Paper Compatibility with Pigment Ink Controlled in Penetration and Viscosity

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Abstract

Recently, the demand of Inkjet printers is remarkably increasing for office use. High-speed printing on plain papers, however, have been producing unsatisfactory image quality in terms of feathering, optical density, print through and so forth.
On the other hand, double-sided printing by inkjet printers require long drying time so that the practical use has been limited.
As an efficient inkjet printer for practical office use, the performance of high-speed printing and double-sided printing quality have to be improved.

Then, we made quick-drying and restrained feathering ink by changing pigment content and solvent composition.
We compared and examined print characteristics among samples with different surface tension and viscosity.
As a result, we developed ink with high plain paper compatibility for inkjet printers.

Introduction

New inkjet technologies have been developed in order to improve printers for business use, which consist of, 1) Pigment ink with high viscosity and penetration improving image quality on plain papers, 2) Print-head of 1.27 inch width for high-speed printing in high quality, and 3) Belt transportation system utilizing electrostatic attractive force for stable paper feed in high speed with a high degree of accuracy.
The water-based pigment ink characteristics for inkjet printers suitable for business-office use were examined. We developed high viscosity ink which was able to make colorant keep on paper surface despite its high penetration by using two penetrants with different osmosis. Therefore, as more images on papers require less ink, the image quality on plain papers has been improved at high-speed printing as well as at double-sided printing.
In this paper, we especially introduce characteristics of the new pigment ink.

Experimental

Samples

Ink: Samples were prepared with Pigment content 5-10%, humectant 20-40%, penetrant 0-3% and residual pure water . Table 1 shows ink composition.

Paper:

1.RICOH PPC Paper Type6200 (plain paper)
2.RICOH My Recycle Paper 100 (recycled paper)

Table 1. Sample Formulation and Viscosity

	No.1	No.3A	No.3B	No.3C	No.4	No.5
Colorant	5%	5%	5%	5%	10%	10%
Humectant	20%	20%	20%	20%	30%	20%
Penetrant A	–	2%	2%	–	2%	2%
Penetrant B	0.3%	–	1%	2%	1%	1%
Viscosity (mPa・s)	2.85	3.08	3.31	3.24	8.04	5.01

Evaluation of ink properties

The dynamic surface tension was measured by the maximum bubble pressure method. (BP-2, KRÜSS GmbH, Germany)
The initial viscosity and the evaporated viscosity were measured with E type viscometer. (RC-500, TOKI SANGYO CO., LTD., Japan) Samples of ink with various moisture evaporation were made under 50ºC, 20%RH condition, and measured evaporated.

Evaluation of penetration

The penetration of samples to paper were measured by the dynamic contact angle meter and the dynamic scanning absorptometer.[1] (Dynamic Scanning Absorpto meter, KYOWA SEIKO CO., LTD., Japan)
Change of dynamic contact angle of 5 μ l ink within two seconds just after dropping on a paper were measured by OCAH200. (OCAH200, DataPhysics Instruments GmbH, Germany)

Evaluation of Print Quality

The optical density and the print through were measured by X-Rite938 (Status-T) printed in speed priority print mode by RICOH Aficio GelSprinter.

Cross sectional view of image

Cross section of the printed paper were observed by an optical microscope to confirm state of penetration at solid image and color boundary areas.

Results and Discussion

Ink properties

According to the results of Table 1 and Figure 1, followings are discussed.

As shown in Table 1, viscosity of samples of No.1 through No.3 are about 3mPa·s with popular pigment formulation.

Samples of No.4 and No.5 which contain large amount of pigment and humectant indicate very high viscosity.

Figure 1 shows dynamic surface tension of the samples.

The difference of penetrants formulation makes different types of dynamic behavior.

Described data according to sample No.1 tells that penetrant B is effective to decreasing γ around 1000msec region which correspond to the static surface tension and but not to that of 10 to 100msec region.

The data of No.3A tells that penetrant A is effective to decrease γ around 10 msec region. Combination of two penetrants A and B realizes high penetration ink which controls γ in small value in 10 to 100msec region.

(see No.3B, No.4 and No.5 in Table 1)

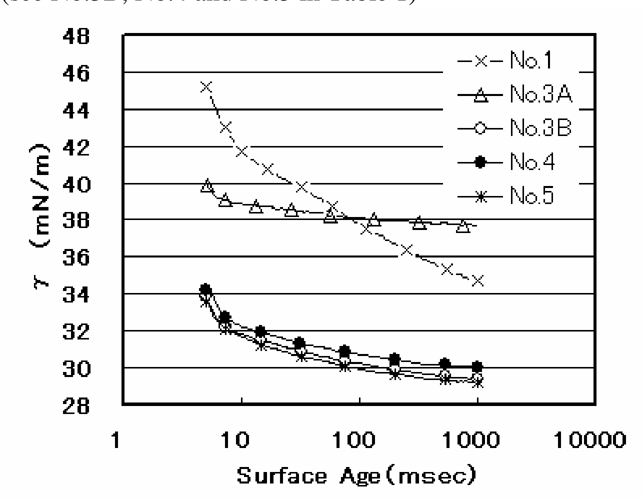

Figure 1 . *Dynamic surface tension of ink samples*

Penetration

Samples with different dynamic surface tension were tested in wettability and the penetration on the paper.

