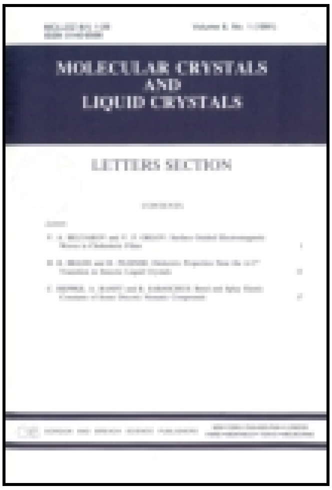

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Full Colour Reflective Display Using Photoluminescence-Polymer Dispersed Liquid Crystal

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Polymer dispersed liquid crystal (PDLC) can be realized as the brighter display compare to conventional LCD because polarizer is unnecessary. We newly proposed a full colour photoluminescence-polymer dispersed liquid crystal (PL-PDLC) which PL materials including red, green and blue PL were added to PDLC, and investigated the colour gamut and the reflectance functioning as applied voltage. We confirmed that our full colour PL-PDLC presented the 12.5% of the reflectance and the 28.8% of color gamut on the basis of National [US] Television System Committee (NTSC). It could be suggested as a potential method to fabricate the high performance and the low cost full colour reflective liquid crystal display without a colour filter and a polarizer.

Keywords PL-PDLC; photoluminescence material; reflectance; colour gamut

1. Introduction

Polymer dispersed liquid crystal (PDLC) is fabricated using mixture of photo-reactive monomer and liquid crystal (LC) mixture by UV exposure. And then LC droplets are randomly dispersed within a three dimensional polymer networks [1–3]. These structures are to enable the control of the light scattering intensities due to the refractive index mismatching between the LC and the polymer by using electric field. For no applied electric field, the PDLC reflects the scattered light due to the refractive index mismatching between the LC and the polymer because LC molecules within LC droplet are randomly oriented in the polymer network. In contrast, for applying the electric field, the PDLC allows the passage of light due to the decrease of the refractive index mismatching between the LC and the polymer because the LC molecules within the LC droplet align to the direction of applied electric field.

In the case of the conventional full colour reflective liquid crystal display, the light efficiency is remarkably reduced because colour filter layer with selective absorption of white light is always required. Many efforts have been performed to improve the reflectance

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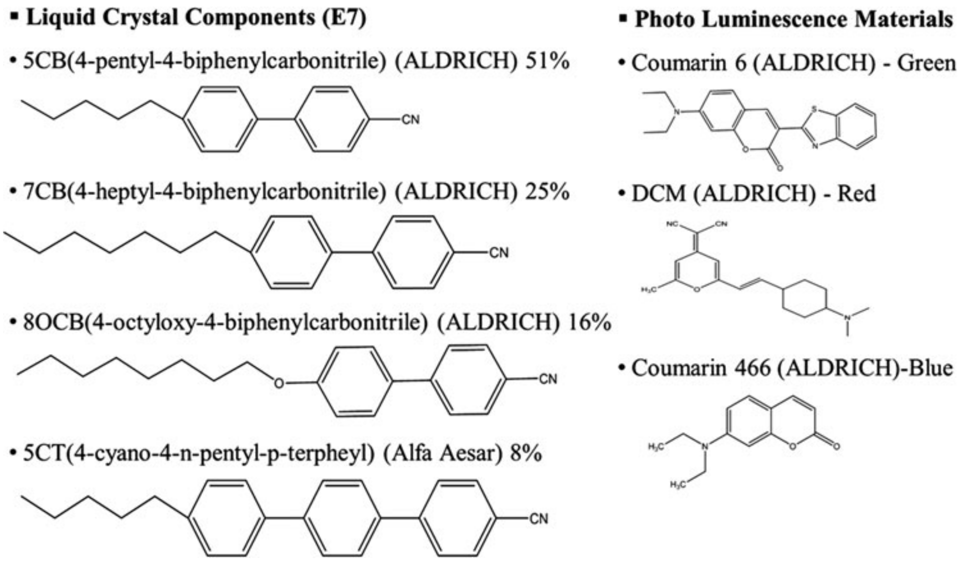

Figure 1. Chemical structures of liquid crystals, photo reactive monomer and photo luminescence materials used in this study.

through e-ink, cholesteric liquid crystal and so on [4–9], but the satisfactory results have not obtained yet.

