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Properties of Bamboo (*Gigantochloa scortechinii*) Thermoplastic Composite: Influence of Particle Sizes

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ABSTRACT

Bamboo particles with the sizes of 0.12, 0.18 and 0.25 mm were compounded with polypropylene (PP) in dispersion mixer and then moulded into thermoplastic composite using a hot press. The effects of particle sizes (PS) on the mechanical and water absorption (WA) properties were analyzed statistically. This study shows that when the particle sizes increased, the tensile strength (TEN), flexural strength (MOR), flexural modulus (FMOE) significantly decreased. However, there was no significant effect on elongation. This study also indicated that an increase in bamboo particle sizes would improve the water absorption (WA) properties significantly.

Keywords: *bamboo, particle sizes, thermoplastic composite*

Introduction

The stability and improvement in the mechanical properties of wood-filled thermoplastic composites depend on a number of factors such as particle size, aspect ratio, filler content, the adhesion and interface properties between the filler and the matrix (Kokta et al., 1983; Maldas et al., 1988; Woodhams et al., 1984). Furthermore, woody materials and thermoplastic are divergent in polarity giving rise to a serious problem of compatibility. This paper discusses the effects of particle size on some properties of bamboo-polypropylene composite.

Bamboo and Its Uses

Bamboo is a perennial giant woody grass belonging to the subfamily Bambusoidae of the family Graminae. It is found growing in areas from sea level up to 3000 m in altitude in all continents except Europe. It is estimated that there are about 1200 to 1500 bamboo species globally (Wong, 1995). In Peninsular Malaysia, Wong (1985) reported the presence of 59 bamboo species representing 14 genera of which 34 of them are indigenous and the other 25 species are introduced or only known in cultivation.

Malaysian bamboos are classified as a minor forest product and are traditionally considered as a weed interfering with the normal regeneration, development and maintenance of the timber species (Ng, 1980). In the past, attempts were made to control their growth but now, due to the rapid expansion of bamboo-based industries, they have become an important non-timber produce in Malaysia after rattan (Aminuddin & Abd. Latif, 1991). In Malaysia, the bamboos are used widely in the production of basket-ware, cords and toys, chopsticks, sate sticks and also furniture.

The bamboo industry has developed into a multi-million dollar industry with its products enjoying very high demand domestically as well as internationally. However, in producing the various products, a lot of bamboo wastes are generated (Abd. Latif et al., 1988), excluding those that are discarded during harvesting and transporting. If no action is taken, then the bamboo industry will be heading towards its downfall. Therefore, the optimum use of the wastes lies in the production of thermoplastic composite.

Potentials of Lignocellulosics Thermoplastic Composites

Recent research and development efforts are focusing on generating new technology in using lignocellulosics materials blended with polyolefins plastics to produce relatively high performance reinforced composite products. This latest development provides a strategy for producing relatively new materials taking advantage of the enhanced properties of both lignocellulosics and plastics. These new biocomposites will give better benefits such as light weight and improved acoustic, impact and heat reformability prioperties (Youngquist et al., 1993).

Materials and Methods

Composite Manufacture

The polypropylene (PP) used in the study was bought locally and had a melt index of 8 gm per 10 min. and a density of 0.9 gm/cm^3. The bamboo particles were taken from the discards of the screening process (retained on the screen size of less than 0.5 mm) in particleboard manufacture. The bamboo particles were first dried in an oven at 60°C for 48 hours and further screened using a laboratory sieve into the desired sizes.

The compounding of the bamboo particles into the PP was accomplished using a dispersion mixer with a capacity of 1 kg. The mixer was first heated to 185°C and the PP was then melted down in about 10 min. followed by the addition of the bamboo particles. The compounded admixture was rolled into thin sheets and fed into a crusher to be pellitised. Tensile and water absorption samples were produced using a chrome-plated mould with dimensions of 150 x 150 x 2 mm. About 70 gm of the pellitised admixture was placed in the mould and hot-pressed at a temperature of about 185°C for about 10 min. and then cooled to ambient temperature using a cold press with running water through the platens. Bending samples were produced using a mould with dimensions of 150 x 150 x 6 mm. All test specimens were prepared and conditioned in accordance with BS 2782 (1992). The test specimens were tested for their mechanical properties using a Testometric testing machine.

