

Optical and U-V Characterization of anisotropic media with nano composite materials

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Abstract:

The optical properties of NPs were investigated in the anisotropic media, which were used as an anisotropic medium. The optical properties of NPs immersed in an anisotropic medium were altered as observed through ultra-violet absorption/transmission spectra. The influences of anisotropic medium on the optical properties of NPs were discussed with respect to isotropic medium.

Keywords: Anisotropic media, Optical Properties, absorption, Nanoparticles

1. Introduction:

Liquid crystalline states are meso-states between solid and liquid states. These materials share the anisotropic properties of optical (uniaxial and biaxial) crystals and the fluid properties of isotropic liquids. These materials are extremely sensitive to small external factors (electric and magnetic fields, surface effects, temperature, etc.), and possess order and mobility at microscopic and macroscopic levels [1]. Liquid crystalline materials have been useful for display devices (watches, calculators, automobile dashboards, television, etc) as well as in electro tunable lasers, optical fibers and lenses, liquid crystal colloids, organic charge transport devices, light modulators, electrically controllable optical shutters, drug delivery systems etc[2-4]. Prominent phase of liquid crystals (LCs), are nematic, smectic, cholesteric, and columnar phase and these are known for their intriguing properties. The self assembling supramolecular columnar phase formed by discotic molecules is well recognized as one-dimensional organic semiconductors useful in many devices like photovoltaic solar cells [5-6]. In the past several years a great deal of research has been carried out to improve the important physical properties of liquid crystals through various methods, other than chemical synthesis. One technique to achieve this goal is the dispersion of nano particles in liquid crystalline materials [7-10]. Liquid crystal-nanoparticle (LC-NP) composites have emerged as a multidisciplinary field of research and attract great attention of scientists from the field of soft matter research [11-14] as they can effectively be used to tune the properties of liquid crystals. Nanoparticles exhibit physical and chemical properties that differ tremendously from their bulk counterparts. The most common of which being metallic nanoparticles. Noble metal nanoparticles are of great interest because of their intense tunable absorption and scattering resonances caused by collective oscillations of the conduction band electrons, which are known as surface plasmons [15-16]. Few groups have reported the enhancement in photoconductivity and efficiency of solar

cells by incorporating gold nano particles [17-18]. Further, display parameters of liquid crystalline materials can be optimized by the dispersion of different nano particles [19-20]. Keeping this view in mind a research plan has been initiated to incorporate nano entities in liquid crystals and determine the physical parameters of these liquid crystal-nano composites. Presently many groups are working on the different facets of liquid crystal-nano composites. A group at Rutgers University, USA has reported that gold nanoparticles dispersed in nematic liquid crystal increases the elastic parameter and the rotational viscosity [21]. A group of University of Southampton, UK has reported large improvement in electro-optic properties of nematic liquid crystals doped with ferroelectric nanoparticles [22]. Also the inter layer spacing and smectic ordering has been successfully tuned by BaTiO₃ nanoparticles by scientists of Kent State University, USA [23]. Research group from University of Leeds, UK investigated the enhancement in the conductivity of a discotic liquid crystal doped with gold nanoparticles [24]. The change of electro-optic properties in liquid crystal devices with the help of Zirconium dioxide NPs has been reported by a group from Yonsei University, South Korea [7]. A large increase in electro-optic properties of liquid crystals doped with ferroelectric nano-powder has been reported by researchers of Institute of Physics, Ukraine [25]. A group at Zhejiang University, China has reported increase in efficiency of polymer solar cells by inserting gold nano particles [17]. A chemist group of Military University of Technology, Warsaw, Poland is engaged with synthesis and characterization of various types of liquid crystals [26-27]. Nanorods size dependent dielectric and electro-optical properties of the LCs have been reported by a German group [28]. Various types of liquid crystals have been synthesized at the national level. Beyond the synthesis of these novel LC materials, their applications in display, photovoltaic cells and other devices with addition of nanomaterials is being studied at different research centers. The various metal, metal oxide, quantum

dots and carbon nanotubes were also dispersed in ferroelectric LC by a research group at NPL, New Delhi. This group has successfully achieved the low power operation of FLCs, enhanced E-O properties, enhanced PL properties, non-volatile FLC based memory devices etc. with the addition of different nanomaterials [29]. Research group at Raman Research Institute is actively engaged in enhancing the photoconductivity by using gold nano particles [17] and characterizing liquid crystal-nano composites for many device applications [30-34]. A group at Center of Soft Matter Research, Bangalore has also performed the altering of electrical conductivity and dielectric properties with the help of nanoparticles in LCs [35]. The research group at Thapar University has reported the physical properties of FLC and discotic liquid crystals with the addition of ZnO, Au and other nanoparticles useful from application point of view [9-36]. The dopant concentration dependent physical parameters of FLC and some nanoparticle induced phenomenon have also been reported by a group of Lucknow University [37]. Our group is also involved with characterization of LCs and their nanocomposites useful in numerous device applications [38-39].

