Gloss of Ink Jet Media at High Ink Loads

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Abstract

A dozen commercially available high gloss photo papers were imaged on several wide format printers. It was found that the gloss of the printed image area is dependent on type of printer and ink used. Most of these media have a significant drop of gloss at 300 and 400 percent ink load, typically used for composite black. Although these photo papers are advertised as universal media, a significant gloss reduction is observed with some printers even for secondary colors at a 200 percent of ink load.

Introduction

Wide format display graphic media should be designed to give an excellent quality of images and at the same time have capability to absorb a high amount of ink. Additionally, images should be characterized by color brilliance and fidelity, freedom from surface dusting and color rub-off, instant dry time and more consistent quality over the wide range of humidity normally encountered during the printing. As often happens, one set of qualities can be obtained at the expense of another, thereby making it difficult to obtain all of the desired qualities.[1-5]

The first generation of photo papers was based on gelatin technology with addition of resins such as polyvinyl alcohol and polyvinyl pyrrolidone. The problem with handling heated gelatin on most coating equipment lead to development of a single layer pure resins coating. Unfortunately, the release of new wide format printers with dye and pigmented inks brought new challenges for chemist developing ink jet media. Additionally, new media should be water-resistant and have good lamination. It is nearly impossible to achieve this task with a single layer coating. The new generation of ink jet having most of above-mentioned feature bears two or more layer coatings.

Each of these two layers in ink jet coatings should have distinctive properties. The top layer should be hydrophobic but permissible to allow fast transfer of inks to underlayer. Additionally, the layer should be relatively thin to prevent excessive dry time and reduction in the colors' density. The underlayer should be hydrophilic to quickly absorb excess ink fluid. Additionally, the underlayer should have good adhesion to hydrophobic base to prevent delamination frequently observed at high ink load areas.

The development of glossy ink jet media is mostly covered by patent.[6-9] Available literature regarding glossy ink jet media is very limited at this moment. McFaden et al[10] studied the effect of coating structure and optics on ink jet printability but the results are mostly limited to inks densities. Omura et al.[11] compared performance of cast coated paper for ink jet printing with polyester film-coated substrate and traditional matte paper.

Khoultchaev and Graczyk[12] reported a change in gloss of glossy media imaged on printers with pigmented inks. They presented theoretical and practical aspects of the consequences of polymer-polymer and polymer-colloid interactions in the ink jet receiver coating.

There are a few factors, which might increase or decrease the gloss of the ink jet coating. First, the most obvious is the interaction between resins leading to the formation of insoluble polymer associates. The combination of these associates with other not reacting resins of the mix results in a coating with uneven optical density and reduced gloss. The second factor is the phase separation of resins in the coating during the solidifying process. Non-compatible polymers form their own micro phases in the coating. Each micro phase may have different light reflecting properties.

The paper discusses the effect of printing conditions on the gloss of images printed on commercial glossy photo papers. These media are recommended for a broad range of printers both for wide and small format. The article initiates the study of gloss two layer model coatings having hydrophilic and hydrophobic layers in different composition, configuration and ratio.

Experimental

Print Quality Test

An imaging pattern (21.59-cm × 27.94 cm) was developed for gloss evaluation of photo papers after printing. The pattern had three rows of large rectangular areas (5.0 cm × 3.75 cm): three primary colors (cyan, magenta, yellow), two secondary colors (blue, green) and black (K) and three composite blacks measured as 300% (C100, M100, Y100), 350% (C100, M100, Y100, K50) and 400% (C100, M100, Y100, K100).

The tested samples were imaged on two wide format printers: Oce 5350 equivalent of EnCad Nova Jet PROe with GS (dye) inks and HP 2500CP with dye inks. All prints were made at TAPPI standard conditions of 72 ^{o}F and 50% RH. The printing file was generated in Corel Draw 8. Composite black was generated on HP 2500CP using a postcript-3 driver with best print quality @ 600dpi without any color profile. For Oce-5350 (300 dpi) with Oce RIP Server using CAT file @ 85% ink load without any color profile. Although original color was set for 400-percent composite black, actual ink load was 320-percent. Printing was done using photo glossy mode on HP 2500CP and on the Oce 5350 the high gloss photobase mode was selected.

