Effect of Dispersing Agents on the Quality of Water Based Inkjet using Black Pigment

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Abstract

Objective of the present research was to study some dispersing agents for carbon black pigment in an aqueous based inkjet ink. The experiment tested on 6 different surfactants which were alcohol ethoxylate, ethylenediamine ethyleneoxide propyleneoxide blockcopolymer, polypropylene glycol blockcopolyme, sodium dodecyl sulphate, sodium polycarboxylate and polymerized naphthalene sulfonate having CMC in a range of 0.01 to 1 %wt studied by measuring surface tension and conductivity of their solution. The black pigment sediment was observed by leaving on a shelf for 30 days. The amorphous particle of the carbon black pigment had a size average in a range of 0.14-0.24 μm dispersed in the inks. The pigmented inks prepared from polymeric dispersants: alcohol ethoxylate and polymerized naphthalene sulfonate gave a high optical density. The pigmented inks which had a small and narrow size distribution gave good inkjet printing runability comparatively.

Introduction

Aqueous based pigmented inkjet inks are developing for using instead of dye based inkjet system because the pigmented ink has better fastness property than that of the dye based ink. Technology for pigmented inkjet ink is pigment-dispersion technology which some of them are different from a process of common printing inks. These are colorant encapsulation [1], pigment-surface modification [2], and dispersing by dispersants [3]. The present research was to study some of dispersants for making an aqueous pigmented inkjet inks. The dispersants used in the study had different hydrophilic property, electrical property, molecular weight and surfactant property. A carbon black pigment was dispersed using these dispersants, and studied particle size distribution. In addition, inkjet printing runability and printed dot reproduction was observed and discussed.

Experimental

Materials and Method

A commercial available carbon black pigment (N330 HAF) was received from Dainippon Ink and Chemicals Inc., Japan. Some dispersing agent were nonionic and anionic surfactants, alcohol ethoxylate, HlB 12 (Sigma Aldrich, Inc.), ethylenediamine eo-po block copolymers, HLB 6 (Clariant Chemicals), polypropylene glycol block copolymers, HLB 4.5, (BASF chemicals), sodium dodecyl sulphate (Ajax Finechem). sodium polycarboxylate (BASF Chemicals), and polymerized naphthalene sulfonate sodium salt.

The surfactant solution of some different concentrations were measured their surface tension and solutions of the anionic surfactants were measured electrical conductivity. The pigment was dispersed into the surfactant solution using a low speed stirrer for 1 day, then brought to centrifuge at 10,000 rpm to remove coarse particles. The dispersion pigments of the different surfactants were brought to observe particle sediment when kept in normal atmosphere for 30 days. The particle size distribution of the pigment dispersion was determined using a light scattering particle size analyzer. Surface tension and viscosity of the pigment dispersion were measured using a ring method tensiometer and Brookfield viscometer. The pigmented inkjet inks were prepared with adding of ethylene glycol as a humectant. The inks were printed via a piezo inkjet printer (a small desktop inkjet printer) having a nozzle size approx. 24 micrometer, printed on a high gloss inkjet paper and a bond paper. The printed test sample was brought to measure optical density.

Results and Discussion

The alcohol ethoxylate, ethylenediamine eo-po block copolymers, polypropylene glycol block copolymers, and sodium dodecyl sulphate have capability to reduce surface tension of water conductivity (Figure 1). The alcohol ethoxylate showed a sharp CMC curve at a point approx. 0.01%wt. The CMC curve of ethylenediamine eo-po block copolymers showed flat reduction of the surface tension and showed its CMC about 1%wt. The polypropylene glycol block copolymers and the sodium dodecyl sulphate showed that they had CMC approx. 1 and 0.1%wt, respectively. The aqueous solutions of the sodium polycarboxylate and polymerized naphthalene sulfonate sodium salt had the CMC at 0.1%wt for the electrical conductivity dependence as showed in Figure 2. The CMCs of the surfactants were important property. Amount of the surfactant used for dispersing the pigment should be the concentration above the CMC.

When compared the sediment results among the dispersants as shown in figure 3, the alcohol ethoxylate showed the lowest sediment comparatively among these dispersants (%wt of pigment sediment) from 2.5%wt which were 25 times of its CMC. The sodium lauryl sulphate had the lowest sediment from 2.5%wt which were 10 times of its CMC. The polymerized naphthalene sulfonate sodium salt could not reduce surface tension but it had good dispersion (low weight of the sediment) from the concentration of 0.5-2.5%wt. The sodium polycarbonate had high weight of sediment, gave poor pigment dispersion.

