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Effect of Wettability on Fabrication of PSCOF Liquid Crystal Cell

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In this research, in order to realize the phase-separated composite organic film (PSCOF) structure of liquid crystal (LC) cell, we have researched in detail its fabrication conditions. Nematic and ferroelectric LCs have been used for the investigation. Furthermore, we try to realize the PSCOF cell by using photocurable LC monomers as polymer materials. The contact angle has been measured in LC and polymer materials to lots of alignment films. As a result, it is found that the important factors for the fabrication of PSCOF structure are the wettability of LC materials to alignment film and the molecular weight of monomer.

Keywords Liquid crystal; PSCOF; monomer; photocure; polymer; contact angle; wettability

1. Introduction

Phase-separated composite organic film (PSCOF) [1] is attractive for novel liquid crystal displays (LCDs) [2–5] and photonics devices [5, 6] with an internal polymer/LC bilayer structure. The PSCOF structure is fabricated by irradiating with UV light and initiating the polymerization reaction on one side substrate of a cell containing a solution of LC and photocurable monomer. The spatially nonuniform rate of polymerization can be realized by a gradient of UV intensity along the substrate normal [7]. The intensity gradient is produced by strong UV absorption of LC medium. As a result, a bilayer structure of polymer/LC can be obtained with the polymer layer on the substrate closer to the UV source, as shown in Fig. 1. The optical axis of the LC layer can be controlled by an alignment film on the LC side substrate. In order to fabricate the PSCOF structure, it is important to understand the phase separation process of polymer/LC. Qian et al. calculated the essential features of this process by using a simple one-dimensional model and predicted that the formation of PSCOF is a result of nonuniform UV illumination caused by the strong UV absorption, slow

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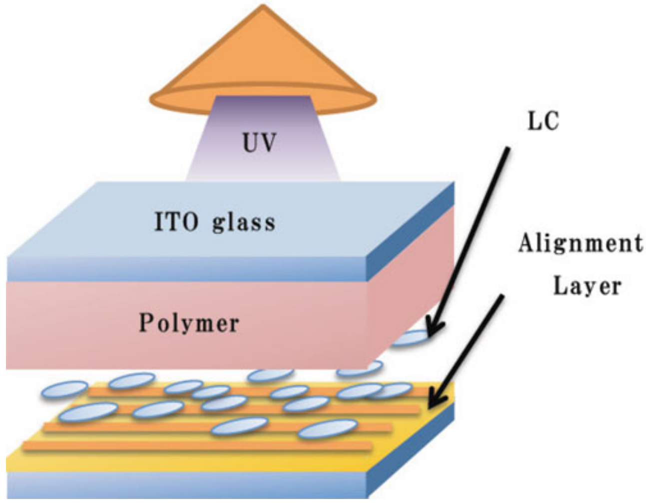

Figure 1. Scheme of PSCOF structure.

polymerization and phase separation of the LC and prepolymer mixture [8]. However, these factors are necessary but not sufficient conditions to realize the PSCOF structure. In fact, PSCOF structure cannot be obtained easily and a polymer-dispersed structure is usually formed [9, 10]. In this research, we focus on the wettability and investigate the influence of LC and monomer materials and alignment films on the formation of PSCOF structure.

2. Experimentals

E7 (Phase sequence [Cryst. (−10°C) N (60°C) Iso.]) and FH8002N (DIC) (Iso. (82°C) N* (76°C) SmA (62°C) SmC*) were used as a nematic and ferroelectric LC samples, respectively. NOA65 (NORLAND) which is a UV curable adhesive and Monomer A and B (Osaka Organic Chemical Industry) which are UV curable LC materials were used as polymer materials. It is well known that the PSCOF cell can be fabricated by using NOA65 [4–6]. Monomer A is nearly same as the dimer of Monomer B. The rubbing alignment film of RN1199, SE150, IPS-A, IPS-B (Nissan Chemical Industries), AL1254 or AL3046 (JSR) was coated on the one side of glass substrate in a cell, and the cell gap was set 4 μm. The polymerization of NOA65 and Monomer A, B was carried out by UV irradiation (310 nm, 2 $\mu W/cm^2$, 120 min at 90°C) from the side of bare indium-tin-oxide (ITO) glass substrate which was not coated with the alignment film. The texture in the cell was observed with a conventional polarizing microscope. In order to investigate the effect of wettability on PSCOF structure, the contact angle was measured with LSE-A100 (Nick).

