Physical and Mechanical Properties of Thermoplastic Composite from Oil Palm Trunk

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ABSTRACT

Oil palm (Elaeis Quieensis Jacq*) particles were used as fillers in the manufacture of polypropylene composite. The oil palm particles were separated from the fibre strand using a vibratory screener and dried in an oven for 48 hours. Filler loading of 10%, 30% and 50% of polypropylene by weight were used in the study. Test samples were then produced using a chrome-plated mould for bending, tensile and water absorption. Results of the bending and tensile, showed that with higher filler loading, the bending and tensile strength and elongation at break decreases while modulus of elasticity increases. Water absorption decreases with increasing percentage of filler whilst MAPP addition shows no significant contribution to the composite properties. As a conclusion, particles of oil palm trunk is a suitable filler and is recommended to be used in the manufacture of thermoplastic products that does not require high strength properties.*

Keywords: *oil palm, thermoplastic, filler loading, MAPP*

Introduction

Increasing awareness towards the environment in terms of deforestation and pollution, along with the constant supply of low quality timber have encouraged the wood-based industry particularly the furniture industry to take a fresh look at switching the use of solid wood to fibre reinforce composites. Interest in wood polymer composite renewed after plastics became expensive, and the use of the environment – friendly renewable biomass began to be taken seriously. Wood fibres are superior to inorganic fillers such as fibreglass and mineral. These fibre reinforced in plastics composite because they are cheaper, lighter, less abrasive, abundant, biodegradable and not a health hazard during its manufacturing process. The main obstacles in wood polymer composite manufacture are the poor compatibility and dispensability of polar hydrophilic fibre with non-polar hydrophobic matrixes, and the thermal instability of wood fibre in polymer matrixes.

Considerable work on lignocellulosics fibres/fillers for plastic composites has been concentrated on wood flour (Myers et al. 1993; Sanadi et al. 1994a). Apart from wood flour, fibres from annual plants are also being used in reinforcing thermoplastics (Sanadi et al. 1994b). As compared to wood fillers/fibres, they have the advantage of being low cost, low density and the less abrasive nature (allowing high filling levels), thereby resulting in significant material cost saving. In spite of their advantages, the inherent high-moisture absorption properties and low-processing temperature requirement limit the usage of fibres from animal plants.

The study was carried with the following objectives:

- To determine the properties of polypropylene composite using oil palm particles as fillers; and
- To determine the effect of filler content and MAPP on the properties of the composite produced.

Materials and Methods

Raw Material Preparation

Samples of oil Palm trunk were obtained from the Malaysian Oil Palm Board MPOB) (Plate 1). The block was further trimmed using a chain saw into smaller blocks with a width of 20 cm. The samples were then reduced into fibrous strand using a disc flaker and dried in the oven with a temperature of 80° for 1 week. The fibrous strands were further processed in the knife ring flaker to produce particle for particleboard manufacture. After the flaking process was done, the particles were screened using a vibrating screening machine to remove the fines (< 0.5 mm). The fines (used in the study) were collected and dried in an oven set at 80° C for 48 hours.

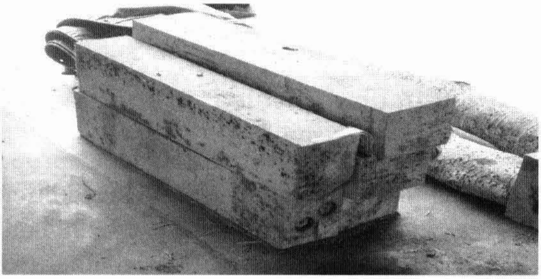

Plate 1: Oil Palm Block

Manufacture of Thermoplastic Composite

Commercially prepared polypropylene (PP-Titanpro) with a melt flow index of 8.0 g/10 min and a density of 0.90 $gcm^{-3}$and maleic anhydride polypropylene (MAPP-D-Mannitol) were used as the matrix and compatibiliser, respectively. The compounding of the fines into the PP was accomplished using a dispersion mixer with a capacity of 3 kg. The mixer was first heated to 180°C, the PP granules were then melted down in about 20 min and the MAPP added and followed by the fines. The compounded admixture was then pelletised by cooling down the dispersion mixer with agitation of the rotors. Tensile and water absorption samples were produced using a chrome-plated mould with dimensions of 150 mm width x 150 mm length x 2 mm thick. About 70 g (giving a density of about 1000 kgm^{-3}) of the pelletised admixture was placed in the mould and then hot-pressed at a temperature of 180°C for about 10 min. Lastly, it was cooled to ambient temperature using a cold of with running water through the platens. Bending samples were produced using a mould with dimensions of 150 mm width x 150 mm length x 6 mm thick.