In this study, we newly proposed a full colour photoluminescence-polymer dispersed liquid crystal (PL-PDLC) which the PL materials including red, green and blue PL were added to PDLC, and investigated the colour gamut and the reflectance functioning as the applied voltage for the full colour PL-PDLCs.

2. Experimental

2.1 Sample

E7 nematic LC mixture was used as a LC material of PL-PDLC. E7 LC mixture consists of 4-pentyl-4-biphenylcarbonitrile (5CB, Aldrich), 4-heptyl-4-biphenylcarbonitrile (7CB, Aldrich), 4-octyloxy-biphenylcarbonitrile (8OCB, Aldrich) and 4-cyano-4-n-pentyl-p-terpheyl (5CT, Alfa Aesar) as shown in Fig. 1. NOA65 (Norland Products) was used as a photo reactive monomer (RM) to construct polymer network. For manufacturing the three kinds of colour PL-PDLCs, we used a 3-(2-Benzothiazolyl)-7-(diethylamino) coumarin (Coumarin6, Aldrich) as a green PL material, a 4-(Dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran (DCM, Aldrich) as a red PL material and a 7(Diethylamino) coumarin (Coumarin466, Aldrich) as a blue PL material as shown Fig. 1.

2.2 Preparation for Three Kinds of PL-PDLC Cells

Three kinds of (PL/LC/RM) mixtures were prepared as (Coumarin6/E7/NOA65) for a green PL-PDLC, (DCM/E7/NOA65) for a red PL-PDLC and (Coumarin466/E7/NOA65) for a blue PL-PDLC. Also, each (PL/LC/RM) mixtures were prepared as three kinds of PL concentration including 0.3, 0.5 and 1 wt% mixture as PL : LC : RM = 0.3 : 59.82 : 39.88, 0.5 : 59.7 : 39.8 and 1 : 59.4 : 39.6 in weight percentage. Here, 0.3, 0.5 and 1 wt% mean the

PL materials weight percentage within PDLC. The each (PL/LC/RM) mixture was filled into the vacant space of no patterned ITO sandwich cell with 50μm gap. A blending of the mixtures was automatically performed over 5 h at 363.15 K and UV light with maximum wavelength of 365nm was then exposed on the (PL/LC/RM) mixture cell for 3 min. The UV light intensity was 2.8 mW/cm^2.

The optical texture of each PL-PDLC cell was observed to know the structure of LC droplet using polarizing optical microscope (POM, Nikon) under crossed Nicols. The observation temperature was 298 K.

2.3 Measurement of Reflectance Against Applied Voltage and Colour Gamut for Full Colour PL-PDLC

The reflectance of each PL-PDLC cell was measured on functioning as the applied voltage using a spectrophotometer (Konica Minolta M-2500d) with specular reflectance. During measurement of the reflectance, the squared arbitrary current electric voltage with 1.0 kHz was applied to each PL-PDLC cell. The colour gamut was estimated on the basis of NTSC by the Commission Internationale de l'Eclairage (CIE) chromaticity coordinates of red, green and blue measured by using a spectrophotometer (Konica Minolta M-2500d) with specular reflectance. The measurement temperature of the reflectance and the CIE chromaticity coordinates for red, green and blue PL-PDLC were 298 K.

3. Results and Discussion

3.1 PL Material Concentration Dependence of Reflectance for Red, Green, and Blue PL-PDLC

Figure 2 shows the measurement results of reflectance for red, green and blue PL-PDLC cells with 0.3, 0.5 and 1 wt% concentration of PL material, respectively. The reflectance of the red PL-PDLC containing of DCM was 6.70% at 0.3 wt%, 6.03% at 0.5 wt% and 2.90% at 1 wt%. Also, the reflectance of the green PL-PDLC containing of Coumarin6 was 25.19% at 0.3 wt%, 22.71% at 0.5 wt% and 15.30% at 1 wt%. Furthermore, the reflectance of the blue PL-PDLC containing of Coumarin466 was 6.48% at 0.3 wt%, 5.03% at 0.5 wt% and 1.57% at 1 wt%. In particular, the green PL-PDLC showed the higher reflectance than the red and blue PL-PDLC.

