Wide viewing angle of reflective cholesteric liquid crystal display

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Abstract

In the paper, we have investigated the reflective cholesteric display based on the polymer stabilization. The bistability in the polymer stabilized cholesteric texture(PSCT) films was observed and wider viewing angle was achieved due to imperfect planar texture.

1. Introduction

. Recently, cholesteric liquid crystal (CLC) displays attracts lots of interest from liquid crystal industry because of their many promising applications[1]. Unlike conventional nematic LCDs, 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 the liquid crystal selectively reflects light incident on the CLC cell. In focal-conic state, randomness of helix axes of CLC scatters light, resulting in dark state in reflective mode. Generally texture stabilization can be obtained via either surface or polymer: surface stabilized and polymer stabilized.

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 %) is added. 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 subsequently polymerized while the liquid crystal is in the planar state. The resulting polymer network drives the initial planar state. A normal mode PSCT display does not require any surface treatment. The cell is irradiated by UV light in the homeotropic texture in the presence of high electric field. 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 reflective CLC displays using Bragg reflecting mode PSCT. Particularly, broadening of viewing angle by polymer network formed in the liquid crystal medium was studied.

2. Experimental

CLC mixture used in this experiment was a mixture of MLC-6200-000 (Merck, Δn=0.1189) and chiral additive CB-15 (Merck). Cleaned ITO(Indium Tin Oxide) glass substrates were prepared, one coated with polyvinyl alcohol(PVA) and the other one without any 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 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 silica sphere spacers were placed between two ITO glass substrates, and nominal thickness of the cells was 6.5 μm.

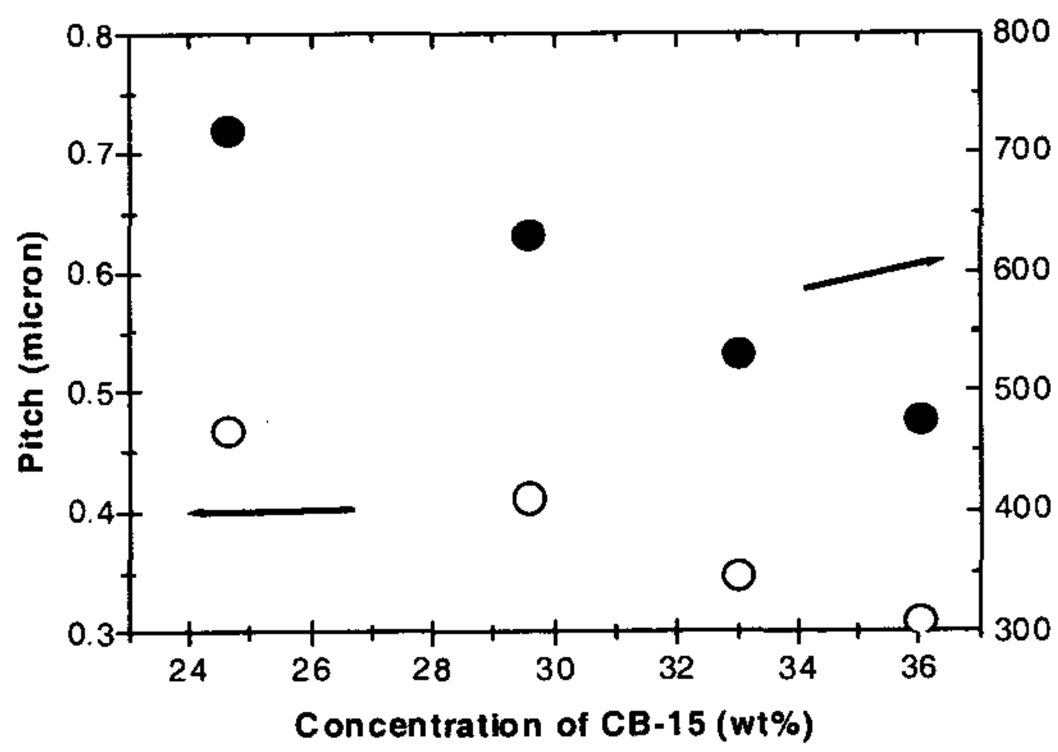


Fig.1 Reflective wavelength (solid) and pitch length (open) of CLC mixture versus concentration of chiral additive CB-15.

