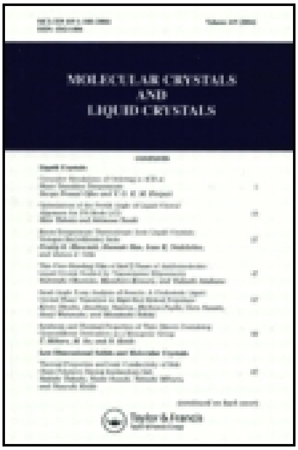

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Chiral Additive Effects on Electrooptical Response and Droplet Structure in Uniaxially Oriented Films of Polymer Dispersed Nematic

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Light transmission and director configurations of the uniaxially oriented ensemble of ellipsoidal chiral nematic droplets dispersed in polymer film have been investigated under applied voltage. Depending on a concentration of the chiral additive three different types of the behaviour of such droplets in an electric field are revealed.

Keywords: polymer dispersed liquid crystals; electrooptics

INTRODUCTION

Recently, the special interest is focused on the uniaxially oriented films of polymer dispersed liquid crystal (PDLC)[1]. These films based on the nematic liquid crystals are effective polarizers of light[2], and they reveal a record response time at use of the ferroelectric liquid crystals[3, 4]. In the case of chiral nematics such PDLC films can be used as linear light modulators utilized the field-induced deviation of the optical axis in the LC droplets without helix unwinding[5]. For the field induced the helix unwinding uniaxially oriented PDLC films based on chiral nematic can be switched from the scattering state to the transparent one via intermediate optical state, which is due to a specific change of director configuration inside the LC droplets[6, 7]. This phenomenon depends strongly on the shape of the droplets and LC composition. In this paper, we study the dependencies of the polarized components of the light transmission and structural transformations inside the droplets upon applied voltage for the uniaxially oriented composite films with various concentration of the cholesteric additive.

EXPERIMENTAL

We used nematic LC-mixture of cyanobyphenyls derivatives (0.7 5CB + 0.2 7OCB + 0.1 8OCB) with $\Delta\varepsilon > 0$, having clearing temperature T_c near 47^0C and cholesteric Ch3 as a chiral additive. The weight concentration of cholesteric ranged from 0 to 30%. Liquid crystal was dispersed in polyvinylbutyral at ratio 1:1 by SIPS method[1] from the solution in ethanol. Tangential surface condition at the polyvinylbutyral surface is characteristic of these nematic mixtures[8]. To obtain uniaxially oriented PDLC films, we stretched or sheared the sample.

The PDLC film texture and director configurations inside the droplets were investigated by using the polarized microscope POLAM-P113.

The dependencies of the light transmission of PDLC films upon applied voltage (volt-contrast curves) were measured using a linearly-polarized light of He-Ne laser (λ=0.633 μm), generator of sinusoidal electric signal of 1kHz, photodiode and XY recorder. The measurements were taken at room temperature.

RESULTS AND DISCUSSION

The volt-contrast curves (see Figure 1) of the samples with a small part of cholesteric (below 2%) and the transformation of director configuration inside the droplets look like the ones for the uniaxially oriented PDLC films based on the pure nematics[6, 7]. The polarizing efficiency $T_{\perp}/T_{\parallel}$ (ratio of the transmitted light polarized perpendicularly $T_{\perp}$ and parallel $T_{\parallel}$ to the film orientation) is maximum at U=0 and reduces

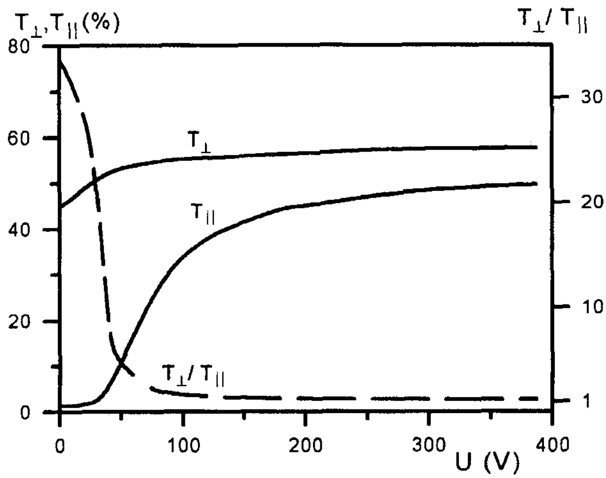

FIGURE 1. Polarized components of light transmission of the sheared PDLC films as a function of the applied voltage. Cholesteric concentration is 2%. Film thickness is 10 μm. Droplets anisometry (ratio of a long axis *a* to a short axis *b* in the film plane) *a/b*=2.6.

to the 1 at the saturation voltage. The texture close to bipolar configuration of the director inside the nematic droplets with the poles localized on the ends of major axis was observed in the whole droplet ensemble.

