Asian Journal of Science and Applied Technology
ISSN: 2249-0698 (P) Vol.7 No.2, 2018, pp.24-26

DOI: https://doi.org/10.51983/ajsat-2018.7.2.1029

Electro-Optical Phase Transition Studies ofChiral SmecticPhase of Nematic and CholestericMaterials

T.N. Govindaiah[1], B.N. Ramakrishna[2] and T.S.Shashikumar[3]
[1]Research Center Post-Graduate Department of Physics, Government College (Autonomous), Mandya,Karnataka,India
[2]Department of Physics, Government College for Women (Autonomous), Mandya, Karnataka, India
[3]Department of Physics, PES College of Engineering, Mandya, Karnataka, India
E-Mail: tngovi.phy@gmail.com

(Received 16 July 2018; Revised 30 July 2018; Accepted 20 August 2018; Available online 29 August 2018)

***Abstract*- In the present work, our investigation is to study the electro-optical properties of the binary mixture of cholesteric and nematic compounds, namely, cholesteryl chloride (ChCl) and n-(4-n-butoxy benzylidene-4-n octylaniline (4O.8), which exhibits a very interesting liquid crystalline cholesteric and induced chiral smectic phases like SmA, SmC∗, SmC, and SmB phases sequentially when the specimen cooled from isotropic phase. Transmittance and electro-optical phase transition studies have also been discussed.**

***Keywords*: Phase Transition, Chiral Smectic Phase, Transmittance Electro-Optical Studies**

I.INTRODUCTION

In recent years, liquid crystal research has gained much prominence in multidirectional aspects with exciting practical applications [1]. The focus is laid on the investigation of new liquid crystalline materials with differing molecular chemistry in order to study their viability in technological applications [2]. The exploration of liquid crystallinity is imperative not only from the view point of their technological applications but also from fundamental studies in the field of molecular interactions.The different physical propertiesof liquid crystals across various phase transition boundaries provides informationabout the order of transition involved and the strength of the intermolecular interactions accompanying the growth of liquid crystal phase [3,4].

Formations of liquid crystalline mesophases are mainly controlled by an attractive interaction between neighboring molecules. These weak interactions are of varioustypes, such as dipole-dipole, dispersion, hydrogen bonding etc. If an understanding the interactions were present in a given crystal structure: that can provide the valuable information on hydrogen-bonding and aggregation of the molecules: not only in solid state but also in the liquid-crystalline state. The ultimate objectives of these studies are very helpful to determine the microscopic and macroscopic properties of binary mixture of nematic and cholesteric liquid crystals.

In the present study,we have considered thebinarymixture of cholesteryl chloride (ChCl) and n-(4-n-butoxy benzylidene-4-n octylaniline (4O.8). Some of the concentrations of thesemixture exhibit Iso-Cho-SmA-SmC*-SmC-SmB-Cryst phases sequentially whenthey are cooled from its isotropic phase. Electro-optical phase transition studieshave also been studied to understand the intermolecular interactions ofbinary mixture of ChCland 4O.8 for different concentrations and at different temperatures [5].

II. EXPERIMENTAL STUDIES

In the present investigation, we have consideredbinary mixtures of liquid crystals, namely, cholesteryl chloride (ChCl) and n-(4-n-butoxy benzylidene-4-n octylaniline (4O.8). The chemicals are purified twice with benzene. Mixtures of different concentrations of ChCl in 4O.8 were prepared. The phase transition temperatures of these mixtures were determined using Gippon Japan polarizing microscope in conjunction with hot stage. Optical transmittance measurements have been done on polarizing microscope (CENSICO 7626). The constant temperature has been maintained by microprocessor based temperature controller Julabo F-25 (Germany) in all studies.Electro-optical phase transition measurements were carried out by the usual experimental setup of Williams [6]. It consists of tin oxide coated transparent conducting glass plate and the sample sandwiched between these two glass plates. Teflon spacers having thickness of d=39 ±1 μm were used and observations were made at 75^0C using Gippon Japan polarizing microscope in conjunction with a hot stage.

