

# Fastness Properties of Ink Jet Prints on Coated Papers—Part 1: Effect of Coating Polymer System on Light Fastness

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The use of low cost coated ink jet papers as a replacement for silica coatings has become more common lately. These novel paper grades consist of components typical for conventional printing papers, but have generally been modified to improve ink jet printability. However, knowledge of the fastness properties obtained with such papers is, to date, quite limited. The objective of this study was to clarify the effects of a coating polymer system on the light fastness of ink jet prints on kaolin coated papers. This was studied with FTIR and Raman spectroscopic methods using experimental dye based inks and papers with a known composition. The data on light fastness were consistent with the hypotheses of the study. The light fastness of ink jet prints was affected by both the physical and the chemical properties of the coating. The light fastness of the prints was improved when the porosity of the coating decreased as a result of increased binder content. This behavior could be observed for all coatings independent of the polymer types. The chemical stabilization of the colorants in consequence of hydrogen bonding to coating polymers was found to improve light fastness in PVA coatings.

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## Introduction

Ink jet technology is becoming more common in small scale color printing and in low cost variable data printing applications, such as direct mail advertising. In order to produce ink jet prints with a high print quality, the use of coated papers is, as a rule, essential. Ink jet coatings based on silica pigments, a PVA binder (polyvinyl alcohol) and a cationic polymer additive are currently the state-of-the-art for coated ink jet papers. This kind of coating works very well in ink jet printing, since it is hydrophilic, highly porous and able to fix the anionic ink jet colorants. However, its high cost and relatively poor printability in other printing processes limit its usability on a larger scale. Therefore, lower cost coated grades, which would consist of the same components as conventional printing papers, would be of potential interest as an ink jet printing medium.<sup>1–3</sup>

The typical coating of conventional printing papers consists of kaolin and secondary pigments such as calcium carbonate. Latexes, such as styrene butadiene or styrene acrylate, are typical binders.<sup>4</sup> However, the conventional coatings must often be somewhat amended to improve ink jet printability, for example, by using modified conventional pigments<sup>1</sup> or special polymers.<sup>5</sup> The ink jet print quality obtained with such novel coatings

has been studied in some degree, but knowledge of the level and the underlying mechanisms of the fastness properties of ink jet prints is still rather limited. The following gives literature background to the topic.

The fastness properties of ink jet prints are controlled by the nature of the coating components, as they determine the chemical and physical environment of the colorant in the print.<sup>6</sup> The photo degradation of azo dyes usually occurs either by oxidation, reduction or by catalytic fading, with the first being the most common in the presence of light, moisture and oxygen.<sup>7,8</sup> The polymer system of the coating is one of the most significant factors affecting the fastness properties of an ink jet print, since polymers can stabilize and immobilize the colorant both physically and chemically.<sup>9,10</sup> Ink jet photo papers often contain a protective surface coating or polymer layer, which literally protects the chromophore from detrimental UV light and oxygen.<sup>11,12</sup> However, it has also been suggested that chromophores would be vulnerable to extensive gas fading (often ozonolysis) in a highly porous ink receiving layer.<sup>13</sup>

Materials with a high proportion of hydroxyl functionality, like PVA and cellulose derivatives, have been found to promote light stability. An increase in the hydrogen bonding capability of the host polymer has been found to reduce the fading of certain azo dyes.<sup>14</sup> Improved light fastness has also been explained in relation to the capability of these polymers to act as free radical quenchers.<sup>10</sup> In some cases polymers containing alkyl groups and ethyl cellulose have been found to enhance the light stability of ink pigments.<sup>15</sup> Conversely, polymers containing UV light absorbers as pendant groups, as well as styrene containing polymers, have been proved to destabilize some azo colorants.<sup>15</sup> This is also said to be the case for coating layers containing PVP

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**TABLE I. Suggested Light Fastness Mechanisms of Ink Jet Prints on Conventionally Coated Papers**

Influencing factor	Light fastness mechanism
Porosity	Protective layer
Roughness	
Dye distribution in z-direction	
Hydrogen bonding	Chemical stabilization
Dye distribution in z-direction	

and polycationic systems.<sup>7,10</sup> For example, poly-DADMAC, which is commonly used in the improvement of water fastness due to its capability to form ionic complexes with anionic dyes,<sup>4,12,16</sup> has been found to decrease the light fastness of some anionic dyes.<sup>16</sup> This behavior has been explained by the location of the colorant in the cationic coating – as the dye is fixed at the surface of the substrate it is more vulnerable to UV and thus to photodecomposition.<sup>11</sup> However, some indications on the destabilizing effect of poly-DADMAC below the surface of the substrate have been noticed as well.<sup>16</sup> In another study, the low light fastness of ink jet prints on media consisting of nitrogen-containing polymers such as PVP, has been suggested to be due to the minor aggregating tendency of nitrogen-containing dyes when they are in contact with these kinds of polymers.<sup>17</sup>

The present study is an extended version of a conference paper<sup>18</sup> presented at IS&T's NIP17. The aim is to obtain a general understanding of the effect of the coating polymer system on the fastness properties of ink jet prints on conventionally coated papers. This survey is divided into two parts; this part concerns light fastness and the second part details water fastness issues. This article is structured as follows. Firstly, the hypotheses and the experimental part of the study are presented. These are followed by results and discussion, and finally the conclusions are presented.

