The Price of Cost Savings in Matte Ink-jet Coatings

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Abstract

High Pore Volume, controlled texture synthetic silica gels have been the product of choice for formulators of high quality matte ink-jet coatings since their onset (1). They have been typically used at 70% w/w concentrations in high quality matte coatings, representing the most influential raw material on the total formula cost. As volumes of coated matte ink-jet paper grow world wide and expectations for high quality ink-jet printing increase, price pressure mounts urging formulators to propose alternative, cost effective coatings. As a result, alternative lower cost pigments are normally investigated such as low pore volume silica gel, precipitated silica and precipitated calcium carbonate. In this paper, the impact of replacing high pore volume silica gels with alternative pigments is investigated. The degradation of dry-time, color and print quality is not the only consequence of replacing high pore volume silica gel with cheaper counterparts. Final material costs are higher due to increased coat weights required to achieve a minimum print quality. These are hidden costs that are often overlooked.

Introduction

Digital printing applications in home, office and graphic arts are still growing worldwide. The expansion of this market is unavoidably associated with a demand for commoditization. In the case of ink-jet, excellent color and print quality is achieved by combining printing technology and media engineering. Therefore, formulators are trying to achieve high quality prints using cheaper coating raw materials.

For many years high pore volume silica gels have represented the benchmark pigment for high quality coated matte ink-jet media. This paper explores the consequence of reformulating matte ink-jet coatings by replacing these materials with less expensive pigments.

Experimental

Specific formulation, sheet preparation and printing details for each section are reported in Table I. PVOH Mowiol 28-99 from Kuraray was used in all formulations. Each sheet was printed by an ink-jet printer with a test print from which optical density, gamut and print quality were evaluated. Optical density was calculated from the sum of measured CMYB optical densities. Gamut was calculated from the sum of the absolute value of CIE a* and b* parameters for CMYBRG colors. Print quality was evaluated by scoring, visually or using Image Analysis, several print features (bleed, mottle, feathering etc..). Numbers from 1=good to 5=bad were assigned and these were summed for each printed sheet.

Results and Discussion

Replacing High Pore Volume Silicas (HPVSG) with Low Pore Volume Silicas (LPVSG)

The perceived advantage of using LPVSG to replace HPVSG in ink-jet coatings is the ability to achieve higher solids using a material that is also typically lower in cost. We conducted a study comparing cost and print performances of LPVSG and HPVSG. Table 1 (Section 1) shows the formulations and application parameters used in this investigation.

Table 1: Formulation and Applications Details

	Section 1	Section 2	Section 3
SiO_2:PVOH ratio	100:40,30,20	100:40	100:60,40,20
Solids %	16% and 20%	15% and 20%	15%
Pigment types	Silica gels 1.8 and 1.1 ml/g	Silica gel, 1.8 ml/g, and precipitated silica	Silica gel,1.8 ml/g, and precipitated $CaCO_3$
Coat weight	10 to 25 gsm	10 to 40 gsm	10 gsm
Printers	Epson700, Canon BJC-3000	Epson 700, Canon BJC-3000	HP BIJ 1200, Epson R300

Print quality measurements reveal a great difference in the performance of the two gel silicas. HPVSG formulas scored consistently better than LPVSG formulas at the same coat weight. The only way to improve print quality of LPVSG coatings was to apply them at higher coat weights. From our results, we have concluded that an increase of 60% (15 gsm to 25 gsm) is needed to achieve equivalent print quality between LPVSG and HPVSG formulas. As an example, one of the print features (resolution) is shown in Fig. 1.

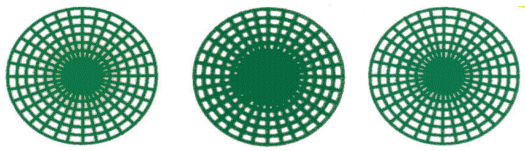

Figure 1. The effect of pore volume on print resolution

Increasing coat weight increases the cumulative pore volume allowing for greater absorption of ink thus achieving an improvement in print quality on LPVSG coated sheets. However, LPVSG is unable to reach the same level of pore volume obtained in half the coat weight of an HPVSG coated sheet as is demonstrated in Figure 2.

