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## Water Absorption and Flexural Property of Unidirectional Polypropylene/Sumberejo Kenaf Fiber Composites

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# Water Absorption and Flexural Property of Unidirectional Polypropylene/Sumberejo Kenaf Fiber Composites

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**Abstract.** Kenaf fiber can be used as an alternative to synthetic fiber reinforcement in composites. This research was conducted in order to determine the flexural and diffusion properties of the composite by varying the fiber fractions. Before being used as a reinforcement, kenaf fiber was firstly treated with alkali treatment in NaOH solution for 24 hours. Polypropylene and kenaf fibers were fabricated with a hot press machine. The fiber fractions were 30 wt%, 40 wt%, 50 wt%, and pure polypropylene samples were also fabricated as a comparison. The highest flexural strength, the minimum water absorption and water content were found in the polypropylene/30 wt% kenaf fibre composites with the value of  $(4.77 \pm 0.799)$  MPa,  $(3.61 \pm 0.823)\%$  and  $(0.192 \pm 0.154)\%$  respectively.

**Keywords:** kenaf fiber, polypropylene, flexural strength, water content, water absorption

## 1. Introduction

Nowadays, composites become one of materials that are widely used in daily necessities, from household appliances to automotive. Synthetic fibers have been used in composites as reinforcements but it have non-biodegradable properties so they are not environmentally friendly materials [1]. Composites with natural fiber reinforcement can be an alternative to replace synthetic fibers that can cause damage to nature. The use of natural fibers as reinforcement in composites has been widely researched and developed at this time. Increased utilization of natural fibers was due to low costs, high specific modulus, lightness, and lower energy requirement [2].

**Table 1.** Chemical composition of kenaf fiber [4].

<b>Cellulose (%)</b>	45.0 – 70.6
<b>Hemicellulose (%)</b>	12.3 – 21.5
<b>Lignin (%)</b>	8.0 – 13.0
<b>Pectin (%)</b>	3.0 – 5.0

Kenaf fiber is one of the natural materials that can be used as an alternative to synthetic fibers. Kenaf is a non-wood lignocellulose material because its main constituent materials are cellulose, hemicellulose, and lignin [3]. Table 1 shows the chemical composition of KF [4].



Before being used as a reinforcement in composites, natural fibers need alkali treatment. Mechanical properties such as strength, flexibility, and stiffness of natural fibers can be improved by this treatment [5]. To obtain optimal strength of kenaf fiber composite, NaOH 5% aqueous solution was used [6]. Fiber fractions were varied to determine which fiber fractions is the best. Based on research conducted by Ollivia [7], the highest tensile strength and deflection temperature were obtained from PP/40wt% Sumberejo kenaf fiber composites. There is a lack of study in water content and flexural properties of PP/Sumberejo kenaf fiber composites. The aim of this research was to determine the value of water content, water absorption, and flexural properties of PP/Sumberejo kenaf fiber composites to meet the requirements of SNI 01-4449-2006.

## 2. Experimental Method

### 2.1. Preparation of Kenaf Fiber

Kenaf fibers (KF) and polypropylene (PP) were materials used in this research. KF was initially treated with alkali treatment to remove lignin by soaking it in NaOH 5% solution for 24 hours. Treated KF was rinsed with distilled water until the distilled water was colorless. After that, KF was dried at room temperature for 48 hours and in the oven with the temperature of 60°C for 24 hours. Both untreated and treated KF were analyzed using Fourier Transform Infrared Spectroscopy (FTIR) to identify the chemical change of the fibers in a range of 400 – 4000 cm<sup>-1</sup>. For this measurement, pelletized mixtures of KF samples and potassium bromide (KBr) powder were used.

### 2.2. Fabrication of Composite

PP pellets were extruded into sheet forms using a hot press machine at 190 °C for 6-7 minutes then were cooled using a cold press machine for 2-3 minutes. The purpose of turning PP into sheet forms was to make PP easily dispersed and wetted the KF. PP and KF respectively weighed and arranged unidirectionally into molds in accordance with certain weight fraction and it was fabricated using a hot press machine with a pressure of 5 MN/m<sup>2</sup>, temperature of 190°C for 6-7 minutes. Fiber fraction used in this experiment was 30 wt% (PP/KF30), 40 wt% (PP/KF40), and 50 wt% (PP/KF50).

Referring to ASTM D7264, the flexural test was carried out by cutting the specimens with size ratio thickness: length equal to 1:20. Then, the specimens was given a dot right in the center. The flexural test conducted with pressure speed of 10mm/minute.

