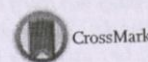
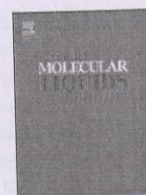




Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq

Probing the effect of temperature and electric field on the low frequency dielectric relaxation in a ferroelectric liquid crystal mesogen

Achu Chandran^a, Jai Prakash^b, Tilak Joshi^a, Ashok M. Biradar^{a,*}

^a Polymeric and Soft Materials Section, CSIR – National Physical Laboratory, Dr. K. S. Krishnan Road, New Delhi 110012, India

^b Centre for Physical and Mathematical Sciences, School of Basic and Applied Sciences, Central University of Punjab, City Campus, Mansa Road, Bathinda 151 001, India

ARTICLE INFO

Article history:

Received 19 May 2014

Received in revised form 11 July 2014

Accepted 17 July 2014

Available online 30 July 2014

Keywords:

Ferroelectric liquid crystals

Dielectric relaxation

Dielectric spectroscopy

ABSTRACT

We present the characterization and dielectric spectroscopic investigations of a ferroelectric liquid crystal (FLC) material, namely KCFLC 10S. We experimentally demonstrate the observation of a low frequency dielectric relaxation mode along with Goldstone mode in the smectic C* phase of the FLC material under investigation. The behavior of low frequency dielectric relaxation mode has been systematically studied with temperature and applied bias field. The relaxation frequency of the low frequency dielectric relaxation has been found to be shifted toward the higher frequency side with an increase in temperature and field strength. This shift has been attributed to the single particle diffusion of fast ions. Further investigations on electrical conductivity (σ) with frequency at different electric field strengths revealed a Schottky-type of charge injection at electrode even under a small DC bias. The studies carried out in the present paper would be helpful to provide ideas for designing and developing advanced liquid crystal materials.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Liquid crystals (LCs), remarkable materials having a high degree of shape, dielectric, and optical anisotropy, attracted the interest of researchers and are used in numerous applications such as flat panel displays, spatial light modulators and optical antennas [1–3]. The combination of order and mobility of LCs enables them to respond to external stimuli, such as electric, magnetic, and optical fields and changes their organization. Chiral smectic liquid crystals (which show ferroelectricity and are also known as ferroelectric LCs) possess a spontaneous polarization P_s , which is perpendicular to the molecular tilt plane, for symmetry reasons [1]. The potential applications of FLCs in fast electro-optical devices and displays have attracted great interest over the last decades [2,4–7]. Physical properties of FLCs such as molecular reorientation during electro-optical switching [8] and dielectric properties [9,10] have widely been studied.

Dielectric spectroscopy is a promising tool to investigate the dipolar response of FLCs to an external electric field. The dielectric relaxation processes in the chiral smectic C (SmC*) phase occur owing to either collective dielectric processes or the molecular reorientation processes connected with the polarization of the molecules. The main collective processes involve the Goldstone mode (GM) and soft mode, connected with the phase fluctuations in the azimuthal orientation of the director and the fluctuations in the amplitude of the tilt angle respectively

[11–14]. In addition to them, the FLCs having higher values of spontaneous polarization show domain modes as well, which have been attributed to the formation of surface and bulk ferroelectric domains [15]. Due to the accumulation of space charges on the interface of LC and polyimide layer, Uehara et al. [16] observed a very low frequency mode. Biradar et al. [17] observed a Debye-like relaxation at very low frequency in non-chiral LCs, which is attributed to space charge accumulation in the surface alignment layer. In the SmC* phase of the FLC material H6/9, a thickness dependent low frequency mode has been detected [18], due to the fluctuations of the director field modified by a non-homogeneous ionic charge distributed across the sample.

Contributions are also made from ionic impurities in LCs to the dielectric relaxation process, in which impurity ions encounter an ionization–recombination process in addition to translational diffusion. Havriliak et al. [19] observed two separate peaks in loss polarizability in the low frequency region of the SmC* phase of a FLC mixture Felix 18/100. Upon further examination of these relaxation modes, they found that the relaxation frequency has shifted toward the low frequency side and high frequency side upon increasing the bias field and temperature. From numerical simulations and experimental results, Jin and Kim confirmed that the dielectric relaxation in the low frequency regime of a non-chiral LC, 8CB, is from two types of ions – fast ions in the single particle diffusion and slow ions in the ionization–recombination-assisted diffusion in the system [20]. Recently, a low frequency dielectric relaxation mode along with the Goldstone mode has been observed in the SmC* phase of the FLC material (KCFLC 7S), which became more dominant by doping gold nanoparticles [21]. The authors

* Corresponding author. Tel.: +91 11 4560 8262.

E-mail address: abiradar@mail.nplindia.org (A.M. Biradar).