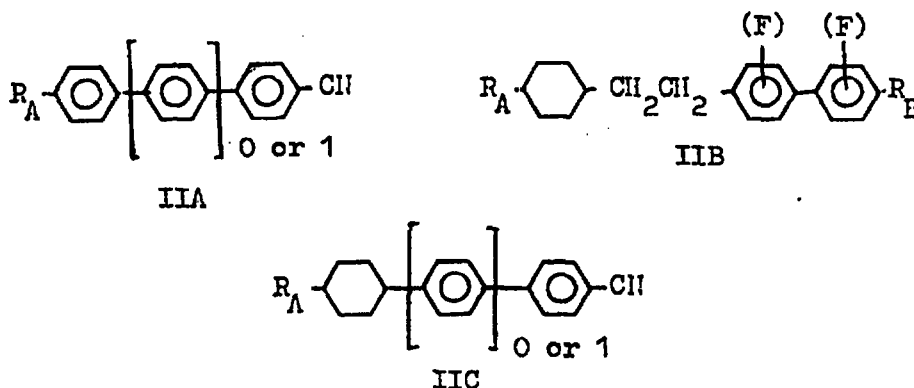


where R₂ is alkyl or alkoxy are described in published WO 89/02425 and WO 89/08687 among others.

The invention also provides a liquid crystal material being a mixture of at least 2 component compounds, at least one of which is a phenyl-naphthalene of formula I. This material may show a nematic or smectic (eg smectic C, S_c^{*} or S_A) liquid crystal phase.

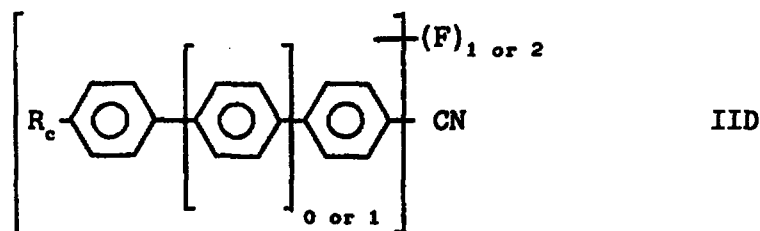
In particular many phenyl-naphthalenes of formula I have a high birefringence, making them suitable for applications in which this characteristic is required, as discussed above. In particular, compounds of formula I which contain an alkyne group may have a high birefringence. Although some have rather high melting points this can in some cases be usefully reduced by introducing one or more lateral fluorosubstituents on the phenyl ring, eg as in 1.1, 1.2, 1.3, 1.5, 1.6, 1.7, 1.10 and 1.12. Phenyl-naphthalenes of formula I may be

used as components of nematic liquid crystal materials together with other known nematic liquid crystalline compounds especially, for example, compounds of general formulae IIA, B and C, in particular IIA:



Where R_A and R_B are independently C_{1-10} n-alkyl or n-alkoxy and (F) indicates that one of the rings carries a fluoro substituent. Other known compounds which may be usefully included as components of nematic liquid crystal materials include those described, for example, in GB 1551043, GB 1558994, GB 1592147, GB 1587819, GB 1603076, GB 2011940, GB 2023136, GB 2027708, GB 2027027, GB 2063250, GB 2063250, GB 2071649, GB 2070594, GB 2071131, GB 2081707, GB 2079275, GB 2080820, GB 2089345, GB-A-8203798, EP 0060646, GB 2111974, US 4482472, GB 2118934, US 4506957, GB 2121406, EP-A-83303348.3, GB 2134110, EP-A-8430494.3, EP-A-84303240.0.

for use in applications where a high birefringence is desirable. The mixture may also contain one or more fluorinated cyanobiphenyls or terphenyls of formula IID:



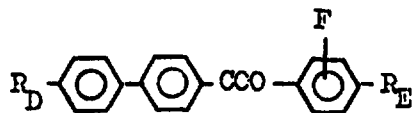
where R_c is C_{1-10} n-alkyl or n-alkoxyl and the fluoro substituent(s) may be in any one or 2 of the available substitution positions. Compound of formula IID are known WO 89/12621 (PCT/GB 89/00647) and their inclusion can further increase the birefringence.

A nematic liquid crystal material of this invention may also contain one or more optically active compounds (especially the biphenyl of formula IIA in which R_A is (+)-2-methylbutyl) to induce a cholesteric phase and one or more pleochroic dyes.

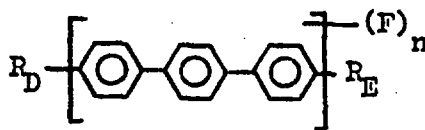
Typically but not exclusively, a nematic liquid crystal material may contain 5-50% by weight of other known nematic materials. Optically active compounds and/or pleochroic dyes if present will generally be present at up to 1% by weight at most.

Phenyl-naphthalenes of formula I may be used as components of smectic C mixtures. Compounds of structure 1.1 above are particularly preferred for this use as they show S_c phases which persist over a wide temperature range and their use can result in Sc^* mixtures which show fast, eg microsecond, switching speeds.

Other compounds which show an Sc phase to provide a mixture having improved properties relative to the individual component compounds. Preferred known compounds which show an Sc phase and may be used in this way include the known compounds of formula IIA and IIB:



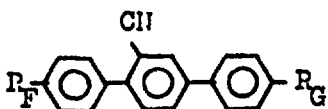
IIIA



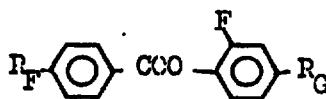
III E

10 where R_D and R_E are independently C₃-C₁₂ n-alkyl or n-alkoxy and n in formula IIIB is 1 or 2. In formula IIIA the fluorine substituent is preferably adjacent to the ester linkage. In formula IIIB when n is 1 the fluorine is preferably on the central ring and when n is 2 the fluorines are preferably in the 2, 3- or 2', 3'- positions.

