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Optical and Dielectric Studies on Binary Mixture of Nematic Dimmer and Cholesteric Liquid Crystalline Materials

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Abstract: In the present work, our investigation is to study the optical, thermal and dielecric properties of the binary mixtures of nematic dimmer and cholesteric compounds, namely, cholesteryl nonanoate (CN) and 1,7-bis-4-(4′-cyanobiphenyl) heptane (CB7CB). Which exhibits a very interesting liquid crystalline cholesteric and induced chiral smectic phases such as SmA, SmC* SmC, reentrant SmA and SmB phases sequentially when the specimen cooled from isotropic phase. These phases have been characterized by using microscopic and optical anisotropic technique. The temperature variations of dielectric parameters have also been discussed.

Keywords: Optical texture; Binary mixture; induced polymorphism; Dielectrics;

I. INTRODUCTION

Characterizations of different mixtures of liquid crystalline materials play a very crucial role in understanding the electro-optical properties and with this knowledge: chiral liquid crystalline phases are formed either by self-assembly or when doped with a non-chiral liquid crystalline material, they are intrinsically characterized by an array of unique properties and molecular structures: that are promising from both advanced technology and fundamental research point of view. Phase transition behavior of molecular orientations of self assembled structure, in which the molecular self assembled organization of different liquid crystal phase is very powerful and can be extended to other molecular architectures and hence such materials are in suitable application for the desired functionality. Optical, electrical, thermal, DSC, X-ray studies are the fundamental characterizations to understand the basic applicability. Optical characterization, gives insight to many physical properties such as the absorption, transmission, reflectivity, refractive index, susceptibility and dielectric constant of the material.

In the present investigation, our aim is to study the binary mixtures of nematic dimmer and cholesteric compounds, namely, cholesteryl nonanoate (CN) and 1,7-bis-4-(4′-cyanobiphenyl) heptane (CB7CB). Different concentrations of these molecules exhibits an cholesteric and induced chiral smectic phases such as SmA, SmC* SmC, reentrant SmA, and SmB respectively at different temperatures. They were observed using microscopic technique and also been verified from the results of optical anisotropic techniques. The dielectric measurements have also been discussed as a function of temperature.

II. EXPERIMENTAL STUDIES

In the present study, we use the materials, namely, cholesteryl nonanoate (CN) and 1,7-bis-4-(4′-cyanobiphenyl) heptane (CB7CB). Mixtures of different concentrations of CN in (CB7CB) were prepared and they were mixed thoroughly. These mixtures of concentrations were kept in desiccators for 6 hours. The samples were subjected to several cycles of heating, stirring and centrifuging to ensure homogeneity. Phase transition temperatures of these mixtures were measured with the help of a polarizing microscope in conjunction with a hot stage. The samples were sandwiched between the slide and cover slip, and were sealed for microscopic observations.

A. Dielectric Measurements

The values of capacitance and dissipation factor of the sample holder with, and without sample, were determined by impedance/ gain phase analyzer of Hewlett-Packard (HP 4194A). The real part of the permittivity of the sample is obtained from the change in the capacitance value of the sample holder, due to the presence of sample, using the following equation:

$$\epsilon' = \frac{\Delta C}{C_G} + 1$$

where, ΔC, the change in the capacitance of sample holder due to the presence of sample, is

$$\Delta C = C_P - C_O$$

where, C_P is the capacitance with sample, and C_O is the capacitance without sample. C_G is the geometrical capacitance of the sample holder.

The loss tangent and dissipation factor (D) of the sample were derived from the dissipation factor and capacitance, measured for the sample holder with, and without sample, and is given by:

$$\tan\delta = \frac{C_P D_P - C_O D_O}{C_P - C_O}$$

where, D_P is the dissipation with sample, and D_O is the dissipation without sample.

