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THE EFFECT OF PIGMENTS AND BINDERS ON INKJET PRINT QUALITY

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ABSTRACT

The effect of silica and calcium carbonate pigments, polyvinyl alcohol and cationic starch binders combined with high-cationic polymers on physical-chemical and printing properties of coated papers were studied. The best printing properties were obtained with coating colour based on silica. Colour gamut significantly improved when the inkjet ink contact angle decreased below 15°. The water fastness was influenced with specific charge density of coating colour. Application of silica provided papers with the largest inkjet ink wetting, colour gamut area, print sharpness and surface roughness. By using of polyvinyl alcohol a high colour gamut area was reached but it resulted in a low print sharpness in comparison with cationic starch. High-cationic polymer poly-DADMAC showed a more significant effect on all printing properties of coated paper in comparison with SMAI 1000. The final inkjet print quality depends on structural and chemical properties of coating.

KEYWORDS: Coating colour, inkjet, printing properties, wettability, cationic polymer, pigments, binders.

INTRODUCTION

In this work we tried to obtain higher quality inkjet papers by coating. High quality images demand bright colours and excellent reproduction of colour tone. Increased trend for use of aqueous-based inkjet inks occurs in high-speed commercial printing. This challenges the hydrophilic and absorptive properties of paper surface. It is desirable during printing process that water part of ink absorbs rapidly into the porous structure of paper. However, excessively rapid absorption of ink into paper could lead to poor optical density. At the other side, too slow absorption leads to edge raggedness, line broading and colour bleeding. Proper ink absorption rate as well as surface smoothness could be reached by paper surface treatment as coating results in a higher colour gamut area, lightness and print sharpness of the paper. A coating layer covers base paper fibres to give a uniform surface. By coating, the optimal contact angle of ink wetting can be reached. The initial contact angle should be high enough to prevent lateral "spreading". The contact angle decreases within time to guarantee a fast rate of drying which minimizes the mixing of ink dot with adjacent dots. By coating low porous papers are obtained which prevent drop penetration of dye into coating whereas water is being preferentially absorbed. It was found that coating with pores up to 0.1 µm absorbs dyes slowly, whereas pores within range 0.1-1.0 µm can cause absorption of the part of dye below coating surface and this may result in a decrease of optical density (Morea-Swift and Jones 2000). The importance for colour purity is homogenous dye "spreading" on the paper surface. Thus parameters contact angle between paper and ink dye as well as porosity have the most significant effect on inkjet paper print quality.

Two basic type of coatings, microporous and swellable, are used, whereby each of them have their own advantages and disadvantages. Silica has become one of the leading pigments due its superior properties in terms of controlled particle size distribution, surface area and pore size distribution. Due to porous network on the surface the dye is rapidly separated from the solvent. Additionally it helps provide a thin absorbing surface layer in which can ink spreads. This results in enhanced colour brightness and purity. At the same time it prevents paper cockle during printing process. However, due a high pore volume of pigment, a large amount of energy for drying is required. Another drawback is higher price and due to rheology is only used in roll blade or air-knife coating installation. Thus the effort is to substitute silica pigments by other pigments.

As the alternative pigments are used clays (Prakash and Devisetti 2005, Cawthorne et al. 2003), calcium carbonate (Cody 1999, Gane 2001a, b), precipitate calcium carbonate (Pelto 2006, Donigian 2005) and zeolites (Rooks 2004). The dye adsorption mechanism of calcium carbonate is different from silica; silicates quickly extract solvent, whereas calcium carbonate directly anchors the dye on pigment surface, so that solvent is transported into the base paper.

Print quality is defined by many parameters: print sharpness, colour gamut area, optical density and water fastness of printed colour areas. These parameters are affected by fibre composition of the base paper. At previous work we found that the contact angle of ink is a suitable proper parameter for colour gamut prediction of surface sized paper. The print sharpness was significantly affected by the presence of high-cationic starch as well as surface roughness of paper (Gigac et al. 2014, 2015). For a high water fastness and print sharpness, the fixation of anionic dye is important, which forms the complex with cationic polymer. During printing process, the attachment of dye is needed on top layer of paper substrate and other components of ink entering deeper region of paper structure.

