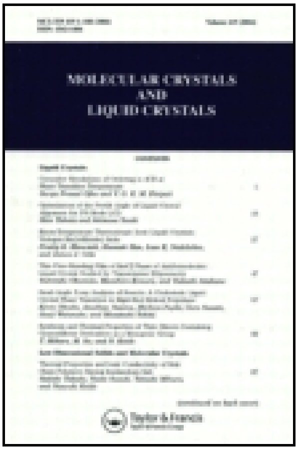

Molecular Crystals and Liquid Crystals

Effect of Polymer Encapsulation on Electrophoretic Property of Organic Pigment

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Effect of Polymer Encapsulation on Electrophoretic Property of Organic Pigment

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Organic pigment has been considered as one of the most suitable materials for the colored electrophoretic ink particles in a microcapsule type electrophoretic display, in which the electrophoretic display is consisted with the electrophoretic ink particles dispersed in the low dielectric medium. In this study, the effect of polymer encapsulation on electrophoretic properties of organic pigment nanoparticles in low dielectric medium was investigated. Blue colored organic pigments were encapsulated with poly(methyl methacrylate) via two step dispersion polymerization of methyl methacrylate with the presence of the organic pigments. Vinyl imidazole was used as a co-monomer to enhance the electrophoretic properties of the pigments. The modified particle surface was characterized by measuring zeta potential in low dielectric medium.

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

INTRODUCTION

Paper-like electronic display technology has attracted great attentions to many researchers recently due to its distinctive advantages such as low cost, low weight, good flexibility, and low power consumption [1–3]. Several different types of paper-like electronic displays such as a microencapsulated electrophoretic display [4], twisting balls [5], and a two-color dyes/liquid crystal type display method [6] have been reported. Among these, the microcapsule typed-electrophoretic flexible display [7–9] is known to be one of the most promising technologies,

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because it demonstrates high readability by high contrast and wide view angle. Organic pigments, which are extensively used in coating, ink industries and even color filter [10] for electronics and communication apparatus, have been considered as one of key materials in the electrophoretic ink particles. Nonetheless, due to poor electrophoretic characteristics and particle aggregation of organic pigments in a suspending medium, it should be modified with polymeric materials.

Lelu *et al.* [11] encapsulated an organic phthalocyanine blue pigment into polystyrene latex particles using mini-emulsion polymerization to improve its dispersion ability in aqueous system. In this study, blue organic pigment nanoparticles were encapsulated with poly(methyl methacrylate-co-vinyl imidazole) using two step dispersion polymerization not only to improve suspension stabilities but also to enhance electrophoretic properties. Basically, two kinds of particles with different colors are used to express the color contrast for the device. In addition, to improve desired images by controlling an electric field, colored particles in a cell should have opposite charge with white particles. In other words, when an electric field is applied across the electrodes, charged particles suspended in the electrolyte are migrated towards the electrode of an opposite charge. Therefore, in order to enhance the surface charge and control electrophoretic properties of the blue pigment particles, vinyl imidazole was adopted as a functional co-monomer in this study. The encapsulated organic pigment with the charge control agent (CCA) (OLOA 1200) was then dispersed in the low dielectric medium of Isopar-G and its electrophoretic mobility was further examined.

EXPERIMENTAL

Synthesis

Blue colored organic pigments, which were received from Clariant, Germany, were encapsulated with poly(methyl methacrylate) using two steps dispersion polymerization [12,13]. Initially, 0.5 g of the organic pigments was dispersed in poly(vinylpyrrolidone) (PVP) solution under sonication for 2 h at room temperature, and then methyl methacrylate monomer was put into a solution of pigment dispersion. The stirring speed was fixed at 100 rpm. Polymerization was carried out at 60°C for 6 h in the presence of 0.8 g of 2,2′-azobisisobutyronitrile (AIBN) as an initiator.

To introduce charge moieties on the synthesized pigment/PMMA composite surface, 0.1 g of AIBN and 5 g of vinyl imidazole as comonomer were slowly added to the reactor and the reaction continued for 12 h at 60°C. After the reaction, products were washed with ethanol and Di-water, and centrifuged at 5500 rpm for 25 min followed by a freezing drying process. Final product was obtained in a powder form.

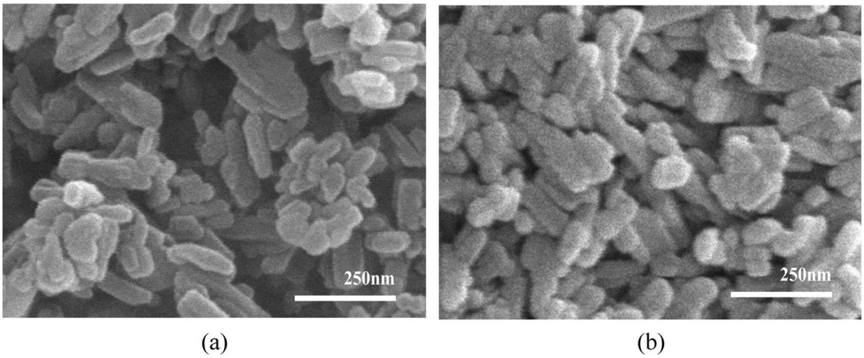
Measurements

Morphology and surface feature of the synthesized pigment/P(MMA-co-vinyl imidazole) composite particles were observed using a scanning electron microscopy (SEM) (S-4300, Hitachi, Japan). Not only zeta potential of the modified pigments in a low dielectric medium but also sizes of both neat pigment and pigment/P(MMA-co-vinyl imidazole) were determined using an electrophoretic light scattering spectrophotometer (Photal ELS-8000, Otsuka electronics) [14].

