The Effect of Cross Linking Agent on the Image Quality of Alumina sol coated Ink jet Paper

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Abstract

A coating material for ink jet printing paper was made by mixing 40-60nm size alumina sol with PVA binder. Alumina sol were made after dispersing the primary alumina particles(size 10x25nm) which are needle shape, Boehmite type and have nano size porosity in water. The coating material was cross-linked by adding zirconium compounds or boric compounds. After cross-linking, the coating material was coated on the base paper(polyethylene coated paper) by 32±1µm thickness. The inkjet printed color image of coated paper cross-linked by zirconium compounds showed better results in both physical properties(water resistance, environmental resistance, humidity resistance and adhesion strength) and optical density.

Introduction

It is said that the ultimate goal in development of coating material for inkjet ink is to enhance both ink absorption speed with maintaining a dye fixing property, color density, coloring property, glossiness and conventional photo quality images. Besides these properties, water resistance is also important to reserve the printed color images. The water resistance can be decided by controlling the degree of cross linking density and by selecting proper cross linking agent.

The coating material for ink absorption comprises water soluble polyvinylalcohol, functional polyacrylamide, alumina sol and additives such as UV absorber, antioxidant and surface agent. The general cross linking agents for this coating material are aldehyde group (formaldhyde, glyoxal, etc.), polyamino group(urea, melamine, etc.), ethylenediamine and hydrazine as organic compounds and boric acid, sodium borate, aluminum sulfate ,zirconium nitrate [1],phosphoric acid [2] as inorganic compounds.

In this research, we investigated the effects of cross linking agents on the water resistance of printed color images. Coating material cross linked by zirconium acetic acid or boric acid was coated on RC paper.

The typing test to measure the adhesion power of inkjet ink printed on the coated paper was performed after dipping the specimen in 40°C water for 30 minutes. Also, to investigate the change of absorption layer and optical density after water condition, the specimens were conditioned in 35 °C flowing water for 2 hours.

Experiment

The emulsion type binder [3,4] was cross-linked by Zirconium acetic acid (Daiichi kigenso kagaku, co., Japan) or boric acid. The final coating material was coated on the 220g polyethylene coated paper of OJI (Japan). The coater used was a slot die type coater having 25 inch-width. We dried the sample for 15 seconds at 5°C and 20 seconds at 30°C, 60 seconds at 60°C, 40 seconds at 80°C, 40 seconds at 110°C, 30 seconds at 60°C, 40 seconds at 30°C. The dried thickness was 32±1µm. The sample paper was cut into 4"x6" and printed with Epson Stylus photo 1290 to make cubic test charts. Color images of Y, M, C, B were printed on the paper and exposed to Xenon Arc (420nm) for 10 hours at 63°C to measure a light stability. The humidity test was performed under the condition of 60°C and 70% relative humidity for 24 hours. Also, taping test was carried out by measuring the adhesion power after dipping the specimen in 40°C water for 30 minutes followed by drying. For the water fastness test, hardness condition was observed after dipping the specimen in 35°C flowing water for 2 hours. The test machine and conditions were as following.

Taping test

Versa Tester (Mecmesin, co.) was used.

Pre-conditioning : dipping in 30°C and 40°C water for 30 minutes followed by drying with hand dryer.

3M Scatch (cat,# 3821) tape was used to measure peel strength (180°)

Density measurement

Photo spectrometer (X-light, co.) was used.

Gloss Measurement

Micro gross Ref-160 (Sheen, co.) at the angles for 85° and 60° was used.

Water Fastness Test

This test was performed by observing the condition of water fastness after dipping 35°C flowing water for 2 hours.