Evaluation

The composite produced was then cut according to the requirement of the British Standard for testing of plastic materials (Anonymous 1992). The test specimen was then conditioned at 23 ± 1°C and a relative humidity of 50 ± 2%. The test specimens were then tested for their bending strength (MOR) and modulus (FMOE), tensile strength (TEN) and their modulus (TMOE), elongation at break (Elong) and water absorption (WA) properties in accordance to the British standard methods (BS 2782:1992).

Results and Discussions

Mechanical Strength and Physical Properties

Table 1 below shows the strength and physical properties of the composites according to filler content and MAPP addition. Composite produced with 10% filler loading without 3% MAPP addition had the highest MOR (39.51 MPa), TEN (23.23 MPa) and Elong (6.43%), lowest value for FMOE (1698.29 MPa) and WA (1.937%). Thermoplastics produces with 50 % filler loading with 3% MAPP addition had the lowest MOR (23.77 MPa), TEN (11.6 MPa) and Elong (2.12%), highest value of FMOE (2698.83 MPa) and WA (4.6%). While the board produced with 50% filler loading without 3% additional MAPP, had produced the highest FMOE (3213MPa).

Table 1: Strength and Physical Properties of Thermoplastic Composites

MAPP (%)	Filler (%)	Density (kg/m³)	MOR (MPa)	FMOE (MPa)	TEN (MPa)	W.A. (%)
0	10	864	39.51	1698	23.23	1.937
0	30	916	31.12	2132	17.12	0.917
0	50	990	35.06	3213	16.19	2.779
3	10	903	25.24	2166	21.50	0.225
3	30	934	29.05	2169	16.20	1.489
3	50	984	23.77	2699	11.6	4.6
PP		880	54.65	1800	28.3	0.05

Notes: MAPP- maleic anhydride polypropylene, MOR-modulus of rupture, FMOE-flexural modulus of elasticity, TMOE-tensile modulus of elasticity, TEN- tensile strength, WA-water absorption, PP-polypropylene

Effects of Filler Loading

The effects of filler loading on the mechanical properties of the thermoplastics composite are shown in Figure 1. Zaini et al. (1996) in their study found that the incorporation of irregular-shaped filler into polypropylene decreases the mechanical strength. From the figure, an increase in filler loading (10 to 50%), decreases the MOR by about

8.85% and TEN (38%). The decrease in MOR and TEN is due to the decreased deformability of a rigid inter-phase between the filler and matrix material. Figure 1 also shows the effect of filler loading on the modulus of elasticity. In plastic composite, the modulus of elasticity is related to the composite stiffness. The primary intention of filler incorporation is to increase the stiffness of the resultant composite. The increase in modulus with an increase in filler loading is a common phenomenon in thermoplastic composite (Fuad et al. 1995; Biggs 1987). An increase from 10% to 50 % filler loading increases the FMOE by about 53% and TMOE by 81%.

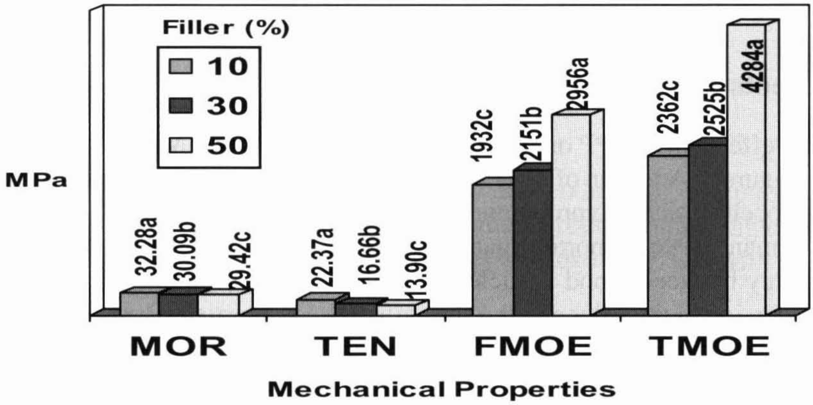

Figure 1: Effect of Filler Loading on the Mechanical Properties

Figure 2 shows the effect of filler loading on the properties of Elong and WA. Zaini (1996) stated that for Elong, it follows the trend set by properties of TEN and MOR. The water absorption increases with the increase in filler content. The high increase in water absorption can pose a big problem in composites with high filler content. When thermoplastics have more filler, water easily absorb in the composite. For the elongation, the effects of filler content are different with water absorption. Less filler content will give a higher value of elongation.

