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PHOTO-CURABLE CHOLESTERIC LIQUID CRYSTAL FILM FOR APPLICATION IN THE LIQUID CRYSTAL DISPLAY

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The cholesteric filters can improve the efficiency of light use when it is applied to a reflective mode. They reflect circularly polarized incident light of the same handedness as the cholesteric helix and transmit the one having the opposite handedness. The transmission bandwidth depends on the helical pitch. In order to widen the bandwidth, we synthesized new cholesteric liquid crystal molecules containing the active reaction moeity to UV light and investigated the various UV treatment methods to broaden the bandwidth of the cholesteric filters. There was appears that the band broadened about 200 nm by using the photo-mask. It is caused of a factor as a consequence of UV-curing when the cholesteric pitch changes locally by using the mask.

Keywords: bandwidth; cholesteric filter; UV treatment

1. INTRODUCTION

Linear polarization of light over a large area is conventionally achieved using dichroic polarizers. The dichroic polarizer is a very common component in optical setup and an instrument to select the particular type of light. The limitations of the polarizers are the dissipation of more than

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50% of light, the inability to withstand high temperatures, and low damage threshold [1–3].

The cholesteric filters can improve the efficiency of light use when it is applied to a reflective mode. They reflect circularly polarized incident light of the same handedness as the cholesteric helix and transmit the one having the opposite handedness. The transmission bandwidth depends on the helical pitch [4–5].

When the cholesteric filters are mounted into an LCD backlight, the transmitted component can be converted from circularly polarized to linearly polarized after passing through a quarter-wave retardation foil (QWF). The component, which cannot pass through the CLC layer, reflected to a mirror, that induces the reverse polarization. The reversed polarization is the same polarization of the transmitted light, and eventually escapes from the CLC film. This indicates that the light can be recycled in between CLC film and reflector. In an ideal case, all the light will eventually emerge linearly polarized from the cholesteric layer/QWF stack [6].

The cholesteric color filter has many optical properties integrated in one layer. It is not only a color filter, but also a reflector and a polarizer. Such advantages can reduce the total number of optical components in the LCD and lead to cost reduction [7–9]. However, the reflection wavelength is related to the helical pitch and the wavelength bandwidth depends on the birefringence that is typically less than 0.3. In the visible spectrum, the bandwidth is often limited to 100 nm that is not suitable for specific purposes such as white-on-black polarizer-free reflective displays.

In order to improve the shortcoming, we synthesized new cholesteric liquid crystal molecules (Ch-chol) containing the active reaction site to UV light and investigated UV treatment methods to broaden the bandwidth of these cholesteric filters.

2. EXPERIMENTAL

We designed new photo-curable cholesteric material (Ch-chol), which has two kinds of reactive sites for UV light. Figure 1 shows the structure and the steps of synthesis.

The in situ polymerization of reactive liquid crystals has been processed. In this process a mixture of cholesteric liquid crystals with a small amount of a radical photo initiator (Irgacure 907 from Ciba-Geigy) is introduced in the isotropic phase over 100°C by capillary in a 13 μm thick glass cell which contains a very thin rubbed polymeric alignment layer. In order to control the center of the wavelength band of the reflected light, we mixed some nematic liquid crystal into the cholesteric mixture. The nematic liquid crystal used has a positive dielectric anisotropy. After alignment in the nematic

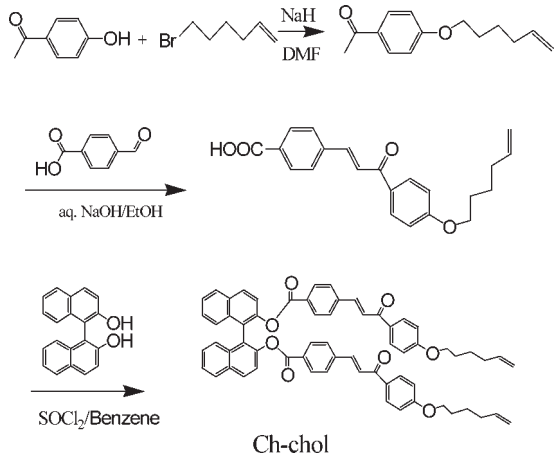

FIGURE 1 Synthesis of the new photo-curable cholesteric material.

phase, a fast UV-induced polymerization process is started to form a polymer and in this way stabilize the anisotropic optical properties of the monomers. By using a photo mask, photolithographic effects can be performed on the coating.

The spectral characteristics are obtained by unpolarized spectrophotometry (HP 8453) in transmittance mode and at ambient temperature. It is checked that negative peaks are due to reflectance and not to absorbance.