### Hypotheses of the Study

This study discusses the effects of the coating polymer system on the light fastness of soluble azo dyes on kaolin coated papers. Therefore, the impact of paper properties and dye-polymer interactions are of particular interest. The print quality obtained with paper grades intended to conventional printing is commonly characterized using the structural properties of the coating, i.e. roughness and porosity, as major variables. Table I summarizes the mechanisms that are expected to govern the formation of light fastness of ink jet prints based on findings taken from the literature, and is extended to include the hypothetical factors affecting these mechanisms.

Firstly, it is assumed that the coating can form a protective layer against light fading. This would mean a physical barrier against environmental factors that promote photo degradation of ink jet prints. In particular, increase in the binder content of the coating containing plate-like pigment is expected to promote the formation of the protective layer because of the denser structure of the coating. The small porosity of the coating is expected to hinder the penetration of light or oxygen to the coating layer, thus inhibiting the photodegradation of the colorants.

Secondly, it is hypothesized that coating components are able to stabilize the colorant of the ink. Polymers containing hydroxyl moieties, like PVA, are expected to form hydrogen bonds with the colorants and thus suppress photodegradation. Thus, the location of the

**TABLE II. Polymer Compositions of the Coating Colors of the Pilot Paper Set**

Paper	Binder Type	Amount [pph]	Dispersant Type	Amount [pph]
A1	PVA	5	CMC	1
A2	PVA	10	CMC	1
A3	PVA	15	CMC	1
A4	Anionic SA	5	–	–
A5	Anionic SA	10	–	–
A6	Anionic SA	15	–	–
A7	Anionic SA	20	–	–
A8	Anionic SA	10	Oxidized starch	4
A9	Weakly cationic SA	10	Weakly cationic starch	4
A10	PVA	5	Poly-DADMAC	3
A11	PVA	10	Poly-DADMAC	3

colorant in relation to the coating components is presumed to have an effect on light fastness.

### Experimental

#### Coated Papers

The focus of the experimental work is on the influences of the coating polymer system of kaolin coated papers on light fastness. Consequently, a pilot paper set was generated, where the absorption properties and the net-charge of the coatings were altered by means of variations in the polymer system, see Table II.

The coating pigment was SPS kaolin (particle size distribution  $80\% \leq 2 \mu\text{m}$ ) supplied by Imerys. The absorption properties were modified using different types and amounts of binders. These were polyvinyl alcohol PVA (Airlvol 107 from Air Products, degree of hydrolysis 98.0–98.8%), styrene acrylate latex SA (Raisional 212 from Raisio Chemicals) and weakly cationic styrene acrylate latex (Raiprint 300 from Raisio Chemicals). The net charge of the coatings and thus the propensity to bind anionic dyes was varied using different dispersants for the kaolin pigment. These were anionic carboxymethyl cellulose CMC (Finnfix 10 from Noviant), oxidized starch (Raisamyl 302 from Raisio Chemicals), weakly cationic starch (Raisamyl 402 from Raisio Chemicals) and cationic polydiallyl dimethyl ammonium chloride poly-DADMAC (Cartafix VXT from Clariant). The coating colors A1-A9 were anionic (pH 8) and the coating colors A10-A11 were cationic (pH 5). The base paper was 80 g/m<sup>2</sup> surface-sized copy paper and the amount of coating was 10 g/m<sup>2</sup>. The coating was accomplished with a pilot-scale coating machine using SDTA coating at a 45° blade angle and a coating speed of 700 m/min. All papers were uncalendered.

#### Model Inks

Three soluble azo colorants with different chemical properties were chosen for the inks. These were CI Acid Red 249 (AR 249), CI Direct Yellow 86 (DY 86) and CI Direct Violet 107 (DV 107), which is a modified direct dye with enhanced fastness properties. Detailed information on the molecular structure of AR 249 and DY 86 can be found elsewhere, i.e., from the *Colour Index*. Information on the molecular structure of DV 107 is not publicly available. The model ink formulation was 4 wt % dye, 20 wt % 2-pyrrolidone and 76 wt % distilled water. This composition was selected for the sake of simplicity. The effect of the ink solvent composition on light fastness using the same set of coated papers has been studied previously.<sup>19</sup> The influences were found to be small compared to the influence of the coating. All

**TABLE III. The Data on Paper Properties and on Light Fastness**

Paper	Porosity		Roughness		Light fastness $\Delta E^*$ (100 h)			
	Av. Pore diameter [ $\mu\text{m}$ ]	Bendtsen air perm.[ml/min]	$\theta_a$ [deg.]	Bendtsen roughness [ml/min]	Unprinted paper	AR 249	DY 86	DV 107
A1	0.099	27	4.80	90	2.32	44.70	23.92	24.98
A2	0.088	15	4.55	100	2.55	45.86	21.39	23.05
A3	0.096	8	5.35	140	3.06	43.45	15.17	21.93
A4	0.089	30	4.12	75	2.61	45.42	32.16	30.46
A5	0.085	24	4.10	60	2.79	45.61	33.42	31.51
A6	0.082	14	3.95	105	3.11	43.37	31.57	26.33
A7	0.076	5	4.18	85	3.30	38.32	26.54	21.71
A8	0.088	11	4.43	110	3.12	44.94	30.11	20.29
A9	0.089	20	4.86	115	2.12	43.03	30.56	22.43
A10	0.096	95	4.78	135	2.34	53.76	30.69	24.51
A11	0.092	75	4.97	150	2.48	49.99	22.82	20.85

colorants were purchased from Avecia Ltd. as aqueous solutions. Co-solvent 2-pyrrolidone (purity grade: purum  $\geq 99.0\%$  GC) was manufactured by Fluka and supplied by Sigma-Aldrich.

