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First Fabrication of Electrowetting Display by Using Pigment-in-Oil Driving Pixels

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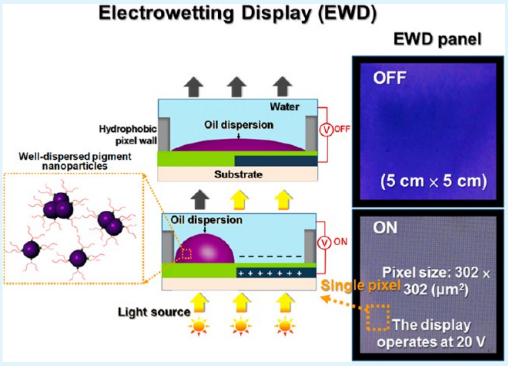
Ⓢ *Supporting Information*

ABSTRACT: We report the first fabrication of pigment particle-based electrowetting display (EWD) by using the requisite poly(isobutylene)-imide (PIB-imide) for effectively dispersing insoluble colorant in decane/water system. The series of PIB-imide dispersants were prepared from the amidation/imidation of PIB-succinic anhydride with different hydrophobic lengths and a suitable amine. The structurally tailored dispersants by adopting the highly hydrophobic PIB tails allows the formation of homogeneous dispersion of nanosized pigment particles in decane and clearly separated from water. The pigment dispersion at particle size of ca. 100 nm and a low viscosity of 2−3 cps was obtained and fabricated into an EWD device which was operated at a driving voltage of 15−20 V in achieving a maximum aperture ratio of 80%. With the advantage of both fast response time and vivid color, the pigment-based EWD, as shown in the video, stands out as a promising new option for future transparent display and serves as a critical foundation for the next-generation advanced display applications.



KEYWORDS: *pigment, display, poly(isobutylene)-succinic anhydride, dispersion, decane, electrowetting display*

1. INTRODUCTION

Although the emissive display technologies still dominate the electronic displays, new development of reflective and transparent displays is emerging for the multimedia and portable applications.[1−3] Among the newly developed alternatives, electrowetting display (EWD) is most promising for high contrast, color brightness, video speed, and relatively low energy consumption.[4] An EWD is characterized of conductive liquid, colorant ink, a hydrophobic layer, a hydrophilic pixel wall, and an electrode, in general, and is a simpler device than the reflective liquid crystal display (LCD).[5−14] More important, EWD can be potentially developed into flexible devices because of its simplicity in design and optical insensitivity to cell gap. Since it was first proposed in 2003,[4] the progress of fabricating EWD has been steadily made, and recent focus is on the colorants.[4−14] Furthermore, a single-layered and multicolored EWD was reported, using various dye colorants in replacing the conventional color filter technology.[15]

Despite the major advantages of simplicity in design, flexible panel, less-expensive material, and power saving, there remain technological challenges, including stable colorants in oil phase for fabricating efficient EWD devices. The present state-of-the-art work has employed traditional dye-colorants that are soluble in oil medium with the drawback of poor light fastness and instability for longevity of uses. The concept of utilizing stable pigments is obvious, however, the homogeneity of dispersing pigments in fine size remains most challenging. It is well-documented that the advantages of organic pigments include considerable stability and excellent optical properties such as good photosensitivity, brilliance, color density, transparency, and high thermal stability.[16] With the same advantages, various colors of organic pigment have been widely reported in a variety of applications as colorants for color filters,[17] cosmetics,[18] plastics,[19] inks,[20] and coatings[21] in electronic devices. However, the technological barrier of using pigments, instead of dyes, lies in the difficulty in solubility or dispersion in most organic mediums because of their inherent molecular structures having the tendency to form aggregated particles through noncovalent bonding interactions.[22] In general, the homogeneous pigment dispersion could be achieved only by the process of tedious grinding procedure, accompanied by judicial selection of suitable dispersants for stabilizing particles from aggregation and controlling the medium viscosity.[23] The use of common organic surfactants to achieve homogeneity and

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stability of dispersions generally falls short because of insufficient noncovalent bonding forces for interacting with the pigment surface. Recent progress for better dispersing ability have been achieved by employing amphiphilic copolymers in dispersing inorganic nanoparticles.[24,25] For example, polymeric structures such as random, A-B block, comblike copolymer, and other structures[26−29] have been reported for dispersing RGB colored pigments.[30−33] Poly(oxyethylene)-segmented oligo(imides) were highly effective for dispersing carbon nanotubes,[34] silver nanoparticles[35] and platinum crystals[36−40] for enhancing the efficiency of dye-sensitized solar cells.