Result

Water Fastness

We made emulsion sample by putting Zirconium Acetic Acid (Zr) or Boric Acid (Ba) into ink receiving emulsion as

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shown in Table 1 below and tested its function of water fastness. From this test we observed that with the low content of hardener the receiving layer of RC paper entirely was solved in water which was dipped in 35℃ flowing water for two hours and this result was shown in the Figure 1. Also, when we put low content of boric acid the ink receiving layer was solved in water severely as it shown in the figure 2 below. We observed that with the more amount of hardener, At high content of zirconium acetic acid or boric acid, the ink printed chart was not solved in water as they shown in the Figure 5 and 6.

Table 1. Content of Cross Linking Agent in 1000ml Emulsion.

Sample Name	Zr1	Zr2	Zr3	Ba 1	Ba 2	Ba 3
Added amount of 3wt% of zirconium acetic acid (ml)	10	20	30	-	-	-
Added amount of 3wt% of boric acid (ml)	-	-	-	10	20	30

Taping Test

We tested typing test by putting the sample RC paper for 30 minutes into 30℃ and 40℃ water each. In result, when we add 10ml of Zirconium Acetic Acid and Boric Acid, base paper and receiving layer were separated each other in Zr 1 meanwhile base paper and receiving layer were torn in one piece, not separated each other, when we add more than 20ml of Zirconium Acetic Acid. In this case we could not get the tensile strength of the sample because it was torn. When we put Boric Acid in amounts of 20ml and 30ml each, the receiving layer was separated and the tensile was 534-704 gf/cm. as show table 2.

Table 2. Taping Test Results (Soaking into 30℃ and 40℃ water for 30 minutes) (gf/cm)

.Temp.	Zr 1	Zr 2	Zr 3	Ba 1	Ba 2	Ba3
30℃	822.5	Surface Torn	Surface Torn	652.5	655	704.35
40℃	675	Surface Torn	Surface Torn	487.35	535	682.61

Humidity Test

In humidity resistance test, we observed that 3% decrease of optical density in Zirconium Acetic Acid, but in case of Boric Acid it decreased by 5% that that of normal optical density. Also, we observed that with less cross linking additives for Boric Acid, the more bleeding formed as it shown Table 3.

Table 3. Change in OD and other physical values by humidity

sample			Zr 1	Zr 2	Zr 3	Ba 1	Ba 2	Ba 3
glossiness	85°		88,6	88.7	88,7	86,5	86,6	87
	60°		47,6	47,8	47,7	45,4	45,6	45,3
Humidity test	normal	Y	0,8	0.8	0,8	0,74	0,74	0,75
		M	1,4	1,42	1,42	1,26	1,25	1,27
		C	1,09	1,09	1,1	0,93	0,92	0,93
		B	1,58	1,59	1,58	1,49	1,48	1,49
	after 24hr	Y	0,78	0.79	0,79	0,63	0,65	0,66
		M	1,21	1,30	1,31	1,10	1,10	1,13
		C	1,04	1,05	1,06	0,85	0,86	0,86
		B	1,59	1,59	1,6	1,40	1,41	1,41

Optical Test

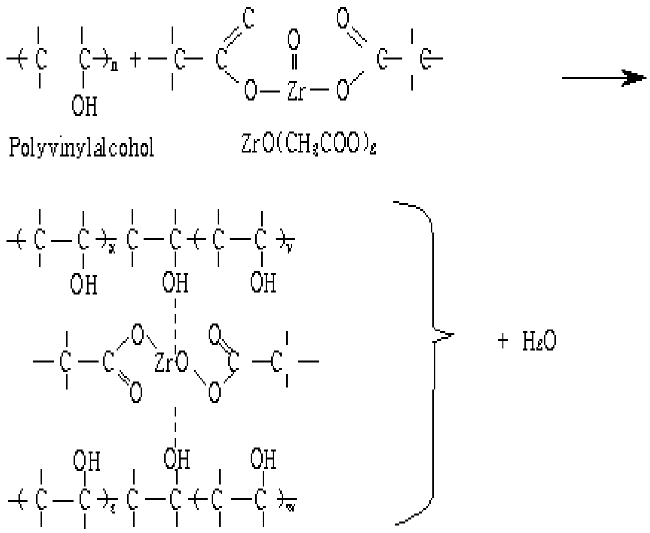
There was no optical density in UV test as it shown in Table 4.

