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Improving tensile properties of kenaf fibers treated with sodium hydroxide

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Abstract

The study on kenaf short fibers compounded with MAPP/MAPE was successfully conducted. Kenaf has potential reinforced fiber in thermosets and thermoplastics composites. Basically, to produce the new type of composite, this project utilized short Kenaf fiber as the main material. The fiber is soaked with 3%, 6% and 9% of sodium hydroxide (NaOH) for a day and then dried at 80°C for 24 hours. The composition of short Kenaf used is 100 grams. Two set of combination were produced; combination between kenaf fiber and MAPP as well as kenaf fiber together with MAPE. The fabrication processes started when the mixture is poured into the mould and it is compacted until it perfectly fulfilled the mould. The mixture took about one to two hours to completely dry. The specimens then were cut into standard dimension according to ISO 5275. MAPP and MAPE were used to improve the matrix-filler interaction and tensile properties of the composites. It has been found that the tensile properties of the treated kenaf fibers have improved significantly as compared to untreated kenaf fibers especially at the optimum level of 6% NaOH.

Keywords: Short kenaf fibers; maleated polyetylene (MAPE); maleated polypropylene (MAPP); sodium hydroxide (NaOH).

1. Introduction

Kenaf fibers have a long history of cultivation in some areas in the world such as India, Bangladesh, Thailand, parts of Africa, Malaysia and southeast Europe. The fibre has been mainly used in rope, twine, coarse cloth and paper. However, nowadays, there is demand for this fibre to be used as reinforcement for polymers [1]. In Malaysia, planting, cultivating and harvesting of kenaf plant has become the subject of interest and is encouraged by the government so that it will replace the tobacco plant in future time. Besides, kenaf fibers is gaining more attention in Malaysia and became the national agenda for further advancement in various applications which included the automotive components, food packaging, furniture as well as sports and leisure. In addition, Malaysia is towards the environmental friendly with the aim to reduce global usage of non-degradable plastics especially for domestic application [2].

The research in kenaf plastic composite is growing tremendously along with the plastic industry's high demand for it for producing petroleum-based materials [3]. Several treatment have been proposed and used to improve inter-laminar bonding effect [4-6] and hence to achieve better quality of mechanical or water resistence properties [7].Various chemical treatments have been used to improve the mechanical performance of the natural fibers including jute and hemp by many researchers in the past [5-9]. Mwaikambo and Ansell [10] have treated hemp, jute, sisal and kapok fibers with various concentrations of NaOH and found out that 6% was the optimum concentration in terms of cleaning the fibers bundle surfaces and retaining a

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high index of crystallinity. It also has been found that alkalizing the kenaf fibers gave better flexural modulus, flexural strength, impact strength and strength modulus for polymeric composites [1, 11, 12].

2. Experimental

2.1. Materials

Kenaf raw fibers used in this work are supplied by MARDI (Malaysian Agricultural Research and Development Institute) and came in curled long fibers as shown in Fig. 1. The polymers used were high-density polyethylene (PE) and polypropylene (PP) and were supplied by Thai Polyethylene Co. Limited. In addition, the coupling agents used in these experiments were maleated polyethylene (MAPE) and maleated polypropylenes (MAPP) which were supplied by DuPont Packaging and Industrial Polymers. Sodium Hydroxide (NaOH) used was supplied by Merck Sdn. Bhd.

Fig. 1. Kenaf fibers supplied by Malaysian Agricultural Research and Development Institute (MARDI)

2.2. Fibers treatment

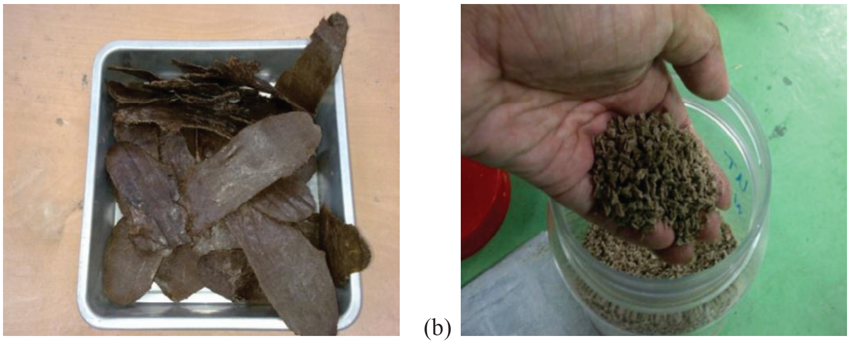
In this study, chemical treatment has been applied to the specimens. The fibers were treated with 3%, 6% and 9% of sodium hydroxide (NaOH) for a day as tabulated in Table 1. The sodium hydroxide concentration has an influence on the thermo physical properties of the composites. After the treatment, the fibers were thoroughly washed with running water and allowed to dry at elevated temperature 100^{o}C for 24 hours.

