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REFRACTIVE INDICES, DENSITY AND ORDER PARAMETER OF SOME TECHNOLOGICALLY IMPORTANT LIQUID CRYSTALLINE MIXTURES

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ABSTRACT Temperature variation of the refractive indices, birefringence, density and order parameter of liquid crystalline mixtures E_7, E_8, N10 and PCH-1132 are reported. The birefringence of PCH-1132 is found to be abnormally low compared to other mixtures.

This letter reports the refractive indices (n_e, n_o), birefringence (Δn), density (ρ) and the order parameter (S) of four mesogenic mixtures E_7, E_8, N10 and PCH-1132 as a function of temperature. These mixtures are widely used in liquid crystal displays due to their suitable nematic range, stability and high positive dielectric anisotropy[1,2].

E_7, E_8 were purchased from M/s. BDH (England) whereas N10, PCH-1132 were purchased from M/s. E. Merck (Germany) in pure form and were used as such. E_7 and E_8 have similar composition i.e. these are the eutectic mixtures of three cyanobiphenyls and one cyanoterphenyl[1,2]. N10 consists of azoxy compounds and aromatic esters while PCH-1132 is a mixture of three cyanophenyl cyclohexanes with one cy-

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anobiphenylcyclohexane[2]. The transition temperatures were determined using a polarizing microscope and are listed below:

E_7	Solid	-10°C	Nematic	58°C	Isotropic
E_8	Solid	-12°C	Nematic	70°C	Isotropic
N10	Solid	9°C	Nematic	55.5°C	Isotropic
PCH-1132	Solid	-6°C	Nematic	70°C	Isotropic

The refractive index in the isotropic phase (n) and the ordinary refractive index (n_o) in nematic phase were measured using Abbe refractometer[3]. The birefringence (Δn) was measured using the modified wedge technique[3]. This technique essentially consists of the measuring the Fizeau fringe separation, Δx, in the air gap and the birefringence fringe separation $\Delta x'$ (reflection geometry), in the gap filled with liquid crystals material in the wedge formed by two glass plates. Δn is then given by the relation[3]

$$\Delta n = \frac{\Delta x}{\Delta x'}$$

The densi-

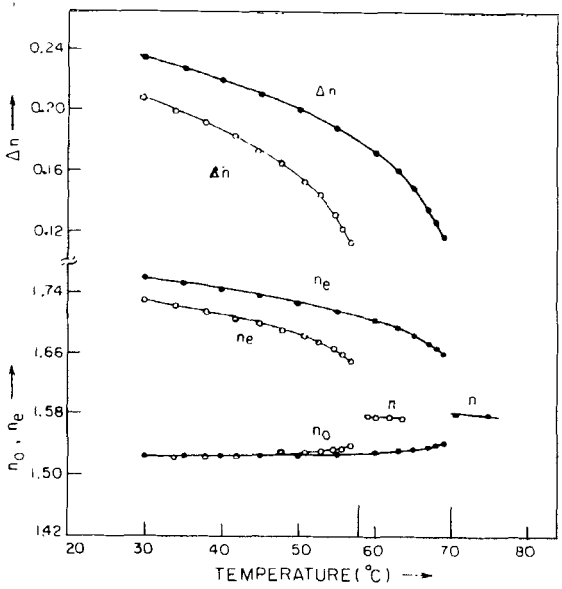

FIGURE 1. Temperature variation of n_o, n_e and Δn of E_7 (—o—o—) and E_8 (—•—•—), $\lambda = 5893$ Å.

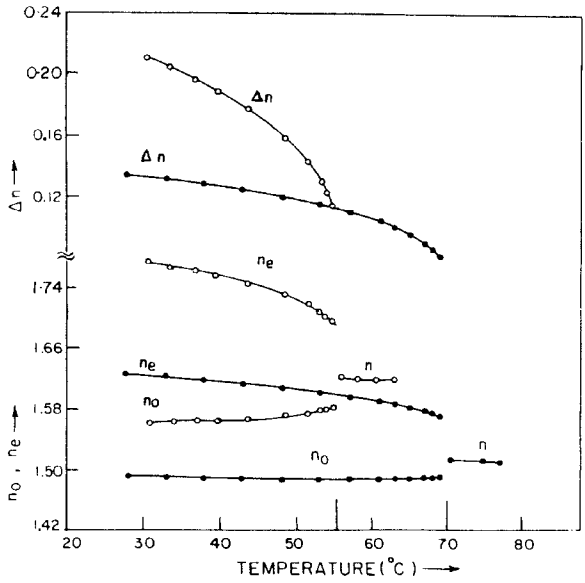

FIGURE 2. Temperature variation of n_o, n_e and Δn of N10 (—o—o—) and PCH-1132 (—•—•—) $\lambda = 5893\text{Å}$.

