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Refractive Index Analysis of Liquid Crystal Doped with Nanopowder

Rita A Gharde*, Sangeeta Y Thakare[1]

Associate Professor, Department of Physics, University of Mumbai , Mumbai, India*
Research Scholar, Department of Physics, University of Mumbai , Mumbai, India1

***Abstract*: It has been observed that doping of ferroelectric nanoparticles in a liquid crystal (LC) improves the electrooptical properties such as enhanced photoluminescence, higher polarization, fast response time, low operating voltage, and improved conductivity. So, these improved properties can be used for better display applications.**
In this paper we studied the optical properties of Cholesteryl Nonanoate doped with ferroelectric nanopowder SrTiO3 and analyzed the results by optical techniques, i.e. Fourier transform infrared spectroscopy (FTIR), Fabry Perot scattering spectroscopy(FPSS). The refractive indices for the ordinary and extraordinary ray were measured by the method of Murthy et al. FTIR gave detailed information about which functional groups is present in a molecule. The graphical mapping of analysis of diameter of FP rings versus temperature shows a variation at the mesophase transition temperature. The refractive indices for the ordinary and extraordinary ray were measured successively. We observed that sensitivity of cholesteryl LC is enhanced by doping with ferroelectric nanoparticles i.e. doping increases the performance of the LC mixtures

Keywords: Liquid crystal, nanoparticles, nematic liquid crystals, optical techniques

I. INTRODUCTION

Liquid Crystals are nature’s anisotropic fluid. They possess structural and behavioural properties that make them unique model systems, to investigate a variety of physical, chemical and biological phenomenon. Liquid Crystal phase is a distinct phase of matter and there are many different types of Liquid Crystal phases [1].
Liquid crystals can be orientated under magnetic or elec-tric field due to their anisotropic properties but the response of liquid crystals to an external magnetic field is weak due to small value of the anisotropy of diamagnetic susceptibility.

Nanoparticles do not disturb the orientation of the LCs but increase their sensitivity to electric, magnetic or light fields .Nanoparticles can even provide spontaneous vertical LC alignment [2]. The most significant change in this case is the appearance of an absorption band at a desired wavelength range of the spectrum.

In particular, the interaction between the Liquid crystal and microcolloidal particles can produce long range orientational distortion around the particle. Electro-optical properties of liquid crystal are enhanced by adding nanopowder to it, but enhancement of the electro-optical properties of liquid crystal is dependent on the size, type, concentration, and intrinsic characteristics of the nanoparticles used for doping. The nanoparticles should share similar attributes to the liquid crystal molecules and be of a size that would not significantly disrupt the order of the liquid crystal. Low doping concentrations are usually chosen to yield a more stable and even distribution in the liquid crystal, which lowers the interaction forces between particles. The low concentration of nano-sized particle also caused the unexpectedly large effect. Since the particles are too small in size to disturb the molecular alignment of the liquid crystal.
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II **Materials and Methods**

1.Refractive index measurement:

The refractive indices for the ordinary and extraordinary ray were measured by the method of Murthy et.al **[3].**A thin wedge was formed between two optically flat glass plates using a fused quartz rod as a spacer.
The light from He-Ne laser was collimated at the edge of the wedge .The wedge was placed vertically in a cylindrical heater with glass windows.A screen was attached and place three meter from it. Liquid crystal sample was placed at the top of wedge. The light from laser produces two spots on the screen one is for the emergent ray after the first internal reflection and other for the transmitted direct ray .When the sample was heated, after melting it became isotropic liquid. When it cooled back to nematic phase, the transmitted direct ray deviated due to liquid crystalline medium. It therefore split into two producing two spot on the screen. One is for ordinary ray and other is for extra ordinary ray. If the ordinary and extra ordinary refractive indices are n_o and n_e then

