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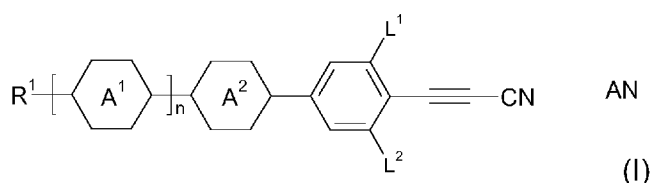
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: LIQUID-CRYSTALLINE MEDIUM



(57) Abstract: The present invention relates to liquid-crystalline media comprising one or more compounds selected from the group of compounds of formula (I), in which the parameters have the meaning indicated in Claim 1, and to components comprising these media for high-frequency technology, in particular phase shifters and microwave array antennas.



Liquid-crystalline medium

5 The present invention relates to liquid-crystalline media and to high-frequency components comprising same, especially microwave components for high-frequency devices, such as devices for shifting the phase of microwaves, in particular for microwave phased-array antennas.

10 Liquid-crystalline media have been used for many years in electro-optical displays (liquid crystal displays: LCDs) in order to display information. More recently, however, liquid-crystalline media have also been proposed for use in components for microwave technology, such as, for example, in DE 10 2004 029 429.1 A and in JP 2005-120208 (A).

15 As a typical microwave application, the concept of the inverted microstrip line as described by K.C. Gupta, R. Garg, I. Bahl and P. Bhartia: Microstrip Lines and Slotlines, 2nd ed., Artech House, Boston, 1996, is employed, for example, in D. Dolfi, M. Labeyrie, P. Joffre and J.P. Huignard: Liquid
20 Crystal Microwave Phase Shifter. *Electronics Letters*, Vol. 29, No. 10, pp. 926-928, May 1993, N. Martin, N. Tentillier, P. Laurent, B. Splingart, F. Huert, Ph. Gelin, C. Legrand: Electrically Microwave Tunable Components Using Liquid Crystals. 32nd European Microwave Conference, pp. 393-
25 396, Milan 2002, or in Weil, C.: Passiv steuerbare Mikrowellenphasenschieber auf der Basis nichtlinearer Dielektrika [Passively Controllable Microwave Phase Shifters based on Nonlinear Dielectrics], Darmstädter Dissertationen D17, 2002, C. Weil, G. Lüssem, and R. Jakoby: Tunable Invert-Microstrip Phase Shifter Device Using
30 Nematic Liquid Crystals, *IEEE MTT-S Int. Microw. Symp.*, Seattle, Washington, June 2002, pp. 367-370, together with the commercial liquid crystal K15 from Merck KGaA. C. Weil, G. Lüssem, and R. Jakoby: Tunable Invert-Microstrip Phase Shifter Device Using Nematic Liquid Crystals,
35 *IEEE MTT-S Int. Microw. Symp.*, Seattle, Washington, June 2002, pp. 367-370, achieve phase shifter qualities of 12°/dB at 10 GHz with a control

voltage of about 40 V therewith. The insertion losses of the LC, i.e. the losses caused only by the polarisation losses in the liquid crystal, are given as approximately 1 to 2 dB at 10 GHz in Weil, C.: Passiv steuerbare Mikrowellenphasenschieber auf der Basis nichtlinearer Dielektrika [Passively Controllable Microwave Phase Shifters based on Nonlinear Dielectrics], Darmstädter Dissertationen D17, 2002. In addition, it has been determined that the phase shifter losses are determined primarily by the dielectric LC losses and the losses at the waveguide junctions. T. Kuki, H. Fujikake, H. Kamoda and T. Nomoto: Microwave Variable Delay Line Using a Membrane Impregnated with Liquid Crystal. *IEEE MTT-S Int. Microwave Symp. Dig.* 2002, pp. 363-366, June 2002, and T. Kuki, H. Fujikake, T. Nomoto: Microwave Variable Delay Line Using Dual-Frequency Switching-Mode Liquid Crystal. *IEEE Trans. Microwave Theory Tech.*, Vol. 50, No. 11, pp. 2604-2609, November 2002, also address the use of polymerised LC films and dual-frequency switching-mode liquid crystals in combination with planar phase shifter arrangements.

A. Penirschke, S. Müller, P. Scheele, C. Weil, M. Wittek, C. Hock and R. Jakoby: "Cavity Perturbation Method for Characterization of Liquid Crystals up to 35GHz", 34th European Microwave Conference – Amsterdam, pp. 545-548 describe, inter alia, the properties of the known single liquid-crystalline substance K15 (Merck KGaA, Germany) at a frequency of 9 GHz.

A. Gaebler, F. Goelden, S. Müller, A. Penirschke and R. Jakoby "Direct Simulation of Material Permittivities using an Eigen-Susceptibility Formulation of the Vector Variational Approach", 12MTC 2009 – International Instrumentation and Measurement Technology Conference, Singapore, 2009 (IEEE), pp. 463-467, describe the corresponding properties of the known liquid-crystal mixture E7 (likewise Merck KGaA, Germany).

DE 10 2004 029 429 A describes the use of liquid-crystal media in micro-wave technology, inter alia in phase shifters. It has already investigated liquid-crystalline media with respect to their properties in the corresponding frequency range. It describes liquid-crystalline media based on mixtures of mostly aromatic nitriles and isothiocyanates; in EP 2 982 730 A1, mixtures are described that completely consist of isothiocyanate compounds.

However, these compositions are all afflicted with several more or less serious disadvantages. Most of them result, besides other deficiencies, in disadvantageously high losses and/or inadequate phase shifts or inadequate material quality. These relatively simple mixtures show limited performance for the application in devices operating in the microwave regime and even need to be significantly improved with respect to their general physical properties, such as, especially, the clearing point, the phase range, especially their stability against storage at low temperatures, and their viscosities, in particular their rotational viscosity.

The known devices for the high frequency-technology comprising these media do still lack sufficient stability and, in particular, fast response.

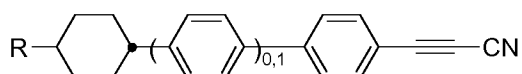
For these applications, liquid-crystalline media having particular, hitherto rather unusual and uncommon properties or combinations of properties are required.

Novel liquid-crystalline media having improved properties are thus necessary. In particular, the dielectric loss in the microwave region must be reduced and the material quality (η , sometimes also called figure of merit, short FoM), i.e. a high tunability and, at the same time, a low dielectric loss, must be improved. Besides these requirements increased focus has to be placed on improved response times for several envisaged applications especially for those devices using planar structures such as e.g. phase shifters and leaky antennas.

In addition, there is a steady demand for an improvement in the low-temperature behaviour of the components. Both an improvement in the operating properties at low temperatures and also in the shelf life are necessary here.

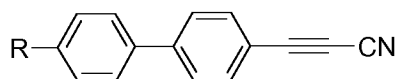
Therefore, there is a considerable demand for liquid-crystalline media having suitable properties for corresponding practical applications.

Cyanoethyne derivatives of the formula



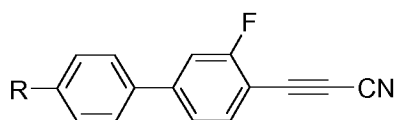
in which R denotes H or alkyl, are described for example in JP 60-019 756 A2.

Biphenylacetylenes of the formula



in which R denotes alkyl, are described in DE 32 46 440 A1.

In DE 19831093A1 fluorinated derivatives of such acetylenes are disclosed, for example the following compound:



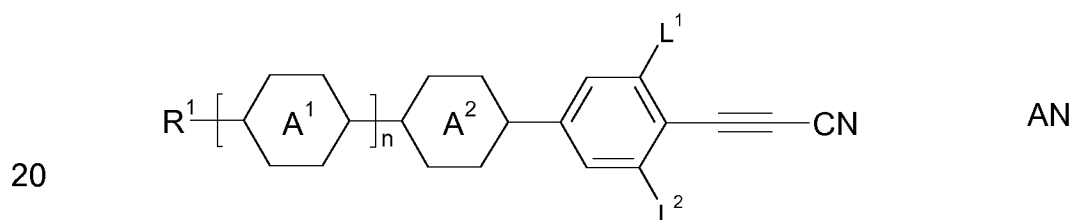
wherein R denotes alkyl.

In DE 198 31 709 A1, DE 199 14 373 A1 and DE 102 29 505 A1, cyanoethynyl benzene derivatives as those shown above are proposed for the use in liquid crystal mixtures for STN displays.

In all of the documents cited above, the use of cyanoethynyl compounds in liquid crystal mixtures for microwave applications was neither disclosed nor suggested.

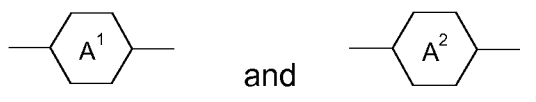
5 Surprisingly, it has been found that it is possible to achieve liquid-crystalline media having a high dielectric anisotropy, suitably fast switching times, a suitable, nematic phase range, high tunability and low dielectric loss, which do not have the disadvantages of the prior-art materials, or at
10 least only do so to a considerably reduced extent, by using compounds of formula AN below.

The present invention relates to liquid-crystalline media comprising one or
15 more compounds of formula AN

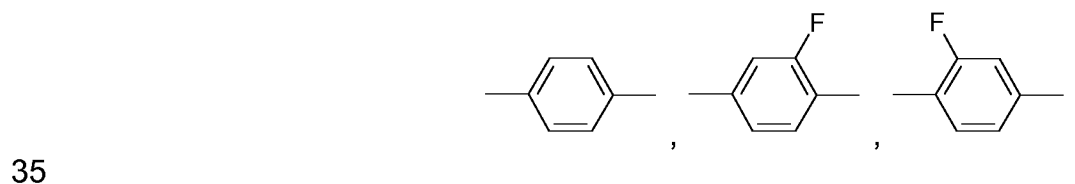


in which

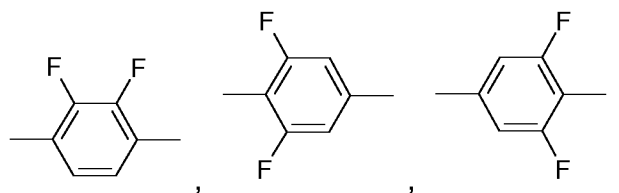
25 R^1 denotes alkyl or alkenyl having up to 15 C atoms,



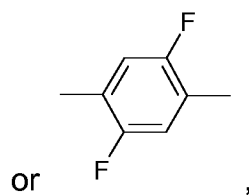
on each occurrence, independently of one another,
denote



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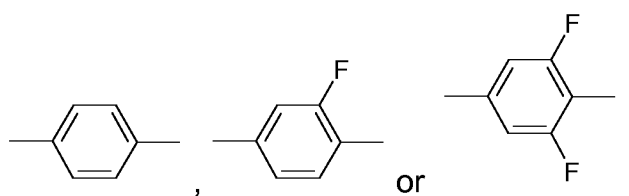
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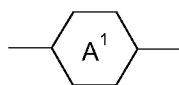
or

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preferably

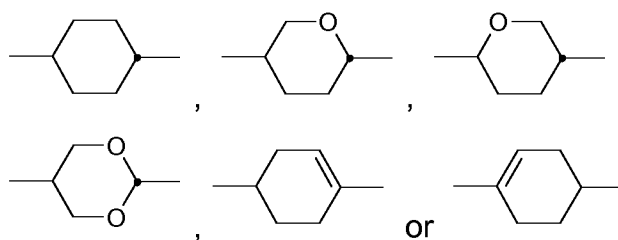


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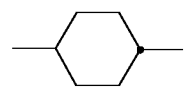
alternatively denotes

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preferably



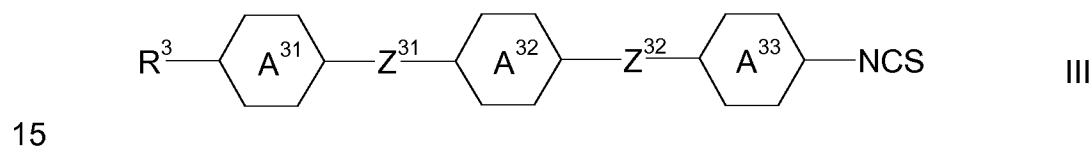
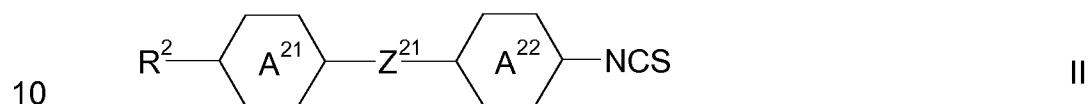
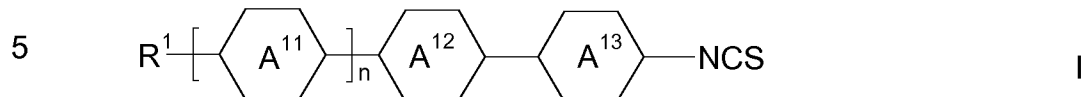
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L^1 and L^2 independently from one another, denote H or F, and

n is 0, 1 or 2;

35

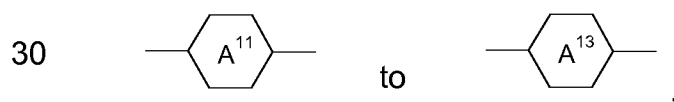
and, optionally, in addition one or more compounds selected from the group of compounds of formulae I, II and III,



in which

20 R^1 denotes H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17, preferably 3 to 10 C atoms, or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms, preferably unfluorinated alkyl or
25 unfluorinated alkenyl,

n is 0, 1 or 2,

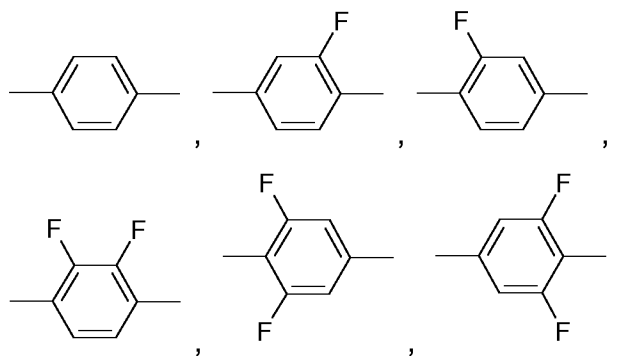


on each occurrence, independently of one another, denote

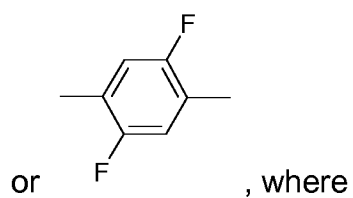
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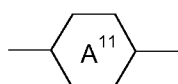
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or

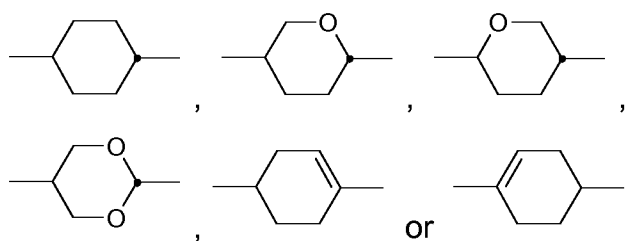
, where

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alternatively denotes

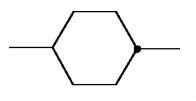
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or

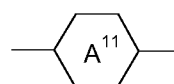
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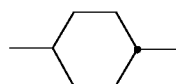
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and in case $n = 2$, one of

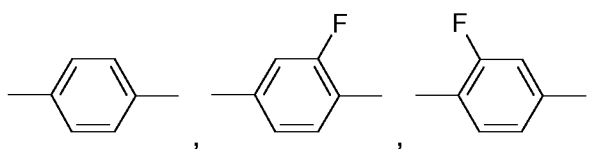
preferably

denotes

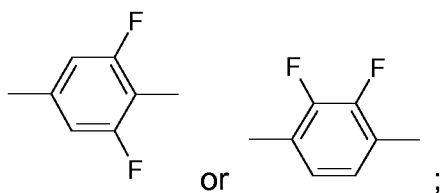


and the other preferably denotes

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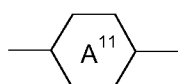
- 9 -



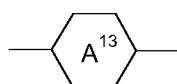
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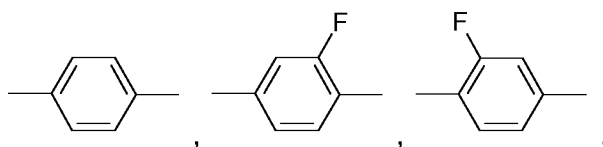
to



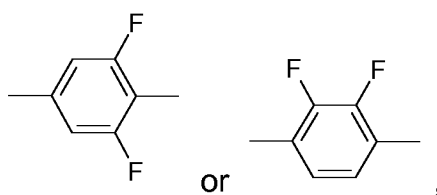
,

independently of one another, denote

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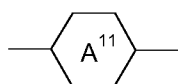


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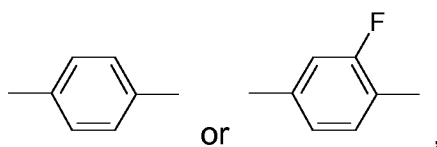


more preferably

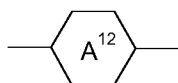
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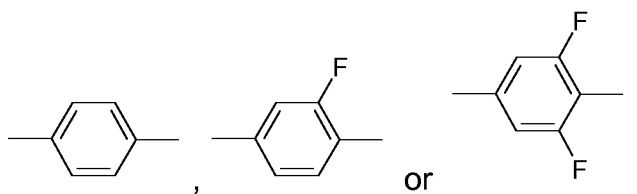
denotes



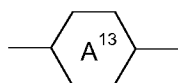
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denotes

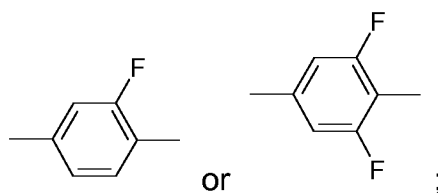


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denotes

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 R^2

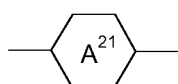
denotes H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17, preferably 3 to 10 C atoms, or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms, preferably unfluorinated alkyl or unfluorinated alkenyl,

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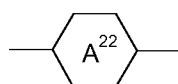
 Z^{21}

denotes *trans*-CH=CH-, *trans*-CF=CF- or -C≡C-, preferably -C≡C- or *trans*-CH=CH-, and

20



and

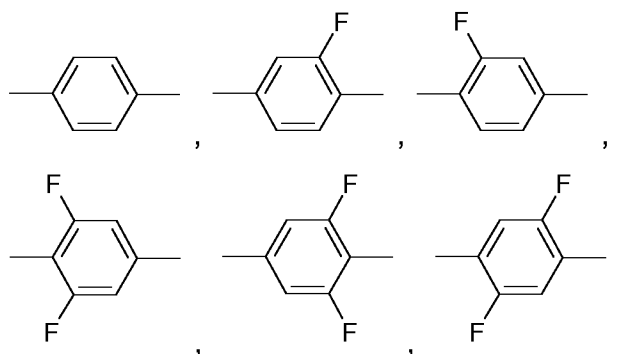


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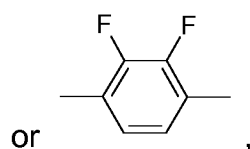
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independently of one another, denote

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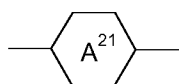


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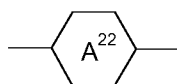


preferably

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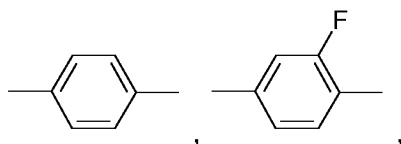
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independently of one another, denote

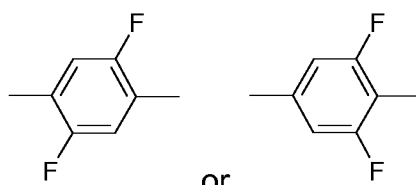
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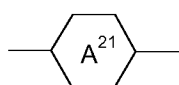
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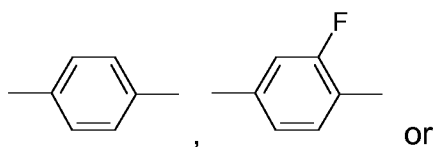
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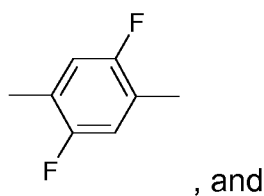
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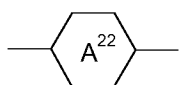
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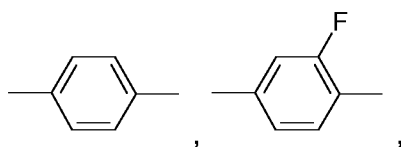


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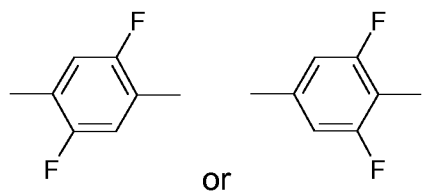


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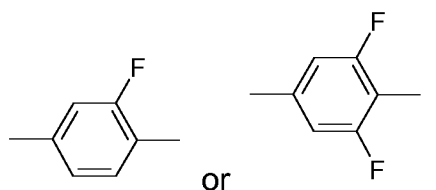
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more preferably



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and in which

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 R^3

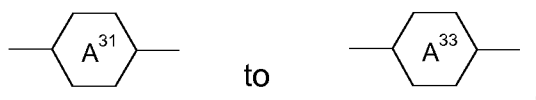
denotes H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17, preferably 3 to 10 C atoms, or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms, preferably unfluorinated alkyl or unfluorinated alkenyl,

20

one of Z^{31} and Z^{32} , preferably Z^{32} ; denotes *trans*-CH=CH-, *trans*-CF=CF- or -C≡C- and the other one, independently thereof, denotes *trans*-CH=CH-, *trans*-CF=CF- or a single bond, preferably one of them, preferably Z^{32} ; denotes -C≡C- or *trans*-CH=CH- and the other denotes a single bond, and

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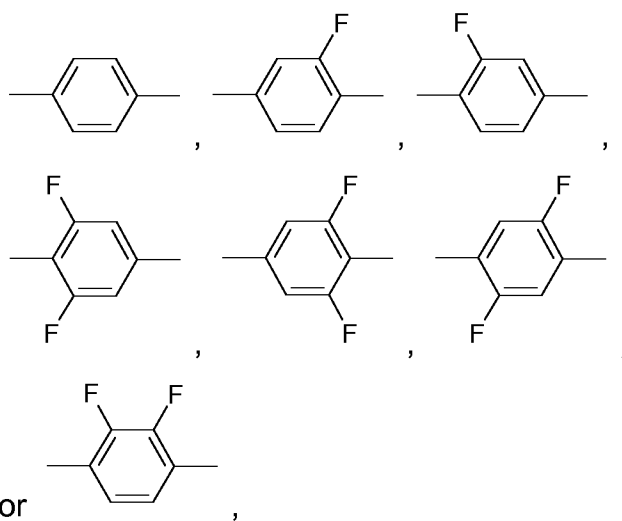


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independently of one another, denote

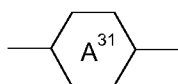
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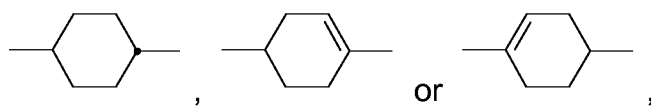


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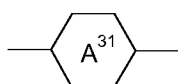


alternatively independently denotes

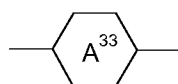


20

preferably



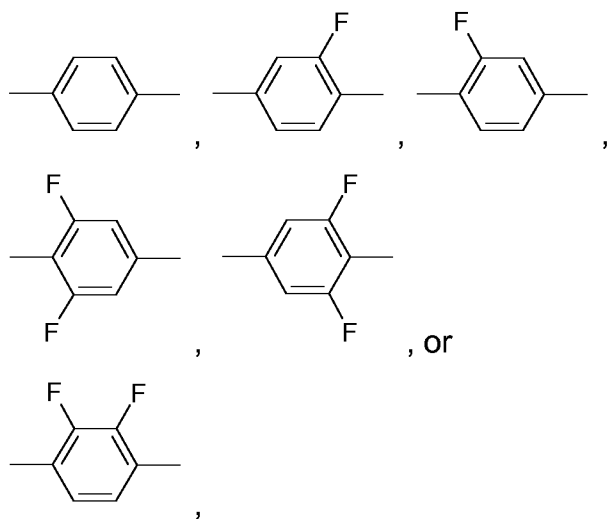
to



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independently of one another, denote

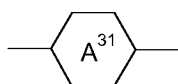
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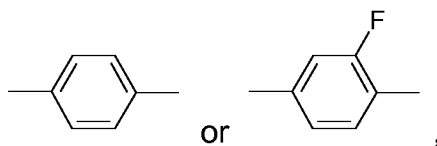
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more preferably

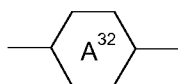
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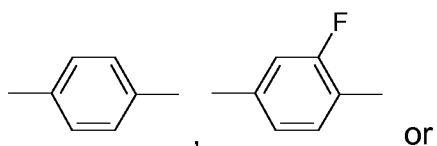
denotes



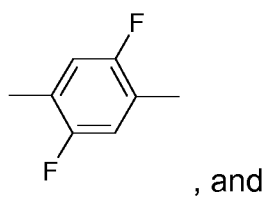
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denotes

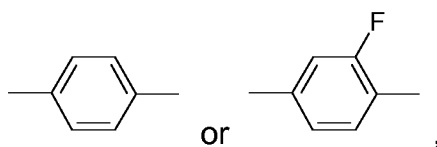


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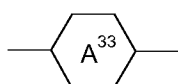


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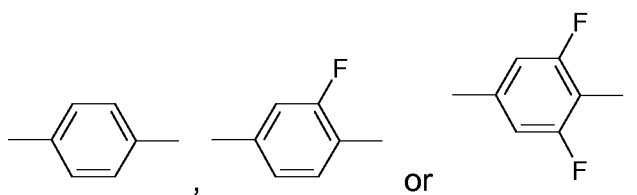
more preferably



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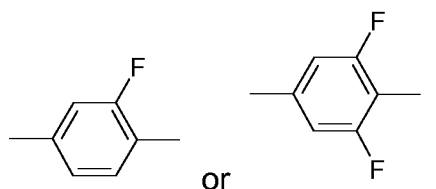
denotes



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more preferably

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5

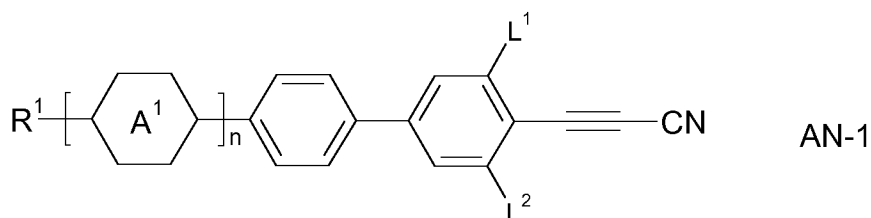
The medium according to the present invention is distinguished by a high value of the dielectric anisotropy. As a result, the threshold voltage, i.e. the minimum voltage at which a device is switchable, is very low. A low operating voltage and low threshold voltage is desired in order to enable a device having improved switching characteristics and high energy efficiency.

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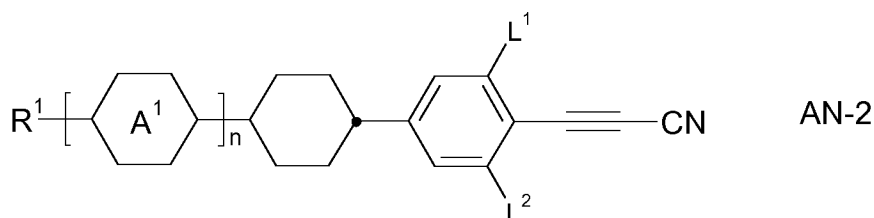
In a preferred embodiment the liquid crystalline medium according to the present invention comprises one or more compounds selected from the group of compounds of the formulae AN-1 and AN-2,

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AN-1

25



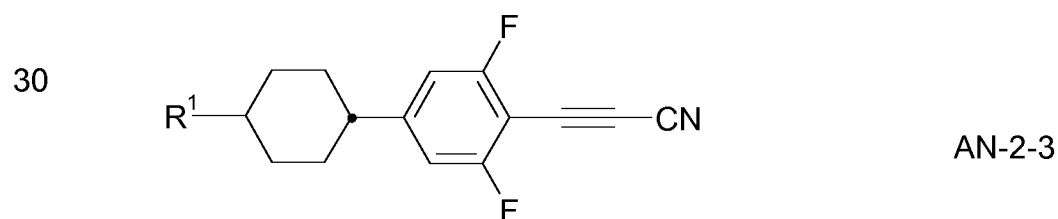
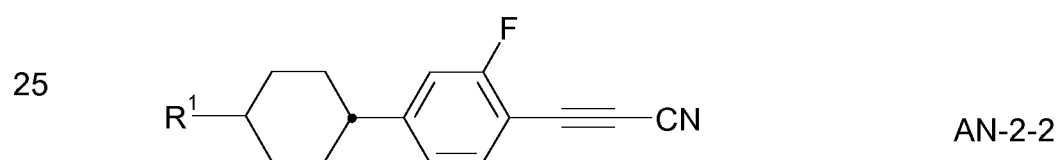
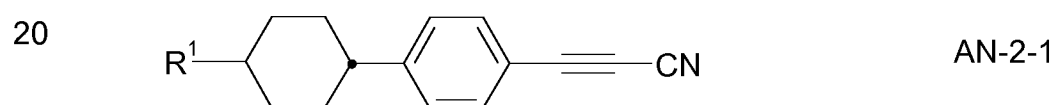
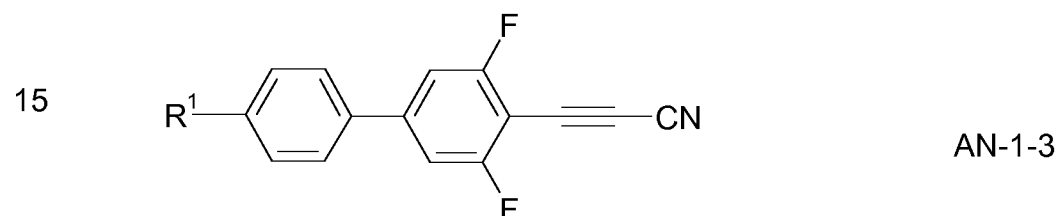
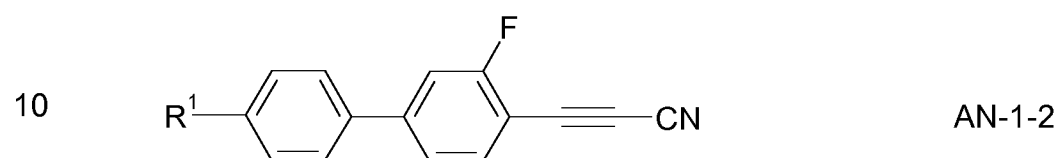
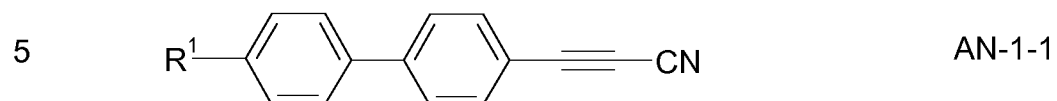
AN-2

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in which the occurring groups and parameters have the meanings given above for formula AN and n preferably denotes 0 or 1.