The loss factor is given by the following equation

$$\epsilon'' = \epsilon' \tan\delta$$

Capacitance values were read up to three significant figures, and the values of the dissipation factor were recorded up to four significant figures in the present study. The temperature of the sample was maintained by placing the sample cell on a specially designed double walled brass chamber, in which heated oil was circulating, with the help of a Julabo F-25 refrigerated circulator. It has the facility of setting the temperature of the sensor used, and so the temperature of the sample, i.e. the sensor temperature, has been measured directly from the display of the monitor (Operating Manual, JULABO). The temperature was measured by placing a thermocouple in close vicinity to the sample, with an accuracy of 0.1^0C.

III. RESULTS AND DISCUSSIONS

A. *Optical Texture Studies*

The molecular orientations of optical textures exhibited by the samples were observed and recorded using the leitz-polarizing microscope in conjunction hot stage. The specimen was taken in the form of thin film and sandwiched between the slide and cover glass. The mixture of different concentrations of given molecules were slowly cooled from its isotropic melt. The genesis of nucleation starts in the form of small bubbles and slowly grows radially, which forms a spherulitic texture of cholesteric phase with large values of pitch [10, 11]. On further cooling the specimen, the cholesteric phase slowly changes over to focal conic fan shaped texture, which is the characteristics of SmA phase and is shown in Figure 1(a). The SmA phase is unstable and then it changes over to the SmC* phase, which exhibits radial fringes on the fans of focal conic textures, which is characteristic of the chiral SmC* phase. On further cooling the specimen, this phase slowly changes over to schlieren texture of SmC phase, as shown in Figure 1(b). The SmC phase is also unstable and then it changes over to bubbles in the form of battonnets, which are the characteristic of SmA phase and this phase has been termed as the reentrant SmA (ReSmA) phase. Sequentially on further cooling the specimen: the existence of reentrant SmA (ReSmA) phase slowly changes over to hexagonal close packed higher ordered SmB phase, which remains stable at room temperature [12].

B. *Dielectric parameters*

The dielectric studies are very useful information about molecular structure, molecular dynamics and phase transition behavior and they are used as an input to its display applications [13, 14]. In addition; the dielectric anisotropy and dielectric loss of the liquid crystal arising from angular correlation between the molecules, not only throw light on individual molecular structure but also their ordering in a particular mesophases, which may be characterized by order parameter. Since the value of dielectric permittivity and dielectric loss vary with the variation of temperature, these parameters can be used to measure the transition temperatures of pure liquid crystals as well as their mixtures.

At constant frequency 5 kHz, the temperature variations of dielectric parameters such as dielectric constant (ε') and dielectric loss (ϵ'') have been measured for the mixture of 50% CN in CB7CB is presented in Figure 2(a-b). From the figure it is clear that, the discontinuities are observed; while the phase transition temperature changes the different liquid crystalline phases, which are appear from smectic - isotropic region. The dielectric parameter ϵ' decreases with increasing the temperatures and the parameter ϵ'' increases with increasing the temperatures and hence the most remarkable feature of these parameters are more tendency to their constituent molecules are segregate in space with the creation of interfaces, which is due to the fact that, the domination of interfacial polarization over dipole polarization. Therefore, it can be concluded that, the interfacial polarization is responsible for the dielectric relaxation of the molecules. The phase transition from smectic- isotropic region, the molecular twist can be of different liquid crystalline phases, which shows different molecular orientational directions in between these regions. Hence the change in dielectric parameters are remains uniform, when it appears nearer to isotropic region, for both parallel and perpendicular orientations and they giving rise to an over all positive dielectric anisotropy caused by the considerable longitudinal dipole moment.

This may lead to the conclusion that the dipole moment exhibits anti-parallel correlations in the isotropic phase of the given molecules [15-25].

