MECHANICAL PROPERTIES OF KENAF/POLYESTER COMPOSITES

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In this study, the reinforced kenaf fibers using polyester resin composites were processed through vacuum infusion method. Before infusion and reinforced applied, the long kenaf fibers were treated by various concentration of sodium hydroxide (NaOH). The effects of the modification on fiber and also the effect of fiber alkalization on composites then is analyzed for mechanical properties and by using the scanning electron microscopy (SEM). The results showed that the alkalization treatment has improved the mechanical properties of the composites as compared to the composites with untreated kenaf fiber. In addition, a general trend of the mechanical performances of alkalized kenaf fiber composites observed showed increase with the increments of NaOH concentration. In this study, the vacuum infusion method used also offers benefits over hand lay-up method due to the better fiber to resin ratio that resulting in stronger and lighter laminates. By vacuum infusion process, the kenaf-polyester composite manufactured provides an opportunity for replacing the existing materials with a higher strength, low cost alternatives, and environmental friendly.

Keywords – kenaf-polyester composite, vacuum infusion, mechanical properties, scanning electron microscopy

I. INTRODUCTION

Nowadays, natural fibres form is an interesting option for the most widely applied fibre in the composite technology. Many studies on natural studied have been done such as kenaf [1-7], bagasse [2], jute [3], ramie, hemp [3] and oil palm [8]. The advantages of natural fiber composites are renewable, environmental friendly, low cost, low density, flexibility of usage and biodegradability [4, 8].

Traditionally, kenaf bast fibers are used and known for rope, twine, and course sacking materials. Kenaf (Hibiscus cannabinus L.) as natural fiber is biodegradable and environmentally friendly crop and has been found to be an important source fiber for composites and other industrial applications. Kenaf fiber also has a potential as reinforced fiber in thermosets and thermoplastics composites. However, the fibers modification is required and needed to improve mechanical properties for composites product [4-7]. The efficiency of the fiber-reinforced composites also depends on the manufacturing process that the ability to transfer stress from the matrix to fiber [5].

In this study, kenaf fiber reinforced polyester resin composite was made by vacuum infusion resin process, and their mechanical performances were investigated.

II. MATERIALS AND METHODS

Materials

Kenaf fiber used in this work was supplied by Lembaga Tembakau Negara (National Tobacco Board), Malaysia. The fiber forms is the long bast fiber and was already through the water retting process, while the polyester resin used and sodium hidroxide (NaOH) for the modification process are supplied by local enterprise.

Fiber treatment

In this study, chemical retting was used. The procedure involves NaOH solution, water washing, and drying. The concentration of sodium hydroxide and soaking time were the key factor affecting the treatment. There are five chemical treatments compositions/concentrations (NaOH and soaking time) used in this as shown in Table 3.1. The fibers were washed thoroughly under the warm tap water for seven times after soaked in NaOH and then dried in room temperature for 24 hours.

Table 1: The chemical solution of the treatment

Treatment	NaOH (%)	Soaking time, (hr)
1	3	12
2	3	24
3	6	12
4	6	24
5	9	12

Composite manufacturing methods

In this study, composites were made by using vacuum infusion process. The process was started with the sealant tape placed on a glass mould measuring 300 x 300 mm lengh and width. Spiral tube was then fitted at resin feed lines and a releasing agent was sprayed evenly onto the surface of the mould. Four layers kenaf fiber were placed on the mould with different of two direction, 0^o and 90^o. Peel ply, distribution media and vacuum bag were placed. Vacuum pump used to vacuum out the air of the system. The leaking check is required and if there is no leaking found, the polyester resin was then infused to the system. Vacuum infusion method used in this study offers benefits over hand lay-up method due to the better fiber to resin ratio, resulting in stronger and lighter laminates. Figure 1 shows the vacuum infusion setup and process.

