

CHAPTER - 9

SUMMARY AND CONCLUSION

Liquid crystals are being increasingly used in display devices due to their extremely low power consumption. The knowledge of physical properties of a liquid crystal is essential for its application in a device. In the present dissertation I have reported the physical properties of different liquid crystalline samples as observed from x-ray diffraction, optical birefringence and elastic constant measurements. I am giving below, in a nutshell, the salient features of the different works undertaken by me.

A short review on the different types of liquid crystals especially, thermotropic liquid crystals, has been presented in chapter 1. Interest in liquid crystals in recent years has increased markedly leading to the discovery of more and more of exotic liquid crystalline mesophases in systems ranging from polymers to biological complexes. Since, it is impossible to cover all the mesophases and their peculiarities, I have concentrated only on those studied by me, namely the nematic, smectic A, smectic C and smectic B phases, and referred a few works which cover other aspects of liquid crystal research.

In chapter 2, I have described briefly the different theories of liquid crystals that have been tested in this dissertation. Detailed description of the x-ray diffraction technique and the analysis of the x-ray data leading to the values of orientational, translational and bond orientational order parameters, correlation length, layer thickness etc. has been given. A method to correct the experimental x-ray intensity data for finite width of the x-ray collimator and to analyse the corrected x-ray intensity profiles for correlation length determination has been given. Experimental procedure for the refractive index measurements by a thin prism method, as well as the method for calculation of the orientational order parameters

from this data have been outlined in this chapter. The bend and splay elastic constant measurements, the data analysis and the technique of preparing aligned samples have been treated.

In chapter 3, the orientational order parameters (OOP) in the smectic C and nematic phases of heptyloxyazoxybenzene (HAB) have been determined from x-ray diffraction and refractive index studies. Order parameters determined from x-ray studies have been corrected for the random orientation of the director in a cone in the smectic C phase of HAB. The orientational order parameters $\langle P_2 \rangle$ and $\langle P_4 \rangle$ as determined from x-ray diffraction studies are found to differ significantly from those calculated from refractive index measurements. Reason for this has been attributed to the different modes of alignment of the sample in the two methods. The transverse correlation length ξ was found to diverge near the smectic C - nematic transition temperature indicating that the transition is of second order. This trend has also been supported by density and refractive index measurements.

In chapter 4, results of small angle x-ray diffraction data from aligned samples of three bicyclohexane compounds (BPBCH, VPBCH and EPEBCH) in smectic B and nematic phase have been analysed to determine the Bond Orientational Order (BOO), Orientational order parameters (OOP), translational order parameter (TOP), layer thickness (in smectic B phase), apparent molecular length (in nematic phase) and lateral molecular distance as function of temperature. Bond orientational orders in the smectic B phase of these compounds are found to be nearly perfect and almost temperature independent throughout the phase. The smectic B phase of these compounds has been characterised to be of the crystal B type. Correlation lengths in the smectic layer plane have also been estimated. The experimental OOP and

TOP values have been compared with McMillan's theory. From the temperature dependences of the orientational order parameters, layer thickness (d) in the smectic B phase or apparent molecular length (l) in the nematic phase and inter molecular distance (D) the order of the smectic B - nematic/isotropic and nematic/smectic B - isotropic phase transition has been found to be of the first order.

I have measured the refractive indices and densities of the three bicyclohexane alkenyl/alkenyloxy compounds, studied in chapter 4, in smectic B and nematic phases, results of which have been presented in chapter 5. These values of refractive indices and densities have been used to calculate orientational order parameters in both smectic B and nematic phases. These order parameter values have been compared with those previously obtained by me for these mesogens from x-ray diffraction studies (Chapter 4). Reasons for discrepancy between the two sets of order parameter data have been discussed. For two of these compounds, the density change at smectic B-nematic transition is significantly greater than that at the nematic-isotropic transition. This implies greater entropy change at the smectic B-nematic transition than nematic-isotropic transition for these mesogens.

I have undertaken small angle x-ray diffraction study of 4-n-HeptyloxyBenzylidene - 4' - AminoAzoBenzene (HBAAB) in chapter 6. HBAAB has nematic, smectic A, smectic B and three crystalline phases. From x-ray diffraction studies of the aligned mesomorphic phases, the orientational order parameters ($\langle P_2 \rangle$ and $\langle P_4 \rangle$), transverse correlation length (ξ), translational order parameter (τ) and layer thickness in the smectic phases or apparent molecular length in the nematic phase and intermolecular distance have been calculated as function of

temperature. Both nematic - smectic A (NA) and smectic A - smectic B (AB) phase transitions are found to be of the first order. The HBAAB molecules remain in the fully extended form throughout the mesomorphic range and the smectic layers are mono molecular. Orientational order parameter values in the nematic and smectic A phases have been fitted satisfactorily with the calculated values from McMillan's theory with $\alpha = 0.45$ and $\delta = 0.595$. Refractive indices (n_o and n_e) have been measured in the nematic phase and $\langle P_2 \rangle$ calculated using both Neugebauer's and Vuk's formulae. These $\langle P_2 \rangle$ values agree within experimental uncertainties with those obtained from x-ray studies. Experimental enthalpy changes, obtained from DSC studies, have been compared with those calculated from McMillan's theory. While agreement between experimental and calculated enthalpy change at Sm A-N transition is quite good, the experimental enthalpy change at N-I transition is much smaller than the theoretical value. The density measurements also show a very small density change at the N-I transition, making it weakly first order.

Orientational order parameters $\langle P_4 \rangle$, $\langle P_6 \rangle$ and $\langle P_8 \rangle$, as calculated from the x-ray diffraction studies done in our laboratory, with aligned samples of nematogens, have been compared with the predictions of Faber's continuum and Maier - Saupe mean - field theories in chapter 7. In contradiction with previous findings regarding $\langle P_2 \rangle$ and $\langle P_4 \rangle$, the agreement with Faber's theory is not good. However, experimental inaccuracies and truncation errors during calculations preclude any definite conclusion in this matter.

The ratio of the bend to splay elastic constants of a binary liquid crystalline mixture (5CB/ME60.5) which show injected smectic phase, has been determined by Fredericksz transition in nematic phase, results of which have been reported in the last

chapter (chapter 8). It has been found that K_3/K_1 values show a divergence as the injected smectic phase is approached. The K_3/K_1 values also show a minimum near equimolar concentration, which is similar to the minimum in other physical properties of this mixture at this concentration found by previous workers. Magnetic susceptibility data at different compositions of this mixture will help in further understanding of this system.