SNI 01-4449-2006 was used as a reference in this research. Specimens with a dimension of 50 mm x 50 mm were tested by soaking the specimens in water at room temperature for 24 hours. To calculate the value of water absorption in the specimens, Equation (1) was used.

$$\text{Water Absorption (\%)} = \frac{W_{\text{before}} - W_{\text{after}}}{W_{\text{after}}} \times 100 \quad (1)$$

According to SNI 01-4449-2006, water contents of composites were obtained based on the weight of specimens with a dimension of 50 mm x 50 mm before and after being heated in an oven at a temperature of 103 °C until the weight was constant. Equation (2) was applied to calculate the value of water content.

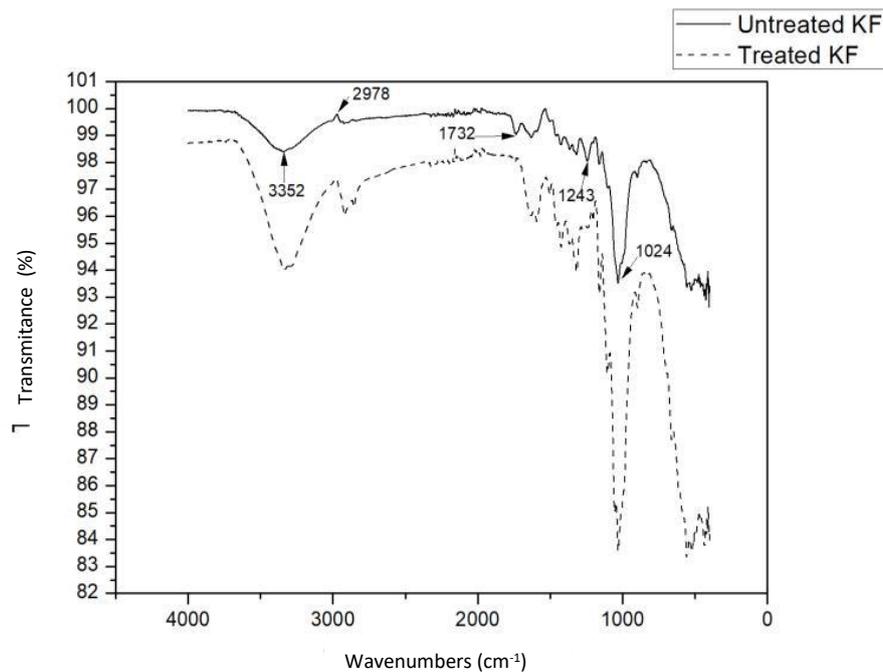
$$\text{Water Content (\%)} = \frac{W_{\text{wet}} - W_{\text{dry}}}{W_{\text{dry}}} \times 100 \quad (2)$$

Specimen morphology before and after flexural test was observed with an optical microscope (OM) to see the type of damage of the composite surfaces.

## 3. Result and Discussion

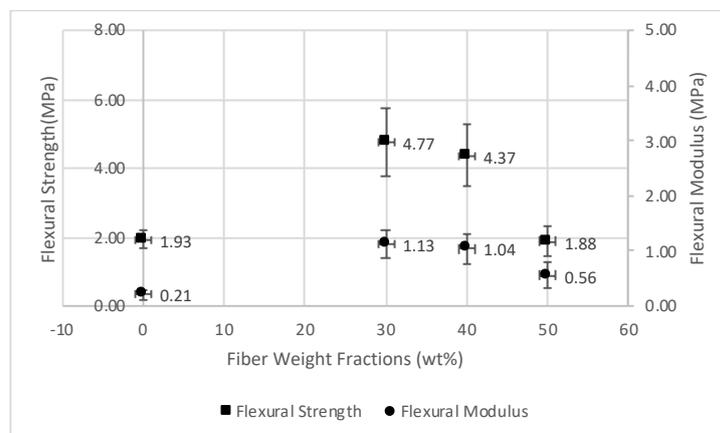
Figure 1 showed the Fourier Transform Infrared spectra of untreated and treated KFs by alkali treatment. The broad peak around 3300 cm<sup>-1</sup> can be associated with the O-H group of raw kenaf fiber and was

identified as cellulose. The peak shown at  $2978\text{ cm}^{-1}$  suitable to the C-H group. The area between  $2000$  and  $1000\text{ cm}^{-1}$  were stretched carbonyl group ( $\text{C}=\text{O}$ ,  $1745\text{ cm}^{-1}$ ) and were related to the presence of lignin and/or hemicelluloses. The peak at  $1732\text{ cm}^{-1}$  belongs to hemicelluloses and it was showed that hemicelluloses were removed from the fiber surface after the alkali treatment. C-O stretching of the lignin was found at peak  $1243\text{ cm}^{-1}$  and the loss of this peak in treated KF confirmed the removal of lignin by alkali treatment. These results are similar to a research by Zarina *et al*, who conducted research on different treatments to kenaf fibers [8].



