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PHOTO INDUCED EFFECTS IN NEMATIC LIQUID CRYSTAL DOPED WITH FERROELECTRIC NANOPOWDER

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ABSTRACT

Liquid crystals are soft materials of self assembling media on a nanoscale level composed of anisotropic molecules. A nematic liquid crystal phase is characterized by a high degree of long range orientational order .The present paper is a study of optical properties of nematic liquid crystal doped with ferroelectric nanopowder. When ferroelectric nanoparticles are doped in nematic liquid crystal,their large dipole and high polarizability can lead to strong interaction with liquid crystal molecules. The investigations were done with various techniques viz: Data Thermal Analysis, Fourier Transformed Infrared Spectroscopy, Ultraviolet Spectroscopy and Fabery Perot Spectroscopic Study.

KEYWORDS: : Nematic Liquid crystal, ferroelectric nanopowder, Data Thermal Analysis,Fourier Transformed Infrared Spectroscopy, Fabery Perot Spectroscopic Study.

INTRODUCTION

Liquid crystals have found wide commercial application over the years in electro optical flat panel display devices. Liquid crystals combine flow properties of liquids with optical properties of crystals. They consist of molecules of anisotropic shape interacting with each other and exhibiting self organizing effect. The anisotropic nature of liquid crystals combined with the ability of magnetic and electric fields to influence the bulk spatial orientation of these molecules renders them of such importance to electrooptical display devices. These displays can also have a high contrast ratio and a much larger viewing angle. To date most displays crystals in the nematic phase. Liquid crystal phases are categorized based on the amount of ordering, both orientational and positional, which they possess, and this ordering can be one-, two-, orthree-dimensional [1]. The least ordered liquid crystal phase is called the nematic phase. The materials used in displays are actually a mixture few different liquid crystal molecules to produce a stable room-temperature nematic phase with the desired electro-optical properties, such as switching time.

In nematic liquid crystal displays the switching is fast in only one direction due to the design of the display. With no electric field applied the polarized light changes polarization as it passes through the molecules and exits through a crossed-polarizer with its polarization rotated by 90°[5,6].

To improve the various LC material parameters which are crucial for their use in display devices and other useful applications. In the scope of our work, we have investigated the relative behavior and enhancement effects of the nanopawder in nematic iquid Crystal media. For this aim, we doped nanopowder in nematic liquid crystal trans trans 4 Propyl (1-1 bicychlohexyle) 4 carbonitrile

We have investigated mesophase transition in thermotropic liquid crystals. The change of phase occurs at precise temperature .At that temperature the ability of the intermolecular forces to cause that at a phase to exist is no longer sufficient. The ferroelectric nano – particle dispersed NLC have attracted attention due to their convenient preparation technique and enhanced physical properties. The ferroelectric nano – particles are so small that macroscopically homogenous structures are obtained i.e. the suspension appear similar to the pure LC with no For enhancing the physical properties, a proper selection of nano – powder for NLC 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 NLC doped with nano – particles [4-7]. The ferroelectric colloids can increase the liquid crystal phase transition temperature, influencing their order parameter and thereby birefringence. The advantage

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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.
It is found that by dispersing ferroelectric nano – powder in NLC, transition temperature changes, formation of new functional group occurs and other changes in physical properties were found due to strong interaction between NLC and ferroelectric nano – powder.

MATERIALS AND METHODS

In this work, we used ferroelectric nano – powder of Strontium titanate ($SrTiO_3$) of size less than 100nm. This material is used extensively in electronics and microelectronics owing to its excellent ferroelectric, piezoelectric and dielectric properties. The $SrTiO_3$ particles are slightly anisotropic and their size is less than100nm. We have chosen heptane as carrier liquid and oleic acid as a dispersing agent (both from Sigma Aldrich.) $SrTiO_3$ were mixed with oleic acid and heptane in appropriate proportion by weight and then mixed with trans trans 4' propyl bicyclohexyle 4 carbonitrile(Zli-1184) by ultrasonication method .

EXPERIMENTAL TECHNIQUES AND RESULTS

In this work, we used ferroelectric nano – powder of Strontium titanate ($SrTiO_3$) of size less than 100nm. This material is used extensively in electronics and microelectronics owing to its excellent ferroelectric, piezoelectric and dielectric properties. The $SrTiO_3$ particles are slightly anisotropic and their size is less than100nm. We have chosen heptane as carrier liquid and oleic acid as a dispersing agent (both from Sigma Aldrich.) $SrTiO_3$ were mixed with oleic acid and heptane in appropriate proportion by weight and then mixed with trans trans 4' propyl bicyclohexyle 4 carbonitrile(Zli-1184) by ultrasonication method .

