Gloss of Model Ink Jet Coatings at High Ink Loads

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Several model ink jet coatings having a broad range of hydrophilicity were imaged on three printers. The gloss of these images was independent of the hydrophilicity of the ink jet coating. However, when the most hydrophobic and hydrophilic systems were coated on top of each other the gloss of printed image areas was dependent on the hydrophobicity of top layer. In experiments having a hydrophilic layer on the top, the gloss of imaged areas was independent of ink load and the ratio between both ink jet coating layers. When a hydrophobic layer was coated on the top hydrophilic layer, drop of 60 points in gloss was observed at a 400% ink load. The gloss reduction can be dependent on a ratio between both ink jet coating layers and ink load. Correlations were found between water absorption, gloss reduction and content of the most hydrophobic component in the coatings. It was shown that the difference in the degree of absorption between the two ink jet coating layers has an effect on the gloss of printed areas.

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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.[1–7]

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 under-layer. Additionally, the layer should be relatively thin to prevent excessive dry time and reduction in the colors' density. The under-layer should be hydrophilic to quickly absorb excess ink fluid. Additionally, the under-layer 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.[8–11] Available literature regarding glossy ink jet media is very limited at this time. McFaden and co-workers[12] studied the effect of coating structure and optics on ink jet printability but the results are mostly limited to inks densities. Omura and co-workers.[13] compared performance of cast coated paper for ink jet printing with polyester film-coated substrate and traditional matte paper.

Khoultchaev and Graczyk[14] 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. They showed how the type of modification and charges of polyvinyl alcohol would have an effect on print quality, especially on gloss with pigmented inks. It was also found that the pH adjustments in the ink receiving layers increase the gloss of the printed media. They stated that the gloss readings of the final product are generally depend on the gloss of the base substrate and the coating. In the case of a printed area the change in the morphology of the coating due to interaction with inks will have an effect on the gloss readout. It is not necessarily true that the mixture of resins yielding clear glossy films if coated individually will give the glossy coating too. There are a few factors, which might increase or de-

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crease 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.

Graczyk and Mody[15] imaged a dozen commercially available high gloss photo papers 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% 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% of ink load.

This article discusses the effect of coating compositions and printing conditions on the gloss of images printed on model two layer systems having different hydrophilicity and compared to single layer systems. An interaction between both layers has an effect on the gloss of images at high ink loads. The ratio of under-layer to top-layer also has an effect of the gloss of images.

Experimental

Materials

We used 7 mil gauge polyethylene extrusion coated photobases - SN 1590 grade with no subbing from Felix Schoeller Technical Papers Inc. as the base material for model coatings. This grade has a certain amount of a high-density polyethylene on the backside to stabilize the sheet and eliminate curl after application of the ink jet coating. Schoeller grade SN 1590 photobase was corona treated to achieve the surface energy about 42 ergs/cm^2.

Formula Preparation

Batches of about 500 g size were prepared for each formulation. The ingredients were added slowly one by one and blended using a high torque laboratory mixer with an RPM display. Most polymers were premixed with water to prevent any possible precipitation or coacervation. Water was used to adjust the final concentration and viscosity of the formulations. Subsequently, the blends were gently mixed by a magnetic bar to prevent settling. Viscosity of the coating formulations was measured at 60 RPM using Brookfield Synchro-Lectric Viscometer. The choice of the spindle was dictated by the viscosity of the formula.

For example, System 2 mix was prepared as follows: 171.5 g of 10% solution of polyvinyl alcohol S 523, supplied by Air Products, was mixed with 51.0 g of polyvinyl pyrrolidone K-90 (22.5% solution) supplied by ISP and 85.6 g of Sancure 815 water polyurethane dispersion (BFGoodrich); 2.5 g of flow agent Byk 380 (Byk Chemie) was added drop-wise during the intense mixing to prevent polymer complex formation and precipitation. Water (189.4 g) was added to adjust concentration and viscosity. The mixture was stirred for additional 20 minutes. The pH of the formulations was measured using a combination pH electrode.

Sample Coatings

All coatings were performed on a Laboratory Band Coater. The machine coating speed was set up to match the best drying and coating conditions. Different sizes of Meyer rods (24 – 65) were used to achieve the desired coat weight. The coated substrate was dried with a combination of hot air and IR heater to remove water. Band coatings were done on an approximately 25 cm wide by 2.5 meter long loop of substrate. The coated web was cut into 21.59 cm × 27.94 cm sheets for printing. The dry coat weight of individual ink jet layers were in the range of 2 to 12 g/m^2 giving total coat weights of about 14-16 g/m^2.

Print Quality Test

An imaging pattern (21.59 cm × 27.94 cm) was developed for evaluating the print quality of single and two layers systems. 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 coated 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 and pigmented inks. All prints were made at TAPPI standard conditions of 72°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 at 600dpi without any color profile. For Oce-5350 (300 dpi) with Oce RIP Server using CAT file at 85% ink load without any color profile. Although original color was set for 400% composite black, actual ink load was 320%. Printing was done using Photo glossy and Back-lit 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 Microsoft Power Point for evaluating the print quality of commercial ink jet media. 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°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.