The ink penetration depth and speed depends also on binder type. Polyvinyl alcohol (PVOH) is a commonly used binder which produces sufficient surface strength of coating layer. PVOH which forms a film on top of coating layer, is being shear and thermally stable and absorbs water in polymer matrix. Its polymerization degree determines binding strength, a high degree of polymerization prevents coating before the peel effect. Molecular weight of PVOH affects the rheological properties of coating colour and binding strength, polymerization degree effects optical density and printability. It has a swelling effect during printing process and it results in closeness of the intra-pores pigment. The disadvantage of aqueous PVOH solution is its difficult dissolution and high viscosity. Another disadvantage of using PVOH is that it covers the pigment surface and can mask any surface cationicity of the pigment.

Cationic starch as another type of binder helps to fix dye on paper surface and defines the diffusion of ink into paper. Surface tension decreasing of paper helps to prevent ink bleeding and edge reggedness.

Cationic polymers made of cationic charge of coating resulted in better interaction with anionic dyes of inks. The result would be a higher optical density and water fastness of printed colour areas. Poly-DADMAC is often used in inkjet coating formulation. Such papers show superior water fastness and low ink bleeding. On the other side, possible rigid coating structure that can crack upon drying was found (Rich et al. 1999). Styrene maleic anhydride imide resin SMAI is low molecular weight cationic polymer which is supposed to introduce a controlled degree of flocculation in the coating colour.

The goal is testing of the influence of pigments, binders and cationic polymers on surface roughness and porosity, wetting, colour gamut area, water fastness and print sharpness.

MATERIAL AND METHODS

Base paper

Commercial paper from 100 % virgin fibres of basis weight 157 $g.m^{-2}$.

Testing liquid

De-ionized water, 16 % isopropyl alcohol (IPA), water-based inks CMYK and pigmented black ink.

Coating colour and coating

In experiment, the pigment of silica Gasil 23F (PQ Corporation, USA) and calcium carbonate Precarb 800 (Schaefer Kalk) were used. Silica pigment Gasil 23 F has an average particle size 5.9 µm, pore volume 1.6 $ml.g^{-1}$, surface area 349 $m^2.g^{-1}$ and controlled particle size distribution. Precipitated calcium carbonate Precarb 800 of disc shape has average particle size 0.5 µm and surface area 17 $m^2.g^{-1}$. As binders were used cationic starch KS (Cerestar SP 05855, Cerestar); polyvinyl alcohols Mowiol 28-99 (Kuraray Specialisties Europe) and Mowiol 26-88 (Hoechst). As cationic polymer were used poly(diallyldimethylamonium chloride) poly-DADMAC (Aldrich) and styrene maleic anhydride copolymer with styrene/maleic anhydride ratio 1/1 SMAI 1000 (Cray Valley). The addition of binders per pigment was 30 %.

The silica coating colour was prepared from 30 % aqueous solution of Mowiol 28-99, which was mixed with Despumol 7401 and after cooling of this solution less than 40°C, poly-DADMAC was added with required amount of water to get desired concentration of coating colour. GASIL 23 F was gradually dispersed at intense mixing into prepared solution.

The calcium carbonate coating colour was prepared in turbine air stirring apparatus type Dissolver from 60 % aqueous dispersion of Precarb 800 with addition of 0.5 % anionic polyacrylate dispersing agent Polysalz CAL and of 0.1 % NaOH. Into a stirred suspension were added Despumol 7401, Mowiol 26-88 and cationic polymer poly-DADMAC (20 % aqueous solution) or SMAI 1000 (25 % aqueous solution). After 30 min of stirring, the pH was adjusted to 9.5.

Coating colours were applied on the paper surface by the laboratory coater DOW CHEMICALS (system Trailing Blade) with the knife of thickness 0.3 mm. The deposit of coating (10-15 $g.m^{-2}$) was regulated with air pressure at the knife 60-120 kPa, with the rate of supporting roll 60 $m.min^{-1}$ depending upon corresponding viscosity of coating colour. Coated paper was dried in a laboratory owen with air circulation at temperature 140°C within time 3 min. After drying, coated papers were loaded for cockle elimination, occurring at one-side coating. The composition and properties of coating colours are in Tabs. 1 and 2.

Tab.1: The composition and properties of silica coating colour.

Materials (*% per pigment*)	**G1**
Gasil 23F	100
PVOH (Mowiol 28-99)	30
Poly-DADMAC	2.5
Despumol 7401	0.02
Solids, %	20.4
Viscosity Brookfield (100 rpm, 23°C), (mPa.s)	1525
pH	5.28
Coat weight, (g.m^{-2})	13.10
Specific charge density, (μeq.g^{-1})	+ 11

Tab. 2: The composition and properties of calcium carbonate coating colours.

