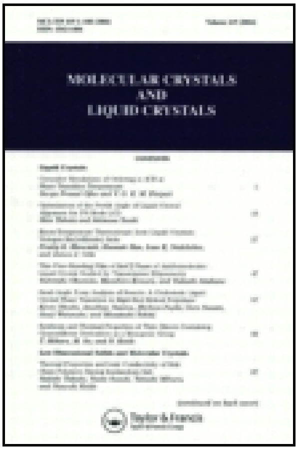

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ELECTRIC FIELD CONTROL BISTABILITY AND LOCAL FREDERICKS TRANSITIONS IN NEMATIC LIQUID CRYSTALS

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Abstract The possibilities of obtaining different metastable orientational states in nematic layers and control by the electric field of local Fredericks transition kinetics are shown. The theoretical substantiation of the obtained results are given.

The problems of bistability, metastability and state-to-state transitions[1,2] in nematic liquid crystals (NLC) arise from the study of local Fredericks transitions[3] which are usually realized by varying the NLC sample thickness of finite anchoring energy W[3,4] or changing W with temperature[5]. It is shown[6] that reversible change of initial homogeneous orientation can be obtained by exciting in NLC with "weak" surface anchoring the auto-waves of the transition to orientational chaos (secondary dynamic scattering mode (DSM2))[7-9]. Such auto-waves arise from the local centres at $U > U_2 \gg U_{th}$, where U_2 is the threshold of DSM2, U_{th} is the threshold of electrohydrodynamic (EHD) instability and propagate in the layer plane. In this paper the kinetics of different metastable states obtained by short-terms DSM2 excitation in "weak" anchoring cells is studied.

The MBBA and MBBA+EBBA mixtures with thickness d= 8-30 μm in sandwich cells are studied. The cells with "weak" anchoring were obtained either by combining the method of chemical purification and rubbing of surfaces or by method described in[10]. The deviation of director at the angle θ from axis X (easy direction axis) was estimated according to the change of optical phase delay.

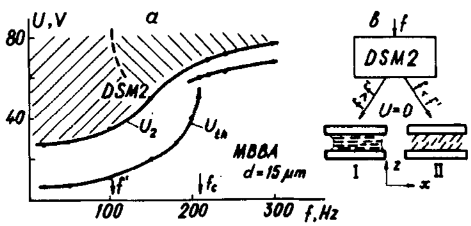

FIGURE 1 (a) Frequency dependence of the thresholds U_{th} and U_2. (b) The control scheme of the bistability in "weak" anchoring cells

The typical frequency dependences of thresholds U_{th} and U_2 and control bistability scheme are shown in Fig. 1. The state with planar (I) orientation is realized at $f > f' \simeq 0.5 f_c$, that with tilt (II) orientation is realized at $f < f'$, where f_c is the critical frequency. The state I as the state II can be more stable. The situation when the areas with different orientations are in equilibrium for a long time is possible. The scheme of the investigated situations is shown on Fig. 2. Depending on the initial situation the growth and collapse of nuclei of new phase occur. However, even in energetically profitable situation only the nuclei of $R > R_c$ size can grow, where R_c is the critical size of nucleus. At $R < R_c$ the nuclei are collapsed with the velocity ($v = dR/dt < 0$) increasing with decreasing R (insert on Fig. 3).

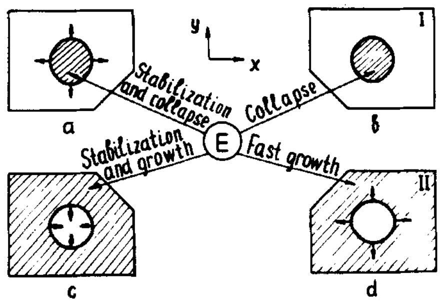

FIGURE 2 Different studied situations ($R \gg R_c$). The effect of electric field on the kinetics of the process is shown by big arrows.

