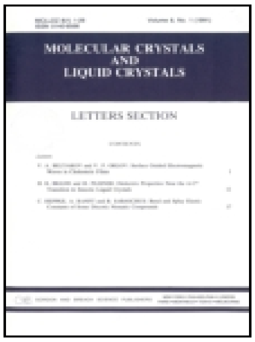

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Color Polymer Dispersed Liquid Crystal Device with Colored Core-Shell Structure

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Due to the fact the conventional polymer dispersed liquid crystal (PDLC) device operates between the transparent state and the scattering sate, color realization is limited. In this paper, we propose the color PDLC device with colored core-shell structure. By the complex coacervation microencapsulation process, liquid crystal droplets are encapsulated by the aqueous solution of gelatin, arabic gum, and color pigments. The size of the color droplet can be controlled by the pore size of the membrane filter. The average diameter of the fabricated color droplets is approximately 10 μm.

Keywords liquid crystals; polymer dispersed; microencapsulation; color

Introduction

The polymer dispersed liquid crystal (PDLC) device has attracted attention due to the low cost and simple process. The PDLC mode is one of promising candidate for the flexible displays [1, 2]. It also has used in various type of display such as the switchable windows and the light shutter devices [2]. The typical PDLC switches between the transparent state and the light scattering state by the electric field. However, the conventional PDLC cannot achieve color without the color filter. The color realization method of the PDLC is using the color filter or the PDLC with the guest-host mode, in which the dichroic dyes are mixed with the liquid crystals [3]. The method of using the color filter requires the additional step. The fabrication process becomes complicated and cost also increases [4]. In the case of the dichroic dye doped PDLC, the color shift occurs between the transparent state and the hazy state.

In this paper, we propose the color PDLC device with colored core-shell structure. liquid crystal droplets are encapsulated by the complex coacervation microencapsulation process [5, 6]. The coacervation process is the separation into two liquid phases in the colloidal systems. It is caused by the interaction of two oppositely charged colloids. In this

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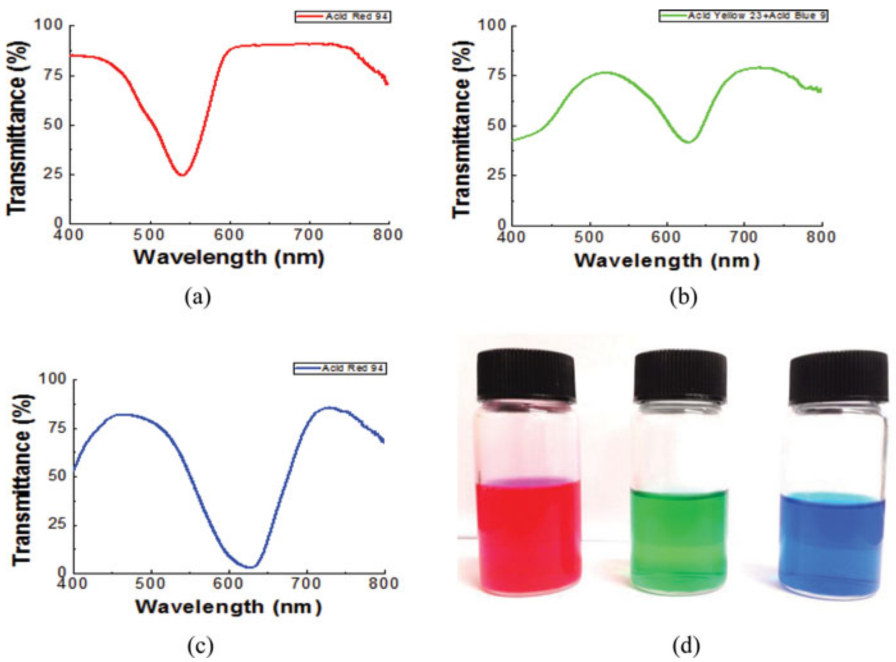

Figure 1. The transmission spectrum of color pigments: (a) acid red 94, (b) acid blue 9 + acid yellow 23, (c) acid blue 9, (d) aqueous solution of each pigments.

process, we fabricated colored core-shell structure with the aqueous solution of the gelatin and color pigment in the shell materials.