Figure 3 shows the observed photographs of POM under crossed Nicols for red, green and blue PL-PDLC cells with 0.3, 0.5 and 1 wt% PL material concentration. We could know that the LC droplet sizes were decreased with a decrease of the PL concentration at all PL-PDLCs from Fig. 3. These results were considered as the reflection intensities are increased with an increase of interface area between the LC droplet and the polymer according to reducing of LC droplet from Fig. 2 and Fig. 3.

3.2 Reflectance Against Applied Voltage for Red, Green and Blue PL-PDLC

Figure 4 shows the measurement results of reflectance against the applied voltage for red, green and blue PL-PDLC with 0.3 wt% PL material concentration. The reflectance of the red (DCM) PL-PDLC showed the maximum value of 6.70% at 0 V, the minimum value of 2.97% at 30 V. Also, the reflectance of the green (Coumarin6) PL-PDLC showed the maximum value of 25.19% at 0 V, the minimum value of 7.2% at 30 V. Furthermore, the reflectance of the blue (Coumarin466) PL-PDLC showed the maximum value of 6.48% at 0 V, the minimum value of 4.03% at 30 V. As a result, we could confirm that the full colour

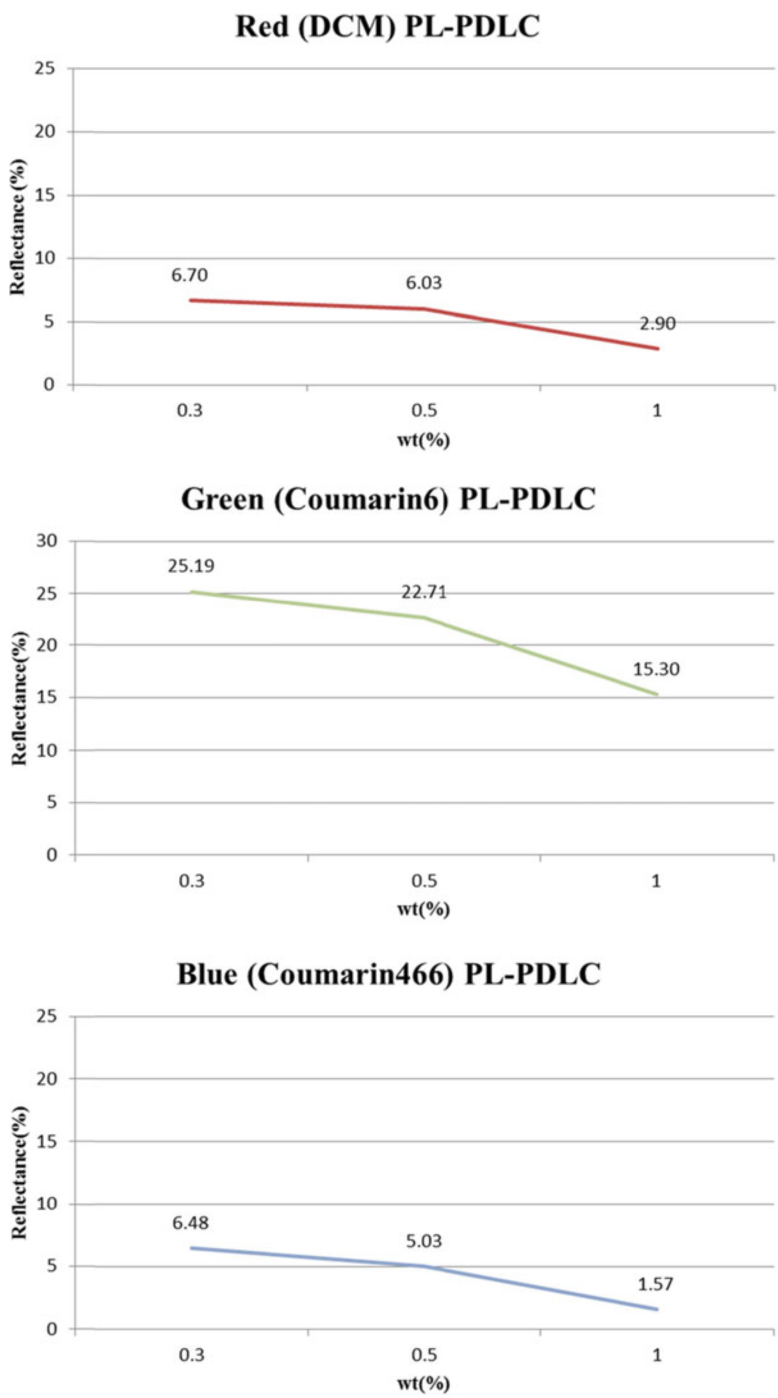

Figure 2. PL material concentration dependence of reflectance for red, green, and blue PL-PDLC.

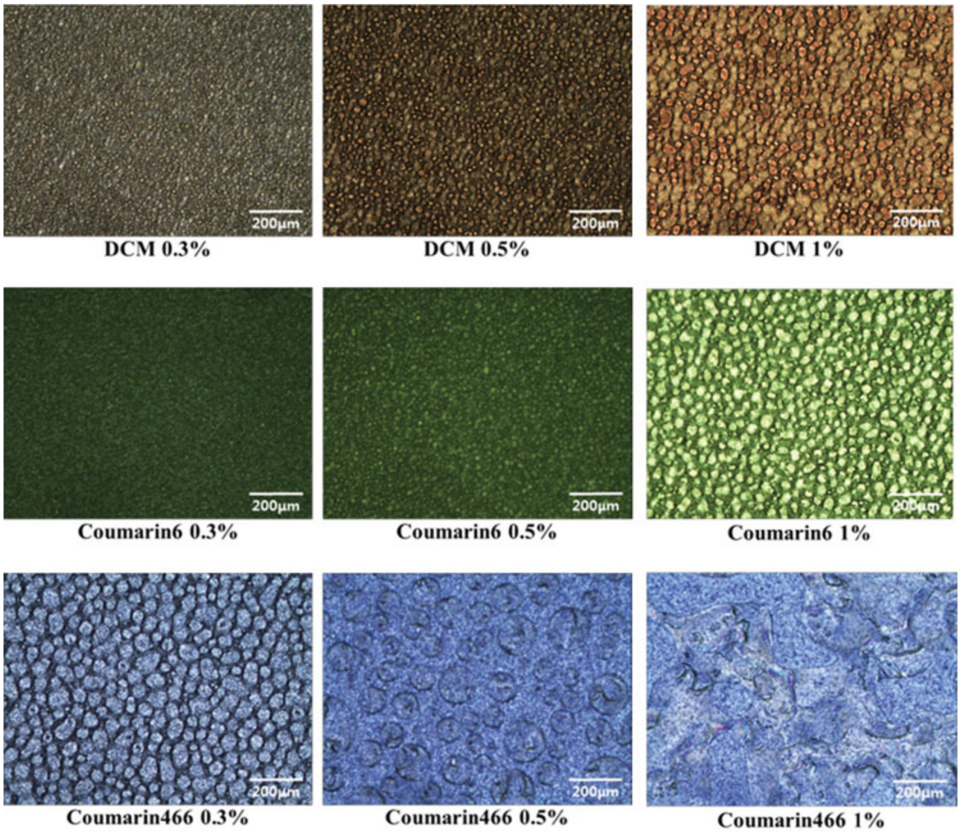

Figure 3. POM observed photographs for DCM PL-PDLC, Coumarin6 PL-PDLC and Coumarin466 PL-PDLC having 0.3, 0.5 and 1 wt% PL material concentration under crossed Nicols.