### Characterization of Coated Papers and Model Inks

The porosity characteristics of the coated papers were measured with a Bendtsen air permeability measurement device (the SCAN-P 60:87 standard) and with mercury porosimetry using an Autopore III 9410 from Micromeritics. The porosimetric parameter average pore diameter was used in the analysis of the results. Roughness was measured with a Mitutoyo SurfTest 401 profilometer and with the Bendtsen-method (the SCAN-P 21:67 standard). The profilometric roughness parameter theta angle  $\theta_a$ , which describes the mean slope of the topological profile of paper, was used in the analysis of the results. The data are presented in Table III.

The inks were analyzed to determine their pH and surface tension, using a Schott pH meter and a Sigma 70 computer-controlled automatic surface tension meter. The pH-values ranged from 7.1 to 8.1 and surface tensions from 41.5 to 58.1 mN/m. The surface tensions of the inks are relatively high, but in spite of this, surfactants were not used in order to simplify the analysis of paper-ink interactions.

### Light Fastness Test

To examine the influence of the polymer system of the coating on the light fastness of ink jet prints, solid single-color areas were printed on the experimental papers with an Olivetti JP 960 thermal ink jet printer using the model inks. Some of the printed solid areas were slightly striped. With this printer the solid area printing results in the final amount were approximately 5 g/m<sup>2</sup> of ink on the paper, which is quite a large amount compared to the current thermal ink jet printers on the market. Dye-paper and dye-dye interactions are thus both possible. In this study only dye-paper interactions are investigated.

The prints were exposed to artificial sunlight for 100 hours with a Suntest CPS+ xenon arc lamp equipped with an optical filter system, which cuts off the wavelengths below 310 nm. Test chamber settings were 615 W/m<sup>2</sup> for irradiance and 40°C for black standard temperature BST in every test. According to the data on test chamber conditions, the test chamber temperature CST remained fairly constant throughout the exposure periods, but the BST tended to rise towards the end of the runs. Relative humidity, temperature and air pol-

lutant composition in the test chamber cannot be adjusted in this test set-up. Hence, they are determined by the predominating conditions of the measurement room (RH 35%, temperature 24°C).

Color difference  $\Delta E^*$  was used as a measure of light fastness, so CIEL\*a\*b\* values were measured from the unprinted papers and prints before and after the light exposure with a Minolta CM-1000 spectrophotometer. Average values from ten measurements were used in the calculation of color differences. The data are presented in Table III. The  $\Delta E^*$  values of the unprinted papers are negligible compared to the  $\Delta E^*$  values of the printed samples, and are therefore omitted.

### Spectroscopic Measurements

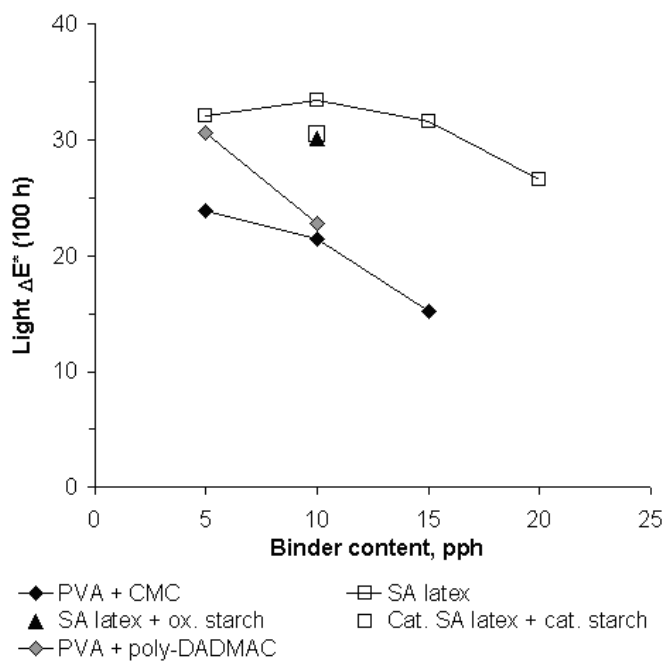
FTIR and Raman spectra of unprinted and printed samples were recorded to get more information on the chemical composition of the samples and conceivable paper-ink interactions affecting light fastness. The FTIR spectra of unprinted and printed paper surfaces were measured with a Bio-Rad FTS 6000 spectrometer using a diamond ATR microcrystal and a sampling resolution 8 cm<sup>-1</sup>. Using this method, the penetration depth of the IR beam to the coating varies between 0.2 – 1.4  $\mu\text{m}$ , depending on the wavelength, the angle of the incident light beam and the refractive indices of the ATR crystal and the sample material.<sup>20</sup> In addition, variation of the contact between the crystal and the sample surface affects the penetration depth. To improve reproducibility, several parallel measurements were made from each sample and the spectra were averaged. Raman depth profiling<sup>21</sup> of the prints was accomplished with a dispersive Kaiser Raman Hololab 5000 spectrometer using 785 nm laser wavelength, a 100 $\times$ -immersion objective, a spectral resolution of 4 cm<sup>-1</sup> and a depth profiling step of 1  $\mu\text{m}$ . Intensive fluorescence complicated Raman measurements and interpretation of the spectra.

## Results and Discussion

### Effect of Physical Properties of the Coating

Measured paper properties and calculated light fastness values after 100 h exposure for the polymer set are presented in Table III.