Material (*% per pigment*)	**P1**	**P3**	**P0-S**	**P1-S**	**P3-S**
Precarb 800	100	100	100	100	100
NaOH	0.1	0.1	0.1	0.1	0.1
Polysalz CAL	0.5	0.5	0.5	0.5	0.5
PVOH Mowiol 26-88	30	30	0	0	0
Cationic starch (Cerestar SP 05855)	0	0	30	30	30
Despumol 7401	0.01	0.01	0.01	0.01	0.01
Poly-DADMAC	2.5	0	0	2.5	0
SMAI 1000	0	2.0	0	0	2.0
pH	9.61	8.51	10.51	10.30	8.68
Solids, (%)	31.3	30.8	40.8	43.1	42.8
Viscosity Brookfield (100 rpm, 23°C), (mPa.s)	3749	1566	467	1650	1710
Coat weight, (g.m^{-2})	9.20	10.7	14.4	10.7	11.3
Specific charge density, (μeq.g^{-1})	+ 55	- 32	+ 288	+ 297	+ 407

Inks properties

At the inkjet printing of the papers in the printer Canon PIXMA i7250, original dye-based inks CLI-521 Y, CLI-521 C, CLI-521 M, CLI-521 BK and pigmented ink PGI-520-BK were used. Their properties are shown in Tab. 3.

Tab. 3: Inks properties.

Liquids at 23 °C	**Cyan C**	**Magenta M**	**Yellow Y**	**Black K**	**Black pigmented**
Specific charge density, (μeq.g^{-1})	-91	-112	-115	-229	-740
Surface energy σ, (mJ.m^{-2})	37.4	37.7	38.2	39.8	43.6
Concentration, (%)	0.30	0.28	0.30	0.28	0.04
Density ρ, (g.cm^{-3})	1.08	1.06	1.07	1.07	1.09

Dynamic of water and 16 % isopropyl alcohol absorption

Water and 16 % isopropyl alcohol absorption was measured by the ultrasound analyzer PDA C.02 (Emtec, Radnor, PA, USA) with frequency 2 MHz within time of 43 ms-60 s. De-ionized water has free surface energy of 72 mJ.m^{-2} and 16 % IPA has 44 mJ.m^{-2}. In the experiment, ultrasound signal intensity in time of 5 s (IR_5^{water}) for evaluation was used. A higher IR intensity corresponds to slower liquid penetration. For evaluation of fine pores content on paper surface was used the time at which 95 % IR (t_{95}^{IPA}) is reached. A higher value corresponds to higher fine pores content.

Specific charge density of coatings

Polarity positive or negative and specific charge density ($\mu eq.g^{-1}$) of coating colours, dye-based inks and pigmented inks was determined by polyelectrolyte titration using the Streaming Current Detector (Waters Associates, Inc.). A cationic standard of 0.001 $mol.l^{-1}$ poly(diallyldimethylamonium chloride) solution and an anionic standard of 0.001 $mol.l^{-1}$ sodium polyvinyl sulphate (PVSNa) solution were used.

Wettability

Contact angle of water and inkjet cyan ink colour of base paper and coated papers was measured by „Sessile drop“method using the optical tensiometer (OCA 35, Dataphysics Instruments GmbH, Germany). Within this experiment, the dynamic contact angle in time of 5 s (CA_5^{water}, CA_5^{Cyan}) was used. The higher contact angle corresponding with reduced surface wetting.

The evaluation of surface topography by photoclinometry

The surface of coated papers was pictured by the CCD camera Coolpix E4500. The measurement process as well as image treatment was published in Wood Research (Gigac et al. 2006, 2014). The surface roughness is evaluated as the surface optical variability (OVS_{CLINO}, %).

Inkjet printing

Coated papers and base paper were printed at the inkjet printing of papers in Canon PIXMA i7250 printer within the mode Matte. Original dye-based inks CLI-521 Y, CLI-521 C, CLI-521 M, CLI-521 BK and pigmented ink PGI-520-BK were used.

Colour gamut area

The colour gamut area CGA was calculated as the pentagram area from a* and b* colour coordinates of the C, M, Y, G and O blocks. Colour coordinates were measured by using the Elrepho spectrophotometer (Lorentzen & Wettre, Sweden).