$$n_{o,e} = 1 + 2\, d_2/d_1$$

Where d1 is the distance between spot before heating the sample and d_2 is the distance between the spot when the sample is cooled to nematic phase. Refractive indices for the ordinary and extraordinary ray were measured by the method of Murthy et.al [3]**.**A thin wedge was formed between two optically flat glass plates using a fused quartz rod as a spacer The light from He-Ne laser was collimated at the edge of the wedge .The wedge was placed vertically in a cylindrical heater with glass windows. A screen was attached and place three meter from it. Liquid crystal sample was placed at the top of wedge. The light from laser produces two spots on the screen one is for the emergent ray after the first internal reflection and other for the transmitted direct ray .When the sample was heated, after melting it became isotropic liquid. When it cooled back to nematic phase, the transmitted direct ray deviated due to liquid crystalline medium. It therefore split into two producing two spot on the screen. One is for ordinary ray and other is for extra ordinary ray.If the ordinary and extra ordinary refractive indices are n_o and n_e then

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2.Fourier Transform Infrared study

Fourier Transform Infrared Spectroscopy (FTIR) identifies chemical bonds in a molecule by producing an infrared absorption spectrum. The spectra produce a profile of the sample, a distinctive molecular fingerprint that can be used to screen and scan samples for many different components. FTIR is an effective analytical instrument for detecting functional groups and characterizing covalent bonding information

3.Fabory Parot Spectroscopy Study

A low power beam of HE-Ne laser light is scattered from the sample of Liquid Crystal at various temperature and made incident on the Fabery-perot etalon. The diameters of FP rings are measured at various temperatures.

A low power beam of HE-Ne laser light is scattered from the sample of Liquid Crystal at various temperature and made incident on the Fabery-Perot etalon. The diameters of FP rings are measured at various temperatures. Changes in the diameter of the FP rings are indicator of the changes in the mesophase of Liquid Crystal. This technique enables us to determine the Phase Transition Temperatures of wide range of Liquid Crystals. The scattering studies gave the information about mesophase transition temperature. Phase Transition Temperatures for Cholesteric Nonanoate and the mixture at various heating and cooling cycles are observed. Experiment is repeated for heating and cooling cycles .

III Result and Discussion

1. **Observations by FTIR**

FTIR gave detailed information about which functional groups are present in a molecule. It produces spectra in shorter times and of better quality than those of conventional grating.

Adding the ferroelectric particles results in a shift of the absorption bands corresponding to the rotation of liquid crystal molecules around their short axes to lower frequencies and in an increase of the amplitude and with of the absorption bands. This suggests that strong interactions occur between the LC molecules and the particles, caused by the large dipole moment and high polarizability of the Ferro-particles. Nanometre scale nanoparticles embedded in Liquid crystal do not significantly disturb the director field in liquid crystal and the interaction between the particles is weak. However nanoparticles show their intrinsic properties with the liquid crystal.[3]

Here the transmittance at the different wavenumbers is shown. The spectra are same for pure and doped liquid crystal .No peak shifting is observed here. The presence of nanoparticles can be seen by strong absorption band at 3100 cm^{-1} .The compound shows absorption around 3000 cm^{-1} -3100 cm^{-1} indicating C-H starching. This indicates the presence of aromatic ring. Weak absorption near 1400 cm indicates presence of COO group.. The compound shows absorption around 3000 cm^{-1} – 3100 cm^{-1} indicating C-H starching. This indicates the presence of aromatic ring. C-H Out of plane bending at 770 cm^{-1} , conforms the presence of aromatic ring. Weak absorption near 1400 cm^{-1} indicates presence of –COO group. -C = O Stretching at 3160 cm^{-1} , 3478 cm^{-1} -CH_3 - C-H bending at 1470 cm^{-1} ,-CH_2 - C-H bending at 1470 cm^{-1} ,C ≡ N - Stretching at 2230 cm^{-1} , C=C - ring Stretching at1472 cm^{-1} , CH_3 - C-H Stretching at 2915 cm^{-1} , CH_2 - C-H bending at 1200 cm^{-1} , CH_2 - C-H Stretching at 2910 cm^{-1} ,CH_2 - C-H Stretching at 1370 cm^{-1}

