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Polythiophene막을 이용한 네마틱액정의 배향효과

Alignment effects of the nematic liquid crystal on polythiophene Surfaces

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Abstract

The high pretilt angles in nematic liquid crystals (NLCs) have been generated on rubbed polythiophene (PTP) surfaces with alkyl chain lengths. The pretilt angle of the NLC was observed on unidirectionally rubbed PTP surfaces with alkyl chains with more than 9 carbon atoms. We obtained the pretilt angle of 1 5~40° on rubbed PTP surfaces with 10 carbon atoms in the alkyl chain. Also, the pretilt angles of 65~80° of NLC were obtained on rubbed PTP surfaces with 11 and 12 carbon atoms in the alkyl chain. We suggest that this high pretilt angle generation in NLC is due to the surface-excluded volume effect by the alkyl chain lengths between the LCs and the PTP surfaces. Finally, we conclude the odd-even effect on rubbed PTP surfaces is clearly contributed to the pretilt angle generation.

1. Introduction

The uniform alignment of the LCs on substrate surfaces is very important in LCD technology. Rubbed polyimide (PI) surfaces have been widely used to align LC molecules in industrial applications, but the detailed mechanism of this alignment is not yet fully understood. Nowadays, uniform alignment of LCs with a high pretilt angle is very important for the proper operating super-twisted nematic LC displays (STN-LCD). The pretilt angle generation in NLC on various alignment layers by unidirectional rubbing was demonstrated and discussed by many investigators.

Previously, H.Yokokura et al. have shown the odd-even effect of the alkyl chain length on pretilt angles of LC on rubbed PI surfaces.[1] The high pretilt angles in NLC were observed on rubbed PI surfaces with even-number of carbon atoms in the alkyl chain length. Also, the odd-even effect for pretilt angles and orientational order of LCs on rubbed PI surfaces were measured by D.Johannsmann et al. using surface optical second harmonic generation (SHG) and birefringence measurements.[2] They demonstrated that PI surfaces with even-numbers of carbon atoms in the alkyl side chain are smoother and capable of inducing high surface order for 8CB surface layers.

In this paper, we report the generation of high pretilt angles of 4-n-pentyl-4-cyanobiphenyl (5CB) on rubbed PTP surfaces with varying alkyl chain lengths by rubbing treatment technique.

2. Experimental

The PTP films were synthesized by electrochemical polymerization using acetonitrile as the solvent and ClO_4 of electrolytes as counter ions. To obtain a good quality film, 1% water was added to the solvent. The molar ratio of the electrolyte and thiophene was 4:3 in this system. The molecular structure of thiophene is shown in Fig. 1. R is the alkyl chain length and used R's are as follows:

R1 : CH_3; R2 : C_2H_5; R3 : C_3H_7; R4 : C_4H_9 ;
R5 : C_5H_{11}; R6 : C_6H_{13}; R7 : C_7H_{15}; R8 : C_8H_{17} ;
R9 : C_9H_{19}; R10 : $C_{10}H_{21}$; R11 : $C_{11}H_{23}$; R12 : $C_{12}H_{25}$

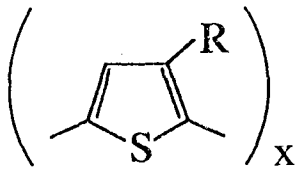

Fig. 1 Molecular structure of thiophene.

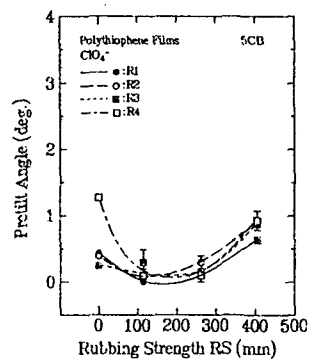

Fig. 2 Dependence of the rubbing strength on the pretilt angle of 5CB on rubbed PTP surfaces with alkyl chain length;
(a) R1~R4; (b) R5~R8; (c) R9~R12.

During the polymerization process, the temperature of the solution was maintained at 0°C, and the current density was set at about 0.63 (mA/cm^2) and was applied for 40sec.

The PTP films were rubbed using a machine equipped with a nylon roller. In previous paper, we reported the definition of the rubbing strength (RS). LC cells were assembled with the antiparallel to rub direction. The LC layer thickness was set at $60\pm0.5\mu$m. Pretilt angles were measured by the crystal rotation method for values up to 10° and the magneto capacitive null method was used for values above 10°, and all the measurements were done at room temperature (22 °C).

3. Results and Discussion

Fig. 2 (a) and (b) show the dependence of the rubbing strength on the pretilt angle of 5CB on rubbed PTP surfaces for alkyl chains of R1~R4 and R5~R8, respectively. It is clear that the pretilt angle of 5CB is very small for all these chains of R1~R8. We believe that the effect due to the alkyl chain length is very small at these alkyl chain lengths. The pretilt angles of 5CB on rubbed PTP surfaces with alkyl chain of R9~R12 as a function of rubbing strength is shown in Fig. 2 (c). For the alkyl chain with R9, pretilt angle increases with the RS, and saturates at about 5°. The high pretilt angles of 5CB were observed for the alkyl chains with R10. The pretilt angle of 5CB is about 38° at RS=0mm, and then decreases with the RS. We observed by microscopic photographs a non uniform alignment at RS=0mm, and then starts showing uniform alignment at RS=100mm. The measured pretilt angle is about 25° at medium RS region (RS=100~300mm) and does not vary much. We believe this pretilt angle about 25° is very suitable for SSFLCD applications. Also, high pretilt angle about 70~80° of 5CB were observed on surfaces with alkyl chains R11 and R12. This alignment of LC is almost like the homeotropic structure. We suggest that this high pretilt angle of 5CB on these rubbed PTP surfaces are due to the contribution of surface-excluded volume effect by the alkyl chains between the LCs and the PTP surfaces. In Fig. 2 (c), the odd-even effect is clearly visible. It is clear that the pretilt angle of

5CB on rubbed PTP surfaces with alkyl chains with even-numbers of carbon atoms is larger compared to that on surfaces with alkyl chains with odd-number of carbon atoms. Therefore, we suggest that the odd-even effect on rubbed PTP surfaces is clearly contributed to the high pretilt angle generation.

4. Conclusions

We investigated the high pretilt angles in NLC have been generated on rubbed PTP surfaces with longer alkyl chain lengths. We obtained pretilt angles of 25 degrees on these surfaces with 10 carbon atom in the alkyl chain and it is stable for medium values of RS. We suggest that this high pretilt angle generation of NLC is due to the surface-excluded volume effect by the alkyl chain lengths between the LCs and the PTP surfaces. Finally, we conclude that the odd-even effect on rubbed PTP surfaces is clearly contributed to the generation of high pretilt angle.

References

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