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Full Length Research Paper

The effect of support media on corona treated paper sorption properties

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The absorbency properties of certain paper products are great important. The basic methods to improve absorbency is the addition of chemical. This method is expensive and cause to loose some absorbent materials due to high shear. In recent years corona discharge treatment were utilized in different application to change surface properties of the materials. In general, corona discharge treatment is carried out on aluminum support. This research objective is to test the effect of Iron (Fe), polyethylene (Pe) and wood (W) support on bibulous paper absorbency capacity. The degree of modification was varied with support media and the time of application period. Changes in the surface chemistry was investigated with Fourier Transform infrared spectroscopy. The signals at 1639 cm^{-1}, 1020 cm^{-1} and 953 cm^{-1} was observed. The peak at 1639 cm^{-1} intensity grew with the iron support, Pe support caused to shift peak at 953 cm^{-1}. Water absorbency of paper products changes with the corona discharge treatment. Pe and wood support gave better absorbency capacity. Optical properties of corona treated paper changes with support media. Fe support lowers more than other support media.

Key words: Corona discharge treatment, paper, absorbent papers, absorptivity, gravimetry.

INTRODUCTION

The interaction of paper with liquid is an important property in various paper products such as bibulous paper, tissue, towel, disposable diapers, sanitary napkins, medical sponges, wound-treating pads, etc. These products need to absorb liquid fast and completely dry surface. An absorbency is the properties of the fibrous material which allows it to take up and retain fluids, particularly water and aqueous solutions. The absorbency is measured as an absorption capacity and absorption rate. The absorption capacity is the measurement of the total water absorbed by the products and absorption rate is the measurement of how fast that product absorb water (Tappi Test Method T561 pm96). The higher the water absorption capacity and the shorter the absorption rate, the better. In general, absorption is controlled by the surface properties of the fiber (Ostenson and Gatenholm, 2005; Vander Wielen et al., 2005). Hydrogen bonding, acid base interaction or electrostatic interaction can take place and they can be changed with the addition of chemical and/or physical treatments (Ribitsch et al., 1996; Ribitsch et al., 2001. Baltazar-y-Jimenez and Bismarck, 2007a,b) Corona discharge treatment, tailo-ring the surface of the fiber and other material, is attracting interest to many researchers.

Corona discharges are electrical discharges that take place at or near atmospheric pressure (Mukhopadhyay and Fangueiro, 2009). The corona is generated by strong electric fields and applied to surface with small diameter wires, needles, or sharp edges on an electrode. Colored glow can frequently be seen when corona treatment is carried out in a darkened environment. Ozone is frequently generated during this process. It is usually accepted that this process has two combined effect on the surface. First one is etching and cleaning the surface. Second, the new functional groups forms on the surface of the material that is treated.

The corona is relatively easy to establish, it has wide application on a variety of processes. treated wool fabric with corona discharge Ke et al. in 2008. The surface properties of the treated wool fabrics was investigated. After the corona discharge treatment, the hydrophilicity of the wool fabric was improved and the dyeability with Rhi-

zoma coptidis was increased. The increased treatment level on material surface can increased the surface polarity (Pykonen et al., 2008a, b; Lim et al., 2002).

Printing and adhesion ability of the material can be improved. Mainly carboxyl, ester, alcohol, ethers, aldehydes and ketones can induce on the surface of the material. All these functional groups contain oxygen. These oxygen atoms are then available to bond with the molecules on the surface of the material being treated. Therefore, treatment changes the surface molecular structure to one that is receptive to inks, coatings, and adhesives. The resulting chemical bond that occurs is better than a simple mechanical bond with the surface.

