Bending Properties of Date Palm Fiber and Jute Fiber Reinforced Polymeric Composite

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Abstract: In this research work, the effects of natural fibers such as date palm fiber(DF) and jute fiber (JF) on bending properties of polypropylene (PP)/ ethylene–propylene–diene–monomer (EPDM) thermoplastic elastomers are investigated. For this purpose,the date palm and jute fibers at five levels of fiber weight fractions (0, 5, 10, 20 and 30 wt. %) are utilized during composite fabrication. Maleic anhydride graftedto polypropylene (MAPP)is used as coupling agent to increase the interfacial adhesion between the polymer and the fibers. Results show that by adding fiber to the matrix, the bending properties are increased, but elongation at break is decreased.

Keywords: Bending Properties, Date Palm Fiber, EPDM, Jute Fiber

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1 INTRODUCTION

As the application of polymer composites in modern industry has intensified, more attention has been paid to non-renewable nature of petroleum-based polymer products as well as associated problems created by waste disposal [1], [2]. The use of natural fiber as reinforcement for polymeric composites has gained significant interest during the last decade. lignocellulosic fibers containing cellulose, hemicelluloses and lignin, are an abundant alternative source of renewable polymers that are also highly biodegradable [3-6].The application of natural fibers is being driven by environmental and economical reasons: natural fibers are renewable, and biodegradable. Also they are less abrasive to tooling and less irritating to the skin and respiratory system of people processing the fibers. Furthermore, they can be formed into light weight composites, which are of special interest to the automotive industry, since they lead to weight reductions and thus fuel saving [7], [8].

However, the main disadvantage of natural fiber is its hydrophilic nature that lowers its compatibility with hydrophobic polymeric matrices. It also presents poor environmental and dimensional stability that prevents a wider use of natural fiber composites [9]. The adhesion between the fibers and the matrix can be improved by either modifying the surface of the fibers to make them more compatible with the matrix, or by modifying the matrix with a coupling agent that adheres well to both the fibers and the matrix [10].

Maleic anhydride (MA) grafted polypropylene (MAPP) has been shown to be one of the most suitable coupling agents available for use in natural fiber reinforced polypropylene composites [11]. Polyolefins, such as polypropylene (PP) is usually modified with elastomers, such as ethylene–propylene–diene–monomer (EPDM), to improve its impact strength [12]. Jute is also one of the most common agro fibers used as a reinforcing component for thermoplastics and thermosetting matrices [13]. The largest producers of jute are India, China, and Bangladesh [4].

Date palm tree is normally found in the Middle East, Northern Africa, the Canary Islands, Pakistan, India, and in the United States. Palm tree stem is covered with a mesh made of single fibers. These fibers create a natural woven mat of crossed fibers of different diameters. The use of fibers surrounding the stem of date palm trees as reinforcement in polymeric materials has been reported in few studies [14].

The aim of this research is to investigate the effect of date palm fibers (DF) and jute fibers (JF) content on the bending properties of PP/EPDM composites. Also bending properties of DF and JF reinforced PP/EPDM compositesare compared. The fiber amounts used were 5, 10, 20 and 30 wt%. To improve the matrix/fiber adhesion, MAPP was used as coupling agent.

2 EXPERIMENTAL

2.1. MATERIALS

The thermoplastic elastomer PP/EPDM (PP:EPDM= 8:2, wt%) used as matrix material, was supplied by Kimia Forooz Inc. Co., Tehran, Iran. Maleic anhydride polypropylene (MAPP) was bought from Sigma Aldrich Chemical Co., USA. Date Palm fibers collected from Bam palm grove.Jute fibreswere obtained from Agricultural Department, Rasht, Iran.

2.2. COMPOSITES PROCESSING

Before grinding and passing DF and JF through determined sieves, they were washed by distilled water and dried in an oven at 70±3ºC for 24 h before being blended with PP/EPDM. Then, granuled PP/EPDM and shortened DPF and JF are mixed by weight ratio of 0, 5, 10, 20 and 30%fiber. MAPP were also added at 2 wt%. Then the mixture was blended using a Twin screw extruder COLLIN (Ebersberg, D-8017, Germany) at temperature of 160~200°C with 60 rpm rotor speed. The compounded materials were grinded using a pilot scale grinder (Wieser, A8992, Germany).Then, the mixed blends were dried at 70ºC for 24 h. Test specimens were injection molded by means of injection molding machine (EM 80, Aslanian Co., Tehran, Iran) at 165~180°C to produce standard ASTM bending specimens. The specimens were stored under controlled conditions (45% relative humidity and 23ºC) for at least 48 h before testing.