RESULTS AND DISCUSSION

The characterization were done by Polarizing Microscopic Studies (PMS), Data Thermal Analysis (DTA), Fourier Transform Infrared (FTIR) Spectroscopy and Ultraviolet Visible (UV) spectroscopy.

Fabery Perot Scattering Study Analysis:

This method is useful in precisely detecting the Phase Transition Temperatures (PTTs). It is highly sensitive enough to identify PTTs not detected earlier with routine techniques. The diameter of Fabery Perot rings are recorded as a function of temperature and plotted. The graph shows abrupt changes in the diameter of FB rings indicates the PTTs.

Observations by Fabery Perot Scattering Study:

Tables:

Table 1. Transition Temperatures By FPSS study

Compound	Known Transition Temperatures 0c	New Transition Temperatures 0c
Pure ZLI-1184	440c,480c,570c,580c, 800c	220c,270c,300c,400c,480c,540c,,600c,700c,740c, 780c
Doped ZLI-1184	-	450c,500c,560c,690c 760c.930c

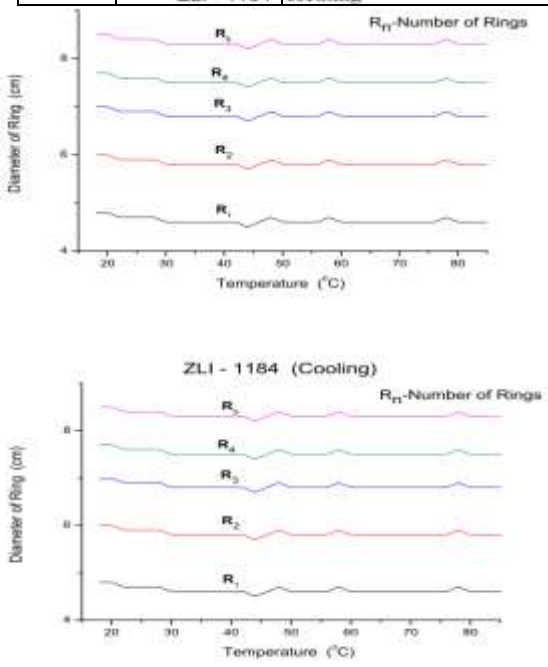

Fig.(A) Diameter of Fabery Perot rings Vs Temperature of Pure ZLI-1184

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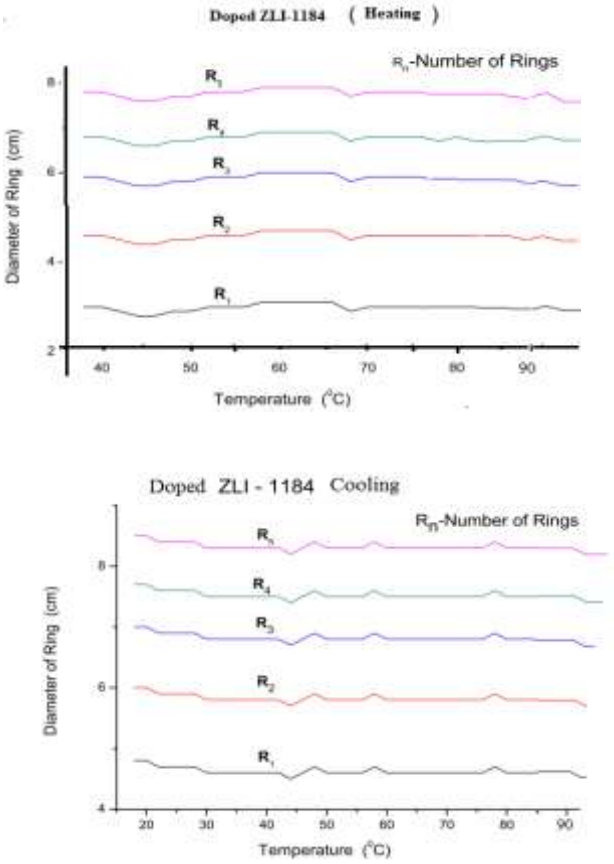
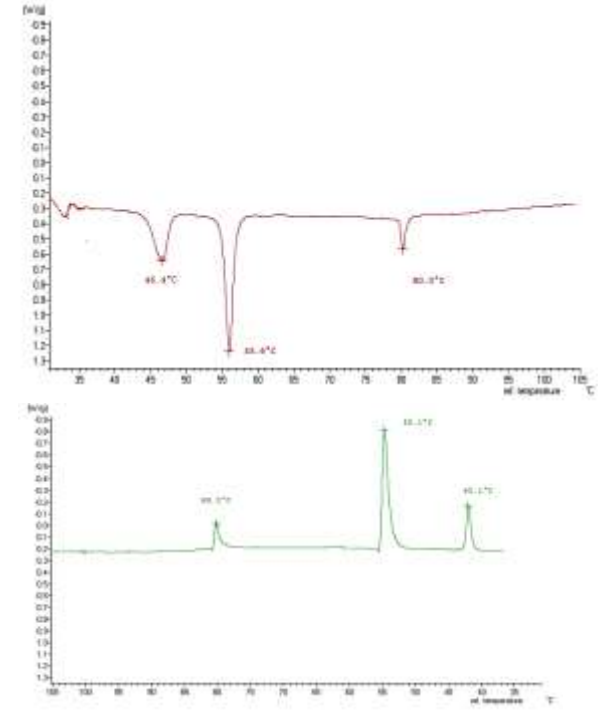