Olefinic polymers such as polypropylene polyethylene have low level of polar groups on the surface and their adhesion properties are very poor. To improve adhesion properties corona treatment can be used(Wolf 2007, Gassan and Gutowski 2000; Comyn et al., 1996). The effect of various corona treatment conditions on the mechanical properties of cellulose fibers polyolefinic composites was studied by several researchers (Ferrero and Bongiovanni, 2006; Belgacem and Giovanni, 2005; Zang et al., 1998). The mechanical properties of composites obtained from different combinations of treated or untreated cellulose fibers and polyolefin were characterized by tensile strength measurements. Their strength was affected with treatment process.

Paper products can easily absorb water by holding the water molecules on hydroxyl groups of cellulose molecules. Corona discharge treatment changes the surface characteristic of the materials. Paper could be easily manipulated by surfactants and additives. The rate of absorption depended largely on the surface characters of the materials, and the fluid it was absorbed.

Tissue, towel industries main interest to develop better absorbent paper products. Disposable paper towels are widely used in the home for wiping spills, especially of water or watery liquids; for cleaning work-surfaces such as those of the kitchen and bathroom. These paper products are usually treated with physically and chemically to improve absorption, softness and bulk properties. Corona treatment improve surface character. However, this treatment is not carried out on different support materials. Therefore, the objective of this study was to perform a comprehensive investigation to characterize the impact of a support media on water absorbency of filter paper. This paper was selected because of fully bleached. Lignin containing paper may impact the topochemical reactions initiated by the corona discharge generated plasma.

MATERIALS AND METHODS

Materials

ISOLAB general purpose filter paper was used to determine sorption properties. Polyethylene(Pe), iron (Fe) and wood (W) were used as support media.

Methods

Corona discharge treatment: Electrotech hand held corona discharge treatment equipment was used. The electric power of this corona discharge was 3 KVA with working width of 100 mm . Five treatment period (15, 30, 60, 120 and 240 s) on different support media were studied. The electrode is moved forward and back on the sample to modify the surface and sorption properties.

FTIR: Fourier transform infrared spectroscopy (FTIR) was carried out to investigate the changes in chemical structure of the sample caused by the corona discharge. Shimadzu IR Prestige 21 model FTIR was used. Paper samples ground together with KBr and pressed into tablets. The spectra of the samples were collected in the transmission mode in the range of 4000 - 400 cm^{-1} .

Whiteness: Whiteness of the paper was measured with Elrepho 071 testing machine. CIE D65/10° (outdoor daylight) whiteness of the paper sample was carried out according to TAPPI Standard test method T560 - pm96 (1996.

Tensile strength: Tensile strength of paper was determined according to Tappi Standard test method T494 om-88. For each paper sample, 10 test specimens were cut with the width of 25.4 ± 1 mm. The length of the strips was 180 mm. The specimen was first aligned and clamped in Tensile tester (Lorentzen Wetre). The tensile strength were recorded when the strip was broken.

Conductivity: Conductivity of the sample was measured with WTW Inolab Level 1 conductivitymeter. 0,1 g of paper sample was shredded and put into 50 ml of distilled water. Conductivity of this solution was measured with conductivitymeter and repeated 3 times.

Water absorbency capacity: Total water absorbency is the measurement of water absorbency capacity. A 76 by 76 mm sample was cut from the paper. The sample was put into weighing container and its mass was measured with OHAUS A264C model electronic balance. The dry weight was measured to the nearest thousandth of a gram. The sample was immersed into distilled water at room temperature for one minute and the sample was allowed to drain its free water for 15 s. The wet sample was weighed and the water absorbency capacity was calculated from the wet and dry sample mass using equation given below.

$$WAC = \frac{m - mo}{mo}$$

Where; WAC is the amount of water absorbed by paper unit mass g/g, m is the wet mass of the sample, g and mo is the dry mass of the sample, g.