Fabrication of Color PDCL

We produced liquid crystal droplets based on the emulsification system. Nematic liquid crystal is dispersed in Sodium Dodecyl Sulfate (SDS) aqueous solution with a concentration of 0.1 wt%. The color pigments of acid red 94, acid blue 9, and acid yellow 23 were used.

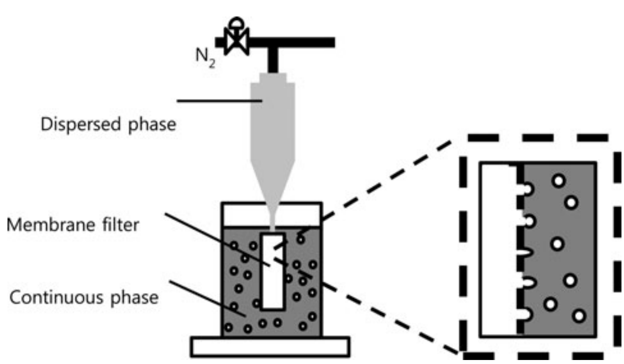

Figure 2. The schematic diagram of the membrane emulsification system.

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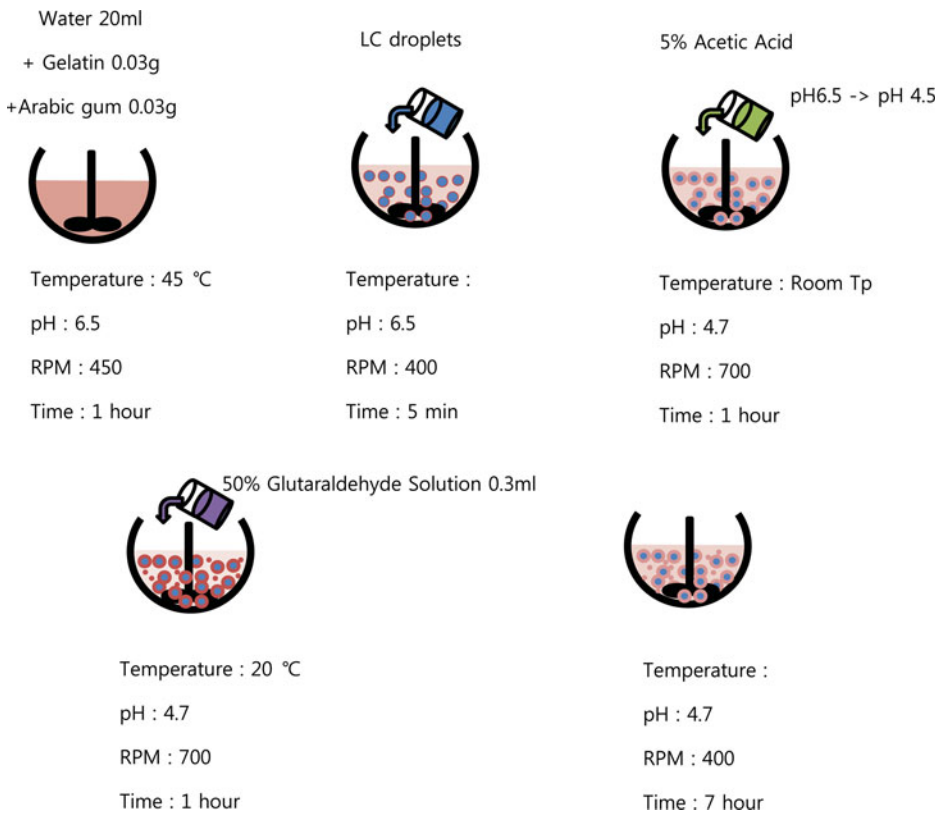

Figure 3. The coacervation microencapsulation process.