Here, we disclose the strategy of utilizing organic pigments for EWD devices by adopting the nanotechnology of dispersing insoluble particles. The molecular design of suitable polymeric dispersants allows the properly balanced noncovalent bonding forces between individual pigment particles and the selected oil medium. Hence, the uniformity of pigment nanoparticles in decane, consequently, could exhibit high color resolution of EWD operation. The synthesized dispersants are required to have dual functions for noncovalently anchoring pigment's surface and simultaneously solvating with oil medium. A high level of intensive interaction with pigment and medium is vital for the dispersant to function as the colorants during the operation in EWD device. The polymeric surfactant was prepared by using the highly hydrophobic component of poly(isobutylene) block in the structure for the oil compatibility. The pigments were then dispersible by the polar tethering functionalities involving amine-derived imides. The structural design was emphasized on the presence of PIB polymer chains that provided steric hindrance when dispersing pigments in decane. The performance metrics such as the pigment particle size, viscosity, and stability were correlated with the polymeric surfactant structures. Overall, the goal of this study is to develop the novel EWD that employs the layer of pigment-based oil phase as the electric switching device.

2. EXPERIMENTAL SECTION

2.1. Materials. Polyisobutylene-*g*-succinic anhydride (PIB-SA) with different molecular weight (M_w) of 700, 950, and 1300 (abbreviated as PIB-700, PIB-950, and PIB-1300, respectively) were obtained from Chevron Corp. A series of primary amines including n-alkylamines ($C_nH_{2n+1}NH_2$, $n = 12$, 14, and 18) and ethylenediamine (EDA, M_w 60 g/mol) were purchased from Aldrich Chemical Co. The organic pigment (C.I. name: Pigment Violet 23) with particle size ca. 20−60 nm (data provided by the manufacturer) was obtained from BASF. Besides C.I. Pigment Violet 23, other organic pigments of red, green, and blue (commercial C.I. name: Pigment Red 254, Pigment Green 36, and Pigment Blue 15) were obtained from BASF in powder form.

2.2. Synthesis of PIB Dispersants. The PIB-succinic anhydride-derived polymeric surfactants were synthesized from the reaction of PIB-1300 and EDA at a 2:1 molar ratio (product PIB-EDA-PIB) according to the following experimental procedures. To a 250 mL three-necked and round-bottomed flask that was equipped with a magnetic stirrer and a thermometer, PIB-1300 (44.5 g, 0.033 mol) in THF (44.5 g) was added and followed by a solution of EDA (1.0 g, 0.016 mol) in THF (1.0 g) through an additional funnel. Under a constant stirring, the mixture was maintained at the temperature of 25 °C for 3 h. An aliquot of reaction mixture was taken and analyzed by using Fourier transform infrared spectroscopy (FT-IR). The characteristic absorption at 1556 and 1644 cm^{-1} was obtained for amidoacid functionalities. While raising the temperature up to 150 °C and maintained for 3 h, the cyclized imide functionality at the absorption of 1713 and 1770 cm^{-1} appeared as the major absorption peaks. The change of characteristic peaks indicated the high conversion from PIB-amidoacid to PIB-imide. The product was recovered by water extraction and rotary evaporation under vacuum to remove the unreacted amines and solvents. PIB-SA of different molecular weights was used to react with EDA by using the similar procedures.

In another run, procedures similar to those used for PIB-EDA-PIB were performed. The reaction of PIB-SA and n-alkylamine at the scale of PIB-950 (9.5 g, 0.01 mol) in decane (9.5 g) and n-$C_{18}H_{37}NH_2$ (2.69 g, 0.01 mol) in decane (2.69 g) generated PIB-N-alkyl amidoacid and the corresponding imide products at a 1:1 molar ratio of PIB-SA and n-octadecylamine.