RESULTS AND DISCUSSION

FTIR

Fourier transform infrared analysis (FTIR) can provide information regarding the nature and the rearrangement of the surface layer functionality. The paper were subjected to corona discharge treatment were analyzed with KBr pellet in FTIR spectroscopy. The results shown in Figure 1. The most prominent carbohydrate bands in the untreated cellulose were between 1,000 and 1,200 cm^{-1}. In order to compare data normalization was done on peak at 1035 cm^{-1} that originates from the C-O strecth

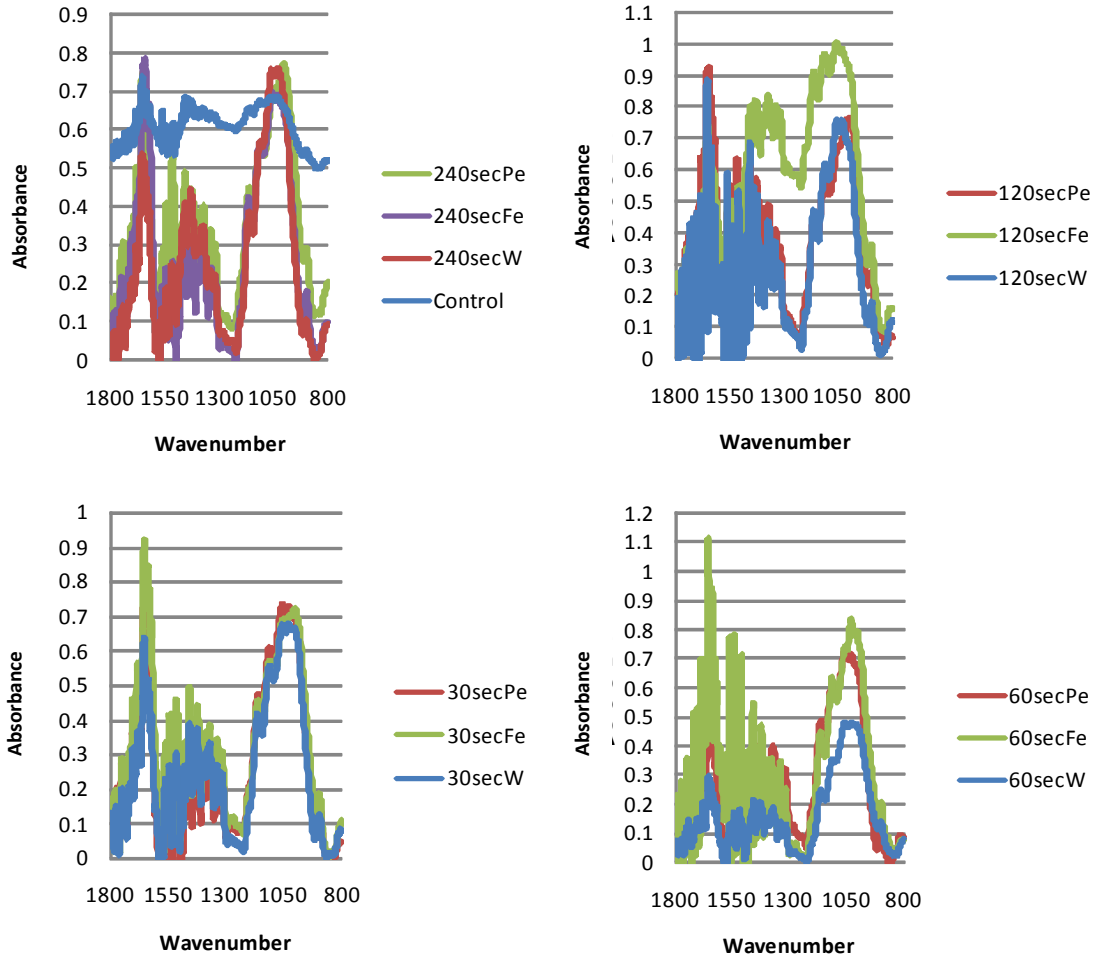

Figure 1. FTIR spectroscopy of corona treated paper samples.

in the carbohydrate ring. The very strong absorption between 1200 and 1000 cm^{-1} is attributed to stretching of the many C-OH and C-O-C bonds in the structure. Some changes in the spectra was found for each treatments. Intensity in 1639 cm^{-1} due to C-O stretch increases when Fe support is used. Wood support gives the least intensity on FTIR spectroscopy at 1639 cm^{-1}. This peak shows probably the oxidation of paper samples. C-C-O stretching at 1020 cm^{-1} and C-C stretching at 993 cm^{-1} were also identified in the spectrum. C-C-O stretching and C-C shows that the changes in surface functionality of the paper. Peaks are shifting towards lower wave-number when Pe support were used.