Another image pattern (21.59 cm × 27.94 cm) was developed in Power Point for evaluating gloss of commercial ink jet media printed without composite black. Large rectangular areas of three primary colors (cyan, magenta, yellow), three secondary colors (blue, red, green) and black were used to check, gloss, mottle and banding of the printing media. Secondary color strips along the paper were used to quantitatively evaluate the dry time. The ink jet media were imaged on several wide format printers using dye-based inks: EnCad Nova Jet PRO, Nova Jet III, HP 750 and HP 2500. All prints were made at TAPPI standard conditions of 72 ^{o}F and 50% RH. The file was printed using regular window drivers. Single black was generated.

Gloss Measurement

Surface gloss and images gloss was measured using a portable Micro Tri-Gloss Meter (BYK-Gardner, Germany) according to the standard procedure. Readings were taken at 60 degree along the machine direction for all tested materials at Tappi conditions seven days after printing if it is not stated otherwise.

Results and Discussion

Gloss Variation of Commercial Photobase Media

Most of photo papers for wide format color ink jet printing are designed for specific family of printers (e.g., HP or EnCad). However, more and more photo papers available on the market can be call universal media because they give acceptable print quality on broad base of printers. Several universal, high gloss photo papers available commercially were printed on Nova Jet PRO printer with GA dye inks using standard window drivers.

The gloss of primary and secondary colors was compared to the gloss of unprinted area - white. It was found that black (K) and two secondary colors: green and blue are the most sensitive to gloss changes. Table 1 shows the gloss data for green and blue measured one week after printing. The maximum gloss change between background white and any of the colors above was reported in the last column of the Table 1 It is seen that gloss of background white for all tested photo papers was in the range of 80-85. The gloss of a black color changes only slightly (below 10 points) with the exception of photo paper D where gloss increased 9 points from 83 to 92. Gloss of other colors was reduced on most tested photo papers though to a different degree. The maximum drop of gloss for secondary colors reached 40-60 points. From two secondary colors, green color has a higher degree of gloss reduction. Photo paper C shows excessive print mottle on green color which scatter light and consequently lower gloss is measured.

Table 1. Gloss reduction for several commercial glossy photo papers printed on Nova Jet PRO printer with GA dye inks.

Photo Paper	White	Black (K)	Green	Blue	White-Color*
A	82.6	82.9	47.8	68.0	34.8
B	79.2	78.0	36.3	40.5	42.9
C	86.9	76.6	6.9	20.6	80.0
D	82.8	91.5	40.4	42.6	42.4
F	81.0	86.7	16.7	64.8	64.3
G	85.0	73.5	22.7	69.1	62.3
H	79.3	88.8	12.0	37.9	67.3

*Maximum gloss difference between white background and secondary color.

The same photo papers were printed on HP 2500 with dye inks and gloss data are presented in Table 2. Once again the variation in gloss among colors is observed. However, there is a significant gloss difference in comparison to images printed on Nova Jet PRO with dye inks. The gloss of single black is lower than background white in most cases due to a banding phenomenon. The exception is a photo paper A, where the gloss of black color increases 20 points after printing. The gloss of printed areas of photo papers B and E changed in the range of 5-9 points. However, other photo papers have a drop of gloss 40-50 points from initial gloss of 80. HP 2500 printer loads much less ink than EnCad printers creating a banding pattern. The pattern is caused by insufficient ink spread due to the excessive absorption power of coating. Non uniform distribution of dye in the coatings scatters light and reduce its reflection. Consequently low gloss is observed. In the case of the HP 2500 printer, the solution could be the use of other printing mode with a higher ink load such as film print mode.

Table 2. Gloss reduction for several commercial glossy photo papers printed on HP 2500 printer with dye inks.

Photo Paper	White	Black (K)	Green	Blue	White-Color*
A	86.4	106.4	83.3	86.6	3.1
B	78.0	75.1	74.2	74.2	3.8
C	86.8	47.2	56.6	34.4	52.4
D	83.4	23.1	54.4	68.6	29.0
E	83.8	81.6	75.3	74.3	9.5
F	85.0	39.7	79.6	74.6	10.4
G	89.9	74.3	61.9	64.5	28.0

* Maximum gloss difference between white background and secondary color.