2.3. Evaluation of Dispersants for Homogenizing Pigment with Bead Mill Grinding Procedures. The dispersion of pigments in decane was prepared by subjecting the C.I. Pigment Violet 23 powder to mechanical grinding in a bead mill (zirconium beads with a diameter of 1.5 mm) in the presence of the PIB-derived dispersant at weight ratio of pigment/dispersant of 1:1. The performance for homogenizing pigment was examined by preparing an aliquot of slurry of 10 wt % in decane and adding pigment. In a typical example, 20 g of pigment dispersion was prepared by mixing the dispersant (1.0 g) in decane (18 g) and the violet pigment powder (1.0 g) added in one portion. The slurry was homogenized further using a mechanical vibrator for 10 min and then transferred to a vertical ball mill containing zirconium beads and processed at 50 rpm for 72 h at room temperature. In a controlled experiment, the pigment (2.0 g) in decane (18 g) was homogenized by following the identical procedures without any dispersant. The dispersions were characterized by measurement of particle size distribution, viscosity, and transmission electron microscope (TEM), oil/water repulsive property, and EWD driving performance.

2.4. EWD Fabrication. The procedures of fabricating EWD are described in the following. The 100 nm ITO layer was deposited on glass substrate by sputtering with 25 °C, then the ITO layer was patterned to form pixel electrodes by photolithographic methods.[9−11,15] After that, 150 nm SiNx dielectric layer was deposited by plasma-enhanced chemical vapor deposition (PECVD) with 200 °C. The 100 nm hydrophobic layer was formed on the dielectric layer by spin-coating the fluoro-polymer, Cytop with 400 rpm. Afterward, 6 μm height of hydrophilic ribs were made by spin-coating a negative photoresist and performing further photolithography. After the EWD backplane was fabricated, slit coating process was adopted to dose the colored oils into each pixel precisely. Finally, deionized water was filled in the cell and the backplane was assembled with the ITO/glass substrate. The EWD structural information is listed in Table S1 in the Supporting Information.

2.5. Characterization and Instruments. Field-emission scanning electronic microscope (FE-SEM) was performed on a Zeiss EM 902A, operated at 80 kV. The samples were prepared by dropping a small amount of the pigment powder on a clean glass surface, followed by a dehydration oven step at 60 °C for 2 h. The samples were then fixed on a FE-SEM holder with conductive carbon paste and coated with a thin layer of Au prior to measuring. Fourier transform infrared spectroscopy

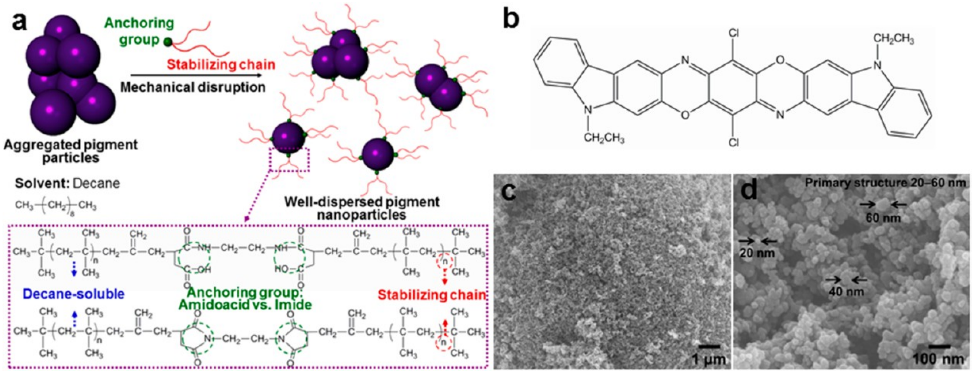

Figure 1. (a) Conceptual illustration of PIB-derived surfactant-dispersed pigment in decane. (b) Chemical structure of the C.I. Pigment Violet 23. (c, d) FE-SEM micrographs of pristine C.I. Pigment Violet 23 at different magnifications.

Table 1. Particle Size Distribution and EWD Driving Performance of the PIB-Derived Surfactant/Pigment Dispersion

dispersants[a]	viscosity (cps)[b] immediately	viscosity (cps)[b] 1 week	particle size (nm)[c]	PDI[c]	decane/water repulsive property[d]	driving test[e]
			PIB-950			
PIB-950	10.7	Gel	1141.0	0.342	+	−
PIB-950-amidoacid-C12	7.2	11.5	564.1	0.303	+	−
PIB-950-amidoacid-C14	3.3	10.2	539.4	0.269	+	−
PIB-950-amidoacid-C18	3.1	8.8	363.8	0.235	+	−
PIB-950-imide-C18	2.6	8.2	192.5	0.159	+	−
			PIB-700			
PIB-700-amidoacid-PIB	3.3	4.8	285.7	0.249	+	−
PIB-700-imide-PIB	2.8	2.8	140.6	0.266	+	−
			PIB-1335			
PIB-1335-amidoacid	3.1	9.1	237.7/4818 (96.8/3.2)[f]	0.232	+	−
PIB-1335-amidoacid-PIB	2.6	2.7	117.7	0.155	+	+
PIB-1335-imide	3.1	8.6	159.3/5368 (97.9/2.1)[f]	0.275	+	−
PIB-1335-imide-PIB	2.3	2.3	91.5	0.144	+	+