Whiteness

Paper samples subjected to corona treatment on iron, polyethylene and wood substrate at different period of time were analyzed using Elrepho whiteness tester. The results are shown in Table 1. Control sample whiteness and opacity around 67 and 77 respectively. After corona discharge treatment. this is not changing much. however they are lower than the control samples. Corona discharge alters the surface chemistry and changes the character but in the bulk this is not significant. Whiteness and opacity are not significantly affected by the time of application period however their whiteness and opacity change with the support media Table 2. Oxidation may cause to form some light absorbing species on the surface.

Tensile strength

After treatment with corona discharge. breaking length changes with support media and treatment period. Tensile strenght of the paper samples can be seen in Figure 2. Control samples has the highest breaking strength. Treatment period is not significantly effective on breaking length. Pe support gives in general highest breaking length and Fe support gives the lowest. When iron support is present under the paper samples. electrical arc becomes spark. it jumps from one point to another

Table 1. Optical properties of corona treated paper samples.

Control (s)	Whiteness (66.64)			Opacity (76.87)		
	PE	Wood	Fe	PE	Wood	Fe
15	64.86	64.85	64.95	74.77	74.46	74.86
30	64.58	64.9	64.57	74.07	73.37	75.69
60	64.89	64.87	64.8	72.73	75.01	75.1
120	65.44	66.04	64.38	74.45	75.57	74.83
240	66.29	65.14	64.99	74.87	75.47	74.45

Table 2. The effect of support media on optical properties of paper.