Table 4. Change in OD and other physical values by UV

sample			Zr 1	Zr 2	Zr 3	Ba 1	Ba 2	Ba 3
glossiness	85°		88,6	88,7	887	86,5	86,6	87
	60°		47,6	47,8	47,7	45,4	45,6	45,3
UV stability	normal	Y	0,8	0,8	0,8	074	0,74	0,75
		M	1,4	1,42	1,42	1,26	1,25	1,27
		C	1,09	1,09	1,1	0,93	0,92	0,93
		B	1,58	1,59	1,58	1,49	1,48	1,49
	after 10hr	Y	0,76	0,78	0,79	0,72	0,73	0,74
		M	1,34	1,35	1,38	1,10	1,15	1,14
		C	1,03	1,05	1,06	0,89	0,88	0,89
		B	1,59	1,59	1,60	1,50	1,49	1,50

Discussion

It was observed that the zirconium acetic acid worked well as a cross linking agent on the ink receiving emulsion binder which comprised nano size alumina sol and polyvinyl alcohol. The suggested mechanism of cross linking between poly vinyl alcohol and zirconium acetic acid is following.



The taping test performed at 40°C water showed that at low contents of zirconium acetic acid for cross linking color ink was separated to tape and the peel strength was 675 gf/cm. As the concentration of zirconium acetic acid became higher, however, the peel strength became so higher that outer part of paper was also separated together to tape. When boric acid was used as a cross linking agent, the peel strength was in the range of 487-704 g f/cm.

It was also observed that the color image was solved in 35°C flowing water at low concentration of zirconium acetic acid, while it was not at high concentration. Humidity resistance became also higher as the concentration of zirconium acetic acid was higher. The optical density showed little relationship with the concentration of zirconium acetic acid.

Conclusion

In this study, it was shown that the printed image cross linked by above two agents was solved (Fig. 1, 2) when the added content of agents was 10 ml, and was solved partly (Fig. 3, 4) when the content was 20 ml, and was not solved (Fig. 5, 6) when the content was 30 ml in 35°C flowing water.

Taping test showed that at the content of 10ml of boric acid the peel strength was 487.35gf/cm and increased to 682.61gf/cm at the content of 30ml, when the test performed after dipping in 40°C water.

It was revealed in Table 3 and 4 that the better results of both optical density and chemcophysical properties were acquired when zirconium acetic acid was used than boric acid. Therefore it was concluded that zirconium acetic acid was proper for binder of ink jet color printing paper as a cross linking agent.

In conclusion, the binder mixed with alumina sol and polyvinylalcohol and cross linked with zirconium acetic acid provided good water resistance, environmental resistance, humidity resistance, adhesion strength and optical density, and made it possible to produce good ink jet color printing paper.

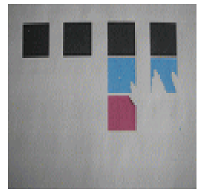


figure 1, *Zr 10ml*

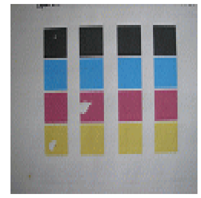


figure 3, *Zr 20ml*

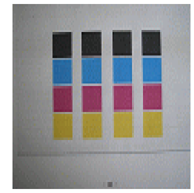


figure 5, *Zr 30ml*

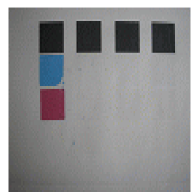


figure 2, Ba1 10ml

figure 4 Ba2 20ml

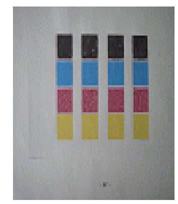


figure 6, Ba 3 30ml

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