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Preferred compounds of formula AN-1 and AN-2 are selected from the group of compounds of the formulae

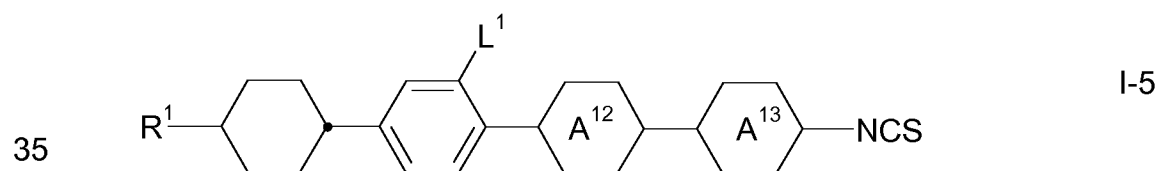
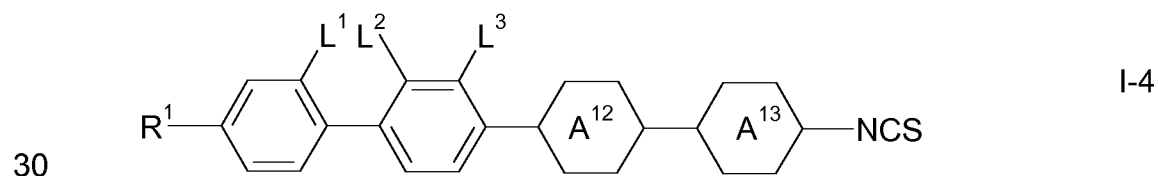
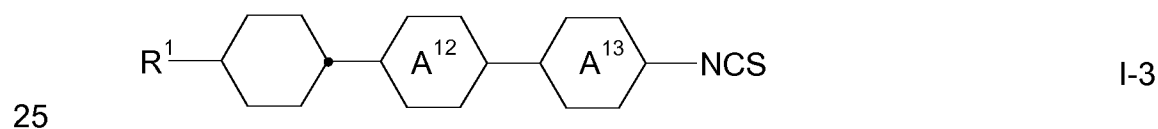
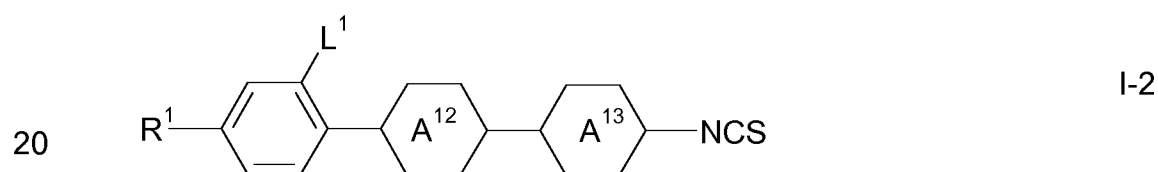
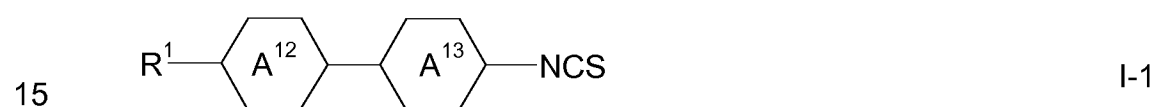


35 in which R¹ has the meaning indicated for formula AN above and preferably denotes alkyl or alkenyl having up to 7 C atoms.

Particularly preferably, the medium comprises one or more compounds of formula AN-2, preferably selected from the group of compounds of formulae AN-2-1, AN-2-2 and AN-2-3, in which

- 5 R^1 denotes alkenyl having 2 to 7 C atoms, preferably $CH_2=CH-$, $trans-CH_3-CH=CH-$ or $CH_2=CH-(CH_2)_2-$.

10 In a preferred embodiment of the present invention, the compounds of formula I are selected from the group of compounds of the formulae I-1 to I-5:



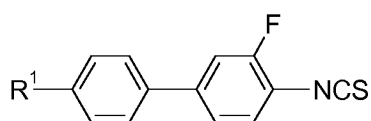
in which

L^1 , L^2 and L^3 on each occurrence, identically or differently, denote H or F,

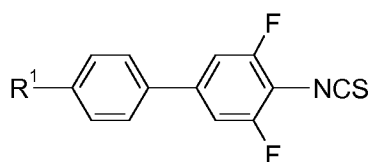
and the other groups have the respective meanings indicated above for formula I and preferably

R^1 denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms.

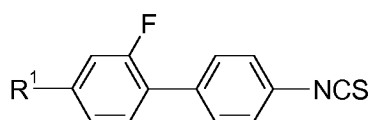
The media preferably comprise one or more compounds of formula I-1, which are preferably selected from the group of the compounds of the formulae I-1a to I-1d, preferably of formula I-1b:



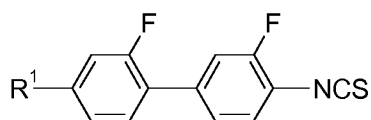
I-1a



I-1b



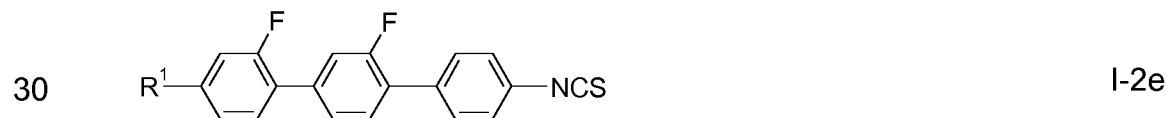
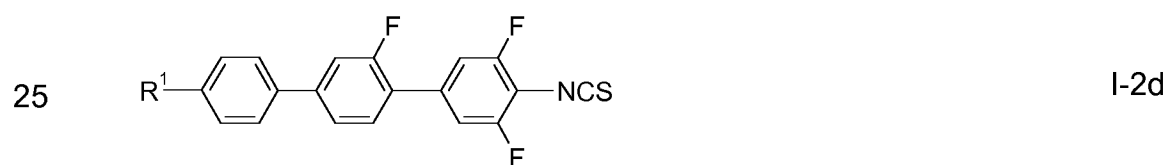
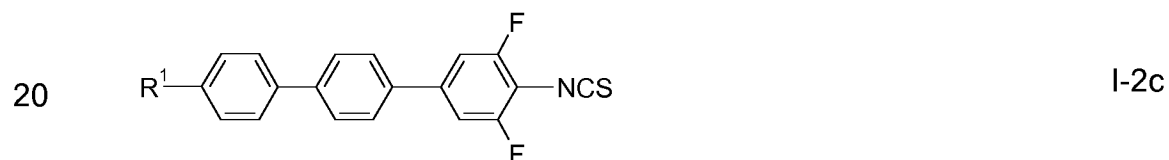
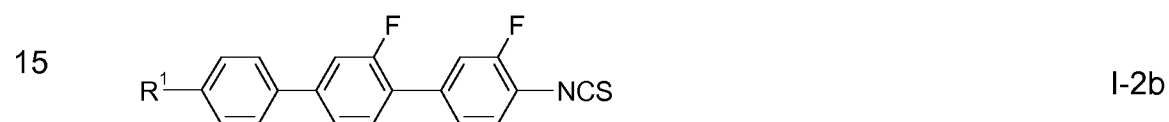
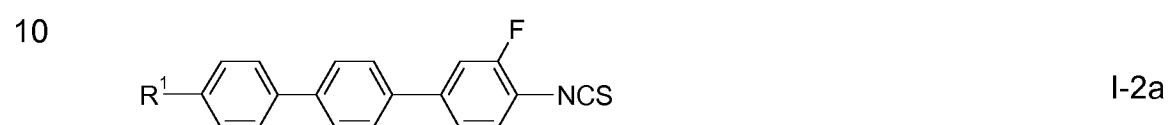
I-1c



I-1d

in which R¹ has the meaning indicated above for formula I and preferably denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms.

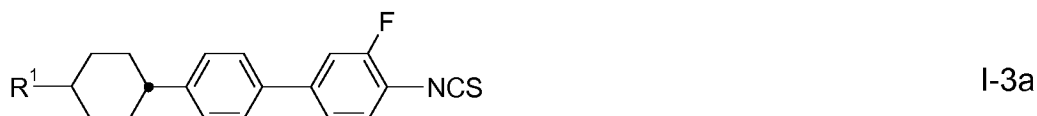
- 5 The media preferably comprise one or more compounds of formula I-2, which are preferably selected from the group of the compounds of the formulae I-2a to I-2e, preferably of formula I-2c:



- in which R¹ has the meaning indicated above for formula I and preferably denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms.
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The media preferably comprise one or more compounds of formula I-3, which are preferably selected from the group of the compounds of the formulae I-3a to I-3d, particularly preferably of formula I-3b:

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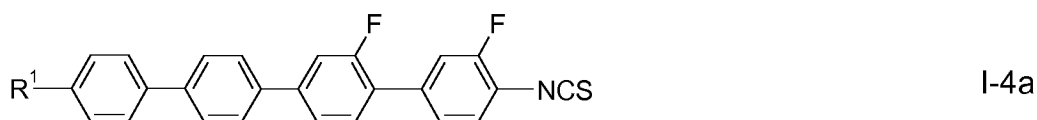
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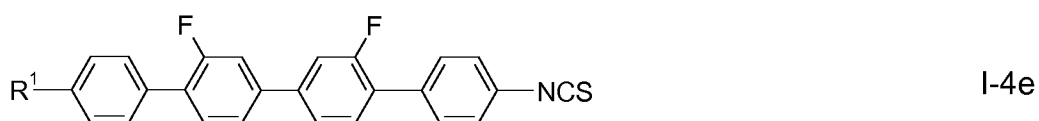
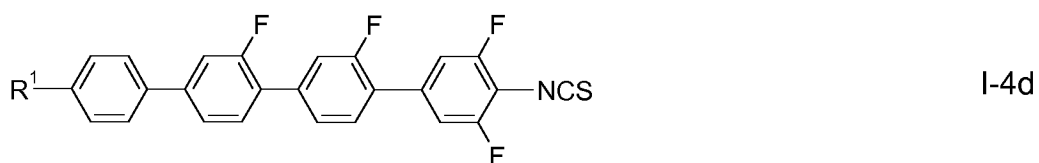
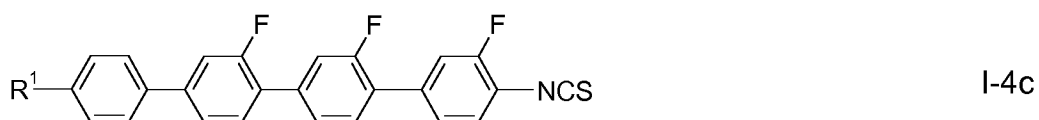
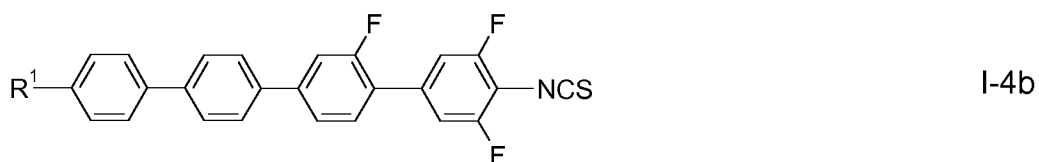


in which R¹ has the meaning indicated above for formula I and preferably denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms.

The media preferably comprise one or more compounds of formula I-4, which are preferably selected from the group of the compounds of the formulae I-4a to I-4d, particularly preferably of formula I-4b:

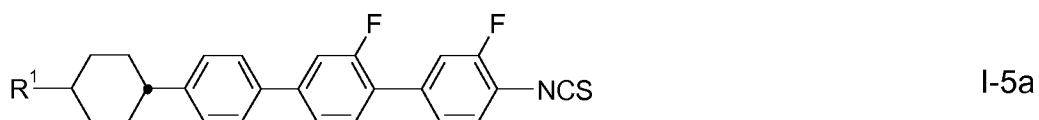
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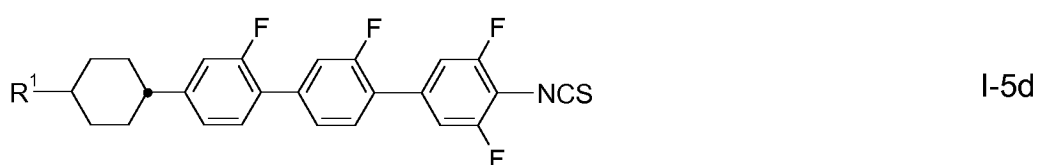
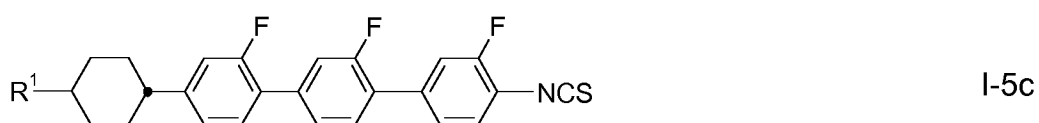
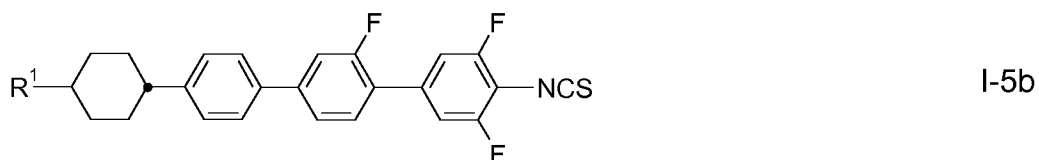




in which R¹ has the meaning indicated above for formula I and preferably denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms.

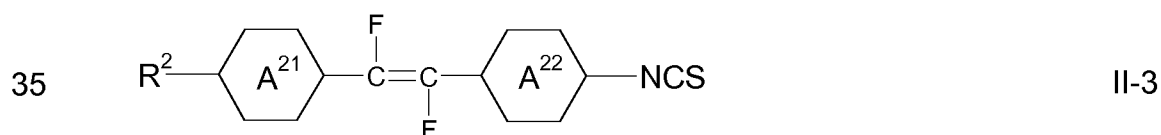
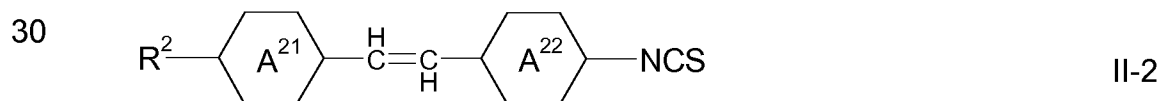
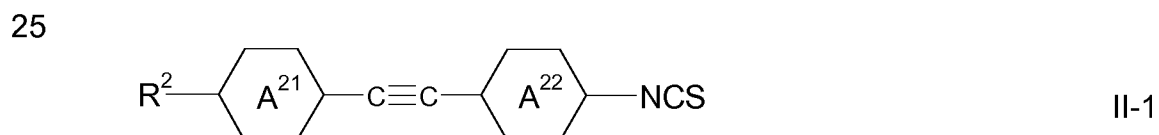
The media preferably comprise one or more compounds of formula I-5, which are preferably selected from the group of the compounds of the formulae I-5a to I-5d, particularly preferably of formula I-5b:





in which R¹ has the meaning indicated above for formula I and preferably denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms.

20 The media preferably comprise one or more compounds of formula II, which are preferably selected from the group of the compounds of the formulae II-1 to II-3, preferably selected from the group of the compounds of the formulae II-1 and II-2:

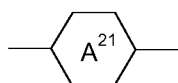


in which the parameters have the meanings given under formula II above
and preferably

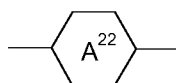
5 R^2 denotes H, unfluorinated alkyl or alkoxy having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms,

and one of

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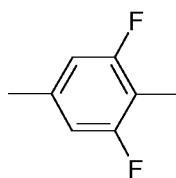


and

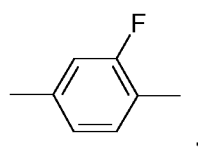


denotes

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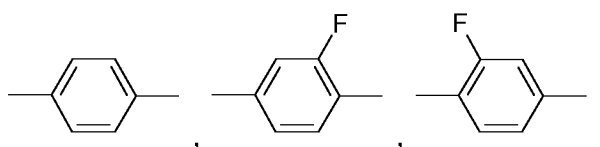


or

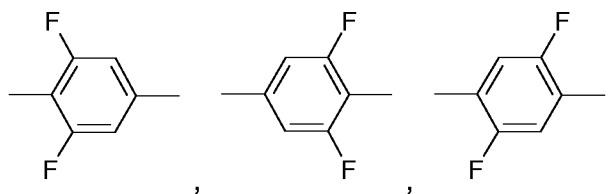


and the other, independently denotes

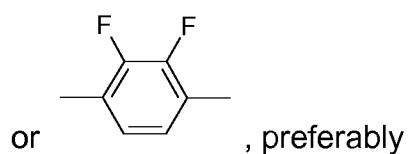
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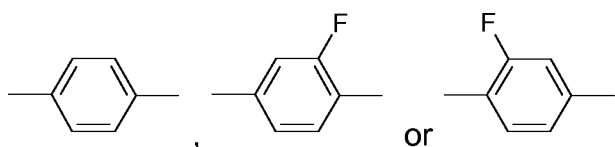
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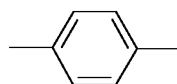


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most preferably

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, and preferably

R^2

denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

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n

denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

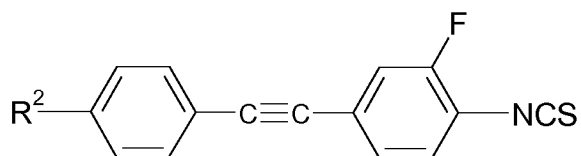
15

z

denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

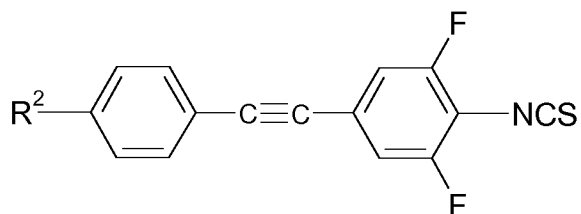
The compounds of formula II-1 are preferably selected from the group of the compounds of the formulae II-1a to II-1e:

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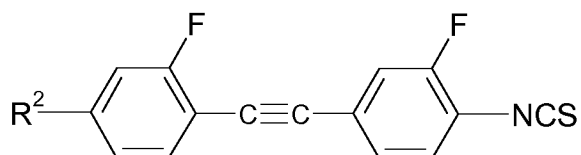
II-1a

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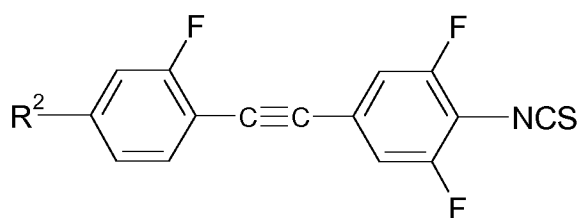
II-1b

30



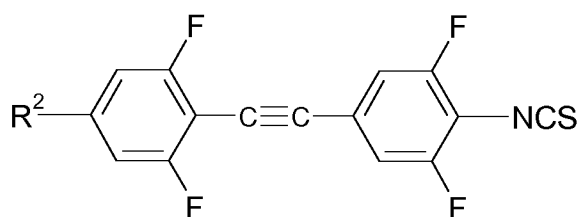
II-1c

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II-1d

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II-1e

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in which

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R^2 has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

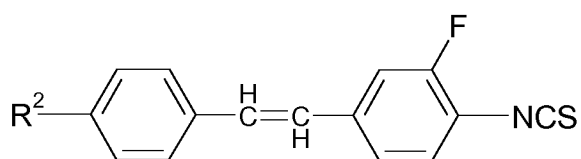
20

n independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

25

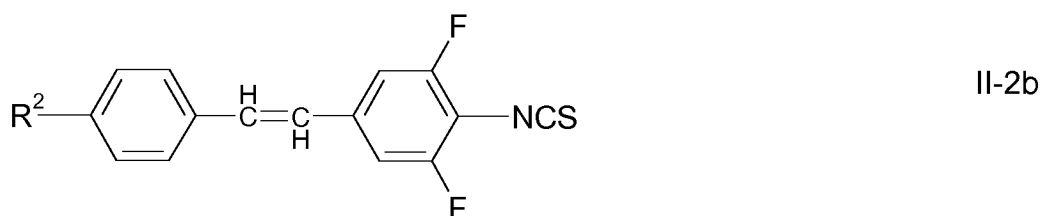
The compounds of formula II-2 are preferably selected from the group of the compounds of the formulae II-2a and II-2b:



II-2a

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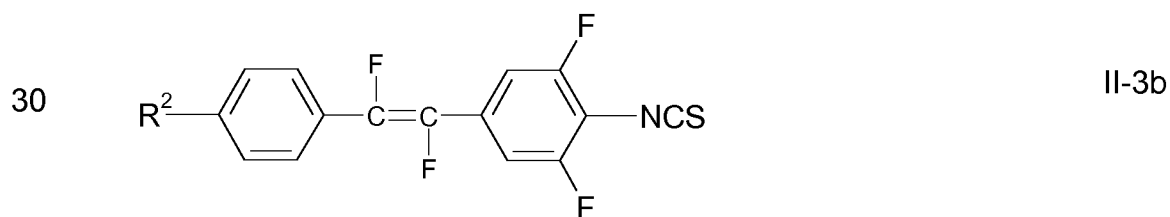
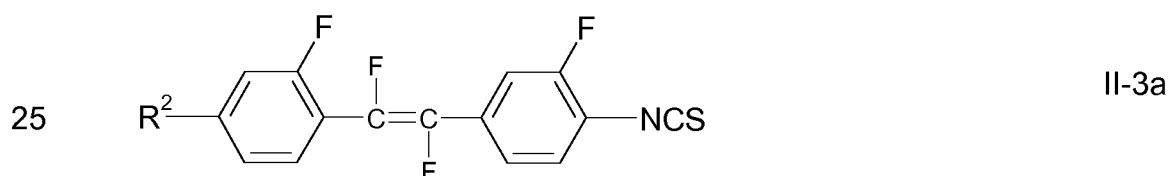
in which

10 R^2 has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$,

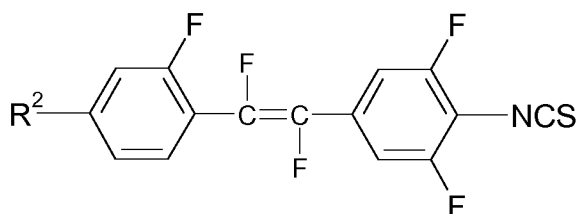
15 n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

20 The compounds of formula II-3 are preferably selected from the group of the compounds of the of formulae II-3a to II-3d:

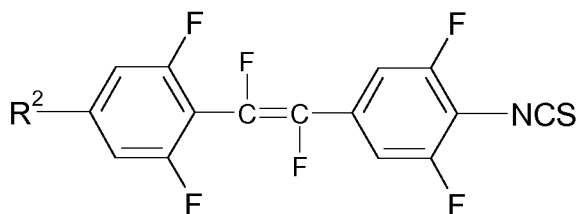


35



II-3c

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II-3d

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in which

15

R^2 has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$,

20

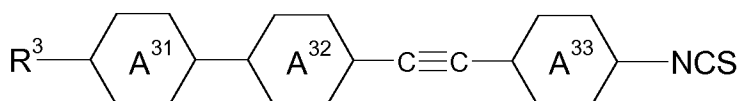
n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

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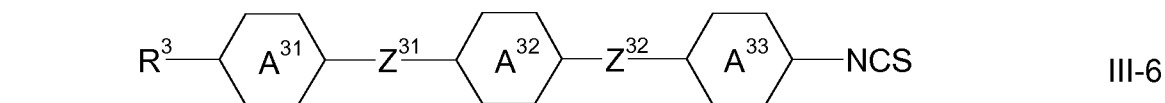
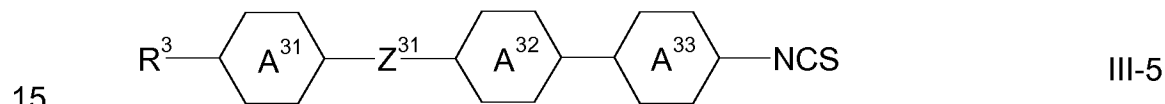
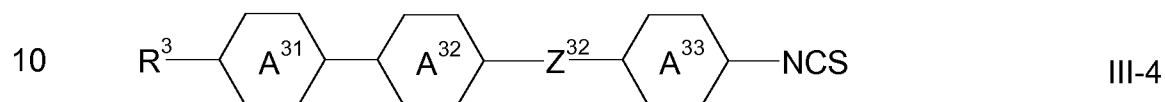
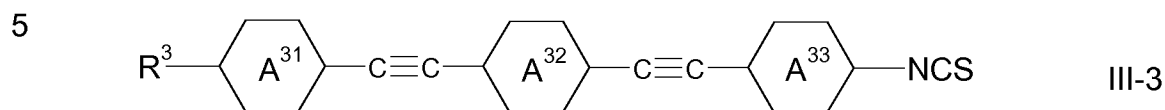
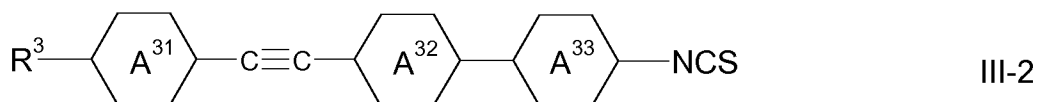
The compounds of formula III are preferably selected from the group of the compounds of the formulae III-1 to III-6, more preferably of the formulae selected from the group of the compounds of the formulae III-1, III-2, III-3 and III-4, and particularly preferably of formula III-1:

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III-1

35



in which

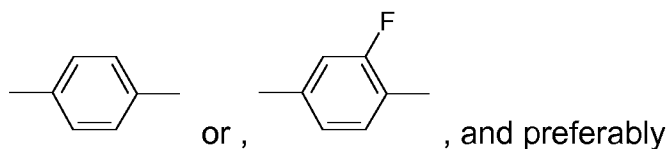
25 Z^{31} and Z^{32} independently of one another denote *trans*-CH=CH- or *trans*-CF=CF-, preferably *trans*-CH=CH-, and in formula III-6 alternatively one of Z^{31} and Z^{32} may denote -C≡C- and the other parameters have the meaning given above under formula III, and preferably

30 R^3 denotes H, unfluorinated alkyl or alkoxy having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms,

35 and one of



- 30 -

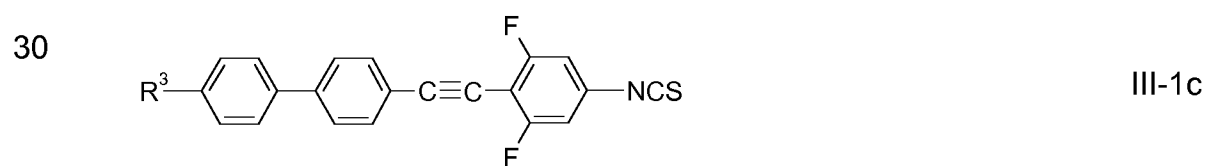
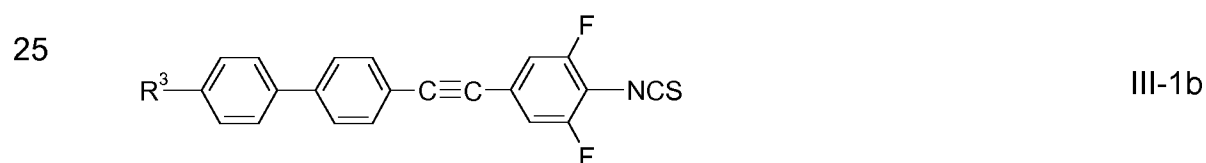
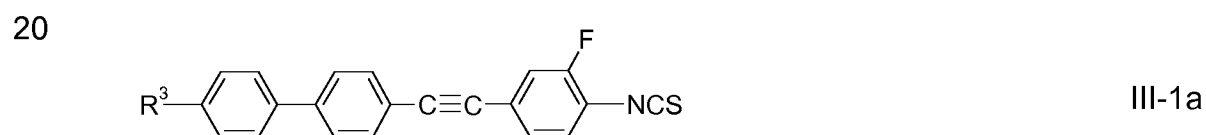


5 R^3 denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$,

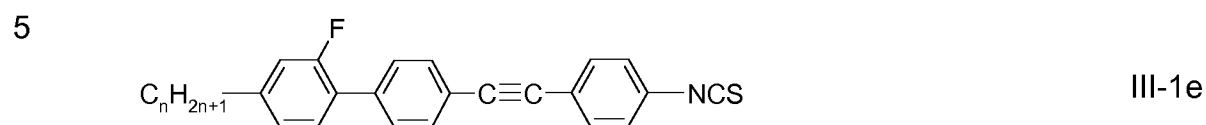
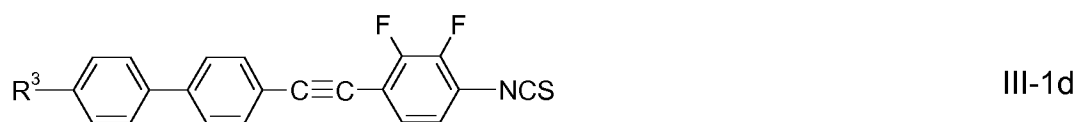
10 n denotes an integer in the range from 0 to 15, preferably
in the range from 1 to 7 and particularly preferably 1 to
5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

15 The compounds of formula III-1 are preferably selected from the group of
the compounds of the formulae III-1a to III-1e, more preferably selected
from the group of the compounds of the formulae III-1a and III-1b,
particularly preferably of formula III-1b,:



35



10 in which

R^3 has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$,

15

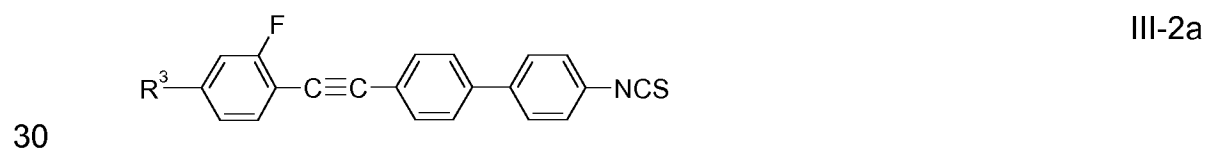
 n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

20

 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

25

 The compounds of formula III-2 are preferably compounds of formula III-2a:



30 in which

35

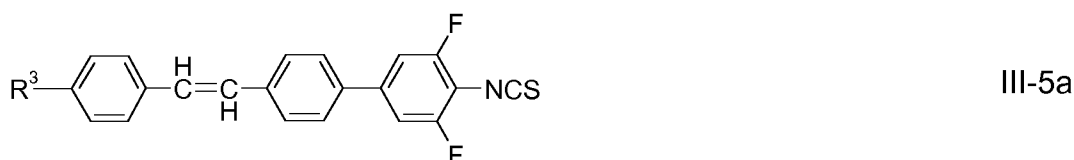
 R^3 has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$,

n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

5 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The compounds of formula III-5 are preferably selected from the compounds of formula III-5a:

10



15

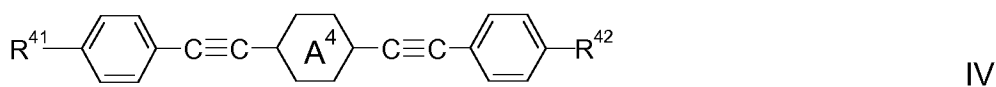
R³ has the meaning indicated above for formula III-5 and preferably denotes C_nH_{2n+1}, in which

20 n denotes an integer in the range from 0 to 7, preferably in the range from 1 to 5.

