ESRF	**Experiment title:** Electric Field Induced Phase in Bent-Core Liquid Crystals	**Experiment number**: sc2525
Beamline: ID02	**Date of experiment**: from: 5-Sep-2008 to: 8-Sep-2008	**Date of report**: 7-Jul-2009
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Report:

Objectives

The aim of the experiment is to investigate a possible electric field induced phase transition in the nematic phase of bent core compounds. The nematic phases of these compounds show an unusual electro-optical response. If a d.c. or a low-frequency a.c. field is applied to a planar oriented nematic phase initially a domain pattern with equidistant stripes parallel to the original director direction arises. With increasing voltage a fan-like texture has been observed. The purpose of this experiment was to induce these optical textures and determine the local structure using X-ray diffraction in order to understand this phenomenon.

Experimental

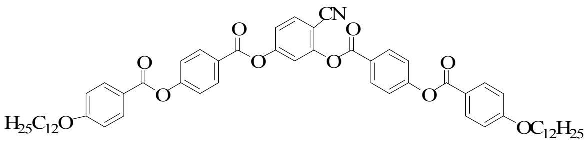
The experiment was done using ID02 with incident energy of 16.5keV and a detector distance of 0.87m. The samples were 6μm thick films of liquid crystal sandwiched between two 1mm thick glass plates which had indium tin oxide electrodes and a polymer alignment agent on their surfaces. The alignment layer was designed to give planar alignment with the nematic director in a horizontal direction. The thick glass was necessary to avoid flexing and flow alignment of the liquid crystal, especially when a field is applied, but their combined transmission was only 0.3% even at the relatively high energy used. Given that the scattering from nematics is diffuse rather than Bragg, the high intensity and low background of ID02 were essential for this experiment.

The samples were contained in an electrically heated environmental box with small gaps to allow the passage of the X-ray beam and to allow the optical texture to be recorded with a zoom microscope and crossed polarizers. An electric field could be applied across the 6μm film using a signal generator and a high voltage amplifier. The environmental box was mounted on a rotation stage so that the samples could be rotated to be perpendicular to the line of sight of the microscope for optimum depth of field. A monochrome optical image was recorded with each X-ray image. These were later processed by histogram equalisation using IDL, to enhance the visibility of the texture. The X-ray scattering patterns were generally recorded as series of ten exposures of one second duration which were summed and displayed as images using IDL. The position, intensity and width of the scattering peaks were determined from the azimuthally regrouped data.

Results

Six candidate samples were examined briefly. Two were chosen for detailed study because they showed nematic phases (at temperatures above the smectic phases) with observable scattering from the smectic-like short range order in the nematic phase (loosely called cybotactic group scattering). It was also important that the nematic phase did not tend to recrystalise. In this report we describe results on LC225.

LC225 [Ref [i]]



In its nematic phase, this material showed observable scattering which transformed into the strong Bragg scattering from the smectic layers on cooling. It was found that the SmC-N transition temperature increased by about 2°C with the application of a 300V ac field. Figure 1 shows the diffraction and optical texture from LC225 at a temperature just above the normal transition temperature with and without an applied field. It can be seen that the field induces a different texture and a strong reflection from the smectic layers.

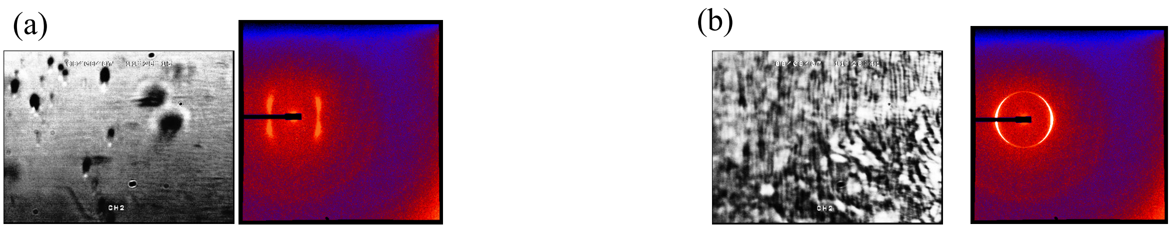


Figure 1 Optical and scattering textures from LC225 at 105°C, (a) without and (b) with 300V applied

The effect of the field on the orientation of the nematic scattering peaks is also significant. When no field is applied, the optical texture is typical for a planar aligned nematic cell as shown in figure 1a and the diffraction pattern has four diffuse spots which is consistent with a well aligned horizontal director and SmC-like short range order (cybotactic groups). The local "layer normal" is tilted away by about 25°. A low frequency ac voltage (40 to 350Vpp at 0.05Hz were used) changes the optical image changes to a grainy texture as shown in figure 2. The X-ray scattering, loses the four-spot appearance and tends towards a diffuse ring, although some preference for the alignment direction is maintained as shown in figure 2. This strongly suggests that the field induced textures that had been observed previously are the result field-driven turbulent flow cells (electro-hydrodynamic convection) forming in the nematic with the director becoming much more randomly oriented.

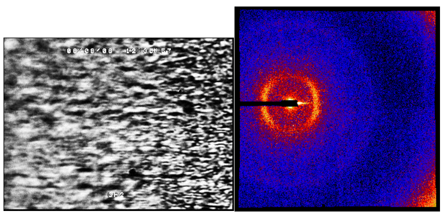


Figure 2. Optical and X-ray images from 225 at 112°C with 350V applied.

Conclusion

The experiment has established two useful conclusions. The cause of the field induced textures in the nematic is director reorientation rather than a change of phase. A small field induced increase in the SmC-N transition temperature has also been observed and this could account for the appearance of fan-like textures with high fields at temperatures just above the transition.

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[i] L. Kovalenko, M. W. Schroeder, R. Amaranatha Reddy, S. Diele, G. Pelzl and W. Weissflog, *Liq. Cryst.*, **2005**, 32, 857.