Bending and Pressing Tolerance of Flexible Polyoxetane based Liquid Crystalline Polymer/Low Molecular Weight Liquid Crystal Device

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Abstract

We have studied the realigning behavior of liquid crystal molecules in liquid crystalline polymer/liquid crystal(LCP/LC) system when they are exposed to external stimulation such as bending and pressing. The birefringence of the LCP/LC in a flexible display device was measured as a function of bending or pressing deformation. The microscopic dynamic behavior of main chain, side chain, and the LC were characterized by FTIR and polarization optical microscopy. When the device is deformed in scattering memory state, liquid crystal(LC) director is found to align from randomly oriented domain state(scattering state) to homeotropic state.

1. Objectives and Background

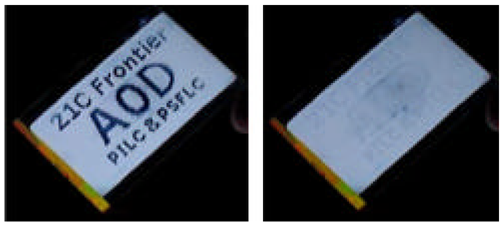
Various kinds of LCP/LC have attracted considerable interest for flexible display devices due to their characteristics of wide-view angle, high contrast, and no use for polarizers [1]. And enhancement in polymer structure of composite films and alternation of weight fraction of LC for fast response speed has been reported [2]. Recently, the deformation properties of the flexible system to bending or to mechanical shock were studied[3].

In this paper we studied the mechanical stability of a flexible LCP/LC device against external pressing or bending.

2. Results

We have synthesized new materials of polyoxetane based LCP/LC and LCcoP/LCs composite systems [4], and studied for microscopic dynamic behavior with POM, EO properties, X-ray scattering and FTIR [5, 6]. Also we studied the dependence of response time on the concentration of free LC(E7, Merck Co.), and could figure out a relationship between the microscopic structure of the sample and its response time[5].

In this paper, with a sample of LCP/LC optimized for best response time, we studied the effect of bending and pressing on the sample. Those prepared LCP/LC are capillary injected on sandwiched two ITO-patterned plastic substrates(PES-120, Sumitomo Bakelite Co.) with no surface-treatment and maintained at 10 μm ball type spacer(Fig. 1).



(a) (b)

Fig. 1. ITO-patterned flexible LCP/LC device placed between crossed polarizers: (a) transmitting state and (b) scattering state

The switching mechanism of the system is as follows. When a low frequency(0.1Hz) electric field is applied, ions randomize the orientation of segments in each main chain and then LCs rearrange to form domains of different birefringence, causing the system to scatter light strongly(Fig 1(b)). On the contrary, if high frequency(100 Hz) electric field is applied, ions do not move enough distance in one period of time to disturb the main chains, and LCs are ordered in nematic or smectic phase, which is a transmitting state(Fig. 1(a)). When the field was removed, the LCs director maintains its current in each state.

The experimental arrangement is shown in Figure 2(a). A normally incidenting beam of He-Ne laser is to prove transmittance, and that incidenting off-axis of 45 ° is to measure for birefringence of LC direction. These incident beams always pass through the same point in the cell and measure the transmittance and birefringence after each bending and pressing.

To quantify pressing method, we used a air-blow gun attatched to nitrogen gas to press a cell surface with a fixed quantity of pressure(Fig. 2(b)). And, Figure 2(c) shows a bending device, which can bend and release a flexible LCP/LC device to a bent state or to a flat state.

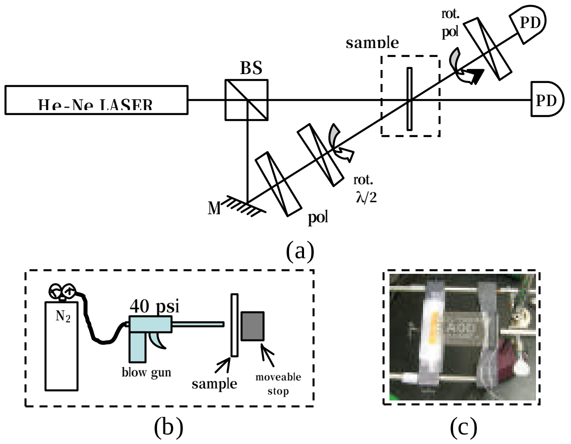


Fig. 2. (a) experimental arrangement for measuring the transmittance and birefringence of LCP/LC, (b) pressing part scheme, and (c) bending machine

