# 38.3: Photochemical Reaction on the Polymer Layer for Liquid Crystal Display

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## Abstract

*Polyimide containing the chalcone moiety is expected to show the high photodimerization rate and stable alignment characteristics. We introduced the chalcone moiety as a side chain into the polyimide backbone to apply to the photo-alignment layer. The photochemical reaction with the tilted incident light produced out-of-the plane orientation of chalcone side chain. The orientation effects align the LC in LCD, which possesses the various pretilt angles depending on the length of side chains.*

## 1. Introduction

The chalcone derivatives have been known to dimerize efficiently[1]. The polyimides are employed for the dielectric layers in microelectronic devices, since they have the low dielectric constant, high thermal stability and good mechanical properties[2-5]. Especially, PI films have also been widely used as liquid crystal (LC) alignment layers because they are inert to the liquid crystal and provide excellent and stable LC alignment quality with high anchoring energy. Polyimide containing the chalcone structure is expected to show the high photodimerization rate and stable alignment characteristics.

We introduced the chalcone moiety as a side chain into the polyimide backbone to apply to the photo-alignment layer. Some chalcone moieties, which did not react under photo-irradiation, were oriented perpendicular to the polarization direction. The angle between polymer surfaces and irradiation angle produced out-of-the plane orientation of chalcone side chain. The two orientation effects align the LC in LCD, which possesses the tilt angle of LC. In our work, we designed the new photo-reactive polyimides containing the chalcone moiety to apply to the LC cell. To understand the effect of the difference of structure, we synthesized the various kinds of polyimides, which have the different alkyl chain length and the content of chalcone moiety respectively.

## 2. Experiments and Results

Photocrosslinkable polyimide was prepared via one-step imidization reaction of DOCDA (5-(2,5-dioxotetrahydro furyl)-3-methyl-3-cyclohexene-1,2-dicarboxylic anhydride) and the chalcone introduced diamine using isoquinoline (5 wt%) in *m*-cresol. The structure of the synthesized polyimide is depicted in figure 1. The polyimide solutions were spin-coated onto the quartz, silicone wafer and ITO-coated glass substrates and the obtained thin films were irradiated obliquely with linearly polarized UV light. After assembling these two ITO-coated glass substrates, we injected the nematic LC (ZLI-3449, Merck) and FLC (FelIX-

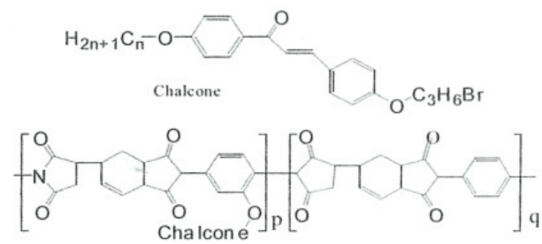


Figure 1. Structure of the photo-reactive polyimides

015/100, clariant) for the measurement of pretilt angles and the observation of the alignment properties in FLC cell respectively.

To make sure these materials align liquid crystal molecules actually, the birefringence was measured as a function of the angle of rotation for the DC8 PI film exposed to LPUV. Figure 2 shows that the birefringence of DC8 film increases drastically upon exposure time and is induced to the direction perpendicular to the polarization axis. This result is consistent with the previous FT-IR study.

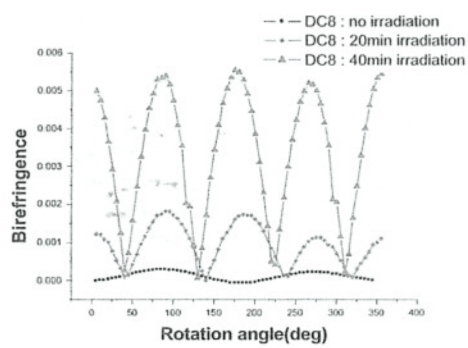


Figure 2. The angular dependence of the optical anisotropy for the LPUV irradiated DC8 film.

In the competition test photoalignment with rubbing technique, we observed that the UV-exposure perpendicular to the rubbing direction enhanced the birefringence as shown in figure 3 but the UV-exposure parallel to the rubbing direction showed the opposite sign to that of the previous case after the 20 minute exposure. This means that the photoalignment overcomes the optical anisotropy caused by rubbing treatment and induces the new alignment.

