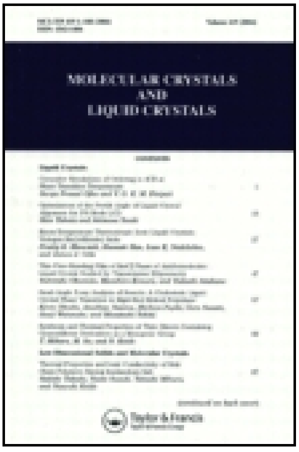

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Anchoring Break in Homogeneously Aligned Nematics at the Nematic/Smectic-A Transition

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Anchoring Break in Homogeneously Aligned Nematics at the Nematic/Smectic-A Transition

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Formation of the striped pattern at the nematic/smectic-A transition which is connected with an anchoring break has been investigated. A model of the pattern structure is developed from the optical behaviour. The influence of a stabilizing electrical field on the pattern formation has been studied.

Keywords: alignment break, orientation, phase transitions

INTRODUCTION

In various LC compounds (e.g. 8 CB, 8 OCB, or nitrophenyl-octyloxybenzoate) which are aligned homogeneously in the nematic phase by surface action and, then, cooled down to the smectic-A phase one can observe the formation of different types of smectic texture patterns near the phase transition.[1–4] This behaviour is, possibly, the consequence of a variation of smectic layer thickness with the temperature.[4] Samples of 8 CB aligned planar by SiO orientational layers show a periodic stripe pattern 1 K below the nematic/smectic phase transition. The evolution of the texture pattern at further cooling depends on the sample thickness. In thick samples (>8 μm) a fine structure with focal conics is formed, whereas in thin samples no changes could be observed.[1]

If the samples are heated from the smectic-A up to the nematic phase the most essential characteristics of the patterns (dark and light stripes) are preserved also in the originally homogeneous aligned nematic structure. The bulk forces which induce the pattern formation are very strong. They disturb the orientation at the surface caused by interactional forces between LC molecules and the substrate surface. This anchoring break can be removed in part by heating the sample into the isotropic state.[5]

In this paper we want to report on some observations concerning the formation of the stripes in 8 CB, on the behaviour of compounds with an additional smectic-C phase, and on the cooling of samples in applied electric fields.

STRIPES IN 8 CB

The LC substance 8 CB has been filled into a glass cell with SiO orientational layers at a temperature of 45°C (isotropic phase). At cooling down a planar nematic structure is formed. The orientational direction (or the direction perpendicular to this) may be defined by rotation of the cell between crossed polarizers to the darkest position. At a temperature of 1 K below the nematic/smectic-A transition (T_{NA} = 33.5°C) a periodic stripe pattern of dark and light bands can be observed (Figure 1). The period is about twice the thickness *d* of the LC sample.[5] At rotation of the sample one can see that the dark stripes become light, and vice versa. In that

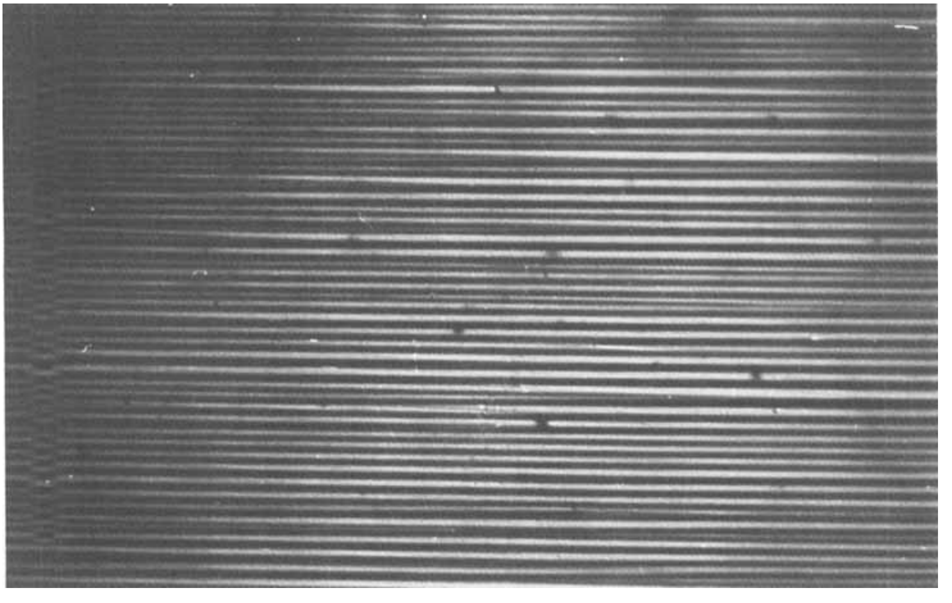

FIGURE 1 Stripe pattern in 8 CB (at 32.5°C).

