The Effects of MAPP on Tensile Properties and Morphology of Kenaf Fiber Reinforced Polypropylene Composites

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ABSTRACT

The effects of maleic anhydride grafted polypropylene (MAPP) addition as coupling agent on untreated and treated kenaf fiber/polypropylene (PP) composites on tensile properties and morphology was investigated in this study. Kenaf fibers were immersed in 6 wt % at 100^{o}C NaOH for 1 hour. The amount of MAPP added is 5 wt% and 10 wt%. The 30 layers of kenaf/PP/MAPP were heated at 170^{o}C with pressure of 26 bar for 3 minutes. From the results, it could be concluded that the optimum tensile strength was obtained with treated kenaf in addition of 5% MAPP. The tensile strength increased of 77.3% by compared to the specimen with untreated kenaf and without MAPP addition. Scanning electron microscopy result of tensile fracture surface showed that there is fiber pull out in composites which indicates the effective load transfer between the PP matrix and kenaf fiber.

Keywords: *kenaf, polypropylene, maleic anhydride grafted polypropylene, tensile, scanning electron microscopy*

INTISARI

Efek penambahan *maleic anhydride grafted polypropylene* (MAPP) sebagai *coupling agent* pada komposit serat kenaf tanpa perlakuan dan dengan perlakuan/matriks polypropylene (PP) terhadap kekuatan tarik dan morfologi dikaji pada penelitian ini. Serat kenaf direndam pada NaOH dengan konsentrasi 6% pada suhu 100^{o}C selama 1 jam. Jumlah MAPP yang ditambahkan adalah 5 *wt.%* dan 10 *wt.%*. 30 lapis kenaf/PP/MAPP dipanaskan pada suhu 170^{o}C dengan tekanan 26 bar selama 3 menit. Hasil pengujian menunjukkan bahwa kekuatan tarik optimum diperoleh untuk komposit dengan serat kenaf yang diberi perlakuan dengan tambahan MAPP 5% dimana kekuatan tarik meningkat sebesar 77,3% dibandingkan dengan spesimen yang memiliki serat tanpa perlakuan dan tanpa penambahan MAPP. Hasil *scanning electron microscopy* pada permukaan patahan uji tarik menunjukkan bahwa terdapat fenomena *iber pull out* yang menandakan bahwa terjadi pemindahan gaya yang efektif antara matriks PP dan serat kenaf.

Kata Kunci: *kenaf, polypropylene, maleic anhydride grafted polypropylene,* tarik*, scanning electron microscopy*

INTRODUCTION

Nowadays, the use of agro-based renewable natural fibers such as kenaf, jute, sisal, coir, etc. in constructing composites with various thermoplastic and thermosetting resins has gained some attention due to their environmental benefits, high mechanical properties, low cost, light-weight and readily available (Mishra, et al. 2001), (Pratiwi, 2016).

Known for low cost of processing, stable in dimension, resistant to moisture and easily repaired, polypropylene is preferred by scientists as matrix material in composites manufacturing. Polypropylene has outstanding characteristics that made it suitable to be fabricated with some fiber materials ((Shubhra, Alam and Quaiyyum 2011).

Natural fibre reinforced polymer composites have been used for extensive applications in automotive and construction industries because of the advantageous properties of these materials (Rajesh, Pitchaimani and Rajini 2016). However, there are some challenges in blending the hydrophilic natural fibers with the hydrophobic matrix. Some researchers have attempted to solve the problem of fiber-matrix adhesion by treating the fiber (Pratiwi and Soekrisno, 2013) or using the coupling agent (Feng, Caulfield and Sanadi 2001).

