International Conference On Emanations in Modern Technology and Engineering (ICEMTE-2017) ISSN: 2321-8169
Volume: 5 Issue: 3 21 - 23

Comparative Phase transition behaviour of PDLC-MWCNT composite system

[1]Jyoti_Mahajan,[2]Sureshchandra J. Gupta,
[3]Swati Kashyap,
Department of Physics,
University of Mumbai, Santacruz (E)
Mumbai - 400 098, India.

[4]Karuna Bhole
Department of HAS,
L.R. Tiwari College of Engineering, Mira road (E),
Thane - 401 107, India.

Abstract - Liquid crystals (LCs) are unique in their properties and uses. Liquid Crystals shows various mesophases before it goes in isotropic state. Various methods can be used to study the phase identification and characterization of LCs Viz. Polarizing Microscopy, XRD, Differential scanning calorimetry (DSC), Fabry-Perot scattering studies (FPSS) etc. In this paper, we will be discussing results obtained for phase transition temperatures (PTTs) by means of Polarizing microscopy (PMS), Fabry-Perot Scattering Studies (FPSS) and differential scanning calorimetry (DSC). We have investigated the undoped Polymer Dispersed Liquid crystals (PDLCs) sample and PDLCs doped with Multi-walled carbon nanotube (MWCNTs) in different concentrations. It is observed that clearing point temperatures goes on decreasing with increase in percentage concentration of MWCNTs.

Index Terms - *Phase transition temperatures (PTTs), Clearing point temperature (CPT), PDLCs, MWCNTs.*

*****

I. Introduction

Nanotechnology is currently the most heavily researched areas in various fields due to their size and shape dependent unique properties. The influence of nanoparticles on the properties of liquid crystals attracts the extensive scientific interest [10]. Out of a variety of nanoparticles, the multi-walled carbon nanotubes are found to be good dopant for LCs as both involve one most important similarity i.e. anisotropy. This anisotropy itself leads to many novel properties and applications. Also, their elongated shape helps them to easily build into the orientationally ordered liquid crystal matrix. This leads to many interesting effects and enhances the properties of LCs especially their electro-optical and dielectric properties [9, 14].

Polymer dispersed liquid crystals (PDLCs) are the materials which combine the special properties of liquid crystals with that of polymers. PDLCs are formed by dispersing micron sized droplets into the polymer matrix. In the present work, we have doped PDLCs with MWCNTs in different concentrations.

A. *Phases of Liquid Crystals*

A phase transition is the transformation of a thermodynamic system from one phase to another. The distinguishing characteristic of a phase transition is an abrupt sudden change in one or more physical properties. These changes in physical properties can be observed using various techniques.

As liquid crystal is the intermediate phase between the solid crystal and that of isotropic liquid. The main manifestations of liquid crystal molecules is their melting (2 melting points) or softening behaviour. When a crystalline solid which does not have mesomorphic behaviour is heated, at melting temperature it directly goes into the isotropic phase. But in liquid crystalline materials several different mesophases may form before it reaches to isotropic melting temperature. Thermotropic LCs exhibit a variety of phases as temperature is changed [3].

II. Materials

A. Cholesteryl Propionate (CP): This liquid crystal is an ester of cholesterol. It has clearing point temperature at around (90 to 95) ^{0}C [Procured from Acros organics]

B. PMMA Poly (methyl methacrylate) is a thermoplastic polymer. The polymer dispersed liquid crystals are prepared using solvent induced phase separation method (SIPS). The proportion used in the preparation is 80% of CP and 20% PMMA. Thus, prepared PDLCs are doped with the following nanoparticles and Multiwalled-Carbon Nanotubes (MWCNTs) with their different concentrations.

MWCNTs Procured from cheap tubes - USA, 10-20 nm outer diameters, length 10-30 micrometers.

C. *Doping of MWCNTs*

For doping of MWCNTs first they are soaked in chloroform and then allowed it to dry for more than 24 hrs. Now these MWCNTs are taken into desired concentration and mixed with chloroforms and sonicated till we get the macroscopically proper disperse solution and then this is mixed with already prepared solution of PDLCs and then magnetic stirring done to prepare homogenous solution.

III. Experimental Techniques

Various methods can be opted to investigate the phase transition temperatures. We have employed three methods to investigate our samples for phase transition temperatures.

A. *Polarized Microscopy Studies (PMS)*

The Polarized Microscopy Studies (PMS) exploits the optical properties of anisotropy to reveal detailed information about the structure and composition of materials which are invaluable for identification and characterization of various phases & phase transitions in LCs and liquid crystal composites.

The identification of mesophases through optical polarizing microscopy usually involves magnified view of a thin sample of a mesogenic material sandwiched between a glass microscope slide and glass coverslip. The polarizing microscope used in this study is LEICA DMLP with METLAR TOLADO hot stage. Texture images are captured by Nikon camera.

