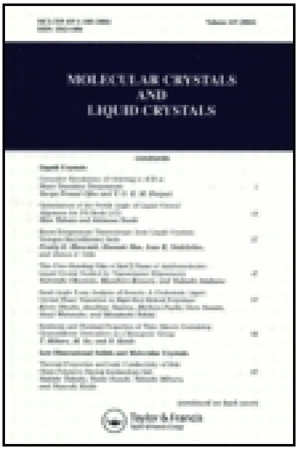

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The Electrooptical Properties of Doped Samples of Smectic C

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THE ELECTROOPTICAL PROPERTIES OF DOPED SAMPLES OF SMECTIC C

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The essential decrease of the threshold voltage of the electrooptical effects has been detected in doped samples of the smectic C liquid crystals. A novel type of high frequency electrohydrodynamic instability is observed in samples with relatively high electrical conductivity.

As has been shown recently, the character of the electrooptical effects, observed in the smectic C, strongly depends on the initial orientation of the molecules of the liquid crystals. If the smectic layers are parallel to the surface of the electrooptical cell, application to the sample of certain threshold voltage causes the appearance in individual parts of the cell nuclei of turbulent motion which, after spreading, fill the whole field of view. The rate of spreading of the turbulence depends on the temperature of the sample and the value of the applied voltage. After the applied voltage is turned off, a stable, strongly scattering, condition persists.[1] In this kind of instability, we didn't observe domains texture.

In the case of the planar texture, when the molecules of the liquid crystals are parallel to the surface of the electrooptical cell one can observe two regimes of instability which are divided with the critical frequency f_c.

In both regimes instability displays are the domains texture. The domains appearing under d.c. and low frequency a.c. electric fields are characterized by lines which are parallel to the initial direction of the director.[2]

The period of these "initial" domains, is nearly equal to the cells thickness d, but the period of the "fundamental" domains appearing under high frequency a.c. electric field more or less than d. The direction of the "fundamental" domains are perpendicular to $\vec{L}$.

Some characteristics of these effects have been studied in the papers,[4-10] have dealings with high resistance (no doped) samples. On the other hand, our preliminary investigation shows that the electrooptical effects in the smectic C phase has a direct relation to the conductivity of the samples. Therefore, in order to have detailed information about the mechanism of these effects others have investigated doped samples of smectic C, having different values of conductivity.

p-Nonyloxybenzoic acid (NOBA) was the compound chosen for investigation. The compound passes through the following sequence: C 93°S_C 117°N 143 J. The initial sample had the conductivity $\sigma \approx 10^{-10}$ $\mathrm{om}^{-1}\cdot\mathrm{cm}^{-1}$ (f = 1 KHz). In order to change σ we used the ionic impurity of tetrabutylammonium bromide.

It was found, that the threshold voltage of instability appearing in the first texture (smectic layers are parallel to the cell surface) decreases with lowering of the resistance of the sample. Decreasing of the U_{th} occurs in all considered frequency regime ($0 \leq f \leq 20$ KHz). This experimental fact shows, that this effect isn't a simple analog of the orientation effects occurring from the anisotropy of the permittivity. The certain role in the mechanism of the effect evidently results from space charge distributed in the defects parts of the cell because of the anisotropy of conductivity.

Frequency dependence of the threshold voltage for the domain texture in the case of the initial orientation of the molecules shown in Fig. 1. It is very interesting that the threshold voltage for the "fundamental" domains are sensitive to the change in the conductivity and anisotropy of the conductivity. It can be concluded that the cause of the rise of the "fundamental" domains is the "anisotropic" mechanism. That is, the anisotropy of the parameters of the liquid crystal play an important role in the beginning of this kind of instability.

