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Effect of Mixed Tropical Hardwood Kraft Pulp and Polyacrylamide Types on Magnetite Retention in Lumen Loaded Handsheets

(Kesan Pulpa Kayu Keras Tropika Campuran dan Poliakrilamida Terhadap Retensi Magnetit dalam Kertas Makmal Lumen Berpengisi)

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ABSTRACT

This paper reports on the preparation of magnetic lumen loaded handsheets from bleached and unbleached mixed tropical hardwood kraft pulps. The lumen coating technique is a physical approach whereby fillers were deposited inside the fibre lumen. In order to produce magnetically responsive fibres, magnetic fillers were loaded into the fibre lumen. The magnetic filler chosen was magnetite which is usually used to make mylar as found in a diskette. Low and high molecular weights of polyacrylamide (PAM) were used as retention aids. The effect of different molecular weight of PAM on filler content in the bleached and unbleached handsheets were studied. The results showed that the amount of fillers deposited in the pulp fibres increased with increasing molecular weight of PAM using both pulps. However the bleached pulps gave better lumen loading than the unbleached when using high molecular weight of PAM.

Keywords: Lumen loading technique; magnetite; magnetic paper; polyacrylamide

ABSTRAK

Kajian ini menumpukan kepada penyediaan kertas makmal lumen berpengisi magnet daripada pulpa terluntur dan tidak terluntur kayu keras tropika campuran. Bagi menghasilkan kertas magnet yang berfungsi, partikel magnet dimasukkan ke dalam lumen gentian. Partikel magnet yang dipilih adalah magnetit, yang banyak digunakan dalam pembuatan mylar di dalam disket. Poliakrilamida (PAM) dengan berat molekul rendah hingga tinggi digunakan sebagai agen retensi. Kesan penggunaan PAM dengan berat molekul yang berbeza ini ke atas kemasukan partikel magnet dikaji. Keputusan menunjukkan kandungan pengisi yang dimasukkan ke dalam gentian lumen bertambah dengan pertambahan berat molekul PAM bagi kedua-dua jenis pulpa. Walau bagaimanapun, pulpa terluntur memberikan hasil yang lebih baik berbanding pulpa tidak terluntur bila PAM dengan berat molekul tinggi digunakan.

Kata kunci: Kertas magnet; magnetit; poliakrilamida; teknik pemasukan lumen

INTRODUCTION

Lumen loading technique is a physical approach where filler is deposited inside the fibre lumen. The outer surface of the fibre is clear from any unwanted filler attachment. According to Green et al. (1982), lumen loading has many advantages for example the filler is protected by the fibre cell wall from any physical action. Lumen loading allows the fibre to produce better interfibre bonding without the interference of filler on the outer surface of the fibres.

Many previous studies concentrated on the usage of unbleached and bleached pulps from softwood fibres in their lumen loading experiments. Green et al. (1982) and Rioux et al. (1992) used unbleached kraft pulp from black spruce throughout their experiments. Miller and Paliwal (1985) chose Southern pine in order to obtain magnetic paper in their studies. Bleached pulp from black spruce was used to make magnetic paper by Middleton and Scallan (1989). Because many studies only focused on the softwood, there is a need to experiment Malaysian hardwood kraft pulps that are easily obtained. Unbleached and bleached hardwood kraft pulps were chosen as the raw material in this study.

In the preparation of magnetic handsheets, polymer was used as a retention aid. It is found that cationic polyelectrolyte used as retention aid plays an important role in optimizing the interaction between negatively charged fibres and pigments (Zakaria et al. 2004). In this study, cationic polyacrylamide (PAM) was chosen. Low to high molecular weight of PAM were used as retention aids. Polymer is very important in order to prevent the filler from dislodgement.

EXPERIMENTAL TECHNIQUES

The unbleached and bleached mixed tropical kraft pulp used were supplied by Sabah Forest Industries (SFI) Sdn. Bhd. The filler chosen was a magnetic pigment called magnetite, Fe_3O_4 (<5 micron, 98%) supplied by Aldrich Chemical. Aluminum sulphate (alum), $Al_2(SO_4)_3.18H_2O$ and PAM (from low to high molecular weight) were used as retention aids. The lowest molecular weight of PAM was labeled as PAM A whereas the highest molecular weight of PAM was labeled as PAM E. These PAM's were obtained from Malayan Adhesives Chemicals Sdn. Bhd.