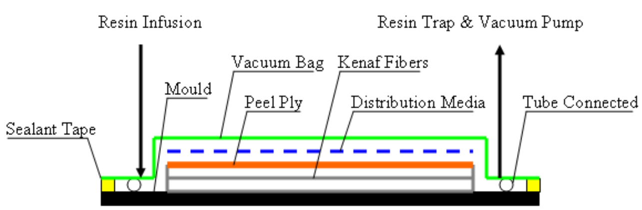

Figure 1: The vacuum infusion configuration.

Measurements

The scanning electron microscope (SEM) machine model Zeiss Evo 50 is used in order to examine physical characteristic of the fibers. Scanning electron microscopy provides an excellent technique for examination of surface morphology of fibers and fracture surfaces of fiber composites. Examinations were carried out on the untreated and treated fibers to study the morphological changes that occurred after treatment of the fibers.

The tensile tests were performed using a testing machine model AG-I Shimadzu. The width and thickness of the specimens were measured and recorded. The tensile tests were carried out according to ASTM D 638 – 01. The tensile strength and tensile modulus were calculated from this test. Three point bending tests were performed using a testing machine model Instron 5585 in according to ASTM D 790 standards. From this tests, flexural strength and flexural modulus were calculated.

The izod impact tests were performed using impact tester model IT 30. The width and thickness of the specimens were measured and recorded. The izod impact tests were carried out according to ASTM D 256 standard. From this tests, impact strength were calculated.

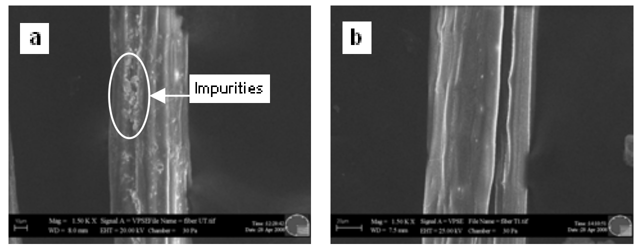

Figure 2 : SEM micrograph of kenaf fiber (a) untreated fiber and (b) treatment 1 (treated 3% NaOH for 12 hours).

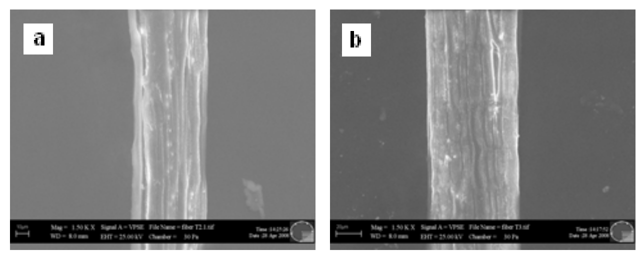

Figure 3 : SEM micrograph of kenaf fiber (a) treatment 2 (treated 3% NaOH for 24hours) and (b) treatment 3 (treated 6% NaOH for 12 hours).

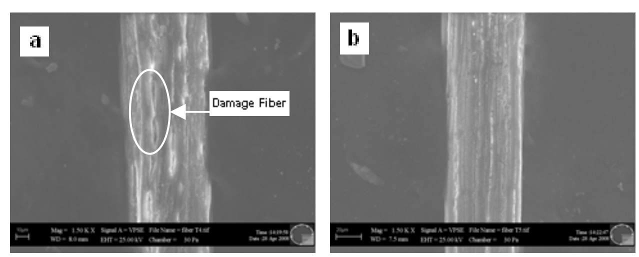

Figure 4 : SEM micrograph of kenaf fiber treatment 4 (treated 6% NaOH for 24 hours) and (c) treatment 5 (treated 9% NaOH for 12hours).

III. RESULTS AND DISCUSSION

Fiber surface morphology

Scanning electron microscopy provides an excellent technique for examination of surface morphology of fibers and fractures surface of fiber composites. In this study, morphological changes that occured after treatment (fibers) were examined. All micrograph in this work are taken with 1500 times (1500 x) magnification.