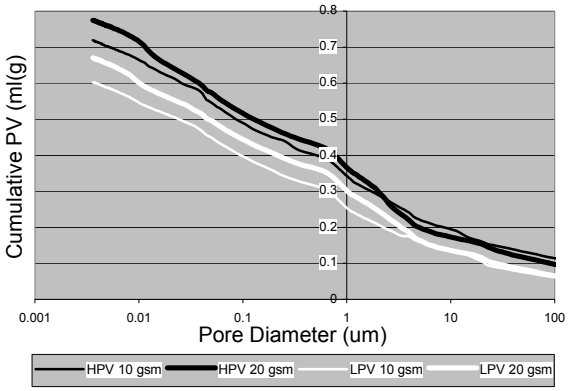

Figure 2. Mercury porosimetry of matte coated ink- jet paper at 10 and 20 gsm coat weights

Our study also revealed that the gain in solids when switching from HPVSG to LPVSG at the same viscosity is only about 3%. Therefore, the savings in drying energy achieved by increasing the solids are insignificant compared to the cost associated with drying heavier coat weights (up to 60%). Also, the lower price of LPVSG will unlikely be able to compensate for the increased cost in total coating materials from the heavier coat weights.

Replacing Silica Gel (HPVSG) with Precipitated Silica (PS)

An HPVSG and a PS were compared in a matte ink-jet coating. Table 1 (Section 2) shows the details of the formulation used. The coatings were applied on both paper and non-absorptive substrate (Syntheape). It was found that in order to match optical densities and print qualities of the HPVSG formulation and PS formulation, a coat weight about 4 times heavier was needed for the precipitated silica. (Figure 3). This difference in performance can be rationalized by the difference in total porosity and pore size distribution between the two silicas (Figure 4).

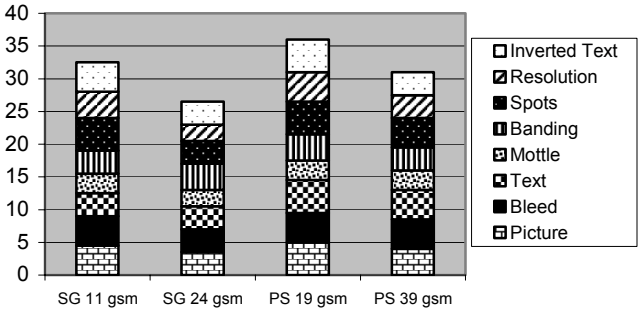

Figure 3. Effect of silica type on print quality on Canon BJC3000

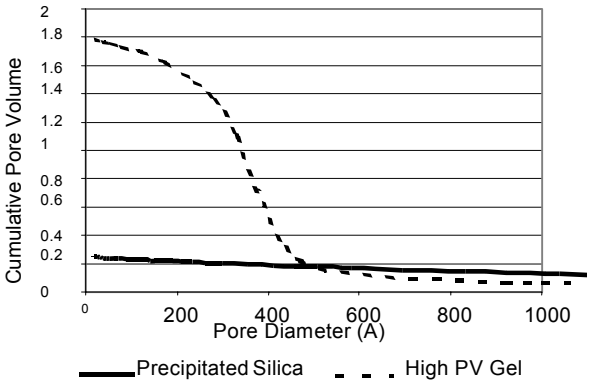

Figure 4. Pore size distribution of two chosen silicas

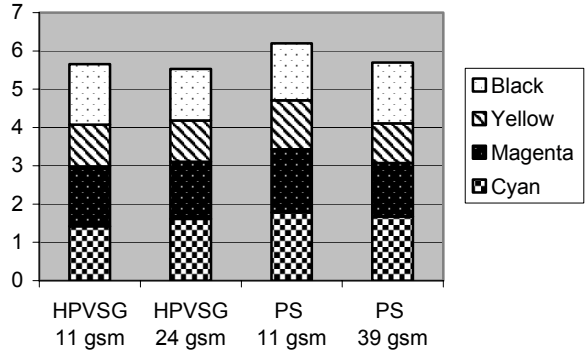

Figure 5. Effect of silica type and coat weight on optical density on Canon BJC3000

