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RESEARCH ARTICLE

Tensile behaviour for mercerization of single kenaf fiber

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Abstract

A natural fiber including kenaf fibers that reinforce with polymeric composite has increased attention in the manufacturing industries. However, the poor adhesion between fiber and matrix are commonly encountered respectively to their compatibility nature namely hydrophilic and hydrophobic. Therefore, alkaline treatment has introduced to reduce the hydrophilic effect of natural fiber. This paper presents the treatment of single kenaf fibers following tensile test and predicted using analysis of variance (ANOVA). Here, the kenaf fibers were modified using NaOH at different solutions. Then, the single kenaf fiber was performed under ASTM D3379-89 standard. The results showed that kenaf fiber which treats with NaOH solution of 6% significantly offered the outstanding performance of the tensile behaviour.

Keywords: Tensile properties, kenaf fiber, alkaline treatment, analysis of variance

INTRODUCTION

Nowadays, varies of the material of composite have been introduced in order to improve the quality of life in society by the advancement of technologies in manufacturing industries. However, the acceleration of advanced technologies in the polymeric composite can contribute to a global environmental problem such as greenhouse gases which ultimately leads to global warming. Thus, many researchers find the alternative material of composite which is an environmentally friendly approach to substitute traditional polymeric composite materials. In order to replace the usage of synthetic polymer, material such as natural fiber is recommended for fulfils those applications.

The natural fiber has the potential to be a good material composite according to their environmental friendly, availability and has good strength and modulus. Hence, the natural fiber including kenaf is used for a wide range of application such as in automotive industry, where kenaf reinforced polypropylene composites utilized in the manufacturing of car component including door trim, inner board and other car components by Toyota Boshoku Corporation (Koronis, Silva, & Fontul, 2013).

Even though, the natural fiber has problems to bonding with the polymer. It consists of cellulose, which is hydrophilic in nature. In order to overcome this problem, the alkaline treatment has been suggested. This treatment can reduce the hydrophilic effect on the fiber. However, based on previous works of literature, the optimizations of the main variable of those parameters are still unclear such as the concentration of a chemical solution, the duration for soaking the fiber in the chemical solution and the drying hours for natural fiber to dry. In order to find suitable values for these parameters, many experimental have done by researchers.

The purpose of this study is to identify the optimum solution of NaOH ranging from 0% to 8% under certain parameter of treatment to improve its tensile properties.

LITERATURE REVIEW

The application of kenaf fiber is widely used in composite industries. It has a good potential to be the reinforcement in the polymer composite. Thus, many researchers augment the research on the natural fiber composite. The natural fiber has a main problem which is to bonding with a polymer according to their hydrophilic in nature. It reveals their poor resistant to moisture, which leads to high water absorption (Sreekumar *et al.*, 2009). Meanwhile, the polymer matrices are hydrophobic. Therefore, this will contribute to a weak bonding of the interfacial between natural fiber and polymer due to their incompatibility that resulting in poor mechanical properties (Sgriccia, Hawley, & Misra, 2008). In order to overcome this problem, the alkaline treatment has been promoted. The alkaline treatment using sodium hydroxide (NaOH) solutions can mercerization the hydrophilic effect of natural fiber (Jacob, Francis, Thomas, & Varughese, 2006). Thus, the properties of natural fiber can optimize by alkaline treatment process (Gassan & Bledzki, 1999).

Many attempts have been made to treat the fiber by varying the solution of the NaOH, length of soaking and drying time. Some researchers found that the mercerization of kenaf fiber can improve its tensile properties at 6% of NaOH solution. Here, the fiber was soaked for 24 hours and then dried at 80°C for a day 6. In contrast, Jacob et al. (2006), founded that 4% of NaOH which was dried at room temperature is the optimum solution to obtain the highest tensile strength properties. Nonetheless, the optimizations of those parameters are still unclear.

METHODOLOGY

Material

Kenaf fiber or also known as Hibiscus cannabinus was purchased from Lembaga Kenaf and Tembakau Negara (LKTN). The kenaf fiber was origin from Kelantan. The diameter of this kenaf fiber is approximately 75 to 125 µm. In order to measure the diameter of the kenaf, an optical microscope (Nikon LV150N) was used as showed in Figure 1. This photo was captured using bright field optical lens at 10x of magnification.

