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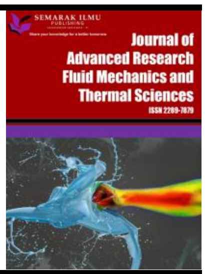

Water Absorption Study on Kenaf/ABS Composites

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ABSTRACT

Many manufacturers have lately expressed an interest in the use of fiber-reinforced polymer composites (FRPs) in structural applications. Carbon and glass fibers, for example, have been commercialized globally for decades. However, they are harmful to the environment since synthetic fibers are non-biodegradable and difficult to recycle once they have fulfilled their purpose. As a result of their better physical and mechanical qualities, natural fiber composites such as kenaf are a prospective substitute for synthetic fiber. Kenaf is the most promising alternative for replacing synthetic fibers in order to achieve the environmental preservation while simultaneously exhibiting great properties such as equivalent specific strength, low density, and renewable resources. Treated kenaf fiber was added to ABS with varying loading (10, 15, 20 and 25 wt.%) via Two Roll Mill machine. The influence of the fiber on the composites was evaluated for water absorption properties. The water absorption test was conducted for 5 days referring to the ASTM D570. The morphology of produced composite was investigated using JOEL Scanning Electron Microscope (SEM) at 200X magnifications. The incorporation of the treated kenaf fiber has an influence on the properties of kenaf/ABS composites. The fiber was well dispersed in the matrix and showed good adhesion to the ABS. Kenaf/ABS composites showed an increment of water absorbed with an increment of fiber loading.

1. Introduction

Composites materials are state-of-the-art and the applications of these materials are highly in demand. The specialty of composite materials is the combination of more than one group of materials that gives the ultimate properties of the combined materials [1].

Composite materials allow variation of the properties to suit the products requirement, owing to their composition of several types of matrix and reinforcing materials as reported by Krzyżak *et al.,* [2]. The reinforcement of composite is in the form of fibers, particles, flakes, or fillers surrounded by the matrix material. Studies by Zainal *et al.,* [3] and Cavdar *et al.,* [4] stated that the properties of composite also depend on the types, shapes, lengths, and orientation of the fibers.

One of the highly demanded composites is fiber-reinforced polymer composites (FRP) has many applications in engineering industries and are vastly used for automotive, structural, and

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construction. In the previous few decades, Singh *et al.,* [5] found that synthetic fibers such as carbon and glass have been vastly used as composite reinforcement fibers. Unfortunately, mass usage of synthetic fibers caused environmental damage due to their non-biodegradability as reported by Kamath and Chandrappa [6]. Thus, recently more FRPs using natural fibers as an alternative to synthetic fiber due to their excellent physical and comparable mechanical properties [7].

More studies in FRPs are using natural fibers such as wood, kenaf, hemp, and sisal as fiber reinforcement. The investigations by Kumar *et al.,* [8] are done due to the nature of the natural fiber that are low density, less abrasiveness, low cost, and renewable and biodegradable compared to synthetic fiber. One outstanding natural fiber is Kenaf fiber which can be considered as one of the strongest fibers among other natural fibers because of the high cellulose content that is able to provide strong structural support reported by Hamidon *et al.,* [9]. Kenaf is a non-wood lignocellulose material that is mainly built by cellulose, hemicellulose, and lignin. The study by Akil *et al.,* [10] found that kenaf has low density, non-abrasiveness during processing, high specific mechanical properties, and biodegradability.

In previous studies, kenaf is applied as a composite reinforcement fiber in various matrices such as polypropylene (PP) in work done by Faridah *et al.,* [11], high density polyethylene (HDPE) in Wang *et al.,* [12], epoxy (EP) in Zainal *et al.,* [3], natural rubber (NR) in Azammi *et al.,* [13] including poly(acrylonitrile-co-butadiene-co-styrene) (ABS) in Mohd *et al.,* [14]. Sharma *et al.,* [15] found that ABS has excellent mechanical qualities and a low density due to the mixture of co-monomers, which plays a significant role in determining its final attributes. Polyacrylonitrile components promote polar interactions between polymer chains, resulting in more mechanical resistance than pure polystyrene. Polybutadiene components provide toughness due to their elastomeric characteristics. Finally, polystyrene components give a glossy appearance as well as electrical insulation. ABS is suitable for automotive parts, electronic components, and urban constructions due to the combination of these features. Besides that, a study by Fonseca *et al.,* [16] discovered that ABS had other benefits, such as increased chemical resistance, toughness, dimensional stability, and processability.