Pigment (30 g) was dispersed in 250 mL of distilled water using a mechanical stirrer. In another beaker 15 g of dry weight pulp was fiberized in 1250 ml of distilled water. Each suspension was added 0.1 g/L alum and stirred at standard rotor speed, 1000 r.p.m.. After 15 minutes, both suspension were mixed into a pulp disintegrator and subjected to 3000 rpm. agitation for 20 minutes. This stage is called impregnation. After impregnation, inter-stage treatment replaced where PAM at 1 w/w polymer on pulp was added. The mixture was left for 3 hours, gently stirred at 600 rpm. Washing stage was done in a self-designed washing box equipped with a filter screen (45 μm) for an hour using filtered tap water at the rate of 6 L/min.

Magnetic handsheet was made using a handsheet machine. The handsheets were pressed using Paper Press machine. The magnetic handsheets were conditioned at 23°C and 50 % relative humidity for 24 hours before being characterized.

Paper samples with 5 mm diameter of circular shape were prepared. The samples (~ 2 mg) were examined using a vibrating sample magnetometer (VSM) LDJ 9500. The percentage of filler content were calculated based on the ratio of saturation magnetization of filler in paper over saturation magnetization of magnetite.

A scanning electron microscope (SEM) model Leo 1450VP was used to observe the morphological structure of required samples focusing on the location of fillers.

Results and Discussion

The filler content for both types of samples increased as the molecular weight of PAM addition increased (Figure 1). This showed that PAM is an important additives in order to aid lumen loading. However, the effectiveness of lumen loading depend on the molecular weight of PAM used.

Comparison between unbleached and bleached pulps showed that both samples have the potential to load until high percentage of fillers. The highest filler content for unbleached was18.08% while for bleached pulps was 35.73%. The filler content's result obtained was parallel to previous experiment conducted by Middleton and Scallan (1989) at low molecular weight PAM used (PAM A and PAM B). Under similar conditions of impregnation unbleached pulps loaded was better than bleached pulps. This may be due to the number of carboxylic acid groups in the bleached pulps which decreases due to the bleaching process. This results in the decrease in the electrostatic charge of the fibre which may lead to a lower number of bonding between filler and fibre (Middleton & Scallan 1985).

However, it was found that at higher molecular weight of PAM (PAM C, PAM D and PAM E) the bleached pulps loaded was better than the unbleached pulps. Charge attraction and repulsion occured in the colloidal system during the impregnation, treatment and washing stage. One of the factors which influence the degree of lumen loading is physiochemical condition of the suspended materials such as surface (Green et al. 1982). In this case, attractive interactions between particles and the bleached lumen wall is believed to have occurred. For example, the achievement of KMTE was seen to be at the same level to lumen loading via insitu synthesis which using manganese-ferrite (30.9%), zinc-feritte (32.4%) and manganese-zinc-ferrite (36.2%) (Fujiwara 2003).

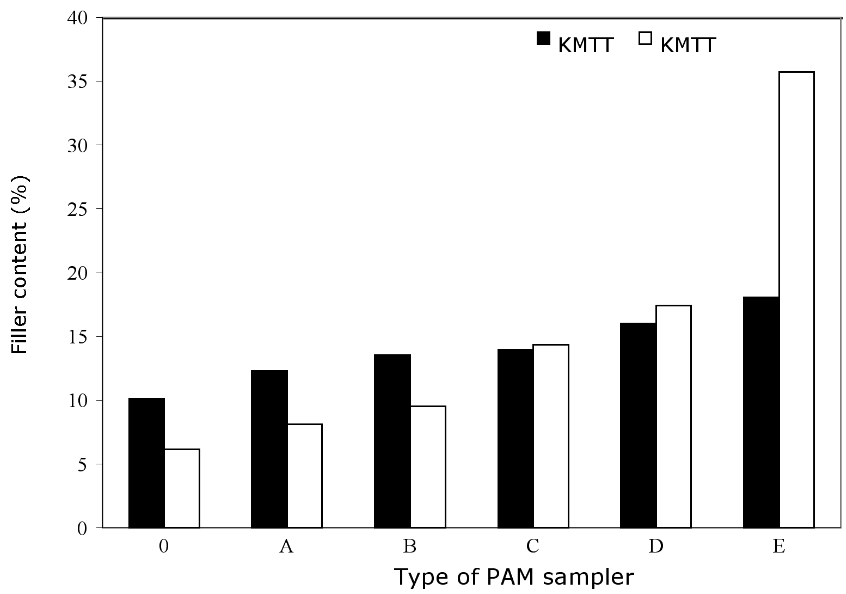

FIGURE 1. Filler content for type of samples using various PAM as retention aid
(KMT =is the magnetic paper from bleached pulp; KMTT is the magnetic paper from unbleached pulp)

Pulp surfaces was observed using SEM. The micrographs in Figure 2 show the surface morphology of unbleached and bleached pulps. Few pits were observed along the fibre showing the fibrilation process of the fibre after bleaching process (Figure 2 (b)). The degradation of particles during bleaching occurs in three different delignification patterns: surface peeling of fibres, rapid partial degradation and fragmentation (Axegård & Gidnert 1996). Surface peeling will affect the fibre surface in order to extract the lignin. The abrasion will shorten the fibre's diameter. In fact, abrasion will also exhibit pit apertures on the fibre surfaces.

