STUDY OF OPTICAL BIREFRINGENCE OF OCTYLOXY-CYANOBIPHENYL AND NONYLOXY-CYANOBIPHENYL

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Abstract: Measurements of optical birefringence (Δn) as a function of temperature of compounds octyloxy-cyanobiphenyl (8OCB) and nonyloxy-cyanobiphenyl (9OCB) have been presented by means of high resolution temperature scanning technique. The temperature variation of the birefringence (Δn) were determined from the transmitted intensity data using wavelengths λ= 632.8 nm.

Keywords**: Optical birefringence, liquid crystalline phase**

1. INTRODUCTION

In condensed matter physics, liquid crystalline state of matter plays significant role for application in display devices as well as fast operating shutters, tunable photonics, nonlinear optics, broad range filters, holographic devices, etc. [1-4]. For such application of liquid crystals the stability of mosophase range, an intermediate phase between the solid and the liquid states [5], and the existence of mesophases at desired temperature need to be satisfied. The knowledge concerning different interesting properties such as refractive indices, birefringence, viscosities, dielectric anisotropies, electric, magnetic susceptibilities and elastic constants are dreadfully necessary for the use of liquid crystals for different types of devices. Hence, in order to invent better materials for display applications most remarkable features of liquid crystals have been characterized. Despite considerable properties of applicability in display applications, order parameter can predict the nature of the liquid crystalline phase transformations.

Alkyloxycyanobiphenyls are very well-known liquid crystalline compounds and these are extensively studied due to their high positive optical anisotropy and good chemical stability. They exhibit long thermal ranges of phases with the change of the number of alkoxy chains. It may be mention that in the investigated series, two of the compounds of nOCB (n=8,9), has an underling smectic A phase along with nematic phase.

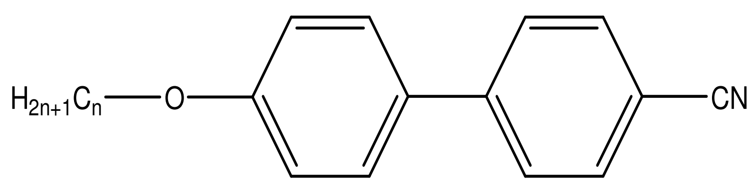
In the present paper we report the comprehensive analysis of the temperature dependence of optical birefringence (Δn) for the two mesogens (n=8,9) of alkyloxycyanobiphenyl homologous series with increasing alkyl chain length. To calculate the optical birefringence (Δn) data high resolution temperature scanning technique has been used.

2. EXPERIMENTAL

2.1 Materials

The nOCB (n=8,9) compounds were obtained from Merck, U.K. and were synthesized and purified by Prof. R. Dabrowsky at the Institute of Chemistry, Military University of Technology, Warsaw, Poland. Its purity was higher than 99.9%, and no further purification was needed. Compounds 8OCB, and 9OCB exhibit the isotropic to the nematic phase, smectic A (SmA) phase .

The general structural formula and the transition temperatures of the eight compounds well-known family of cyanobiphenyls are given below:



nOCB (n=5-12)

Octyloxy-cyanobiphenyl(8OCB): Cr 54.5ºC SmA 67.5 N 81ºC I

Nonyloxy-cyanobiphenyl(9OCB): Cr 61.3ºC SmA 77.5 ºC N 80ºC I

2.2 Optical transmission (OT) method

The intensity of the laser beam have been employed to derive the optical birefringence ($\Delta n = n_e - n_o$) through high resolution temperature scanning technique. These laser beam have been directed to pass through a linear cell (procured from AWAT Co. Ltd., Warsaw, Poland) filled with liquid crystal. The cell have been placed between two crossed polariser in such a way that they are parallel to each other. To investigate the phase interruption concerning with experimental set up two laser beam , one was He-Ne laser having wavelength λ=632.8 nm and the other was green laser of wavelength λ=532 nm have been managed. A heater made up of brass have been engaged for inserting the cell on it and its temperature have been monitored by means of a temperature controller (Eurotherm PID 2404) having a precesion of about ± 0.1 K. [6] The cell temperature also maintained by this temperature controller. The heater temperature have been altered by a rate of about 0.5 K min^{-1}, so that the interval between two successive raeding raised by 0.025 K. The transmitted optical intensity is an oscillatory function of the optical phase difference Δφ. The optical birefringence and the phase difference are closely connected. So to derive the temperature variation of optical birefringence we have to measure phase difference first considering light intensity assuming the following relation [7,8]

$$I_t = \frac{\sin^2 2\theta}{2}(1-\cos\Delta\varphi) \qquad (1)$$

Where θ is the angle made by the polarizer with the optic axis and is set at 45^o to optimize the measurements.

$$\Delta\varphi = \frac{2\pi}{\lambda}\Delta n d \qquad (2)$$

where d is the sample thickness. Several cooling and heating run have been performed to acquire suitable outcome. The quite precession has been done by this method which was better than 10^{-5}.

