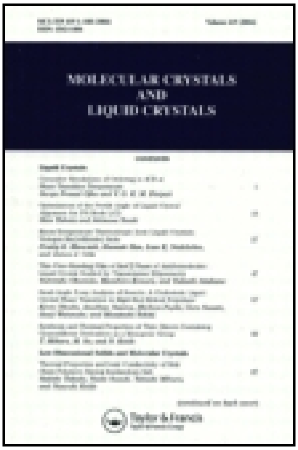

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Orientational Ordering of a Liquid Crystal on a Photoaligned AZO-Polyimide Substrate

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Orientational Ordering of a Liquid Crystal on a Photoaligned AZO-Polyimide Substrate

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We have studied a method of pretilting liquid crystal on the surface of a substrate by photoaligning the polyimide substrate containing azo type chromophores. The liquid crystal molecules were pretilted by inducing anisotropy in the cell substrate with anisotropic photopumping of the chromophores. Using the crystal rotation method, we have investigated the orientational ordering of 5CB liquid crystal on a photoaligned azo-polyimide substrate.

Keywords: pretilt; liquid crystal; crystal rotation method; polyimide; chromophore; infrared absorption

INTRODUCTION

The pretilt of liquid crystal molecules on the substrate surface is an important factor to improve the speed and viewing angle in the liquid crystal display technology. There have been some efforts of pretilting liquid crystal by inducing anisotropy in the substrate through the photoalignment of dye molecules doped in the matrix.[1-4] In this paper, we have studied a new method of pretilting liquid crystal on the surface of a polyimide substrate containing azo type chromophores by photoaligning the chromophoric groups. In this way, we hoped to achieve a better anisotropy in the substrate. The chromophores attached to the polyimide main chains were aligned by irradiation of a polarized light, and this alignment caused the polyimide to be aligned. The anisotropy induced by the alignment was measured spectroscopically using UV and FT-IR absorptions. Using the crystal rotation method, we have studied the orientational ordering of a liquid crystal (5CB) on the photoaligned azo-polyimide substrate.

EXPERIMENTAL RESULTS AND DISCUSSION

A polyimide carrying two side-on attached azobenzene type chromophores was prepared for this experiment (Fig. 1)[5]. The average molecular weight of this polymer was measured to be 80,000 using GPC, and the glass transition temperature was determined as 193 ℃ by DSC under N_2 at a heating rate of 10℃/min. The precursor solution was spin-coated on the slide glass or sapphire. We used sapphire plate which allows spectroscopic measurement at infrared region (1400-2000 cm^{-1}). This film was dried at 60℃ for 12h and then at 100℃ for 24h under the vacuum. The film thickness was 0.4 μm.

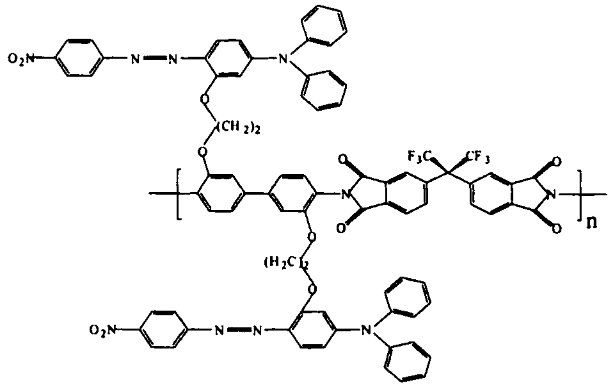

FIGURE 1. Chemical structure of the polyimide carrying two side-on attached azo type chromophores.

After the repeated absorption and relaxation processes through trans-cis-trans isomerization, chromophores align themselves along the direction perpendicular to the polarization direction of the pump light when it is linearly polarized.[1-3] It was also reported that a circularly polarized pump light induces the trans molecules to be aligned along the propagation direction of the pump beam.[4] As the chromophores attached to the main chain were aligned in this way, the main chains themselves will be aligned to a certain direction through interactions with the chromophores.[1-4] Figure 2 shows the transmittances measured as a function of the probe polarization angle for the probe whose propagation direction is either parallel or perpendicular to that of pump beam. The transmittance of the probe beam is independent of its polarization angle when it propagates along the propagation direction of the pump beam (Fig. 2(a)). On the other hand, these values show polarization angle dependence for the probe beam with the propagation direction perpendicular to that of the pump beam (Fig. 2(b)). In our experiment, the wavelength and the intensity of the pump beam were 488 nm and 300 mW/cm^2, respectively.

