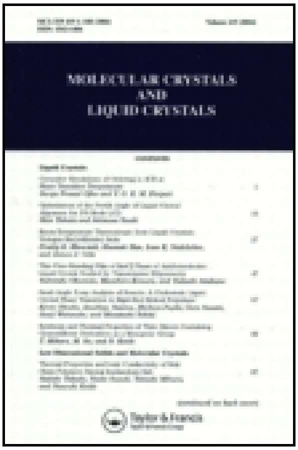

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In this work, we have investigated the liquid crystal (LC) aligning capabilities and the electro-optical (EO) characteristics for the photo-aligned twisted nematic (TN) cell with linearly polarized UV exposure of normal direction on the PMCh (poly (4'-methacryloyloxy chalcone)) surfaces using a new photo-alignment method. Good thermal stabilities of synthesized PMCh were obtained by TGA (Thermogravimetric Analysis) measurement. The excellent voltage transmittance (V-T) curve of the photo-aligned TN-LCD with UV exposure on the PMCh surface for 1 min using a new photodimerization method was observed. The voltage holding ratio (VHR) of the photo-aligned TN-LCD with photodimerized on the PMCh surface using a new photodimerization method was higher than that of a conventional photo-dimerization method. Consequently, a good LC aligning capabilities using a new photo-alignment method can be achieved.

Keywords: photo-alignment; electro-optical (EO); nematic liquid crystal; photo polymer; voltage-holding ratio

INTRODUCTION

Currently, active matrix (AM) – liquid crystal displays (LCDs) are commonly used for notebook computer, desktop monitors, and televisions. Surface alignment of LCs on treated substrate surfaces is key technology in LCD. Rubbed polyimide (PI) surfaces have been widely used to align LC molecules. They have suitable characteristics such as high transparency, uniform alignment, and good thermal stability. However, the rubbing-treatment method has several problems, such as the generation of electro-static charges and the creation of contaminating particles.[1] Thus, rubbing-free techniques for LC aligning are required in liquid crystal display (LCD) fabrication. Photoalignment methods such as photodimerization,[2-5] photoisomerization,[6] and photodissociation[7-11] have been proposed. The synthesis of photo-alignment materials such as PMCh (poly (4'-methacryloyloxy chalcone)), PMCh-F (poly (4-fluoro-4'-methacryloyloxy chalcone)), PVCi (poly (vinyl) cinnamate), and PMCi (poly (2-methacryloyloxy ethyl cinnamate)) has been reported by Y Makita et al.[12] Recently, we have reported the synthesis of the photoalignment material PM4Ch (poly (4-methacryloyloxy chalcone)) and the EO performance of photo-aligned TN-LCD on the PM4Ch surfaces.[13]

In this paper, we report on the LC alignment and EO performance of photo-aligned TN-LCD on the PMCh surface using a new photodimerization method.

EXPERIMENTAL

Figure 1 shows the chemical structure of the PMCh used in this study. The polymer is synthesized by the following method. In a 250ml round bottom flask, 4'-hydroxy chalcone and triethylamine were dissolved in 2-butanone and cooled to between -5 and 0℃ in an ice bath. Methacryloyl chloride solution in 2-butanone was then added dropwise while stirring and keeping the temperature at between -5 and 0℃. After stirring at room temperature for 4 hr the precipitated ammonium salt was filtered off. The organic layer was washed successively with 5% aqueous sodium hydroxide solution and distilled water, dried over anhydrous magnesium sulfate and the 2-butanone was evaporated. The product was purified by recrystallizatinon from ethylacetate/ethanol (1:1) mixture. Polymerization of monomers was carried out as solution in toluene using 2,2'-azoisobutyronitrile(AIBN)(2 mol%) as initiator at 70℃. The required amounts of monomers, initiator and toluene were mixed in a flask, and flushed with oxygen free nitrogen for 30min. After reacting for 48 hr at 70℃, the polymer was precipitated in excess methanol. The crude polymer was purified by reprecipitation in methanol from chloroform solution, and was finally dried under a vacuum. The polymers were coated on indium-tin-oxide (ITO)-coated glass substrates by spin-coating, and were cured at 80℃ for 10 min. The thickness of the polymer layer was 400 Å. To measure the EO characteristics of the photo-aligned TN-LCD, it was assembled with linearly polarized UV exposure in the normal direction on the PMCh surface. The polarized UV source was a 500 W Xe lamp. UV light at a wavelength of 365 nm exposed on the substrates. For a new photodimerization method, the polymer's PMCh surface was exposed by polarized UV exposure at a temperature of 100℃ during the curing process. In the conventional photodimerization method, the polarized UV was exposed on the PMCh surface to the radiation at room temperature after being cured at 150℃ for 1 h. The thickness of the LC layer of the photo-aligned TN-LCD was 5 μm. The NLC used a fluorinated mixture (T_c=87℃). Measurement of the V-T, response time, and voltage-holding ratio (VHR) for the photo-aligned TN-LCD were carried out at room temperature.

