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Comparative study of nanoparticles doped in Liquid Crystal Polymer System

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ABSTRACT

A comparative study of three nanoparticles Zn, ZnO and CuO doped in Nematic Liquid Crystal Polymer System (NLCPS) with different concentration was studied. The NLCPS combines the orientational ordering properties of liquid crystals, polymer and nanoparticles. The investigations were performed using Polarizing Microscopic Studies (PMS) and Fabry Perot Spectroscopic Studies (FPSS). After doping Zn, ZnO and CuO nanoparticles with liquid crystal polymer system, the response was studied at high temperature. The phase transition temperatures obtained by FPSS were confirmed by PMS. LCPS is useful for displays and may also be used for tunable wavelength filters, tunable liquid-crystal lenses and polarization-independent phase modulators.

1. Introduction

Liquid crystals are anisotropic in nature and some of their properties depend on the direction along which that is oriented [1]. Refractive indices, electric permittivity, electrical conductivity, magnetic susceptibilities, elastic and viscosity tensors are the properties which can be tuned by electric and magnetic fields by switching liquid crystal films. Liquid crystals are important because of the richness of their structures and transitions. Technologically, they have gained tremendous success in display and photonic applications [2]. The order of stability of the different phases on a scale of increasing temperature simply by utilizing the fact that a rise in temperature leads to a progressive destruction of molecular order. Thus, the less symmetric the mesophase is, the closer in temperature it lies to the crystalline phase [3]. Liquid crystal is highly transparent in the visible and near infrared wavelength regions [4,5]. The inorganic nanocomposites have optical, electrical, catalytic and mechanical properties and it also has potential application in microelectronics [6]. Quantum dots, especially II–VI such as CdS (Se, Te) and ZnO (S, Se, Te) etc. have photo luminescent properties [7]. We have used Zn, ZnO and CuO nanoparticles which are doped in LCPS. The phase transition temperature was measured using FPSS and PMS. Different types of textures were also observed by PMS. Defects and textures in liquid crystalline phases are important because it allows for the characterization and classification of mesophase type where the combinations of textures can be used. It gives information about the mesophase structure. Optical anisotropy is an essential physical property of liquid crystal for application in liquid crystal display devices. Because of optically anisotropy materials, the speed of propagation of light waves is dependent upon the direction and polarization of the light waves traversing through the material. Owing to this, material possesses different refractive indices in different directions.

2. Materials

The NLCP used in our studies has been prepared from 4-Pentyl-4′-cyano-biphenyl (45%) and ethylhexyl acrylate (20–40%), acrylate oligomer (15–30%) that on polymerization forms a cross-linked network. 4-Pentyl-4′-cyano-biphenyl liquid crystal is also known as '5CB'. Nematic Liquid Crystal Polymer System (NLCPS) is procured from Nematel. It is in the liquid form and has colorless to slightly yellowish characteristic tends to which polymerize when heated. Nano powder size is 35 nm for Zn, 50 nm for ZnO and 30–45 nm for CuO. Particle morphology for ZnO nanoparticles is nearly spherical, hexagonal crystal structure, SSA-50 m^2/g procured from Nanoshell, USA.

We have made the homogeneous alignment of the sample. The slide and cover slip are rinsed with acetone and then wiped with a tissue in a parallel direction. Few drops of the sample is added on the slide and then covered with the cover slip sliding in the same direction mentioned above. The sonication and magnetic stirring need to be done before preparing slide. We get a homogenous mixture of Zn, ZnO and CuO nanoparticles dispersed in LCPS. We have used LCPS and concentration of the nanoparticles is varied in LCPS in order to study the behavior of

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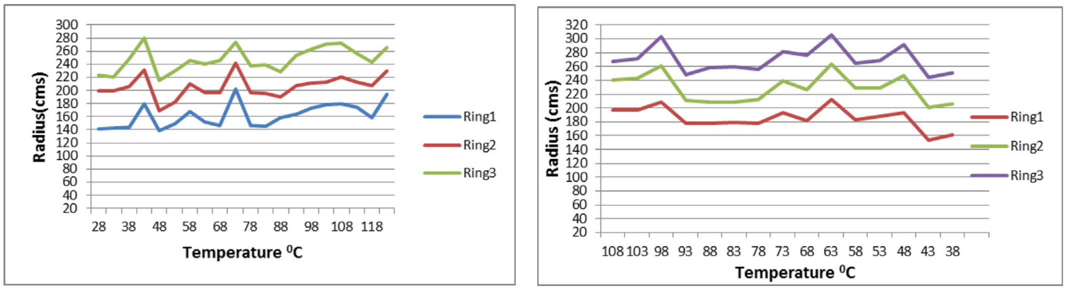
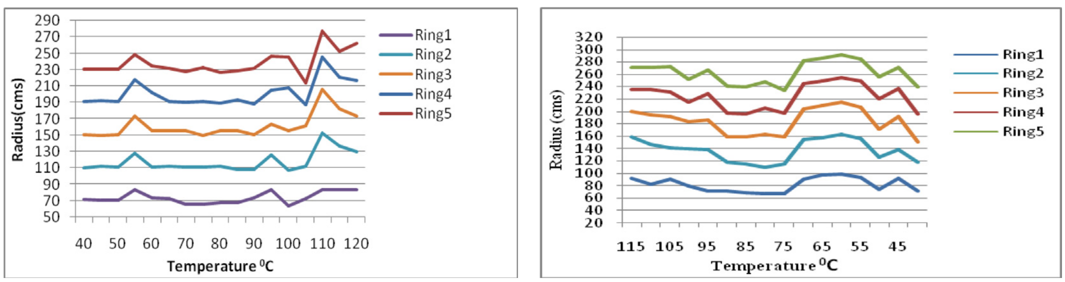