Type of Printer and Gloss Reduction

The degree of gloss variation among colors for photo papers is strongly dependent on type of printer used. In Table 3 the gloss reduction for commercial photo paper A is presented. Once again, gloss of primary black and secondary colors of green and blue were reported. It is seen that gloss reduction in the range 5-10 points is very common. Higher gloss is observed for black color on HP

2500 printer. However, images printed on NJ PRO printer with GA inks and HP 750 printer had gloss reduction in the range of 20-35 points.

Table 3. Gloss reduction for glossy photo paper A printed on several commercial wide format printers with dye inks.

Printer	White	Black (K)	Green	Blue	White-Color*
NJ PRO GA	82.6	82.9	47.8	68.0	34.8
NJ PRO GS	82.8	85.3	77.2	73.9	5.6
Nova Jet III	85.4	81.1	71.0	81.3	14.4
HP 2500	86.4	106.4	83.3	86.6	3.1
HP 750	85.2	64.4	66.2	77.2	19.0

* Maximum gloss difference between white background and secondary color.

Table 4 presents gloss reduction data for another commercial photo paper F. The gloss level on black color imaged on EnCad printers was independent of printing device. On the other hand, a significant drop of black color gloss was observed on HP 2500 and HP 750 printers. The gloss of secondary colors decreased 10 - 15 points independently of the type of printer. The exception is NJ PRO printer with GA inks. The gloss of green color dropped about 64 points to 17. As a result, printing caused the gloss level of this particular photo paper to change from high gloss to the range of low satin – high matte.

Table 4. Gloss reduction for glossy photo paper F printed on several commercial wide format printers with dye inks.

Printer	White	Black (K)	Green	Blue	White-Color*
NJ PRO, GA	81.0	86.7	16.7	64.8	64.3
NJ PRO, GS	86.7	88.3	72.3	67.7	14.4
Nova Jet III	86.7	84.9	72.9	80.7	13.8
HP 2500	85.0	39.7	79.6	74.6	10.4
HP 750	87.0	62.7	76.5	73.8	10.5

* Maximum gloss difference between white background and secondary color.

It worth mentioning that the secondary color blue printed on Nova Jet Pro with GA inks had significantly higher gloss retention than green and that the difference in gloss between two colors was nearly 50 points. Blue is a combination of primary cyan and magenta, while green is a combination of cyan and yellow. The interaction of yellow dye with an ink jet layer could have significant effect on non-uniform distribution in the coating and consequently on gloss. Graczyk and Xie reported the non-uniform distribution of yellow dye in ink jet receiving layers and poor lamination.[16] More work is needed to fully understand this phenomenon.

Ink Load and Gloss Reduction

The results presented above were limited to secondary colors (200 percent ink load) utilizing regular Windows drivers. However, in high-end graphic art applications composite black is used beside primary black. Graphic art software such as Corel and PhotoShop in combination with RIP software allow depositing up to a 400 percent ink load. The 400-ink load is a composition of three primary colors (cyan, magenta and yellow) and black.

Figure 1 presents gloss data for five commercial photo papers recommended for and printed on HP 2500 printers at different ink loads. It is seen that gloss reduction was the highest at 300 percent ink load (composite black). All tested photo papers had at least a 10 point lower gloss in the area imaged with composite black. Photo papers E and J at 300-ink load had a drop of gloss of about 30 and 60, respectively.

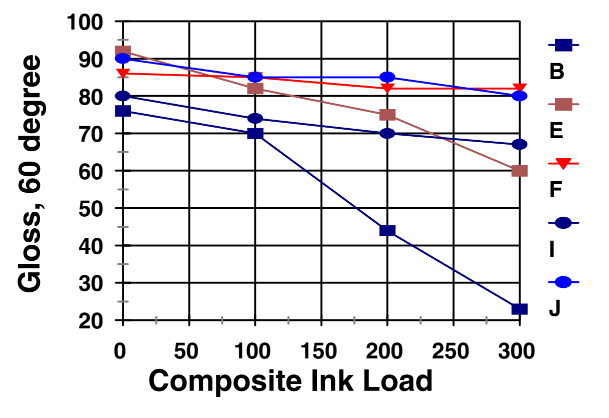

Figure 1. Gloss of commercial photo papers printed on HP 2500 with dye inks as a function of ink load.