III. RESULTS AND DISCUSSION

A. Optical Texture Studies

In the present study, optical textures exhibited by the samples were observed and recorded using Gippon Japan polarizing microscope. The specimen was taken in the form of thin film and sandwiched between slide and cover glass. Here we have been considered for the experimental studies only the concentrations of 25 % and 40 % ChClin4O.8. The concentrations of 25 % and 40% of given mixture are slowly cooled from its isotropic melt, the genesis of nucleation starts in the form of small bubbles and slowly grow radially, which form a spherulitic texture of cholesteric phasewith large values of pitch [7-9] andthe same is shown in Figure 1.

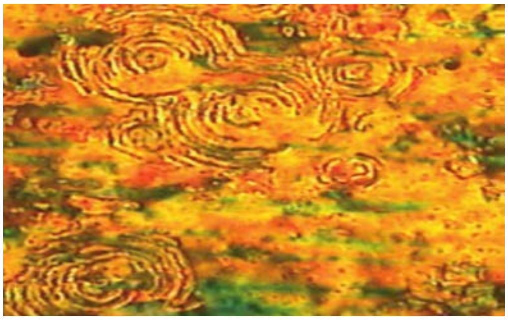

Fig. 1 SpheruliticTextureofCholesteric Phase

On further cooling the specimen, spherulitic texture of cholesteric phase changes over to a focal conic fan-shaped texture, which is the characteristic of smectic-A phase, as shown in Figure 2and this phase appears to be meta-stable and then changes over to smectic-C^*phase and hence this phase exhibits radial fringes on the fans of the focal conic textures, which is the characteristic of chiral smectic-C* phase as shown in Figure 3.

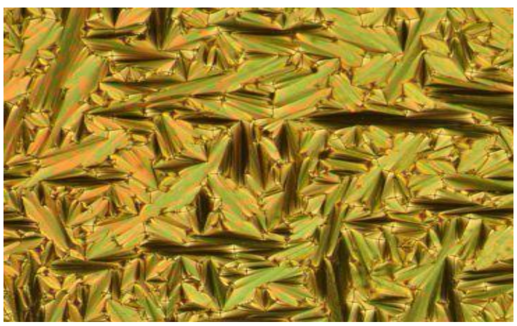

Fig. 2 Focal Conic Fan Shaped Texture of Smectic-A Phase

Fig. 3 Chiral Smectic-C* Phase

The molecular twist can be of constituent molecules in chiral smectic-C∗ phase and whichpossesa point symmetry in relation to their asymmetric centers, when they are packed in the form of layers, where the molecular long axes are tilted with respect to the layer planes [10, 11]. The stacking of layer planes on the axis, which are tilt in the direction normal to the layerplanes:thatshows a macroscopic helical structure of given phase. On further cooling the specimen, the unstable chiral smectic-C∗ phase slowly changes over toschlieren texture of smectic-C and this phase as shown in Figure 4[12] and sequentially on cooling the specimen, hence it finally crystallizes with smectic-B phase at room temperature.

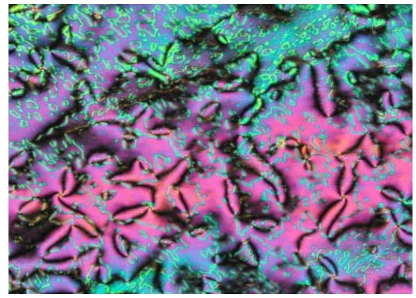

Fig. 4 SchlierenTexture of Smectic-C Phase

B. Optical Transmittance Studies

Temperature variation of optical transmittance for the samples of 30% ChCl in 4O.8is shown in Figure 5. This clearly illustrates that, the value of optical transmittance increases slowly with increase in temperature from 35^0C to 105^0C, while the sequence of phase appear from crystalline region to near isotropic region and there region suddenly some changes have been observed in the value of optical transmittance from 105^0C to 121^0C [13, 14]. In this studythe molecular interaction energy is continuous at the smectic-B to smectic-Cphase,smectic-C phasetosmectic-C*, smectic-C* to smectic-A and smectic-A to cholesteric phase. Here it is pertinent to remark that, the molecular orientation of different liquid crystalline phase transition is not energetic. The optical transmittance decreases while increasing the temperature and it diverges on approaching an induced chiral smectic and cholesteric phases.