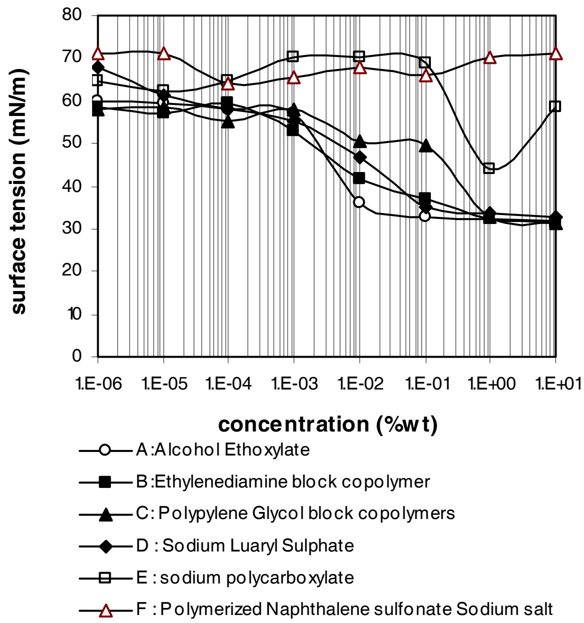

Figure 1 *Surface tension of the dispersant solutions versus concentration*

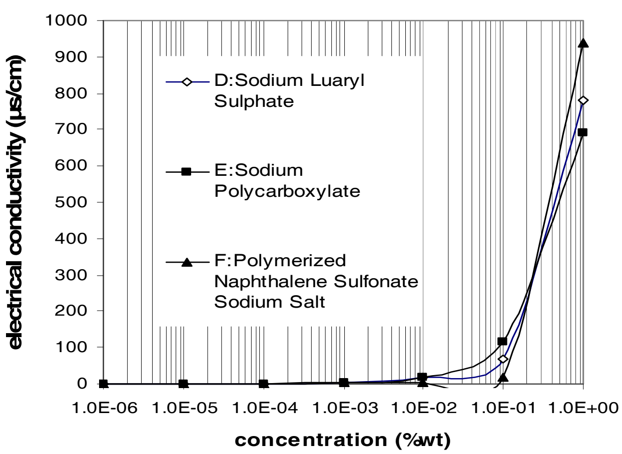

Figure 2 *Electrical conductivity of the dispersant solutions versus concentration*

When considered on particle size distribution of the pigment in the dispersant solutions on figure 4, it found that printing runability of the printer depended on size distribution and minimum particle size of the pigment. That is, the alcohol ethoxylate dispersant of 2.5, 5 and 7.5 %wt conc., which showed narrow distribution and smallest particle size at 7.5%wt conc. gave better print runability comparatively. The sodium lauryl sulphate dispersant of 1, 2.5 and 5 %wt conc., which showed narrow distribution and smallest particle size at 1%wt conc. gave better printing runability comparatively. The naphthalene sulfonate sodium salt dispersant of 0.5, 1 and 2.5 %wt conc., which showed narrow distribution and smallest particle size at 2.5%wt conc. gave better printing runability comparatively. However the pigmented inks of the naphthalene sulfonate sodium salt dispersant gave poorer print runability than those of the alcohol ethoxylate dispersant because it might have improper high surface tension and viscosity values for the piezo inkjet printer (table 1). Whereas, the average particle size values of the pigment could not imply the printing runability clearly. The best printing runability of the prepared pigmented inkjet ink was that of the alcohol ethoxylate dispersant, comparatively.