Preparation of Nano- Composite

The composites were prepared by adding a small weight percentage of NPs in the nematic liquid crystalline material. Generally a sample is analyzed by UV-spectra in solution form. Accordingly, the type and the concentration of the solvent must be adequate. A solvent that dissolves the sample well and that is free from shared action must be used. As a solvent, chloroform is excellent for measuring absorbance in visible/ultraviolet range, as it has no absorbance itself. Hence NLCs and NPs were dissolved in chloroform (CHCl₃) and composites were prepared by adding them together. Overnight evaporation of the solvent (CHCl₃), resulted in the formation of desired dispersion. The composites were sonicated to obtain

uniform dispersion. In the present study CHCl₃ were also used as a reference in a standard quartz cells with 50 mm path length. The samples were separately placed in the spectrometer, with another quartz cell as reference for absorption measurements.

Results & discussion:

The absorbance spectrums of NPs in reference isotropic medium and anisotropic host were recorded by UV Spectrometer. Figure 1 shows the UV absorption spectra from 200 nm to 900 nm for NPs dispersed in the chloroform. In Fig. 1, an absorption peak has been observed at 290 nm. The sizes of NPs were calculated from recorded absorption peak in reference medium. The radius of the quantum dot affects the wavelength of the absorption spectra due to quantum confinement. Hence the Brus equation was used for calculating the radius of a quantum dots from experimentally determined parameters.

$$E(r) = E_{\text{gap}} + \frac{\hbar^2}{8r^2} \left[\frac{1}{m_e^*} + \frac{1}{m_h^*} \right] \quad (1)$$

Where $E(r)$, E_{gap} , m_e^* , and m_h^* are band gap energy of the bulk CdSe at room temperature, band gap energy of the nanoparticle, effective mass of an electron in conduction band of CdSe and effective mass of a hole in valence band of CdSe respectively. These parameters are unique and depend on nanocrystal composition. For CdSe quantum dots: $E_{\text{gap}}(\text{CdSe}) = 1.7 \text{ eV} = 2.8 \times 10^{-19} \text{ Joules}$, $m_e^*(\text{CdSe}) = 0.13 m_e = 1.18 \times 10^{-31} \text{ kg}$, $m_h^*(\text{CdSe}) = 0.45 m_e = 4.09 \times 10^{-31} \text{ kg}$. The value of $E(r)$ was obtained from Figure 1 and by substituting it in equation (1), average diameter of NPS were calculated. The sizes of NPS in reference isotropic (chloroform), isotropic phase of NLCs & host anisotropic NLCs have been found to be $\sim 4.0 \text{ nm}$, $\sim 4.3 \text{ nm}$ and $\sim 4.20 \text{ nm}$ respectively.

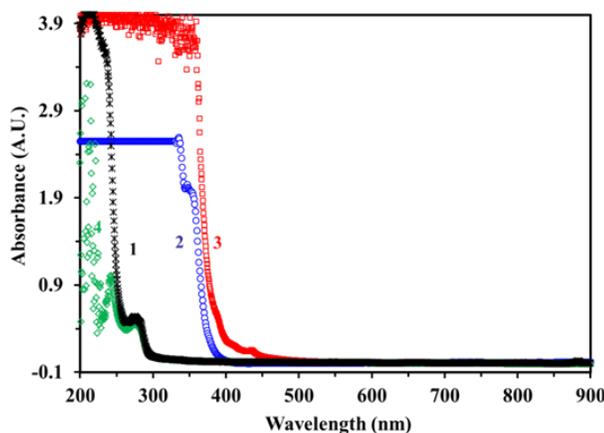


Figure: Xaxis Wavelength(nm). Yaxis Absorbance(A.U.)

