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Thermo-optical studies of nematic liquid crystal mixtures

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Abstract Integrated optical transmittance (IOT) and differential scanning calorimeter (DSC) studies of two nematic liquid crystal mixtures ZLI-3497-100 and ZLI-3741) were made for phase transition measurements, during both heating and cooling cycles. Transition temperatures, transition enthalpies (ΔH) and entropies (ΔS) have been determined using DSC technique.

The IOT and DSC studies indicated good agreement for the transition temperatures for the both mesogens, which exhibited broad nematic – sotropic phase transition. The different peaks observed in IOT studies during phase transitions seems to correspond to different constituents of the mesogens.

Keywords IOT, DSC, phase transition, liquid crystal mixtures

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Introduction

Differential scanning calorimetry (DSC) [1, 2] has been a major ool to study the phase transition and thermodynamical properties of liquid crystals (LC). The transition phenomenon everely limits the useful range of liquid crystals for use in various device applications [3, 4]. The integrated optical ransmittance (IOT) is also used to localize the phase transition points. Various studies on phase transition behaviour of liquid crystals have been made [5-9] to understand the transition phenomenon. In the present work, we report the experimental measurements of IOT and DSC on two nematic mixtures ZLI-3497-100 and ZLI-3741. Using DSC data, transition temperature, ransition enthalpies (ΔH) and entropies (ΔS) have been stimated. The white light optical transmission study has provided the dynamic change in its percentage transmittance s a function of continuous change in temperature during both heating and cooling runs. The mixtures under study, were procured from M/s E-Merck, Germany. These LCs contain multi-component systems having molecules of different structures *viz.* cyano-biphenyls (CB), biphenylcyclohexane (BCH), phenylcyclohexane (PCH), cyclohexyl cyclohexanes (CCH), aromatic esters (AE) *etc.*

2. Experimental details

2.1. IOT:

The nematic-isotropic transition temperature of the mixtures were determined using a polarizing microscope fitted with a hot stage arrangement in which a shielded light dependent resistance (LDR) monitors transmitted light [7]. Sample holder consists of a glass-slide and cover slip combination, the temperature of which is regulated by keeping it in an electrically powered hot stage, driven by a variac. Both cover-slip and glass-slide are

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unidirectionally PVA (Polyvinyl alcohol) aligned to induce homogeneous alignment of sample. Temperature of the sample is measured, by a copper-constantan thermocouple. Temperature was stable to an accuracy of ± 0.1°C as controlled by Shimaden micro-controller (SR 7 1B/8Y 1/10).

2.2 *DSC:*

Thermodynamical study of the samples were made using a Perkin-Elmer Differential Scanning Calorimeter (model DSC-7) which has a built-in soft-ware **'PEAK'** to determine the peak transition temperature, the on set temperature and the transition enthalapy (ΔH). The calorimeter was allowed to run at the scanning rate of 5°C/ min. in the temperature range 70°C – 125°C. Maximum accuracy in the transition temperature is ± 0.1°C.

3. Results and discussion

Figure 1 shows typical DSC plots of heat flow in mW with temperature in °C in both heating and cooling runs of ZLI-3497-100 and ZLI-3741 respectively at the scanning rate (SR) of 5 °C/ min. The peak transition temperature (Tp), the differences of ending (Te) and starting temperatures (Ts), transition enthalpies (ΔH) and transition entropies (ΔD) in heating and cooling ru are given in Table 1.

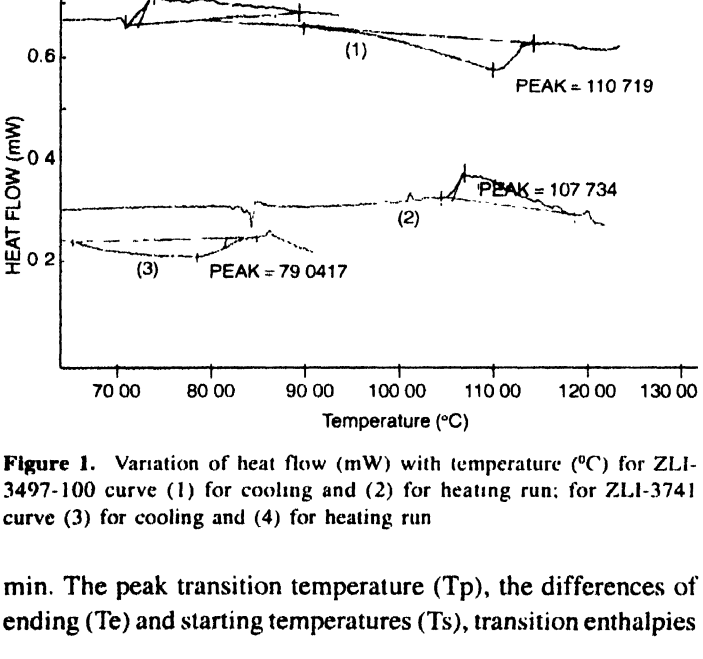

Figure 1. Variation of heat flow (mW) with temperature (°C) for ZLI-3497-100 curve (1) for cooling and (2) for heating run; for ZLI-3741 curve (3) for cooling and (4) for heating run

The DSC study on ZLI-3497-100 has clearly identified th transition peaks at 107.73°C for heating run and 110.71°C fo cooling run with transition enthalpies 0.6834 and 1.1923 J/gr and entropies 0.001795and 0.00310 J/gm °K respectively fo heating and cooling cycles. For ZLI-3741, the transition peak are at 76.34 °C for heating run and 79.04°C for cooling ru exhibiting the enthalpies 0.6690 and 1.3774 J/gm and entropie 0.00191 and 0.00390 J/gm°K for heating and cooling cycle respectively. During heating, the peak transition temperatur agree quite well with the literature values [10].