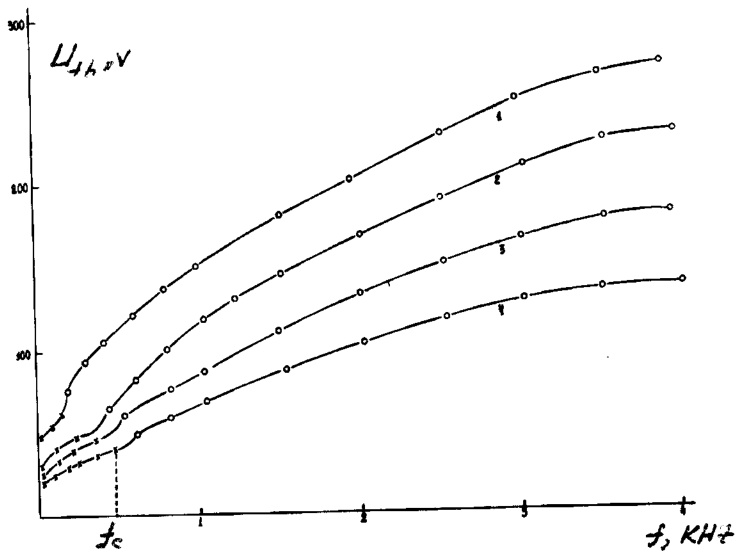

Fig. 1. Frequency dependence of the threshold voltage of "initial" (xxx) and "fundamental" (...) domains for the doped samples of the smectic C phase 1-6 = $2 \cdot 10^{-10}$ om^{-1} cm^{-1}; 2-$4 \cdot 10^{-10}$; 4-8.10^{-10}, d = 20μ; t = 110°C

For the samples, having sufficiently high conductivity ($\sigma \geq 3\cdot10^{-9}$ om^{-1} cm^{-1}) in the low frequency regime could be detected by ordinary "initial" domains. But, by increasing the frequency, beginning from certain values of f we observed new domains, which were perpendicular to $\vec{L}$. Unlike the "fundamental" the period of the new domains was approximately equal to the cell thickness.

It was established, that the period of new domains depends on the frequency, while the period of the "fundamental" domains decreases strongly with frequency. For this reason, discovering domains are clearly observed right up to frequency f $\sim$ 10 KHz. In the case of polaroid, having the direction of vibration of $\vec{E}$ parallel to $\vec{L}$, the new domains appeared better.

For all investigated samples the threshold voltage of the "fundamental" domains subordinates to low (Fig. 1):

$$U_{th} \sim f^{1/2}$$

But, for the new domains the frequency dependence of U_{th} differs from this low and close to the linear function (Fig. 2, curve 1). From the different frequency behavior U_{th} in the same sample we could observe both the "fundamental" and new domains (Fig. 2, curve 2). In such samples after the "initial" domains we observed the "fundamental" domains which were with increasing frequency, "replaced" by new domains (Fig. 2, curve 2).

The frequency interval for the "fundamental" domains increases with decreasing conductivity and they spread to high frequency regime (Fig. 2, curve 3). We want to note, that the new domains are detected also in the smectic C phase in other liquid crystals. It was established that for their stimulation it is necessary to have certain

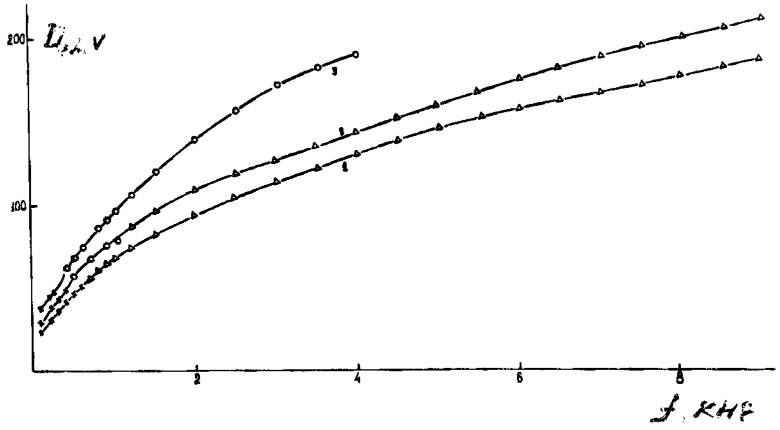

Fig. 2. Frequency dependence of the threshold voltage for "initial" (xxx), "fundamental" (...) and new domains (ΔΔΔ)
1-6 = 4.10^{-9} om^{-1} sm^{-1}; $2\text{-}2.10^{-9}$; $3\text{-}10^{-9}$, d = 20μ; t = 100°C.

values of the electrical conductivity. This fact emphasizes that the value of conductivity is an important factor for the origin of the new domains in the smectic C phase.

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