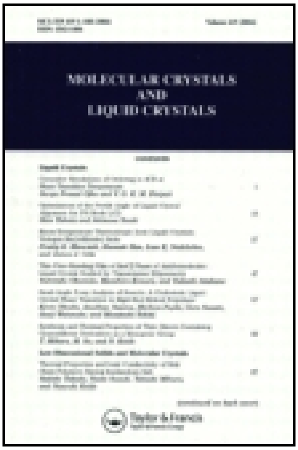

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EO Performances of the Photoaligned VA-LCD on the Polynorbornene Derivative Layers

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EO PERFORMANCES OF THE PHOTOALIGNED VA-LCD ON THE POLYNORBORNENE DERIVATIVE LAYERS

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A synthesis of new photoalignment material PNC, poly norbornene-2,3-dicarboxylic acid cholesteryl ester, and the electro-optical (EO) performances of the photoaligned vertical-alignment (VA)-liquid crystal display (LCD) on the PNC surface were studied. EO characteristics of the photoaligned VA-LCD on the PNC layer using a UV filter-less method proved more effective that of the UV filter method for short UV exposure time. The response time of the photoaligned VA-LCD on the PNC layer by the photoalignment method without UV filter is almost the same as the rubbing aligned VA cell.

Keywords: EO characteristics; nematic liquid crystal; PNC (poly norbornene-2,3-dicarboxylic acid cholesteryl ester); response time; vertical-alignment

INTRODUCTION

The physical mechanisms involved in both surface and bulk LC alignment, is not only of fundamental interest, but also finds its application in electro-optic LC cells. Uniform alignment of the LC layer can be achieved by several methods, such as the rubbed polymer film [1–4], Langmuir-Blodgett films [5], and oblique evaporation of SiO films [6]. The most

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widely used technique for the production of LC cells is the rubbing of polymer-coated glass substrates. This method produces characteristics such as high transparency, uniform alignment, and pretilt angle stability. However, the rubbing method creates several problems, such as the generation of electrostatic charges and the contamination of particles [7]. Recently, many investigators have proposed photoalignment, such as the photodimerization [8–13] and photodissociation methods [14–18]. But the synthesis of photoalignment material PNC (poly norbornene-2,3-dicarboxylic acid cholesteryl ester) and the EO performance of the photoaligned VA-LCD cell on the photopolymer layer is, as of yet, unreported.

In this study, we report on the synthesis of the new photoalignment material PNC (poly norbornene-2,3-dicarboxylic acid cholesteryl ester), as well as the voltage-transmittance (V-T) and response time characteristics of the photoaligned VA-LCD by with polarized UV exposure on the PNC surface.

EXPERIMENTAL

Synthesis of Monomer

In a round bottom flask, cholesterol and triethylamine were dissolved in chloroform. Trans-5-Norbornene-2,3-dicarbonylchloride in chloroform was added dropwise at room temperature. After stirring at room temperature for 4 h, the reaction mixture was washed with water. The solvent was evaporated and the residue was passed over a silica gel column (Figure 1).

Polymerization

For a monomer/catalyst mole ratio of 100, a mixture of the palladium chloride dimmer, AgBF4, and chlorobenzene were stirred for 15 min at room temperature. The solution of the yellow catalyst was filtered off with a

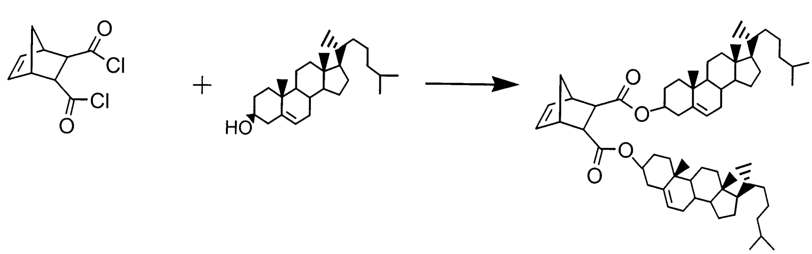


FIGURE 1 Synthesis of norbornene-2,3-dicarboxyolyl cholesterol monomer.

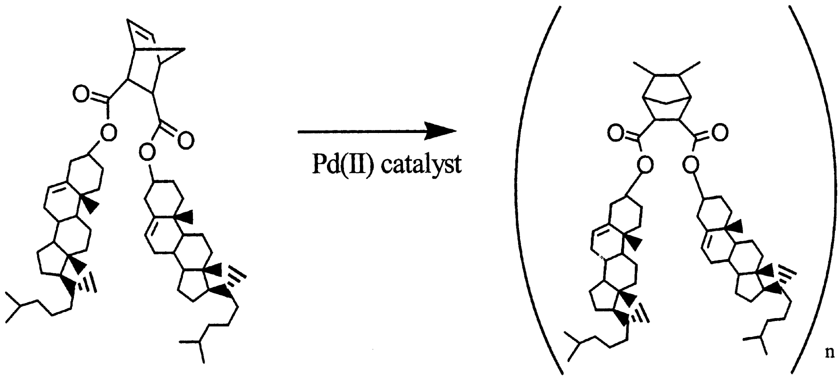


FIGURE 2 Chemical structure and copolymerization of PNC.

syringe filter (0.45 μm) and added to the monomer solution in chlorobenzene at room temperature and allowed to stir for 5 h the polymer was isolated by precipitation with excess methanol (Figure 2).