IV. CONCLUSIONS

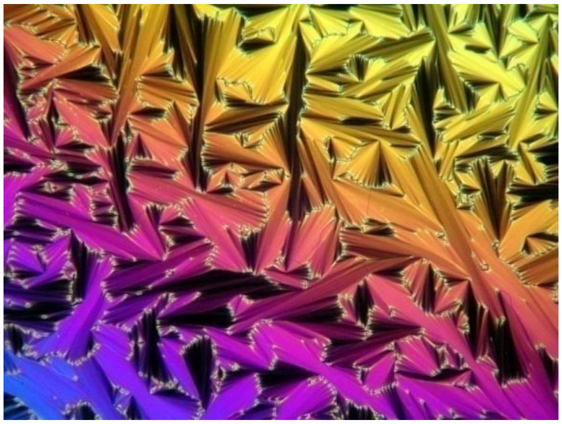
In light of the above results, we have drawn the following conclusions. The binary system of nematic dimmer and cholesteric compound shows the existence of cholesteric and induced chiral smectic phases such as SmA, SmC* SmC, reentrant SmA and SmB phases for all concentrations of CB7CB. Changes in the values of dielectric parameters shows the molecules are segregate in space with the creation of interfaces, which is the domination of interfacial polarization over dipole polarization. The changes in dielectric parameters are same in isotropic region, which shows positive dielectric anisotropy caused by the considerable longitudinal dipole moment. This may lead to the conclusion that the dipole moment exhibits anti-parallel correlations in the isotropic phase of the given molecules.

REFERENCES

[1] Ferrarini, A., Luckhurst, G.R., Nordio, P.L. and Roskilly, S.J. (1993). Chem. Phys. Lett. 214, 409-417.
[2] Umadevi, S., Sadashiva, B. K., Murthy, H.N. and Raghunathan, V. A. (2006). Soft Matter. 2, 210-214.
[3] Umadevi, S. and Sadashiva, B.K. (2007). Liq. Cryst., 34, 673-681.
[4] Lueder, E.(2000). Liquid Crystal Displays, John Wiley & Sons, Ltd.
[5] Gleeson, J. T., Gheorghiu, N. and Plaut, E.(2002). Eur. Phys. J. B 26, 515.
[6] Meyerhofer, D. (1975). J. Appl. Phys. 46, 5084.
[7] Wong, K. Y., Jen, A. K.-Y., Rao, V. P. and Drost, K. J. (1994). Journal Chemical Physical, 100, 6818-6825.
[8] Bauman, D. and Haase, W. (1989). Mol. Cryst. Liq.Cryst. 168, 155-168.
[9] Bauman, D. (1989). Mol. Cryst. Liq.Cryst. 174, 1-10.
[10] Govindaiah, T. N. and Sreepad, H R. (2015). Phase Transitions. Vol-88(4), 368-374.
[11] Serafin Delica, Melvin Estonactoc, Mary Claire Micaller, Leonorina Cada and Zenaida Domingo. (1999). Science Diliman. 11(2), 22-24.
[12] Govindaiah, T. N., Sreepad, H. R., Kempegowda, B. K., and Nagappa. (2013). Mol. Cryst. Liq.Cryst., 587, 54-59.
[13] Gharadjedaghi, F. and Robert J. (1976). Rev. Phys. Appl. (Paris). 11(4), 467-473.
[14] Hill, N. E., Vaughan, W. E., Price A. H. and Davies M. (1969). Vannostrand, New York.
[15] Hourri, A., Jamee, P., Bose, T. K. and Thoen, J. (2002). J. Liq. Cryst. 29(3), 459.
[16] Hikmet, R. A. M. (1990). J. Appl. Phys. 68, 4406.
[17] Maier, W. and Meier, G. (1961). Z. Naturforsch, Teil A. 16(3), 262–267.
[18] Arodz, M. M., Stettin, H. and Kerrese, H. (1989). Mol. Cryst. Liq. Cryst. 177, 155-161.
[19] Druon, C. and Wacrenier, J. M. (1984). Mol. Cryst. Liq. Cryst. 108, 291-308.
[20] Prasad, S. K., Sandhy, K. L., Nair, G. N., Hiremath, U. S., Yelamaggad, C. V. and Sampath, S. (2006). Liq Cryst. 33(10), 1121-1125.
[21] Humphries, R. L. and Luckhurst, G. R. (1973). Chem. Phys. Lett. 23(4), 567-570.
[22] Manohar, R., Manohar, S. and Chandel, V. S. (2011). Materials Sciences and Application. 2011(2), 839-847.
[23] Gupta, G. K., Arora, V. P. and Agrawal, V. K. and Man-Singh, A. (1979). Mol. Cryst. Liq. Cryst. 54(3-4): 237-243.
[24] Arora, V. P., Agrawal, V. K. and Man-Singh, A. (1978). J. Chem. Phys. 68(11), 4860- 4861.
[25] Johri, G. P. and Goldstein, M. (1971). J. Chem. Phys. 55(9), 4245-4252.

