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# EFFECTS OF FILLER LOADING AND MALEATED ANHYDRIDE POLYPROPYLENE ADDITION ON SOME SELECTED PROPERTIES OF BAMBOO THERMOPLASTIC COMPOSITE

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## ABSTRACT

*Bamboo particles were used as filler in the manufacture of bamboo-polypropylene thermoplastics composite. Bamboo particles of three different filler loading of 10, 30 and 50% and maleated anhydride polypropylene at 3% were used in the study. Results indicated that regardless of filler loading and maleated anhydride polypropylene addition the bamboo particles are suitable to be use as filler in the manufacture of thermoplastic composite. Increasing the filler loading from 10 to 50% decrease the tensile (33.8%), flexural strength (47.6%) and elongation at break by 70%, while the water absorption increased from 0.19 to 1.65%. The addition of 3% maleated anhydride polypropylene increased the tensile, flexural strength and decreased the water absorption significantly.*

*Keywords :* Gigantochloa scortechinii-*bamboo-polypropylene composite -filler loading- Maleated anhydride polypropylene effects.*

## INTRODUCTION

In Malaysia, many wood and bamboo-based industries produce substantial quantities of wood waste, which have been burned or left to rot in the open. Abd. Latif (1987) reported that about 27 to 48% of the bamboo used in the bamboo industries are discarded as wastes if converted or use as fillers would generate further income to the industries. Kline (1980) reported that wood flours have traditionally comprised only a small percentage of the filler market for plastics products when compared to inorganic fillers. The wood fillers have been limited to their low aspect ratio and increase in stiffness of the resultant composite which also contribute to the reduction in strength and toughness of the product. This paper presents the properties of the bamboo-polypropylene composite and the effects of filler loading and maleated anhydride polypropylene (MAPP) addition are also discussed.

## MATERIALS AND METHODS

The bamboo particles in the study were taken from the discards of the screening process (retained on the screen size of < 0.5 mm) of particles utilized in the particleboard manufacture. The bamboo particles were first dried in an oven at 60°C for 48 hours. The polypropylene (PP) used was bought locally from a plastic manufacturer and had a melt index of 8.0 g / 10 minutes and a density of 0.90 g $cm^{-3}$. The MAPP was an epolene E-43 wax used as the coupling agent

The study was designed to determine the effects of filler loading and MAPP addtion on the composite properties. Bamboo particles used as fillers was at ratios of 10, 30 and 50%, while MAPP addition was at 0 and 3% of the total composite weight. The compounding of the bamboo particles into the PP was accomplished using a Dispersion mixer D1-5 with a capacity of 1 kg. The mixer was first heated to the working temperature of 185°C, the PP was then melted down in about 10 minutes and the MAPP added followed by the bamboo particles. The compounded admixture was then rolled into thin sheets and fed into a crusher to be pelletized. Tensile and water absorption samples were produced using a chrome-plated mould with a dimension of 150 x 150 x 2 mm. About 70 g (giving a density of about 1000 kg $m^{-3}$ of the pelltized admixture) was placed in the mould and hot-pressed at a temperature of 175-185°C for about 10 minutes 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 25 x 6 mm. All the test specimens were prepared and conditioned in accordance with the British Standard 2872: Part 0: 1992 (Anonymous 1992) for tropical countries. The test specimens were tested for their mechanical properties using a Testometric Testing Machine Model Micro-500.

## RESULTS AND DISCUSSION

### *Effect of Filler Loading*

The effects of filler loading on the thermoplastic board properties are shown in Figures 1 to 3. Figure 1 shows that by increasing the filler loading from 10% to 50%, resulted in a significant decrease in TEN (33.8%) and MOR (47.6%). Incorporation of bamboo filler to 50% into polypropylene decreased the elongation (Elong) at break of the composite by about 69.6%. Zaini et al. (1996) stated the decreases in TEN, MOR and Elong are common observations in all filled polymer systems and are probably due to the decreased deformablity of a rigid interphase between the filler and the matrix material. The correlation analysis (Table 1) showed that TEN (r= -0.79), Elong (r = -0.89) and MOR (r = -0.94) are correlated negatively with filler loading.