The results of the light fastness tests show that an increase in the amount of binder generally improves light fastness independent of the type of binder or dispersant. An example of this is presented in Fig. 1. However, the level of light fastness and the ranking of the coating types appear to be dependent on the specific colorant-coating



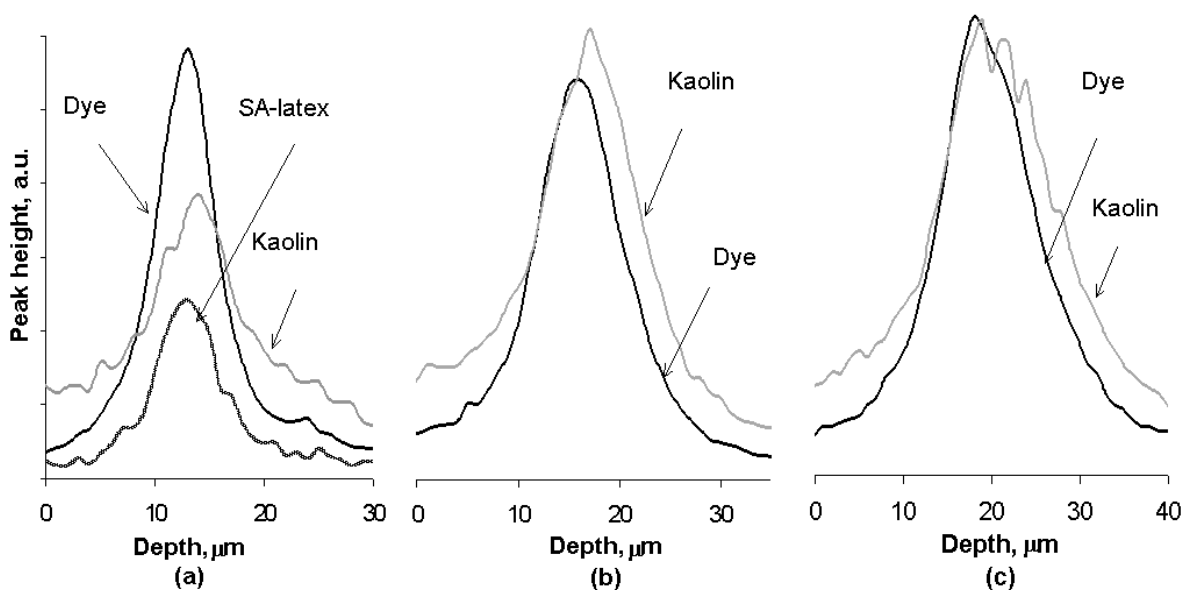
**Figure 1.** Effects of coating polymer system on light fastness of direct dye DY 86 after 100 h light exposure.

interactions. Depending on the dye type, the lowest light fastness is obtained either with cationic PVA-poly-DADMAC coating or with the anionic SA latex coating. In contrast, the highest light fastness is generally obtained with anionic PVA-CMC coatings. The use of starch in latex coatings has a beneficial influence on light fastness compared to plain anionic latex coatings. In addition to the distinctions between the coating types, there were also differences between the colorants. The acid dye AR 249 was clearly less stable than the direct dyes DY 86 and DV 107, whose light fastnesses were almost equal.

Raman depth profiles measured from the DV 107 prints on various coating types, presented in Fig. 2, give an indication of the location of the colorant in the coating layer. As graph (a) in Fig. 2 suggests, the colorant is located primarily among the binder in the anionic SA latex coating, as the distributions of the colorant and the SA latex are coincident. The PVA binder cannot be detected in the Raman-spectra of the prints since it is a weak Raman scatterer whose bands overlap substantially with the other coating components and the colorants. Graphs (b) and (c) in Fig. 2 indicate, nevertheless, that the distributions of the colorant and the kaolin are not coincident, which implies that the dye is not located primarily among the kaolin pigment.

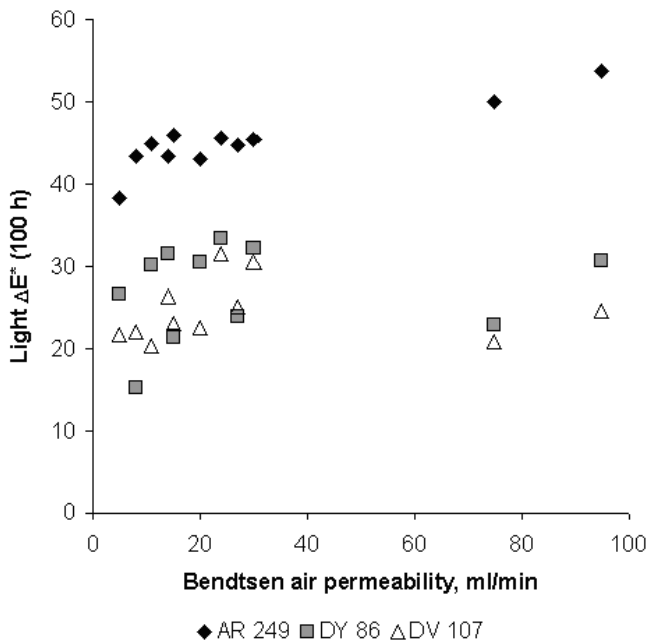
The coating polymer system thus inevitably has an effect on both the physical and chemical environment of the colorant. Therefore, the effect of the binder content on light fastness can be explained with reference to both the structural and the chemical properties of the coating. In this study, the porosity and roughness of the coating are used as structural variables. The porosity of the coating, manifested by Bendtsen air permeability and average pore diameter, decreases as binder content increases. The data presented in Table III suggest that light fastness generally deteriorates slightly as porosity of the coating increases. This is shown for instance in Fig. 3, which presents the relation of Bendtsen air permeability and light fastness for all colorant-coating combinations. However, as the data suggests (Table III), for each colorant type the level of light fastness depends also on the coating polymer system.

