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

Synthesis and Electrophoretic Properties of Poly(acrylamide-co-methylmethacrylate) Coated Organic Pigments

Mi Ah Lee [a] , Yoon Hee Kim [a] , Bong Jun Park [a] & Hyoung Jin Choi [a]

[a] Department of Polymer Science and Engineering, Inha University, Incheon, Korea

To cite this article: Mi Ah Lee, Yoon Hee Kim, Bong Jun Park & Hyoung Jin Choi (2009): Synthesis and Electrophoretic Properties of Poly(acrylamide-co-methylmethacrylate) Coated Organic Pigments, Molecular Crystals and Liquid Crystals, 499:1, 305/[627]-310/[632]

To link to this article: http://dx.doi.org/10.1080/15421400802619669

Mol. Cryst. Liq. Cryst., Vol. 499, pp. 305/[627]–310/[632], 2009
Copyright © Taylor & Francis Group, LLC
ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400802619669

Taylor & Francis
Taylor & Francis Group

Synthesis and Electrophoretic Properties of Poly(acrylamide-co-methylmethacrylate) Coated Organic Pigments

Mi Ah Lee, Yoon Hee Kim, Bong Jun Park, and Hyoung Jin Choi
Department of Polymer Science and Engineering, Inha University, Incheon, Korea

In order to apply organic color pigments into the electrophoretic display technique, they were encapsulated with copolymer, poly(acrylamide-co-methyl methacrylate) using dispersion polymerization of acrylamide and methyl methacrylate in the presence of red colored organic pigment in this study. Chemical structure of the product was characterized via an FT-IR spectroscopy to confirm the polymer coating. Surface charge transfer after the coating process was also analyzed by measuring zeta potential of the fabricated particles in distilled water. Electrophoretic response of the particles in the low dielectric suspending medium was analyzed using an electrophoresis light scattering measurement. Effect of charge control agent on the zeta potential of the suspended particles in low dielectric solution was further investigated.

Keywords: dispersion polymerization; electrophoretic particle; encapsulation; organic pigment; zeta potential

INTRODUCTION

Since the pioneering work by Comiskey *et al.* [1], microcapsule type electrophoretic flexible display, usually called an e-ink display, has attracted great attentions of many researchers recent years due to their various advantages such as low cost, low power consumption and reflectivity [2]. Concurrently, the electrophoretic ink nanoparticles have been widely investigated for the industrial application as one of the important elements in the e-ink display [3–6]. Especially,

This work was supported by Samsung Electronics, Korea.

Address correspondence to Prof. Hyoung Jin Choi, Department of Polymer Science and Engineering, Inha University, Incheon 402-751, Korea. E-mail: hjchoi@inha.ac.kr

development of colored electrophoretic ink is considered to be an essential work in commercializing full color display [7]. Meanwhile organic pigments as one of the promising electrophoretic ink particles for the electrophoretic color display have been studied due to their distinctness of the colors [8]. However, the organic pigments seldom have electrophoresis characteristics and surface charge. In addition, colored organic pigment particles have problems with particle aggregation followed by poor dispersion in a suspending medium. In order to solve these problems, the organic particles should be modified with polymeric materials. There have been many researches on polymeric modification of the nanoparticles because polymer-coated particles have good surface properties and compatibility with the organic suspending medium in general [9,10]. Especially, polymer encapsulation via an *in-situ* radical polymerization was considered as an effective method to modify the nanoparticles with polymer [11]. In this work, red organic pigment nanoparticles were encapsulated with poly(acrylamide-co-methylmethacrylate) (PAAm-co-MMA) using *in-situ* dispersion polymerization to be applied to the electronic display application. For the colored display, each of colored and white particles should have opposite charge on their surface. The methods to make the white pigment possessing charge on their surface and dispersion stability were reported previously [12]. For red particles, acrylamide group as a comonomer was used to enhance surface charge of the polymer-coated organic nano-pigment.

In this study, shape and size of the surface modified nano-pigment with polymer were observed using SEM, and chemical structure and morphology of the modified organic pigments were also characterized. Moreover, electrophoretic properties of the product particles were observed when they were dispersed in the low dielectric medium. The effect of charge control agent on the particles was further examined.

EXPERIMENTAL

Synthesis of Electrophoretic Particle

Red organic particles (R2), which were received from DPI Co., Ltd., Korea, were encapsulated with the PAAm-co-MMA by dispersion polymerization using methanol and poly(vinyl pyrrolidone) as solvent and dispersant, respectively. The R2 was dispersed in the MMA in which the AAm was dissolved. The mixture was slowly dropped into the methanol media in which both initiator and dispersant were dissolved.

The polymerization was performed at 60°C for 24 h. After being washed using methanol and DI-water, and dried using a freezing-drier, the final product was obtained in a powder type.