[a] Polyisobutylene-g-succinic anhydride (PIB-SA) with different molecular weights (M_w) of 700, 950, and 1335 are abbreviated as PIB-700, PIB-950, and PIB-1335, respectively. [b] Dispersion: 1.0 g of pigment, 1.0 g of dispersant, and 18 g of decane; viscosity was measured (spindle S18; 100 rpm; 25 °C) immediately and 1 week settling after milling. [c] Samples were diluted to 2 ppm concentration for particle size analysis (25 °C); particle size was measured immediately after milling. [d] +, repulsiveness; −, emulsion. [e] +, working; −, nonworking. [f] Particle size (nm) and distribution (%; bimodal peaks).

(FT-IR) was recorded on a Perkin-Elmer Spectrum One FT-IR Spectrometer in the range of 4000−400 cm^{-1}. Samples of PIB-derived dispersants were prepared by dissolving in decane and evaporating into a thin film on a KBr plate. The average particle size of pigment dispersion was estimated using a Laser Particle Size Analyzer (90 Plus Brookhaven Instrument Corp.) equipped with a 15 mW solid-state laser (675 nm). The sample was then recorded 1 run for 1 min per measurement and the results of 20 runs were averaged. The results are quoted as average particle size (mean-diameter). Transmission electron microscope (TEM) was performed on a Zeiss EM 902A, operated at 80 kV. The samples (0.1 wt % in decane) were deposited onto a carbon-coated copper grid. General procedure for viscosity measurements was using the DV-II+ PRO Digital Viscometer (Brookfield), spindle number S18 was used. Measurements were taken after 3 min of rotation to ensure equilibration of the reading.

3. RESULTS AND DISCUSSION

3.1. Synthesis of PIB-Derived Polymeric Surfactants.

The synthesis of polymeric surfactants, PIB-imides, involves the reaction of polyisobutylene-graft-succinic anhydride (PIB-SA) and a group of selected amines with primary amine ($-NH_2$) functionalities. Oil-soluble poly(isobutylene) (PIB) tails with succinic anhydride reactive sites are selected in the structural design. By adopting different molecular weights of PIB-succinic anhydride and a number of selected primary amines, the synthesis of PIB-amidoacids and PIB-imides was screened systematically. As illustrated in Scheme S1 and S2 in the Supporting Information, the preparation of single-tailed PIB-imide and two-tailed PIB-imide-PIB dispersants was described. The reaction progress was easily monitored by the appearance of the characteristic absorption in FT-IR analyses (see Figure S1 in Supporting Information). The products consist of chemical moieties including the PIB alkyl amide and the subsequent imide formation. During the process, the anhydride ring-opening reaction occurred at ambient temperature to afford the corresponding amidoacids, evidenced by the appearance of the IR absorption for amide at 1556 and 1644 cm^{-1} at the expense of anhydride at 1782 and 1852 cm^{-1}. The conversion of anhydride to amidoacids was quantitative by the IR measurement. The PIB-amidoacid intermediates underwent a ring-closure reaction to form the corresponding PIB-imides under the conditions of elevated temperature up to 150 °C and 3 h period of time. The ring closure of amidoacid into the imide