The polymers were coated on indium-tin-oxide (ITO) coated glass substrates by spin-coating, and were cured at 150°C for 1 h. The thickness of the polymer layer was 500 Å. Figure 3 shows the UV exposure system used in this study. The UV source used was a 500 W Mercury lamp. UV exposure methods are as follows:

ξ280 nm UV filter used (energy density = 0.016 mW/cm^2);
ξUV linear dichroic polarizer (230 nm ~ 700 nm) used (energy density = 15.5 mW/cm^2);

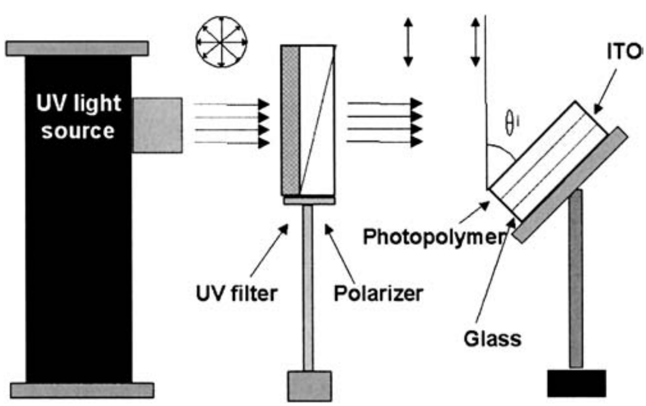


FIGURE 3 UV exposure systems used.

ξ280 nm UV filter used and using the *in-situ* method (substrate temperature: 150°C)

The UV exposure times were 1 min, 10 min, 20 min, and 40 min. The photoaligned VA-LCD was fabricated with an anti-parallel structure by polarized UV exposure on the PNC surfaces. The thickness of the LC layer for the photoaligned VA-LCD was 4.25 Πm. The NLC used was negative-type dielectric anisotropy (∋H = 4; MJ98468 from Merck Co.). Also, the rubbing aligned VA-LCD was fabricated at medium rubbing strength (164 mm) for comparison with a photoaligned VA-LCD. The NLC used also was a negative-type dielectric anisotropy (∋H = 3.8; MJ951294 from Merck Co.) on the rubbing-aligned VA-LCD. The V-T and response time measurements for the photoaligned VA-LCD were performed using the DMS (display measurement system; from Autronic Co.) at room temperature.

RESULTS AND DISCUSSION

Figure 4 shows the microphotographs of photoaligned VA-LCDs with polarized UV exposure on the PNC layers using the three kinds of photoalignment methods (in crossed Nocols). Monodomain alignment of the NLC for the photoaligned VA-LCD on the PNC layer can be observed.

Figure 5(a), (b), and (c) show the V-T curves of the photoaligned VA-LCDs with polarized UV exposure on the PNC layers using the three kinds of photoalignment methods. As shows in Figure 5(a), the excellent V-T curves of the photoaligned VA-LCD by UV exposure with 280 nm UV filters on the PNC layer for 1 min and 40 min were observed. Also, the good V-T curve of the photoaligned VA-LCD with the UV linear dichroic polarizer for 10 min on the PNC layer was observed as shown in Figure 5(b). But, the poor V-T curve of the photoaligned VA-LCD with UV linear dichroic polarizer on the PNC layers for 20 min and 40 min was measured. It is considered that the decrease in transmittance for the photoaligned VA-LCDs with UV linear dichroic polarizer on the PNC layer is attributable to the high energy, which was three times higher than the 280 nm UV filter used. Therefore, the V-T characteristics of the photoaligned VA-LCD using a UV filter-less method were better than that of the UV filter method on the PNC layer for short UV exposure time. As shown in Figure 5(c), the good V-T curve of the photoaligned VA-LCD, which was on the PNC layer for 10 min using the *in-situ* photoalignment method with 280 nm UV filter was observed. However, poor V-T curves of the photoaligned VA-LCDs on the PNC layer for 10 min using the *in-situ* photoalignment methods with 280 nm UV filter were measured. It reveals that the transmittance of the photoaligned VA-LCD on the PNC layer using the *in-situ* method decreased with increasing UV exposure time.

