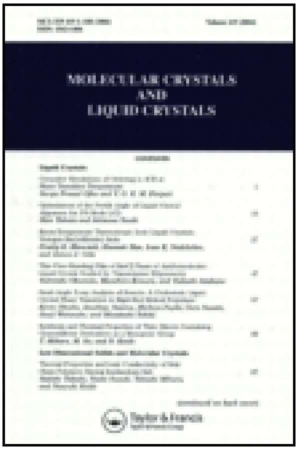

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Temperature Dependence of Anisotropic Surface Anchorage of Nematic Liquid Crystals

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A phase modulation technique using a photoelastic modulator is employed for measuring the optical retardation as a function of temperature in the whole range of the nematic state. The surface parameters are determined self-consistently from both the capacitance and the phase retardation of the nematic liquid crystal. It is found that the surface anchoring energy is on the order of 1.0 erg/cm^2 at room temperature.

Keywords: anchoring, extrapolation, mean-field

INTRODUCTION

The molecular alignment of liquid crystals (LCs) on the treated surfaces of solid substrates is of great importance for a basic understanding of interfacial phenomena as well as technological applications[1]. Among a variety of parameters, the anisotropic surface anchoring energy is the most important one which governs the surface ordering of LCs at the solid/LC interfaces. This allows for the homogeneous or homeotropic alignment of LCs on solid substrates. Several methods have been suggested for measuring the anchoring energy[2].

In the present work, the phase modulation technique in a high field regime[3] was employed for measuring the optical retardation of a nematic LC as a function of temperature. The surface parameters were determined self-consistently from both the capacitance and the phase retardation of the LC.

EXPERIMENTAL

The LC mixture studied was ZLI-2293 of Merck. The clearing temperature of this material is 85.0 °C. The LC cell was made with transparent, conductive indium-tin-oxide coated glasses. The homogeneous alignment was produced on the inner surface of the cell coated with the polyimide layer, followed by unidirectional rubbing. The thickness of the polyimide layer was about 300 Å. and the cell gap was maintained by glass spacers of 10 μm thick.

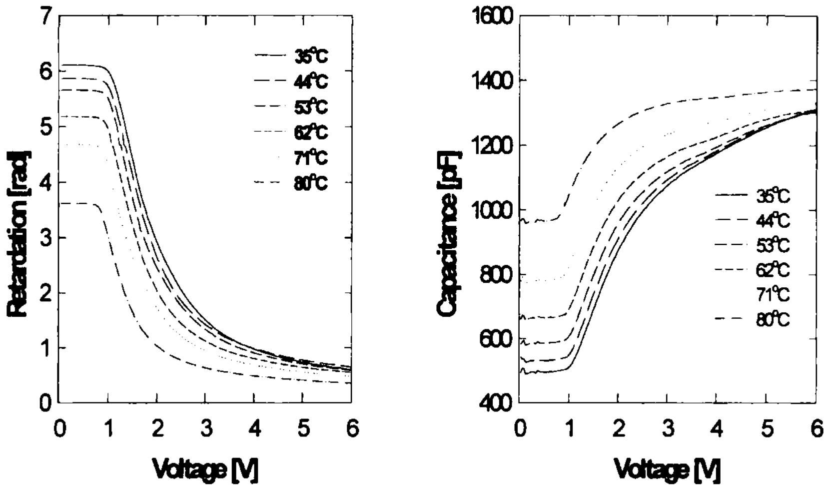
The optical retardation was measured using a phase modulation technique in a high field regime (above 4 V). A sinusoidal voltage of upto 10 V at a step of 0.05 V was used for measuring the capacitance of the LC cell.

RESULTS AND DISCUSSION

We first derive the expression for the phase retardation R in terms of the capacitance C, the surface anchoring strength W, and the relevant material parameters in the high field limit[3].

$$R/R_o = \xi I(\gamma, \kappa, \nu)/CV - 2K_1/Wd, \tag{1}$$

where R_o is the phase retardation under no electric field, and $I(\gamma, \kappa, \nu)$ depends on the material parameters such as the elastic constants (κ), the dielectric constants (γ), and the refractive induces (ν). Here, ξ is dependent on the geometrical factor of the cell (the area and the thickness). Assuming that the surface anchoring energy is given by $(1/2)W\theta^2$ with θ the molecular tilt at the surface, the magnitude of W is readily determined from the measured C and R.



(a) (b)

FIGURE 1. (a) The phase retardation and (b) the capacitance as a function of the applied

Fig. 1 shows the phase retardation and the capacitance as a function of applied voltage at various temperatures. The threshold voltage is about 1 V. The retardation decreases and the capacitance increases with increasing temperature.

The temperature dependence of the surface anchoring energy, determined from the data of R and C using Eq. (1), is shown Fig. 2. It was found that the surface anchoring energy is on the order of 1.0 erg/cm^2 at room temperature, which agrees well with the literature value[4]. The anchoring energy increases with decreasing temperature T as $(T_{NI}-T)^{\alpha}$ with $\alpha = 1$. Here, T_{NI} denotes the isotropic-nematic transition temperature. This is consistent with the mean-field prediction[5].

In summary, we have measured the surface anchoring energy of a nematic LC as a function of temperature using a phase modulation technique in the high field regime with the help of the capacitance of the LC cell.

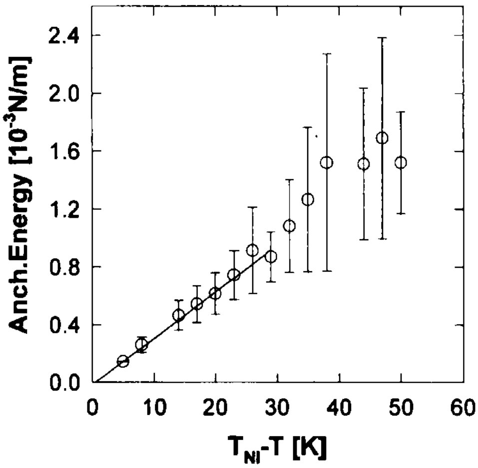


FIGURE 2. The temperature dependence of the surface anchoring energy.

The surface anchoring energy is on the order of 1.0 erg/cm^2 at room temperature. The temperature dependence is consistent with the mean-field prediction.

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