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RELAXATION PHENOMENA IN NEMATIC- POLYMER MIXTURES

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Typical Liquid Crystal Cells containing mixtures of nematic (MBBA or 6601 Merck) with small additives of azo-polymers were subjected to different DC magnetic fields. The optical transmission of a laser beam through these cells was recorded when the magnetic field was switched off. The critical field for magnetic Freedericksz transition B_c *and the relaxation time corresponding to switching off the magnetic field were determined.*

1. Introduction

The researches concerning phenomena related to mechanical stability of liquid crystals are connected to elastic and viscous properties. When a liquid crystal cell is subjected to an electric or magnetic field, viscous torques are acting on the nematic director when its orientation is changed by these fields. Several investigations were performed on pure nematic liquid crystals (NLC) [1], [2] or in mixture of liquid crystals with non-mesogenic additives, such as azodyes or ferroparticles [3, 4, 5] subjected either to electric or magnetic fields. It was shown that in pure nematics or in mixtures of nematics with nonmesogenic additives [6, 7, 8, 9, 10] a complete reorientation of the molecular director appears after a short period of time (relaxation time).

Is the aim of this paper to investigate relaxation phenomena in nematic mixtures with azopolymers when subjecting them to magnetic fields..

2. Theoretical considerations

The relaxation phenomena were first investigated by Pieranski et al. [6]. When a magnetic field B, higher than the critical one, for magnetic Freedericksz transition B_c is switched on/off fluctuations in the light transmission are noticed.

As it has been shown in [1, 9] the transmitted light intensity through the nematic sample is given by

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$$I = I_0 \sin^2[2\Phi(B)]\sin^2 \frac{\delta(B)}{2}, \tag{1}$$

where $\Phi(B)$ is the angle between the molecular director and the direction of incident light polarization. As it can be seen, the light intensity will pass through a sequence of minima and maxima when increasing the magnetic field above the critical field for Freedericksz transition. The maxima are obtained when the path difference is

$$\delta(B) = 2\pi N \tag{2}$$

where N is the the extinction order for high deviations [7]:

$$N = \frac{d\Delta n}{2\lambda}(\theta_m^2 - \frac{1}{4}\theta_m^4) \tag{3}$$

where d is the cell thickness, Δn the birefringence, λ the wavelength of incident light and θ_m is the maximum distortion angle of nematic director.

In order to obtain the maximum deviation angle we have to minimize the free energy of the system by solving the Euler-Lagrange equations for the free energy. Using a procedure similar to those used in [1, 10 and] one obtains for the maximum deviation angle when the magnetic is switched off :

$$\theta_m^2(t) = \frac{\theta_m^2(0)}{\alpha\theta_m^2(0) + (1 - \alpha\theta_m^2(0)\exp(t/\tau_B)} \tag{4}$$

where $\theta_m^2(0)$ is the initial maximum distortion angle, α is a constant and τ_B is the relaxation time. It can also be written as a function of the elastic constants of the liquid crystal:

$$\tau_B = \frac{\gamma\mu_0}{2\chi_a B_c^2} \tag{5}$$

In (4) γ is the rotational viscosity, and K_1, K_2, K_3 are the twist, splay and bend deformation elastic constants.

3. Experimental set up

Liquid crystal cells with Mylar spacers of 180 μm thicknesses were filled by capillarity with planar aligned nematic liquid crystal MLC 6601 (Merck) and with a mixture MCL 6601-3Ba polymer (1% by weight). Previously both cell electrodes were chemically processed for a planar alignment with PVA solution.

The experimental set-up is shown in Fig.1. The LC cell was positioned in the middle of the electromagnet (E) provided with hollow poles. The He-Ne laser beam (632.8 nm, 1 mW) falls at normal incidence on the cell's glass plates. Therefore, in this configuration, the magnetic field is parallel to the incident light. At the exit point, the polarization plane was determined by rotating a Glan-

Thomson polarizer (P) to obtain the extinction of the transmitted light. Its intensity was recorded by means of a photomultiplier (Ph) connected to a computer for registering the light intensity as function of time ($I = I(t)$). The magnetic field strengths were controlled by a DC power supply which allowed both current adjustment and change of polarity.

