Silica Filler for Ink Jet paper

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Abstract

Fillers with high initial ink-absorbing speed and high glossiness have been required for photo quality ink jet papers. We have studied three types of silica with almost the same pore diameter of around 12nm.

The coated layer made of sub-micron silica is found to be high homogeneous in structure in addition to high ink-absorbing capacity, suggesting that sub-micron silica is a excellent filler for high performance ink jet paper, compared with conventional silica.

1. Introduction

As digital camera comes into wide use, photo quality ink jet paper attracts public attention. They are required to print out pictures in higher degree of quality, which demands that its coated layer is of a homogeneous structure with high degree of ink-absorbing capacity.

Surface of ink jet paper is generally coated with ink-absorbing material, main ingredient of which is inorganic fine particles such as silica and alumina.

In order to improve the printing properties of ink jet papers, it is important to use fillers, which have high initial ink-absorbing speed, and high ink-absorbing capacity. Precipitated silica with controlled particle size and pore size has been used as fillers for ink jet papers. [1),2)]

Ink jet papers with conventional precipitated silica layer show high ink-absorbing capacity. However, they are insufficient in glossiness for photo quality ink jet paper, because their surfaces are coarse due to the existence of several micrometer particles.

Therefore, we have evaluated novel silica as filler for ink jet papers having high glossiness and fine printing quality in addition to high ink-absorbing capacity.

2. Experimental

2-1. Physical Properties of Silica

In this study, colloidal silica A, precipitated silica (Finesil X-37, Tokuyama Corp.) and sub-micron silica were used as the filler. They are different in particle size but are almost the same in pore diameter around 12nm, which is suitable region for absorption of dye. Colloidal silica A and Finesil X-37 is commercially available and sub-micron silica is prepared by precipitating method. Properties of these fillers are shown in Table1.

Table 1. Typical Physical Properties of Silica

	colloidal silica A	Finesil X-37	sub-micron silica
Specific surface area ($m^2 g^{-1}$)	70	270	260
Average particle size [1)] (μm)	0.07	5.8	0.21
Pore diameter[2)] (nm)	13	12	12

1) Measured by BeckmanCoulter. Inc LS-230
2) Measured by Quantachrome Corporation PoreMaste-60

From the specific surface area the ultimate particle diameter of colloidal silica A is estimated about 0.05 micrometers, which is almost equivalent to the average particle diameter shown in the Table1, suggesting that colloidal silica A is not agglomerated.

On the other hand, ultimate particle diameter of Finesil X-37 and sub-micron silica is not equivalent to the average particle diameter in the table, implying that the average particle diameter of Finesil X-37 and sub-micron silica denotes agglomerated particle size.

2-2. Preparation of Silica Coated Film

Silica layers were coated on transparent PET film using three types of silica by the method shown in Figure 1.

2-3. Evaluation of Silica Coated Film

(1) Thickness and Morphology

The film was cut and its cross-section was observed by FE-SEM (JEOL, JSM-840F).

(2) Specular gloss

45°, 60°, 75°, and 85° specular gloss of the film was measured by the gloss meter (SUGA TEST INSTRUMENTS, UGV-5D), and the gloss index, normalized specular gloss, was calculated as follows;.

$$Gloss\ \ index(\%) = \frac{(Gloss\,of\ silica\,coated\ film)}{(Gloss\,of\ bare\,PET\ film)} \times 100$$

(3) Ink-Absorbing Capacity

Commercially available magenta ink (EPSON Co., PMIC-1C) was dropped on the film and dried. Then ink-absorbed area was measured and ink-absorbing index was calculated as follows;

$$Ink - absorbing\ index = \frac{\left(\begin{array}{c}\text{Ink - absorbed area on the surface}\\ \text{with Finesil X - 37}\end{array}\right)}{\left(\begin{array}{c}\text{Ink - absorbed area on the surface}\\ \text{with each type of silica}\end{array}\right)}$$

(4) Optical Density

Optical density of printed image, which was printed by ink jet printer (EPSON Co., PM700C) with cyan, magenta, yellow and black, was measured for each color by the reflective densitometer (GretagMacbeth, RD918).

