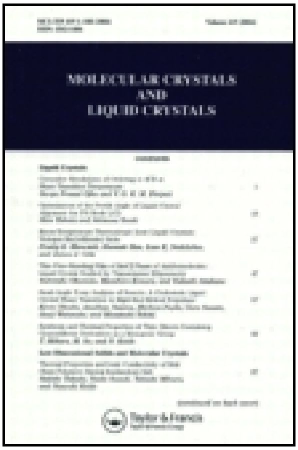

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Orientation of Liquid Crystal Molecules on a Photoreactive Polymer Alignment Layer

Byung-Hyun Lee [a], Sie-Hyug Choi [a], Yang-Kook Kim [b] & Kigook Song [a]

[a] Department of Chemical Engineering, Kyung Hee University, Yongin, Kyunggi-do, Korea

[b] LG Cable Co., Anyang, Kyunggi-do, Korea

Version of record first published: 04 Oct 2006

To cite this article: Byung-Hyun Lee, Sie-Hyug Choi, Yang-Kook Kim & Kigook Song (1998): Orientation of Liquid Crystal Molecules on a Photoreactive Polymer Alignment Layer, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 316:1, 197-200

To link to this article: http://dx.doi.org/10.1080/10587259808044490

Mol. Cryst. Liq. Cryst., 1998, Vol. 316, pp. 197–200
Reprints available directly from the publisher
Photocopying permitted by license only

Published by license under
the Gordon and Breach Science
Publishers imprint.
Printed in India.

Orientation of Liquid Crystal Molecules on a Photoreactive Polymer Alignment Layer

BYUNG-HYUN LEE[a], SIE-HYUG CHOI[a], YANG-KOOK KIM[b], and KIGOOK SONG[a]
[a]Department of Chemical Engineering, Kyung Hee University, Yongin, Kyunggi-do, Korea; [b]LG Cable Co., Anyang, Kyunggi-do, Korea

In order to elucidate the alignment mechanism of liquid crystal molecules on a photosensitive polymer surface, orientations of polymer molecules in the alignment layer and of liquid crystal molecules in the cell prepared using this polymer layer were measured with UV irradiation time. Our findings suggest that the liquid crystal alignment is induced through intermolecular interactions between polymer and liquid crystal molecules.

Keywords: liquid crystal; polymer alignment layer; photoreactive polymer

INTRODUCTION

Liquid crystal displays (LCD) have stimulated a tremendous amount of research interest in the past decade as a replacement for the cathode ray tube in applications where weight, volume, and power consumption are important. One of the key technical points for successful LCD production is to develop a new liquid crystal alignment method since the current rubbing technique has a problem of producing a narrow-viewing angle and causes electrical and mechanical damages to the underlying thin-film transistors. Recently, liquid crystal (LC) alignment on photo-sensitive polymer films has been studied as an alternative LC alignment method which is a promising technique for the future LCD fabrication process due to its non-contact nature and the possibility of producing a multi-domain structure. However, the mechanism of LC molecule alignment on a polymer surface has not been yet sufficiently understood. Two speculations are suggested as an induction mechanism of LC alignment: surface topology effects and intermolecular interaction effects between LC and polymer molecules. In the present study, we measured both orientations of polymer molecules in the alignment layer and of LC molecules in the LC cell prepared using this alignment layer. The correlation between the orientation changes of polymer and LC molecules with light irradiation was investigated to elucidate the LC alignment mechanism.

EXPERIMENTAL

The photoreactive polymer used in this study was poly(vinyl fluoro cinnamate) (PVCN-F) which was synthesized by LG Cable Co. and the nematic liquid crystal of Merck ZLI-3449 (T_{NI} = 85 °C) was used for preparation of the LC cell. The birefringence of the PVCN-F alignment layer (100 nm thick) on a glass plate was measured following Senarmont method using He-Ne laser, two polarizers, and a quarter wave plate.[1] The parallel-aligned LC cell was constructed using two PVCN-F coated glass plates. 5 μm thick glass spacers were used to create the cell gap and the LC was injected into the cell by capillary action. The cell was cleared at 85 °C, and was sealed with UV-curable epoxy. The optical transmission of the LC cell between the crossed polarizer and analyzer was measured using the configuration shown in Figure 1. With an Oriel 75155 mechanical chopper and EG&G Model 5209 lock-in amplifier, the phase sensitive detection was achieved. The crossed polarizers had an extinction ratio greater than 10^5 and thus the intensity transmitted by the crossed polarizers was negligible compared to the lowest LC cell transmission measurement.