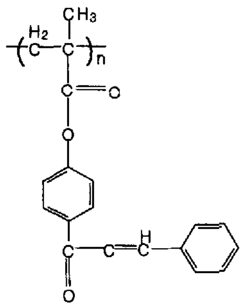


FIGURE 1 Chemical structure of PMCh used.

RESULTS and DISCUSSION

Figure 2 shows the TGA (Thermogravimetric Analysis) characteristics of the PMCh. Good thermal stabilities of synthesized PMCh are obtained by TGA measurement.

Microphotographs of the photo-aligned TN-LCD with linearly polarized UV exposure in the normal direction on the PMCh surface during thermal curing of the polymer at 100°C for 1 min are shown in Figure 3. They show that the monodomain alignment of the NLC was obtained.

Figures 4(a) and 4(b) show microphotographs of the photo-aligned TN-LCD on the photodimerized PMCh surface using the conventional photodimerization method. The reverse tilt disclination defects of the NLC were clearly observed, as shown in Figure 4(b). Therefore, monodomain alignment using the new photodimerization method is possible.

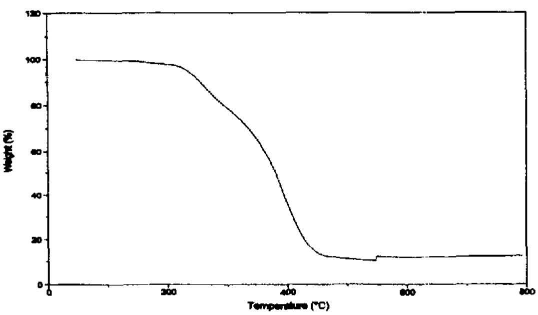
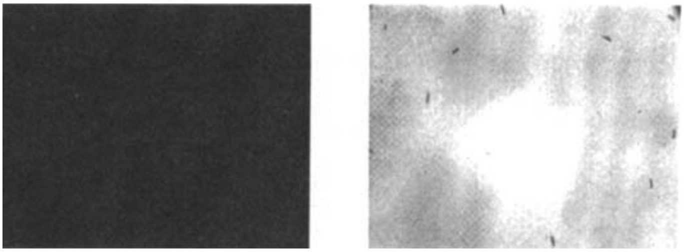
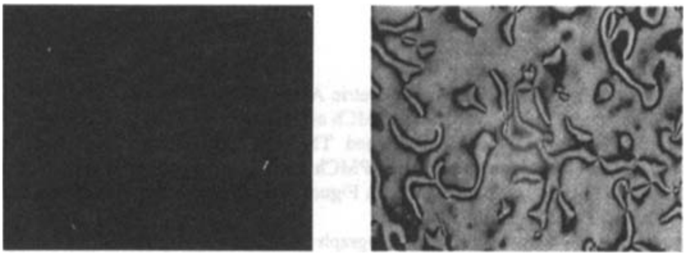


FIGURE 2 TGA characteristics of the PMCh.



(a) On-state (V=5(V)) (b) Off-state

FIGURE 3 Microphotographs of the photo-aligned TN-LCD using a new photodimerization method on the PMCh surface (in crossed Nicols).