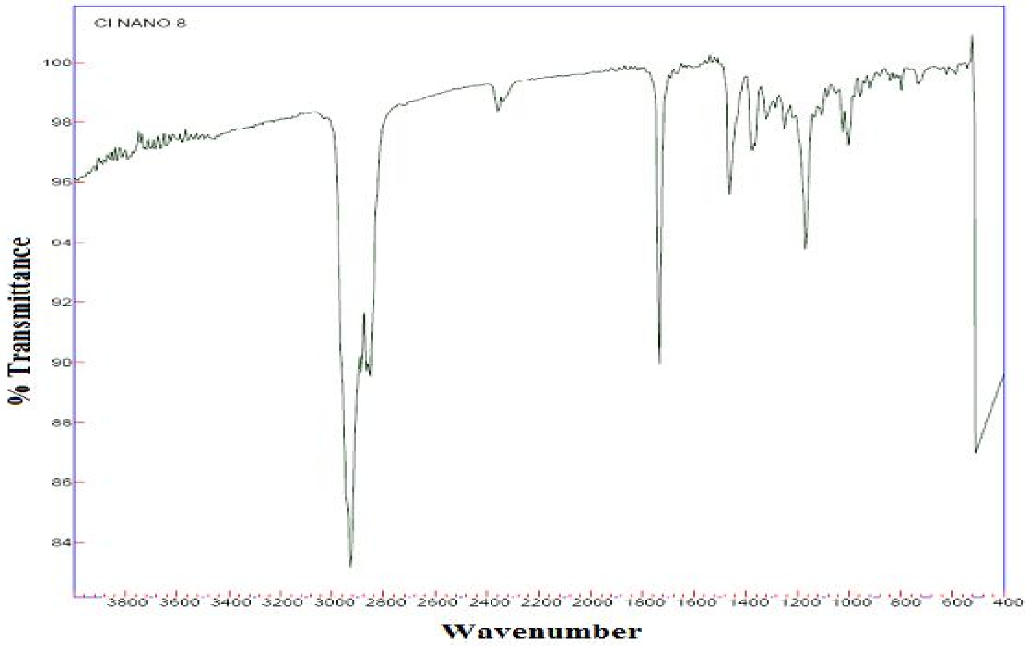

Fig. 1.FTIR graph of Cholesteryl nanoate

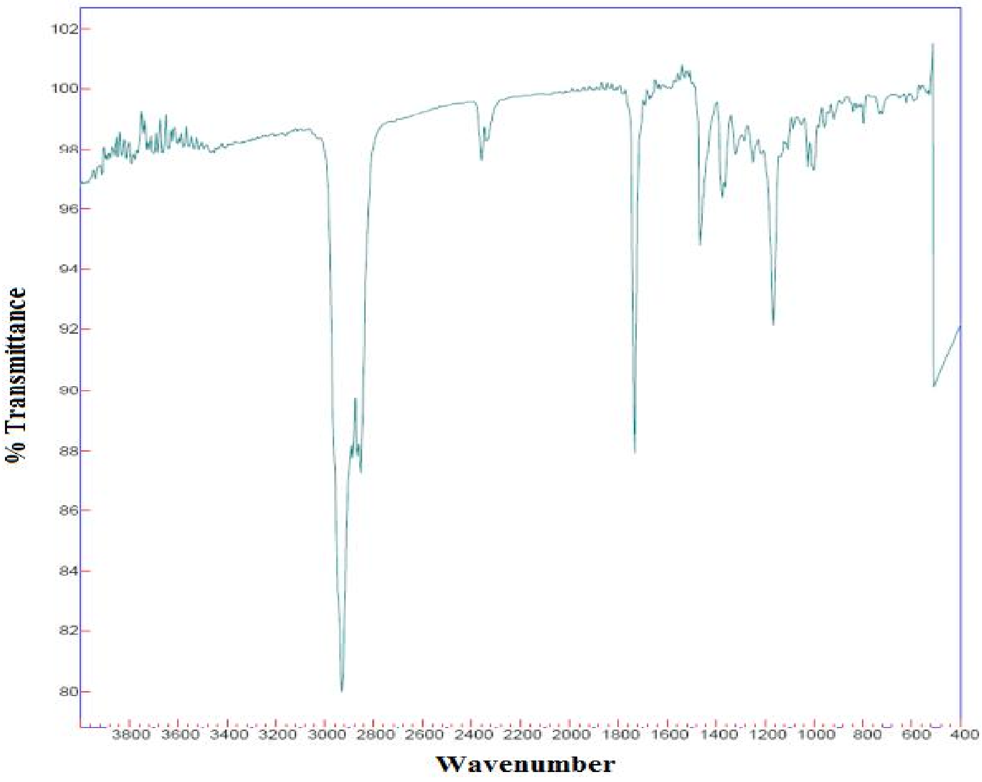

Fig. 2.FTIR graph of Doped CholesterylNonanoate

2. Observations by FPSS

The graphical mapping of analysis of Diameter of Fabery-Perot rings Vs temperature shows a variation at the mesophase transition temperature.

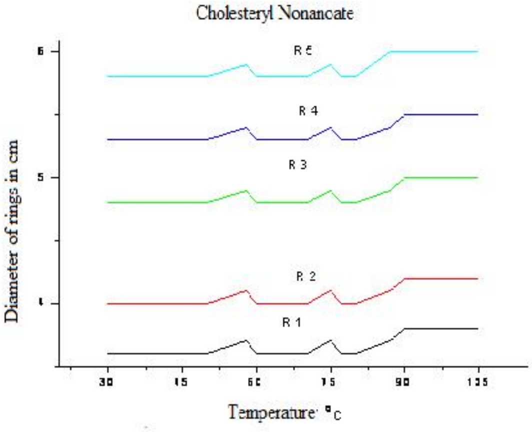

Fig.3 FPSS graph of Cholesteryl Nonanoate

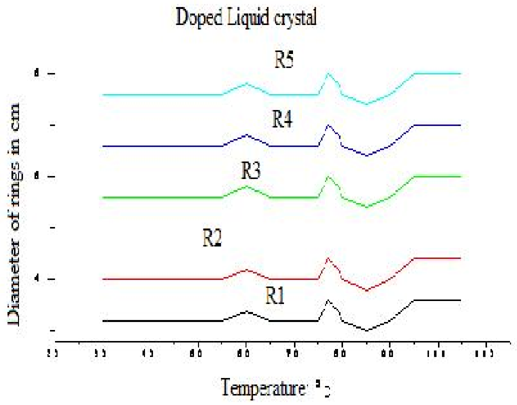

Fig.4 FPSS graph of Doped Cholesteryl Nonanoate

Table1.PTTS by FPSS-

	Phase transition Temperature
Cholesteryl Nonanoate	58,75,90
Doped Cholesteryl nonanoate	60,76,85,95

Transition temperatures of Doped Cholesteryl Nonanoate have been enhanced indicating strong interaction of liquid crystal particles and nanopowder.

3.Observations to find Refractive indices:

The temperature variation of ordinary and extra ordinary refractive indices n_e and n_o is shown in fig. The ordinary refractive indices n_e increases slightly while the extraordinary refractive index decreases sharply with increases in temperature when it becomes isotropic refractive index values changes and becomes almost constant .This is the kind of behaviour due to birefringent nature of liquid crystal phase. as we increase the temperature the molecular ordering decreases and the birefrigent nature becomes less significant and after isotropic temperature the Δn(ne-no) vanished and sample behaves like any ordinary organic liquid .
Following figures show temperature dependence of refractive indices at heating cycles for Cholesteric Nanoate and the mixture. We have calculated refractive indices of samples where were changes in phases occurred. Refractive indices are observed at wavelength 589 nm.