The cell was placed on a hot plate that was heated up to 100 °C. Then after the cell was infiltrated with the CLC/polymer solution via capillary action, it was subjected to UV light irradiation to induce polymerization. UV light intensity was about 0.3 mW/cm^2, and irradiation time was 5 minutes.

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 cells covered with a black tape to enhance contrast between planar and focal conic states. Detailed measurement scheme can be found elsewhere [1,10,11].

3. Data and results

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. Figure 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 (λ=633 nm) for electro-optical experiments, we chose c=29 wt%.

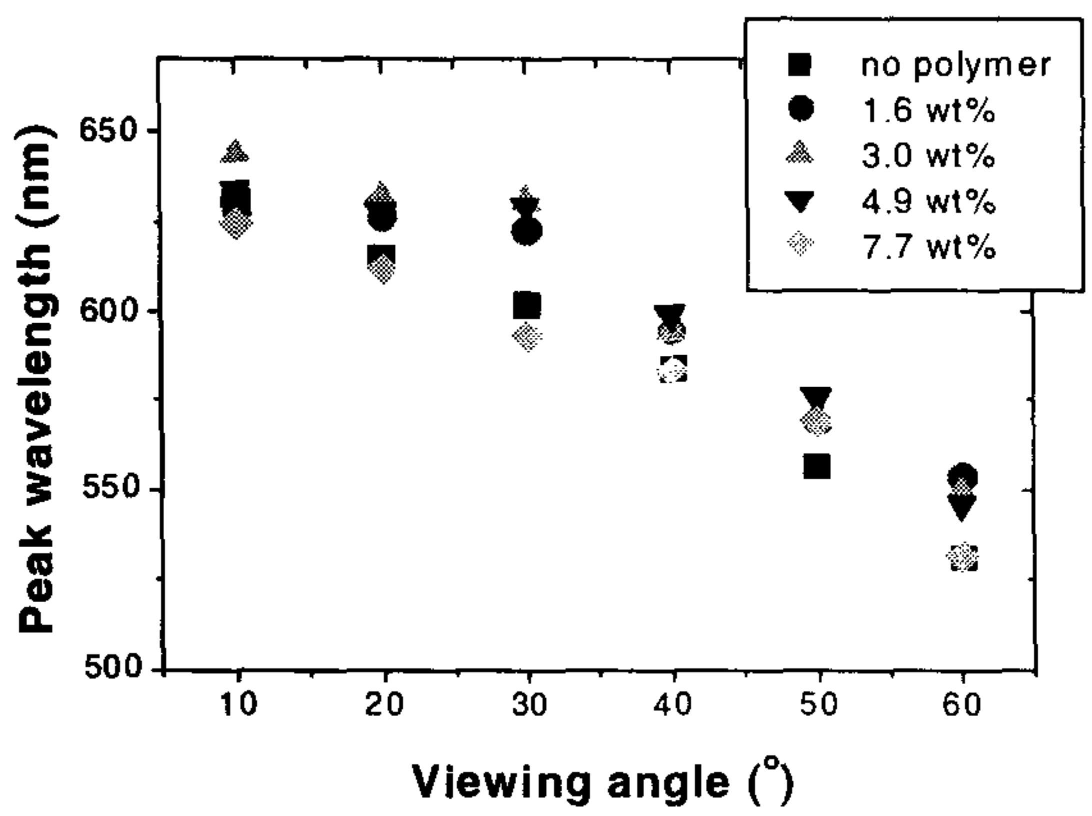
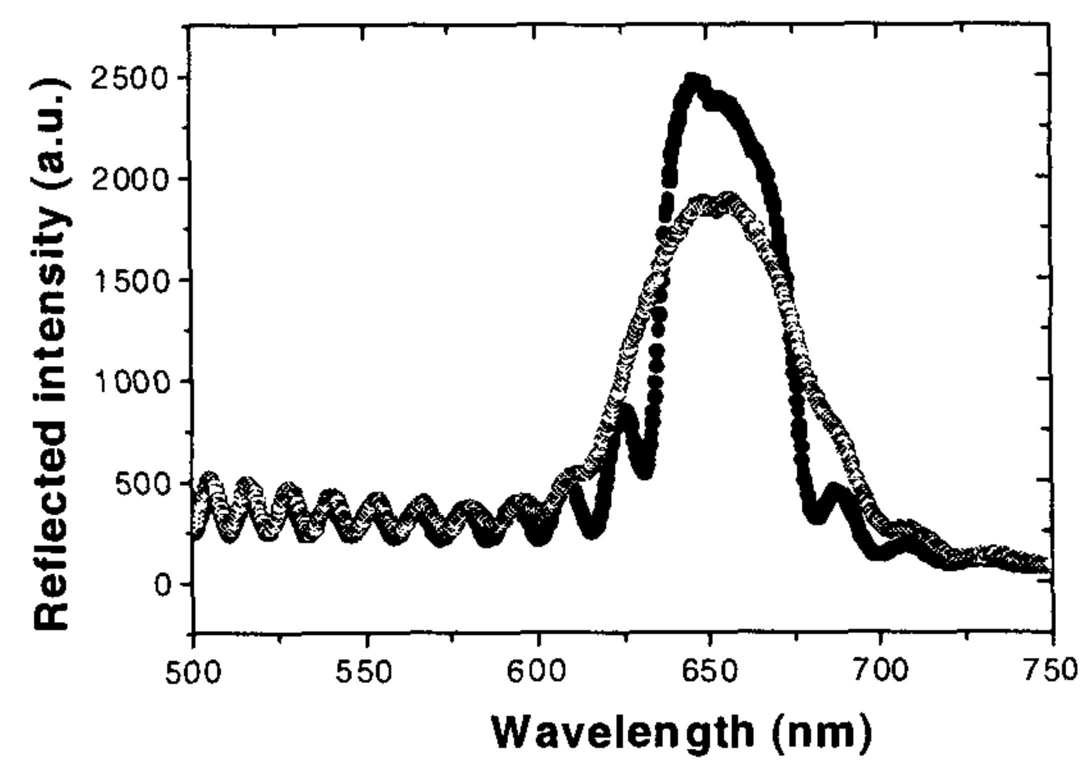
