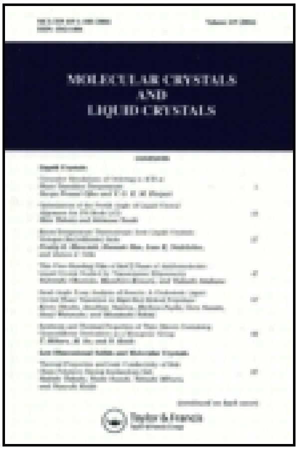

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Application of Photo-Alignment Techniques to AntiFerroelectric Liquid Crystal Cell

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APPLICATION OF PHOTO-ALIGNMENT TECHNIQUES TO ANTIFERROELECTRIC LIQUID CRYSTAL CELL

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The photosensitive polyimide (PI) films containing chalcone derivative [4-n-propyl-4-(3-propylene hydroxide)chalcone] induced orientation of liquid crystal, which aligned perpendicular to the polarization direction. The anisotropy of alignment layer was induced by irradiating linearly polarized UV(LPUV). The changes at surface by irradiating of UV light were measured by SPR. The photoaligned films were applied for the alignment of antiferroelectric liquid crystal (AFLC) molecules, which needed planar alignment. By measuring the dielectric constants of AFLC molecules on the alignment layer, the changes at the AFLC molecules – alignment layer interface were investigated.

Keywords: AFLC; chalcone derivatives; LPUV; photoalignment technique; polyimide; SPR

I. INTRODUCTION

The merits of ferroelectric liquid crystal (FLC) molecules and antiferroelectric liquid crystal (AFLC) molecules, such as fast response time, wide viewing angle, and memory effect make ferroelectric liquid crystal devices (FLCD) and antiferroelectric liquid crystal devices (AFLCD) as an alternative display devices [1]. FLC molecules in SmC* have a layer structure and are tilted in a regular angle to each layer forming a helicoidal structure with a pitch through layer by layer. It is difficult to make well-aligned FLC cells, so, good alignment of layers and a planar alignment of FLC are need. In order to make uniformly aligned AFLC cell without defects, many researches

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have been tried efforts such as application of electric field [2], the application of magnetic field [3], and controlling temperature [4]. Especially aligning of AFLC is affected by cell fabrication conditions such as cooling rate and applying DC voltage.

In this experiment we tried to apply photoalignment technique to AFLC, and investigated the effect of linearly Polarized UV (LPUV) when the cell was irradiated by LPUV light after cell fabrication. Dielectric constant of alignment materials was very important point which decides the alignment of liquid crystals. Thus the changes of interfaces can be studied sensitively by using SPR (Surface plasmon resonance). The changes of structure of alignment layer surface have important role to control the liquid crystal molecules on surface of alignment layer. Especially some kinds of liquid crystal molecules can have a rule on the surface, so the effect of surface can be of consequence. The changes of the surface of the alignment layer were also investigated by SPR.

II. EXPERIMENT

Preparation of Alignment Layer

The molecular structures of the materials used in this experimental is shown in Figure 1. The chalcone attached polyimide (DOCDA/DAP/Chalcone) film was used as an alignment layer.

Polyimide

4 wt% DOCDA/DAP/Chalcone[5-2,5-dioxotetrahydrofuryl]-3-methyl-3-1, 2dicarboxylic anhydride/1,4-diaminophenol/4-n-propyl-4-(3-propylene hydroxide) chalcone] solution in 1-Methyl-2-pirrolidone (NMP) were spin-coated at 4000 rpm on glass slides for cell fabrication, quartz for UV/Vis. spectra, Si-wafer for FT-IR spectra, and ITO glass for AFLC cell fabrication. Coated films were cured at 250°C for 10 min.

