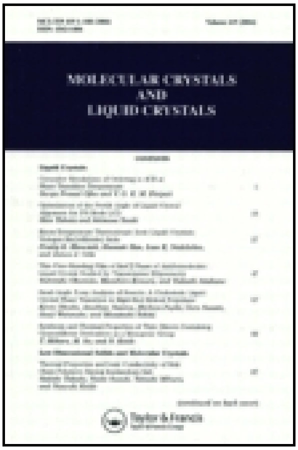

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Control of High Pretilt Angle for Nematic Liquid Crystal on Homeotropic Alignment Layer by In-situ Photoalignment Method

Yong-Je Jeon [a], Jeong-Yeon Hwang [a], Dae-Shik Seo [a], Sang-Hee Nam [b] & Jeong-In Han [c]

[a] Dept. of Electrical and Electronic Eng.(C-724), College of Eng., Yonsei University, Seodaemoon-ku, Seoul, Korea

[b] Medical Image Research Center, Inje University, Kimhae, Kyungnam, Korea

[c] Display Research Center, Korea Electronics Technology Institute, Pyungtaek-shi, Kyunggi-do, Korea

Version of record first published: 18 Oct 2010

To cite this article: Yong-Je Jeon, Jeong-Yeon Hwang, Dae-Shik Seo, Sang-Hee Nam & Jeong-In Han (2004): Control of High Pretilt Angle for Nematic Liquid Crystal on Homeotropic Alignment Layer by In-situ Photoalignment Method, Molecular Crystals and Liquid Crystals, 412:1, 269-275

To link to this article: http://dx.doi.org/10.1080/15421400490439905

Mol. Cryst. Liq. Cryst., Vol. 412, pp. 269/[1879]–275/[1885], 2004

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400490439905

Taylor & Francis
Taylor & Francis Group

CONTROL OF HIGH PRETILT ANGLE FOR NEMATIC LIQUID CRYSTAL ON HOMEOTROPIC ALIGNMENT LAYER BY *IN-SITU* PHOTOALIGNMENT METHOD

Yong-Je Jeon, Jeong-Yeon Hwang, and Dae-Shik Seo
Dept. of Electrical and Electronic Eng.(C-724), College of Eng., Yonsei University, 134 Shinchon-dong, Seodaemoon-ku, Seoul 120-749, Korea

Sang-Hee Nam
Medical Image Research Center, Inje University, Kimhae, Kyungnam 621-749, Korea

Jeong-In Han
Display Research Center, Korea Electronics Technology Institute, 455-6 Masan-ri, Jinwi-Myon, Pyungtaek-shi, Kyunggi-do 451-860, Korea

Pretilt angle generation and liquid crystal (LC) aligning capabilities for a nematic (N) LC with obliquely polarized UV exposure on a homeotropic polyimide (PI) surface by an in-situ photoalignment method were studied. The high pretilt angle of 30θ for NLC with obliquely polarized UV exposure on the PI surface for 20 min can be achieved. The pretilt angle generated in NLC by the in-situ photoalignment method was higher than that generated by a conventional photoalignment method on a homeotropic alignment layer. Also, we suggest that the generation of pretilt angle in NLC with obliquely polarized UV exposure during imidization of the polymer for homeotropic alignment is a promising method to generate a high pretilt angle. Lastly, the good electro-optical (EO) characteristics of the photoaligned vertical alignment (VA)-liquid crystal display (LCD) by UV exposure on the PI surface for 10 min were observed.

Keywords: homeotropic alignment; *in-situ* photoalignment method; nematic liquid crystal; photodissociation; polyimide; pretilt angle

This work was supported by National Research Laboratory program (M1-0203-00-0008).
Address correspondence to Dae-Shik Seo, Dept. of Electrical and Electronic Engineering (C-724), College of Engineering, Yonsei University, 134 Shinchon-Dong, Seodaemoon-Ku, Seoul 120-749, Korea.

INTRODUCTION

Liquid crystal displays (LCDs) are now widely investigated for their promising application in large-size and high-quality image displays. Most LCDs with pretilted homogenous LC alignment are prepared using rubbed polyimide (PI) surfaces [1]. However, rubbing causes electrostatic charges and dust [2]. Thus, a rubbing-free method for LC alignment is required for the fabrication of a LCD. LC aligning capabilities for NLC using a photodissociation method on a PI surface for homogeneous alignment have been reported recently by many researchers [3–6]. Also, LC alignment effects for NLC using a photodissociation method on a PI surface for homeotropic alignment have been reported [7,8].

