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Study on Thermal Properties of Liquid Crystal Ternary Mixtures

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ABSTRACT

We studied the mixtures of Cholesteric Liquid crystal at various concentrations. Thermotropic liquid crystal occurs at definite phase transition temperature. In this paper we used the mixtures of Cholesteryl pelargonate, Cholesteryl Chloride and Cholesteryl oleate. In our mixture, new Phase Transition temperature and mesophases have been detected. Characterisations were carried out on Polarising Microscopic Study (PMS), Fabry perot scattering studies (FPSS). Fabry perot scattering studies is a multiple beam instrument capable of extremely high resolution designed which yields bright fringes on a wide dark background. The diameters of the ring were measured at the various temperatures. Temperatures measured by remote sensing IR thermometer. It is observed the Phase transition which occur at a known temperature were shifted the transition range, with increase in the concentration. This Phase transition temperature (PTTs) will confirm by PMS study. Also we are finding the absorption and transmission peaks by Fourier Transform Infra-red Spectroscopy (FTIR) method. By Fourier Transform Infra-red Spectroscopy the compound shows structural changes in mixtures due to addition of Cholesteryl Chloride. It is used in display application such as LCD monitor with colour Variation and so many others.

Keywords:--Liquid crystal, Fabry-perot scattering studies, Polarising Microscopy studies, Phase transition temperature. Fourier Transform Infra-red Spectroscopy.

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1. INTRODUCTION:

For many application of Liquid crystal characteristics need to be satisfied such as stability of mesophase range and existence of phases at a desired temperature. Liquid crystal materials generally have several common characteristics; one of the characteristics is the transition temperature which is measured over temperature range of phases. To achieve useful temperature range, mixture can be used. The anisotropy of the physical properties is very important not only from the viewpoint of molecular theory but also practical applications, because it strongly affects the electro-optical properties of liquid crystal displays. Recently liquid crystal mixtures are used to enhance physical properties of these materials. Small concentrations of optically active material is mixed with emetic compounds shows changes in their behavior.

There are several methods to identify, characterization the various liquid crystalline phases viz. Polarizing microscopy (PMS). X-Ray Diffraction (XRD), Differential Scanning Calorimetry DSC / Differential Thermal Analysis (DTA), UV, IR.etc.

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In the present work we have studied the phase transition of Cholesteryl pelargonate, Chloride and oleate with various concentrations. The phase transition of liquid crystal between various mesomorphic forms occurs at a thermodynamically defined temperature as the liquid crystal undergoes a change in internal order at the point of phase transition. FPSS is used to determine the some new PTTs along with known transition temperatures of liquid crystals. PMS are used for textures. Infrared spectroscopy has become the most informative tool in the study of conformation of liquid crystalline materials. As IR spectra of liquid crystals yield interesting information from the point of view of both the degree of ordering in mesophases and characteristics of particular vibrational modes.

1. Fabry-perot scattering studies (FPSS):

Different forms of interferometer are now used for a large number of very different purposes, for example high precision metrology, measurements of refractive index and density, study of surfaces and microscopy. For high-resolution spectroscopy only two types of interferometer are important, the Fabry-Perot and Michelson. The FP etalon consists of two glass plates (fused silica) 2cm - 15 cm in diameters, held accurately parallel to one another at a fixed distance't'. The spacers are normally made of quartz or invar. The plates themselves are made slightly prismatic, in order to avoid disturbing effects due to reflections at the outer uncoated surfaces. An interference pattern formed by the FP interferometer consists of fringes of equal inclination.

Fabry-Perot etalon are perfectly parallel, the circular fringes are at infinity. If a strongly convergent light beam is allowed to fall on the etalon, there are many multiple reflections in the gap between the plates. The rings are obtained in the field of view. The diameter of these rings depends upon the wavelength of the light used and the angle of incidence and the thickness of the air-gap. The fringes obtained in the FP interferometer are based on the multiple reflection of beam of source.

2. Polarizing Microscopic Studies (PMS):

Polarizing microscope is the most widely used method in identifying different phases. Liquid crystal substances placed between two glass cover slips. Depending on the boundary condition and the type of phase, various textures which are characteristics of a phase are observed. Usually the textures changes while going from one phase to another. Polarizing microscopy is powerful tool when used in combination with miscibility of binary mixtures. Liquid crystals phases possess characteristic textures when viewed under polarized light. These textures, which can often be used to identify phases, result from defects in the liquid crystals. Polarizing Microscopy is used for various phases like Nematic, SmA, SmB. SmC. When Liquid Crystal goes from a solid to liquid crystal phase, the degree of length order decreases. This is expressed by a decrease in order parameters. In case of orientational disorder it is possible to see changes between different Liquid Crystal Phases during the heating and cooling cycles of liquid crystals.

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". FTIR is most useful for identifying chemicals that are either organic or inorganic.