Figure Captions

Figure 1. Microphotographs obtained in between the crossed polars.



a. Focal conic fan-shaped texture of SmA phase (250X).

b. Schlieren texture of SmC phase (250X).

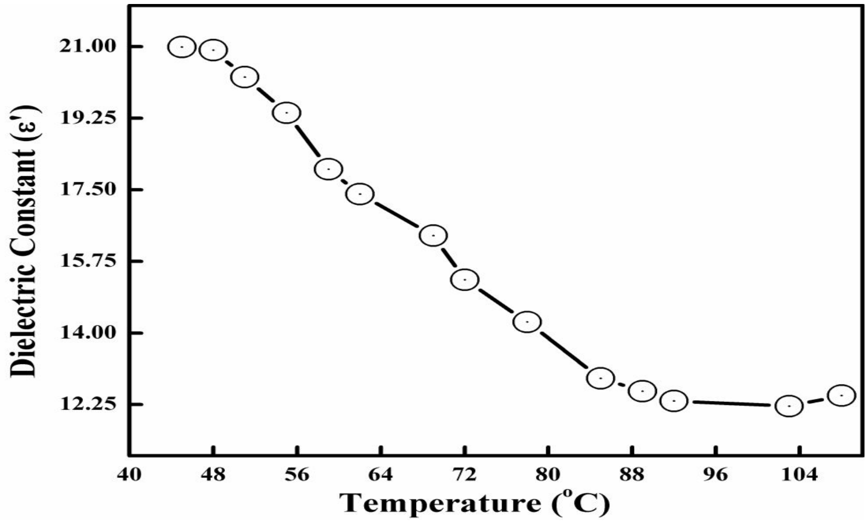


Figure 2 (a). Temperature variation of dielectric constant for the sample of 50% CN in CB7CB.

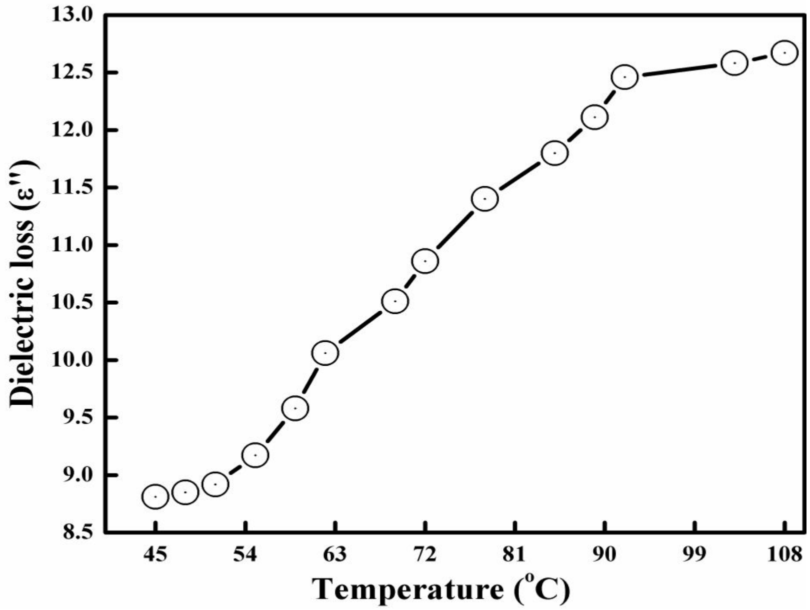


Figure 2 (b). Temperature variation of dielectric loss for the sample of 50% CN in CB7CB.