Contact Angle and Surface Energy

The contact angle was measured using FTÅ200 Dynamic Contact Angle Analyzer according to the standard procedure. Three fluids were used: water, glycerine and diiodomethane. The surface energies were calculated with the Girifalco-Good-Fowkes-Young model using software ACCUSOFT, version 1.5051, manufactured by First Ten Ångstroms.

Results and Discussion

Single Layer Model Coatings

Photo base pretreated for aqueous coatings was coated with five model resin compositions having good film form-

TABLE I. Composition of Five Systems with Different Degree of Hydrophobicity

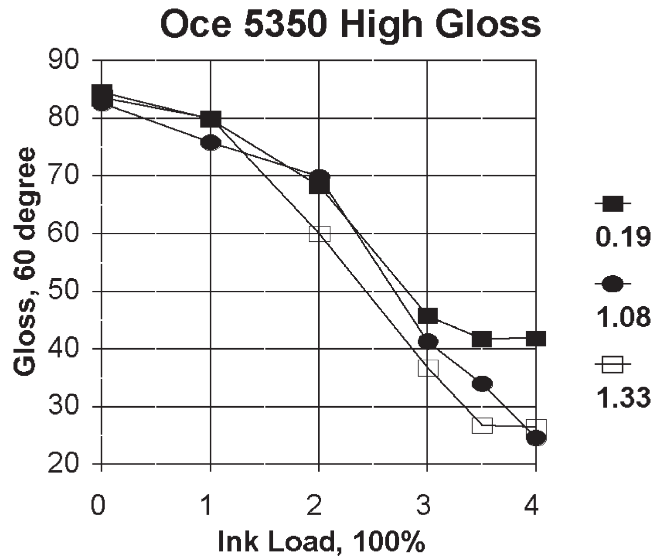
Materials	2	1	3	4	5
Polyvinyl Alcohol	28.5	40.5	50	56	59
Polyvinyl Pyrrolidone	19.5	27	33	37	39
Polyurethane	50	30.5	15	5	-
Flowing Agent	2	2	2	2	2
pH	7.8	7.5	7.2	6.9	5.7
Coat Weight, gsm	14	14.8	12.5	14	11.5
Contact Angle, water	59.6	54.1	42.3	33.4	24.7
Contact Angle, glycerine	62.6	56.5	48.4	37.8	33.2
Surface Energy, ergs/cm^2	41.2	51.7	55.3	61.7	66.3
Water Absorption, %	2.24	2.37	3.31	3.46	3.97

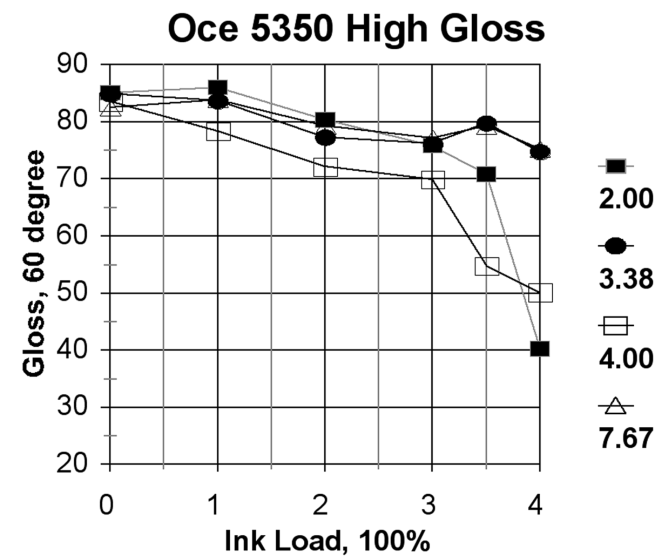
ing characteristic but different degree of hydrophilicity. System 5 was composed of polyvinyl alcohol and polyvinyl pyrrolidone and had the highest surface energy (66.3 ergs/cm^2). On the other hand, System 2 had the lowest surface energy (41.2 ergs/cm^2) due to presence of 50% by weight of polyurethane. We limited the amount of polyurethane in the system to 50% and did not add more hydrophobic polymers to make coatings compatible and homogenous without phase separation. The most hydrophilic, System 5, absorbed nearly twice as much water as the most hydrophobic System 2 (2.37 and 3.97%, respectively measured at 23°C, 50% RH, 24 h). The composition of five systems, coated at 12-14 g/m^2 is presented in Table I. Samples of above mentioned coated weight had relatively short dry time and decent image quality.

The coated papers were imaged on an Oce 5350 printer with GS inks and on an HP 2500 printer with dye and pigmented inks using high gloss printing mode. It was found that gloss for images printed on these coatings were very high about 84 – 86 at 60° and independent of ink load. Printing of samples at low and high relative humidity and temperature did not have effect on gloss level of the printed areas. At coat weight of 12 – 14 g/m^2 all inks were easily absorbed by polymeric matrix preventing accumulation of ink on the surface that could artificially boost gloss. The inks were uniformly distributed in the matrix without excessive accumulation at the bottom of the coating.

