

Bragg Reflective Polymer Stabilized Cholesteric Liquid Crystal Display

Jang Un Kwon** and Daeseung Kang*

Abstract

In the paper, we investigated the Bragg reflective cholesteric display based on polymer stabilization. We studied the bistability in the polymer stabilized cholesteric texture (PSCT) films and baised on which we achieved wider viewing angle though imperfect planar texture.

Keywords : cholesteric liquid crystal, PSCT, bistability, viewing angle

1. Introduction

Recently, cholesteric liquid crystal (CLC) displays have attracted mang interest in the liquid crystal industry because of their many promising applications [1]. Unlike the conventional nematic liquid crystal displays, the CLC displays do not require polarizers and color filters.

It is known that planar and focal-conic states are stable in CLC cells in the absence of the electric field. When the CLC is in the planar state, the helical axis is normal to the substrates, and thereby, the liquid crystal selectively reflects light incident on the CLC cell. In the focal-conic state, randomness of helix axes of CLC scatters light, resulting in dark state in the reflective mode. Generally, texture stabilization can be achieved via either surface polymers.

Polymer networks can be incorporated to enhance the two stable states of the cholesterics [2]. D.K.Yang et al [3] proposed the polymer stabilized cholesteric texture(PSCT) films, in which small concentration (less than 10 %) of polymer is added to the host CLC.

Depending on the treatment of the substrates and on the pitch length of the CLC, three operation modes are proposed: normal mode, reverse mode, and Bragg reflection mode [3-9]. In the reverse mode PSCT, a CLC with a pitch of several microns is used. A low concentration of a mesogenic monomer is dissolved in the liquid crystal, and then, polymerized by surface treatment while the liquid crystal is in the planar state. The resulting polymer network drives the initial planar state at zero field. On the other hand, a normal mode PSCT display does not require any surface treatment as the cell is irradiated by UV light while the liquid crystal in the presence of high electric field is in the homeotropic state. A focal conic texture is then formed as a result of competition between the intrinsic helical power and the constraining effect of polymer.

In this paper, we investigated the reflective CLC displays using Bragg reflecting mode PSCT. In particular, the expansion of the viewing angle by polymer network formed in the liquid crystal medium was studied.

2. Experimentals

The CLC mixture used in this experiment was a mixture of MLC-6200-000 (Merck, $\Delta n=0.1189$) and a chiral additive CB-15 (Merck). Cleaned ITO(Indium Tin Oxide) glass substrates were prepared: one coated with polyvinyl alcohol(PVA) and the other without any

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* Member, KIDS; ** Student Member, KIDS.

Corresponding Author : Daeseung Kang

Department of Electrical, Electrical Engineering, Soongsil University 1-1, Sangdo-Dong, Dongjak-Gu, Seoul 156-743, Korea.

E-mail : dkang@ssu.ac.kr Tel : +2 820-0642 Fax : +2 817-7961

treatment. The PVA film was deposited by spin-coating on clean glass substrates at 3000 rpm for 20 seconds. The coated PVA films were then baked at 120 °C for 20 minutes. To achieve the planar alignment, rubbing process was carried out. For the photo-polymerization, UV epoxy NOA72 (Norland) was mixed with the CLC mixture. The photopolymer concentration in the CLC/polymer solution was varied from 1.61 ~ 7.69 wt%. The glass sphere spacers were placed between two ITO glass substrates, and the nominal thickness of the cells was measured to be 6.5 μm

The cell was placed on a hot plate heated up to 100 °C. Then, the cell was infiltrated with the CLC/polymer solution via capillary action, it was subjected to UV light of about 0.3 and irradiated for 5 minutes to induce polymerization.

Ocean Optic S2000 spectrometer was used to characterize the reflective properties of the cells filled with CLC/polymer solution as a function of polymer concentration. Electro-optical experiments were performed in the reflective mode with the back of the cells covered with a black tape so as to distinguish the contrast between planar and focal conic states. Detailed measurement scheme can be found elsewhere [1,10,11].

3. Results and Discussions

Helical twist power of CB-15 is 6.5 μm . As shown in Fig. 1, the helical pitch p of CLC is linearly dependent on weight percentage of CB-15, c , that is $p = \zeta / c$, where ζ is the proportional coefficient. Fig. 1 also shows the corresponding reflection peak wavelength, $\lambda = np$, where n is the average refractive index. Because we use the monochromatic He-Ne laser ($\lambda=633$ nm) for electro-optical experiments, we chose $c=29$ wt%.

