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The effect of pigment coating composition on paper durability

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Abstract: *The effect of pigment coating composition on paper durability.* The purpose of the study was to test how the composition of pigment coatings affects the paper colour durability. Paper made of mechanical pulp was used in the tests. This paper grade gets yellow quite quickly and its strength rapidly falls with ageing. Coating mixtures, containing different pigments, were applied to the surface of paper. Calcium carbonate, kaolin and titanium dioxide (rutile) were used as pigments. Coated papers were aged with outdoor daylight in a closed room and then tested for their brightness. In the initial stage of ageing, the brightness slightly grows, and then it decreases over next weeks of ageing.

Keywords: mechanical pulp, casting of paper, resistance to ageing, brightness of paper

INTRODUCTION

Wood is the most common raw material in papermaking, namely cellulosic fibres contained in wood.

Pulp making is based on processing of the material of dense fibrous structure into slurry made up of loose, single fibres. This process is known as pulping. Pulp can be manufactured using chemical, mechanical or chemical and mechanical methods [1].

The mechanical pulp is an attractive high-yield semi-finished product and papers manufactured from this pulp grade are characterized by good optical and strength properties. For those reasons they often replace low-yield and quite expensive chemical pulps [2,3]. However, the lignin content is the reason why paper made from the mechanical pulp has lower brightness and it gets yellow quite rapidly with ageing. To stop ageing to some extent and to enhance other optical parameters, these grades can be coated with pigment mixtures.

The main reasons why the pigment coating is applied include better appearance and surface smoothness, higher brightness and opacity as well as improved printability. Besides it is easier to finish coated papers and boards [4].

To coat paper products, a wide range of chemicals is used. Among them there are pigments, binding agents (hydrophilic and hydrophobic) and auxiliaries. The pigments have to be characterized by high refractive index, opacity and hiding power of paper substrate, good rheological properties and high absorption of printing inks.

MATERIALS AND METHODS

The paper made from the mechanical pulp delivered by the manufacturer in sheets was used in the tests. The paper was coated with coating mixtures consisting of a pigment, hydrophilic and hydrophobic binding agents, dispersant and water. Kaolin, calcium carbonate and titanium dioxide were used as the pigments. The following proportions were used in relation to kaolin:

- 0% of titanium dioxide (100% of kaolin),

- 25% of titanium dioxide,
- 50% of titanium dioxide,
- 75% of titanium dioxide,
- 100% of titanium dioxide,
- 25% of calcium carbonate,
- 50% of calcium carbonate,
- 75% of calcium carbonate,
- 100% of calcium carbonate.

Each coating was applied to the surface of paper by means of Meyer bars 1, 3 and 5. The higher the bar number the higher is the coating grammage. The coatings applied with the bars were as follows: 7 g/m^2, 14 g/m^2 i 21 g/m^2.

Other samples were conditioned and aged with outdoor daylight in the closed room [5]. The samples were removed every 7 days and then their ISO brightness was tested by means of the Elrepho meter [6].

RESULTS

The optical properties of paper products are very important parameters, mostly due to their aesthetic aspects, however they also play an important role in print or writing showing-through paper product. The properties are defined by reflecting ability, absorbing capacity and penetration of light through paper.

Figure 1 and Figure 2 illustrate the effect of titanium dioxide and calcium carbonate in different proportions in relation to kaolin in pigment coating on ISO brightness of paper.