CHARACTERIZATION

Chemical structure and morphology of the fabricated particles were examined using FT-IR and SEM. Furthermore, zeta potential and electrophoretic mobility of the particles when dispersed in a low dielectric medium were measured via an electrophoretic light scattering apparatus (ELS, ELS8000, Otsuka electronics, Japan). The effect of OLOA1200 addition as a charge controlled agent (CCA) on the zeta potential of the coated particles was also examined. In order to observe the device performance, both coated and white particles were dispersed in media and the mixture was put into prototype device consisted with two ITO glasses. Electrophoretic response of the particles in the gap of the device was observed using a voltage source device (487, Keithley, USA).

RESULTS AND DISCUSSION

Figure 1 shows the SEM image of both uncoated (a) and coated organic nano-pigment with polymer (b). It was clearly observed that both uncoated and coated nanoparticles have irregular shape and size, indicating that the shape of organic pigment nanoparticle was still maintained through the coating process.

On the other hand, the polymer coating can be confirmed by determining its chemical structure. FT-IR spectra of the P(AAm-co-MMA) coated R2 pigment and uncoated R2 were shown in Figure 2. The characteristic peaks of the polymer coated R2 show characteristic wave numbers of both R2 and fabricated polymer layer. The adsorption around 3150 cm^{-1} indicated the N-H functional group of amide. In addition, it can be also noted that the peaks for C=O of MMA and AAm increased compared to that from the uncoated R2.

In addition, Table 1 shows zeta potential and mobility value of the coated particles when they were dispersed in a low dielectric oil media. It was found that polymer coated R2 had average net charge of plus 6 mV on their surface, while the uncoated R2 has no specific value, demonstrating that the introduced acrylamide functional group helps to enhance the plus charge on their surface. However, it was also observed that both uncoated and p(AAM-co-MMA) coated R2 have minus value when the 2 wt% of OLOA1200 was added into the systems as a charge control agent. The OLOA1200 enhances the

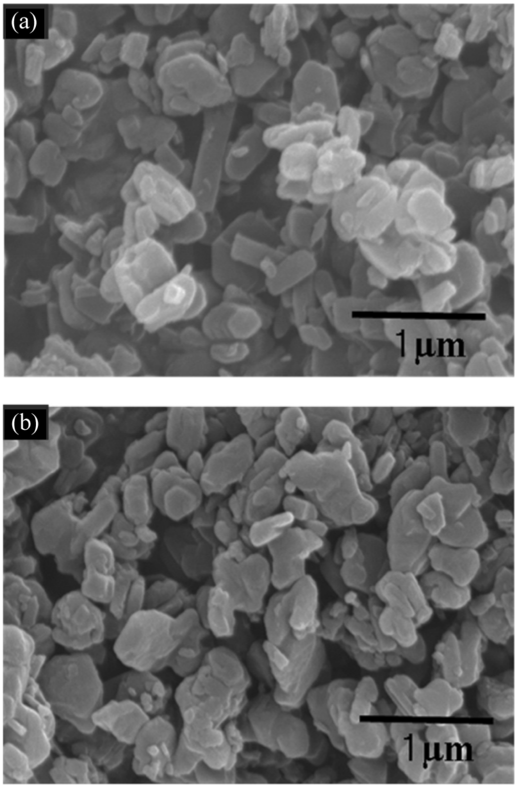

FIGURE 1 SEM image of (a) uncoated pigment and (b) Poly(AAm-MMA) coated organic pigment.

nanoparticles only with minus charge although the particles was modified to be plus-charged [13]. It was also found that the CCA addition was more effective to the modified pigment than to the pristine pigment.

In order to analyze the device performance and to investigate the electrophoretic properties in the two particle system, a prototype device was prepared and then tested. The prototype device was consisted with two ITO glass and voltage source. The electrophoretic movement of the electrophoretic particles can be detected by observing color transition when the product particles were dispersed with the white pigment particles. As white pigment particles, the poly(ethylene glycol methyl ether acrylate-co-methyl methacrylate) coated TiO_2 nanoparticles were used. The experiment was performed in the presence of OLOA1200. Figure 3 displays the prototype device of two

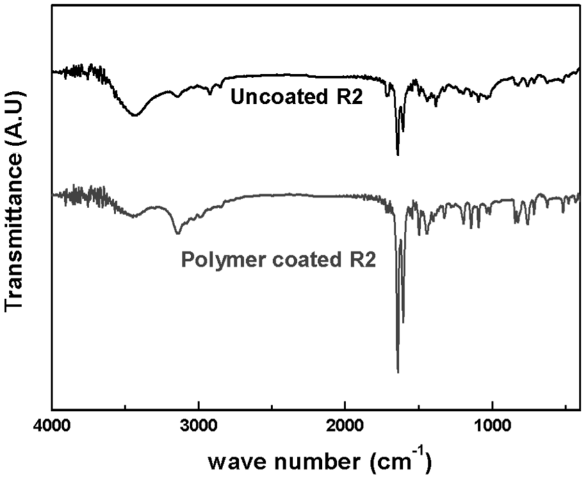

FIGURE 2 FT-IR spectra of uncoated and polymer coated organic pigment.

