Thermal behavior of Polymer dispersed Liquid Crystals

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ABSTRACT

Polymer – dispersed liquid crystals (PDLCs) have combined application of polymers and liquid crystals. They are the focus of extensive research in the display industry. PDLCs are composite materials in which liquid crystalline material is dispersed within a polymer matrix to form micron-sized droplets. These tiny droplets (a few microns across for practical applications) are responsible for the unique behavior of the material. By changing the orientation of the liquid crystal molecules with an electric field, it is possible to vary the intensity of transmitted light.

Transmission of light through PDLCs depends primarily on scattering which in turn depends on the difference in refractive index between droplets and their environment. In the case of high droplet density, the environment consists mainly of other droplets, which makes the relative orientation of their directors an important factor. The liquid crystals, both as mesogenic moieties and as dispersed droplets exhibit s various textures according to their molecular order and orientation.

Recently liquid crystal doped with polymer as well as monomer is used to enhance physical, optical properties of the material. In the present paper we used Fabry Perot Scattering Studies (FPSS), Polarizing Microscopy Studies (PMS), Differential Scanning Calometry (DSC)/ Data Thermal Analysis (DTA) to study the phases (textures) and phase transition.

The mesomorphic properties of pure and PDLCs were compared. The PDLC phase transitions occurred at temperatures lower than those exhibited by the mesogenic compounds in the pure state. These results were confirmed by DSC, FPSS and texture study of PMS. The changes in refractive index of PDLC suggest the change in orientation of molecules of pure liquid crystal. Our result provides good and new opportunity for technological development and hold potential for verity of electro-optic application ranging from display to light shutters.

Key words: Liquid Crystal (LC), Polymer dispersed liquid crystal (PDLC), DSC, FPSS and PMs.

INTRODUCTION

Polymer dispersed liquid crystal (PDLC) displays are interesting new uses for liquid crystals which could allow liquid crystalline materials to be used in electro-optic applications such as projection displays [1-3].

PDLC displays exhibit several advantages in comparisons to conventional displays. In production of the PDLC cells no surface-alignment treatment is required and they can work without polarizers. For that reason, the PDLC devices are currently of high interest [5-7] and they have promising new applications for light control and flexible electro-optic displays.

EXPERIMENTS AND MATERIALS

The nematic liquid crystal (NLC), polymer (P) and monomer (M) are purchased from Sigma Aldrich Company. The polymers, monomers are mixed with NLC in different proportions.

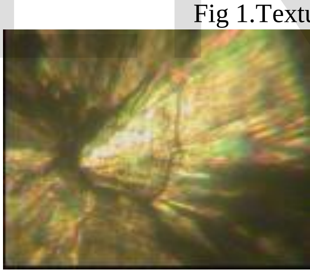
CHARACTERIZATION

The experimental parameter involved in the present study was investigated in detail .The liquid crystal images of mixture were observed with Polarizing microscopy (PMS). Differential Scanning Calorimetery (DSC) and Fabry-Perot scattering Studies (FPSS) were used to measure phase transition temperatures.

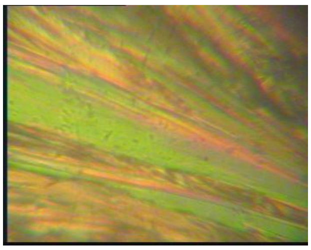
RESULT AND DISCUSSION

OBSERVATIONS BY POLARIZING MICROSCOPY:

