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Influence of Polyaniline Coated Kenaf Fiber on Kenaf Paper Sheet

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Abstract. This paper reports the properties of newly developed electrically conductive natural fiber paper sheet made up of kenaf fiber (KF) incorporated with polyaniline coated kenaf fiber (KF-PANI). This study proposed on dispersion of conductive filler in different amount (wt %) into kenaf pulp for developing different electrical conductivity. The conductive sheet (KF/KF-PANI) revealed a percolation concentration at 25 wt% of KF-PANI. Its scanning electron micrograph showed good paper formation with no significant damages.

1 Introduction

The use of natural fibers for commercial products is relatively modern scenario since the fiber extracts have main components such as cellulose, pectin, wax, lignin and hemicellulose that have potential for making bionatural products [1]. Kenaf fiber (KF) Hibiscus cannabinus L plant, is receiving great attention through the utilization of its fiber for pulp and paper industry [2]. Kenaf is non-woody plant that can grow until four meter height and can be harvested in four to five months. KF consists of bast long fiber of about 35 %. The rest is core fibers with higher lignin content and much shorter than bast fibers [3]. Kenaf bast fibers are cellulose-rich, thus, they are attractive substitute raw material for pulp and paper production [4]. Interest in new hybrid materials of fibers coated conductive polymers has great attention in recent years due to its functional properties that produced good mechanical properties with high electrical conductivity level [5]. Polyaniline (PANI) as conductive polymer has several unique properties such as ease of preparation, light weight, low cost, better electronic, and soluble in various solvents [6]. PANI as coating agent has been applied in many research and useful in wide area of application studied due to their unique electrical properties [7]. Thus the main aim of this study is to evaluate the influence of polyaniline coated kenaf fiber on kenaf paper sheet for its mechanical strength, surface morphology and conductivity level.

2 Experimental

2.1 Preparation of PANI modified KF

PANI coated KF were prepared according to method described previously [8]. Briefly the treated KF were immersed in the reaction mixture containing aniline solution, followed by the addition of ammonium persulfate solution. The temperature of the reaction mixture was maintained at 10 °C in an ice bath. The KF-PANI obtained were then washed several times by deionized water until the suspension is clear from excess oxidants and clear green fibers can be seen. The samples were dried at 100 °C for 24 h.

2.2 Preparation of KF/KF-PANI sheet

Briefly, kenaf bast fibers (KF) (supplied by Everise Crimson (M)) were treated with active alkali charge of 15% and sulphidity of 17.5%. The mercerized fibers were washed with running water. The pulp was then mechanically disintegrated by a three-bladed mixer for 2 min. KF-PANI were incorporated in the pulp (5, 10, 15, 20, 25 and 30 wt%).The prepared KF/KF-PANI pulp was formed into paper sheets by hand, screened via the flat-plate screen with 0.15-mm slits, pressed for 4 min using a hydraulic press and further conditioned at 90 °C for at least 6 h.

2.3 Characterizations

The electrical conductivity was measured on samples of compressed pellets (200 kPa) using a resistance meter (Advantest) by the four-probe method. Samples were dried for 24 h at 100 °C prior to testing to remove adsorbed moisture and stored in a desiccator filled with silica gels. Five measurements were made on each sample. Tear test was performed using the Elmendorf Tearmethod (ASTM D-1922). The tear index of the paper

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was calculated using average tearing force (mN)/average grammage (g/m2), whereby the average tearing force is given by (16 × 9.81 × average scale reading). The sheet morphology was examined by above mentioned scanning electron microscope (SEM) equipment Leo Supra 50VP.