TABLE 1 Zeta Potential and Electrophoretic Mobility of the Fabricated Particles in the Dielectric Medium

Sample	Zeta potential	Electrophoretic mobility
Uncoated R2	–	–
P(AAm-co-MMA) cated R2	6.2 mV	1.8×10^{-6} cm^2/Vs
Uncoated R2 (with CCA)	−11.3 mV	-2.6×10^{-6} cm^2/Vs
P(AAm-co-MMA) cated R2 (with CCA)	−16.4 mV	-5.23×10^{-6} cm^2/Vs

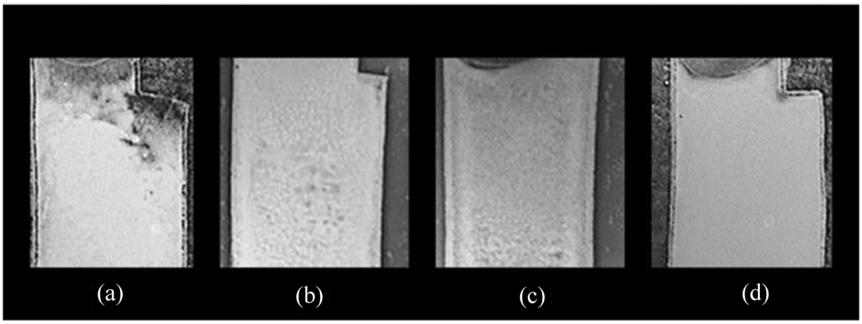

FIGURE 3 Prototype device performance using EGMEA-PMMA coated TiO_2 particles and organic pigment particles: (a) polymer coated, (b) uncoated pigment without CCA, (c) polymer coated, and (d) uncoated pigment with CCA.

particle systems using (a) coated R2, (b) raw R2 without OLOA1200, and both (c) and (d) with the CCA, when 20 V of voltages was applied. In duo particles system, both R2 and polymer coated R2 were found to have plus charge. Also, the color difference for polymer coated R2 was observed to be more distinct than for raw R2 in the presence of OLOA1200, while they show similar color of very weak pink, without OLOA1200. It showed that the polymer encapsulation enhance the electrophoretic mobility of organic pigment.

CONCLUSIONS

The red organic pigment nanoparticles were successfully encapsulated with poly(acrylamide-co-methylmethacrylate) to enhance the electrophoretic movement. It was found that the acrylamide allowed organic particles to posses the plus charge on their surface. The copolymer coating was also found to be helpful for improving electrophoretic mobility and zeta potential. In the duo particles system, it was indicated that the encapsulated organic pigments had more synergy effect than raw organic pigment with the OLOA1200.

REFERENCES

[1] Comiskey, B., Albert, J. D., Yoshizawa, H., Jacobson, J. (1998). *Nature*, *394*, 253.

[2] Kim, K., Sung, J. H., Lee, J. Y., Song, J. K., Chin, I., Choi, H. (2006). *J. Mol. Cryst. Liquid Cryst.*, *445*, 43.

[3] Yu, D. G., An, J. H., Bae, J. Y., Lee, Y. E., Ahn, S. D., Kang, S. Y., Suh, K. S., (2004). *J. Appl. Polym. Sci.*, *92*, 2970.

[4] Jang, I. B., Sung, J. H., Choi, H. J., Chin, I., (2005). *J. Mater. Sci.*, *40*, 3021.

[5] Park, L. S., Park, J. W., Choi, H. Y., Han, Y. S., Kwon, Y., Choi, H. S., (2006). *Current Appl. Phys.*, *6*, 644.

[6] Yu, D. G., Kim, S. H., An, J. H., (2007). *J. Ind. Eng. Chem.*, *13*, 438.

[7] Yu, D. G., An, J. H., Bae, J. Y., Jung D. J., Kim, S., Ahn, S. D., Kang, S. Y., Suh, K. S. (2004). *Chem. Mater.*, *16*, 4693.

[8] Pei, G. L., Wang, T. J., Yang, Y., Jin, Y. (2005). *Acta Phys.-Chim. Sin.*, *21*, 430.

[9] Erdem, B., Sudol, .E. D., Dimonie, D. L., El-Aasser, M. S. (2000). *Macromol. Symp.*, *155*, 181.

[10] Zheng, H. Z., Zhang, J., Lu, S. Q., Wang, G. C., Xu, Z. F. (2006). *Mater. Lett.*, *60*, 1219.

[11] Cho, M. S., Lim, S. T., Jang, I. B., Choi, H. J. (2004). *IEEE Trans. Magn.*, *40*, 3036.

[12] Park, B. J., Sung, J. H., Kim, K. S., Chin, I., Choi, H. J. (2006). *J. Macromol. Sci. Phys.*, *B45*, 53.

[13] Park, B. J., Sung, J. H., Choi, H. J. (2006). *J. Electroceram.*, *17*, 1031.