Optical density and Water fastness of inkjet prints

The water fastness was measured by immersing the printed samples into de-ionized water for 5 min without agitation and allowing the immersed prints to dry for 24 hours at room temperature. Optical density was measured by densitometer QUIKDens 100. Water fastness (WF) was calculated as optical density of prints before (OD_1) and after (OD_2) exposing them to water:

$$WF = 100 - 100 \times ((OD_1 - OD_2)/OD_1) \qquad (\%) \qquad (1)$$

Print sharpness

The print sharpness was evaluated as deformation of the letter “s” in the text. The digitalized image of the printed surface area was captured using a CCD Coolpix E4500 camera with an adapter for homogenous lighting. For calculation of print object deformation, the method BOX

Counting of the harmonic and fractal analysis HarFA 5.3 software was used (Nežádal et al. 2000). Print object deformation POD was evaluated from the ratio r_p/r_a, where r_p is perimeter radius of the object and r_a is area radius of the object. Reduced print object deformation corresponding with improved print sharpness according to equation:

$$\text{Print sharpness} = 100 \text{ x } POD_{IDEAL} / POD_{MEASURED} \qquad (\%) \qquad (2)$$

where: POD_{IDEAL} - 3.5 for inkjet gloss paper (photo quality) printed in the printer Canon PIXMA i7250.

SEM analysis

Porosity of coated surface was evaluated by a high magnification scanning electron microscopy. Preparation of samples: sample surfaces were covered with gold in the BALZERS SCD 040 sputtering device in 0.15 barr vacuum for a period of 40 s with 50 mA electric current.

SEM image preparation: JEOL 760F scanning electron microscope equipped with Schottky thermo emission cathode (thermal FEG – W platting by ZrO_2) and with energy and wavelength dispersive cathode (Oxford Instrument) was used. Specification of scanned images: Magnification X1000 and X10000, accelerating voltage 2 kV, work distance 7.9 mm, image size 2530x1890 pixels^2, image resolution 0.005 μm.pixel^{-1} .

RESULTS AND DISCUSSION

Physical and printing properties of base paper and matt coated paper are shown in Tab. 4. The silica coating colour G1 have low specific charge density (+11 μeq.g^{-1}). It is the result of cationic standard poly-DADMAC adsorption on the structured silica pigment with a high specific surface area and using of the titration method for determination of specific charge density with higher molecular polyelectrolyte.

Tab. 4: Coated papers and the base paper properties.

Labelling	Base paper	G1	P0-S	P1	P1-S	P3	P3-S
Specific charge density of coating colour, (μeq.g^{-1})		+11	+288	+55	+297	-32	407
Porosity Gurley, (s)	53	102	108	1191	131	557	132
Roughness OVS, (%)	14.2	10.1	12.8	15.2	12.9	15.7	12.8
Wetting CA_5^{water}, °	78	13	22	69	27	47	20
Wetting CA_5^{Cyan},°	35	10	18	16	33	27	29
Penetration t_{95}^{IPA} , (s)	0.07	0.41	0.06	0.05	0.05	0.05	0.06
Penetration IR_5^{IPA} , (s)	0.22	9.99	6.05	2.10	12.96	5.40	12.66
Colour gamut area CGA	4402	9888	7177	7556	6756	7009	6287
Print sharpness, (%)	27.5	79.2	54.1	35.3	55.8	24.3	66.0
Water fastness WF_C, (%)	38	103	94	77	99	22	94

Porosity

Porosity of coated papers markedly decreased (Gurley 102-1191 s) compared with the base paper (Gurley 53 s), due to the film-forming binders as cationic starch and PVOH. PVOH had the most significant effect in combination with poly-DADMAC (Gurley 1191 s). Porosity decreased in the order of polymers: G1 = P0-S > P1-S = P3-S > P3 > P1. It is evident that PVOH is a better film-forming agent than cationic starch when combined with high-cationic polymers.

Surface roughness

The surface roughness OVS_{CLINO} of the base paper was 14.2 %. By coating resulted in its decreased (10.1-12.9 %) excepting the application of coating colour P1 and P3 (15.2 and 15.7 %). The increasing of roughness is the result of fibres swelling in aqueous solution at coating process when the surface structure could be opened.