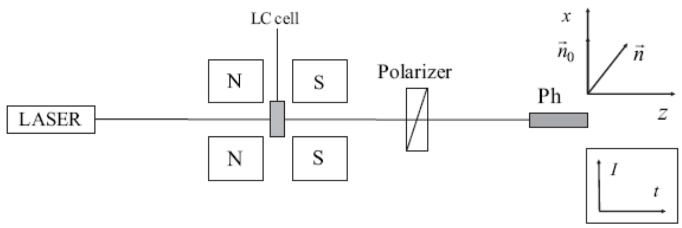


Fig. 1 Experimental setup for planar aligned LC cell

4. Experimental results and discussion

First, the critical fields for magnetic Freedericksz transition were determined by measuring the changes in light intensity when the external magnetic field is increased. The results are shown in Fig.2 and Fig.3. These critical fields correspond to the first minima of the $I = I(B)$ plots (B_c = 420 Gauss for the nematic LC sample and B_c = 560 Gauss for the nematic+3Ba sample).

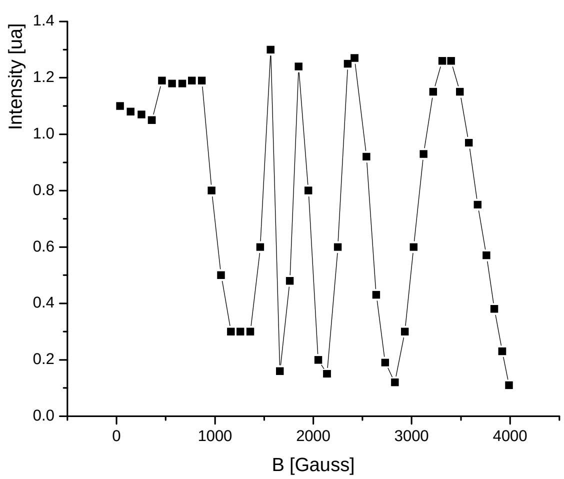


Fig. 2 Changes in the incident light intensity versus magnetic field strength for the planar alligned MLC 6601 cell

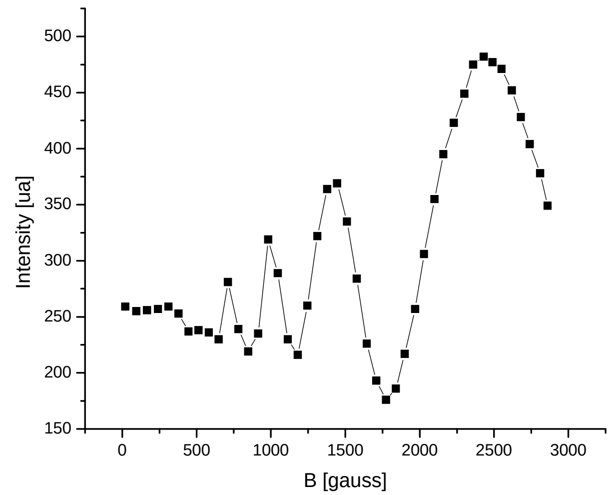
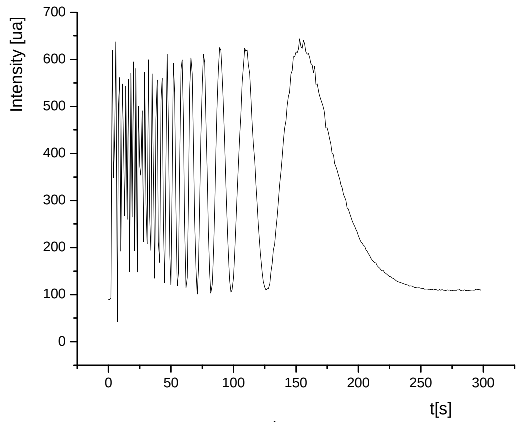


Fig . 3 Changes in the incident light intensity versus magnetic field strength for the planar aligned mixture MLC 6691-3Ba (polymer) cell.