In the case of more cholesteric concentration (5-15 %) LC droplets have the spiral structure in unpowered state [7]. Spiral axis is perpendicular to the surface of a droplet and directed to its centre. This orientational structure produces the intensive scattering of any polarized light. Applied voltage results in the increasing of both polarized components of light transmission, but the perpendicular component rises at lower voltage then parallel one (see Figure 2). In intermediate state, the spiral axis in the entire volume of the droplet is perpendicular to the long axis of the droplets and oriented in the film plane [7]. Therefore, this sample is transparent only for the light polarized perpendicular to the film orientation due to the matching of ordinary LC refractive index and polymer one. At the higher voltage a spiral structure is completely unwound. The director inside the droplets is oriented along the field and, as a result, PDLC film becomes transparent for the both light components. So the polarizing efficiency $T_{\perp}/T_{\parallel}$ rises under applied voltage, reaches a maximal value in intermediate state and reduces to the 1 in saturation state.

For high cholesteric concentration (above 20%), the inversion of light transmission anisotropy is observed in absence of a field, i.e. the perpendicular component is scattered more strongly than parallel one (see Figure 3). As a result, $T_{\perp}/T_{\parallel}<1$ at U=0. The increase of a voltage initially to 80 V results in the state with usual anisotropy ($T_{\perp}/T_{\parallel}>1$), and then in transparent one for the both components ($T_{\perp}/T_{\parallel}\approx 1$, U>170 V).

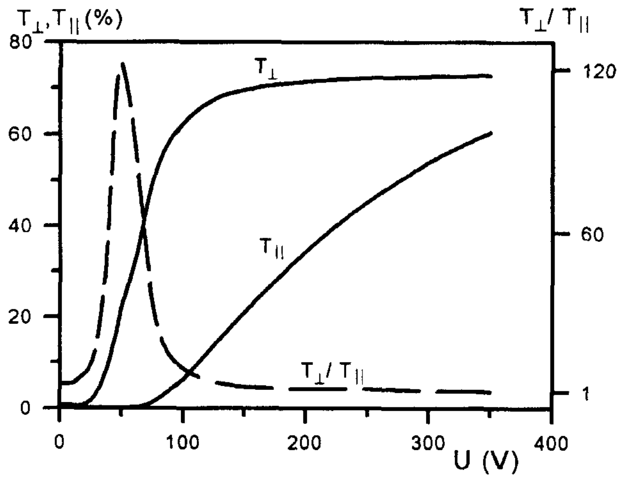

FIGURE 2. Polarized components of light transmission of the sheared PDLC films as a function of the applied voltage. Cholesteric concentration is 5%. Film thickness is 45 μm. Droplets anisometry *a/b*=2.

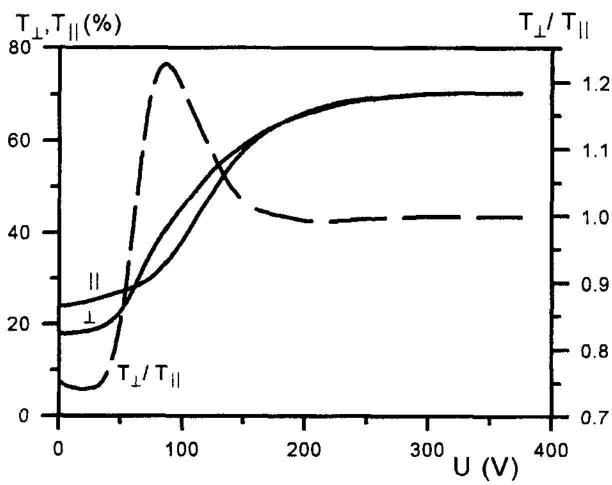

FIGURE 3. Polarized components of light transmission of the sheared PDLC films as a function of the applied voltage. Cholesteric concentration is 22%. Film thickness is 10μm. Droplets anisometry *a/b*=2.

Texture of spherical droplets in undistorted sample (see Figure 4a) looks like a fingerprint pattern observed also in [9] for chiral nematic droplets, but for a case of polymer surface with perpendicular anchoring. The axis of cholesteric spiral forms a bipolar configuration [9]. The axes of symmetry of the droplets in whole ensemble are oriented randomly.

After unidirectional deformation of the sample the axis of symmetry in everyone droplet lines up along direction of sample orientation and coincides with major axis of ellipsoidal droplets (see figure 4b).

To analyze the scattering properties of such droplets we observed them in the geometry with just one polarizer. Figure 5a,b illustrates, that in a field-off state, the optical inhomogeneity of the droplet interface is more clearly visible for the light polarized perpendicular to the long axis, than for parallel one. It explains the inversion of anisotropy of light transmission of PDLC film at zero voltage (see Figure 3). Electric field causes an unwinding of cholesteric spiral beginning from lateral areas of a droplet. At some value of field the internal structure of a droplet is shown equally distinctly for light of both polarization (see Figure 5c,d), that corresponds $T_{\perp}/T_{\parallel}=1$ on the Figure 3 at $U\approx 55V$. Further increase of the electric field results an unwinding of cholesteric spiral so, that its axis turns perpendicularly to the long axis of the ellipsoid in the film plane (see Figure 5e,f). In this state the ratio $T_{\perp}/T_{\parallel}$ reaches a maximum. At higher voltage the spiral structure in droplets is unwounded completely, and the LC director is oriented along the field in whole volume of the droplet ($T_{\perp}/T_{\parallel} \rightarrow 1$).

