Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Archives of Physics Research, 2011, 2 (3):84-93
(http://scholarsresearchlibrary.com/archive.html)

ISSN : 0976-0970
CODEN (USA): APRRC7

Influence of ZnO/CdO Nanoparticles on Embedding in Polymer Dispersed Liquid Crystals

[*1]Krishnakant G. Mishra and [2]Sureshchandra J. Gupta

University Department of Physics, University of Mumbai, India

ABSTRACT

Structural, electrical and optical characterization of polymer-dispersed liquid crystal (PDLC) doped with small amount of inorganic nanoparticles (NP) are studied. The ZnO/CdO NP Doped PDLC is prepared using solvent induce phase separation method (SIPS). The prepared ZnO/CdO NP doped PDLC are studied by XRD, TG/DTA, SEM, UV, dielectric measurement, conductivity measurement, and the cole-cole plot . The semi conducting nature of the grown samples were confirmed by the semicircle nature of the impedence spectrum. The optical and electrical properties of the PDLC is enhanced on the addition of ZnO/CdO Nanoparticles to the PDLC matrix.

Keywords: liquid crystal, nanoparticle, doping, polymer dispersion.

INTRODUCTION

Liquid crystal (LC) devices are quickly finding their way into systems as active phase modulators and optical band pass filters in order to improve imaging capability and flexibility [1, 2, 3]. Liquid crystal has high optical and light scattering properties are depends on the arrangement of molecule in liquid crystals phase (nematic, smectic or cholesteric) and size of the LC [4]. Polymer-dispersed liquid crystals are used as light shutters, Flexible displays, holographic recording media and Switchable windows [5, 6, 7]. And we use the material or equipment, which made by polymer dispersed liquid crystal in our recent life as computer and video devices displays. This is used because the display made by PDLC is flat and thin [8]. Not only in this it had also used in military purpose liked thermal imaging etc [9].

The large-scale study of dispersion of nematic liquid crystal in a polymer matrix (PDLC) began after it was shown that these systems could be used to create a new type of electro optical devices. Mostly the polymer-dispersed liquid crystals are formed by phase separation method, which is more beneficial than the Encapsulation method [10-12, 1]. PDLC film has another important property as it controls the radiation passed through it [4, 13]. PDLC consists of micron-sized LC droplet dispersed in polymer matrix and LC droplets are randomly distributed in the polymer matrix and their sizes are close to the visible wavelength. Because of these results, light scattering, which originates from the refractive index mismatch between the LC droplets and polymer matrix, is strong [14, 15].

The inorganic nanocomposites have optical, electrical, catalytic and mechanical properties and it also has potential application in microelectronics [16]. Quantum dots, especially II-VI such as CdS (Se, Te) and ZnO (S, Se, Te) etc has photoluminescent properties [17]. The ZnS–PUMM nanocomposite films have a good refractive index and high thermal stability [18, 19]. The polymer dispersed liquid crystals and polymer dispersed Nano-particles have several applications in many fields. Based on the above literature, in our present work we make an attempt to grow ZnO / CdO nano particle doped Polymer dispersed Liquid crystals.

MATERIALS AND METHODS

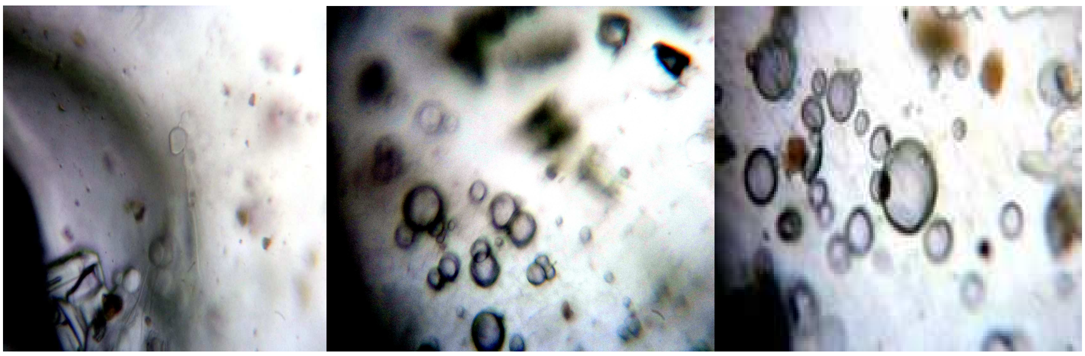
Extremely pure phenyl benzoate liquid crystal (0.5 g), Dimethyl sulfoxide (15 mL), PVA (5 g), ZnO Nano-particles (0.05 g) and 15 mL of DMSO are Used to prepare ZnO doped PDLC.