reflectivity was 12.5% at the red, green and blue PL-PDLCs at 0 V of applied voltage. Here the full colour reflectivity was estimated as the arithmetic average of the reflectance among the red, the green and the blue PL-PDLC. In particular, the reflectance for the Coumarin6 PL-PDLC and the DCM PL-PDLC showed the large change from 25.19% to 7.2%, from 6.70% to 2.97% with increase of applied voltage, respectively, while that of the Coumarin466 PL-PDLC showed the small change and from 6.48% to 4.03%. This result is considered as the Coumarin466 PL-PDLC was not sufficiently polymerized by UV exposure, since the absorption wavelength of 380 nm for Coumarin466 was overlapped with the absorption wavelength range between 350 nm to 380 of the NOA 65 for polymerization [10, 11]. Whereas the Coumarin6 PL-PDLC and the DCM PL-PDLC were sufficiently polymerized by UV exposure, since the absorption wavelength of the Coumarin6 and the DCM were the 444 nm and the 468 nm, respectively. Therefore, we can say that it is possible to realize the new reflective liquid crystal display mode having continuous gray scale according to applied electric field.

3.3 Colour Gamut of Full Colour PL-PDLC

Table 1 shows the CIE chromaticity coordinates and the colour gamut of red, green and blue PL-PDLC measured by the spectrophotometer at 298 K. Here the CIE chromaticity

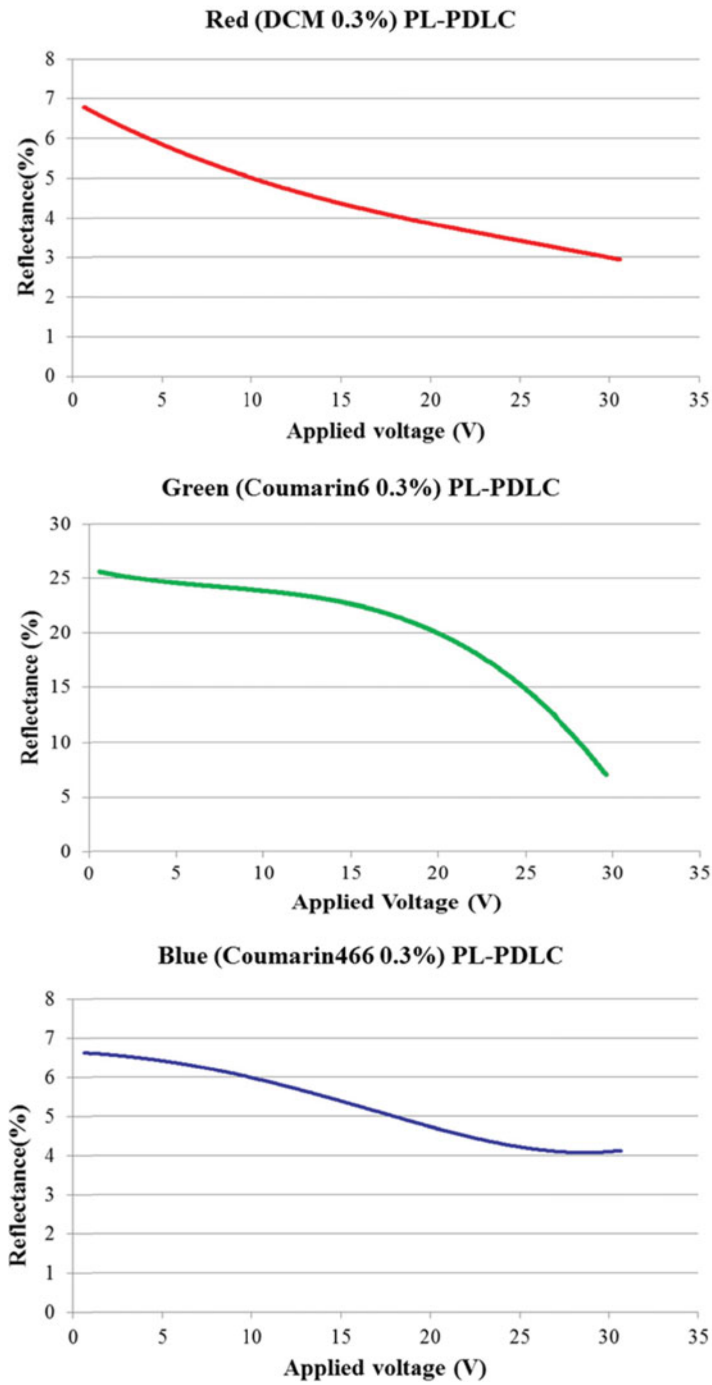

Figure 4. Reflectance against applied voltage for red, green, and blue PL-PDLC.

