Relation Between Image Quality of Inkjet Printing Media and Power Charge of Micro-Porous Nano-Alumina

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Abstract

We made micro-porous nano-alumina sol with water soluble binder polymers, hydrophilic polymers and cation surfactant for an inkjet receiving layer. After coating this sol on the resin coated paper, we have studied about changes in zeta potential energy which might give some effects on the image quality such as physical properties and optical density.

Introduction

To make an ink absorption layer on a high-quality color ink-jet printing media, micro-porous nano-alumina sol is usually made by the mixture of water-soluble Polyvinyl alcohol (PVA), Polyvinylpyroridone, Hydroxy-propylmethylcellulose (HPMC) and its modified polymer or water dispersion latex such as styrene-butadiene copolymer, acryl-butadien -styrene copolymer or hydrophilicity of the functional groups such as polyurethane, polyacrylates, polyacryl-urethane copolymer, polyacrylamide, etc.

It could be said that the ultimate goal in development of color ink receiving media is to enhance ink absorption speed meanwhile maintaining a favorable dye fixing property, excellent color density, high coloring property, high glossiness and conventional photo quality images even through the chemicophysical changes in the situation after printing. In manufacturing ink absorption layer of ink jet printing media, it is general to use inorganic and organic pigments that already have micro porous so as to speed up ink absorption. Also, it is selectable to make a binder with water soluble polymer, water dispersible polymer and water soluble hydrophilicity of the functional groups polymer in absorbing solvent.

Chemicophysical features of microporous nano alumina sol,[1-3] the subject material for ink absorption, depend upon the concentration, viscosity, primary particle, secondary particle, particle shape, pH, zeta potential, pore volume and pore size crystallinity of alumina sol. Also, pore radius[4] and BET model[5] in the ink absorption layer are keys to the quality of color printing image, so it is important to choose a material.

On the other hand, the quality of printing image depends upon the binders and the additives such as water soluble polymer, hydrophilic polymer, hardener, UV absorber, water fastness agent, antioxidant agent and surface agent, etc.

In this study, we put four kinds of cation surfactant into ink receiving emulsion which was made with micro porous nano alumina sol, water soluble polymer and hydrophilic polymer to examine the changes in zeta potential. And we coated the emulsion on the RC paper to compare two different zeta potentials of the dried ink absorption layer and of four cubic-chart-printing-points; yellow, magenta, cyan and black.

We had observable improvement on physical effects in dry time, light stability, water fastness and glossiness.

Experimental

Each porosity alumina sol has a different character depending upon the manufacturing method and it makes different quality in ink received images. In this study, we made ink receiving emulsion with micro porous nano alumina sol (Korea Institute of Ceramic Engineering & Technology) which had physical properties shown in the table 1.

Table 1. Chemicophysical Features of Alumina Sol

Test Item	Analysis Result
Solidity (wt%)	30
pH	3.7
Primary Particle Size (nm): TEM	10x25
Secondary Particle Size (nm): PSA	87
Zeta Potential (mV)	46
Pore Size (nm)	11
Pore Volume (cc/g)	0.9
BET (m^2/g)	359
Viscosity (cp)	33
Particle Shape	Needle Shape
Crystallinity	Boehmite

We also used four kinds of cation surfactant such as bisimidazolium methyl sulfate, dodecyl benzyl dimethyl ammonium chloride, tetradeyl methyl ammonium chloride and alkyl trimethyl ammonium methyl sulfate (Dongnam Chemical, Korea). Test conditions and formulation of the ink receiving emulsion was the same in the previous papers.[5]

Sample Coating

In coating of ink receiving layer, we selected 270g polyethylene paper of OJI(Japan). The coater was a slot die coater with 25inch-width. We dried the sample paper for 15 seconds on 5°C and 20 seconds on 20°C, 60 seconds on 50°C, forty seconds on 80°C, forty seconds on made the thickness 33 ~ 34 µm. We cut the sample paper into the size of 4"x6" and printed it on Epson Stylus Photo 1290 to make a cubic test chart. Colors of Y, M, C, B were printed on the paper and exposed to Light Stability Xenon Arc (420nm) for 10 hours at 63°C. After the exposure, we tested the paper with conditions and equipments as follows;

Zeta Potential Measurement

Measured by ELS-8000(Otsuka Electronics, Co.) Cubic Chart: Put the printed sample on a plate and dropped a monitoring solution (diluted solution with polystyrene latex 504nm HPC and 10mM of NaCl)

Density Measurement

Photospectrometer (X-light Co.)