SEM analyses

The images of paper surface prepared by electron microscopy (Fig. 1) enable a good identification of the size as well as distribution of pores (dark areas) in the coatings. Combined processing of SEM paper surfaces images using harmonic and fractal HarFa analysis and ImageJ software numerical data were obtained about representation of pores on surface of coating. At a higher magnification X10000 of coating surface (Fig. 2) it is possible to observe a microporous surface structure of silica pigment. Calcium carbonate pigment has a shape with smoothed surface. Differences in the surface structure of pigments result also in different specific surface area. The images show that surface of paper coated with silica pigment Gasil 23 F has markedly larger pores but also more micropores in comparison to surface coated with calcium carbonate pigment Precarb 800.

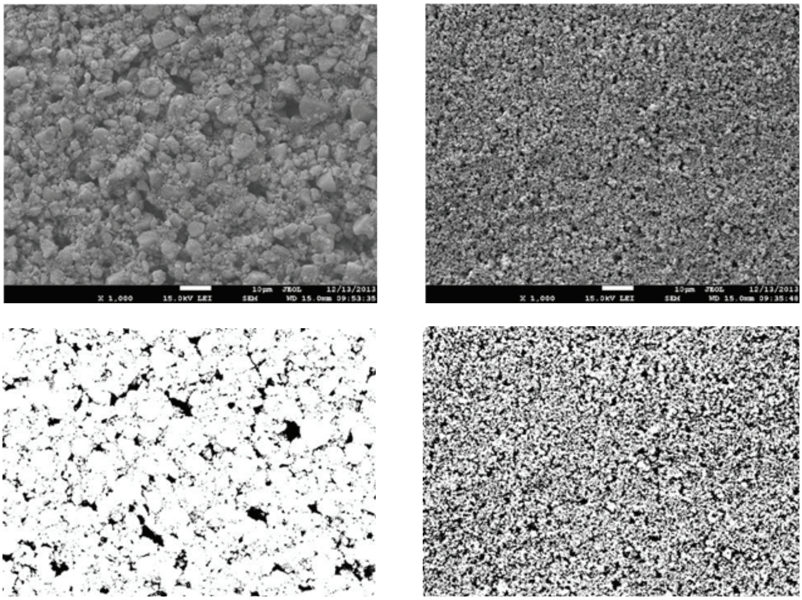

Fig. 1: SEM images of surface (top) on coated side of papers prepared with Gasil 23 F (left) and Precarb 800 (right) - at 1.000 multiple magnification. Area of surface pores created by thresholding of images at grey level GL 95 (bottom).

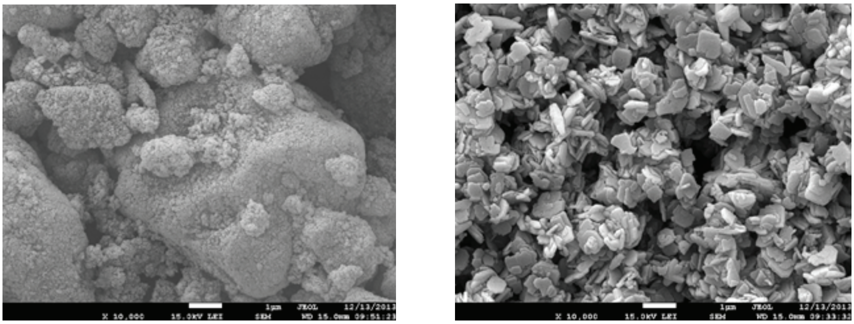

Fig. 2: SEM images of surface (top) on coated side of papers prepared with Gasil 23 F (left) and Precarb 800 (right) – at 10.000 multiple magnification.

Water wetting and dynamic penetration of water

Wetting of coated paper surface increased in comparison to the base paper from contact angle CA_5^{water} 78° to 13-69°. The lower contact angle and thus a higher wetting, the faster ink solvent penetrates under the coating layer. The highest wetting was obtained with silica pigment G1 (CA_5^{water} 13°). At the application of calcium carbonate pigment the highest wetting was reached with coating colours P0-S and P3-S (CA_5^{water} 20-22°) and the lowest with coating colour P1 (69°). Use of the combination of binder with cationic polymers led to higher wetting with cationic starch (CA_5^{water} 20 and 27°) than PVOH (CA_5^{water} 47 and 69°). The wettability order of the coated papers following CA_5 water was: G1 > P3-S = P0-S > P1-S > P3 > P1 > base paper. Time course of ultrasound signal intensity IR at the contact of water with base paper and coated papers is shown in Fig. 3. Ultrasound signal intensity IR of the base paper and coated paper prepared with coating colour P3 increased at the beginning phase. In this case, the surface wetting and fibres swelling occurred firstly and later the water penetration. It is the consequence of time-limited surface hydrophobicity. The curve shape of the base paper shows a gradual wetting process. Other coated papers have a hydrophilic surface, where the immediate wetting and water penetration take place.

