# High-Gloss and Wide Color Gamut Pigmented Inks for Ink-Jet Printing

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## Abstract

To obtain ink-jet prints that exhibit both high gloss and a wide color gamut using pigmented inks, a new type of pigmented ink set was developed. The four technical features described below distinguish the new ink set.

(1) The pigment, with an improved capsulation resin, easily wets and spreads on the surface of micro porous media.
(2) All ink colors have a low concentration of pigment, not more than 3 wt%.
(3) Special colors—red and blue—were used to enable the reproduction of print images with a small amount of pigment.
(4) An optimized deposition method was used to deposit a clear ink containing a transparent resin on low print duty areas (including areas where no ink is deposited) so as to obtain uniform resin coverage across the entire print image.

This ink set achieves high gloss and a wide color gamut on EPSON Premium Glossy Photo paper by

(1) Depositing the thinnest possible layer of pigment; and by
(2) Making as uniform as possible the amount of resin coating on the printed image.

## Introduction

Ink-jet printers have evolved to the point where they produce images whose quality rivals that of conventional analog photographs. Dramatic improvements in image quality have been achieved by shrinking ink droplet size, for reduced graininess and increased resolution. However, the overall level of image stability — that is, lightfastness, gas-fastness, water resistance, and so forth — has by no means been high enough to earn user satisfaction. The major reason for the lack of image stability is that dyes were being used as ink colorants.

Over the past few years, ink-jet printers that use pigmented inks have been commercialized in an effort to dramatically increase image stability.[1] Some pigmented inks on the market achieve a wide color gamut by having a higher concentration of pigment within the ink. The UltraChrome™ ink[2] that comes with the large format printers (LFP) in the EPSON Stylus Pro series is a prime example. Some of these pigmented inks are now widely used in such areas as proofing, sign graphics, fine art, and professional photos. Still, pigmented inks have yet to win broad acceptance in the consumer photo market. One of the reasons for lack of acceptance is that pigmented inks have not been able to produce "high gloss prints," a staple of conventional consumer photo-finishing.

This paper describes pigmented inks that are designed to provide high gloss and a wide color gamut when used on an ink-jet printer.

## Experimental

First, to identify the conditions necessary for producing high gloss prints on an ink-jet printer, we subjected the surface of print samples to microscope observation. One group of print samples was produced using dye inks having adequate gloss on a micro porous type ink-jet printer medium (EPSON Premium Glossy Photo Paper, or "PGPP"). The other group of print samples was created using pigmented inks having inadequate gloss on PGPP.

Next, in order to study the causes that lead to differences in the state of the surface of print samples generated using dye inks and pigment inks, the PGPP surface was subjected to electron microscope observation.

And the subjective gloss was judged by actual print samples on PGPP.

## Results and Discussion

For the dye ink, we used the same ink as that used with the EPSON Stylus Photo 960. For the pigment ink, we decided to use a pair of black inks in the UltraChrome™ ink set used with the EPSON Stylus Photo 2200. The print duty setting for all samples was 80%. The subjective gloss of four samples—the aforesaid three samples plus a conventional silver halide photograph were compared (Table 1).

**Table 1. Comparison of subjective gloss of samples at 80% print duty**

| | Subjective gloss |
|---|---|
| Dye ink | Good |
| Photo Black Ink (UltraChrome™ ink) | Fair |
| Matte Black ink (UltraChrome™ ink) | No good |
| c.f. Conventional silver halide photo | Good |

As is clear from Table 1, although Photo Black Ink (UltraChrome™ ink) has fair level of subjective gloss, Matte Black Ink (UltraChrome™ ink) has markedly inferior subjective gloss.

Photographs from microscope observations of the surface of each sample are shown below.

As is clear from Photos 1, 2 and 3, the higher the gloss, the smoother the surface of the medium.


*Photo 1. Microscopic observation of dye ink sample on PGPP*

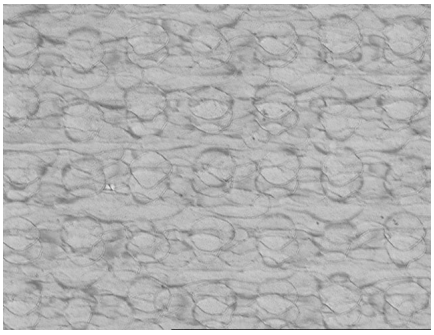


*Photo 2. Microscope observation of Photo Black Ink (UltraChrome™ ink) sample on PGPP*

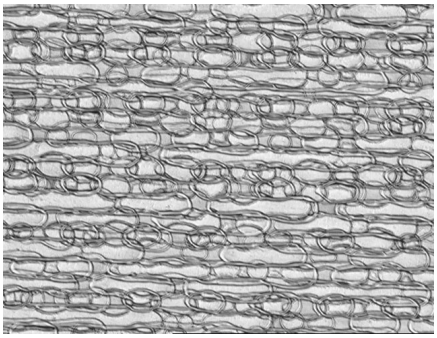


*Photo 3. Microscopic observation of Matte Black Ink (UltraChrome™ ink) sample on PGPP*