ty (ρ) was measured by dilatometric technique[3,4]. The temperature regulation was better than $\pm 0.1^{\circ}C$. The accuracies of n, n_o and Δn measurements are 0.1%, 0.1% and 0.5% respectively. The absolute accuracy of ρ measurement is $\sim$0.2% while the relative accuracy is better than $\pm$ 0.01%.

Temperature variation of n, n_o, n_e and Δn for E_7 and E_8 are shown in Fig. 1 while those of N10 & PCH-1132 are shown in Fig. 2. The measurements were carried out at the principal radiation of sodium ($\lambda = 5893\text{Å}$). The n_o and n_e of E_7 have also been recorded in its entire nematic range by Tarry[5] at 436 nm, 509 nm, 577 nm and 644 nm wave-lengths. Our values fit well in this series. In case of E8, N10, PCH-1132 too, the commercial firms have reported the value of Δn, but only at one temperature ($20^{\circ}C$)[2]. Our values at $20^{\circ}C$ are in good agreement with those reported by these

firms in case of E_7, E_8 and PCH-1132. However, in case of N10 there exists a small difference in values reported by us and M/s E. Merck. This may be due to significant differences in percentage composition of this mixture in various batches. These comparisons are listed in Table 1. n, n_o, n_e and Δn exhibit the normal behaviour of liquid crystals. The values of Δn for N10, E_8 and E_7 are of the same order and are much higher than those of PCH-1132.The polarizability anisotropy (and hence Δn) being mainly contributed by the polarizable  groups in these mixtures, it can be inferred on structural grounds that PCH-1132 should have much lower value of Δn as it contains one  group less. In PCH-1132 one highly anisotropic  group is replaced by  group, which has negligible polarizability anisotropy.

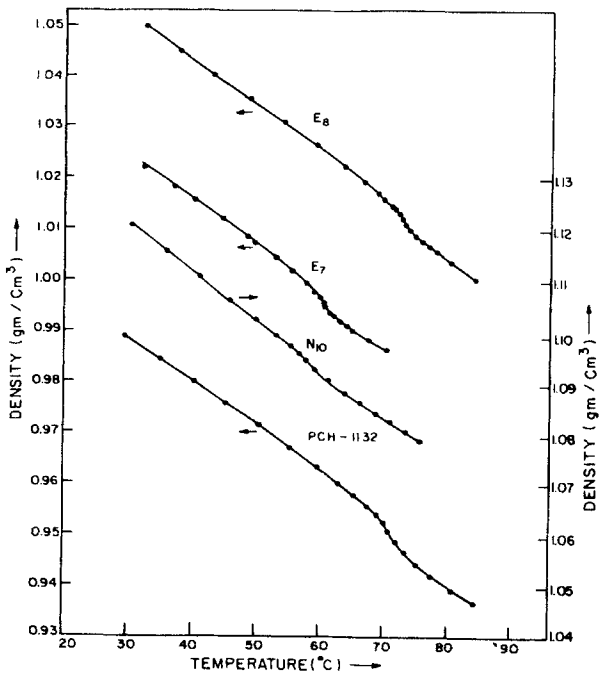

FIGURE 3. Temperature variation of the density of E_7, N10, E_8 and PCH-1132.

The density (Fig.3) shows the normal behaviour i.e. it increases with decrease in temperature.

TABLE I

(A) REFRACTIVE INDICES (n_o, n_e) OF E_7

Temperature (°C)	Values reported by Tarry[5]								Our Values at 589 nm	
	436 nm		509 nm		577 nm		644 nm			
	n_e	n_o	n_e	n_o	n_e	n_o	n_e	n_o	n_e	n_o
20	1.8208	1.5440	1.7737	1.5311	1.7500	1.5231	1.7354	1.5175	1.7450	1.5230
38	1.7898	1.5447	1.7456	1.5320	1.7238	1.5236	1.7104	1.5175	1.7190	1.5235
48	1.7656	1.5500	1.7238	1.5356	1.7030	1.5262	1.6904	1.5201	1.6980	1.5260
53	1.7452	1.5551	1.7057	1.5398	1.6860	1.5305	1.6739	1.5242	1.6827	1.5297
57	1.7174	1.5636	1.6821	1.5477	1.6639	1.5371	1.6521	1.5307	1.6601	1.5356
63(isotropic)	1.6136		1.5888		1.5761		1.5681		1.5750	

