Anchoring Strength Characteristics by the Washing Process after Rubbing on the Polyimide Layers

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Abstract

The polar anchoring strength and surface ordering in a NLC, 4-n-pentyl-4'-cyanobiphenyl (5CB), on a rubbed polyimide (PI) surface containing trifluoromethyl moiety were studied. The large extrapolation length de of 5CB for washing process of water was measured at RS=114 mm. The polar anchoring energy of 5CB on the rubbed PI surface is decreased by the washing process. Also, the polar anchoring energy of 5CB increases with the rubbing strength on the PI surface. The surface ordering of 5CB for all washing processes is smaller than the non-washing process; it is attributed to the washing process.

Key Words : nematic liquid crystal, washing, rubbing, anchoring strength, trifluoromethyl moiety

1. INDUCTION

Recently, thin film transistor (TFT) - liquid crystal display (LCD) are widely utilized for the information display device. The LC alignment mechanism is not understood completely, rubbed polymer surface are widely used as an alignment film in practical applications. TFT-LCD is damaged by the induced electrostatic charges produced during rubbing process. Previously, H. Matsuda et al. reported the induced electrostatic charges and pretilt angle generation of NLC on various rubbed PI surface as a function of rubbing strength[1]. In the practical fabrication of LCDs, the washing process is used to remove the dust and electrostatic charges after the PI surfaces are rubbed.

The LC aligning capabilities and anchoring strength (energy) on treated substrate surfaces have been discussed[2-4]. In this paper, we report the washing effects on the polar anchoring strength and the surface ordering in NLC, 5CB, on rubbed PI surfaces containing trifluoromethyl moiety.

2. EXPERIMENTAL

The molecular structure of the polymer (from Nissan Chemical Industries Co.) used is shown in Fig. 1. The PI films were coated on indium-tin-oxide (ITO) coated glass substrates by spin-coating, and were imidized at 250℃ for 1 hr. The thickness of PI layers was about 500Å. The PI films were rubbed using a machine equipped with a nylon roller (Yo-15-N, Yoshikawa Chemical Industries Co.). The definition of the rubbing strength RS was given in a previous paper[5]. The rubbed PI surfaces were washed after for rubbing. The following washing materials are used: isopropylalcohol (IPA), pure water, and freon. The characteristics of washing materials are amphiphilic, hydrophilic, and hydrophobic, respectively. We used the wet method for 20 min. for the washing process. LC cells were assembled

with the antiparallel to rubbing direction. We measured the anchoring strength by using "high electric-field techniques"[2]. We measured the optical retardation (R) and the electric capacitance (C) as a function of applied voltage (V) in order to determine the polar anchoring strength as shown in Fig. 2. The optical retardation measurement system consists of a polarizer, an acousto-optic modulator, and an analyzer. The output signal is detected by a photodiode. The electric capacitance of the LC cell is obtained by measuring the out-of-phase component of the current produced by changing the voltage which is applied to the cell.

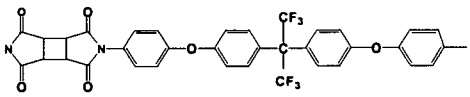


Fig. 1. Chemical structure of the polymer.

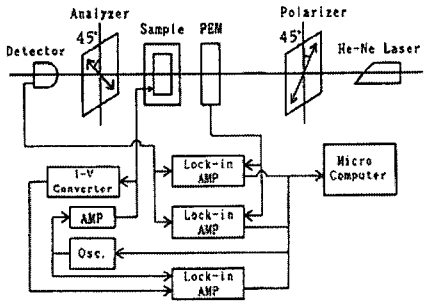
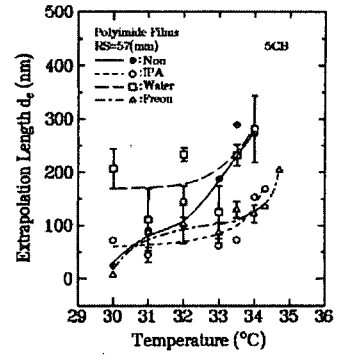


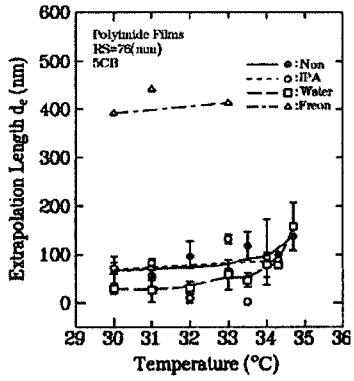
Fig. 2. Measurement system of polar anchoring strength.

3. RESULTS AND DISCUSSION

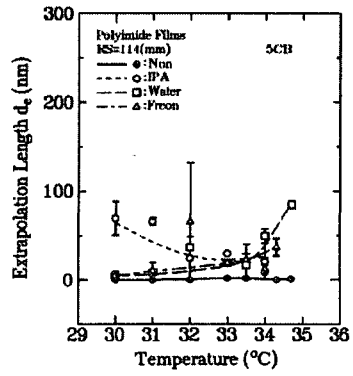
Figure 3 shows the temperature dependence of the extrapolation length d_e of 5CB for non-washing and washing process on the rubbed PI surface containing trifluoromethyl moiety. The extrapolation length d_e of 5CB for non-washing and washing on the rubbed PI surface increases with increasing the temperature.



