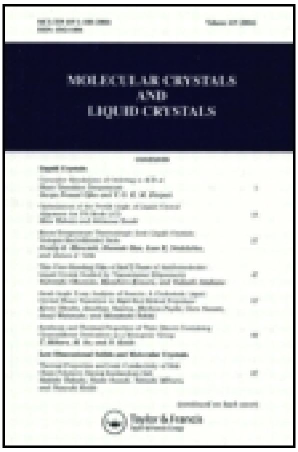

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PREPARATION OF NEMATIC MIXTURES FROM SMECTIC COMPOUNDS

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Abstract A simple method has been developed to obtain multicomponent mixtures with a wide range of the nematic phase from smectic compounds. The properties of these mixtures make them suitable for use in displays of twist type.

Keywords: nematic mixtures, induced nematic phase, smectogens, nematic gap

INTRODUCTION

Many binary mixtures of polar smectic compounds are known in which the nematic phase may be induced. It has been found that the factor which is decisive for the occurrence of nematic phase induction is the ratio of the smectic layer spacings of the compounds used in the mixture[1-5]. It is known that induction of the nematic phase occurs only if the orientations of the dipole moments of the terminal group and of the remaining groups in the molecules forming the mixture are in accordance[6]. When the ratio of the smectic layer spacings assumes similar values the energy bonding the molecules in the smectic layer is the factor determining the width of the nematic gap[7-8].

The effect has also been observed in the terminal substituents in the smectic molecules used in the mixture in the range of the induced nematic phase[9-10]. It has been found that the kind of substituent is decisive for the character of the smectic phase and the bonding energy in the smectic lattice; such factors affect indirectly the range of the induced nematic phase.

The induction of the nematic phase was observed in binary mixtures of smectics A_1 and A_d[1-4], A_1 and A_1[5], A_d and C, C and C[11], and E and A_d[10].

From X-ray studies and measurements of viscosity it follows that the nematic phase formed from smectic compounds is a normal nematic phase such as that encountered in most nematic compounds[3,6]. The nematic mixtures obtained from smectic compounds have a moderate viscosity of small temperature dependence what allows obtaining nematic mixtures of low viscosity at low temperatures.

On the basis of the above results we decided smectic compounds for designing and realizing nematic mixtures with properties allowing their application in displays.

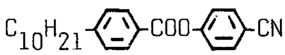
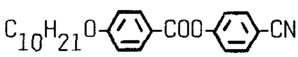
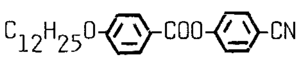
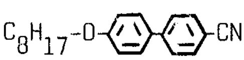
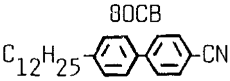
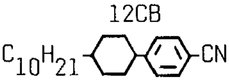
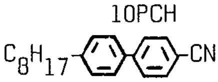
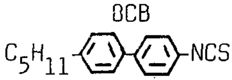
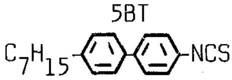
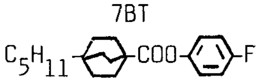
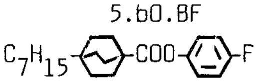
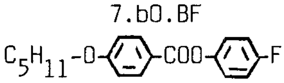
RESULTS AND DISCUSSION

All the mixtures investigated in the present work were composed of smectic compounds synthesized in our laboratory that are known to induce the nematic phases in binary mixtures. The properties of these compounds are summarized in Table 1.

Using the mentioned compounds and taking advantage of thermodynamic relations (CSL equations[12,13] and regular solution theory[13,14]) we designed with the help of a computer multicomponent mixtures of the eutectic composition. The components of these mixtures were adjusted in such a way that they reveal the same kind of smectic phase (the mixtures comprising smectic compounds yielding monomolecular layers were denoted by M, and those yielding bimolecular layers by D), and also that their molecules have a similar chemical structure. Next, taking advantage of these computer calculations we prepared the mixtures and measured their phase transition points. The properties and compositions of some of the eutectic smectic mixtures are summarized in Table 2. The eutectic mixtures composed of compounds yielding the same kind of smectic phase reveal the same smectic properties of the components they have been made up from.

In mixtures whose components differ significantly as regards the lengths of their molecules an induced nematic phase appears in a small temperature range apart from the smectic phase (mixture D1, D2). In mixture M2, in which

TABLE 1. Chemical formulae, symbols, phase transition points, melting enthalpies, smectic layer spacings and lengths of molecules of the mesogen used in the mixtures.