Table 1. CIE chromaticity coordinates and colour gamut of red, green and blue PL-PDLC

	x	y	Y
Red	0.5725	0.4247	6.70
Green	0.3621	0.5901	25.19
Blue	0.2498	0.2450	6.48
Color gamut			28.80%

coordinates were presented as the reflective mode value which the all PL-PDLC had the maximum reflectance when the applied electric voltage was 0V. Also, Fig. 5 shows the chromaticity coordinates on the CIE colour diagram for full colour PDLC on the basis of Table 1. Here, a dotted line and a solid line triangle represent NTSC chromaticity coordinates space and our PL-PDLC chromaticity coordinates space, respectively. It was confirmed that the colour gamut of full colour PL-PDLC in the reflective mode having maximum reflectance was 28.8% on the basis of NTSC from Table 1 and Fig. 5. However, we need further study to improve the reflectance and the chromaticity coordinate for blue PL-PDLC using a new PL material and a sensitizer to control the emission and absorption wavelength.

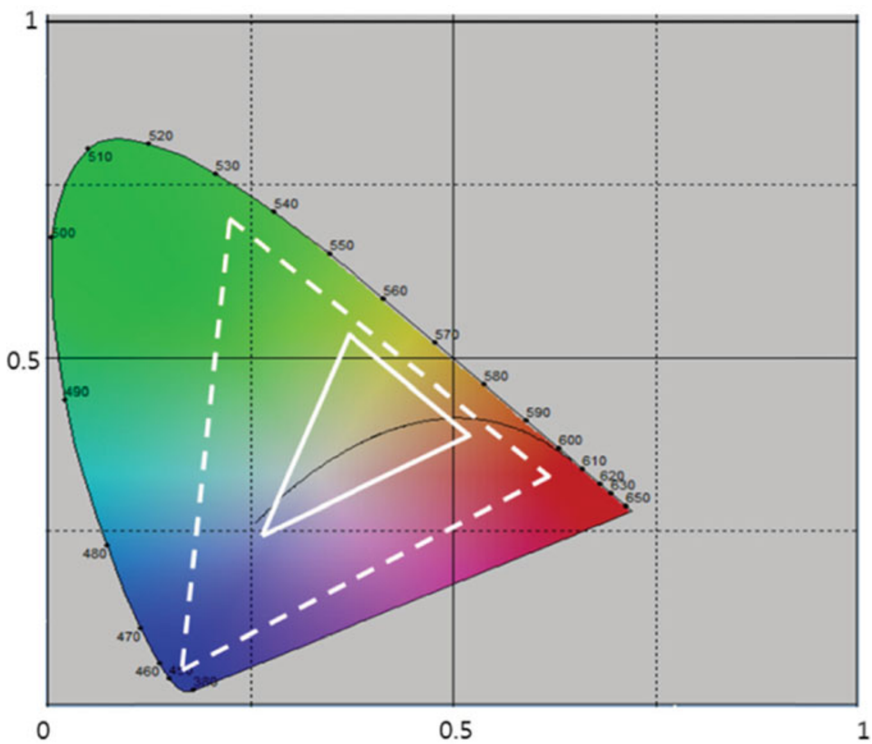

Figure 5. Chromaticity coordinates and the colour gamut on the CIE Colour diagram for full colour PL-PDLC.

4. Conclusions

We newly proposed the full colour photoluminescence-polymer dispersed liquid crystal (PL-PDLC) which PL materials including red, green and blue PL were added to PDLC. We confirmed that our full colour PL-PDLC presented the 12.5% of the reflectance and the 28.8% of colour gamut on the basis of NTSC in the absence of electric field. It could be suggested as a potential method to fabricate the high performance and low cost full colour reflective liquid crystal display without color filter and polarizer.

Acknowledgments

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