Additionally, the liquid-crystalline media according to the present invention in a certain embodiment, which may be the same or different from the previous preferred embodiment, preferably comprise one or more compounds of formula IV,

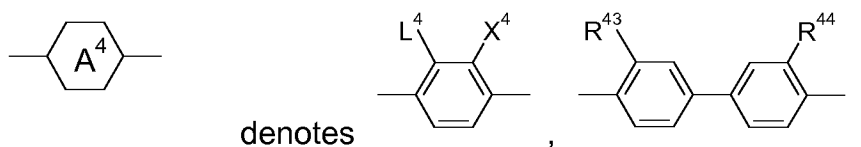
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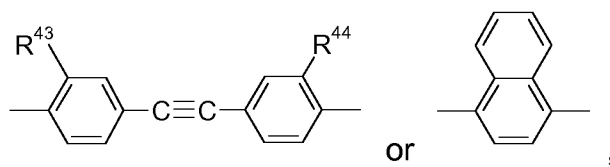


in which

35



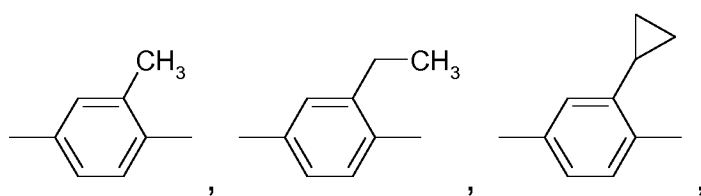
- 33 -



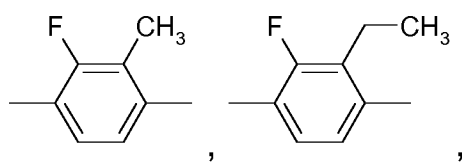
5

preferably

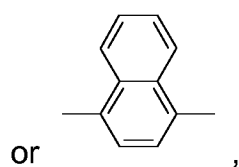
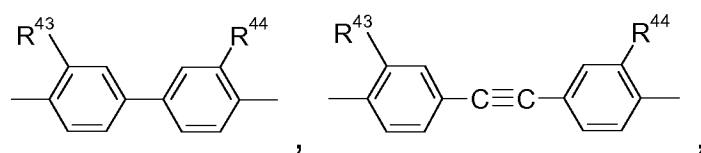
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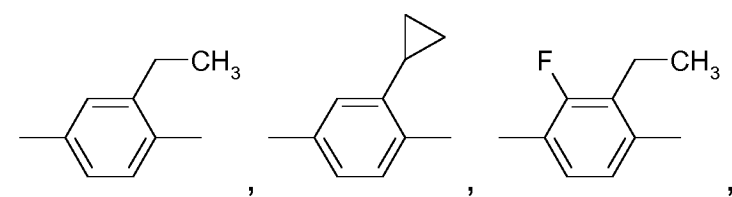
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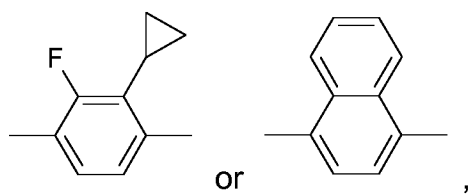
25

particularly preferably

30



35



5	L^4	denotes alkyl having 1 to 6 C atoms, cycloalkyl having 3 to 6 C atoms or cycloalkenyl having 4 to 6 C atoms, preferably CH_3 , C_2H_5 , $n-C_3H_7$ ($-(CH_2)_2CH_3$), $i-C_3H_7$ ($-CH(CH_3)_2$), cyclopropyl, cyclobutyl, cyclohexyl, cyclopent-1-enyl or cyclohex-1-enyl, and particularly preferably CH_3 , C_2H_5 , cyclopropyl or cyclobutyl,
10	X^4	denotes H, alkyl having 1 to 3 C atoms or halogen, preferably H, F or Cl, and particularly preferably H or F and very particularly preferably F,
15	R^{41} to R^{44} ,	independently of one another, denote unfluorinated alkyl or unfluorinated alkoxy, each having 1 to 15 C atoms, unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl, each having 2 to 15 C atoms, or cycloalkyl, alkylcycloalkyl, cycloalkenyl, alkylcycloalkenyl, alkylcycloalkylalkyl or alkylcyclo-
20		alkenylalkyl, each having up to 15 C atoms, and alternatively one of R^{43} and R^{44} or both also denote H,
25	preferably R^{41} and R^{42} ,	independently of one another, denote unfluorinated alkyl or unfluorinated alkoxy, each having 1 to 7 C atoms, or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl, each having 2
30		to 7 C atoms,
35	particularly preferably R^{41}	denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl, each having 2 to 7 C atoms, and

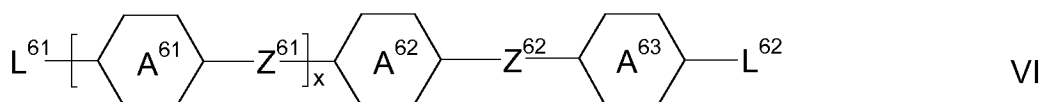
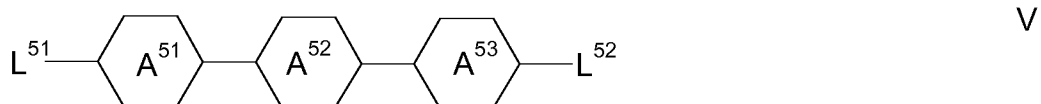
particularly preferably

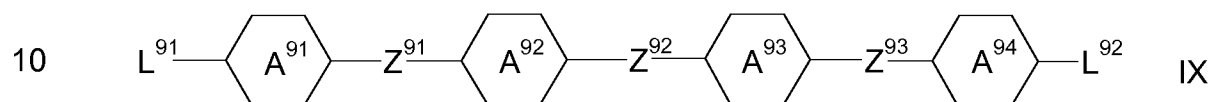
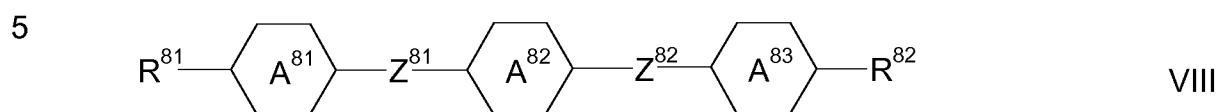
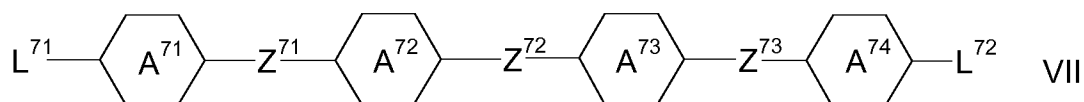
R^{42} denotes unfluorinated alkyl or unfluorinated alkoxy,
each having 1 to 7 C atoms, and

preferably

R^{43} and R^{44} denote H, unfluorinated alkyl having 1 to 5 C atoms, un-
fluorinated cycloalkyl or cycloalkenyl having 3 to 7 C
atoms, unfluorinated alkylcyclohexyl or unfluorinated
cyclohexylalkyl, each having 4 to 12 C atoms, or
unfluorinated alkylcyclohexylalkyl having 5 to 15 C
atoms, particularly preferably cyclopropyl, cyclobutyl or
cyclohexyl, and very particularly preferably at least one
of R^{43} and R^{44} denotes *n*-alkyl, particularly preferably
methyl, ethyl or *n*-propyl, and the other denotes H or
n-alkyl, particularly preferably H, methyl, ethyl or
n-propyl.

In a preferred embodiment of the present application, the liquid-crystal
medium additionally comprises one or more compounds selected from the
group of compounds of the formulae V, VI, VII, VIII and IX:





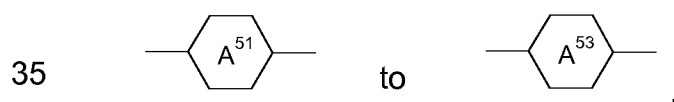
in which

L^{51} denotes R^{51} or X^{51} ,

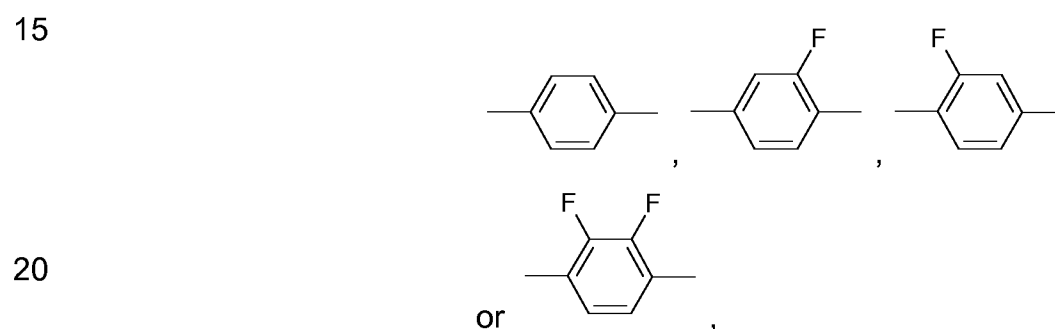
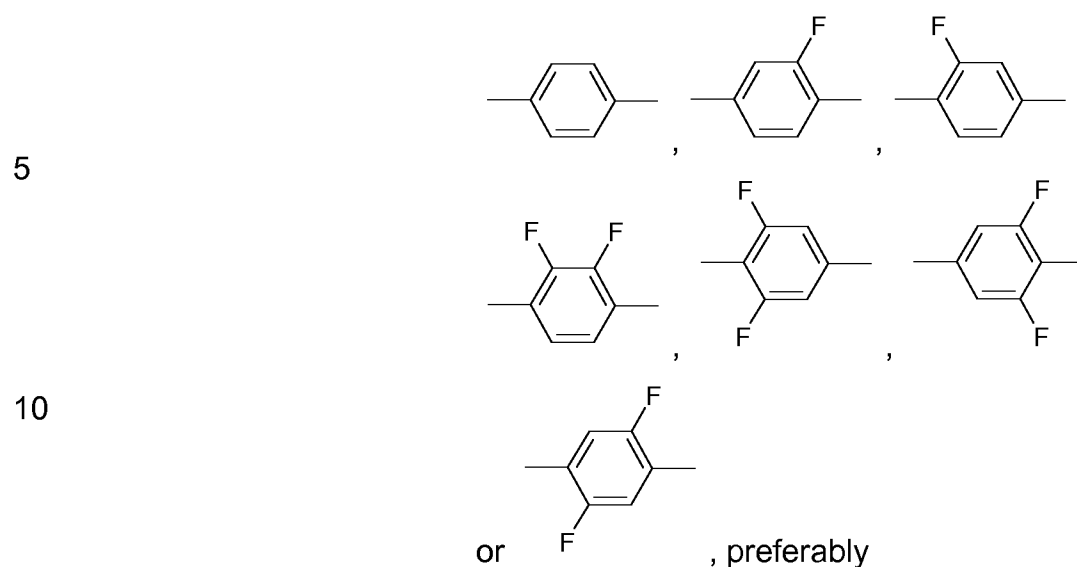
L^{52} denotes R^{52} or X^{52} ,

R^{51} and R^{52} , independently of one another, denote H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17, preferably 3 to 10, C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms, preferably alkyl or unfluorinated alkenyl,

X^{51} and X^{52} , independently of one another, denote H, F, Cl, -CN, SF_5 , fluorinated alkyl or fluorinated alkoxy having 1 to 7 C atoms or fluorinated alkenyl, fluorinated alkenyloxy or fluorinated alkoxyalkyl having 2 to 7 C atoms, preferably fluorinated alkoxy, fluorinated alkenyloxy, F or Cl, and



independently of one another, denote



25

L^{61} denotes R^{61} and, in the case where Z^{61} and/or Z^{62} denote *trans*-CH=CH- or *trans*-CF=CF-, alternatively also denotes X^{61} ,

30

L^{62} denotes R^{62} and, in the case where Z^{61} and/or Z^{62} denote *trans*-CH=CH- or *trans*-CF=CF-, alternatively also denotes X^{62} ,

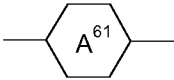
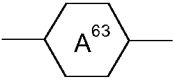
35

R^{61} and R^{62} , independently of one another, denote H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17, preferably 3 to 10, C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15,

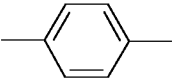
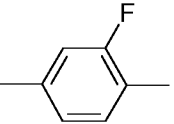
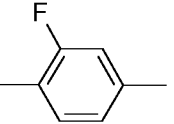
preferably 3 to 10, C atoms, preferably alkyl or unfluorinated alkenyl,

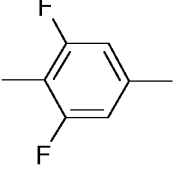
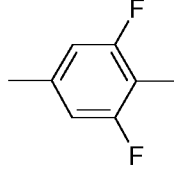
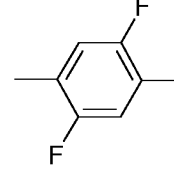
5 X^{61} and X^{62} , independently of one another, denote F or Cl, -CN, SF_5 , fluorinated alkyl or alkoxy having 1 to 7 C atoms or fluorinated alkenyl, alkenyloxy or alkoxyalkyl having 2 to 7 C atoms,

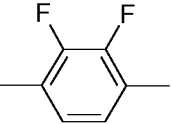
10 one of Z^{61} and Z^{62} denotes *trans*-CH=CH-, *trans*-CF=CF- or -C≡C- and the other, independently thereof, denotes *trans*-CH=CH-, *trans*-CF=CF- or a single bond, preferably one of them denotes -C≡C- or *trans*-CH=CH- and the other denotes a single bond, and

20  to ,

independently of one another, denote

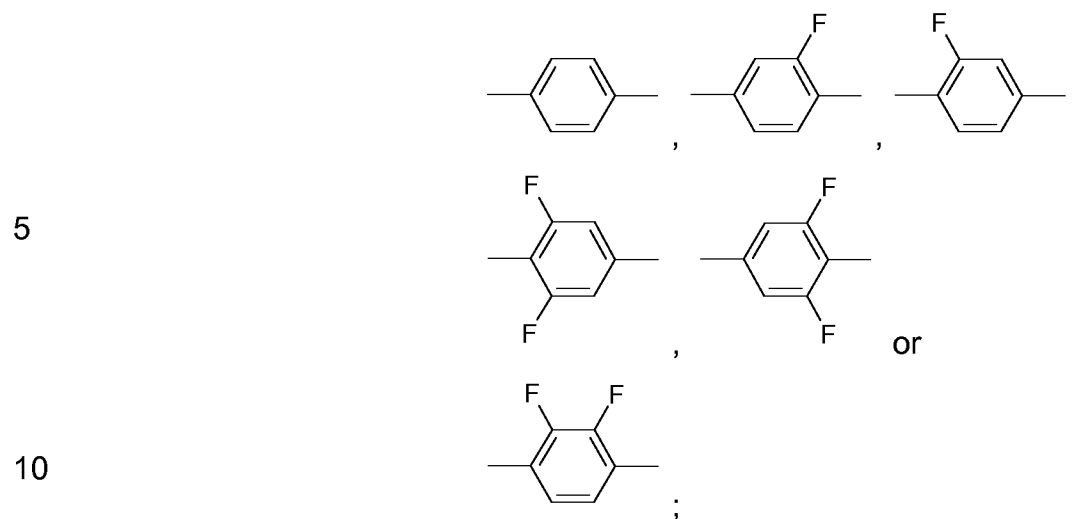
25 , , ,

30 , , ,

or , preferably

35

- 39 -



and

x denotes 0 or 1;

15

 L^{71} denotes R^{71} or X^{71} , L^{72} denotes R^{72} or X^{72} ,

20

R^{71} and R^{72} , independently of one another, denote H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17, preferably 3 to 10, C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms, preferably alkyl or unfluorinated alkenyl,

25

X^{71} and X^{72} , independently of one another, denote H, F, Cl, -CN, -NCS, -SF₅, fluorinated alkyl or fluorinated alkoxy having 1 to 7 C atoms or fluorinated alkenyl, unfluorinated or fluorinated alkenyloxy or unfluorinated or fluorinated alkoxyalkyl having 2 to 7 C atoms, preferably fluorinated alkoxy, fluorinated alkenyloxy, F or Cl, and

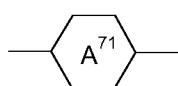
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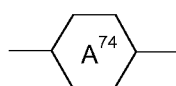
Z^{71} to Z^{73} ,

independently of one another, denote *trans*-CH=CH-,
trans-CF=CF-, -C≡C- or a single bond, preferably one
 or more of them denote a single bond, particularly
 preferably all denote a single bond and

5



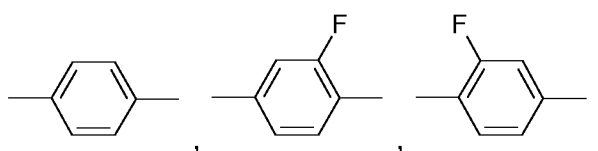
to



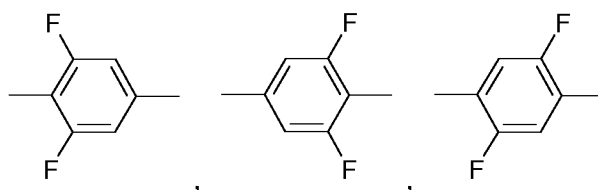
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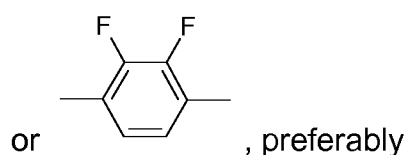
independently of one another, denote



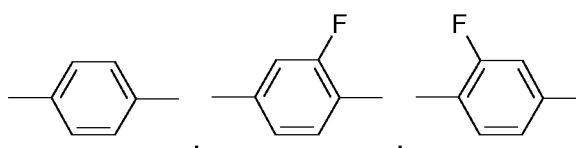
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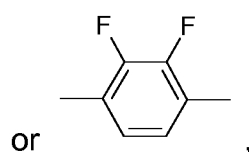
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25



30



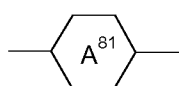
R^{81} and R^{82} ,

independently of one another, denote H, unfluorinated
 alkyl or alkoxy having 1 to 15, preferably 3 to 10, C
 atoms or unfluorinated alkenyl, alkenyloxy or

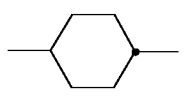
35

alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms,
preferably unfluorinated alkyl or alkenyl,

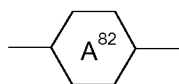
one of
5 Z^{81} and Z^{82} denotes *trans*-CH=CH-, *trans*-CF=CF- or -C≡C- and the
other, independently thereof, denotes *trans*-CH=CH-,
trans-CF=CF- or a single bond, preferably one of them
denotes -C≡C- or *trans*-CH=CH- and the other denotes
10 a single bond, and



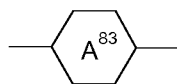
denotes



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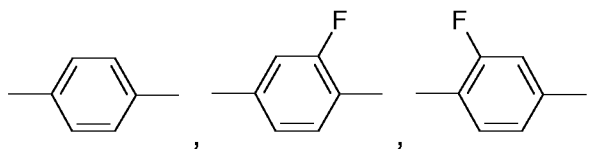


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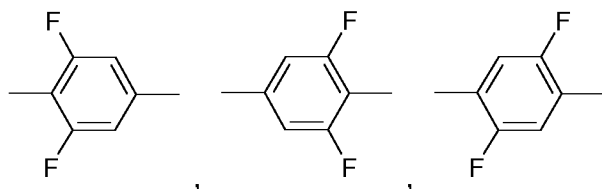


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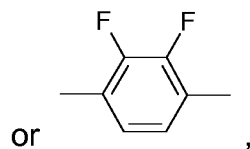
independently of one another, denote



25



30



L^{91}

denotes R^{91} or X^{91} ,

35

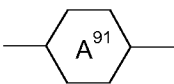
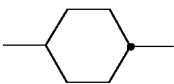
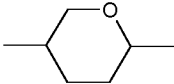
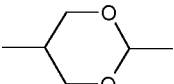
L^{92}

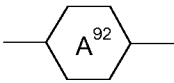
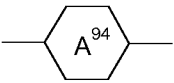
denotes R^{92} or X^{92} ,

5 R^{91} and R^{92} , independently of one another, denote H, unfluorinated alkyl or alkoxy having 1 to 15, preferably 3 to 10, C atoms or unfluorinated alkenyl, alkenyloxy or alkoxyalkyl having 2 to 15, preferably 3 to 10, C atoms, preferably unfluorinated alkyl or alkenyl,

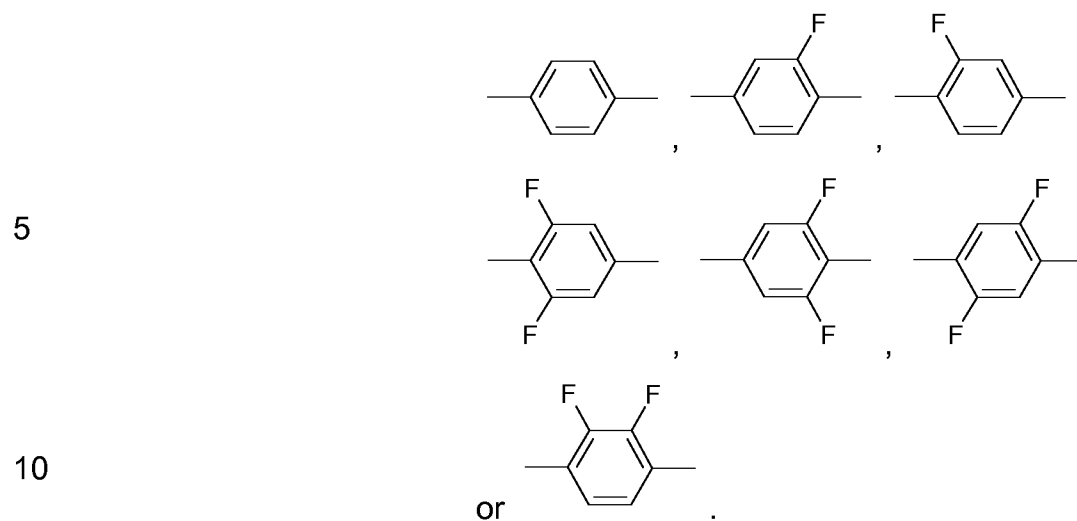
10 X^{91} and X^{92} , independently of one another, denote H, F, Cl, -CN, -NCS, -SF₅, fluorinated alkyl or fluorinated alkoxy having 1 to 7 C atoms or fluorinated alkenyl, unfluorinated or fluorinated alkenyloxy or unfluorinated or fluorinated alkoxyalkyl having 2 to 7 C atoms, preferably fluorinated alkoxy, fluorinated alkenyloxy, F or Cl, and

20 Z^{91} to Z^{93} , independently of one another, denote *trans*-CH=CH-, *trans*-CF=CF-, -C≡C- or a single bond, preferably one or more of them denotes a single bond, and particularly preferably all denote a single bond,

25  denotes ,  or ,

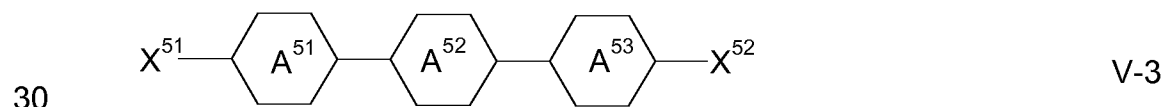
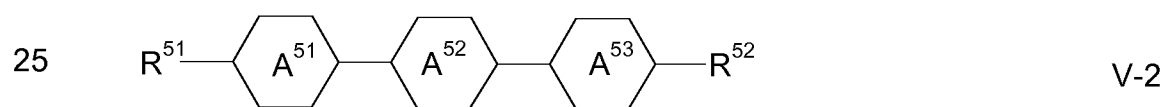
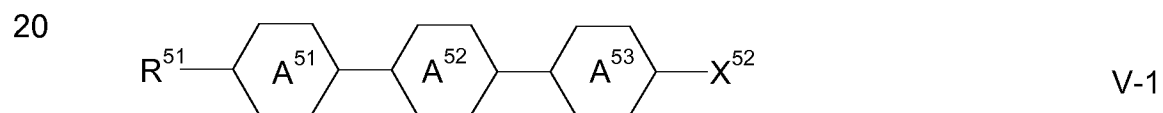
30  to 

35 independently of one another, denote



15

In a preferred embodiment of the present invention, the liquid-crystal medium comprises one or more compounds of the formula V, preferably selected from the group of the compounds of the formulae V-1 to V-3, preferably of the formulae V-1 and/or V-2 and/or V-3, preferably of the formulae V-1 and V-2:



in which the parameters have the respective meanings indicated above for formula V and preferably

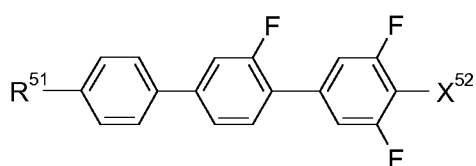
R^{51} denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms,

5 R^{52} denotes unfluorinated alkyl having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms or unfluorinated alkoxy having 1 to 7 C atoms,

10 X^{51} and X^{52} , independently of one another, denote F, Cl, $-OCF_3$, $-CF_3$, $-CN$ or $-SF_5$, preferably F, Cl, $-OCF_3$ or $-CN$.

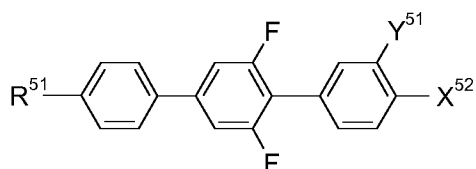
The compounds of the formula V-1 are preferably selected from the group of the compounds of the formulae V-1a to V-1d, preferably V-1c and V-1d :

15



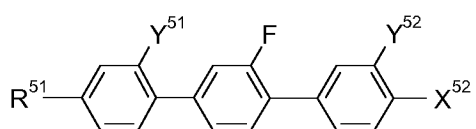
V-1a

20



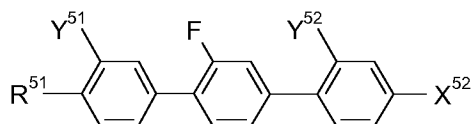
V-1b

25



V-1c

30



V-1d

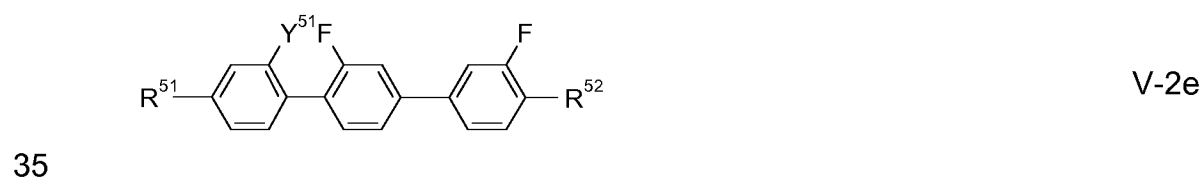
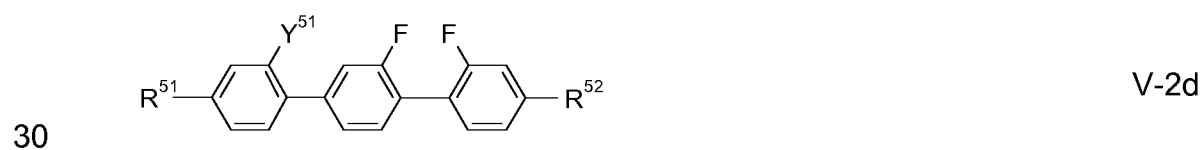
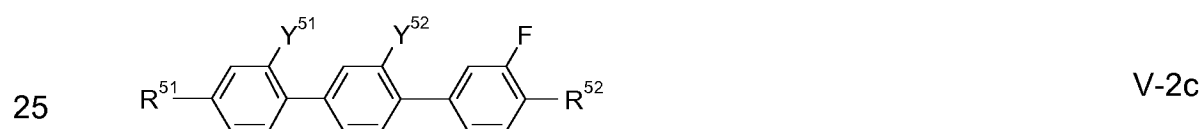
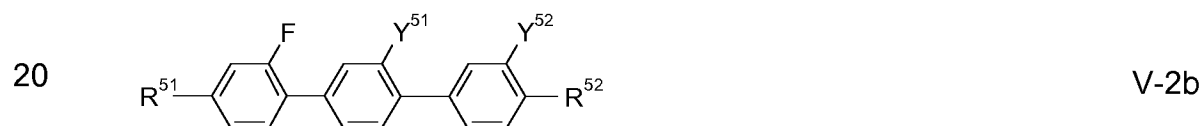
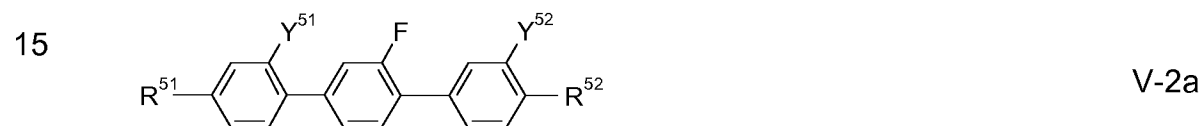
35 in which the parameters have the respective meanings indicated above for formula V-1 and in which

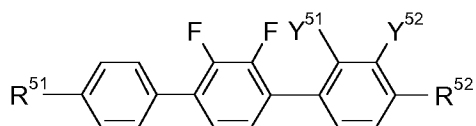
Y^{51} and Y^{52} , in each case independently of one another, denote H or F, and preferably

5 R^{51} denotes alkyl or alkenyl, and

X^{51} denotes F, Cl or $-OCF_3$.

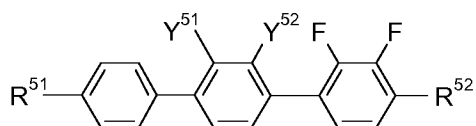
10 The compounds of the formula V-2 are preferably selected from the group of the compounds of the formulae V-2a to V-2e and/or from the group of the compounds of the formulae V-2f and V-2g:





V-2f

5



V-2g

10

where in each case the compounds of the formula V-2a are excluded from the compounds of the formulae V-2b and V-2c, the compounds of the formula V-2b are excluded from the compounds of the formula V-2c and the compounds of the formula V-2e are excluded from the compounds of the formula V-2f, and

15

in which the parameters have the respective meanings indicated above for formula V-1 and in which

20

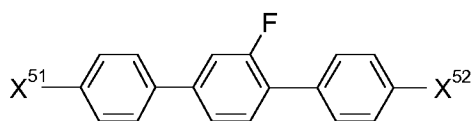
Y^{51} and Y^{52} , in each case independently of one another, denote H or F, and preferably

Y^{51} and Y^{52} denotes H and the other denotes H or F, preferably likewise denotes H.

25

The compounds of the formula V-3 are preferably compounds of the formula V-3a:

30



V-3a

35

in which the parameters have the respective meanings indicated above for formula V-1 and in which preferably

X^{51} denotes F, Cl, preferably F,

X^{52} denotes F, Cl or $-OCF_3$, preferably $-OCF_3$.

5 The compounds of the formula V-1a are preferably selected from the group of the compounds of the formulae V-1a-1 and V-1a-2, more preferably these compounds of the formula V predominantly consist, even more preferably essentially consist and very particularly preferably completely consist thereof:



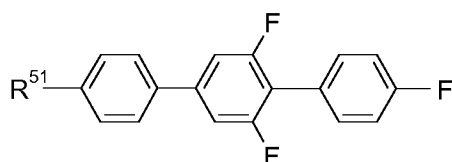
in which

25 R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} , in which

30 n denotes an integer in the range from 0 to 7, preferably in the range from 1 to 5 and particularly preferably 3 or 7.

The compounds of the formula V-1b are preferably compounds of the formula V-1b-1:

35



V-1b-1

5

in which

R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} , in which

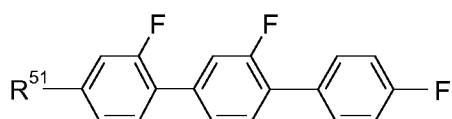
10

n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5.

15

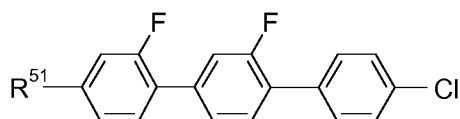
The compounds of the formula V-1c are preferably selected from the group of the compounds of the formulae V-1c-1 to V-1c-4, particularly preferably selected from the group of the compounds of the formulae V-1c-1 and V-1c-2:

20



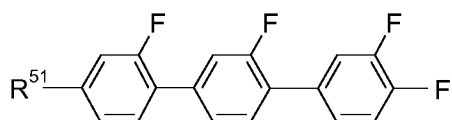
V-1c-1

25



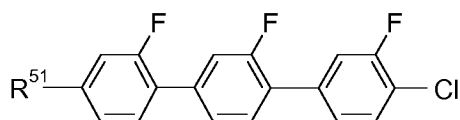
V-1c-2

30



V-1c-3

35



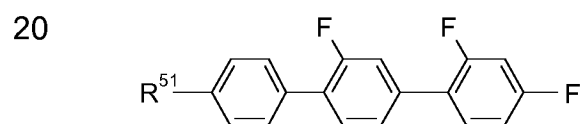
V-1c-4

5 in which

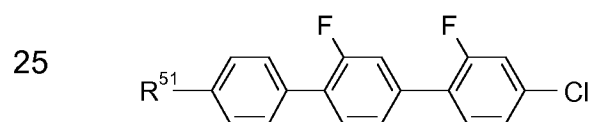
R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} , in which

10 n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5.

15 The compounds of the formula V-1d are preferably selected from the group of the compounds of the formulae V-1d-1 and V-1d-2, particularly preferably the compound of the formula V-1d-2:



V-1d-1



V-1d-2

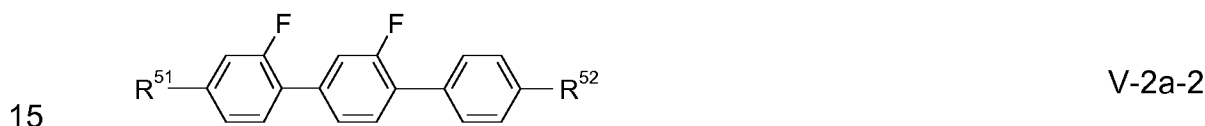
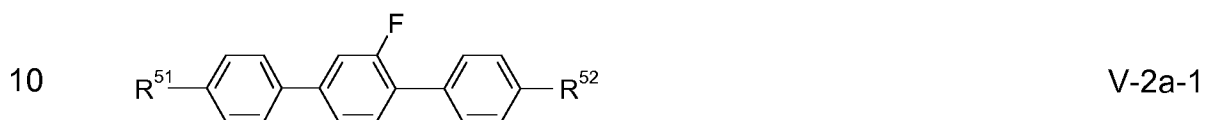
in which

30 R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} , in which

35

n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5.

