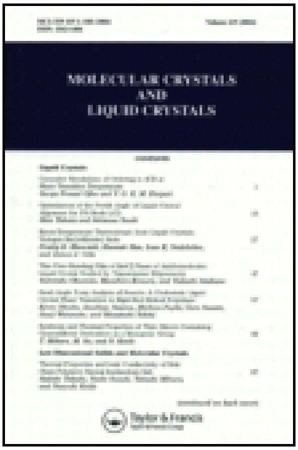

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Optical Properties of Colorants-Containing Polymethyl Methacrylate for the Front Filter of Plasma Display Panel

Ji-Young Son [a], Do Kyung Lee [b], Sang-Mok Lee [c], Sang Geul Lee [c] & Sang Ho Sohn [c]

[a] Digital Display Research Lab., LG Electronics, Seoul, Korea

[b] R&D Affairs Department, Gumi Electronics & Information Technology Research Institute, Gumi, Korea

[c] Department of Physics, Kyungpook National University, Daegu, Korea

Version of record first published: 10 Nov 2009

To cite this article: Ji-Young Son, Do Kyung Lee, Sang-Mok Lee, Sang Geul Lee & Sang Ho Sohn (2009): Optical Properties of Colorants-Containing Polymethyl Methacrylate for the Front Filter of Plasma Display Panel, Molecular Crystals and Liquid Crystals, 514:1, 258/[588]-264/[594]

To link to this article: http://dx.doi.org/10.1080/15421400903240902

Mol. Cryst. Liq. Cryst., Vol. 514, pp. 258/[588]–264/[594], 2009

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400903240902

Optical Properties of Colorants-Containing Polymethyl Methacrylate for the Front Filter of Plasma Display Panel

Ji-Young Son[1], Do Kyung Lee[2], Sang-Mok Lee[3], Sang Geul Lee[3], and Sang Ho Sohn[3]
[1]Digital Display Research Lab., LG Electronics, Seoul, Korea
[2]R&D Affairs Department, Gumi Electronics & Information Technology Research Institute, Gumi, Korea
[3]Department of Physics, Kyungpook National University, Daegu, Korea

We have prepared colorants-containing polymethyl methacrylate (PMMA) films for the front filter of plasma display panel (PDP) by solvent casting method and investigated their optical properties. In this study, a cyanine dye and a Cu-hydrate pigment have been used as the colorants for neon-cutting and color control, respectively. The experimental results have revealed that PMMA films act as a band rejection-type color filter indicating characteristics of sharp absorptions in specific regions. In the PDP devices with our band rejection color filters, the luminance from unnecessary emissive light is sufficiently reduced, resulting in wider color gamut and higher color purity.

Keywords: color adjusting film; colorants-containing PMMA; front filter; plasma display panel

INTRODUCTION

In commercial plasma display panel (PDP), a front filter has a structure of an electromagnetic interface shielding film, a color adjusting film, a near infrared blocking film, and an anti-reflection film sequentially stacked on the transparent plate [1]. Among the functional films, a color adjusting film comprises a mixture of a neon-cut dye, a color control dye, and a binder polymer and is inserted into the PDP front

This work was supported by the Industrial Technology Infrastructure Promotion Program of the Ministry of Commerce, Industry and Energy of Korea.

Address correspondence to Prof. Sang Ho Sohn, Department of Physics, Kyungpook National University, Sangyuk-dong, Buk-gu, Daegu 702-701, Korea (ROK). E-mail: shsohn@knu.ac.kr

filter as the form of adhesive. Sometimes, however, the transmittance of dye-containing film may be changed with temperature and humidity [2]. The stability of color adjusting film depends not only on the dye but also on binder resin used for making the film. Although various binder resins have been studied to improve the durability and stability, it is not optimized. For the purpose of solving the problem, without the binder resin, we suggest the transparent polymethyl methacrylate (PMMA) films having color filter function as a color adjusting film. This is reason why PMMA films have been attracted much attention for use as optical components and in optoelectric devices due to inexpensiveness, volume productivity, and manageability [3,4]. Accordingly, studies on this topic will be of benefit in helping to investigate new type for front filter of PDP.