Make a clear solution of PVA with DMSO (Dimethyl sulfoxide). Then the 0.5 g of pure phenyl benzoate is added to the clear PVA solution made before with continuous stirring and heat the solution at the time of addition. Then made a colloidal sample with 0.05 g of ZnO nano-particles using DMSO and then the colloidal sample is added to the above mixture drop-wise. The prepared sample mixture is poured on a Petri dish. Evaporate the solvent from sample in sunlight. And the same way followed for the preparation of CdO doped PDLC.

RESULTS AND DISCUSSION

3.1 Structural Studies

The structure of all the grown samples was analyzed by using the OLYMPUS 51 optical microscope and the images are shown in Figure 1. The photo image shown below will give a clear-cut of the presence of liquid crystal and nanoparticles dispersion in polymer matrix. The cavity like transparent mater shown in the images is the liquid crystal droplet and the small size dots like colored mater shown in the image denoted the presence of(ZnO / CdO) nano-particles. Besides, the cavities, which are the traces of LC droplets, do not contain nanoparticles or their aggregates



1a) PDLC **1b) ZnO doped- PDLC** **1c) CdO doped -PDLC**

Figure: 1 Optical microscopy image for pure PDLC and ZnO/CdO NP Doped PDLC

3.2 XRD

The PXRD patterns obtained in the present study are shown in Figure 2 and 3.The sharp peak at 21 ^{o} and at 40 ^{o} confirm the presence of dopants in Polymer matrix. The broadening of peaks indicates the size of the grown samples is in the order of nano meter levels. The composition of peak at 20 ^{o} in Figure 2 and 3 shows as the crystalline properties of the ZnO/CdO NP doped PDLC. The addition of ZnO NP to the PDLC matrix enhanced the crystalline properties better than CdO doped PDLC matrix this is conformed by the sharp peaks shown in the Figure 2.

