Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713926090

PRELIMINARY COMMUNICATIONS A novel alignment technique for ferroelectric smectics

M. J. Bradshaw[a]; V. Brimmell[a]; E. P. Raynes[a]
[a] Royal Signals and Radar Establishment, Malvern, Worcestershire, England

To cite this Article Bradshaw, M. J. , Brimmell, V. and Raynes, E. P.(1987) 'PRELIMINARY COMMUNICATIONS A novel alignment technique for ferroelectric smectics', Liquid Crystals, 2: 1, 107 — 110
To link to this Article: DOI: 10.1080/02678298708086642
URL: http://dx.doi.org/10.1080/02678298708086642

Liquid Crystals, 1987, Vol. 2, No. 1, 107–110

PRELIMINARY COMMUNICATIONS

A novel alignment technique for ferroelectric smectics

by M. J. BRADSHAW, V. BRIMMELL and E. P. RAYNES
Royal Signals and Radar Establishment, Malvern, Worcestershire WR14 3PS, England

(*Received 1 September 1986; accepted 3 December 1986*)

Until now a major problem in achieving practical ferroelectric displays has been the lack of a suitable technique for producing uniform alignment over large areas. This preliminary communication reports a novel alignment technique which utilizes mixtures with extended cholesteric pitches and has been found to give excellent alignment of ferroelectric smectics using the standard surface treatments employed in the nematic display industry.

Fast, bistable switching utilizing the spontaneous ferroelectric polarization (P_s) found in chiral smectic C materials (S_C^*) has been demonstrated [1], however, its application in devices has been restricted by the difficulties encountered in achieving the necessary 'bookshelf' geometry in which the smectic layers are perpendicular to the cell surfaces [2]. Various techniques have been suggested [2, 3] but none of these is suitable for the commercial production of large area devices.

We have discovered that excellent bookshelf geometry alignment can be produced by combining parallel rubbed polymer surface alignments with liquid crystals showing the following phase sequence:

$$I\text{–}N^*\text{–}S_A\text{–}S_C^*,$$

provided that the twist in the cholesteric (N*) phase is completely unwound. The natural twist in the N* phase is completely unwound to zero twist by parallel aligned surfaces provided the cholesteric pitch, P, satisfies the relationship $P > 4d$, where d is the thickness of the liquid crystal layer. Figure 1 shows the alignment achieved on cooling with no applied voltage from the unwound N* phase, through the smectic A (S_A) to the S_C^* phase, which becomes well aligned in the bookshelf geometry. This is confirmed by the excellent uniformity obtained on electrically switching the S_C^* phase with small fields of $\pm 1\ V/\mu m$ between the polarization UP and DOWN states (cf. figure 2). The quality of alignment is not significantly affected by the type of polymer used for the surface alignment nor by the rate of cooling through the phases.

The chirality necessary for producing ferroelectricity in the S_C^* phase usually introduces a short pitch length, ($P < 1\ \mu m$) in the cholesteric phase. We have used two methods of achieving the long pitches ($P > 4d$) necessary for good alignment. In one the concentration of chiral dopant is small while for the other compensated chiral mixtures are used.

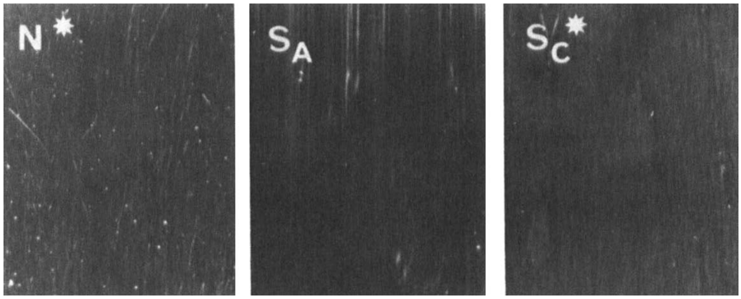


Figure 1. Liquid crystal mixture CM6; $d = 6\,\mu$m, polyimide alignment (rubbed ↑↓), crossed polars (↔↕), ×100 magnification.