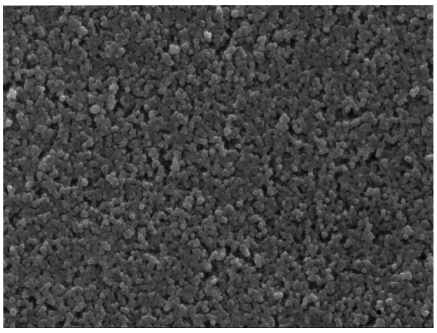


*Photo 4. Electron microscope observation of PGPP surface*

Photo 4, an electron microscope photo of the PGPP surface, shows that the ink absorption layer of the PGPP is made up of extremely small particles of silica. The primary silica particle diameter is approximately 12 nm. This suggests that enhancing the surface smoothness of the media itself may be a prerequisite for achieving high gloss prints. With the pores in the ink-absorbing layer having a diameter of 10 nm, it is easy to predict that whereas dye creeps into the ink absorption layer along with the solvent and the surface stays flat, pigment particles fail to penetrate the ink absorption layer, causing the surface of the media to become rough and take on a dull gloss due to the scattering of light. In the case of UltraChrome™ Photo Black Ink, moreover, it is thought that a comparatively good gloss can be obtained by capsulating the pigment particles with a styrene-acrylate resin so that the deposited ink forms a resin coating and a smooth surface, thereby suppressing the scattering of light (Figures 1, 2 & 3).

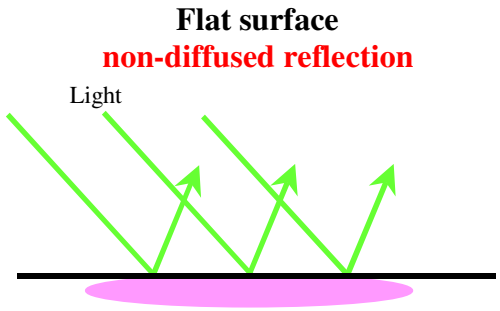


*Figure 1. Dye ink sample on PGPP*

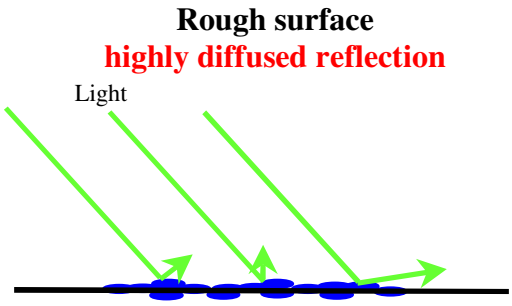


*Figure 2. Pigment ink sample on PGPP*

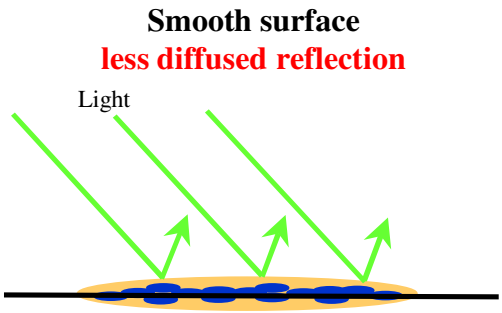


*Figure 3. Photo Black ink (UltraChrome™ ink) sample on PGPP*

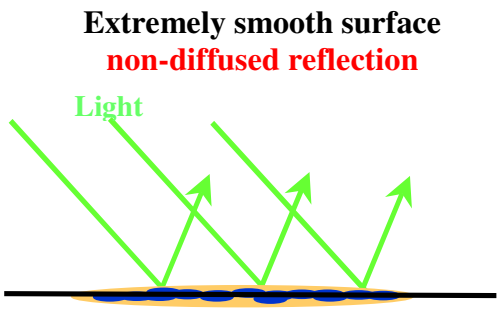


*Figure 4. New type of pigmented ink sample on PGPP*

Judging from above, to obtain high gloss prints using pigment ink on an ink-jet printer, it is essential to

(1) The pigment has to be deposited as thinly as possible; and
(2) The resin overcoat must be as uniform as possible over the printed image.

However, an attempt to achieve a thin coating of pigment simply by reducing the amount of pigment deposited will result in a markedly narrower color gamut. In other words, both high gloss *and* wide color gamut must be simultaneously achieved. The new type of pigmented ink set developed to achieve both high glossy and wide color gamut is described below.

## New Type of Pigmented Ink Set

The four technical features described below distinguish the new ink set.