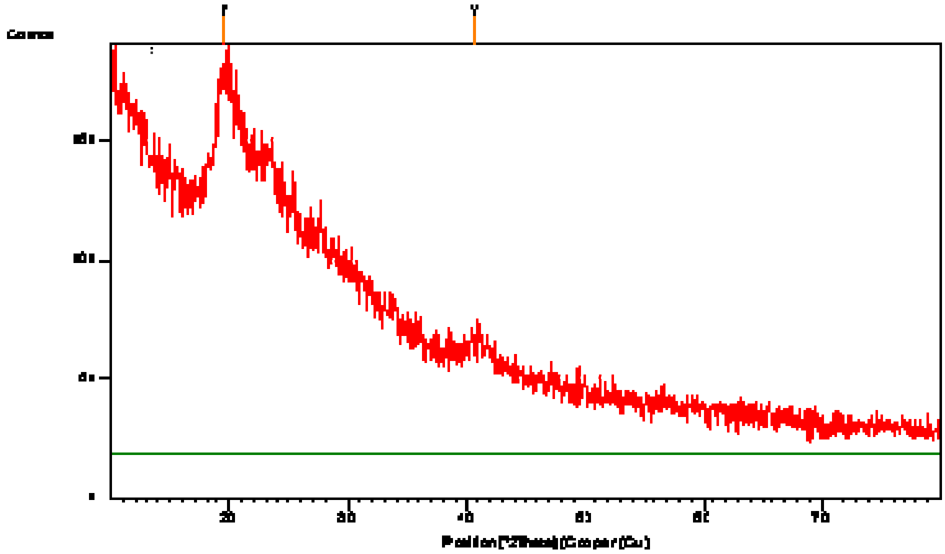


Figure: 2 XRD for the ZnO NP doped PDLC

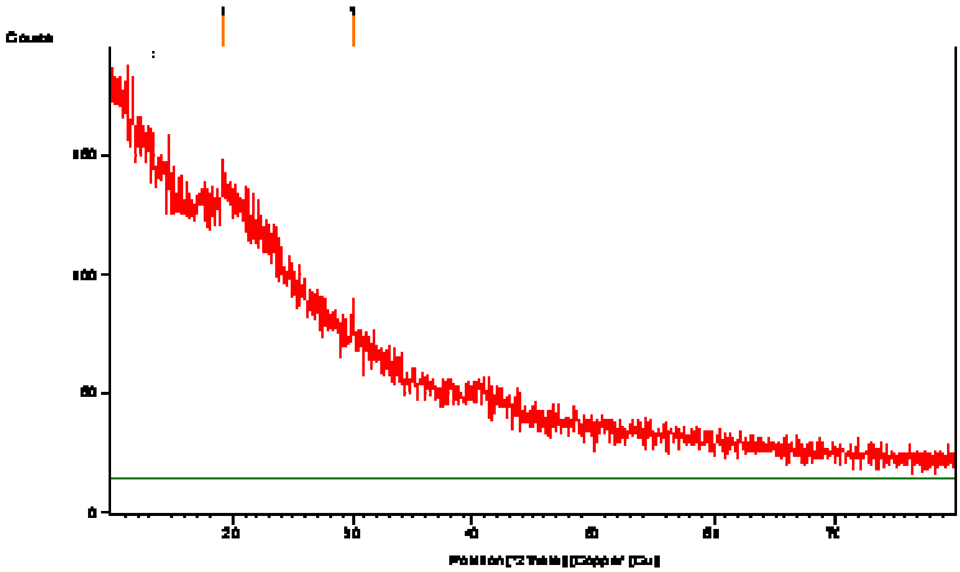
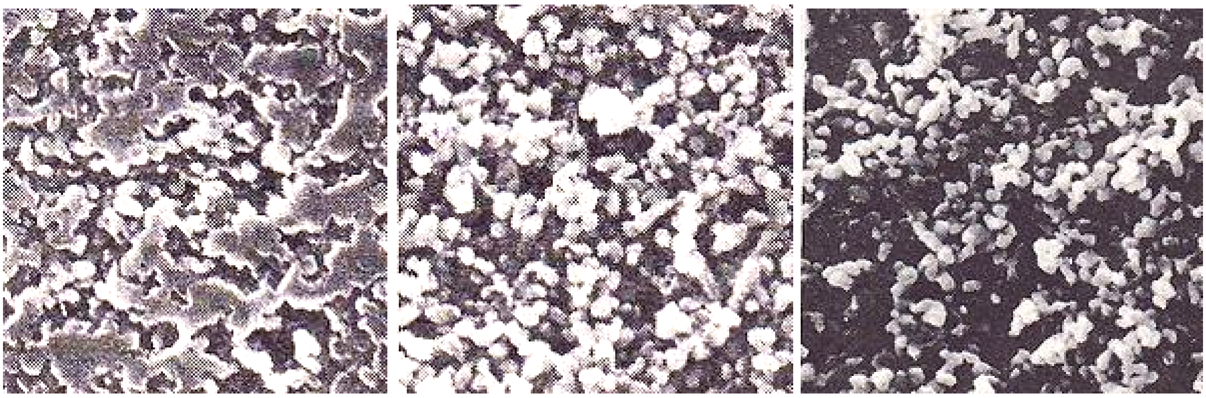


Figure: 3 XRD for the CdO NP doped PDLC

3.3 SEM

The SEM image of the grown samples are shown in Figure 3.From the SEM picture, we can conclude that dopants addition improves the formation of liquid crystals in polymer matrix. But NP do not distort notably PDLC morphology.



4a) PDLC 4b) ZnO doped- PDLC 4c) CdO doped -PDLC

Figure: 4 SEM image for (a) Pure PDLC and (b) ZnO and (c) CdO NP doped PDLC

3.4 TG / DTA Analysis

In order to find the thermal stability of the grown samples, all the three samples are characterized by TG/ DTA analysis. TG / DTA spectrum of pure and doped samples are shown in Figure 5,6 and 7.