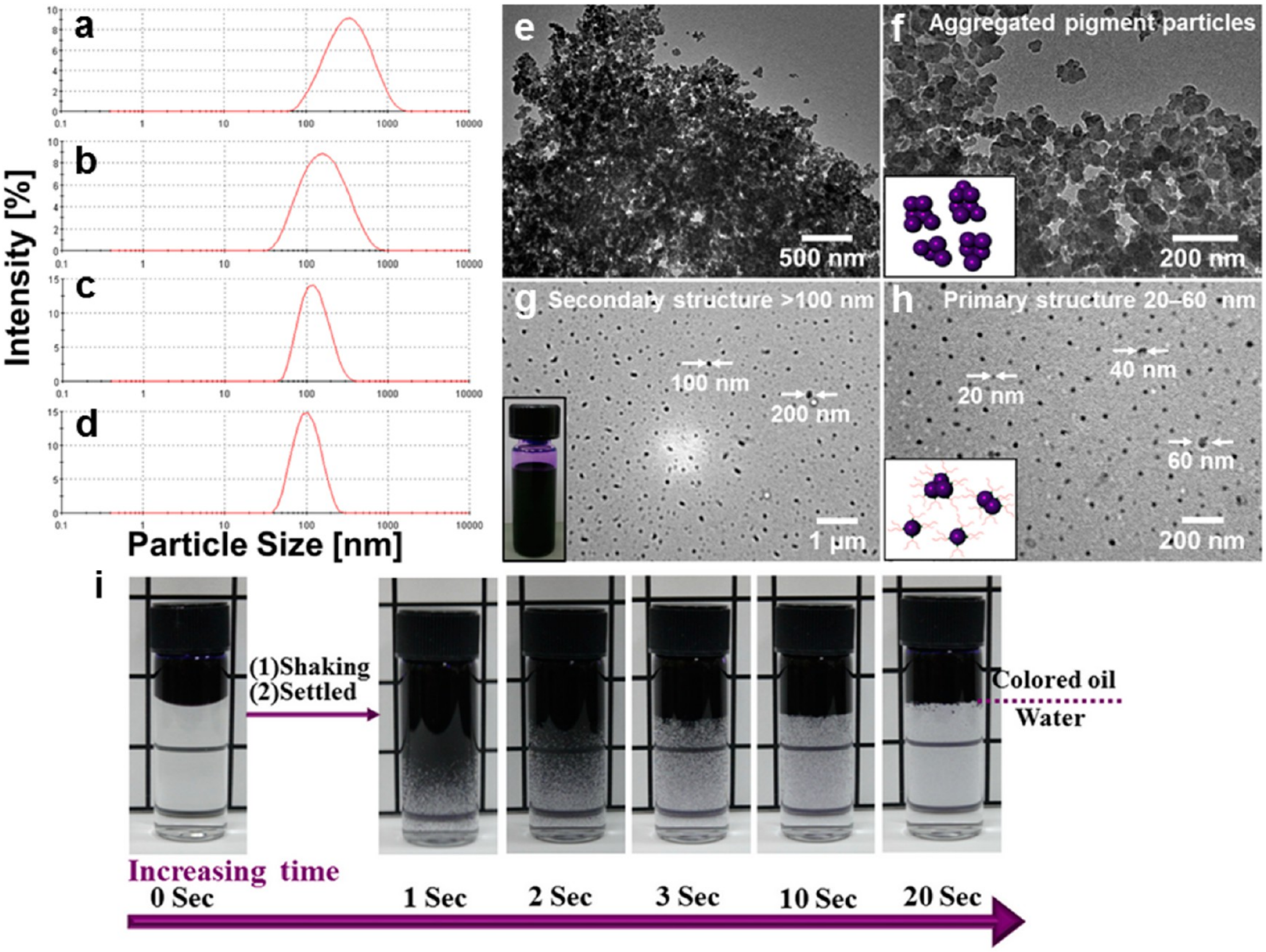

Figure 2. Particle size and the mono distribution of pigment dispersion by PIB derivatives: (a) PIB-700-amidoacid-PIB, (b) PIB-700-imide-PIB, (c) PIB-1300-amidoacid-PIB, and (d) PIB-1300-imide-PIB. TEM micrographs of C.I. Pigment Violet 23 dispersions: (e, f) milling without dispersant and (g, h) milling with PIB-1300-imide-PIB at different magnification, indicating the primary structure about 20−60 nm and secondary structure over 100 nm, from the sample with ca. 10 wt % content of C.I. Pigment Violet 23 in the dispersion. The inset in g shows the good dispersion after 6 months of undisturbed suspension. (i) Oil/water repulsive property of PIB derivative−pigment dispersion. After vigorous shaking, the dispersion settled into two layers.

was evidenced by the appearance of strong imide absorption at 1713 cm^{-1} and weak absorption at 1770 cm^{-1}.