In this study, the colorants-containing PMMA films have been fabricated by a solvent casting method, and their optical properties and application to PDP are investigated. In particular, the effects of the concentration of colorants in films are mainly discussed.

EXPERIMENTAL

The color-adjusting PMMA films for the front filter were prepared by dissolving both PMMA and colorants in appropriate solvents, and by casting the solutions. The doping of colorants into the PMMA was achieved by mixing several amounts of the colorants with PMMA in a common solvent such as acetone or dichloromethane. A cyanine dye and a Cu-hydrate pigment have been used as colorants. The mixture was stirred well for 48 hours at room temperature in order to ensure homogeneous mixing. The well-stirred solutions were cast in a teflon mold and were allowed to dry in an oven for 24 hours at room temperature. Finally, for thermal stability, a color adjusting PMMA was treated in an oven at a temperature of 50°C for 2 hour [5]. The thickness of the films prepared by this solvent casting method was about 1 mm.

The optical transmittance characteristics of the films were measured by means of an UV-VIS-NIR spectrophotometer (Varian CARY5G) in the visible region. Investigation for the spectral performances of our PMMA filters was carried out on a surface-type PDP device, seen in Figure 1. In the experiments, a He–Ne–Xe gas mixture of 400 Torr pressure for surface discharge and commercial phosphors, blue-emitting $BaMgAl_{10}O_{17}$:Eu, green-emitting Zn_2SiO_4:Mn, and red-emitting (Y,Gd)BO_3:Eu were used in the panel. All measurements were performed at room temperature.

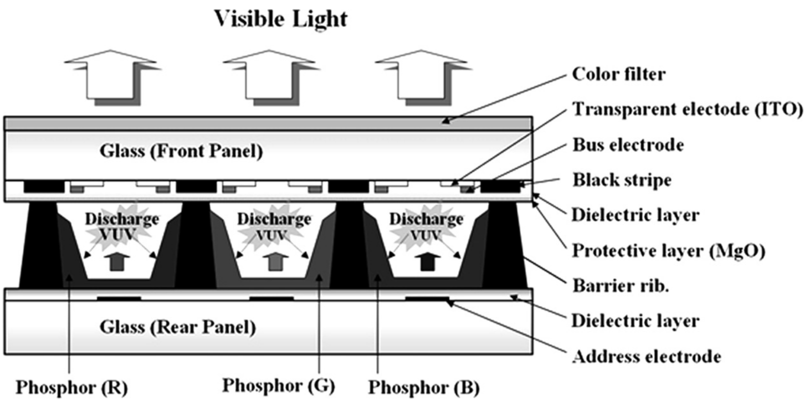

FIGURE 1 Schematic diagram of a surface-type PDP device with PMMA color filter.

RESULTS AND DISCUSSION

Figure 2 shows the optical transmittances of cyanine dye-containing PMMA with varying dye concentration in films. For reference,

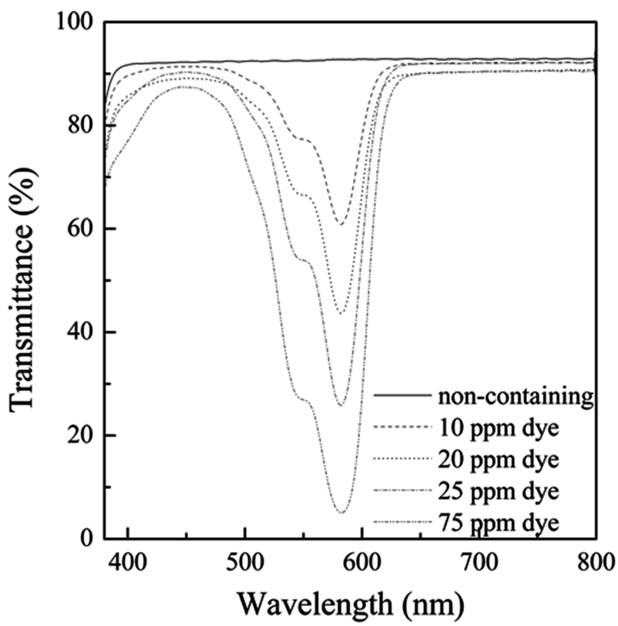

FIGURE 2 Optical transmittances of the neon-cut PMMA with varying dye concentration.