Table 1: Summaries of the Correlation Coefficients of Filler Loading and MAPP Addition with the Board Properties

| Property | TEN | TMOE | Elong | MOR | MOE | WA |
|---|---|---|---|---|---|---|
| Filler loading | -0.79** | 0.74** | -0.89** | -0.94** | 0.49** | 0.82** |
| MAPP | 0.37** | 0.38** | -0.16** | 0.11ns | -0.22** | -0.29** |

Note: ns - not significant at $p < 0.05$, ** - highly significant at $p < 0.01$
TEN-Tensile strength, TMOE-Tensile modulus of elasticity, Elong- Elongation at break, MOR- Modulus of rupture, FMOE- flexural modulus, WA- water absorption

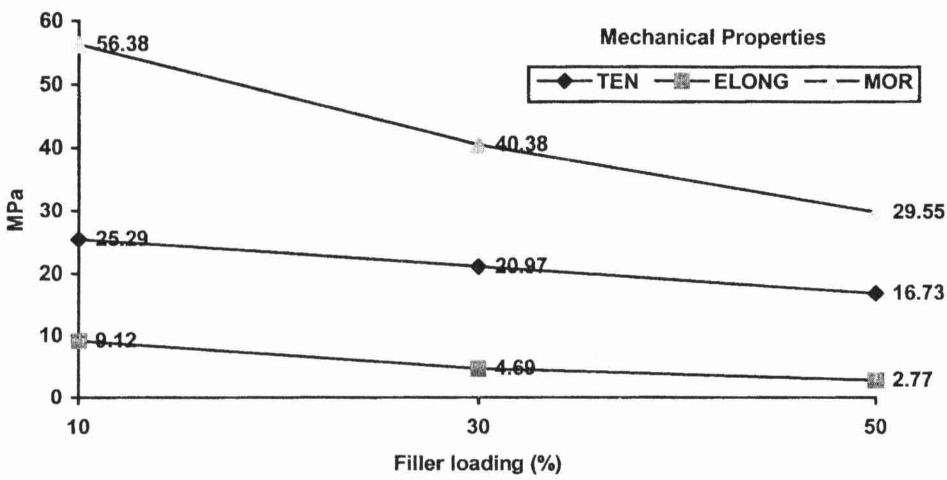


Figure 1. Effects of Filler Loading on the TEN, Elong and MOR

Modulus of elasticity (stiffness) is one of the basic properties of composites where the primary intention of filler incorporation is to increase the stiffness of the resultant composite. The effects of filler loading on the TMOE and FMOE were shown to be significant (Figure 2). Increasing the filler loading from 10% to 50%, TMOE and FMOE were observed to increased by about 95.6% and 22.9%, respectively. It was further revealed from the correlation analysis that the properties of TMOE (r = 0.38) and FMOE (r = 0.49) showed a positive correlation with filler loading. loading According to Fuad et al. (1995) and Bigg (1987) the increase in modulus with an increase in filler is a common phenomenon.

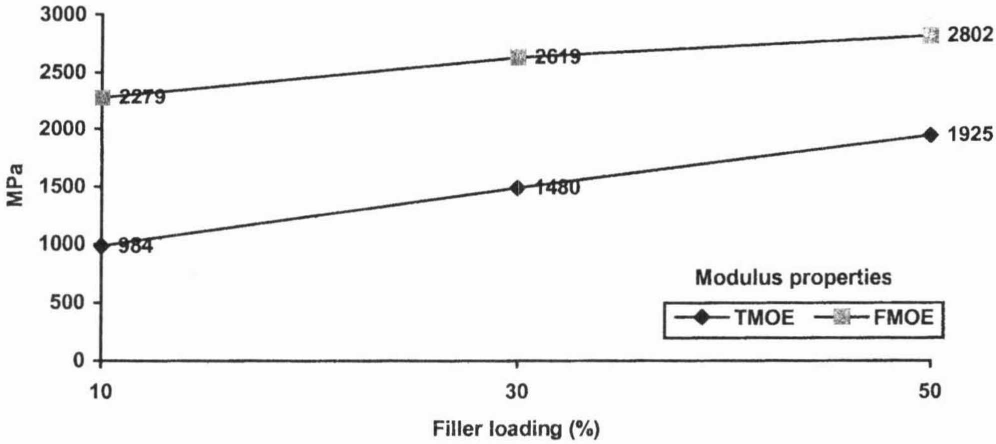


Figure 2. Effect of Filler Loading on the Tensile and Flexural Modulus

The WA properties influences composite product usage and could pose a big problem in composites with high filler content. Filler loading was shown to significantly affect the WA properties (Figure 4) where an increase in the WA (750 %) was observed when the filler loading was increased from 10% to 50 %. This tremendous increase in WA would have a dramatic effect on the final product. The correlation analysis further showed that WA (r = 0.82) was positively correlated with filler loading. The increase in WA could be explained by the increase in surface area of the filler, which are hygroscopic in nature.