(a) **Radius Vs. Temperature graph of Pure LCPS for FPSS rings while heating**

(b) **Radius Vs. Temperature graph of Pure LCPS for FPSS rings while cooling**

Fig. 1. (a) Radius vs. temperature graph of pure LCPS for FPSS rings while heating. (b) Radius vs. temperature graph of pure LCPS for FPSS rings while cooling.



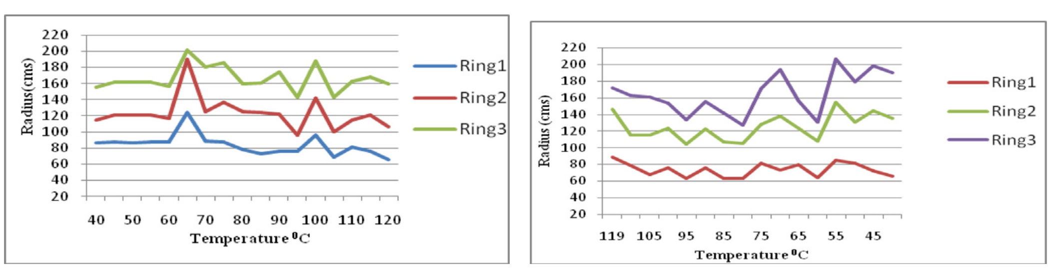
(a) **Radius Vs. Temperature graph of Zn doped LCPS**

(b) **Radius Vs. Temperature graph of Zn doped LCPS**

Fig. 2. (a) Radius vs. temperature graph of Zn doped LCPS for FPSS rings while heating. (b) Radius vs. temperature graph of Zn doped LCPS for FPSS rings while cooling.

the system. The concentrations of the samples have been prepared using weight percentage. The pure sample concentration 100% LCPS (PE10) and different concentrations of nanoparticles and LCPS are given as follows:

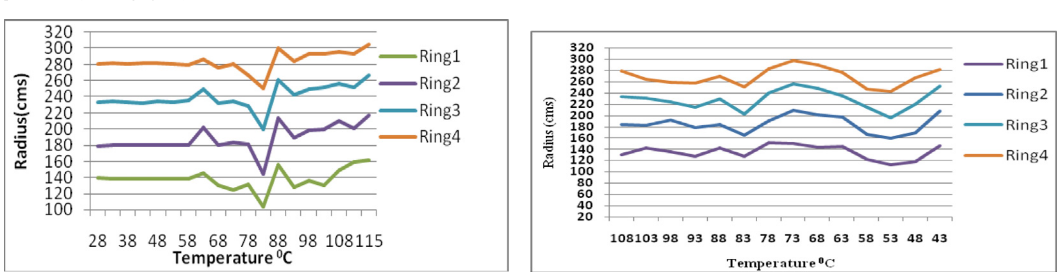
- **Sample I-Pure (Undoped) LCPS (PE10):** 100% LCPS (PE10) + 0% NP
- **Sample II- LCPS (PE10) + ZnO NP:** The 4 different proportions are (1) 99.8% LCPS (PE10) + 0.2%ZnO (2) 99.5% LCPS (PE10) + 0.5% ZnO (3) 99.2% LCPS (PE10) + 0.8% ZnO and (4) 99.0% LCPS (PE10) + 1% ZnO
- **Sample III- LCPS (PE10) + Zn NP:** The 4 different proportions are (1) 99.8% LCPS (PE10) + 0.2%Zn (2) 99.5% LCPS (PE10) + 0.5% Zn (3) 99.2% LCPS (PE10) + 0.8% Zn and (4) 99.0% LCPS (PE10) + 1% Zn
- **Sample IV- LCPS (PE10) + CuO NP:** The 4 different proportions are (1) 99.8% LCPS (PE10) + 0.2% CuO (2) 99.5% LCPS (PE10) + 0.5% CuO (3) 99.2% LCPS (PE10) + 0.8% CuO and (4) 99.0% LCPS (PE10) + 1% CuO.



(a) **Radius Vs. Temperature graph of ZnO doped LCPS for FPSS rings while heating**

(b) **Radius Vs. Temperature graph of ZnO doped LCPS for FPSS rings while cooling**

Fig. 3. (a) Radius vs. temperature graph of ZnO doped LCPS for FPSS rings while heating. ZnO doped LCPS (heating cycle). (b) Radius vs. temperature graph of ZnO doped LCPS for FPSS rings while cooling. ZnO doped LCPS (cooling cycle).



(a) **Radius Vs. Temperature graph of CuO doped LCPS for FPSS rings while heating**

(b) **Radius Vs. Temperature graph of CuO doped LCPS for FPSS rings while cooling**

Fig. 4. (a) Radius vs. temperature graph of CuO doped LCPS for FPSS rings while heating. (b) Radius vs. temperature graph of CuO doped LCPS for FPSS rings while cooling.