The Raman depth profiles in Fig. 4 illustrate the effect of the binder amount on the light fastness of an anionic azo dye. The example is for SA latex coatings. At SA latex contents of 10 pph, light exposure of the print results in distinct decomposition of the dye. However, as SA latex content increases to 20 pph, more dye remains in the coating. As was previously discussed, this can be partly related to the porosity of the coating, which decreases as binder content increases. The research



**Figure 2.** Distributions of modified direct dye DV 107 (a) on anionic SA latex paper (b) on anionic PVA-CMC paper and (c) on cationic PVA-poly-DADMAC paper. Binder amount is 10 pph in every case.





**Figure 3.** The relation between porosity of the coating and light fastness for all colorant-coating combinations.

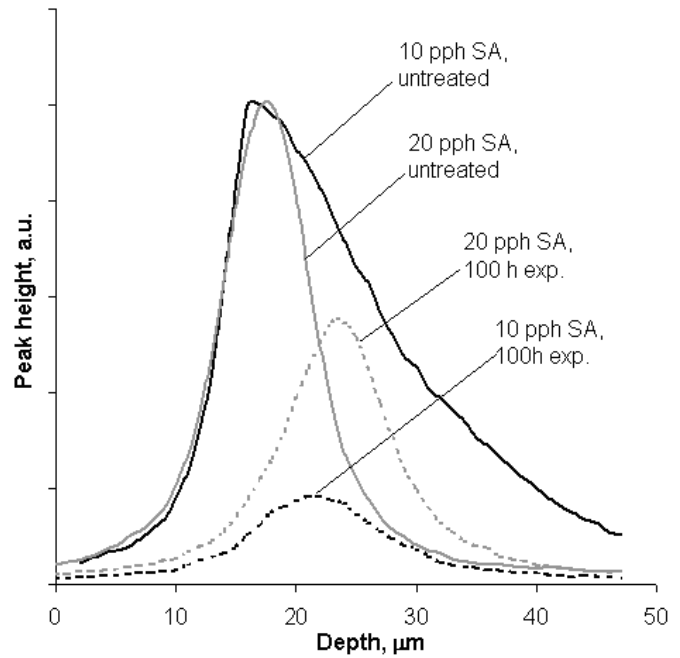
would suggest that at high SA latex contents there are less possible locations where the colorant is vulnerable to environmental factors. This supports the idea that dense coatings could act as a protective layer against light fading.

On the other hand, the effect of the roughness of the coating on light fastness is not completely unambiguous. Roughness and porosity are in fact interdependent, as Table III indicates: roughness increases along with porosity. In spite of this, an increase in roughness only slightly improves the light fastness of DY 86 and DV 107 colorants, whereas no manifest trend can be observed for AR 249, see Fig. 5.

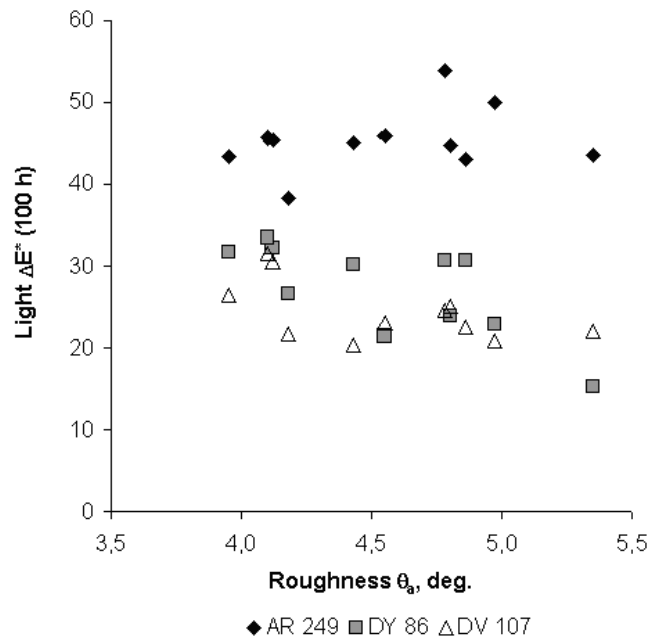
### Chemical Paper-Ink Interactions on PVA Coatings

The results presented in Fig. 1 suggested that an increase in the binder content acts by improving light fastness. PVA was expected to form hydrogen bonds with the azo colorants and thus suppress photodegradation. This was studied in more detail with FTIR spectroscopy. Figure 6 presents the OH stretching region of hydroxyl groups of the FTIR-ATR spectra of unprinted and printed PVA coatings, whose binder contents are 5 and 15 pph. The spectra were scaled to the kaolin band at the wavenumber  $3686\text{ cm}^{-1}$ .

In the case of a 5 pph unprinted PVA coating, the main absorption is located at wavenumber  $3359\text{ cm}^{-1}$  and its shoulder at  $3430\text{ cm}^{-1}$ . These are most likely due to the hydrogen bonds in the PVA network (self-association) and interactions between PVA and other coating components, respectively.<sup>22</sup> As binder content is increased from 5 to 15 pph, it is evident that the band at hydroxyl self-association area increases in intensity and shifts to a smaller wavenumber ( $3330\text{ cm}^{-1}$ ). This indicates increased PVA-PVA interaction.