3. RESULTS AND DISCUSSION

4.1 Optical birefringence measurements

The nature of variation of optical birefringence (Δn) with temperature (T) using wavelengths λ = 632.8 nm for the two members of 4'-alkoxy-4-cyanobiphenyls homologous series upon cooling from the isotropic liquid to the room temperature, are illustrated in Figures 1.

The birefringence (Δn) data covers the nematic as well as the smectic phases. The birefringence of all the liquid crystals exhibits the normal behavior i.e. it increases with decreases in temperature. Near the nematic– isotropic (N–I) phase transition temperature (T_{NI}), the Δn value changes promptly which significantly points out that this transition is a first order transition. After this significant change at T_{NI}, the birefringence (Δn) value increases with decreasing temperature enhancing nematic molecular ordering. In case of 8OCB and 9OCB a sluggish but perceptible deviation, known as nematic-smectic A transition, is detected on decreasing temperature further towards crystalline state. In this vicinity of transition, the deviation of birefringence is found to be very small ranging from 1-3 K above and below the same indicating it to be a very weak first order transition. This transition also involved strongly for shortening of the nematic range. A pretransitional behavior in the variation of birefringence with temperature is observed on the both side of this transition exhibiting more pronounced on the nematic side. The stronger coupling between the nematic and smectic order parameters may be the reason for this prediction possibly. It is to be found that the pretransitional signature for 9OCB on the nematic side is more prominent than for 8OCB as nematic range 9OCB is smaller than 8OCB. From figure 1

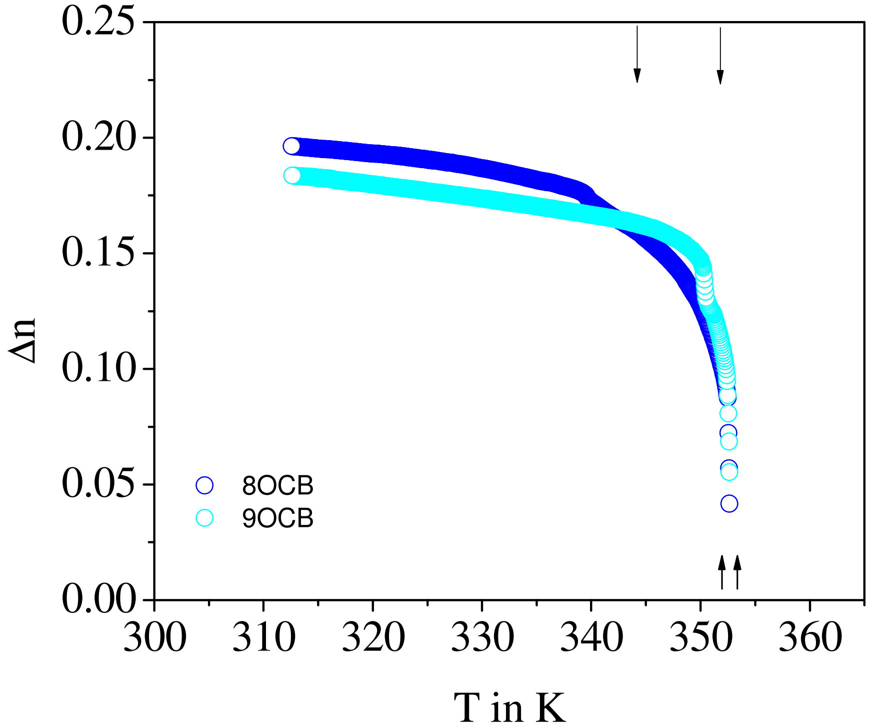


Figure 1. Temperature variation of birefringence ($\Delta n=n_e-n_o$) of compounds studied. o data for Δn measured from optical transmission method using wavelength λ= 632.8 nm. The solid upper head arrows and lower head arrows indicate the nematic- isotropic (N-I) and nematic- smectic A (N-SmA) transition temperature respectively.

4. CONCLUSIONS

5. Conclusions

The birefringence of two members of the 4-cyano-4'-n-alkylbiphenyls (n=8,9) has been measured with a relatively acceptable precision (better than ±10-4) using the high resolution temperature scanning method, a straightforward and accurate methodology. In the neighborhood of N-Sm, the smectic phase compound 8OCB exhibits pretransitional behavior. a change caused by the nematic and smectic order parameters coupling. High resolution temperature scanning technology has shown that to be enough to illustrate the temperature at which a solid turns into a liquid crystal and a liquid crystal into an isotropic liquid. The different physical characteristics needed for display systems have made it possible to determine how liquid crystal samples and their mixes behave during phase transitions. The mixes made from the distinct samples each have their own phases, which allows for the expansion of phase-related features of these materials in various ways.

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