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The Magnetic Field-Sweeping Rate Dependence of Molecular Orientation in the Cholesteric-Nematic Transition

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THE MAGNETIC FIELD-SWEEPING RATE DEPENDENCE OF MOLECULAR ORIENTATION IN THE CHOLESTERIC-NEMATIC TRANSITION

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The dynamics of cholesteric↔nematic transition was studied on a drop of cholesteric-nematic mixture. It is found that the orientation of the director depends on the sweeping→rates of the magnetic field during the nematic-cholesteric transition.

The kinetic description of cholesteric-nematic transition in the Grandjean planar droplet has been shown by Prost.[1] In this letter, dependences of molecular orientation on the sweeping rates of a magnetic field will be discussed. A mixture of MBBA with cholesteryl chloride is used. The pitch is measured by means of the Cano-wedge method and it was found to be 25 μm. The critical magnetic field in the cholesteric-nematic transition is about 7kG. The drop is placed on a rubbed glass surface. The direction of rubbing is parallel to the magnetic field. The experimental configuration is similar to that of Prost except for some details (Fig. 1). The magnetic field can linearly vary from 0 to 10 kG (reciprocally 10 to 0 kG)

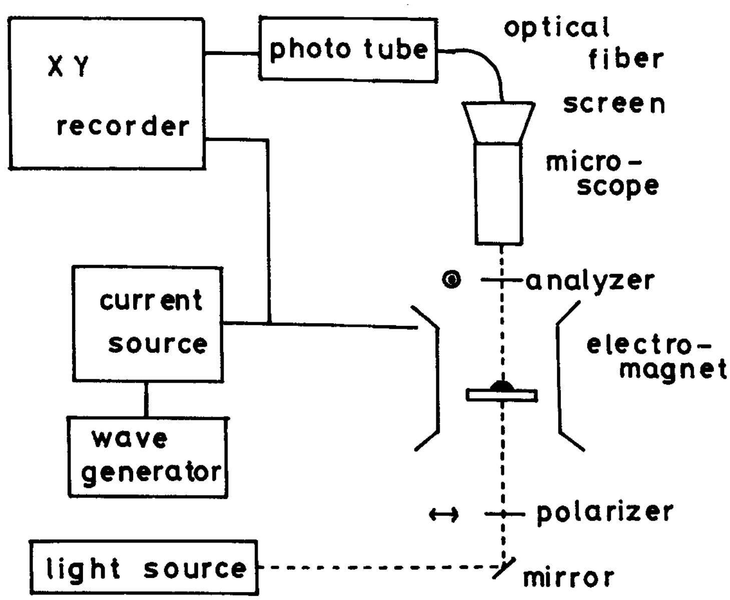

FIGURE 1. Experimental configuration.

by means of a sweeping current source. The light source is a 30 W tungsten lamp. The image of the drop is magnified by a microscope (x80) on the screen. An optical fiber (1mm ϕ) is set on the screen to catch the light passed through the top of the drop.

In the nematic→cholesteric transition, the molecular orientation process is found to be dependent on the sweeping rates of the magnetic field as described below. A circular thread appears and migrates toward the edge of the drop at the field-decreasing rate about 5 G/s. At the decreasing rates from 25 to 600 G/s, characteristic curves are recorded (Fig. 2). The director of a surface rotates

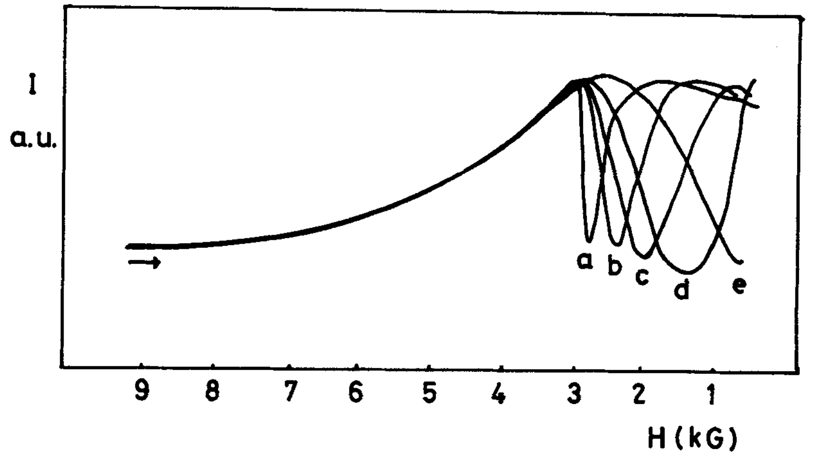

Figure 2: The intensity of the transmitted light at various field-decreasing rates vs. magnetic field: a: 25 G/s, b: 75 G/s, c: 150 G/s, d: 300 G/s, e: 600 G/s.

