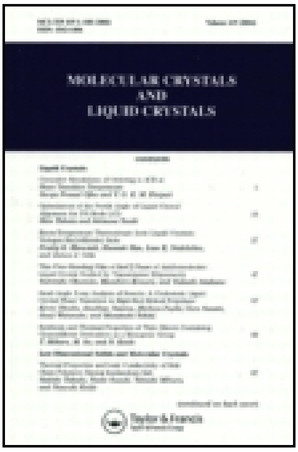

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Wide-Band Reflective Polarizers from Variable Pitch Cholesteric Liquid Crystal Films

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Wide-Band Reflective Polarizers from Variable Pitch Cholesteric Liquid Crystal Films

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Due to their periodic helical structure, cholesteric liquid crystals (CLC) have a unique ability to selectively reflect visible light. CLC films reflecting a broad wavelength band were made by inducing a pitch gradient in CLC through a diffusion of small molecules and through a thermal diffusion between two CLC oligomer films with different pitch gradients.

Keywords: cholesteric liquid crystal, reflective polarizer, pitch gradient

INTRODUCTION

Cholesteric liquid crystals (CLC) are interesting materials since they selectively reflect light when the helical pitch is the order of the wavelength of an incident beam propagating along the helix axis. They reflect circularly polarized incident of the same handness as the cholesteric helix and of wavelength band that depends on the helical pitch. When a cholesteric is in the planar state, the helix axes are perpendicular to the surface of the cell and the CLC material reflects light whose wavelength is related to the helix pitch by the Bragg relation [1]. Although CLC have been subjected to many applications in reflective polarizers and optical filters, a drawback lies in the fact that bandwidth of the reflected light is limited to a few tens of nanometers. In the present study, by introducing a gradient in the pitch of the cholesteric helix, we can obtain reflection of one of the two circularly polarized components over broad ranges of visible spectrum. Polarizers with such broad band reflectivity would greatly improve the light yield and energy efficiency of liquid-crystal display (LCD) devices by recycling reflected circularly polarized light in the back light system.

EXPERIMENTAL

The cholesteric oligomers from Wacker Chemie Ltd. are cyclic siloxane with two types of side-chains attached by a spacer to the main chain [2]. One is chiral and the other is not, so that the pitch and reflection color are determined by molar ratio of these two side groups. Two CLC-siloxane oligomers chosen were one with 50% chiral side chains (Blue) and the other with 31% chiral chains (Red). Thin layers of CLC-siloxane (thickness: 13 μm) were oriented by shearing them between glass plates at 120 °C. This procedure changes the CLC structure from focal conic to planar structure in which helical axis of the cholesteric phase is oriented perpendicular to the glass surface. After two (Blue and Red) CLC-siloxane films were separately prepared, they stacked together and put on a heating stage. For the study of small molecules diffusion, a mixture of unsaturated polyester and styrene (60:40) was used for stacking with one of CLC-siloxane films. Transmission spectra were recorded using a Hitachi U-2000 UV/Vis spectrometer.

RESULTS AND DISCUSSION

Fig. 1 shows the variation of transmitted light intensity as the sandwich cell made of two CLC-siloxane films (Blue and Red) was annealed at 100 °C. The mean reflection wavelengths exhibited by the pure Blue and Red films are 440 and 680 nm, respectively. As the cell was annealed at the temperature at which a stable cholesteric phase is maintained, the reflection bandwidth of light broadens to 300 nm through mixing of two CLC-siloxane oligomers. Since two oligomers have a good miscibility each other, it is expected that a diffusion process between the Red and Blue films occurs in a direction perpendicular to the plane of films and results in a pitch gradient in the CLC layers. Such a pitch gradient created in the layers could be verified by our scanning electron microscopy investigations made on cross-sections of the cell. Further annealing of the films results in a decrease of bandwidth while shifting its mean reflection wavelength to 500 nm.

A pitch gradient in CLC layers was also induced through a diffusion of small molecules into CLC-siloxane films. By swelling the Red film with styrene vapor, the reflection band shows red-shift to 800 nm while its bandwidth increases to 150 nm. Since this process is reversible through evaporation of styrene from the film, a mixture of unsaturated polyester and styrene was used to fix the induced pitch gradients. Figure 2 shows a progressive increase of the reflection bandwidth of the Red film with time after the styrene mixture containing 7% of hydrogen peroxide was put on the film. As the polymerization reaction occurs during the diffusion of styrene into CLC layers, the change in the pitch variation becomes smaller and has not changed after

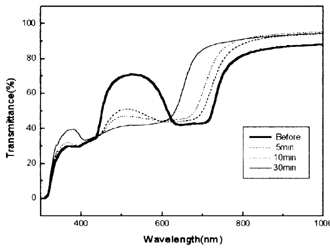

FIGURE 1. Transmitted light spectra of stacked Blue and Red films annealed at 100 °C.

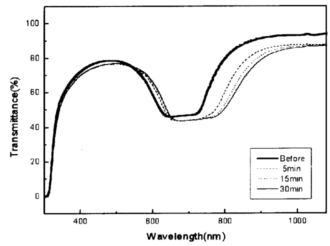

FIGURE 2. Transmitted light spectra of Red films after diffusion of styrene.

30 min. as seen in Figure 2. When 2% of initiator was added, the reflection band was shifted to a longer wavelength as well as broadened its bandwidth, whereas no broadening and shifting was observed with much larger amount of initiator. Thus, the rate of band broadening and shifting can be controlled by changing the amount of initiator. In conclusion, to broaden the light reflection band of CLC films, two experimental processes based on diffusion of molecules have been presented.

Acknowledgment
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