DEVELOPMENT OF REINFORCED THERMOPLASTIC ELASTOMER WITH KENAF BAST FIBRE FOR AUTOMOTIVE COMPONENT

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Abstract

This paper compared mechanical properties of kenaf fibre (KF) composites in different matrix systems namely; thermoplastic natural rubber (TPNR) and polypropylene/ethylene-propylene-diene-monomer (PP/EPDM). Both composites were produced via melt blending method using Haake internal mixer, and then compression moulded. The ratio of thermoplastic:elastomer was 70:30 for both polymer blends. The composites were reinforced with 20% kenaf fibre by volume. In addition, maleic anhydride polypropylene (MAPP) was also added as a compatibilizer in the case of treated composite. From the tensile tests, it was found that the tensile strength for TPNR is about 12% higher than the PP/PPDM matrix system. However the present of KF and MAPP has significantly increased the tensile strength of the PP/EPDM composite by approximately 81% while only 55% increment attained in TPNR-KF-MAPP as compared to unreinforced TPNR. This shows that KF has imparted its strength to the PP/EPDM system with good interaction provided by the compatibilizer agent. From the scanning electron micrographs (SEM), it has revealed that the improvement achieved in mechanical properties was due to the interaction between both matrix systems and kenaf fibre. As a conclusion, development of reinforced PP/EPDM with kenaf fibre has a potential to be applied as automotive component.

1 Introduction

In recent years, elastomeric rubber-plastic blends have become technologically interesting for use as thermoplastic elatomers (TPE). These materials exhibit some of the physical properties of elastomers at lower temperatures and are processable at elevated temperatures. Polypropylene (PP) because of its poor impact strength is often modified by elastomers [1]. Among the various elastomers used as an impact modifier are natural rubber and ethylene-propylene-diene monomer (EPDM) which have proven to be the most effective modifiers.

Thermoplastic natural rubber (TPNR) is a blend of natural rubber with any of polyolefin. While PP/EPDM is a blend of polypropylene with ethylene-propylene-diene-monomer. For both types of polymer blends, it properties lying between rubber and plastic, thus make it different class of polymeric material. Both polymer blends can be processed using any existing thermoplastic machinery at comparable prices.

Properties of thermoplastic elastomer can be improved by the addition of vastly available natural fibre such as flax fibre, hemp, abaca, sisal, coir, kenaf and etc. As reported elsewhere, natural fibre may provide reduction in weight of the final composite, lessen the dependent on petroleum-based matrix, less harm to the environment as well as human and many other benefits [2-5].

But up to date, there is no study reported on PP/EPDM-kenaf fibre composite and hardly found study reported on TPNR-kenaf fibre composite. Thus, this study is important to analyze the preliminary properties of reinforced thermoplastic elastomer composite with kenaf fibre. This article comparing the present of two types of elastomers namely, EPDM and NR in the PP blend. In addition, the addition of coupling agent, maleic anhydride polypropylene (MAPP) in thermoplastic elastomer composite is also discussed.

2 Experimental Methods

2.1 Materials

Kenaf (Hibiscus cannabinus, L) bast fiber (KF) was obtained from (Lembaga Tembakau Negara, Kelantan). Polypropylene (PP) was supplied by Propylene (M) Sdn. Bhd. Ethylene-propylene-diene monomer (EPDM) was obtained from Centre West Industrial Supplies Sdn. Bhd., natural rubber (NR) was bought from Lembaga Getah Malaysia and maleic anhydride polypropylene (MAPP) was obtained from Aldrich Chemical Co., USA.

2.2 Preparation of TPNR Composite

TPNR were prepared via melt blending of NR, LNR and PP at ratio of 20:10:70 in Thermo Haake 600p internal mixer. During processing the temperature used was 180^{o}C, 50rpm of rotation speed for a period of 12minutes. Ratio of PP:NR was 70:30.
TPNR matrix and 20% KF by volume were premixed before charged into internal mixer. The components were allowed to melt blend for 12 minutes, at 180^{o}C with 11rpm of rotor speed. In the case of treated composites, MAPP was premixed together with matrix and fibers. The final processed is compression moulding the composites at 175^{o}C for 16minutes.

2.3 Preparation of PP/EPDM-kenaf fibre composite

As for the preparation of TPNR composite, PP/EPDM composite also was prepared via double melt blending. Ratio of PP:EPDM was 70:30. Blending was carried out according to optimum processing parameters obtained which were at 180 ºC, with 40 rpm rotor speed for 10 min processing time.

PP/EPDM-kenaf fibre composite was compounded using the same internal mixer. The samples were prepared using the same parameters as with the preparation of the matrix. The compound was then compression molded for mechanical testing.

3 Results and Discussion

3.1 Strength

The tensile strength of TPNR-kenaf composite and PP/EPDM-kenaf fibre composite with and without MAPP, respectively are shown in Figure 1. It was found that the tensile strength for TPNR matrix is higher than PP/EPDM matrix by about 2 MPa. The value obtained for PP/EPDM blend is even lower than commercially available polypropylene which is around 20-25 MPa. However, the present of reinforcement has significantly enhanced the tensile strength of both types of thermoplastic elastomers.