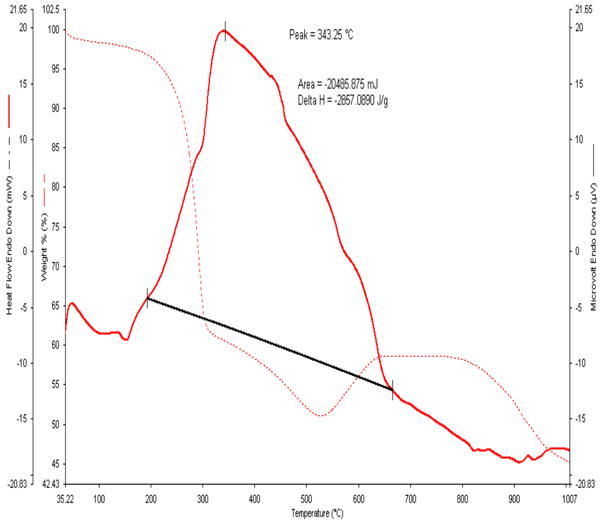


Figure 5: The TG/DTA for pure PDLC

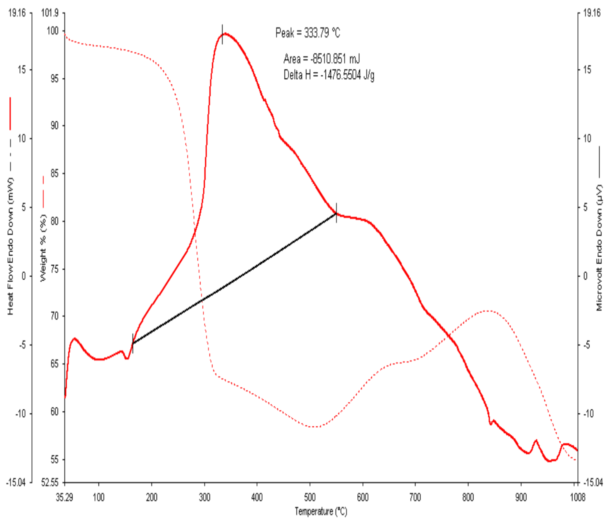


Figure 6: The TG/DTA ZnO NP doped PDLC

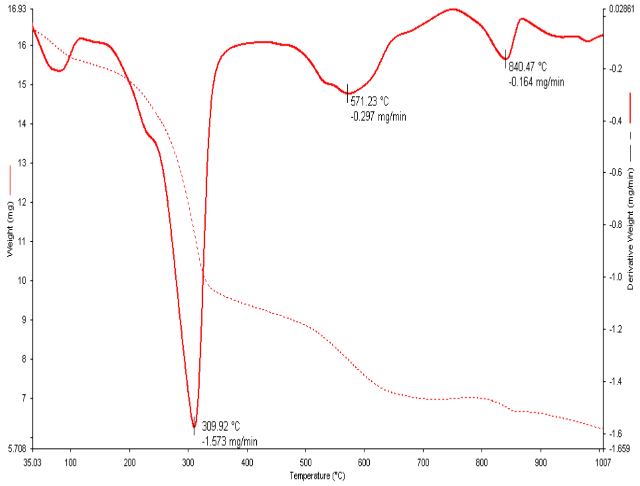
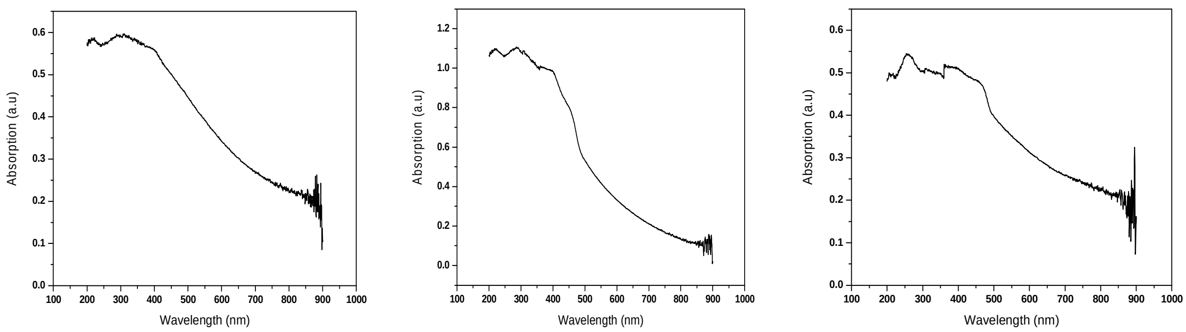


Figure 7: The TG/DTA CdO NP doped PDLC

3.5 UV spectroscopy

The Optical absorption spectrum (UV) of the pure and nano-particle dispersed PDLC is represented in Figure 8.The absorption peak at near 240nm, 340nm and 360nm reveals the presence of PDLC, ZnO and CdO Nanoparticles respectively.



8a) 8b) 8c)

Figure 8: Optical absorption spectrum (UV) for Pure PDLC and ZnO/CdO NP doped PDLC.

3.6 Dielectric Measurements

The capacitance (C_{crys}) and dielectric loss factor (tan δ) measurements are carried out on all the five grown crystals at an accuracy of $\pm$ 2% using an LCR meter (Agilent 4284A) for five different frequencies, viz. 100 Hz, 1 kHz, 10 kHz, 100 kHz and 1 MHz at various temperatures ranging from 40-150^{o}C. The observations are made while cooling the sample. PDLC sheets cut into small circles of diameter 12mm are used for electrical measurements.