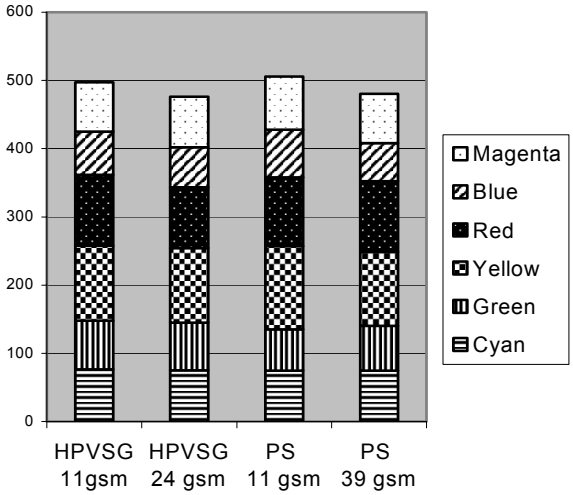

Figure 6. Effect of silica type and coat weight on gamut on Canon BJC3000

The coating made with precipitated silica lacks the porosity to dry the ink by absorption. Thus, the colorant pools on the surface, giving rise to the resulting increased optical density and color gamut as indicated in Figures 5 and 6. Unfortunately, this benefit is

accompanied by unacceptable print quality. Without absorption, the ink tends to spread horizontally destroying print attributes such as bleed, resolution, and inverted text. As mentioned above, the print quality can be improved by increasing the coat weight but at the expense of optical density and gamut also shown in Figures 5 and 6.

Replacing Silica Gel (HPVSG) with Precipitated Calcium Carbonate (PCC)

A series of coatings were prepared according to Table 1 (Section 3). They were applied on both paper and non-absorptive substrate (Syntheape). On the paper substrate, or all ratios investigated the Optical Densities and Gamuts were significantly inferior for PPC than they were for silicas. The print properties were also inferior for PCC.

The values of optical densities were closer on Syntheape at a significant expense of the print quality as shown in Figures 7 and 8. This could be explained by the insufficient adsorption provided by PCC resulting in ink pooling on the surface of the sheet.

Conclusions

High Pore Volume Silica Gel has unique structural properties, which makes it the material of choice for high quality matte ink-jet paper. Its internal pore volume and controlled pore size distribution is unmatched using alternative cheaper materials. Only the acceptance of a compromise in quality can warrant a reduction in raw material costs. Furthermore, these savings are often lost if the full processing and full material costs of alternative formulations are considered.

Reference

1. Patent EP 0423 829 B1

Author Biography

Stephanie Rose was educated at Western Michigan University where she obtained a Bachelor of Science in Paper Science and Chemistry. She then joined Curtis Specialty Papers as Process Engineer later becoming Product Specialist. She now works as Application Specialist for Paper and Coatings at Ineos Silicas Americas LLC in Joliet Illinois.

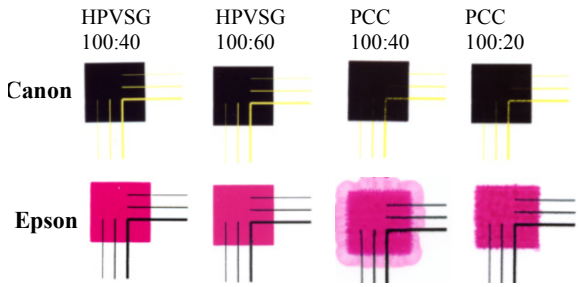

Figure 7. Details of bleed observed on different ink- jet coatings

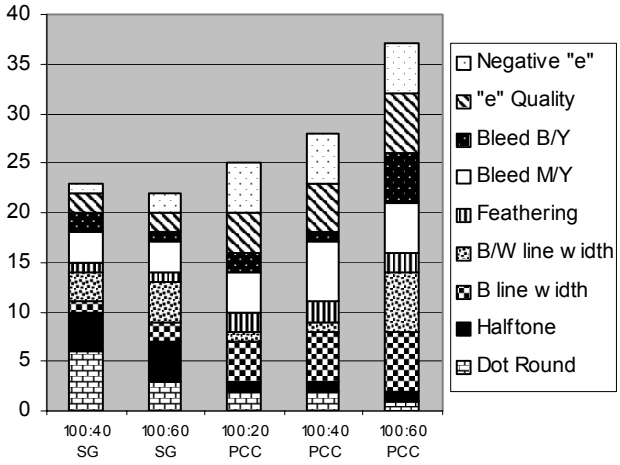

Figure 8. Print quality at various pigment/binder ratios on Epson Stylus Photo R300