The Sc mixture may also include additives which suppress undesirable smectic phases such as S_B, or which promote the phase transition sequence S_C - S_A at higher temperatures. Examples of additives which may be used for these purposes are compounds of formula IIIC or IIID:



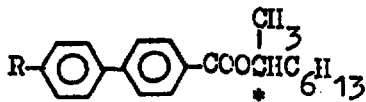
IIIC



IID

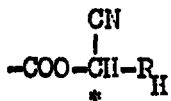
25 wherein R_F and R_G are independently $C_1 - C_{12}$ n-alkyl or n-alkoxy.

When the mixture is intended to show an Sc* phase it is necessary to include one or more optically active compounds, ie "dopants" in the mixture. A large variety of such dopants is known, for example, the compounds described in EP-A-0110299, which are esters of 1-methylheptanol, eg:



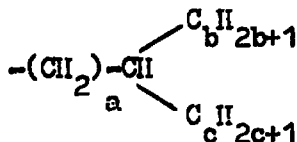
where R is C₁₋₁₅ n-alkyl or alkoxy.

Particularly preferred dopants are however the known compounds containing an asymmetrically substituted group IV:



IV

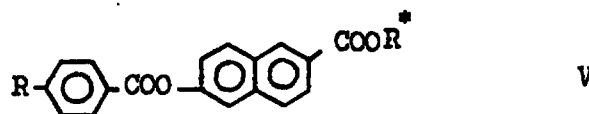
45 where R_H is cycloalkyl, a cyclic terpenoid ring system or C₁₋₈ n-alkyl or branched alkyl, especially C₁₋₄ n-alkyl or branched alkyl having a formula:



where a is 0 or an integer 1-6 and b and c are independently 1-6. In such compounds R_H is preferably methyl, CH(CH₃)₂ or a camphor residue.

Suitable and preferred examples of such dopants are described in WO 87/07890 and PCT/GB 88/01111.

Another preferred class of optically active dopants are the naphthyl esters disclosed in WO 87/06577, eg V:



10 where R_1 is C_{1-12} n-alkyl or n-alkoxyl and R^* is 1-methylethyl.

Advantageously the Sc^* mixture may contain at least 2 optically active dopants having opposite helical twisting effects.

Typically but not exclusively, a ferroelectric Sc^* mixture of this invention may contain 1-99% by weight of compounds of formula I, plus 0-99% by weight of other compounds which show an Sc phase, plus 0-30% by weight of additives, plus 1-20% by weight of optically active compounds.

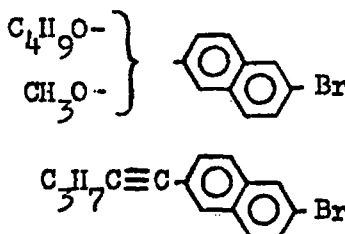
15 Liquid crystal materials of the invention may be used in display devices of known construction and method of operation. Typically an electro-optical display device will consist of 2 substrates between which a layer of the liquid crystal material may be sandwiched. At least one of the substrates is optically transparent and both have electrodes which are preferably made of a transparent material on their opposing face. By applying an electric field across the layer of liquid crystal material via the electrodes an electro-optic effect is achieved which may be viewed directly or preferably through one or more polarising filters.

Having a high birefringence nematic materials of this invention may be particularly suitable for use in ECB effect devices. They may also be particularly suitable for use in polymer dispersed liquid crystal (PDLC) materials in which small droplets of a liquid crystal material are dispersed within a matrix of a transparent polymer.

25 Examples illustrating this invention are now described with reference to Fig. 1 which shows schematic routes A, B, C and D to phenylnaphthalenes of formula I.

In each synthesis drying was by magnesium sulphate.

30 Example 1 - Route A Used To Prepare



Step A1 (R = butyl)

45 A solution of 1-bromobutane (50g 0.36 mol) in acetone (90 ml) was added dropwise to a stirred refluxing mixture of 2-hydroxy - 6-bromonaphthalene (40 g 0.18 mol) and potassium carbonate (51 g 0.37 mol) in acetone (1L). The stirred mixture was heated under reflux for 24 hours. The potassium carbonate was filtered off, water was added to the filtrate and the product was extracted into ether (twice). The combined ethereal extracts were washed with water, 5% sodium hydroxide, water and dried. The solvent and the excess of 1-bromobutane were removed in vacuo to yield an off-white powder which was recrystallised from ethanol. Yield 32.2 g (64%) mp 52-53 °C.

50 In an alternative method where R = methyl, dimethyl-sulphate (33.80 g 0.268 mol) was added to a stirred solution of 2-hydroxy - 6-bromonaphthalene (50 g 0.224 mol) and potassium hydroxide (15 g 0.268 mol) in water at room temperature. The stirred mixture was heated at 70 °C for one hour and stirred at room temperature over night. The produce was filtered off, washed with 10% sodium hydroxide, water and dried well and then extracted into dichloromethane. The organic extract was washed with 10% sodium hydroxide, water and dried. The solvent was removed in vacuo to give a colourless solid. Yield 50.9 g (96%) mp 108-110 °C.

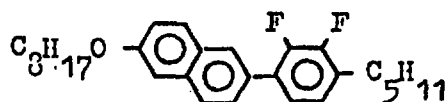
Step A2

A solution of N-phenyltriflamide (4.93 g 0.0138 mol) in dry dichloromethane (25 ml) was added dropwise to a stirred, cooled (-78 °C) solution of 2-hydroxy - 6-bromonaphthalene (2.80 g 0.0126 mol) in dry dichloromethane (40 ml) and dry triethylamine (2.55 g 0.025 mol) under dry nitrogen. The stirred mixture was allowed to warm to room temperature overnight and was then washed with aqueous sodium carbonate and the separated aqueous layer was washed with dichloromethane. The combined organic extracts were washed with water and dried. The solvent was removed in vacuo and the residue was purified by column chromatography (silica gel/ dichloromethane) to give a colourless solid. Yield 7.20 g (99%) mp 93-94 °C.

