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# Orientational properties of PVA coated SiO films

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# Orientational properties of PVA coated SiO films

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A new method for producing tilt angle in liquid crystal cells is proposed. The method requires a SiO vacuum deposition layer which is subsequently covered with a polyvinyl alcohol (PVA) layer, obtained by dipping in a solution. It was possible to obtain tilt angles between 7 and 30° by changing the concentration of PVA in the solution.

## 1. Introduction

The orientation of liquid crystal molecules at surfaces is usually described in terms of the tilt angle defined as the angle between the liquid crystal director and the plane of the surface.

Various methods for creating surface alignment have been reported and already reviewed (see, for example, [1, 2]). Rubbed organic films can induce both low and high tilt angles [3, 4]. SiO films evaporated at incidence angles greater than 75° give high tilt angles [5, 6] while combinations of SiO layers among which ones were evaporated at an incidence angle of 60° and the others at an angle greater than 80° allow tilt angles between 0 and 30° [7–9]. On the other hand, combinations of SiO layers and plasma deposited organic ones were developed for high tilt angles [10].

In this work we present a new method of producing tilted orientations: the obliquely deposited SiO layer is coated with PVA by dipping the plate in a PVA solution. Starting from the value of 30° corresponding to the uncoated SiO layer, the tilt angle decreases to 7° as the PVA concentration rises. This behaviour allows us to obtain a desired tilt angle in the range 7–30°. In addition, these preliminary results seem to support the important role of topography for surface alignment.

## 2. Experimental

Soda lime glass plates of 23 × 32 × 1·7 mm, coated with an $In_2O_3$ transparent conductive layer were used as substrates. They were precleaned in detergent solution using an ultrasonic cleaner, rinsed in distilled water and then dried at 110°C.

The SiO layer of about 140 Å thickness was deposited onto these plates using B30.2 evaporation equipment (Hochvakuum, Dresden) to which a rotable carriage having 16 plate holders and assuring an evaporation angle greater than 80° and a special crucible were connected. The work pressure was $10^{-5}$ T. The layer thickness was measured with a quartz crystal monitor MSV 1842 (MIKI) and was corrected for the experimental geometry.

PVA coating was performed after SiO deposition. The plates were dipped into the aqueous PVA solution and withdrawn vertically at a constant speed of $0{\cdot}05\,\mathrm{mm\,s^{-1}}$,

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provided by an electric motor. The lifting set-up was used in a clean atmosphere. PVA concentration was varied between 0·25 and 1·70 wt%. The coated plates were then kept for 30 min at 120°C. The films obtained were optically transparent and clearly visible on the substrate.

The plates were sealed to obtain test cells which were filled under vacuum with nematic liquid crystal ZLI 1132 (Merck) in the isotropic phase (see figure 1). The 15 μm thickness of the liquid crystal layer was realized by Mylar spacers. The plates were so mounted so as to assure a parallel orientation of the molecules in the bulk.

The tilt angle was measured at 20°C using the method of retardation extrema as described in [11] for angles less than 15° and the magnetic null method with optical detection [12] for those greater than 15°.

The topography of SiO and PVA covered SiO films were investigated using a scanning electron microscope JSM-50 A (JEOL).

## 3. Results and discussion

We have found a linear dependence of the tilt angle on PVA concentration in the dipping solution as shown in figure 2. The tilt angle decreases as the concentration increases up to 1·65 wt%. At the value of 1·70 wt% PVA, the cells seemed to have an unidirectional homogeneous alignment; however we failed to measure their tilt angle since an angle satisfying the extremum condition for the given set of wavelengths in

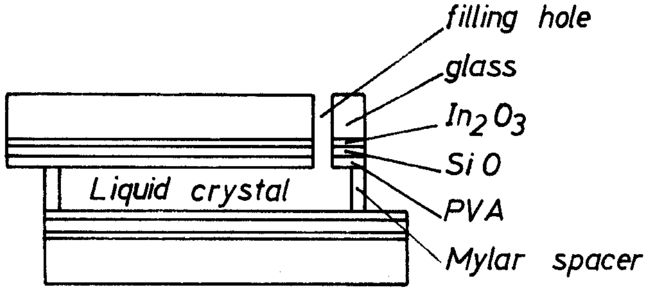


Figure 1. Schematic view of a test cell.