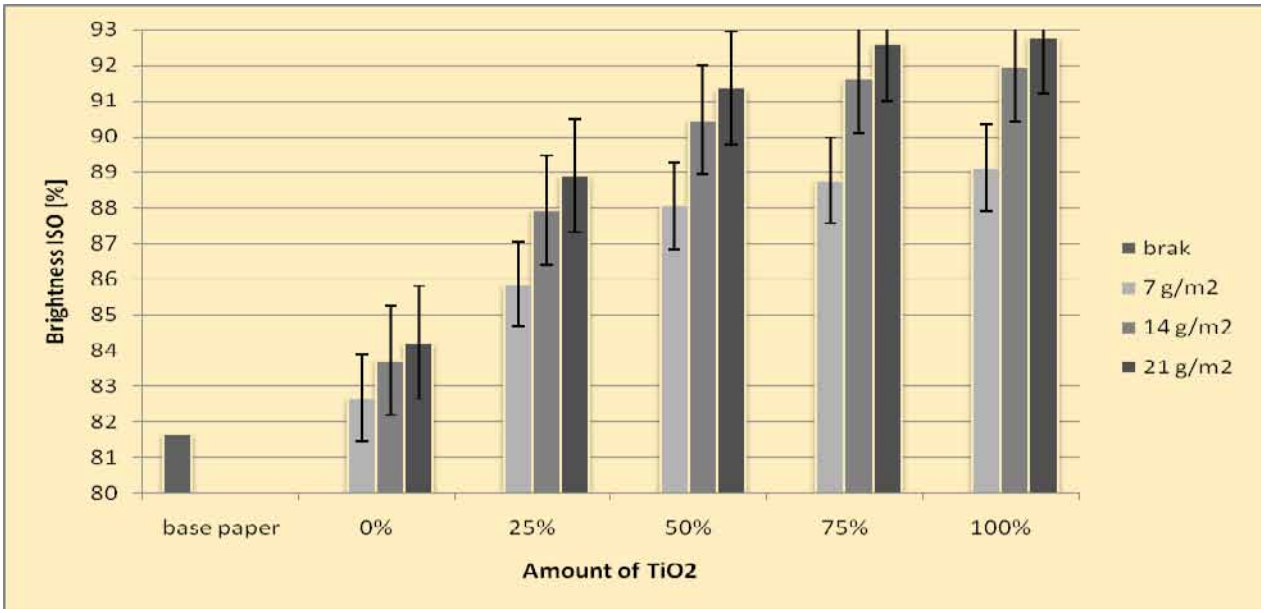

Figure 1: Effect of titanium dioxide amount in kaolin and rutile coating on ISO brightness

When analyzing the above figure we can see that coating increases paper ISO brightness. The papers coating grammage of 21 g/m^2 show the highest ISO brightness. It is connected with the fact that the highest amount of mixture is applied to the paper surface, that is the highest number of pigment particles. The pigment particles form pores with air. The higher the number of pores, the more boundaries of light refraction appear, followed by higher brightness of coating.

Aside from that, it can be clearly seen that along with the increase in the amount of titanium dioxide in relation to kaolin, the paper ISO brightness is higher. It should be noted that the brightness of titanium dioxide is significantly higher than the kaolin brightness.

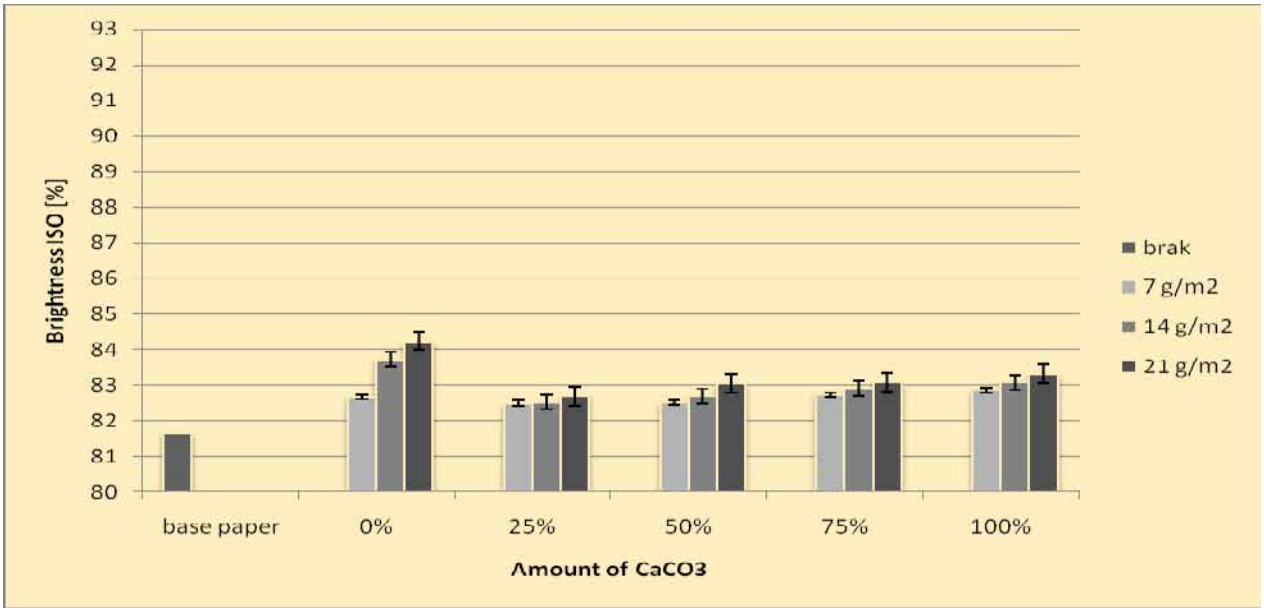

Figure 2: Effect of calcium carbonate content in kaolin and carbonate coating on paper ISO brightness