5 The compounds of the formula V-2a are preferably selected from the group of the compounds of the formulae V-2a-1 and V-2a-2, particularly preferably the compounds of the formula V-2a-1:



in which

20 R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

25 R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

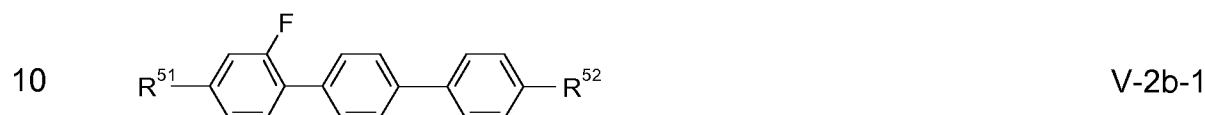
30 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

35 Preferred combinations of (R^{51} and R^{52}), in particular in the case of formula

V-2a-1, are (C_nH_{2n+1} and C_mH_{2m+1}), (C_nH_{2n+1} and $O-C_mH_{2m+1}$), ($CH_2=CH-(CH_2)_Z$ and C_mH_{2m+1}), ($CH_2=CH-(CH_2)_Z$ and $O-C_mH_{2m+1}$) and (C_nH_{2n+1} and $(CH_2)_Z-CH=CH_2$).

5 Preferred compounds of the formula V-2b are the compounds of the formula V-2b-1:



in which

15 R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

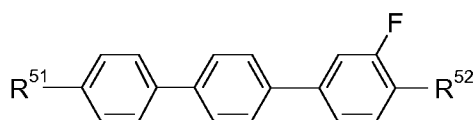
20 R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

25 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

30 The preferred combination of (R^{51} and R^{52}) here is, in particular, (C_nH_{2n+1} and C_mH_{2m+1}).

35 Preferred compounds of the formula V-2c are the compounds of the formula V-2c-1:



V-2c-1

5 in which

R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

10

R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

15

n and m , independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

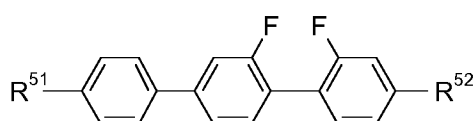
20

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combination of (R^{51} and R^{52}) here is, in particular, (C_nH_{2n+1} and C_mH_{2m+1}).

25

Preferred compounds of the formula V-2d are the compounds of the formula V-2d-1:



V-2d-1

30

in which

35

R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

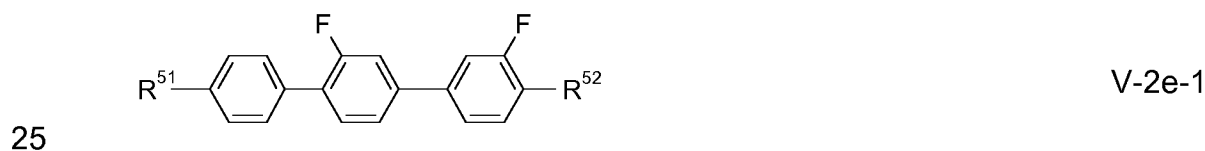
5 R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

10 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

15 The preferred combination of (R^{51} and R^{52}) here is, in particular, (C_nH_{2n+1} and C_mH_{2m+1}).

20 Preferred compounds of the formula V-2e are the compounds of the formula V-2e-1:



in which

30 R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

35 R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

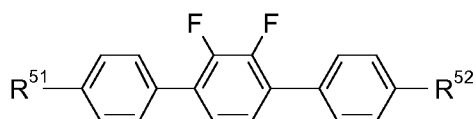
5 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combination of (R^{51} and R^{52}) here is, in particular, (C_nH_{2n+1} and $O-C_mH_{2m+1}$).

10

Preferred compounds of the formula V-2f are the compounds of the formula V-2f-1:

15



V-2f-1

in which

20

R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

25

R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

30

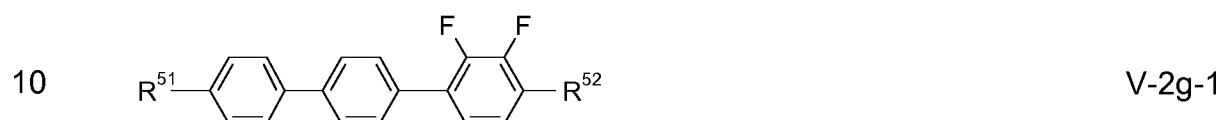
n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

35

The preferred combinations of (R^{51} and R^{52}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

5 Preferred compounds of the formula V-2g are the compounds of the formula V-2g-1:



in which

15 R^{51} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

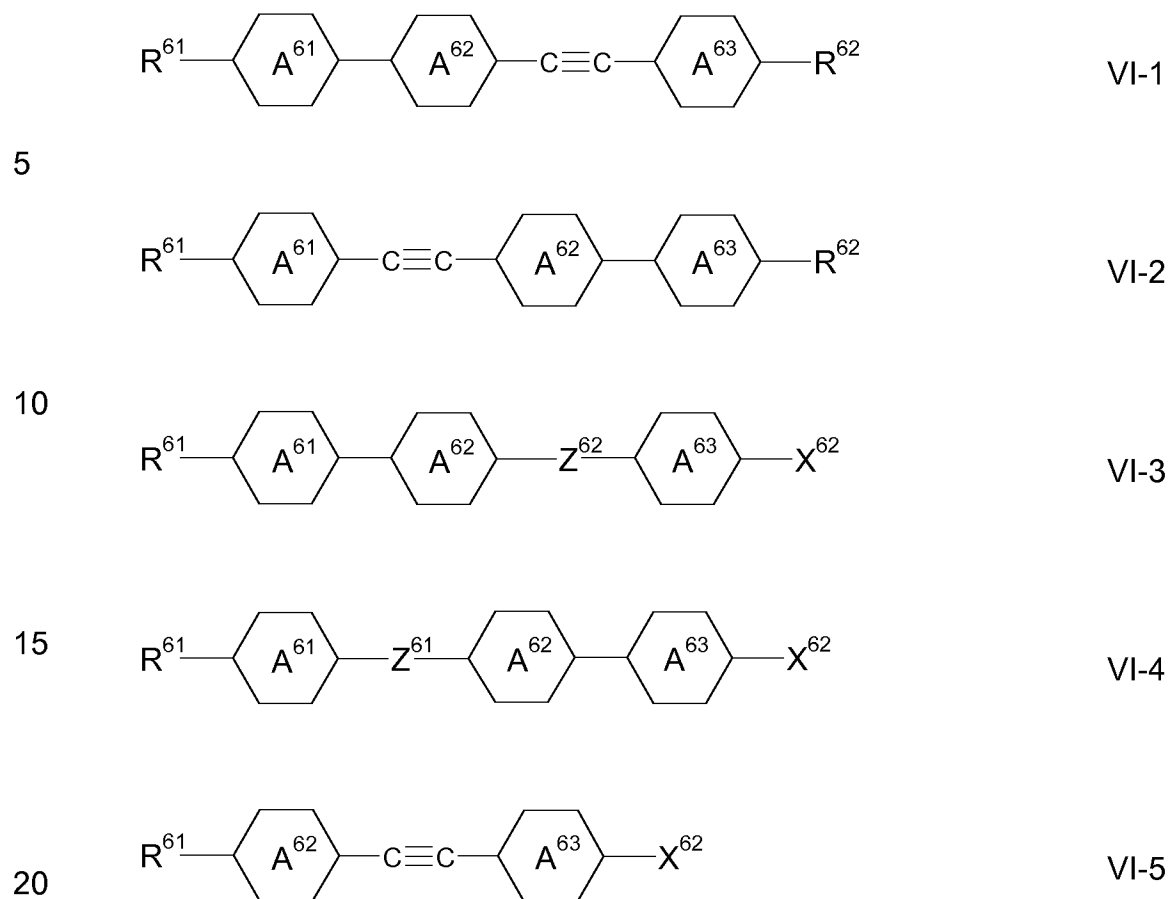
20 R^{52} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

25 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

30 The preferred combinations of (R^{51} and R^{52}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and $O-C_mH_{2m+1}$).

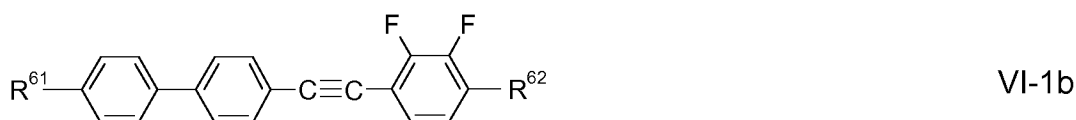
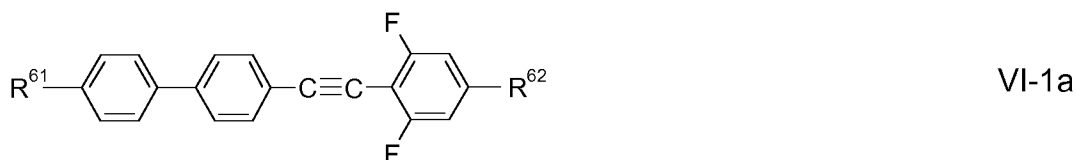
35 The compounds of the formula VI are preferably selected from the group of the compounds of the formulae VI-1 to VI-5:



in which

- 25 Z^{61} and Z^{62} denote *trans*-CH=CH- or *trans*-CF=CF-, preferably *trans*-CH=CH-, and the other occurring groups and parameters have the meaning given above under formula VI,
- 30 and preferably
- R^{61} and R^{62} , independently of one another, denote H, unfluorinated alkyl or alkoxy having 1 to 7 C atoms or unfluorinated alkenyl having 2 to 7 C atoms,
- 35 X^{62} denotes F, Cl, -OCF₃ or -CN,

The compounds of the formula VI-1 are preferably selected from the group
of the compounds of the formulae VI-1a and VI-1b, more preferably
selected from compounds of the formula VI-1a:



in which

R^{61} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

R^{62} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

n and m , independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

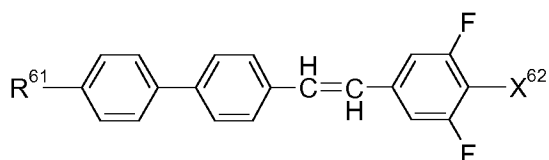
The preferred combinations of (R^{61} and R^{62}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), in the case of for-

mula VI-1a particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}) and in the case of formula VI-1b particularly preferably (C_nH_{2n+1} and $O-C_mH_{2m+1}$).

5

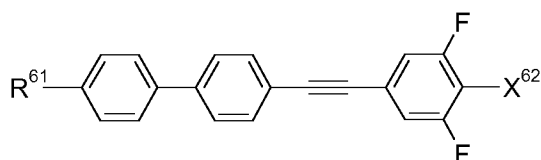
The compounds of the formula VI-2 are preferably selected from the compounds of the formula VI-2a to VI-2c:

10



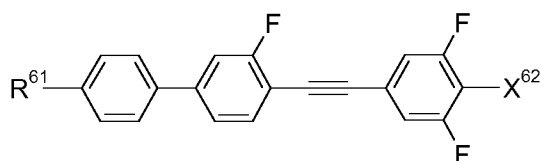
VI-2a

15



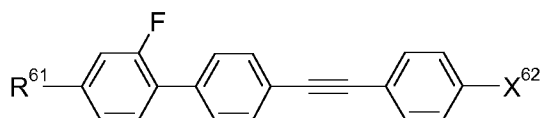
VI-2b

20



VI-2c

25



VI-2d

in which the parameters have the meaning given above under formula VI-2 and preferably

30

R^{61} has the meaning indicated above and preferably denotes C_nH_{2n+1} , in which

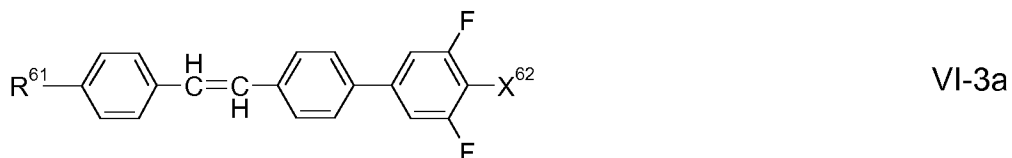
35

n denotes an integer in the range from 0 to 7, preferably in the range from 1 to 5, and

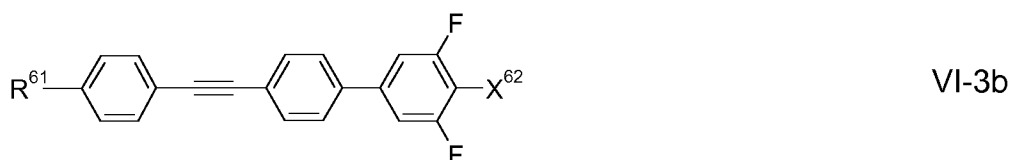
X^{62} denotes -F, -Cl, -OCF₃, or -CN.

The compounds of the formula VI-3 are preferably selected from compounds of the formulae VI-3a to VI-3c:

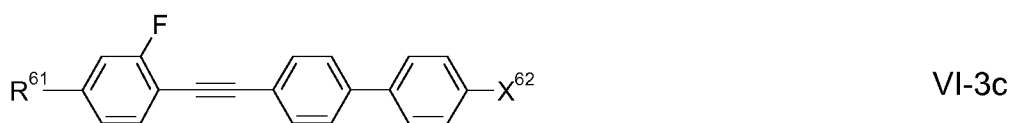
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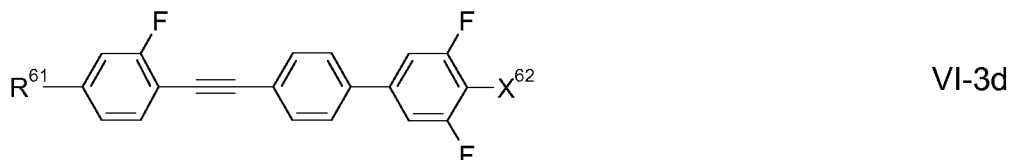
10



15



20



25

in which the parameters have the meaning given above under formula VI-3 and preferably

30

R^{61} has the meaning indicated above and preferably denotes C_nH_{2n+1}, in which

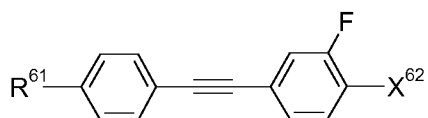
n denotes an integer in the range from 0 to 7, preferably in the range from 1 to 5, and

35

X^{62} denotes F, Cl, OCF₃, or -CN.

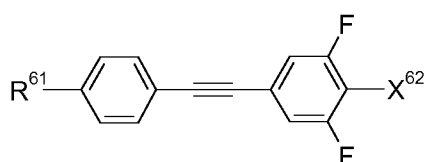
The compounds of the formula VI-5 are preferably selected from the compounds of the formula VI-5b:

5



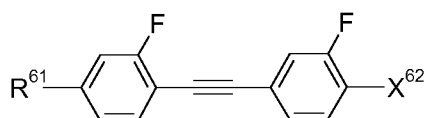
VI-5a

10



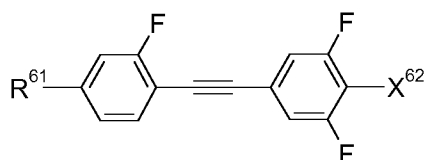
VI-5b

15



VI-5c

20



VI-5d

in which the parameters have the meaning given above under formula
VI-5 and preferably

R^{61} has the meaning indicated above and preferably denotes C_nH_{2n+1} , in which

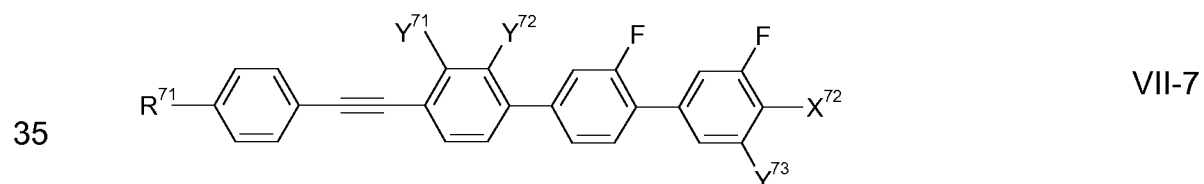
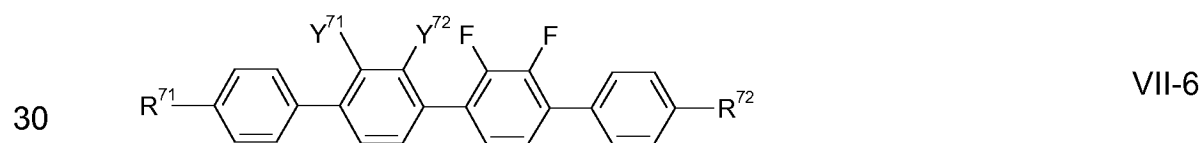
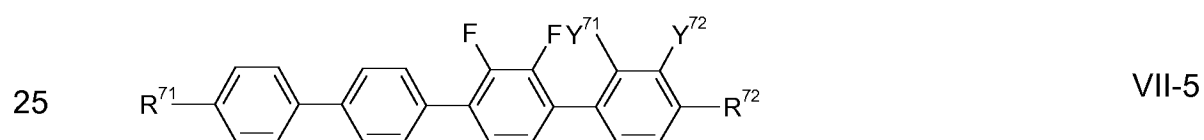
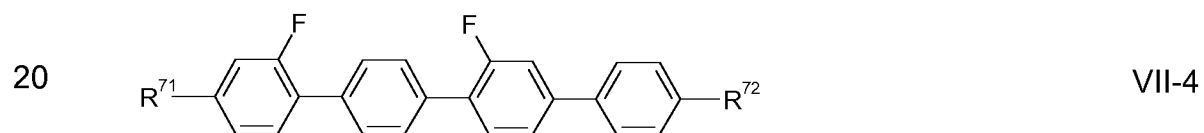
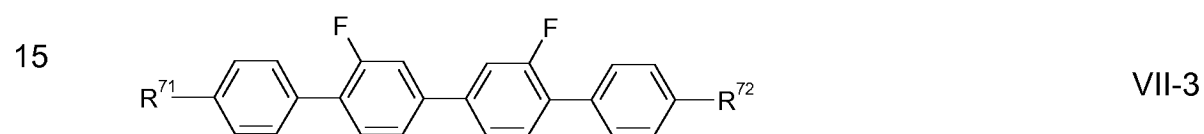
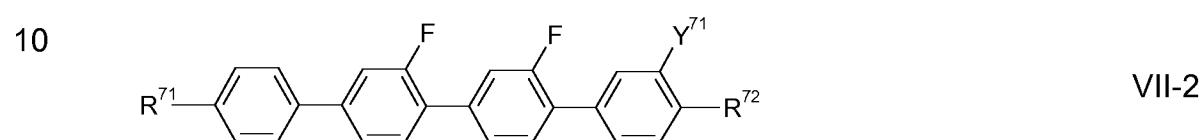
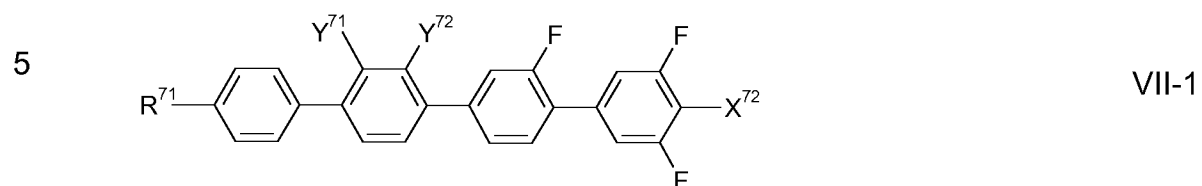
30

n denotes an integer in the range from 0 to 7, preferably in the range from 1 to 5, and

X^{62} denotes -F, -Cl, -OCF₃, or -CN, particularly preferably -OCF₃.

35

The compounds of the formula VII are preferably selected from the group of the compounds of the formulae VII-1 to VII-6:



where the compounds of the formula VII-5 are excluded from the compounds of the formula VII-6, and

5 in which the parameters have the respective meanings indicated above for formula VII,

10 Y^{71}, Y^{72}, Y^{73} independently from one another, denote H or F,

and preferably

15 R^{71} denotes unfluorinated alkyl or alkoxy, each having 1 to 7 C atoms, or unfluorinated alkenyl having 2 to 7 C atoms,

20 R^{72} denotes unfluorinated alkyl or alkoxy, each having 1 to 7 C atoms, or unfluorinated alkenyl having 2 to 7 C atoms,

25 X^{72} denotes F, Cl; NCS or $-OCF_3$, preferably F or NCS, and particularly preferably

R^{71} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

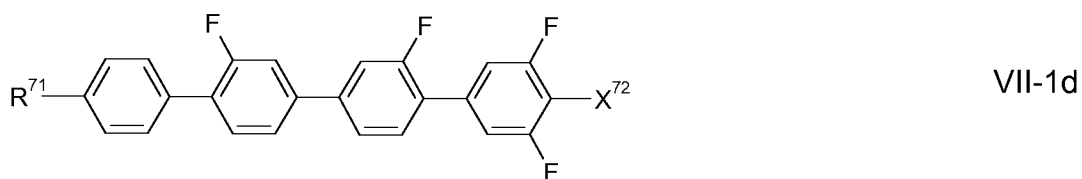
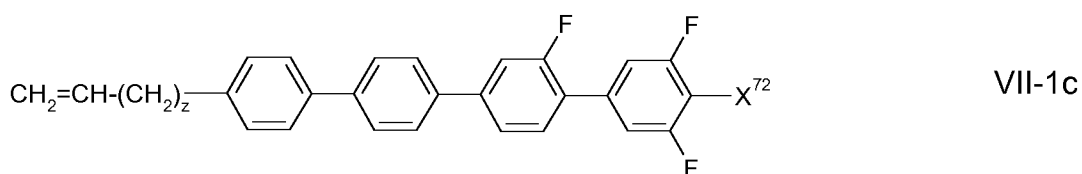
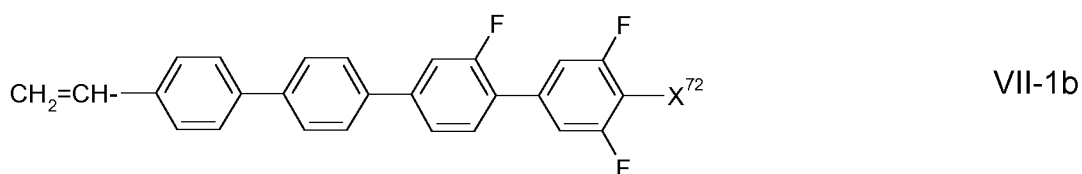
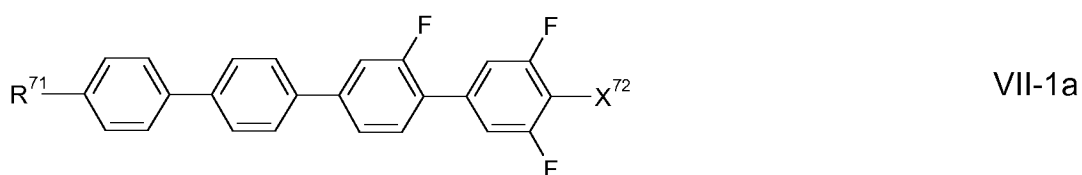
30 R^{72} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

35

n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The compounds of the formula VII-1 are preferably selected from the group of the compounds of the formulae VII-1a to VII-1d:



in which X⁷² has the meaning given above for formula VII-2 and

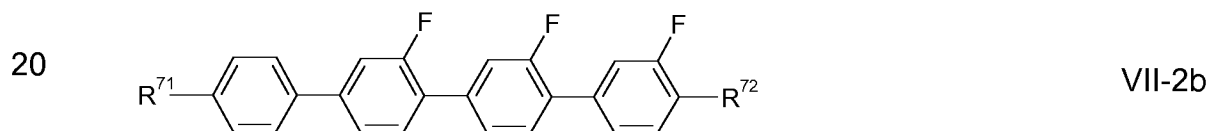
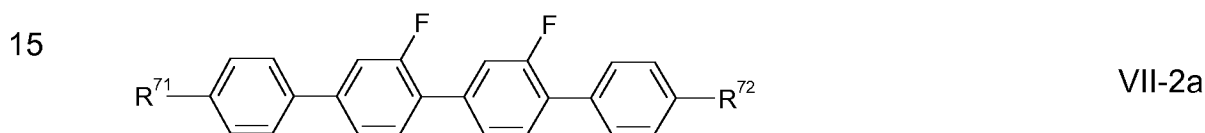
R⁷¹ has the meaning indicated above and preferably denotes C_nH_{2n+1}, in which

n denotes 1 to 7, preferably 2 to 6, particularly preferably 2, 3 or 5, and

5 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2, and

X^{72} preferably denotes F.

10 The compounds of the formula VII-2 are preferably selected from the group of the compounds of the formulae VII-2a and VII-2b, particularly preferably of the formula VII-2a:



in which

25 R^{71} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

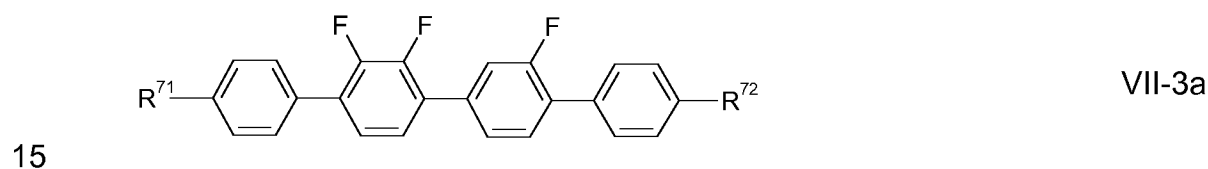
30 R^{72} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

35 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

5 The preferred combinations of (R^{71} and R^{72}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

10 The compounds of the formula VII-3 are preferably compounds of the formula VII-3a:



in which

20 R^{71} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

25 R^{72} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

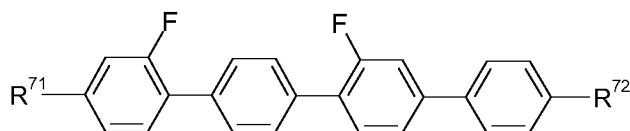
30 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

35 The preferred combinations of (R^{71} and R^{72}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

The compounds of the formula VII-4 are preferably compounds of the formula VII-4a:

5



VII-4a

10 in which

R^{71} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

15

R^{72} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

20

n and m , independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

25

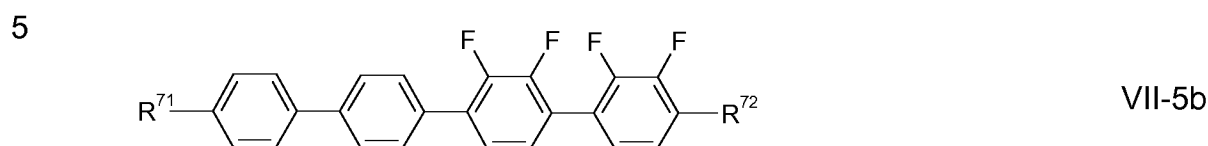
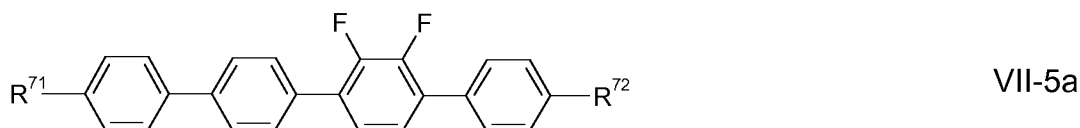
z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{71} and R^{72}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

30

The compounds of the formula VII-5 are preferably selected from the group of the compounds of the formulae VII-5a and VII-5b, more preferably of the formula VII-5a:

35



10 in which

R^{71} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

15 R^{72} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

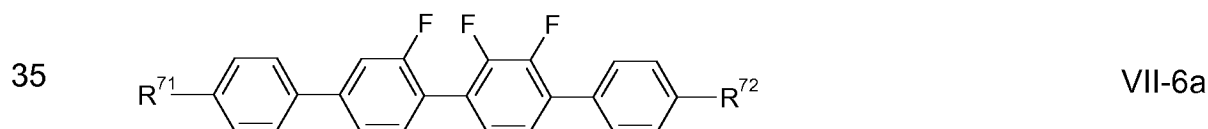
20 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

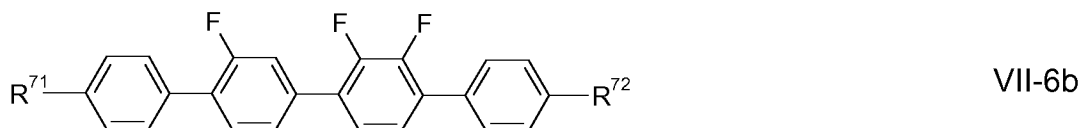
25 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{71} and R^{72}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

30

The compounds of the formula VII-6 are preferably selected from the group of the compounds of the formulae VII-6a and VII-6b:





5

in which

R^{71} has the meaning indicated above and preferably
denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

10

R^{72} has the meaning indicated above and preferably
denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and
in which

15

n and m , independently of one another, denote an integer in the
range from 0 to 15, preferably in the range from 1 to 7
and particularly preferably 1 to 5, and

20

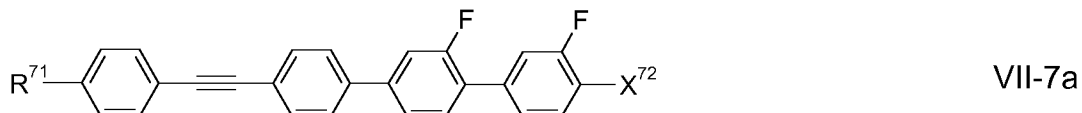
z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{71} and R^{72}) here are, in particular,
(C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly prefera-
bly (C_nH_{2n+1} and C_mH_{2m+1}).