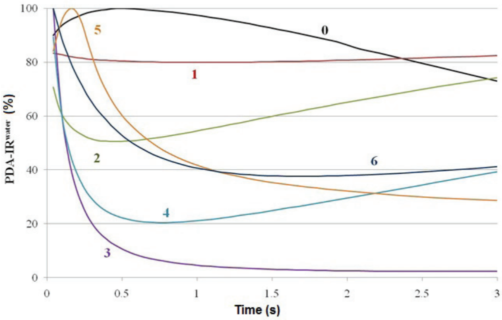

Fig. 3: Time course of ultrasound signal at the contact of coated papers and base paper with water. Sample labelling: 0) base paper; 1) G1; 2) P0-S; 3) P1; 4) P1-S; 5) P3; 6) P3-S.

Dynamic penetration of isopropyl alcohol

In Fig. 4 is time course of ultrasound signal intensity at the contact of 16 % IPA with surface of coated papers and the base paper. An aqueous solution of IPA has a lower surface energy (44.24 mJ.m^{-2}) which helps to eliminate the effect of paper hydrophobicity. The surface energy is similar to water-based inks (37-40 mJ.m^{-2}). By coating, the surface with a higher fine pores content was achieved only at using of G1 (t_{95}^{IPA} 0.41 s) in comparison to the base paper (t_{95}^{IPA} 0.07 s). From time course curve in Fig. 4 we can observe slower IPA penetration (curve 1) in the coated paper with coating colours G1 and P0-S, where saturation occurring in 5 s. At other coated papers saturation occurs in early stage. Silica coating colour did not decrease coated paper porosity as markedly as calcium carbonate coating colours but formed a closed surface structure. This structure together with an uniform distribution of pores and particles of pigments causes a fast absorption of solvent from the ink. The result is an uniform anchoring of dye at the surface due to its smoothness, as confirmed by the measurement of printing properties, mentioned below.

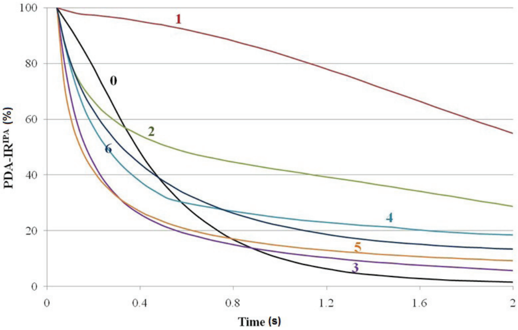

Fig. 4: Time course of ultrasound signal at the contact of coated papers and base paper with 16 % IPA. Sample labelling: 0) base paper; 1) G1; 2) P0-S; 3) P1; 4) P1-S; 5) P3; 6) P3-S.

Inkjet cyan ink wetting

Coating increased the inkjet cyan ink wettability of coated papers (CA_5^{cyan} 10-29°) against of the base paper (CA_5^{cyan} 35°) with the exception of coating colour P1-S (CA_5^{cyan} 33°). The highest wetting was obtained with G1. Calcium carbonate pigment markedly improved the wettability when coating colour P0-S and P1 (CA_5^{cyan} 16 and 18°) was applied. The coating colour containing SMAI 1000 influenced wettability in a reduced size (CA_5^{cyan} 27 and 29°) in comparison with poly-DADMAC.

Colour gamut area

The colour gamut area CGA increased from 4402 (base paper) to 6287 up to 9888. The highest colour gamut area was reached with coating colour G1 (CGA 9888) against the base paper. The colour gamut area of coated papers was increased by application of all polymers in order: P3-S < P1-S < P3 < P0-S < P1 < G1. The combination of high-cationic polymers with a cationic starch has not been as effective as with film-forming PVOH. The film forming effect leads to a poor penetration of dye and the dye is concentrated in the top region of coating. Fig. 5 displays the dependence of colour gamut area from dynamic inkjet cyan (A) and water (B) contact angle of coated papers and the base paper. As in the case of surface sized papers (Gigac et al. 2015) at the coated papers was found a correlation between colour gamut area and CA_5^{cyan} (R = 0.869). For a good CGA, a highest inkjet cyan wettability of paper surface is required. The effect of CA_5^{water} on CGA does not seems to be so significant (R = 0.702).