Figure 2 shows the change of dynamic contact angle of each sample ink on the plain paper. You can see that No.3B, No.4, and No.5 samples which are combined two penetrants A and B have tendency to decrease the contact angle rapidly within 100msec and spread after the droplet reached a paper to wet swiftly.

Also, the dynamic scanning absorptometer characteristics are shown in Figure 3. From the view point of penetrant formulation and absorption coefficient, sample No.1 with small amount of penetrant B has a small absorption coefficient, while No.3C with larger amount of penetrant B has a larger absorption coefficient.

Penetrant B in combination with penetrant A indicates larger absorption coefficient than penetrant B independently.

Concerning ink viscosity, samples of No.3B, No.4 and No.5 indicate that ink of lower viscosity has higher penetration.

Figure 4 shows the enlarged Figure 3 within 10msec$^{1/2}$ of contact time where the synergic effect of two penetrants is able to be analyzed easily. No.3A and No.3C intersected near 7msec$^{1/2}$, penetrant A contributes to the wettability increase just after the contact of paper and ink.

Sample No.4 with high viscosity shows the decreasing absorption depending on its viscosity in the long contact time region, but has better absorption character near 7msec$^{1/2}$ region.

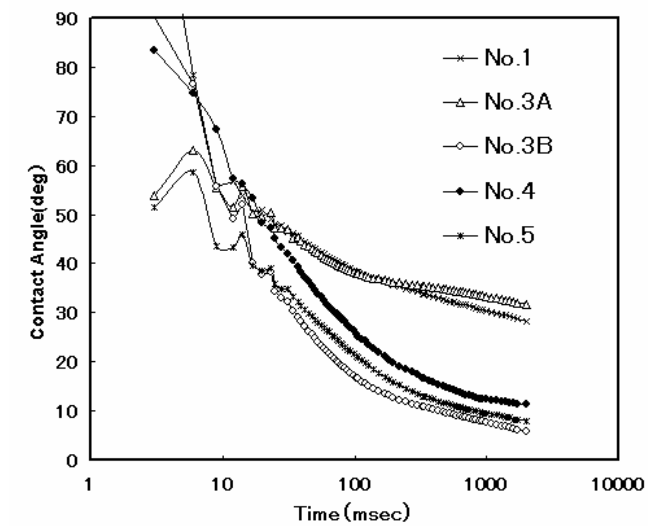

Figure 2. *Dynamic contact angle of the ink samples on the Type 6200 Paper*

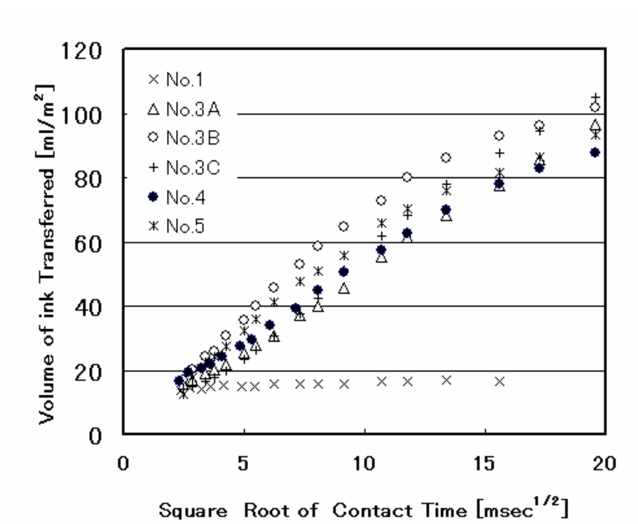

Figure 3. *Absorption of ink on the Type 6200 Paper*

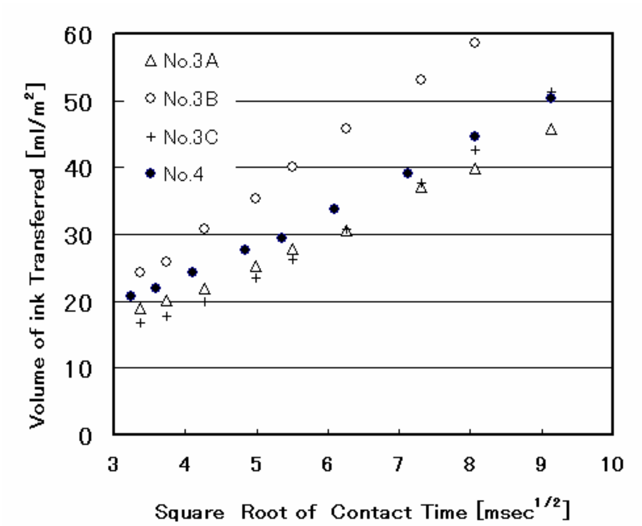

Figure 4. Absorption of ink on the Type 6200 Paper (The enlargement of Figure 3 below 10msec)