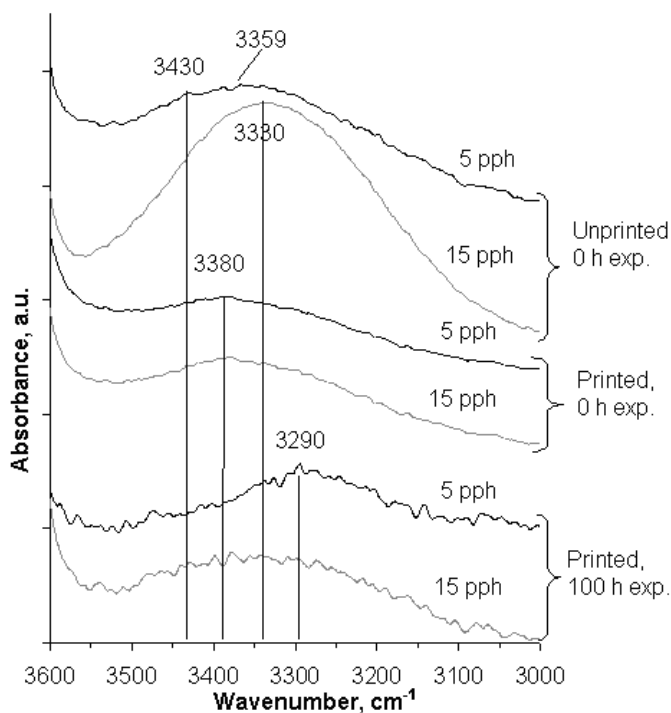


**Figure 4.** Dye distributions (DY 86) on SA latex coatings before and after light exposure.



**Figure 5.** The relation between roughness  $\theta_a$  and light fastness for all colorant-coating combinations.

As a result of printing, the center point of the OH stretching band is shifted to the wavenumber  $3380\text{ cm}^{-1}$  in both unexposed coatings (5 and 15 pph binder contents). This indicates the presence of colorant-polymer interaction (hydrogen bonding)<sup>22</sup> and diminished PVA-PVA interaction. After 100 hours light exposure the OH stretching band of the 5 pph PVA coating has shifted towards smaller wavenumbers, so that the main ab-

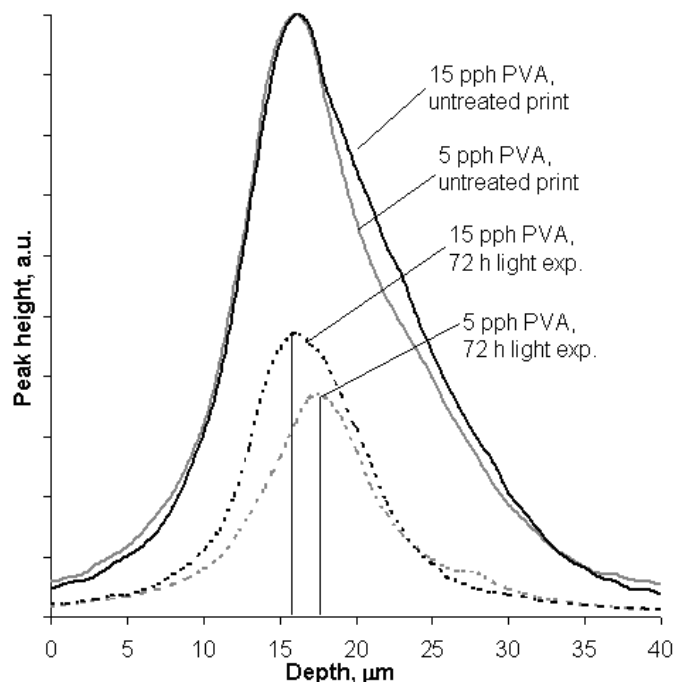


**Figure 6.** FTIR-ATR spectra of unprinted and printed (AR 249) PVA coatings. The spectra have been shifted vertically for clarity.

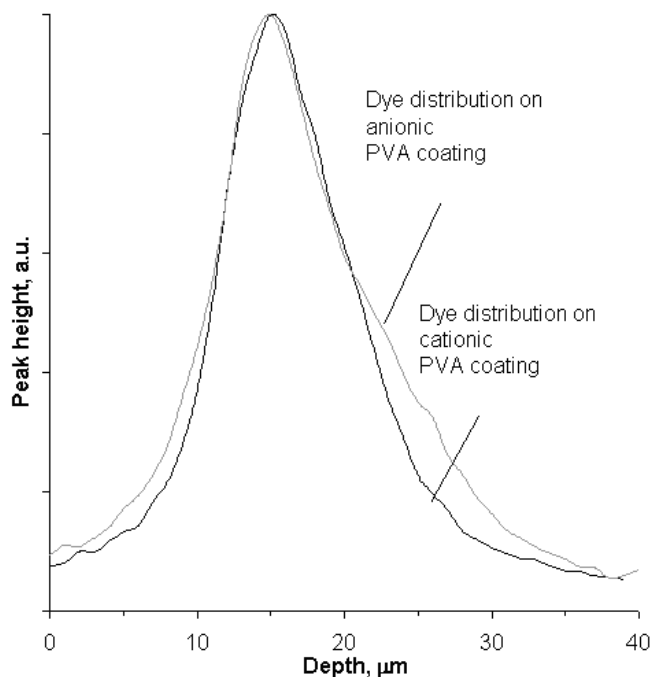
sorption is at the wavenumber  $3290\text{ cm}^{-1}$ . However, in the case of 15 pph PVA coating, the OH stretching band is much broader than in the case of the 5 pph PVA coating, and it resembles that of an unexposed print. This suggests that the increase in the PVA content of the coating increases colorant-polymer interaction (in this case hydrogen bonding).

