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Electro-optic investigations on ferroelectric and silica nanoparticles doped ferroelectric liquid crystal mixtures

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Dispersed liquid crystal composites have attracted significant interest among scientific community due to their practical and technological applications in various fields including displays. In this work, a ferroelectric liquid crystal and silica nanoparticles doped ferroelectric liquid crystal composites are studied in SmC* phase. The effect of doping and temperature on the spontaneous polarization, switching time and viscosity of FLC are investigated in thin planar sample cell of thickness 9 µm. The doping of silica decreases the polarization and increases the switching time. The viscosity of the sample also changes after dispersion of silica nanoparticles.

Keywords: Ferroelectric liquid crystal, Silica nanoparticle, Polarization, Switching time.

1 Introduction

Dispersed liquid crystal composites have attracted significant interest among scientific community due to their practical and technological applications in various fields including displays [1-5]. In recent years, dispersion of nanoscale materials in liquid crystals (LC) has shown unique features and promising applications. Dispersion of metallic, semiconducting, and oxides NPs (CdSe, $BaTiO_3$, $Sn_2P_2S_6$, Au, ZnO, etc.) into LCs have created tremendous interest due to thermal and electrical properties of NPs [6-13]. Among the various type of NPs, silica nanoparticles in LCs are novel functional materials. In the initial age dispersion of NPs into Nematic LCs was focused on the dielectric and its phase transition temperature studies. In the present work, an attempt has been made to study the effect of silica nanoparticle on electro-optic parameters of FLC in a thin planar cell.

2 Experimental

A ferroelectric liquid crystal mixture (KCFLC10R) (obtained from Kingston Chemicals, UK) [17] has been used in present investigation. FLC material has a phase sequence as

$$K \xleftrightarrow{5°C} SmC^* \xleftrightarrow{64.5°C} SmA \xleftrightarrow{99.5°C} N^* \xleftrightarrow{112°C} I$$

Metallic nanoparticles (Silica) (purchased from M/S Sigma Aldrich, India) of particle size 30-40 nm were used for dispersion into FLC. Silica NPs in a fix concentration (0.05%, wt./wt. of FLC) was doped into FLC mixture. The homogenize mixture of SNP and FLC was obtained at room temperature by manually mixing and then ultrasonication was done slightly at higher isotropic temperature of FLC at a frequency of ~30 kHz for two hours. Planar aligned cells, each of thickness 9 µm consisting of indium tin oxide (ITO) coated glass substrates were used for electrooptic studies. For alignment purpose, a solution of nylon 6/6 and m-cresol was spin coated on ITO coated glass substrates and then uni-directionally rubbed. The prepared homogenized mixtures was filled in empty sample cells by the well-known capillary action at the

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isotropic temperature of FLC. Filled sample cells was placed in a hot stage (model THMS600) attached with temperature controller (Linkam TP94). Electro-optic measurement was done using field reversal technique.

3 Results and Discussion

Electro-optic measurement:

The spontaneous polarization (P_s) and switching time (τ) parameters were measured using a field reversal technique. The details of technique is given elsewhere [19,20]. A symmetric triangular wave was applied to the cell to reorients the existing dipoles between two stable polarization states. A series resistance of 200 kΩ was also used. In the ferroelectric SmC* phase, for a fix voltage the current I(t) consist of three major parts: the capacitance term (I_c) and the ionic conductivity term (I_R). The third term is the polarization current (I_P) which occurs due to the charge induced by the dipole realignment in the form of a polarization hump. Total current can be expressed by

$$I(t) = (I_R) + (I_c) + (I_P) \tag{1}$$

The area under the appeared hump is a measure of P_s and given by $P_s = \dfrac{A(V \times t)}{R}$ (2)

where $A(V \times t)$ is the area under the curve and R is an active electrode area of the LC cell.

The switching time is also measured by applying a square wave of sufficient amount of electric field. The output signal was recorded on DSO (Model TDS 2024). The temperature dependence of spontaneous polarization at ~10$V_{p\text{-}p}$ is shown in Fig 1.

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