Two Layers Model Coatings

The most hydrophilic System 5 was coated as an under-layer in one set of model coatings and as a top layer in the second set of experiments. The most hydrophobic System 2 was used as the second layer. The ratio of both systems was changed from roughly 2:1 to 1:2 for both layer combinations. Total coat weight of both layers was about 15 – 17 g/m^2. The gloss of imaged areas printed with single black (K) and composite black (C plus K), that is the equivalent of a 100 and 400% ink load, respectively, is presented in Table II. Once again in the model coatings we disregarded image quality and print resolution and focused on gloss level only.



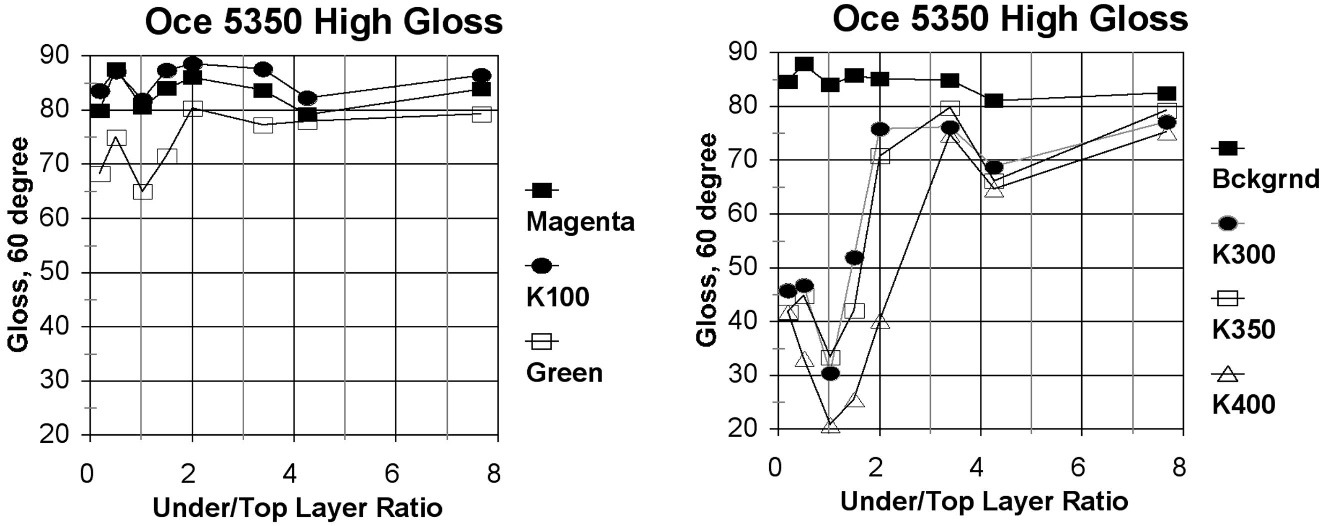


Figures 1 and 2. Gloss of images printed on an Oce 5350 printer as a function of ink load for different ratios of underlayer to top layer. The coating contains hydrophilic System 5 as underlayer and hydrophobic System 2 as a top layer.

It is shown that the gloss of printed areas on coatings having a hydrophilic layer on the top was independent of the ink load even at 400% of ink load. Changing the

TABLE II. Two Layer Composition of High and Low Level of Hydrophobicity. The Samples Were Imaged on Oce 5350 Printer with GS Inks.

Layers		Coat weight		Ratio	Unprinted	Black (K)	Black (C,K)
Under	Top	Under	Top			100%	400%
Phobic	Philic	10.25	6.25		87.3	86.4	87.4
Phobic	Philic	9.8	8.25		85.5	83.6	82.1
Phobic	Philic	6.5	10.75		86.4	86.7	86.7
Philic	Phobic	6.25	12.5	0.50	86.6	86.9	27.8
Philic	Phobic	7.25	7.5	0.97	84.9	84.1	17.8
Philic	Phobic	10.75	6.5	1.65	86.6	88.5	25.1



Figures 3 and 4. Gloss of two layer coatings as a function of hydrophilic underlayer to hydrophobic top layer.

order of coatings with a hydrophobic layer on the top brought about completely different phenomenon. All images had high gloss at 100% ink load but a very low gloss at 400% ink load. The gloss drops about 60 points.

Another set of experiments was carried out with a broad ratio of hydrophilic underlayer to hydrophobic top-layer. The total coat weight of two layers was in the range of 12 – 15 g/m². It was found that a higher variation in total coat weight could significantly change flow and absorption of inks and consequently impact gloss. The gloss numbers as a function of ink load are presented in Figs. 1 and 2 separately for low and high ratio of under-layer and top-layer. It is seen that the image gloss decreased with ink load but was strongly dependent on the ratio of hydrophilic underlayer to hydrophobic top layer. In the extreme case gloss drops 50 points from about 85 for background white to 25 for 350 – 400% ink load.

