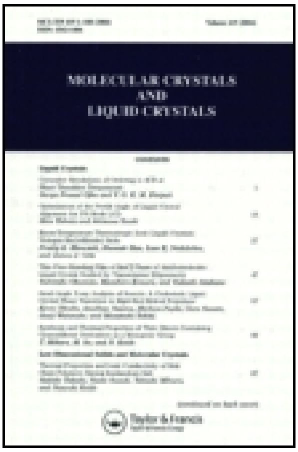

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Alignment of Nematic and Ferroelectric Liquid Crystals on Rubbed Polyaniline Films

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Alignment of Nematic and Ferroelectric Liquid Crystals on Rubbed Polyaniline Films

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Alignment of nematic (7CB) and ferroelectric (CS 1013) liquid crystals on rubbed polyaniline films has been investigated. It was found that polyaniline serves as an excellent template for the alignment of both nematic and ferroelectric liquid crystal molecules. Polyaniline also acts as a conducting surface under the conditions of preparation.

Keywords: Nematic, smectic, ferroelectric, liquid crystal, polyaniline, conducting polymer.

1. INTRODUCTION

The alignment of liquid crystal molecules in the desired orientation is the major requirement in liquid crystal display technology. Various polymer matrices, such as rubbed polyimide films[1], polymide Langmuir-Blodgett films[2], rubbed polypyrrole films[3] and obliquely evaporated SiO films[1] are generally used as templates for obtaining homogeneous orientations of liquid crystals in such displays. These films are grown on a conducting glass surface and among the materials listed above, only polypyrrole films enhance the conductivity of the glass plate. Polyaniline is another such conducting polymer which shows potential dependent conductivity when prepared from a solution of pH below 3.[4] In this article, we discuss the use of polyaniline as a template for the alignment of liquid crystal molecules.

2. EXPERIMENTAL

All chemicals used were of Analar grade and used without further purification if not specified otherwise. Aniline was distilled at 184°C under N_2 atmosphere and stored in a refrigerator. The water used was doubly distilled.

3. PREPARATION OF POLYANILINE FILMS

2.00 cm^3 of aniline was dissolved in 200 cm^3 of 0.100 mol dm^{-3} NaCl (aq) and the pH of the solution was adjusted to 2 using HCl. All solutions used in the experiments described here were purged with N_2 gas (O_2 free) for 30 min.

A three-electrode system was employed for potentiostatic electrosynthesis of polyaniline. The electrodes used were an antimony-doped tinoxide (ATO) (7.5 cm × 2.5 cm, prepared *in situ* according to the procedure described in ref. 4, the conductivity of the electrode = $10^{-3}\,\Omega^{-1}\,cm^{-1}$) as the working electrode, a platinum gauze electrode as the auxillary electrode kept in a separate compartment of the cell and a saturated calomel electrode (SCE) as the reference electrode. The reference electrode was placed very close to the working electrode using a Lugguin capillary in order to minimize the ohmic potential drop through the solution. The cell was thermostatted at 4°C. A slow flow of N_2 was held above the solution to prevent the re-entry of O_2 into the solution. The working electrode was held at + 0.70 V with respect to the SCE for 30 min using an electrochemical apparatus comprising a triangular wave generator, a potentiostat and voltage followers (oxford Electrodes). This resulted in a fine layer of polyaniline on the ATO electrode which was pale blue in colour. The films thus prepared had a conductivity of $3 \times 10^{-1}\,\Omega^{-1}\,cm^{-1}$ in the dry state.

4. PREPARATION OF LIQUID CRYSTAL CELLS

ATO glass plates with polyaniline films were cleaned with a detergent (teepol); rinsed well with doubly distilled water and dried in an oven at 100°C. They were then subjected to unidirectional rubbing. The cells were prepared by separating two rubbed plates by 4 μm thick mylar spacer and sealing two sides. Care was taken to ensure that the rubbed faces formed inside of the cell with the directions of rubbing of the two plates being parallel. These cells were filled with nematic liquid crystal, 4-cyano-4′-heptyl biphenyl (7CB), and ferroelectric liquid crystal, CS 1013 (Chisso Petrochemical Corp.). The nematic liquid crystal 7CB has the phase sequence of crystal 28.5°C N 42.5° Iso. and CS 1013 has Sm C* 63°C, SmA 70°C, N* 80*C Iso.

5. RESULTS AND DISCUSSION

The orientation of liquid crystal cells thus prepared were observed under a polarizing microscope and optical micrographs of both nematic and ferroelectric liquid crystal cells were taken under crossed polarizers. Figure (1) shows the texture of 7CB aligned on rubbed polyaniline films under crossed polarizers. Dark and bright positions were observed repeatedly when the 7CB cell was rotated under crossed polarizers. High quality, planar orientation was achieved with high contrast for nematic liquid crystals.

Figures 2(a) and 2(b) show the texture of Sm A and Sm C* phases of CS 1013 respectively under crossed polarizers. A planar orientation was observed in the Sm A phase. When the cell was cooled down to Sm C* a uniform state with director tilted with respect to layer normal was observed. The quality of the liquid crystal cells prepared using polyaniline as the template is comparable with that obtained with conventional polyimide templates.