The figure shows that the brightness of papers coated with calcium carbonate is significantly lower than the ISO brightness of papers coated with calcium carbonate, however it brings higher ISO brightness when compared to the base paper. It results from the fact that the brightness of calcium carbonate and kaolin is similar, whereas the brightness of titanium dioxide is significantly higher. Papers with higher grammage of coat does not cause any significant increase in the ISO brightness of papers coated with calcium carbonate.

Figure 3 and Figure 4 show changes in the ISO brightness of the papers coated with titanium dioxide and calcium carbonate in different proportions in relation to kaolin, aged with outdoor daylight in the closed room.

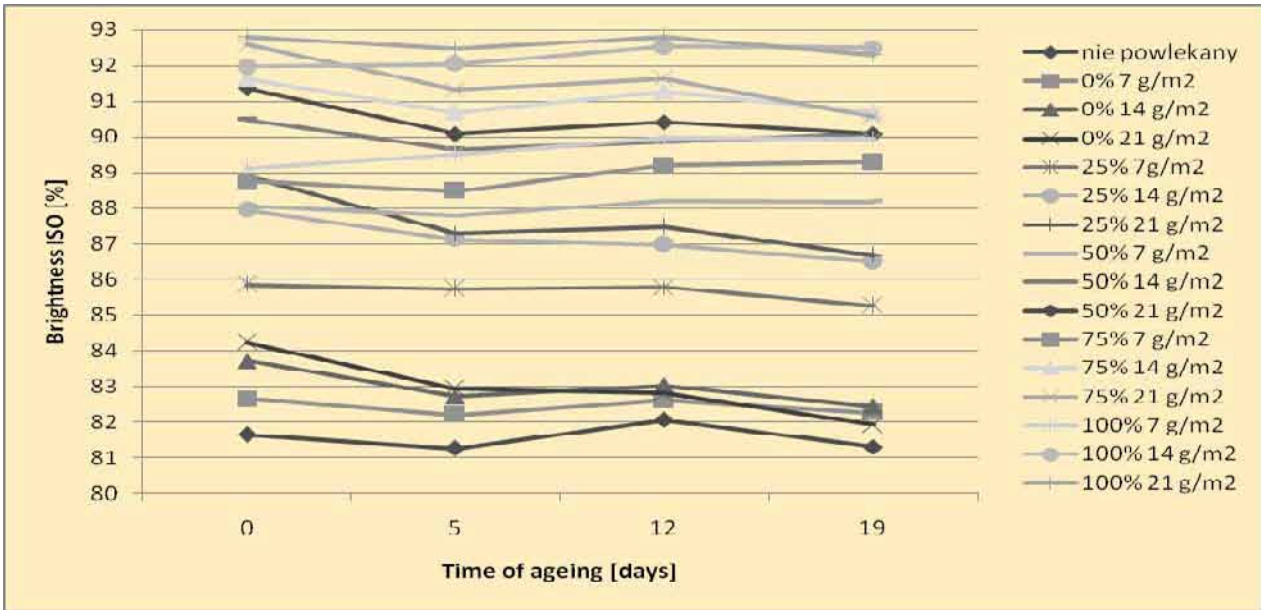

Figure 3: Effect of ageing time with outdoor daylight in closed room on ISO brightness of paper with kaolin and rutile coatings

The above figure shows that after a first week of ageing, the ISO brightness fell for almost each sample. After another week of ageing the changes in the ISO brightness were very small, however in the next week they started to fall. The most significant changes were noticed for papers with coating of 21 g/m^2. The lowest changes were observed for papers with coating of 7 g/m^2. Initially, the ISO brightness of base paper rose and started to fall quite rapidly.