Microcapsules have the core-shell structure. The micro-sized core material is coated with the shell material. The complex coacervation method using gelatin/arabic gum is the typical encapsulation process. This method refers to the separation of an oppositely charged mixture into two distinct phases. The gelatin is transparent and has enough mechanical strength to withstand external pressures. The gelatin also has the advantage that it prevents the liquid crystal from dissolving within the capsule. Therefore, the gelatin is suitable for the capsule material. In order to fabricate color liquid crystal capsules, after adding the color pigments to the aqueous solution of gelatin and arabic gum, we put the liquid crystal

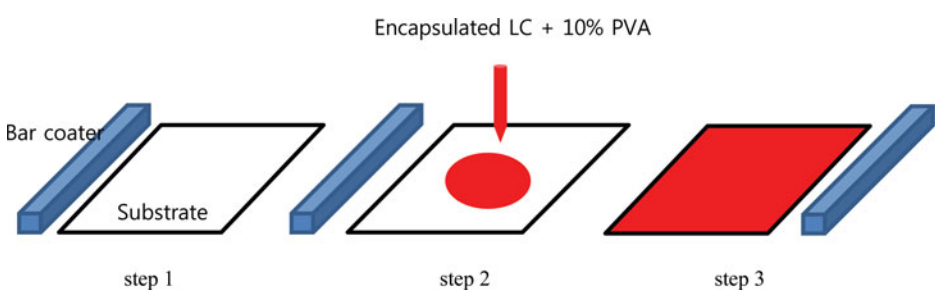

Figure 4. The fabrication process of PDLC sample using the bar coater.

(a) (b)

Figure 5. (a) Color LC capsules with red, green, and blue colors and (b) fabricated color PDLC device.

droplets fabricated by the membrane filter. Liquid crystal droplets are encapsulated by the coacervation method.

To fabricate the color PDLC device, we prepared the PVA aqueous solution of 10 wt% and mixed with liquid crystal capsules. It was coated with a thickness of 150 μm. After the PVA is cured, the color PDLC was fabricated with a thickness of about 15 μm.

Experimental Results

For the color shell of the core-shell structure, we used color pigments soluble in water. Red, green, blue color were achieve by acid red 94, acid yellow 23 + acid blue 9, and acid blue 9, respectively. Fig. 1 shows the transmission spectrum of red, green, blue color

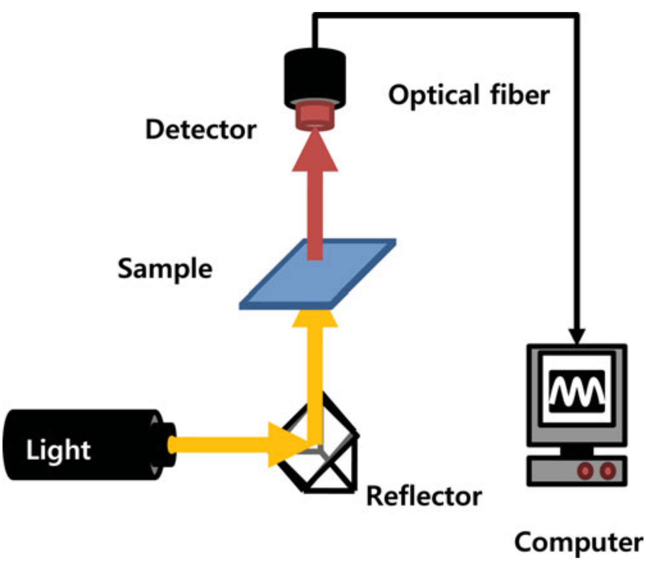

Figure 6. The measuring system for the optical properties of the PDLC.