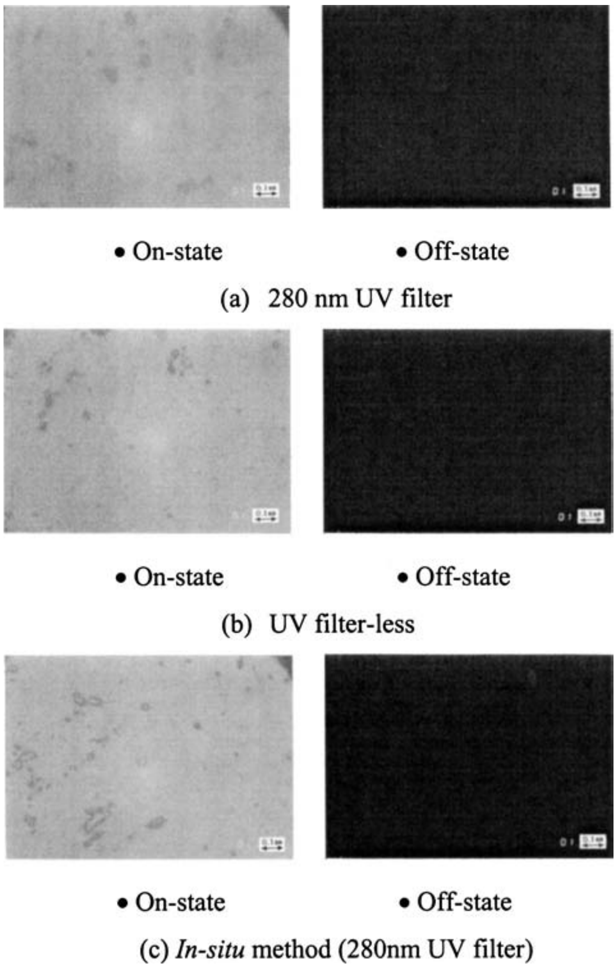
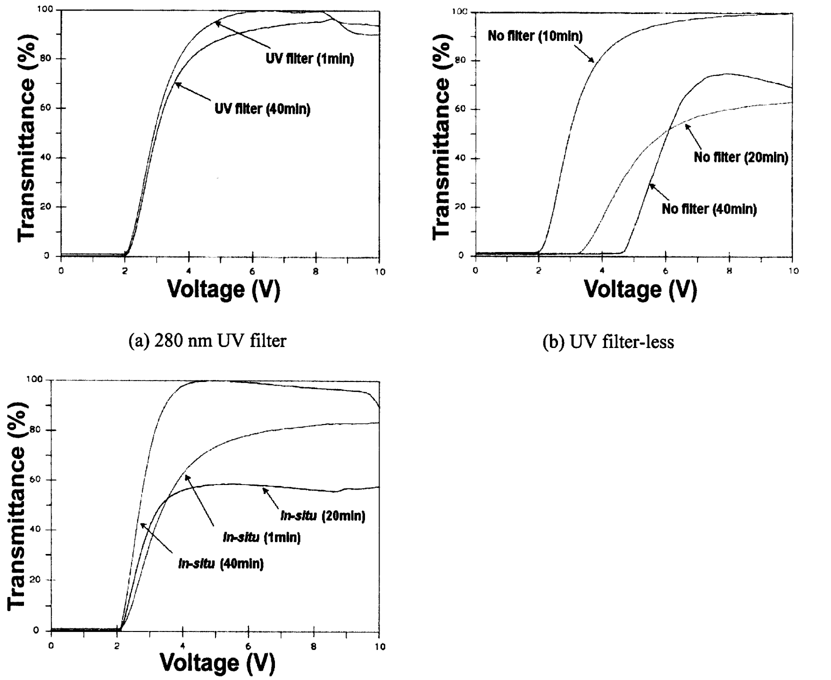


FIGURE 4 Microphotographs of photoaligned VA-LCD with polarized UV exposure on the PNC layers using the three kinds of photoalignment methods (in crossed Nocols).

Figure 6(a), (b), and (c) show the response time of the photoaligned VA-LCD with polarized UV exposure on the PNC layers using the three kinds of photoalignment method. In Figure 6(a), good response time characteristics for the photoaligned VA-LCD on the PNC layers with 280 nm UV filters for 1 min and 40 min were observed. Also, good response time characteristics for the photoaligned VA-LCD with UV linear dichroic polarizer on the PNC layer for 10 min can be obtained as shown in Figure 6(b).



(a) 280 nm UV filter

(b) UV filter-less

(c) *In-situ* method (280 nm UV filter)

FIGURE 5 V-T curves of the photoaligned VA-LCDs with polarized UV exposure on the PNC layers using the three kinds of photoalignment methods.