B. *Fabry-Perot Scattering Studies (FPSS)*

FPSS based on the concept of Fabry-perot etalon method for determining the phase transition temperatures (PTTs) has been introduced in 1990 [6]. Since then we have determined PTTs of various LC molecules, LC mixtures and also composites system of Polymer dispersed liquid crystals (PDLCs) and Nanoparticles/Nanotubes. Experimental setup consists of a Fabry – Perot etalon coupled with spectrometer, a He-Ne laser as optical source & an electric heater to heat the sample and a thermometer [1, 6].

C. *Differential Scanning Calorimetry (DSC)*

Differential scanning calorimetry or DSC measures the heats of transition of the samples with linear temperature ramp. The temperatures and heat flows associated with phase transitions in materials are measured as a function of temperature in controlled atmosphere. These measurements provide quantitative and qualitative information about physical and chemical changes that involve exothermic (heat flows out of the sample) and endothermic (heat flows into the sample) processes. Phase transition temperatures (PTTs) and clearing point temperatures (CPT) are studied with the help of DSC. Clearing Point Temperatures (CPT) is a temperature at which anisotropic liquid crystal sample goes into isotropic state.
DSC used in this study is Shimadzu DSC-60.

IV. Results & Discussions

A. *Results obtained from Optical Polarizing Microscopy*

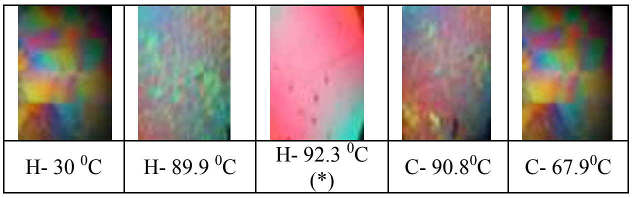

Fig.1. Textures Obtained for Undoped PDLC

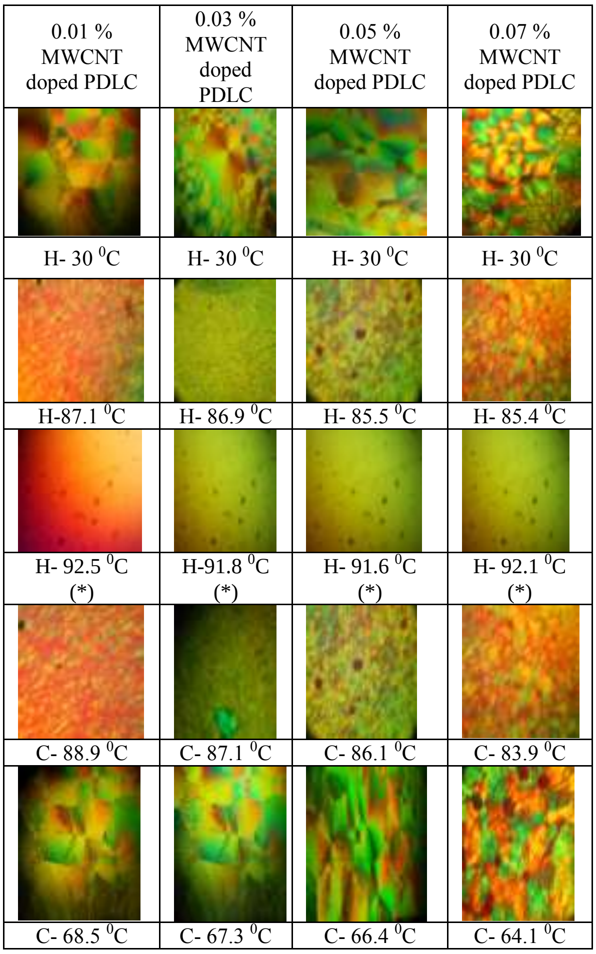

Fig.2. Textures Obtained for PDLC-MWCNT composite System

B. *Clearing point temperature (CPT) obtained from DSC*

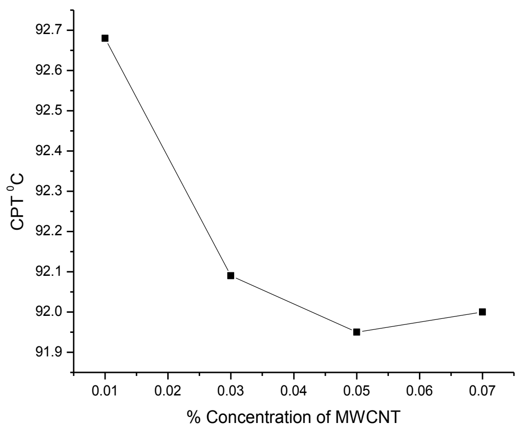

Fig.3. Variation of CPT with % concentration of MWCNT

C. Comparative results Obtained from FPSS, PMS, DSC

Table 1. Comparative results for Undoped PDLC

Sample	FPSS (PTTs in ^{0}C)		PMS (PTTs in ^{0}C)		DSC (PTTs in ^{0}C)	
	Heating	**Cooling**	**Heating**	**Cooling**	**Heating**	**Cooling**
	89.7,	89.5,	89.9,	90.8,	90.29*	72.78,
CP+PMMA	90.2*	72.3,	92.3*	67.9		67.96
		67.4				

