Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 15; April-June, 2015 pp. 1272-1276

http://www.krishisanskriti.org/jbaer.html

Optical Study of Liquid Crystal Polymer System Doped with ZnO Nanoparticles

Rita A. Gharde[1] and Krishnakant Mishra[2]

[1]Department of Physics University of Mumbai,Mumbai. 400 098.
[2]Department of Physics University of Mumbai
E-mail: [1]gharde.rita@gmail.com, [2]kkmishra372@gmail.com

Abstract—*The influence of Nematic Liquid Crystal Polymer System (NLCPS) was studied to understand the response of optical property by doping ZnO nanoparticles in liquid crystal polymer system to temperature. The NLCPS combines the orientational ordering properties of liquid crystals and polymer networks. The investigations were performed using Polarizing Microscopy Studies (PMS), Fabry Perot Spectroscopic Studies (FPSS) and Abbe Refractometer (AR). After doping ZnO nanoparticles with Liquid Crystal Polymer System (LCP), there is response of refractive index at higher temperature and also increase in clearing point temperature from nematic to isotropic phase transition. The Phase transition temperatures by FPSS are confirmed by PMS. The observed thermal response effect of NLCPS is useful for developing its application in Optical display, LCD display, Sensors, Medical devices. A variety of devices are suitable for optical fiber telecommunication which allow the passage of light to be switched from one optical fiber to another while others allow a particular wavelengths to be separated from a group of wavelengths.*

Keywords*: Nematic Liquid Crystal Polymer System (NLCPS), Polarizing Microscopy Studies (PMS), Fabry Perot Spectroscopic Studies (FPSS), Abbe Refractometer (AR), Liquid Crystal Polymer System(LCPS).*

1. INTRODUCTION

Liquid crystal (LC) has been used extensively for direct view and projection displays, tunable photonics, and nonlinear optics [1-4]. Mixing two or more liquid crystals together allows the scientist or engineer to vary the properties of liquid crystals almost continuously [5].

Recently Liquid crystal polymer system are used as display materials in monitor screens and other type of displays, this is because of the RI (Refractive Index) properties of liquid crystals, liquid crystals have high RI properties in lower voltage and also it has two basic effects electrically controlled birefringence and electrically controlled light scattering. Majority of the LC devices use the electric, thermal, or optical-field-induced refractive index change to modulate light. LC refractive indices are determined mainly by the molecular structure, wavelength, and temperature.

Liquid crystal are highly transparent in the visible and near infrared wavelength regions [6, 7]. The inorganic nanocomposites have optical, electrical, catalytic and mechanical properties and it also has potential application in microelectronics [8]. Quantum dots, especially II-VI such as CdS (Se, Te) and ZnO (S, Se, Te) etc has photoluminescent properties [8]. Nanoparticles, whether they originate from semiconductors or from metals are generally associated with the appearance of novel properties: if the particles are small enough, they become electronically comparable to atoms and molecules, following the quantum mechanical rules instead of the laws of classical physics. Biphenyl systems can prove more mobile.

We have used 4-Pentyl-4'-cyano-biphenyl which is a commonly used nematic liquid crystal with the chemical formula $C_{18}H_{19}N$, molar mass 249.35 g.mol^{-1} , appearance is colourless if isotropic or cloudy white if nematic .The common name is 5CB.It is a member of the cyanobiphenyls. ZnO nanoparticles are doped in 5CB. ZnO has unique optical, semiconducting, piezo electric and magnetic properties. It has high catalytic efficiency and strong adsorption ability.

Here we describe the formation of a composite material that results from the dispersion/doped ZnO in polymeric. A special attention given to the phase behaviour of ZnO doped nanoparticles in Liquid Crystal Polymer System (LCPS).

In this article, we also describe the temperature-dependent LC refractive indices using Abbe Refractometer. In an isotropic phase, the optical anisotropy disappears (*i.e.,* $n_e = n_o$) regardless of wavelength. As the wavelength increases, refractive index for the ordinary ray decrease and then gradually saturate in the near-infrared region. Temperature plays an important role in affecting the LC refractive indices. As the temperature increases, n_e behaves differently from n_o. The concept of refractive index is widely used within the full electromagnetic spectrum, from x – rays to radio waves.

2. MATERIALS AND METHODS

The NLCP used in our studies has been prepared from 4-Pentyl-4'-cyano-biphenyl as shown in figure1 and ethylhexyl acrylate 20-40% , acrylate oligomer that forms a cross-linked network on polymerization.

