

Preparation and encapsulation of white/yellow dual colored suspensions for electrophoretic displays



Jingjing Han, Xiaoxu Li, Yaqing Feng*, Bao Zhang*

School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, PR China

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ABSTRACT

C.I. Pigment Yellow 181 (PY181) composite particles encapsulated by polyethylene (PE) were prepared by dispersion polymerization method, and C.I. Pigment Yellow 110 (PY110) composite particles encapsulated by polystyrene (PS) with mini-emulsion polymerization method were achieved, respectively. The modified pigments were characterized by fourier transform infrared spectroscopy, scanning electron microscope and transmission electron microscope. Compared with the PE-coated PY 181 pigments, the PS-coated PY-110 particles had a narrow particle size distribution, regular spherical and average particle size of 450 nm. Suspension **1** and suspension **3** were prepared by the two composite particles dispersed in isopar M. A chromatic electrophoretic display cell consisting of yellow particles was successfully fabricated using dispersions of yellow ink particles in a mixed dielectric solvent with white particles as contrast. The response behavior and the contrast ratio to the electric voltage were also examined. The contrast ratio of pigments modified by polystyrene was 1.48, as well as the response time was 2 s, which were better than those of pigments modified by polyethylene.

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1. Introduction

In the past decades, several types of reflective paper-like displays have been developed, among which electrophoretic display (EPD) due to its legibility, low power consumption, flexibility, memorization, and portability [1,2] has attracted a lot of attentions. It was considered as one of the most promising candidates used in the electronic media such as e-books, e-newspaper and so forth. For example, e-books, flexible watch and smart paper based on black/white microcapsule-type EPD have been already commercially available. Studies on the full-color EPD are also under way to enhance the display performance so that EPD can show rich, vibrant colors and patterns. Installation of an optical color filter on the electrophoretic display medium was one way to achieve full-color EPD. However, because of the filter, the contrast ratio and brightness of EPD were decreased. Another way to realize the colorization was to use color pigments as the electrophoretic particles [3].

In general, EPD exhibits visible images by moving the charged pigment particles to the opposite electrode in an applied electric field. Two kinds of particles with different colors possessing opposite charges and electrophoretic fluid are placed between two parallel conductive plates with 10–100 mm spacing [4]. If the back of the conductive plates was divided into many tiny picture elements,

an image could be formed by applying appropriate voltage to different region of the plates.

For the full-color EPD, TiO₂ was commonly selected as the white particles, and the studies were mainly focused on the TiO₂ surface modification [5,6]. Recently, more effort has been involved in the modification of color electrophoretic particles, and the development of technologies for particle preparation [7–10]. For example, Guo et al. prepared a type of functional materials which contained a suspension of pigment phthalocyanine green (PPG) [11]. Badila et al. prepared the multilayered latex particles by dispersion polymerization, which were suitable for use in electronic inks [12]. However, to the best of our knowledge, the studies on the yellow pigments applied in the full-color EPD were still limited. We recently reported the modification and characterization of two kinds of yellow pigment particles used in the dual colored electrophoretic displays [13–16].

In this article, C.I. Pigment Yellow 181 (PY181) composite particles encapsulated by polyethylene were prepared by dispersion polymerization method, and C.I. Pigment Yellow 110 (PY110) composite particles encapsulated by polystyrene with mini-emulsion polymerization method were achieved, respectively. To improve the electrophoretic properties of the charged particles, we focused our studies on the compositions of electrophoretic fluid. Furthermore, the response behavior and the contrast ratio to the electric voltage were also examined. We obtained modified particles with higher contrast ratio and faster response time than that of previously reported.

* Corresponding authors.

E-mail addresses: yqfeng@tju.edu.cn (Y. Feng), baozhang@tju.edu.cn (B. Zhang).

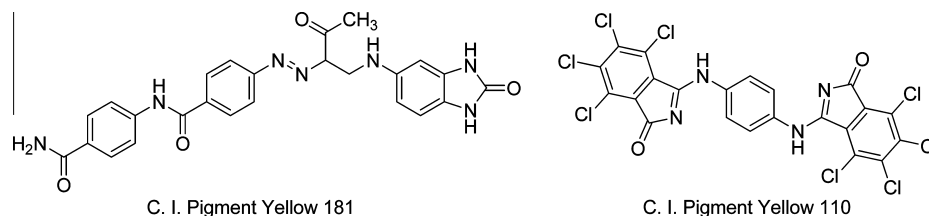


Fig. 1. Chemical structure of PY 181 and PY 110.

2. Experiment

2.1. Materials

C. I. Pigment Yellow 181 (PY 181) and C. I. Pigment Yellow 110 (PY 110) were obtained from Claraint Tianjin Co., Ltd (Tianjin, China), and their chemical structures were shown in Fig. 1. Polyethylene (linear low density polyethylene (LLDPE)), tetrachloroethylene, toluene, styrene, hexadecanol, sodium dodecyl benzene sulfonate, potassium persulfate and sodium dodecyl sulfate were obtained from Guangfu Co. Ltd., Tianjin, China. Hyper-dispersant CH-5, mono succinimide T-151, anhydrosorbitol ester of oleic acid Span 85 and Isopar M were purchased from Sanzheng Polymer Co., Ltd. The chemical structure of T-151 and Span 85 were shown in Fig. 2. All the chemicals used in this study were of reagent grade.