Irradiation of LPUV

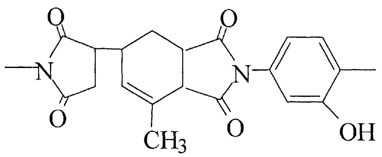
The prepared substrates were irradiated by high pressure mercury lamp equipped with Glan-Thompson polarizer. The power density at the film surfaces was kept at 10 mW/cm^2. The UV light was exposed at the right angle.

Spectroscopy

The UV absorption, and FT-IR absorbance of alignment layer were obtained by using HP8452 UV Spectrometer and Nicolet Magna IR Spectrometer. To investigate the morphological effect of the surface on aligning liquid crystal, AFM images were obtained. The surface plasmon resonance (SPR)

* DOCDA/DAP

[5-2,5-dioxotetrahydrofuryl]-3-methyl -3-cyclohexene-1,2-dicarboxylic anhydride /1,4-diaminophenol]



* Chalcone

4-n-propyl-4-(3-propylene hydroxide) chalcone

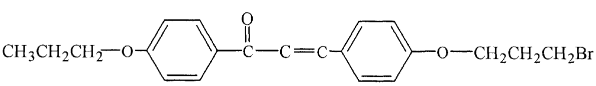


FIGURE 1 DOCDA/DAP [5-2,5-dioxotetrahydrofuryl]-3-methyl-3-cyclohexene-1,2-dicarboxylic anhydride/1,4-diaminophenol]Chalcone 4-n-propyl-4-(3-propylene hydroxide) chalcone.

spectroscopy was used to observe the changes of the surface, dielectric and reflective index anisotropy.

Cell Fabrication

Two ITO coated glass substrates with the alignment layer were assembled parallel for a liquid crystal cell. The cell gap was maintained 2 μm for AFLC cells by PET film, 5 μm for nematic liquid crystal cells, and 50 μm for pretilt angle measurement. And then they were fixed with UV curable adhesive (Hernon manufacturing Inc.). Liquid crystals were injected by capillary effect at isotropic temperature to avoid flow effect.

Confirmation of Alignment

The polar diagram of the LC cells containing dichroic dye was obtained. The dichroic dye (violet, Merck) had strong absorption at 522 nm.

III. RESULTS AND DISCUSSION

Figure 2 shows IR absorption of DOCDA/DAP/Chalcone film. The finger print region in IR spectra obtained before and after linearly polarized (LP)

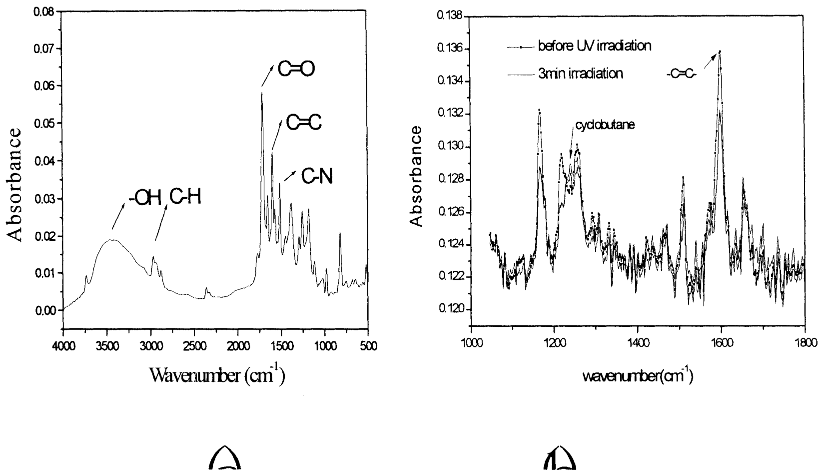
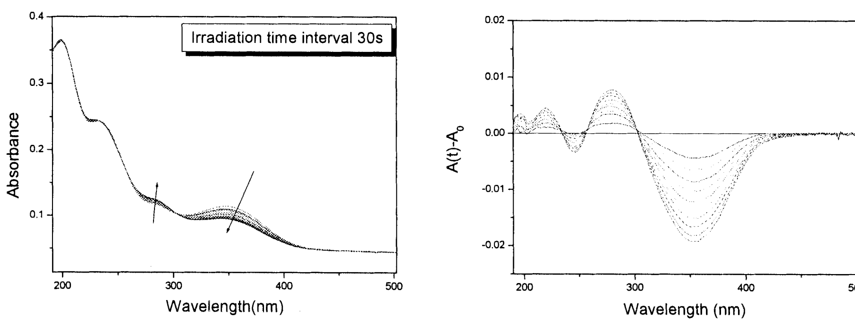