It can be utilized to quantitative some components of an unknown mixture. It can be applied to the analysis of solids, liquids, and gasses. The term Fourier Transform Infrared Spectroscopy (FTIR) refers to a fairly recent development in the manner in which the data is collected and converted from an interference pattern to a spectrum. Today's FTIR instruments are computerized which makes them faster and more sensitive than the older dispersive instruments.

2. EXPERIMENTAL DETAILS:

In this paper, we used the sample of the CLCs Cholesteryl pelargonate (97%) (A) Cholesteryl Chloride (97%) (B) And Cholesteryl Oleate (C) and their mixtures in appropriate proportions by weight ChP (80%) + ChCL (15%) + ChO (5%) have been investigated. The sample has been studied using low power (2mw) He-Ne laser as the optical source. A Fabry-Perot etalon coupled with a spectrometer telescope forms the rest of the experiment set up. The LC sample was heated by an indigenous electric heater. The laser light scattered by the LC sample at 90^0 to the incident beam was allowed to fall on the Fabry-perot Etalon and the Fabry-Perot rings were obtained. The angular diameters of the rings were measured at various temperatures. The temperature were measured accurately using a Remote Sensing Infra-red thermometer having a resolution of 0.1^0C The measurement of Scattering experiment were plotted The graphical mappings of Angular diameter Vs Temperature show an abrupt variation (20' to25' with a spectrometer of least count = 1') at the mesophase transition temperatures Cholesteric Liquid crystal (CLC) mixtures as well as individual component of A, B and C.

In FTIR technique, the transmitted light reveals how much energy was absorbed at each wavelength. This will produced transmittance or absorbance spectrum, which showing IR wavelengths the sample absorbs. The compounds show spectra in which many peaks spread over the wide range of frequencies (4000cm^{-1}-600 cm^{-1}). Each peak is associated with a particular vibration. The complexity of spectra reflects large number of fundamental vibrations. From IR spectra, we found the type of functional groups present in organic compounds. Fourier Transformed Infrared Spectroscopy gave us the detailed information about which functional groups are present in a molecule.

3. OBSERVASTIONS:

In FPSS study we found the new phase transition temperatures. The phase transition temperatures of the liquid crystal samples in pure as well as mixture are shown in below observation table (1). New transition temperatures are denoted by "*".

1. **Analysis on FPSS Graph of mixture of**

ChN (A) + ChCL (B) + ChO(C)

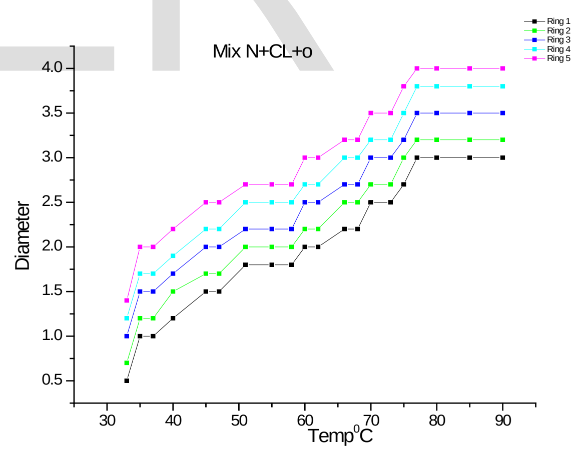

Fig: 1

2. Analysis by PMS

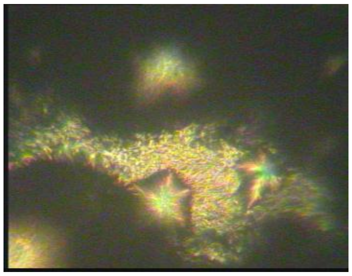

Fig 2: Star Shaped G domain with Symmetry at cooling 62^{0}C.

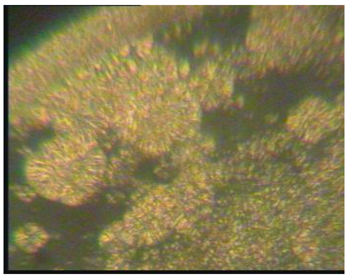

Fig 3: Schlieren texture of the twisted smectic state towards crystalline state at cooling 58^{0}C.

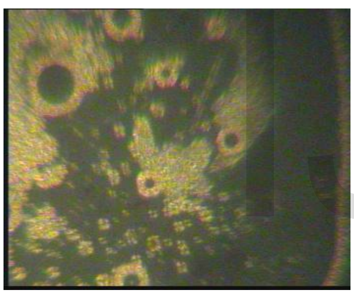

Fig 4 : Stable texture of rotating petals at cooling 56^{0}C.

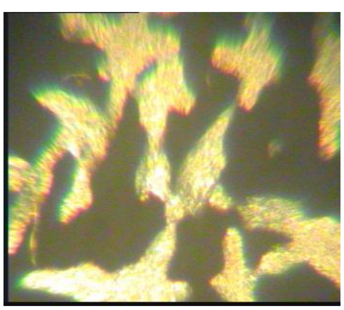

Fig 5 : Phase transition isotropic at heating 58^{0}C.