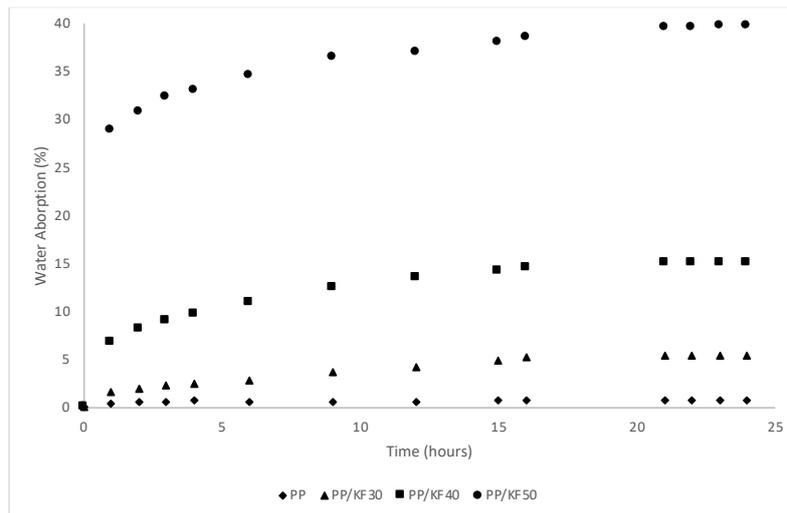
**Figure 1.** FTIR spectra of untreated and treated Sumberejo kenaf fiber.

Figure 2 represents the flexural strength and flexural modulus of PP/KF composites. Based on this research the highest flexural strength and flexural modulus were found in PP/KF30 with the value of  $(4.77 \pm 0.799)$  MPa and  $(1.13 \pm 0.574)$  MPa respectively. These results have similar trends with a research about epoxy/KF composites, conducted by Sapiai N *et al* [9]. In Sapiai research, it was indicated that the presence of kenaf fiber increased the flexural strength and flexural modulus.



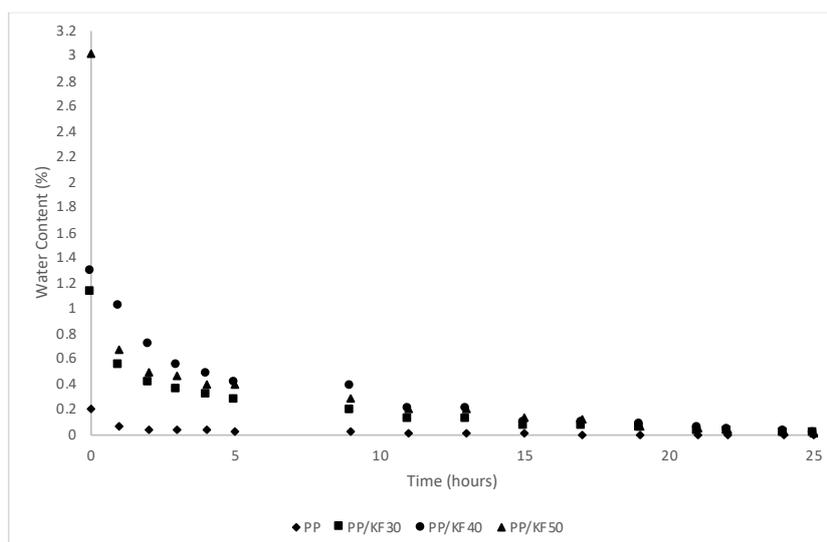
**Figure 2.** Flexural strength and flexural modulus of PP/Sumberejo kenaf fiber composites versus fiber fraction.

Figure 3 presents the water absorption of PP/KF composites at temperature of 25°C for 24 hours. PP/KF50 composites water up-take has a greater value because these composites contain the highest KF that absorbed more water. According to previous research on kenaf fiber/unsaturated polyester composites conducted by E. Osman [10], the higher the amount of fiber fraction, the higher the water absorption. PP/KF30 has the smallest value of  $(0.192 \pm 0,154) \%$ . All of the Sumberejo kenaf fiber composites fulfilled SNI 01-4449-2006.