3 RESULTS AND DISCUSSION

3.1. BENDING PROPERTIES

Bending tests were performed according to ASTM D-790 specification. Bending tests were carried out using a universal testing machine (Hounsfield, H25K-S, UK) at 23 ±2°C and relative humidity 40 ± 5% at a cross-head speed of 5 mm/min. Load displacement curves, flexural strength and modulus of fabricated DF and JF composites were obtained. Bending properties of DF and JF fiber reinforced PP/EPDM at different fiber loading are shown in Table 1.Figure 1 demonstrates bending strength of DF and JF loaded composites as a function of fiber loading. Flexural strength increases with fiber loading [15]. Increased fiber–matrix adhesion provides increased in-between transfer stress [16].

It was observed that bending strength of PP/EPDM composites increases with increasing fiber loading, irrespective of fiber type. At 20wt% fiber loading, the increase was 8.3% for DF and also, at 30wt% fiber loading, the increase was 20% for JF. However there was a decrement from 20% to 30% fiber for DF, which results in inefficient fiber–matrix bonding and a lower transfer stress between fibers and the matrix [17]. The same trend can be observed for bending strength where PP/EPDM/DF composites always possess higher strength than PP/PDM/JF composites.

As seen in Figure 2, bending modulus tends to increase with increasing fiber loading, except 20 to 30% for DF. The maximum improved bending modulus of PP/EPDM composites with DF and JF were 75 and 86% at 20wt% and 30wt% fiber loading, respectively. Therefore, using a fiber weight fraction of 20% and 30% for DF and JF, respectively will produce the highest flexural propertiesas expected since the addition of fiber increases the stiffness of the composites, which in turn decreases the strain at break. Reduction of elongation at break caused by increased fiber loading might be due to the decreased deformability of a rigid interface between the fiber and PP/EPDM matrix [18].

Table1 Bending test results for PP/EPDM composites reinforced with DF and JF

properties	Fiber loading	0%	5%	10%	20%	30%
Bending Strength (BS) (MPa)	DPF JF	30 30	29.74 31.27	32.4 33.4	32.5 34	27.87 36
Bending Modulus (BM) (MPa)	DPF JF	925 925	1156.2 1110.21	1535.5 1413.16	1618.7 1605.35	1572 1720.43
Strain at Break (%)	DPF JF	unlimited unlimited	21.6 23.4	14.4 20.2	12.8 15.4	12.4 13.6
Increased BS with respect toPP/EPDM (%)	DPF JF	0 0	-0.1[1] 4.2	8 11.3	8.3 13.3	-7 20
Increased BM with respect to PP/EPDM (%)	DPF JF	0 0	25 20	66 53	75 73	69 86