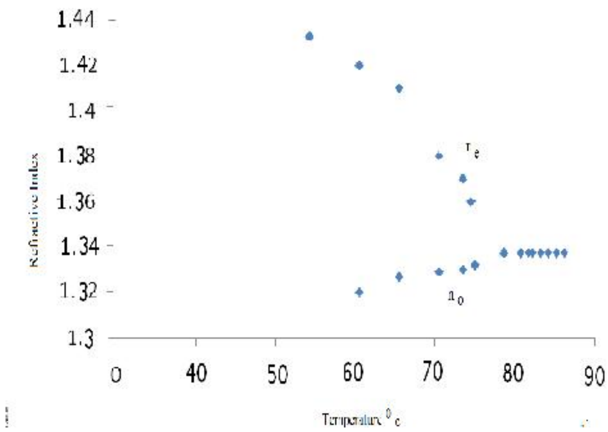

Fig.5. RI graph of Cholesteryl nanoate

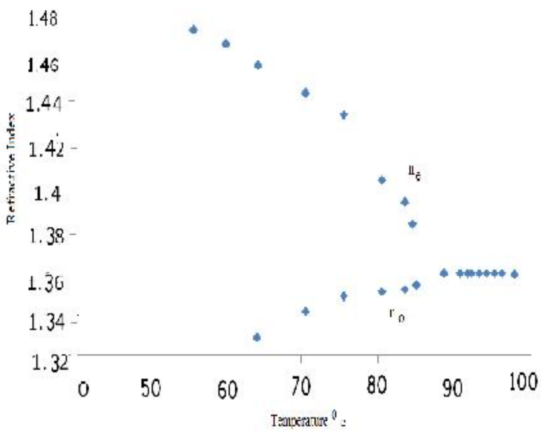

Fig.6. RI graph of Doped Cholesteryl Nonanoate

4. Birefringent

Birefringent is calculated by following equation

$$\Delta n = ne - n_o$$

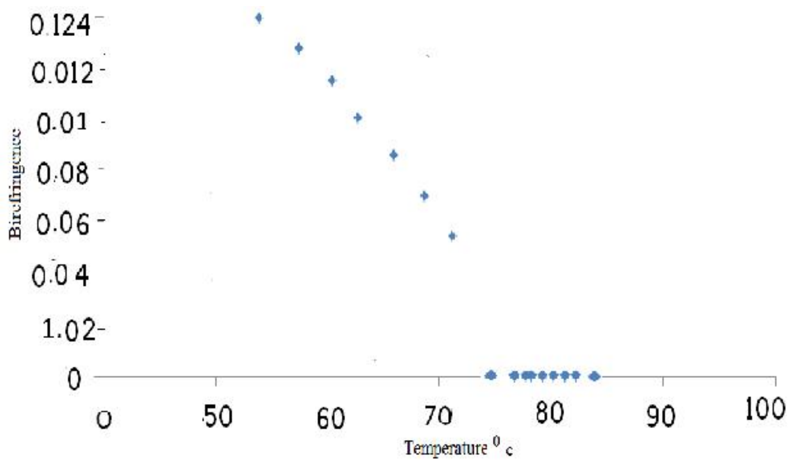

Fig.7. Birefringent graph of Cholesteryl Nonanoate

IV.CONCLUSION

We successfully study various characteristics of liquid crystal. The sensitivity of Cholestric liquid crystal is enhanced by doping with ferroelectric nanoparicles. Doping increases the performance of the liquid crystal. A low concentration of SrTiO3 nanoparicles in Liquid Crystal host can increase the transition temperature (T_{NI}.) This result indicates that the low concentration of nanoparticles can increase the orientational ordering of the Liquid Crystal. These modified characteristics of the liquid Crystals are caused by the interaction of the nanoparticles with the liquid Crystals. This extended temperature range of Liquid Crystal is very useful in future applications.

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