(B) BIREFRINGENCE (Δn) AND ORDER PARAMETER (S) OF E_7, E_8, N10 AND PCH-1132

Material	Δn at 20°C		Order Parameter (S) by Vuks Approach				by Neugebauers Approach			
	Reported by firms[2]	Our Values	25°C	30°C	50°C	65°C	25°C	30°C	50°C	65°C
E_7	0.225	0.222	.655	.635	.480	0.0	.670	.665	.530	0.0
E_8	0.247	0.245	.675	.655	.565	.425	.720	.705	.615	.485
N10	0.21	0.230	.620	.600	.430	0.0	.635	.615	.445	0.0
PCH-1132	0.14	0.141	.700	.690	.610	.490	.735	.730	.615	.430

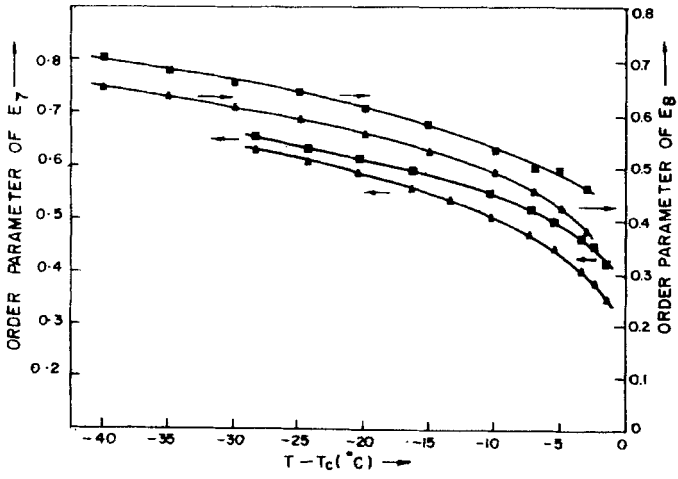

FIGURE 4. Temperature variation of the order parameter of E_7 amd E_8, ▲—▲ using Vuks approach; ■—■ using Neugebauer's approach.

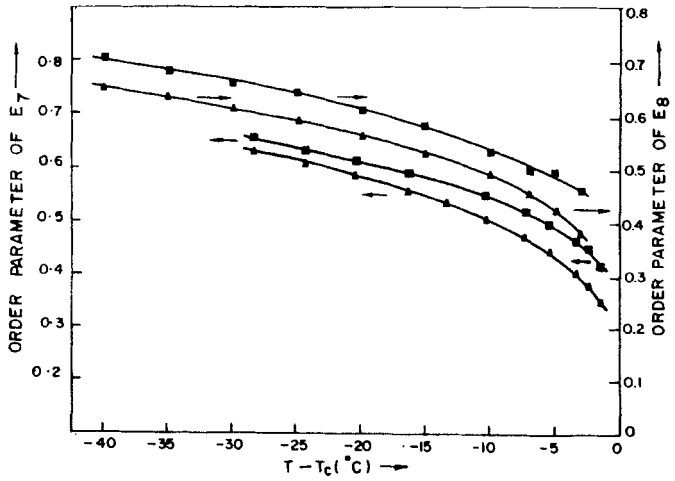

FIGURE 5. Temp. variation of the order parameter of N10 and PCH-1132, ▲—▲ using Vuks approach; ■—■ using Neugebauer's approach.

Abrupt jumps were observed in the vicinity of nematic-isotropic transition temperature which indicates that nematic-isotropic transition in all these materials is of first order, However, it is observed that the density jump at nematic-isotropic transition in these materials is not as sudden and sharp as in some pure mesogens.[4] The pre-transitional variations in density are observed on both sides of the transition though it is more pronounced on the nematic side.

Using refractive indices and density data, the order parameter is evaluated by both Vuks and Neugebauer's approaches.[3] The temperature variation of order parameter evaluated from the approaches is displayed in Fig. 4 and 5. It is clear from the figures that the order parameter evaluated from Vuks and Neugebauer's approaches are in good agreement.

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