The conductivity of the ATO plate is enhanced by the application of a thin film of polyaniline. Polyaniline and its conductivity remain unchanged even in the anhydrous state. However, if the applied potential is changed to a lower value (negative with

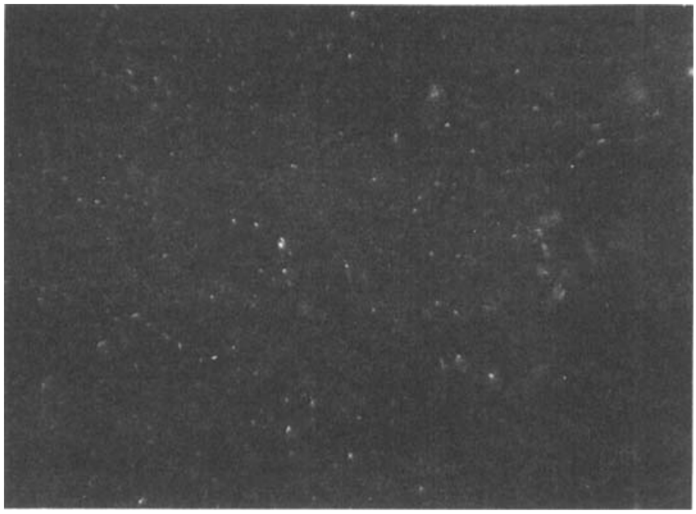

FIGURE 1 An optical micrograph of nematic liquid crystal 7CB aligned on polyaniline. The micrograph was taken under crossed polarizers and the thickness of the cells is 4 μm.

respect to SCE) the polymer is yellow in colour and is non-conducting. The switching between the conducting and non-conducting forms can be achieved without much degradation of the polymer films. The form of polymer suitable for the purpose described in this article is the conducting blue polymer. To demonstrate the advantages of polyaniline over the conventional non-conducting polymers for supporting liquid crystals, we have also prepared a twisted nematic liquid crystal cell using polyaniline coated films. For comparison another cell was prepared with polyvinylalcohol (PVA) coated plates. It was found that, under crossed nicols, cells prepared with polyaniline-coated plates required 2.5 V for complete rewinding and that for those prepared with PVA-coated plates is 4 V. These features clearly indicate the suitability of polyaniline as a template to align liquid crystal molecules along a given substrate.

Polyaniline is also better than polypyrrole for this purpose. This is because the latter is darker (black) when conducting while the former is much lighter (pale blue) in its conducting state. Thus the liquid crystal cells prepared using polypyrrole would not show high contrast under crossed polarizers, if the thickness of the film is sufficiently large. Therefore, the thickness of the film is a crucial factor in the case of polypyrrole and extra care has to be taken in order to keep the thickness of the film small enough. Fortunately, this is not a limiting factor in the case of polyaniline.

The other advantage of polyaniline is that it can be prepared chemically using a suitable oxidant such as a persulphate ion. Therefore, a conducting glass plate is no longer required for liquid crystal displays. Polyaniline grown on ordinary glass plates by means of chemical methods is sufficiently conducting and may have potential applications in the liquid crystal display technology. Further study in this line is in progress.

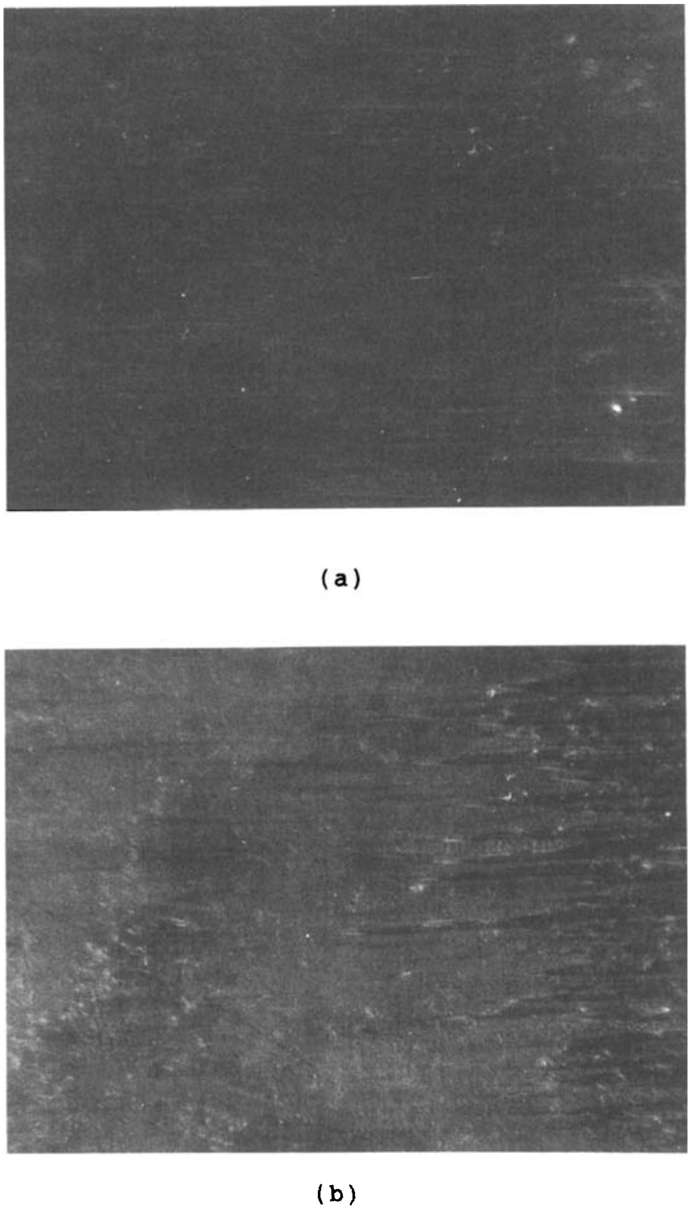

FIGURE 2 Optical micrographs of ferroelectric liquid crystal CS 1013 in the (a) Smectic A phase (b) Smectic C* phase aligned on polyaniline, under crossed polarizers. Cell thickness = 4 μm.

Acknowledgments

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