Microcapsulation Technique of the Black and White Particles Suspension for Electrophoretic Display

Chul Am Kim, Meyoung Ju Jeong, Seong Deok Ahn, Seung Youl. Kang,
Yong Eui Lee, and Kyung Soo Suh
Electronics and Telecommunications Research Institute, Daejeon, 305-350, Korea
Phone: 82-42-860-5259, e-mail: cakim@etri.re.kr

Abstract

We present a microcapsule manufacturing technique, which contains a polymer coated white TiO_2 and black particles suspension as the core material for a electrophoretic display ink, via the in-situ polymerization method using melamine? formaldehyde as a wall material. The obtained capsules have 50 ~ 300 μm of the diameter range. They show a good mechanical strength and thermal and optical property. We fabricate the microcapsules to the single layer to test the black/white electrophoretic display application.

1. Introduction

In the recent information technology days, a lot of information as electronic documents has been distributed on a computer network. Base on the fact, lightweight, flexible displays are of great interest for applications in portable displays and advertisement, such as PDAs, electronic newspapers, and e-books as well as out- and in-door advertisement. One of the most promising candidates to meet these requirements is a microcapsule-type electrophoretic display which is a reflective paper-like display. The microcapsule-type electrophoretic display [1,2], relying on electrostatic migration of light-scattering particles in a dielectric colloidal suspension. The microcapsule-type electrophoretic display consists of millions of microcapsules containing charged particles in the clear dielectric fluid. The schematic diagram of the microcapsule-type electrophoretic display is represented in Fig. 1.

A positive voltage applied to the top surface causes the negative white particles to move to the top of capsule and the surface to appear white; reversing the electric potential induces the positive black particles to migrate at the top surface and create a dark image. See the Fig. 1.

The internal phase of the microcapsule for the microcapsule-type electrophoretic display is composed of sub-micron scaled pigment (white and black) particles and the clear dielectric fluid. To obtain the white particle, rutile titanium oxide particles is coated using a polymeric material. To realize the bistable black pigment particle, it is necessary to be coated with functionalized polymer for matching the density of the particles that of the dielectric fluid.

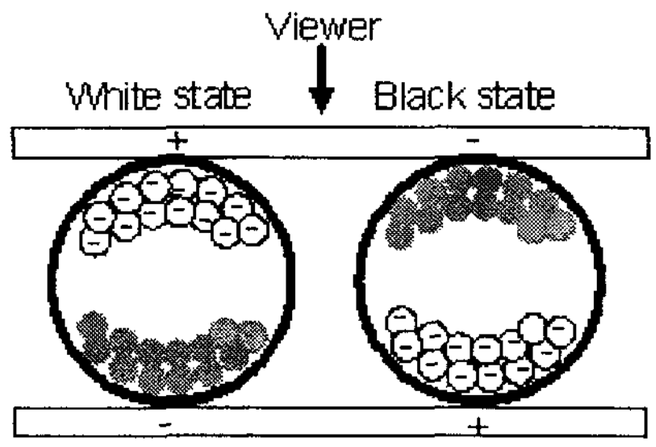

Figure 1. Schematic illustration of microcapsule-type electrophoretic display.

To construct the microcapsule-type electrophoretic displays, itis necessary to prepare the stable microcapsule. In this study, we manufactured the microcapsules enveloping the charged pigment particle suspension as the internal phase through in-situ polymerization method[3,4].

2. Experimentals

2.1 Materials

The following chemicals were used in the present study: urea (Daejung Chemicals & Materials Co., Korea) and melamine (Lancaster Co., England), and formalin (Aldrich Co., USA) were used to form the capsule wall. Sulfonated polystyrene (SPS) (Alco Chemical Co., USA) was selected to protect the particle suspension droplets into an aqueous phase. Citric acid and sodium hydroxide (NaOH) as a pH controller were obtained from Junsei Chemicals

(Japan) without any further purification. All of the chemicals used in this study were a reagent grade.