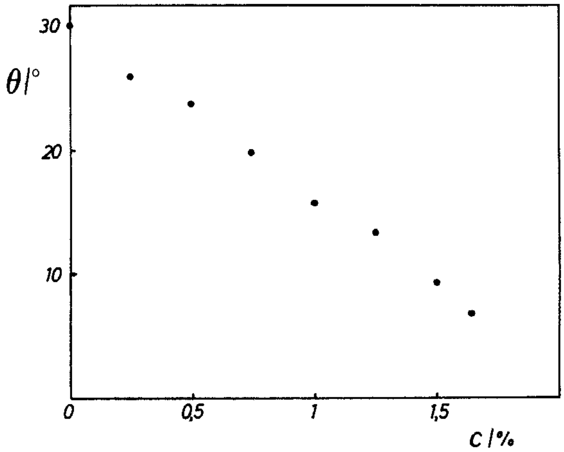
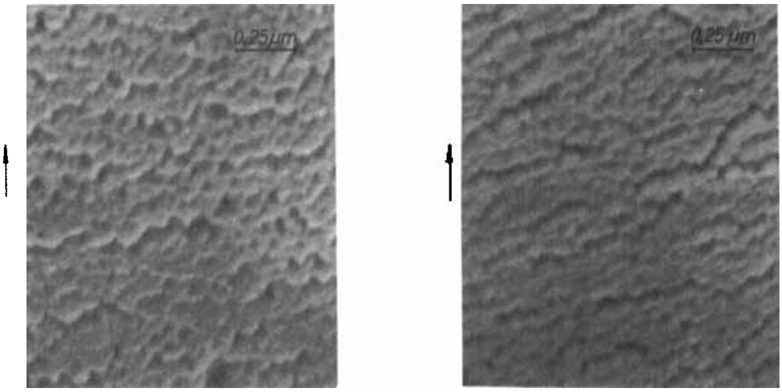


Figure 2. Tilt angle versus PVA concentration in the dipping solution.



(a) (b)

Figure 3. Electron micrographs of (a) obliquely deposited SiO film, (b) PVA coated SiO film. The samples were inclined by 45°. Arrows show the direction of evaporation.

transmitted light was not obtained by the retardation extrema method. This behaviour could indicate some dispersion of the molecular orientation.

The thickness of the PVA layer is not uniform as this layer was deposited onto a substrate with known columnar structure [5, 6]. This is why in figure 2 we have plotted the tilt angle versus the PVA concentration instead of the mean PVA thickness value, which is difficult to estimate. The obtained linearity allows easy control of the tilt angle.

Surface alignment produced by our method is stable, the tilt angle value remaining the same even after 7 months after cell filling.

Because the chemical nature of the substrate film and consequently the nature of the interactions between the liquid crystal molecules and the substrate is the same in all cases, the differences observed among the samples might be due to differences in topography. This supposition was confirmed by SEM studies. Some of the microphotographs obtained for two of the plates are shown in figure 3: one of the plates was deposited with SiO film only, the other has a PVA coated SiO film (the concentration of PVA in the solution being 1·5 wt%). We can notice that for the PVA coated SiO layer the column length (as defined in [6]) is shorter and the width is larger than for a simple SiO layer.

As expected, for a 1·7 wt% concentration of the PVA solution the topographic structure is quite obscured, this fact leading to the loss of alignment properties. An obscuring effect was also mentioned in the case of polyethylene coated SiO film [13].

At this stage of investigations, we can only speculate on the mechanism acting in surface alignment on our samples. The alignment and the tilt of liquid crystal molecules on treated surfaces is generally a complex phenomenon, involving many mechanisms [14]. However, we could conclude that our results seem to support the important role [5, 6] played by topography.

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