Temperature is controlled unto an accuracy of $\pm$ 1^{o}C. Air capacitance (C_{air}) is also measured. The dielectric constant of the crystal is calculated using the relation

$$\varepsilon_r = \frac{C_{crys}}{C_{air}}$$

The AC conductivity (σ_{ac}) is calculated using the relation [20]

$$\sigma_{ac} = \varepsilon_o \varepsilon_r \omega \tan\delta,$$

The ε_r, and σ_{ac} values obtained in the present study are shown in Figures. It has been found that the ε_r, and σ_{ac} values increase as the temperature increases for all the five frequencies considered in the present study. The ε_r value is found to decrease and the σ_{ac} value is found to increase with frequency for all values of temperatures. This is a normal dielectric behavior. Due to doping of PDLC with Nano particles, significant changes in the value of ε_r are observed in the frequency range of 100- 1MHz. Because the properties of polymer P may substantially differ from the properties of pure polymer depending on particle's material, size and aggregation rate[21]. In this frequency range, the conductivity of PDLC has two components: the ion component due to transfer of ions in liquid crystal and the electron component due to transfer of electrons inside polymer. The presence of nano particles in PDLC increases the ion component of the conductivity as well as the electron component of the conductivity. The impedance (Z and θ) measurements are carried out using an LCR meter (Agilant 4284 A). The Cole-Cole plots constructed for all doped and undoped samples show that CdO addition increases the bulk resistance of the sample.

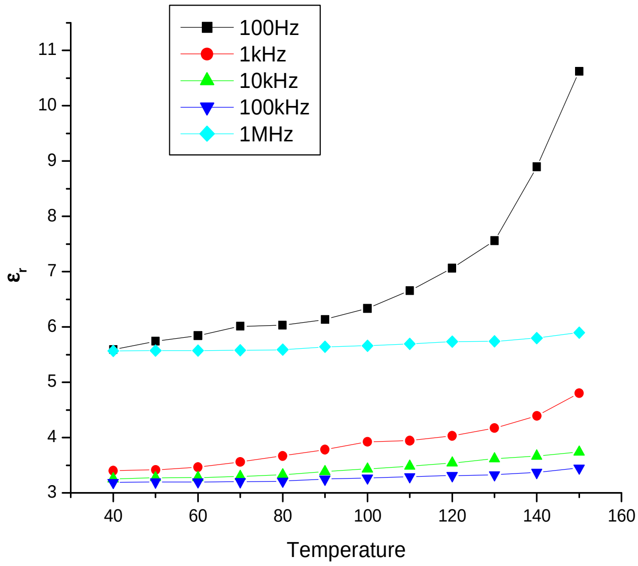


Figure 9 : Variation of dielectric constant with temperature for pure PDLC for various frequencies.

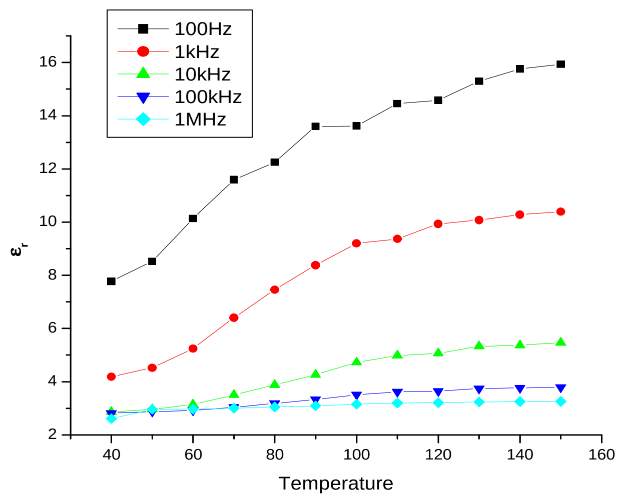


Figure 10 : Variation of dielectric constant with temperature for ZnO NP doped PDLC for various frequencies.

