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RESEARCH ARTICLE

Spectroscopic Study of Liquid Crystal doped with Nano - Powder

Rita A. Gharde[1], Santosh A. Mani[1,2], Madhavi S. Pradhan[1,3]

1.Department of Physics, University of Mumbai, Mumbai 400098, INDIA

2. K. J. Somaiya College of Engineering, Vidyavihar, Mumbai 400 077, INDIA

3. G. N. Khalsa Collage of Arts, Science and Commerce, Mumbai 400 019, INDIA

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Corresponding Author

Rita A. Gharde

Abstract

Suspensions of ferroelectric nanoparticles in a**c**holesteric liquid crystal host possess enhanced anisotropy and are sensitive to an applied electric field. Here we also show that the particles contribute to the total achievable phase shift of the composite material.The textures and Phase transition Temperatures have been studied by Polarizing Optical Microscopy (POM) and Differential Scanning Calorimetry (DSC).The absorption of sample in visible range were found by Ultraviolet – Visible (UV) Spectroscopy. These results may be used to design new materials for displays
.

Introduction

Doped Liquid Crystals (LCs) have attracted much attention over a number of years because of their improvement in electro-optic, optical properties and novel display applications. Typical examples of these systems are polymer dispersed LCs [1], suspensions of aerosils in LC matrices [2] and suspensions of ferro – particles in LCs [3, 4]. Recently, a new approach, based on controlling the properties by adding a low concentration of nano – particles into a LC matrix is proposed. These doped LC have attracted great deal of attention due to their unique structure and physical properties, because the nano – particles are so small that macroscopically homogenous structures are obtained i.e the suspension appear similar to the pure LC with no readily apparent evidence of dissolved particles. The nano – particles doped LCs were studied to enhance photoluminescence, higher polarization, response time, low operating voltage etc. For enhancing the physical properties, a proper selection of nano – powder for LC depend upon various factors such type, size, shape, preparation method, surfactant concentration and amount of doping material. Our research is inspired by many previous publications that describe the behaviour of LC doped with nano – particles [6-11]. The ferroelectric nano – particles can change phase, transition temperatures, influence their order parameter and thereby the birefringence, viscosity, elastic constants and dielectric anisotropy. From this point of view, doping LC with the nano – particles may be a ‘nonsynthetic method’ to create new LC by modifying the properties of existent LC.The advantage of ferroelectric particles over other material is that they significantly maintain the intrinsic properties of the material from which they are made and do not significantly perturb the director field in the LCs. In particular, doping at a low volume concentration of ferroelectric particles does not change the elastic and anchoring properties. Here we report the studies Cholesteric Liquid Crystals (CLCs) doped with ferroelectric nano – powder.We found that doping of ferroelectric nano – powder in LC results in changes of transition temperature, formation of new functional group and other changes, due to strong interaction between CLC and ferroelectric nano – powder.

Experimental

Material and Methods:

We used ferroelectric nano – powder of Strontium titanate (SrTiO3). The $SrTiO_3$ particles are slightly anisotropic and their size is less than100nm. $SrTiO_3$ were mixed with Oleic acid and Heptane in appropriate proportion by weight and then this mixture was doped with CLC of Palmitateby ultra-sonication method.[5].The ultrasonicator ensures homogeneous distribution of nano – powder in CLC. The mixtures were kept in vacuum for 6hours for evaporation of heptane completely. The resulting sample contains the small concentration (~1%) of $SrTiO_3$ nano – particles.

Characterization Techniques:

The investigations were done by Polarizing Optical Microscopy (POM), Differential Scanning Calorimetry (DSC), Fourier – Transform Infrared (FTIR) Spectroscopy and Ultraviolet – Visible (UV) Spectroscopy.

1. Polarizing Optical Microscopy (POM):

Polarizing Optical Microscopy (POM) is the most widely used method in identifying different phases. LC phases possess characteristic textures when viewed under polarized light. In case of orientational disorder, it is possible to see changes between different LC phases during the heating and cooling cycles.

2. Differential Scanning Calorimetry (DSC):

Differential Scanning Calorimetry (DSC)is a thermo analytical technique in which the difference in the amount of heat required to increase the temperature of sample and reference are measured as a function of temperature. Both sample and reference are maintained at nearly the same temperature throughout. When they undergo physical transformation such as phase transition, heat will need to flow to it than to the reference to maintain both at the same temperature. The amount of heat flow to the sample depends on whether the process is exothermic or endothermic.