Although few research has been conducted to explore the behavior and effect of natural fiber as a composite reinforcement, however, the hydrophobicity of kenaf/ABS is still limited. A study by Baba *et al.,* [17] compared kenaf/epoxy and kenaf/polyester composites and showed the addition of more kenaf increases water absorption and polyester resists more water than epoxy. The objective of this paper is to study the effect of water absorption on kenaf/ABS composites. The work done in this paper uses natural fiber kenaf as reinforcement in ABS matrix at a different loading ratio of kenaf/ABS for its water absorption property.

2. Materials and Methodology

Kenaf fibers were provided by National Kenaf and Tobacco Board (NKTB) with a diameter ranging from 10 µm to 350 µm. Kenaf fibers having an average diameter of 112 m were used in this study. ABS was provided from Toray Plastics (Malaysia) with a specified melt flow index of 35 g/10 min (at 210°C and 10 kg).

The surface of the kenaf fiber was treated with alkali to remove impurities, minimize moisture absorption, and increase surface contact with other materials. The fibers were alkalized by immersing them in a 5% NaOH solution. Following treatment, the fibers were crushed into smaller pieces and combined with ABS pellets using a Two Roll Mill at 10, 15, 20, and 25% weight loading. The operation was repeated many times at 150°C until the components were properly combined. All work was completed in the University College TATI (UC TATI) workshop, Faculty of Engineering Technology laboratory. Figure 1 depicts the step-by-step production of the kenaf/ABS composite.

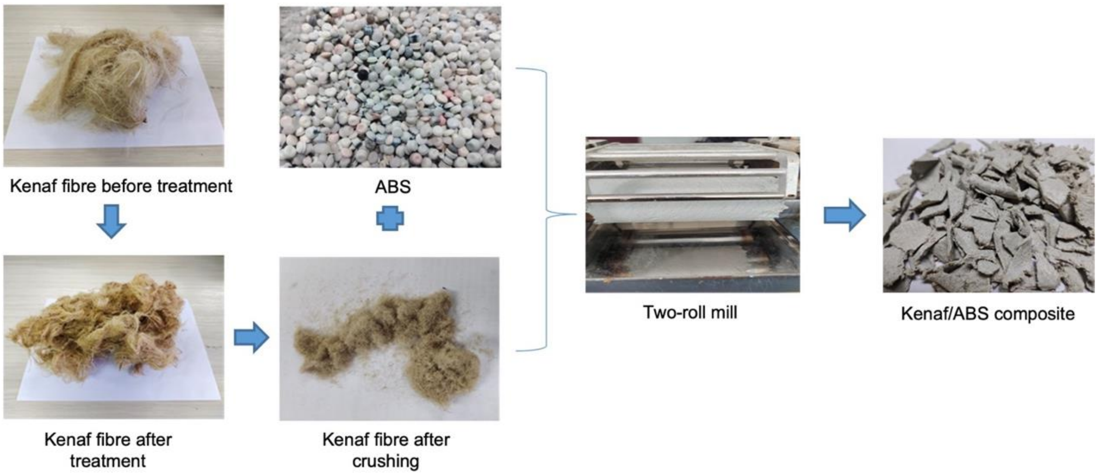

Fig. 1. Fabrication of kenaf/ABS composites

The samples went through a water absorption test, for 5 days following ASTM D570. Before the immersion, all samples were conditioned in an oven at 50°C for 24 hours. The kenaf/ABS composite samples were cut into 2cm x 2cm sample sizes and weighted before immersion in water. The test was conducted at room temperature. The increase in weight was reported as a percentage of water absorbed. The calculation is shown in Eq. (1)

$$\text{Water absorption percentage}=\frac{(\text{W1-W0})}{\text{W0}} \text{ x } 100\% \quad (1)$$

where W0 represents the weight before immersion and W1 represents the weight of the immersed sample.

The surface morphology of kenaf/ABS composites was analyzed using JOEL Scanning Electron Microscope (SEM) coupled with Energy Dispersive X-ray (EDX) JSM 7800F at 200X magnifications.

3. Results and Discussion

3.1 Kenaf/ABS Water Absorption Property

The absorption of water by a material was assessed in the water absorption test. Various materials absorb different quantities of water, and the presence of absorbed water may change polymers in a variety of ways, including physical appearance, dimensions, and characteristics. The results of water absorption of kenaf/ABS composites at different loading are shown in Figure 2. The water absorption was conducted for 5 days at room temperature. The results acquired were in percentages of water absorbed into the samples.