3.2. Homogeneous Dispersion of Pigments in PIB-imide/Decane. Pigments are insoluble in organic solvents and generally existed as aggregated lumps or large particles because of the intensive molecular interaction and crystalline property. Through mechanical ball milling in the presence of a suitable dispersant, the fine particles of pigments may be separated and maintained at a homogeneous state of particle individuality that is required for the specific applications. In the stabilized dispersion, the primary units of particles may be maintained without the possible flocculation or aggregation into secondary aggregates at microscale size. The avoidance of the particle aggregation can be achieved by designing the dispersant structure that could generate intensive noncovalent bonding forces anchoring the pigment surface and simultaneously stabilizing particle primary units. Previously, we developed polymeric surfactants for the functions of stabilizing various nanoparticles including platinum and organic pigments.[29,34−40] The findings revealed that the dispersant molecules comprising of the common oxyethylene/oxypropylene backbone were not hydrophobic enough to be compatible with the oily medium. The noncovalent bonding ability between the dispersed materials in oil medium is essential for avoiding the particles from self-aggregation. To achieve the homogeneous dispersion, the requisite polymeric dispersant is structurally tailored for its functionalities to be soluble in decane solvent. By comparison, the previously developed amphiphilic poly(oxyalkoxy)-backboned dispersants are toluene-soluble but insoluble in decane.

The amphiphilic dispersant with the optimal balance of noncovalent bonding forces enables the pigment dispersion in decane as conceptually illustrated in Figure 1a. The dispersants comprise the PIB tails for oil solubility and the polar functionalities including amidoacids and imides. The functionalities of the dispersants tend to interact with the surface of pigments including C.I. Pigment Red 254, Green 36, Blue 15, and Violet 23 and solvate in oily medium. Their chemical structures are provided in Figure 1b and Figure S2 in the Supporting Information. The morphology of the powder form of the C.I. Pigment Violet 23 nanoparticles was characterized by FE-SEM micrographs (Figure 1c, d). The performance of pigment dispersion in decane by PIB-imide dispersant has been