The effect of the ratio of hydrophilic underlayer to hydrophobic top layer on gloss of printed images is better seen on Figs. 3 and 4. The gloss of background white was in a narrow range of 83 – 87 and can be said was independent of the ratio of both layers. The gloss of primary colors such as magenta and black (K100) was nearly independent of the ratio of these two layers. Green is a secondary color (200% load) of two primary colors: cyan and yellow. A small gloss reduction to about 65 was observed for an underlayer to top layer ratio of about unity. For composite black equal to 300, 350 and 400% ink load, gloss of printed areas was strongly dependent on the ratio of underlayer to top layer. A decrease in the image gloss was observed for the ratio of under-layer to top layer in the range of 0.5 – 3. The gloss of images had minimum value at equal coat weight of both layers. At high coat weight of hydrophobic layer (low ratio) severe mottle was observed at ink load 300% and up. The mottle pattern reduced gloss significantly. An increase in the layer ratio (a reduction of hydrophobic top layer and an increase in coat weight of hydrophilic underlayer) increases absorption power of the coatings. The inks cover all printed areas due to the elimination of glossy white spots and the gloss of images drops even further, reaching the minimum at a ratio of underlayer to top layer of about unity.

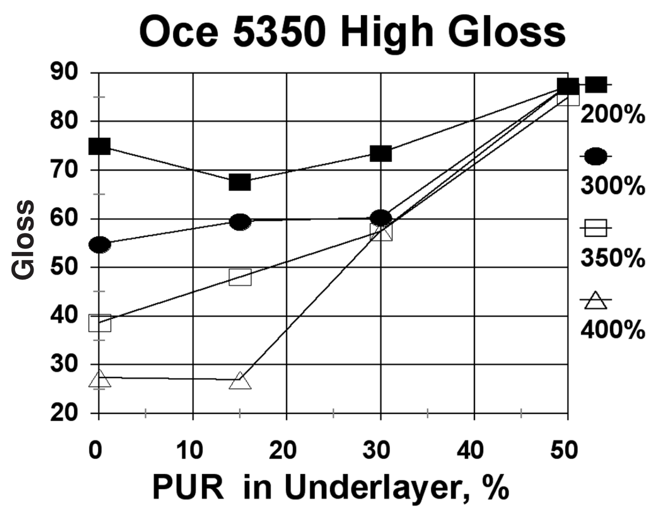


Figure 5. Gloss of images printed on Oce 5350 printer as a function of polyurethane content in the underlayer. The coating contains hydrophobic System 2 as a top layer.

Subsequently, higher ratios increase the gloss of images. This could be due to higher absorption power of the underlayer as determined in water absorption experiments presented above. Above a ratio of four, the gloss of printed areas again reached high values of about 75 – 80. The coat weight of the hydrophobic layer was relatively low and all inks penetrated easily to hydrophilic underlayer. The difference in expansion of both layers was minimized and gloss came back to the original level.

In another set of experiments, model systems having different amounts of polyurethane (hydrophobicity) were applied as underlayer. At 50% polyurethane by weight in the system, the underlayer achieved the same composition as the top layer. The gloss data as a function of polyurethane content in under-layer system is presented in Fig. 5. The gloss of the coating was independent of ink load when both layers had the same composition. The gloss of the printed areas decreased when hydrophilicity of the underlayer increased. The image gloss

TABLE III. Two Layers Composition of High and Low Levels of Hydrophobicity. The Samples Were Imaged on A HP 2500 Printer with Dye Inks and Back-lit Mode.

Layers		Coat weight		Ratio	Unprinted	Black (K)	Black (C,K)
Under	Top	Under	Top			100%	400%
Phobic	Philic	10.25	6.25		87.3	79.0	82.0
Phobic	Philic	9.8	8.25		85.5	77.9	80.0
Phobic	Philic	6.5	10.75		86.4	81.1	79.8
Philic	Phobic	6.25	12.5	0.50	86.6	81.0	43.2
Philic	Phobic	7.25	7.5	0.97	84.9	80.4	38.5
Philic	Phobic	10.75	6.5	1.65	86.6	82.7	50.9

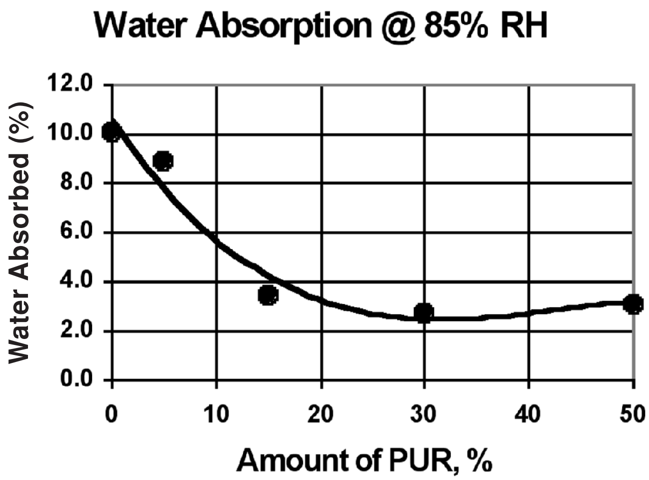


Figure 6. Water absorption of single layer coatings depending on the amount of polyurethane.