Particle Sizes

The particle sizes (PS) used in the manufacture of bamboo plastic composite were screened through four different sieve sizes: > 0.25, 0.25, 0.18 and 0.12 mm. The amount of particles collected at each sieve size varied from about 20.35% for size 0.12 mm, 26.97% for 0.18 mm, 21.59% for 0.25 mm and 30.92% for > 0.25 mm (Figure 1). The particles collected at the > 0.25 mm sieve were not used in the manufacture of bamboo plastic composite.

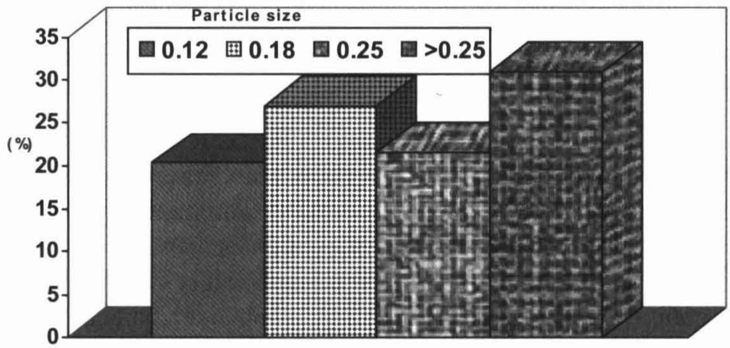

Figure 1: Percentage of Bamboo Particle Sizes

Results and Discussion

The size of wood fillers plays a significant role in modifying the mechanical properties of wood-filled thermoplastic composites. For this reason, this study used three different sizes of bamboo particles: 0.25, 0.18 and 0.12 mm PS. The most prominent effect of fillers is the stiffening or modulus increase in composites (Ferrigno, 1978).

The effects of PS on the mechanical properties and elongation at break and water absorption properties are shown in Figures 2 and 3, respectively. An increase in PS significantly decreased the tensile strength

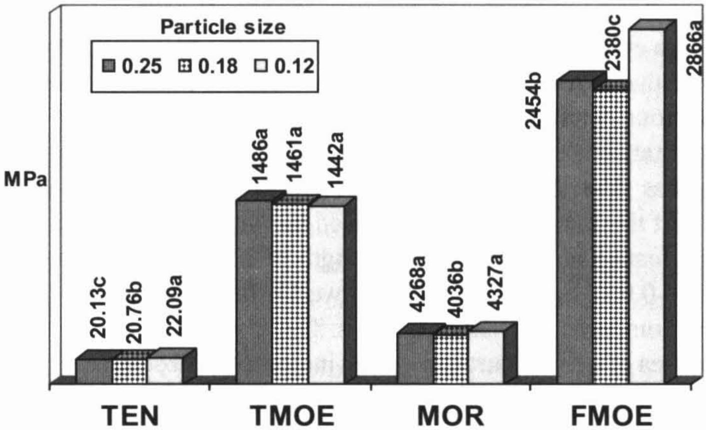

Figure 2: Effects of PS on the Mechanical Properties

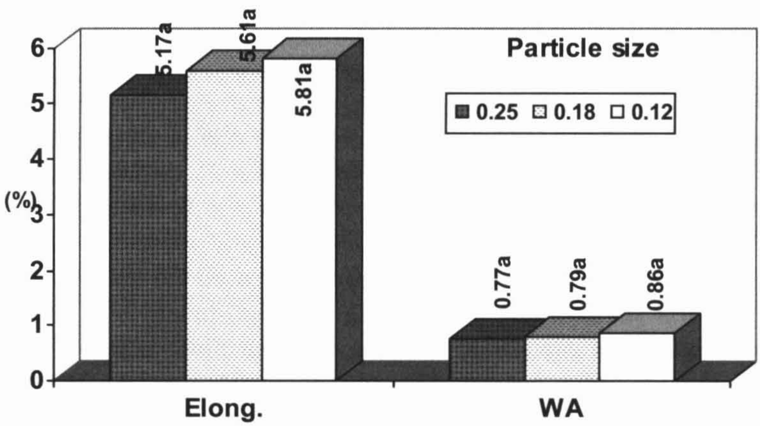

Figure 3: Effects of PS on Elong. and Water Absorption Properties

(TEN), flexural strength (MOR), flexural modulus (FMOE) but did not show a significant effect on elongation (Elong.). However, with bigger PS, it improved the water absorption (WA) properties. A reduction of PS used in the study from 0.25 mm to 0.12 mm showed that TEN increased by 9.74%, Elong. by 12.4%, MOR by 13.8% and FMOE by 17.8%. However, tensile modulus (TMOE) decreased by 3.0% and WA decreased by 10.4%.

