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Chemical treatment evaluation of tensile properties for single Kenaf fiber

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ABSTRACT

The attractions to kenaf fiber as reinforcement in polymer composite are getting wider. However, the hydrophilic in nature is one of the affecting factors to their properties. Treatment to the fiber using sodium hydroxide (NaOH) has significantly proven to improve the drawback. This paper presents the mechanical properties of untreated and treated of single. Initially, kenaf fibers were treated with sodium hydroxide with varies of concentration, soaking time and drying period of conditions. Then, each of kenaf fibers is mounted on a cardboard paper frame. The single fiber tests are performed in accordance with ASTM D3379-89. Prior to testing, the frame sides were carefully cut in the middle. It has been shown that treated fibers with 6% of NaOH significantly offered an outstanding performance than the untreated.

Keywords:
Tensile properties, kenaf, alkaline treatment, sodium hydroxide

1. Introduction

The natural fiber including kenaf is introduced for a wide range of application in order to replace the uses of a synthetic polymer. People starting to realize that the environment is getting worsen due to non-biodegradability waste and the cost of disposal keep increasing according to increase the unrecyclable products.

In automotive industries, Toyota [1] has developed an eco-plastic container from sugar cane fiber and will be commercialized to combat that issue. Meanwhile, Loh and Al [2] stated that the composition of kenaf-polypropylene (K-PP) composite has a potential to be applied in automobile interior parts. Hence, the natural fiber can be good alternative material for manufacturing automotive parts due to their advantages such as lightweight, low energy production and cost saving

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[3]. Furthermore, the reinforcement between natural fiber and polymer composite are able to enhance the mechanical properties [4,5] and physical properties [6].

However, natural fibers including kenaf richly consist of cellulose, which is hydrophilic. In contrast, the polymer matrices are mostly hydrophobic. That has led a weak compatibility bonding between of natural fiber and polymeric resin. In order to overcome this problem, the alkaline treatment has been promoted. The alkaline treatment can reduce the hydrophilic effect of natural fiber. Jacob *et al*. [7] studied the effect of different sodium hydroxide (NaOH) concentrations on sisal fiber reinforced composites. They suggested that the alkaline treatment can reduce the hydrophilic effect of natural fiber. Tabil and Al. [8] also stated that alkaline treatment process can optimize the properties of natural fibers. Many attempt has been made to treat the fiber by varying the concentration of the NaOH, length of soaking and drying time. Meon *et al*. [9] found that alkalizing the kenaf fibers can improve its tensile properties at 6% of NaOH concentration. Here, the fiber were soaked for 24 hours and then dried at 80°C for a day. In contrast, Jacob et al. [7] founded that 4% of NaOH which was dried at room temperature is the optimum concentration to obtain highest tensile strength properties. Nevertheless, the optimizations of those parameters are still unclear.

The aim of this study is to identify the optimum composition of NaOH for treating the fiber. The 2%, 4%, 6% and 8% of NaoH concentration are used and compared with untreated fiber following tensile test.

2. Material and Method

2.1 Material

Kenaf fiber (Hibiscus cannabinus) harvested in Kelantan was purchased from Lembaga Kenaf and Tembakau Negara (LKTN). The diameter of this kenaf fiber is approximately 75 to 125 µm. It was measured using an optical microscope (Nikon LV150N) as showed in Figure 1. This photo was captured with bright field optical lens at 10x of magnification.