2.2. Preparation of yellow polyethylene-coated PY 181 particles and dual-particle suspensions with yellow/white particles

In paper, we prepared PY181/PE by dispersion polymerization which was simple and easy to carry out.

A mixture of 0.8 g polyethylene (PE) and 250 ml toluene was placed in a 3-neck flask. The resultant mixture was refluxed at 110 °C for 1 h with stirring. Then the anhydrous 1 g PY 181 particles were added. The reaction mixture was kept stirring at a rate of 400 rpm for 6 h. The resultant emulsion was centrifuged (6000 rpm, 10 min). After filtration, the solid product was washed with ethanol three times to remove the excessive PY 181 particles. The product was then dried in vacuum at room temperature for 24 h.

Above modified PY 181 particles (0.25 g) were dispersed in 10 ml tetrachloroethylene (PCE). Appropriate concentrations of 0.100 g T-151, 0.075 g CH-5 and 0.075 g Span 85 were then added to the mixture suspension. The resultant mixture was grinded by the ball grinder for 48 h, and suspension 1 was then obtained.

To 10 ml PCE, 4 g TiO₂ particles (home-made TiO₂/KH-570/PMMA as electrophoretic particles) [17], 0.25 g T-151 as a charge

control agent (CCA) and 0.15 g Span85 as the emulsifier were added. Then the mixture was homogenized by ball milling. The white electrophoretic suspension (suspension 2) was then obtained.

Suspension 1 and suspension 2 were mixed at certain proportion and dispersed ultrasonically for 0.5 h. The dual-colored electrophoretic suspension was then obtained.

2.3. Preparation of yellow polystyrene-coated PY 110 particles and dual-particle suspensions with yellow/white particles

PY 110 (0.5 g) was dispersed in 10 mL styrene in a beaker by ultrasound. Then the mixture was added to a three-neck flask together with 1.5 g sodium dodecyl benzene sulfonate (SDBS), 350 mL water, 0.3 g potassium persulfate (KPS) and 0.4 g hexadecanol. The mixture was ultra-sonicated (ultrasonic cleaner, 400 W) for 30 min to form a mini-emulsion and then stirred for 12 h at 70 °C under N₂ atmosphere. After the polymerization process, the resulting reaction mixture was centrifuged at 6000 rpm thrice and then it was dried in vacuo at room temperature for 24 h.

Above modified PY 110 particles (0.50 g) were dispersed in 10 ml Isopar M. Appropriate concentrations of 0.15 g T-151, 0.10 g CH-5 and 0.05 g Span 85 were then added to the mixture suspension. The resultant mixture was grinded by the ball grinder for 48 h, and suspension 3 was then obtained.

To 10 ml Isopar M, 2.0 g TiO₂ particles, 0.10 g T-151 as a charge control agent (CCA), 0.15 g CH-5 and 0.25 g Span85 as the emulsifier were added. Then the mixture was homogenized by ball milling. The white electrophoretic suspension (suspension 4) was then obtained.

Suspension 3 and suspension 4 were mixed at certain proportion and dispersed ultrasonically for 0.5 h. The dual-colored electrophoretic suspension was then obtained.

2.4. Characterization

The sizes of PE-coated PY 181 particles and PS-coated PY 110 particles in the electrophoretic suspension were determined by zeta

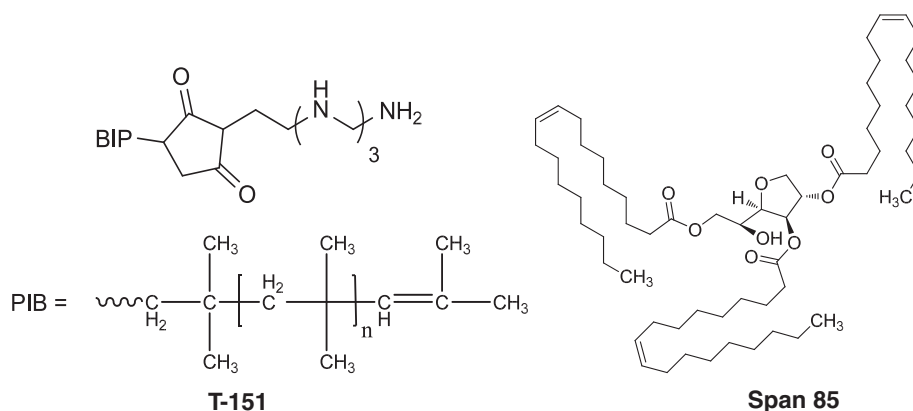


Fig. 2. Chemical structure of T-151 and Span 85.

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