Controllable Pretilt Angles for Liquid Crystal Molecules using a Rubbing Treated Mixture Layer

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We have investigated the continuous pretilt angle generation for liquid crystals using a rubbing treated mixture layer consisting of homogeneous and homeotropic polyimides. Various pretilt angles in the range from 0° to 60° were achieved as a function of the concentration of homeotropic PI. The transmittance characteristics used to measure the pretilt angle showed that the pretilt angles were measured with a high reliability. We observed uniform liquid crystal alignment on the rubbing treated mixture layer.

Keywords: Rubbing, Pretilt angle, Mixture, LC alignment

1. INTRODUCTION

Recently, liquid crystal displays (LCDs) have been widely used in information displays devices such as LCD TVs, notebook computers, monitors, portable devices and etc[1-5]. Amongst the technologies associated with the performance of LCDs, liquid crystal (LC) alignment is the key technology needed to improve the image quality and response time (RT) of LCs. The mechanical rubbing method has been widely used to align LC's in the LCD industry, which generates parallel grooves of about micron size by means of a rubbing roller. The grooves endow LC molecular alignment through the so-called "grooving" mechanism[6]. The rubbing method is suitable for mass production.

Recently studies of fast RT's have been performed by many researchers. The no-bias-bend (NBB) pi cell, operating in the no-bias optically compensated bend (OCB) mode, was a strong candidate for the achievement of fast RT's of LCDs. In order to operate a NBB pi cell, it is essential to have an intermediate pretilt angle[7-9]. Therefore many researchers have studied controllable pretilt angle. The SiO_2 evaporation method is the best available method to generate intermediate pretilt angles[10]. The topological surface structures of SiO_2 made by various deposition conditions can generate intermediate tilting orientations of LC molecules. Numerous alternative methods to alignment with intermediate pretilt angles have been proposed, including rubbed polyimide (PI) with trifluoromethyl moieties[11], a dual alignment layer with PI and poly-dimethylsiloxane (PDMS)[12], and amorphous fluorinated carbon thin film via an ion-beam (IB)[13].

In this paper, we report that the pretilt angle of LCs can be controlled by the use of a rubbing treated mixture layer with homogeneous and homeotropic PIs.

2. EXPERIMENTAL

Commercially available PIs (JSR Co.) were blended in various ratios. The mixtures were deposited uniformly on indium-tin-oxide coated glass substrates using spin coating. The substrates were prebaked at 80°C for 10 min, and then fully baked at 230°C for 1 hr. The thickness of the mixture layer was 50 nm. The PI films were rubbed using a machine equipped with a nylon roller (Y0-15-N, Yoshikawa Chemical Industries Co., Ltd). The definition of the rubbing strength RS was given in previous papers. LC cells were assembled with the antiparallel to rubbing direction in order to measure the pretilt angle and observe the LC alignment characteristics. The commercially available LC E7 (Merck) is sucked into the LC cell through capillary force. The thickness of LC cells was set to 25.0 ± 0.5 mm. The pretilt angle of the LC's on a rubbing treated mixture layer was measured by means of a crystal rotation method at room temperature. In addition, the LC alignment characteristics were observed by photomicrographs.

3. RESULTS AND DISCUSSION

Figure 1 shows the pretilt angle of the LCs on a rubbing treated mixture layer as a function of the concentration of homeotropic PI. For small concentrations of homeotropic PI, the pretilt angle is near zero because the alignment layer is

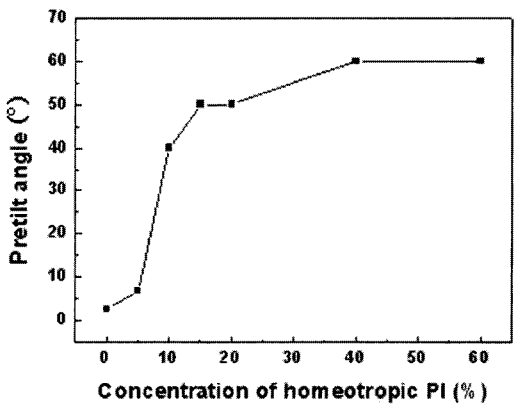

Fig. 1. The pretilt angle of LCs on a rubbing treated mixture layer as a function of the concentration of homeotropic PI.

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composed fully or mainly of the homogeneous orienting PI. At higher concentrations of homeotropic PI, the pretilt angle increases relatively rapidly to ~60° at a 60% concentration of homeotropic PI. Table 1 summarizes the measured pretilt angle as a function of the concentration of homeotropic PI.

Table 1. The Measured pretilt angle of LCs on a rubbing treated mixture layer as a function of the concentration of homeotropic PI.

Concentration of homeotropic PI (%)	Pretilt angle
0	2.51
5	6.8
10	~40
15	~50
20	~50
40	~60
60	~60

Figure 2 shows the transmittance characteristics corresponding to the measured pretilt angle of LCs on a rubbing treated mixture layer by the use of a crystal rotation method. A shift of the symmetric point from zero was measured on a mixture layer. The plots indicating the pretilt angles were measured with a high reliability.