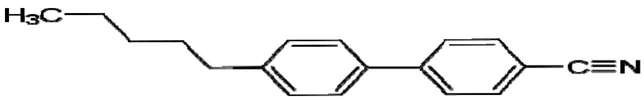


Fig. 1: Structural formula for 4-Pentyl-4'-cyano-biphenyl

4-Pentyl-4'-cyano-biphenyl liquid crystal is also known as (5CB). Nematic Liquid Crystal Polymer System (NLCPS) is procured from Nematel. ZnO Nanopowders whose size is 50nm, particle morphology nearly spherical, hexagonal crystal structure, SSA- 50m^2/g procured from Nanoshell, USA.

We have used for the homogeneous alignment of the sample. First rinsed both the slide and cover slip with acetone and then wiped with a tissue in a direction parallel to the one fixed direction of the slide. Few drops of the sample is then added on the slide and is then covered with the cover slip sliding in the same direction mentioned above. After the sonication and magnetic stirring we are getting homogenous mixture of ZnO nanoparticles dispersed in LCPS. We use varied concentrations of LCPS and ZnO nanoparticles in order to study the behavior of the system as a whole.

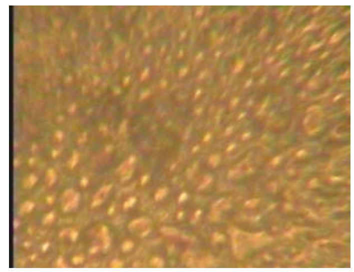
2.1 Optical observation

Polarising Microscopic Studies (PMS) is powerful tool when used in combination with miscibility of mixtures. LC phases possess characteristic textures when viewed in polarized light under a microscope. These textures, which can often be used to identify phases, result from defects in the textures. PMS is used for various phases like Nematic, SmA, SmB. SmC,……..When LC, 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 LC phases of heating and cooling from the textures. We have noted textures of doped and undoped samples at various temperatures.

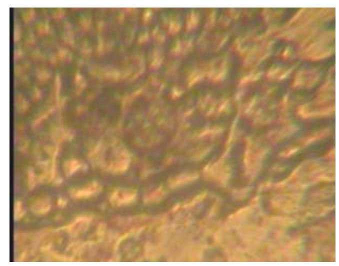
Some of the mixture is deposited between two glass slides where it cools down and then it is heated again above the nematic isotropic transition. On cooling below, the isotropic, nematic transition appears under the microscope, as the formation of droplets which means rich in zinc oxide nanoparticles. On reversible way, droplets disappear on heating above transition temperature. We observed that the neighbouring droplets remain aligned together as shown in Fig. 2. The localization of these rings appears somehow superposition with the Schlieren texture. The existence of biphase below transition is a direct consequence of multicomponent system.

Texture of Pure PE10 sample is shown in Fig. 2 (a), (b). It shows a phase change at 70.3 ^{0}C, 86.0 ^{0}C. However after doping it with ZnO, it exhibits varied changes in the texture, which is recorded during persistent heating and cooling cycles shown in Fig. 3(a), (b). Heating the nematic phase near the clearing point temperature often gives a coloured texture as the phase becomes more fluid.

3. POLARISING MICROSCOPY IMAGES(PMS)

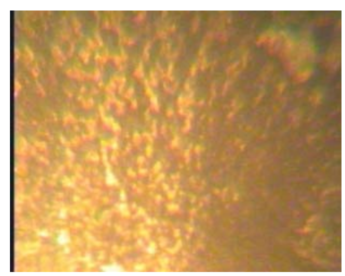


a) 73.1 oC – C

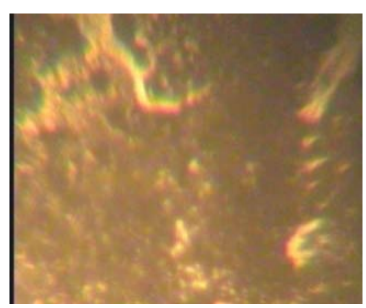


b) 70.0 oC – C

Fig. 2. Pure Liquid Crystal Polymer System (Cooling cycle)



a) 37.9 oC – C Smectic C* phase



b) 62.1 oC – C Nematic Schlieren texture

Fig. 3: ZnO doped Liquid Crystal Polymer System (Cooling cycle)

2.2 Phase transition measurement

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 scattering studies gives the information about mesophase transition temperature. Phase transition temperatures for doped ZnO Nanoparticles in Liquid Crystal Polymer System at various heating and cooling cycles are observed. Experiment is repeated for heating and cooling cycles.

