폴리이미드 표면에서의 프리틸트각 발생에 대한 UV조사 조건과 이미드화온도의 영향

Effects of UV light irradiation condition and imidization temperature for the generation of pretilt angle on polyimide surfaces

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Abstract

We have investigated the effects of ultraviolet (UV) light irradiation condition and imidization temperature for the generation of pretilt angle in nematic liquid crystal (NLC) on the two kinds of the polyimide (PI) surfaces. High pretilt angle of NLC is generated with oblique p-polarized UV light irradiation of 30° on PI surface for 20 min. Also, the high pretilt angle of NLC is generated with oblique p-polarized UV light irradiation of 10-30° on PI surface at 20min. The pretilt angle of NLC decreases with increasing the imidization temperature on all rubbed PI surfaces ; the pretilt angle of NLC with oblique p-polarized UV light irradiation of 30° on PI surface decreases with increasing the imidization temperature. The high pretilt angle of NLC is observed due to high photo-depolymerization reaction by low surface energy at low imidization temperature. We suggest that the pretilt angle of NLC is strongly attributed to the photo-depolymerization reaction with the UV light irradiation condition and imidization temperature.

1. Introduction

Commercially available liquid crystal displays (LCDs) are mainly monodomain displays. The successful operation of LCDs requires uniform alignment and controlled pretilt of LCs on substrate surfaces. The pretilt angle prevents creation of reverse tilted disclinations in twisted nematic (TN)-LCD. LCDs with the pretilted homogeneous LC alignment are prepared by using the rubbed PI surfaces. However, this method creates several problems, such as generation of electrostatic charges and dust.[1] Recently, the photo-alignment method for LC alignment is expected to achieve the high resolution LCDs; Gibbons et al. have reported the new method for LC alignment by using polarized laser light. Also, recently the LC alignment by polarized UV light irradiation on PI surface has been reported by some researchers.[2-6] Recently, Yamamoto et al. have reported the LC alignment in a cell with oblique irradiation of non-polarized UV light on PI surface.[10] The generated pretilt angle of NLC is about 0.8° on PI surface with side chains. However, this pretilt is not enough to avoid reverse tilted disclinations in a TN-LCD. Most recently, we reported the pretilt angle generation in NLC with oblique non-polarized UV light irradiation on PI surface; it is successfully observed to about 3° .[4] The detailed mechanism of LC alignment by photo-alignment method has not been understood yet.

In this study, we report that the effects of UV light irradiation condition and imidization

condition of PI in pretilt angle generation for NLC on two kinds of the PI surfaces.

2. Experimental

In this study, we used the two kinds of the polymer materials as follows:

PI-A : with side chain (from Japan Synthetic Rubber Co., Ltd.)
PI-B : without side chain (from Nissan Chemical Industries Co., Ltd.).

The PI films were coated on indium-tin-oxide (ITO) coated glass substrates by spin-coating, and were imidized at 180℃ (PI-A) and 250℃ (PI-B) for 1 hr, respectively. The thickness of PI layers was about 500Å. The definition of the rubbing strength, RS was given in previous papers.[6] The oblique polarized UV light (power : 1kW) irradiation system is shown in Fig. 1. The substrates were irradiated by using UV light at a wavelength of 365nm. To measure the pretilt angle, the LC was assembled in sandwich-type

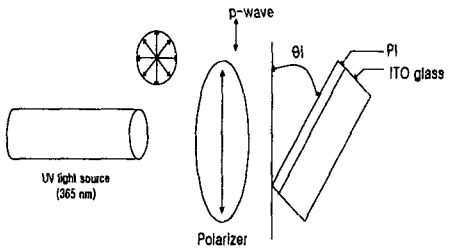

Fig. 1. A schematic diagram of oblique polarized UV light irradiation system.

cells with anti-parallel UV light irradiation direction. All the sandwich-type cells had LC layer thickness of 60㎛. After assembly, the cells were filled with fluorinated mixture type NLC (T_c=87° C) in the nematic phase ; and then the cells were annealed in the isotropic phase for 15 min. The LC orientation capability was evaluated by optical microscopic textures and generation of pretilt angles. To measure pretilt angles, we used the crystal rotation method and measurements were done at room temperature.

3. Result and discussion

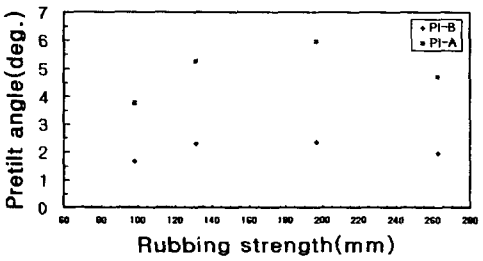

Fig. 2. Generation of pretilt angle in NLC on two kinds of the rubbed PI surface as a function of RS.

Figure 2 shows the generated pretilt angle of NLC on two kinds of the PI surface. The observed pretilt angle of NLC is about 6° on rubbed PI-A surface with side chain; it is very stabilized at wide RS region. The rubbing gives rise to a unidirectional alignment of NLC and asymmetric triangular structure of PI surface. The pretilt angle of NLC is attributed to the steric interaction between the LC molecules and the polymer surfaces. However, the pretilt angle of NLC increases with increasing the RS on rubbed PI-B surface without side chain. Previously, we reported that the pretilt angle of 5CB increases with increasing the RS on rubbed PI surface without side chain; same results are observed.[7]

Figure 3 shows the generation of pretilt angle of NLC with oblique p-polarized UV light irradiation on two kinds of PI surface for 20 min. as a function of incident angle. The pretilt angle of NLC increases with increasing the incident angle up to 30° ; peak point is observed at 30° . And then, the pretilt angle of NLC decreases with increasing the incident angle above the 30° . The high pretilt angle of NLC is observed with oblique p-polarized UV light irradiation of 30° on PI surfaces for 20 min.

