

Ink Absorption Mechanism of Silica Based Ink Jet Paper Coating

Noriaki Mizutani and Masahiro Kondo
Tokuyama Corporation, Tokuyama, Japan

Abstract

As digital cameras have become a popular consumer product, higher standards for ink jet paper is required in order to produce better picture quality. The surface of ink jet paper is generally coated with ink-absorbing material that mainly consists of inorganic particles such as silica, alumina or hydrophilic swelling resin. The required function of the coat layer is to quickly absorb only the solvent of the ink which is distributed from the printer and to keep the dye on the surface, which is the key to determine the quality of printed pictures. In this presentation, we report the results of our analysis of the ink-absorption mechanism of the coat layer materials containing various types of silica using a mercury porosimeter. We found that the precipitated silica "Finesil X Series" keeps more dye on the surface than other types of silica because it has more pores with diameter around 100 Å, which is the suitable size for adsorbing dye. As the result, ink jet paper coated with "Finesil X Series" generates high optical densities.

Introduction

Following two points are most important to improve the printing property of ink jet paper :

1. Initial ink-absorbing speed, which is the initial traveling speed of the ink through silica particles.
2. Ink adsorbing capacity of pores.

According to the Lucas-Washburn theory, Point 1 depends on the particle size distribution and agglomeration of silica. Point 2 relates to the capacity of pores and pore size distribution of silica. When these functions are insufficient, the ink will spread and infiltrate the layer, causing a poor-printing result.

We analyzed the ink absorbing mechanism of silica-coated ink jet paper in terms of pore size distribution on silica particles. We prepared coated papers with different types of silica and conducted the experiment by printing on these papers and a commercially available ink jet paper. Then we estimated the size of pores that absorb the ink by measuring the pore size distributions before and after printing.

Experimental

In this experiment we used two types of commercially available ink jet paper (Epson Super Fine, and PM Glossy) and our prototype papers coated with different types of silica.

Preparation of Prototype Silica Coated Paper

Three types of silica with different surface area and pore size distribution were used. Particle properties and pore size distribution are shown in Table 1 and Fig.1-3.

Table 1. Typical Physical Properties of Silica

		Finesil X-37B	Tokusil USA	Gel Silica A
Specific surface area	m^2/g	285	190	430
Average particle size	µm	3.7	10	4
Pore radius peak	Å	80	300	Nothing (<37.5)
pH (5%-slurry)	—	6.6	6.0	6.2
Moisture	%	5.7	5.9	6.1

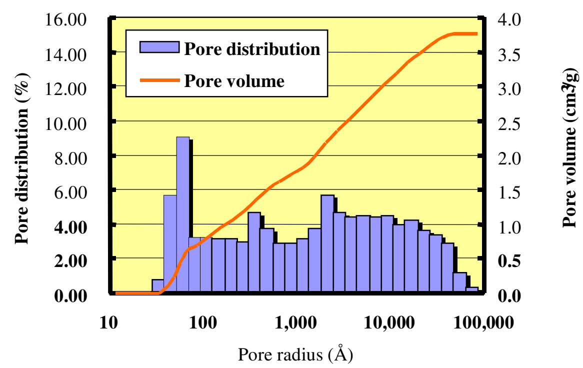

Figure 1. Pore size distribution of Finesil X-37B

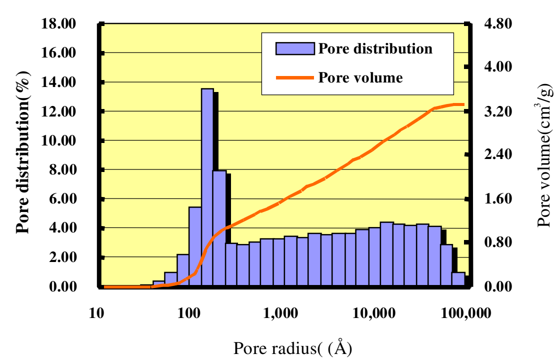

Figure 2. Pore size distribution of Tokusil USA

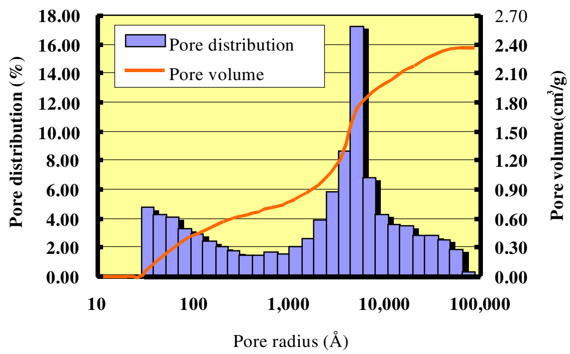

Figure 3. Pore size distribution of Gel Silica

Both Finesil X-37B and Tokusil USA are precipitated silica. Although the pore size distributions are different, both types of silica have large pore capacity. The pore capacity of Gel silica A is smaller than the other two. We prepared ink-jet paper coated with these three types of silica with the method described in Fig. 4.

