Washing Effects on Generation of Pretilt Angle in NLC, 5CB, on a Polyimide Surface with Trifluoromethyl Moieties

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Abstract

The washing effects on pretilt angle generation in a nematic liquid crystal (NLC), 4-n-pentyl-4'-cyanobiphenyl (5CB) on a rubbed polyimide (PI) surface with trifluoromethyl moiety have been successfully studied. The pretilt angle of 5CB is increased by the washing process on the rubbed PI surface. The surface tension on the rubbed PI surface increases with the rubbing strength RS and then saturated above RS=150 mm. The pretilt angle of 5CB for all washing processes on the rubbed PI surface decreases with the surface tension. We have found that the pretilt angle of 5CB on the rubbed PI surface may be attributed van der walls (VDW) dispersion interaction between the LC molecules and the polymer surfaces having trifluoromethyl moieties.

Keywords : washing effect, pretilt angle, nematic liquid crystal, van der walls (VDW)

1. INDUCTION

The uniform alignment of liquid crystals (LCs) on treated substrate surfaces is very important in LC science and technology. Interfacial properties between the LC and the alignment surface are the key to understand the alignment mechanism of LCs. To align LC molecules, unidirectionally rubbed PI surfaces have been widely used, but the detailed mechanism of LC alignment is not yet fully understood. Pretilt angle which is very important step in the alignment process prevents the creation of reverse tilt disclinations in LCDs. High pretilt angle is required in order to prevent the stripe domains in super twisted nematic (STN)-LCD and for the proper operation of optically compensated bend (OCB) mode[1]. Pretilt angle generation of the NLCs by unidirectional rubbing treatment on rubbed PI surfaces was demonstrated by many investigators[2-3]. Previously, we have reported that the generation of high pretilt angle in NLC, 5CB on the rubbed PI surfaces containing trifluoromethyl moieties[4].

In this paper, we report the washing effects on pretilt angle generation in NLC, 5CB on the rubbed PI surface with trifluoromethyl moiety.

2. EXPERIMENTAL

The molecular structures of the polymer used in this study (JSR Co.) are shown in Fig. 1. The precursors were coated on indium-tin-oxide (ITO) coated glass substrates by spin-coating, and imidized at 180oC for 1h. The PI films were unidirectionally 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 previous paper[3]. Sandwich-type cells with a thickness of 60±0.5㎛ were assembled with substrates keeping the rubbing direction antiparallel to each other.

The induced optical retardation on the rubbed PI surface was measured by measurement of optical retardation system[3]. The surface tension of PI film was obtained from the measurement of

contact angles of water and methylene iodide on the PI films. The pretilt angles of the LCs in the nematic phase were measured by the crystal rotation method at room temperature.

3. RESULTS AND DISCUSSION

The induced optical retardation on the PI surface with trifluoromethyl moiety as a function of rubbing strength RS are shown in Fig. 2. The induced optical retardation increases with the rubbing strength RS on the PI surface. The increased optical retardation with the rubbing strength RS on the PI surfaces is attributted to

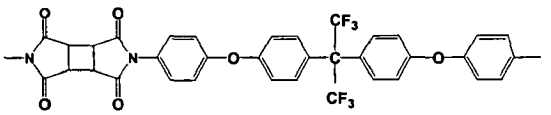

Fig. 1. Molecular structures of the polymers.

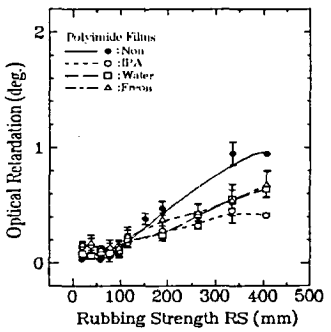

Fig. 2. Induced optical retardation on the PI surface with trifluoromethyl moiety as a function of rubbing strength RS.

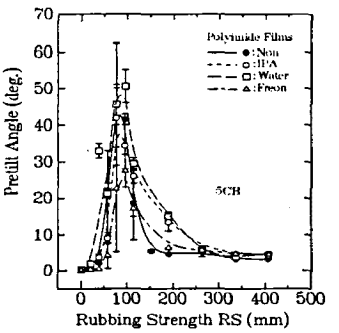

Fig. 3. Pretilt angle of 5CB on the PI surface with trifluoromethyl moiety as a function of rubbing strength RS.

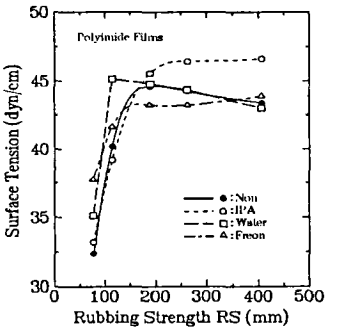

Fig. 4. Surface tension on the PI surface with trifluoromethyl moiety as a function of rubbing strength RS.

increased orientational ordering and streching of polymer chains caused by mechanical stress coming from the rubbing process. The induced optical retardation on for washing process on the rubbed PI surfaces with trifluoromethyl moiety is smaller than the non-washing process.

Figure 5 shows the pretilt angle of 5CB on the PI surface with trifluoromethyl moiety as a function of surface tension. The pretilt angle of 5CB for washing process on the PI surface is larger then the non-washing process, washing effects are cleary observed. Also, the pretilt angle of 5CB decreases with the surface tension. Therefore, the pretilt angles of 5CB may be attributed to van der waals (VDW) dispersion

interactions between the LC molecules and polymer surface having low surface energy. Rubbing treatment is considered to generate obliquely inclined force to the PI surfaces. Before rubbing treatment, the PI chains in the side view and the overview show a zig-zag conformation, and the PI chains in the axial view show a circle conformation[5]. After the rubbing treatment, the expansion of the PI chains in the side and the inclination of zig-zag of PI chains in the overview is shown. The generation of micro-scopic asymmetric triangles may be origin of the pretilt angle. Therefore, the pretilt angle may be caused by the combination of VDW dispersion and the steric interaction between the LC molecules and the polymer surface containing trifluoromethyl moieties.

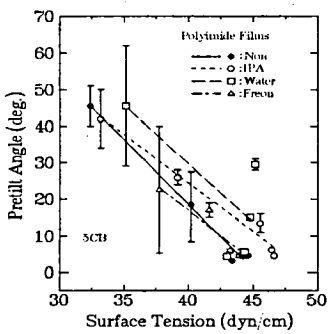

Fig. 5. Pretilt angle of 5CB on the PI surface with trifluoromethyl moiety as a function of surface tension.

4. CONCLUSION

In conclusion, the washing effects on pretilt angle generation in NLC, 5CB on the rubbed PI surface with trifluoromethyl moiety have been successfully studied. The induced optical retardation is decreased by the washing process on the rubbed PI surface. We have found that the pretilt angle of 5CB is increased by the washing process on the rubbed PI surface. The surface tension on the rubbed PI surface increases with the rubbing strength RS and then saturated above RS=150 mm. Finally, the pretilt angle of 5CB for all washing processes on the rubbed PI surface decreases with the surface tension. Therefore, the pretilt angle of 5CB on the rubbed PI surface may be attributed to the VDW dispersion interaction between the LC molecules and the polymer surfaces.

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