1: negative sign shows decrease

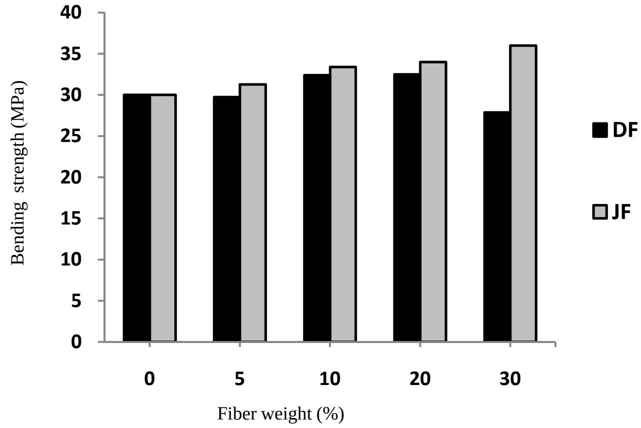


Fig. 1 Variation of bending strength at different fiber loading

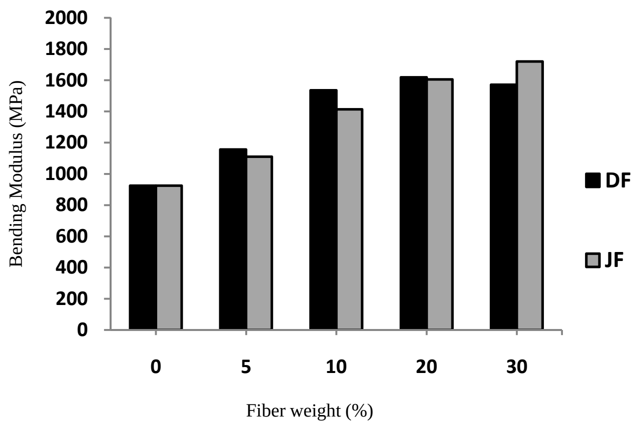
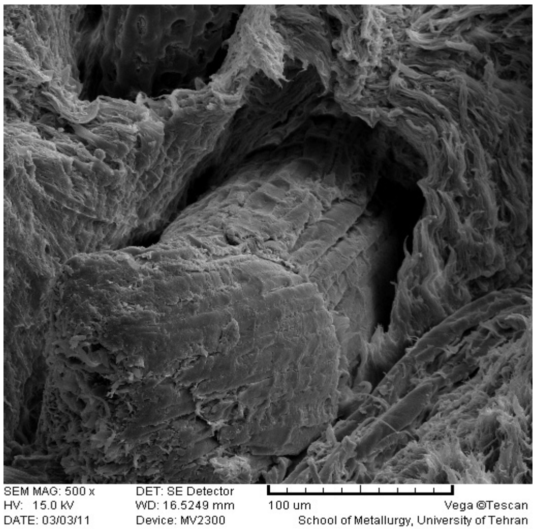


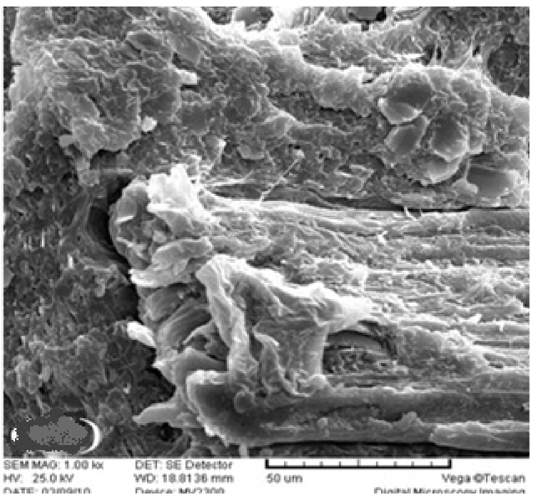
Fig. 2 Variation of bending modulus at different fiber loading

3.2. MORPHOLOGICAL STRUCTURE

The surface morphology of fractured surfaces of composite specimenswere investigated using Scanning Electron Microscopy (SEM) (Vega©Tescan, MV230). The corresponding micrographs are shown in Fig.3 (a) and (b),respectively. The Figures show that, the DPF and JF are packed closely by the polymer matrix and some polymer matrix may be linked to the surface of the fiber.There was less pull of the PP/EPDM matrix with the presence of MAPP. There is evidence of improvement in the interfacial bonding between the fibers and PP/EPDM composites.



(a)



(b)

Fig. 3 SEM micrographs of fractured surfaces of PP/EPDM composites reinforced (a) with DPF and (b)with JF

4 CONCLUSION

Composites reinforced with natural fibers (date palm and jute fiber) were processed. The MAPP was used as a compatibiliser to improve the compatibility of fiber reinforced PP/EPDM composites. Results show that:

1-In PP/EPDM composites,bending strength and bending modulus increases due to increased fiber loading.

2-In PP/EPDM composites, the strain at break is decreasingwith increased fiber loading.

3- The bending properties of specimens reinforced with JF are more than specimens with DPF.

4-The surface morphology by SEM studies, indicates that the interfacial adhesion between fibers and the PP/EPDM matrix is improved with the presence of MAPP.