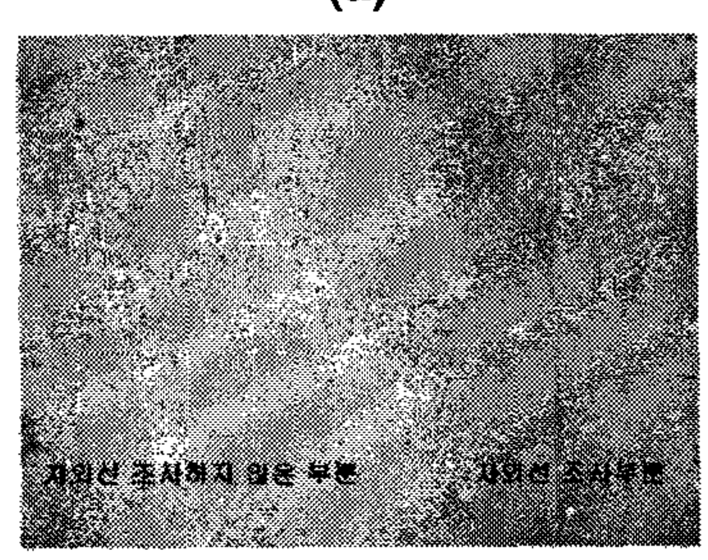


Fig.2. Reflection peak wavelength with respect to the incidence angle for a different concentration of NOA72 polymer.

Figure 2 shows 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, shift of the peak wavelength of reflected light noticeably reduced until around 30°. In other words, as polymer concentration increases, the viewing angle increases. However, as shown in Fig. 2, at high polymer concentration 7.7 wt%, we could not have improvement of the viewing angle. It comes from the fact too many defects hinder the stabilization of planar texture. Figure 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 FWHW of reflection increased. Figure 3(b) shows optical image of a cell; half is UV illuminated and 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).