Table 2. Comparative results for PDLC-MWCNT composite system

% Concentration of MWCNT	FPSS (PTTs in ^{0}C)		PMS (PTTs in ^{0}C)		DSC (PTTs in ^{0}C)	
	Heating	**Cooling**	**Heating**	**cooling**	**Heating**	**Cooling**
	86.9,	88.7,	87.1,	88.9,		
0.01%	90.4,	73,	92.5*	68.5	92.68*	69.79
	92.42*	68.44				
	86.9,	87,		87.1,		69.38,
0.03%	89.5,	75.1,	86.9,	67.3	92.09*	66.19
	91.67*	67.26	91.8*			
	85.3,	85.9,	85.5,	86.1,		71.23,
0.05%	88.43,	73.96,	91.6*	66.4	91.95*	67.68
	91.45*	66.34				
	85.33,	83.9,	85.4,	83.9,		
0.07%	88.4,	68.3,	92.1*	64.1	92*	68.9
	91.95*	64				

Note: 1) * indicates clearing point temperature.

D. Discussions of the results obtained

1. Phase transition temperatures studied with all 3 techniques (PMS, DSC, FPSS) are in good agreement with each other.
2. FPSS being an optical technique, able to detect even small heats of transition, it is observed to be more sensitive technique for the study of PTTs as compared to DSC & PMS.
3. The colour of the textures changes due to the doping of MWCNTs and it also changes with change in the dopant concentration of the MWCNTs.
4. At R.T both doped and undoped samples shows similar nature of textures i.e. focal conic in nature.
5. Clearing point temperatures decrease with increase in concentration of MWCNTs. This leads us to conclude that stability of LC mesosphere decreases due to the doping of MWCNTs.
6. The lowest CPT is observed for 0.05 % MWCNT.

IV. Conclusion

The study of the phase transition temperature gives us the information about the sample to be used in which temperature range and its suitability for the applications. The PTTs study for PDLC-MWCNT composite system shows that the system is more stable at 0.05 % MWCNT doped material than other concentration. All doped samples maintained their liquid crystalline nature and the nature of the texture is same for doped and undoped samples at respective temperature.

References

[1] Gupta Sureshchandra, J., et al. (2000). ‘‘Phase Transition Temperatures of LCs using Fabry-Perot Etalon’’ Molecular Crystals; Liquid Crystals, Procs of ILCC 2000, Japan, Vol. 364–368.

[2] Gupta Sureshchandra, J., (2000). Liquid Crystals: Chemistry, Physics and Applications, (Proceedings of SPIE, Poland), 4147 23.

[3] Liquid Crystals - I.C.Khoo, John Wiley & Sons,(2007)

[4] Handbook of Liquid Crystals- H.Kelker & R.Hatz (V. Chemie,Weinheim, 1980).

[5] Liquid Crystals-Experimental Study of Physical Properties and Phase transition Satyendra Kumar.(CUP, 2001)

[6] S. J. Gupta, et.al. “Charactrisation of Mixtures of Cholesteric liquid crystals using Fabry-Perot scattering studies” Proceedings of SPIE-2005

[7] Liquid Crystals - S. Chandrasekhar, Cambridge University Press, 2nd Edition.1993.

[8] Liquid Crystals - Natures Delicate Phase- Peter J. Collings, New Age International Publishers, 2nd edition,2007.

[9] Sang youn jeon et.al “Dynamic response of CNT dispersed in Nematic Liquid crystal”Nano: brief Reports and Reviews, Vol.2, No.1 (2007) 41-49.

[10] Anton Sadovoy et.al “Study of electro-optical response of Polymer dispersed Liquid crystal doped with MWCNT” Proc. of SPIE Vol. 6164 616407-1

[11] Handbook of Advanced Electronic and Photonic Materials and Devices,Edited by H.S.Nalwa, Volume 7: Liquid Crystals, Display and Laser materials.

[12] R. A. Shanks and D.Staszczyk “Thermal and Optical Characterization of Polymer-Dispersed Liquid Crystals”,Hindwi Publishing Corporation, International Journal of Polymer Science, Volume 2012, Article ID 767581, 13 pages doi: 10. 155/2012/767581.

[13] S. J. Gupta* et.al. “Laser-Fabry-Perot technique for characterization of liquid crystals”, *Proc. SPIE* 4970, Laser Crystals, Glasses, and Nonlinear Materials Growth and Characterization, 89 (June 13, 2003); doi:10.1117/12.479012

[14] H. DURAN, B. and T. KYU* et.al. “Effect of carbon nanotubes on phase transitions of nematic liquid crystals”, Liquid Crystals, Vol.32, No. 7, July 2005, 815-821.