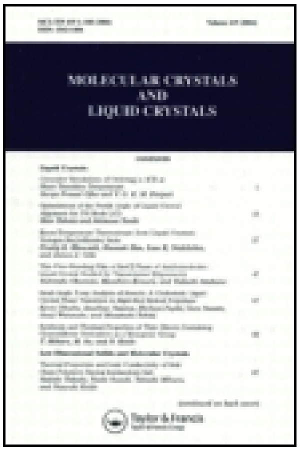

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V. N. Chirkov [a] , D. F. Aliev [a] , G. M. Radshabov [a] & A. Kh Zeinally [a]
[a] Azerbaijan State University, Baku, USSR
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STIMULATION OF THE ELECTROHYDRODYNAMIC INSTABILITY IN THE SMECTIC A PHASE

V.N. CHIRKOV, D.F. ALIEV, G.M. RADSHABOV, A.Kh, ZEINALLY
Azerbaijan State University, Baku, USSR

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ABSTRACT: The electrooptical properties of 4-n-octyl-4'-cyano-biphenyl (8CB) in the smectic A phase were investigated. The electrohydrodynamic instability in the smectic A phase was observed, when a small quantity of any homologue (C_7, C_8, C_9) of 4-n-alkoxybenzoic acid was added to this material. After the electrical field is turned off, the stable focal-conic texture is formed. A reverse focal-conic to homeotropic transition can be as well induced by means of an electric field.

The electrohydrodynamic (EHD)instability in the smectic A phase of liquid crystals was predicted theoretically[1] and recently confirmed experimentally in p-nitrophenyl-p-n-octyloxybenzoate.[2,3] Apparently, the analogous phenomenon was observed in the p-decyloxybenzylidene-p'-aminobenzonitrile.[4] In both cases the phenomenon takes place in materials with positive dielectric anisotropy and relatively high conductivity. However, these conditions are not sufficient for the rise of instability in the smectic A phase. There are many smectic A compounds in which EHD instability does not appear under these conditions.

In this letter, we report the possibility of stimulating the instability in the smectics mentioned above. We have studied the 8CB, which has a smectic A phase at room temperature. The electrooptical properties of this material were investigated[5-7], but neither turbulence nor dynamic scattering were observed. Also, in our experiments the EHD phenomenon, similar to that described in References 2 through 4, was not discovered in the initial 8CB.

In order to stimulate the EHD instability we doped 8CB with various dopants. After adding a small quantity (<1%) of any of the homologues (C_7, C_8, C_9) of 4-n-alkoxybenzoic acid to 8CB, the specific motion and scattering, analogous to that described in References 2 and 3, were discovered in the electrical fields. This effect arises in the d.c. and low frequency a.c. fields and has a threshold character (Fig. 1). In certain sections of the sample with planar or homeotropic orientation, local regions with intensive turbulence appear. They spread until the whole area of the cell is covered by them and the sample passes from optically transparent to the scattering state. The turbulence appears immediately (no domain picture is observed in the cell). The process of turbulence spread takes place with great velocity at fields exceeding the threshold. The increase of the alkoxybenzoic acid concentration leads to the increase of the number of local turbulence centers. The threshold of the EHD instability increases with the increase of the applied field frequency.

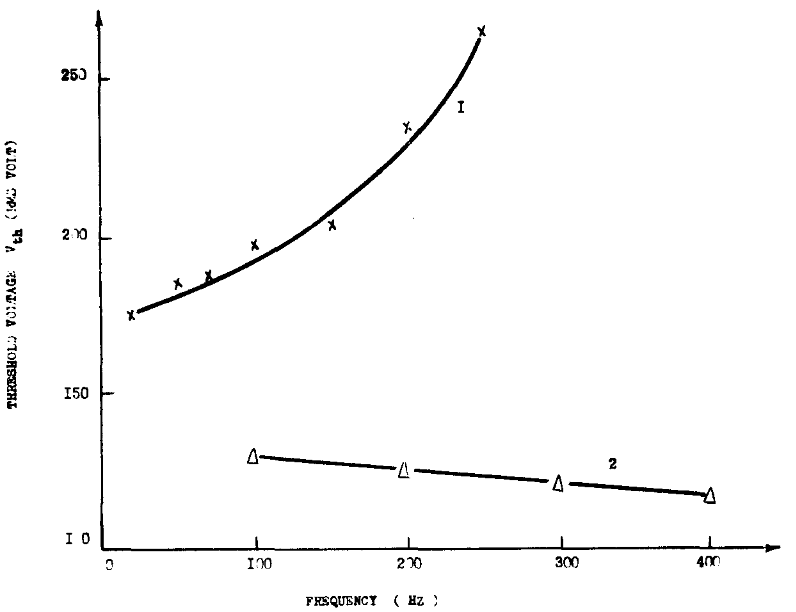

FIGURE 1 Frequency dependence of the threshold voltage for the EHD instability (1) and focal-conic to homeotropic transition (2) in the smectic A phase of 8CB + 1% Heptyloxybenzoic acid. T = 25^{o}C.