Another illustration on the effect of the PVA amount on the light fastness of an anionic azo dye is shown in the Raman depth profile of Fig. 7. At PVA contents of 5 pph, light exposure of the print results in the decomposition of the dye, especially from the surface layers of the coating. This is seen as a shift of the dye maximum deeper into the coating. As the amount of PVA is increased from 5 to 15 pph, more dye remains in the surface layers after light exposure, although the total amount of dye in the print is decreased. A comparison of anionic and cationic PVA coatings (Fig. 1) reveals that light fastness is slightly worse with cationic (PVA-poly-DADMAC) coatings when AR 249 or DY 86 is used. In the literature<sup>11</sup> the detrimental effect of polycationic systems on the light fastness of dye based ink jet prints has been explained by the location of the colorant in the cationic coating – as the dye is fixed at the surface of the substrate it is more vulnerable to photodegradation. However, according to the Raman depth profiles presented in Fig. 8, there are only minor differences between the locations of the dye distributions on anionic and cationic coatings.

The porosity data in Table III indicates that the Bendtsen air permeability of cationic PVA-poly-DADMAC coatings is clearly larger than that of an anionic PVA-CMC coating, despite their similar pore diameters. It has been suggested in the literature<sup>13</sup> that in a highly porous ink-receiving layer the chromophore would be vulnerable to extensive gas-originated fading. On cationic PVA-poly-DADMAC coatings the dye mol-

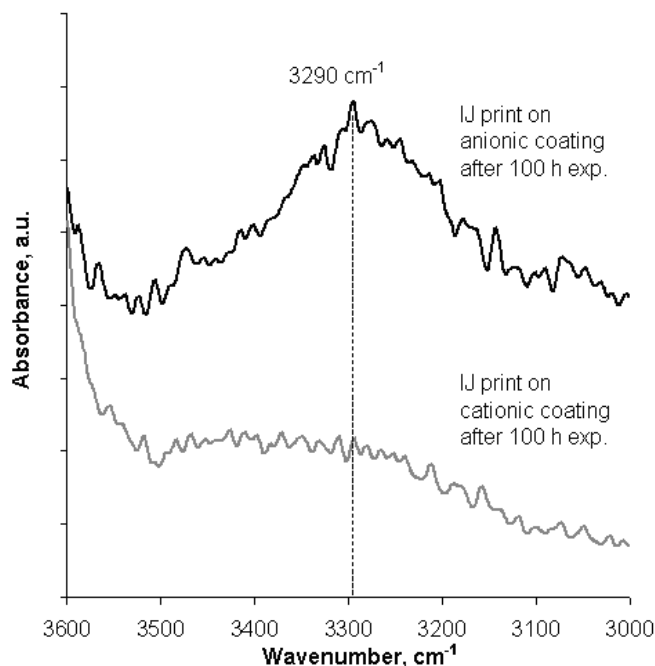


**Figure 7.** Dye (DY 86) distributions on PVA coatings before and after light exposure.



**Figure 8.** Dye distributions (DY 86) on anionic and cationic PVA coatings before fastness tests.

ecules may also have a weaker tendency to form hydrogen bonds with coating components than with anionic PVA coatings. This is because the attraction between anionic dye and cationic poly-DADMAC is stronger than the attraction between OH and NH groups of the dye

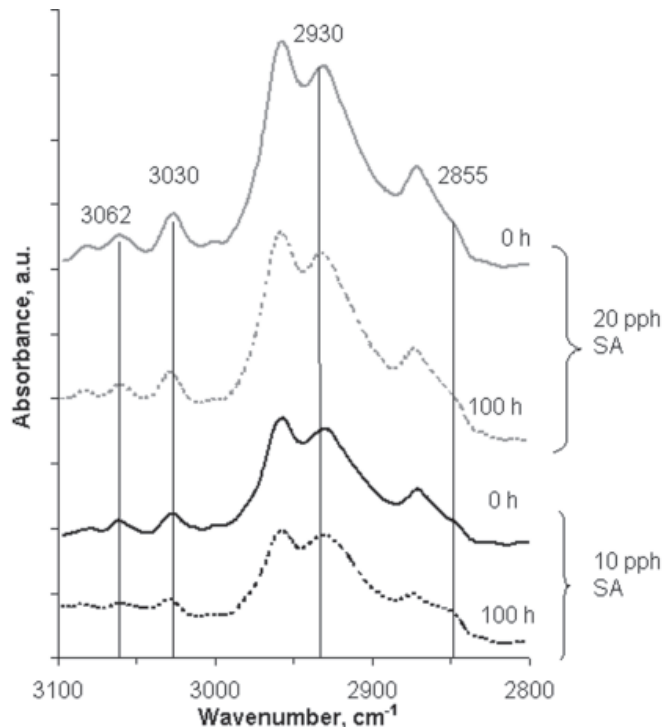


**Figure 9.** FTIR-ATR spectra of printed (AR 249) anionic and cationic PVA coatings after 100 h light exposure. The spectra have been shifted vertically for clarity.

and OH groups of the coating. Indications of this can also be seen from the FTIR spectra presented in Fig. 9, which illustrates the OH stretching region of printed anionic and cationic PVA coatings after 100 h light exposure. As previously, the spectra were scaled to the kaolin band at the wavenumber 3686  $\text{cm}^{-1}$ . It is evident that after 100 h light exposure the broad band in the wavenumber region 3500–3000  $\text{cm}^{-1}$  is more intensive in the case of anionic coating. This indicates that there are more hydrogen bonds present on the anionic coating than on the cationic coating.