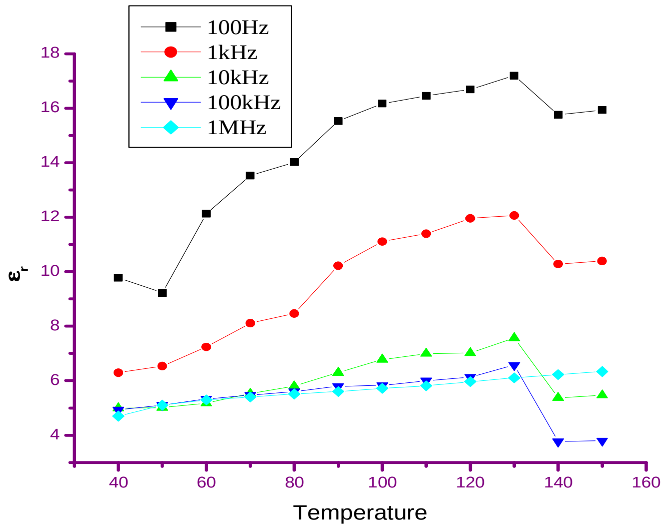


Figure 11 : Variation of dielectric constant with temperature for CdO doped PDLC for various frequencies.

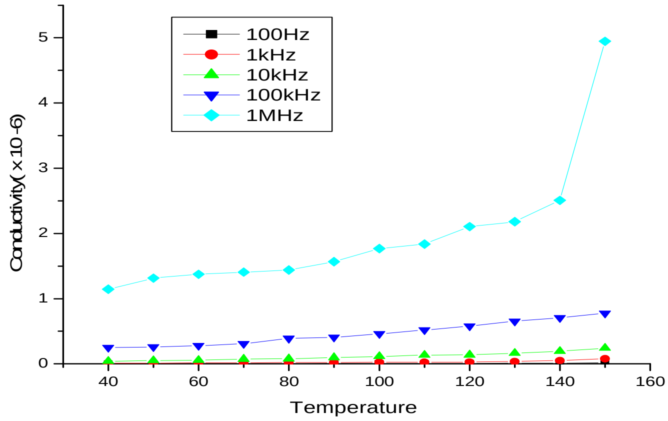


Figure 12 : Variation of AC conductivity with temperature for pure PDLC for various frequencies.

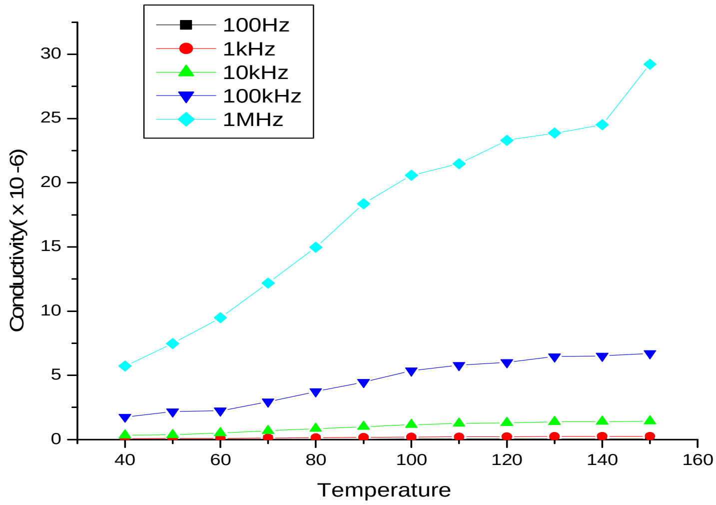


Figure 13 : Variation of AC conductivity with temperature for ZnO doped PDLC for various frequencies.

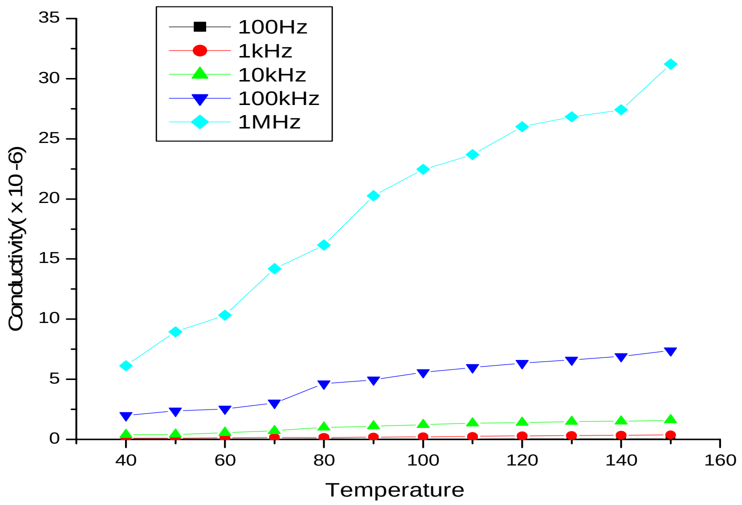


Figure 14 : Variation of AC conductivity with temperature for CdO doped PDLC for various frequencies.