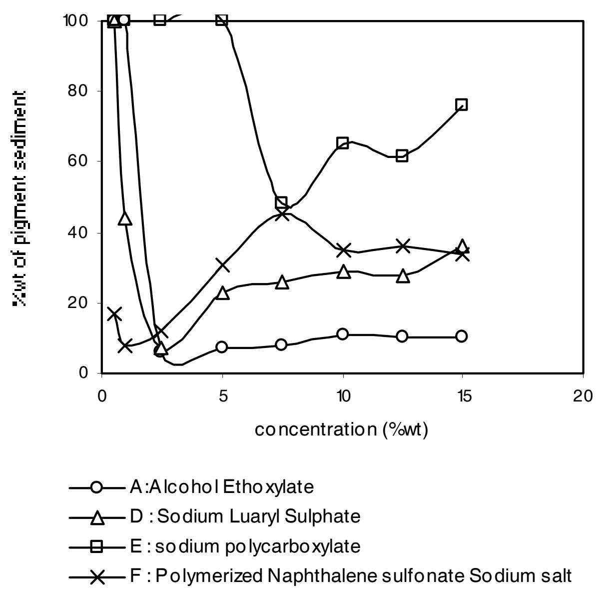

Figure 3 *Pigment sediment from the surfactant solution versus concentration*

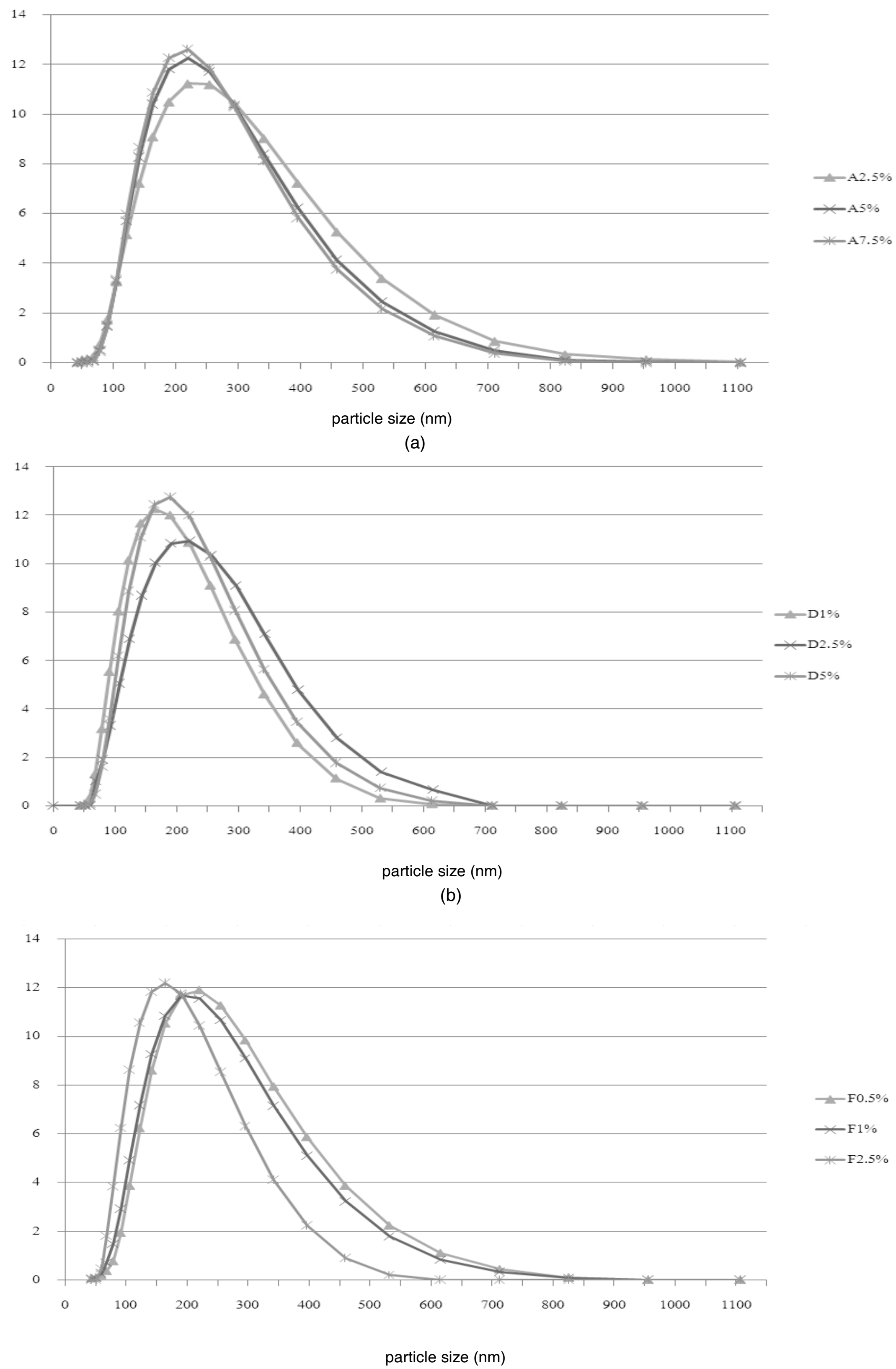

Figure 4 *Particle size distribution of the black pigment using dispersing agent; Alcohol ethoxylate (a) , Sodium Luaryl Sulphate*

Table 1 Properties of the pigmented inkjet inks prepared from some dispersants

surfactants (%wt of total ink)	Properties				
	average particle size (nm)	visible light absorption (% at λ = 350 nm)	viscosity (cP)	surface tension (mN/m)	electrical conductivity (μs/cm)
A (2.5)	207.9	1.433	4.67	34.02	6.32
A (5.0)	216.4	1.582	3.42	33.87	4.19
A (7.5)	216.0	1.534	3.08	32.59	7.80
D (1.0)	208.3	0.207	7.17	37.04	580
D (2.5)	136.96	1.232	6.83	35.67	760
D (5.0)	206.4	1.230	6.33	33.62	1,040
F (0.5)	238.2	0.677	5.33	58.32	690
F (1.0)	233.47	1.701	7.33	61.15	940
F (2.5)	176.7	1.902	4.83	61.43	1,280