2.2 Preparation of microcapsule

The crosslinked polystyrene (PS) coated TiO_2 particle suspension [5,6] was prepared as the core material. In the first step for the microencapsulation, U/M-F precondensate was prepared to obtain polymeric wall composed of thermosetting resin. 0.1M urea and 0.1M melamine, and 0.3M formalin are mixed with 100 ml of distilled water then adjusted pH range 8.5 ~ 9 with 10% NaOH aqueous solution.

By stirring the mixture at 60 °C, a semitransparent U/M-F prepolymer was obtained after a reaction time of 30 min. Simultaneously, the core material suspension was prepared following: 35 ml of the dye solution is placed in a 50 ml flask, to which are added pigment particles. OLOA 1200 (Chevron, USA) as a charge control agent, 3% of the white particle, and Span 85 (Aldrich) as a dispersion agent, 10% of the particle are added to the mixture. This mixture is then sonicated for 60 min in a Branson 3210 sonicator.

In a 1 l dual-jacketed batch reactor is mixed 400 ml of SPS aqueous solution, 1 g resorcinol (Aldrich), and the resulting mixture suspension under agitation. The mixture emulsion is stirred and pH adjusted to 4.5 ~ 4.8 with 10 wt% citric acid aqueous solution over a period of 10 min at 60 °C.

The U/M-F prepolymer is added into the emulsion prepared in the above emulsifying step, and then pH of emulsion is adjusted to 5.5 with 10 wt% NaOH solution. The resolution is maintained the agitation state for 2 ~ 3 hours. After the in-situ polymerization on o/w emulsion surface, microcapsules slurry is allowed to cool to room temperature. The resulting capsule slurry is sieved and washed with distilled water.

3. Results and Discussion

In this study, the electrophoretic particle suspension microcapsules were obtained by the in-situ polymerization. In the initial dispersion step, oil phase droplets composed of the ink particles and the dielectric fluid were formed in the aqueous anionic polymer solution. An optical microscopy photograph of the electrophoretic particles suspension droplets in the reaction medium solution. The droplet phase is grey scale, meaning all pigment particles are uniformly suspended in dielectric fluid, as shown in Fig. 2.

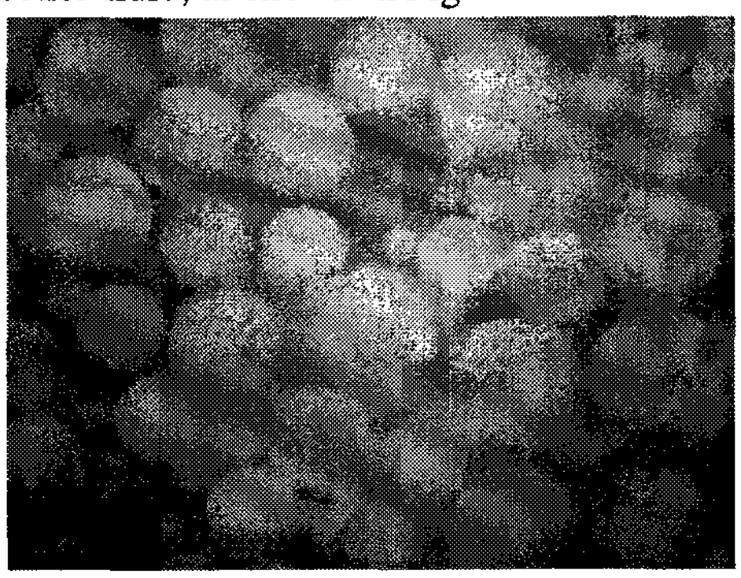

Figure 2. Optical microscopy photograph of the electrophoretic ink suspension droplets in aqueous anionic polymer solution.

Figure 3 represents the microcapsule photograph after reaction. As shown, the microcapsule shape is spherical; it means the droplets in the initial dispersion state keep through the reaction procedure.