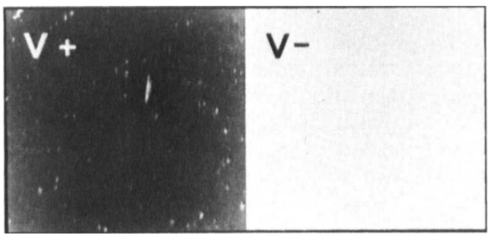
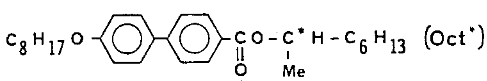
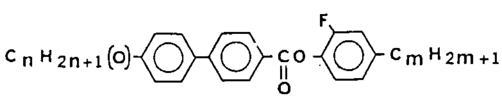


Figure 2. Ferroelectric switching of CM6 cell (figure 1) with crossed polars rotated through the S_C^* tilt angle, and $\pm 1\,V/\mu m$ applied.

An example of a mixture containing a small concentration of chiral dopant is 1 per cent



and 99 per cent H1 which combines the octanol chiral dopant [4] with a host mixture (H1) based on the esters [5]



The long pitch mixture has the following transition temperatures:

$$\mathrm{I}\quad 150^{\circ}\mathrm{C}\quad \mathrm{N}^*\quad 109{\cdot}2^{\circ}\mathrm{C}\quad \mathrm{S_A}\quad 103^{\circ}\mathrm{C}\quad \mathrm{S_C^*}\quad 27^{\circ}\mathrm{C}\quad \mathrm{S?}$$

and a N* pitch of $12\,\mu$m (figure 3(*a*)) so that an unwound cholesteric structure is formed for cells thinner than $3\,\mu$m. The N* pitch was determined by measuring the temperature at which Grandjean twist disclinations formed in calibrated thick cells (typically $d \leqslant 50\,\mu$m). The measured P_s is small ($\sim 0{\cdot}5\,\mathrm{nC\,cm^{-2}}$) but could be increased by using chiral dopants with a larger value of ($P \times P_s$).

An alternative technique which is more suitable for the chiral materials currently available involves combining chiral components with opposite cholesteric twist senses such that the left and right hand twists are balanced and the pitch extended. The compensation point where the pitch is infinite occurs at just one temperature and the

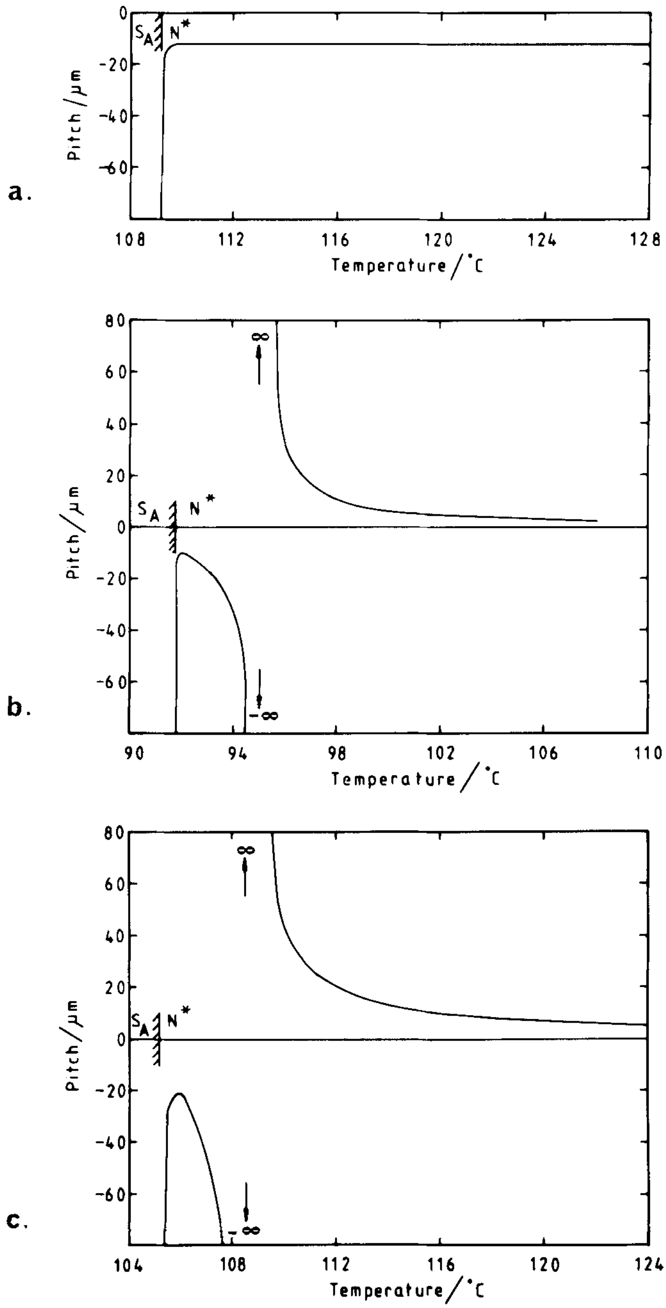
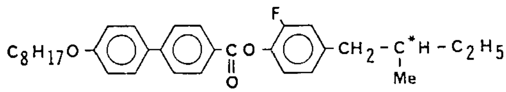