Figure 2 shows optical transmission (rate of change of LD resistance dR/dT) *versus* temperature of the samples. Here th scanning rate was <1°C and temperature was measured to a accuracy of ± 0.1°C. Measurements were taken for heating an cooling cycles. The transition temperatures of the mixture ZLI 3497-100 and ZLI-3741 were not as sharp as in a single componer such as EBBA [7]. The breadth of nematic-isotropic phas transitions in ZLI-3497-100 was found to vary between 96 109° C for heating cycle, and between 99° C- 110°C for cool cycle; while in ZLI-3741 this breadth was 75°C-85°C for heatin cycle and 74° C–84° C for cooling cycle.

Such a behaviour of phase transition over a temperatur width in a mixture, has also been observed earlier in many mixtur [9, 11- 14]. Demus *et al* [12] concluded that the breadth of t transition depends upon purity of the substance and increase with lower purity. The different peaks in Figure 2 migh correspond to different components present in the mixture The preliminary data sheet of the mixtures indicate that ZLI 3497-100 contains five components: PCH/BCH/CCH/ CBC/AE while ZLI-3741 contains- PCH/BCH/ CBC only three components Thus, the five peaks observed in ZLI-3497-100 and three peaks in ZLI-3741 seem to correspond to their components. Different components in the mixture may behave as impurities with respect to each other and thus cause a broad phase transition (multi-phase region). The N-I transition temperatures using IOT (giv in Table 1) agree fairly well with the peak transition temperatures using DSC.

Table 1. Transition temperature by IOT and thermodynamical data of samples from DSC measurements.

	DSc						IOT		Lit
Sample	Cycle	Ts (Tstart) °C	Tp (T peak) °C	Te (Tending) °C	ΔH (J/gm)	ΔS (J/gm°k)	Ts - Te °C	N-I Transition °C	Literature values (16) °C
ZLI-3497-100	Heating	105.38	107.73	119.42	0.6834	.001795	96-109	109	107
	Cooling	88.50	110.71	115.41	1.1923	.00310	99-110	110	
ZLI-3741	Heating	74.93	76 34	83.87	.6690	.00191	75-85	85	73
	Cooling	66.72	79.04	84.86	1.3774	.00390	74-84	85	

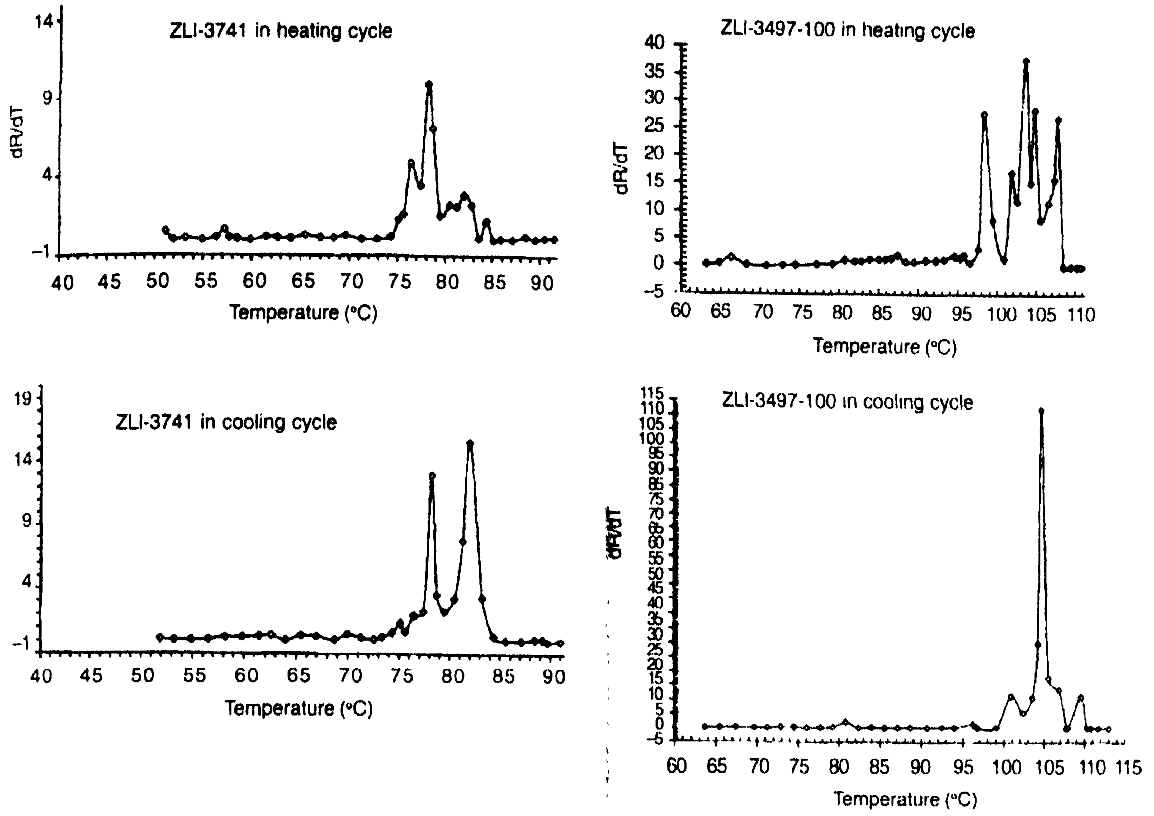

Figure 2. Temperature T (^{0}C) dependence of rate of change of LDR resistance (dR/dT) for ZLI-3497-100 and ZLI-3741 in heating and cooling cycle.

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