Silica Properties for Matte-Coated Media for Pigment Based Inks

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Abstract

Pigment-based inks are widely used in applications where long-term stability is of great importance. Choosing the ink-jet ink type is only one step in creating the optimal ink-jet printed product. The media must work synergistically with the ink and printer to obtain the optimum printed product. Formulators of the media must choose the proper materials for the ink receptive coatings to ensure outstanding performance. Silicas are one of the top-performing materials used by formulators to achieve quick dry times and excellent print quality. This paper examines the influence of silica properties on the performance of media printed by pigment based ink jet inks.

Introduction

A variety of ink-jet inks exist on the market. Their main differences are in the vehicle (organic solvent, water, or resin) and the type of colorant (dye or pigment). A variety of additives are used according to several proprietary formulations.

The primary interest of this paper is pigmented inks, which are technically superior for prints that require longevity and light stability. The drawback is that pigment inks tend to have lower gamut and poor ink adhesion as compared to dye based inks [1]. However, the ink does not work alone, a poorly chosen media can aggravate the deficiency in an ink. With the variety of ink formulations available on the market, the best approach, when designing an ink receptive media, is to start by selecting the coating ingredients based on the basic effects of the materials on the desired print properties.

Pigmented inks consist of dispersed pigment particles at low concentrations in organic or aqueous vehicles. The print quality is affected by the penetration and by the lateral spread of the ink droplet into the microporous media. [2] It has been well documented that pigmented inks form a filter cake on a surface of a microporous media during the drying phase. [1, 3, 4, 5] The filter cake creates a physical barrier that alters the surface of the media thus preventing penetration of the pigment. [3] In addition to print quality, the filter cake affects the dry-time as the vehicle is also unable to be absorbed by the porous coating due to the physical barrier that has been created.

High quality digital media are coated with an ink receptive formulation designed to enhance the print quality through faster dry times, colorant fixation, and stability. Silicas are one of the more frequently used materials in porous matte media. Silica, being a porous pigment, increases the void volume of the coating. As silica particles can vary by manufacturing route, pH, pore volume and particle size the choice of materials is wide. This paper investigates the influence of silica properties on print and color quality of pigmented ink prints.

Experimental

A series of silicas were chosen to represent a range of pore volumes, particle sizes, pH and silica types. The properties of the silicas have been summarized in Table 1.

Table 1. Silica Properties

Pore Volume	Average Particle Size	pH
1.0 g/ml	4 – 7 microns	7
1.2 g/ml	4 – 10 microns	6
1.8 g/ml	4 – 14 microns	3.5 – 7

While the silica properties were varied in the experiment, the other raw materials and their ratios were kept constant to maintain a focus on the effects of silica. The silica to polyvinyl alcohol ratio was 1:0.5. The formulation consisted of PVA 235 supplied by Kuraray, PVP K15 supplied by ISP, and Catiofast SF supplied by BASF. The formulation was made at 19% solids. The formulation viscosity was measured with a Brookfield Viscometer at 10, 20, 50, and 100 rpm prior to application to a Syntheape (synthetic paper) substrate. Syntheape was chosen to ensure a consistent substrate that would not influence the performance of the coating. The coatings were applied by an automated k-bar for targeted dry coat weights of 7.5 gsm and 15 gsm. The coated Syntheape paper was dried for 20 minutes at 105 degrees C. Then each sample was printed on an Epson Stylus Photo R800 printer. Print quality was analyzed by Image-Xpert print analysis software, assessing several print features such as bleed, mottle, and dot quality. A lower value represents better quality. Color gamut and optical densities were measured by the X-Rite 938 spectrodensitometer. Optical density was calculated from the sum of measured C, M, Y, and B optical densities. Gamut was

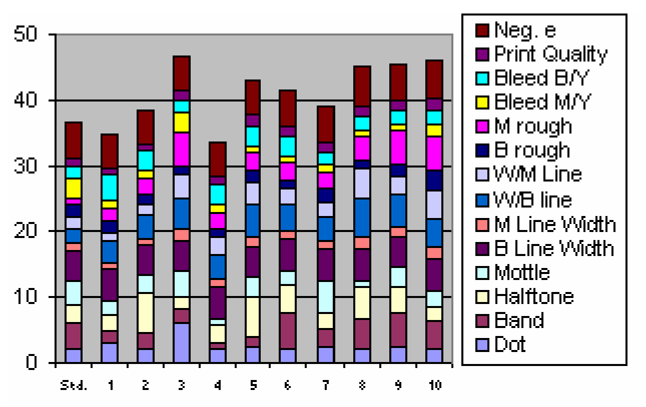

Figure 1. *Print quality of laboratory produced matte coated media printed by Epson Stylus Photo R800 printer.*

calculated from the sum of the absolute value of CIE a* and b* parameters for C, M, Y, B, R, and G colors. For optical density and gamut a higher number represents a better value.

The commercially available premium ink-jet paper from Hewlett Packard, HP51634Z, was used as a standard in the laboratory evaluations. Figure 1 demonstrates that print quality of media prepared in the laboratory is comparable to commercially available product.