However, poor response time characteristics for the photoaligned VA-LCDs with UV linear dichroic polarizer on the PNC layers for 20 min and 40 min were measured. It is considered that the lower response time characteristics of the photoaligned VA-LCD on the PNC layer with UV linear dichroic polarizer is attributable to high energy, which is of 3 times that of the 280 nm UV filter used. The poor response time characteristics of the photoaligned VA-LCDs on the PNC layer using the *in-situ* photoalignment method with 280 nm UV filter were measured as shown in Figure 6(c). It is considered that the poor response time characteristics of the photoaligned VA-LCD on the PNC layer using the *in-situ* photoalignment method are attributable to fluctuation of the photopolymer by increasing UV exposure time at 150°C.

Table I shows the response time characteristics of the photoaligned VA-LCDs with polarized UV exposure on the PNC layers using the three kinds of photoalignment method. First, the response time of the photoaligned VA-LCD with 280 nm UV filters on the PNC layer decreases with

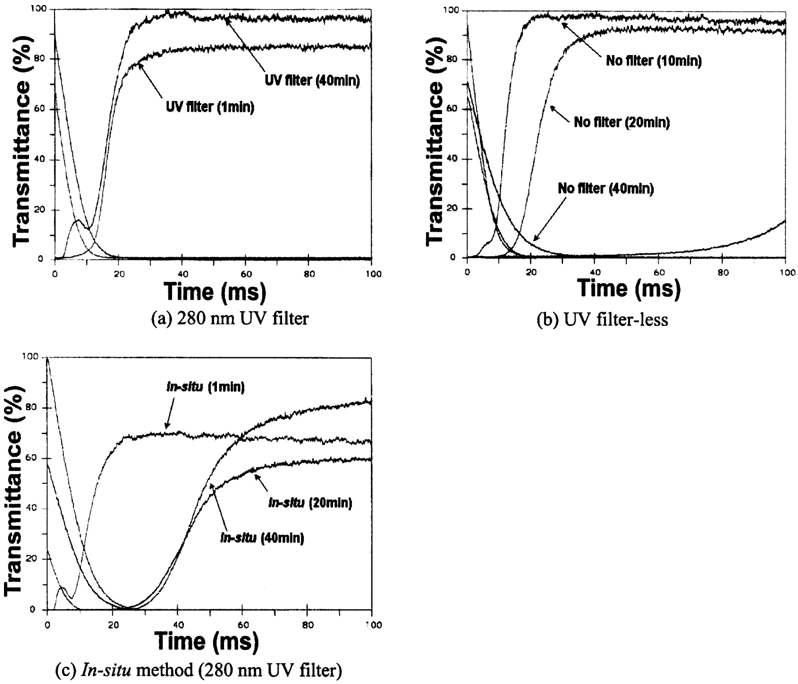


FIGURE 6 Response time characteristics of the photoaligned VA-LCDs with polarized UV exposure on the PNC layers using the three kinds of photoalignment methods.

TABLE I Response Times for the Photoaligned VA-LCDs on the PNC Surface Using the Three Kinds of Photoalignment Methods and the Rubbingaligned VA-LCD on the PI Surface

Alignment layer		Response time		
		τ_r (ms)	τ_d (ms)	τ (ms)
280 nm UV Filter	1 min	16.8	10.8	27.6
	40 min	6.5	8.1	14.6
UV Filter-less	10 min	7.1	9.1	16.2
	20 min	8.6	10.5	19.1
In-situ (280 nm UV Filter)	1 min	8.5	7.1	15.6
	20 min	24.7	7.1	31.8
	40 min	63.1	14.1	77.1
Rubbing method	11.2	16.5	28.7	

increasing UV exposure time. Secondly, a response time of 1.62 ms for the photoaligned VA-LCD with UV linear dichroic polarizer on the PNC layer for 10 min was measured and increases with increasing UV exposure time. This value is almost the same as the rubbing aligned VA-LCD. Thirdly, a fast response time for the photoaligned VA-LCDs on the PNC layer for 1 min using the *in-situ* photoalignment method with 280 nm UV filter was measured, but the response time increased with increasing UV exposure time. Specifically, the rising time of the photoaligned VA-LCD increased with increasing UV exposure time. From these results, the slow response time of the photoaligned VA-LCD is attributable to the low order parameter with increasing UV exposure time.

CONCLUSION

In conclusion, the new photoalignment material, PNC, was synthesized; In addition, the EO characteristics of the photoaligned VA-LCD with polarized UV exposure on the PNC layer were studied. The EO characteristics of the photoaligned VA-LCD on the PNC layer using a UV filter-less method were better than those of the UV filter method for a short UV exposure time. However, the EO characteristics of the photoaligned VA-LCD on the PNC layer using the *in-situ* method decreased with increasing UV exposure time due to the low order parameter. Finally, the response time of the photoaligned VA-LCD, without a UV filter on the PNC layer, is almost the same as the response time of the rubbingaligned VA-LCD.

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