Figure 2 (a) shows the SEM micrograph of an untreated kenaf fiber. The impurities were clearly observed on the surface of untreated fiber. The modification of fiber by sodium hidroxide (NaOH) were effectively removed the impurities of the fiber surface. Figure 2 (b) shows the SEM of the surface of treatment 1 (treated 3% NaOH for 12 hours) kenaf fiber. It was found that the fiber more cleanliness than untreated fiber. Figure 3 (b) shows the SEM micrograph of treatment 3 (treated 6% NaOH for 12 hours) fiber. It was observed that almost all impurities have been remove from the fiber surface. The increasing of soaking time in NaOH showed the damage of fiber surface. It shown in Figure 3 (a) (treated 3% NaOH for 24 hours) and Figure 4 (a) (treated 6% NaOH for 24 hours) that a lot of fiber surface were damage. Figure 4 (b) shows the SEM micrograph of treatment 5 (treated 9% NaOH for 12 hours) fiber that presented the cleanest fiber surface.

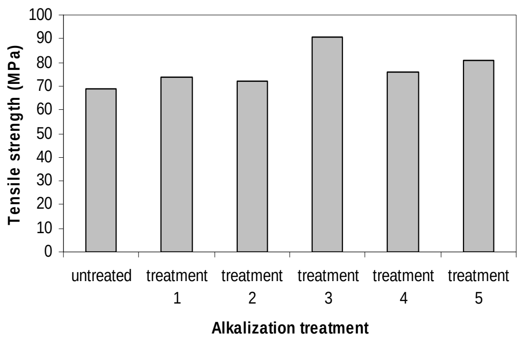

Figure 5: Tensile strength of alkalized treatment and untreated kenaf fiber composites

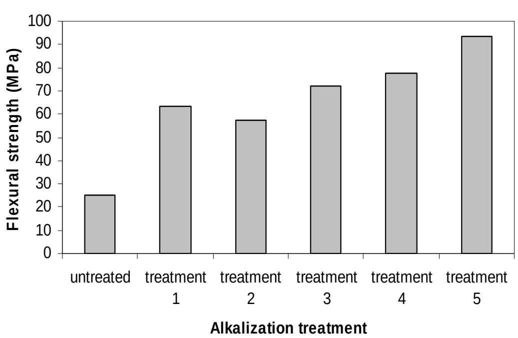

Figure 6: Flexural strength of alkalized treatment and untreated kenaf fiber composites

Tensile and flexural strengths

Figure 5 shows the measured tensile strength of alkalized treatment and untreated kenaf fiber composites. Treatment 3 (treated 6% NaOH for 12 hours) composites displayed the highest (90.8 MPa) tensile strength, while the untreated kenaf fiber composites showed the lowest (69.1 MPa). The tensile strength increase with the increasing of NaOH concentration on the fibers. However, its decreased when the concentration of NaOH was increased up to 9%. It might the high concentration of NaOH could be damage the fibers [5]. The soking time of the fibers also gave an effect on the mechanical performance of the composites. There are found that the increasing of soaking time of the fibers were decreased the tensile strength. For the flexural strength, the highest (93.4 MPa) resulted at treatment 5 (treated 9% NaOH for 12 hours) composite. The results were shown in Figure 6 where the lowest (25.1 MPa) flexural strength was the untreated fiber composites. There was displayed that the flexural strength increased with increase of NaOH concentration and soking time. However, the flexural strength of 3% NaOH fiber composite decreased after a soking time increase from 12 hours (63.2 MPa) to 24 hours (57.3 MPa).