Whiteness			Opacity		
PE	Wood	Fe	PE	Wood	Fe
65.21	65.16	64.74	74.18	74.77	74.99

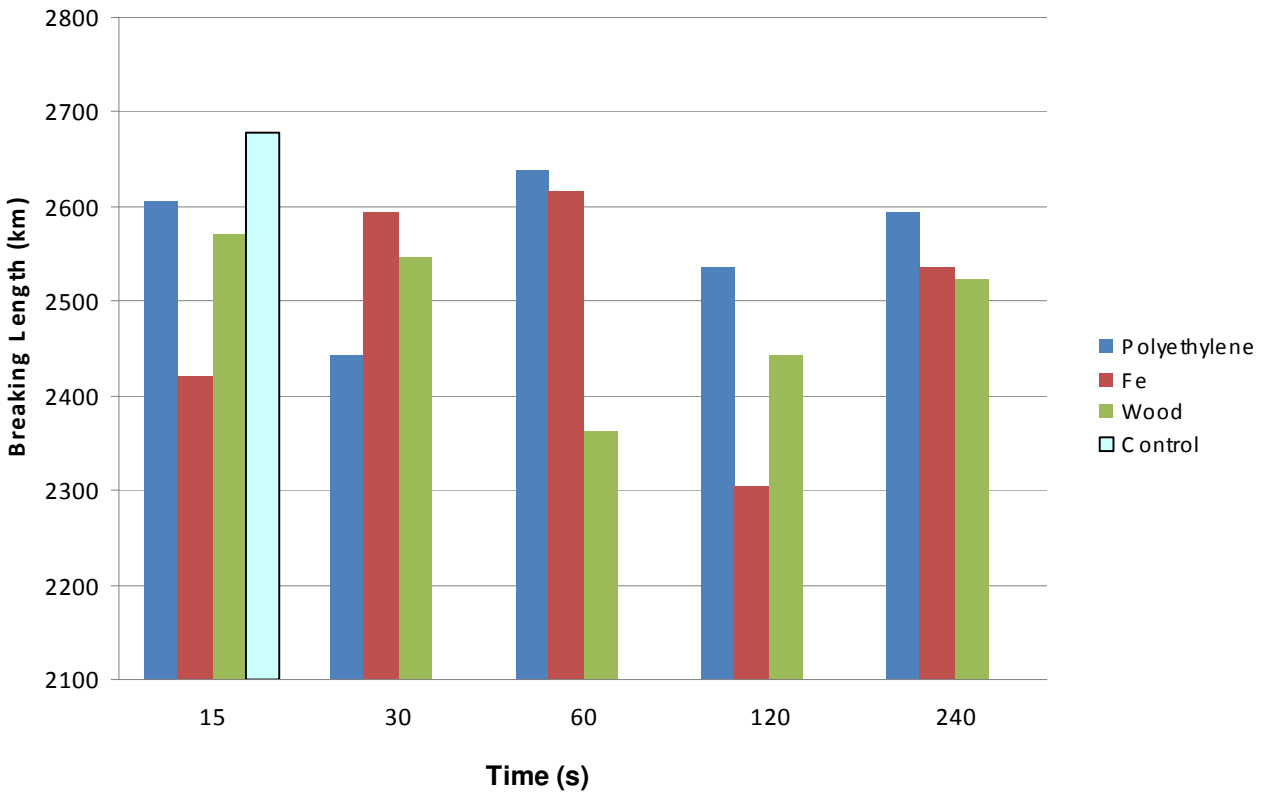

Figure 2. Breaking length of the paper samples in different treatment period and support media.

another (Figure 3). As a result it looks like only one point is treated on surface. In contrast. wood and Pe support provides treatment along the length of corona discharge electrode and blue glows can be seen along the line. This could be due to the conductivity of Fe metal. The other two support media are non-conducting elements, therefore electrical flow from them could not take place.

Conductivity

After treatment with corona discharge. surface properties of the paper changes. Oxygen atoms are available to bond with the molecules on the surface of the material beeing treated. The increased treatment level on paper surface may increase the polarity. The interaction of fiber

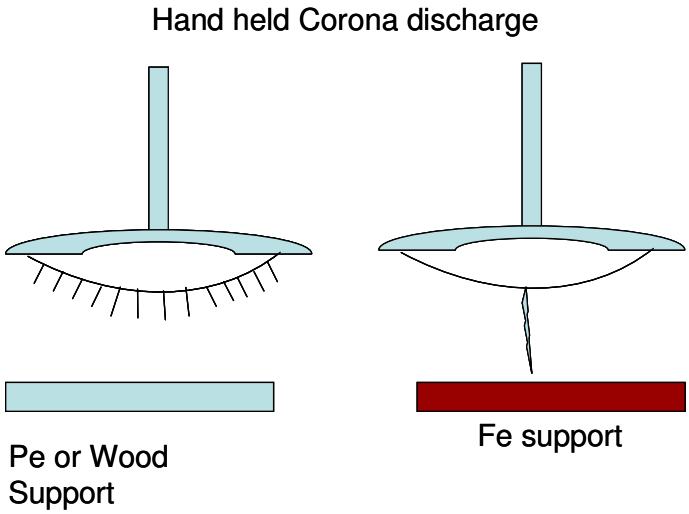

Figure 3. Nature of glow discharge and electrical sparc on different support media.

Table 3. Conductivity of the paper samples.

Control (s)	Conductivity 8.3		
	PE	Wood	Fe
15	8.3	9.0	7.5
30	8.5	8.1	8.1
60	9.8	9.5	9.2
120	8.4	9.5	8.2
240	10.1	10.0	9.4

interface may be increased due to the rise of the number of OH and COOH groups. as demonstrated by the increase in the surface polarity (Table 3). The overall strength and fracture performance of the material was lowered when papers are over-treated.