Table 1. Information on fibers treatment

Specimen reference code	NaOH (%)	Soaking time (hr.)
KFMAPP3	3	24
KFMAPP6	6	24
KFMAPP9	9	24
KFMAPE3	3	24
KFMAPE6	6	24
KFMAPE9	9	24

2.3. Samples preparation

After all specimens have been treated with NaOH, the kenaf fibers, the matrix (PE and PP) and the coupling agents (MAPE and MAPP) were weighted by using digital precision scale with 1 mg precision according to 30%, 67% and 3% mass fraction respectively. Next, the combination earlier was mixed together using Dispersion Mixer (at Faculty of Applied Science, UiTM) at temperature 180ºC for 30 minutes. The total weight per mixture used in this study is 5 kg. A completed homogenous mixture were taken out and rolled until it become like crackers form as shown in Fig. 2(a) and then were chopped again by using Crusher Machine to make it like cereals form as illustrated in Fig. 2(b). Finally, the mixture was poured into the mould equally and compressed by using Hot Press Machine at 140ºC for 30 minutes and then by using Cold Press Machine at room temperature for 15 minutes. Two set of combination have been produced for the testing purposes as shown in Table 2.



(a) (b)

Fig. 2. (a) crackers form mixture; (b) cereals form mixture

Table 2. Information on specimens produced

Combination No.	Natural fiber	Matrix	Coupling Agent
1	Short Kenaf Fibers	Polyethylene (PE)	maleic anhydride polypethylene (MAPE)
2	Short kenaf Fibers	Polypropylene (PP)	maleic anhydride polypropylene (MAPE)

2.4. Post-impact tensile tests

Tensile tests were performed after all the specimens were impacted with various energy in the low velocity impact test (depend on the combination). This was conducted by using 250 kN servo-hydraulic universal tester machine (Instron 3382), equipped with computerized data acquisition system at the room temperature with rate 3 mm/min at Strength of Material Laboratory, UiTM. Five specimens for each case were tested for this test. The specimens will be pulled until it fractures. From the result obtained, stress-strain graph will be generated. A number of properties such as Modulus of elasticity and Ultimate Tensile Stress (UTS) will be attained from the analysis.

3. Result and discussions

3.1. Tensile strength

Figure 3(a) and Figure 3(b) present the measured ultimate tensile strength (UTS) of alkalized treatment and untreated kenaf fiber composites. For combination using MAPE, the impact load was quite small because it can't withstand higher load. Apart from that, combination using MAPP gave higher value of UTS as compared with MAPE.

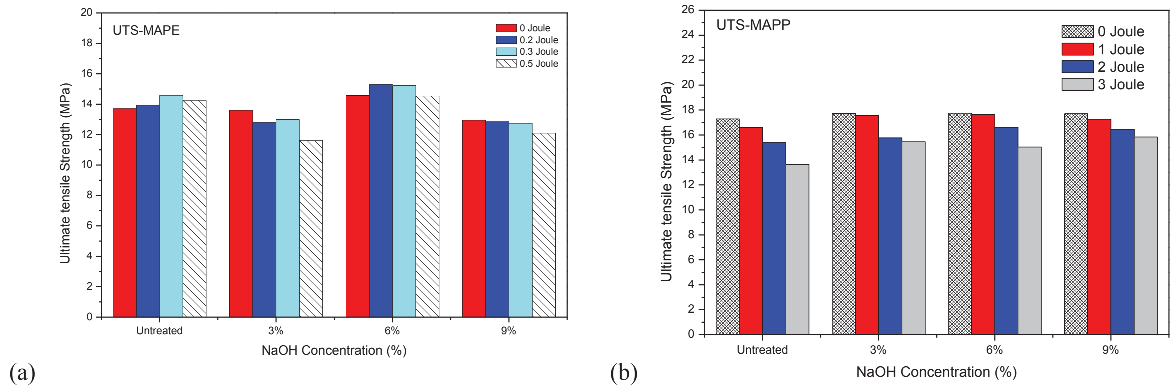


Fig. 3. Tensile strength of kenaf fibers (a) with MAPE under different impact load; (b) with MAPP under different impact load

