

Flexo-electric behavior of bimesogenic liquid crystals in the nematic phase - observation of a new self-assembly pattern at their twist-bend nematic and nematic interface.

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Flexoelectric properties - the effective flexoelectric coefficient and flexoelectric polarisation are investigated for a bimesogenic liquid crystal CBC11CB with a twist bend nematic phase (N_{tb}). Results show that the effective flexoelectric coefficient is at least two times higher than for bimesogens that do not exhibit the N_{tb} phase. The flexoelectric polarization for the N_{tb} phase is also two times greater than in its nematic phase. In a temperature gradient cell, we observe surprisingly a new phenomenon, in the bimesogens CBC7CB and CBC9CB and their mixtures with 5CB, of periodic self-assembly in the N phase close to the N - N_{tb} phase transition temperature. This phenomenon is reminiscent of the self-deformation and spontaneous chirality that appears in the system.

I. INTRODUCTION

Two mesogens, connected by an odd number of methylene units are shown to exhibit a second nematic phase (N_x)¹⁻⁶ at temperatures below those observed for the characteristic uniaxial nematic (N) phase. This low temperature phase is now characterized as a twist bend nematic phase (N_{tb}) with ~ 8 nm helical pitch, determined independently by two groups using freeze-fracture transmission electron microscopy^{7,8}. This is in amazing coincidence with the pitch found from the measurements of the electro-clinic coefficient^{9,10}, on assuming the effective flexoelectric coefficient, e , to be 5 pC/m^{9,10}. The complicated internal structure of the phase results in a number of fascinating macroscopic self-assembly properties¹¹. When the LC in the N_{tb} phase is confined to a planar homogeneously rubbed cell of thicknesses ranging from 2 to 10 μm , the cell shows spontaneously formed self-assembled periodic patterns appearing under a polarising optical microscope as uniform stripes parallel to the rubbing direction with a periodicity two times the sample thickness⁵. The phase also exhibits a linear optical response¹² similar to the electroclinic effect with the switching time of the order of a few microseconds. In the achiral materials this is possible due to the formation of macroscopic chiral domains of opposite handedness separated by the domain walls¹². When a large electric field of a certain frequency range is applied, these domains turn into another type of periodic striped texture, with handedness of the neighboring domains¹³ alternating from one to the other. The walls of these domains are normal to the rubbing direction. A range of interesting properties exhibited, so far, by bimesogens in N_{tb} motivates us to investigate additional macroscopic properties

with the final objective as to how the macroscopic structure evolves from the nanoscale one. In this paper, we investigate the bulk flexoelectric coefficient $e = |e_1 - e_3|$ in the conventional nematic phase, and the flexoelectric polarization, P_f in both N and N_{tb} phases of the bimesogen CBC11CB in order to gain better understanding of the material properties of such systems. In addition, we also report an unusual pre-transitional phenomenon observed in the bimesogens CBC7CB and CBC9CB, and their mixtures with 5CB. The chemical formulae of the liquid crystalline materials studied are given in Fig 1. To the best of our knowledge, such results for this class of materials have not been reported in the literature before. The ultimate question as to what drives this nanoscale helical pitch to the formation of beautiful stripes under cell confinement of thickness of a few μm needs to be explored. Some of the other intriguing issues that remain to be addressed are (i) how do the competing elastic forces of splay, bend and twist play a role in LC cells under dimensions of a few μm confinement? (ii) do the bimesogens display large flexoelectric coefficient that drives the electroclinic coefficient? (iii) what happens at the phase transition from a conventional nematic to the N_{tb} phase?

II. RESULTS AND DISCUSSION

The flexoelectric polarization arising from a coupling between the elastic deformations and the electric polarization is expressed in terms of the splay and bend flexoelectric coefficients by Meyer¹⁴ as follows:

$$P_f = e_1 \mathbf{n}(\nabla \cdot \mathbf{n}) - e_3 [\mathbf{n} \times (\nabla \times \mathbf{n})] \quad (1)$$

In equation (1), e_1 and e_3 are the flexoelectric coefficients that correspond to the splay and bend deformations, respectively. Flexoelectric coefficients in bimesogens, measured using indirect methods, are found to

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