Results and Discussion

Since pigmented inks are well known for having UV and ozone stability, the focus of this experiment was to evaluate the basic print properties needed to produce high-end photo quality or fine art prints.

Gamut

The excellent long term stability of pigmented inks makes it a preferred choice for prints in the fine art and other photo applications. However, the main weakness of pigmented inks is low color gamut. It is, therefore, important that the media design does not degrade the gamut. Maximizing the gamut will lead to improved color reproduction in the prints. Figures 2 and 3 show how silicas with high pore volume, small particle size, and neutral pH produce the largest gamut. This trend was demonstrated on both the 7.5 gsm and 15 gsm coat weights. Both the high pore

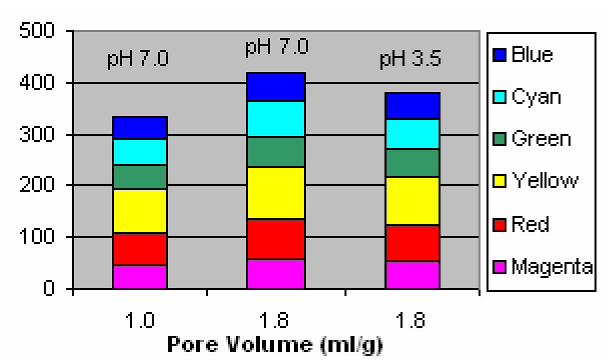

Figure 2. *The effect of pore volume and pH on the color gamut.*

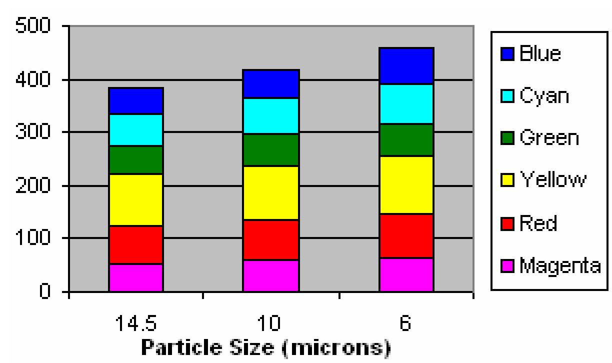

Figure 3. *The effect of particle size on color gamut.*

volume and smaller particle size are likely to contribute to keeping the pigment in the ink on the surface of the microporous coating. High pore volume silicas immobilize the pigment quickly by fast absorption of the ink vehicle. This prevents the penetration of pigments into the coating. The smaller particle packs in such a way that the resulting coating structure has a finer texture than a coating structure containing large sized silica particles. This fine structured network of coating particles prevents deep penetration of pigment particles. Figure 4 shows the surface texture difference between small and large particle size silicas in a matte ink-jet coating.

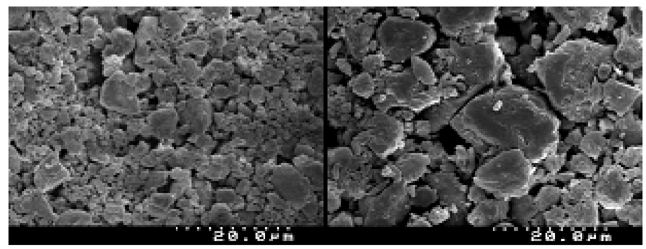

Figure 4. *SEMs of matte ink-jet media, 6 microns silica on left, 10 microns silica on right.*

Optical Density

The silica properties have a similar affect on the optical density as was noted for color gamut. Therefore, choosing the high pore volume silica with a small particle size and neutral pH will improve both the gamut and optical density. When the

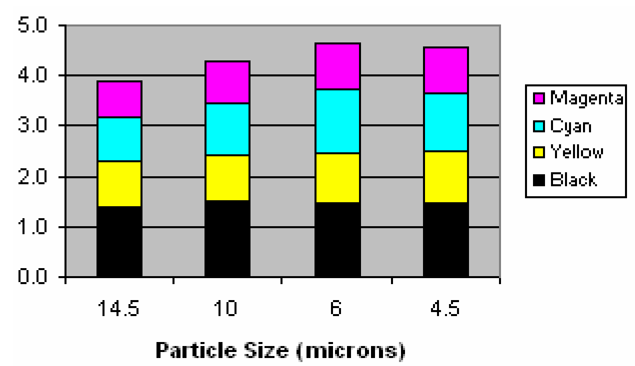

Figure 5. *The effect of particle size on optical density.*

pigment remains on the surface of the media, the maximum benefit of the pigment color can be utilized in color reproduction. Figure 5 demonstrates the effect of these properties on the optical density. Again, this trend was identified in both the 7.5 gsm and 15 gsm coat weights.