From the histogram, it is obvious that 6 % NaOH treated specimens gave superior UTS values as compared to others. When the NaOH concentration is increased to 6%, an approximation of 0.4% increment is noticed for both cases (KFMAPE and KFMAPP). This was explained by the increment of uniformity that yields to the enhancement in strength, due to the removal of the impurities [13]. However, the trend was decreased when the concentration of NaOH was increased up to 9% due to high concentration applied that yields to damage the fibers inter-laminar bonding [14]. When the impact load is increased (i.e. at 3% NaOH), the trend of UTS portrayed a decremented pattern. Previous researchers [14] have noted that as increasing the value of impact energy, the value of UTS will decrease. The higher the energy impacted, the lower UTS recorded.

The results based on 6% NaOH treatment is an evident that treatment of fibers by alkalization helps in improving the mechanical interlocking and chemical bonding between the matrix and fibers resulting in better mechanical properties [15].The alkali treatment enhance the fibers surface adhesion characteristics by removing natural and artificial impurities, as well as producing a rough surface topography [16].

3.2. Modulus of elasticity

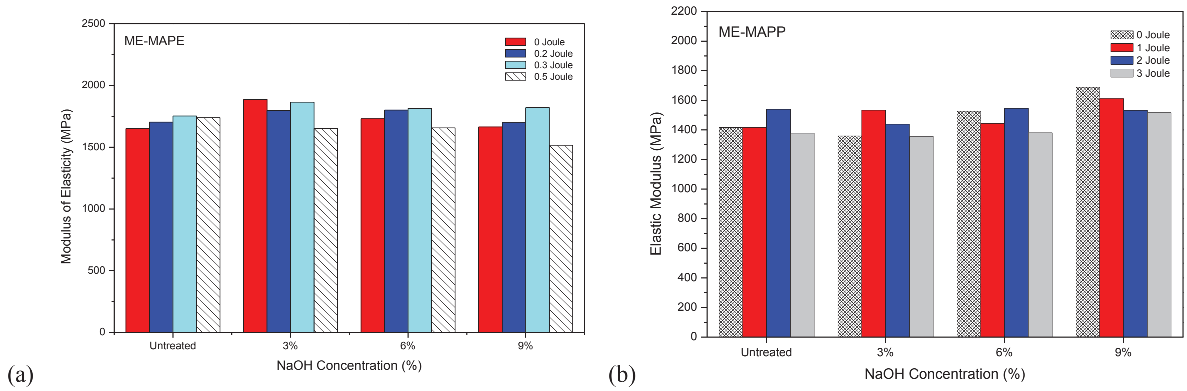


Fig. 4. Modulus of elasticity of kenaf fibers (a) with MAPE under different impact load; (b) with MAPP under different impact load

From the Fig. 4 (a) and (b) above, the values of elastic modulus for short kenaf fibers are uncertain due to the arrangement of the short kenaf fibers are not aligning properly and also the thickness is not the same along the specimen length [17]. It has been reported by few researcher that, this scenario occurred because of uneven fibers distribution during the fabrication [18]. The kenaf fibers are difficult to manually separate and visually disperse evenly during manufacturing. Shibata et al. [19] noted that, short kenaf fibers had clearly porous structure in the cross section. This is due to insufficient resin because it was found that many fibers on composite surfaces were not wetted by the resin sufficiently. The uncertainty of the value of modulus of elasticity also appears in combination of kenaf fibers and MAPP as presented in Fig. 4.The similar explanations and arguments with arrangement using MAPE as coupling agent can be reported.

In general, the existence of MAPP and MAPE as well as alkalization treatment on specimens related to kenaf fibers have contributed to the increment of elastic modulus.

4. Conclusion

From this research paper, the investigation of the effect of chemical treatment on the mechanical properties of short kenaf fibers with MAPP and MAPE had been achieved and presented. It has been found that;

- The alkalization treatment has improved the tensile properties of the short kenaf fibers significantly as compared to untreated short kenaf fibers.
- It is also interesting to highlight that, 6% NaOH yields the optimum concentration of NaOH for the chemical treatment.
- Furthermore, by adding MAPP or MAPE as coupling agent together with the short kenaf fibers has also amplified the tensile strength in all untreated and treated cases.

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