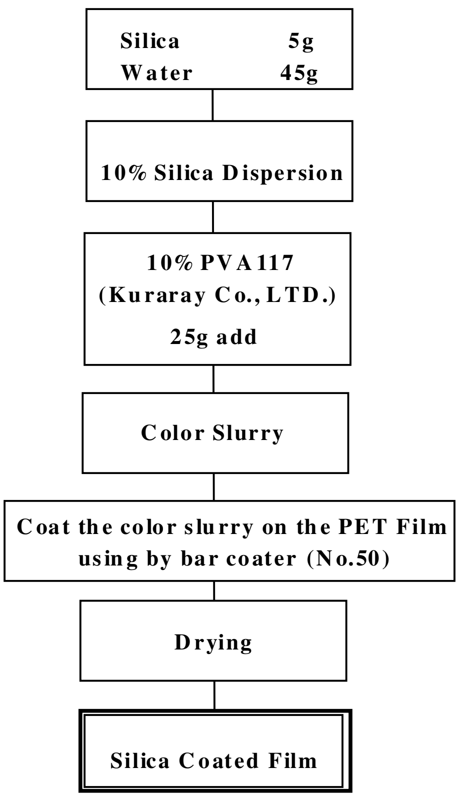

Figure 1. Flow chart for preparing film with silica.

3. Results

3-1. Thickness and Morphology of Coated Layer

The cross-sectional photograph of silica coated film is shown in Figure 2. As can be seen from Figure, thickness of coated layer using colloidal silica A, sub-micron silica, and Finesil X-37 was increased in that order. The volume of ink-absorptive cavity and pore is increased as the layer thickness is increased, because the quantity of silica and PVA are controlled to be the same in this study. In fact, many large cavities were observed in coated layer using Finesil X-37, whereas dense packed structure was observed in coated layer with colloidal silica A.

In case of the coated layer using sub-micron silica, no cavity was observed in spite of large layer thickness. This observation suggests that the coated layer with sub-micron silica has many fine pores with high homogeneous structure. Nevertheless, the surface of the film using sub-micron silica was smooth compared with the film when Finesil X-37 was used, and was almost equivalent to the film with colloidal silica A.

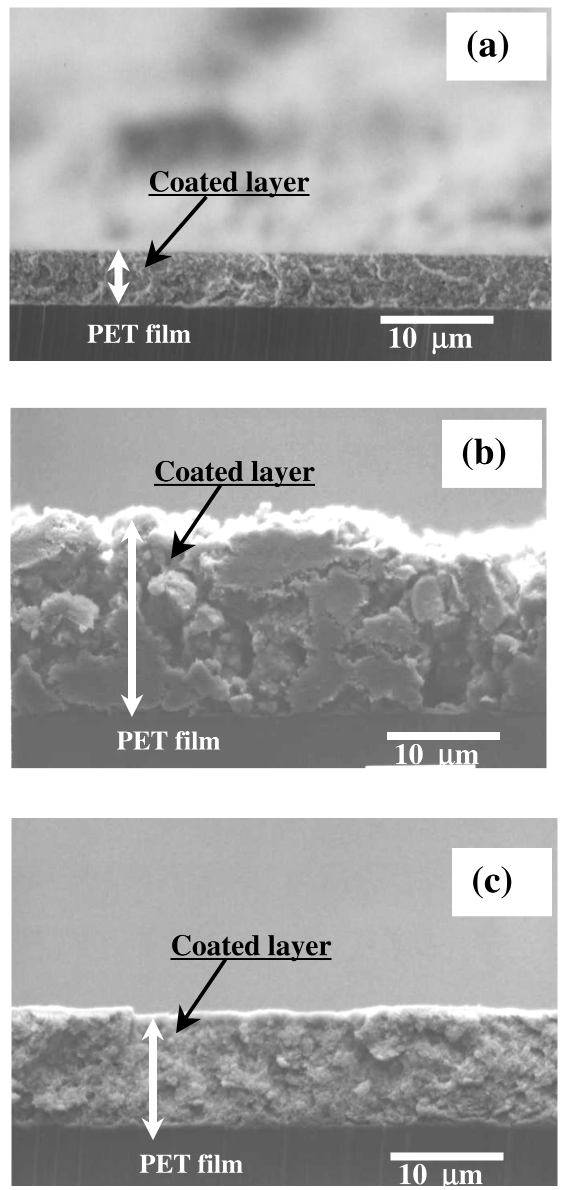

Figure 2. SEM images of cross-section of coated layer using, (a) colloidal silica A, (b) Finesil X-37, (c) sub-micron silica.