References:

- [1]. D. Gennes, P.G. & Prost, J. The Physics of Liquid Crystals 2nd edn (Oxford Science Publications, Oxford, 1993).
- [2]. Lee SH, Bhattacharyya SS, Jin HS, Jeong KU. J. Mater. Chem. 2012;22:11893-11903.
- [3]. Lowe AM, Abbott NL. Chem. Mater. 2012;24:746-758.
- [4]. Pandey MB, Dhar R, Wadhawan VK. Phase Trans. 2009;82:831-849.
- [5]. Sergeev S, Pisula W, Geerts YH. Chem. Soc. Rev. 2007;36:1902-1929.
- [6]. Kumar S. Chem. Soc. Rev. 2006;35:83-109.
- [7]. Ha YS, Kim HJ, Park HG, Seo DS. Opt. Express. 2012;20:6448-6455.
- [8]. Kumar S, Paul SK, Suresh P, Lakshminarayanan V. Soft. Matter. 2007;3:896-900.
- [9]. Supreet, Pratibha R, Kumar S, Raina KK. Liq. Cryst. DOI: 10.1080/02678292.2014.893032. (hard copy yet not appeared)
- [10]. Pandey AS, Dhar R, Kumar S, Dabrowski R. Liq. Cryst. 2011;38:115-120.
- [11]. Sio LD, Caputo R, Cataldi U, Umeton C. J. Mater. Chem. 2011;21:18967-18970.
- [12]. In I, Jun YW, Km YJ, Kim SY. Chem. Commun. 2005;6:800-801.
- [13]. Tripathi S, Prakash J, Chandran A, Joshi T, Kumar A, Dhar A, Biradar AM. Liq. Cryst. 2013;40:1255-1262.
- [14]. Kaur S, Singh SP, Biradar AM. Appl. Phys. Lett. 2007;91:023120-1-3.
- [15]. Nakaya M, Kanehara M, Teranishi T. Langmuir. 2006;22:3485-3487.
- [16]. Eutis S, EI-Sayed MA. Chem. Soc. Rev. 2006;35:209217.
- [17]. Chen X, Zuo L, Fu W, Yan Q, Fan C, Chen H. Solar Energ. Mater. & Solar Cells. 2013;111:1-8.
- [18]. Kavitha C, Avinash BS, Kumar S, Lakshminarayanan V. Mater. Chem. & Phys. 2012;133:635-641.
- [19]. Ashok Chaudhary A, Malik P, Mehra R, Raina KK. J. of Mol. Liq. 2013;188:230-236.
- [20]. Singh UB, Dhar R, Dabrowski R, Pandey MB. Liq. Cryst. 2013;40:774-782.
- [21]. Vardanyan KK, Walton RD, Bubb DM. Liq. Cryst. 2011;38:1279-1287.
- [22]. Kaczmarek M, Buchnev O, Nandhkumar I. Appl. Phys. Lett. 2008;92:103307.
- [23]. Lorenz A, Zimmermann N, Kumar S, Evans DR, Cook G, Kitzerow HS. Phys. Rev. E. 2012; 86:051704-1-5.
- [24]. Bushby RJ, Kawata K. Liq. Cryst. 2011;38:1415-1426.
- [25]. Kasyanyuk D, Slyusarenko K, West J, Vasnetsov M, Reznikov Y. Phys. Rev. E. 2014;89:022503-1-5.
- [26]. Roy JS, Majumdar TP, Dabrowski R. J. of Luminesc. 2014;148:330-333.
- [27]. Chelstowska A, Czerwinska M, Tykarska M, Bennisbc N. Liq. Cryst. 2014;41:812-820.
- [28]. Podgornov FV, Ryzhkova AV, Haase W. Appl. Phys. Lett. 2010;97:212903-1-3.
- [29]. Chandran A, Prakash J, Naik KK, Srivastava AK, Dabrowski R, Biradar AM. J. Mater. Chem. C. 2014;2:1844-1853.
- [30]. Kumar S. Liq. Cryst. 2009;36:607-638.
- [31]. Kavitha C, Avinash BS, Kumar S, Lakshminarayanan V. Mater. Chem. & Phys. 2012;133:635-641.
- [32]. Kumar S, Paul SK, Suresh P, Lakshminarayanan V. Soft. Matter. 2007;3:896-900.
- [33]. Kumar S, Lakshminarayanan V. Chem. Commun. 2004;1600-1601.
- [34]. Kumar S. Liq. Cryst. 2014;41:353-367.
- [35]. Prasad SK, Kumar MV, Shilpa T, Yelamaggad CV. RSC Adv. 2014;4:4453-4461.
- [36]. Supreet, Kumar S, Raina KK, Pratibha R. Liq. Cryst. 2013;40:228-236.
- [37]. Tripathi PK, Mishra AK, Pandey KK, Yadav SP, Manohar R. Phase. Trans. 2013;86:1241-1255.
- [38]. Dhar R, Pandey AS, Pandey MB, Kumar S, Dabrowski R. Appl. Phys. Express. 2008;1:121501-1-3.
- [39]. Singh UB, Dhar R, Dabrowski R, Pandey MB. Liq. Cryst. DOI:10.1080/02678292.2014.894209.