Step A3

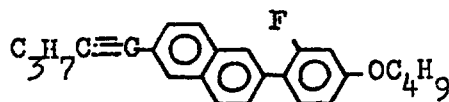
A solution of n-butyllithium (6 ml 2.5 M in hexane) was added dropwise to a stirred, cooled (-5 to 0 °C) solution of pent-1-yne (1.02 g 0.015 mol) in dry THF (10 ml) under dry nitrogen. This mixture was stirred at room temperature for 15 minutes and a solution of 6-bromonaphth-2-yl triflate (from Step A2) (4.80 g 0.0135 mol) in dry THF (20 ml) was added dropwise at -5 to 0 °C followed by the addition of tetrakis (triphenylphosphine) palladium (0) ("TTPP") (0.5 g 0.43 mmol). The mixture was heated under reflux (90 °C for 4 hours) and then poured into 10% hydrochloric acid. The product was extracted into ether (twice) and the combined ethereal extracts were washed with aqueous sodium hydrogen carbonate and dried. The solvent was removed in vacuo and the crude product was purified by column chromatography (silica gel/petroleum fraction (bp 40-60 °C) to give a colourless solid. Yield 2.10 g (57%).

This product could be used directly in Steps B1, C1 and D1 or could be reduced using known methods to convert the alkynyl group to an alkyl group.

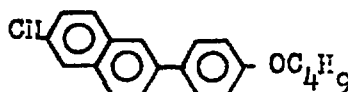
Example 2 - Route B Used To PrepareStep B1

A solution of 2-octyloxy - 6-bromonaphthalene (1.75 g 5.22 mol) prepared via Step A1 above in ethanol (15 ml) was added to a stirred solution of 1-pentyl-2, 3-difluoro phenylboronic acid (known) (1.60 g 7.02 mmol) and TTPP (0.312 g 0.27 mol) in benzene (30 ml) and 2 M sodium carbonate (30 ml) at room temperature under dry nitrogen. The stirred mixture was heated under reflux (100 °C) for 23 hours. The product was extracted twice into ether and the combined ethereal extracts were washed with brine and dried. The solvent was removed in vacuo and the residue was purified by column chromatography (silica gel/petroleum fraction (bp 40-60 °C) -dichloromethane 10:1) to give a colourless solid which was recrystallised from ethanol-ethyl acetate (20:1) to yield colourless crystals. Yield 1.90 g (83%).

By an analogous procedure the compound



was prepared, using the product of Step A3 and known 1-butyloxy-3-fluorophenylboronic acid. Yield 63%.

Example 3 - Route C Used To Prepare10 Step C1

A mixture of 2-methoxy-6-bromonaphthalene (12 g 0.051 mol) and copper (I) cyanide (5.26 g 0.059 mol) in dry DMF (75 ml) was heated at 185 °C for 5 hours. The cooled mixture was poured into 10% hydrochloric acid and the product was extracted into ether. The insoluble salts were filtered off and the separated aqueous layer was washed with brine and dried. The solvent was removed in vacuo and the residue was purified by column chromatography (silica gel/petroleum fraction (bp 40-60 °C) -dichloromethane 1:2) to give a pale yellow solid. Yield 7.60 g (81%) mp 103-104 °C.

20 Step C2

A solution of boron tribromide (24 g 10.0 ml 0.0956 mol) in dry dichloromethane 200 ml was added dropwise to a stirred, cooled (-78 °C) solution of the product of Step C1 (6.90 g 0.0377 mol) in dry dichloromethane (125 ml) under dry nitrogen. The stirred mixture was allowed to warm to room temperature overnight. Water was carefully added and a yellow precipitate was produced. The product was extracted twice into ether and the combined organic extracts were washed with water and dried. The solvent was removed in vacuo. Yield 6.40 g (100%) mp 156-157 °C.

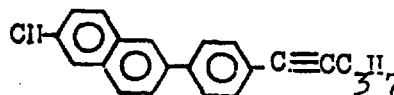
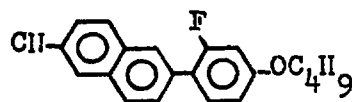
Step C3

30 The procedure was as described for Step A2 above. Quantities: N-phenyltriflamide (9 g 0.024 mol), product of Step C2 (4 g 0.024 mol), trichthylamine (4.9 g 0.049 mol). Yield 7.20 g (99%) mp 93-94 °C.

Step C4

35 The procedure for the boronic acid coupling step was as for Step B1 using the product of Step C3 instead of the bromonaphthalene and lithium chloride was added with the TTPP. Quantities: product of Step C3 (0.53 g 1.76 mmol), 4-n-butyloxyphenylboronic acid (0.45 g 2.32 mmol) prepared as on Page 30-31 of WO 89/02425, TTPP (0.13 g 0.11 mmol), lithium chloride (0.22 g 5.22 mmol). The crude product was purified by column chromatography (silica gel/petroleum fraction (bp 40-60 °C) -dichloromethane 1:1) to give a colourless solid which was recrystallised from hexane-dimethoxyethane ((1:1) to yield colourless crystals. Yield 0.30 g (58%).

By analogous methods the compounds:



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were prepared. The 4-butyloxy-2-fluorophenylboronic acid was prepared as described on Page 34-35 of WO 89/02425. The 4-pent-1-ynylphenylboronic acid was prepared as below.

