Control of Characteristics in Polymer-Stabilized Ferroelectric Liquid Crystals by Using Binary Mixture System of Monomers

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Polymer-stabilized ferroelectric liquid crystals (PSFLCs), in which photocurable mesogenic monomers are doped into ferroelectric liquid crystals and UV photocure is carried out in the SmA phase, can show the monostable electrooptical characteristics. In this research, we have investigated the dependence of the electrooptical characteristics of PSFLCs on the ratio of binary mixture of monomers. As a result, it is found that the polymer anchoring strength of acrylic acid which does not have mesogenic moiety can be almost ignored, and the polymer anchoring strength of the binary mixture of mesogenic monomer and acrylic acid can be controlled by the variation of their ratio.

Keywords: polymer-stabilized ferroelectric liquid crystal, monomer, mixture, monostability, polymer anchoring strength, acrylic acid

1. Introduction

Ferroelectric liquid crystals (FLCs) are attractive for a next generation of LC display (LCD) having high performances such as high-quality moving video image and very low power consumption, because of their unique characteristics such as high-speed response, wide viewing angle and bistability [1-6]. However, the bistability is disadvantageous for LCDs which possess grayscale or full-color capability. In previous papers [7-27], we reported that polymer-stabilized FLCs (PSFLCs), in which a photocurable mesogenic monomer is doped into an FLC medium and UV photocuring is carried out, may show monostable electrooptical characteristics with a grayscale capability without a threshold. Although the monostability can be obtained, the saturation voltage of molecular switching, i.e. the driving voltage of LCD, become higher due to the polymer stabilization. In this study, in order to control the polymer anchoring strength and decrease the saturation voltage, we propose an idea that the mixture system of monomers is introduced into the fabrication of PSFLCs. In this paper, we report the dependence of the electrooptical characteristics of PSFLCs on the ratio of the binary mixture of monomers which are a mesogenic monomer and acrylic acid which does not have mesogenic moiety.

2. Experimentals

The materials used in this research were as follows: the FLC was FH-8006N (DIC); the photocurable monomers were mesogenic diacrylate 2A363 (DIC) and acrylic acid which were doped 1wt% photoinitiator; and the LC alignment film was polyimide RN1199 (Nissan Chemical Industries) which induced a defect-free FLC molecular alignment with the C2-chevron structure [28, 29]. The relevant properties of FH-8006N given by the catalogue are shown in Table 1.
Table 1 Properties of FH-8006N.

| Property                        | Phase sequence | Iso.(96)N*(85)SmA(78)SmC* [°C] |
|---------------------------------|----------------|---------------------------------|
| Spontaneous polarization        | 50 nC/cm²      |                                 |
| Tilt angle                      | 30° (at room temp.) |                               |

A solution of polyimide was spun on glass substrates coated with indium-tin oxide (ITO) and then baked. After the thermal treatment, the substrates were rubbed. Then, the FLC, which was doped with the photocurable monomers (6wt%), was injected in the isotropic phase via capillary action into an empty cell, in which the rubbing directions and the cell gap were set parallel and 2μm, respectively. Next, the cell was cooled gradually to the temperature where the LC medium was in the SmA phase. After that, the LC medium was photocured with a UV light source (365nm, 30mW/cm², 15s) under the quiescent condition.

PSFLCs fabricated by above method were observed with a polarizing microscope and their electro-optical characteristics were measured with a conventional measuring system. We define the memory angle of FLC molecules as the twice of the apparent tilt angle in the quiescent condition, and the memory angle becomes 0 in the perfect monostable situation. The switching angle (apparent tilt angle) of FLC molecules was calculated from the measurement results of the electro-optical characteristics. The memory angle is defined as the switching angle shown in Fig. 1. Moreover, we defined the saturation voltage as the voltage at which the variation of the transmitted light intensity finishes responding to the triangular waveform voltage (1Hz), as shown in Fig. 3. Since the finish point of the response is usually unclear, the saturation voltage was defined as the voltage at which the transmittance reaches 95%.

3. Results and discussion

Figure 3 shows microscopic textures of PSFLCs in the dark state. It is found that the zigzag defect is not observed and the uniform alignment can be obtained even after the polymerization.

Table 2 shows memory angle and saturation voltage of PSFLCs fabricated in this research. It is found that the characteristics of the PSFLC, in which only acrylic acid is doped into FLC medium, is almost same as those of pure FLC. Therefore, it is concluded that the polymer anchoring strength of acrylic acid which does not have mesogenic moiety may be almost ignored. On the other hand, in the case of only 2A363 doping, the memory angle of the PSFLC is nearly equal to 0, and the saturation voltage is much higher than that of pure FLC. Thus, the rigid parts of mesogenic core in monomer
molecules strongly influence the polymer anchoring strength and the characteristics of PSFLC. Furthermore, it is found that the higher the concentration ratio of acrylic acid is, the higher the memory angle is and the lower the saturation voltage is. Therefore, it is concluded that the polymer anchoring strength and the properties of PSFLC can be controlled by introducing the mixture system of monomers. As a result, the driving voltage of PSFLCD can be decreased to some extent by using a monomer mixture.

4. Conclusions

In order to control the polymer anchoring strength and decrease the saturation voltage, we investigated the dependence of the electrooptical characteristics of PSFLCs on the ratio of the binary mixture of monomers which are a mesogenic monomer and acrylic acid which does not have mesogenic moiety. As a result, it is found that the polymer anchoring strength of acrylic acid can be almost ignored, and the polymer anchoring strength of the binary mixture of mesogenic monomer and acrylic acid can be controlled by the variation of their ratio. Therefore, the control of the physical properties of PSFLC is possible by means of mixing the monomer materials.

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