(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) are of the cell. The polymer(NOA72) concentration was 4.9 wt%.

Figure 4 shows the electro-optical switching characteristics of CLC/polymer cells. Bistablity of Bragg reflecting planar state and scattering focal conic state at zero field was clearly seen from Fig. 4.(a) and (b) for both with and without polymer. Switching between two states can be achieved by crossing high field homeotropic state where helixes are unwounded and CLC is highly transparent (reflecting in this experiment). In Figure 4(a), the cell was initially in planar state by applying high resetting voltage (60 Vpp), whereas in Fig 4(b) the cell was initially in focal conic state by applying low resetting voltage (30Vpp) before the application of each addressing voltage pulse. Above Vapp=37 V, the state can be switched to homeotropic state.

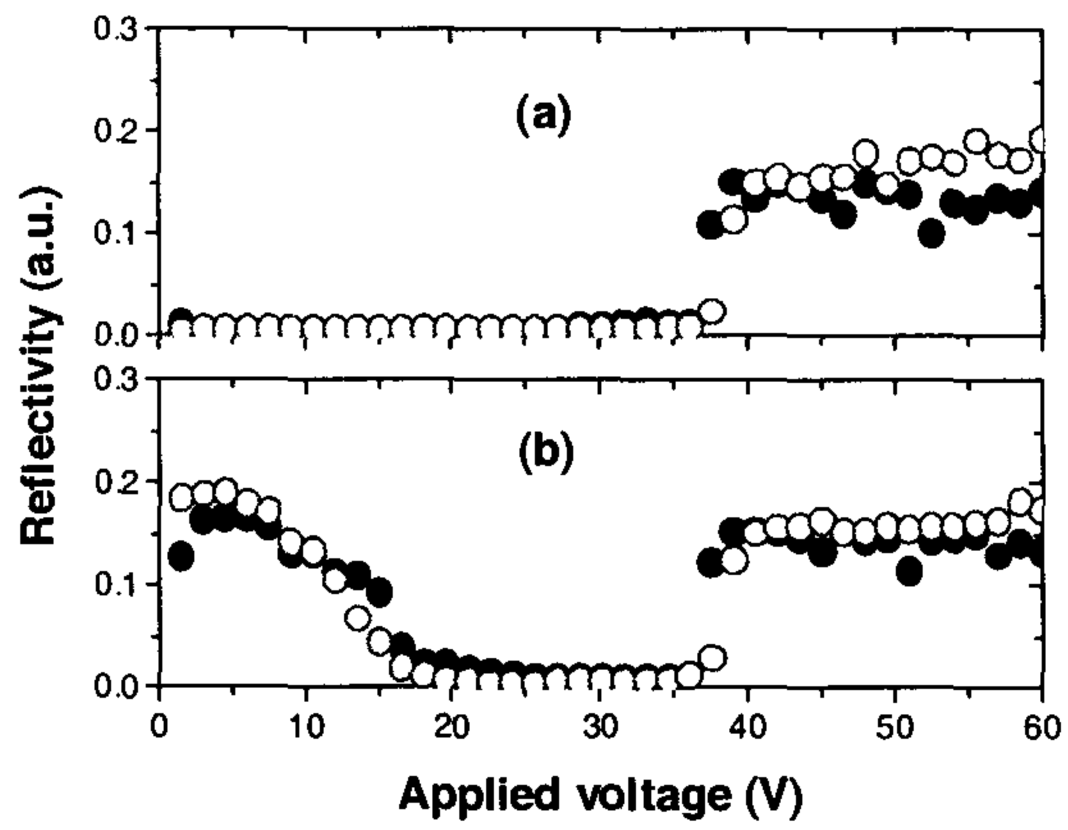


Fig.4. Bistability in reflectivity versus applied voltage on the cell. Solid and open circles correspond to polymer concentration 0 wt% and 3.0 wt%, respectively. Initial state is (a) planar, (b) focal conic, respectively.

With the addition of polymer, the threshold voltage for the homeotropic transition slightly increased.

4. Conclusion

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, wider viewing angle was realized due to imperfect planar state.

5. Acknowledgements

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6. References

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