Figure 3 show the fibres with and without filler. The lumen loaded fibre showed that part of the lumen that has been filled with magnetite while the outer surface of the fibre was clear from any unwanted filler attachment.

In this study it was found out that lumen loading depended on the type of pulp used and the molecular weight of polymer choosen as retention aids. Both unbleached and bleached hardwood kraft pulps may be loaded until high percentage of lumen loading provided that suitable polymer and its molecular weight is used. It is suggested that further experiments to be carried out using unbeaten and beaten pulp (at series of beating condition using PFI Mill) in order to investigate the lumen loading capability.

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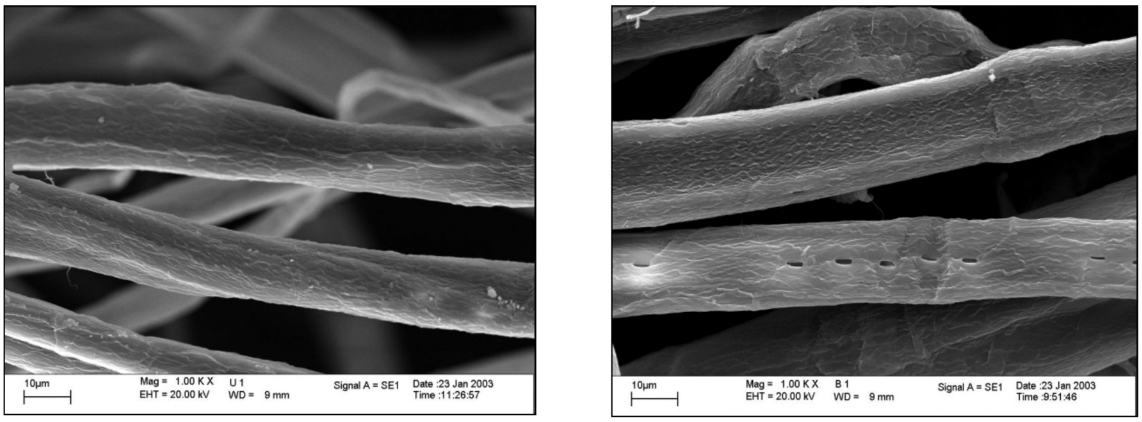
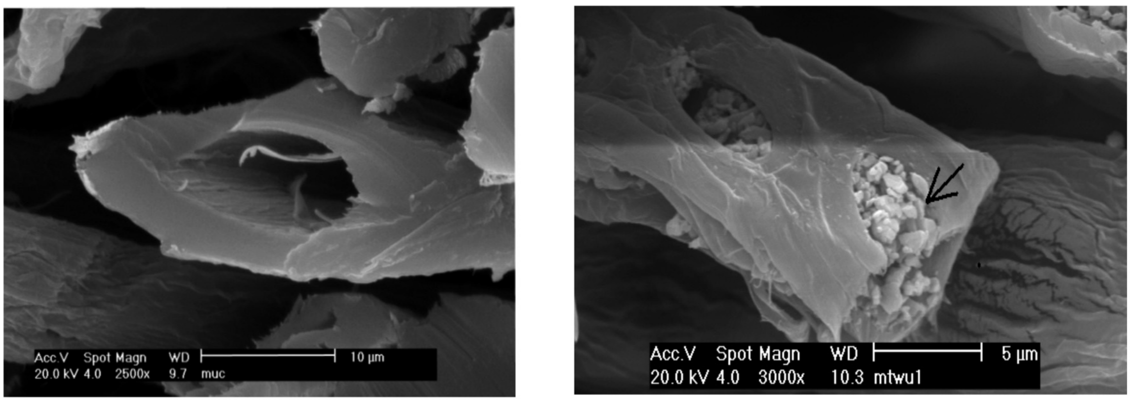


(a) (b)

FIGURE 2. Micrographs of (a) unbleached pulp (b) bleached pulp



(a) (b)

FIGURE 3. Micrographs of (a) unloaded pulp (b) lumen loaded pulp for KMTT sample

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