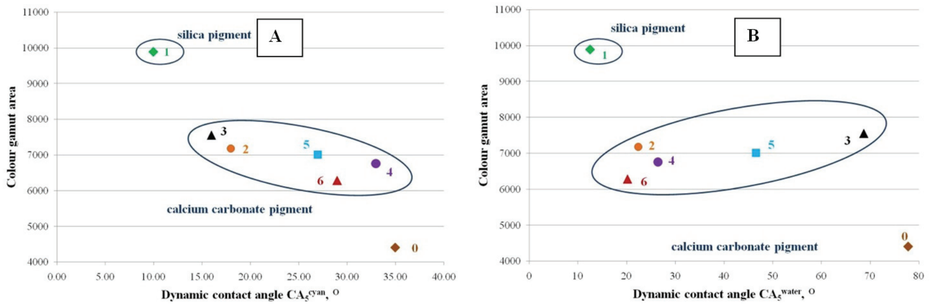

Fig. 5: Recording of colour gamut area of coated papers and base papers and dynamic cyan ink (A) and water (B) contact angle. Sample labelling: 0) base paper; 1) G1; 2) P0-S; 3) P1; 4) P1-S; 5) P3; 6) P3-S.

Print sharpness

A lower surface roughness of coated paper and a higher positive specific charge density of coating colours increase print sharpness. Decreasing of print sharpness (24.3 %) by using of coating colour P3 is related to a higher surface roughness and with a negative specific charge density (-32 $\mu eq.g^{-1}$). The best print sharpness 79.2 % and surface roughness 10.1 % was reached with coating colour G1. Print sharpness improved from 27.5 to 35.3-79.2 %, in the order of coating colours: P1 < P0-S < P1-S < P3-S < G1. Using of cationic starch as a binder decreased paper surface energy and the best water wetting (CA_5^{water} 20 and 27°) was reached in comparison to PVOH (47 and 69°). A better surface wetting prevents "bleeding". The result is a higher print sharpness 55.8 and 66.0 % even in the absence of cationic starch (54.1 %) in comparison to PVOH (35.3 and 24.3 %).

Water fastness of inkjet cyan ink

The coated papers reached high water fastness of cyan printed area (WF_C 77-103 %), besides coated paper prepared with coating colour P3 which has a negative charge density. In this case, WF_C is lower (22 %) in comparison to the base paper (38 %). WF_C increase in the order of coating colours: P1 < P0-S = P3-S < P1-S < G1. The highest WF_C was reached with coating colour G1 as the result of structured silica pigment surface. Better results were obtained with high-cationic polymer poly-DADMAC in comparison to SMAI 1000. These results are inconsistent to other work (Swanholm et al. 2007). Correlations between water fastness and specific charge density of calcium carbonate coating colour were R 0.928.

CONCLUSIONS

For evaluation of inkjet print quality were used: colour gamut area, print sharpness, porosity and surface roughness, water and inkjet ink wettability and water fastness of cyan printed area.

Silica coated paper reached the best colour gamut area, print sharpness and water fastness. Silica coated paper showed the best water and cyan ink wettability of surface. The optimal inkjet paper surface needs to be able to rapidly absorb the ink solvent and dye must to be anchored on the surface. This condition is the best accomplished by the silica coating colour which provides a uniform pores and particle distribution. The prevalence of large pores enabled rapid absorption of the ink solvent. On the contrary, a large surface area of pigment with fine pores enabled fixation of dye on the surface. Furthermore, the smoothed surface enables a uniform spreading of inkjet dye.

Calcium carbonate coated papers did not achieve such colour gamut area and print sharpness as silica coated paper. Polyvinyl alcohol is a better film-forming agent than cationic starch and allows preparing coated papers with better colour gamut area. On the other side, PVOH causes a lower water wettability of the surface, a higher surface roughness resulting in a weak print sharpness.

The papers coated with cationic starch combined with high-cationic polymers showed worse colour gamut area than those with application of PVOH, but print sharpness improved. Higher print sharpness is due to smoothed surface as well as better wettability. In this case, an excess of high-cationic polymers remains free (unadsorbed) and forms the complex with anionic dye. This complex penetrates through pores of size 0.1-1 μm into coating or under coating layer. The presence of cationic starch binder has a positive effect on water fastness of printed area.

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