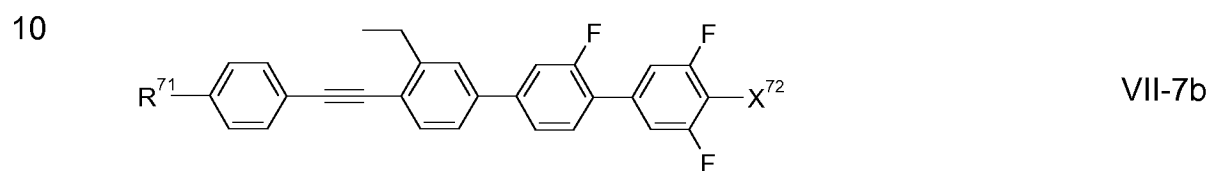
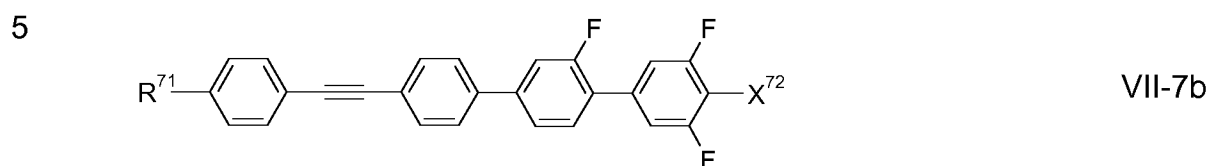
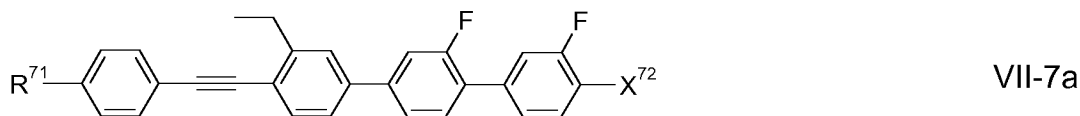
25

The compounds of the formula VII-7 are preferably selected from the
group of the compounds of the formulae VII-7a and VII-7b:

30



35



15

in which

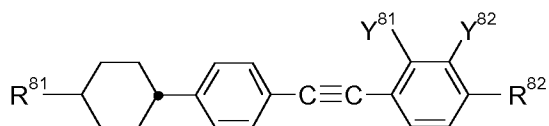
20
 R^{71} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$,

X^{72} denotes F, $-OCF_3$ or $-NCS$,

25
 n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and,

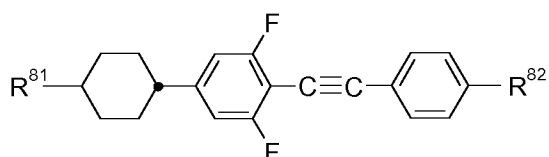
30
 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

35
 The compounds of the formula VIII are preferably selected from the group of the compounds of the formulae VIII-1 to VIII-3, more preferably these compounds of the formula VIII predominantly consist, even more preferably essentially consist and very particularly preferably completely consist thereof:



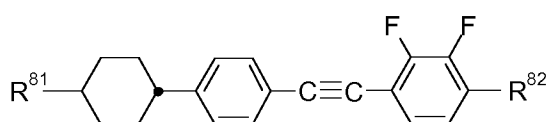
VIII-1

5



VIII-2

10



VIII-3

15

in which

one of

 Y^{81} and Y^{82}

denotes H and the other denotes H or F, and

20

 R^{81} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

25

 R^{82} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

30

n and m,

independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

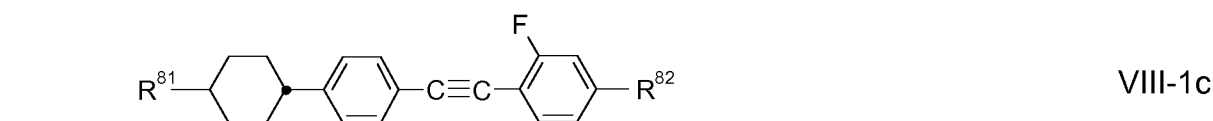
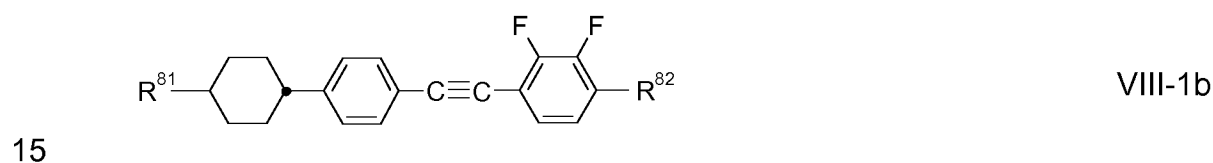
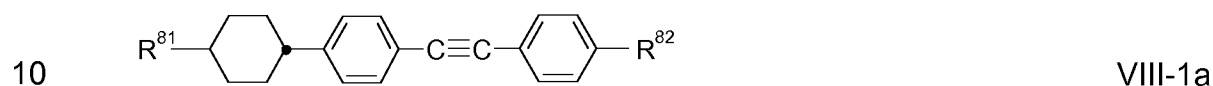
z

denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

35

The preferred combinations of (R^{81} and R^{82}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

5 The compounds of the formula VIII-1 are preferably selected from the group of the compounds of the formulae VIII-1a to VIII-1c:



in which

25 R^{81} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

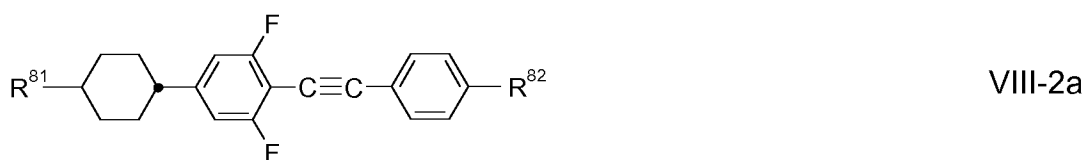
30 R^{82} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

35 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{81} and R^{82}) here are, in particular,
 (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably
 (C_nH_{2n+1} and C_mH_{2m+1}).

The compounds of the formula VIII-2 are preferably compounds of the formula VIII-2a:



15 in which

R^{81} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

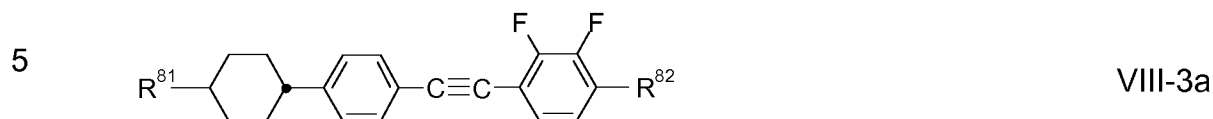
20 R^{82} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

25 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

30 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{81} and R^{82}) here are, in particular,
 (C_nH_{2n+1} and C_mH_{2m+1}), (C_nH_{2n+1} and $O-C_mH_{2m+1}$) and $(CH_2=CH-(CH_2)_z$ and
 35 C_mH_{2m+1}), particularly preferably (C_nH_{2n+1} and C_mH_{2m+1}).

The compounds of the formula VIII-3 are preferably compounds of the formula VIII-3a:



in which

10

R^{81} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_z$, and

15

R^{82} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_z-CH=CH_2$, and in which

20

n and m , independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

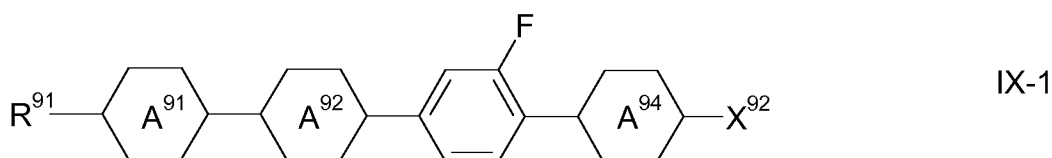
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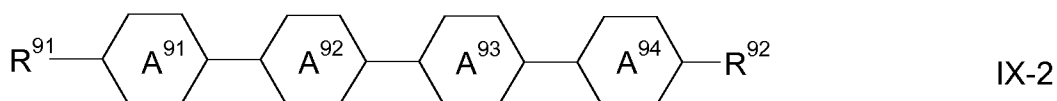
The preferred combinations of (R^{81} and R^{82}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$).

30

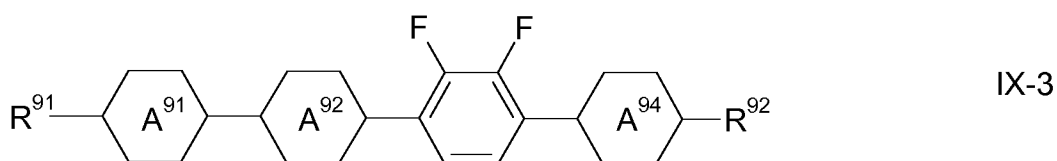
The compounds of the formula IX are preferably selected from the group of the compounds of the formulae IX-1 to IX-3:

35





5

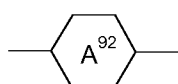


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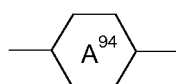
in which the parameters have the respective meaning indicated above under formula IX and preferably

15

one of

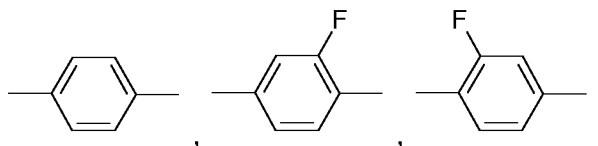


to



denotes

20



and

25

in which

30

R^{91} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

R^{92} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

35

n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

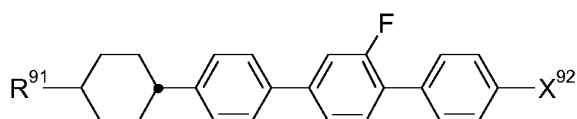
5 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{91} and R^{92}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$).

10

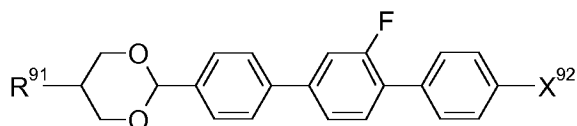
The compounds of the formula IX-1 are preferably selected from the group of the compounds of the formulae IX-1a to IX-1e:

15



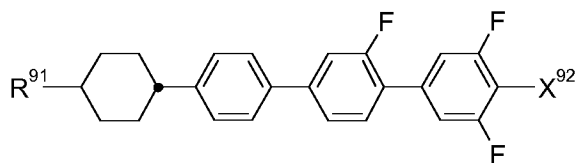
IX-1a

20



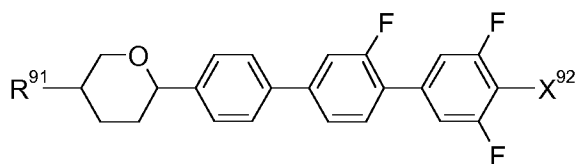
IX-1b

25



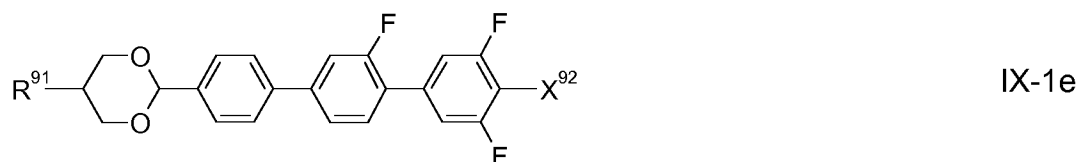
IX-1c

30



IX-1d

35



5

in which the parameters have the meaning given above and preferably

R^{91} has the meaning indicated above and preferably denotes C_nH_{2n+1} , and

10

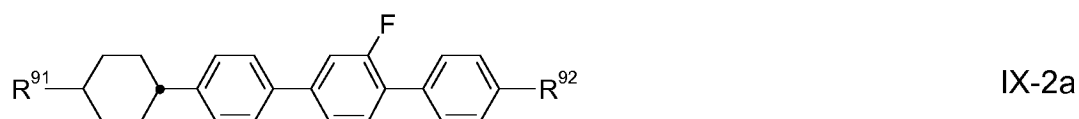
n denotes an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

15

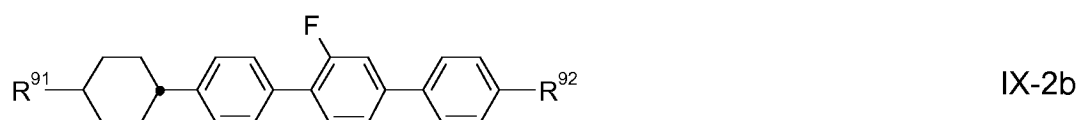
X^{92} preferably denotes F or Cl.

The compounds of the formula IX-2 are preferably selected from the group of the compounds of the formulae IX-2a and IX-2b:

20



25



30

in which

R^{91} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

35

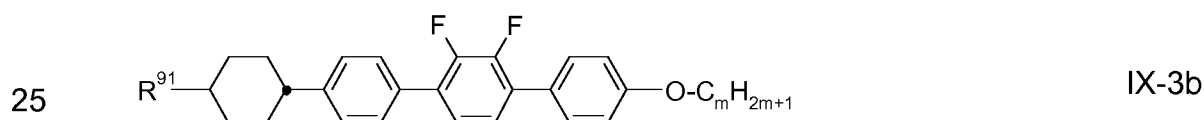
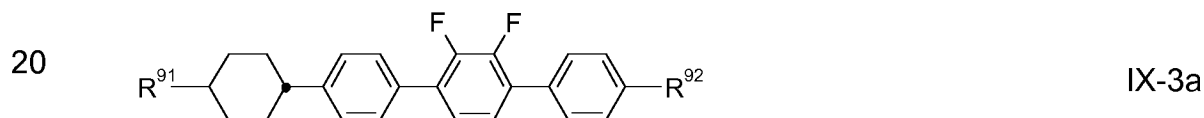
R^{92} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

5 n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

10 z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combination of (R^{91} and R^{92}) here is, in particular, (C_nH_{2n+1} and C_mH_{2m+1}).

15 The compounds of the formula IX-3 are preferably compounds of the formulae IX-3a and IX-3b:



in which

30 R^{91} has the meaning indicated above and preferably denotes C_nH_{2n+1} or $CH_2=CH-(CH_2)_Z$, and

R^{92} has the meaning indicated above and preferably denotes C_mH_{2m+1} or $O-C_mH_{2m+1}$ or $(CH_2)_Z-CH=CH_2$, and in which

35

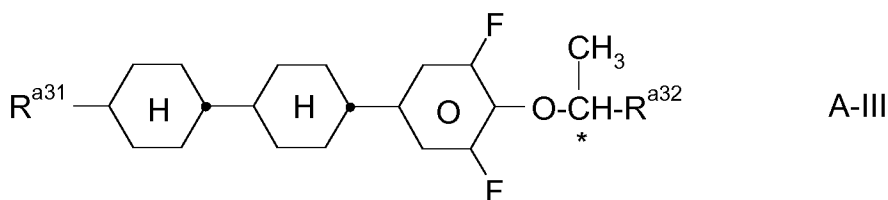
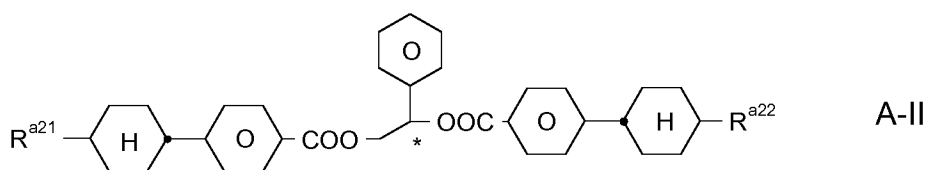
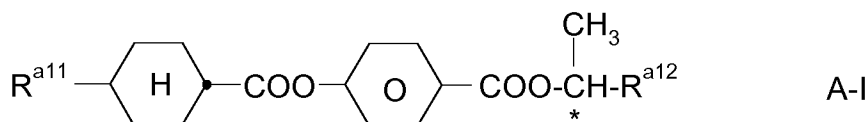
n and m, independently of one another, denote an integer in the range from 0 to 15, preferably in the range from 1 to 7 and particularly preferably 1 to 5, and

z denotes 0, 1, 2, 3 or 4, preferably 0 or 2.

The preferred combinations of (R^{91} and R^{92}) here are, in particular, (C_nH_{2n+1} and C_mH_{2m+1}) and (C_nH_{2n+1} and $O-C_mH_{2m+1}$), particularly preferably (C_nH_{2n+1} and $O-C_mH_{2m+1}$).

In a preferred embodiment the liquid crystal medium according to the invention comprises one or more chiral compounds.

In a preferred embodiment the liquid crystal medium according to the invention comprises one or more chiral compounds selected from the group of compounds of formulae A-I to A-III:



in which

5 R^{a11} and R^{a12} , independently of one another, are alkyl, oxaalkyl or alkenyl having from 2 to 9, preferably up to 7, carbon atoms, and R^{a11} is alternatively methyl or alkoxy having from 1 to 9 carbon atoms, preferably both are alkyl, preferably n-alkyl,

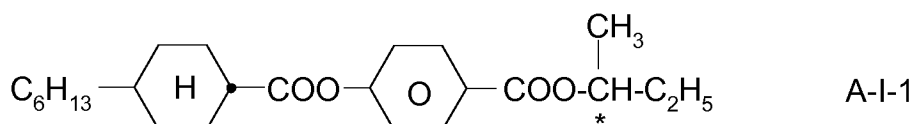
10 R^{a21} and R^{a22} , independently of one another, are alkyl or alkoxy having from 1 to 9, preferably up to 7, carbon atoms, oxaalkyl, alkenyl or alkenyloxy having from 2 to 9, preferably up to 7, carbon atoms, preferably both are alkyl, preferably n-alkyl,

15 R^{a31} and R^{a32} , independently of one another, are alkyl, oxaalkyl or alkenyl having from 2 to 9, preferably up to 7, carbon atoms, and R^{a11} is alternatively methyl or alkoxy having from 1 to 9 carbon atoms, preferably both are alkyl, preferably n-alkyl.

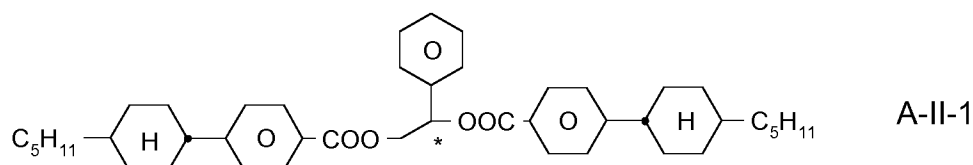
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Particular preference is given to dopants selected from the group consisting of the compounds of the following formulae:

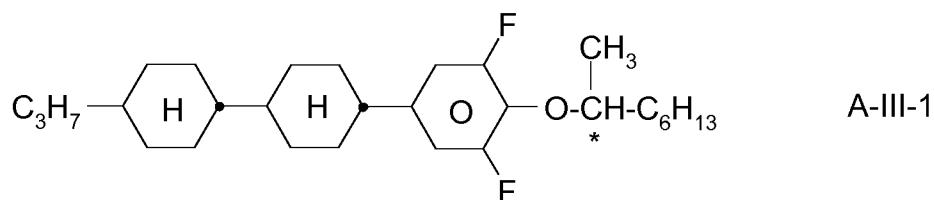
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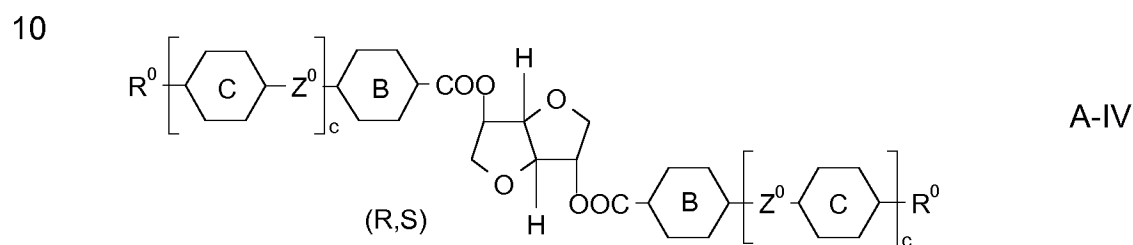


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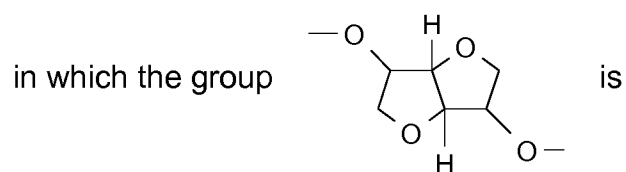
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Further preferred chiral compounds are derivatives of the isosorbide, isomannitol or isoiditol of the following formula A-IV:

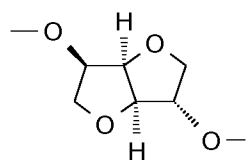


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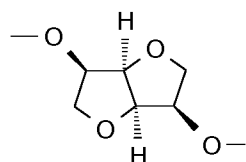


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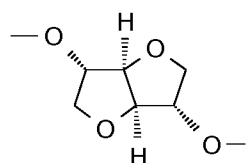
(dianhydrosorbitol),

25



(dianhydromannitol), or

30



(dianhydroiditol),

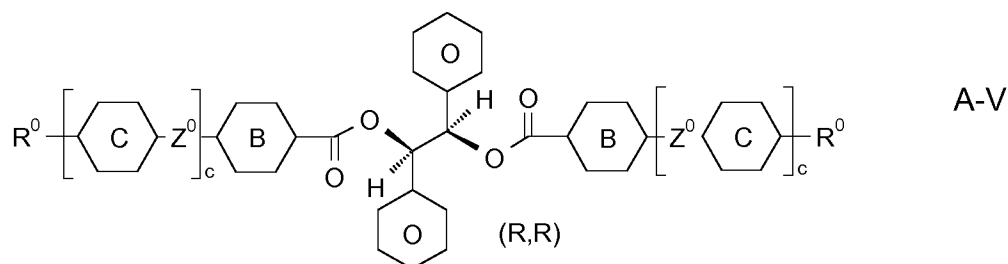
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preferably dianhydrosorbitol,

and chiral ethanediol derivatives, such as, for example, diphenylethanediol (hydrobenzoin), in particular mesogenic hydrobenzoin derivatives of the following formula A-V:

5

10

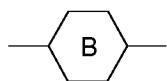


including the (R,S), (S,R), (R,R) and (S,S) enantiomers, which are not shown,

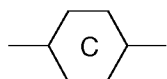
15

in which

20



and



25

are each, independently of one another, 1,4-phenylene, which may also be mono-, di- or trisubstituted by L, or 1,4-cyclohexylene,

30

L is H, F, Cl, CN or optionally halogenated alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl or alkoxy carbonyloxy having 1-7 carbon atoms,

c is 0 or 1,

35

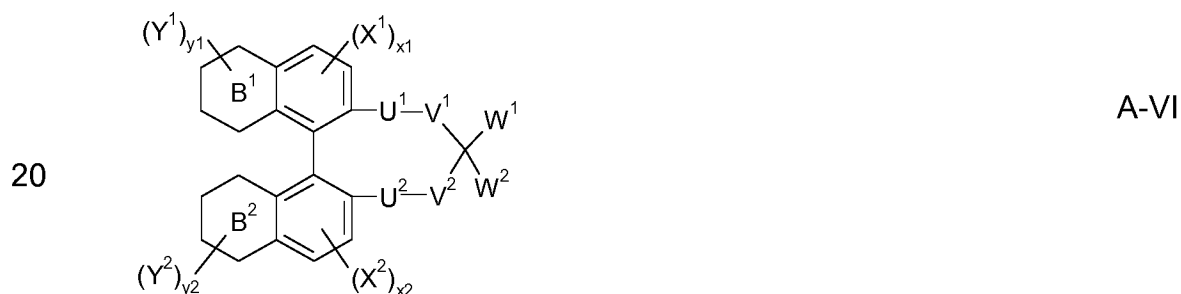
Z⁰ is -COO-, -OCO-, -CH₂CH₂- or a single bond, and

R^0 is alkyl, alkoxy, alkylcarbonyl, alkoxy carbonyl or alkylcarbonyloxy having 1-12 carbon atoms.

The compounds of the formula A-IV are described in WO 98/00428. The compounds of the formula A-V are described in GB-A-2,328,207.

Very particularly preferred dopants are chiral binaphthyl derivatives, as described in WO 02/94805, chiral binaphthol acetal derivatives, as described in WO 02/34739, chiral TADDOL derivatives, as described in WO 02/06265, and chiral dopants having at least one fluorinated bridging group and a terminal or central chiral group, as described in WO 02/06196 and WO 02/06195.

Particular preference is given to chiral compounds of the formula A-VI



in which

X^1 , X^2 , Y^1 and Y^2 are each, independently of one another, F, Cl, Br, I, CN, SCN, SF_5 , straight-chain or branched alkyl having from 1 to 25 carbon atoms, which may be monosubstituted or polysubstituted by F, Cl, Br, I or CN and in which, in addition, one or more non-adjacent CH_2 groups may each, independently of one another, be replaced by -O-, -S-, -NH-, NR^0 -, -CO-, -COO-, -OCO-, -OCOO-, -S-CO-, -CO-S-, -CH=CH- or -C≡C- in such a way that O and/or S atoms are not bonded directly to one another, a polymerisable group or cycloalkyl or aryl having

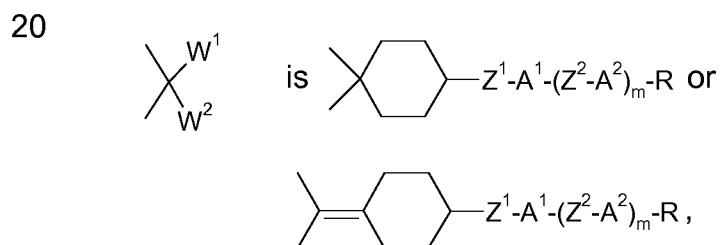
up to 20 carbon atoms, which may optionally be monosubstituted or polysubstituted by halogen, preferably F, or by a polymerisable group,

5 x^1 and x^2 are each, independently of one another, 0, 1 or 2,

y^1 and y^2 are each, independently of one another, 0, 1, 2, 3 or 4,

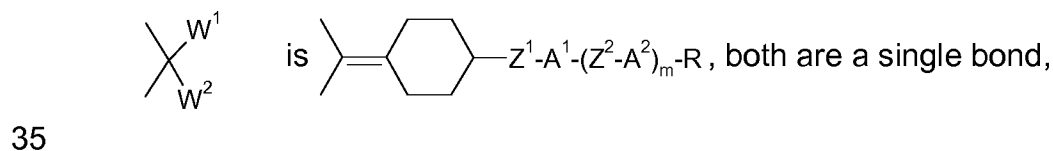
10 B^1 and B^2 are each, independently of one another, an aromatic or partially or fully saturated aliphatic six-membered ring in which one or more CH groups may be replaced by N atoms and one or more non-adjacent CH_2 groups may be replaced by O and/or S,

15 W^1 and W^2 are each, independently of one another, $-Z^1-A^1-(Z^2-A^2)_m-R$, and one of the two is alternatively R^1 or A^3 , but both are not simultaneously H, or



25 U^1 and U^2 are each, independently of one another, CH_2 , O, S, CO or CS,

30 V^1 and V^2 are each, independently of one another, $(CH_2)_n$, in which from one to four non-adjacent CH_2 groups may be replaced by O and/or S, and one of V^1 and V^2 and, in the case where



Z^1 and Z^2 are each, independently of one another, -O-, -S-, -CO-, -COO-,
 -OCO-, -O-COO-, -CO-NR⁰-, -NR⁰-CO-, -O-CH₂-, -CH₂-O-, -S-
 CH₂-, -CH₂-S-, -CF₂-O-, -O-CF₂-, -CF₂-S-, -S-CF₂-, -CH₂-CH₂-,
 -CF₂-CH₂-, -CH₂-CF₂-, -CF₂-CF₂-, -CH=N-, -N=CH-, -N=N-,
 -CH=CH-, -CF=CH-, -CH=CF-, -CF=CF-, -C≡C-, a combination
 of two of these groups, where no two O and/or S and/or N
 atoms are bonded directly to one another, preferably -CH=CH-
 COO-, or -COO-CH=CH-, or a single bond,

10

A^1 , A^2 and A^3 are each, independently of one another, 1,4-phenylene, in
 which one or two non-adjacent CH groups may be replaced by
 N, 1,4-cyclohexylene, in which one or two non-adjacent CH₂
 groups may be replaced by O and/or S, 1,3-dioxolane-4,5-diyl,
 1,4-cyclohexenylene, 1,4-bicyclo[2.2.2]octylene, piperidine-1,4-
 diyl, naphthalene-2,6-diyl, decahydronaphthalene-2,6-diyl or
 1,2,3,4-tetrahydronaphthalene-2,6-diyl, where each of these
 groups may be monosubstituted or polysubstituted by L, and in
 addition A^1 is a single bond,

20

L is a halogen atom, preferably F, CN, NO₂, alkyl, alkoxy,
 alkylcarbonyl, alkoxy carbonyl or alkoxy carbonyloxy having 1-7
 carbon atoms, in which one or more H atoms may be replaced
 by F or Cl,

25

m is in each case, independently, 0, 1, 2 or 3, and

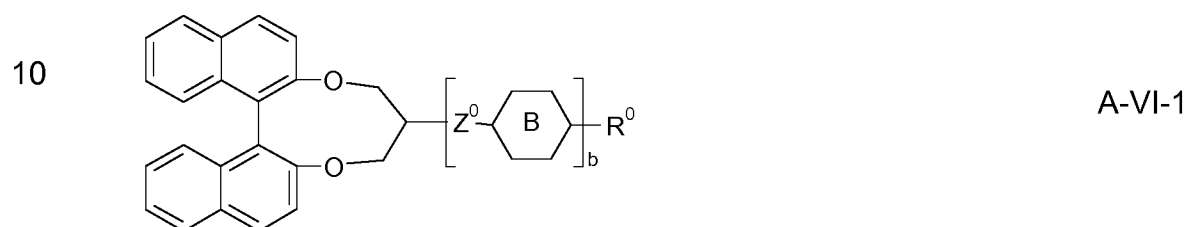
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R and R^1 are each, independently of one another, H, F, Cl, Br, I, CN,
 SCN, SF₅, straight-chain or branched alkyl having from 1 or 3 to
 25 carbon atoms respectively, which may optionally be mono-
 substituted or polysubstituted by F, Cl, Br, I or CN, and in which
 one or more non-adjacent CH₂ groups may be replaced by -O-,

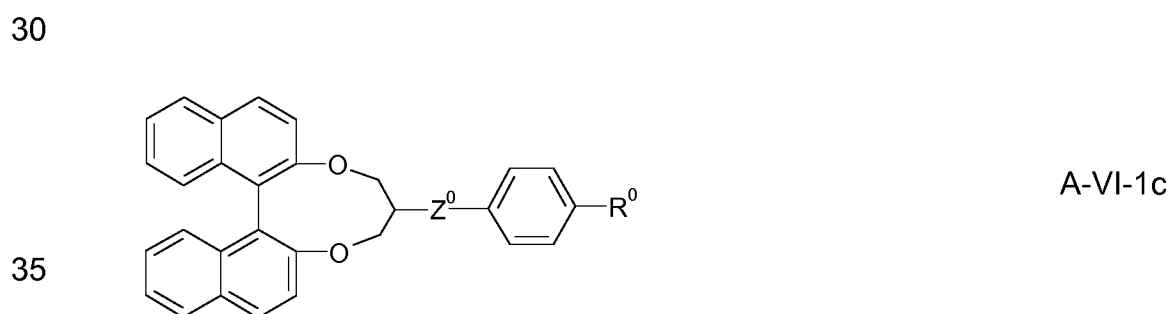
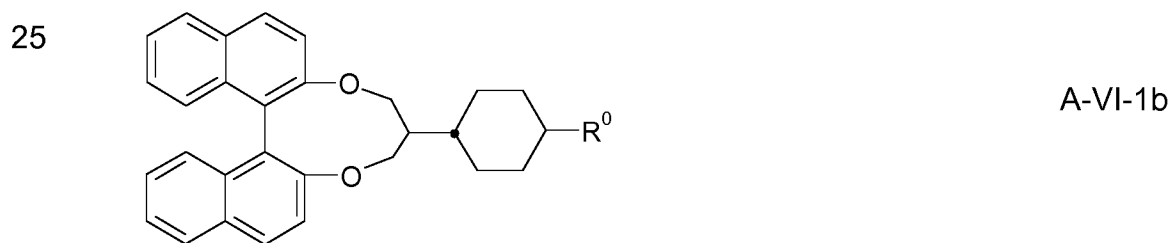
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-S-, -NH-, -NR⁰-, -CO-, -COO-, -OCO-, -O-COO-, -S-CO-, -CO-S-, -CH=CH- or -C≡C-, where no two O and/or S atoms are bonded directly to one another, or a polymerisable group.

5 Particular preference is given to chiral binaphthyl derivatives of the formula A-VI-1



15 in particular those selected from the following formulae A-VI-1a to A-VI-1c:



in which ring B and Z^0 are as defined for the formula A-IV, and

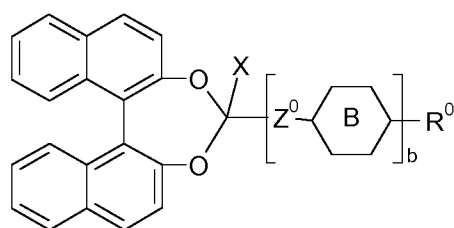
5 R^0 as defined for formula A-IV or H or alkyl having from 1 to 4 carbon atoms, and

b is 0, 1 or 2,

10 and Z^0 is, in particular, -OCO- or a single bond.