3. Fourier Transform Infra-red Spectroscopy (FTIR):

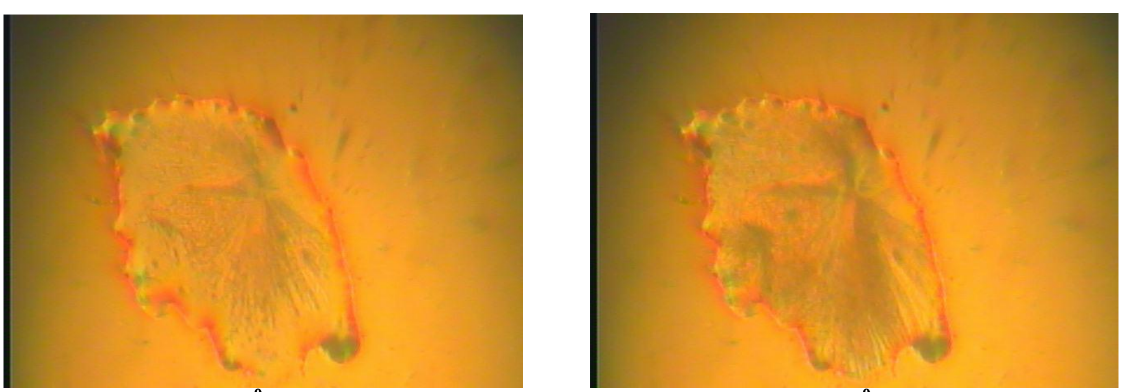
Fourier Transform Infrared Spectroscopy (FTIR) is a powerful tool for identifying types of chemical bonds in a molecule by producing an infrared absorption spectrum that is like a molecular "fingerprint".

4. Ultraviolet – Visible (UV) Spectroscopy:

UV spectroscopy is an accurate and powerful procedure to analyze a substance. It measures the absorption, transmission, absorption and emission of ultraviolet and visible light by matter. Absorption of ultraviolet or visible light causes electron to move from lower to higher energy levels. Because the spectrum of an atom or molecule depends on its electron density level, it is useful for identifying unknown substances.

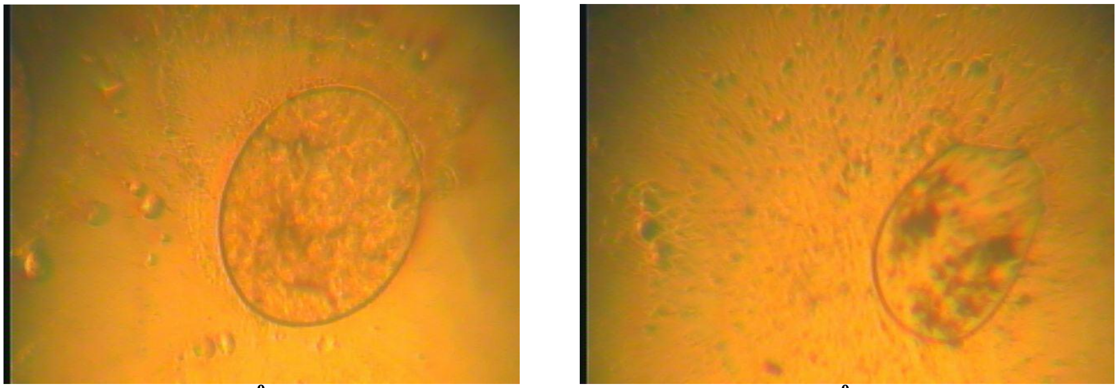
Results and Discussion:

1. **Polarizing Optical Microscopy (POM):** The textures of pure CLC and doped CLC obtained by POM are shown in fig (1) and fig (2).



(a) 75.2^{0}C **(b) 75.4^{0}C**

Fig (1) Texture of pure CLC



(a) 77.3^{0}C **(b) 73.5^{0}C**

Fig (2) Texture of doped CLC

Appearance of fan like structure are found in temperature range of 45^{0}C to 76^{0}C

