TWO-LAYER COATED PAPERS USING PRECIPITATED CALCIUM CARBONATE

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1. Introduction

There is a constant need to improve paper products regarding printing quality. This work presents some simple solutions, based on cheap additives, for producing premium printing and writing papers without excessive costs (high values of optical, physical and printing properties).

In order to obtain a high level of quality, one-layer coated papers are usually used, but there is a limit for the coating pick-up. Therefore the paper should be coated in two-layers: the pre-coat (bottom-layer) is used to prepare the base paper for the surface layer coating, by closing its surface. The top coat (surface layer) will receive the ink pigments [1].

In this work, a reference paper was single and double layer coated with formulations containing precipitated calcium carbonate (PCC) as pigment and polyvinyl alcohol (PVOH) or starch as binders. PCC is a material with excellent rheological behavior and high brightness besides being less expensive than the other pigments.
The coated papers were characterized by measuring the surface energy and some structure, mechanical and optical properties. After inkjet printing the gamut area, optical density and print through were measured.

2. Materials

•A commercial uncoated paper (77 g/m^2) was used as base paper. Different formulations using **PCC** as pigment and **ammonium polycarbonate** (Targon 1128®) as dispersant were prepared for the paper coating.

•For the PCC/PVOH suspension, PCC and Targon were mixed. Then, a previously prepared solution of **Polyvinyl Alcohol** - PVOH (Mw=13000-23000 and 98% hydrolyzed) and an **acrylic polymer** (Acrosol®) were added.

•For the PCC/starch suspension, PCC and Targon were mixed and a **native starch** suspension was added. The latter was prepared as reported elsewhere [2].

•The formulations obtained were applied in the paper surface by using a Mathis laboratory device, SVA-IR. The **drying process** was performed firstly by IR and secondly by air-drying. The second layer was applied in the top of the first one, after its complete drying. Table 1 lists the seven samples obtained (3 one-layer coated and 4 two-layer coated).

Table 1 - Sample Description and Pick-up of coated papers

Formulation	Sample	Coating Pick-up (g/m^2)	Formulation	Sample	Coating Pick-up (g/m^2)
Base Paper	**BP**	-	**TWO-LAYER:**		
			1.Starch 2.PCC/PVOH	**1S-2PPV**	7.1
ONE LAYER:					
PCC/PVOH	**PPV**	5.1	1. Starch 2.PCC/Starch	**1S-2PS**	5.0
PCC/Starch	**PS**	5.3			
Starch	**S**	1.9	1. PCC/PVOH 2.Starch	**1PPV-2S**	8.6
			1.PCC/starch 2.Starch	**1PS-2S**	9.9

3. Results and Discussion

Table 2 - Contact angle of the samples.

Contact angle with water (°)	
BP	104.4 ± 5.5
ONE LAYER:	
PPV	100.0 ± 2.0
PS	18.0 ± 1.6
S	34.2 ± 0.5
TWO-LAYER:	
1S-2PPV	99.1 ± 2.1
1S-2PS	11.3 ± 1.4
1PS-2S	21.7 ± 3.5
1PPV-2S	79.5 ± 3.2

Table 2 shows that the base paper has a strong hydrophobic character nature and confirms that starch increases the hydrophilic character of the paper surface. On the contrary PVOH leads to a considerable increment of the hydrophobic character.

The values of the dispersive and polar components of the surface energy (Figure 1) are in agreement with the water contact angle determinations (Table 2).

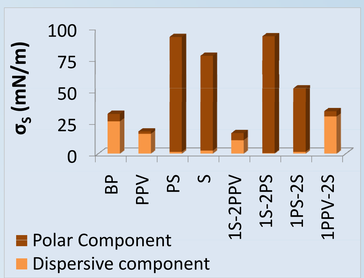

Figure 1- Surface Energy of the coated papers.

Table 3 - Physical and optical properties of the coated papers.

	Tensile Stiffness (KN/m)	Bendtsen Roughness (ml/min)	Opacity (%)	Brightness R457 C (%)
BP	704	452	94.2	95.6
ONE LAYER:				
PPV	690	318	95.4	94.9
PS	663	277	95.3	95.0
S	667	348	93.9	95.1
TWO-LAYER:				
1S-2PPV	695	210	94.7	94.1
1S-2PS	672	240	94.9	95.2
1PS-2S	677	242	95.2	93.6
1PPV-2S	436	253	94.9	94.0

The **roughness** of the papers decreases with the coating. The coating formulations do not have a great impact in the **optical properties**, since the variations of opacity and brightness are of small magnitude. A slight decrease of tensile is detected.

A remarkable **gamut area** value of 10690 was achieved (Lexmark printer) with the paper coated with PCC/starch and starch (1PS-2S) (Figure 2). For this paper a black optical density of 1.56 and a print-through of 0.72 were obtained, which are much better results than those of the base paper, with values of 1.18 and 1.38, respectively.
From the results it is legitimate to conclude that the first layer is covering the base paper surface, allowing the top layer to remain at the surface with a small penetration of the coating components. In this situation ink remains mostly at the coat surface.

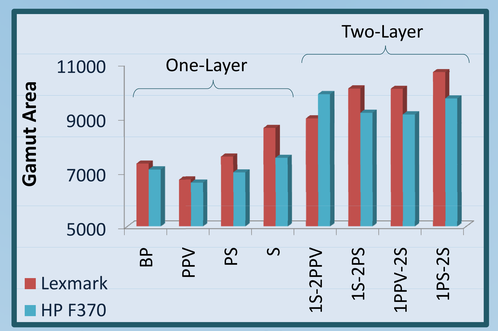

Figure 3 - Gamut Area of the printed papers.

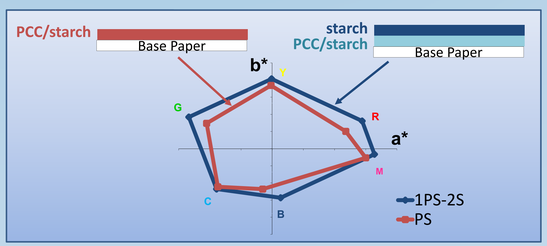

Figure 4 –Schematic representation showing that the two-layer coating (sample 1PS-2S) leads to higher gamut area (larger hexagon) than the one-layer coating (sample PS).

4. Conclusion

Superior values for the print quality using simple and not too expensive materials, by applying two coating layers at the paper surface are obtained. The bottom layer closes the base paper surface, allowing the top layer to receive effectively the printing ink.

The best values were achieved for the paper coated with a bottom layer consisting of a mixture of PCC and starch and a top layer of starch. A gamut area value of 10691 (about 1.5 times superior to the base paper), a print-through of only 0.72 and a black optical density of 1.56 were achieved. This values can be compared to a photographic paper [3]. This is also the paper sample that has the best ratio cost/quality.

5. References

[1] Wygant, R. *et al*. Pigment Coating and Surface Sizing of Paper – Paper. Sci. Tech. Chap.34. Vol 11. Finnish Paper Eng. Ass. & TAPPI. Helsinki. 2000

[2] Saraiva, M. *et al* . A New Approach for the Modification of Paper Surface Properties using Polyoxometalates. Materials, 2010; vol.3: 201-215

[3] Svanholm, E. *et al.* Printability and Ink-Coating Interactions in Inkjet Printings. Dissertation. Karlstad University Studies 2007:2