Anchoring and Alignment Behavior of Liquid Crystals on Poly(vinyl cinnamate) Thin Films Treated in Various Ways

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One of the most recently developed and important applications of polymers is their use in liquid crystal (LC) alignment layers for LC flat-panel display devices [1-9]. The polymers need to be treated as a thin film if they are to produce a uniform alignment of LC molecules [1-9]. At present, a rubbing process using a fabric is the only technique adopted in the LC display industry to treat PI film surfaces for the mass-production of flat-panel LC display devices [1-5]. This process has become the method of choice because of its simplicity and the controllability with this method of both the LC anchoring energy and the pretilt angle [1-5]. However, this process has some shortcomings, such as dust generation, electrostatic problems, and poor control of rubbing strength, uniformity, and limited applicability to large area. The search for new methods that do not suffer from the shortcomings of the rubbing process has led to the development of several approaches to polymer alignment layer surface treatment based on irradiation of the polymer with linearly polarized ultraviolet light (LPUVL) [6-11]. These techniques have attracted considerable attention in academia and industry because they offer the possibility of rubbing-free production of LC aligning films.

In the present study, we chose poly(vinyl cinnamate) (PVCi) as a model alingnment layer material, and processed its thin films by various combinations of rubbing and LPUVL exposure. The films were investigated in detail in aspects of film surface morphology, polymer chain orientation, LC alignment, and LC anchoring energy.

The 1 wt % chloroform solutions of PVCi were spin-coated onto gold-coated silicon wafers for the atomic force microscopy (AFM) measurement, and onto indium tin oxide (ITO) glasses for optical retardation and LC alignment measurements. The PVCi films coated onto substrates were rubbed using a laboratory rubbing machine (Wande Company). Those films were subjected to UV light irradiation with a linear dichroic polarizer using a high-pressure Hg lamp system equipped with an optical filter, which transmits a band beam of wavelength 260-380 nm. Samples were produced with the combinational matrix of UV exposure and rubbing. The PVCi films were sequentially irradiated with linearly polarized UV light of exposure dose of 0.02, 0.2, and 1.0 J/cm^2, and then rubbed with rubbing density of 50, 100, and 150, respectively, and vice versa. However, the direction of optical axis produced by rubbing was perpendicular to it produced by LPUV exposure. LC cells were prepared as follows. First, paired pieces cut from each glass substrate were assembled together antiparallelly with respect to the rubbing direction, giving antiparallel nematic LC cells. Second, paired pieces from each glass substrate were assembled together orthogonally with respect to the rubbing direction, giving 90 - twisted nematic LC cells. Surface images were obtained using a tapping mode atomic force microscope (Digital Instruments, mode Multimode AFM Nanoscope IIIa). Optical phase retardations were measured using an optical setup described elsewhere [1]; LC alignment was measured using UV spectrometer equipped with one Glan-Laser prism as polarizer. For the TN cells, the azimuthal anchoring energy was measured by using an ultraviolet-visible (UV-vis) spectrophotometer equipped with two Glan-Laser prisms (one a polarizer and the other an analyzer) [1].

All the results will be discussed with the surface nature, chain orientation, and molecular interactions, and lead to a conclusion for the correlation of LC alignment and anchoring energy to the film characteristics.

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