Print Quality

Modern print assessment software is able to objectively analyze and assign a numeric value for a variety of print parameters. The objective of this experiment was to identify how silica properties affect the print quality. When adding all of the print attributes together for a general over view of the print assessment it's noted that the small particle size silicas perform consistently better. This is demonstrated in Figure 6. A familiar trend occurs when the pore volume is examined. Again, in the general over view of the print assessment, the high pore volume

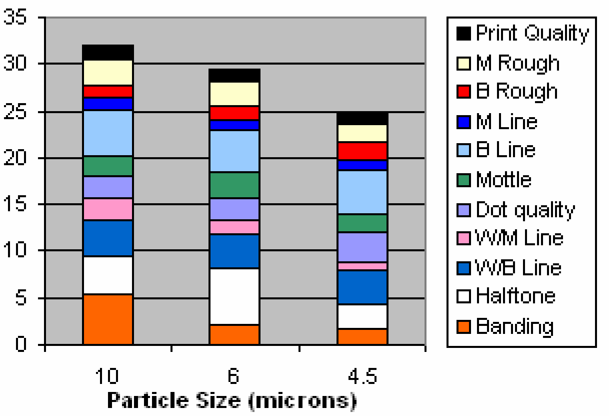

Figure 6. The effect of particle size on print properties

silica shows the most promising results. The pH of the silica does not appear to have any affect on the print quality.

Taking a look at the dot quality, each sample produced good results. This is explained by the interaction between the porous media and pigmented ink. As it has been shown in previous research, the wetting characteristics of the filter cake result in constant dot diameters. [3] It has also been shown that the resulting dots will be smaller in diameter due to the drying mechanisms. [6] This small dot diameter can affect other properties such as banding. [6] Examples of dot quality are shown in figure 7.

Figure 7. *Examples of dot quality for pigment-based ink on matte coated media, poor on left, good on right.*

While the dot quality may be consistent and good, the bleed characteristics of these papers are poor. Pigmented inks tend to form a filter cake during drying on a microporous media. [1, 3, 4, 5] When multiple colors are jetted on to a substrate the first ink, as expected, will form a filter cake altering the surface at the contact point of the subsequent inks. The contact angle is decreased thus increasing the likelihood of lateral spreading. [5] Additionally, the drying rate is further reduced since absorption is hindered by the first ink's filter cake.

While the bleed characteristics of the lines were poor, the print quality parameter was consistently good amongst all the silicas. Figure 8 demonstrates the good print quality of the small sized, high pore volume silica.

Conclusions

In every category the small sized, high pore volume gel silica performed the best on the Epson Stylus Photo Printer R800. The pH of the silica has an impact on gamut and optical density but no impact on print assessment. While the bleed characteristics of these papers were poor other print properties such as dot quality were excellent.

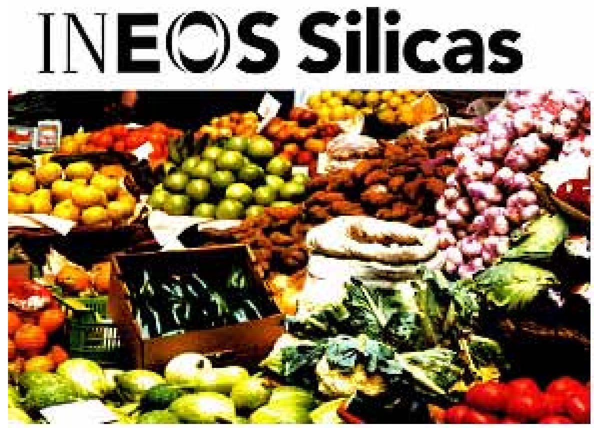

Figure 8*. Print quality on Epson Stylus Photo R800 Printer*

References

[1] G. Desie, C. Van Roost, M. Graindourze, and R. De Keyzer, Validation of Ink Media Interaction Mechanisms via Microscopic Analysis, Proc. NIP20, pg. 946, (2004).

[2] P.A.C. Gane, J. Schoelkopf, D.C. Speilmann, G.P. Matthews, C.J. Ridgway, "Fluid Transport Into Porous Coating Structures: Some Novel Findings", TAPPI Journal, 83, 5, (2000)

[3] G. Desie, G. Deroover, F. De Voeght, and R. Claes, Fundamental Mechanisms in Ink Media Interactions for Aqueous, UV-Curing and Solvent Based Inks, Proc. NIP20, pg. 774, (2004)

[4] Wolfgang Storbeck, Daniella Dietrich, and Rita Schneider, Fixation of Pigmented Black Ink on Matte Coated Ink-Jet Substrates, Proc. NIP21, pg. 306, (2005)

[5] G. Desie, G. Deroover, F. De Voeght, and A. Soucemarianadin, "Printing of Dye and Pigment-Based Aqueous Inks onto Porous Substrate", J. Imaging Science and Technology., 48, 389 (2004)

[6] Takao Abe, "Ink Jet Printing with Pigmented Inks for Photofinishing", J. Imaging Science and Technology, 48, 383 (2004).

[7] D. M. Chapman, Design Considerations for Matte-Coated Microporous Media for Pigmented Inks, Proc. NIP19, pg. 598, (2003)

[8] Gemma Morea-Swift and Helen Jones, The Use of Synthetic Silicas in Coated Media for Ink Jet Printing, Proc. TAPPI Coating Conference, (2000).

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