The inherent polar of lignocellulosic fibers and the non-polar characteristics of the polymers result in difficulties in compounding the fibers and matrix. The interactions between non-polar thermoplastics such as PP and any coupling agent, such as MAPP, is principally due to the chain entanglement. Maleic anhydride (MA) grafted polypropylene (MAPP) has been shown to work efficiently as

a coupling agent for natural fiber-PP composites (Amir, Abidin and Faizzaty 2017). Maleated polypropylene (MAPP) wax as coupling agent has been used by Schneider et al. (Schneider, Madison and Karmaker 1995) in order to enhance the properties of jute and kenaf reinforced polypropylene composites. In favor of improving the tensile and flexural strengths of jute fiber reinforced polypropylene composites, Karmaker et al. (Karmakar and Youngquist 1996) have used MAPP as the coupling agent. The present study reveals the influence of MAPP amount on tensile strength and morphology of kenaf fibers/PP composites.

MATERIALS AND METHODS

Kenaf fibers are supplied by Balittas (Balai Penelitian Tanaman Tembakau dan Serat) Malang. There are two types of fiber used in the composites: treated and untreated. The untreated kenaf fibers (code UT) were used directly into composites and the treated kenaf (code T) were immersed first in the 6 wt.% NaOH solutions at 100^{o}C for 1 hour. The fibers then were washed with sterilized water and dried at 60^{o}C. After dry, the fibers were chopped approximately up to 5 mm length. The fiber mass fraction used was 50% where MAPP used was 5 wt.% and 10 wt.%. The 30 layers of PP/kenaf/MAPP were place inside a frame then heated at 170^{o}C with pressure of 26 bar for 3 minutes.

The tensile specimens were tested using an ultimate tensile machine (Torsee AMU-5-DE) according to the ASTM D638-91 standard at the specified loading rate of 10 mm/min. Fracture surfaces of tensile test specimens were examined by scanning electron microscope (JEOL 7800F SEM), operated at 5 kV, to investigate the effects of MAPP on fiber–matrix interfacial adhesion.

RESULTS AND DISCUSSIONS

The tensile strength of composites as a function of the amount of coupling agent used is shown by Fig. 1. Overall, the addition of the coupling agent increased the tensile strength of composites. For the treated kenaf with the addition of 5% MAPP, the tensile strength increased by 77.3% compared to untreated kenaf and without MAPP. This improvement is because of the good interface bonding between fiber and matrix resulting from alkali treatment and the improved load transfer from the matrix to the fiber trough the compatibilizer.

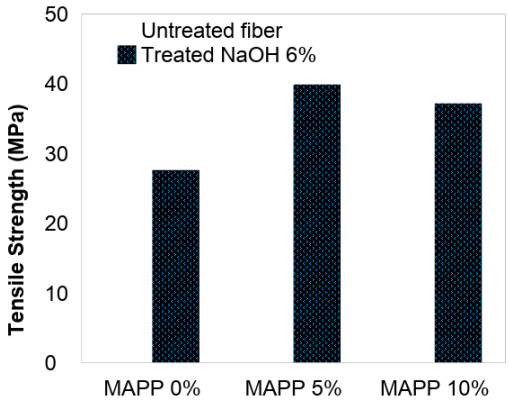

Figure 1 Influence of MAPP amount on tensile strength of 50% kenaf fiber/PP composites.

From the tensile results, it could also be seen that both contents of MAPP lead to different trends in composites strength. The tensile increased with an increase in MAPP content for untreated kenaf. On the other hand, it seems that the addition 5% MAPP gave the maximum strength of treated fiber/PP composites. This is because there is a critical amount of compatibilizer at which MAPP exhibits the strongest interactions with cellulose fibers as well as with PP matrix. This is supported by the investigation of Arbelaiz et al. (Arbelaiz, et al. 2005). They observed the influence of the type and amount of MAPP used in flax fiber bundle/PP composites in order to achieve the optimum mechanical properties of composites. They reported that 5 and 10 wt.% compatibilizer are the optimum doses for E43 and G3003, respectively.