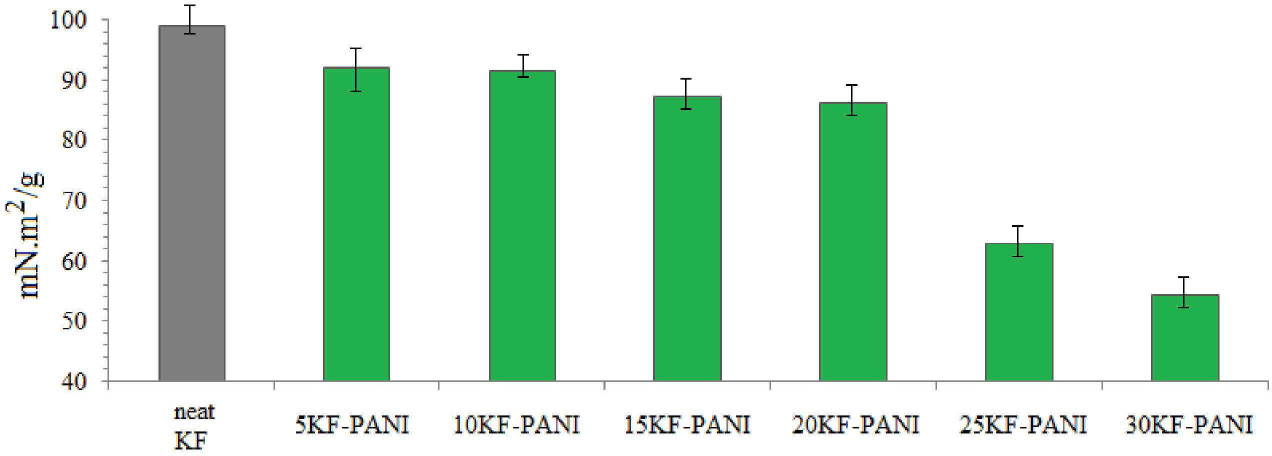

Figure 1. Tear index of KF sheetsmodified with KF-PANI.

3 Results and discussion

Table1. Electrical conductivities of KF sheet and KF/KF-PANI sheets

Sample	DC Conductivity (S·cm-1)
KF	10-13
KF/5KF-PANI	10-13
KF/10KF-PANI	10-13
KF/15KF-PANI	10-12
KF/20KF-PANI	10-12
KF/25KF-PANI	10-8
KF/30KF-PANI	10-8

As seen in Fig. 1a, tear index of neat KF sheet corresponds well with previously reported studies [9]. KF/KF-PANI (5-20 wt% loading) shows slight reduction compared to neat KF. The minimal decline in tensile strength is mainly caused by the inherently poor mechanical properties of KF-PANI and difference in crystallinity/polarity of the two surfaces (PANI and KF). The drop in tear index however is limited by the mechanical interlocking between the fibers. Incremented amount of cellulose being exposed on the fiber surface after mercerization resulted in better fiber-polymer interaction provided by potential H bonding with the amide groups of PANI which leads to preservation of mechanical strength. The significant drop at 25 wt% of KF-PANI is due to the high presence of KF-PANI fiber which percolated in the KF sheet that might lowers the fiber-fiber interaction during the pulping stage.

Table 1 presents the DC conductivities of the prepared samples. DC conductivity of the neat KF sheet is recorded to be around 10-13 S·cm-1, exhibiting the typical conductivity values of insulating natural fiber. Inclusion of 5 wt% of KF-PANI into the paper pulp shows no changes in its conductivity. No significant changes occurred up to 20 wt% KF-PANI loading. This signifies that the KF-PANI component have not reached its percolating state to provide any charge transport to the KF sheet. On the other hand, 25 wt.% of KF-PANI reveals an abrupt jump in the conductivity. This indicates that the percolation of the KF-PANI in the KF sheet has been achieved at 25 wt.% loading. At this particular concentration, the conductive system has created sufficient pathways and junctions for the electron to flow in the KF sheet, thus increasing its electrical conductivity. KF/30KF-PANI shows no changes even with higher wt.% of KF-PANI.