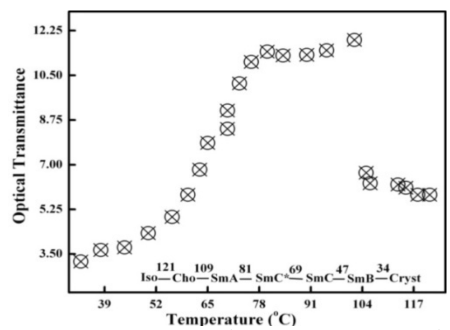

Fig. 5 Temperature Variation of Optical Transmittance for the Given Sample

The divergence of optical transmittance can be related to the first-order or second order transition. Here in the region of induced chiral smectic and cholestericphases, the optical transmittance shows a steep decrease and it is very nearer to isotropic region. The change of phase transition are exhibited by a given liquid crystalline materials shows a change in enthalpy of molecular interaction energy induced chiral smectic and cholesteric phases.From this enthalpy studies we can able to identify a type of the phase transition [15], which is the characteristic of first-order transitions of induced chiral smectic and cholestericphases respectively at different temperatures.

C. Electro-Optical Phase Transition Studies

Electro-optical phase transition measurements are a very important tool in getting better idea on the phase transition behavior of liquid crystal with the applied electric field at constant temperature. In this experimental study we have been considered a samplefor the concentrations of30% ChCl in 4O.8at constant temperature 75^0C.When the electric field applied on this concentration of given molecule, it leads to an elastic deformations and hence it becomes greater towards the sample surfaces: because of the surface anchoring. For thin enough samples one can suppose the electric energy is accumulated into the bulk elastic energy which is balanced by the surface anchoring energy on both surfaces.For a critical field: if at constant temperature the elastic energy of given molecules shows a different direction of molecular re-orientations, which are in the form of flow patterns: such as stripped pattern and chevron textures: the formations of zig-zag domains are characteristic of chevron textures: the forming time of these patterns are mainly depends on the applied electric field. If at there: we have been observed significant differences in the electro-mechanical responsesofradial fringes on the fans of focal conic textures of chiral smectic-C* phase. Radial fringes on the fans of chiral smectic-C* phase does not have a linear electro-mechanical effect at low fields; if only at higher fields it does the mechanical vibration have a component of frequency of the field. This indicates that the spontaneous polarization has rotated and is no longer parallel to the electric fields. In contrast to the director re-orientations, the molecular layer structures are unchanged by the application of applied electric field and then sequentially we have to increase the applied electric field above 22.20 V, the observed pattern becomes dynamic scattering mode-like and it has been appearing like irregularity of molecular re-orientations of chiral smectic-C* phase. The new disordered regions are arises probably due to the molecules not being confirmed to the orientations in the X, Z plane. If the applied voltage is kept at constant for some time, a completely stationary and regular two-dimensional hexagonal grid pattern has been observed. The hexagonal grid pattern textures are as shown in Figure 6.

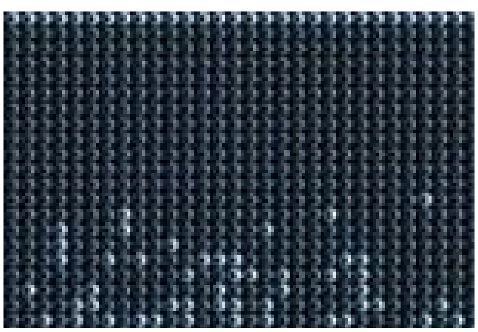

Fig. 6 Hexagonal Grid Pattern Electro-Optical Texture

The hexagonal grid pattern deforms gradually with increasing frequency and at some stage it becomes indistinguishable from the chevron texture. However: the hexagonal grid pattern is rather stationary and is formed in a short time at 250Hz, 23V. From the Figure 6, it follows that: an extremely regular hexagonal grid pattern is formed when the external electric field is applied. One of the regions is that: the formation of hexagonal grid pattern is the electronic charge injected by the applying external electric field [16-18].