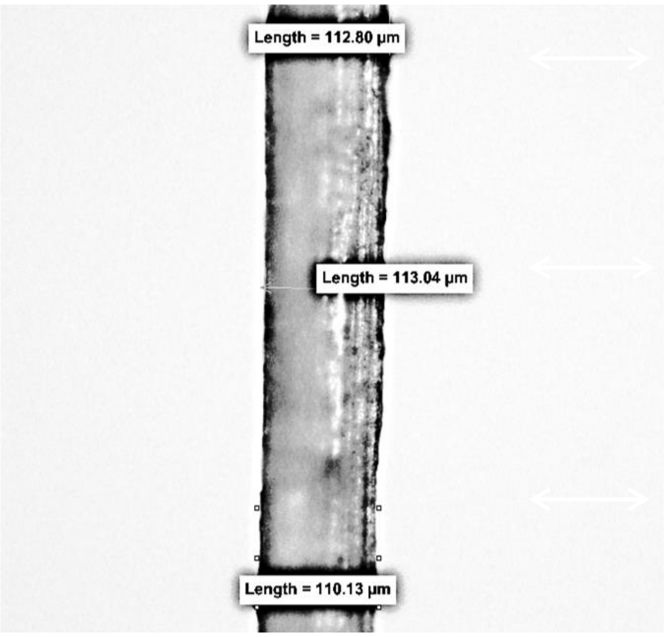

Fig. 1 Diameter measurement of kenaf fiber using the optical microscope.

Alkaline treatment

In this study, sodium hydroxide (NaOH) solution was used to treat, modified and indirectly improve the specification of the kenaf fiber. The NaOH solution was prepared according to the weight per volume (w/v) basis. There are four solutions of NaOH solution were selected, namely 2%, 4%, 6% and 8%. The kenaf fibers were soaked in NaOH solution for approximately 3 hours before dried at a temperature of 80°C for 6 hours.

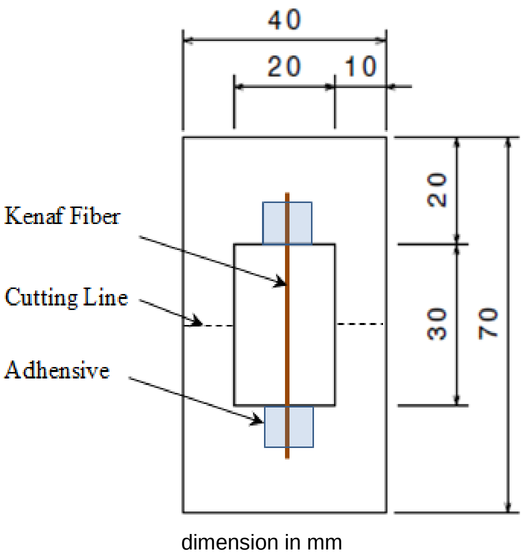

Fig. 2 Kenaf fiber specimen setup for tensile test.

Preparation and tensile test of specimens

The tensile specimen was prepared by sticking the fiber on the cardboard paper frame to prevent damage and easy handling of a fiber during testing as shown in Figure 2. Mechanical tests were performed in Universiti Putra Malaysia (UPM) using the universal testing machine at a crosshead speed of 0.5 mm/min. The tensile test was carried out according to ASTM D3379-89 standards. The ends of the cardboard paper frame were gripped by hydraulic clamps to align the fiber with the machine axis. The test begun after the cutting lines were cut off. The load-displacement trace was recorded in order to determine the tensile strength and young modulus of single kenaf fiber.

RESULTS AND FINDINGS

Mechanical properties of single kenaf fiber

Table 1 presents the results of tensile properties of treated and untreated of single kenaf fiber. It is clearly shown that the treated kenaf fiber with a solution of 6% NaOH has significantly increased its tensile strength compared to the untreated fibre. This is similar to the finding from Nirmal et al. (2014), where they suggest a solution of 6% NaOH will offer greater interfacial strength performance. Nonetheless, the untreated kenaf fiber still showing greater value than the treated at the solution of 2%, 4% and 8%. According to table 1, the cellulose of kenaf fiber has good young modulus and tensile strength than the solution treatment of 2%, 4% and 8%. However, cellulose has a weak interfacial bonding with the polymer.

Table 1 Tensile properties for treated and untreated of single kenaf fiber.

Solution NaOH (%)	Young Modulus (GPa)	Tensile Strength (MPa)	Fracture Strain (%)
2	4.28	25.28	1.28
4	5.38	104.32	1.72
6	11.88	267.69	2.07
8	7.67	89.58	1.21
untreated	9.02	129.10	1.35

Figure 3 showed the stress-strain curves of treated single kenaf fiber which is treated with the NaOH solution of 2%, 4%, 6% and 8%. It is observed that kenaf fiber treated with 6% of NaOH offers the highest tensile strength, with a value of 268 MPa. Furthermore, the tensile strain for 6% treated kenaf fibre has outperformed approximately 30% higher than the others solution treatment. However, no significant differences in tensile strain are seen for treated fibre with 2%, 4% and 8%, which lies between 1.25% and 1.5%. A close observation on the tensile strength shows an increasing value as the solution percentage increased, even though a dramatic drop occurs at 8% solution. This may be due to higher solution treatment agent has eroded the fibers and reduce some of its properties.