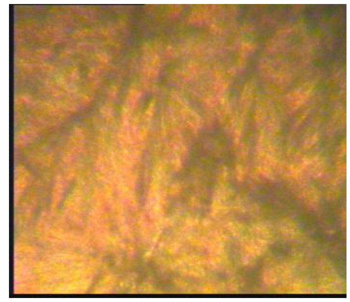

Fig 6 : Thread like nematic at heating 45^{0}C.

Observation table for FPSS

A	B	C	FPSS	PMS
100%	----	----	70,77*, 80*, 80.5, 92	75,76, 77.5,79.5*,81* ,85,89,90.5,92 , 94,
------	100%	----	35,47,57,62.5* , 67,73*, 75,88*, 96	38,44,57,64,7 3,75,80
-----	-----	100%	41,43*, 50*,55	39,41,43*,45*, 47*,60
80%	15%	5%	37,40*, 47, 58, 62*,68,73*,75, 90	32,45*,53,56,5 8, 60*,80*,92.

3. Graph of FTIR of mixture.

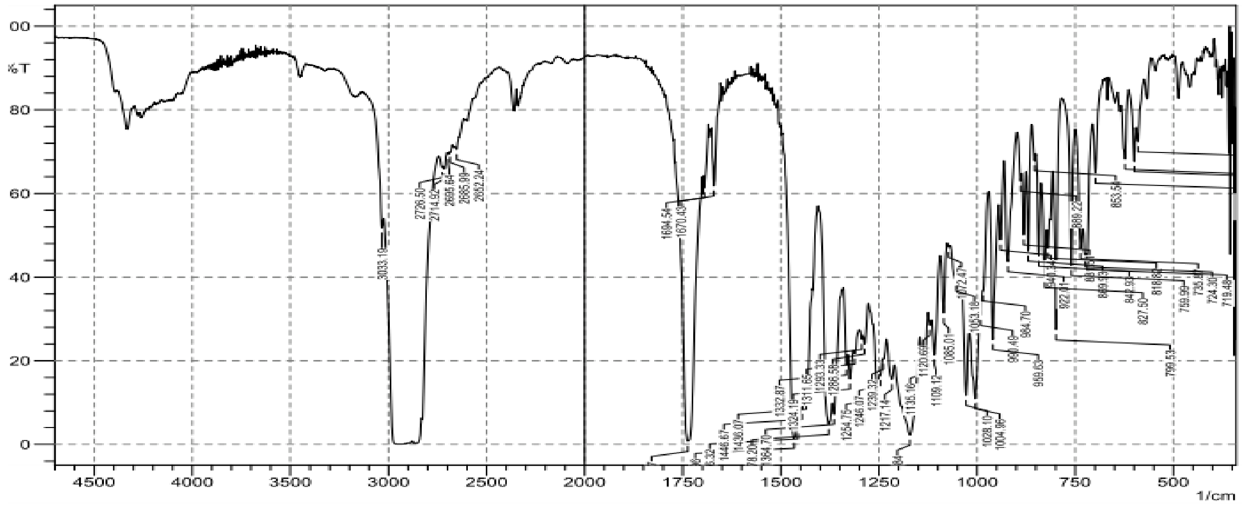

Fig: 7: FTIR of Ternary Mixture

RESULT AND DISSCUSION:

In Fabry–Perot Scattering Studies more Phase transition temperatures are found than Polarizing Microscopy. From the study of PMS we observe the textures and analyzed the transition temperatures as well as nature exhibited by liquid crystals. The number of phase transitions increases as the percentage of one component takes precedence over the other. The Phase Transition temperature shows more complex behavior at the lower heating cycle and diverse concentrations. We observed ,some interesting phases like, Star Shaped G domain with Symmetry at cooling 62^0C (fig2), Schlieren texture of the twisted smectic towards crystalline state at cooling 58^0C (fig3), Stable texture of rotating petals at cooling 56^0C (fig4), Phase transition isotropic at heating 58^0C (fig5), Thread like nematic at heating 45^0C(fig6). Structural changes due to various concentrations at various excitations were studied by FTIR shown in the fig 7. We found the different functional groups which are present in a molecule like carboxylic acid, Aldehydes, Hydro halide, and Epoxide all over the mixtures. The compounds show spectra in which many peaks spread over the wide range of frequencies (1500cm^{-1}-3000 cm^{-1}). Mainly the changes occur due to cholestryl chloride in the graph. FTIR analysis showed in mixture a strong absorption peak (between 1600-1700) of chloride indicating group RCH=O, was stretch and appear two peaks. A small peaks occurs at (between 2500-3000) indicating –NH absorption.

5. CONCLUSION:

Cholesteric-nematic phase transitions can be induced in such compensated mixtures thermally. By the FPSS technique, it is found that in some of concentration the transition temperature has been extended by 2^0-4^0C and lower by 4^0-6^0C and are confirmed by PMS.FTIR analysis showed a strong absorption peak (between 1600-1700) in mixture.

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