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STUDIES ON MOLECULAR LAYER SPACING'S OF RE-ENTRANT NEMATIC AND RE-ENTRANT SMECTIC-A PHASES OF CARBONITRILE AND BENZONITRILE LIQUID CRYSTAL MOLECULES

Physics

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ABSTRACT

Optical phase transition studies on thermal properties of binary mixtures of P-[(*P'* hexyloxybenzilidene)-amino] benzonitrile (HBAB) and 4-hexyl-4-biphenylcarbonitrile (6CB) materials exhibits a re-entrant nematic and re-entrant smectic-A phases sequentially when the specimen cooled from its isotropic melt for the given different concentrations at different temperatures respectively. X-ray studies are helps us to understand the molecular layer spacing's of re-entrant nematic, re-entrant SmA phases at different temperature. Temperature variations of tilt angles have also been discussed.

KEYWORDS

Phase Transition; Optical Texture Molecular Orientation; Layer Spacing's; Tilt Angle;

INTRODUCTION

Liquid crystals are partially ordered and physical anisotropic materials. These materials are very sensitive to different external effects, e.g. electric, magnetic and thermic fields, surfaces, boundary conditions, flow etc. Most applications of these materials in liquid crystals technique and liquid crystals technology depend upon their thermo-optical, electro-optical and magneto optical properties [1-4]. These properties exhibit a very interesting behaviour in both regions of liquid crystalline mesophases and the regions of phase transitions. For the technical and technological applications of liquid crystals, information about the optical anisotropy, refractive and polarization properties, and also about their temperature behaviour is important.

The thermo-optical and electro-optic properties of cyano group of nematics, dyes, drugs and nucleic acids materials govern their use in different industrial technological applications of liquid crystalline display devices. The study of molecular and thermodynamic parameters provides the necessary input to understand the irregular interlocking intermolecular interactions are involved to show the formation of mesophases such as unusual sequence of phases such as re-entrant nematic, re-entrant smectic, fog blue phase, chromonic, re-entrant TGB phases. The appearance of higher symmetry phase at a lower temperature compare to less symmetric one is not special to a liquid crystals. There are quite few a few examples in other fields of condensed matter physics [5].

In the present investigation, we have been consider a cyano groups of two compounds namely; P-[(*P'*-hexyloxybenzilidene)-amino] benzonitrile (HBAB) and 4-hexyl-4-biphenylcarbonitrile (6CB), mixture of these molecules exhibits a re-entrant nematic and re-entrant smectic-A phases sequentially when the specimen is cooled from its isotropic melt.X-ray studies are helps us to understand the molecular layer spacing's of re-entrant nematic, re-entrant SmA and SmC phases at different temperature. Temperature variations of tilt angles have also been discussed.

Experimental Studies

In the present work: we have been considered two compounds namely: P-[(*P'*- hexyloxybenzilidene)-amino] benzonitrile (HBAB) and 4-hexyl-4-biphenylcarbonitrile (6CB). For the experimental studies; here we have chosen a 55% of HBAB molecules mixed with 45% of 6CB. The given concentrations of these molecules were kept in desiccators for a long time. The samples were subjected to several cycles of heating, stirring, and centrifuging to ensure homogeneity. The phase transition temperatures of these concentrations were measured with the help of Gippon-Japan polarizing microscope in conjunction with a hot stage. The samples were sandwiched between the slide and cover slip and were sealed for microscopic observations. The X-ray diffraction patterns were obtained using SHIMADZU - XRD-6000. Diffractometer [6-8].

RESULTS AND DISCUSSIONS

Liquid Crystalline Properties

The hot-stage Gippon-Japan-polarizing microscope were used to observed the molecular orientation of optical textures of re-entrant nematic and re-entrant smectic-A phases were exhibited by the sample of binary mixture of benzonitrile and carbonitrile molecules: such as: 55% of concentrations of HBAB and 45% concentrations of 6CB. Here in this microscopic textural study: the given concentrations of benzonitrile and carbonitrile group of molecules are exhibits an very interesting unusual sequence of re-entrant nematic and focal conic domains of re-entrant SmA phases with an additionally induced schileren texure of chiral smectic-C phases, which are obtained sequentially on cooling the specimen from its isotropic phase. The following Figure 1 shows the microscopic observation of microphotographs corresponding to the transformations of re-entrant nematic- re-entrant-smectic-A phases.