Fig. 2 shows the effect of viewing angle on polymer concentration in the CLC/polymer solution. For pure CLC cells, the peak wavelength of reflected light shifted as viewing angle increases. However, with the polymer concentration, the shift of the peak wavelength of reflected light noticeably reduced until around 30°. In other words, as polymer concentration increased, the viewing also angle also increased. However, as shown in Fig. 2, at high polymer concentration of 7.7 wt%, we could not observe any improvement of the viewing angle. This is due to the fact that too many defects hinder the

stabilization of planar texture. Fig. 3(a) presents reflection spectrum of CLC/polymer cells both with and without photo-polymerization. By forming polymer network on CLC, the reflectivity lowered, but the FWHM of reflection increased. Fig. 3(b) shows optical image of a cell; half is UV illuminated while the other half is not. Clearly, due to polymer network by polymerization, imperfect planar texture was observed in the area illuminated with UV, as shown in Fig. 3(b).

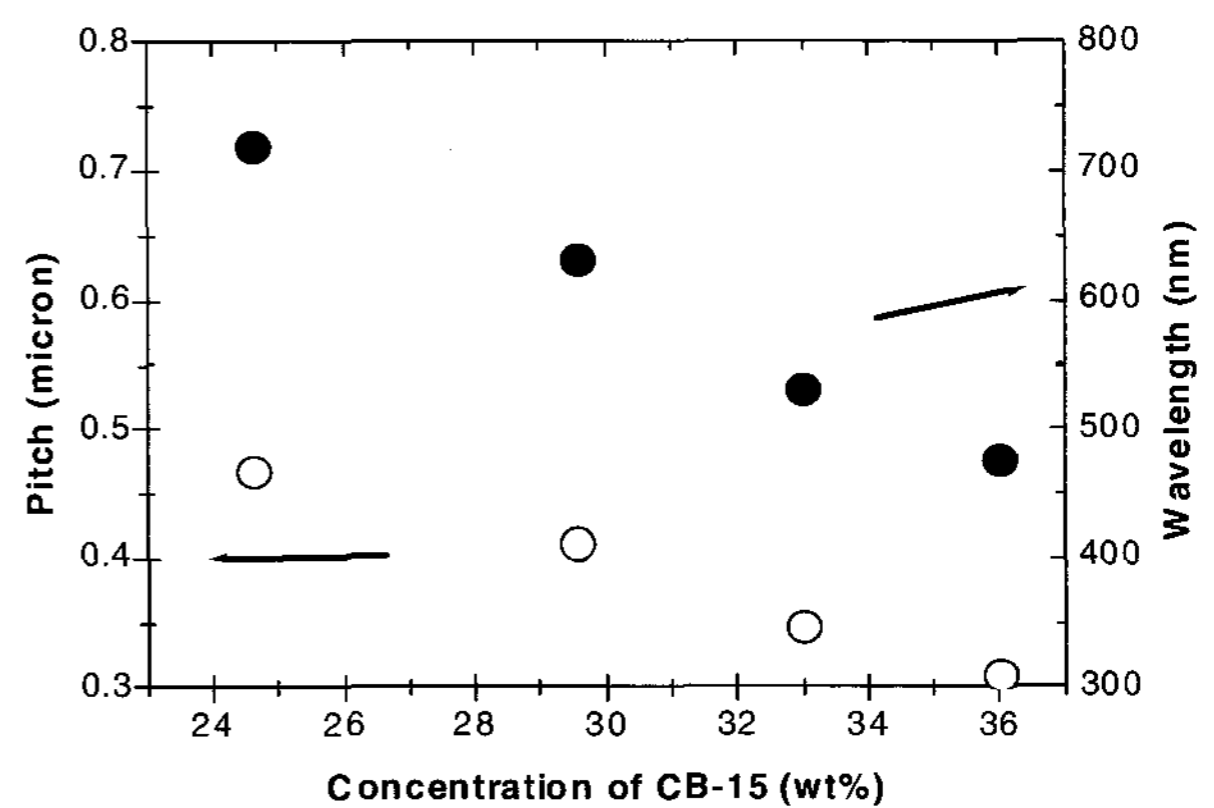


Fig. 1. Reflective wavelength (solid) and pitch length (open) of CLC mixture versus concentration of chiral additive CB-15.