Most recently, the LC alignment and pretilt angle generation using the *in-situ* photoalignment method on a PI surface for homogeneous alignment have been reported [6]. The *in-situ* photoalignment method produces a higher thermal stability of LC alignment than that produced using the conventional photoalignment method. However, the pretilt angle using an *in-situ* photoalignment method was smaller than that using the conventional photoalignment method on the PI surface for homogeneous alignment. The effect of the NLC pretilt angle generated using the *in-situ* photoalignment method on the PI surface for homeotropic alignment has not yet been reported.

In this study, we report the generation of a high pretilt angle and LC alignment using the *in-situ* photoalignment method with obliquely polarized UV exposure of the PI surface of homeotropic alignment. Also, EO performances of the photoaligned VA-LCD with UV exposure on the PI surface are studied.

EXPERIMENTAL

In this experiment, the polymer (JALS-696-R2, for homeotropic alignment from JSR Co.) was used. The polymers were uniformly prepared by spin coating on indium-tin-oxide (ITO) electrodes. The polymers used for the conventional photoalignment method were soft-baked at 100°C for 10 min and baked at 180°C for 1 h. The thickness of the PI layer was set at 500 Å. The polymer surfaces were exposed to oblique UV at a wavelength of 365 nm [6]. The energy density of UV used was 15.5 mW/cm^2. In the *in-situ* photoalignment method, polymers were exposed to obliquely polarized UV during imidization at 150°C. A cell was fabricated as a sandwich type, and the thickness of the cell was 60 μm. After fabricating the cell, a mixture of negative type NLC ($\ni H = -3.8$, MJ951294 from Merck Co.) was injected to the isotropic phase. LC cells were cooled to room temperature. Also, the LC layer for the photoaligned VA-LCD was a 4.25 μm. NLC is used in negative dielectric anisotropy (∋H = −3.8, MJ951294 from Merck Co.). The pretilt angles of the NLC were measured using the crystal-rotation method at room temperature. The voltage-transmittance and response time characteristics for the photoaligned VA-LCD were measured by DMS (Display Measurement system, from Autronic Co.) equipment.

RESULTS AND DISCUSSION

Figure 1 shows NLC pretilt angles with obliquely polarized UV exposure of the PI surface for 20 min as a function of incident angle. It is shown that the pretilt angle generated in NLC increases with increasing incident angle. The peak of the pretilt angle was observed at an incident angle of 30θ. When the incident angle was more than 30θ, the pretilt angle tended to decrease with increasing incident angle. It was also observed that the pretilt angle of NLC generated using the conventional photoalignment method was smaller than that generated using the *in-situ* photoalignment method. On the basis of these results, we can consider that the *in-situ* photoalignment method is sufficient to generate a high pretilt angle. This is because the *in-situ* photoalignment method induces a photodissociation reaction during imidization of polymers, and in this case, the surface layer of polymers is not stabilized. However, in the conventional photoalignment

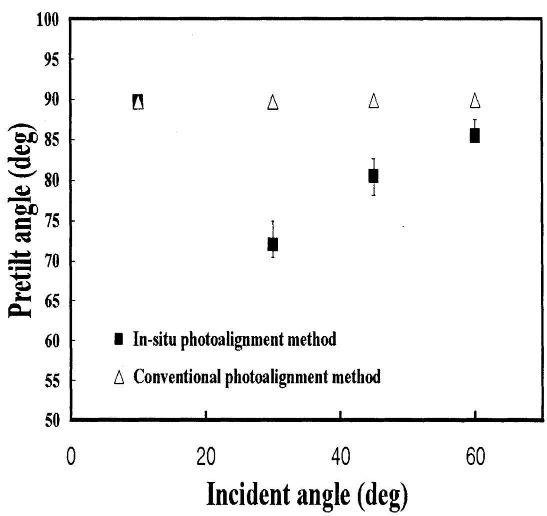

FIGURE 1 NLC pretilt angles with obliquely polarized UV exposure of the PI surface for 20 min as a function of incident angle.

method, the PI surface is exposed to UV light after imidization of the polymers at 180°C, and the surface layer of polymers is stabilized.