X-ray Studies

X-ray diffraction patterns were taken to understand the change in layer spacing's of re-entrant nematic, re-entrant SmA and SmC phases with temperature. The obtained x-ray traces for samples of 55% of HBAB in 6CB at different temperatures correspond to re-entrant nematic, re-entrant SmA phases respectively. From the Table 1, the values have been observed that: as the temperature increases the molecular layer spacing's of re-entrant smectic-A phase are constant, but in re-entrant nematic phase and molecular layer spacing's are abruptly increases. In contrast to the birefringence of benzonitrile and carbonitrile groups of given molecules are abruptly changes at re-entrant smectic-A to re-entrant nematic transition. This suggests that a general increase in orientational order. The increase in orientational order and tilt angle may explain low shrinkage of smectic layers [9, 10].

The following Figure 2 shows the variations of layer spacing's with temperature for the sample of 55% of HBAB in 6CB at the transition from re-entrant smectic-A to re-entrant nematic phases.

Temperature Variations Of Tilt Angle Studies On Smectic-c Phase

Measurements of temperature variations of tilt angle on chiral smectic phase of liquid crystalline materials are the good test for theory. In tilted smectic planes, the tilt angle can be measured by using x-ray diffraction data to determine the change in interlayer spacing distance due to the tilting of molecules. Temperature variations of tilt angle on chiral smectic-C phase for the sample of 55% of HBAB in 6CB molecules are shown in Figure 3. The tilt angle increases with an increasing temperature and it attains a saturation value. The saturation value of tilt angle for the chairal smectic-C phase is found to be 3.67° is shown in the figure. The chiral molecular tilt angle values are attributed to the directions of soft covalent bond interaction and it extends along with the molecular axis with finite inclination.

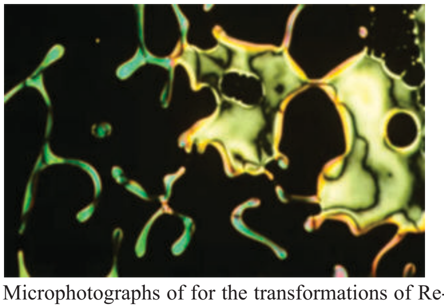

Figure 1 Microphotographs of for the transformations of Re-entrant nematic to Re-entrant smectic-A phases

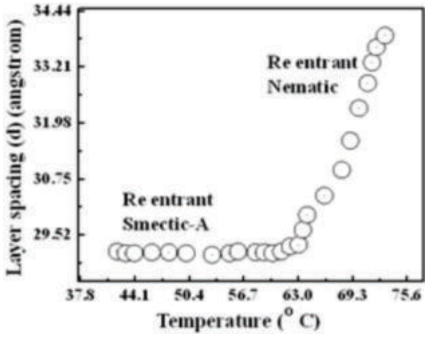

Figure 2 Temperature variations of layer spacing's with temperature

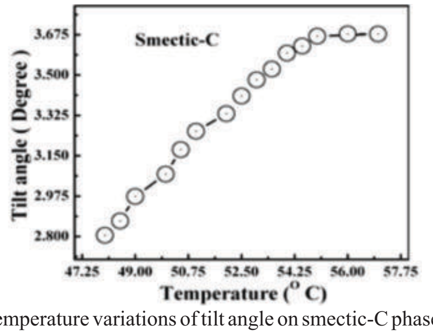

Figure 3 Temperature variations of tilt angle on smectic-C phase.

The increases in tilt angles are showing strong coupling of aggregated nano-molecular self assembly, which provides larger dipole-dipole interaction between the molecular systems. Some times a small discontinuity of tilt angle has been observed at every phase transition between tilted chiral smectic planes. The tilt angle studies helps us to understand polar interactions between the neighboring layers provides excellent agreement with the experiment for given phase transitions between smectic-A and smectic-B phases [11-17].

CONCLUSIONS

Microscopic investigation of binary mixture of benzonitrile and carbonitrile groups of molecules shows the existence of re-entrant nematic and re-entrant smectic-A phases for given concentrations respectively at different temperatures. The x-ray data of intermolecular layer spacing's are helps us to understand the tilt angles studies on chiral smectic-C phase: it shows a strong coupling of aggregated nano-molecular self assembly: which provides larger dipole-dipole interaction between the central core and side chain of liquid crystalline molecules.

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