The correlation analysis (Table 1) further revealed that a decrease in TEN ($r = -0.18$), FMOE ($r = -0.37$), Elong. ($r = -.009$) and MOR ($r = -0.02$) led to an increase in PS used. The TMOE ($r = 0.04$) however increased insignificantly with an increase in PS. The above findings were similar to those reported by Maldas et al. (1988), Woodhams et al. (1984) and Kokta et al. (1983). They speculated that the better properties were probably due to the better distribution of smaller particles, which were homogenous compared to the larger ones. This could be explained by the fact that smaller particles covered a larger specific surface area in composites than the same weight of larger particles. Nielsen (1974) stated that the amount of stress created by larger particles was another probable cause in reducing the strength of composites. However, for WA ($r = -0.05$), bigger particles showed better resistance to intake of water as compared to smaller particles. This is probably due to the higher surface area of smaller particles which increases its absorption properties.

Table 1: Summary of the Correlation Coefficients of Particle Sizes with Composite Properties

Property	TEN	TMOE	Elong.	MOR	FMOE	WA
PS	-0.18*	0.04ns	-0.09ns	-0.02ns	-0.37*	-0.05ns

Note; ns – not significant at $p < 0.05$, * significant at $p < 0.05$

Conclusion

Increasing PS from 0.12 mm to 0.25 mm decreased the tensile strength and flexural strength and increased the flexural modulus. Elongation increased insignificantly with particle size reduction. However, water absorption properties decreased insignificantly. Bamboo particle at any particle size can be used as filler in the production of thermoplastic composite use where strength criteria is not important.

References

Aminuddin, M., & Abd. Latif, M. (1991). *Non-wood resource and products of Peninsular Malaysia: Its status and future trends in research*. Paper presented at Winroc International F/Fred Utilization Research Programme Development Workshop, 21-25th January, Taipei, Taiwan.

BS 2782 (British Standard Methods), (1992). *Methods of testing plastics*. British Standards Institution, London.

Ferrigno, T.H. (1978). Principles of filler selection and use. In H. Katz, & J.V. Milewski (Eds.), *Handbook of fillers and reinforcements* (pp. 11-66). New York: Van Nostrand Reinhold.

Kokta, B.V., Chen, R., Naneault, C., & Valde, J.L. (1983). Improvement of the mechanical properties of composites from polystyrenes. *Polymer Composites, 4*(4): 229.

Maldas, D., Kokta, B.V., Raj, R.G., & Daneault,C. (1988). Improvement of the mechanical properties of sawdust wood fiber-polystryrene composite by chemical treatment. *Polymer 29*(7): 1255-1265.

Ng, F.S.P. (1980). Bamboo research in Malaysia. In G. Lesard & A. Chouinard (Eds.), *Proceedings of the Seminar on Bamboo Research in Asia*. pp 91-95. Singapore.

Nielsen, L.E. (1974). *Mechanical properties of polymer and composites (Vol. 2)*. New York: Marcel Dekker.

Woodhams, R.T., Thomas, G., & Rodgers, D.K. (1984). Wood fibers as reinforcing fillers for polyolefins. *Polymer Engineering Science 24*(5): 1166-1171.

Wong, K.M. (1995). The bamboos of Peninsular Malaysia. *Malayan Forest Records, No. 41*. Forest Research Institute Malaysia.

Youngquist, J.A., Krysik, A.M., Muehl, J.H., & Carll, C. (1993). Properties of wood fiber and polymer composites. *Proceedings of 1st Wood Fiber-plastic Composite Conference: Fundamentals Concepts, Processes and Materials Options* (pp. 79-86). USA: Madison, WI, Forest Products Society.

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