of the coating with an under-layer containing 30% PUR (System 1) drops 25 points at 400% ink load while the gloss of images printed on a coating with an underlayer containing 15% of PUR (System 3), drops even more (60 points from 85 to 25). The systems with 15% polyurethane and lower give the same values of gloss drop as an underlayer without polyurethane.

At an ink load level of 300%, gloss changes are much smaller and gloss stabilizes at the level of 55 – 60 for PUR content in the underlayer below 30%. It is well seen that hydrophobicity of the under-layer has to match closely with hydrophobicity of top layer to minimize variation of gloss at different ink loading. For a hydrophobic top layer, the higher the hydrophilicity of under-layer, the greater the variation in gloss at high ink loads.

Figure 6 shows water absorption data for single layers with different amounts of polyurethane. The samples were coated on polyester film instead of photobase (coat weight 20 gsm) and conditioned at 30°C and 85% relative humidity for 42 h to obtain a broader range of water absorption. A drop of 6 – 7% water absorption was observed for zero to 15% of polyurethane in the coating. From this point water absorption is nearly independent of the percentage of PUR in the system. Water absorption was four times higher for hydrophilic system than for hydrophobic

The variation in gloss of printed areas were observed for the polyurethane range of 15 – 50%, while water absorption changed in the polyurethane range of 0 – 15%. It means that gloss changes are probably caused by other factors than difference in water absorption. In one of the following sections we will discuss changes in polymer matrix and its influence on gloss.

HP 2500 Printer with Dye Inks

Two layer model coatings having the most hydrophobic system as a top layer in one set of experiments and a hydrophilic system in the second combination were also printed on HP 2500 printer with dye inks. HP printers deposit much less inks than EnCad printers when media are imaged at high gloss mode. To have a fair comparison we imaged these samples using back-lit-printing mode. This mode is designed for high ink load images that are looked at on the non-printed side. The studied ratio of underlayer to top layer was in the range of 0.5 to 1.65. The data presented in Table III are consistent with the gloss variation of images printed on the Oce 5350 printer. The image gloss is independent of the ratio of under-layer to top layer when the top layer is hydrophilic. Reversing hydrophilic and hydrophobic layers causes significant gloss reduction.

The gloss of images printed on an HP 2500 with dye inks was studied in a broad ratio of hydrophilic underlayer to hydrophobic top layer. The gloss numbers as a function of ink load are presented in Figs. 7 and 8 separately for low and high ratio of underlayer and top layer. It is seen that gloss decreases with ink load but was strongly dependent on the ratio of hydrophilic underlayer to hydrophobic top layer. At 400% ink load the image gloss drops 55 points from about 85 for background white to 30.

The gloss of primary colors such as magenta and black (K100) rise slightly with an increase in layers ratio and leveled off at a ratio of underlayer to top layer of three. At a high coat weight of the hydrophobic top layer, banding (a print defect) is observed in the area of primary colors due to insufficient ink spread. The defect can significantly decrease gloss of printed areas. The reduction in coat weight of the hydrophobic top layer and an increase in hydrophilic underlayer increases the dot size completely covering the printed area. Consequently, the image gloss increases at higher ratios of underlayer to top layer. Green is a secondary color (200% load) of two primary colors: cyan and yellow. A small gloss increase is observed moving from a 0.19 to a 0.5 ratio due to the increase in dot size. However, further increase in the ratio shows a moderate drop in gloss to about 50-55.

A significant decrease in gloss is seen for prints imaged with 300, 350 and 400% ink load. Once again a small peak in gloss is observed for a ratio of under-layer to top-layer of 0.5 due to better ink spread. Above this point gloss drop 40 points and stabilizes at this level of 30- 40 for a ratio of underlayer to top layer of two and higher. We did not observed an increase in gloss at a high ratio of underlayer to top layer. This may be due to differences in ink load between the HP printer and the