3-2. Specular Gloss

Gloss indexes of the film with three types of silica are shown in Figure 3. Although the film with sub-micron silica showed lower gloss index than the film containing colloidal silica A, it showed higher gloss index compared with the film with Finesil X-37.

Generally, as incidence angle is low, slight unevenness of the surface causes a decrease in glossiness. The film using colloidal silica A shows high gloss index even at low incidence angle, suggesting that the coated layer has flat surface.

On the other hand, the film using sub-micron silica has small gloss index at low incidence angle. However, the gloss index improved as the incidence angle became higher, and reached to sufficient value at incidence angle of 75°, which is generally used for the evaluation of glossy coated paper property.

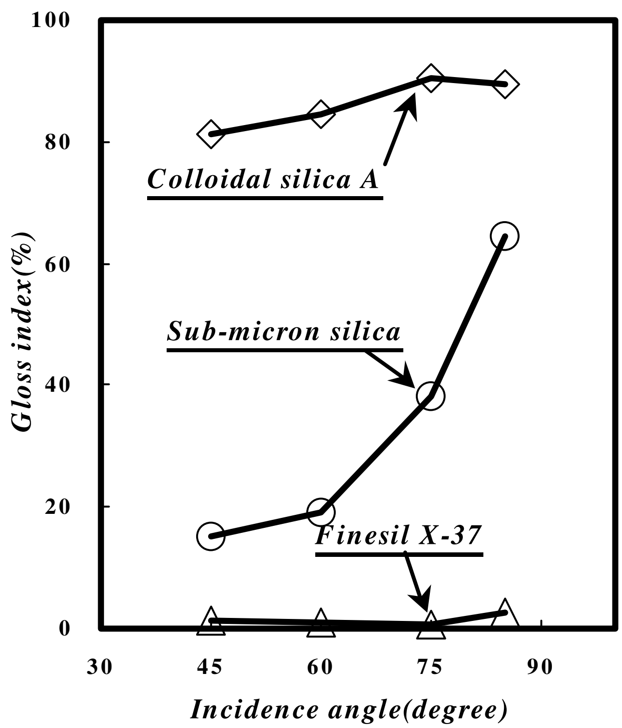

Figure 3. Gloss index of films consisting of colloidal silica A, Finesil X-37 and sub-micron silica.

3-3. Ink-Absorbing Capacity

As shown in Table 2, the film with sub-micron silica had smaller ink-absorbing index than that with Finesil X-37 due to the lower cavity volume in the coated layer. However, it has several times higher ink-absorbing ability compared with the film using colloidal silica A.

3-4. Optical Density

Results are shown in Table 2. The film using sub-micron silica showed higher optical density in each color than other films.

Table 2. Typical Properties of Film Consisting of Different Silica

		colloidal silica A	Finesil X-37	sub-micron silica
Thickness of the coated layer (μm)		5	16	11
Ink-absorbing index		0.15	1.00	0.54
Optical density[1)]	C	0.6	0.7	0.8
	M	0.5	1.1	1.2
	Y	1.1	1.2	1.6
	Bk	1.3	1.7	2.0

1) Measured by GretagMacbeth Reflection Densitometer RD-918

4. Conclusion

We investigated three types of silica for high-performance ink jet paper, which have high ink-absorbing capacity, high glossiness and fine printing quality.

The film using colloidal silica A showed a poor ink-absorbing ability with high gloss index, implying that it is not adequate filler for ink jet paper.

Although the film using Finesil X-37 has excellent ink adsorption nature due to large cavities in coated layer, its glossiness was low. In addition, optical density was a smaller compared with the film using sub-micron silica, since light scattering occurred owing to inhomogeneous structure of the film. Consequently, Finesil X-37 is not suitable filler for photo quality ink jet papers, which require high glossiness.

On the other hand, the film using sub-micron silica, the coated layer has smooth surface and large pore volume without large cavity. Thus, the film with sub-micron silica has high glossiness and fine printing quality as well as adequate ink-absorbing capacity.

These facts imply that sub-micron silica which is precipitated silica having controlled particle size in submicron order and controlled pore size, is useful filler for photo quality ink jet paper.

References

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Biography

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