transmittance of the pure PMMA is also indicated, which is about 93%. The optical transmission spectra are found to be practically the similar patterns for all films with different dye concentration, and indicated selective absorption characteristics in specific region. A selective absorption band of cyanine colorant having a maximum absorbance around 587 nm due to the π–π^* transitions between ground and excited state energy level is nearly agreed with the orange light of 585.2 nm wavelength from the neon gas discharge, which is satisfied the requirement for the front filter of PDP. Also, it is found that the band rejection character of our PMMA is superior to the inorganic color filter [6].

For the cyanine colorant, the optical transmission color is pink, and somewhat low color temperature. Hence, a neon-cut PMMA filter is added with Cu-hydrate colorant to improve color temperature and reproducibility of the PDP. Figure 3 represents the transmittances of the cyanine and Cu-containing PMMA with varying Cu contents in the films. The concentration of dye in the films is fixed at 20 ppm. Compared with PMMA film contained with dye only, it is clearly shown that there are two principal absorption bands. One is the band

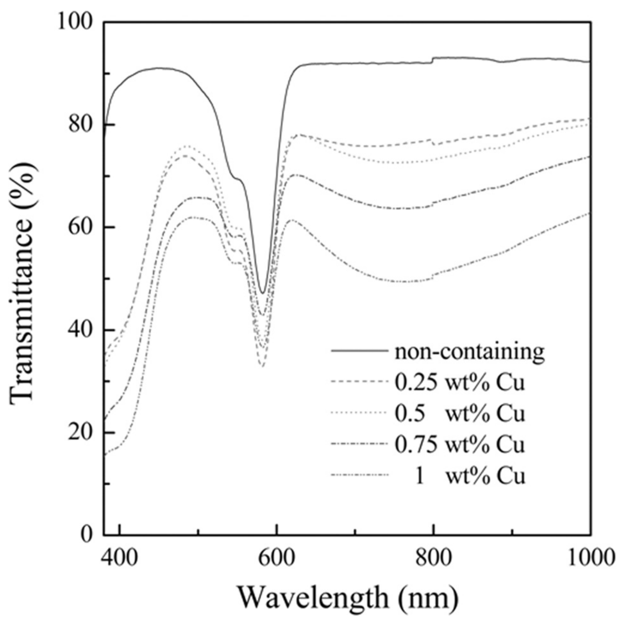

FIGURE 3 Optical transmittances of the PMMA filter with varying Cu concentration.