In conclusion, it should be noted, that the PDLC films with the middle and high concentration of the chiral additive are the convenient objects to study the flexoelectric effect in the chiral nematic droplets [5].

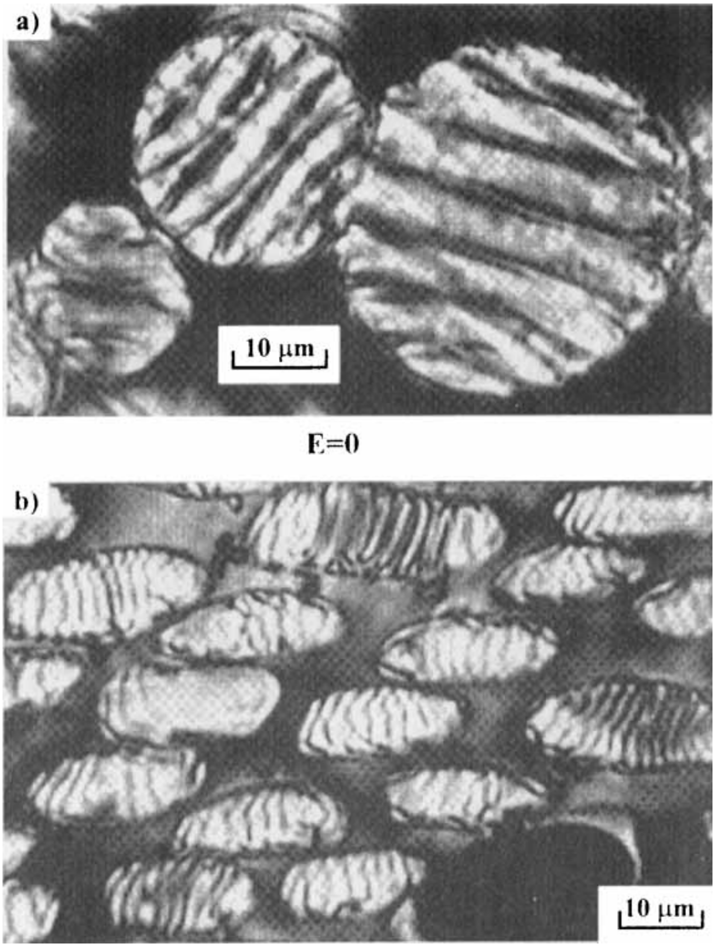

FIGURE 4. A typical texture of nematic droplets with a high concentration of chiral additive (more than 20%): a) in the undistorted PDLC film; b) in the stretched PDLC film. Polarizers are crossed.

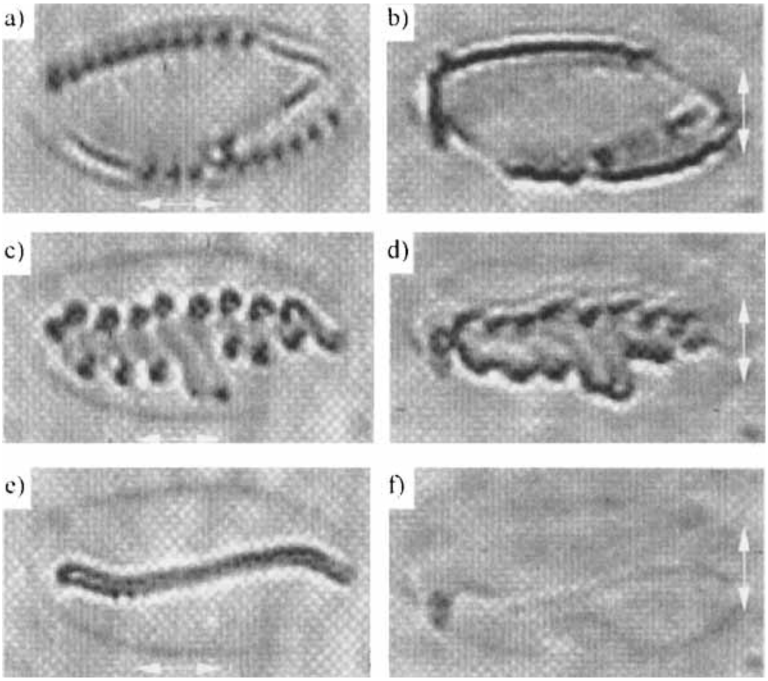

FIGURE 5. The texture of the same droplet, as in Figure 4, in the geometry of just one polarizer. a),b) – U=0V; c),d) – U=55V; e),f) – U=80V. Thin arrows show the orientation of the polarizer.

Acknowledgements

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