From Figure 1, it can be seen that the present of kenaf fibre has considerably increased the tensile strength of the TPNR matrix both with and without compatibilizer agent. As expected, the strength for composite without compatibilizer agent is always lower than the compatibilized composite. However, it is interesting to note that the tensile strength for PP/EPDM-kenaf composite is more than twofold of unreinforced PP/EPDM. This shows that kenaf fibre has effectively plays its role as reinforcement and rendered its good mechanical properties to the basic materials. The present of MAPP in PP/EPDM-kenaf system has amplified the tensile strength by about quadruple as compared to PP/EPDM matrix. This indicates that, maleic anhydride polypropylene has linked the matrix and reinforcement so that the system become compatible as reported by many researchers [5-7]. Physically, the interaction between matrix-fibre can be observed in the scanning electron micrographs in Figures. 2-3.

As can be seen in Figure 1, the flexural strength for PP/EPDM matrix is almost 25% higher than the TPNR matrix. The same trend can be observed for flexural strength where the compatibilized composite always possess higher strength than the composite without MAPP. Compatibilized PP/EPDM-kenaf fibre composite shows highest flexural modulus approximately 39% higher than compatibilized TPNR-kenaf composite. Similar explanation can be offered to the flexural strength which is related to the effectiveness of the reinforcement as well as due to the good bonding between matrix and fibre. Thus, when the composite is subjected to load, the matrix will transfer the stress to the fibre and the fibre may act as load carrier. It is noted also in Figure 1, that the standard deviation for all the systems are less than 1%, which could suggest that the uniform stress distribution has occurred and leading to composite having good mechanical properties.

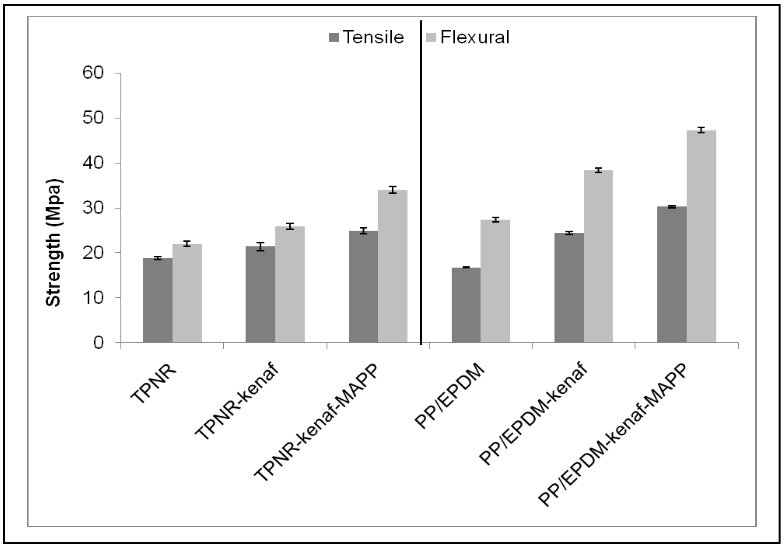
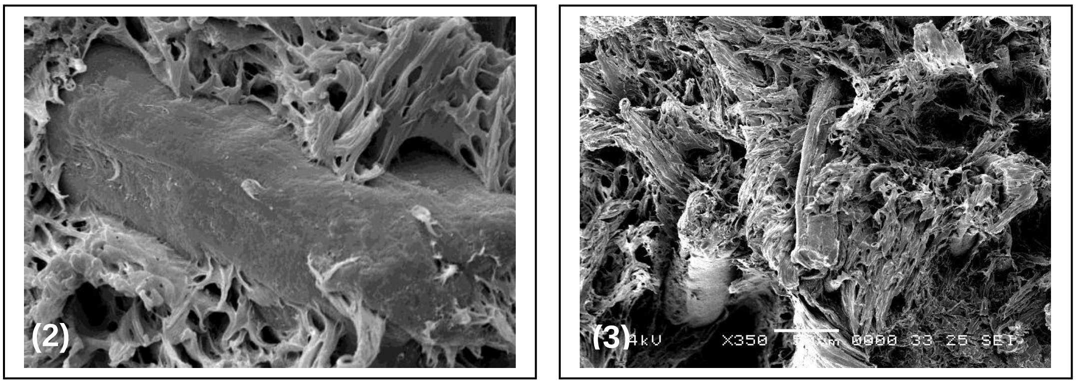


Figure 1. Tensile strength and flexural strength of TPNR composite and PP/EPDM composite.



Figures. 2-3 Scanning electron micrographs (SEM) of (2) TPNR-KF-MAPP and (3) PP/EPDM/KF-MAPP composites.