The graphical mappings of Fabery-Perot rings Vs temperature for heating and cooling cycle is shown in Fig. 3 and Fig. 4. It shows a variation at the mesophase transition temperature. While heating the sample, phase transition occurs at 63^0C , 96^0C and at the time of cooling , phase transition occurs at 62 ^{0}C and 93 ^{0}C .

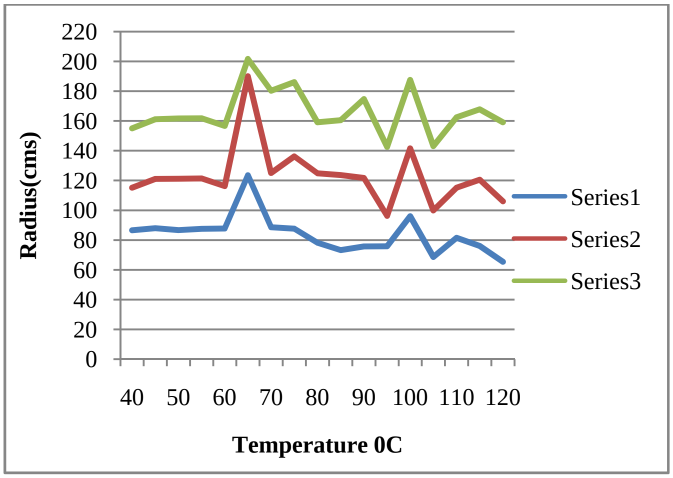


Fig. 3. Radius Vs. Temperature graph (heating cycle) for ZnO doped LCPS

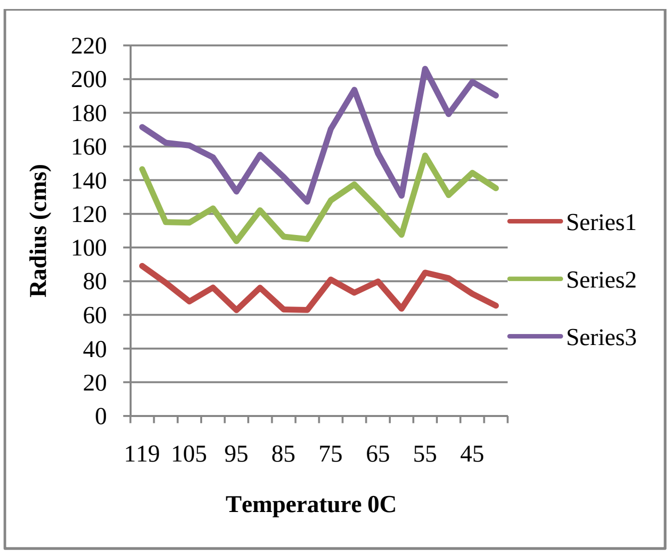


Fig. 4: Radius Vs. Temperature graph (cooling cycle) for ZnO doped LCPS

The graph of intensity vs temperature for heating and cooling cycle is shown in Fig. 5 and Fig. 6.On heating cycle ,the phase transition occurs at 55^0C , 90^0C and at the time of cooling , phase transition occurs at 60^0C and 90^0C .