Gloss Measurement

Micro Gross Ref-160 (Sheen Co.) at the angles of 85° and 60°.

Water Fastness Test

Immersed the paper into deionized water of 20°C for 3 hours and dried. Photospectrometer (X-light Co.) was used to measure the density.

Printing Ink (Inktech Co., Korea)

Yellow (pH = 9.58), Magenta (pH = 9.25), Cyan (pH = 9.45), Light Magenta (pH = 9.09), Light Cyan (pH = 9.50), Black (pH = 8.88)

Results

Both BET model disposition of interplanar of alumina hydrate in the ink receiving layer and pore radius of planar of alumina hydrate, the color balance of printing image, were found key points to get the high quality color printing image. By using hydrophilic dye and hydrophobic dye, functions like protection of dye bleeding and color balance were found much improved.

In the previous papers, we found that blending hydrophilic PVC, HPMC and its modified polymer with porosity alumina could make fast ink absorption and high quality color printing image and that blending hydrophilic polymer with cation surface agent could make the same.

In this study, we put four different kinds of cation surface agents into nano alumina sol ink receiving emulsion and examine what zeta potential of ink receiving recording layer had relation with the quality of color image and how it improved the chemicophysical functions like ink absorbing speed, dry time, light stability, water fastness and glossiness. In the first case, we observed increased zeta potential when we put four different kinds of cation surface agents into ink receiving emulsion.

In particular, we observed rapid increase in the sample C and D as shown in the table 2.

We made four different kinds of emulsion such as above and coated them on the RC paper (275gr/m^2) and dried to get the sample sheets. We printed the sample sheets on the inkjet printer in cubic chart as figure 1 to get the zeta potential of the color (Y, M, C, B) printed image. Measurements were as shown in the table 3.

Table 2. Zeta Potentials After Adding 3 Parts of Cation Surfactant 5% in Ink Receive Emulsion

Sample	pH	Zeta Potential(mV)
Basic	3.5	46
A	3.5	48
B	3.5	50
C	3.6	52
D	3.5	54

A:Bisimidazolium Methyl Surface
B:Dodecyl Benzyl Dimethyl Ammonium Chloride
C:Tetradecyl Methyl Ammonium Chloride
D:Dodecyl Trimethyl Ammonium Methyl Surface

Table 3. Zeta Potentials in Ink Printing Cubic Chart

	Sample / Color Image	Zeta Potential (mV)			
		A	B	C	D
No Printing	Ink Receiving Layer	2	3	5	5.6
Printing Image	Black	22.44	23.31	23.01	22.80
	Cyan	26.08	27.30	26.67	26.43
	Magenta	18.22	19.06	28.23	27.64
	Yellow	26.58	26.19	25.60	26.66

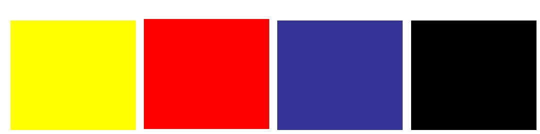

Figure 1. Color Ink Printing Cubic chart

As shown in the table 3, we observed that zeta potentials of ink-absorbed cubic chart image were higher than the ones of the ink receiving layer surface. In sample C and D, we observed that zeta potentials around the color Y, M, C, B were stable meanwhile zeta potential of magenta in sample A and B were lower than the ones of other colors.