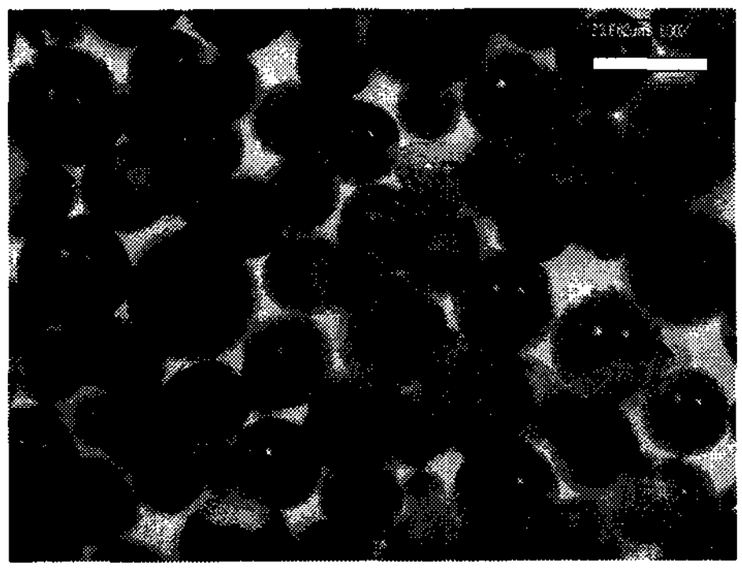

Figure 3. Optical photomicrograph of the microcapsule contained the black/white electrophoretic particle suspension.

Scanning electronic microscope (SEM) photograph of microcapsules is shown in Fig. 4. Surface morphology of the microcapsules represents the smooth exterior wall membrane.

SEM picture (Figure 5(a)) has been obtained on fractured microcapsules in slushed nitrogen and shows the membrane the thickness of which is about 0.3 μm. Figure 5(b) shows the interior semi-sphere of the microcapsule. The small particles represent the enveloped black and white pigment particles. Figure 5(b) confirms the pigment particle loading in the microcapsule through breaking the

microcapsule.

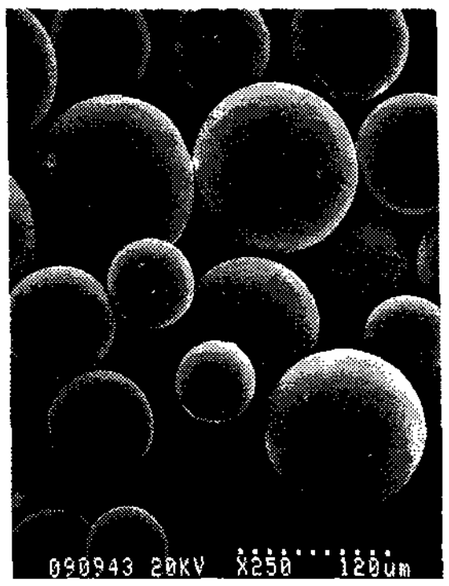

Figure 4. Scanning electronic microscopy photograph of the wall of microcapsule contained the black/white electrophoretic particle suspension.

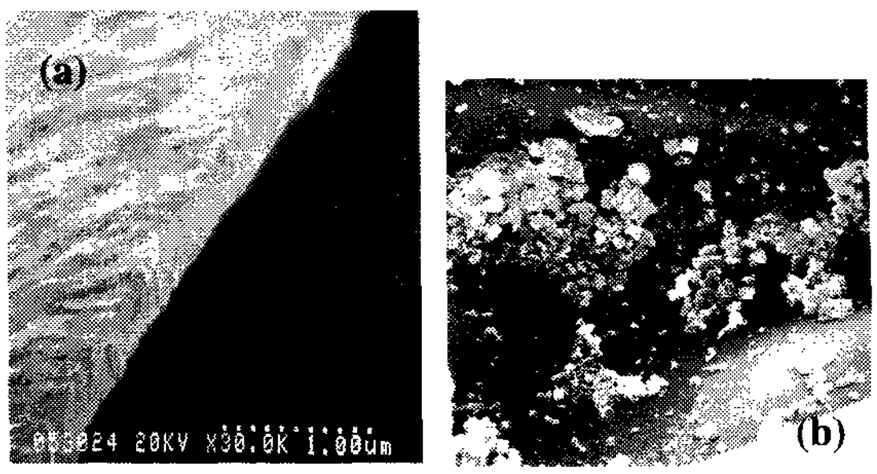

Figure 5(a). SEM picture of microcapsule fractured in slushed nitrogen: the picture exhibits the membrane structure; (b) the interior semi-sphere of the microcapsule.