FIGURE 2 FT-IR spectra (a) peak assignment of DOCDA/DAP/Chalcone, (b) the spectra obtained before and after irradiation of UV light.

UV irradiation, clearly indicates that the molecular structure of chalcone derivative has been modified during photo irradiation.

The photoreaction of the films was also confirmed in UV absorption spectra as shown Figure 3. Changes in the UV absorbance of films at the 340 nm show that the photoreaction of chalcone was completed with in 20 min. Surface morphology of films was monitored (Fig. 4).

AFM images indicate the morphologic changes of DOCDA/ DAP/Chalcone film.



(a) (b)

FIGURE 3 UV/Vis spectra change; (a) DOCDA/DAP/Chalcone, and (b) difference.

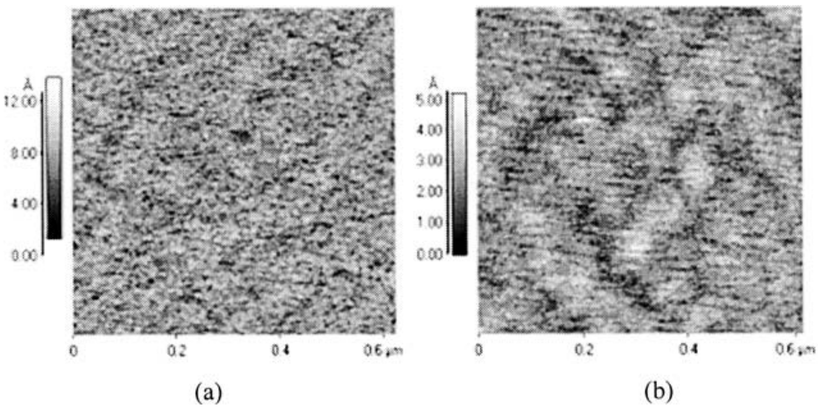


FIGURE 4 AFM images or DOCDA/DAP/Chalcone (a) before irradiation and (b) after irradiation.

The dielectric anisotropy and reflective index anisotropy of alignment layer were observed. The properties of alignment layers were measured the resonance angle by SPR spectroscopy parallel and perpendicular to the irradiation directions (Fig. 5). In this paper Δ means the difference of the results ($\perp$-//).

The LC cells were fabricated with the DOCDA/DAP/Chalcone film. Figure 6 shows the polar diagram of the cell obtained at the absorption peak of the dichroic dye. The direction of LC molecules was uniformly aligned perpendicular to polarization direction of irradiated light.

The LC alignment properties of the films with chalcone derivatives were observed from the texture of nematic LC cells with cross polarized microscope (ΠoJIaM JI-213).

Figure 7 shows microphotographs of nematic LC (BL001, Merck) cells with the alignment layer between crossed polarizers. The angle (ϕ) between the direction of one of crossed polarizer and the x direction of the nematic LC cell was set at 0° (left) and 45° (right). The homogeneous alignment of LC molecules is observed with good contrast (Fig. 7).