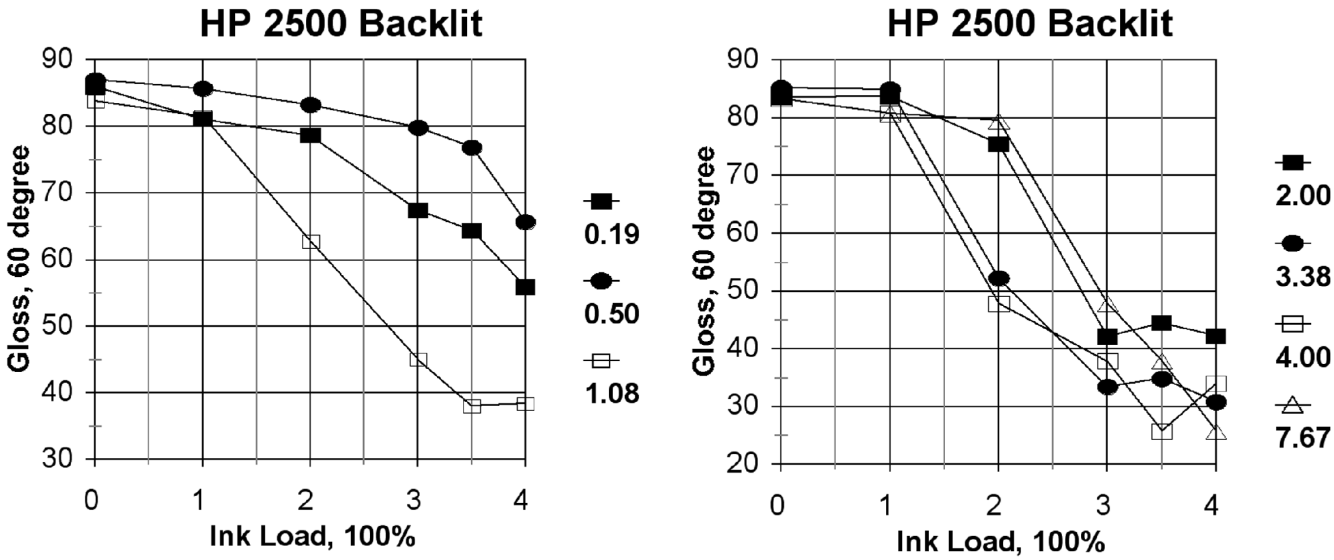
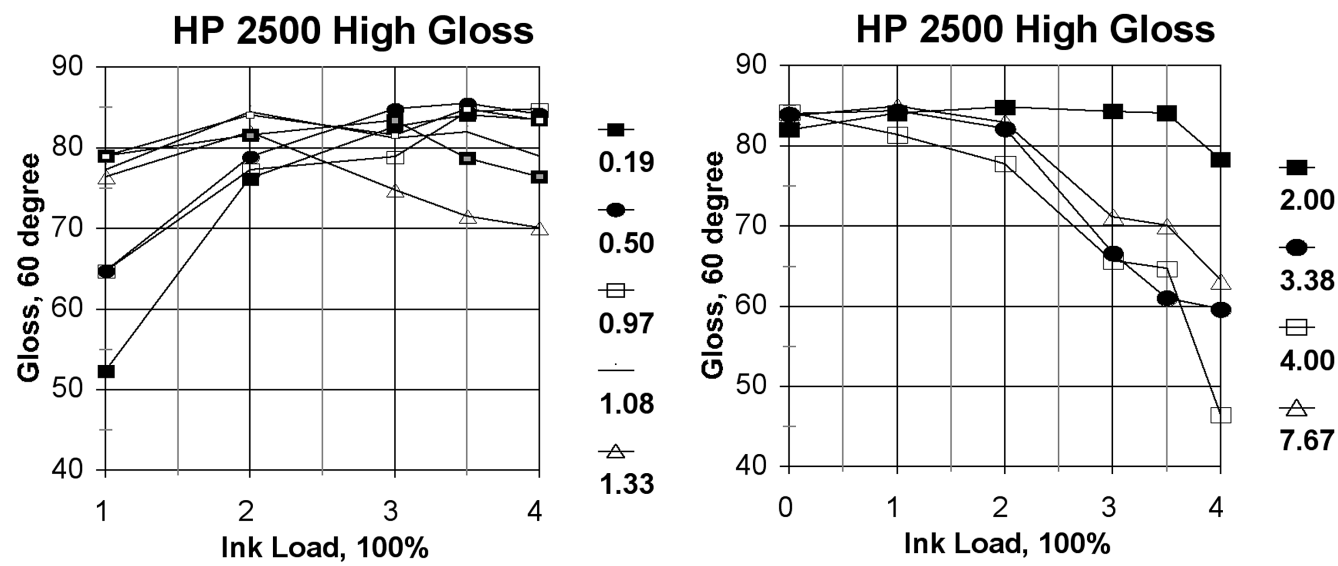


Figure 7 and 8. The Gloss of images printed on a HP 2500 printer using back-lit mode as a function of ink load for different ratios of underlayer to top layer. The coating contains hydrophilic System 5 as underlayer and hydrophobic System 2 as a top layer.



Figures 9 and 10. Gloss of images printed on HP 2500 printer using high gloss mode as a function of ink load for different ratios of underlayer to top layer. The coating contains hydrophilic System 5 as underlayer and hydrophobic System 2 as a top layer.

Oce 5350. The surface tension and differences in the chemistry of the inks could also play a role.