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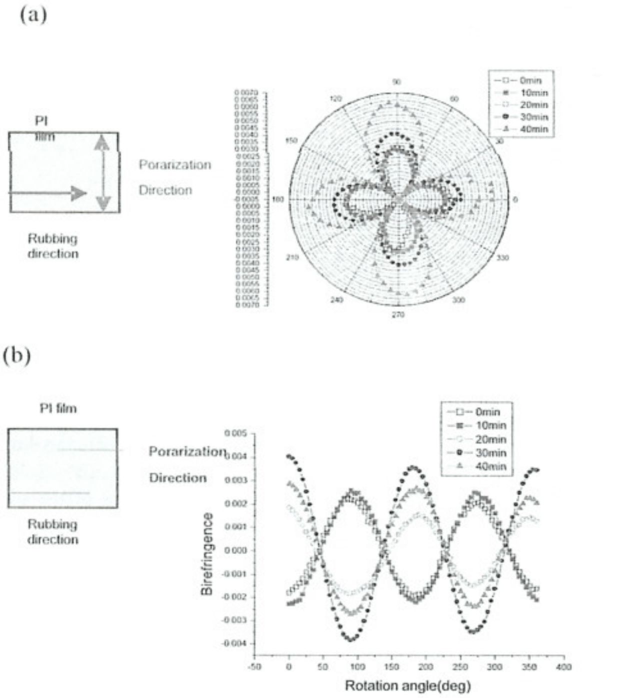


Figure 3. Birefringence as a function of the rotation angle of the sample

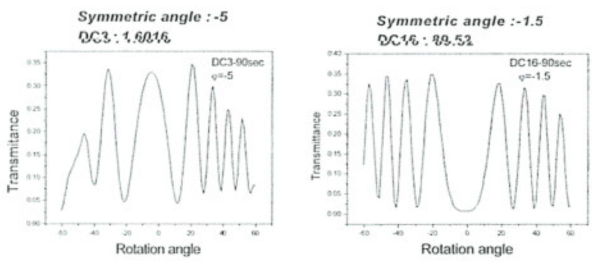


Figure 4. Pretilt angles of LC cells (DC3 and DC16)

To understand the effect of the number of carbon in chalcone moiety on pretilt angle, we fabricated the LC cells with polyimides having the various length of chalcone moiety and measured the pretilt angles by crystal rotation method. As shown in figure 5, the pretilt angles are 1-2° for DC3 and 90° for DC16, but those for the other polyimides were not obtained. It is believed that the pretilt angles of these polyimides (DC8 and DC12) are out of range as much as possible by crystal rotation method. Short alkyl chain of DC3, that is, induces a low pretilt angle and planar alignment. Instead, the alignment layers have the high pretilt angles under the increasing number of carbon in chalcone moiety. Also we studied the influence of the content of the chalcone moieties on the pretilt angle. Figure 5 shows the conoscopic image of LC cells fabricated with DC12(p). The cross points in conoscopic images, which presents the optical axis of an LC, moves to the center as the pretilt angle becomes higher [7]. From the first row, the textures of untreatment, rubbing and LPUV-exposed LC cells are arranged. Before some treatments, the cells of much content of chalcone moieties have high pretilt angles. By rubbing, the pretilt angle have a tendency to decrease, but the cell of DC12(100) shows the uniform vertical alignment with LPUV-exposure. In generally, the pretilt angles become higher in proportion to the content of chalcone moieties. In order to get a high pretilt angle, photo-alignment technique is needed. We applied theses polyimides to align FLC (FelIX-015/100, clariant). We observed that the similar uniformity was obtained in both photo-alignment and rubbing technique. The alignment properties however become worse on increasing the content of chalcone moieties.

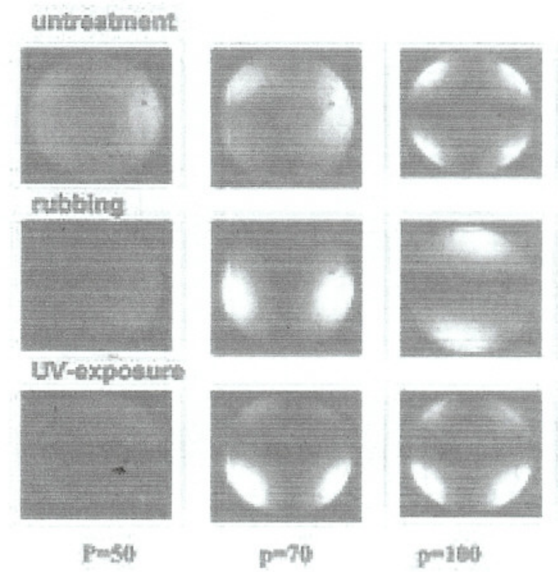


Figure 5. Conoscopic images for the LC cells of DC12(p) (p = the content(%) of chalcone moiety)

## 3. Conclusions

We synthesized the photo-reactive polyimides and characterized the reactivity with the birefringence measurement. In the LC cell, we have investigated the effect of the structure of these materials on pretilt angles and alignment properties. As the number of carbon in chalcone moiety increases, the alignment layers have the high pretilt angles and the increased content of chalcone contributes to the high pretilt angle. In FLC cell, the similar uniformity is observed in both photo-alignment and rubbing technique, but the alignment properties become worse on increasing the content of chalcone moieties.

## 4. References

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