Abstract

Due to the coexistence of liquid-like fluidity with conventional solid like anisotropy, liquid crystals exhibit unique optical, dielectric or elastic properties which make them suitable for a variety of technical and scientific applications, especially in display devices. The dielectric and electro-optic properties of these materials, along with their phase behaviour, are of immense importance from application perspective. It's essential to know the said parameters, to decide whether a LC compound is fit to be used in display devices or not. Moreover, the study of the phase behaviour of liquid crystal materials, which can typically have various mesophases with different structures within a short temperature range, may help us to comprehend the physics behind the different kind of phase transitions in such compounds.

Though traditionally nematic liquid crystals are used in the most LCDs but they have higher response time and thus are unsuitable for fast display applications. Chiral liquid crystals may have ferroelectric or antiferroelectric mesophases for which the response time is sharper. Thus chiral liquid crystals are of current interest for display technology.

Keeping these in mind we have chosen eight chiral liquid crystal compounds (**1F3R, 2F3R, 3F3R, 5F3R, 6F3R, 4F4R, 4F5R** and **7F3R**) to study their phase behaviour and dielectric, electro-optic characteristics. For a few of them synchrotron X-ray diffraction study has also been performed to explore their structural behaviour. All the selected compounds have biphenyl benzoate core and fluorinated chains. The biphenyl benzoate core normally ensures higher thermal stability often with wide range low temperature ferroelectric and antiferroelectric

phases and chiral liquid crystals with fluorinated chain usually exhibit enhanced spontaneous polarization, higher dielectric anisotropy, lower optical anisotropy which are beneficial for display applications.

Since all the compounds, selected for investigation, have the same back bone differing only by the number of carbons and the number of oligomethylene spacers in the fluorinated chain, efforts have been made to explore a relationship of their phase behaviour and dielectric, electro-optic, structural properties with change in their molecular structures. Also to see the efficacy of the compounds in formulating mixtures suitable for display applications, one multi-component mixture has been prepared using 7F3R as dopant and its various properties have been investigated.

The compound 1F3R, with least number of carbon atoms in the chain, has only orthogonal phases. Tilted phases are induced when one extra carbon is added in the fluorinated chain (2F3R) and sustained in all other compounds. Hexagonal phases are observed only in 1F3R (orthogonal), 2F3R (tilted) and 3F3R (tilted), but not in higher homologous. SmA* phase is observed in 1F3R and 2F3R but is found to disappear in higher homologous and re-entered in the phase sequence of the longest compound 7F3R. A new smectic *subphase*, termed as SmX* phase, has been observed in 4F4R. All compounds except 1F3R have SmC* phase and the temperature span of that phase (ΔT_{SmC}^{*}) increases with chain length except in 4F4R which might be due to the presence of the *subphase* SmX*.

In the Frequency dependent dielectric relaxation study non-collective mode of relaxation is observed only in the SmE*, $SmB_{hex}^{*\,mo}$ and, $SmB_{hex}^{*\,lo}$ phases of 1F3R which exhibited short axis rotation mode in those phases. In SmF* phase of 2F3R and 3F3R both bond orientation

order phason and tilt phason relaxations are observed, to the best of our knowledge for the first time in a single compound. In all compounds having only SmC* phase, Goldstone mode relaxation is observed in that phase but no soft mode. In nF3R compounds the Goldstone mode critical frequencies are found to increase with chain length. However, after addition of extra oligomethylene spacers it decreases. Soft mode relaxation is observed only in 2F3R and 7F3R throughout the SmA* phase and also in SmC* phase in the vicinity of SmC* to SmA* transition. From the absence of soft mode relaxation in all compounds having only SmC* phase it is concluded that in absence of any orthogonal to tilted phase transition soft mode relaxation cannot be observed.

The shortest three compounds (1F3R, 2F3R, 3F3R) and the longest one (7F3R) have also been investigated by synchrotron X-ray diffraction technique. Existence of two variants of SmB* phase has been confirmed in 1F3R along with SmE* and SmA* phases. Cell parameters of 1F3R in SmE*, $SmB_{he}^{*\,mo}$ and $SmB_{hex}^{*\,lo}$ phases are determined and a hexagonal lattice with herringbone structure has been confirmed in these phases. All the phases of 1F3R are found to be partially bilayer type, which has been observed for the first time in a chiral system. Tilted hexagonal phases - SmJ* and SmF* - in 2F3R while SmG* and SmF* in 3F3R have been identified and cell parameters of these phases have also been determined. A coexistence phase of (SmC*+SmF*) has also been observed. The SmA* phase of 2F3R and 7F3R is found to have de Vries type characteristics.

All the compounds have moderate value of spontaneous polarisation (P_S). In nF3R series of compounds the spontaneous polarisation (P_S) is found to increase with the molecular length. However, P_S in SmC* phase

is observed to increase significantly after addition of oligomethylene spacer and possesses the highest in 4F5R.

Micro second range response time (τ) is observed in all the compounds, however, in 2F3R the response is found to be the fastest. In nF3R compounds, the response times exhibit an inverse correlation with the molecular dipole moment, except in 7F3R. However, addition of oligomethylene spacers results in slower response, being the slowest in 4F4R.

Rotational viscosity (γ_φ) is found to be lowest in 2F3R which also showed smallest response time. Among the compounds nF3R, rotational viscosity (γ_φ) initially increases with chain fluorination and reaches the highest value in 5F3R then it decreases again. γ_φ is found to be highest in 4F5R.

Finally a ferroelectric liquid crystal mixture has been formulated by doping 7F3R in an achiral pyrimidine based host mixture. The mixture is found to exhibit ferroelectric SmC* phase over a wide temperature range from below room temperature and then shows SmA* phase before melting into isotropic phase. The SmA* phase is found to have partial de Vries type property as well as electroclinic effect. It is found to possess moderate spontaneous polarization. Optical tilt of around 20° at room temperature and a response time of a few hundred microseconds make the mixture suitable to use in SSFLCDs.

Most of the results have been published in journals of repute.