### Chemical Paper–Ink Interactions on SA Latex Coatings

The data presented in Table III indicate that the light fastnesses of DY 86 and DV 107 on anionic SA latex coatings are lower than on PVA coatings. In general, at certain binder levels SA latex coatings have a slightly smaller average pore diameter but larger Bendtsen air permeability than anionic PVA coatings. It has been found<sup>15</sup> that polymers bearing UV light absorbers as pendant groups, as well as styrene-containing polymers, destabilize some azo dyes. This was explained with a possible radical formation as a result of reaction between an excess of phenyl groups in the resin matrix and excited oxygen molecules. Figure 10 presents the CH stretching region of the FTIR-ATR spectra of unprinted SA latex coatings with 10 and 20 pph binder contents. The spectra were scaled to the kaolin band at the wavenumber 3686  $\text{cm}^{-1}$ . In the case of the 20 pph SA latex coating, the band intensities at the wavenumbers 3062 and 3027  $\text{cm}^{-1}$ , representing aromatic CH stretching of the benzene ring<sup>23</sup> in the styrene moiety, do not markedly change as a result of light exposure. In contrast, in the case of the 10 pph latex coating, they seem to diminish as a result of light exposure. Additionally, the intensities of the bands at



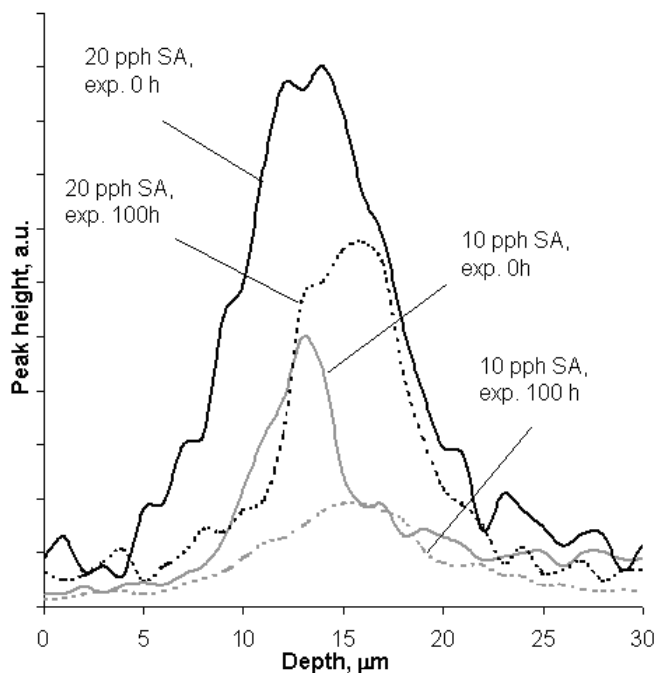
**Figure 10.** FTIR-ATR spectra of unprinted SA latex coatings before and after light exposure. The spectra have been shifted vertically for clarity.

2930 and 2855  $\text{cm}^{-1}$  assigned to asymmetric and symmetric CH stretching of  $\text{CH}_2$  groups<sup>23</sup> increase slightly in the 10 pph SA coating, whereas they remain unchanged in the spectra of the 20 pph SA coating. These changes suggest that at lower amounts of SA latex in the coating the aromatic styrene moieties of the latex decompose as a result of light exposure and aliphatic hydrocarbons are formed instead.

An FTIR study<sup>24</sup> has shown that in the case of uncoated papers made from mechanical pulps, UV light is responsible for changes in the aromatic structures. This was manifested by a decrease in the intensity of the band at 1510  $\text{cm}^{-1}$ , which represents aromatic ring CH stretching. Typical photosensitizers in pulp and paper include i.e., entities containing aromatic and conjugated carbonyl groups, and double bond structures.<sup>25</sup> The effect of light exposure on the styrene content of the coating can be seen also from Fig. 11, which presents the distributions of SA latex in coating measured with Raman spectroscopy. The distributions in Fig. 11 represent the intensity of the styrene band at 999  $\text{cm}^{-1}$ , which can be associated with symmetric ring breathing of the benzene ring.<sup>23</sup> It is evident that the styrene content of the 10 pph coating is reduced by almost half as a result of light exposure, whereas in the case of the 20 pph coating, the effect is not so marked.

### Conclusions

The purpose of this paper was to gain an understanding of the effects of coating polymer systems on the light fastness of ink jet prints on coatings consisting of the same components as conventional printing papers. This was studied with FTIR and Raman spectroscopy, using dye based model inks with known composition and a



**Figure 11.** Latex distributions of printed SA latex coatings before and after light exposure. Solid lines denote untreated samples and dotted lines light-exposed samples.

set of kaolin coated pilot papers, which had the composition of the polymer system as a variable.

The data on light fastness were consistent with the hypotheses of the study. The presumption that the coating would be able to form a protective layer against environmental factors that promote light fading was found to hold true for all colorant-coating combinations. This could be related to a decrease in the porosity of the coating due to an increase in the binder content. The role of the roughness of the coating was not manifest.

Chemical stabilization of the colorants was assumed to occur with coating polymers containing hydroxyl moieties. In the case of anionic PVA coatings this hypothesis proved to hold true. Moreover, the deteriorated light fastness of the studied dye based inks on cationic PVA coatings was postulated to be associated with a lesser amount of hydrogen bonding between the dyes and PVA. Spectroscopic measurements on anionic styrene acrylate latex coatings showed some indications

of decomposition of the styrene moiety as a result of light exposure.

Summarizing, the light fastness of ink jet prints could be affected by both the physical and chemical properties of the coating. This study also gave indication that the light fastness of ink jet prints on papers consisting of the same components as conventional printing papers is governed by the same mechanisms that have been suggested for special ink jet papers. These results can be utilized in the development of low cost coated ink jet media. ▲

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