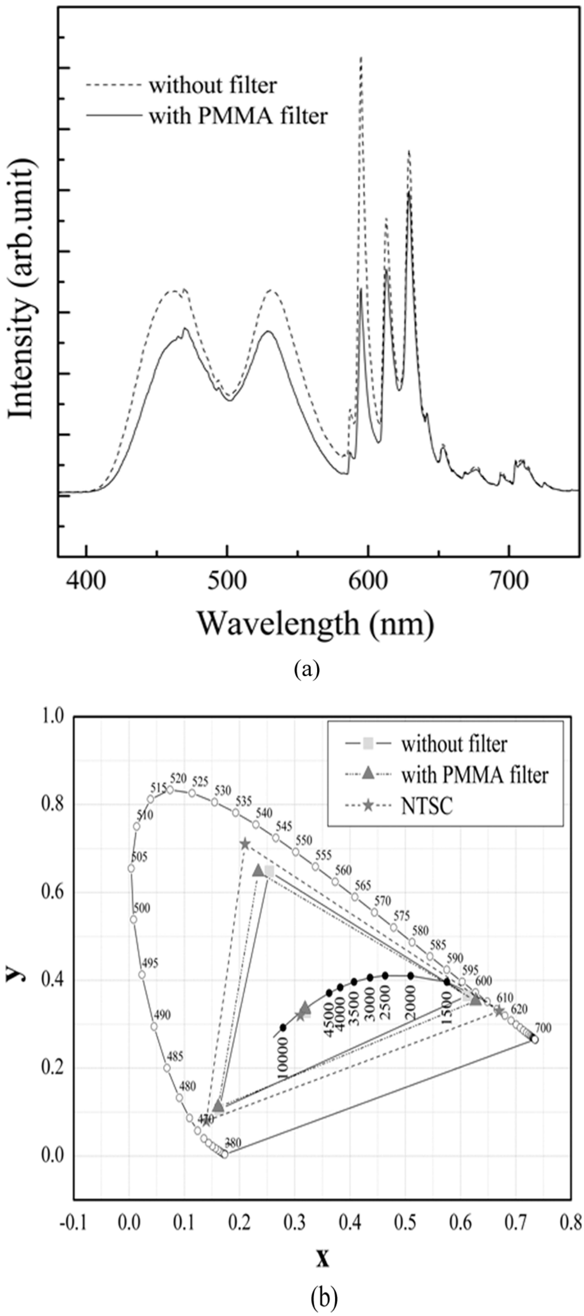

FIGURE 4 Visible emission spectra of PDP device with PMMA filter (a) and the corresponding CIE color coordinates.

centered about 400 nm in spectral range, the other is the band with peak of around 740 nm. The existence of broad absorption bands around 400 and 740 nm is caused by the localized 3d–3d transition of Cu^{2+} ion. By virtue of absorption bands near 740 nm, it can be expected to shield near-infrared region slightly. As revealed in Figures 2 and 3, the absorptions in PMMA filter become larger with increasing the concentration of colorants. According to the Beer-Lambert law [7], the absorbance or optical density for material is known to be proportional to the colorant concentration amounts for a fixed film thickness, and the transmittance is exponentially decreased.

Figure 4(a) and (b) represent visible emission spectra from a PDP device with the PMMA filter contained with 20 ppm dye and 0.5 wt% Cu and the corresponding Commission Internationale de l'Eclairage (CIE) color coordinates, respectively. The spectra are included not only visible emission from the Ne gas discharge but also luminance from stimulation of the red, green, and blue luminescent materials. By stronger absorption bands near 587 nm of manufactured filter, larger amount of emission of Ne gas discharge at 585.2 nm is filtered and the tails of luminescent spectra from red, green, and blue phosphors are reduced, in addition that luminance positioned at 593 nm wavelength with narrow band width from $(Y,Gd)BO_3$:Eu phosphor are attenuated. As shown in Figure 4(b), hence, the color purity and color reproducibility of a PDP device with PMMA filter are improved.

CONCLUSIONS

The dye and Cu colorants-containing PMMA filters have been fabricated by a solvent casting method and their properties are investigated. The PMMA filter shows a band rejection-type color filter indicating characteristics of sharp absorptions in specific regions. Application of the colorants-containing PMMA filters to PDP devices yields wider color gamut and color purity of devices. Our experimental results suggest that PMMA filters having color-adjusting function can be applied to a front filter of PDP.

REFERENCES

[1] Okamura, T., Fukuda, S., Koike, K., Saigou, H., Yoshikai, M., Koyama, M., Misawa, T., & Matsuzaki, Y. (2001). *J. Vac. Sci. Technol.*, *19*, 1090.
[2] Noda, N. & Aoyama, T. (2007). *US Patent 7*, *241*, 404.
[3] Xu, X., Ming, H., & Zhang, Q. (2001). *Optics Comm.*, *199*, 369.

[4] Zidan, H. M. & Abu-Elnader, M. (2005). *Physica B*, *355*, 308.
[5] Cho, Y., Choi, Y. K., & Sohn, S. H. (2006). *Appl. Phys. Lett.*, *89*, 051102.
[6] Lee, D. K., Seo, S. M., Lee, S. G., Sohn, S. H., Park, S. H., & Kim, H. M. (2002). *Appl. Phys. Lett.*, *80*, 983.
[7] Hollas, J. M. (1996). *Modern Spectroscopy,* 3rd ed. John Wiley & Sons: New York.