3.2 Modulus

Figure 4 shows the effect of kenaf fibre and compatibilizer agent on tensile modulus and flexural modulus of TPNR and PP/EPDM composite, respectively. PP/EPDM matrix is about 50% stiffer than the TPNR matrix. The present of kenaf fibre into TPNR has increased the tensile modulus by about 70% as compared to unreinforced TPNR, while compatibilized TPNR-KF system improved by about 91%. As for PP/EPDM system, it should be noted that the present of kenaf fibre dramatically improved the tensile modulus by almost 146% compared to unreinforced PP/EPDM. However adding the MAPP into PP/EPDM-KF slightly reduced the tensile modulus by about 16%.

From Figure 4, it is demonstrated that TPNR has 25% higher bending modulus than PP/EPDM matrix. Kenaf fibre has increased the tensile modulus of PP/EPDM by about 156% as compared to unreinforced PP/EPDM. This value is about 665 MPa higher than TPNR-KF composite. However the flexural modulus dropped by 14% for compatibilized PP/EPDM-KF composite. Meanwhile compatibilized TPNR-KF composite is about 116% higher than TPNR-KF without MAPP. Compatibilized TPNR-KF is almost 365 MPa higher than compatibilized PP/EPDM-KF composite.

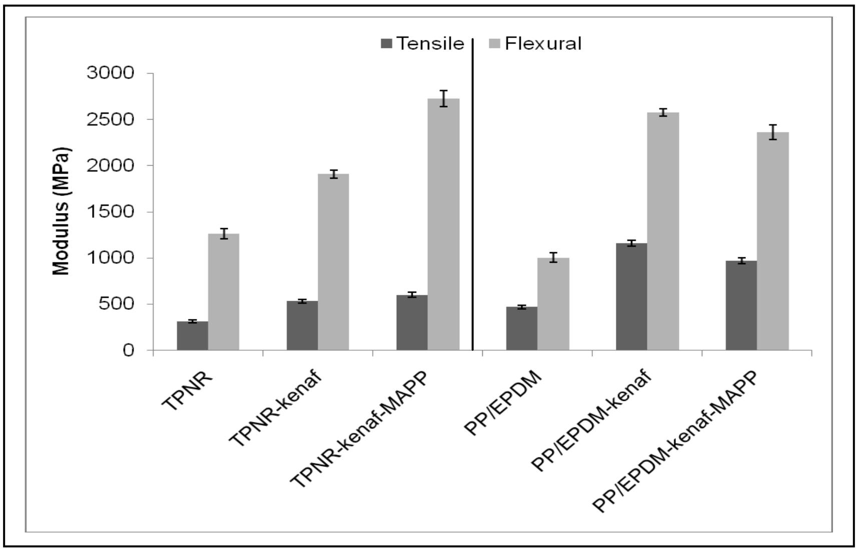


Figure 4 Tensile modulus and flexural modulus of TPNR composite and PP/EPDM composite.

4 Conclusion

As a conclusion, TPNR-kenaf fibre composite and PP/EPDM-kenaf fibre composite are potentially developed based on enhancement in value obtained for tensile and flexural strength and stiffness, respectively. The present of maleic anhydride has compatibilized the fibre and matrix, and hence significantly increased the value of mechanical properties.

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References

[1] Abdullah, I.. & Dahlan, M. 1998. Thermoplastic Natural Rubber Blends. Prog. Polym. Sci. 23: 65-706.

[2] Arbelaiz, A., Fernandez, B., Cantero, G., Llano-Ponte, R., Valea, A. & Mondragon, I. 2005. Mechanical properties of flax fiber/polypropylene composites. Influence of fiber/matrix modification and glass fiber hybridization. Compos. Part (A): Appl. Sci. & Manufact. 36(12): 1637-1644.

[3] Brahmakumar, M., Pavithran, C. & Pillai, R.M. 2005. Coconut fiber polyethylene composites: effect of natural waxy surface layer of the fiber on fiber/matrix interfacial bonding and strength of composites. Compos. Sci. & Technol. 65: 563-569.

[4] Idicula, M., Malhotra, S.K., Joseph, Kuruvilla & Sabu Thomas. 2005. Dynamic mechanical analysis of randomly oriented intimately mixed short banana/sisal hybrid fiber reinforced polyester composites. Compos. Sci. & Technol. 65: 1077-1087.

[5] Maya Jacob, Sabu Thomas & Varughese, K.T. 2004. Mechanical properties of sisal/oil palm hybrid fiber reinforced natural rubber composites. Compos. Sci. & Technol. 64: 955-965.

[6] Joseph, P.V., Joseph, K., Thomas, S., Pillai, C.K.S., Prasad, V.S., Groeninckx & Sarkissova, M. 2003. The thermal and crystallisation studies of short sisal fiber reinforced polypropylene composites. *Compos. Part (A)* 34: 253-266.

[7] Rowell, R.M., Sanadi, A., Jacobson, R. & Caulfield, D. 1999. Kenaf Properties, Processing and Products, Missisippi State University, Ag & Bio Engineering, pp: 381-392.