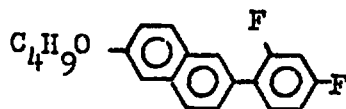
A solution of n-butyllithium (7.8 ml 10 M in hexane 0.078 mol) was added dropwise to a stirred, cooled (-5 to 0 °C) solution of pent-1-yne (5.28 g 0.078 mol) in dry THF (50 ml) under dry nitrogen. This mixture was stirred for 10 minutes and then a solution of dry zinc chloride (10.80 g 0.079 mol) in dry THF (100 ml) was added dropwise at -5 to 0 °C. The mixture was stirred at room temperature for 15 minutes and a solution of para-iodobromobenzene (5.28 g 0.078 mol) in dry THF (100 ml) was added dropwise at -5 to 0 °C followed by the addition of TTPP (2.31 g 2.0 mmol). The mixture was stirred overnight and then

poured into 10% hydrochloric acid.

The product was extracted twice into ether and the combined ethereal extracts were washed with aqueous sodium hydrogen carbonate and dried. The solvent was removed in vacuo. Yield 14.20 g (82%).

This 1-bromo-4-pent-1-ynylbenzene (13.45 g 0.06 mol) into the boronic acid in 91% yield using the same method as used in Step 1B on Page 31 of WO 89/02425. Quantities: magnesium (1.7 g 0.07 mol), tri-isopropyl borate (23 g 0.12 mol).

Example 4 - Route D Used To Prepare



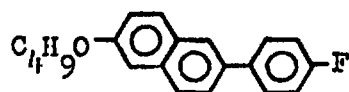
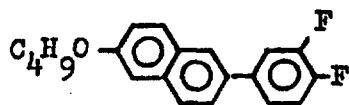
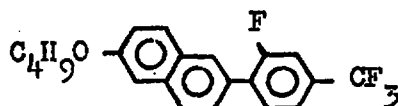
Step D1

N-butyllithium (12.40 ml 2.5 M in hexane 0.031 mol) was added dropwise to a stirred, cooled (-78°C) solution of 2-bromo-6-butoxynaphthalene (from Step A1) (8.60 g 0.031 mol) in dry THF (60 ml) under dry nitrogen. The reaction mixture was maintained under these conditions for 2.5 hours and then a previously cooled solution of tri-isopropyl borate (12 g 0.064 mol) in dry THF (50 ml) was added dropwise at -78°C. The mixture was allowed to warm to room temperature overnight and then stirred for one hour with 10% hydrochloric acid (80 ml). The product was extracted twice into ether and the combined ethereal extracts were washed with water and dried. The solvent was removed in vacuo to yield a colourless solid. Yield 8.5 g (100%).

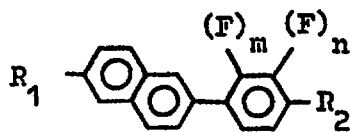
Step D2

The coupling of the boronic acid (2.27 g 9.30 mmol) from Step D1 with 1-bromo-2,4-difluorobenzene (known) (1.37 g 7.10 mmol) was carried out as for Step B1 above using TPP (0.26 g 0.23 mmol). The product was recrystallised from ethanol to yield colourless crystals. Yield 1.40 g (63%).

Using analogous procedures and known 4-bromo-3-fluoro-trifluoromethyl benzene, 1-bromo-3,4-difluorobenzene and para-bromofluorobenzene the compounds:

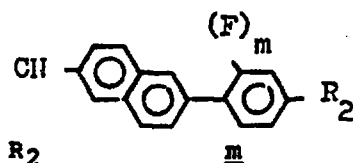


were prepared.

Example 5 - Properties of Compounds PreparedTable 1

	<u>R₁</u>	<u>R₂</u>	<u>m</u>	<u>n</u>	<u>Liquid Crystal Transitions (°C)</u>
1.1*	n-C ₈ H ₁₇ O	n-C ₅ H ₁₁	1	1	K 36 Sc 44.5 S _A 75 N 83.5 I
1.4	n-C ₄ H ₉ O	F	0	0	K 128.5 (N 112.9) I
1.5	n-C ₄ H ₉ O	F	1	0	K 72 (N 63.0) I
1.6	n-C ₄ H ₉ O	F	0	1	K 81.5 N(42.0) I
1.7	n-C ₄ H ₉ O	CF ₃	1	0	K 73.5 S _A 105.5 I
1.12	n-C ₃ H ₇ C≡C	n-C ₄ H ₉ O	1	0	K 68.5 N 106.5 I

*This compound showed a birefringence $\Delta n = 0.19$ at 20°C.

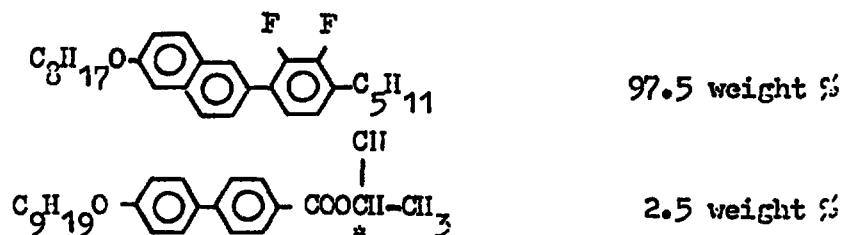
Table 2

	<u>R₂</u>	<u>m</u>	<u>Liquid Crystal Transitions (°C)</u>
1.9	OC ₄ H ₉	0	K 98.5 N 167.5 I
1.10	OC ₄ H ₉	1	K 64.5 N 129.5 I
1.11	C≡CC ₃ H ₇	0	K 113 N 193 I

These properties indicate that phenylnaphthalenes of formula I have useful nematic and/or smectic C liquid crystalline properties, showing these useful phases over a broad temperature range.