Fig.B) Diameter of Fabery Perot rings Vs Temperature of Doped ZLI-1184

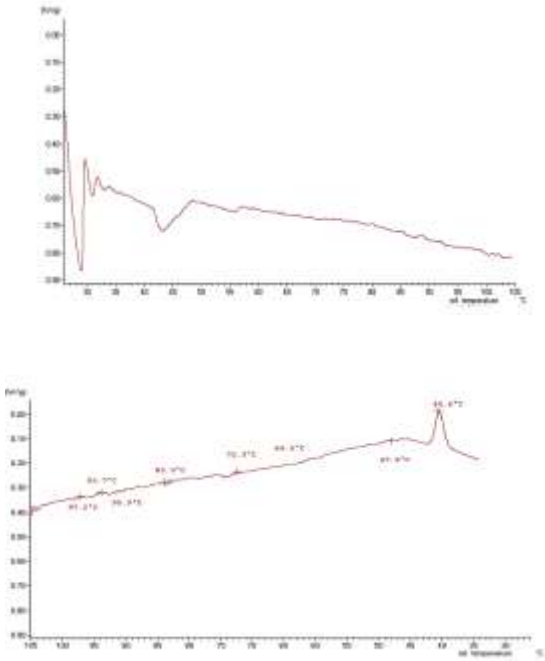
Data Thermal Analysis (DTA)

Data Thermal Analysis (DTA) 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 undergoes 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

Observations of Data Thermal Analysis (DTA)



Fig(C) Thermographs of Pure ZLI-1184



Fig(D) Thermographs of Doped ZLI-1184

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The clearing temperature of pure ZLI-1184 is 80^0c but that of doped LC , clearing temperature is93^0c which is increased by 13^0c

Fourier Transform Infrared Spectroscopy

FTIR is powerful tool for identifying types of chemical bonds in a molecule by producing an IR absorption spectrum. FTIR is most useful for identifying chemicals that are either organic or inorganic.

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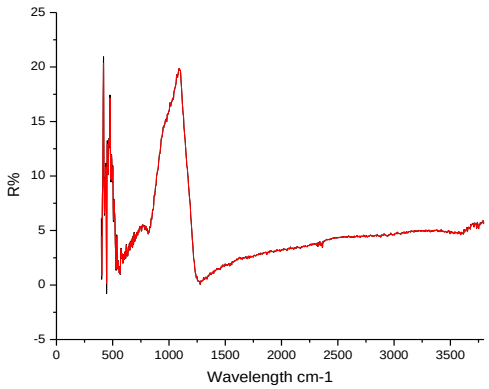
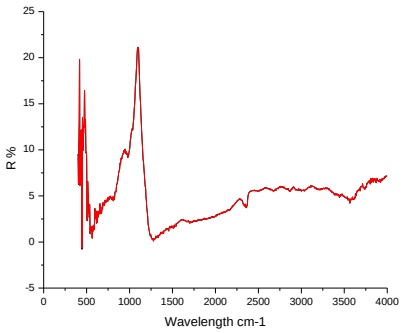
Observations of Fourier Transform Infrared Spectroscopy

Electromagnetic radiation consists of energy - the shorter the wavelength, the more energetic the light is. Liquid crystal molecules can absorb this energy, but only at specific energy levels characteristic of a specific atom or molecule. Thus, Liquid crystals are likely to absorb radiation at certain energies, and so only at certain wavelengths. Specific molecules absorb characteristic wavelengths of radiation, which can be identified through their spectra. Energy that is not absorbed is reflected, this reflected energy is what is measured with the spectrometer. We can easily determine the amount of absorption by inspecting dips in the reflectance spectrum. The infrared spectrum of a sample is recorded by passing a beam of infrared light through the sample.