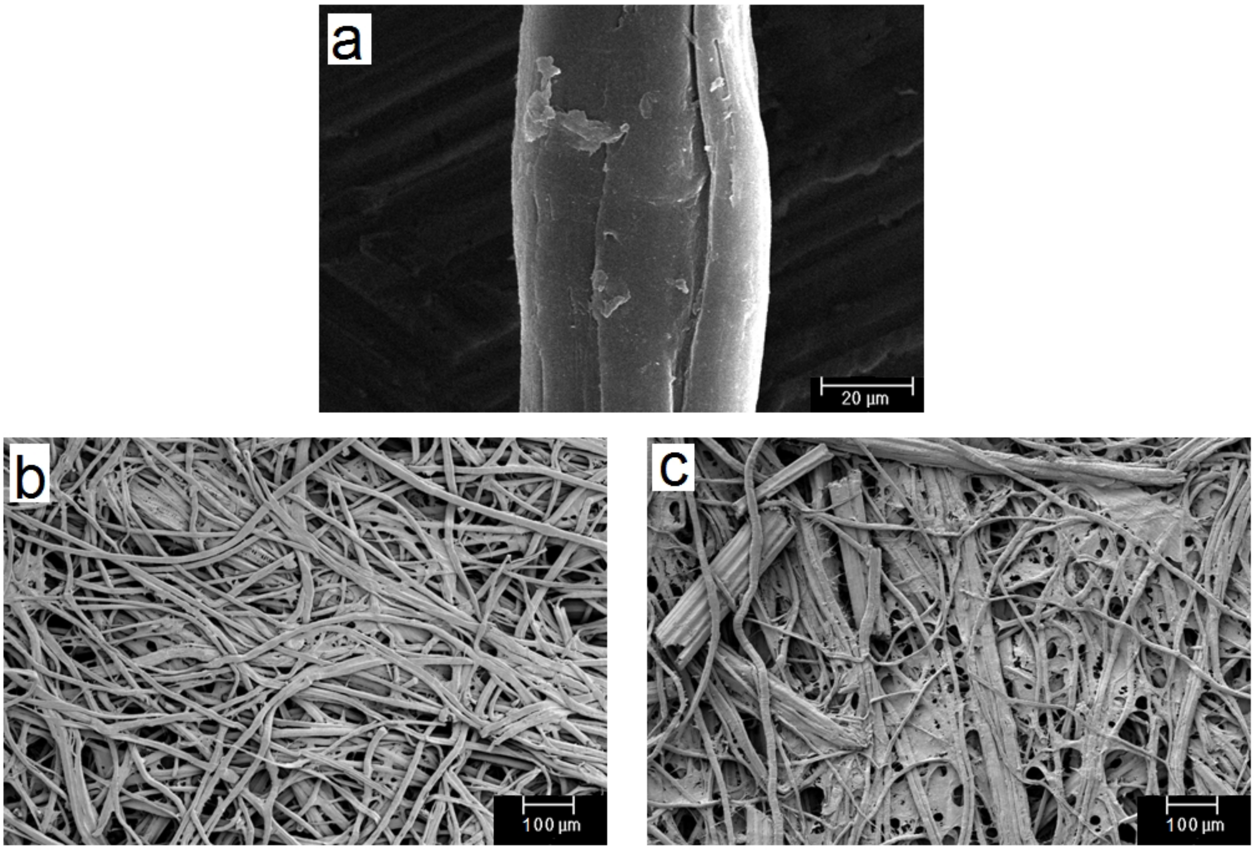

Figure 2. SEM images of a)KF-PANI b)neat KF sheet c) KF/25KF-PANI

Fig.2a depicts the SEM image of PANI coated KF (KF-PANI). Fig. 2b illustrates the SEM image of the neat KF sheet. The sample exhibits typical surface features of lignocellulosic fibers. Incorporation of KF-PANI into the KF (Fig. 2c) reveals that the morphology of the fibrous sheet is still intact, no fiber rupture and damages are observed. This is apositive indication of a possible way to obtain conductive paper, while preserving its fiber characteristics.

4 Conclusions

Conductive kenaf paper sheet (KF/KF-PANI) was prepared by incorporating polyaniline coated kenaf fiber (KF-PANI) during the pulping stage. This new electronically modified natural fiber shows promise for multifunctional applications which require electrical conduction and mechanical strength. By using this method, the mechanical strength can be preserved at a useable level while achieving its conductive state.

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