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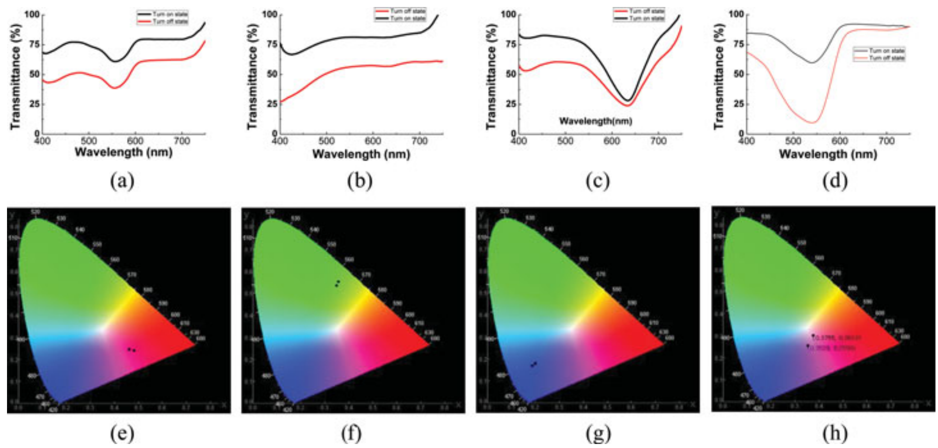

Figure 7. (a)-(c) the transmission spectrum of the non-driving and driving state and (d) the transmission spectrum of guest-host doped PDLC. (e)-(h) measured color coordinates.

from the color pigments. The aqueous solution of each color is shown in Fig. 1(d). The green color solution was produced with the mixing ratio with 30% of yellow 23 and 70% of blue 9.

Figure 2 shows a schematic diagram of membrane emulsification system. After injecting the liquid crystal and by slowly injecting the nitrogen gas toward the membrane filter, liquid crystal droplets are fabricated and dispersed in SDS solution. When the pore size of the membrane filter was 5 μm, we obtained liquid crystal droplets with the diameter of about 10 μm. The size of the droplets can be changed by the pore size of the membrane filter.

Figure 3 shows the coacervaiton microencapsulation process with the gelatin/arabic gum. 10 ml of 0.3 wt% gelatin solution and 10 ml of 0.3 wt% arabic gum solution were added to the liquid crystal droplets at 40°C, respectively. After the mixture solutions was stirred for 1 h, it was added with 5% of acetic acid for adjusting pH 4.5 for the phase separation. One milliliter of 50% glutaraldehyde aqueous solution was added to indurate the mixtures after stirring for 1 h at 20°C. Then the mixture was stirred continuously for 7 hours at 8°C.

Figure 4 shows the fabrication process of PDLC device using a bar coater. After dispersing the 10 wt% PVA aqueous solution with liquid crystal capsules, we coated a PDLC layer with a thickness of 150 μm using the bar coater. The PDLC layer then was cured to evaporate a water and formed about 15 μm.

Figure 5 shows the red, green, blue liquid crystal capsules fabricated by the coacervation method and the color PDLC device. Fig. 6 shows the measuring system for the optical properties of the PDLC. The transmission spectrum is measured by the spectrometer. The color coordinates measured by the luminance meter. Fig. 7 shows the transmission spectrum of the non-driving and driving state. Fig. 7(d) represents the transmission spectrum of guest-host doped PDLC. Furthermore, the measured color coordinates are shown in Figs. 7(e)-(h).

Conclusion

In this paper, we proposed the color PDLC with colored core-shell structure. By the complex coacervation microencapsulation process, liquid crystal droplets are encapsulated

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by the aqueous solution of gelatin, arabic gum, and color pigments. The average size of the fabricated color droplets was about 10 μm in diameter. Our color PDLC suppress the color shift comparing to the guest-host doped PDLC

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