ABSTRACT

LIQUID CRYSTAL is a thermodynamic stable phase characterized by anisotropy of properties, lying in between crystalline solid and isotropic liquid and hence termed as mesophase. As research into this field continues and applications for this special kind of materials are still being discovered, liquid crystals will play an important role in many areas of science and technology. The most common application of liquid crystal technology is liquid crystal displays (LCDs). Performance of a liquid crystal (LC) display device depends on the nature of the LC material and the construction of the device. Fluoro-substituted LC materials are found to be useful in large information content display devices. High birefringence liquid crystals are important for fast switching display and various other applications like laser beam steering, tunable color filters, focus tunable lens, electrically controlled phase shifter in GHz and THz region. Besides Ferroelectric liquid crystals (FLCs) are very promising due to their various interesting basic properties. FLCs are also effective for fast switching electro-optical displays with wide viewing angle. Keeping all this in view, nine fluorinated achiral and 3 fluorinated chiral (ferroelectric) liquid crystalline compounds have been selected for investigation. Various physical properties have been studied using optical polarizing microscopy, X-ray diffraction, optical birefringence, dielectric spectroscopy and electro-optic methods.

The first Chapter of this thesis contains a brief introduction to liquid crystal (LC) physics, which includes a description of different types of ordering as well as the effect of fluorination on liquid crystalline materials. In the second Chapter all relevant experimental procedures and theoretical back-grounds have been described in details.

Two doubly fluorinated (2TP-3',3F-4NCS, 4TP-3',3F-4NCS) and one singly fluorinated (2TP-3'F-4NCS) isothiocyanato terphenyl compounds exhibiting a broad range of nematic phase were investigated by X-ray, dielectric and optical methods and compared with their properties to see the effect of fluorination and chain flexibility. Contrary to common perception, weak antiparallel correlation of isothiocyanato molecules is observed in each compound both from X-ray and dielectric studies. All the compounds exhibit high birefringence (0.373 - 0.331). They also show high order parameters at low temperatures. These results have been described in Chapter 3.

Chapter four deals with dielectric behavior of six fluorinated bicyclohexyl compounds (3ccp-f, 3ccp-ff, 3ccp-fff and 5ccp-f, 5ccp-ff, 5ccp-fff) and crystal structure analysis of one of them (5ccp-fff). It is observed that as number of fluorine increases threshold voltage (V_{th}) as well as driving voltage (V_d) decrease considerably in both the series (3ccp series & 5ccp series) while with increasing chain length V_{th} and V_d increases slightly except in triply fluorinated compound. Dielectric anisotropy increases as number of fluorine atom increases in a particular series. The splay elastic constant (K_{11}) is found to exhibit similar decreasing trend with temperature as observed in dielectric anisotropy. Only one strong dielectric absorption process is exhibited by the compounds which were almost Debye type.

In Chapter five, two partially fluorinated ferroelectric liquid crystals (4F3R, 4F6R) are investigated by X-ray diffraction, dielectric relaxation spectroscopy and electrooptic techniques. One of the compounds possesses SmC^* phase and the other possesses SmC^* phase as well as SmC_A^* phase. Tilt angle, measured by X-ray and optical methods are found to be high. Only Goldstone mode relaxation process is observed. Increase of dielectric strength and critical frequency with temperature has been explained in the light of generalized Landau model. No soft mode is observed since the compound directly melts into isotropic phase. Both of them possess moderate value of spontaneous polarization and the data fitted nicely to mean-field model. Fitted critical exponent (0.29 and 0.33) suggests that SmC*-I transition is first order which is supported by DSC measurements. The compound 4F3R induces ferroelectric phase even below room temperature when mixed in a proper host mixture.

In Chapter six, phase behavior, structure and molecular dynamics of a chiral liquid crystalline compound, which exhibits SmG*, SmJ*, SmF*, SmI*, SmC*, SmA*, N* and BP*, have been presented. Observed optical textures, synchrotron radiation diffraction data and frequency dependent dielectric spectroscopic study clearly depict the temperature evolution of the different hexatic smectic phases along with cholesteric and blue phase in a single compound. In hexatic phases dielectric absorption spectra show one low frequency relaxation process, related to the phase fluctuation of the bond orientational order, and one high frequency process related to amplitude fluctuation of the bond orientational order coupled with the polarization and tilt of the molecules. Goldstone and soft mode relaxation processes are detected, respectively, in SmC* and SmA* phases.

Conclusions of all the experimental results have been summarized in Chapter seven.