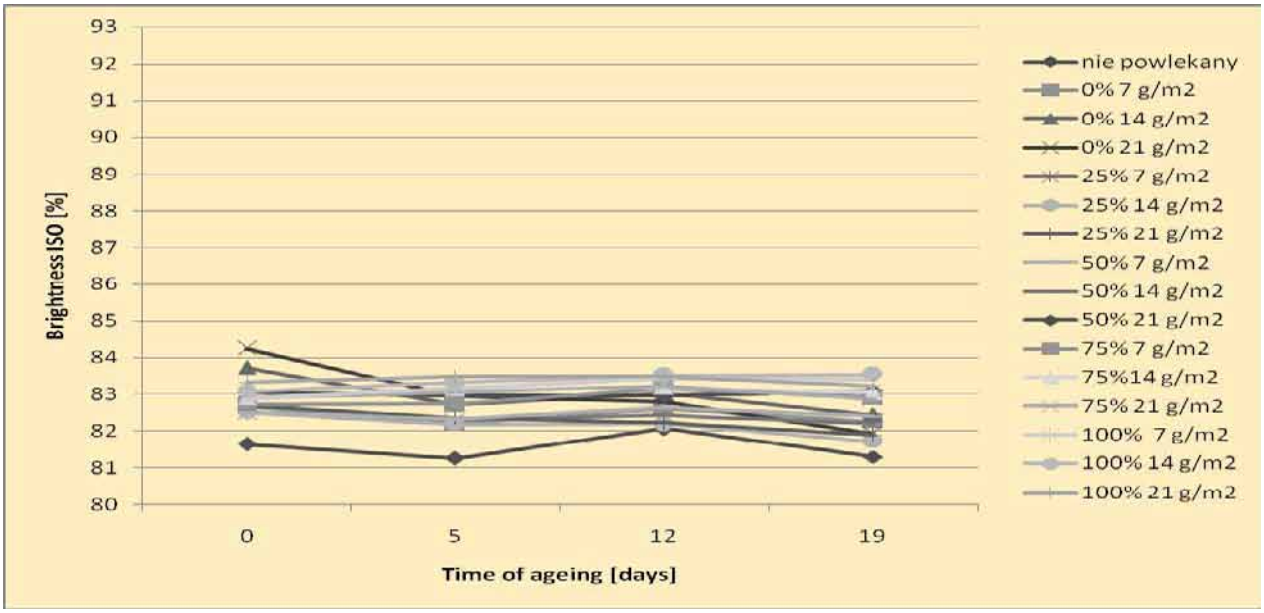

Figure 4: Effect of ageing time with outdoor daylight in closed room on ISO brightness of paper with kaolin and calcium carbonate coatings

The papers coated with calcium carbonate and then aged with the outdoor daylight in the closed room showed a slight growth in the ISO brightness and then a minor decrease.

CONCLUSIONS

High environmental requirements and limited availability of fibrous materials make the paper industry increase the efficiency of lignocellulose pulps derived from wood. The mechanical pulp grades are more and more atractive, however one of their weak points is a tendency to get yellow quickly. Similarly to wood, the mechanical pulps are white with yelowish tint. It is caused by high amount of lignin with chromophore groups absorbing uv radiation and visible violet and blue radiation (from approx. 280 nm to approx 500 nm). To enhance the colour of the papers made from the mechanical pulps and to stop the ageing gradually, the papers were coated with pigment mixture.

On the basis of the tests conducted it was found that the ISO brightnesss of the base paper after coating was increased, because the brightness of the pigments is higher than the brightness of pulp components (cellulose fibres, lignin, etc.). The papers with coatings of higher grammage showed the higher ISO brightness. The highest ISO brightness was obtained by the papers with coatings which contained titanium dioxide.

Over the course of ageing time with the outdoor daylight in the closed room, the ISO brightness of the coated papers slightly grows at the beginning and then it starts to fall in the next weeks of ageing. The most significant changes were showed by the uncoated paper, that

is the base paper. It means that at least in the initial phase of ageing, the process was gradually stopped thanks to applied pigment coatings.

The ageing time with the outdoor daylight in the closed room was however too short to notice more significant changes in the ISO brightness of the coated papers.

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Streszczenie: *Wpływ składu powłok pigmentowych na trwałość papieru***.** Celem pracy było zbadanie w jaki sposób skład powłok pigmentowych wpływa na trwałość barwy papieru. Do badań użyto papieru wytworzonego z masy mechanicznej, który dość szybko żółknie, a jego wytrzymałość gwałtownie spada w procesie starzenia. Na powierzchnię papieru naniesiono mieszanki powlekające zawierające różne pigmenty. Jako pigmentów użyto węglan wapnia, kaolin oraz dwutlenek tytanu (rutyl). Powleczone papiery zostały poddane procesowi starzenia światłem dziennym zewnętrznym w pomieszczeniu zamkniętym, po czym zbadano ich białość. W początkowej fazie starzenia białość nieznacznie wzrasta, dopiero w dalszych tygodniach starzenia zauważono jej spadek.

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