It is important to investigate LC alignment capabilities for LCD applications. Therefore we observed LC alignment characteristics by the use of photomicrographs. Figure 3 shows the photomicrograph of LCs on a rubbing treated mixture layer as a function of the concentration of homeotropic PI (in crossed Nichols). The black states show the uniform alignments in the crossed polarizer and analyzer. Excellent LC alignment textures were observed in all samples subjected to the rubbing treated mixture layer.

4. CONCLUSIONS

In conclusion, we have studied the controllable pretilt angle using a rubbing treated mixture layer with homogeneous

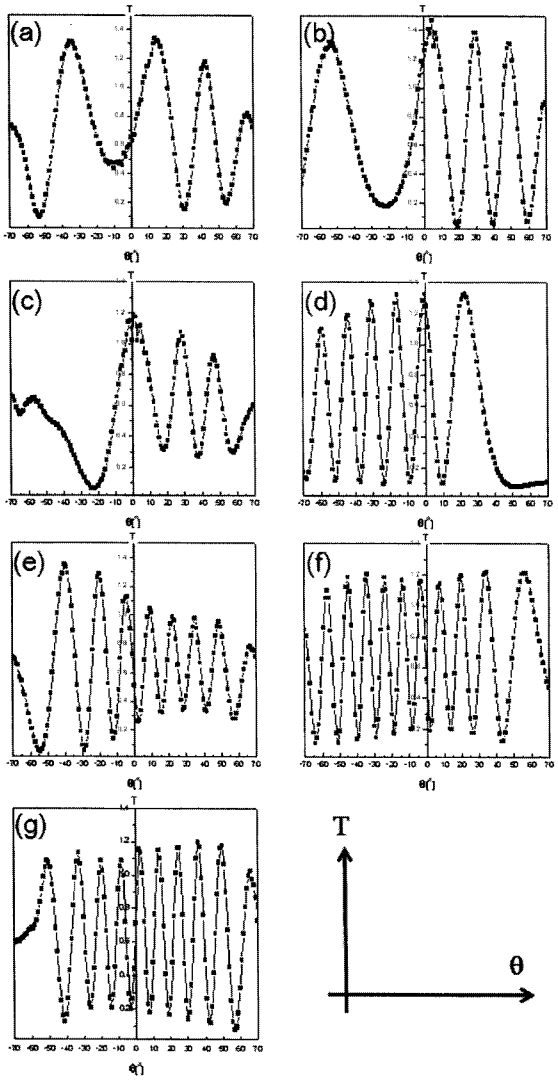

Fig. 2. The transmittance characteristics corresponding to the measured pretilt angle of LCs on a rubbing treated mixture layer obtained by a crystal rotation method.

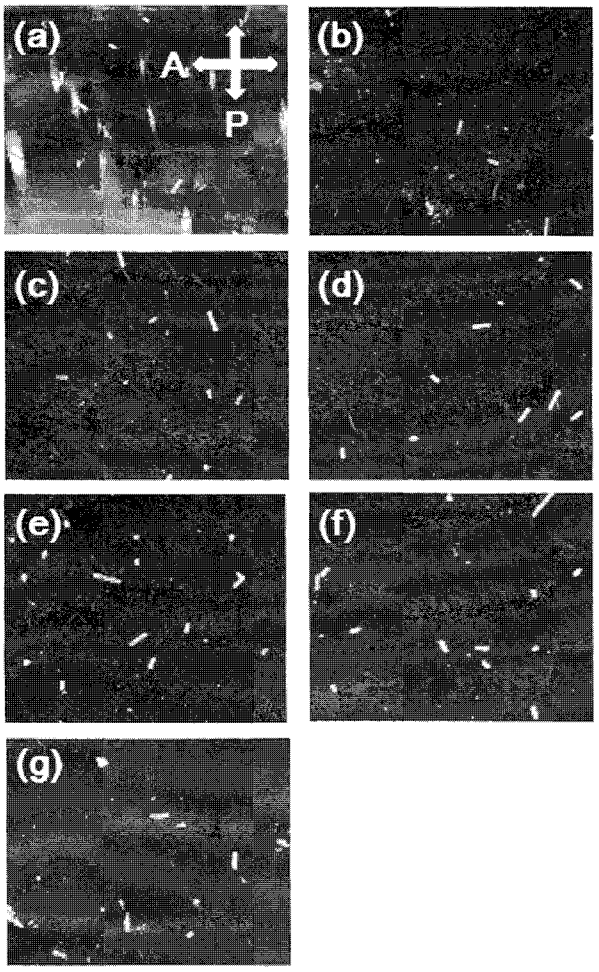

Fig. 3. The photomicrograph of LCs on a rubbing treated mixture layer as a function of the concentration of homeotropic PI (in crossed Nichols).

and homeotropic PIs. Continuous pretilt angles in the range from 0° to 60° were achieved as a function of the concentration of homeotropic PI. The transmittance characteristics corresponding to the measured pretilt angle of LCs on a rubbing treated mixture layer, obtained by means of a crystal rotation method were measured with a high reliability. We also observed uniform LC alignment on the rubbing treated mixture layer.

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