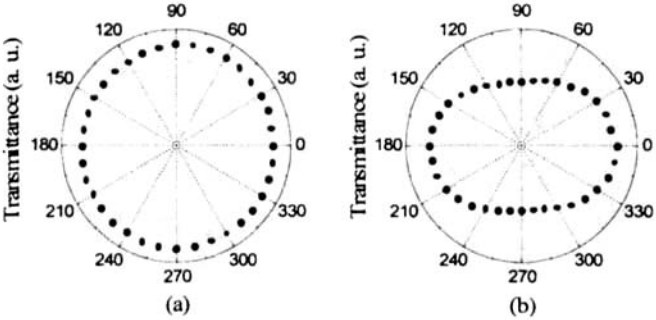

FIGURE 2. Polarization angle dependence of transmittance of the probe beam with the propagation direction of the probe beam parallel (a) or perpendicular (b) to that of the pump beam.

To see whether the main chains are aligned when the chromophores attached to them are aligned through photopumping, we have measured the infrared absorption spectra of the main chain before and after optical pumping. The absorptions of those vibration modes are sensitive to the polarization direction of probe beam when it is linearly polarized. We have measured anisotropy in the IR absorptions to verify the anisotropy of the average orientation of main chains. The ratios of these infrared transmission spectra of the illuminated samples show two peaks at 1730 and 1589 cm^{-1}; one corresponds to the characteristic vibrational mode of main chain, and the other to that of chromophore. This indicates that main chains as well as chromophores are aligned by polarized pump light

To verify whether liquid crystal molecules are actually tilted through interactions with the photoaligned polyimide substrate, we measured the angle-dependent transmission of the liquid crystal cells that were located between the crossed polarizers(Figs. 3(a), 3(b) and 3(c)). We used 5CB for liquid crystal molecule. And the substrates for the liquid crystal cells were made in three different ways, each cell differs by the incident angle of pump beam for different photoalignment direction of main chains. The incident angles of pump beam were 30°, 45° and 60° for Figs. 3(a), 3(b) and 3(c), respectively. The pretilt angles of these cells were measured to be 0.75°, 1.49° and 2.98° from the data of Fig. 3(a), 3(b) and 3(c), respectively.

In colclusion, we found that photoalignment of the polyimide substrate containing the azo type chromophores causes the orientational ordering of liquid crystal through interactions between the photoaligned polyimides and the liquid crystal molecules.

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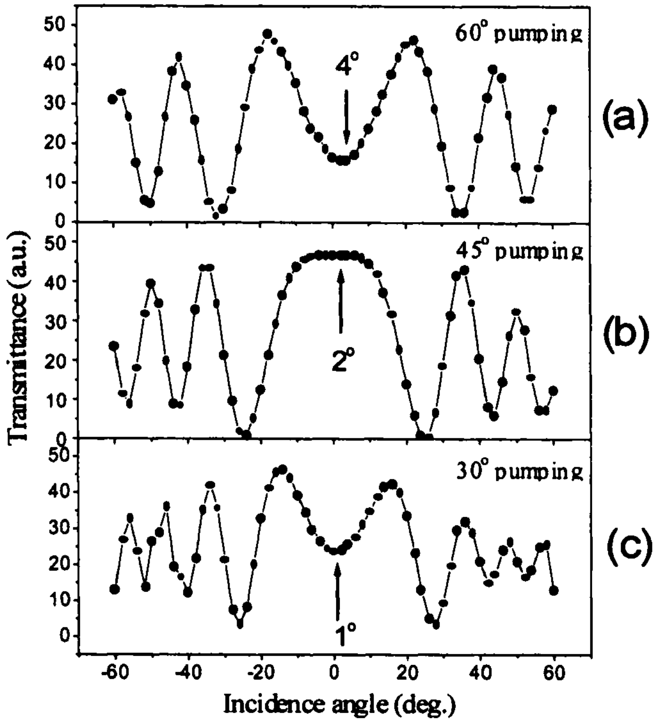

FIGURE 3. Transmission of the liquid crystal cell as a function of incidence angle.

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