



HAL
open science

ALIGNMENT OF NEMATIC LIQUID CRYSTALS CONTROLLED BY FERROELECTRIC DOMAIN STRUCTURE

M. Glogarová, V. Janovec, N. Tikhomirova

► **To cite this version:**

M. Glogarová, V. Janovec, N. Tikhomirova. ALIGNMENT OF NEMATIC LIQUID CRYSTALS CONTROLLED BY FERROELECTRIC DOMAIN STRUCTURE. *Journal de Physique Colloques*, 1979, 40 (C3), pp.C3-502-C3-504. 10.1051/jphyscol:19793100 . jpa-00218701

HAL Id: jpa-00218701

<https://hal.science/jpa-00218701>

Submitted on 4 Feb 2008

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

ALIGNMENT OF NEMATIC LIQUID CRYSTALS CONTROLLED BY FERROELECTRIC DOMAIN STRUCTURE

M. GLOGAROVÁ and V. JANOVEC

Institute of Physics, Czech. Acad. Sci., Na Slovance 2, 18040 Prague 8, Czechoslovakia

N. A. TIKHOMIROVA

Institute of Crystallography, Acad. Sci. USSR, Leninskii prospekt 59, Moscow V-333, USSR

Résumé. — Sur la surface clivée du sulfate triglycine ferroélectrique (TGS) deux alignements distincts de cristaux liquides nématiques ont été observés, qui correspondent à deux directions possibles de la polarisation spontanée du substrat de TGS. Le renversement de la polarisation du TGS, produit par un champ électrique externe, entraîne la transformation de l'alignement en un autre qui reste stable après la disconnexion du champ. Par ailleurs, l'alignement peut être modifié par l'ancrage de la lame de verre couvrant la couche du cristal liquide nématique.

Abstract. — On cleaved surface of ferroelectric triglycine sulphate (TGS) two distinct alignments of nematic liquid crystals (NLC's) have been observed which correspond to two possible directions of spontaneous polarization in TGS substrate. Polarization reversal of TGS accomplished by external electric field brings about switching from one alignment into the other which remains stable after disconnecting the field. The alignment can be modified by anchoring properties of a glass plate covering the NLC layer.

1. **Introduction.** — The alignment of liquid crystals on solid crystal substrates was investigated by Mauguin [1] and Grandjean [2]. They found that on cleaved surfaces of various minerals nematic liquid crystals (NLC's) form homogeneous layers (*plages*) with distinct orientations of optical axis which were in simple relation to the symmetry of the crystal substrate. Later on, attention has been focused on anchoring properties of glass surfaces whereas crystal substrates have been examined only occasionally [3].

Here we report on the alignment of NLC's on the surface of triglycine sulphate (TGS). This crystal is ferroelectric below 49 °C with spontaneous polarization P_s along the monoclinic b axis [4]. It was established that domains with opposite polarization impose different alignment in a NLC layer which is in contact with a cleaved TGS surface. This effect has been utilized for revealing ferroelectric domains in TGS [5, 6].

2. **Experimental results.** — TGS plates 0.5-1 mm thick were cleaved in (010) plane perpendicular to the spontaneous polarization. The cleaved surface was coated with a layer of a NLC. The layer was covered with a glass plate sometimes supplied with spacers. Experiments were performed with NLC's of negative dielectric anisotropy (MBBA and

MBBA + EBBA mixtures) and of positive dielectric anisotropy (mixture of cyano-biphenyls).

Between crossed polarizers and at the extinction position of TGS the sandwich exhibits a pattern of dark and bright areas (Fig. 1) which are identical

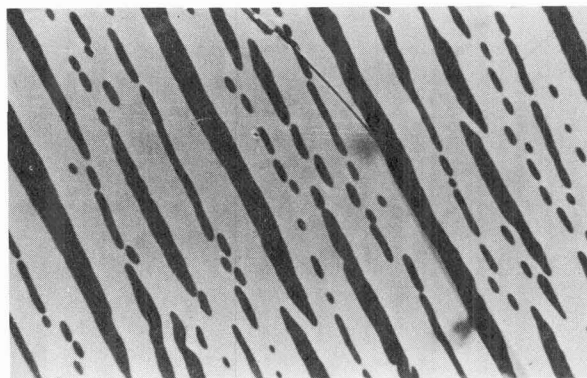


FIG. 1. — Ferroelectric domain structure of TGS revealed by MBBA. Dimensions of the surface region are (0.4×0.3) mm².

with antiparallel domains of TGS [5, 6]. Domain structure is well revealed with NLC layers of the thickness from 1 μ m to 50 μ m. Minimum dimension of domains visualized by this method was 1 μ m.

With MBBA or MBBA + EBBA mixture *plus*

domains (with P_s pointing towards the NLC layer) appear bright and *minus domains* (with opposite P_s) are dark. Similar picture is observed with mixture of cyano-biphenyls covered with a glass plate. For very thin layers of cyano-biphenyls without a covering glass the contrast reverses : plus domains appear darker than the minus domains.

When a covering glass coated with lecithine is applied the domain structure can be revealed with all NLC's but only for tens of seconds ; then the image darkens and finally becomes uniformly black.