Figure 2 shows the NLC pretilt angles with obliquely polarized UV exposure of 30° on the PI surfaces as a function of UV exposure time. Using the *in-situ* photoalignment method, the pretilt angle of NLC exhibited an immediate sharp increase with increasing exposure time until 20 min, at which a peak was observed. When the exposure time was more than 20 min, the pretilt angle tended to decrease. It is considered that the energy density from UV exposure for 20 min is adequate to generate high pretilt angles. Also, the imidization of the PI using the *in-situ* photoalignment method is sufficient above the UV exposure time of 40 min. On the other hand, the tilt angle of NLC generated using the conventional photoalignment method was 90 θ for all UV exposure time. From these results, it is evident that the *in-situ* photoalignment method is more reliable in generating high pretilt angles of NLC than the conventional photoalignment method.

Figure 3 shows the microphotographs of aligned NLC using the *in-situ* photoalignment method with obliquely polarized UV exposure of 30° on the PI surfaces for homeotropic alignment. Large disclinations of NLC were observed for all UV exposure time. The alignment of NLC decreases with increasing *in-situ* UV exposure time. Also, the uniform alignment of NLC

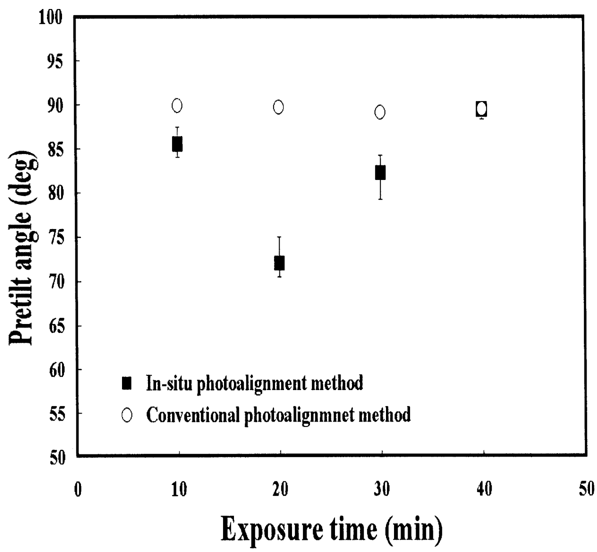

FIGURE 2 NLC pretilt angles with obliquely polarized UV exposure of 30° on the PI surfaces as a function of UV exposure time.

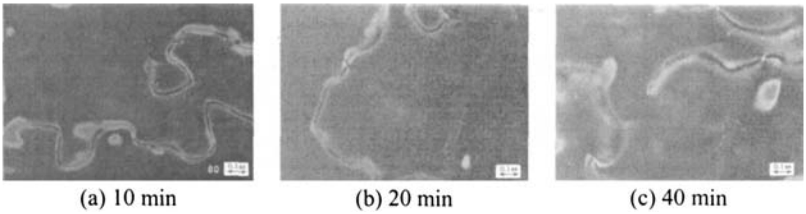

FIGURE 3 Microphotographs of aligned NLC using the *in-situ* photoalignment method with obliquely polarized UV exposure of 30° on the PI surfaces for homeotropic alignment.

using the conventional photoalignment method with UV exposure of 30 θ on the PI surface for 20 min was observed. However, the disclinations of NLC with UV exposure on the PI surfaces for 0 min and 40 min were observed. We consider that the LC aligning capabilities of NLC are more influenced by photodissociation reaction above the UV exposure time of 40 min. Therefore, we suggest that the UV energy using the conventional photoalignment method on the PI surface of homeotropic alignment is sufficient to obtain the monodomain alignment.

Figure 4 shows the V-T curves of the photoaligned VA-LCDs with oblique UV exposure using *in-situ* photoalignment method on the PI surface.

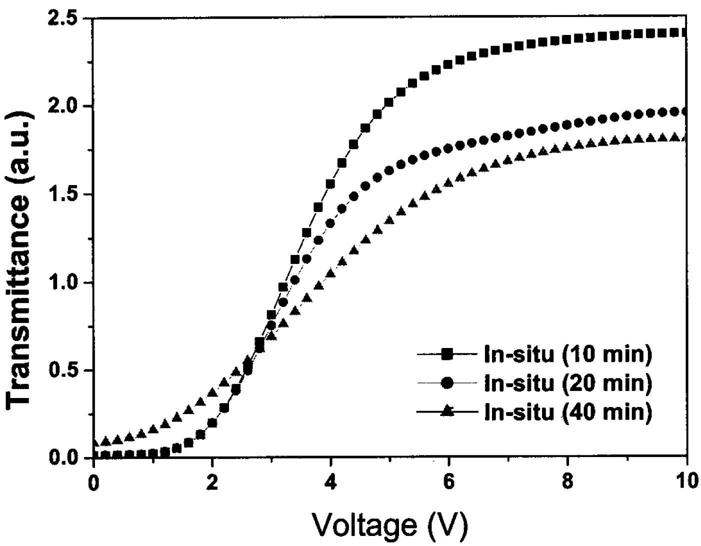

FIGURE 4 V-T curves of the photoaligned VA-LCDs with oblique *in-situ* exposure on the PI surface.