Example 6 - Ferro-electric Sc* Liquid Crystal Mixture

A mixture was prepared having the composition:



97.5 weight %

2.5 weight %

This mixture showed the liquid crystal transitions:

K 5 Sc* 33 S_A 75 N 80.5 I

The mixture showed spontaneous polarisation P_s (nC cm^{-2}) and Sc^* cone angles as listed below:

Table 3

Temp ($^{\circ}\text{C}$)	P_s (nC cm^{-2})	Cone Angle ($^{\circ}$)
32	0.1	3.5
30	1.3	6.5
28	1.8	8.5
25	2.2	10.5
20	2.8	11
18	2.9	
15	3.1	
10	3.3	
5	3.5	

Using a $2.0\text{ }\mu\text{m}$ cell at 25°C the switching speed of this mixture was measured as below:

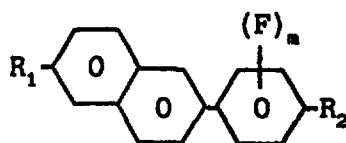
Table 4

Voltage (V peak)	Response Time ($\mu\text{ sec}$)
20	120
30	76
40	54
50	45
60	37
70	32

The mixture is therefore a fast switching ferro-electric Sc^* material showing a room temperature Sc^* phase.

Claims

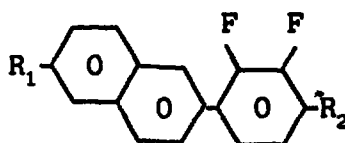
1. Phenylanthracenes of general formula I:



formula I

wherein R_1 and R_2 are selected from C_{1-15} alkyl, alkoxy, perfluoroalkyl, perfluoroalkoxy and alkynyl, R_1 may also be CN and R_2 may also be fluorine or NCS; m is 0, 1 or 2; provided that if R_1 is alkyl or alkoxy and R_2 is alkyl, alkoxy or perfluoroalkyl then m is 1 or 2.

2. Phenylanthracenes according to Claim 1 characterised in that R_1 and R_2 are independently selected from alkyl and alkoxy and m is 1 or 2.
3. Phenylanthracenes according to Claim 2 characterised by a formula:



The mixture showed spontaneous polarisation P_s (nC cm^{-2}) and Sc^* cone angles as listed below:

Table 3

Temp ($^{\circ}\text{C}$)	P_s (nC cm^{-2})	Cone Angle ($^{\circ}$)
32	0.1	3.5
30	1.3	6.5
28	1.8	8.5
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20	2.8	11
18	2.9	
15	3.1	
10	3.3	
5	3.5	

Using a $2.0\ \mu\text{m}$ cell at 25°C the switching speed of this mixture was measured as below:

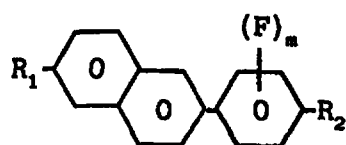
Table 4

Voltage (V peak)	Response Time ($\mu\text{ sec}$)
20	120
30	76
40	54
50	45
60	37
70	32

The mixture is therefore a fast switching ferro-electric Sc^* material showing a room temperature Sc^* phase.

Claims

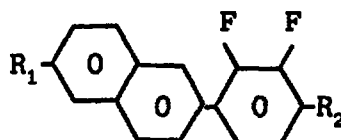
1. Phenylanthralenes of general formula I:



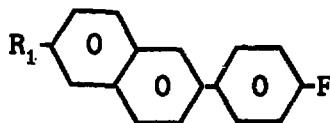
formula I

wherein R_1 and R_2 are selected from C_{1-15} alkyl, alkoxyl, perfluoroalkyl, perfluoroalkoxyl and alkynyl, R_1 may also be CN and R_2 may also be fluorine or NCS; m is 0, 1 or 2; provided that if R_1 is alkyl or alkoxyl and R_2 is alkyl, alkoxyl or perfluoroalkyl then m is 1 or 2.

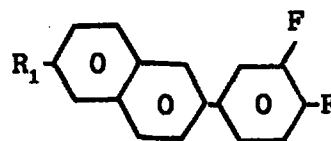
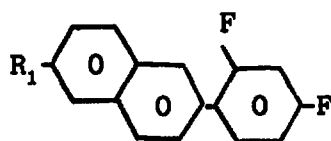
2. Phenylanthralenes according to Claim 1 characterised in that R_1 and R_2 are independently selected from alkyl and alkoxyl and m is 1 or 2.
3. Phenylanthralenes according to Claim 2 characterised by a formula:



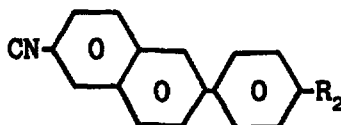
4. Phenylanthracenes according to Claim 1 characterised in that R_1 is alkyl or alkoxy and R_2 is fluorine.
5. Phenylanthracenes according to Claim 4 characterised by a formula:



6. Phenylanthracenes according to Claim 4 characterised by a formula selected from:

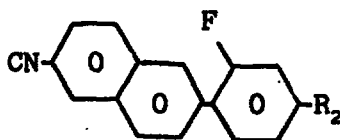


7. Phenylanthracenes according to Claim 1 characterised in that R_1 is CN and R_2 is alkyl, alkoxy or alkynyl.
8. Phenylanthracenes according to Claim 7 having a formula:



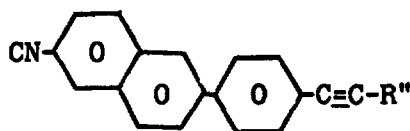
where R_2 is alkyl or alkoxy.

9. Phenylanthracenes according to Claim 7 having a formula:



where R_2 is alkyl or alkoxy.

10. Phenylanthracenes according to Claim 7 having a formula:

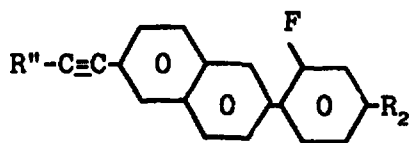


wherein R'' is alkyl.