IV. CONCLUSION

Microscopic investigation of binary mixture of ChCl in 4O.8shows the existence of cholesteric and induced smectic phases like SmA, SmC∗, SmC, and SmBphases, sequentially when they are cooled from its isotropic phase.The experimentally measured optical transmittance has been discussed based on the order of phase transition of different liquid crystalline phases. Under the applied electric field at constant temperature unambiguously corresponds to optical purity of liquid crystalline phases. The various aspects of frequency effects on given mixture show different directions of molecular re-orientations: which exhibit a flow patterns formations such as stripped pattern chevron textures and hexagonal grid pattern textures and hence these textures microscopically have been observed.

REFERENCES

[1] P. G. DeGennes and J.Prost, “The Physics of Liquid Crystals”, OxfordScience Publications, New York, ed. 2, 1993.

[2] P. M. Chaikin and T. C. Lubensky, “Principles of Condensed Matter Physics”, Cambridge University Press Cambridge, 1995.

[3] M. Iwamoto,C. X. WuandZ. C. Ou-Yang,“Separation of chiral phases by compression: kinetic localization of the enantiomers in a monolayer of racemic amphiphiles viewed as mixing cholesteric liquid crystals*Chem. Phys. Lett.*,Vol. 285,pp. 306-312, 1998.

[4] F. ZhangandD. K. Yang,“Temperature dependence of pitch and twist elastic constant in a cholesterictosmectic A phase transition”,*Liq. Cryst.*,Vol. 29, pp. 1497-1501, 2002.

[5] T. N. Govindaiah,“Temperature-dependent Anisotropic Nano-Molecular Orientations of Liquid Crystalline Materials”, *Mol. Cyst. Liq. Cryst.*, Vol. 626, pp. 151-159, 2016.

[6] R. Williams,“Liquid Crystals in an Electric Field”, *Nature,* Vol. 199, pp. 273-274, 1963.

[7] D.DemusandC. Richter,*Textures of Liquid Crystals,*VerlagChemie:Weinheim,NewYork, 1978.

[8] Nagappa, D. RevanasiddaiahandD. Krishnamurti,“Optical Behaviour of MixturesofNematic and CholestericCompounds”, *Mol. Cryst. Liq. Cryst.*,Vol. 101, No. 1-2, pp. 103-127, 1983.

[9] T. N. Govindaiah,“Phase Diagram Involving the Thermal Stability of TGB and Induced Smectic Phases in Binary Mixture of Thermotropic Liquid Crystals”, *Mol. Cryst.Liq. Cryst.*,Vol. 626, pp. 115-123, 2016.

[10] A. J. Slaney andJ. W. Goodby, “The effect of molecular chirality on the incidence oftwistedsmectic A phases”, *Liq. Cryst.*,Vol. 9, pp. 849-861,1991.

[11] M. Marthandappa,Nagappa, R. SomashekarandK. M. LokanathaRai,*Phys.Stat. Sol.*,Vol.129, pp. 389-398,1992.

[12] P. G. DeGennes, “The Physics of Liquid Crystals”, Clarendon Press: Oxford, U.K. pp.239, 1991.

[13] N. A. VazandG. P. Montgomery, “Refractive indices of polymer-dispersed liquid-crystal film materials: Epoxy-based systems”, *J. Appl. Phys.*, Vol. 62, pp. 3161, 1987.

[14] T. N. Govindaiah,“Studies on Anisotropic Molecular Orientation and Mesophase Stability in a Ternary Mixture of Liquid Crystalline Materials”,*Mol. Cryst. Liq. Cryst.*,Vol. 626, pp. 141-150, 2016.

[15] P. J. Collings and M. Hird,“Introduction to Liquid Crystals: Physics and Chemistry”, Taylor and Francis, London, 1997.

[16] W.Helfrich,“Electric Alignment of Liquid Crystal”, *Mol. Cryst. Liq. Cryst.*,Vol. 21, No. 3-4, pp. 187-209, 1973.

[17] D. KrishnamurtiandD. Revannasiddaiah,“Optical Studies on Williams Domains”, *Mol.Cryst.Liq.Cryst.*,Vol. 55, No. 1, pp. 33-46, 1979.

[18] S. Kai, K. Yamaguchiand andK. Hirakawa,“Observation of Flow Figures in Nematic Liquid Crystal MBBA”,*Japan. J. Appl. Phys.*,Vol. 14, No. 11, pp. 1385,1975.