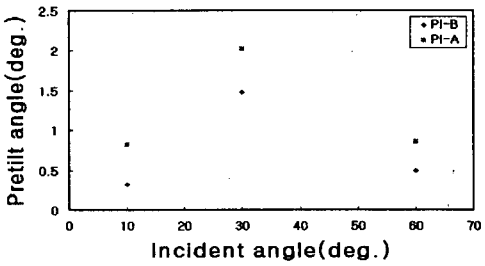

Fig. 3. Generation of pretilt in NLC with oblique p-polarized UV light irradiation on two kinds of PI surface for 20min. as a function of incident angle.

Recently, we observed the high pretilt angle of NLC is generated with oblique p-polarized UV light irradiation of 70° on PI surfaces for 30 min.[17] The high pretilt angle of NLC is attributed to the irradiation angle and irradiation time of UV light.

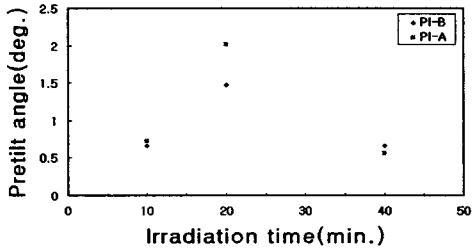

Fig. 4. Generation of pretilt angle in NLC with oblique p-polarized UV light irradiation on two kinds of PI surfaces as a function of irradiation time.

The generation of pretilt angle in NLC with oblique p-polarized UV light irradiation on two kinds of PI surfaces as a function of irradiation time is shown in Fig. 4. It is shown that the pretilt angle of NLC increases with increasing the irradiation time up to 20 min. for incident angle of 10° and 30° ; peak point is observed at 20 min. However, the pretilt angle of NLC decreases with increasing the irradiation time above 20 min. It is considered that the pretilt angle of NLC is increased due to increase of photo-depolymerization reaction up to 20 min; however, the pretilt angle of NLC is decreased due to more photo-depolymerization above 20 min. A similar behaviors are reported and discussed by some researchers.[2,5] The pretilt angle of NLC is decreased due to more polar surface for long irradiation time of UV light on PI surface.

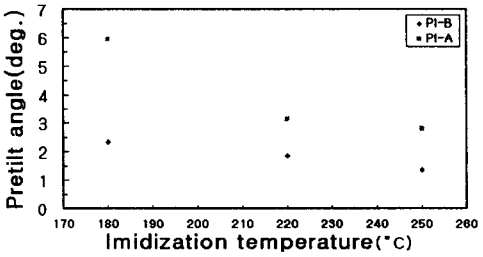

Fig. 5. Pretilt angle of NLC in cells on two kinds of the rubbed PI surface as function of imidization temperature.

Figure 5 shows the generation of pretilt angle of NLC in cells on two kinds of the rubbed PI surface as a function of imidization temperature. The pretilt angle of NLC decreases with increasing the imidization temperature on rubbed PI-A surface with side chain; it may be attributed to the high surface energy. However, the pretilt angle of NLC is almost same in all imidization temperature on rubbed PI-B surface without side chain. In LCD production, the stability of pretilt angle of NLC is required for wide imidization temperature. Previously, we reported that the pretilt angle of 5CB increases with increasing the imidization temperature on rubbed PI surface containing thiophenylene moieties; it is attributed to more crystallinity of rubbed PI above the imidization temperature of 250℃. Therefore, the pretilt angle of NLC on rubbed PI surface with different imidization temperature depends on the PIs.

The pretilt angle of NLC in cells with oblique polarized UV light irradiation of 30° on two kinds of PI surfaces for 20 min. as a function of imidization temperature is shown in Fig. 6. The pretilt angle of NLC decreases with increasing

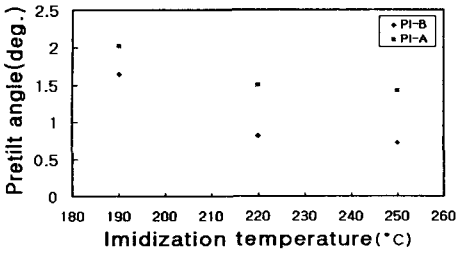

Fig. 6. Pretilt angle of NLC in cells with oblique polarized UV light irradiation of 30° for 20min. as a function of imidization temperature.

the imidization temperature on two kinds of rubbed PI surfaces at RS=200 mm. The high pretilt angle of NLC may be generated due to high photo-depolymerization reaction with low imidization temperature. The generation pretilt angle of NLC is attributed to the photo-depolymerization reaction by changing the imidization temperature. The behaviour of generation of pretilt angle in NLC with UV light irradiation on PI surface is almost same on rubbed PI surfaces. The generated high pretilt angle of NLC on all rubbed PI surface at imidization temperature of 190℃ is strongly attributed to the low surface energy of PIs; the pretilt angle of NLC is attributed to photo-depolymerization reaction with UV light irradiation condition and imidization temperature on PI surface.

4. Conclusion

In a summary, we obtained that the high pretilt angle of NLC is observed with oblique p-polarized UV light irradiation of 30° on PI surface for 20 min. Also, the high pretilt angle of NLC is generated with oblique p-polarized UV light irradiation of 10-30° on PI surface at 20 min. The pretilt angle of NLC decreases with increasing the imidization temperature on rubbed PI surfaces ; also, the pretilt angle decreases with increasing the imidization temperature with oblique p-polarized UV light irradiation of 30° on PI surface at 20 min. The high pretilt angle of NLC is observed due to high photo-depolymerization reaction and low surface energy at low imidization temperature.

Acknowledgement

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