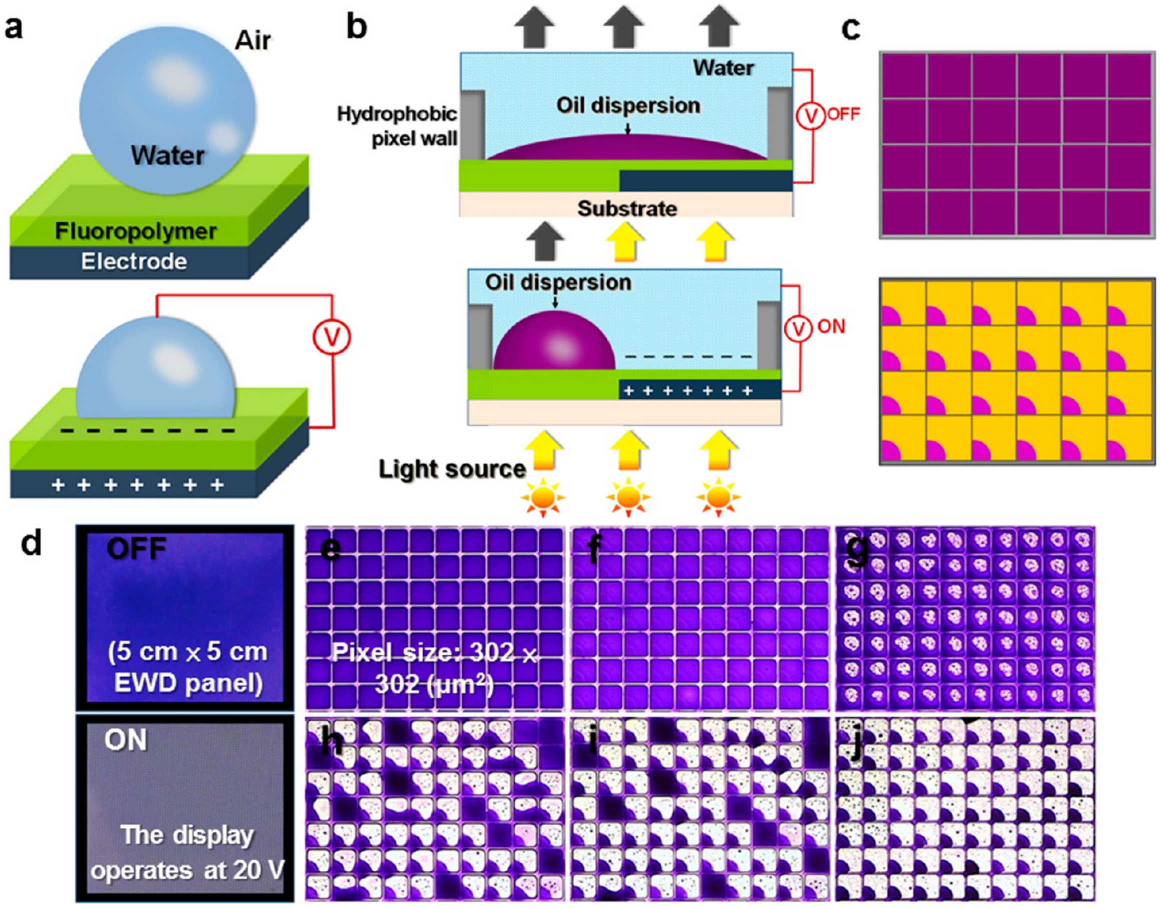

Figure 3. (a) Representation of electrowetting process under the applied electric field. (b) Schematic illustration of a cross section of OFF and ON EWD pixels with reservoirs and (c) top view of pixel operation. (d) Electrowetting display panel of violet pigment under on/off voltage driving; magnified panels under the operation voltages of (e) 0, (f) 5, (g) 7.5, (h) 10, (i) 15, and (j) 20 V. The maximum aperture ratio of 80% was reached at the optimized voltage of 20 V.

evaluated by measuring particle size of pigment and viscosity in the dispersions (Table 1). The detailed results regarding to the distribution of particle sizes were obtained by using dynamic light scattering analyzer (Figure 2a–d and Figures S3–S6 in Supporting Information). Because decane has been previously selected for dissolving dyes better, it was adopted to be the oily phase for the pigment dispersing medium against water as the conductive path. The PIB interaction by hydrophobic effect could be the primary noncovalent bonding force for driving pigments into decane. Hence, the structural design including single- and dual-tailed PIB-imides were systematically prepared. The initial performance screening indicated that the uncyclized amidoacids had a weaker anchoring force and less effective for homogenizing the pigment particle size than the corresponding PIB-imide analogs. Hence, the performance was compared for PIB-imides in affecting various pigments initially. The representative pigment, C.I. Pigment Violet 23, was further selected for the single-color EWD fabrication for the detailed performance test including particle size, viscosity, and stability under on/off operation.

The viscosities of the pigment dispersions by the synthesized dispersants with different molecular weights and multiplicity of PIB tails such as PIB-950-imide-C18, PIB-700-imide-PIB, and PIB-1300-imide-PIB in decane were measured to be 8.24, 2.89, and 2.39 cps, respectively. A considerably low viscosity was achieved by the dual-tailed PIB-imides in comparison with the single-tail one. Generally, the interactions among pigment/dispersant/medium in composition fractions largely determine the existence of the homogeneity and the stability of the dispersion. Individual particle units were stabilized by polymer strains through imide anchoring and PIB tails solubilizing in the continuous phase of medium. It was realized that the homogeneous dispersion could slowly set into inhomogeneous states such as coalescence, flocculation and sedimentation, and large precipitation. Curing the process, the increase in viscosity often occurs. Hence, a viscosity change of the dispersion is informative for probing the efficiency of a dispersant. Among the PIB-derived dispersants, the measurements of particle size and viscosity over time have resulted the following trend for the rating of effectiveness: PIB-imide-PIB > PIB-amidoacid-PIB > PIB-imide > PIB-amidoacid. The PIB length was optimized at the molecular weight of 1300 g/mol. The correlation between the performances of pigment dispersion and polymeric dispersion in terms of particle size, viscosity, and stability is established.

The pigment dispersions can be finely dispersed in decane and characterized by TEM, as shown in Figure 2e–h. The comparative experiments without dispersant were shown to be large size pigment particles of *ca.* 1000 nm in decane (Figure 2e, f). When the PIB-1300-imide-PIB dispersant was added and pulverized, the pigment dispersion was stabilized and remained a fine particle size (91.5 nm and PDI 0.144) in the medium

(Figure 2g, h). It was observed the primary units of pigment particles about 20−60 nm and secondary aggregates or clusters over 100 nm. It was noted the dispersion may maintain the homogeneity for a long period of time (over months during standing).