3. Results and Discussion

Figure 2 shows the microscopic textures, which were observed at the room temperature, in the cells fabricated using NOA65 after UV irradiation. It is found that uniform alignment structures are obtained only in the cases of RN1199 and IPS-B alignment films. The direction of LC molecular orientation is in accordance with the rubbing direction of the alignment film. On the other hand, in the cases of other alignment films, the phase separation

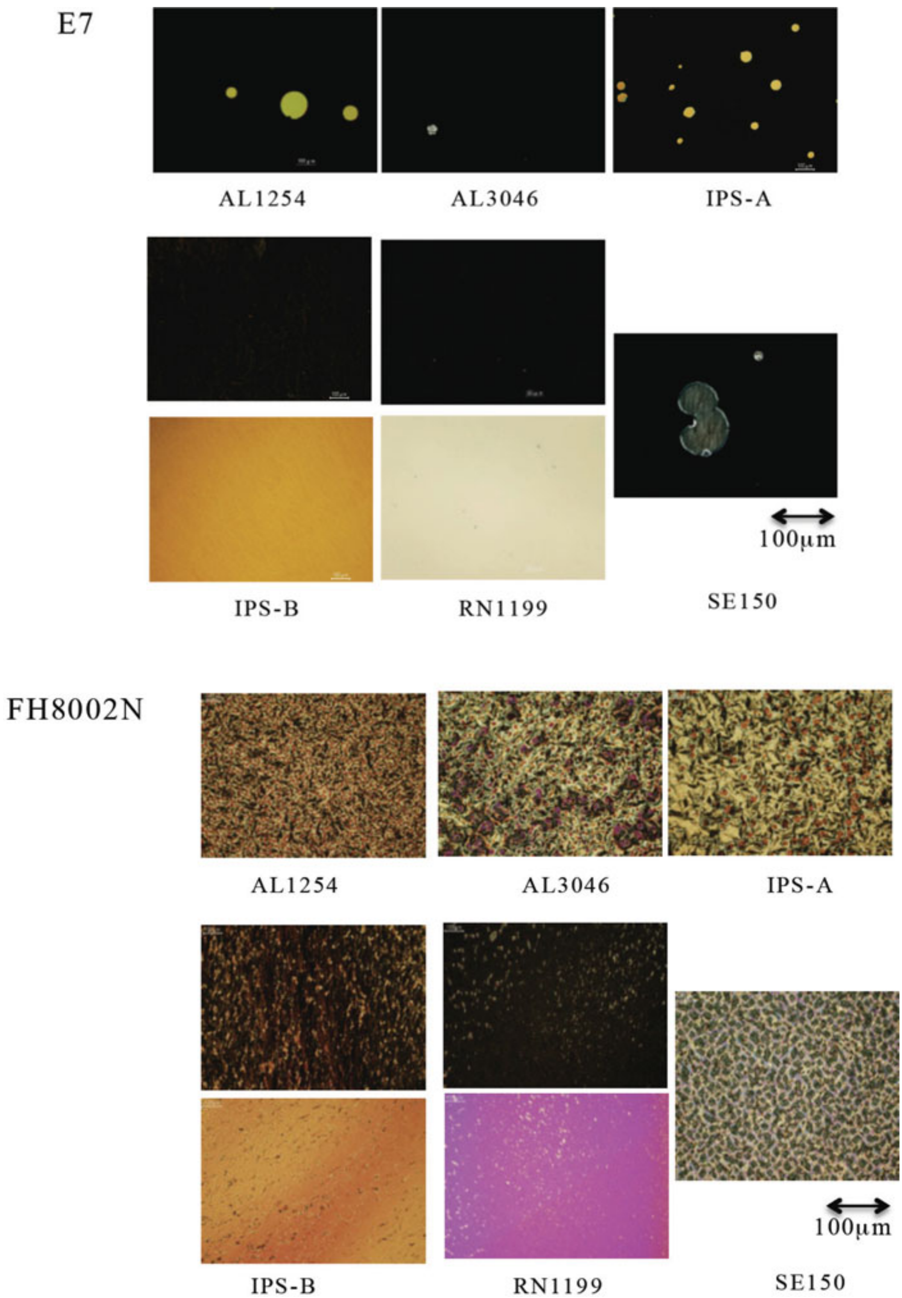

Figure 2. Microscopic textures in cells fabricated using NOA65.

in cell plane is observed and the isotropic regions remain even at the room temperature. It is guessed that since the UV irradiation was performed in the isotropic phase at 90°C, a random molecular alignment can be maintained in a polymer-dispersed situation.

Figure 3 and Table 1 show the contact angle measured at 90°C in E7 and NOA65 and 75°C in FH8002N. FH8002N was most wettable at 90°C, and then, because the contact