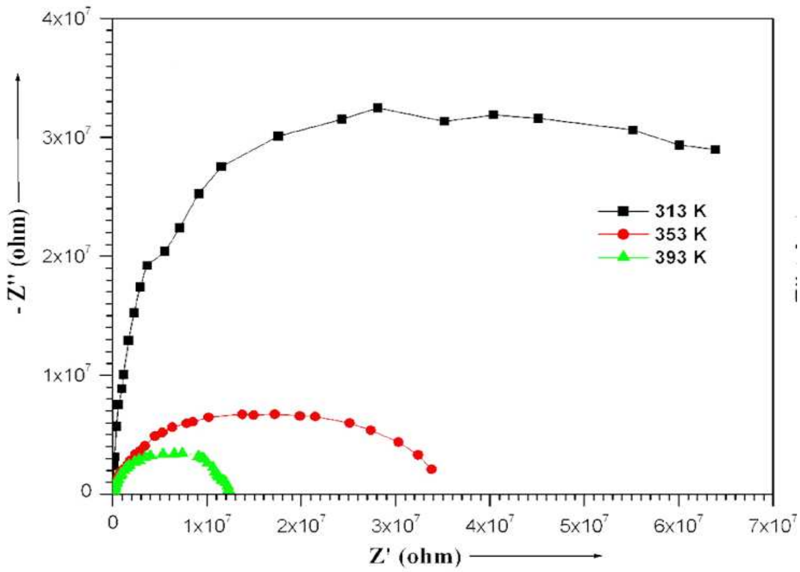


Figure 15: Cole-Cole Plot for pure PDLC

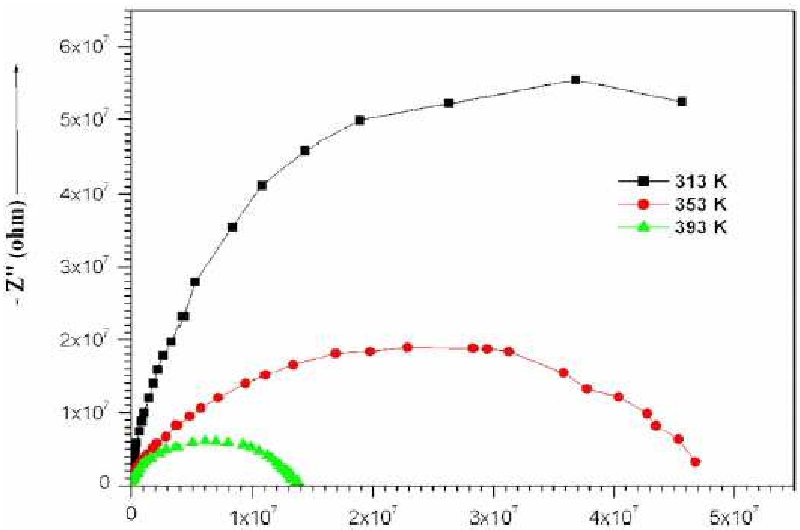


Figure 16: Cole-Cole Plot for ZnO NP doped PDLC

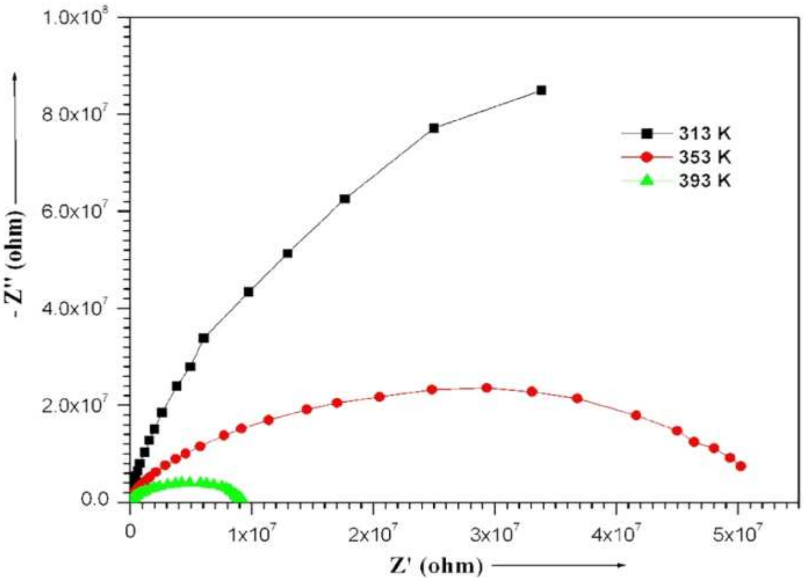


Figure 17: Cole-Cole Plot for CdO NP doped PDLC

CONCLUSION

The, XRD shows as that the crystalline properties are higher for ZnO doped PDLC compare with CdO doped PDLC. We know that the Optical properties are enhancing with the increasing of crystalline properties. Thus by insertion of NP, LC–P system is transformed to the LC–˜P system, where ˜ P is a polymer modified by NP. Doping of polymer phase with inorganic NP leads to enhancement of thermal and mechanical stability of polymer matrix .Also ZnO is the better dopant for the formation of optically active PDLC materials when compared with CdO.

REFERENCES

[1]K.Beev, S.Sainov, T.Angelov, A.G.Petrov, *Journal of optoelectronics and Advanced Materials*, **2004**, 6, 799-803.
[2]Jatin Shah, John W.Brown, Eileen M.Buckley-Dhoot and Asoka J.Bandara, *Journals of materials chemistry*, **2000**, 10, 2627-2628.
[3]Jiandong Ding, Hongdong Zhang, Jianming Lu and Yuliang Yang, *Japan Journal Applied physics*, **1995,** 34, 1928-1934.
[4]S.M.Dmitriev, V.P.Dick, N.N.Kostyuk, T.A.Dick, V.A.Loiko, *Journals of Semiconductor Physics, Quan-tum Electronics & Optoelectronics*, **2010**, 13, *2*, 132-136.
[5]Ebru A.Buyuktanir, Maxim Mitrokhin, Borre Holter, Anatoliy Glushchenko and John L.West, *Japanese Journal of Applied Physcis*, **2006**, 45, *5A*, 4146-4151.
[6]Y.Sarov, T.Angelov, S.Sainov, *Bulgarian Journal of Physics*, **2004**,31,33-38.
[7]S.A.Carter, J.D.LeGrange, W.White, J.Boo and P.Wiltzius, *Journal of Applied Physics*, **1997**, 81,9, 5992.