Fig(E) FTIR graph of Pure ZLI-1184 Reflectance Vs Wavelength



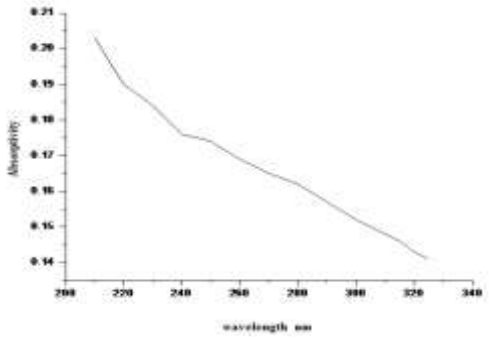
Fig(F) FTIR graph of Pure ZLI-1184 Reflectance Vs Wavelength

Pure ALI-1184 shows absorption at 900 cm-1 ,1400 cm-1 ,and 3600 cm-1 where as in doped LC ,nanoparticals arranged in their layer and strongly absorbed radiations at 1200 cm-1 ,1800 cm-1250cm-1and 3600 cm-1.Absorption of theses bands shows aromatic structures of the compound

UV spectroscopy Analysis

UV spectroscopy is an accurate and powerful procedure to analyze a substance. It measures the absorption, transmission 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. The UV absorption spectra of a LC compound depend on its conjugation length both the core and the terminal group make contributions to this molecular conjugation length. The most common nematic Liquid Crystals structure for displays consists of an alkyl chain, one or two cyclohexane rings, a phenyl ring, and a polar group.

Observation by UV spectroscopy



Fig(G) UV spectra of Pure ZLI-1184

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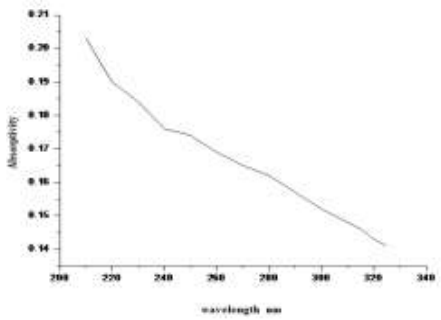
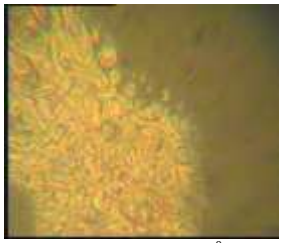


Fig(H) UV spectra of Doped ZLI-1184

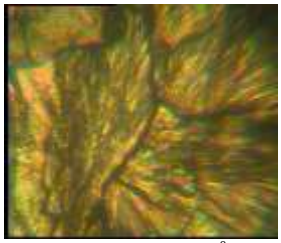
The two major transitions pure ZLI-1184, appears at 220 nm, 240nm,245 nm and 280 nm and the tail ending at 325 nm. In doped ZLI-1184, the transitions occurs at 230 nm,250nm 285 nm and tail ending at 325nm.Absorption at higher wavelengths in doped ZLI-1184 shows interaction of nanoparticals with the LC Absorptions at these wavelength indicate n → π*, absorption, which conforms presence of C=N group in the compound

Polarizing Microscopy Study

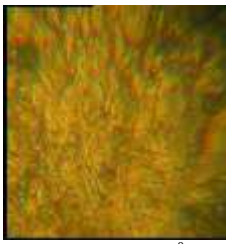
PMS is used to characterize the textures of Liquid Crystals. From these textures we have analyzed the transition temperatures as well as nature exhibited by Liquid Crystals.ZLI-1184 becomes isotropic at 800c . Schlerian nematic texture appears at 780C*. At 700c Twist Grain Boundary appears which is characteristicsa of chiral nematic structure. It shows Smectic C mesophase at 450C.



Schlerian nematic at 80^0C



Smectic C mesophase at 45^0C



Threaded Nematic at 74^0C*

Twist Grain Boundary at 70 C*

Fig (J) Textures of ZLI-1184 by Polarizing Microscopy

CONCLUSION

Due to low concentration of nanopowder, we observed that there was increase in various phase transition temperatures of mixture. it indicates that there is strong interaction of Liquid Crystal particles with nanoparticles. Transition temperatures ,observed by DTE and FPSS shows that isotropic temperature is enhanced by 13^0c.

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