11. Phenylanthracenes according to Claim 1 characterised in that R_1 is alkynyl and R_2 is alkyl or alkoxy.

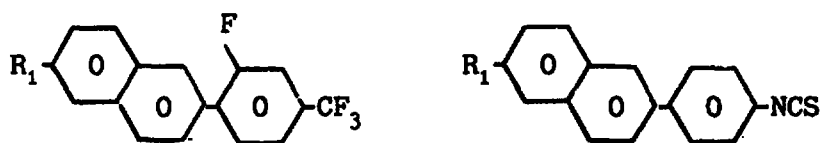


12. Phenyl naphthalenes according to Claim 11 having a formula:



wherein R'' is alkyl.

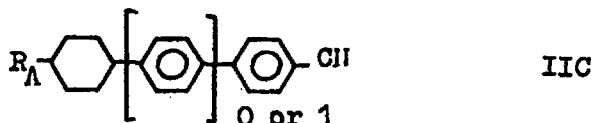
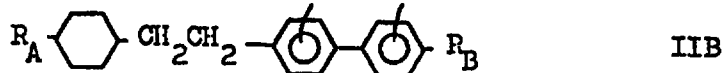
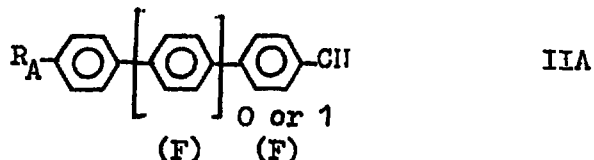
13. Phenyl naphthalenes according to Claim 1 having a formula selected from:



wherein R₁ is alkyl or alkoxy.

14. Liquid crystal material being a mixture of at least 2 component compounds, at least one of which is phenyl naphthalene of formula I as claimed in Claim 1.

15. Liquid crystal material according to Claim 14 characterised in that it is a nematic material that contains 5-50 weight % of phenyl naphthalene(s) of formula I in which R₁ is alkyl or alkoxy and R₂ is fluorine, or R₁ is alkynyl and R₂ is alkyl or alkoxy, or R₁ is CN and R₂ is alkyl, alkoxy or alkynyl, and in that the material contains 50 - 95 weight % of compound(s) of formula IIA, IIB or IIC:



wherein R_A and R_B are independently C₁₋₁₀ n-alkyl or n-alkoxy and (F) indicates that one of the rings carries a fluoro substituent.

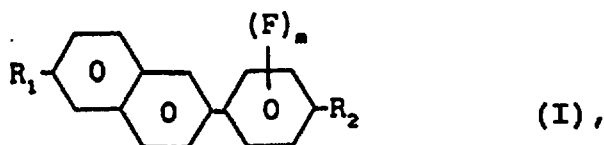
16. Liquid crystal material according to Claim 14 characterised in that it is a ferro-electric chiral smectic C liquid crystal material that contains 1-99 weight % of phenyl naphthalene(s) of formula I in which R₁ and R₂ are selected from n-alkyl or n-alkoxy and m is 1 or 2 and in that the material contains 1-20 weight % of optically active compound(s), the total being 100 weight %.

17. Material according to Claim 16 characterised in that m is 2, the fluorines being in the 2, 3 positions.



Patentansprüche

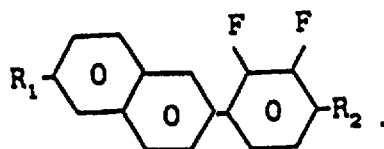
1. Phenylnaphthaline der allgemeinen Formel I,



in der R_1 und R_2 unter C_{1-15} -Alkyl, -Alkoxy, -Perfluoralkyl, -Perfluoralkoxy und -Alkynyl ausgewählt sind, R_1 auch CN und R_2 auch Fluor oder NCS bedeuten können und m für 0, 1 oder 2 steht, mit der Maßgabe, daß, wenn R_1 Alkyl oder Alkoxy und R_2 Alkyl, Alkoxy oder Perfluoralkyl bedeuten, m 1 oder 2 darstellt.

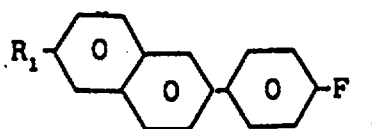
2. Phenylnaphthaline nach Anspruch 1, dadurch gekennzeichnet, daß R_1 und R_2 unabhängig unter Alkyl und Alkoxy ausgewählt sind und m für 1 oder 2 steht.

3. Phenylnaphthaline nach Anspruch 2, gekennzeichnet durch die Formel:

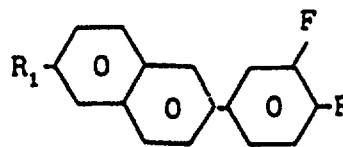
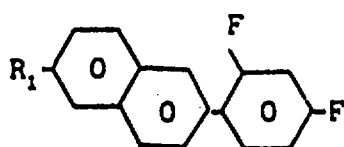


4. Phenylnaphthaline nach Anspruch 1, dadurch gekennzeichnet, daß R_1 Alkyl oder Alkoxy und R_2 Fluor bedeuten.

5. Phenylnaphthaline nach Anspruch 4, gekennzeichnet durch die Formel:

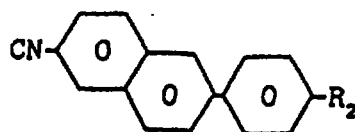


6. Phenylnaphthaline nach Anspruch 4, gekennzeichnet durch eine der folgenden Formeln:



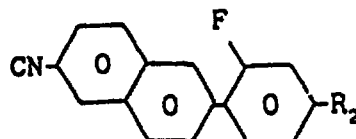
7. Phenylnaphthaline nach Anspruch 1, dadurch **gekennzeichnet**, daß R_1 CN und R_2 Alkyl, Alkoxy oder Alkynyl bedeuten.

8. Phenylnaphthaline nach Anspruch 7 der Formel:



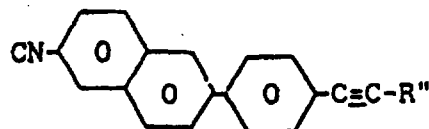
in der R_2 für Alkyl oder Alkoxy steht.

