

## Improving switching time from homeotropic state to planar state in cholesteric liquid crystal by polymer stabilization

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### Abstract

A polymer stabilization method is employed to reduce the transition time from field-induced homeotropic(H) state to reflecting planar(P) state in the cholesteric liquid crystal(ChLC) display. To stabilize ChLC by polymer, we mixed ChLC with diacrylate of 2 wt%~6 wt%. Two samples were made with different method of stabilization. For one sample the diacrylate of 2 wt% was polymerized with the ChLC in P state, while for the other sample diacrylate of 16 wt% was polymerized with ChLC in H state. In the former case, the transition time was 1000 times faster than those in the pure sample. In the latter sample, the transition time was 1700 times faster than those in pure ChLC sample.

### 1. Objectives and Background

The positive dielectric anisotropic of ChLC exhibits two stable states at zero field. One state is the Bragg reflecting planar (P) state. The other state is the weakly scattering Focalconic (FC) state. When the electric is applied to the sample at P state, it goes to FC state and will remain at FC state after removal of the electric field (P-FC transition). However, if the electric field is applied to the sample at the FC state, the sample will be changed to intermediate homeotropic (H) state. One has to then remove the field to make the sample to be P state (H-P transition). The P-FC transition is fast by field-induced process, but H-P transition is usually slow due to nucleation in the HP transition process [1]. So, in order to utilize the CHLC for display device, the transition time from H state to P state (H-P) needs to be reduced.

For this purpose, technique such as polymer stabilization [2,3] or improving the driving waveform [4] were proposed recently. When the applied field is weak, the transition behavior of polymer stabilized

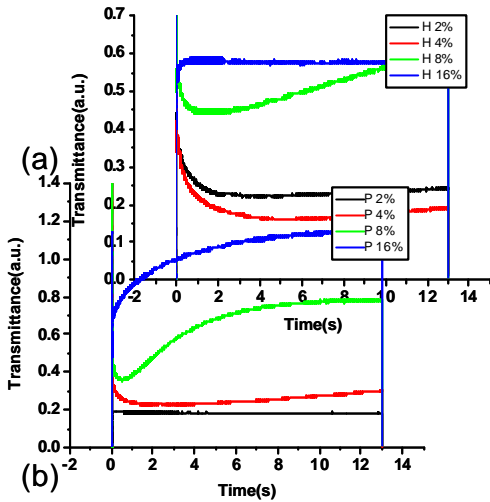
cholesteric system (PSC) is similar to that in the pure cholesteric system. However, if the applied voltage is high for polymer stabilized cholesteric(PSC), the system goes to FC state instead of going to P state. In the case of improving the driving waveform, one need extra small bias voltage just before the field is removed for about 1 msec to improve the reponce time. But technically, it is difficult to apply such an extra waveform.

In this work, we have investigated how the transition time depends on the polymerization procedure of the diacrylate. We have polymerized the diacrylate of concentration 2 ~ 16 wt% either at both H state or at P state of ChLC. The polymerization is done by irradiating the sample with U.V. light. (The transit was measured as a function of dyacrylate concentration and as that of state ChLC at which the polymerization is performed.

### 2. Result

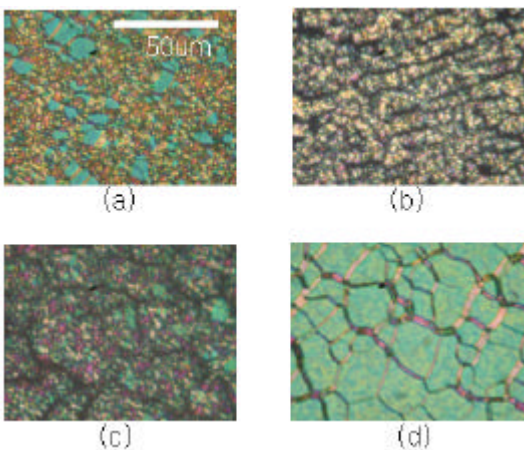
The optical transmittance was measured as a function of time elapsed after the field is turned on for the case of two samples prepared differently, one in which the diacrylate is polymerized at the H state of ChLC [Figure 1. a] and the other in which the diacrylate is polymerized at P state of ChLC [Figure 1. b]. In the sample polymerized at H state, H-P transition time was reduced as the diacrylate's concentration was increased, and in the sample polymerized at P state, the trend was opposite.

In high diacrylate concentration (16 wt%), we observed the transition time of former sample was faster than that of latter sample. On the other hand, in low diacrylate concentration (2 wt%), we found that the transition time of the former sample was slower than the latter sample.

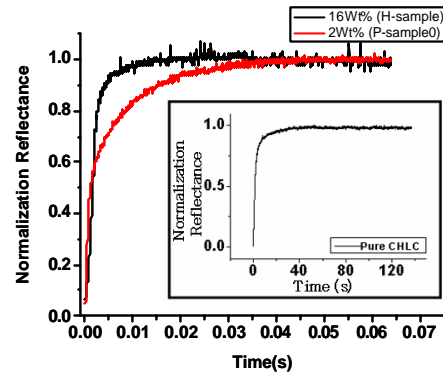


**Figure 1.** H-P transition time of (a) H-samples and (b) P-samples. (These data show the reorientation from H state to P following the removal of the applied field at t=0s.)

The picture of sample is taken with a polarizing optical microscope (POM). It shows that smaller domains are predominant in the sample with low diacrylate concentration (2 wt%), while sample with high diacrylate concentration shows both polymer walls and small domains. [Figure 2]



**Figure 2.** Micrograph of the Planar state (a) 2 wt% (P-sample), (b) 16 wt% (H-sample), (c) 16 wt% (P-sample), (d) Pure ChLC (The black texture is the polymer wall)



**Figure 3.** H-P transition time of P-sample (2 wt%) and H-sample (16 wt%) (The insert shows pure ChLC)

Figure 3 shows that the normalized intensity of light reflected from the P state of sample with diacrylate polymerized at H state as well as those of the sample with diacrylate polymerized at P state. One can see that the former sample shows much faster transition time than those of the latter sample.

We think the reason why the former sample is faster than latter is that there is extra interaction of ChLC with polymer wall in the former case.

### 3. Impact

ChLC display has attracted worldwide attention due to its bistability for reflective displays. However, in order to use ChLC display for video application, H-P transition time has to be reduced.

In this study, we investigated the dependence of transition time on the concentration of polymer as well as on the state of ChLC at which the UV is irradiated to the samples to reduce H-P transition time.

### 4. References

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