Particular p reference is furthermore given to chiral binaphthyl derivatives of the formula A-VI-2

15

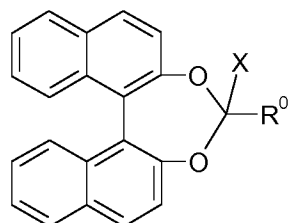


A-VI-2

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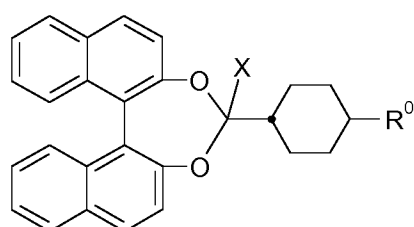
in particular those selected from the following formulae A-VI-2a to A-VI-2f:

25



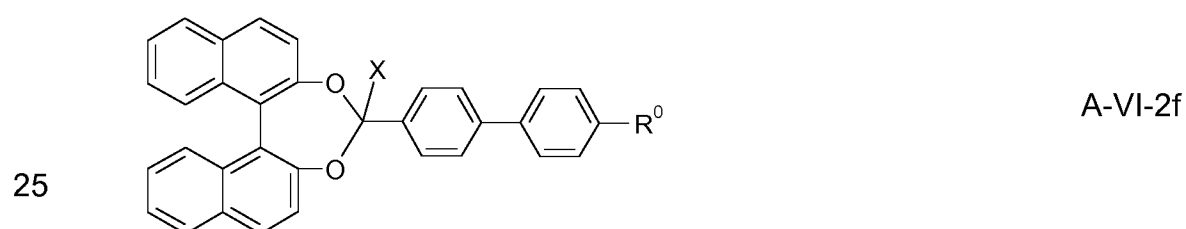
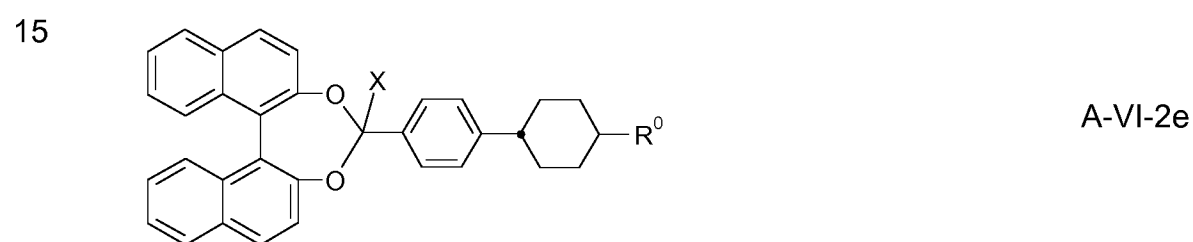
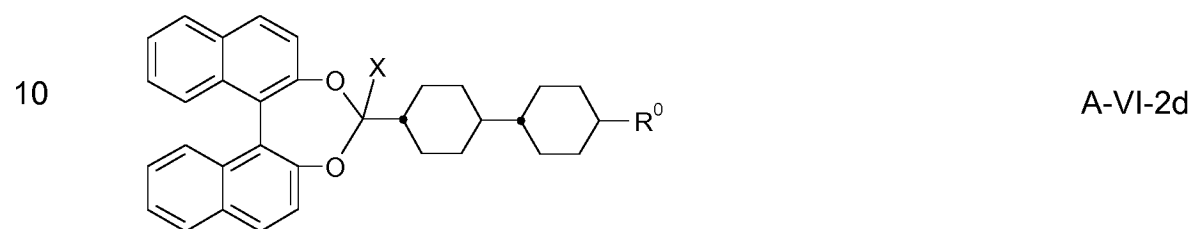
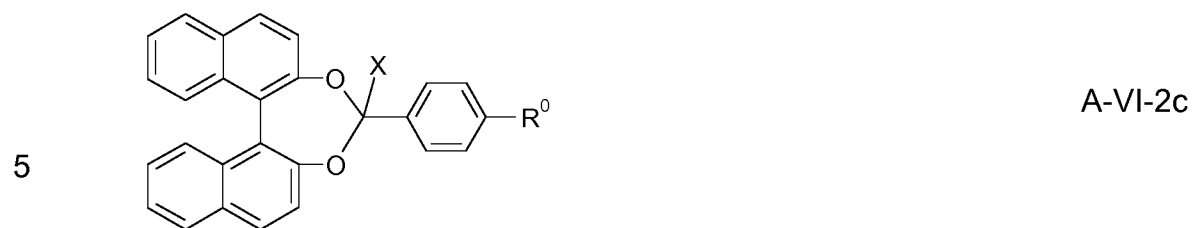
A-VI-2a

30



A-VI-2b

35



25

in which R^0 is as defined for the formula A-VI, and X is H, F, Cl, CN or R^0 , preferably F.

30

The present invention further relates to compounds of formula I above, in which n is 2.

35

The compounds according to the present invention can be synthesized by or in analogy to known methods described in the literature (for example in

the standard works such as Houben-Weyl, Methoden der Organischen Chemie [Methods of Organic Chemistry], Georg-Thieme-Verlag, Stuttgart), under reaction conditions which are known and suitable for said reactions. Use may also be made here of variants which are known per se, but are not mentioned here. In particular, they can be prepared as described in or in analogy to the following reaction schemes. Further methods for preparing the inventive compounds can be taken from the examples.

The liquid-crystalline media in accordance with the present invention preferably comprise, more preferably predominantly consist of, even more preferably essentially consist of and very preferably completely consist of compounds selected from the compounds of the formula I.

In a preferred embodiment of the present invention the liquid-crystalline media predominantly consist of, more preferably essentially consist of, and, most preferably completely consist of isothiocyanate compounds, preferably selected from the group of the compounds of the formula I

In this application, "comprise" in connection with compositions means that the entity in question, i.e. the medium or the component, comprises the component or components or compound or compounds indicated, preferably in a total concentration of 10 % or more and very preferably 20 % or more. The expression "predominantly consist of" means that the entity in question comprises 55 % or more, preferably 60 % or more and very preferably 70 % or more of the component or components or compound or compounds indicated. The expression "essentially consist of" means that the entity in question comprises 80 % or more, preferably 90 % or more and very preferably 95 % or more of the component or components or compound or compounds indicated. The expression "completely consist of" means that the entity in question comprises 98 % or more, preferably

99 % or more and very preferably 100.0 % of the component or components or compound or compounds indicated.

5 Other mesogenic compounds which are not explicitly mentioned above can optionally and advantageously also be used in the media in accordance with the present invention. Such compounds are known to the person skilled in the art.

10 In a preferred embodiment of the present invention, the total concentration of compounds of formula AN in the liquid-crystalline medium is 5 % or more, preferably 10 % or more, and particularly preferably 12 % or more.

15 In a preferred embodiment of the present invention, the liquid-crystalline media preferably comprise in total 5 % to 100 %, preferably 10 % to 95 % and particularly preferably 15 % to 90 % of compounds of formula AN.

20 In a preferred embodiment of the present invention, the liquid-crystalline media preferably comprise in total 3 % to 30 %, preferably 7 % to 25 % and particularly preferably 12 % to 20 % of compounds of formula AN.

25 In a preferred embodiment of the present invention, the liquid-crystalline media comprise in total 70 % to 98 %, preferably 75 % to 92 % and particularly preferably 80 % to 85 % of compounds of formula AN.

30 In a preferred embodiment of the present invention, the total concentration of compounds of formula AN-2 in the liquid-crystalline medium is 5 % or more, preferably 10 % or more, and particularly preferably 12 % or more.

35 In a preferred embodiment of the present invention, the liquid-crystalline medium comprises in total 30 % or more, preferably 40 % or more and particularly preferably 50 % or more compounds of formula I.

5 In a preferred embodiment of the present invention, the liquid-crystalline medium comprises in total 30 % or more, preferably 40 % or more and particularly preferably 50 % or more compounds of formula I, preferably selected from the group of compounds of the I-1, I-2 and I-3, particularly preferably selected from the compounds of the fomulae I-2 and I-3.

10 In a preferred embodiment, the total concentration of the compounds of formula I-2 in the media according to the present invention is in the range from 7 % to 30 %, more preferably from 10 % to 25 %, and particularly preferably from 15 % to 20 %.

15 In a preferred embodiment, the total concentration of the compounds of formula I-3 in the media according to the present invention is in the range from 10 % to 50 %, more preferably from 20 % to 45 %, and particularly preferably from 30 % to 40 %.

20 In a preferred embodiment, the total concentration of the compounds of formula I-3 in the media according to the present invention is 20 % or more, more preferably 25 % or more and particularly preferably 30 % or more.

25 In a preferred embodiment of the present invention the medium comprises one or more compounds of formula II in a total concentration of 5 % to 35 %, more preferably 10 % to 30 %, particularly preferably 15 % to 25 % of the mixture as a whole.

30 In a preferred embodiment of the present invention the medium comprises one or more compounds of formula III in a total concentration of 2 % to 20 %, more preferably 5 % to 15 %, particularly preferably 8 % to 12 % of the mixture as a whole.

35

Further preferred embodiments of the present invention are as follows:

- The medium consists of compounds of formula AN;
- The medium comprises one or more compounds of formula AN-1;
- The medium comprises one or more compounds of formula AN-2;
- 5 - The medium comprises one or more compounds of formula AN-1 and AN-2
- The medium comprises one or more compounds of formula AN-1 and/or AN-2 and one or more compounds of formula I and or II and or
- 10 III
- The medium comprises one or more compounds of formula III-1
- The medium comprises the compound CP-V2-AN
- The medium comprises the compound PTU-V2-OT, preferably in a
- 15 concentration in the range of from 2% to 10%
- The medium comprises three or more compounds of formula AN-1
- The medium comprises three or more compounds of formula AN-2

20 The liquid-crystal media in accordance with the present invention preferably have a clearing point of 90°C or more, more preferably 100°C or more, even more preferably 120°C or more, particularly preferably 150°C or more and very particularly preferably 170°C or more.

25 The liquid-crystal media in accordance with the present invention preferably have a clearing point of 160 °C or less, more preferably 140°C or less, particularly preferably 120°C or less, and very particularly preferably 100°C or less.

30 The nematic phase of the media according to the invention preferably extends at least from 0°C or less to 90°C or more. It is advantageous for the media according to the invention to exhibit even broader nematic phase ranges, preferably at least from -10°C or less to 120°C or more,

35 very preferably at least from -20°C or less to 140°C or more and in

particular at least from -30°C or less to 150°C or more, very particularly preferably at least from -40°C or less to 170°C or more.

5 The $\Delta\epsilon$ of the liquid-crystal medium according to the present invention, at 1 kHz and 20°C, is preferably 1 or more, more preferably 2 or more and very preferably 3 or more.

10 The Δn of the liquid-crystal media according to the present invention, at 589 nm (Na^D) and 20°C, is preferably in the range from 0.200 or more to 0.90 or less, more preferably in the range from 0.250 or more to 0.90 or less, even more preferably in the range from 0.300 or more to 0.85 or less and very particularly preferably in the range from 0.350 or more to 0.800 or less.

15 In a preferred embodiment of the present application, the Δn of the liquid-crystal media in accordance with the present invention is preferably 0.50 or more, more preferably 0.55 or more.

20 The compounds of the formulae I to III in each case include dielectrically positive compounds having a dielectric anisotropy of greater than 3, dielectrically neutral compounds having a dielectric anisotropy of less than 25 3 and greater than -1.5 and dielectrically negative compounds having a dielectric anisotropy of -1.5 or less.

30 The compounds of the formulae I, II and III are preferably dielectrically positive.

35 In the present application, the expression dielectrically positive describes compounds or components where $\Delta\epsilon > 3.0$, dielectrically neutral describes those where $-1.5 \leq \Delta\epsilon \leq 3.0$ and dielectrically negative describes those where $\Delta\epsilon < -1.5$. $\Delta\epsilon$ is determined at a frequency of 1 kHz and at 20°C.

The dielectric anisotropy of the respective compound is determined from the results of a solution of 10 % of the respective individual compound in a nematic host mixture. If the solubility of the respective compound in the host mixture is less than 10 %, the concentration is reduced to 5 %. The capacitances of the test mixtures are determined both in a cell having homeotropic alignment and in a cell having homogeneous alignment. The cell thickness of both types of cells is approximately 20 μm . The voltage applied is a rectangular wave having a frequency of 1 kHz and an effective value of typically 0.5 V to 1.0 V, but it is always selected to be below the capacitive threshold of the respective test mixture.

$\Delta\epsilon$ is defined as $(\epsilon_{||} - \epsilon_{\perp})$, while $\epsilon_{\text{ave.}}$ is $(\epsilon_{||} + 2 \epsilon_{\perp}) / 3$.

The host mixture used for dielectrically positive compounds is mixture ZLI-4792 and that used for dielectrically neutral and dielectrically negative compounds is mixture ZLI-3086, both from Merck KGaA, Germany. The absolute values of the dielectric constants of the compounds are determined from the change in the respective values of the host mixture on addition of the compounds of interest. The values are extrapolated to a concentration of the compounds of interest of 100 %.

Components having a nematic phase at the measurement temperature of 20°C are measured as such, all others are treated like compounds.

The expression threshold voltage in the present application refers to the optical threshold and is quoted for 10 % relative contrast (V_{10}), and the expression saturation voltage refers to the optical saturation and is quoted for 90 % relative contrast (V_{90}), in both cases unless expressly stated otherwise. The capacitive threshold voltage (V_0), also called the Freedericks threshold (V_{Fr}), is only used if expressly mentioned.

The parameter ranges indicated in this application all include the limit values, unless expressly stated otherwise.

5 The different upper and lower limit values indicated for various ranges of properties in combination with one another give rise to additional preferred ranges.

10 Throughout this application, the following conditions and definitions apply, unless expressly stated otherwise. All concentrations are quoted in per cent by weight and relate to the respective mixture as a whole, all temperatures are quoted in degrees Celsius and all temperature differences are quoted in differential degrees. All physical properties are
15 determined in accordance with "Merck Liquid Crystals, Physical Properties of Liquid Crystals", Status Nov. 1997, Merck KGaA, Germany, and are quoted for a temperature of 20°C, unless expressly stated otherwise. The optical anisotropy (Δn) is determined at a wavelength of 589.3 nm. The dielectric anisotropy ($\Delta \epsilon$) is determined at a frequency of 1 kHz. The
20 threshold voltages, as well as all other electro-optical properties, are determined using test cells produced at Merck KGaA, Germany. The test cells for the determination of $\Delta \epsilon$ have a cell thickness of approximately 20 μm . The electrode is a circular ITO electrode having an area of 1.13 cm^2 and a guard ring. The orientation layers are SE-1211 from Nissan
25 Chemicals, Japan, for homeotropic orientation ($\epsilon_{||}$) and polyimide AL-1054 from Japan Synthetic Rubber, Japan, for homogeneous orientation ($\epsilon_{\perp}$). The capacitances are determined using a Solatron 1260 frequency response analyser using a sine wave with a voltage of 0.3 V_{rms} . The light
30 used in the electro-optical measurements is white light. A set-up using a commercially available DMS instrument from Autronic-Melchers, Germany, is used here. The characteristic voltages have been determined under perpendicular observation. The threshold (V_{10}), mid-grey (V_{50}) and
35

saturation (V_{90}) voltages have been determined for 10 %, 50 % and 90 % relative contrast, respectively.

5 The liquid-crystalline media are investigated with respect to their properties in the microwave frequency range as described in A. Penirschke, S. Müller, P. Scheele, C. Weil, M. Wittek, C. Hock and R. Jakoby: "Cavity Perturbation Method for Characterization of Liquid Crystals up to 35GHz", 34th European Microwave Conference –
10 Amsterdam, pp. 545-548.

In this respect, see also: A. Gaebler, F. Gölden, S. Müller, A. Penirschke and R. Jakoby "Direct Simulation of Material Permittivities ...",
15 12MTC 2009 – International Instrumentation and Measurement Technology Conference, Singapore, 2009 (IEEE), pp. 463-467, and DE 10 2004 029 429 A, in which a measurement method is likewise described in detail.

20 The liquid crystal is introduced into a polytetrafluoroethylene (PTFE) capillary. The capillary has an internal radius of 180 μm and an external radius of 350 μm . The effective length is 2.0 cm. The filled capillary is introduced into the centre of the cavity with a resonance frequency of 30 GHz. This
25 cavity has a length of 6.6 mm, a width of 7.1 mm and a height of 3.6 mm. The input signal (source) is then applied, and the result of the output signal is recorded using a commercial vector network analyser.

30 The change in the resonance frequency and the Q factor between the measurement with the capillary filled with the liquid crystal and the measurement without the capillary filled with the liquid crystal is used to determine the dielectric constant and the loss angle at the corresponding target frequency by means of equations 10 and 11 in A. Penirschke, S. Müller, P.
35 Scheele, C. Weil, M. Wittek, C. Hock and R. Jakoby: "Cavity Perturbation

Method for Characterization of Liquid Crystals up to 35GHz", 34th European Microwave Conference – Amsterdam, pp. 545-548, as described therein.

5 The values for the components of the properties perpendicular and parallel to the director of the liquid crystal are obtained by alignment of the liquid crystal in a magnetic field. To this end, the magnetic field of a permanent magnet is used. The strength of the magnetic field is 0.35 tesla. The align-
10 ment of the magnets is set correspondingly and then rotated correspondingly through 90°.

Preferred components are phase shifters, varactors, wireless and radio
15 wave antenna arrays, matching circuit adaptive filters and others.

In the present application, the term compounds is taken to mean both one compound and a plurality of compounds, unless expressly stated other-
20 wise.

The liquid-crystal media according to the invention preferably have nematic phases in preferred ranges given above. The expression have a
25 nematic phase here means on the one hand that no smectic phase and no crystallisation are observed at low temperatures at the corresponding temperature and on the other hand that no clearing occurs on heating from the nematic phase. The investigation at low temperatures is carried out in a flow viscometer at the corresponding temperature and checked by stor-
30 age in test cells having a layer thickness of 5 µm for at least 100 hours. At high temperatures, the clearing point is measured in capillaries by conventional methods.

35 Furthermore, the liquid-crystal media according to the invention are characterised by high optical anisotropy values in the visible range, especially at a wavelength of 589.0 nm (i.e. at the Na"D" line). The birefringence at

589 nm is preferably 0.20 or more, particularly preferably 0.25 or more, particularly preferably 0.30 or more, particularly preferably 0.40 or more and very particularly preferably 0.45 or more. In addition, the birefringence is preferably 0.80 or less.

5

The liquid crystals employed preferably have a positive dielectric anisotropy. This is preferably 2 or more, preferably 4 or more, particularly preferably 6 or more and very particularly preferably 10 or more.

10

Furthermore, the liquid-crystal media according to the invention are characterised by high anisotropy values in the microwave range. The birefringence at about 8.3 GHz is, for example, preferably 0.14 or more, particularly preferably 0.15 or more, particularly preferably 0.20 or more, particularly preferably 0.25 or more and very particularly preferably 0.30 or more. In addition, the birefringence is preferably 0.80 or less.

15

The dielectric anisotropy in the microwave range is defined as

20

$$\Delta\epsilon_r \equiv (\epsilon_{r,\parallel} - \epsilon_{r,\perp}) .$$

The tunability (τ) is defined as

25

$$\tau \equiv (\Delta\epsilon_r / \epsilon_{r,\parallel}) .$$

The material quality (η) is defined as

30

$$\eta \equiv (\tau / \tan \delta_{\epsilon_{r,\max}}), \text{ where}$$

the maximum dielectric loss is

35

$$\tan \delta_{\epsilon_{r,\max}} \equiv \max. \{ \tan \delta_{\epsilon_{r,\perp}}; \tan \delta_{\epsilon_{r,\parallel}} \} .$$

The material quality (η) of the preferred liquid-crystal materials is 6 or more, preferably 8 or more, preferably 10 or more, preferably 15 or more, preferably 17 or more, preferably 20 or more, particularly preferably 25 or more and very particularly preferably 30 or more.

5

In the corresponding components, the preferred liquid-crystal materials have phase shifter qualities of 15°/dB or more, preferably 20°/dB or more, preferably 30°/dB or more, preferably 40°/dB or more, preferably 50°/dB or more, particularly preferably 80°/dB or more and very particularly preferably 100°/dB or more.

10

In some embodiments, however, liquid crystals having a negative value of the dielectric anisotropy can also advantageously be used.

15

The liquid crystals employed are either individual substances or mixtures. They preferably have a nematic phase.

20

The term "alkyl" preferably encompasses straight-chain and branched alkyl groups having 1 to 15 carbon atoms, in particular the straight-chain groups methyl, ethyl, propyl, butyl, pentyl, hexyl and heptyl. Groups having 2 to 10 carbon atoms are generally preferred.

25

The term "alkenyl" preferably encompasses straight-chain and branched alkenyl groups having 2 to 15 carbon atoms, in particular the straight-chain groups. Particularly preferred alkenyl groups are C₂- to C₇-1E-alkenyl, C₄- to C₇-3E-alkenyl, C₅- to C₇-4-alkenyl, C₆- to C₇-5-alkenyl and C₇-6-alkenyl, in particular C₂- to C₇-1E-alkenyl, C₄- to C₇-3E-alkenyl and C₅- to C₇-4-alkenyl. Examples of further preferred alkenyl groups are vinyl, 1E-propenyl, 1E-butenyl, 1E-pentenyl, 1E-hexenyl, 1E-heptenyl, 3-butenyl, 3E-pentenyl, 3E-hexenyl, 3E-heptenyl, 4-pentenyl, 4Z-hexenyl, 4E-hexenyl, 4Z-heptenyl, 5-hexenyl, 6-heptenyl and the like. Groups having up to 5 carbon atoms are generally preferred.

30

35

5 The term "fluoroalkyl" preferably encompasses straight-chain groups having a terminal fluorine, i.e. fluoromethyl, 2-fluoroethyl, 3-fluoropropyl, 4-fluorobutyl, 5-fluoropentyl, 6-fluorohexyl and 7-fluoroheptyl. However, other positions of the fluorine are not excluded.

10 The term "oxaalkyl" or "alkoxyalkyl" preferably encompasses straight-chain radicals of the formula $C_nH_{2n+1}-O-(CH_2)_m$, in which n and m each, independently of one another, denote 1 to 10. Preferably, n is 1 and m is 1 to 6.

15 Compounds containing a vinyl end group and compounds containing a methyl end group have low rotational viscosity.

20 In the present application, both high-frequency technology and hyper-frequency technology denote applications having frequencies in the range from 1 MHz to 1 THz, preferably from 1 GHz to 500 GHz, more preferably 2 GHz to 300 GHz, particularly preferably from about 5 GHz to 150 GHz.

25 The liquid-crystal media in accordance with the present invention may comprise further additives and chiral dopants in the usual concentrations. The total concentration of these further constituents is in the range from 0 % to 10 %, preferably 0.1 % to 6 %, based on the mixture as a whole. The concentrations of the individual compounds used are each preferably in the range from 0.1 % to 3 %. The concentration of these and similar
30 additives is not taken into consideration when quoting the values and concentration ranges of the liquid-crystal components and liquid-crystal compounds of the liquid-crystal media in this application.

35 Preferably the media according to the present invention comprise one or more chiral compounds as chiral dopants in order to adjust their cholesteric pitch. Their total concentration in the media according to the

instant invention is preferably in the range 0.05 % to 15 %, more preferably from 1 % to 10 % and most preferably from 2 % to 6 %.

5 Optionally the media according to the present invention may comprise further liquid crystal compounds in order to adjust the physical properties. Such compounds are known to the expert. Their concentration in the media according to the instant invention is preferably 0 % to 30 %, more preferably 0.1 % to 20 % and most preferably 1 % to 15 %.

10 The response times are given as rise time (τ_{on}) for the time for the change of the relative tuning, respectively of the relative contrast for the electro-optical response, from 0 % to 90 % ($t_{90} - t_0$), i.e. including the delay time
15 ($t_{10} - t_0$), as decay time (τ_{off}) for the time for the change of the relative tuning, respectively of the relative contrast for the electro-optical response, from 100 % back to 10 % ($t_{100} - t_{10}$) and as the total response time ($\tau_{\text{total}} = \tau_{\text{on}} + \tau_{\text{off}}$), respectively.

20 The liquid-crystal media according to the invention consist of a plurality of compounds, preferably 3 to 30, more preferably 4 to 20 and very preferably 4 to 16 compounds. These compounds are mixed in a conventional manner. In general, the desired amount of the compound used in the
25 smaller amount is dissolved in the compound used in the larger amount. If the temperature is above the clearing point of the compound used in the higher concentration, it is particularly easy to observe completion of the dissolution process. It is, however, also possible to prepare the media in
30 other conventional ways, for example using so-called pre-mixes, which can be, for example, homologous or eutectic mixtures of compounds, or using so-called "multibottle" systems, the constituents of which are themselves ready-to-use mixtures.

35

All temperatures, such as, for example, the melting point $T(C,N)$ or $T(C,S)$, the transition from the smectic (S) to the nematic (N) phase $T(S,N)$ and the clearing point $T(N,I)$ of the liquid crystals, are quoted in degrees Celsius.

All temperature differences are quoted in differential degrees.

5

In the present invention and especially in the following examples, the structures of the mesogenic compounds are indicated by means of abbreviations, also referred to as acronyms. In these acronyms, the chemical formulae are abbreviated as follows using Tables A to D below. All groups C_nH_{2n+1} , C_mH_{2m+1} and C_lH_{2l+1} or C_nH_{2n-1} , C_mH_{2m-1} and C_lH_{2l-1} denote straight-chain alkyl or alkenyl, preferably 1-*E*-alkenyl, respectively, in each case having *n*, *m* or *l* C atoms. Table A lists the codes used for the ring elements of the core structures of the compounds, while Table B shows the linking groups. Table C gives the meanings of the codes for the left-hand or right-hand end groups. Table D shows illustrative structures of compounds with their respective abbreviations.

10

15

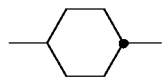
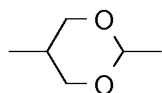
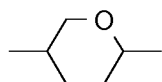
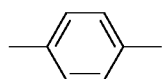
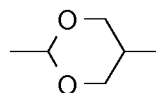
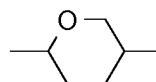
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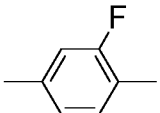
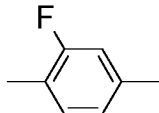
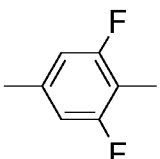
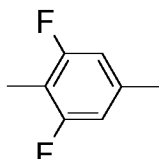
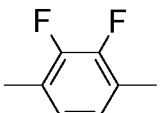
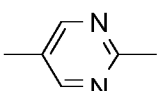
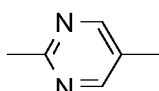
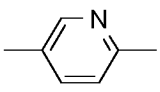
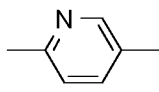
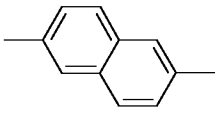
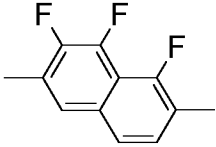
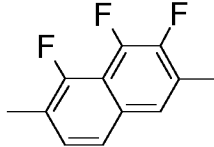
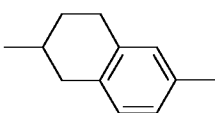
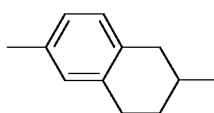
Table A: Ring elements

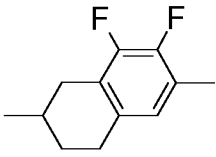
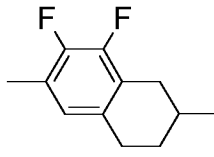
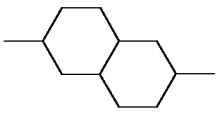
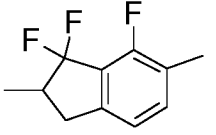
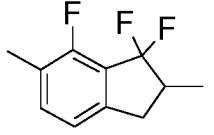
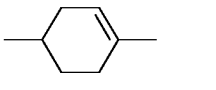
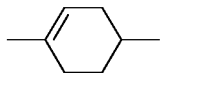
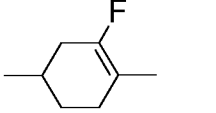
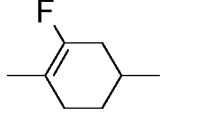
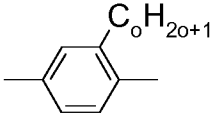
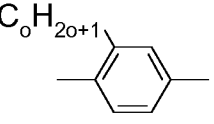
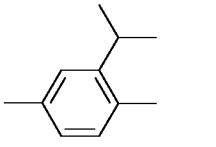
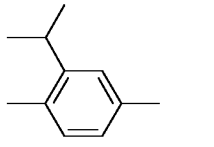
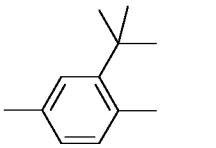
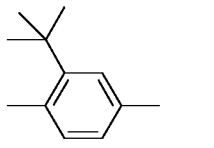
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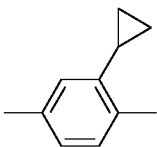
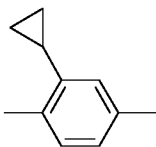
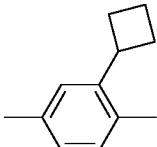
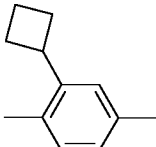
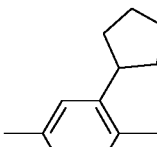
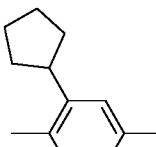
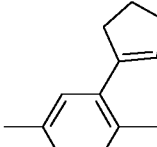
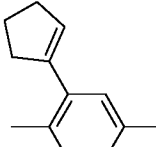
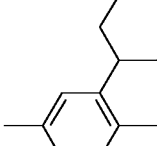
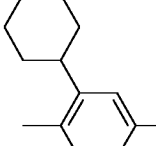
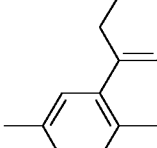
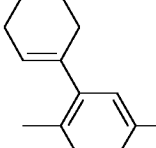
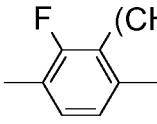
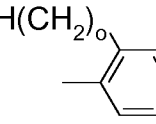
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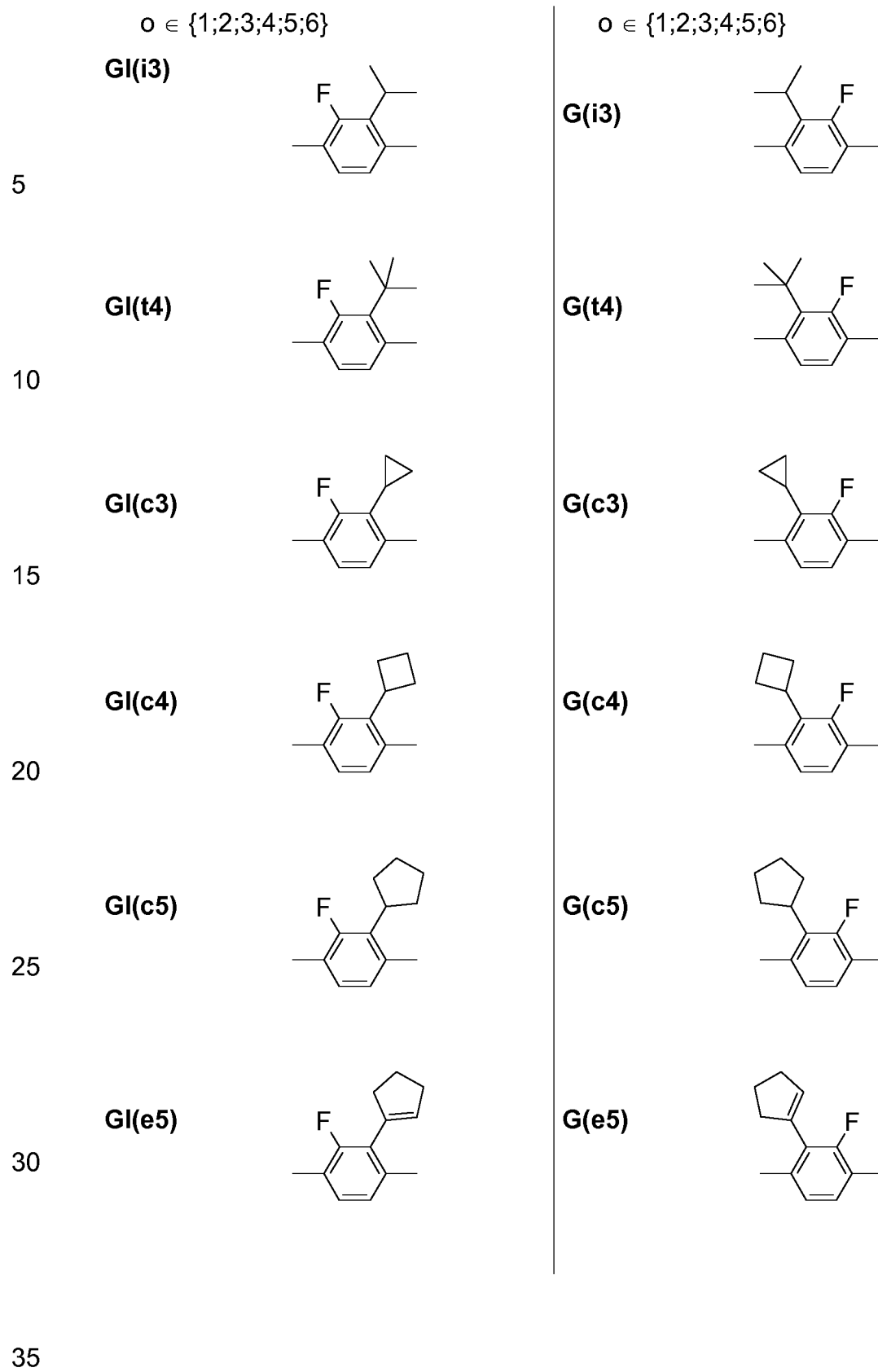
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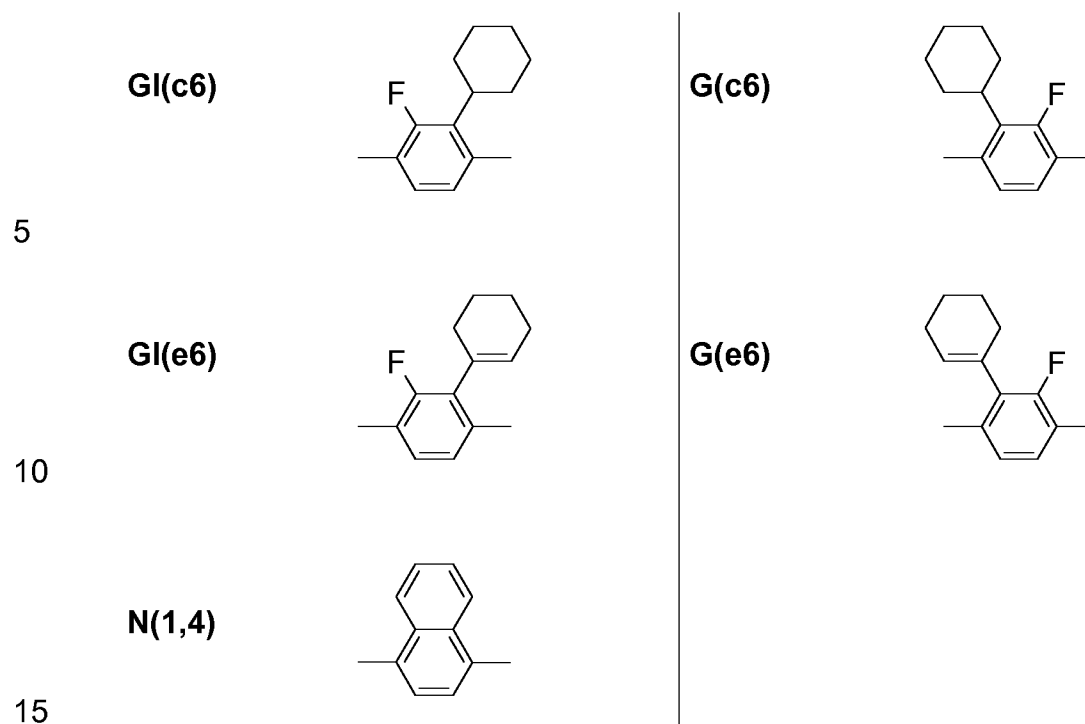
C**D****A****P****DI****AI**