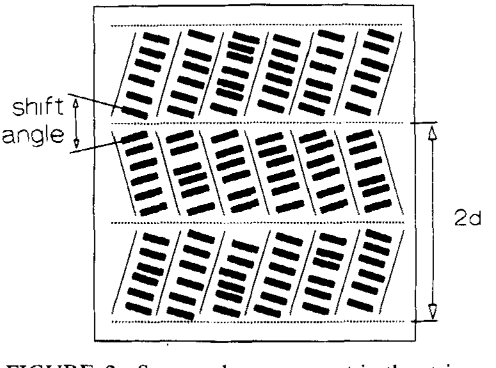

FIGURE 2 Supposed arrangement in the stripes.

position where the nematic state have shown the lowest transmission the two groups of bands are nearly invisible because their transmission is equal to each other. The positions where in each case the groups of bands have the smallest transmission are arranged symmetrically to the orientational direction in the nematic state. These observations support a structural model, as shown in Figure 2. The measured shift angle between the orientational directions of two bands is 1.5°. This pattern can be removed by heating of the sample into the nematic state.

If the cooling is continued to 1.5 K below T_{NA}, the shift angle increases to 3°. Now, the dark and light stripes are preserved at heating to the originally homogeneous aligned nematic phase. An anchoring break has taken place.

We observed that in spite of the planar surface alignment the LC molecules, and the smectic layers consequently, are tilted to the substrate plane. Conoscopical measurements show that the mean tilt angle which depends on the sample thickness[5] is about 3° in the 5 μm thick cell at 22°C. In the nematic phase a tilt of about 1° remains. Consequently, the anchoring break caused by bulk forces produces not only an orientational change in the surface plane, but also a tilt.

The patterns in our experiments are different from those of Takanishi *et al.*[4] (chevron-like structure). The reason for these deviations at the same used 8 CB is, probably, the different experimental set-up. We used a heating stage with a thermal gradient through the cell where the smectic phase grows from one surface to the other.

COMPOUNDS WITH A SMECTIC-C PHASE

We investigated also some LC compounds which show an additional smectic-C phase. In the used hexyloxyphenyl-decyloxybenzoate (HOPDOB), which exhibits a transition temperature of T_{NA} = 83°C, a stripe pattern is developed immediately below the nematic/smectic-A transition (Figure 3). It is similar to that in 8 CB, but not stable. The pattern disappears at further continuous cooling. In other LC compounds slight different stripes with disclination lines are possible. But, also in that case the tendency to a homogeneous structure at further cooling could be observed.

If, however, the temperature is slightly increased in the region below T_{NA}, a stripe pattern appears again. Additionally, the formation of zig-zag-defects has been observed in HOPDOB (Figure 4), indicating a chevron-like structure. This pattern is very stable and involves also an anchoring break, visible in the textured nematic state.

The pattern formation has been observed in various LC compounds at different sample thickness and surface preparation.[3] There may be quantitative differences in the appearance of the patterns in samples prepared in different ways. But, in every case we observed a variation of the homogeneous alignment in the bulk modified by the surface conditions. Even in free standing LC films a striped pattern could be found (Figure 5). This confirms the assumption that bulk forces are responsible for the pattern formation.

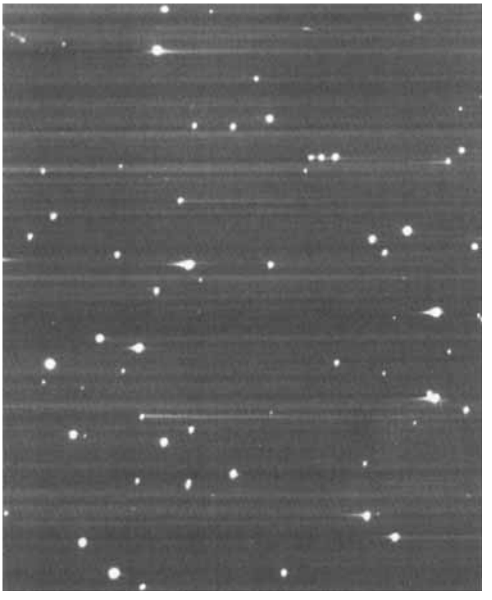

FIGURE 3 Instable stripes in HOPDOB.

