

# Phase diagram study octylcyanobiphenyl-cyclohexane binary mixtures

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## ARTICLE DETAILS

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## ABSTRACT

The present paper is made on to discuss the effect of solvent, cyclohexane, on the transition temperature by doping with thermotropic liquid crystal such as octylcyanobiphenyl (8CB). Cyclohexane is known as a non-mesogenic, low molecular weighted solvent. The high resolution optical birefringence measurements have been employed to study the transition temperatures. The transition temperature is changed by doping. The variation of transition temperature is shown and discussed by producing several concentrations.

## 1. Introduction

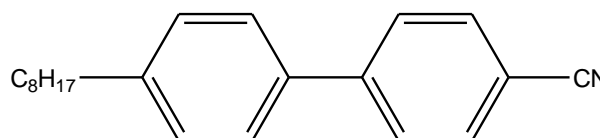
The liquid crystal is a distinct state of matter observed intermediate between the isotropic liquid and the crystalline solid. These compounds exhibit different types of phase transitions temperatures [1, 2]. In recent years, liquid crystalline mixtures integrating rodlike and other reduced symmetry molecules have gained considerable attention owing to their competence in bringing out the effect of the molecular conformation on the intermolecular interaction and thereby on the phase behavior of combined systems. Mixtures obtained by combining rod like and solvent have repeatedly been endowed with a number of remarkable properties. Nowadays, liquid crystal materials have broadly been developed in research area by better understanding for their various important physical properties [3] such as refractive index, birefringence, order parameter etc. Their prospective technological applications in electro-optical liquid crystal devices were extensively explored.

In the present work the phase diagram of a binary system of octylcyanobiphenyl (8CB) and solvent (cyclohexene) as obtained by using the high resolution optical transmission method is presented. The nature of the N-SmA phase transition dramatically changes with addition of cyclohexane on 8CB. The heat capacity peak associated with the N-SmA transition increases toward lower temperature region as concentration of solvent increases.

## 2. Materials

The pure compound 8CB were purchased from Merck, U.K. and was synthesized and purified by Professor Dabrowsky in the Institute of Chemistry, Military University of Technology, Warsaw, Poland. By chromatography, the purity was stated to be higher than 99.9% and no further purification was carried out. Liquid crystal homogeneous binary mixtures of 8CB+Cyclohexene were prepared at room temperature by weighing the pure in compounds in selected proportions and heated up to the isotropic phase. Cyclohexane is a cycloalkane with the molecular formula  $C_6H_{12}$ . It is a colourless, flammable liquid with a distinctive detergent-like odor and is used for the industrial production of adipic acid and caprolactam, which are precursors to nylon. The general structural formula and the

chemical name with transition temperature of the compound 8CB are given below:



Octyl-cyanobiphenyl (8CB): Cr 21.5°C SmA 33.5° N 40.2°C I

## 3. Experimental

A solid state green laser of wave length 532 nm was directed onto a homogeneously aligned (planar) liquid crystal cell of thickness 5.1 mm (purchased from AWAT Co. Ltd., Warsaw, Poland). The cell is placed between two crossed linear polarizer's. The temperature of the cell was regulated and measured with a temperature controller (Eurotherm PID 2404) with an accuracy of  $\pm 0.1$  °C by placing the cell in a custom built heater made of brass. The transmitted light intensity was measured by a photo diode at an interval of 3 seconds. When the heater temperature is varied at a rate of 0.5°C min<sup>-1</sup>, this translates into a temperature difference of 0.025°C between two readings [4-6].

## 4. Phase diagram

It has been observed that for polar smectogenic compounds, 8CB, the nematic – smectic A (N-SmA) transition is second order in [2] nature and for due to symmetry results the nematic – isotropic (N-I) transition temperature is first order. M.B Sied et al. [7] were capable to predict temperature 313.75 K and 306.43 K for the N-I and N-SmA transition respectively.

The experimental phase diagram of the binary system of 8CB+cyclohexene has been displayed in Figure1. by studying the birefringence data as obtained from optical scanning technique in the concentration range  $0.024 < X_{Chex} < 0.191$ , where  $X_{Chex}$  represents the mole fraction of cyclohexene. The N-I and N-SmA phase transition temperatures as a function of cyclohexane mole fraction are plotted during cooling scan. With increases of concentration of cyclohexene a nonlinearly

decreasing trend exhibits a fascinating feature, area of stability region, within certain concentration range of about 0.06 to 0.09. The nature of I-N and N-SmA phase transition temperature's curves is found to be same in the whole mesomorphic region.

The nature and the phase transition temperature as observed from our experiment have made nearly a similar agreement with those investigated from Sigdel et al. [8] for 8CB and hexane mixtures.