Figure 3. Temperature dependence of the cholesteric pitch of (*a*) 1 per cent Oct* + 99 per cent H1, (*b*) CD3, and (*c*) CM6.

composition of the mixture needs to be adjusted so that this temperature occurs either just above or just below the S_A–N* transition—the latter corresponding to a virtual compensation point. To maximize the P_s of the mixture all of the chiral components should have the same sign of P_s, but in practice this is not necessary, as often one of the chiral components has a dominant contribution to P_s. We give two examples of such compensated mixtures.

(i) CD3 contains two chiral components with opposite N* twist senses 22 per cent Oct* and 78 per cent



The transition temperatures of CD3 are

I 108°C N* 91·8°C S_A 71°C S_C^* 49°C K

and its pitch in the N* phase is shown in figure 3 (*b*). The compensation point can be seen to occur at 95·0°C, which is close enough to the S_A phase to enable a completely unwound cholesteric phase to be obtained in 3 μm cells.

(ii) CM6 is formed by adding H1 to CD3 to lower the melting point below ambient temperatures. It has the composition 44 per cent CD3, 56 per cent H1 and shows the following phase transition temperatures:

I 134°C N* 105·2°C S_A 83°C S_C^* 14°C S?.

The pitch in the N* phase is given in figure 3 (*c*); it shows the compensation temperature occurs at 108·6°C. An unwound cholesteric phase can easily be obtained in 6 μm cells. At 20°C the P_s of CM6 is reasonably high at 25 nC cm^{-2}.

Finally, it should be noted that mixtures compensated in the S_C^* phase [6] have too short a pitch in the N* phase for good alignment.

We have demonstrated a convenient and reliable method of achieving the bookshelf geometry in smectics using mixtures with extended pitches in the N* phase. The quality of the alignment is excellent and the method is particularly suited for use with standard nematic alignment techniques.

We gratefully acknowledge Mrs J. Constant for the photomicrographs and BDH Chemicals Ltd for the liquid crystal materials. This work was supported by the JOERS/Alvey scheme.

References

[1] Clark, N. A., and Lagerwall, S. T., 1980, *Appl. Phys. Lett.*, **36**, 899.
[2] Flatischler, K., Sharp, K., Lagerwall, S. T., and Stebler, B., 1985, *Molec. Crystals liq. Crystals*, **131**, 21, and references therein.
[3] Patel, J. S., Leslie, T. M., and Goodby, J. W., 1984, *Ferroelectrics*, **59**, 137.
[4] Bradshaw, M. J., Constant, J., and Raynes, E. P., 1986, *Eleventh International Liquid Crystal Conference*, Berkeley, U.S.A. (to be published).
[5] Bishop, D., Jenner, J., and Sage, I., 1986, *Eleventh International Liquid Crystal Conference*, Berkeley, U.S.A. (to be published).
[6] Blinov, L. M., and Beresnev, L. A., 1984, *Soviet Phys. Usp.*, **27**, 492.