For each measurement of the birefringence and the transmittance after each deformation of bending and pressing the initial state always starts from the scattering memory state. Figure 3 shows that the transmittance increases as the number of deformation increases. In the case of pressing the birefringence changes its magnitude as more external deformation is applied to the sample(Fig. 4(a) and Fig. 5). As to the bending of the sample, the birefringence changes not only magnitude but also the orientation of the principal axis of LC(Fig. 4(b) and Fig. 5). It shows that as the more deformation on the cell, the more LC direction arranges to homeotropic state which is called transmitting state similar to that sample with high frequency applied.

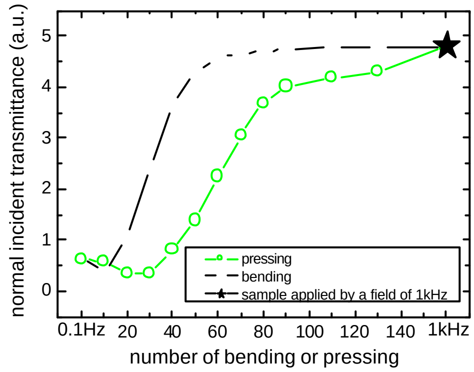


Fig. 3. Normal incident transmittance vs. deformation times

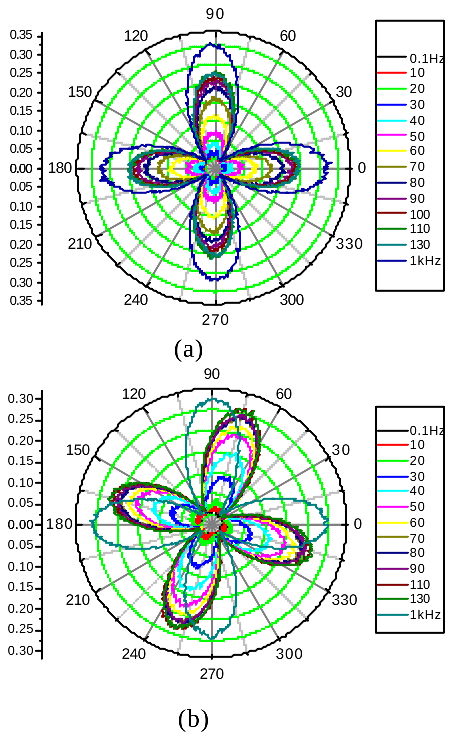
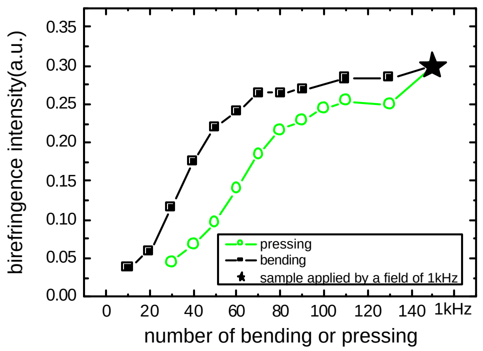
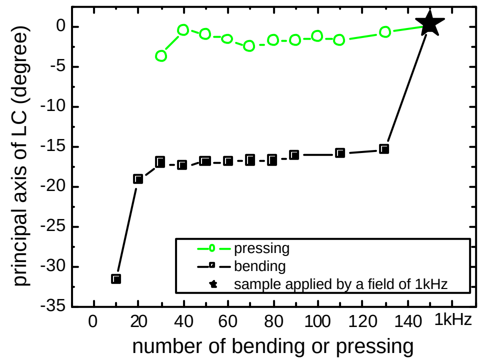


Fig. 4. Optical intensity measurement of in rotation of crossed polarizers on off-axis: birefringence after each pressing(a) and bending(b)



(a)



(b)

Fig. 5. (a) magnitude of birefringence and (b) principal axis of LC

3. Conclusion

We investigated the deformation of the flexible LCP/LC device with respect to external bending and pressing. With the electric field removed in the scattering state, the LC director changes more to homeotropic alignment as the more deformation of bending or pressing are applied. The orientation of LC did not change very much up to 10 times of bending or up to 40 times of pressing. However the transmitting state is found to be shock proof to bending or pressing at all time.

4. Acknowledgements

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5. References

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