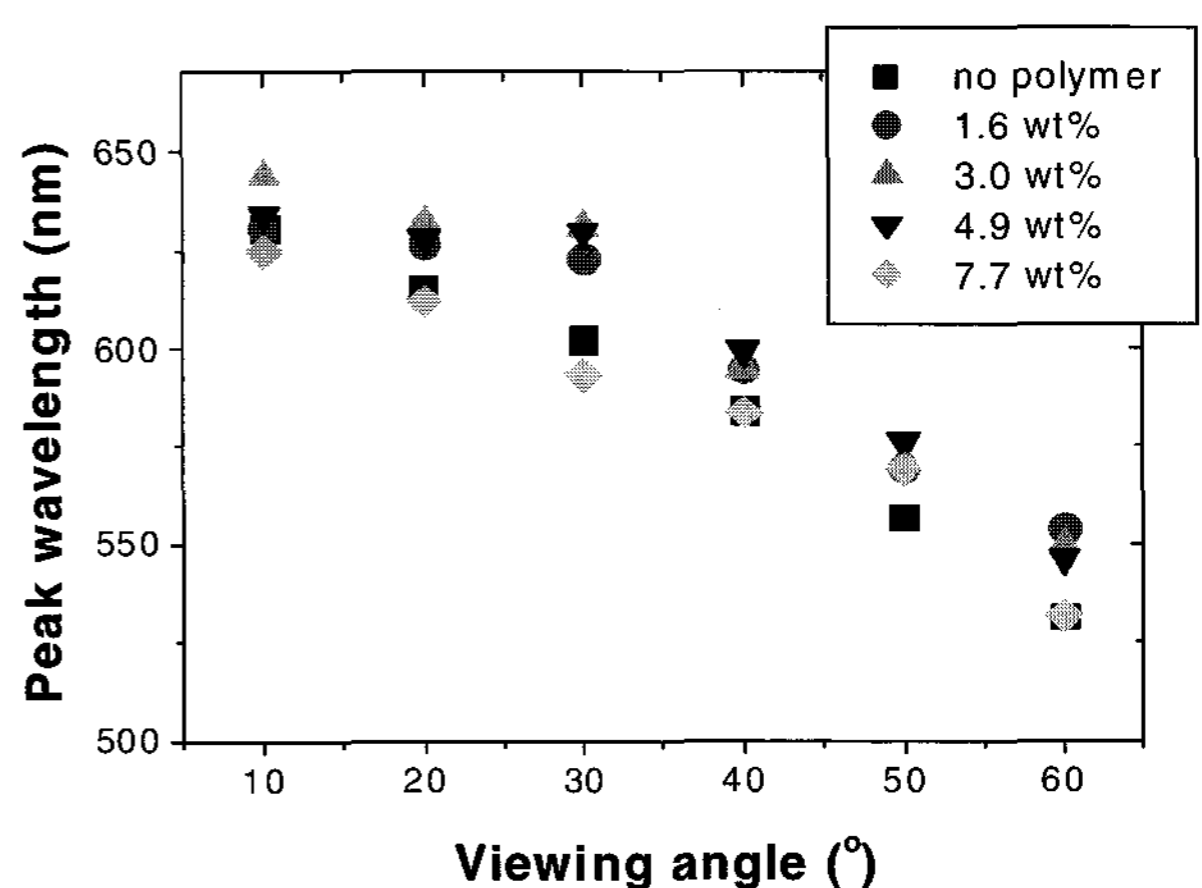
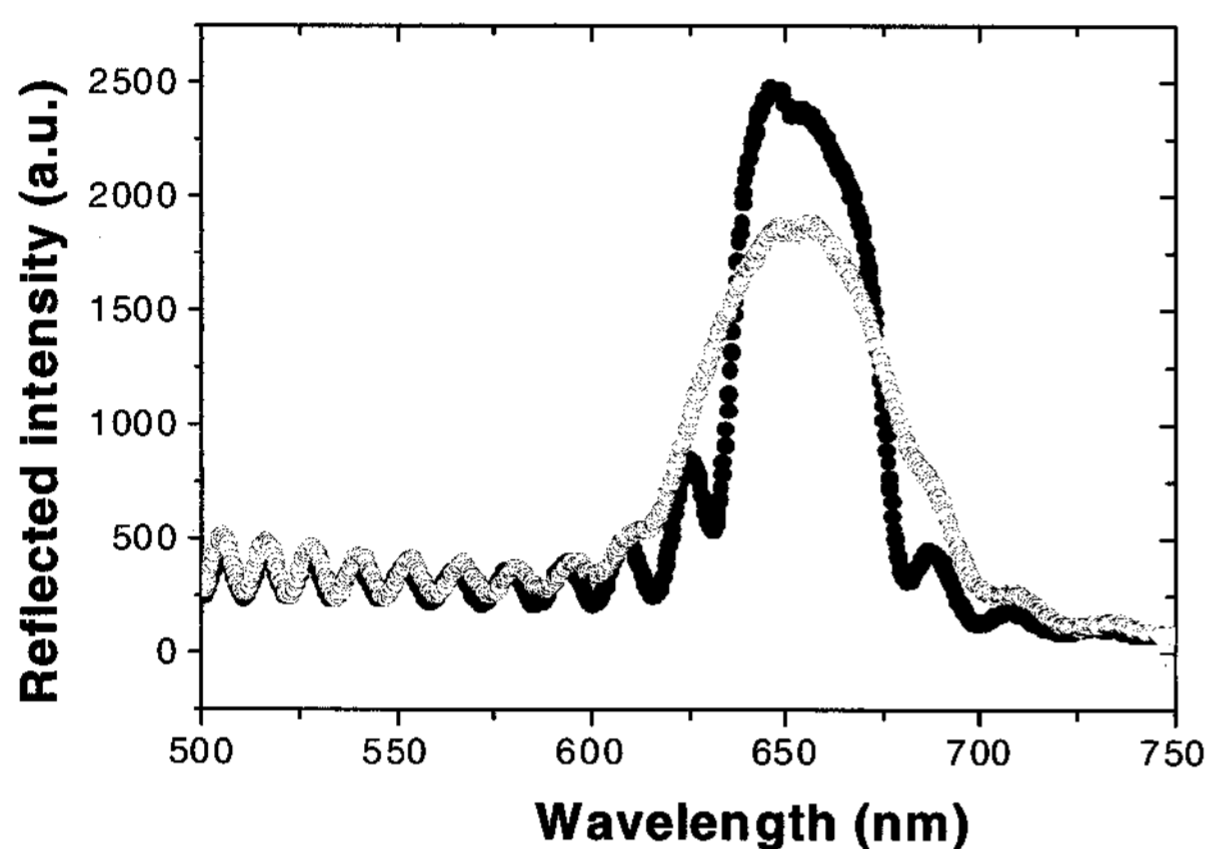