A = Alcohol Ethoxylate, D = Sodium Luaryl Sulphate, and F = the Polymerized Naphthalene sulfonate Sodium salt

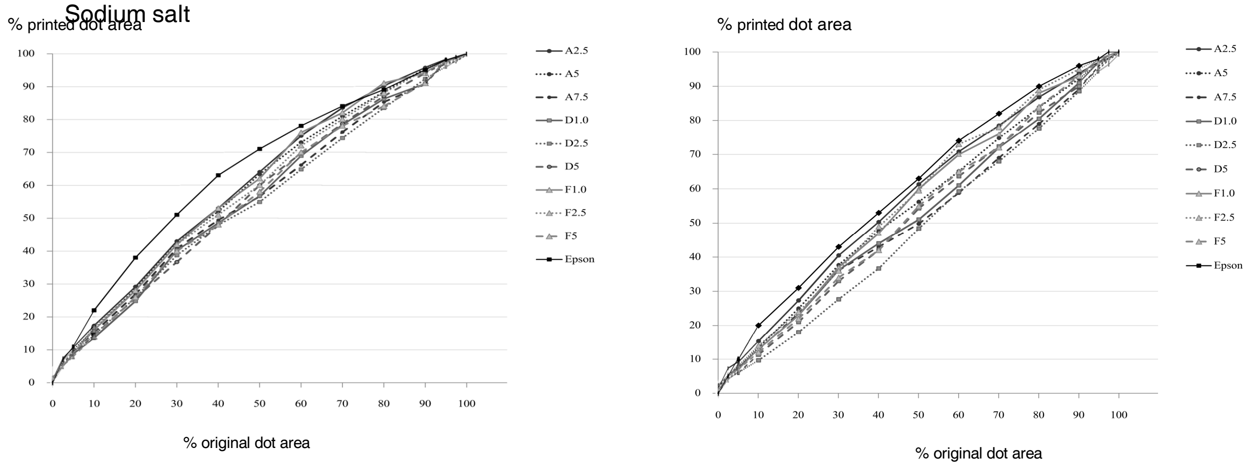

Figure 5 *print reproduction of the pigmented inkjet inks compared to a commercial available pigmented ink of a glossy inkjet paper (right) and a uncoated paper (left) A = Alcohol Ethoxylate, D = Sodium Luaryl Sulphate, and F = Polymerized Naphthalene sulfonate Sodium salt*

The results of printed reproduction (figure 5) showed that the pigmented ink prepared from the alcohol ethoxylate dispersant at 2.5%wt conc. gave the printed reproduction close to a commercially available pigmented inkjet ink for the uncoated paper. On the glossy inkjet paper, the inks prepared from the polymerized naphthalene sulfonate sodium salt at 1%wt conc. showed the printed reproduction close to that of the alcohol ethoxylate dispersant at 2.5%wt conc. It might be that the larger size distribution of the pigment particle (figure 4) could effect to increase the ink density. The prepared pigmented inkjet inks showed the lower printed reproduction from hightlight to midtone (0-60% dot area) for the glossy inkjet paper.

Conclusion

The pigment-dispersant, which gave a good aqueous based inkjet ink, was the high hydrophilic property. The alcohol ethoxylate having HLB 12 so it showed the good printing runability and print reproduction. While, the ethylenediamine eo-po block copolymers, HLB 6 and polypropylene glycol block copolymers, HLB 4.5 could not disperse the pigment particle. The small molecule of sodium lauryl sulphate could disperse pigment particle but could not gave better inkjet printing quality than those of the polymeric dispersants. There were complexity factors which influenced to quality of the inkjet printing. For the pigmented inkjet ink, many properties of the ink such as particle size, size distribution, surface tension, viscosity, rheology, solid content and so on had some complicated relation for further study.

References

[1] Masao Tanaka, Kengo Yaui, and Yoshikazu Seki, IS&T Conference Proceeding Book NIP15, (Orland, 1999), pg. 82.

[2] J. E. Johonson et.al, US Patents 5,837,045 (1998).

[3] H. Noguchi and T.Hosoda, "Fine Particle Dispersion of Pigment for Ink-Jet Ink," Jour. of the Japan Society of colour Material, 69, 855-866 (1996).

Author Biography

Juntira Komasatitaya received her BS in photographic science and printing technology, MS in imaging technology from Chulalongkorn University, Bangkok (1995) and her PhD in material engineering from Gifu University, Gifu, Japan (2006). She has worked as a lecturer in King Mongkut's University of Technology Thonburi, Bangkok, Thailand. Her work has focused on material development for printing and packaging application such as printing inks, printing substrates, printing plate and so on. She is currently a member of Printing Association of Thailand.