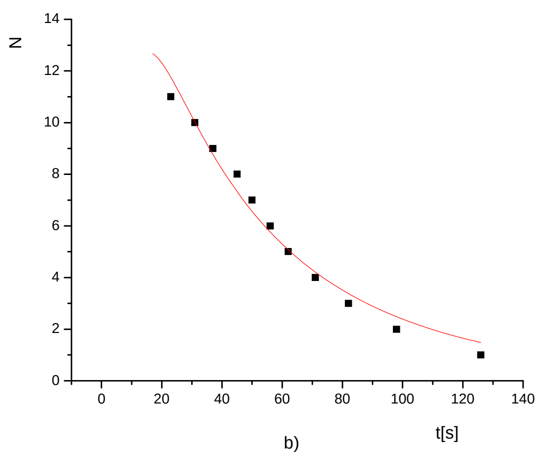
The dynamic behaviour of both cells was studied when the magnetic field was switched off. Fluctuations in the light transmission were followed in time for both samples. Using a procedure described in [2,3] the extinction number was determined as function of time:

$$N = \frac{\Delta n}{2\lambda}\left[\frac{\theta_m^2(0)}{\alpha\theta_m^2(0)+\left[1-\alpha\theta_m^2(0)\right]\exp(t/\tau_B)} - \frac{1}{4}\left(\frac{\theta_m^2(0)}{\alpha\theta_m^2(0)+\left[1-\alpha\theta_m^2(0)\right]\exp(t/\tau_B)}\right)^2\right] \tag{5}$$

The results are shown in Fig. 4 (nematic 6601) and Fig. 5 (nematic 6601-polymer 3Ba).



a)



b)

Fig. 4 (a) Light transmission versus time changes after subjecting the sample nematic- 6601 to B = 2990 Gauss, (b) The extinction number versus time in the same sample

For the nematic cell we obtained a relaxation time $\tau_B = 50\,s$ while when the 3Ba additive was mixed into the LC cell the relaxation time decreases strongly down to $\tau_B = 9\,s$.

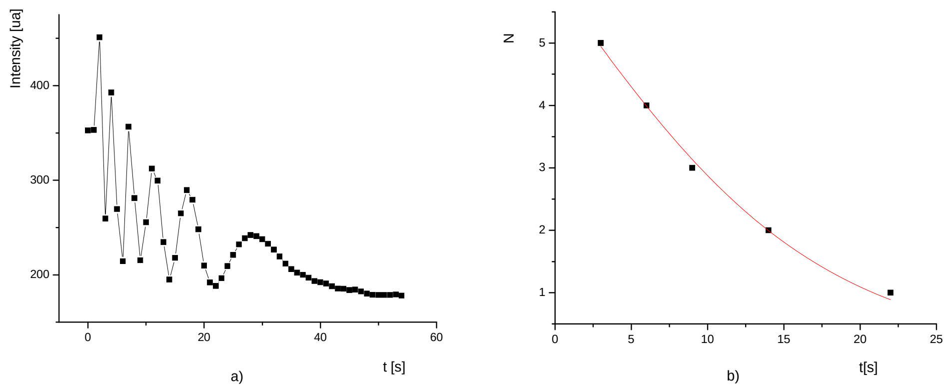


Fig.5 (a) Light transmission versus time changes after subjecting the sample nematic- 6601-polymer 3Ba for a magnetic field B = 2990 Gauss (b) The extinction number versus time in the same sample

5. Conclusions

In this paper a relaxation method has been used in order to determine the relaxation time constants when the magnetic field has been switched off. We found that the relaxation time constant is decreased when the nematic was doped with a small fraction of azopolymer (3Ba). It may be suggested that changes in the viscosity of nematic-polymer mixture are responsible for this decrease and may be also considered responsible for changing the switching time of new liquid crystal displays.

R E F R E R E N C E S

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