Printing and Pore Size Distribution Measurement

Epson PM-700C was used, and solid black rectangle was printed. Mercury Porosimeter 2000 from Carlo Elba was used to measure pore size distributions.

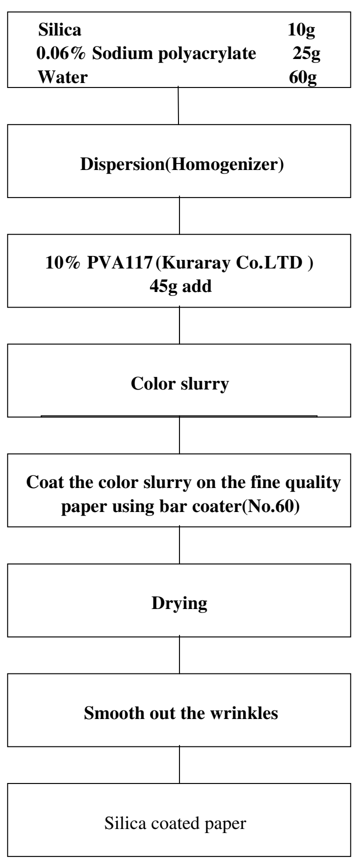

Figure 4. Preparation of test coated paper

Results

Ink Adsorption Result in Commercially Available Ink Jet Paper

In Fig. 5 shows the pore size distributions of Epson Superfine Ink-jet Paper before and after the printing. The vertical axis is pore volume, and the horizontal axis is radius of pores. The peak around 100 Å is due to silica, and the one around 40000 Å is due to the paper. The decrease of pores with radius around 100 Å indicates that ink was adsorbed mainly by these pores. We had the same result with Epson PM Glossy.

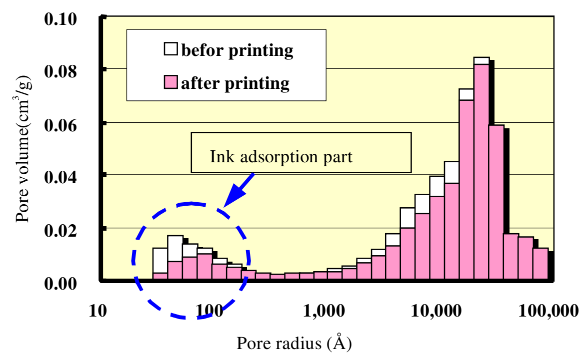

Figure 5. Pore size distribution of EPSON Super Fine paper before and after printing

Pore Size Distribution and Printing Result on Prototype Papers

For more detailed analysis of ink adsorbing mechanism, we studied the relation between pore size distribution and printing quality on prototype papers with different silica.

Figures 6, 7 and 8 show the pore size distributions of Finesil X-37B, Tokusil USA and Gel silica A before and after printing. The result indicates that the ink was adsorbed by micro pores of silica in all three cases. Table 2 shows the relation between the pore size peak point, the capacity of pores with radius around 100 Å (smaller than 200 Å) and the print density.

Table 2 Relationship Between Pore Volume and Optical Density of Various Silica Coated Paper

Silica	Pore radius peak (Å)	Pore volume under 200 Å (cm^3/g)	Optical density*) (Black ink)
Finesil X-37B	80	0.075	1.94
Tokusil USA	300	0.017	1.43
Gel Silica A	Nothing(<37.5)	0.035	1.75

*) : mesured by Macbeth Reflection Densitometer RD-918(Kollmorgen Instruments Corp.)

We conclude that there is an interrelationship between the capacity of pores with radius smaller than 200 Å and the print density. Finesil X-37B, having more pores with radius within this range, is more suitable than other types of silica for ink-jet paper.

