

ABSTRACT

Now-a-days displays have become a field of tremendous importance as they provide the best means for interface between man and machine. Large numbers of displays are presently available in the market, but among all these displays about 90% are controlled by the liquid crystal display (LCD) technology. Most of the LCD devices starting from simplest wrist watches or calculators to complex laptops or flat TV sets mainly use the nematic liquid crystal phase for their operation. Although a tremendous improvement in the quality of display as well as reduction of manufacturing cost has taken place over the years, there are many issues which the LC industry is trying hard to address. Ferroelectric liquid crystals (FLC) are of current interest in the LCD industry since among various other advantages FLC based displays have micro-second order switching compared to milli-second order switching in nematic based displays. To meet the market demand much effort has been made to optimize the physical parameters of FLCs, such as temperature range, spontaneous polarization (P_s), helical pitch (p), switching time (τ), tilt angle (θ) and rotational viscosity (γ_ϕ). Multicomponent mixtures are, usually formulated to optimize all the required properties for practical applications since no single FLC compound can satisfy the above requirements. Keeping all these in mind we have prepared room temperature ferroelectric and antiferroelectric liquid crystal mixtures to the best of our knowledge first time by any Indian group, which have properties suitable for FLC based display devices and at par with mixtures used in the industry. Suitability of the formulated mixtures for display applications were characterized by optical polarizing microscopy, differential scanning calorimetry, synchrotron X-ray diffraction, dielectric spectroscopy and electro-optic methods.

First of all, six binary mixtures (**M1-M6**) were formulated by using a biphenyl benzoate ester with oligomethylene spacer based non-fluorinated chiral compound (**DP1**) as dopant and a three ring pyrimidine compound (**H5**) as host. Of these, **M4** exhibit the wide range (100°) and lowest temperature (24°C) ferroelectric phase at 10wt% concentration of **DP1**. In addition to I-N*-A*-C* phase sequence all the mixtures found to exhibit weakly temperature dependent optical tilt ($\sim 22.5^{\circ}$) and fast response time ($\sim 200\mu\text{s}$), can be useful for high speed SSFLCD applications where contrast and brightness will be less temperature dependent. Temperature range and response time are also found to improve when the binary mixture **M4** is used as chiral dopant in a multi-component host mixture (**HM**) to formulate another mixture (**M7**).

Next, six multi-component mixtures (**M8-M13**) were prepared by doping a non-mesogenic chiral terphenyl compound (**DP2**) with chiral centers at opposite ends in the multi-component host mixture (**HM**). This **HM** was prepared mixing four phenyl pyrimidine compounds. Although **DP2** is non-mesogenic but only 2wt% of it induces SmC* phase in the **HM** at or close to room temperature and with increased concentration it produces SmC* phase below ambient down to at least 12°C with physical properties useful for SSFLCD based applications.

An oligomethylene spacer based partially fluorinated chiral liquid crystal (**DP3**) which has smaller spacer length than **DP2** and which has only SmC* phase when doped in the **HM**, resulting mixture (**M14**) was found to exhibit very broad temperature range SmC* phase ($\sim 93^{\circ}$) from below ambient down to at least 12°C and almost temperature independent high optical tilt, low driving voltage and switching speed around $100\mu\text{s}$ suitable for display applications.

To study the effect of SmC*_A- SmC*- SmA* phase sequence and molecular structure, four partially fluorinated chiral compounds **DP4**, **DP5**, **DP6**, **DP7**,

which differ only in the number and position of fluorine atoms in the benzoate ring of the molecular rigid core, were doped in the multi-component host mixture (**HM**). Number and location of fluorine atoms in the dopant structure shows significant effect on the phase sequences as well as on the different physical properties of the mixtures (**M15-M18**) critically important for display applications. Mixture **M15** and **M18** showed extended antiferroelectric phase while **M16** and **M17** exhibited only ferroelectric phase.

A wide range room temperature electroclinic mixture, **M19** was obtained when only 10wt% of **DP6** was mixed in the **HM**. The mixture exhibits large field induced optical tilt ($\sim 23.5^\circ$) with less than 0.1% shrinkage of layers suitable for developing fast electroclinic devices free from defects due to buckling of layers.

Most of the results have been published in the peer reviewed journals viz; Journal of Applied Physics, Journal of Molecular Liquids, RSC Advances, Liquid Crystals.