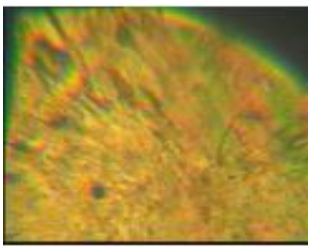
Fig 1.Textures of NLC



Focal Conic texture 34.5˚C

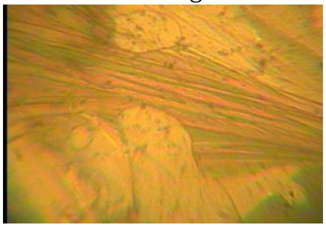


Smectic phase at 38.0˚C

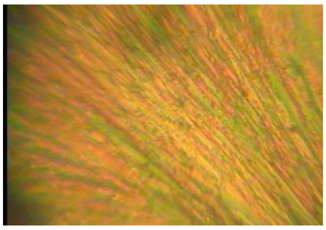


Nematic texture 43.5˚C

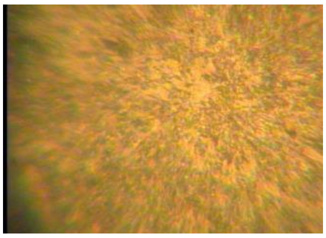
Fig 2.Textures of NLC+ M



Focal Conic 30.5˚C

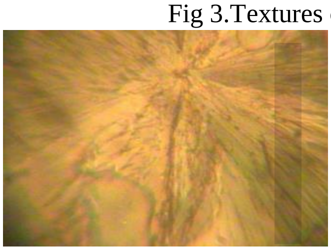


Smectic phase at 40.2˚C

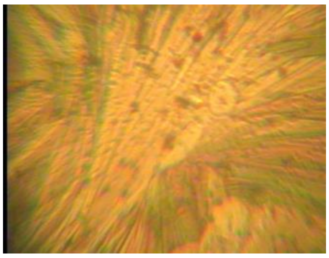


Nematic texture at 47.2˚C

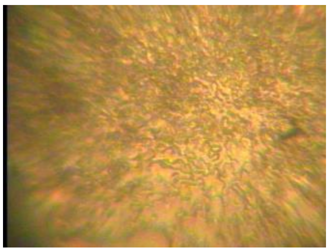
Fig 3.Textures of NLC + P



Fan like texture at 29.2˚C



Smectic phase at 43.6˚C



Nematic texture at 43.6˚C

1. Hexyle Benzoate exhibits smectic A and nematic phases.
2. Their isotropic temperature is 47.5˚C when cooling down from isotropic liquid a nematic texture appears at 43.5˚C.
3. Upon further cooling the nematic texture turn into fan like texture at 38.5˚C. At 34.5˚C smectic A phase is appeared.
4. With monomer the isotropic temperatures of NLC obtained as 75.0˚C. The nematic texture is appeared at 47.2˚C and fan like texture is observed at 30.5˚C.
5. With Polymer the isotropic temperatures of pure liquid crystal obtained as 80.0˚C the nematic texture is appeared at 48.0˚C and fan like texture is observed at 29.2˚C.

OBSERVATIONS BY FABERY PEROT SCATTERING STUDY

The scattering studies gave the information about mesophase transition temperature. Phase Transition Temperatures for hexyle Benzoate and its mixture with monomer and Polymer at various heating and cooling cycles are observed .Experiment is repeated for heating and cooling cycle's .The graphical mapping of analysis of Diameter of Fabry-Perot rings Vs temperature shows a variation at the mesophase transition temperature.

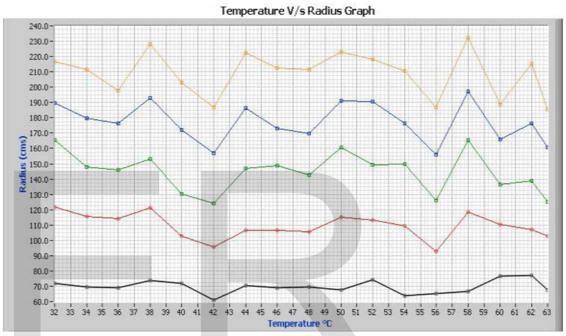


Fig 4. Graph of FPSS of NLC

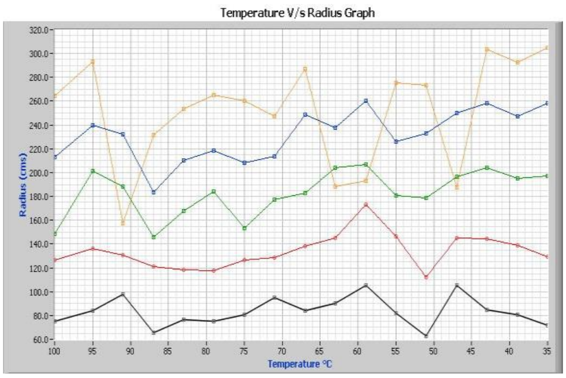


Fig.5. graph of FPSS of NLC + M

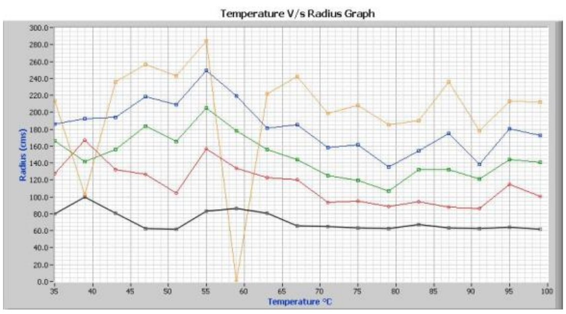


Fig 6. Graph of FPSS of NLC + P

Table 1. FPSS- Phase Transition Temperature 0C

Sample	PTTs ^{0}C
NLC	34.5*,38.5^{0}C*,41.5*,44.5 47.5,43.5*,46.5*
NLC+M	47, 51, 69,71,75,
NLC+P	48,51,55,65,80