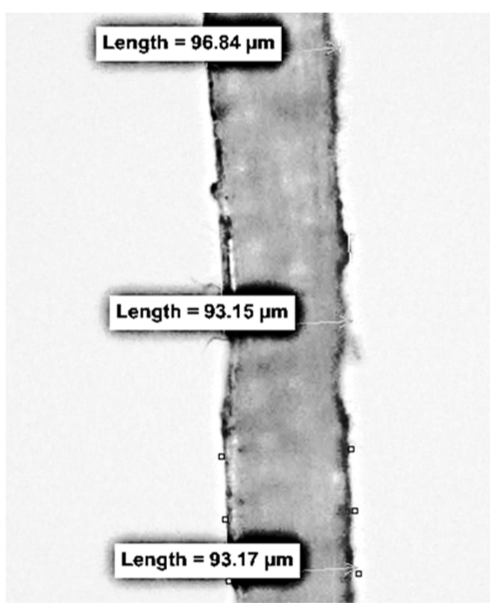


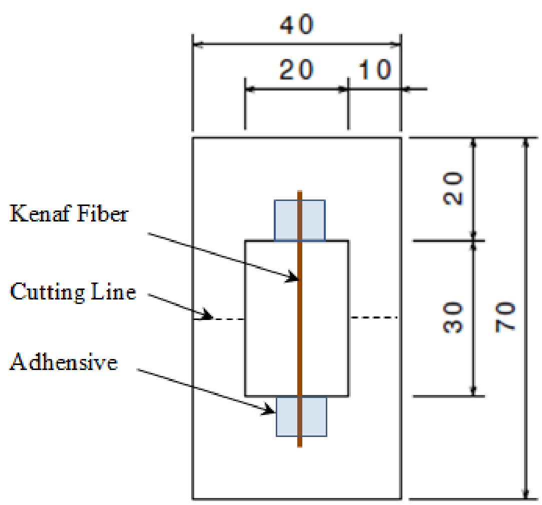
Fig. 1. Diameter measurement of kenaf fiber using optical microscope

2.2 Alkaline Treatment

The sodium hydroxide solution was utilized throughout this study in purpose to treat the kenaf fiber. The NaOH concentration was prepared according to the weight per volume (w/v) basis. Here, four concentrations of NaOH solution, which 2%, 4%, 6% and 8% were obtained. Following, kenaf fibers were soaked in NaOH concentration for 3 hours, then be dried at 80°C for 6 hours.

2.3 Preparation and tensile test of specimens

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.



Dimension in mm

Fig. 2. Kenaf fiber specimen setup for tensile test

3. Result and Discussion

Figure 3 showed the stress-strain curves of treated single kenaf fiber at 2%, 4%, 6% and 8% of concentration of NaOH. The highest tensile strength for kenaf fiber after alkali treatment is obtained at 6% of NaOH concentration with value of 267.69 MPa. Again, this condition is also offered an outstanding performance of fracture strain, however there are not much differences in strain values, which are between 1.25% and 1.5% for NaOH concentration of 2%, 4% and 8%. It can be seen from the figure, the stress increases with increasing of NaOH concentration, however slightly drop at 8% of NaOH treatment.