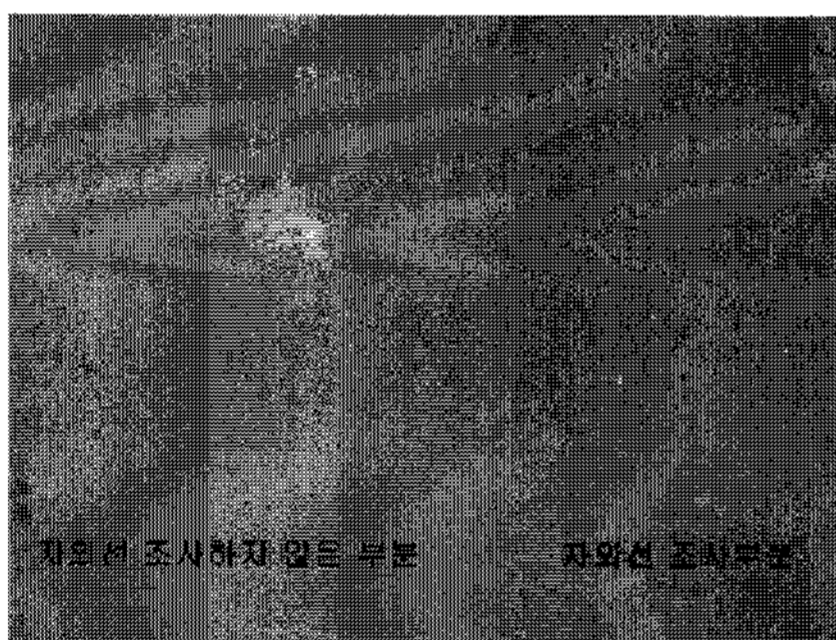
Fig. 2. Reflection peak wavelength with respect to the incident angle for a different concentration of NOA72 polymer.

Fig. 4 shows the electro-optical switching characteristics of CLC/polymer cells. Bistability of Bragg reflecting planar state and scattering focal conic state at zero field is clearly seen from Figs. 4(a) and (b) for both with and without polymer. Switching between two states can be achieved by crossing high field homeotropic state where helices are unwound and CLC is highly

transparent (reflecting in this experiment). In Fig. 4(a), the cell was initially in a planar state by applying high resetting voltage ($60 V_{pp}$), whereas in Fig 4(b) the cell was initially in focal conic state by applying low resetting voltage ($30V_{pp}$) prior to the application of each addressing voltage pulse. Above $V_{pp}=37 V$, the states for both cases were switched to homeotropic state. With the addition of polymer, the threshold voltage for the homeotropic transition slightly increased.