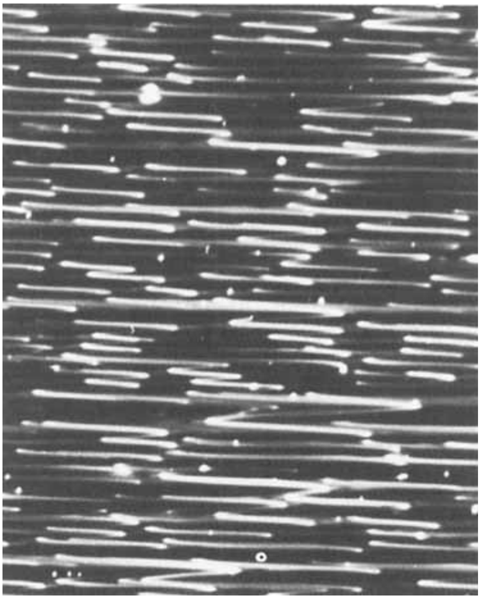

FIGURE 4 Zig-zag-defects in HOPDOB.

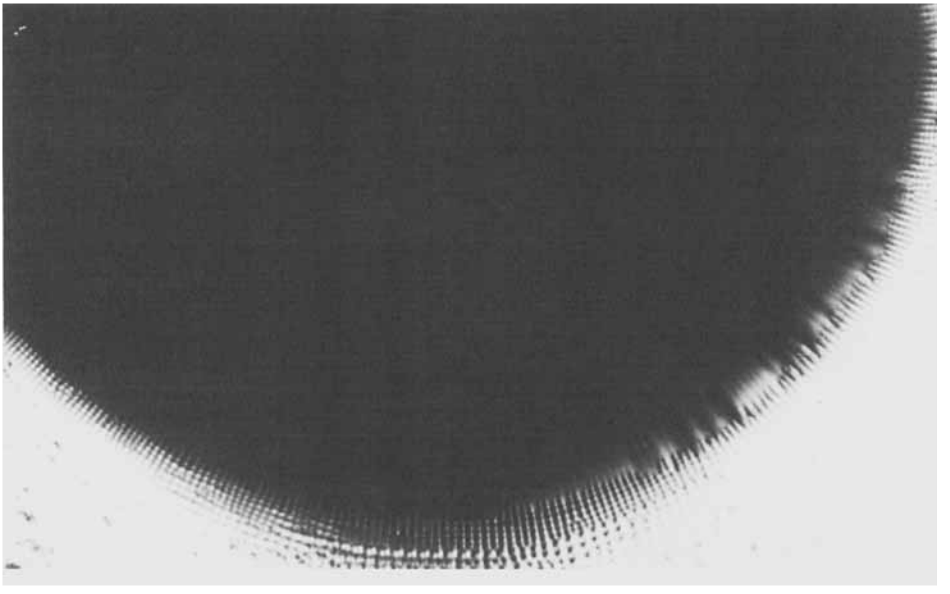

FIGURE 5 Free standing film with stripes.

INFLUENCE OF ELECTRIC FIELDS

To stabilize the homogeneous structure during the cooling process we applied an electric field parallel to the original orientational direction. For this purpose, aluminum electrodes has been deposited onto one of the glass substrates of the cell. The distance between the two electrodes was 0.2 mm, and their thickness 2 μm. The orientational layers has been deposited on the electrodes in such a way that the alignment in the nematic phase is parallel to the field direction. In such cells it was possible to apply an a.c. field of about 3 kV/cm at 500 Hz parallel to the glass surfaces during the cooling from the nematic to the smectic-A phase.

In a thin layer of 8 CB (d = 3 μm) the electric field does not change the formation of the stripe pattern below T_{NA}, as shown in Figure 6. In the space between the electrodes the ordinary stripes can be seen. After switching-off the field and heating into the nematic state the known for 8 CB behaviour was observed.

In thick cells the field behaviour is different from the discussed one. Figure 7 presents the pattern in the smectic phase of 8 CB (d = 12 μm). Here, a great part of the electric field in the sample is not parallel to the substrate surface because of the great difference between the thickness of the electrode and the cell thickness. A highly distorted structure results which does not have any similarity with the ordinary one. It remains after the switching-off of the field. The characteristics of this pattern is preserved also, after heating, in the nematic phase. If the sample is cooled again, the ordinary pattern results. But, after a subsequent heating the distorted structure can be observed, and not the ordinary stripes. Consequently, in the case of thick cells the applied field affects the pattern formation and the anchoring break.