	G		GI	
5	U		UI	
10	Y			
15	M		MI	
20	N		NI	
	Np			
25	N3f		N3fi	
30	tH		tHi	
35				

	tH2f		tH2fl	
5	dH			
10	K		KI	
15	L		LI	
20	F		FI	
	P(o)		PI(o)	
25	P(i3)		PI(ic3)	
30	P(t4)		PI(t4)	

5	P(c3)		PI(c3)	
	P(c4)		PI(c4)	
10				
	P(c5)		PI(c5)	
15				
	P(e5)		PI(e5)	
20				
	P(c6)		PI(c6)	
25				
	P(e6)		PI(e6)	
30				
35	GI(o)		G(o)	



**Table B: Linking groups**

20	E	-CH ₂ CH ₂ -	Z	-CO-O-
	V	-CH=CH-	ZI	-O-CO-
	X	-CF=CH-	O	-CH ₂ -O-
	XI	-CH=CF-	OI	-O-CH ₂ -
	B	-CF=CF-	Q	-CF ₂ -O-
25	T	-C≡C-	QI	-O-CF ₂ -
	W	-CF ₂ CF ₂ -		

Table B: End groups

30	Left-hand side		Right-hand side	
			Used alone	
35	-n-	C _n H _{2n+1} -	-n	-C _n H _{2n+1}
	-nO-	C _n H _{2n+1} -O-	-On	-O-C _n H _{2n+1}
	-v-	CH ₂ =CH-	-v	-CH=CH ₂

	-nV-	$C_nH_{2n+1}-CH=CH-$	-nV	$-C_nH_{2n}-CH=CH_2$
	-Vn-	$CH_2=CH-C_nH_{2n+1}-$	-Vn	$-CH=CH-C_nH_{2n+1}$
	-nVm-	$C_nH_{2n+1}-CH=CH-C_mH_{2m}-$	-nVm	$-C_nH_{2n}-CH=CH-C_mH_{2m+1}$
5	-N-	$N\equiv C-$	-N	$-C\equiv N$
	-S-	$S=C=N-$	-S	$-N=C=S$
	-F-	$F-$	-F	$-F$
	-CL-	$Cl-$	-CL	$-Cl$
	-M-	CFH_2-	-M	$-CFH_2$
10	-D-	CF_2H-	-D	$-CF_2H$
	-T-	CF_3-	-T	$-CF_3$
	-MO-	CFH_2O-	-OM	$-OCFH_2$
	-DO-	CF_2HO-	-OD	$-OCF_2H$
15	-TO-	CF_3O-	-OT	$-OCF_3$
	-FXO-	$CF_2=CH-O-$	-OXF	$-O-CH=CF_2$
	-A-	$H-C\equiv C-$	-A	$-C\equiv C-H$
	-nA-	$C_nH_{2n+1}-C\equiv C-$	-An	$-C\equiv C-C_nH_{2n+1}$
20	-NA-	$N\equiv C-C\equiv C-$	-AN	$-C\equiv C-C\equiv N$

Used in combination with others

	-...A...-	$-C\equiv C-$	-...A...	$-C\equiv C-$
	-...V...-	$-CH=CH-$	-...V...	$-CH=CH-$
25	-...Z...-	$-CO-O-$	-...Z...	$-CO-O-$
	-...ZI...-	$-O-CO-$	-...ZI...	$-O-CO-$
	-...K...-	$-CO-$	-...K...	$-CO-$
	-...W...-	$-CF=CF-$	-...W...	$-CF=CF-$
30				

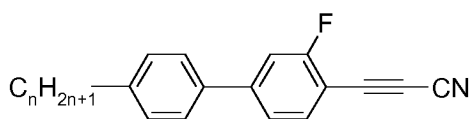
in which n and m each denote integers, and the three dots “...” are placeholders for other abbreviations from this table.

35 The following table shows illustrative structures together with their respective abbreviations. These are shown in order to illustrate the meaning of

the rules for the abbreviations. They furthermore represent compounds which are preferably used.

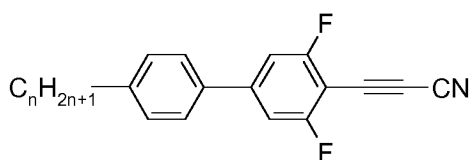
Table C: Illustrative structures

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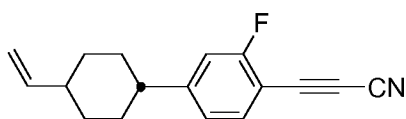
PG-n-AN

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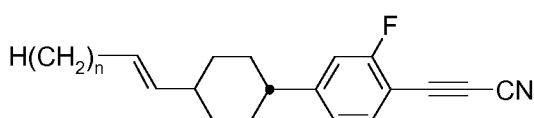
PU-n-AN

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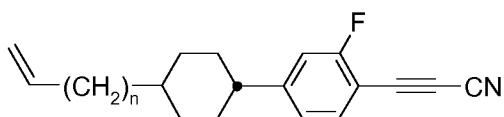
CP-V-AN

20



CP-nV-AN

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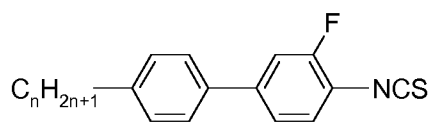


CP-Vn-AN

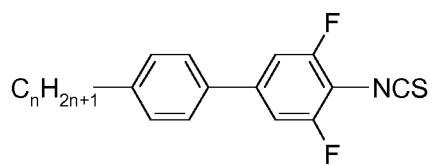
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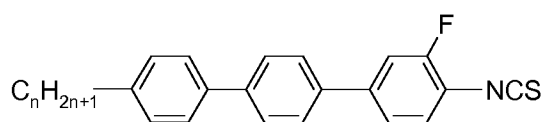
The following illustrative structures are compounds, which are preferably additionally used in the media:

**PG-n-S**

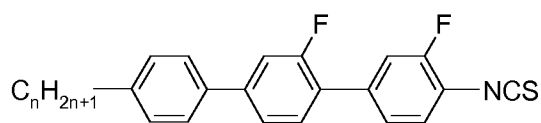
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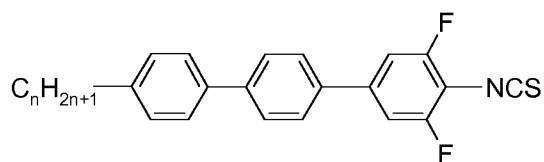
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PU-n-S

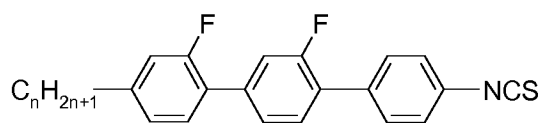
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PPG-n-S

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PGG-n-S

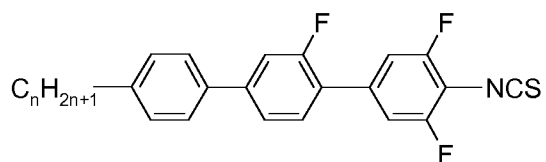
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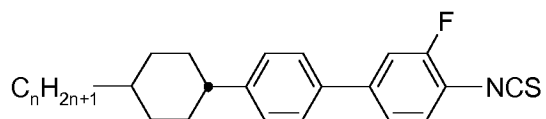
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GGP-n-S

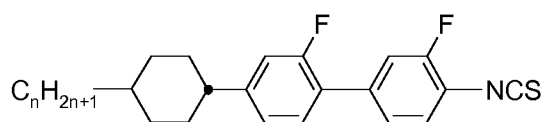
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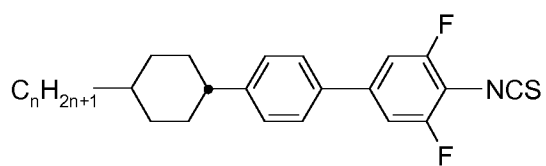
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PGU-n-S

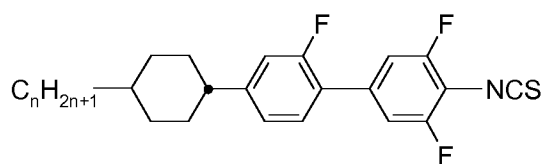
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CPG-n-S

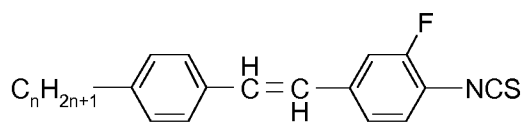
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CGG-n-S

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CPU-n-S

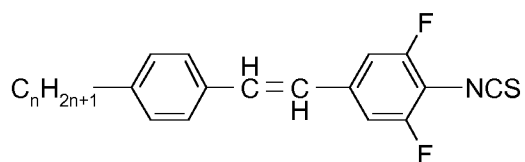
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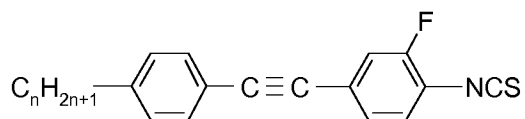
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PVG-n-S

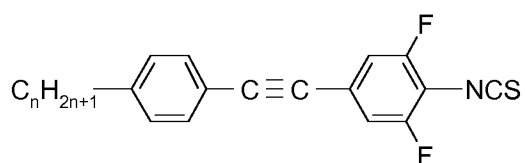
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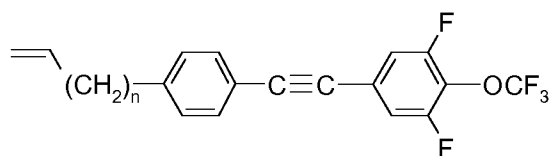
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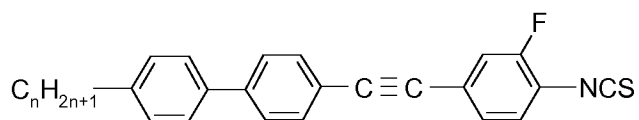
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PTG-n-S

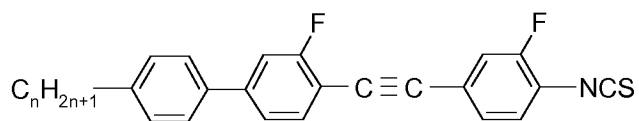
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PTU-n-S

20

PTU-Vn-OT

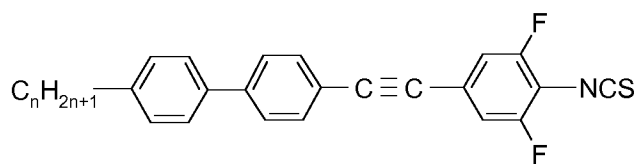
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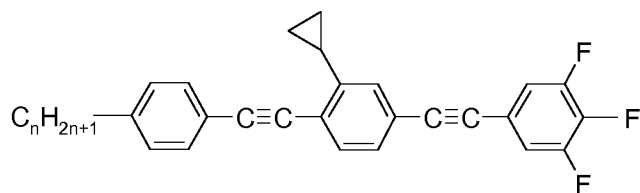
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PGTG-n-S

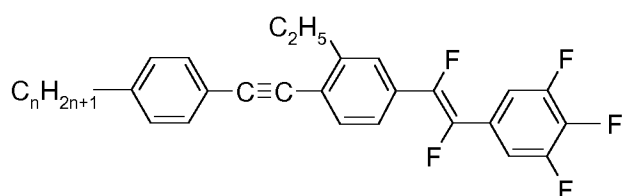
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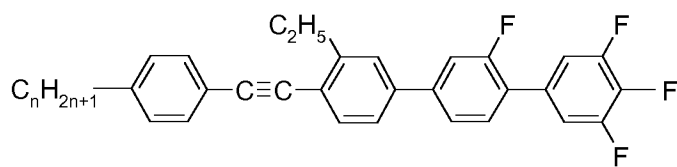
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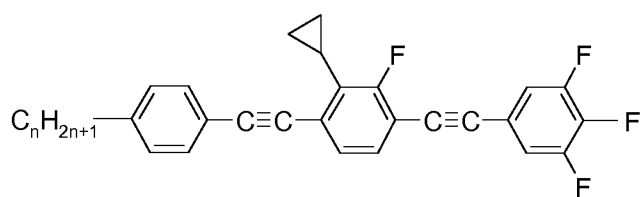
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PTPI(c3)TU-n-F

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PTPI(2)WU-n-F

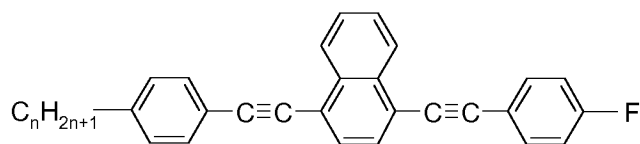
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PTPI(2)GU-n-F

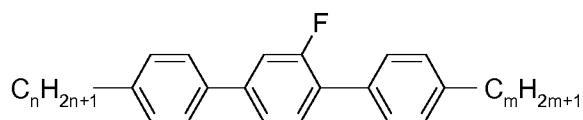
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PTG(c3)TU-n-F

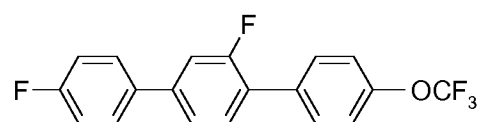
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**PTN(1,4)TP-n-F**

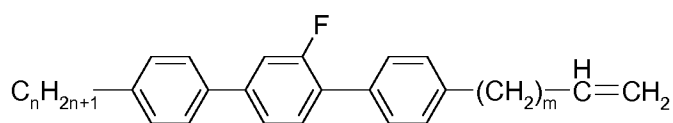
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**PGP-n-m**

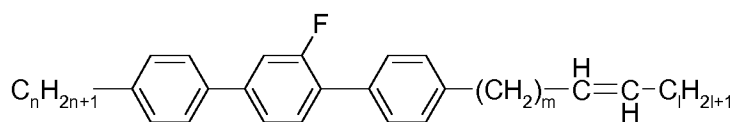
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**PGP-F-OT**

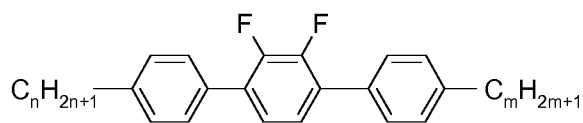
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**PGP-n-mV**

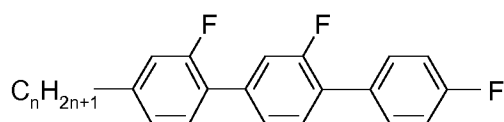
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**PGP-n-mVI**

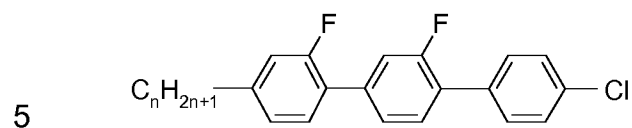
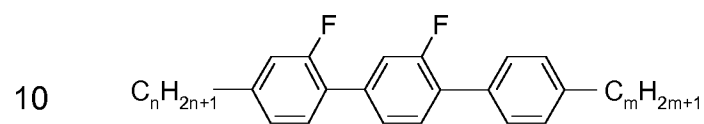
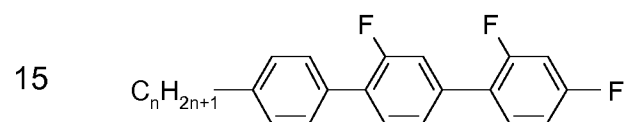
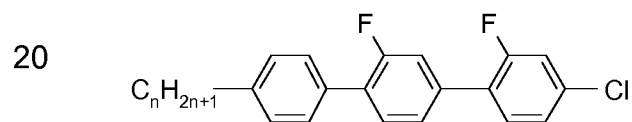
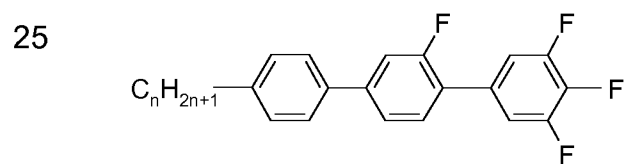
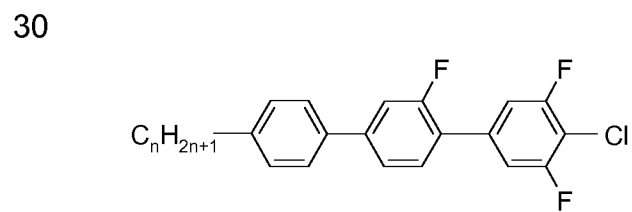
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**PYP-n-m**

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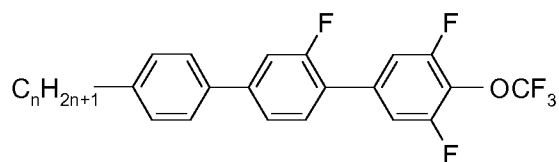


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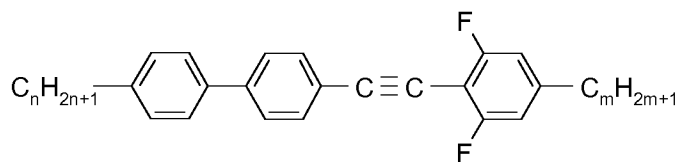
GGP-n-F**GGP-n-CL****GGP-n-m****PGIGI-n-F****PGIGI-n-CL****PGU-n-F**

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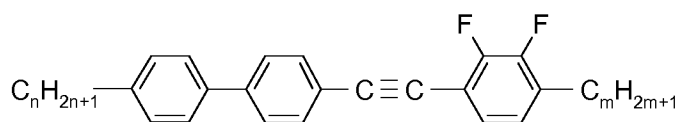
PGU-n-CL



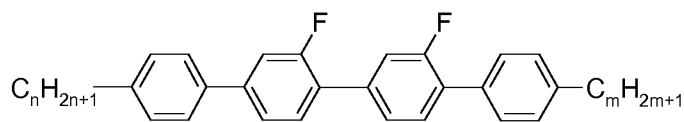
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PGU-n-OT

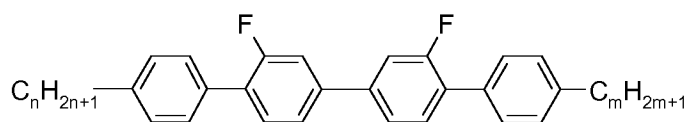
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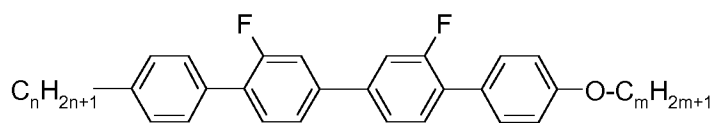
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PPTY-n-m

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PGGP-n-m

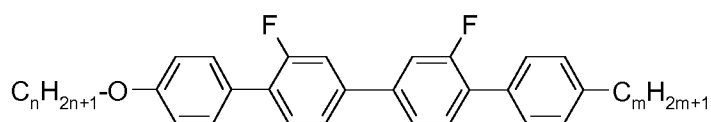
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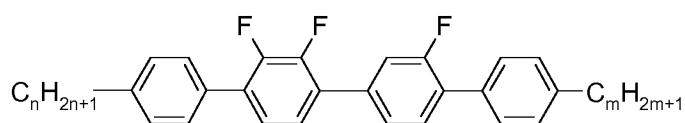
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PGIGP-n-Om

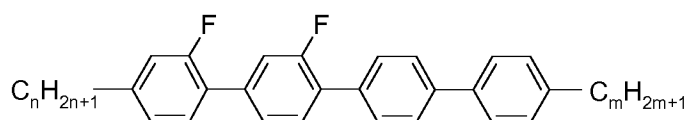
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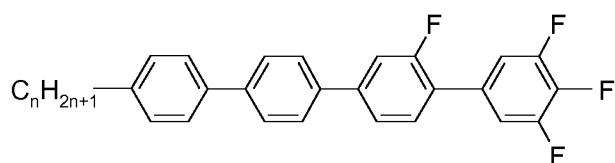
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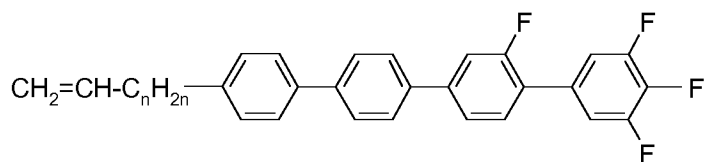
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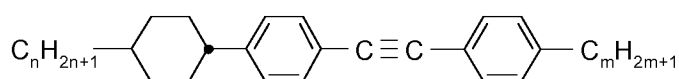
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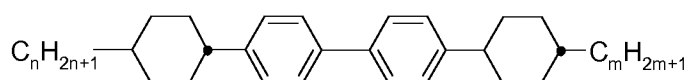
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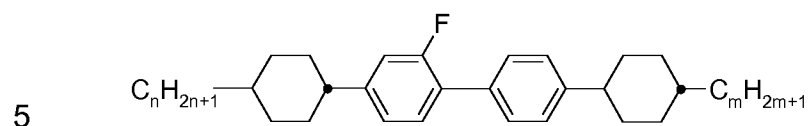
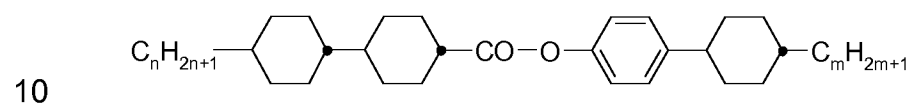
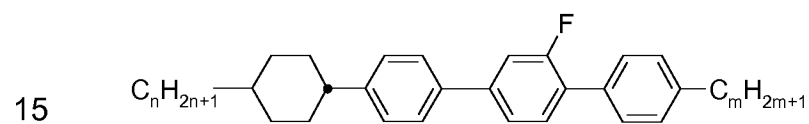
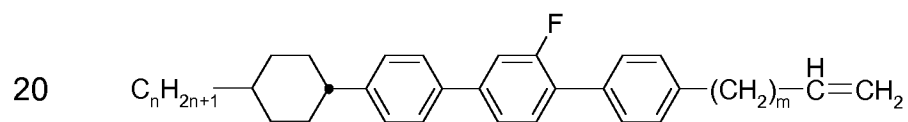
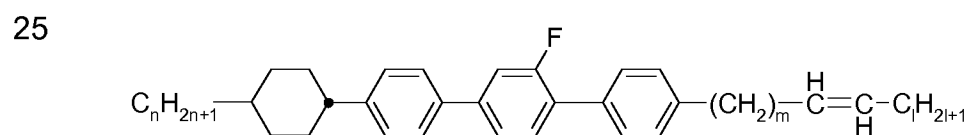
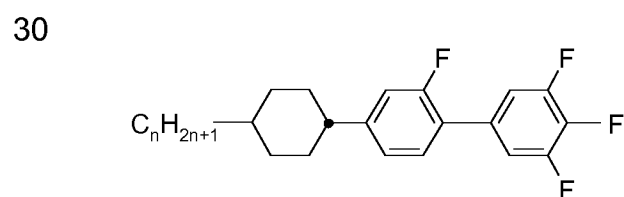
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**CPTP-n-m**

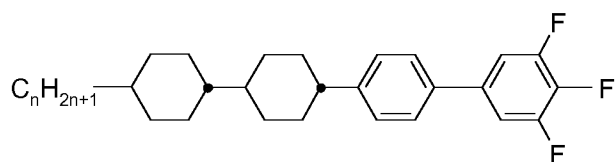
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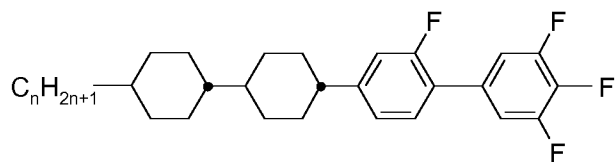
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CPPC-n-m**CGPC-n-m****CCZPC-n-m****CPGP-n-m****CPGP-n-mV****CPGP-n-mVI****CGU-n-F**

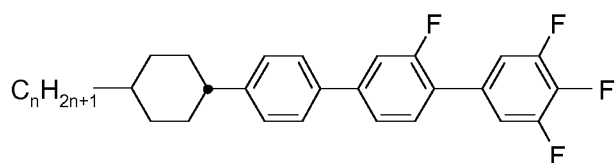
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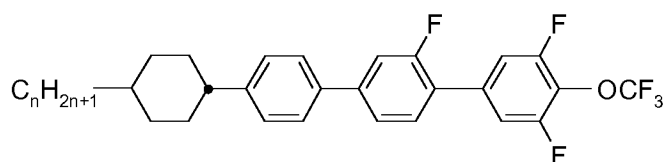
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CCPU-n-F

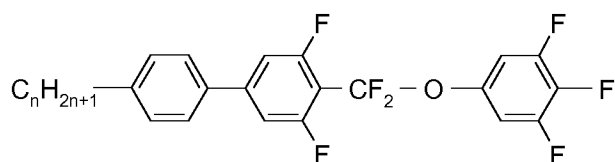
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CCGU-n-F

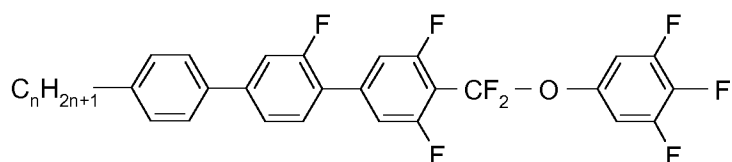
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CPGU-n-F

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CPGU-n-OT

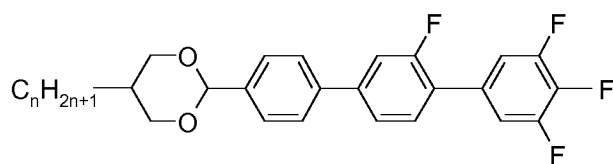
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PUQU-n-F

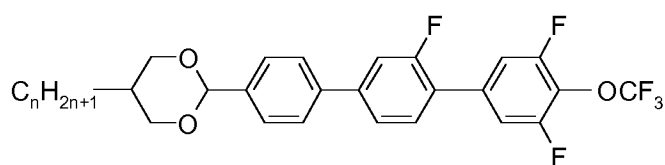
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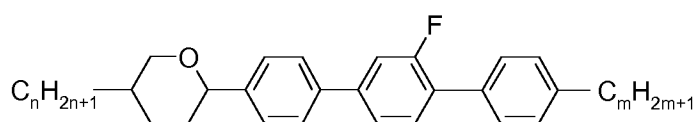
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**DPGU-n-F**

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**DPGU-n-OT**

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**APGP-n-m**

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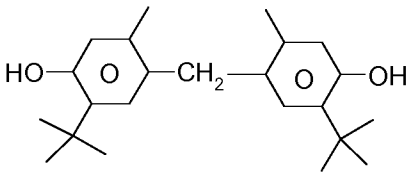
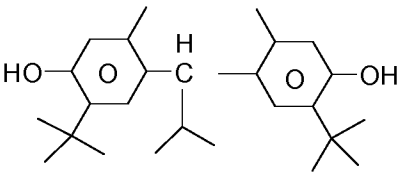
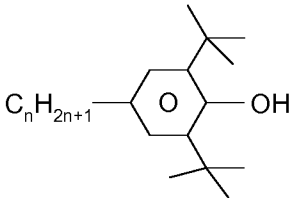
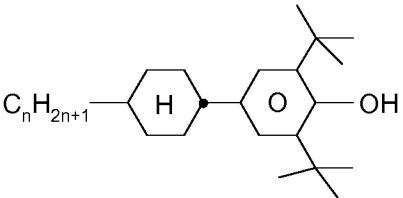
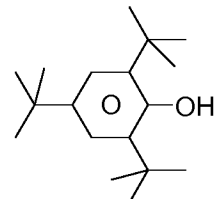
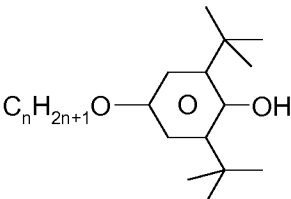
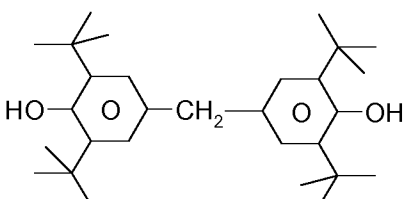
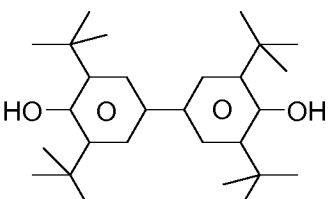
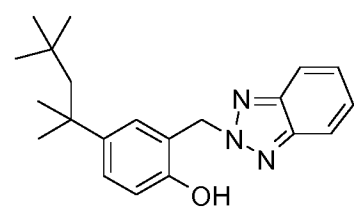
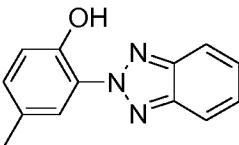
The following table, Table E, shows illustrative compounds which can be used as stabiliser in the mesogenic media in accordance with the present invention. The total concentration of these and similar compounds in the media is preferably 5 % or less.