Coated samples were also imaged on an HP 2500 printer using the high gloss photobase printing mode. Hewlett Packard optimized the mode to achieve best resolution for most commonly used photobase. The gloss data as a function of ink load are presented in Figs. 9 and 10.

It is seen that image gloss is both dependent on ink load and the ratio of underlayer to top layer. The gloss of primary colors such as magenta and black (K100) rise significantly with an increase in layers ratio. The gloss of magenta increases from 50 – 55 range at a ratio of underlayer to top layer of 0.2 and levels off at the level of 85 similar to background white at a ratio of 1.5-2. The gloss of images printed with black ink (not seen on figures) increases to the level of 95 (10 points higher than background) due to a nature of black ink. At a high coat weight of hydrophobic top layer, the size of ink dots is very small and this creates print banding (invisible areas of white background and color dots). The reduction of coat weight of the hydrophobic top layer and an increase of the hydrophilic underlayer increases the dot size, allowing for complete coverage of the printed area. Consequently, gloss increases at a higher ratio of underlayer to top layer. Since less ink is loaded on media using the high gloss photobase mode than when using the back-lit mode, the gloss increase is more pronounced.

A small boost in gloss is observed for secondary color green with an initial increase in the layers ratio, but above the ratio of two, gloss stabilizes at the same level

TABLE IV. Two Layers Composed of High and Low Levels of Hydrophobicity. The Samples were Imaged on a HP 2500 Printer with Pigmented Inks.

Layers		Coat weight		Unprinted	Black (K)	Black (C,K)
Under	Top	Under	Top1		00%	400%
Phobic	Philic	10.25	6.25	87.3	31.4	30.0
Phobic	Philic	9.8	8.25	85.5	28.0	27.5
Phobic	Philic	6.5	10.75	86.4	31.4	29.2
Philic	Phobic	6.25	12.5	86.6	46.3	39.0
Philic	Phobic	7.25	7.5	84.9	39.0	29.9
Philic	Phobic	10.75	6.5	86.6	40.2	34.0

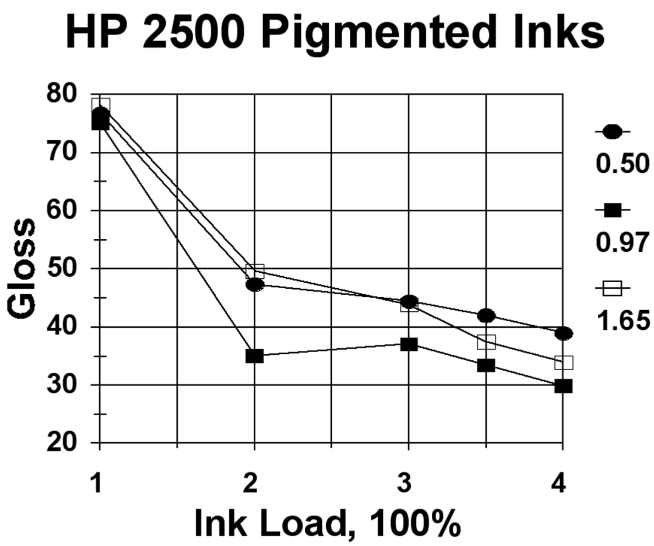


Figure 11. Gloss as a function of ink load for different ratios of under-layer to top layer.

as the background white. The gloss of composite black is strongly dependent on the ratio of underlayer to top layer and drops to 60 at a ratio above three. However, due to lower ink load the decrease in gloss of images is less dramatic (to 60 instead of to 20 as in the case of back-lit mode).

HP 2500 with Pigmented Inks

Two layer coatings having hydrophobic or hydrophilic top layer were imaged on a HP 2500 printer with pigmented inks. The results presented in Table IV show that gloss of images printed at 100 and 400% ink load dropped nearly 60 points from 85 to 25 – 30. The gloss reduction was observed both for hydrophilic and hydrophobic top layers and all studied ratio of under-layer to top-layer. This is a striking difference to the gloss of images printed on the Oce 5350 printer and the HP 2500 printer with dye inks. The gloss of images printed with black ink was high and equal to the gloss of the white background independent of hydrophobicity of top layer. Additionally, the gloss of images printed with other colors was independent of ink load when the hydrophilic system was a top layer.

Some gloss variation is observed for images printed with 100% load of black ink. The gloss of images printed on a hydrophobic top layer was 10 – 15 points higher than on a hydrophilic top layer. Pigments in pigmented inks are dispersed in aqueous media and hydrophobic pigments are more compatible with a hydrophobic top layer. Consequently, the gloss of images printed at 100% ink load on a coating with a hydrophobic top layer is higher than with a hydrophilic layer. The 400% of ink load is sufficiently high that any difference in coating hydrophilicity disappears and both systems have the same low gloss.

Figure 13 shows the gloss of images as a function of ink loads. Primary colors magenta (100%) and green (200%) were used as examples of ink load. The gloss of magenta is significantly higher than single black and in the range of 75 – 80. A steady drop of gloss is seen with an increase in ink loads. It is worth mentioning that the same coatings imaged on a HP 2500 printer with dye ink had significant drop in gloss with ink loads of between 300 and 400%.