3. RESULTS AND DISCUSSION

Carboxylic acid containing the chalcone structure (see Fig. 1) was converted into the acid chloride through the reaction with thionylchloride. The new photo-curable cholesteric material (Ch-chol) was obtained from the reaction (S)-(-)-1,1′-Bi-2-naphthol with the highly reactive acid chloride of chalcone derivative. This product was confirmed by FT-IR and H-NMR spectroscopy.

When the cholesteric liquid crystal film is perfectly aligned, the liquid crystal molecules have the planar texture in which the helix is perpendicular to the glass plate. If the cholesteric layer is not perfectly aligned, however, there are various domains in the cholesteric layer. The cholesteric layer with the good planar texture reflects polarized light in a specular way, while the layer with the imperfect planar texture reflects polarized light in a diffuse way.

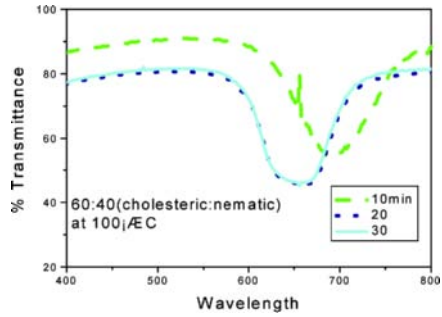

FIGURE 2 Transmittance of CLC films depending on the curing time (cholesteric LC/nematic LC = 60/40).

After irradiation, there is an important modification of the liquid crystal's pitch. There is a shift of the pitch towards the lower wavelengths. Modifying the UV intensity slightly changes the location of the pitch and the bandwidth measured at half-height is almost of 100 nm as shown in Figure 2.

The microscopic image is also observed with the temperature. Up to the clearing point about 125°C, the wavelength decreases with increasing temperature. After photo-polymerization around 100°C, however, almost constant reflection wavelength is obtained up to 180°C.

Figure 3 also shows how the broadening range of color are made by one irradiation step using a patterned mask between the light source and a coating of the material.

When cured at 100°C, the film was not clear and the light scattering was observed. The light scattering is due to a focal conic texture exhibiting

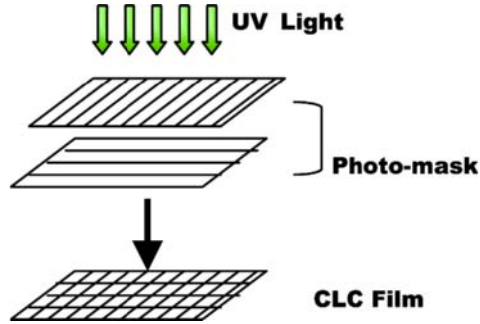

FIGURE 3 Color formation process for the new photo curable CLC film.

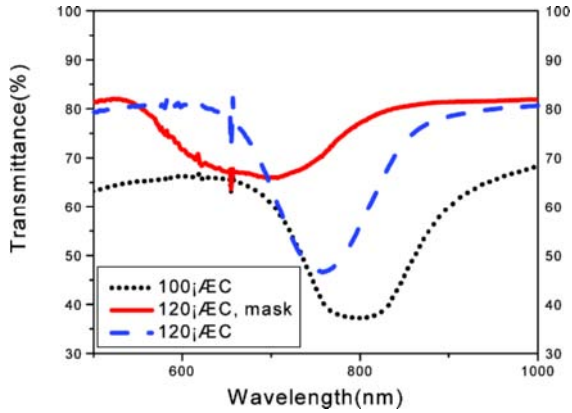

FIGURE 4 Transmittance spectra of the CLC films made in several curing conditions.

polydomains. This is the result of a competition between LC molecules close to the polymer network which have a tendency to contribute to a stable planar reflecting texture and the other molecules which is to destroy this order by untwisting the helix. While cured at the 120°C, the film reflected the light shifted to blue and had the high vividness of color as shown in Figure 4. There was also appears that the band broadened about 200 nm by using the photo-mask. It is caused of a factor as a consequence of UV-curing when the cholesteric pitch changes locally by using the mask.

We can think that this broadening is the result of memory effects introduced by the polymer network, which has been built in a CLC medium for which a major structural characteristic such as the helical pitch was changing.

4. CONCLUSIONS

The bandwidth of CLC filter is often limited to 100 nm that is not suitable for specific purposes such as white-on-black polarizer-free reflective displays. In order to widening the bandwidth, we synthesized new cholesteric liquid crystal molecules containing the active reaction moeity to UV light and investigated the various UV treatment methods to broaden the bandwidth of the cholesteric filters. There was appears that the band broadened about 200 nm by using the photo-mask. It is caused of a factor as a consequence of UV-curing when the cholesteric pitch changes locally by using the mask.

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