After the field is turned off, the focal-conic texture is formed. The relaxation of this texture to the initial one is difficult, i.e. the stimulated scattering state is stable. This state remains for a long time after the field is removed. The focal-conic texture of smectics is more scattering, more stable and remains longer than the focal-conic texture of cholesteric systems with memory.

The smectic phase of 8CB has a positive

dielectric anisotropy and therefore it is possible to realize a reverse focal-conic to homeotropic transition by means of the electric field. The threshold of this transition depends insignificantly on frequency. The time of EHD instability turn on and focal-conic to homeotropic transition turn on is determined by the relation $\tau \sim (U-U_{th})^{-2}$, where U_{th} = threshold voltage. The thresholds of the EHD instability and focal-conic to homeotropic transition decrease in the range of smectic A phase with the temperature increase and abruptly falls near the phase transition to the nematic phase (Fig. 2). In the smectic A phase the threshold of the EHD instability is directly proportional to the thickness (d) of the sample and the threshold of focal-conic to homeotropic transition is proportional to $\sqrt{d}$.

The value of the electric conductivity of 8CB in the smectic A phase does not change considerably after adding a small quantity of alkoxybenzoic acid.

If a sufficient quantity of dopants is added to the 8CB, the temperature of phase transitions is somewhat displaced and the range of existence of the smectic mesophase is extended. Unlike substances investigated before,[2-4] the EHD instability and focal-conic to homeotropic transition in this case takes place at room temperature, that is an important advantage for practical application of this effect.

The homologous series of alkoxybenzoic acid,

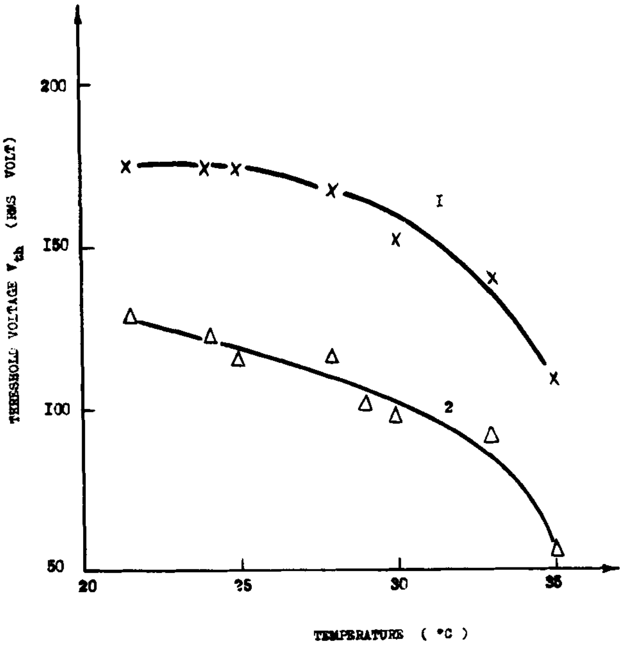

FIGURE 2 Temperature dependence of the threshold voltage for the EHD instability (1) and focal-conic to homeotropic transition (2) in the smectic A phase of 8CB + 1% Heptyloxybenzoic acid. 1-20 Hz; 2-5 kHz.

cited in this letter, also essentially affects electrooptical properties of other smectics with positive dielectric anisotropy. The local defects, which are nucleators of turbulence, arise when dopants are brought into the smectic A phase. When the initial smectic state does not exhibit the EHD instability, then addition of alkoxybenzoic acids stimulates this effect in it. When this phenomenon takes place in the initial smectic, these dopants considerably decrease the threshold of EHD instability. Perhaps, this behaviour of the homologous series of alkoxybenaoic acid leads to increase of the anisotropy of electric conductivity in smectics. The decrease of the threshold voltage may be explained according to the Carr-Helfrich model for EHD instability in nematic phase.

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