(a) RS = 57m



(b) RS = 76 mm



(c) RS = 114 mm

Fig. 3. Temperature dependence of the extrapolation length d_e of 5CB for non-washing and washing processes on the rubbed PI surface containing trifluoromethyl moiety.

It is considered that the extrapolation length d_e of 5CB on the rubbed PI surface increased due to the decreasing of surface ordering[2].

Figure 4 shows the extrapolation length d_e of 5CB for non washing and washing processes on the rubbed PI surface containing trifluoromethyl moiety as a function of rubbing strength RS. The extrapolation length d_e of 5CB for non-washing process on the rubbed PI surface at RS=114 mm was obtained about 0, it is indicates the strong anchoring strength. The extrapolation length d_e of 5CB for all washing processes on the rubbed PI surface is larger than the non-washing process. The weak anchoring strength of 5CB for all washing processes on the rubbed PI surface was obtained.

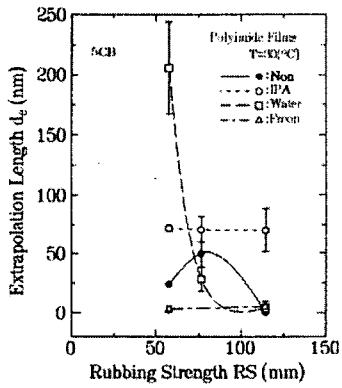
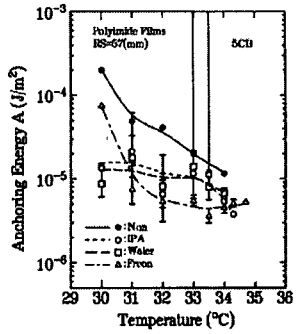
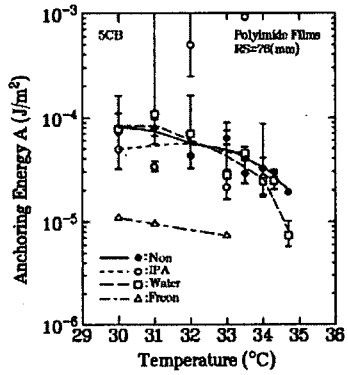


Fig. 4. Extrapolation length d_e of 5CB for non-washing and washing processes on the rubbed PI surface containing trifluoromethyl moiety as a function of rubbing strength RS.

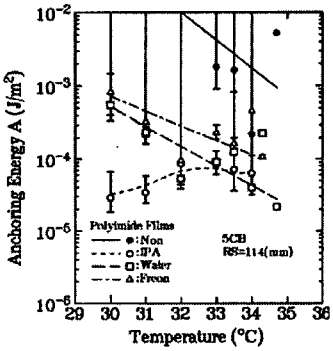
Figure 5 shows the temperature dependence of the polar anchoring energy of 5CB for non-washing and washing process on the rubbed PI surface containing trifluoromethyl moiety. The polar anchoring energy 5CB for non-washing and washing on the rubbed PI surface increases with increasing the temperature. The polar anchoring energy of 5CB for non-washing process on the rubbed PI surface is approximately 1×10-3 (J/m2) at 30℃ as shown in Fig. 5 (c). The polar anchoring energy of 5CB for non-washing process on the rubbed PI surface is larger than the all washing processes at all temperature region.



(a) RS = 57 mm



(b) RS = 76 mm



(c) RS = 114 mm

Fig. 5. Temperature dependence of the polar anchoring energy of 5CB for non-washing processes on rubbed PI surface containing trifluoromethyl moiety.

Figure 6 shows the polar anchoring energy of 5CB for non-washing and washing processes on weakly rubbed PI surface with trifluoromethyl moiety as a function of rubbing strength RS. The polar anchoring energy of 5CB for non-washing process on weakly rubbed PI surface is approximately 2×10^{-4} (J/m2) at RS=57 mm and then increases with increasing the RS. Also, the polar anchoring energy of 5CB is decreased by the washing process; the washing effects are clearly observed.

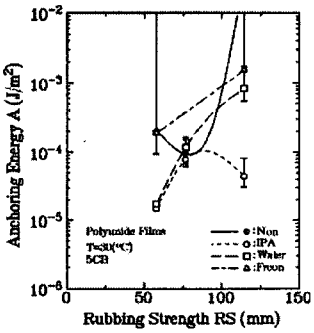


Fig. 6. Polar anchoring energy of 5CB for non-washing and washing processes on the rubbed PI surface as a function of rubbing strength RS.

4. CONCLUSION

In summary, the polar anchoring strength and surface ordering in 5CB by washing process on the rubbed PI surface containing trifluoromethyl moiety were studied. The extrapolation length d_e of 5CB on the rubbed PI surface decreases with the rubbing strength. Also, the large extrapolation length de of 5CB for washing process of IPA was measured at RS=114 mm. The polar anchoring energy of 5CB on the rubbed PI surface is decreased by the washing process ; the washing effects are clearly observed. Also, the polar anchoring energy of 5CB increases with rubbing strength on the PI surface. The surface ordering of 5CB for all washing processes is smaller than the non-washing process; it is attributed to the washing process. Finally, the polar anchoring strength and surface order parameter in 5CB is largely attributed to the washing effects.

ACKNOWLEDGEMENTS

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