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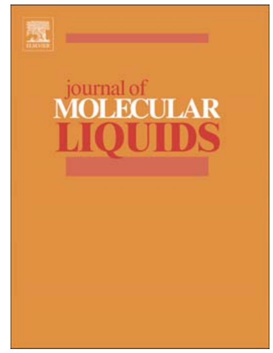

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Bent core nematics as optical gratings

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Abstract

The possibilities to induce regular, stationary stripe patterns with easily controllable wavenumber have been investigated with the aim to apply them in optical devices as gratings. Several, electric field induced phenomena have been studied on three members of a homologous series of a bent core nematic. Pattern morphologies, threshold voltages and wave numbers have been determined. Temporal evolution and switching dynamics have been analysed.

Keywords: liquid crystals, pattern formation, optical grating, flexoelectricity
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1. Introduction

Diffraction gratings are devices to separate light of different wavelengths with high resolution. The monochromatic light beam diffracts in multiple orders when striking the grating. Gratings are very widely used optical components; they are usually made of solids with an array of closely spaced parallel, equidistant ridges or rulings on their surface. As a consequence, the grating spacing is a fixed parameter of the device.

It is well known that liquid crystal (LC) cells can also create gratings. The set of equidistant parallel lines may be induced by different applied fields (such as shear, electric field, etc) [1] and as a consequence, the grating parameters are tunable by the control parameters. The most convenient way of inducing a regular set of parallel lines is to apply electric field to the liquid crystal. There is a great variety of pattern morphologies induced by a voltage depending on the frequency, field strength, temperature, surface alignment, etc. [2]. Even the basic phenomena induced by the field can be classified into several groups: (a) the transient patterns at the Freedericksz transition [3, 4], (b) the dissipative phenomenon of electroconvection (EC) [5–10], associated with electric current and fluid flow, and (c) the periodically deformed equilibrium state called flexodomains (FDs) [9–13]. In this article we will address groups (b) and (c).

Pattern formation in calamitic nematics has intensely been studied in recent decades, both experimentally and theoretically [2, 5–8]. The basic phenomenon – standard electroconvection – has been fairly well explored and understood on the basis of the Standard Model of electroconvection [14] for certain classes of nematics, the (- +) and (+ -) materials. Here the first sign stands for the dielectric anisotropy, while the second one is for the conductivity anisotropy of the material.

Nematics not belonging to the above classes may also exhibit patterns – nonstandard electroconvection [8]; however, their formation mechanisms are only partially understood [15] and many details are still waiting for clarification. Bent-core nematics [16], a recently invented group of liquid crystals with unconventional, bent molecular structure belong to the latter category. They have been reported exhibiting unusual physical properties (e.g., high viscosities, small bend elastic constants, giant flexoelectricity [17], etc.) as well as novel electroconvection scenarios [18, 19], unprecedented among calamitic nematics; that makes bent-core nematics materials with wide perspectives for research as well as for applications. In view of these arguments, the investigations reported in the present paper have been carried out using bent-core nematic compounds.

2. Experimental

A newly synthesised homologous series of an ether-bridged bent core nematic 2,5-di4-[(4-alkylphenyl)-difluoromethoxy]-phenyl-1,3,4-oxadiazole (nP-CF2OODBP) has been used for studying the conditions for the formation of the patterns. The chemical structure of the molecule is shown in Fig. 1. Three members ($n = 7, 8, 9$) of the series have been investigated. Their phase sequence and phase transition temperatures are listed in Table 1. The materials have a conveniently broad nematic temperature range; the type of the smectic phase has not been identified yet.

Though full characterization of all three compounds could not be performed, some important material param-

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