Figure 2 shows gloss of colors printed on photo paper K and measured after 1, 3 and 7 days. The gloss of these colors was independent of ink load up to ink loads of 200 - 300 percent. A sharp drop of gloss of about 40 points was observed when an ink load was increased from 300 to 400 percent. That gloss decreases with time is an indication of an interaction of inks with the ink receiving layer. Ink jet inks contain several glycols that slowly evaporate with time. The decrease in glycol level can–change the solubility of inks in the polymeric matrix and cause a reduction in gloss.

Extensive testing in our lab showed that all photo papers on the market face the same phenomenon of gloss reduction on imaged areas to varying degrees. Gloss reduction can be an indication that the coat weight of ink jet coating(s) was not sufficient to handle such high amount of ink. Although print quality was still acceptable the first symptom of under capacity of the coating was a loss of the image gloss. We also reported that too low coat weight of ink jet receiving layer(s) could have a negative effect on the adhesion of laminating film to secondary colors.[13]

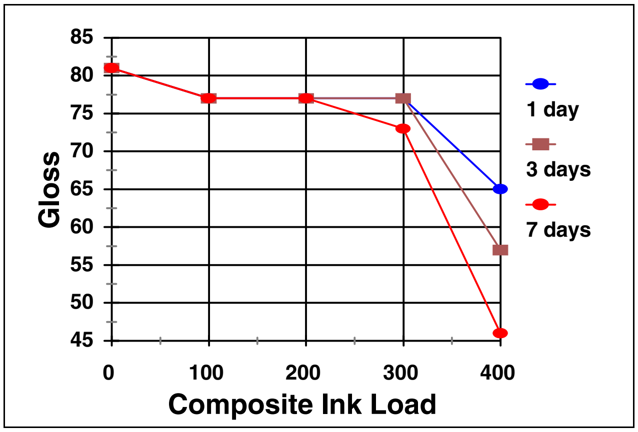

Figure 2. Gloss of photo paper K printed on Oce 5350 with GS inks as a function of ink load measured several days after printing.

The development of media capable of absorbing a high ink load is a challenge but these media can find quick and practical applications. For example, back lit and back view films require coatings of different design than traditional high gloss photo paper. The printer set up at back lit mode deposits a high amount of inks on media. Such high level of ink is needed to obtain vivid images because a source of light comes from the backside and viewer is in the front of the image. New generation high-speed ink jet devices also requires media, which absorbs inks at much higher rate. The side effect of developing these media is significant gloss reduction in some combinations of printers and inks.

Conclusions

The paper discussed several factors influencing the gloss of commercial ink jet media. It is a fact, that significant change of gloss after imaging is very common in ink jet printing. The gloss reduction would not be a problem on satin and matte media but is unacceptable for end users on glossy photo papers. Even unsophisticated customer will easily notice the high gloss reduction on intensive graphic application. The gloss of printed areas was strongly dependent on media - inks combination and type of printer. The gloss was also influenced by printing mode that regulates the amount of ink load deposit on the paper.

A better understanding of the factors affecting ink-coating interactions should help in designing new generation of ink jet media with minimal gloss variations on different printers and good lamination.

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Biography

Tom Graczyk received his Master's and Ph.D. in Polymers Chemistry and Technology from Technical University of Lodz. He worked for ten years in Pulp and Paper Research Institute in the area of polymers coating for specialty papers. Subsequently, he worked as a visiting scientist at several universities in Canada. He joined Oce Imaging Supplies in 1996 to work on media for digital printing with strong emphasis on ink jet media. Dr. Graczyk published over 50 technical papers in the area of polymers, pulp and paper, hot-melts and holds 6 patents.