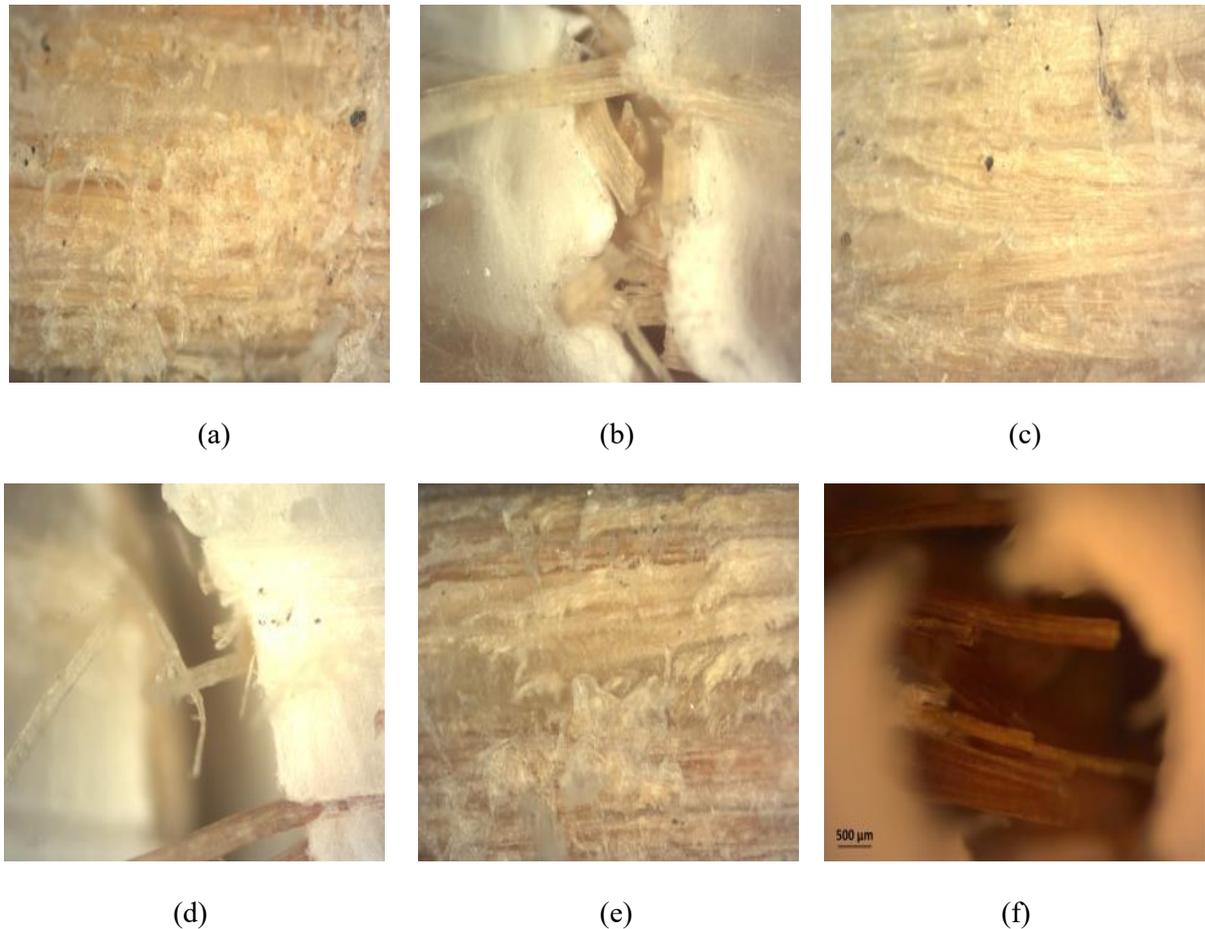
**Figure 3.** Water absorption test of PP/Sumberejo KF composites.

The result of water content test is illustrated by Figure 4. The water content of all specimens compatible with SNI 01-4449-2006. However, the PP/KF30 composites had the lowest value of water content because these composites had the lowest fiber loading. PP as a polymer does not contain water and KF was the one that released water from the composites.



**Figure 4.** Water content test for PP/Sumberejo KF composites.

PP/KF composites were observed with OM before and after flexural test. Figures 3 (a), (c), (e) show the OM images of PP/KF30, PP/KF40, PP/KF50 respectively before flexural test. These images show a typical homogeneous PP/KF surfaces and this indicates that the matrix and the fiber has a good interface. While figures 3 (b), (d),(f) show the OM images of PP/KF30, PP/KF40, PP/KF50 after flexural test. These images exhibit that fiber pull-out occurred on all composites. This mode of failure indicates that the kenaf fiber was able to hold the flexural load.



**Figure 5.** OM image of PP/KF30, PP/KF40, PP/KF50 respectively, (a), (c), (e) before flexural test, (b), (d), (f) after flexural test.

#### 4. Conclusion

It can be concluded that the highest flexural strength, the minimum water content and water absorption were found in PP/Sumberejo KF30 composites with the values of  $(4.77 \pm 0.799)$  MPa,  $(3.61 \pm 0.823)\%$  and  $(0.192 \pm 0.154)\%$ , respectively. The optical microscope observation indicated fiber pulled-out occurred after the flexural test.

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