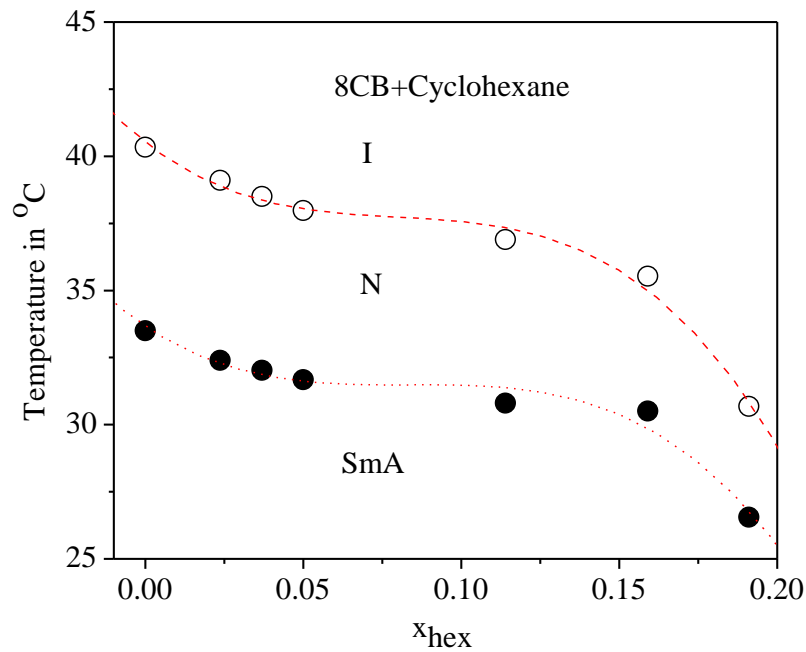


Figure 1. The phase transition temperatures of pure 8CB compounds and mixtures with cyclohexane have been explored as a function of concentration of cyclohexane in wt percentage. The  $\circ$  and  $\bullet$  represents the isotropic-nematic ( $T_{NI}$ ) and nematic-smectic A ( $T_{NA}$ ) transition temperatures respectively. The dashed and dotted lines represent the polynomial fit to the isotropic-nematic and nematic-smectic A transition temperature respectively.

increasing concentration of cyclohexene in weight percentage upto  $x_{Chex} = 0.191$  from pure 8CB. The nematic range decreases from 6.83 for pure 8CB to 4.12 for the binary mixture  $x_{Chex} = 0.191$  exhibiting a nearly stability region in certain concentration range of about 0.06 to 0.09 of mole fraction of cyclohexene. The possible reason of such type of behavior may be for the more suppression [50] of orientational order parameter in nematic phase than for smectic phase due to introducing the non mesogenic, low molecular weighted solvent.

It is also to be noted that we are able to determine the nematic range ( $N_R = T_{NI} - T_{NA}$ ) for all concentration under study on

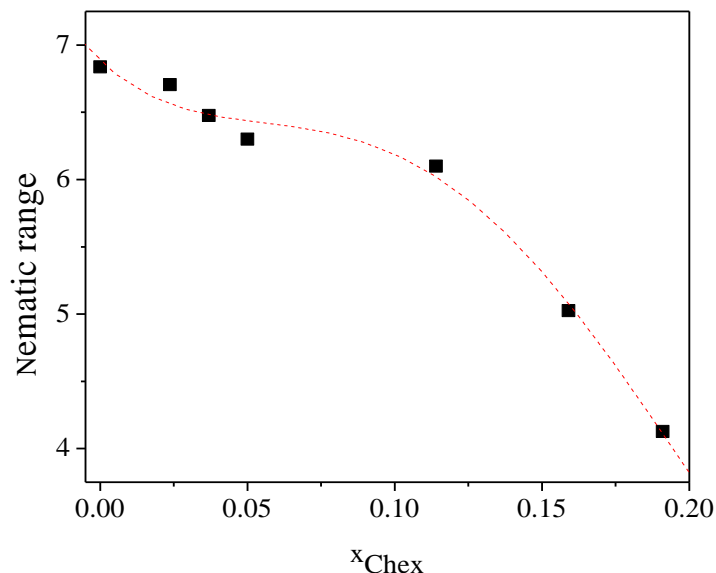


Figure 2. The nematic temperatures range ( $N_R = T_{NI} - T_{NA}$ ) of pure 8CB compounds and mixtures with cyclohexane

concentration. Where,  $T_{NI}$  = isotropic-nematic transition temperature and  $T_{NA}$  = nematic-smectic A transition

temperatures respectively. The dotted line represents the polynomial fit.

## 5. Summary and conclusions

In this paper we have undertaken detailed studies on the phase transition temperatures. A continuous second order nematic-smectic A phase transition of 8CB doped with nonmesogenic, low-molecular weight solvent, cyclohexene, is observed. A dramatic change in pretransitional effect at the nematic-smectic A (N-SmA) phase transition is detected. In addition it is found that the nematic range decreases from 6.83

for pure 8CB to 4.12 for the binary mixture  $x_{\text{Chex}} = 0.191$  exhibiting a nearly stability region in certain concentration range of about 0.06 to 0.09 of mole fraction of cyclohexene.

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