Discussion

To measure the faces charged of zeta potentials of color printing cubic chart samples, we observed external apparent migration velocity of particle at several cell position by using Mori Okamoto Model.[6]

$U_{obs}(Z) = AU_0(z/b)2 + \triangle U_0(z/b) + (1\text{-}A)U_0 + U_p$

Z : distance from the core of the cell

$U_{obs}(Z)$: Apparent migration velocity of particle at cell position

A = 1/[(2/3) – (0.420166/K)]

K = a/b : A ratio of a to b (a>b), the length of cell cross section

U_p : True immigration velocity of particle

U_0 : Average velocity of solvent above and below of the cell

$\triangle U_0$: Difference in velocity of solvent above and below of the cell

The key point in this study was to find out what the zeta potential has a relation with the chemicophysical features of color inkjet printing such as ink absorbing speed, light fastness, water fastness and dry time.

We observed zeta potential on the ink receiving layer of which emulsion was made with four different kinds of cation surface agents, after absorbing color ink, was higher than the ones of no ink printing ink receiving layer.

Table 4. Changes in OD and Other Physical Values by UV

Sample			A	B	C	D
Glossiness	85°		88.78	88.79	88.76	90.56
	60°		47.52	47.81	47.86	48.35
Light Stability	Normal	Y	0.8	0.8	0.8	0.82
		M	1.4	1.41	1.42	1.44
		C	1.09	1.09	1.1	1.12
		B	1.58	1.59	1.6	1.61
	After 10 hours	Y	0.76	0.78	0.79	0.8
		M	1.21	1.30	1.39	1.42
		C	1.04	1.04	1.06	1.09
		B	1.59	1.59	1.6	1.62
Water Fastness	Decreased		3%	3%	3%	3%
Drying Time	Sec.		0.3	0.3	0.3	0.3

Upon this result, we guess that ink receiving layer, which has a positive charge of micro porous nano alumina emulsion, absorbed negative charge ink and then in reaction the zeta potential of porosity ink receiving layer became higher.

Also we guess that the color absorption volume of positive charge in the ink receiving layer would change the zeta potential of ink printing image.

In sample A and B, the reason why zeta potentials in magenta color were lower than the ones of sample C and D was that the magenta ink absorption volume of negative charge was small.

We could be assured of this by UV test on Optical Density, as shown in the table 4, which shows that decrease in the density of magenta on sample A, B was bigger than the ones on sample C and D.

Conclusion

In this study, we put four different kinds of cation surface agents into alumina sol ink receiving emulsion and observed that the zeta potential of basic emulsion increased from 46mV to 48mV or higher. Also we had results of zeta potential, which ranged from 2 to 5, on the ink receiving surfaces of each sample of coated RC paper which was coated with the emulsion made for this study. Once ink was absorbed, the zeta potential was stabilized in the range of 22mV-28mV.

Particularly, we observed that optical density of magenta of sample A was decreased from 1.4 to 1.21 after UV test and also that optical density of magenta of sample B was decreased from 1.41 to 1.30. We think this was because zeta potentials of those two samples (A and B) was lower than the ones of other samples (C and D), so this makes the samples (A and B) absorb inks less than other two samples (C and D) and this fact brought decreases in optical density.

This result can be different depending upon the kinds of ink but in this study, we observed that due to the zeta potential, chemicophysical features like image quality, glossiness, light stability, water fastness, dry time can be improved.

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Biographies

Tai-Sung Kang obtained Ph. D at ChungAng University, Korea in 1984. He had studied on AgX for more than 30years at the Korea Research Institute Chemical Technol-

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Seung-Ho Lee received Ph. D at Pusan University, Korea in 1989. He had studied on characterization and evaluation of powder for 15 years at the Korea agency for Technology and Standard. Since 1997, he has been team leader of composite material Lab at Korea Institute of Ceramic Engineering and Technology and directing studies and projects on preparation of uniform micro- and nano-particles and specially simple and composite sol for application of coating media.