REFERENCES

[1] Mohanty A. K, Misra M., and Drazel L.T., “Sustainable bio-composites from renewable resources: opportunities and challenges in the green materials world”, J Polym Environ, Vol. 10(1–2), 2002, pp. 19–26.

[2] Pandey J. K, Misra, M., Mohanty, A. K., Drzal, L. T., and Singh, R. P., “Recent advances in biodegradable nano composites”, J NanosciNanotechnol, Vol. 5(4), 2005, pp. 497–526.

[3] Nascimento, D. C. O., Lopes, F. P. D., and Monteiro, S. N., “Tensile behavior of lignocellulosic fiber reinforced polymer composites Part I piassava/epoxy”, Revist Matéria, Vol. 15, 2010, pp. 199-205.

[4] Taj, S., Munawar, M. A., and ullah, SH.,“Natural fiber-reinforced polymer composite”, Proc. Pakistan Acad, Vol. 44(2), 2007, pp. 129-144.

[5] Shukala, S. R., and Roshan, S. P., “Comparison of Pb(II) uptake by coir and dye loaded coir fibers in a fixed bed column”, J. Hazard. Mater, Vol. 125 (1–3), 2005, pp. 147–153.

[6] Al-Kaabi, K., Al-Khanbashi, A., and Hammami, A., “Date Palm Fibers as Polymeric Matrix Rein for cement”, Polymer composites, Vol. 26,2005, pp. 486–497.

[7] Harritte, L. B., J., M., and Martien J. A. V. D. O., “Mechanical properties of short-flax-fibre reinforced compounds”, Composites, Vol. 37, 2006, pp.1591–1604.

[8] Beg, M. D. H., and Pickering, K. L. “Reprocessing of wood fibre reinforced polypropylene composites. Part II: Hygrothermal ageing and its effects”, Composites: Part A, Vol. 39(9), 2008, pp. 1565–1571.

[9] Espert, A., Vilaplana. F., and Karlsson, S., “Comparison of water absorption in natural cellulosic fibres from wood and one-year crops in polypropylene composites and its influence on their mechanical properties”, Composites: Part A Vol. 35, 2004, pp. 1267–1276.

[10] Beckermann, G. W., and Pickering, K. L. “Engineering and evaluation of hemp fibre reinforced polypropylene composites: Fibre treatment and matrix modification”, Composites: Part A, Vol. 39, 2008, pp. 979–988.

[11] Anuar, H., and Zuraida, A., “Improvement in mechanical properties of reinforced thermoplastic elastomer composite with kenafbastfibre”, Composites: Part A, Vol. 42, 2011, pp. 462–465.

[12] Wang, W., Tang, L., and Qu, B., “Mechanical properties and morphological structures of short glass fiber reinforced PP/EPDM composite”, European Polymer Journal, Vol. 39(13), 2003, pp. 2129–2134.

[13] Gassan, J., and Bledzki, A. K.,“The influence of fiber surface treatment on the mechanical properties of

Jute–polypropylene composites", Composite Part A Vol. 28, 1997, pp. 1001–5.

[14] Alawar, A., Hamed, A. M., and Al-Kaabi, K., "Characterization of treated date palm tree fiber as composite reinforcement, Composites", part B, Vol. 40, 2009, pp. 601–606.

[15] Ma, X., Yu, J., and Kennedy, J. F., "Studies on the Propertied of Natural Fibres-Reinforced Thermoplastic Starch Composites", Carbohydrate Polymers, Vol. 62, 2005, pp. 19-24.

[16] Mominul, H., Mahbub, H., Saiful, I., and Ershad, A., "Physico-mechanical properties of chemically treated palm and coir fiberreinforced polypropylene composites", Bioresource Technology Vol. 100, 2009, pp. 4903–4906.

[17] Al-Kaabi, K., and Al-Khanbashi, A., "Date Palm Fibers as PolymericMatrix Reinforcement:DPF/Polyester Composite Properties", polymer composites, Vol. 26, 2005, pp. 604–613.

Nekkas, S., Chebira, F., and Haddaoui, N., "Effect of Fiber Treetment The Mechanical andRheolological properties of Polypropylen/Broom Fiber Spartiumj unceum Composites", Jornal of Engineering and Applied Sciences, Vol. 1(3), 2006, pp. 278-283.