9. Phenylnaphthaline nach Anspruch 7 der Formel:



in der R_2 für Alkyl oder Alkoxy steht.

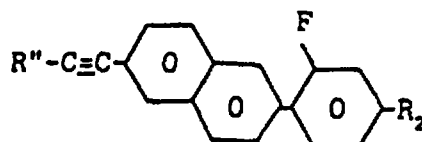
10. Phenylnaphthaline nach Anspruch 7 der Formel:



in der R'' für Alkyl steht.

11. Phenylnaphthaline nach Anspruch 1, dadurch **gekennzeichnet**, daß R_1 Alkynyl und R_2 Alkyl oder Alkoxy bedeuten.

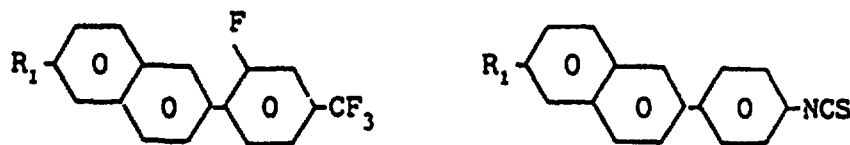
12. Phenylnaphthaline nach Anspruch 11 der Formel:



in der R'' für Alkyl steht.



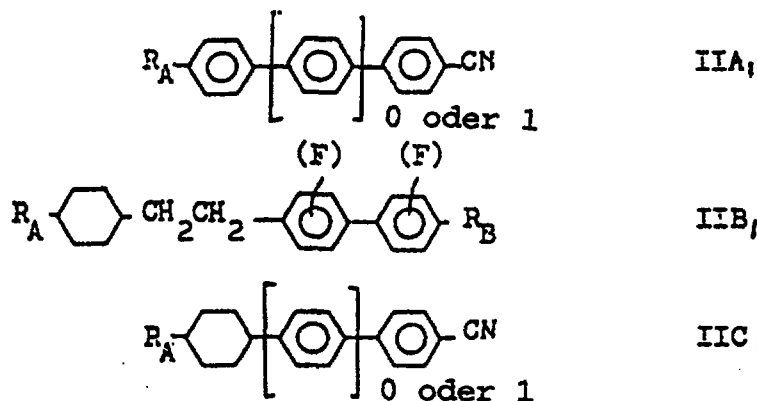
13. Phenylnaphthaline nach Anspruch 1, die eine der folgenden Formeln besitzen:



in denen R_1 für Alkyl oder Alkoxy steht.

14. Flüssigkristallmaterial, bei dem es sich um ein Gemisch aus mindestens 2 Verbindungen als Bestandteilen handelt, von denen mindestens eine ein Phenylnaphthalin der Formel I nach Anspruch 1 ist.

15. Flüssigkristallmaterial nach Anspruch 14, dadurch gekennzeichnet, daß es sich um ein nematisches Material handelt, das 5 - 50 Gew.-% Phenylnaphthalin(e) der Formel I enthält, in der R_1 Alkyl oder Alkoxy und R_2 Fluor oder in der R_1 Alkynyl und R_2 Alkyl oder Alkoxy oder in der R_1 CN und R_2 Alkyl, Alkoxy oder Alkynyl bedeuten, und dadurch, daß das Material 50 - 95 Gew.-% einer oder mehrerer Verbindungen der Formeln IIA, IIB oder IIC enthält:



in denen R_A und R_B unabhängig für C_{1-10} -n-Alkyl oder -n-Alkoxy stehen und (F) anzeigt, daß einer der Ringe einen Fluor-Substituenten trägt.

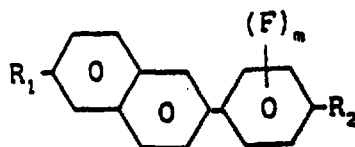
16. Flüssigkristallmaterial nach Anspruch 14, dadurch gekennzeichnet, daß es sich um ein ferroelektrisches, chirales, smektisch-C-Flüssigkristallmaterial handelt, das 1 - 99 Gew.-% Phenylnaphthalin(e) der Formel I enthält, in der R_1 und R_2 unter n-Alkyl oder n-Alkoxy ausgewählt sind und m für 1 oder 2 steht, und dadurch, daß das Material 1 - 20 Gew.-% optisch aktive Verbindung(en) enthält, wobei die Gesamtsumme 100 Gew.-% beträgt.

17. Flüssigkristallmaterial nach Anspruch 16, dadurch gekennzeichnet, daß m für 2 steht und sich die Fluoratome in den Stellungen 2,3 befinden.



Revendications

1. Phénylnaphtalènes de formule générale I :

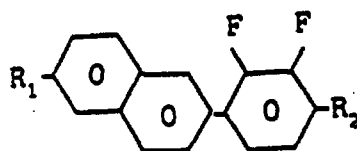


Formule I

dans laquelle R_1 et R_2 sont choisis parmi un groupe alkyle, alcoyle, perfluoroalkyle, perfluoroalcoyle et alcényle en C_1 à C_{15} ; R_1 peut également représenter CN et R_2 peut également représenter un atome de fluor ou un groupe NCS ; m vaut 0, 1 ou 2, à la condition que, si R_1 représente un groupe alkyle ou alcoyle et que R_2 représente un groupe alkyle, alcoyle ou perfluoroalkyle, le nombre m vale 1 ou 2.

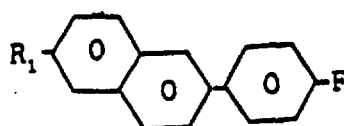
2. Phénylnaphtalènes selon la revendication 1, caractérisé en ce que R_1 et R_2 sont choisis chacun, indépendamment, parmi un groupe alkyle et alcoyle, et m vaut 1 ou 2.