*New Phase Transition Temperature

OBSERVATIONS BY DIFFERENTIAL SCANNING CALORIMETERY (DSC)

The phase transition temperatures were determined using DSC. It measures the temperature and heat flows associated with transitions in materials as a function of time and temperature in a controlled atmosphere. The peaks correspond to transition from solid to isotropic phase.

For Pure liquid crystal the nematic to isotropic transition temperature obtained are 44.0˚C and 47.0˚C. Whereas the transition temperatures of liquid crystal with monomer are observed as 46.5˚C and 47.5˚C. In case of doped liquid crystal with polymer, the nematic to isotropic transition temperature observed as 47.5˚C and 48.0˚C.

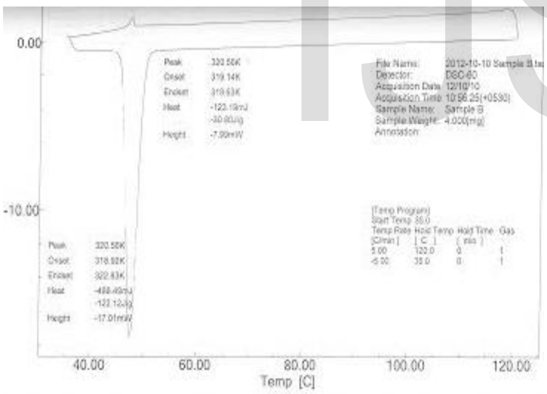


Fig 7. DSC of pure NLC

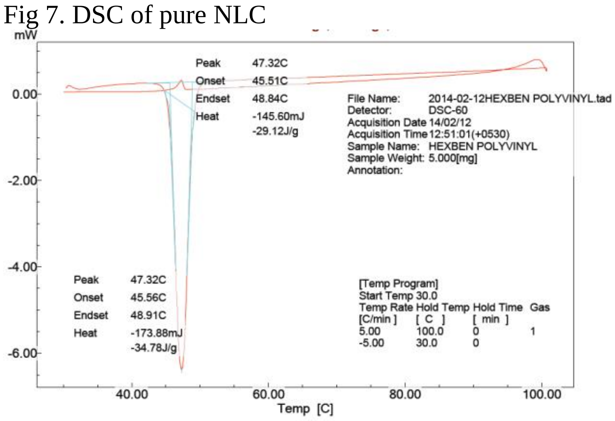


Fig 8.DSC of NLC+P

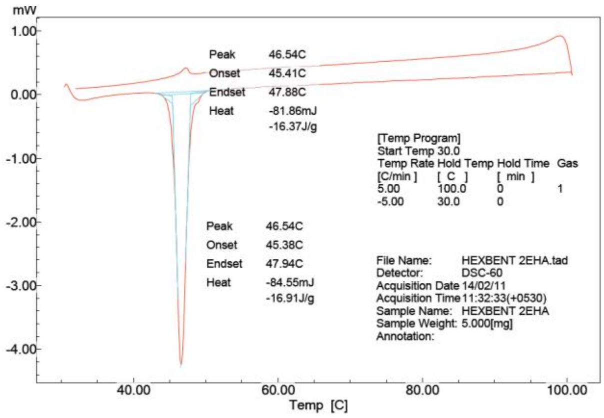


Fig 9.DSC of NLC+M

Table 2. Phase Transition Temperatures by various techniques 0C

Sample	FPSS	DSC	PMS
NLC	34.5*,38.5*,41.5*, 44.5,47.5 ,43.5*, 46.5*	46.50, 48.50	34.5,38, 43.5, 47.5
NLC+M	47, 51,69,71, 75	46.50,47.94	30.5,40.2 , 47.2
NLC+P	48,51,55, 65,80	47.94, 48.90	29.5, 43.6, 48

CONCLUSION

The phase behavior of liquid crystal between various mesomorphic forms in monomer and polymer is measured by PMS, FPSS and DSC. New transition temperatures were detected. In the morphological observations it is confirmed that the cross linking of polymer influence the behavior of Liquid crystals. The Phase transition temperatures we got by PMS are confirmed by FPSS and DSC. This could be applied to optical devices.

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