Water absorbency capacity

Water absorbency is the important properties of tissue towel products. This is generally controlled by the surface properties of the fiber. In order to improve water absorption. fiber usually treated with chemical (Adachi et.al. 2007; Ona and Ozaki. 1994; Barcus and Bjorkquist 1992; Mackey and Seyed-Rezai 1991; Box 1990). Chemical addition involves highly absorbent materials such as polycarboxylate polymers. However. these chemicals are very difficult to use on paper machine. Superabsorbent material tends to disintegrate due to high shear.

It is possible to produce absorbent layer on the surface of the paper products with corona discharge treatment. Absorbent properties of the paper can be seen in Figure 4. In general trend on Pe and Wood support. water absorbency was better than the control samples. In contrast to that. when Fe support was used. the water absorbency capacity became lower. Corona treatment on Pe and wood support improved absorbency with modification. Treatment on Fe surface only caused to apply small range of the paper surface and its application caused the break fiber and lower the absorbency. However. these changes are not significant.

Conclusion

This study investigated the effect of support media on paper properties. It was possible to oxidize paper with corona discharge to different degrees with changing the support material. FTIR spectroscopy clearly showed the change on the surface chemistry on different support media. The intensity of the peak at 1639 cm^{-1} was increased. Absorbency of the material changed with the support media. However. breaking length of the paper became smaller. Polarity of the paper surface was modi-

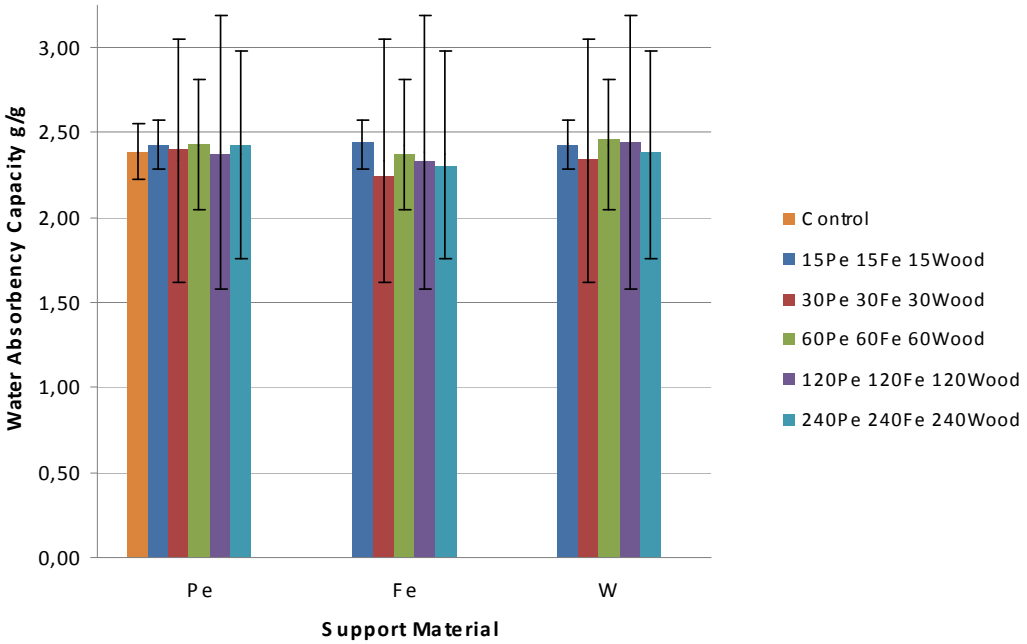

Figure 4. Absorbency of paper products on different treatment period and support media.

modified with corona discharge. After treatment. more polar groups probably be formed on the surface. Optical properties of paper surface changes and this change different on each support media. Iron surface gives the lowest whiteness. However it is not significant. Iron surface lowers the absorbency capacity of the paper samples. Pe and wood samples gives better absorbency however this change is not significant.

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