(a)



(b)

Fig. 3. (a) Reflection spectrum of a CLC/polymer cell before (open) and after (solid) photo-polymerization of the cell. (b) Microscope image of photo-polymerized (right) and non-polymerized (left) of the cell. The polymer(NOA72) concentration was 4.9 wt%.

4. Conclusions

In summary, we have investigated the PSCT display,

and observed bistability of the planar and focal conic states at zero voltage. At 4.9 wt% of polymer concentration, we could realize wider viewing angle to imperfect planar state

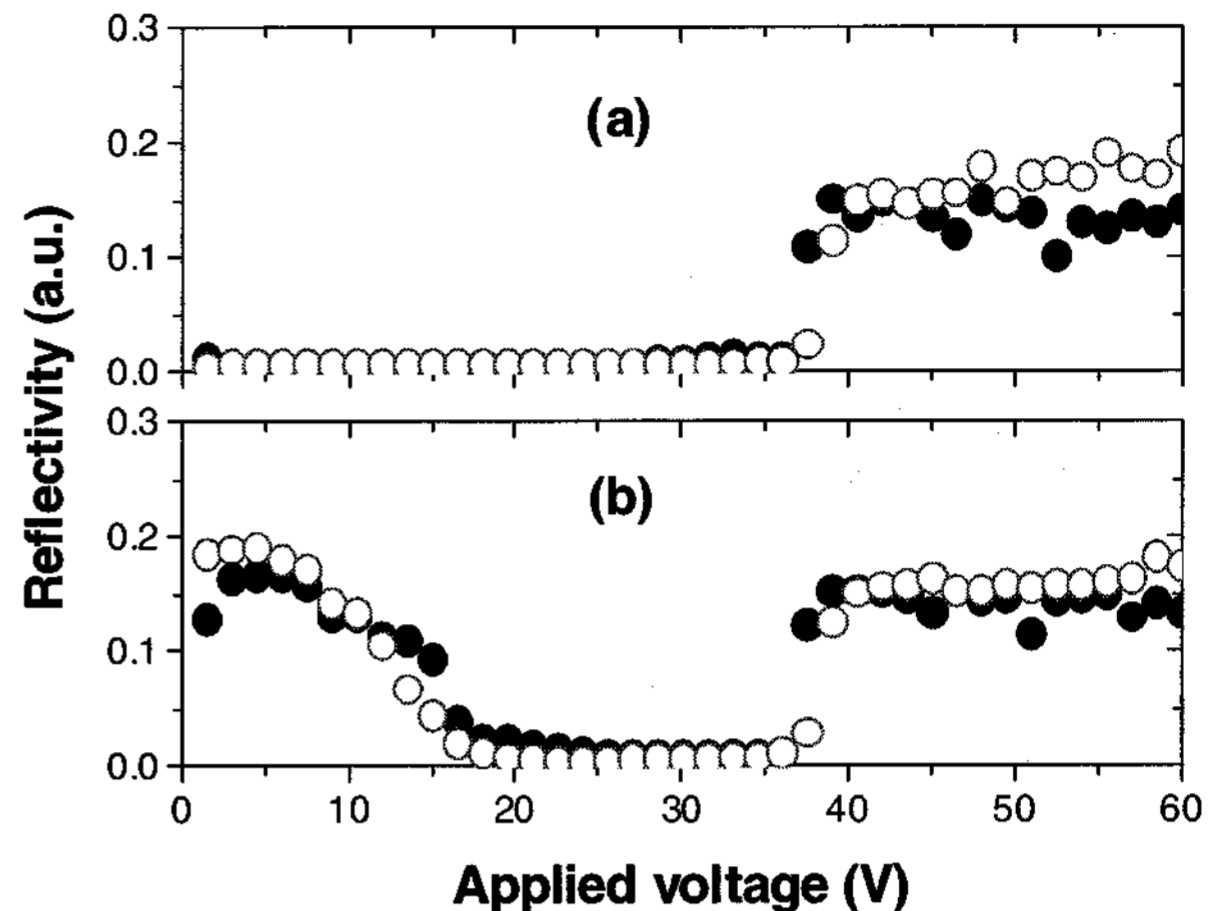


Fig. 4. Bistability in reflectivity versus applied voltage on the cell. Solid and open circles correspond to polymer concentration 0 wt% and 3.0 wt%, respectively. Initial state is (a) planar and (b) focal conic, respectively.

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