3.3. Distinct Phase Separation between Oil/Water Repulsive Mediums. Besides facilitating the pigment dispersion in decane, the dispersant further functioned to distinctly separate the oil/water interface that is required in the EWD operation. As shown in Figure 2i and in Movie S1 in the Supporting Information, the clear oil/water repulsive property in the presence of PIB-1300-imide-PIB dispersant in association with pigment in oil medium is illustrated. The oil/water biphase separation was first examined by dispersing pigment violet in decane at the concentration of pigment/dispersant weight ratio (1:1) and followed by adding water as the second phase while shaking and allowing a settlement. It was observed that, in this example, the dispersion settled into two separated layers during the time frame from 1 to 20 s. The comparative time and clearness of separation are the parameters for satisfying the EWD requirement.

3.4. EWD Principle. In the electrowetting process, a voltage is applied for changing the wetting properties of a solid material.[4,6] An example of such increased wettability of a water droplet on a hydrophobic surface is illustrated in Figure 3a. Water droplet has the tendency of minimizing its contact surface in avoiding the hydrophobic surface. When a voltage is applied on the hydrophobic substrate, the water droplet contact may change because of the increase in the wettability of the surface. When the voltage is removed, the droplet resumes to its original surface minimization state. This principle of reflective EWD is illustrated in Figure 3b, c. The EWD device comprises a transparent electrode, a hydrophobic insulator, and a colored oil layer on water layer[4,6,9−14] in sandwiched layer structure by glass plates or polymeric frames. At voltage off position, the colored oil phase becomes a continuous layer between the water and the hydrophobic insulator as the lowest energy state of the system. When a voltage is applied across the hydrophobic insulator, an electrostatic force is added to the water phase that is contracted to facilitate the current flow. As a result, the water phase pushes the oil phase aside and exposing the underlying reflecting surface. The voltage on/off shift could then generate two stages of oil−water phase transformation and, consequently, the color display.

3.5. EWD Performance. In Figure 3d−j and Movie S1 in the Supporting Information, 5 × 5 cm^2 single-layer monochromatic EWD substrate is shown. The electrode pattern was etched on the sector corner (20%) in the pixel by photolithography. To reduce the reflectivity of the white color, we inserted pixels for the violet oil of PIB-1300-imide-PIB dispersion. Furthermore, the display panel was operated with an applied AC voltage of 0−20 V and the frequency of 60 Hz. In Figure 3e and f, it is shown that the violet-oil film is still filled in the pixels when the voltage rises to 0−5 V. In Figure 3g, the oil film is pushed aside when the voltage rose to 7.5 V. When 20 V is applied to the color EWD panel, the maximum aperture ratio of 80% has been achieved Figure 3j. The operation demonstrated for the first time the use of polymeric surfactants for dispersing pigments in decane and the ability of exhibiting the colored oil and water phase movement in an EWD device. By comparison, the PIB-950-imide-C18 had a less capability of dispersing the pigment at particle size of ca. 200 nm and formed aggregates in EWD panel (see Figure S7 in the Supporting Information). Moreover, the driving performances of RGB-oil films are poorer than violet pigment under on/off voltage driving (see Figure S8 in the Supporting Information). Hence, it is established that the homogeneity of dispersed pigments in fine size could be the most critical factor for EWD driving performance.

4. CONCLUSION

A series of new polymeric dispersants were structurally designed, synthesized, and tailored for homogenizing pigment particles in decane/water biphase. The dispersion was then fabricated into a layer device of monochromatic EWD, exhibiting a high color resolution of fast electrically driven wetting response. The requisite dispersant consisted of hydrophobic PIB oil-like tails and polar anchoring imide functionalities. In decane, the imide functionalities in PIB-imide molecule serve as the strong chelating moieties toward the surface of pigment surface in maintaining low viscosity (2−3 cps), fine particle size (ca. 100 nm), a narrow polydispersity index (0.144), and long-term storage stability. The presence of PIB-imide dispersant is vital for facilitating the homogeneity of pigment particles in oil and succinctly separating oil/water phase. Finally, the pigment-based EWD was demonstrated to have a maximum viewable area ratio of 80% at a driving voltage of 20 V. With the advantage of using pigments replacing dyes as the colorants, the polymer-assisted pigment dispersion was for the first time fabricated into EWD with a high quality of display performance.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Figures showing synthesis and FT-IR of PIB-derived dispersants and chemical structures, dynamic light scattering, and EWD driving test of pigment dispersions. In addition, a movie showing the oil/water repulsive property and EWD panel. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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