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Phase Transition Temperature Study of Zns Nano Particle Dispersed Octyloxycyanobiphenyl

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Abstract- We have performed the phase transition of a binary mixture of ZnS nano particles and a thermotropic liquid crystal octyloxycyanobiphenyl (8OCB). A different concentration of the mixture is prepared. In this paper the transition temperatures of different concentrations are determined by using high resolution optical birefringence method.

Keywords-Liquid crystal, Octyloxycyanobiphenyl, ZnS.

I. INTRODUCTION

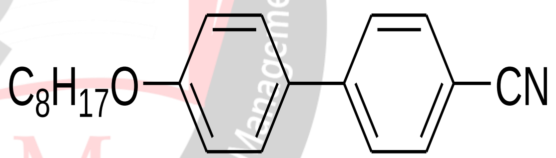
The simplest mesophase of liquid crysatal is the nematic (N) which contains a long-range orientational order of the long molecular axis along a chosen direction is known as the director [1]. But limited positional order, in addition to the long-range orientational order for smectic A (SmA) mesophases, is observed. The anisotropic properties of LCs serve as the basis of many functional applications in modern devices [2, 3].

Nowadays liquid crystal research has made huge contributions to nano science and nanotechnology and a new field i.e. liquid crystal nano science has gained growing interest. LC compounds are very sensitive to external perturbations and their physical properties can be suitably tuned by preparing binary mixtures. Development of such hybrid systems having mixtures of liquid crystalline compounds with nano particles at different concentrations [4, 5] proved to be a useful technique to enhance the optical as well as some other physical properties of the host LC materials. Study of the different thermal parameters of nano doped liquid crystals has attracted a new interest owing to their consequence for several application devices based on the electro-optical properties of the same. In the field of liquid crystal research, the nematic-smectic A (N-SmA) phase transition is extensively studied due to its rich phenomenology associated with the first order or second order nature of this transition. N-SmA phase transition involves the breaking of a continuous symmetry and according to de Gennes it belongs to the three dimensional-*XY* (3D-*XY*) universality class [1].

II. EXPERIMENTAL

IIA. Materials

The compound octyloxycyanobiphenyl (8OCB) was purchased from Merck, UK and was used without further purification. ZnS nano particles were purchased from Sigma-Aldrich (product number 244 627) and the average particle size is 10 μm. The structural formula and different phase transition temperatures of 8OCB are given below:



Cr 54.5°C Sm-A 67°C N 80°C I.

Five mixtures have been arranged having concentrations (in wt%) of ZnS equal to 0.098, 0.197, 0.495, 1.01 and 2.08. A small amount of ZnS was first dispersed in acetone and repeatedly shaken on a vortex shaker for about 30 min [6]. The LC compound (8OCB) was then added to appropriate amount of acetone + ZnS mixture to achieve the desired concentration of ZnS in 8OCB. Afterward the mixtures were ultrasonicated in an ultrasonic bath for about 1 h to facilitate complete dispersion. After the ultrasonication the mixtures were placed over a hot brass plate to evaporate the acetone slowly out of the mixtures. The nature of the phases and the corresponding phase transition temperatures have been determined by a

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polarizing optical microscope (Motic BA 300) equipped with a Mettler FP900 hot stage.

IIB. Optical Transmission (OT) Method

High resolution optical birefringence (Δn) measurements were carried out by measuring the intensity of a laser beam transmitted through a planar aligned LC cell of thickness 8.9 μm. A He-Ne laser (λ = 632.8 nm) was used to probe the related phase retardation. The temperature of the liquid crystal cell was controlled and measured with a temperature controller (Eurotherm PID 2404) with an accuracy of $\pm 0.1^0$C by placing the cell in a heater made of brass. The intensity of the transmitted light was measured by a photo diode at an interval of 3 s. The heater temperature was varied at a rate of 0.5^0C min−1; this translates into a temperature difference of 0.025^0C between two successive readings. The experimental details for the birefringence measurement from optical transmission method in the nematic and SmA phases have been illustrated in our earlier publications [7, 8]. In our present method, the precision of measurement of the birefringence values is found to be slightly higher than 10¯5.

