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Determination of phase transition from nematic to isotropic state in carbon nano-balls' doped nematic liquid crystals by electrical conductivity-dielectric measurements

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Abstract

The phase transition in carbon nano-balls' doped nematic liquid crystals has been investigated by electrical conductivity-dielectric measurements. The results of electrical conductivity and dielectric constant as a function temperature and frequency indicate that a phase transition, which is of the first order, takes place from nematic state and isotropic state. The phase transition for E7 and E7/C60 samples takes place at 326 and 321 K temperatures, respectively.

Keywords: Liquid crystal; Conductivity; Dielectric; Phase transition

1. Introduction

Composites based on liquid crystals (LCs) have been extensively investigated because of their unique electro and magneto-optic properties and novel display applications. Typical examples of the systems are polymer dispersed liquid crystals [1,2]. Fullerene doped LC systems were extensively studied due to their positive effects in possible technological applications [3,4]. Photorefractive like reorientation is a famous molecular mechanism in which photo excited dopants bring about the formation of space-charge complexes and their induced fields force the molecules to reorient by enhancing the photoconductivity. Effect of fullerene on reorientation process is explained by this approach indeed [3–5]. Molecular orientation of LC molecules determine the electro-optical behavior of the system and because laser molecule interaction causes molecules to reorient in these systems, our aim was to examine electro-optical measurements so that we could demonstrate the molecular reorientation

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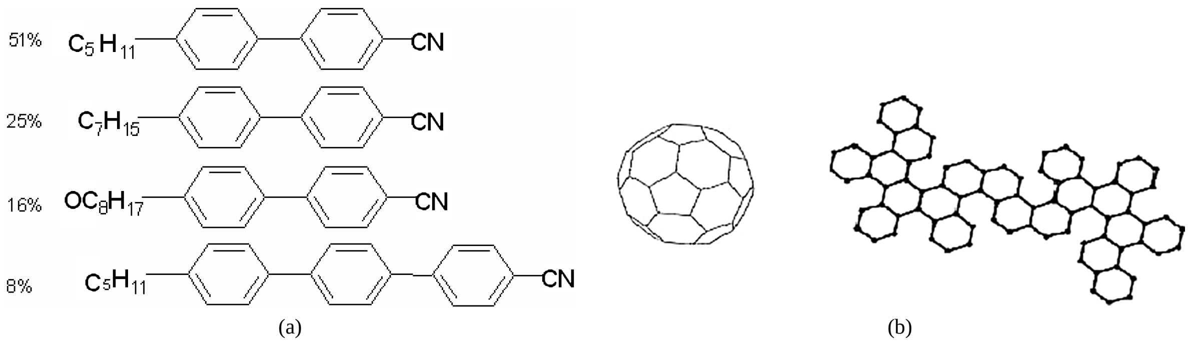

Fig. 1. Chemical formulas of: (a) nematic host, E7; (b) fullerene, C60.

based changes in capacitance, impedance and dielectric coefficients and refractive index dispersion. Such works have been performed on dye doped and polymer doped LC previously [6–8].

Liquid crystals (LCs) are highly nonlinear optical materials due to their susceptible property activating under even relatively low optical fields and are a class of materials exhibiting thermodynamically stable but only partially ordered phases. Each mesophase is described by its own order parameter, such as a second rank tensor for orientational order (nematic) phase or a two-component tensor vector for one-dimensional translational order (smectic phase) [9]. The dielectric and electrical conductivity measurements provide about phase transition in the investigated temperature.

The aim of our study is to investigate the determination of the phase transition by dielectric–electrical measurements.

2. Experimental

2.1. The preparation of the nematic liquid crystal cell

High purity fullerene (C60) was purchased from Dr. Andrei Ponomarev (St. Petersburg, Russia). Measurement cells were made up of two glass slides separated by Mylar sheets having ~ 8.5 µm thickness. Before the construction of the cells, indium tin oxide (ITO) coated glass substrates were spin coated with polyvinyl alcohol (PVA) at 2000 rpm and they were cured at 50 °C for ~ 2 hours. The thickness of the coating is ~ 100 nm and these coating layers were exposed to surface treatment of unidirectional rubbing with velvet in order to obtain preliminary molecular orientation. The ultimate form of the constructed cell is planar with 2 degree rubbing tilt. The volume fraction of C60 in the E7 sample studied was taken as 1% wt/wt. Fullerene (C60) was dissolved within toluene and toluene fraction was evaporated to eliminate fullerene powders, which later mixed to LC under the reinforcement of ultrasonic effect. Once the sample cell was filled with homogenous LC/C60 content, which was prepared in the ultrasonic mixing machine, it is almost impossible to face with any colloids in such a thin medium. Even if such fullerene groups were suspected to be formed in the sample, it was going to be easily understood by color spots on the cell. Color of sample cell is still homogenous and there is no any different color spot on it after more than 1 years. Chemical formulas of fullerene and nematic host are depicted in Fig. 1.

2.2. Measurements

Electrical conductivity and dielectric constant measurements were performed by impedance analyzer. HP 16089B Kelvin clip leads were used with the Hawlett–Packard (4194A) impedance/gain-phase analyzer at various spot frequencies 10^2, 10^3, 10^4 and 10^5 Hz as a function of temperature range (285–345 K). A closed-cycle helium cryostat system and Lakeshore 340 model temperature controller were employed in the system, whereby it allowed to scan the temperature with a rate of about 2 K/min. Data were recorded in a PC under isothermal conditions and temperature was stabilized with an accuracy better than 0.05 K. GaAlAs diode sensor having an accuracy of 0.01 K was utilized in the determination of temperature values.