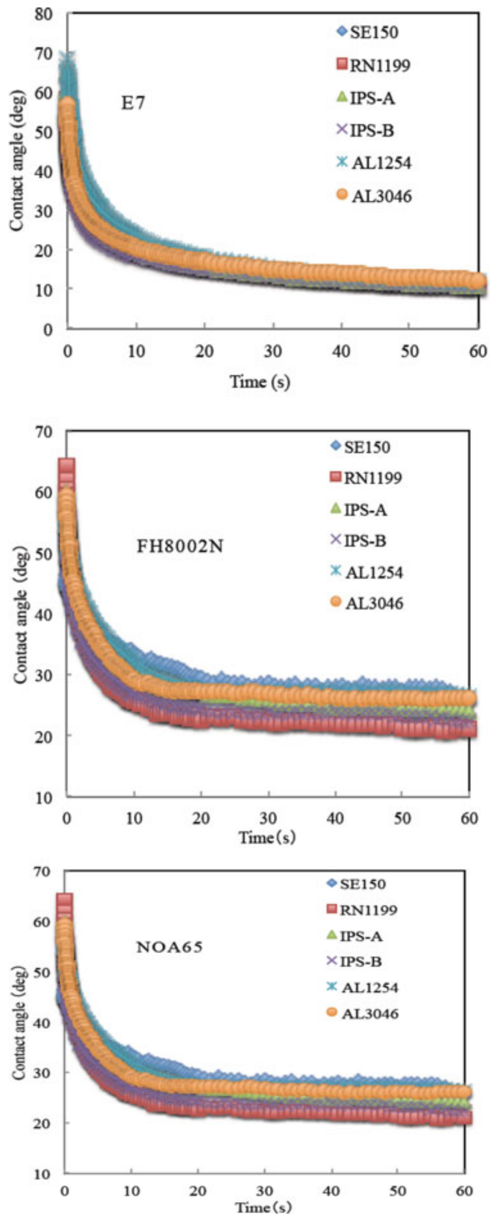

Figure 3. Time dependence of contact angle in E7, FH8002N and NOA65.

Table 1. Contact angle in E7, FH8002N and NOA65 after 60s from dropping

	AL1254	AL3046	IPS-A	IPS-B	RN1199	SE150
E7 (90°C)	2.6°	3.9°	2.7°	2.2°	2.4°	2.7°
FH8002N (75°C)	26.6°	26.2°	24.1°	22.3°	20.9°	25.8°
NOA65 (90°C)	11.7°	12.4°	11.0°	10.6°	10.8°	11.4°

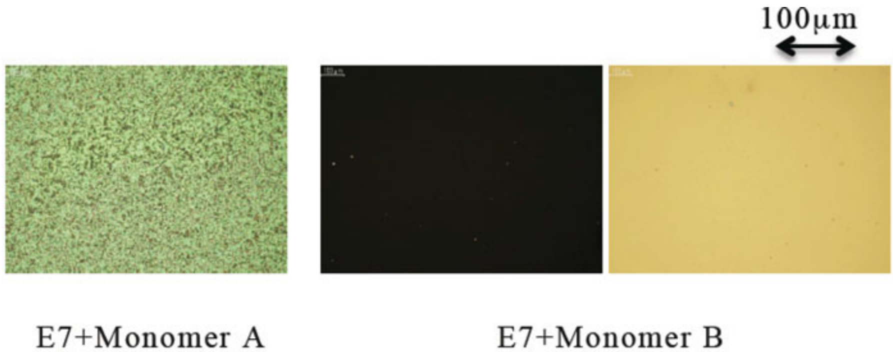

Figure 4. Microscopic textures in cells fabricated using E7 as LC and RN1199 as alignment film.

angle is very low, it cannot be measured in the isotropic liquid phase of FH8002N at 90°C. Therefore, LC materials are more wettable to alignment films than NOA65. In the difference of the contact angle between the alignment films, the wettability of LC materials to RN1199 and IPS-B is relatively well. Therefore, it is thought that the good wettability of LC materials to alignment film is important to fabricate PSCOF structure. The LC molecules can be biased to the alignment film surface during UV photocure in the case of better wettability, and then, the bilayer phase separation of polymer/LC can be realized after UV photocure.

Figure 4 shows microscopic textures in the cells fabricated using RN1199 alignment films and the combination of E7 and Monomer A or B. It is found that a uniform bilayer separation can be obtained in the case of Monomer B. Although the contact angle in Monomer A and B could not be measured because the fluid LC phase appear at a high temperature, since the molecular structures of Monomer A and B are almost same except for monomer or dimer, the wettabilities of both monomers would be almost same. Therefore, it is guessed that the molecular weight of monomer is also important to fabricate PSCOF structure. In order to form the bilayer structure of polymer/LC, the UV curable monomers have to diffuse and gather around the substrate close to the UV light source. The diffuseness strongly depends on the molecular weight of monomer. Therefore, it is thought that the PSCOF structure can be obtained by using Monomer B whose molecular weight is much smaller than Monomer A.

4. Conclusions

In this research, we investigated the influence of LC and monomer materials and alignment films on the formation of PSCOF structure. In the case of good wettability of LC materials to alignment film, a uniform bilayer phase separation of polymer/LC can be obtained. Therefore, the wettability is an important factor to fabricate PSCOF structure. Furthermore, in the cell fabricated using Monomer B whose molecular weight is much smaller than Monomer A, the PSCOF structure can be obtained. In order to form the bilayer structure of polymer/LC, the UV curable monomers have to diffuse and gather around the substrate close to the UV light source. Since the diffuseness strongly depends on the molecular weight, the molecular weight of the monomer is an important factor to realize PSCOF structure.

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