IIC. Polarizing Microscopy

Polarizing microscopy is one of the essential tools for the characterization of newly synthesized mesogenic materials. It provides a determination of both phase transition temperatures and phase type. This is done by temperature dependent texture investigations between crossed polarizer's. Characteristic textures and defect structures, which change when passing a phase transition, reveal the phase type observed.

It consists of a light source of white light with a wavelength characteristic. The light is reflected upwards by a mirror, passes through a lens, and is linearly polarized by a sheet polarizer, which can often be rotated by 360^0. For a white light source we can also insert a wavelength filter at this point, if wavelength dependent experiments have to be carried out. The light then enters the condenser, probably the most neglected part of a polarizing microscope, despite its importance for optimal imaging of the sample. The condensor collects the light from the light source and assures a uniform illumination of the sample.

III. Results and discussions

IIIA. Study of phase transition temperature by optical transmission method

The phase transition temperatures of the mixtures have been measured by optical transmission method. The nematic and smectic-A transition temperatures of the nano doped liquid crystal mixture are shown graphically. The nematic range ie the difference between nematic and Smectic A temperature increases from 12.625 to 12.7. 12.625 is observed for the mixture of concentration 0.09 and that of 12.7 for the mixture 1.0. If the concentration of ZnS increases then the nematic range does not vary.

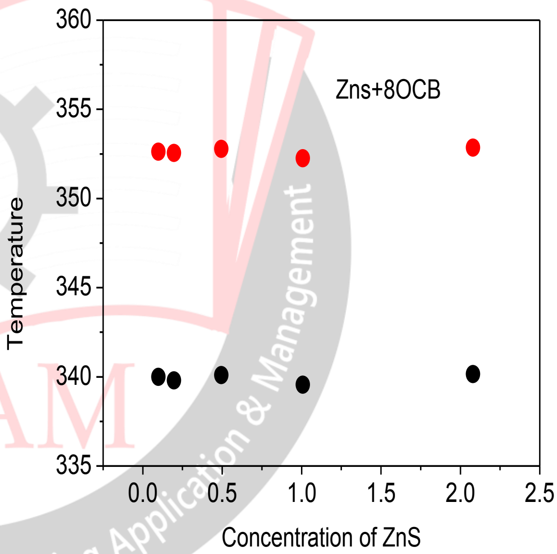

Figure1.1 variation of phase transition temperature

IIIB. Study of Phase Transition Temperature by Texture

a. Nematic Phase

The general structure of the nematic phase i.e., the long molecular axes of the molecules orient more or less parallel to each other, while their centers of mass are isotropically distributed. The nematic phase exhibits solely long range orientational order. Nematics between untreated glass plates often orient with their director parallel to the substrates. If this orientation is not homogeneous, but varies slowly in the plane of the

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substrate, it is called Schlieren textures [9, 10] are observed between crossed polarizers.

b. Smectic Phases

The fluid smectic phases are characterized by a one dimensional positional order of the molecule's centers of mass in addition to the orientational order of the long molecular axis, and thus the formation of a more or less pronounced layer structure. Within a particular smectic layer the molecule's centers of mass are isotropically distributed, making the fluid smectic phase locally a two dimensional liquid [11]. The basic structural features of the SmA phase, as shown in figure below:

Figure1.2 Texture of Smectic-A phase

IV. SUMMARY AND CONCLUSIONS

This paper presents the results transition temperatures by the high resolution optical birefringence method has been determined. For case of all mixtures the nematic range increase initially upto the concentration x_{ZnS} = 0.495% and remains almost the same over the investigated concentration range. It is also concluded that upto the equal weight of both the component of the investigated mixture the nematic range increases but when the concentration of ZnS is greater than that of 8OCB then the nematic range stays fixed.

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