From the graph shown in Figure 2, it can be seen that all samples at all filler loading of kenaf/ABS composites showed an increment in water absorption for the 5 days' duration. The absorption was high for the first 3 days and increased steadily until day 5. The trend was similar for all samples, with loading at 25 wt.% showed the highest of water absorbed. This is due to the incorporation of kenaf fibers that encourage more water uptake in the samples. The variation of water uptake was found to differ slightly for all loading of kenaf/ABS composites. The water absorbance increased considerably in the first week due to the difference in the concentration gradient of water and the composites.

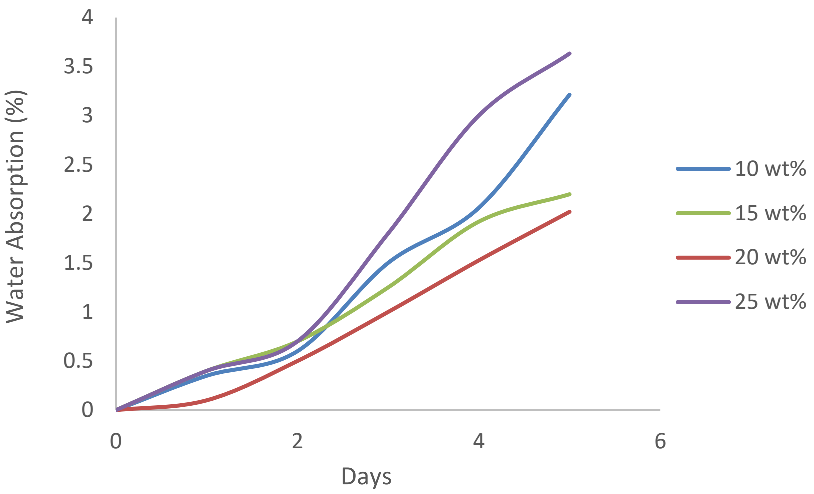

Fig. 2. Water absorption of kenaf/ABS composites

3.2 Kenaf/ABS Morphology

The modification of kenaf fiber loading in the composite had an effect on the overall kenaf/ABS characteristics, which may be investigated by examining the morphologies of the kenaf/ABS composites. Figure 3 shows the morphology of the composites at different fiber loadings.