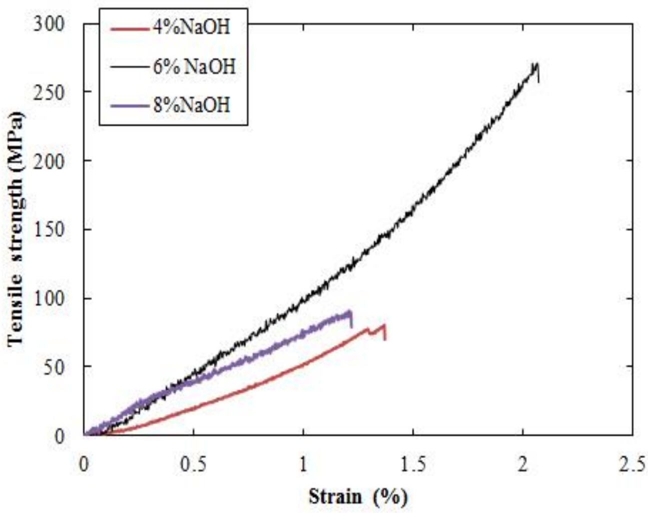

Fig. 3 Stress-strain curve of single kenaf fiber following tensile test.

The comparison of tensile strength and Young's modulus for treated fiber under several of NaOH solution are shown in Figure 4. Clearly, both tensile strength and Young's modulus for 6% NaOH shows the maximum values and the properties decreases at 8% of NaOH solution. It can be suggested that over the treatment of the fiber can decrease their mechanical properties. An excessive solution of NaOH would certainly degrade the fiber and result of a reduction in the tensile strength of the fiber as studied by l (Mwaikambo & Ansell, 2002). On the other hand, the insufficient chemical solution would also reduce the tensile behavior of treated fiber as compared to untreated fiber.

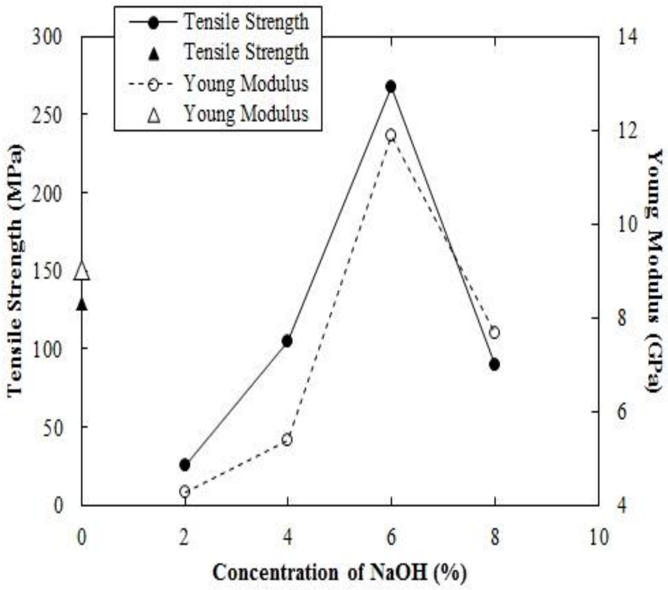

Fig. 4 Typical of tensile strength and Young modulus curves of the treated and untreated single kenaf fiber.

Analysis of variance for mechanical properties of kenaf fiber

Table 3 and 4 showed the result of one-way analysis of variance (ANOVA) for difference NaOH solution regarding tensile strength and modulus respectively. The result of ANOVA analysis in Table 1 showed the F-Ratio of tensile strength is 9.19 and their P-value is 0.0288. On the other table, table 2 showed F-Ratio of tensile modulus is 12.56 and their P-value is 0.0167. Since the P-value of F-test of tensile strength and modulus are less than 0.05, their results are significant at $p < 0.05$. The result of the ANOVA test in table 1 and 2 are the significant value of NaOH solution, it can be concluded that the increasing NaOH solution has affected the tensile strength and modulus of fiber.

Table 3 ANOVA test for the tensile strength of NaOH solution.

Source	ss	df	MS	F-Ratio	P-value
Between Groups	71619.76	3	23873.25	9.19	0.0288
Within Groups	10387.25	4	2596.81		
Total	82007.01	7			

Table 4 ANOVA test for tensile modulus of NaOH solution.

Source	ss	df	MS	F-Ratio	P-value
Between Groups	67.83	3	22.61	12.56	0.0167
Within Groups	7.2	4	1.8		
Total	75.03	7			

CONCLUSION

In this study, the single kenaf fiber has been treated with a different solution of NaOH. Then, the tensile properties of the single kenaf fiber were determined using an Instron universal testing machine. The results showed that the optimum tensile properties are obtained at 6% of NaOH solution. It is found that an insufficient of the chemical solution will decrease the tensile properties, whereas the excessive solution of NaOH can easily erode the fiber. The performance of properties of fiber also can enhance with the optimum time of drying and soaking.

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