Evaluation of Print Quality

Two ink samples were chosen to evaluate print quality; one is No.3B which has high absorption coefficient. And another is No.4 which has high viscosity with more pigment and humectant added to No.3B.

The image density and the print-through were measured at the printing test for these two samples, and their results were shown in Table 2.

The print quality of the printer was set as the plain paper standard (speed priority) mode.

No.3B requires little waiting time to dry because of its high penetrance though, it is insufficient for the double-sided printing since the printed image indicates low image density and high print-through density.

Conclusively printed sample of No.4 with high image density and low print-through is applicable for the double-sided printing.

Table 2. Image density and Print-Through

	Ink No.3B		Ink No.4	
Paper	OD	Print Through	OD	Print Through
Plain Paper	1.17	0.18	1.28	0.15
Recycled Paper	1.08	0.15	1.15	0.09

Plain Paper: RICOH Plain Paper Type 6200
Recycled Paper: RICOH My Recycle paper 100
Optical Density was measured by X-Rite938(Status-T)

Also, sample No.4 indicates little feathering on My Recycle Paper 100 (MRP100) with less absorption of ink as shown in Figure 5 which are microscopic views of a black character on the printed yellow solid image ground respectively. Very small black ink is bleeding to yellow ground.

Also as in Figure 6, printing image with the high quality mode on plain paper is almost compatible to that of laser printer.

Ink No.3B **Ink No.4**

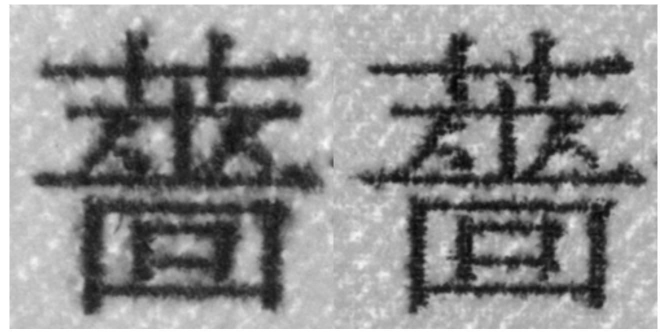

Figure 5. Microscope View of Character printed with standard mode (speed priority) on the recycle paper. (My Recycle Paper 100)

GelSprinter Ink No.4 **Laser Printer**

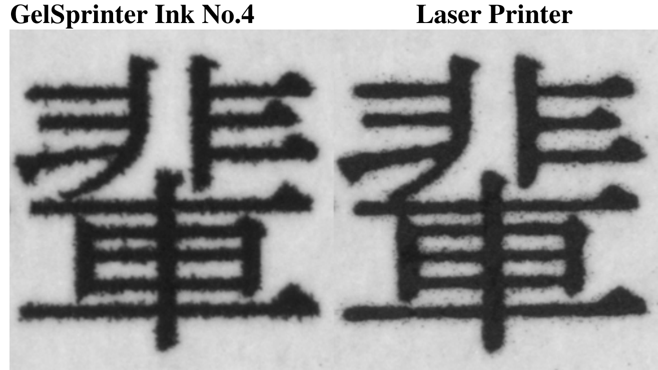

Figure 6. Plain paper Image of GelSprinter (High Quality mode) and Laser printer(MF7070)

Cross sectional view of image

Cyan, Magenta and Yellow inks based on No.4 prescription sample were made for observations of the penetration at secondary color parts and color boundaries printed on plain paper Type 6200 with the standard mode (speed priority).

The cross sectional views of Cyan and RED/GREEN solid image boundaries are shown in Figure 7 and Figure 8.

In the solid cyan image, the pigment kept near the paper surface and did not penetrate to back side of paper as in Figure 7.

Hence, no print-through, no color bleeding and pigment surface stay make high quality printing with less ink possible.

In spite of a large amount of ink consumption in the RED/GREEN solid printed part, no paper-through and no color mutual dispersion at the boundary is observed like shown in Figure 8.