3. Phénylnaphtalènes selon la revendication 2, caractérisé par une formule

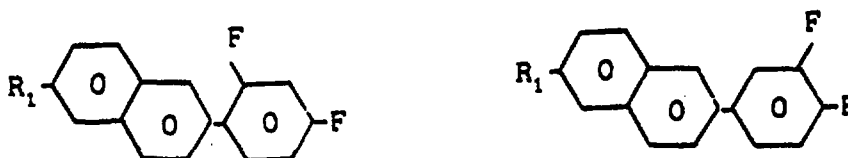


4. Phénylnaphtalènes selon la revendication 1, caractérisés en ce que R_1 représente un groupe alkyle ou alcoyle et R_2 représente un atome de fluor.

5. Phénylnaphtalènes selon la revendication 4, caractérisés par une formule :



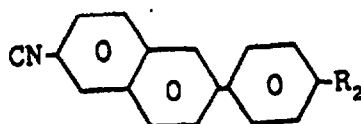
6. Phénylnaphtalènes selon la revendication 4, caractérisés par une formule choisie parmi



7. Phénylnaphtalènes selon la revendication 1, caractérisés en ce que R_1 représente CN et R_2 représente un groupe alkyle, alcoyle ou alcynyle.

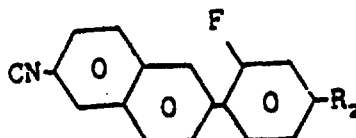


8. Phénylnaphtalènes selon la revendication 7, ayant pour formule



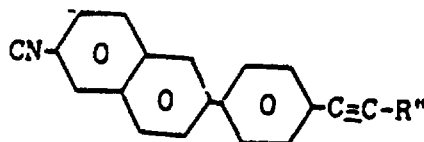
dans laquelle R_2 représente un groupe alkyle ou alcoxy.

9. Phénylnaphtalènes selon la revendication 7, ayant pour formule



dans laquelle R_2 représente un groupe alkyle ou alcoxy.

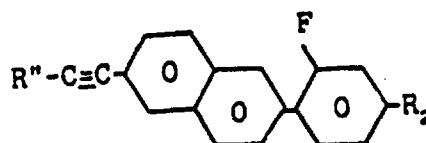
10. Phénylnaphtalènes selon la revendication 7, ayant pour formule



dans laquelle R'' représente un groupe alkyle.

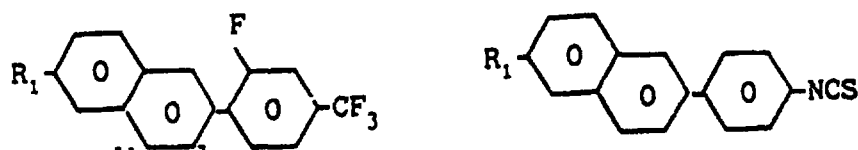
11. Phénylnaphtalènes selon la revendication 1, caractérisés en ce que R_1 représente un groupe alcynyle et R_2 représente un groupe alkyle ou alcoxy.

12. Phénylnaphtalènes selon la revendication 11, ayant pour formule



dans laquelle R'' représente un groupe alkyle.

13. Phénylnaphtalènes selon la revendication 1, ayant une formule choisie parmi

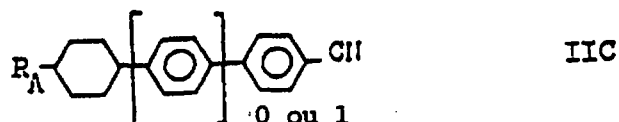
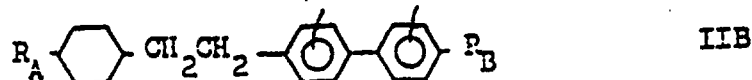
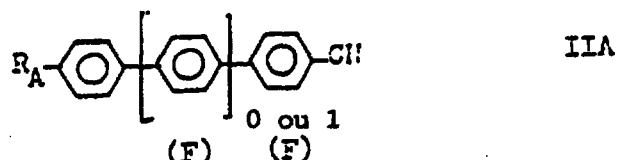


dans lesquelles R_1 représente un groupe alkyle ou alcoxy.



14. Matière à propriétés de cristaux liquides, qui est un mélange d'au moins deux composés constitutifs, dont l'un au moins est un phénylnaphtalène de formule I selon la revendication 1.

15. Matière à propriétés de cristaux liquides selon la revendication 14, caractérisée en ce qu'elle est une matière nématique qui contient 5 à 50 % en poids de phénylnaphtalène (s) de formule I, dans laquelle R₁ représente un groupe alkyle ou alcoyle et R₂ représente un atome de fluor, ou bien R₁ représente un groupe alcynyle et R₂ représente un groupe alkyle ou alcoyle, ou bien R₁ représente CN et R₂ représente un groupe alkyle, alcoyle ou alcynyle, et en ce que la matière contient 50 à 95 % en poids d'un ou plusieurs composés de formules IIA, IIB ou IIC :



formules dans lesquelles R_A et R_B sont choisis chacun, indépendamment, parmi un groupe n-alkyle ou n-alcoxy en C_1 à C_{10} , et (F) indique qu'un des noyaux porte un substituant fluoro.

16. Matière à propriétés de cristaux liquides selon la revendication 14, caractérisée en ce qu'elle est une matière smectique C chirale ferroélectrique à propriétés de cristaux liquides, qui contient 1 à 99 % en poids de phénylnaphtalène (s) de formule I, dans laquelle R₁ et R₂ sont choisis parmi un groupe n-alkyle ou n-alcoyle et m vaut 1 ou 2, et en ce que la matière comprend 1 à 20 % en poids d'un ou plusieurs composés optiquement actifs, le total formant 100 % en poids.

- 17. Matière selon la revendication 16, caractérisée en ce que m vaut 2, le fluor étant sur les positions 2, 3.**

