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INVESTIGATION OF THERMODYNAMIC AND ELECTRO-OPTICAL PROPERTIES OF ANISOTROPIC MEDIA DISPERSED WITH BARIUM TITANATE NANOPARTICLES

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Abstract- Admixture was prepared by dispersing barium titanate nanoparticles into a multi-component anisotropic media having wide range room temperature nematic phase. The thermodynamic and electro-optical properties of the composite sample were studied along with pristine materials. Effect of NPs dispersion on various display parameters of nematic liquid crystals has been observed. The host liquid crystals have nematic ordering which supports alignment NPs parallel to the liquid crystals director; which consequently improves electro-optical parameters of the composite system.

Keywords – Anisotropic, Nanoparticles, Composites, Display parameters, Electro-optical properties.

I. INTRODUCTION

Liquid Crystals (LCs) are fascinating organic materials being unique in their properties such as directional anisotropy like crystals and fluidity like ordinary liquids [1]. In the last fifteen years, a tiny inclusion of carbon nanotubes, nano particles [2], and quantum dots [3] into LCs medium have been studied. Composite materials consisting of LCs dispersed with nanoparticles (NPs) have indeed attracted considerable scientific and technological interest, mainly because the incorporation of NPs enhances the electro-optical properties of the liquid crystals itself with ease of alignment of composites [4]. There are studies in which inclusion of metal NPs in LCs have changed the electro-optic response and other physical properties of the host medium [5]. There are some reports which show that inclusion of ferroelectric NPs in LCs have changed the electro-optic response and alter the surrounding molecular alignment [6-9]. The suspension of ferroelectric NPs can lead to enhancement of the orientational order of the LC medium due to the electrostatic interactions between the NPs and the LC molecules. Therefore, dispersions of NPs having ferroelectric properties might improve physical parameters of LCs which could be used in electro-optic devices. On the other hand, assembly and reorientation of ferroelectric NPs could be achieved in LC medium by applying external stimulus for example electric field. In the present work, we have prepared a composite by dispersing ferroelectric Barium Titanate (BT) NPs into a room temperature nematic liquid crystalline material and studied the alignment of BT-NPs into LCs medium. Further we have investigated the thermodynamic, electro-optic and dielectric properties of the composite along with pristine LCs which is reported here.

II. EXPERIMENTAL TECHNIQUES

A liquid crystalline material has been procured from Merck, India. BT-NPs have been procured from Merck and are used. The sizes of dispersed BT-NPs are less than 50 nm. The composite is prepared by adding a small weight percentage of BT-NPs (0.02%) in the nematic liquid crystalline materials. Homogeneous dispersion of BT-NPs in LCs matrix and their alignment are examined under a Polarized Optical Microscope (POM) with magnification

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(×200). For electro-optic and dielectric measurements, the LCs and composite are filled in the cells by capillary action. The cells have been made in the form of parallel plate capacitor using indium tin oxide (ITO) coated glass electrodes. To measure the transmission intensity, white light was passed through the cell and intensity was recorded by a photo-detector and corresponding photo-voltage was measured with a Multimeter.

III. RESULTS AND DISCUSSION

Electro-optical studies:

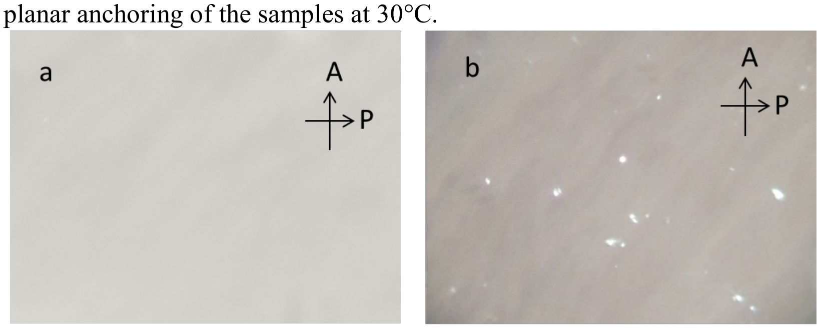
The transmission-voltage (T-V) characteristics of the pristine NLCs and BT-NPs dispersed system is carried out by applying an alternating voltage of 1 kHz with varying amplitude across the planar anchored cells and thereby measuring the intensity of transmitted light by a photo diode. By recording transmission intensity with applied field, T-V characteristics of the samples were drawn and shown in Fig 2. Threshold voltage was determined from the drawn T-V curves. These experiments were performed at room temperature. When the applied voltage was initially low, the LC molecules lie in the plane of the cell substrate because of the anchoring conditions and due to this bright state is obtained which correspondence to the maximum intensity on T-V curves. This state continues from low voltages up to 0.50V for pure NLC and 0.35V for 0.02% BT-NPs composite. On further increasing the amplitude of applied voltage steadily, intensity of transmitted light reduces gradually and finally minimum intensity was observed. The minima of transmitted intensity are referred to the dark state for respective samples which happens due to the electrical switching or reorientation of LC molecules perpendicular to glass electrodes. This phenomenon is called Fredericks transition which is independent of sample thickness. Threshold voltage (V_{th}) is