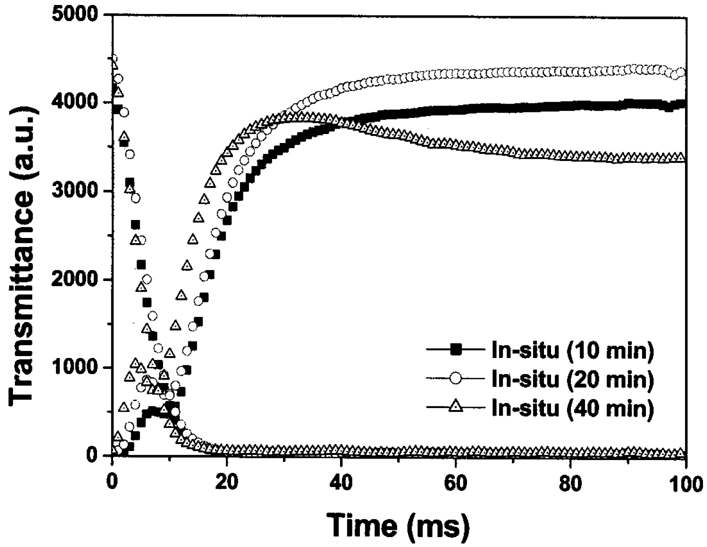

FIGURE 5 Response time characteristics of the photoaligned VA-LCDs with oblique *in-situ* exposure on the PI surface.

An excellent V-T curve can be achieved in the photoaligned VA-LCD using *in-situ* photoalignment method on the PI surface for 10 min.

Figure 5 shows the response time characteristics of the photoaligned VA-LCD with *in-situ* UV exposure on the PI surface. A good curve for the photoaligned VA-LCD was obtained using the *in-situ* photoalignment method on the PI surface for 10 min and 20 min as shown in Figure 5. However, it reveals that the tansmittance in the photoaligned VA-LCD on the PI surface for 40 min exposure time decreases as increasing time. Therefore, after applied voltage in the LC cell, transmittance of LC cell was not maintained, and was decreased as operation time. This results affect to decrease of display performance.

CONCLUSION

In this study, we investigated the LC aligning capabilities for NLC using the *in-situ* photoalignment method with obliquely polarized UV exposure of the PI surface for homeotropic alignment. Also, EO performances of the photoaligned VA-LCD were studied using an *in-situ* photodimerization method on the PI surface. The pretilt angle generated in NLC using the *in-situ* photoalignment method was higher than that generated using the conventional photoalignment method. Also, we suggest that the control of high pretilt angle in NLC with obliquely polarized UV exposure during imidization of the polymer for homeotropic alignment is a promising method to generate high pretilt angle. Finally, the good EO characteristics of the photoaligned VA-LCD by *in-situ* UV exposure on the PI surface for 10 min can be achieved.

REFERENCES

[1] Seo, D.-S., Araya, K., Yoshida, N., Nishikawa, M., Yabe, Y., & Kobayashi, S. (1995). *Jpn. J. Appl. Phys. 34*, L503.
[2] Matsuda, H., Seo, D.-S., Yoshida, N., Fujibayashi, K., Kobayashi, S., & Yabe, Y. (1995). *Mol. Cryst. Liq. Cryst. 264*, 23.
[3] Hasegawa, M. & Taira, Y. (1994). IDRC' 94 Digest paper, *213*.
[4] Nishikawa, M., Taheri, B., & West, J. L. (1998). SID' 98 Digest paper, *131*.
[5] Lee, K.-W., Lien, A., Stathis, J. H., & Paek, S.-H. (1997). *Jpn. J. Appl. Phys. 36*, 3591.
[6] Seo, D.-S., Kim, H.-K., & Jeon, H.-J. (2000). *Liq. Cryst. 27*, 1189.
[7] Yoshida, H., Seino, T., & Koike, Y. (1997). *Jpn. J. Appl. Phys. 36*, L1449.
[8] Seo, D.-S., Kim, H.-K., & Jeon, H.-J. (2001). *Liq. Cryst. 28*, 313.