When the temperature of a sandwich with MBBA + EBBA layer is raised above 49 °C, where the domain structure of TGS should disappear, the dark areas brighten from their centres while domain walls retain clearly visible for several seconds (Fig. 2).

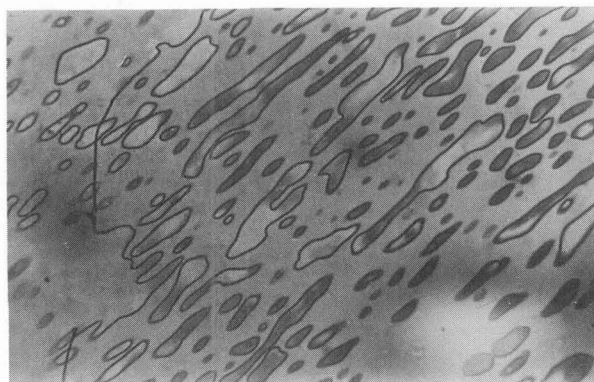


FIG. 2. — The pattern revealed in the paraelectric phase of TGS by MBBA + EBBA mixture.

After supplying the free TGS surface and the covering glass with suitable transparent electrodes one can apply an electric field on the sandwich and reverse the direction of P_s . The switching process can be observed as growing and diminishing of dark and bright areas. With the voltage of about 10 V a single domain state of TGS can be reached which remains stable even after disconnecting the voltage. In this state the whole sample appears dark or bright according to the direction of P_s .

When a semitransparent copper layer, deposited on the covering glass in vacuum, serves as one electrode of a MBBA sandwich the image becomes dark for both directions of P_s , similarly as for lecithine. If, however, the TGS substrate is switched from minus to plus domain (which usually appears as uniformly bright area) the Schlieren texture can be seen for a moment and then dark spots form and growth as shown in figure 3. If TGS is switched subsequently to minus domain only the moving domain walls can be observed as bright lines while the domains remain dark. When the switching process stops bright lines dissolve.

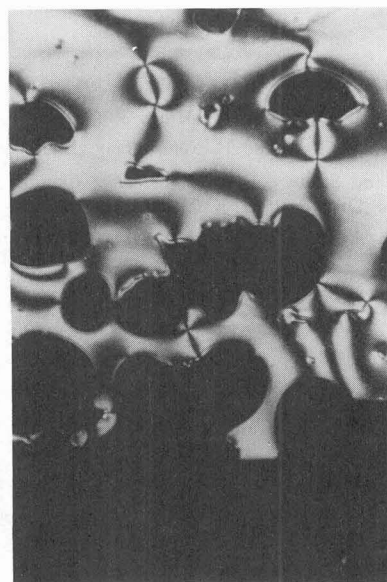


FIG. 3. — The Schlieren texture in MBBA layer and its transition to a homeotropic alignment after switching of the TGS substrate from minus to plus domain. A domain wall passed upwards.

3. Discussion. — Homogeneous dark areas imposed by lecithine or copper coatings can be associated with a homeotropic alignment. This implies relatively weak anchoring on the TGS substrate. Birefringence measurements further indicate that the alignment of MBBA molecules in dark areas (i.e., above minus domains) is close to a planar orientation with director nearly parallel to (100) plane. For cyano-biphenyls the dark areas correspond either to homeotropic or tilted alignments with directors approximately parallel to (102) or (100) planes. Above 49 °C and in bright areas below 49 °C tilted or planar orientations occur for all NLC's examined. Exact determination of the molecular alignment is difficult due to high birefringence of TGS.

Different alignments can be tentatively explained as an interplay of two factors : the anisotropy of the TGS substrate which introduces several non-equivalent easy directions for NLC molecules [7], and depolarizing electric fields which can differ in absolute value above plus and minus domains (thus, e.g., the field above the plus domain could be compensated by air humidity [8] due to higher solubility of the plus domain surface [9]). Depolarizing field exerts a torque on NLC molecules and can thus alter the preference of easy directions above plus and minus domains. For NLC's with positive dielectric anisotropy the torque favours small tilt angles and weakens the anisotropic influence of the TGS substrate.

Further details will be published elsewhere.

References

- [1] MAUGUIN, C., *Bull. Soc. Fr. Minér.* **34** (1911) 71.
- [2] GRANDJEAN, F., *Bull. Soc. Fr. Minér.* **39** (1916) 164.
- [3] RYSCHENKOW, G., Thèse 3^e cycle, Orsay (1975).
- [4] JONA, F. and SHIRANE, G., *Ferroelectric Crystals* (Pergamon Press, Oxford) 1962, p. 28.
- [5] FURUHATA, Y. and TORIYAMA, K., *Appl. Phys. Lett.* **23** (1973) 361.
- [6] KONSTANTINOVA, V. P., TIKHOMIROVA, N. A. and GLOGAROVÁ, M., *Ferroelectrics* (in press).
- [7] DE GENNES, P. G., *The Physics of Liquid Crystals* (Clarendon Press, Oxford) 1974, Chap. 3.
- [8] TIKHOMIROVA, N. A., DONCOVA, L. I., PIKIN, S. A., GINZBERG, A. V. and ADOMENAS, P. V., *Kristallografiya* (in press).
- [9] SAWADA, A. and ABE, R., *Japan. J. Appl. Phys.* **6** (1967) 699.