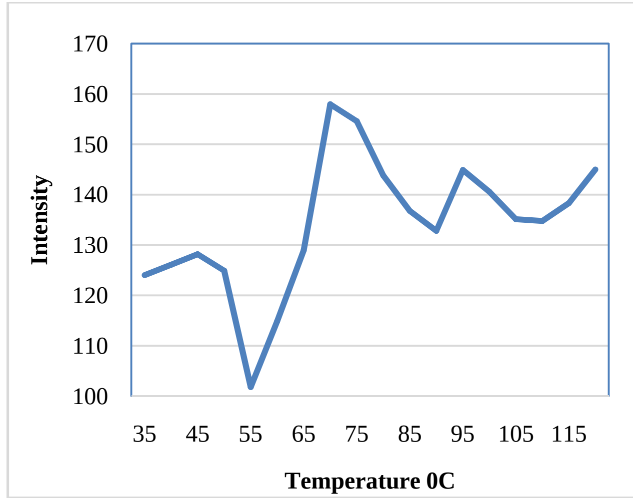


Fig. 5: Intensity Vs. Temperature graph (heating cycle) for ZnO doped LCPS

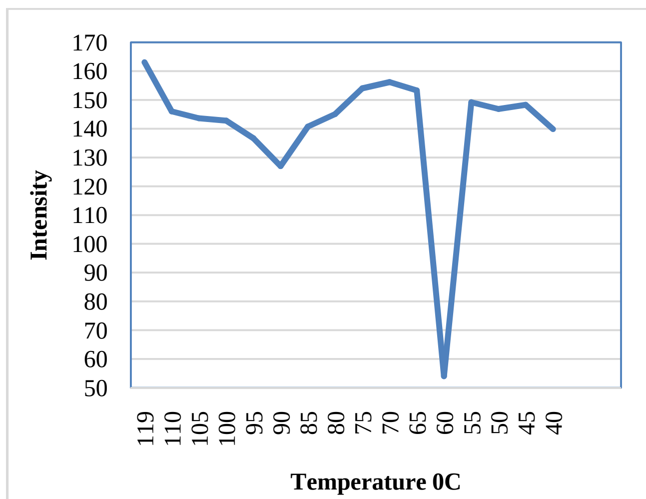


Fig. 6: Intensity Vs. Temperature graph (cooling cycle) for ZnO doped LCPS (PE10)

2.3 Refractive Index measurement

For a full color display, we need to know the refractive indices for different colors[11]. Fig. 7 and Fig. 8 depicts the temperature-dependent refractive indices of pure LCP and ZnO doped LCP at 404.7, 435.8, 486.1, 548.1, 589.3, 656.3, and 706.5 A^0. Table 1 depicts the variation of refractive index with temperature from 20^0C to 40 ^{0}C for pure LCP at different wavelengths. As temperature increases, the refractive index also increases. Table 2 depicts the variation of refractive index with temperature is observed from 30^0C to 75 ^{0}C for ZnO doped LCP at different wavelengths.

The ordinary refractive indices n_o increases slightly with increase in temperature and when it becomes isotropic, refractive index values changes and becomes almost constant .This behaviour due to birefringent nature of liquid crystal phase. As we increase the temperature, the molecular ordering decreases and the birefringent nature becomes less significant and after isotropic temperature.

Table 1: Pure LCP

Sr. No.	Temperature in 0C	Wavelength in A0						
		404.7 A0	435.8 A0	486.1 A0	548.1 A0	589.3 A0	656.3 A0	706.5 A0
1	20	1.55935	1.54844	1.53719	1.52879	1.52452	1.51972	1.51677
2	25	1.56376	1.5545	1.54023	1.5315	1.52703	1.52203	1.51898
3	30	1.56785	1.55557	1.54307	1.53391	1.52927	1.52413	1.52094
4	35	1.57241	1.55961	1.54656	1.537	1.53219	1.52682	1.52361
5	40	1.57704	1.56365	1.54997	1.53999	1.53502	1.52941	1.52609

Table 2: ZnO doped LCP

Sr. No.	Temperature in 0C	Wavelength in A0						
		404.7 A0	435.8 A0	486.1 A0	548.1 A0	589.3 A0	656.3 A0	706.5 A0
1	30	1.57163	1.5591	1.54631	1.53717	1.5326	1.52748	1.52469
2	35	1.5762	1.56311	1.54969	1.54	1.53517	1.52978	1.52676
3	40	1.58039	1.56664	1.55276	1.54277	1.53776	1.53217	1.52911
4	45	1.58373	1.5694	1.55514	1.54482	1.53965	1.53384	1.53067
5	50	1.58143	1.56724	1.55302	1.54274	1.53758	1.53186	1.52863
6	55	1.57912	1.56507	1.55088	1.54061	1.5350	1.52979	1.5266
7	60	1.57685	1.56292	1.54873	1.53854	1.53345	1.52777	1.52457
8	65	1.57457	1.5607	1.54656	1.53643	1.53138	1.52571	1.52251
9	70	1.57265	1.55878	1.5447	1.53461	1.52959	1.52388	1.52075
10	75	1.57129	1.5574	1.54332	1.53324	1.52818	1.5225	1.51933