Khoultchaev and Graczyk[14] reported a change in gloss of glossy media imaged on printers with pigmented inks. The gloss of single layer model systems was dependent on pH and hydrophilicity of the coatings. The two layer coatings bring additional factor to this equation. The comprehensive study of the effect of pigmented ink on the gloss of single and double layer high gloss media is in progress and may be expected to be reported sometime in the future.

Gloss of Coated Papers and Image Gloss

The properties of the final print in traditional printing such as offset, lithography, rotogravure are a function of the ink, the substrate, the interaction between the substrate and the ink, and have been subject of numerous publications.[17–22] A number of processing problems are also linked to ink-substrate interactions.[23] However, these findings can be utilized only to a limited degree in this study due to difference in type and chemistry of inks, type of printing technique and the structure of the coating, which is pigment free and generally smooth without pores.

The differences in the gloss of images printed with ink jet dye inks on two layer coatings having more hydrophobic top layers are due to the complexity of the composition of dye inks and the polymeric matrix. Apparently, the interaction of dye inks with the resins of the coating locally changes the structure and the surface, which results in different light scattering properties of the printed area. This effect is more pronounced in the case of composite black because that area takes at least three times the amount of inks in comparison to areas of primary colors.

Khoultchaev and Graczyk[14] demonstrated that ink-coating interactions had an effect on the gloss of images. They studied gloss reduction as a function of different pH levels of the coatings. The change in the pH of coating did not have an effect on the base gloss. System having anionic polyvinyl alcohol responded to the gradual reduction of pH by increased gloss readings for both primary and secondary colors with EnCad and

HP pigmented inks. In the contrary, there were no changes in gloss for the system having cationic polyvinyl alcohol. A decrease in pH reduces the amount of negative charges in the system with anionic polyvinyl alcohol, subsequently, increasing the possibility of the (ink polymer)/(coating resins) interaction. The same correlation was made between the gloss of images and the PVOH/PUR ratio in terms of charge density in the system. Gloss readings were higher in the coatings with anionic polymer in comparison to cationic polymer. The higher the number of cationic charges in the coating the higher the coating/ink interaction.

It is important to note that the degree of interaction, e.g., gloss reduction, is dependent on the chemistry of both coatings and inks. For instance, the gloss of composite black was always lower than the gloss for primary colors in systems having a hydrophobic top layer (images printed on an Oce 5350 printer with GS inks). The difference in gloss readings between composite black and primary colors was lower for images printed on a HP 2500 with dye inks. It is well known that an HP printer loads much less ink, and the coating can absorb all the inks, while in the case of the Oce 5350 printer ink load is over the capacity of the polymeric matrix.

Shaw-Klein[4] studied dye distribution in two layer coatings using two dye fixatives, poly(vinylbenzyl trimethyl ammonium chloride) and poly(diallyldimethyl ammonium chloride). They were printed on two HP desktop ink jet printers. The effect of dye fixative placement in the coated structure (top-layer, under-layer, or through) was investigated using optical cross sectional micrographs and correlated with water fastness data. Prints were made on the films using an HP Photosmart printer (C3844A and C3845A cartridges) or a Hewlett Packard 722 or 890 printer (C1823A cartridge).

The placement of the mordant within the layer has a significant effect upon the distribution of the dyes in the structure. This is particularly apparent in the case of magenta and yellow dyes, which are strongly attracted to the dye fixatives. They are practically absent from the top-layer when dye fixative is present only in under-layer. The cyan dye, while obviously attracted to the dye fixative in the underlayer, still remains substantially distributed in the top layer.

All the inks have similar solvent mixture, so no differences in solubility or swellability of the layers should be observed for the different inks. Shaw-Klein tries to explain such differences by taking into account the molecular size, and hence mobility, of typical anionic ink jet dyes. While magenta and yellow dyes are generally fairly small molecules, cyan dyes often belong to the bridged phtalocyanine family and are of a higher molecular weight and larger size, inhibiting their ability to travel as freely throughout the swollen ink jet receiver layers.

Unlike the HP Photosmart magenta, the HP 722/890 magenta dyes do not tend to migrate to the underlayer when the dye fixatives are concentrated there. The cyan dye acts similarly to the magenta, remaining near the top surface regardless of the mordant location. The yellow dye shows more evidence of migration to dye fixative-rich areas of the film.

Conclusions

This article discusses several factors influencing the gloss of two layer high gloss ink jet media. The gloss of single layer systems of different hydrophilicity and two-layer coatings with a hydrophilic layer on the top was independent of ink loads and the ratio between both layers. However, coatings having a hydrophobic layer on the top, experienced a severe drop of gloss. The drop of gloss was dependent on ink loads and the ratio between hydrophobic and hydrophilic layers. It was demonstrated that the difference in the degree of absorption between two layers has an effect on gloss.

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