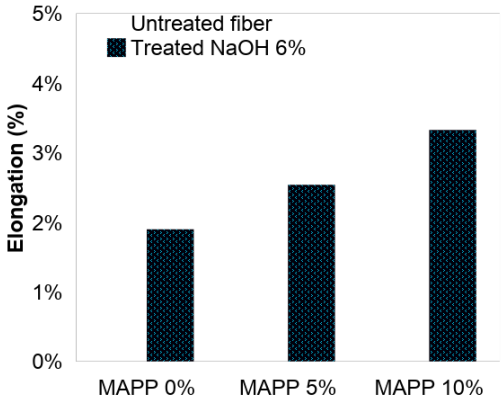

Figure 2 Influence of MAPP amount on elongation of 50% kenaf fiber/PP composites

The influence of MAPP adition on the ductility measurement of kenaf fiber/PP

composites is shown in Fig. 3. It shows an interesting observation where 10 wt.% MAPP has the highest capability to endure strain compared to the other composites. Treated kenaf composite has an increasing elongation with more MAPP whereas the untreated kenaf has a softer effect.

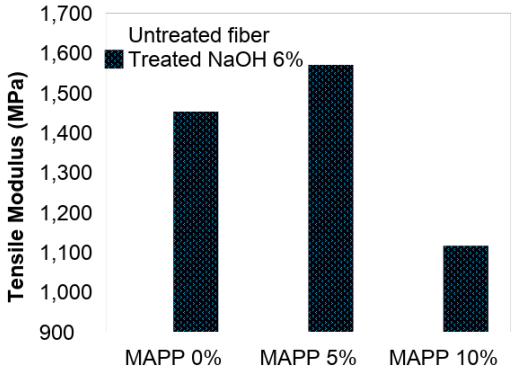

Figure 3 Influence of MAPP amount on tensile modulus of 50% kenaf fiber/PP composites

Tensile modulus is a measure of the stiffness of a solid material. The addition of MAPP on untreated fiber causes the modulus continues to increasing (Fig. 3). This phenomenon can be explained in terms of the more coupling sites which are demonstrated in better fibre/matrix adhesion and hence higher stiffness (El-Sabbagh 2013).

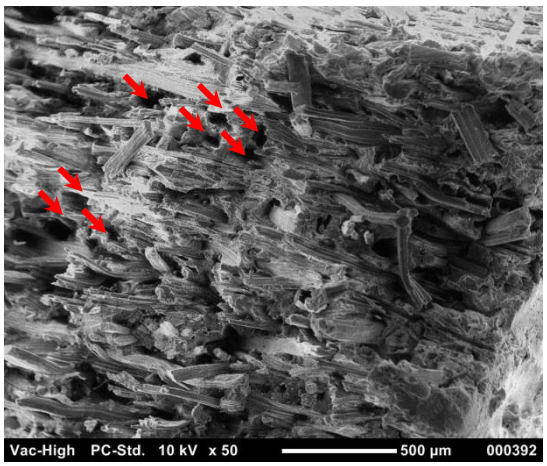

Figure 4 Failure surface of tensile specimen characterized by fiber breakage (50 wt.% fiber fraction, alkali treatment 6 wt.% NaOH, MAPP addition 5 wt.%).

Good fiber-matrix interfacial bonding is confirmed by the failure mode of alkali treated and MAPP added composites using 6% NaOH and 5% MAPP presented in Fig. 4. Fiber pull-out was observed and indicated by an arrow in the figure. Fiber fractures are significant. This failure mode is a clear indication of effective load transfer between the matrix and fiber. There was also an evident of PP matrix cracks, matrix penetration in between kenaf fibres, which called for the role of MAPP for improved adhesion bonding between the matrix and its reinforcements.

CONCLUSIONS

The effects of MAPP addition as coupling agent on untreated and treated kenaf fiber/PP composites on tensile properties and morphology was discussed in this study. The amount of MAPP added is 5 wt.% and 10 wt.%. From the results, it could be concluded that the optimum tensile strength is obtained when treated kenaf is incorporated with the addition of 5% MAPP where the strength increased by 77.3% compared to the specimen with untreated kenaf and without MAPP addition. Treated kenaf composite has an increasing elongation with more MAPP whereas the untreated kenaf has a softer effect SEM micrograph of tensile fracture surface shows that there is fiber pull out in composites which indicates the effective load transfer between the PP matrix and kenaf fiber.

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