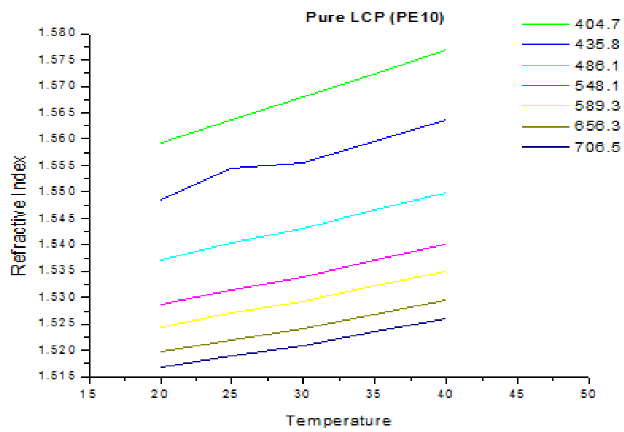


Fig. 7: Refractive index Vs Temperature for pure LCPS

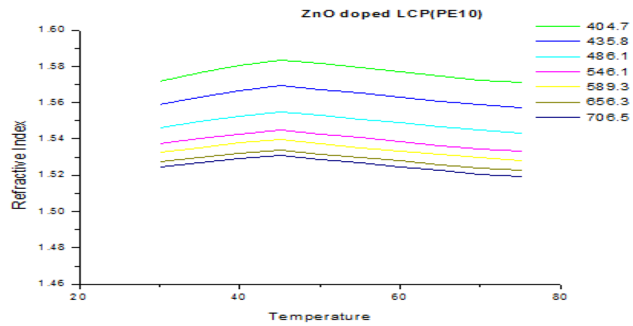


Fig. 8: Refractive index Vs Temperature for ZnO doped LCPS

4. CONCLUSION

We studied optical characteristics of Nematic Liquid Crystal Polymer System (NLCPS-PE10) using FPSS, PMS and Abbe Refractometer. The influence of liquid crystal polymer system is enhanced for display purpose by doping with ZnO nanoparticles. Doping increases the performance of the liquid crystal polymer system. A low concentration of ZnO nanoparticles in liquid crystal can increase the transition temperature as well as clearing temperature. This result indicates that the low concentration of nanoparticles can increase the orientational ordering of the liquid crystal polymer system. These modified optical characteristics of the liquid crystal polymer system are caused by the interaction of the nanoparticles with the liquid crystals polymer system.

The variation of refractive index with temperature has been observed for temperature range of 20^0C - 40 ^{0}C for pure LCPS,whereas for ZnO there is increase in the temperature range from 30^0C- 75 ^{0}C at different wavelengths.This extended temperature range of liquid crystal polymer system is very useful in future applications.

5. ACKNOWLEDGEMENTS

I would like to thank Dr. Anuradha Misra, Head , Department of Physics, University of Mumbai, Mumbai and our sincere and heartfelt thanks to our guide, Dr. Rita A. Gharde for her continuous supervision, inspiring guidance and constant encouragement in carrying out this research work.

REFERENCES

[1] E. Lueder, “Liquid Crystal Displays”; 2001, Wiley, New York,

[2] E. H. Stupp and M. S. Brennesholtz, “Projection Displays”; 1998, Wiley, New York,

[3] S. T. Wu and D. K. Yang, “Reflective Liquid Crystal Displays” ; 2001,Wiley, New York

[4] I. C. Khoo and S. T. Wu, “Optics and Nonlinear Optics of Liquid Crystals”; 1993, World Scientific, Singapore,

[5] Peter J. Collings “ Liquid Crystals: Nature’s Delicate Phase of Matter” 1990 , ISBN 0-691-08509-9

[6] Andy Y.G. Fuh, Tsung-Hsien Lin; *Journal of Applied Physics*; 2004; Vol.96 (10); pp.5402-5404.

[7] L. O. Dolgov O. V. Yaroshchuk; *Journal of the SID*; 2006; Vol.14 (7); pp.1-6.

[8] Xuefeng Wang, Jonathan Engel and Chang Liu, 2003, 13,628-633.

[9] Huan-Ming Xiong, Dong-Ping Xie, Xiao-Yan Guan, Yu- Jing Tan and Youg-Yao Xia, “*Journal of Materials*

[10] Peter J. Collings and Jay S. Patel ” Handbook of Liquid Crystal Research*”*,2007**,** 63, 2490-2496.

[11] Collings, Peter J.; Hird, Michael. Gray, George William; Goodby, J. W.; Fukuda, A., eds. “Introduction to Liquid Crystals:Chemistry and Physics”, Taylor and Francis Ltd. 1997, ISBN 0-7484-0643-3.

[12] Jun Li, Sebastian Gauza, and Shin-Tson Wua “Temperature effect on liquid crystal refractive indices”, *Journal of applied Physics*, 2004; Vol. 96;

[13] F.Brochard and P.G.De.Gennes, “*J.Physics Paries”* 1970 , 31,691.