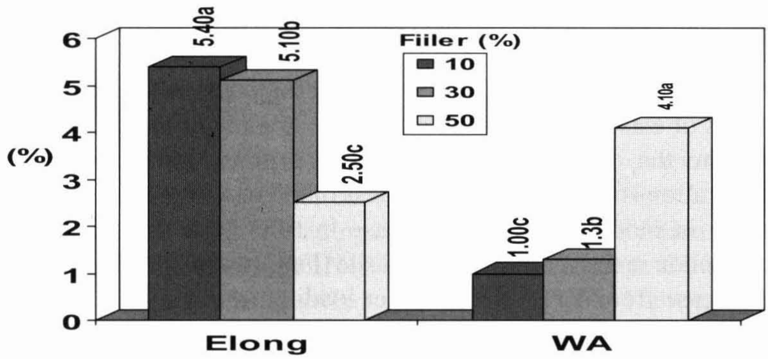

Figure 2: Effect of Filler Loading on Elongation at Break and Water Absorption

Effects of MAPP

The effects of MAPP on the MOR, FMOE, TEN and TMOE are shown in Figure 3. Addition of MAPP during blending serves as compatibles in lignocellulosics polypropylene system. Felix and Gatenhelm (1991) and Oksman (1996) reported that MAPP addition reduces the interfacial energy between wood particles and plastic matrix thus improving the dispersion of the filler and the strength of the properties. The high value of MOR and FMOE without MAPP indicates that, this species is not suitable to use MAPP as the coupling agent. This might be due to the high silica and starch content in oil palm that avoids MAPP from functioning. Figure 4 shows the map effect on elongation at break and water absorption. Addition of 3% MAPP decreases the Elong significantly by 18.97%, while the value of WA changes for about 2.8%.

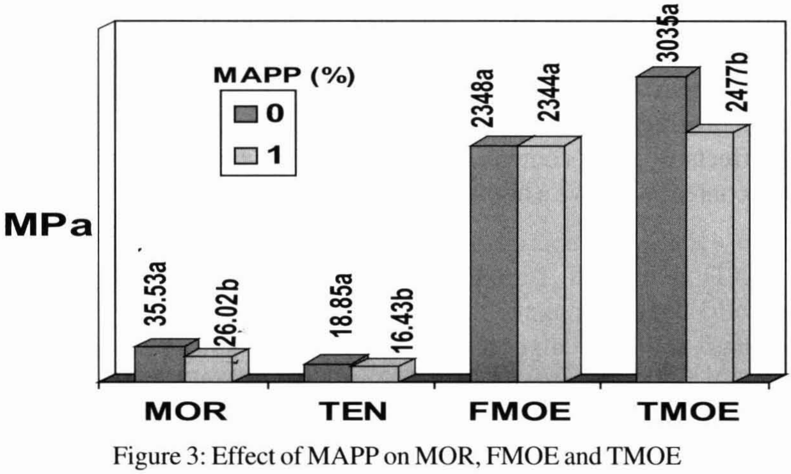

Figure 3: Effect of MAPP on MOR, FMOE and TMOE

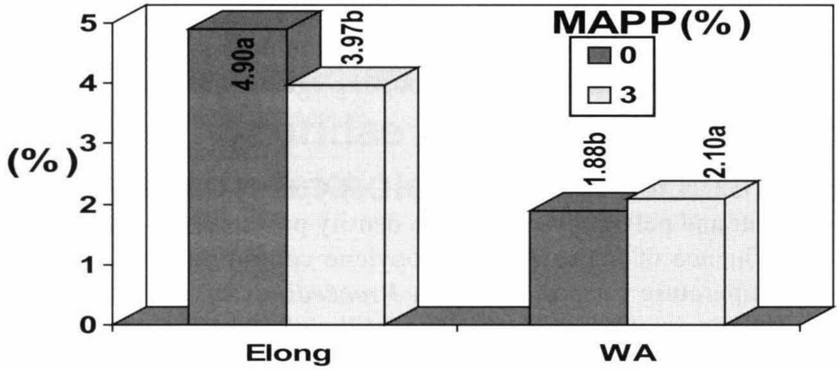

Figure 4: Effect of MAPP on Elong and WA

Conclusion and Recommendation

An increase in the filler content increases the modulus of elasticity of the thermoplastics, but decreases the modulus of rupture and elongation at break. An increased in water absorption was also observed with 3% MAPP addition.

Oil palm-polypropylene composite with 10%, 30% and 50% filler content with or without MAPP could be produced successfully. As a conclusion, oil palm particles are suitable fillers to be used in the manufacture of thermoplastics composite and are recommended for use where strength is not the main criteria.

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