RESULTS AND DISCUSSION

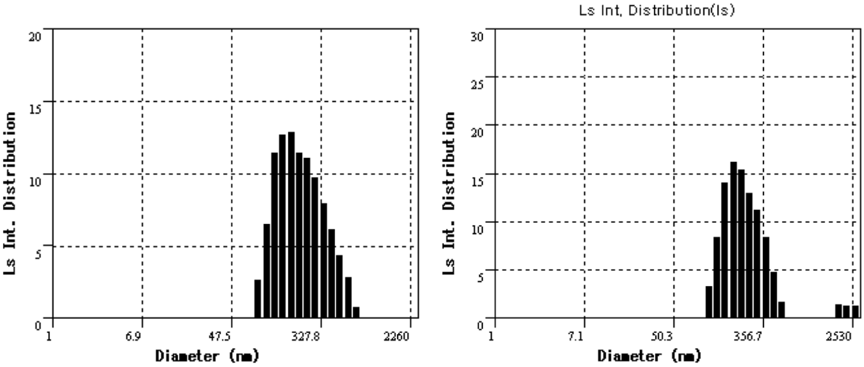
Figure 1 represents the SEM images of both (a) neat organic pigments and (b) PMMA-co-vinyl imidazole coated organic pigment nanoparticles. Shape and particle size of the polymer coated particle were observed to be similar to those of raw organic pigments with irregular shape and size. It was also observed that the polymer coated nanoparticles are larger than the neat organic pigments without encapsulation.

Furthermore, the particle diameter was also measured via an another method of electrophoretic light scattering spectrometer equipped with a dynamic light scattering cell. Figure 2 shows the



(a) (b)

FIGURE 1 SEM micrographs of (a) neat organic pigment and (b) pigment/P(MMA-co-vinyl imidazole).



(a) (b)

FIGURE 2 Size distribution of (a) neat organic pigment (b) pigment/P(MMA-co-vinyl imidazole) measured by electrophoretic light scattering spectrometer.

particle size and size distribution of the neat organic pigment and pigment/P(MMA-co-vinyl imidazole). The average diameter of unmodified organic pigments was determined to be 177 nm, whereas that of modified pigments was around 204 nm. The particle diameter was observed to be increased because of the polymer coating, indicating that thickness of the polymer coating layer was around 15 nm.

Table 1 represents both zeta potential and mobility value of the coated particles when they were dispersed in a low dielectric oil media with and without CCA. It was observed that the polymer coated organic pigments possess an average net charge of plus 12 mV on their surface, while the uncoated organic pigments exhibit an average charge of minus 1 mV on their surface. The surface charge of P(MMA-co-vinyl imidazole) coated organic pigments changed from negative to positive upon coating with organic pigments, suggesting that the comonomer, vinyl imidazole, affected the charge of particle

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

Sample	Zeta potential	Electrophoretic mobility
Organic pigment	−1.26 mV	$-2.777 \times 10^{-7}\,\mathrm{cm^2/Vs}$
Pigment/P(MMA-co-vinyl imidazole)	12.58 mV	$2.780 \times 10^{-6}\,\mathrm{cm^2/Vs}$
Organic pigment (with CCA)	−6.40 mV	$-1.415 \times 10^{-6}\,\mathrm{cm^2/Vs}$
Pigment/P(MMA-co-vinyl imidazole) (with CCA)	−6.67 mV	$-1.474 \times 10^{-6}\,\mathrm{cm^2/Vs}$

surface to have a plus charge [15]. When the CCA, OLOA 1200, was added into the dielectric medium, both neat organic pigments and P(MMA-co-vinyl imidazole) coated organic pigments were represented to have stable minus values. The OLOA 1200 improves the only minus charge of the nanoparticles although the particles was modified to be plus-charged. It was also found that the CCA addition was more effective to the color particles than to the white particles when the two particle systems were investigated for their electrophoretic properties.

CONCLUSIONS

The blue organic pigment nanoparticles were successfully encapsulated with poly(methyl methacrylate-co-vinyl imidazole) to be applied as the electrophoretic ink particles of E-paper display. It was found that the PMMA-co-vinyl imidazole coating enhances the dispersion of organic nanoparticles in the dielectric medium due to improved surface characteristics. The surface modified pigments showed to have positive charge and their electrophoretic response was observed to be much better than the neat organic pigment.

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