The rotational speed of the blade in the emulsification step is the important factor affecting both size and the size distribution of the capsules. Figure 6 shows the results of the size distribution for the microcapsules containing the electrophoretic particles suspension under 400 rpm condition. The mean particle diameter of the capsules is estimated to be 203 μm within a range of 200 μm width. The mean particle size decreased when the stirring speed of the motor is raised. The mixing power efficiency is enhanced critically, therefore, the microcapsule size decreased suddenly.

4. Conclusion

In this study, the electrophoretic particle suspension/melamine formaldehyde microcapsules were obtained by the in-situ polymerization. Utilizing the microcapsule produced via the in-situ polymerization allowed us to fabricate the microcapsule-type electrophoretic display.

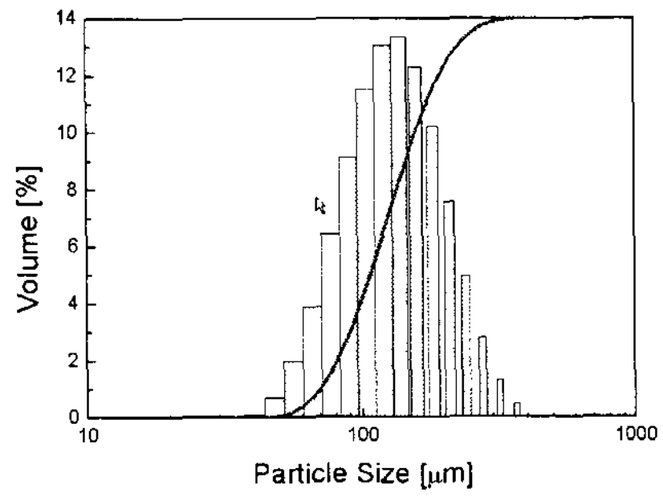

Figure 6. Particle size distribution of the microcapsule containing the electrophoretic particle suspension reached at 400 rpm.

5. Acknowledgements

Research was financially supported by the Korea Ministry of Information and Communications.

6. References

[1] Chomiskey, B., Albert, J.D., Yoshizawa, H., and Jacobson, J. An electrophoretic in for all-printed reflective electronic displays. Nature, 394 p. 253 (1998).

[2] Jo, G.-R., Hoshino, K., and Kitamura, T., Toner Display Based on Particle Movements. Chemistry of Materials, 14, p. 664 (2002).

[3] Benita, S., (ed.). Microencapsulation: methods and industrial applications, Marcel Dekker, Inc., New York, (1996).

[4] Hong, K. and Park, S., Melamine Resin microcapsules Containing Fragrant Oil: Synthesis and Characterization. Materials Chemistry and Physics, 58, p. 128 (1999).

[5] Ahn, S.D., Kim, M.K., Jeong, M.J., Kim, C.A., Lee, Y.E., Kang, S.-R., and Suh, K.S., Electrical and Optical Properties of Polymer Coated TiO_2 Particles Using Dispersion Polymerization Technique for Electrophoretic Display. Proceedings of IDWI02, p.1361 (Hiroshima, Dec., 2002).

[6] Kim, C.A., Kim, M.K., Jeong, M.J., Ahn, S.D., Kang, S.-R., Lee, Y.E., and Suh, K.S., Amino Resin Microcapsules Contained the Polystyrene Coated Titanium Oxide Particles. Colloid and Polymer Science, (submitted).