RESULTS AND DISCUSSION

PVCN-F films were spin-coated and dried on a glass plate, and were exposed

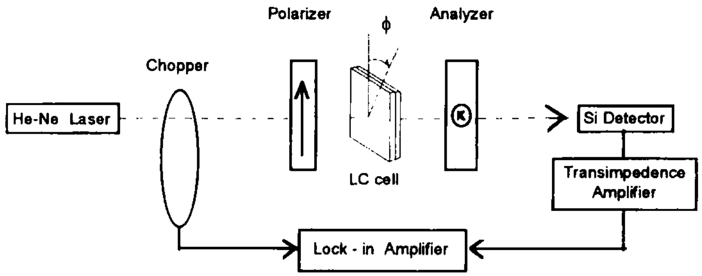

FIGURE 1. Optical transmission measurement set-up

to a linearly polarized UV light using a Glan-Laser polarizer and a 500 W high pressure mercury lamp. The photochemical reaction in side chain cinnamate groups of PVCN-F is a well known [2+2] cycloaddition reaction of cinnamoyl groups. Prior to the linearly polarized UV exposure, the polymer chains are isotropically distributed in the film. Since irradiated linearly polarized UV light is selectively absorbed by PVCN-F molecules whose side chain cinnamate group is parallel to the polarization direction of the UV light, these PVCN-F molecules are preferentially dimerized and resulting in the anisotropy in the polymer film after the UV exposure.[2]

Such anisotropy in the PVCN-F film can be easily verified by observing the birefringence changes of the polymer film with UV irradiation time. Figure 2 shows a time variation of the optical retardation of the PVCN-F film induced by a linearly polarized UV irradiation. The changes of birefringence were monitored using a He-Ne laser of which the absorption of the laser light in the PVCN-F film was negligible. It is shown that the birefringence of the PVCN-F film increases with irradiation time, and saturates after 20 seconds exposure of the UV light. This finding indicates that the polymer molecules are oriented through the photo-dimerization by absorbing linearly polarized UV light.

In order to find out if such orientation changes of the polymer molecules are related to the orientations of LC molecules, LC cells were prepared using these UV irradiated polymer films as alignment layers. The alignment of LC molecules in the cell was evaluated by measuring the transmitted light intensity through the LC cell. Transmitted intensity (I) for a birefringent plate between crossed polarizers is given by (see Figure 1)

$$I = E^2 \sin^2 2\phi \sin^2 (\delta /2)$$

where ϕ is the angle between the extraordinary axis and polarizer, and δ is the optical phase difference.[3] The ratio of minimum to maximum intensity for any δ can be given by I(0°)/I(45°). This ratio is zero for perfectly aligned liquid crystals and is unity for completely random alignment of LC domains. Thus, this ratio was used as a parameter representing the alignment of LC molecules in the cell. As shown in Figure 3, LC alignment strength of the PVCN-F layer increased with UV irradiation time and saturates after 20 seconds exposure of the UV light. This finding exactly coincides with the result of the orientation of PVCN-F molecules shown in Figure 2. It can be, therefore, concluded that the orientation changes of polymer molecules in the alignment layer induce the orientation of LC molecules on top of the polymer surface through intermolecular interactions.

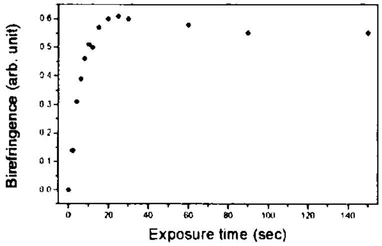

FIGURE 2. Birefringence of PVCN-F film with UV exposure time

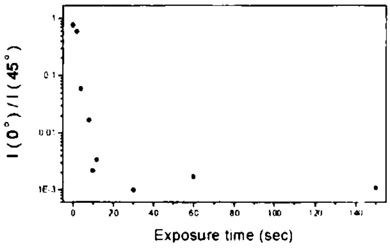

FIGURE 3. Effects of exposure time on LC cell alignment

Acknowledgments

This study was supported by the academic research fund of the Ministry of Education, Republic of Korea.

References

[1.] E. S. Lee, P. Vetter, T. Miyashita, and T. Uchida, *Jpn. J. Appl. Phys.*, **32**, 1339 (1993).
[2.] B. Lee, S. Ham, J. Lim, and K. Song, *Polymer(Korea)*, **21**, 1059 (1997).
[3.] M. Born and E. Wolf, in *Principle of Optics, 5th Ed.* (Pergamon Press, New York, 1975), p. 694.