It was found that electric field can control the velocity v and the direction of process evolution (see Fig.2).Electric field ($f>f_c$) induces the Fredericks effects for state II and the angle Θ smoothly decreases with U increased from Θ_0 value to quasiplanar orientation at $U \geqslant 8V$.It is seen from Fig.3 that with increase of $U>0$ velocity v decreases in respect with growth (curve 3) and collapse (curve 2) for situations a and c in Fig.2.The system stabilizes (v=0) at some voltage $U=U_c$.With increase $U>U_c$ the directi of the process is changed and the velocity v is increased.

As it was seen from the experiments the existence of two local minima of energy W is possible in the conditions of "weak" anchoring.The difference $\Delta W=W_2-W_1$ has any sign.The minima of energy W_1 and W_2 are divided by potential barrier W_m.Within the framework of the theory of nucleus generation in homogeneous metastable phase[1],the thermodynamic probability of generation of nuclei of one of two orientational states with $R<R_c$ size is proportional to "equilibrium" distribution function of nuclei of different sizes:

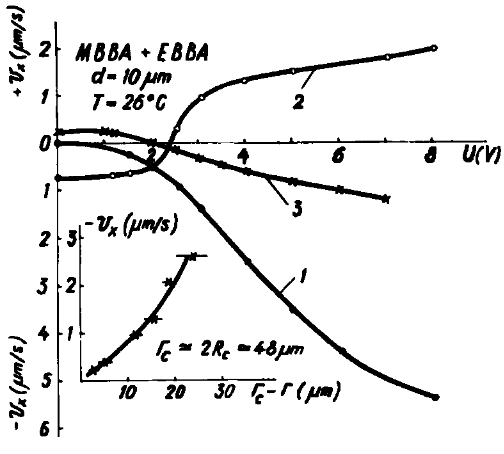

FIGURE 3 Voltage dependence of the velocity v. (curve 1 corresponds to Fig.2b, curve 2 corresponds to Fig.2c and curve 3 corresponds to Fig. 2a.Insert-dependence of v on difference($r_c - r$) (corresponds to Fig.2a at $R<R_c$).

$$f_0(R) \sim \exp[-A_{min}(R)/T],$$

where A_{min} is minimal energy for obtaining nucleus of cylindrical form with radius R and height d.In our case the different nuclei are formed due to excitation and relaxation of DSM2 regions.Let us consider the situation when the medium is in metastable state I,and the nucleus has the state II with $\Delta W<0$ (see Fig.2a). Applying low electric field E the gain in energy ΔF_1 of cylindrical nucleus is

$$\Delta F_1 = (\Delta W - d\varepsilon_a E^2 \sin^2\theta_0/2)\,\pi R^2,$$

where $\varepsilon_a<0$ is the dielectric anisotropy.The loss in energy ΔF_2 due to nucleus wall in which the orientation of director changes from θ_0 to zero is

$$\Delta F_2 = [Kd(\theta_0/\delta)^2/2 + W_m]\,2\pi R\delta,$$

where K is the elastic constant and δ is the wall width For clarity propose $\theta_0<1$.The energy of Amin can be written as $A_{min}=\Delta F_1+\Delta F_2$. The critical value of radius $R=R_c$ corresponds to the maximum of energy A_{min}

$$R_c=(dK\Theta_0^2\delta^{-1}+2W_m\delta)/(d\varepsilon_a E^2\Theta_0^2-2\Delta W) \quad (1)$$

near which

$$A_{min}=Const-\pi(2\Delta W-d\varepsilon_a E^2\Theta_0^2)(R-R_c)^2/2$$

The velocity $v=dR/dt$ can be evaluated as

$$V\sim a\,dA_{min}/dR=\pi a(d\varepsilon_a E^2\Theta_0^2-2\Delta W)(R-R_c) \quad (2)$$

where a is some constant depending on temperature. According to (2) certain critical value is

$$E_c^2=2\Delta W/d\varepsilon_a\Theta_0^2 \quad (3)$$

at which the nucleus is stabilized. This situation corresponds to curve 3 in Fig.3. From (3) the difference $\Delta W\approx 5\ 10^{-3}$ erg/cm^2 can be evaluated at $\varepsilon_a=-0.46$, $d=10\ \mu m$, $U_c\simeq 2V$ and $\Theta_0\simeq 0.7$. The detailed descriptions of experimental and theoretical results will be done later.

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