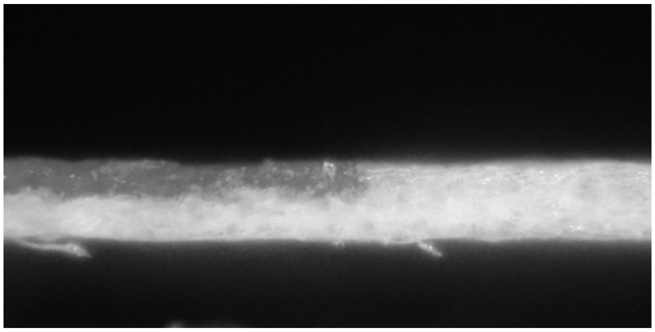

Figure 7. Cross section of the CYAN solid image

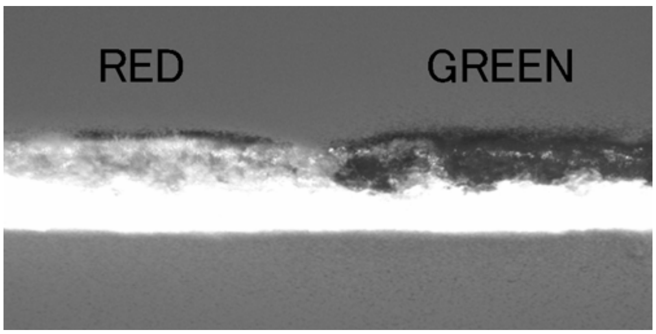

Figure 8. Cross section of the Inter-color Bleeding

Change of the viscosity in drying progress

The high quality image at high-speed printing needs not only penetration control but also high viscosity. The evaporation loss after the drop on paper was highlighted and measured the change of viscosity in drying progress.

Figure 9 shows the change of the viscosity in drying progress. The samples are made as follows. The high viscosity inks (8mPa・s) based on No.4 prescription were prepared by the adjustment of humectant. While the low viscosity inks (3mPa・s) were prepared by change of pigment content for every colors.

The black, yellow, magenta, cyan inks were shown respectively from the left. The similar initial viscosity inks do not differ largely among their viscosity characters.

The low viscosity ink of 5% pigment content changed slightly in viscosity by evaporation loss, this ink kept liquidity. While, high viscosity ink of 10% pigment content rapidly increased the viscosity by evaporation loss of over 30%. This ink acted like gel in a broad sense.

It may be considered as follows.

Just after the ink drop was happened this drastic viscosity rising, the ink of liquidity was restrained in penetration process, then, feathering and print through were decreased.

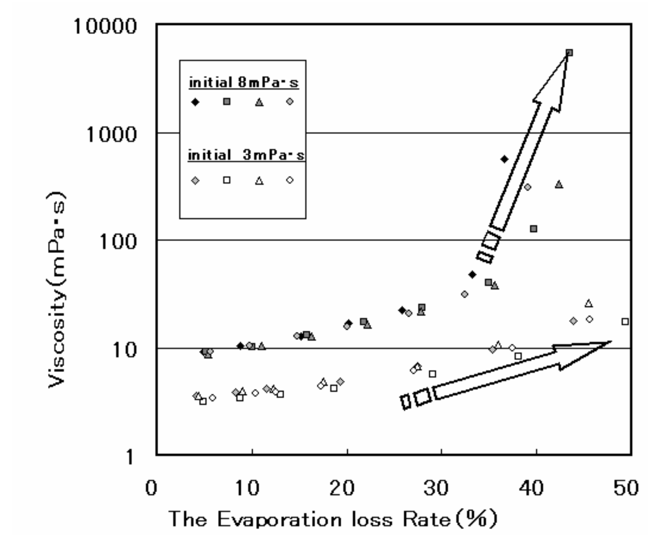

Figure 9. Change of Viscosity in Drying Progress

Conclusion

Using high viscosity and high penetration pigment ink which enhanced the wettability, increased pigment content caused drastic viscosity rising in order to certain evaporation loss. Then, feathering and the print through were restrained by characteristics.

Therefore, as more images on paper requires less ink, image quality on plain paper has been improved at high-speed printing as well as at double-sided printing.

Furthermore, new GelSprinter's ink is a great improvement of enhanced of uniform wettability and changed the characteristic of viscosity during the penetration progress for certain evaporation loss.

This improvement of characteristic is provided extended color gamut over former ink at high-speed printing.

Finally, we develop the pigment ink for practical office-use inkjet printers such as new GelSprinter wide-head which is capable of high viscosity ink control.

References

1) Toshiharu Enomae, "Automatic Scanning Absorptometer to determine liquid absorption rate of paper for printing presses and inkjet" IGAS2003, New Technology, No.9 (2003)

Author Biography

Michihiko Namba received his B.S.(1992) and M.S.(1994) in chemistry, both from Gakushuin University. He joined Ricoh Company Ltd. in 1994. Since then he has been engaged in research and development. From 2001, he has focused on the development of inkjet materials.