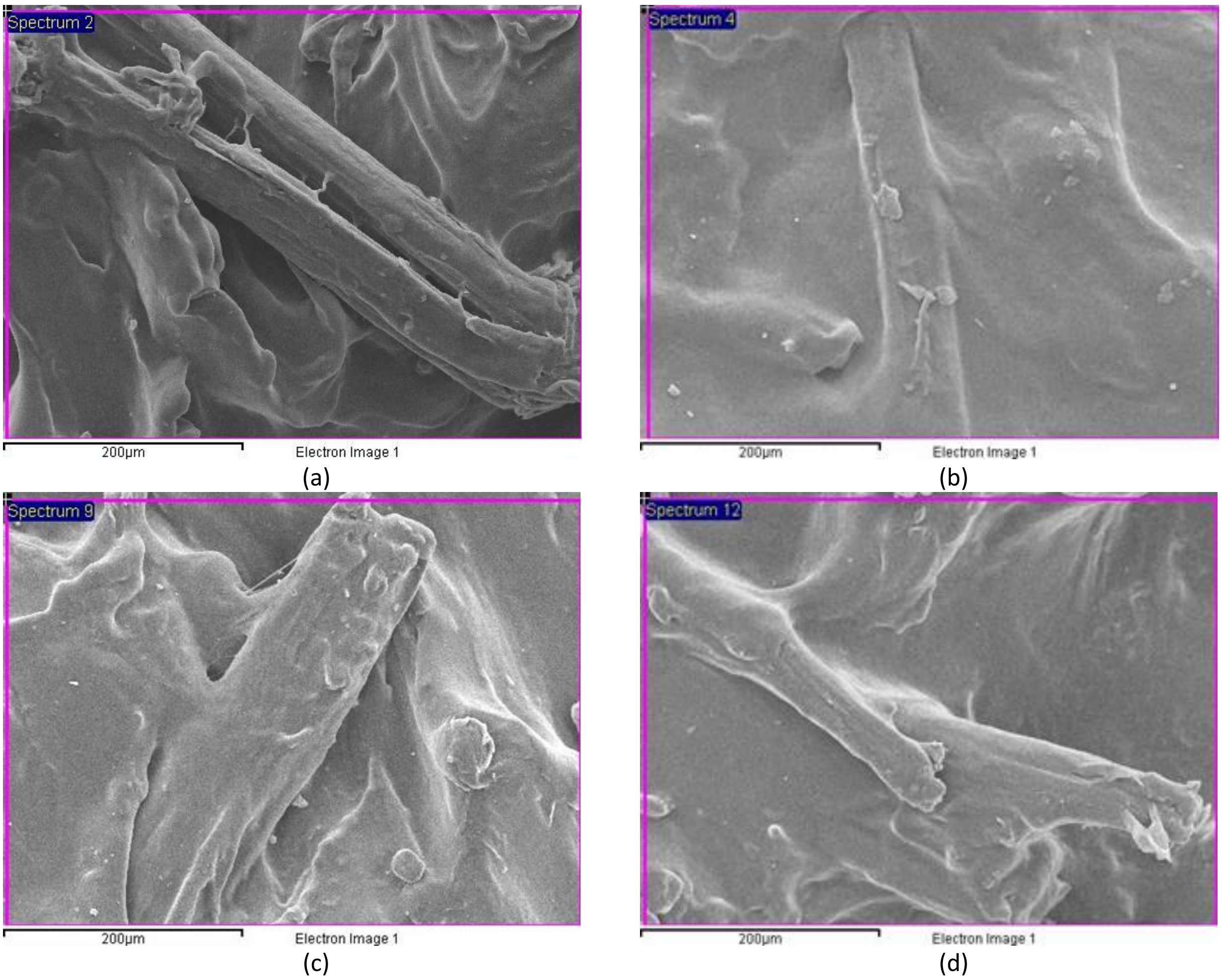

Fig. 3. Morphologies of kenaf/ABS composites at different loadings: (a) 10 wt.%, (b) 15 wt.%, (c) 20 wt.% and (d) 25 wt.%

The figures show that the addition of 10 wt.% kenaf had less adhesion with the matrix. The fibers were not fully adhering to the matrix and gaps were seen between them. An increment of fiber to 15 wt.% showed good interaction between the fibers and ABS with no gap shown and the micrographs showed better adhesion between the fiber and the matrix. Improvement of the interfacial adhesion was also seen in the 20 and 25 wt.% loadings of the composites. The fiber matrix interfacial can be seen as shown in Figure 4, at a magnification of 300X.

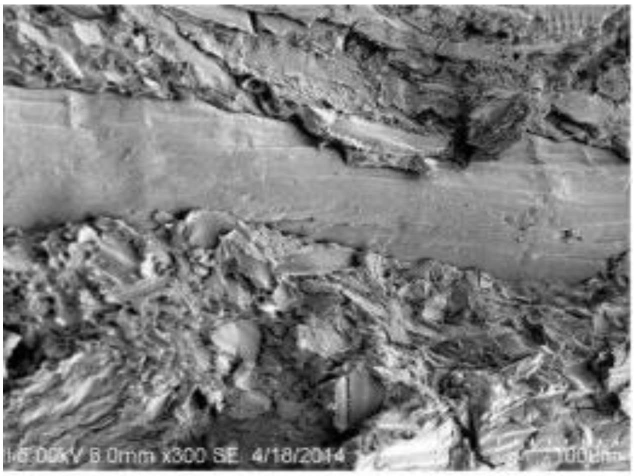

Fig. 4. Kenaf/ABS composites interfacial morphology

The addition of kenaf fibers can cause voids in the kenaf/ABS composite. According to Mohammad and Arsad [18], this might lead to a decrease in composite characteristics. These might also occur during the sample's processing using a two-roll mill, causing voids in the composites. The voids in kenaf/ABS composites were relatively shallow and not deep enough to cause a loss in their properties. As a result, even though no coupling agent was utilized in the composites, good interaction between the fiber and the matrix was shown, which was aided by the treatment of the fiber before addition into the matrix.

These findings suggest for future manufacturing composites using kenaf fibers incorporated into ABS polymer need to be treated to improve the interaction between fiber and ABS as well as the utilization of a two-roll-mill is also recommended for composites preparation.

4. Conclusions

The kenaf/ABS composite was produced by adding the treated kenaf fiber to ABS matrix at different fiber loading at 10, 15, 20, and 25 wt.% using the Two Roll Mill machine. The water absorption test was conducted for 5 days according to ASTM D570. Before the immersion, all samples were conditioned in an oven at 50°C for 24 hours. Based on the research conducted and the results obtained from kenaf/ABS composites, it can be concluded that the water absorption percentage increase with the increment of filler loading in kenaf/ABS composites. Kenaf loading at 25 wt.% showed the highest water absorption at 3.63% for 5 days' immersion. The micrographs also showed good interfacial adhesion between treated kenaf fiber and ABS matrix. NaOH treatment contributed to better adhesion between the fiber and matrix, even with the absence of a coupling agent.

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