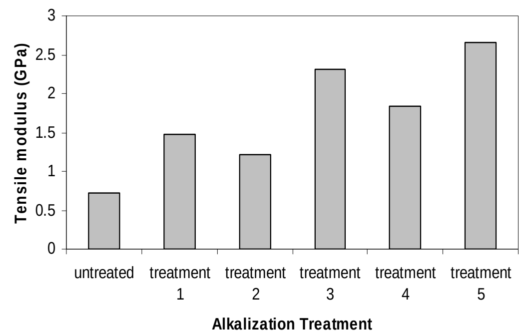

Figure 7: Tensile modulus of alkalized treatment and untreated kenaf fiber composites

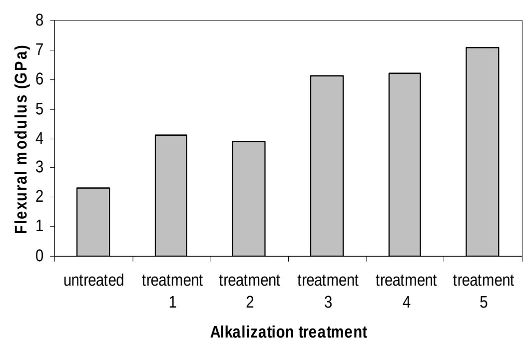

Figure 8: Flexural modulus of alkalized treatment and untreated kenaf fiber composites

Tensile and flexural moduli

Figure 7 and 8 shows the tensile modulus and flexural modulus of the alkalized treatment and untreated fiber composites, respectively. From the histograms, it is obvious that the all treated fiber composite types gave superior modulus values compared to the untreated fiber composites.

Treatment 5 (treated 9% NaOH for 12 hours) composites resulted the highest for both tensile modulus (2.66 GPa) and flexural modulus (7.1 GPa). The tensile modulus increase when the concentration of NaOH was increased, but it was then decreased with the increasing of fibers soking time. However, for the flexural modulus, the results showed there are no an effect of the fiber soking time.

The alkalization treatment of fibers helps in improving the chemical bonding between the resin and fiber resulting in superior mechanical properties. It has been reported by several authors that mechanical properties of composites were improved by the modification of fibers [4-7, 24].

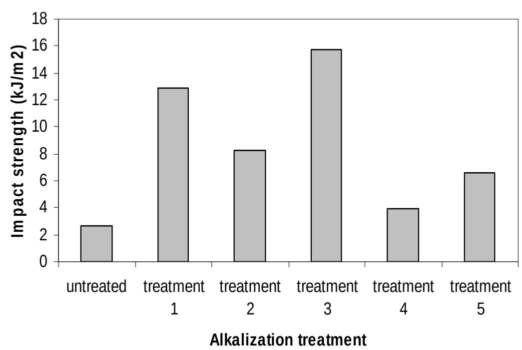

Figure 9: Impact strength of alkalized treatment and untreated kenaf fiber composites

Impact strength

Figure 9 presented the izod impact strength results of the composites. The composites tested displayed low impact strength for the untreated (2.61 kJ/m^2), the treatment 4 (treated 6% NaOH for 24 hours) (3.9 kJ/m^2) and the treatment 5 (treated 9% NaOH for 12 hours) (6.57 kJ/m^2) composites. The treatment 3 (treated 6% NaOH for 12 hours) composites showed the highest impact strength (15.77 kJ/m^2). In spite of thier low tensile and flexural properties, the treatment 1 (treated 3% NaOH for 12 hours) composites demonstrate better in impact strength (12.84 kJ/m^2). It is the impact response of fiber composites by the interfacial bond strength. Impact energy is dissipated by debonding, fiber fracture and fiber pull out. Fiber fracture dissipates less energy compared to fiber pull out [3, 23].

IV. CONCLUTIONS

Kenaf fiber have been treated with NaOH solution of different concentrations and soking time. The morphological changes were investigated using scanning electron microscope (SEM). It has been found that NaOH solution was effective to remove the impurities of the fiber surface. However, the increasing of soaking time in NaOH showed the damage of fiber surface.

The mechanical properties of kenaf fiber reinforced polyester composites made by vacuum infusion method were investigated. It has been found that the alkalization treatment used has improved the mechanical properties of the composites. Kenaf fiber can be a good reinforcement candidate for high performance polymer composites. The kenaf-polyester composite manufactured by vacuum infusion process provides an opportunity of replacing existing materials with a higher strength, low cost alternative that is environmentally friendly.

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