2. Differential Scanning Calorimetry (DSC): DSC of the pure CLC and doped CLCs are shown in fig (3) and (4).

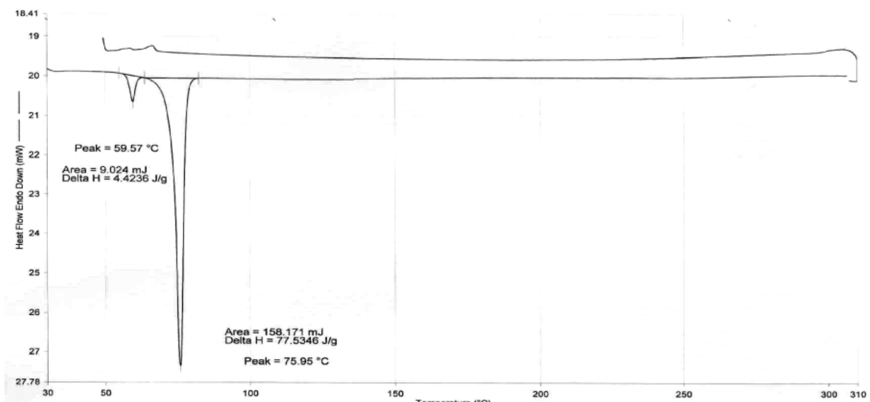


Fig (3) DSC of pure CLC

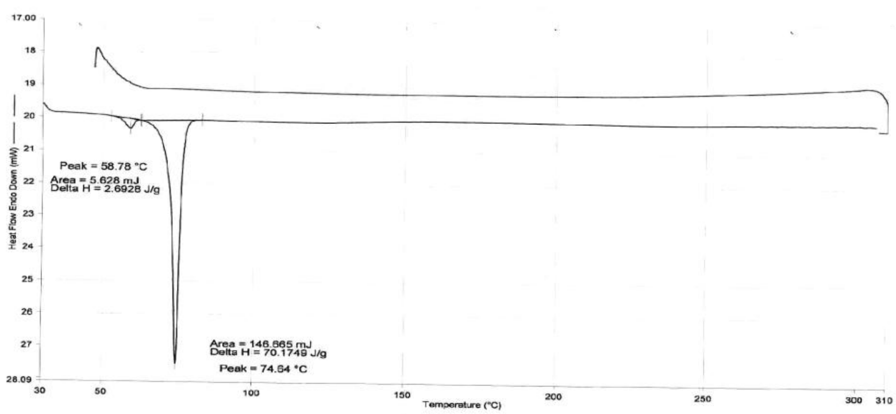


Fig (4) DSC of doped CLC

For pure CLC, in heating mode, first peak was observed at 59.57 ^{0}C, whose ΔH value is 4.4236 J/g, whereas second peak was observed at 75.95 ^{0}C,whose ΔH value is 77.5346 J/g. Transition temperatures were observed between 60 ^{0}C to 77 ^{0}C. In cooling mode no prominent peak was observed. For doped CLC, heating mode, first peak was observed at 58.78 ^{0}C, whereas second peak was observed at 74.64 ^{0}C. The ΔH value is reduced by half of the pure sample. In cooling mode endothermic peak is observed at 48 ^{0}C.

3. Fourier Transform Infra-red Spectroscopy (FTIR):

FTIR spectroscopy of the pure CLC and doped CLCs are shown in fig (5) and (6).