It is well known that the AFLC alignment is affected by cell fabrication condition, and treatment. In order to investigate the effect of cooling rate on AFLC alignment, cells were cooled down from isotropic state to SmC*a via SmA at the rate of 10, and 1°C/min. The texture of AFLC cells was shown in Figure 8. The rapid cooled cells with cooling rate of 10°C/min showed no clear patterns (Fig. 8(a)). The larger aligned domain was observed at the slower cooled cell (Fig. 8(b)). The effect of UV exposure as an after treatment was also presented (Fig. 8(c)). UV exposure as an

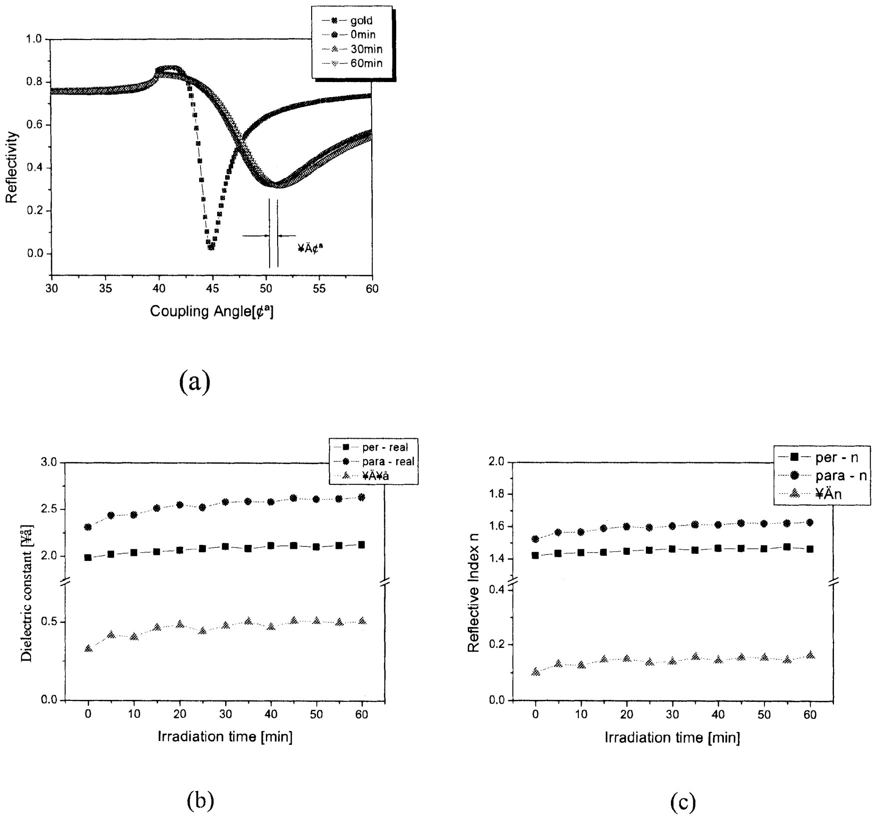


FIGURE 5 (a) Calculating the changes of dielectric constants from SPR coupling angle difference, (b) Dielectric constants of LPUV irradiated PI film and (c) Refractive index of LPUV irradiated PI film.

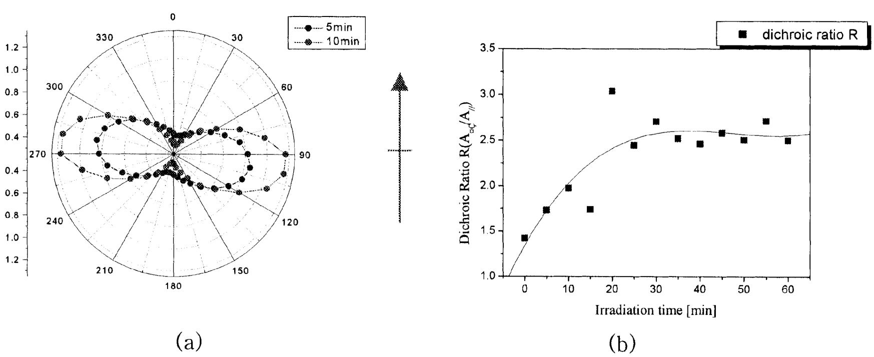


FIGURE 6 (a) Polar diagram of LC cell aligned by DOCDA/DAP/Chalcone, and (b) Dichroic ratio R of LC cells.