(1) The pigment, with an improved capsulation resin, easily wets and spreads on the surface of PGPP.
(2) The concentration of pigment within all ink colors is kept at a low level, not more than 3 wt%.
(3) Special colors—red and blue—were used to enable the reproduction of print images with a small amount of pigment.
(4) An optimized deposition method was used to deposit a clear ink containing a transparent resin on low print duty areas (including areas where no ink is deposited) so as to obtain uniform resin coverage across the entire print image.

According to print by new type of pigmented ink on PGPP, the model figure of print

In the case of new type of pigmented ink, it is thought that good gloss can be obtained by capsulating the pigment particles with improved resin so that the deposited ink forms a resin coating and an extremely smooth surface, thereby losing the scattering of light. (Figure 4)

Print samples were prepared on PGPP using this ink set. Areas having a print duty of 80% were subjected to microscope observation. (Photo 5)

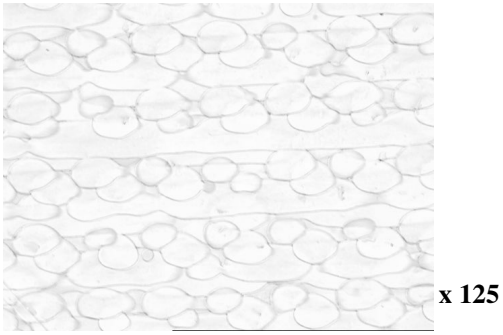


*Photo 5. Microscope observation of new type of pigmented ink on PGPP*

The subjective gloss of new type of pigmented ink set print sample was shown below. (Table 2)

**Table 2. Subjective gloss of new type of pigmented ink at 80% print duty**

| | Subjective gloss |
|---|---|
| New type of pigmented ink | Good |

As is clear from the samples printed on PGPP using the newly developed ink set have an extremely smooth surface. The new ink set produced high gloss prints with a gloss that rivals that of even dye ink prints and conventional photographs. (Refer to print samples)

Investigating the color gamut of the newly developed ink set on PGPP, we compared a print sample made using UltraChrome™ ink used in the EPSON Stylus Photo 2200 and a digital silver halide photo printed out on conventional photo paper (Figure 5).

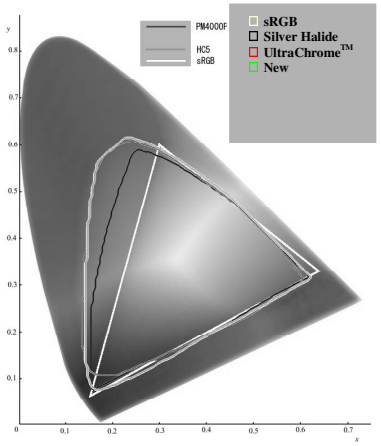


*Figure 5. Comparison of color gamut: new type of pigmented ink on PGPP, UltraChrome™ ink on PGPP, and digital silver halide photo on conventional photo paper*

As is clear from Figure 5, an extremely wide color gamut is obtained on the print samples made using the new type of pigmented ink on PGPP.

## Conclusion

To obtain prints that exhibit both high gloss and a wide color gamut with pigmented inks for ink-jet printers, the surface of the media itself must first be made smoother. Then, on top of that

(1) Pigment has to be deposited as thinly as possible; and
(2) The resin overcoat must be as uniform as possible across the printed image.

The four technical features described below characterize the new type of pigment ink set.

(1) The pigment, with an improved capsulation resin, easily wets and spreads on the surface of PGPP.
(2) The concentration of pigment within all ink colors is kept at a low level, not more than 3 wt%.
(3) Special colors—red and blue—were used to enable the reproduction of print images with a small amount of pigment.
(4) An optimized deposition method was used to deposit a clear ink containing a transparent resin on low print duty areas (including areas where no ink is deposited) so as to obtain uniform resin coverage across the entire print image.

These four features make it possible to obtain both high gloss and a wide color gamut on EPSON Premium Glossy Photo Paper.

## References

1. Katsuhiko Iida, "EPSON Perfect Imaging System And New Colorfast Ink," Proceedings of IS&T's DPP2001, pg. 288-290.
2. Kiyohiko Takemoto, Kazuaki Watanabe, and Takashi Oyanagi, "New Pigmented Inks for High Image Quality Large Format Ink-Jet Printing," Proceedings of IS&T's DPP2003, pg.187-188.

## Biography

**Kiyohiko Takemoto** is a manager in the TP Research & Development Dept. of Seiko Epson Corporation. He received a B.E. in Applied Chemistry from Waseda University, Japan, in 1985. He has developed a variety of key ink-jet technologies, notably dye-based inks for EPSON Stylus™ color printers. His primary responsibilities are developing and designing pigment-based inks for EPSON Stylus™ photo printers.