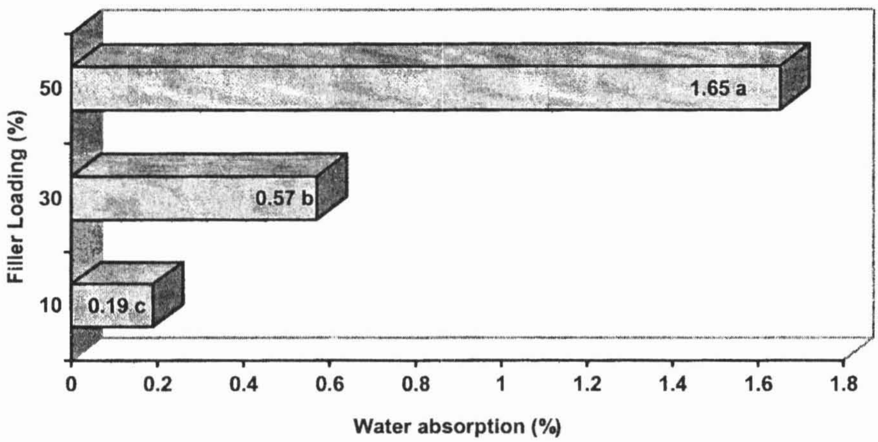


Figure 3. Effects of Filler Loading on the Water Absorption Property

*Effect of MAPP*

The effects of MAPP on the thermoplastic properties are shown in Figure 4. Addition of 3% MAPP during composite manufacture significantly improved the TEN by about 17%, TMOE (31%) and MOR (6%) compared to those without MAPP. The correlation coefficients in Table 3 further showed that MAPP addition caused the properties of TEN (r = 0.37) and TMOE (r = 0.38) to increase significantly while Elong (r = - 0.16) and MOE (r = - 0.22) decrease insignificantly. However, MOR (r = 0.11) tended to increase with MAPP addition.

The increase in TEN, TMOE and MOR values are probably due to the better adhesion occurring between the components. Gatenholm et al. (1992) stated that the anhydride groups present in MAPP could covalently bond to the hydroxyl groups on the bamboo filler surface. The improved interaction and adhesion between the bamboo fillers and matrix could be either through covalent bonding or acid-base interaction (H-bonding), or combination of both, leading to better matrix to fiber stress transfer. Figure 4 further shows that MAPP decreases the Elong and MOE significantly. The reduction in Elong and MOE values are due to the matrix being severely restricted by interfacial bonding which in fact increase the tensile (Ferrigno 1978).

Depending upon the end use of the product, the dimensional stability in water, especially the water absorption, could be a major problem in composites with high percentages of wood fillers. The WA showed a significant decrease of about 42% with 3% MAPP addition (Figure 4), while the correlation analysis (Table 1) showed that WA (r = - 0.29) decreased significantly with MAPP addition. The better resistance to water penetration could be due to the existence of better bonding between the fillers and the matrix. Krzysik and Youngquist (1991) also reported similar trends in the WA property with MAPP addition.

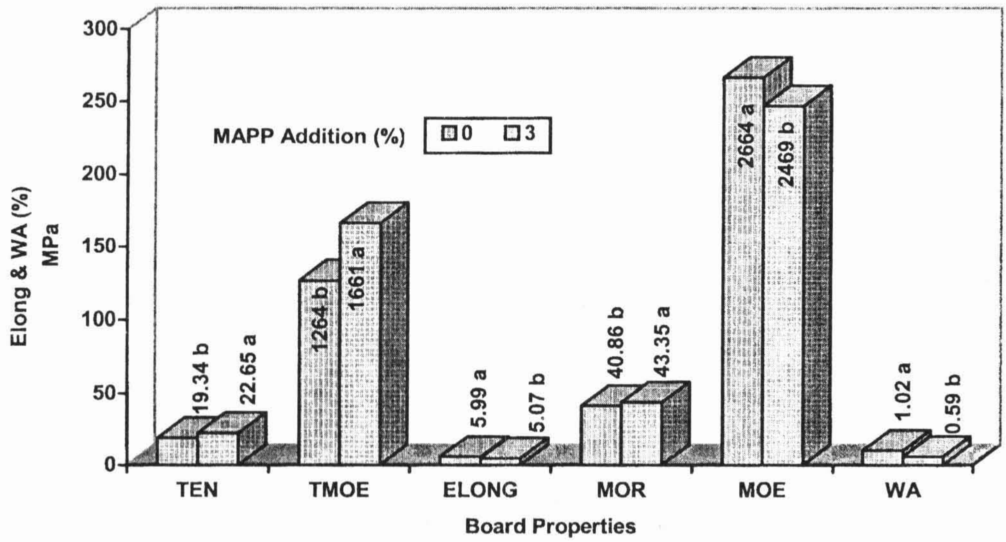


Figure 4: Effects of MAPP Addition on the Board Properties

## CONCLUSION

The mechanical and water absorption properties of bamboo plastic composite were shown to be significantly affected by filler loading and MAPP addition. With higher filler addition the water absorption and mechanical properties decrease except for tensile and flexural modulus. Addition of MAPP was found to reduce the interfacial energy and improved the filler dispersion leading to better mechanical and water absorption properties.

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