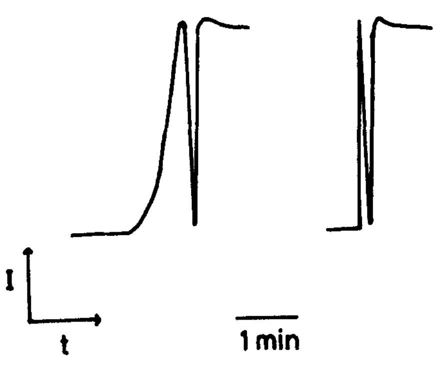

Figure 3: The intensity of the transmitted light vs. time: a: magnetic field off, b: 50 G/s.

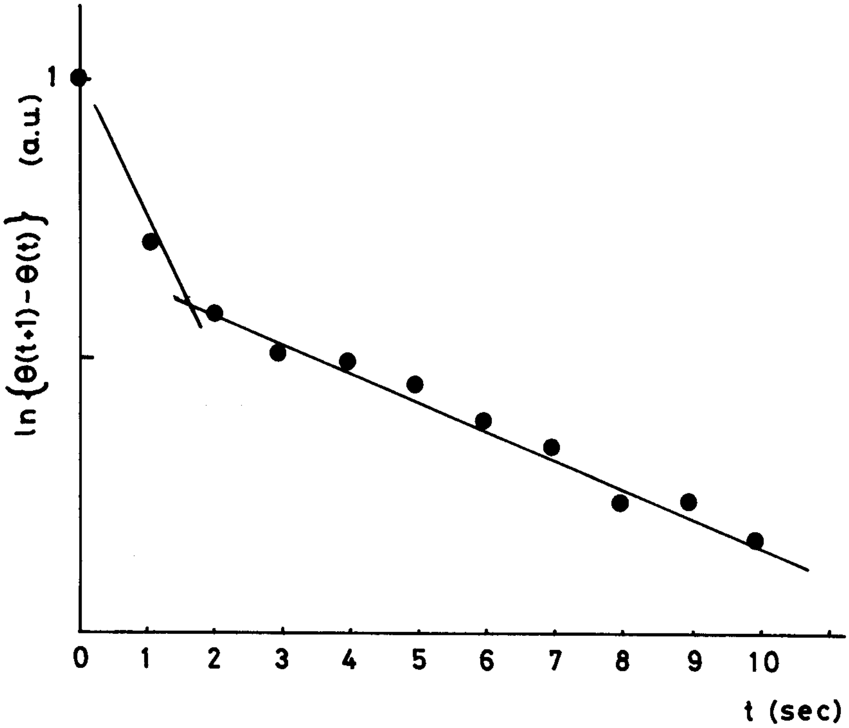

FIGURE 4. The rotational angle vs. time on the semilogarithmic plot.

with the magnetic field until a 90° rotation from the initial angle (nematic state). The intensity of the transmitted light has the maximum value at the 90° rotation-angle. After that, the director rotates independently of the field on the cholesteric states. When the field is switched off (decay time ca. 140 ms) the director rotates freely in the cholesteric state in the same manner as described by Prost.

In the cholesteric→nematic transition, the circular thread appears and migrates toward the top of the drop at any field-increasing rate. Figure 3 shows the time dependence of the light signals for the two rates of field change in the nematic→cholesteric transition. Each curve changes in the same manner after the 90^{o} rotation-point. The charge of the rotational angle in the case of the magnetic field off is plotted as a function of time on semilogarithmic graph (Fig. 4). It is found that the graph can be approximated by two straight lines: The nematic→cholesteric transition consists of two processes.

It is concluded that the relaxation process in nematic→cholesteric transition has two mechanisms; one dominates the process from the nematic state to the director's 90^{o}-rotated point and the other dominates it from that to the cholesteric state. The latter mechanism is due to K_{22}/γ_1 (K_{22}: twist elastic constant, γ_1: twist viscosity constant) and the former mechanism is due to surface tension.

Reference

1. J. Prost and H. Gasparoux, Mol. Cryst. Liq. Cryst. 22, 25 (1973).