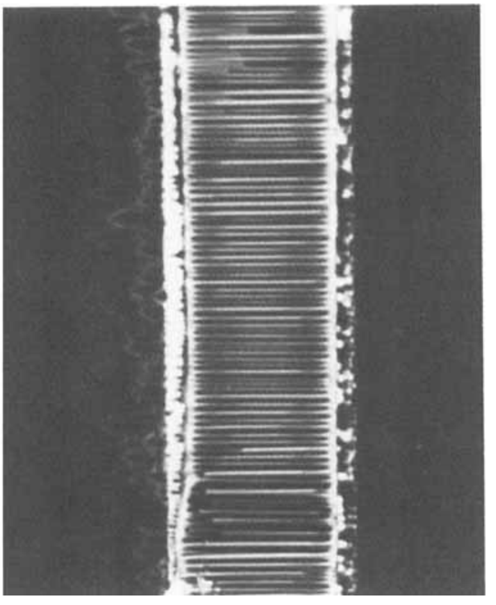

FIGURE 6 Pattern between the electrodes in thin cells.

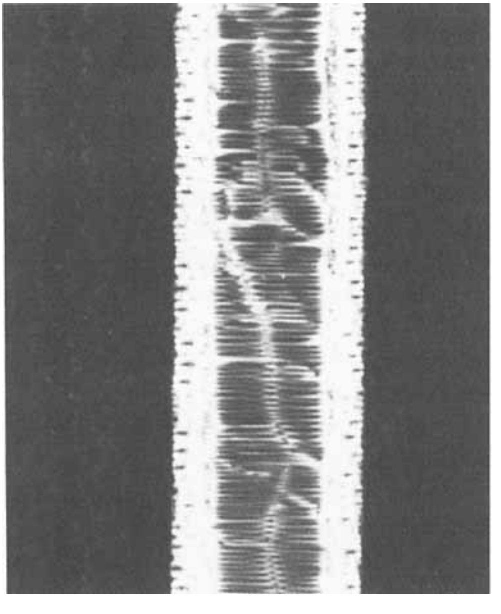

FIGURE 7 Distorted pattern in thick cells.

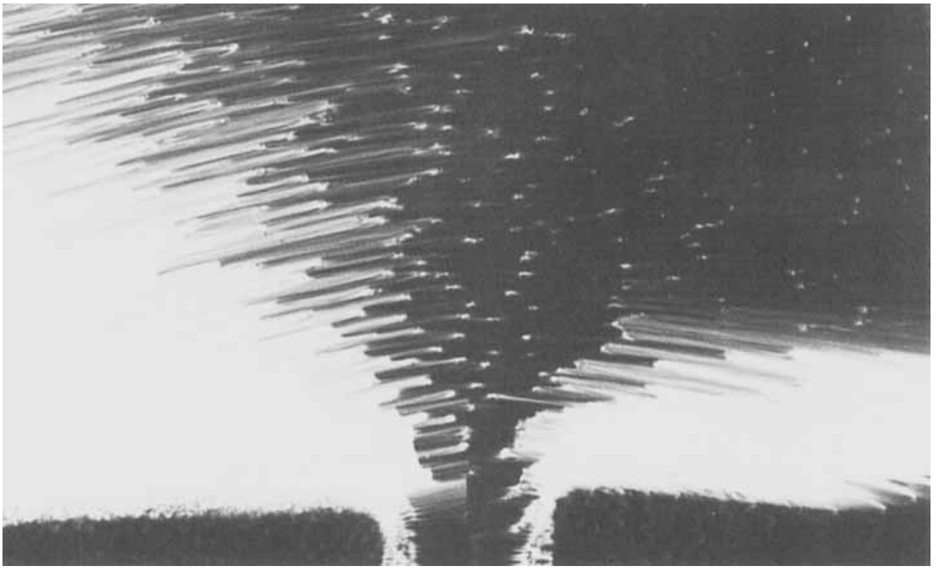

FIGURE 8 Distorted stripes outside of the electrodes.

A similar behaviour one can see outside the electrodes (Figure 8). The smectic stripes are arranged nearly parallel to the bended field lines out of the space between the electrodes. This picture is independent on the sample thickness.

In conclusion, the applied electric field is not able to stabilize the original homogeneous structure, but it can modify the resulting pattern.

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