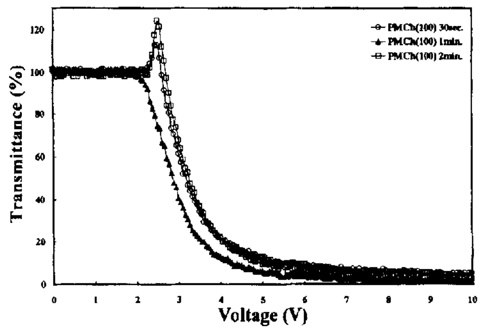
(a) On-state (V=5(V)) (b) Off-state

FIGURE 4 Microphotographs of the photo-aligned TN-LCD using a conventional photodimerization method on the PMCh surface (in crossed Nicols).

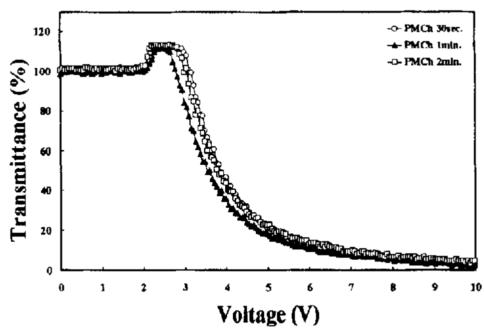
Figure 5 shows the V-T characteristics of photo-aligned TN-LCDs for a new and a conventional photodimerization methods on the PMCh surfaces. Good V-T curves of the photo-aligned TN-LCD using a new photodimerization method for 1 min were obtained. Also, good V-T characteristics of the photo-aligned TN-LCD using a conventional photodimerization method for 1 min were obtained. However, poor V-T characteristics of the photo-aligned TN-LCD using a new photodimerization method for either 30 sec or 2 min were obtained. Therefore, an excellent V-T curve of the photo-aligned TN-LCD using a new photodimerization method on the PMCh surfaces for 1 min can be achieved.

It seems that the nonreacted polymer main chain can move toward the UV exposure direction by photoreacted chalcone at 100°C. This temperature is near T_g of the polymer. Therefore, nonreacted chalcone of the polymer can easily convert to photoreacted chalcone. The LC aligning capabilities increased due to the alignment of chalcone in the UV direction with the increasing photodimerization reaction.

However, the LC aligning capabilities decreased due to the movement of photodimerized chalcone with increasing curing time. Suitable V-T characteristics of the photoaligned TN-LCD on the PMCh surface were obtained with an UV exposure time of 1 min. Also, the V-T curve of the photo-aligned TN-LCD using a new photodimerization method was better than that of a conventional photodimerization method.



(a) New photodimerization method



(b) Conventional photodimerization method

FIGURE 5 V-T characteristics of photo-aligned TN-LCDs for new and conventional photodimerization methods on the PMCh surfaces.

Table 1 shows the threshold voltage of photo-aligned TN-LCDs for a new and a conventional photodimerization methods on PMCh surfaces. The low threshold voltage of the photo-aligned TN-LCD using a new photodimerization method on the PMCh surface for 1 min was measured.

TABLE 1 Threshold voltage of photo-aligned TN-LCDs for a new and a conventional photodimerization methods on PMCh surfaces.

(a) New photodimerization method.

Orientation layer	V_{th}
PMCh 100 (30 sec)	2.26
PMCh 100 (1 min)	2.33
PMCh 100 (2 min)	2.79

(b) Conventional photodimerization method

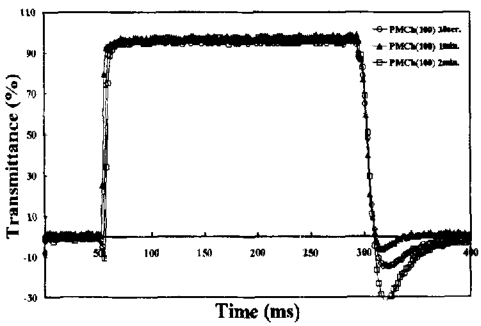
Orientation layer	V_{th}
PMCh (30 sec)	3.27
PMCh (1 min)	2.95
PMCh (2 min)	3.16

The response time characteristics of photo-aligned TN-LCD for a new and a conventional photodimerization methods on the PMCh surfaces are shown in Figure 6(a) and 6(b). A good curve for the photo-aligned TN-LCD was obtained using a new photodimerization method on the PMCh surface for 1 min as shown in Figure 6(a). Also, the backflow bounce behavior on the photo-aligned TN-LCD for a new and a conventional photodimerization methods on PMCh surfaces for all UV exposure times was observed. The fast response time of photo-aligned TN-LCDs for the new and conventional photodimerization methods on the PMCh surfaces for 1 min was observed. The response time for the photo-aligned TN-LCD using new photodimerization method on the PMCh surface for 1 min was about 17.4 ms.