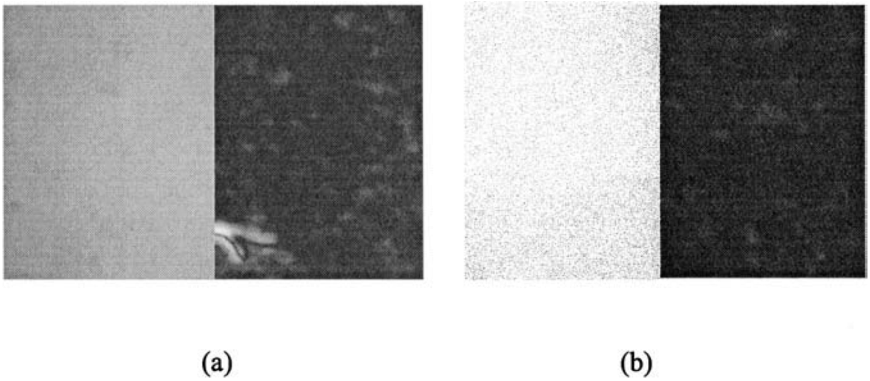


FIGURE 7 Polarized microphotographs of a nematic LC (BL001, Merck) cell with alignment layer contained chalcone derivatives irradiated with LPUV light (left for $\phi = 0^\circ$ and right for $\phi = 45^\circ$) (a) without applying voltage, (b) applying DC.

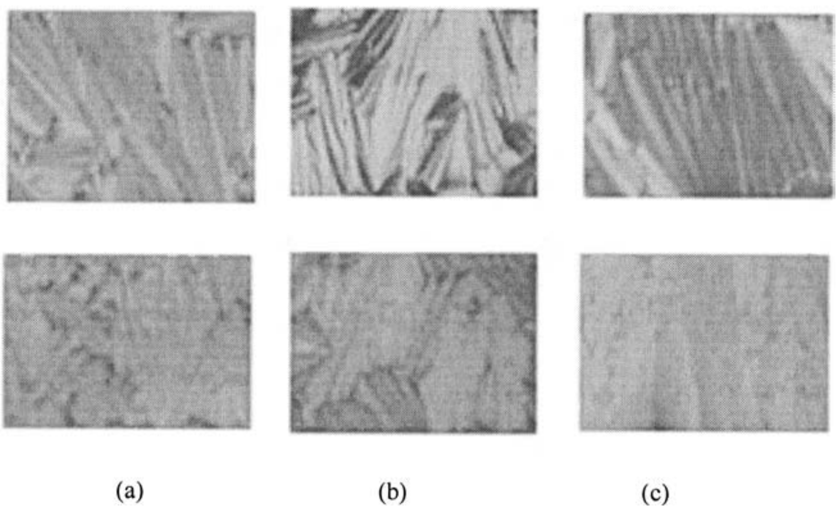


FIGURE 8 Texture of AFLC (a) 10 °C/min, (b) 1 °C/min, (c) After UV exposure.

after treatment increases the aligned domains. The cell was irradiated with LPUV at 100°C for 30 min.

The application of low pretilt angle photoalignment layer for the development of well aligned AFLC cells, and the effect of irradiation UV light after cell fabrication are under investigation.

IV. CONCLUSION

The alignment of nematic liquid crystal molecules and AFLC molecules in the cells with DOCDA/DAP/Chalcone by irradiating LPUV were studied. To investigate the orientation of the liquid crystal molecules, the polar diagram were obtained. LC molecules were aligned perpendicular to the polarization direction of UV light. The dielectric and reflective index anisotropy were observed by SPR. This indicates that the unreacted chalcone determines the orientation of liquid crystal molecules. The photoreaction was completed within 20 min at 10 mW/cm^2.

AFLC cell showed some defects, however, the alignment of AFLC cell was enhanced by controlling the cooling rate and post-UV treatment.

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