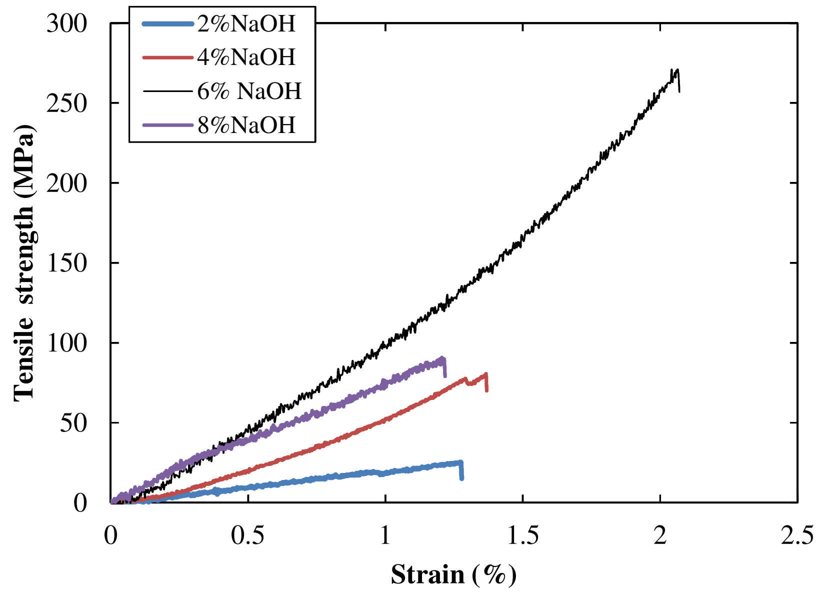


Fig.3. Stress-strain curve of single kenaf fiber following tensile test

Table 1 shows that the result of young modulus, tensile strength and fracture strain with increases of sodium hydroxide (NaOH) concentration. The table also includes the finding from tensile properties of untreated fiber. This is clearly evident in tensile properties as shown in Table 1, where the average tensile properties increases from 129.10 MPa in the untreated system to over 267.69 MPa while treated at 6% of NaOH solution. The similar trend of finding was also reported by Nirmal et al. [10]. They investigated the interfacial adhesion between kenaf fibers and epoxy resin following chemical treatment with 4% and 6% of NaOH concentrations respectively. They concluded that a kenaf fibers treated with 6% of NaOH significantly offered an outstanding interfacial strength performance.

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

Concentration NaOH (%)	Young Modulus (GPa)	Tensile Strength (MPa)	Fracture Strain (%)
untreated	9.02	129.10	1.35
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

Figure 4 depicted the tensile strength and young modulus in varies of NaOH concentration following tensile test. It is shown that the maximum of tensile strength and tensile modulus when increasing the NaOH concentration is obtained at 6% of NaOH concentration. Both of tensile strength and Young modulus decrease at 8% of NaOH concentration. It can be suggested that over treated of the fiber could drop on their mechanical properties. Mwaikambo et al. and Edeerozey et al. [11,12] reported that an excessive concentration of NaOH would certainly degrade the fiber and resultant to reduce the tensile strength of the fiber. On the other hand, insufficient of chemical concentration to treat the fiber would also significantly lower the tensile behavior as compare to untreated fiber, as shown in Figure 4.

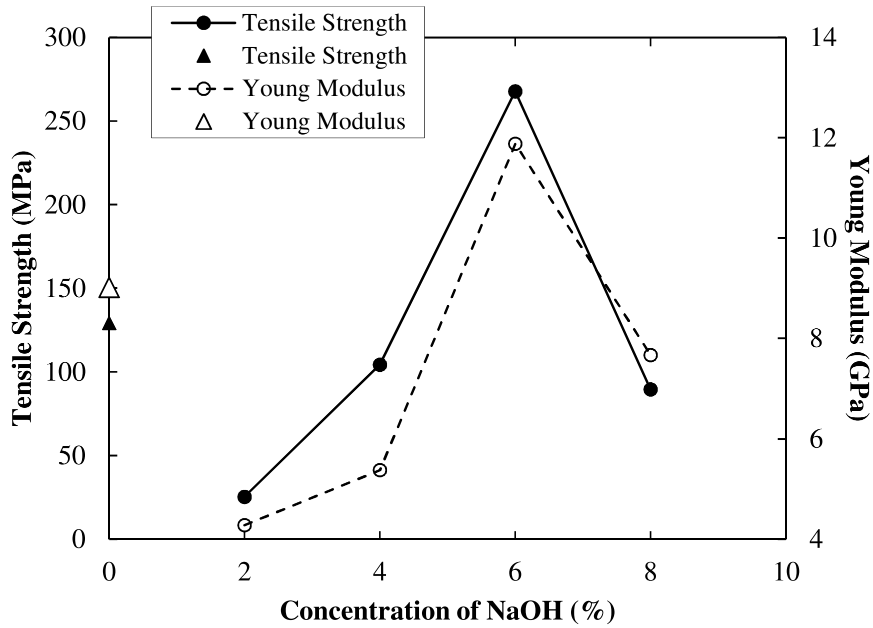


Fig. 4. Typical of tensile strength and Young modulus curves of the treated and untreated single kenaf fiber

4. Conclusion

In this study, the tensile properties of the single kenaf fiber were determined using a universal testing machine. This fiber was been treated with different concentrations of NaOH. The results showed that the optimum mechanical properties are exhibited at 6% of NaOH concentration. Insufficient of the chemical concentration would decrease the tensile properties, however an excessive concentration of NaOH would easily damage the fiber.

Acknowledgement

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