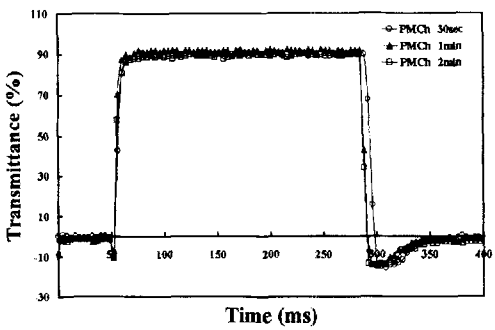
Figure 7 shows the VHR measurement of photo-aligned TN-LCD for a new and a conventional photodimerization methods on the PMCh surfaces. A similar VHR characteristic for a new and a conventional photodimerization methods on the PMCh surfaces was obtained.

Table 2 shows the VHRs of photo-aligned TN-LCDs for a new and a conventional photodimerization methods on the PMCh surfaces. The VHR of photo-aligned TN-LCD using a new photodimerization method was about 84%. The VHR of the photo-aligned TN-LCD using a conventional photodimerization method was 80%.

A conventional photodimerization TN-LCD was baked at 150°C for 1 h. The lower T_g of the polymer damaged the photo-alignment layer. The resistivity decreased due to damage of the polymer. The VHR was decreased due to the lower insulation break of the polymer. A new photodimerization method TN-LCD was heated at 100°C for 1 min. A higher VHR can be achieved in a short UV exposure time. Therefore, the VHR of the photo-aligned TN-LCD using a new photodimerization method was higher than that of a conventional photodimerization method on the PMCh surface. Consequently, we suggest that the LC alignment and EO characteristics for photo-aligned TN-LCDs using a new photodimerization method on the PMCh surfaces is good, depending on the UV exposure time.

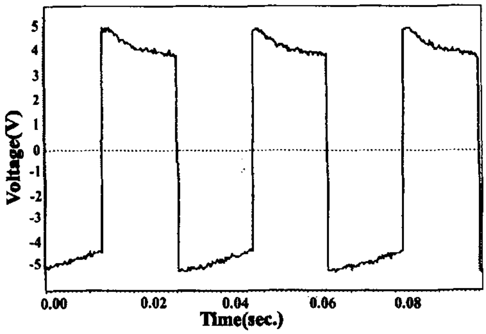


(a) New photodimerization method

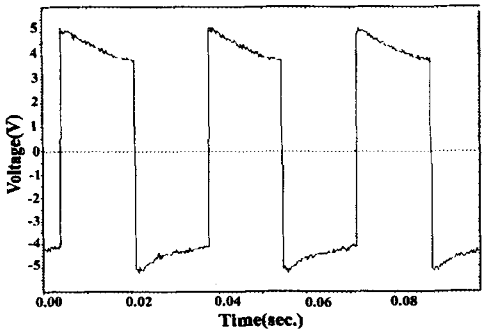


(b) Conventional photodimerization method

FIGURE 6 Response time characteristics of photo-aligned TN-LCDs for a new and a conventional photodimerization methods on the PMCh surfaces.



(a) New photodimerization method



(b) Conventional photodimerization method

FIGURE 7 VHR measurement of photo-aligned TN-LCD for a new and a conventional photodimerization method on the PMCh surface for 30 sec. of UV exposure time.

TABLE 2 Voltage-holding ratio (VHR) of photo-aligned TN-LCDs for a new and a conventional photodimerization methods on the PMCh surfaces.

	New photodimerization method	Conventional photodimerization method
VHR (%)	84.4	80.0

CONCLUSION

In conclusion, the LC aligning capabilities and EO performance of a photo-aligned TN-LCD were studied using a new photodimerization method on the PMCh surface. Good thermal stabilities of synthesized PMCh are obtained by TGA measurement. An excellent V-T curve of the photo-aligned TN-LCD using a new photodimerization method was observed. The VHR of the photo-aligned TN-LCD using a new photodimerization method was higher than that using a conventional photodimerization method.

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