	Phase transition temperatures (°C)	ΔH_{melt} (kcal/mol)	d (nm)	l (nm)
 10.CN	Cr59.8N60.7I(55S_{A_d})	9.51	3.68	2.74
 10.O.CN	Cr79.5S_{A_d}81.2N86.8I	10.40	3.63	2.86
 12.O.CN	$Cr_1$67$Cr_2$72.7S_{A_d}90I	10.67	3.63	3.11
 4.CPCHB	Cr105.5N228I	4.20	-	2.14
 8OCB	Cr54.5S_{A_d}67.5N81I	5.80	3.20	2.34
 12CB	Cr45S_{A_d}58.5I	8.50	3.98	2.76
 10PCH	Cr49N57.5I(31.5S_{A_d})	8.72	3.53	2.44
 8CB	Cr21S_{A_d}32.1N40I	6.30		2.22
 5BT	Cr53S_E74I	2.70	2.00	2.13
 7BT	Cr54S_E72.5I	2.30	2.26	2.36
 5.bO.BF	$Cr_1$49$Cr_2$54.5I(51.5N)	5.20	-	1.95
 7.bO.BF	$Cr_1$47.5$Cr_2$54.6I(51.5N)	5.00	-	2.18
 5.O.F	Cr66.4I (36.3S_{A_1})	8.50	-	2.02

only one component reveals the smectic phase, in the range from the melting to the clearing point we observe only the nematic phase. All the presented examples of eutectic smectic mixtures show relatively low melting points and a wide temperature range of the mesophase.

TABLE 2. Composition and phase transition points of the eutectic mixtures.

	Mixtures of A_d smectics		
D1:	10.CN	37.5 %mol	$Cr39.6N_{re}50.7S_{A_d}65.4N110.8-113.4I$
	10.O.CN	14.2 %mol	
	12.O.CN	16.6 %mol	
	4.CPCHB	31.7 %mol	
D2:	8.OCB	20.4 %mol	$Cr4.9S_{A_d}46.3N52.9-53.1I$
	8 CB	53.6 %mol	
	12 CB	14.4 %mol	
	10 PCH	11.6 %mol	
	Mixture of E smectics		
M1:	5 BT	47.5 %mol	$Cr36S_E71.9-72.6I$
	7 BT	52.5 %mol	
	Mixture of nematics and A_1 smectic		
M2:	5.bO.BF	37.8 %mol	Cr21.2N39.5-39.8I
	7.bO.BF	38.1 %mol	
	5.O.F.	24.1 %mol	

The described eutectic base mixtures were use to prepare "binary" mixtures in which the base mixture with smectic A_d properties constituted one component and the base mixture with the properties of smectic A_1 or E was the second component. In the course of preparation of these mixtures we kept to the rule that compounds contained in both combined bases have a similar chemical structure. Phase diagrams were plotted for the mixtures in the system: temperature - mean mole fraction of the combined bases (Figs. 1a and 1b).

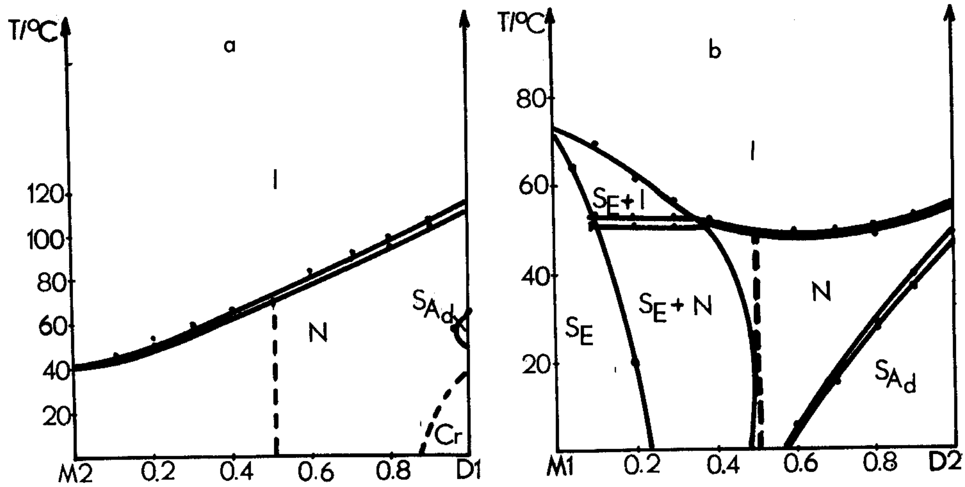


FIGURE 1. Phase diagrams of "binary" mixtures: (a) M2-D1 and (b) M1-D2.

Analysis of the obtained phase diagrams showed that such a mole ratio of the mixed bases can be established in which only the induced nematic phase exists in a wide temperature range. To test the usefulness of the nematic mixtures obtained in this way for application in liquid crystal twist type displays we selected mixtures with a equimolecular ratio of the base mixtures. The properties of these mixtures are summarized in Table 3.

The results of our research show that by selecting appropriately the smectic components of mixtures we can obtain nematic compositions with a wide temperature range of operation, relatively low viscosity, low threshold voltage.

TABLE 3. Principal properties of some nematic mixtures obtained from smectic compounds.

	M2D1 0.5	M1D2 0.5
T_{melt} (°C)	-30	0
T_{clear} (°C)	71.5	50
η (mPa·s), 25°C	24.0	19.3
Δn, 25°C	0.118	0.177
n_e, 25°C	1.613	1.700
$\Delta\varepsilon$, 25°C	11.73	9.24
$\varepsilon_{\parallel}$, 25°C	17.92	14.00
V_{10} (V), 25°C	1.2	1.7
V_{90} (V), 25°C	2.8	2.7
T_{on} (ms) 25°C, 3V		110
T_{off} (ms) 25°C, 3V		50

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