$$V_{th} = \pi \left(\frac{K_{11}}{\varepsilon_0 \Delta \varepsilon'} \right)^{\frac{1}{2}} \quad (1)$$

Where ε_o (=8.85 pF/m) is the permittivity of free space. From above equation, it can be seen that squire of V_{th} is proportional to the ratio of $K_{11}/\Delta\varepsilon'$. It is observed that V_{th} decreases significantly ~30% for BT-NPs dispersed sample. From Figure 2, it is apparent that steepness of the T-V curve is also improving for composite (see table 1) which is desirable for energy efficient devices and other application point of view. This might be due to the proportionate decrease of splay elastic constant of dispersed samples. According to Gorkunov and Osipov theory, the anisotropic nature of BT-NPs in the matrix of nematic liquid crystalline molecules (spherical NPs in the matrix of rod shaped LCs host) is responsible for the decrease of K_{11}.

Figure captions:

Figure 1: Optical textures of pristine (2a) and 0.01 wt % BT-NPs dispersed NLCs (2b) under crossed polarizer for planar anchoring of the samples at 30°C.



Pure NLC NLC + 0.01wt% BT-NPs

(1a) (1b)

(c) (d)

Figure 2: Transmission-Voltage (T-V) characteristic of the sample cell to the applied alternating voltage of frequency 1 kHz. Curves 1 (Blue) and 2 (Green) are corresponding to the pristine and 0.01 wt% BT-NPs dispersed NLCs respectively.

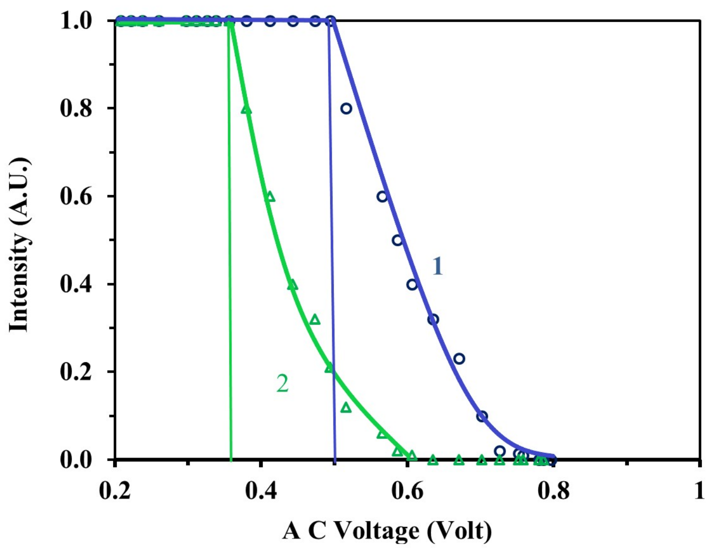


Table -1 Transition temperature (T_{IN} in °C) and Threshold voltage (V_{th} in V) of pure NLCs and BT-NPs dispersed sample.

Sample	T_{IN}	V_{th}	K_{11}
NLCs pure	52.0	0.50	2.51
NLCs +0.01 wt% BT-NPs	56.0	0.35	0.94

IV.CONCLUSION

The inclusion of small amount of BT-NPs in the nematic matrix of host increases nematic-isotropic transition temperature and stabilizes nematic phase. It decreases threshold voltage required for switching of molecules from planar to homeotropic configuration. As well the steepness of T-V curves also improves for composite sample which might be useful for new electro-optic and display devices.

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