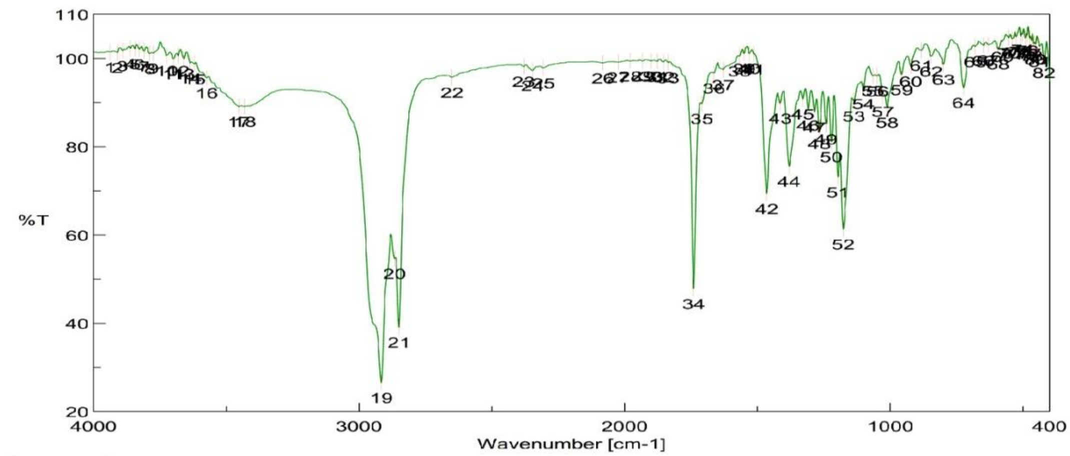


Fig. (5) FTIR of pure CLC

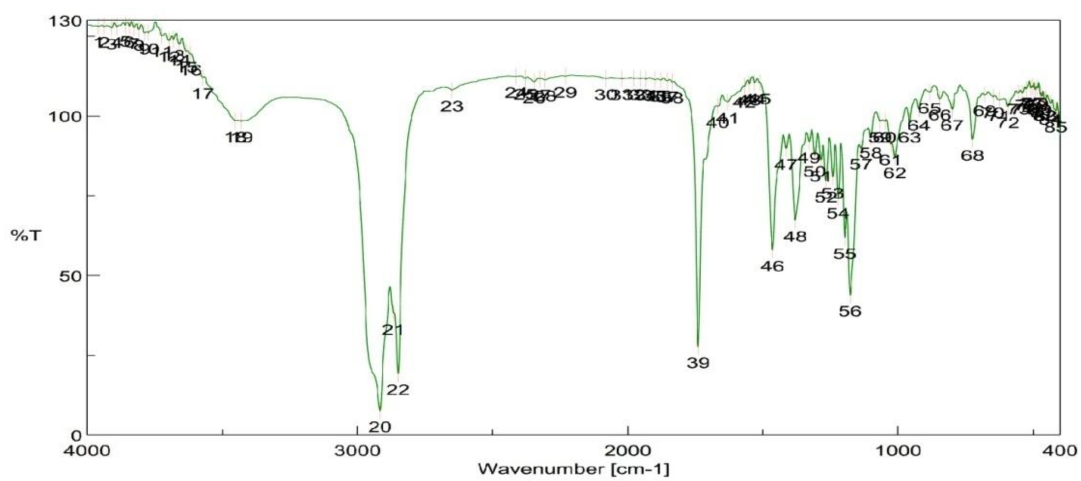


Fig. (6) FTIR of doped CLC

Some of peaks remain unchanged, but occurrence of new peaks shows there is strong molecular interaction between the CLC and the ferroelectric nano – powder. The suspension of Strontium titanate affect the induced dipole of LC and intensity is increased by 27%.

Table of functional group of stretching frequencies of doped CLC

Sr. No.	Wavenumber(cm^{-1})	Functional Group	
1	2916	Carboxylic acid	SCH_3, CH_2, CH_3
2	2853	Aldehyde	OCH_2, - CH_2, CH_3
3	1739	Lactone	Aroma Ester
4	1464	Methyl	- CH_3O
5	1379	Methyl	Acid salts
6	1177	Sulfanyl Chloride	Aliph.Ester

4. Ultraviolet – Visible (UV) Spectroscopy: The UV of Pure CLC and doped are shown in fig. (7) and Fig (8).

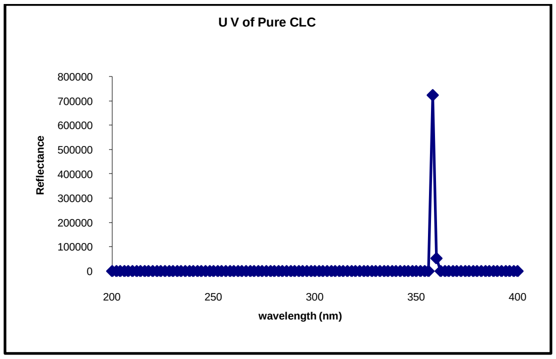


Fig (7) UV of Pure CLC

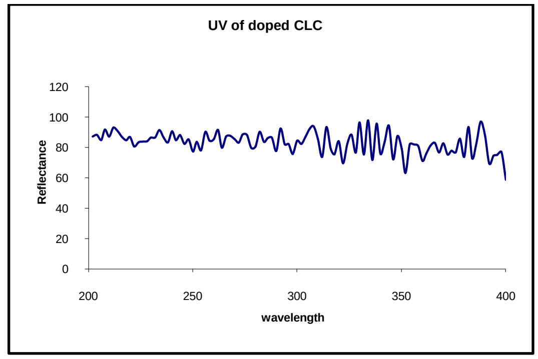


Fig (8) UV of Doped CLC

For Pure CLC Reflectance peak was found near 359 nm, whereas for doped CLC, peaks were found near 330nm and 390nm.

Conclusions:

After doping CLCs with ferroelectric nano – powder, changes were found in phase transition temperatures, which influence their order parameter and the sensitivity of CLCs were enhanced. This indicates that low concentration of ferroelectric nano – powder can modify the characteristics of CLCs, which play an important role design new materials. We are continuing our studies to understand the mechanism of this behaviour.

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