Ink Absorption Mechanism

The following is our assumption why the pores with radius around 100 Å perform best in absorbing ink. The size of molecules of dye in ink used for ink-jet printers are approximately 10 Å in radius. These molecules generally form micelles. When the size of the micelle is similar to the size of the pore, the solvent and the dye are separated in the pore and the dye will be adsorbed around the surface. We estimate the size of the micelle to be around 100 Å and this is the mechanism how Finesil X-37B keep dye molecules near the surface.

Tokusil USA has more pores with larger size than around 100 Å. Therefore, both dye and the solvent enter deeper inside the pores rather than separated near the entrance, this results in lower density of printing.

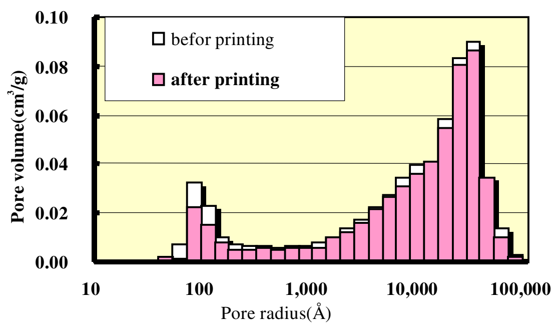

Figure 6. Pore size distribution of Finesil X-37B coated paper before and after printing

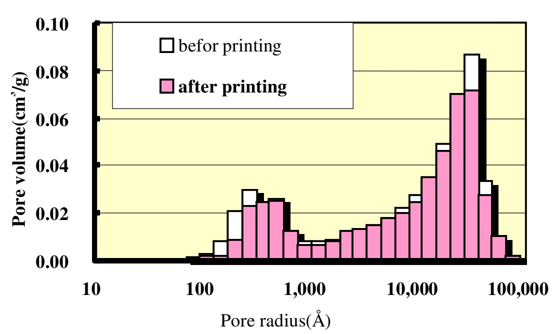

Figure 7. Pore size distribution of Tokusil USA coated paper before and after printing

Although Fig.8 does not show any peak position of the pore size of gel silica, it is because the measuring device we used does not detect the pores smaller than 37.5 Å in radius. Most pores of this silica are too small for dye molecules to enter. Also, the capacity of pores with radius around 100 Å are not big enough to support the dye near the surface. As the result, dye molecules do not stay near the surface but infiltrate the paper instead, and the printing quality will be poor.

Figure 9 shows the imaging ink absorption mechanism of silica based inkjet paper coating.

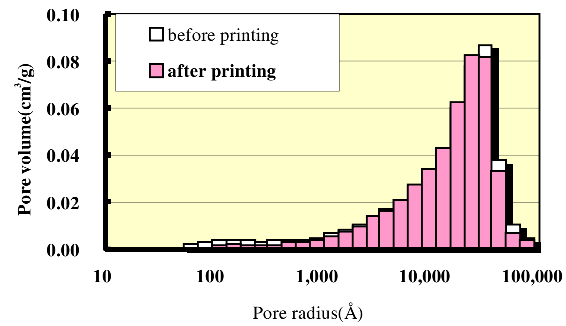

Figure 8. Pore size distribution of Gel Silica A coated paper before and after printing

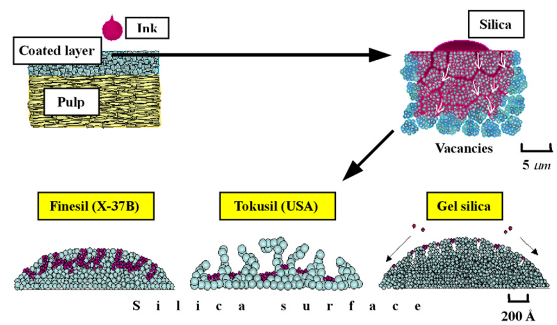

Figure 9. Ink absorption mechanism

Conclusion

(1) Dye in ink for ink-jet printer is adsorbed by silica's micro pores with radius around 100 Å.
(2) Finesil X-37B, which has the pore size distribution peak of around 100 Å, can separate dye molecules from the solution and keep the dye near the surface. The reason why ink is adsorbed by the pores of this size is due to the size of dye micelles.

References

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Biography

Noriaki Mizutani received his BD in chemistry from the University of Hiroshima in 1971. He joined Tokuyama Corporation in the same year, and he has been working in the development of precipitated silica. e-mail address n-mizutani@tokuyama.co.jp

Masahiro Kondo received his ME in Department of Materials Science from Kyushu Institute of Technology in 1990. He joined Tokuyama Corporation in the same year, and he has been working in the development of precipitated silica. e-mail address m-kondo@tokuyama. co.jp