[8]Paul S.Drzaic, *Pure and applied chemistry*, **1996**,68, *7*,1435-1440.
[9]James W.McCargar Renate Ondris-Crawford, John L.West, *Journal of Electronic Imaging*, **1992**,1, *1*, 22-28.
[10] Marek Aleksander, Stanislaw J.Klosowicz, Possibilities of application of polymer-dispersed liquid crystals in information displays XV Conference on Liquid Crystals, edited by Józef Zmija, *Proceedings of SPIE* Vol. 5565 (SPIE, Bellingham, WA, 2004), **2004**, 5565, 304.
[11] T.Kyu, I.Ilies and M.Mustafa, *Journals of Physique IV*, **1993**,3,37.

[12] Humaira Masood Sid diqi, Michel Dumon and Jean Pierre Pascault, *Journal of Materials chemistry*, **1998**, 8, *8*, 1691-1695.
[13] Andy Y.G.Fuh, Tsung-Hsien Lin, *Journal of Applied Physics*, **2004**, 96, *10*, 5402.
[14] Yi-Hsin Lin, Hongwen Ren and Shin-Tson Wu, *Applied Physics:Letters*, **2004,** 84, *20*,4083.
[15] Yang Li, Eric Chun Yeung Liu, Nigel Pickett, Peter J.Skabara, Siobhan S.Cummins, Stephen Ryl-ey, Andrew J.Sutherland and Paul O'Brien, *Journal of materials chemistry*,**2005,** 15, 1238-1243.
[16] Xuefeng Wang, Jonathan Engel and Chang Liu, **2003,**13,628-633.
[17] Huan-Ming Xiong, Dong-Ping Xie, Xiao-Yan Guan, Yu-Jing Tan and Youg-Yao Xia, *Journal of Materials chemistry*,**2007,**17,2490-2496.
[18] Changli Lu, Zhanchen Cui, Yao Wang, Zuo Li, Cheng Guan, Bai Yang and Jiacong Shen, *Journals of materials chemistry*,**2003,**13,2189-2195.
[19] L.Todorova, S.Naydenova, T.Angelov, Y.Marinov, A.G.Petrov; *Bulgarian Journal of Physics*, **2004,** 31, 39-48.
[20] M.Meena and C.K.Mahadevan, *Mater.Lett.*, **2008**, 62, 3742.
[21] O.V. Yaroshchuk , L.O. Dolgov, *Optical Materials*, **2007**, 29, 1097–1102.