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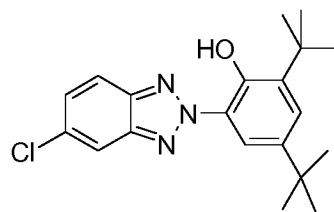
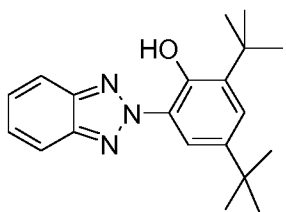
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Table E

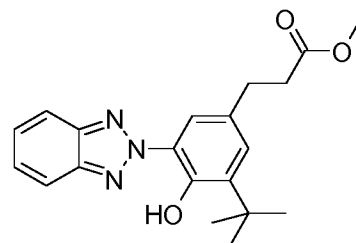
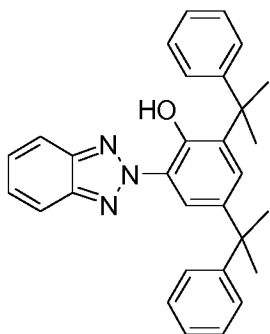
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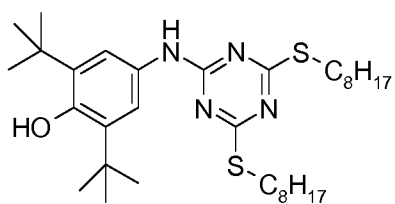
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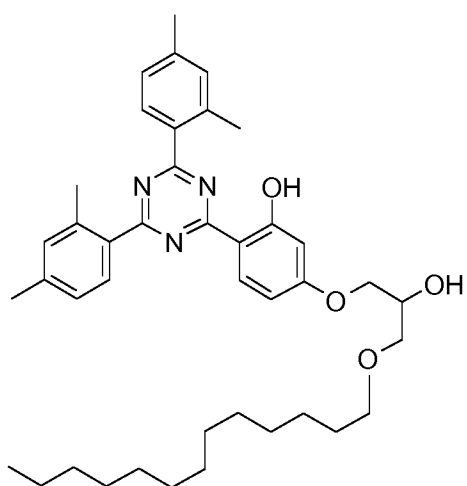
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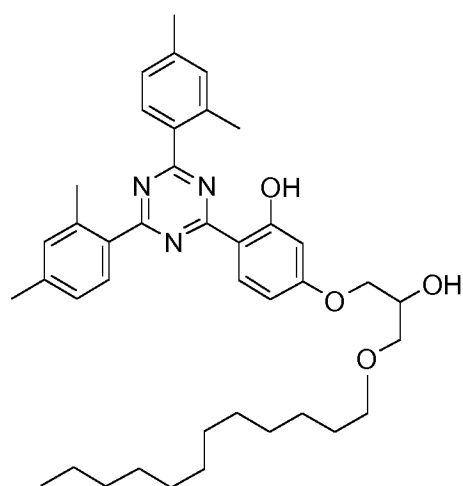
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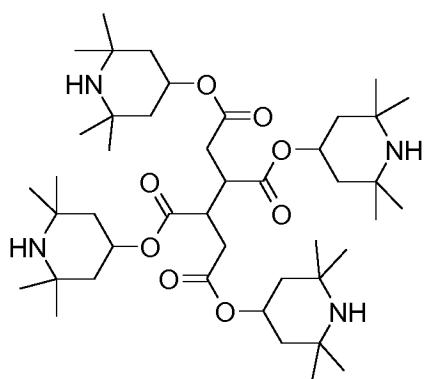


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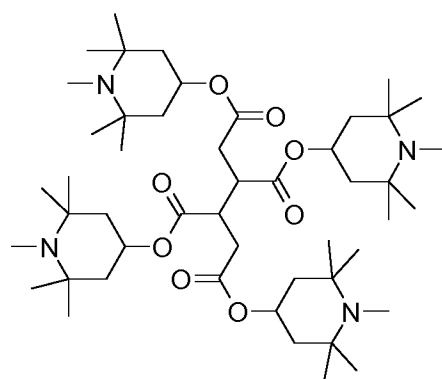


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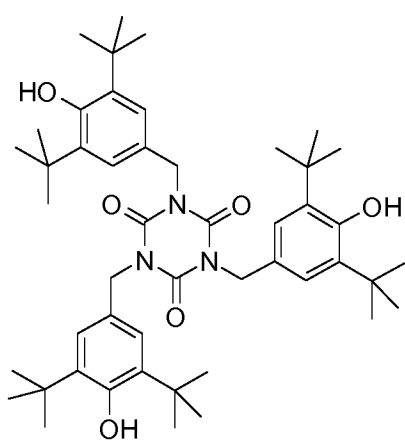
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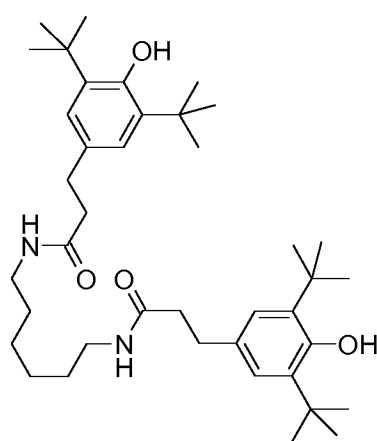
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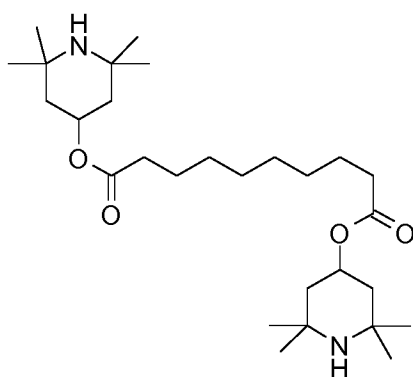
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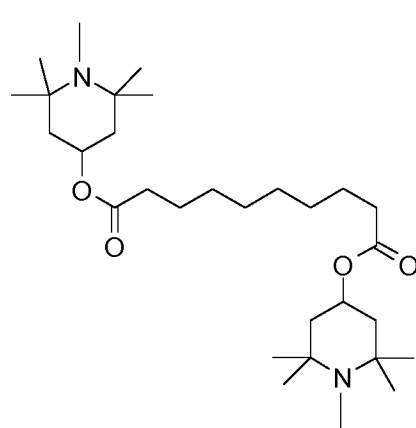
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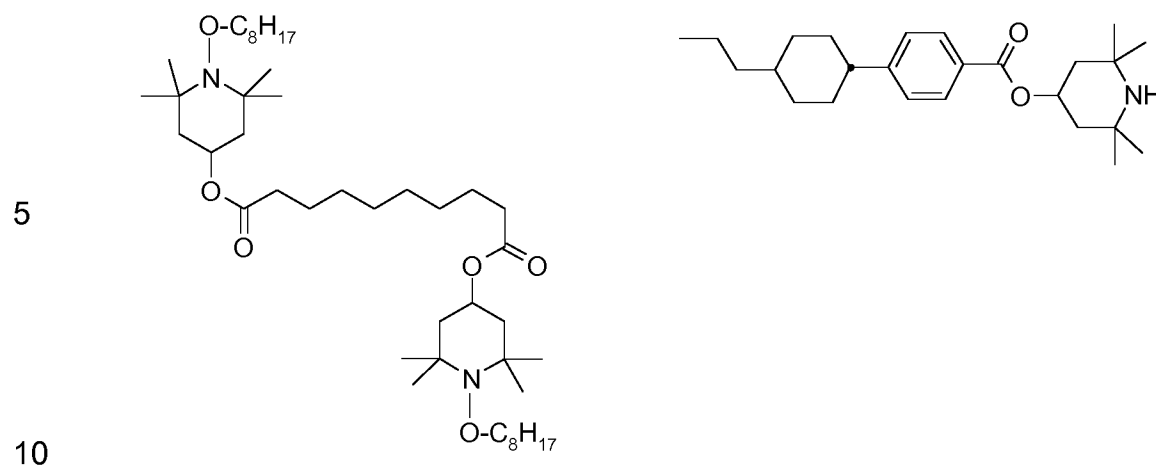
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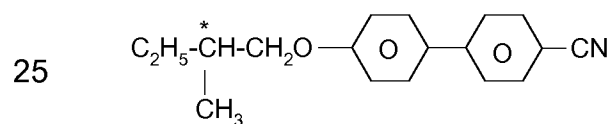
In a preferred embodiment of the present invention, the mesogenic media comprise one or more compounds selected from the group of the compounds from Table E.

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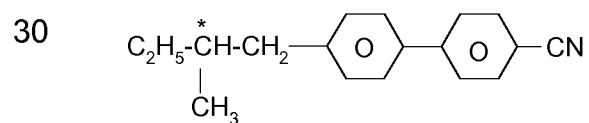
The following table, Table F, shows illustrative compounds which can preferably be used as chiral dopants in the mesogenic media in accordance with the present invention.

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Table F

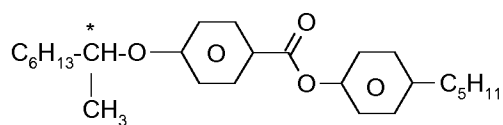


C 15

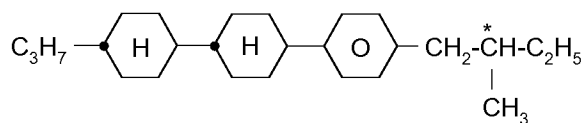


CB 15

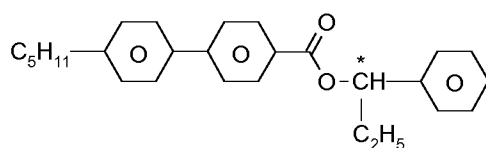
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**CM 21**

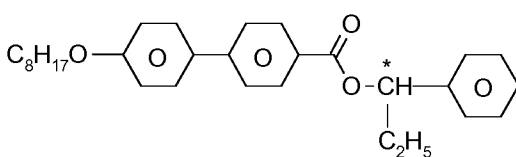
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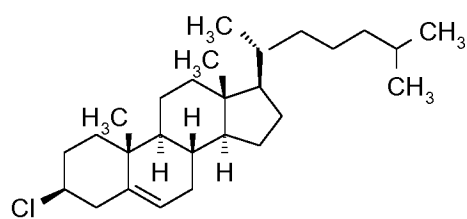
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**CM 45**

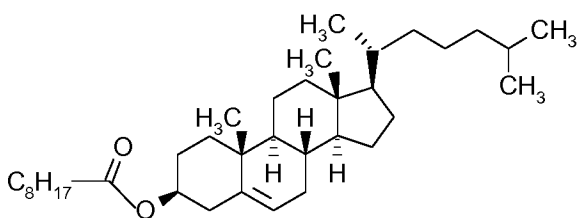
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**CM 47**

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**CC**

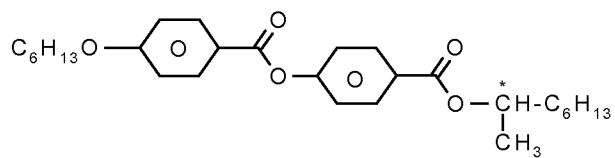
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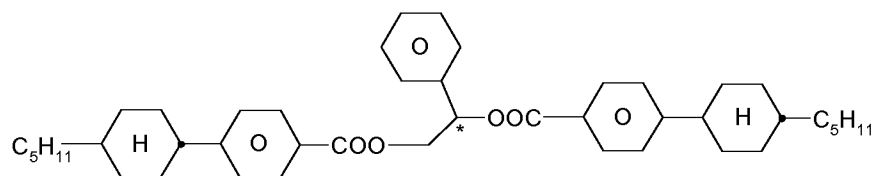
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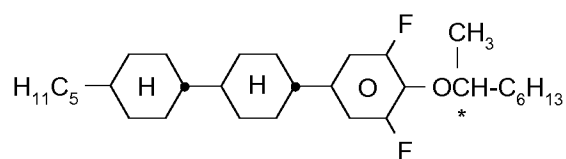
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**R/S-811**

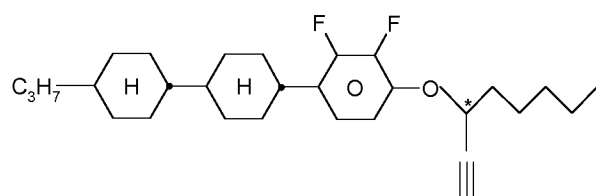
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**R/S-1011**

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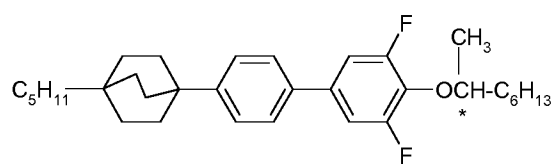
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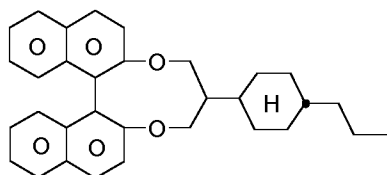
**R/S-3011**

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**R/S-4011**

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R/S-5011

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In a preferred embodiment of the present invention, the mesogenic media comprise one or more compounds selected from the group of the compounds from Table F.

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The mesogenic media in accordance with the present application preferably comprise two or more, preferably four or more, compounds selected from the group consisting of the compounds from the above tables.

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The liquid-crystal media in accordance with the present invention preferably comprise

- seven or more, preferably eight or more, compounds, preferably compounds having three or more, preferably four or more, different formulae, selected from the group of the compounds from Table D.

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Examples

The following examples illustrate the present invention without limiting it in any way.

However, it is clear to the person skilled in the art from the physical properties what properties can be achieved and in what ranges they can be modified. In particular, the combination of the various properties which can preferably be achieved is thus well defined for the person skilled in the art.

10 Mixture Examples

Liquid-crystal mixtures M-1 and M-2 having the composition and properties as indicated in the following tables are prepared and characterized with respect to their general physical properties and their applicability in microwave components at 19 GHz.

15 Mixture Example M-1

Composition				Physical Properties	
	Compound		Conc.		
	No	Abbreviation	[mass-%]		
20	1	PU-3-AN	5.0	T(N, I) [°C]	= 114
	2	PU-5-AN	5.0	$\epsilon_{ }$ (20°C, 1 kHz)	= 38.9
	3	PG-3-AN	20.0	$\Delta\epsilon$ (20°C, 1 kHz)	= 32.9
	4	CP-1V-AN	10.0	γ_1 (20°C) / mPa · s	= 324
25	5	CP-V-AN	20.0	K ₁ [pN]	= 11.9
	6	CP-4-AN	20.0	K ₃ [pN]	= 33.6
	7	CP-V2-AN	<u>20.0</u>	V ₀ [V]	= 0.64
	Σ		100.0		
30				$\tan \delta_{\epsilon_{r,\perp}}$ (20°C, 19 GHz)	= 0.0312
				$\tan \delta_{\epsilon_{r, }}$ (20°C, 19 GHz)	= 0.0088
				τ (20°C, 19 GHz)	= 0.186
				$\epsilon_{r, }$ (20°C, 19 GHz)	= 3.1800
35				$\epsilon_{r,\perp}$ (20°C, 19 GHz)	= 2.5870
				η (20°C, 19 GHz)	= 6.0

This mixture is very well suitable for applications in the microwave range, in particular for phase shifters or LC based antenna elements in the microwave (MW) region.

5

Mixture Example M-2

	Composition			Physical Properties	
10	Compound		Conc.		
	No	Abbreviation	[mass-%]		
15	1	PTU-3-S	10.0	T(N, I) [°C]	= 121.5
	2	PTU-5-S	10.0	$\epsilon_{ }$ (20°C, 1 kHz)	= 27.8
	3	PGU-3-S	16.0	$\Delta\epsilon$ (20°C, 1 kHz)	= 23.1
	4	PPTU-4-S	5.0	γ_1 (20°C) / mPa · s	= 502
	5	PPTU-5-S	5.0	K ₁ [pN]	= 12.8
20	6	CPU-2-S	18.0	K ₃ [pN]	= 18.6
	7	CPU-4-S	18.0	V ₀ [V]	= 0.78
	8	CP-V2-AN	12.0		
	9	PTU-V2-OT	<u>6.0</u>	$\tan \delta_{\epsilon_{r,\perp}}$ (20°C, 19 GHz)	= 0.0114
	Σ		100.0	$\tan \delta_{\epsilon_{r, }}$ (20°C, 19 GHz)	= 0.0058
25				τ (20°C, 19 GHz)	= 0.258
				$\epsilon_{r, }$ (20°C, 19 GHz)	= 3.3471
				$\epsilon_{r,\perp}$ (20°C, 19 GHz)	= 2.4846
				η (20°C, 19 GHz)	= 22.6

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This mixture is very well suitable for applications in the microwave range, in particular for phase shifters or LC based antenna elements in the microwave (MW) region.

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In addition, for comparison the properties of the compound *n*-1-pentyl-4'-cyanobiphenyl (also called PP-5-N or CB15, Comparative Example C-1)

and the liquid-crystal mixture ZLI-4792 (product from Merck KGaA, Darmstadt, Germany, Comparative Example C-2) were investigated at 19 GHz.

In the following table 1, the application-relevant properties of the comparative Examples C-1 and C-2, measured at 20°C and 19 GHz, unless indicated otherwise, are summarised in comparison with the corresponding values of the mixture examples M-1 and M-2.

Table 1

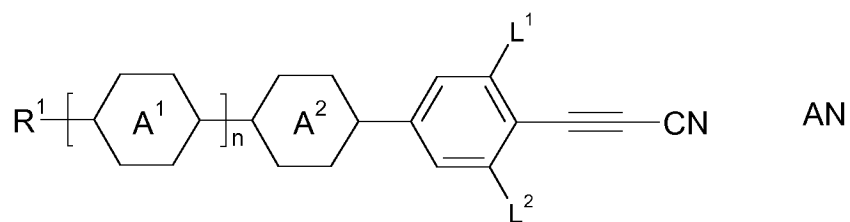
Example	$\Delta\epsilon^*$	$\epsilon_{r,\parallel}$	$\epsilon_{r,\perp}$	τ	$\tan \delta_{\epsilon_{r,\text{Max}}}$	η
C-1	20.1	3.06	2.66	0.131	0.0273	4.8
C-2	5.2	2.57	2.29	0.107	0.0126	8.5
M-1	32.9	3.1800	2.5870	0.186	0.0312	6.0
M-2	23.1	3.3471	2.4846	0.258	0.0114	22.6

* measured at 1 kHz

As can be seen from the values given in table 1, the comparative example C-1 has a high dielectric anisotropy but a very high dielectric loss and, therefore a very low figure-of-merit. The comparative example C-2 is a commercial mixture with an acceptable figure of merit, but with a comparatively low dielectric anisotropy. On the contrary, surprisingly the mixture examples M-1 and M-2 according to the present invention exhibit a very high dielectric anisotropy and low threshold voltage resulting in very good switching behaviour and low switching voltages of a device, while showing high tunability, low dielectric loss and high figures-of-merit.

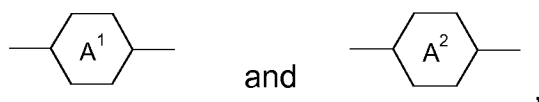
Patent Claims

1. Liquid-crystal medium, characterised in that it comprises one or more compounds of formula AN

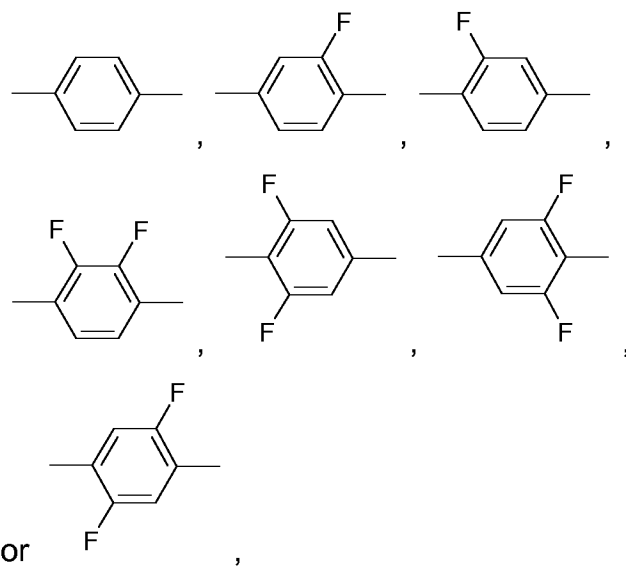


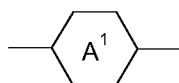
in which

R^1 denotes alkyl or alkenyl having up to 15 C atoms,



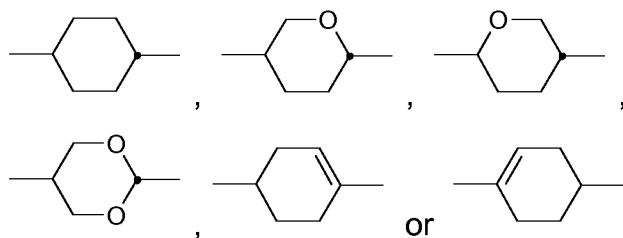
on each occurrence, independently of one another, denote





alternatively denotes

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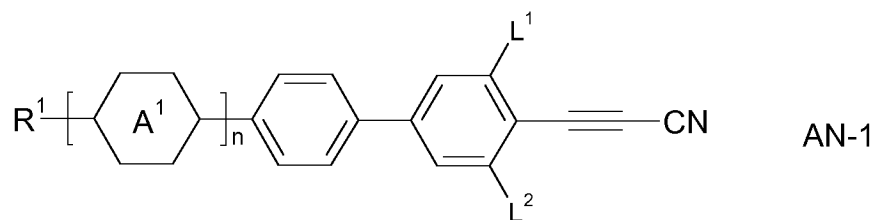
L^1 and L^2 independently from one another, denote H or F, and

n is 0, 1 or 2.

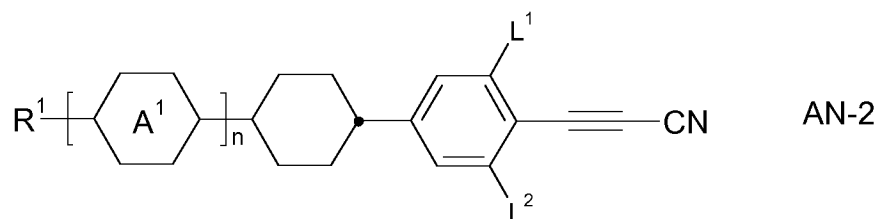
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2. Liquid-crystal medium according to claim 1, characterised in that it comprises one or more compounds selected from the group of compounds of the formulae AN-1 and AN-2

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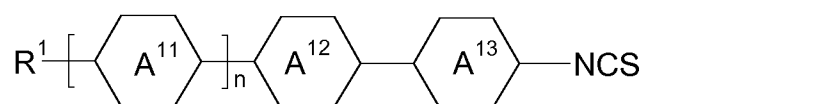
in which the occurring groups and parameters have the meanings given in claim 1 for formula AN.

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3. Liquid-crystal medium according to claim 1 or 2, characterised in that it comprises one or more compounds of formula AN-2 as indicated in claim 2, in which

R^2 denotes alkylene having up to 7 C atoms and
n is 0.

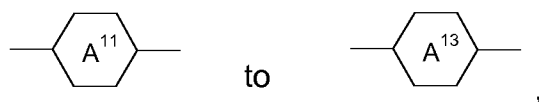
4. Liquid-crystal medium according to one or more of claims 1 to 3, characterised in that it additionally comprises one or more compounds selected from the group of compounds of formula I



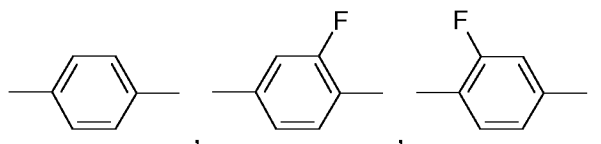
in which

R^1 denotes H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17 C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15 C atoms,

n is 0, 1 or 2, and

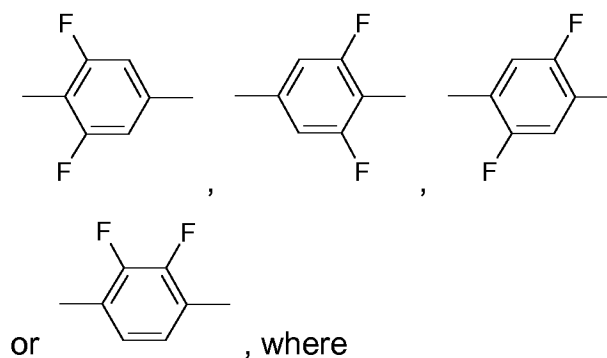


independently of one another, denote

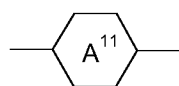


- 133 -

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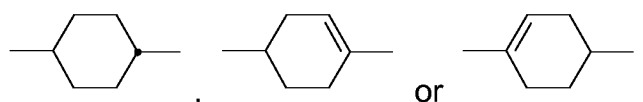


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alternatively denotes

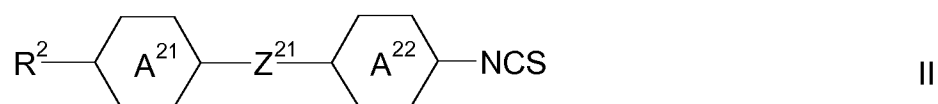
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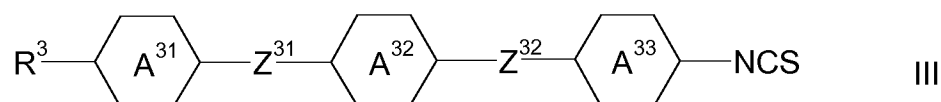
20

5. Liquid-crystal medium according to one or more of claims 1 to 4, characterised in that it comprises one or more compounds selected from the group of compounds of the formulae II and III

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in which

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R^2 denotes H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17 C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15 C atoms,

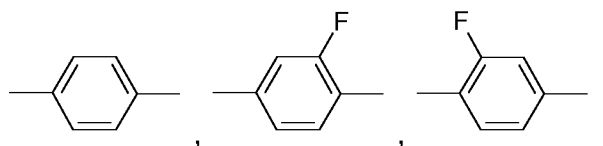
Z^{21} denotes *trans*-CH=CH-, *trans*-CF=CF- or -C≡C-,

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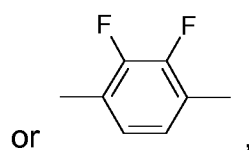
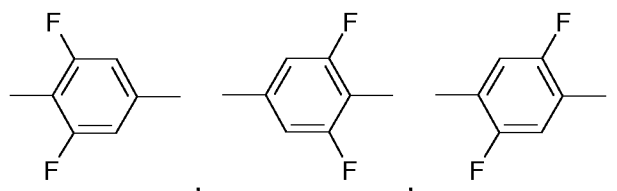


independently of one another, denote

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R^3 has the meaning given for R^2 above,

one of

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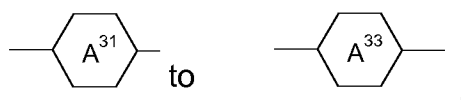
Z^{31} and Z^{32} denotes *trans*-CH=CH-, *trans*-CF=CF- or -C≡C-,

and the other

one of

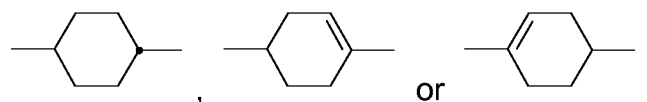
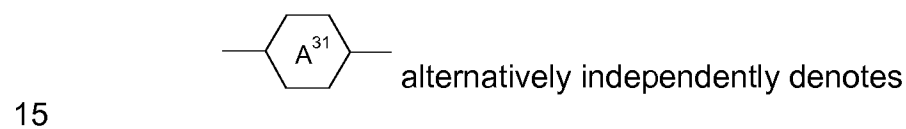
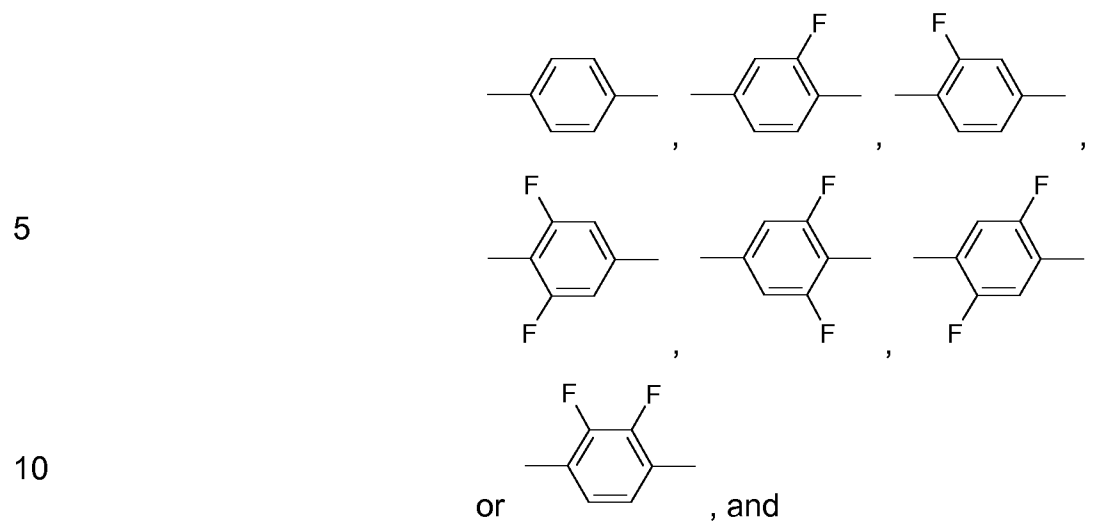
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Z^{31} and Z^{32} denotes *trans*-CH=CH-, *trans*-CF=CF- or a single bond,

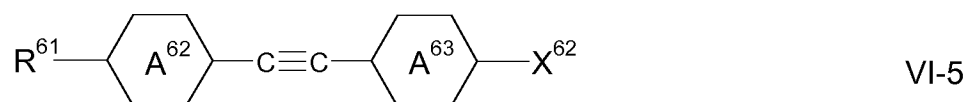


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independently of one another, denote



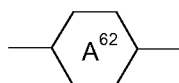
- 20 6. Medium according to one or more of claims 1 to 5, characterised in that it comprises one or more compounds of formula VI-5



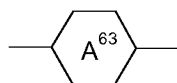
in which

30 R^{61} denotes H, unfluorinated alkyl or unfluorinated alkoxy having 1 to 17 C atoms or unfluorinated alkenyl, unfluorinated alkenyloxy or unfluorinated alkoxyalkyl having 2 to 15, C atoms,

35 X^{62} denotes F or Cl, -CN, SF_5 , fluorinated alkyl or alkoxy having 1 to 7 C atoms or fluorinated alkenyl, alkenyloxy or alkoxyalkyl having 2 to 7 C atoms,



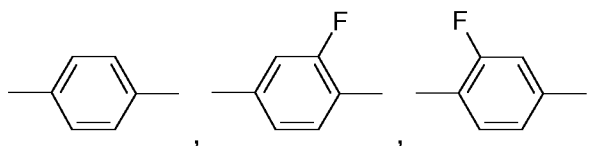
and



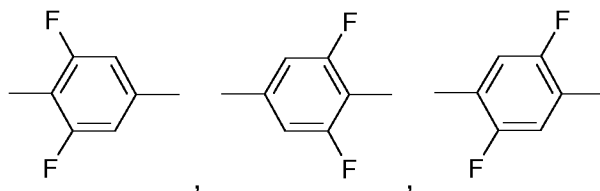
,

independently of one another, denote

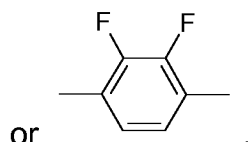
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or

7. Medium according to one or more of claims 1 to 6, characterised in that it comprises one or more compounds of formula AN, as indicated in claim 1, in a total concentration in the range of from 5 % to 100 %.

8. Medium according to one or more of claims 1 to 7, characterised in that it comprises one or more compounds of formula AN-2, as indicated in claim 2, in a total concentration of 5 % or more.

9. Medium according to one or more of claims 1 to 8, characterised in that it additionally comprises one or more chiral compounds.

10. Component for high-frequency technology, characterised in that it comprises a liquid crystal medium according to one or more of claims 1 to 9.

11. Component according to Claim 10, where the component is suitable for operation in the microwave range.

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12. Component according to Claim 10 or 11, where the component is a phase shifter or an LC based antenna element operable in the microwave region.
13. Use of a liquid-crystal medium according to one or more of Claims 1 to 9 in a component for high-frequency technology.
- 10 14. Process for the preparation of a liquid-crystal medium, characterised in that one or more compounds of formula AN are mixed with one or more compounds of fomrula AN or additional mesogenic compounds and optionally a chiral compound is added.
- 15 15. Microwave antenna array, characterised in that it comprises one or more components according to one or more of Claims 10 to 12.

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2018/056138

A. CLASSIFICATION OF SUBJECT MATTER

INV. C09K19/04 C09K19/18
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 198 31 093 A1 (MERCK PATENT GMBH [DE]) 4 February 1999 (1999-02-04) cited in the application	1-9,14
A	page 1, lines 1-56; examples A-K -----	10-13,15
X	JP 2002 012871 A (MERCK PATENT GMBH) 15 January 2002 (2002-01-15)	1-9,14
A	paragraphs [0087], [0092]; claims -----	10-13,15
X	EP 0 816 332 A1 (CHISSO CORP [JP]) 7 January 1998 (1998-01-07)	1-9
A	page 1, lines 5-6; examples 5-8,11-13,16,19,20,24-26,29,30,32,36 -----	10-13,15
A	WO 2016/066242 A1 (MERCK PATENT GMBH [DE]) 6 May 2016 (2016-05-06) claims; examples -----	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

8 June 2018

Date of mailing of the international search report

19/06/2018

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European Patent Office, P.B. 5818 Patentlaan 2
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Fax: (+31-70) 340-3016

Authorized officer

Schoenhentz, Jérôme

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/056138

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		TW 201623588	A 01-07-2016
		US 2017306230	A1 26-10-2017
		WO 2016066242	A1 06-05-2016
