Properties of Wood Plastic Composites (Wpc) from Batai *Spp.* (*Paraserianthes Falcataria*)

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ABSTRACT

The woods of Batai spp. (Paraserianthes falcataria) were harvested from Dong Hwa MDF Factory in Merbok, Kedah. Three trees with DBH of 20-30cm were chipped and then grounded into sawdust. The sawdust and polypropylene (PP) were blended and mixed together using a dispersion mixer at a temperature of about 180 C. Composite boards were then produced and tested for their mechanical and physical strength in accordance to ASTM Standards. MAPP shows significant effect on MOE, TS and WA. PS showed a significant effect on FMOR, FMOE, Impact, WA and impact value while no significant effect on TMOR, TMOE and TS. The highest value of FMOR and FMOE was shown by particle size 75μm. No significant different in FMOR for WPC with MAPP or without MAPP. The effect of MAPP on water absorption (WA) and thickness swelling (TS) was shown to be significant. In conclusion, batai sawdust can be used as raw material in the manufacture of wood plastic composite.

***Keywords**: wood plastic composites, Paraserianthes falcataria, polypropylene,*

Introduction

Bhagwan and Lawrence (1980) defined composite as any material consisting of two or more distinct parts. Any material having two or more distinct constituent materials or phases may be considered as a composite material and the phases have significantly different physical, chemical and mechanical properties and the resultant composite properties are noticeably different from the constituent properties. The formation of new types of composites that combine lignocelluloses with glass and plastics or synthetic fibres are ongoing all over the world. Most composite material developed so far has been fabricated in order to improve its mechanical properties such as strength, stiffness, toughness and high temperature performance.

Wood plastics composites (WPC) found in many widely range of composite materials uses plastics ranging from polypropylene to PVC and also fillers ranging from wood flour to flax. Wood plastic composites, is the first composites that was produced using a combination of recycled wood flour and plastics. This product is suitable for relatively undemanding applications. The WPC have good mechanical properties, high dimensional stability and can be used to produce complex shapes and are tough, stable and can be extruded to high dimensional tolerances. WPC also are resistant to cracking and splitting, these materials can be moulded with or without simulated wood grain details (Blezki at el., 1998). According to H'ng at el. (2008), wood plastic composites (WPC) are renewable, less-abrasive to processing equipment, environmental friendly, low maintenance and similar as wood feature.. For most WPC products, the starting raw materials are produced by mixing wood flour and plastics to produce a material that can be processed just like a plastic with the best features of both, wood and plastics. The wood flour is produced from sawdust and scrap wood products that currently incurred cost for disposal but are now a valuable resource and recycling them can be both profitable and ethical. Tangram (2002) reported that the use of wood waste as filler make WPC as to be promoted environmental friendly products. The plastics are from recycled plastic bags and recycled battery case materials although new plastics materials are used for demanding uses. The recycling ethos is to use materials recovered from short life cycle applications and used in long life cycle applications.

At present, more wood is being used for furniture, construction materials, paper and other applications. Due to this usage the volume of trees in the forest is being cut at an alarming rate and in order to fulfill the demand for the wood-based products. In producing the wood products huge amount of wood

wastes are being generated by the wood industries. Therefore the conversion of wood waste materials into the final products will create new opportunities and, if the wood wastes are unutilized, they will create environmental problem. In order to overcome the problem, this study proposed to use the wood wastes as a raw material in the production of thermoplastic composite. The study was carried out to determine mechanical and physical properties of wood plastic composites. The effects of particle size and *Maleic anhydride-grafted* PP (MAPP) on wood plastic composites properties will also be discussed.

Materials and Methods

For this study, Batai *spp.* (*Paraserianthes falcataria*) was use as the raw material for making wood plastic composites. The polypropylene was supplied by a local plastic manufacturer.

Field Procedure

The woods of Batai *spp.* (*Paraserianthes falcataria*) were harvested from Dong Hwa MDF Factory in Merbok, Kedah. Three trees with DBH of 20-30cm were cut into 8' length logs. The logs were transported in a lorry to the UiTM Pahang Wood Technology Workshop. All the billets were debarked manually using machetes. After debarking the billets were all cut into 1" x 1" x 8' planks and send to the chipper.

Materials Preparation

All the planks were chipped using wood chipper machine into chips and passed through the knife ring flaker machine to reduce the chips into particles. After this process, the particles were air dried for one week. The air dried particles were screened into specific sizes. There are five different sizes which are fines, 0.5mm, 1.0mm, 2.0mm and 5.0mm. For wood plastic composites, only the fines were collected and kept in plastic bags. The sawdust was further process in the grinder machine to produce wood flour. After grinding, the wood flour was screened using the vibrator screener to separate the wood flour according to the required size 75µm, 150µm and 250µm. The bulk density of the screened sawdust was then determined using a 1000ml flask.

Wood Plastic Composites Manufacture

The wood flour and polypropylene (PP) were blended and mixed together using a dispersion mixer. The temperature of dispersion mixer was first heated up to 180°C before the plastic (PP) was slowly poured into the dispersion mixer until it melted and reached 180°C again. The wood flour was then added into the dispersion mixer until it mixed well with PP. The admixture used in the process are shown in Table 1.

Table 1. The amount of sawdust, polypropylene (PP) and *Maleic anhydride-grafted* PP (MAPP) of particle size

Particle Size (µm)	Sawdust (%)	Polypropylene (%)	MAPP (%)
250	20	80	0
	20	77	3
150	20	80	0
	20	77	3
75	20	80	0
	20	77	3

After homogenous admixture was attained the dispersion mixer temperature was reduced until all the admixture granulates into small pieces. Then, the granules were transferred to a crusher to reduce them into pellets. The pellets were placed in a mould meant to produce bending and tensile board. The thermoplastic pellets were pressed under heat and pressure in the hot press to melt the thermoplastic pellets and produced the thermoplastic board. For the tensile board, the mould was pressed under the temperature at 180°C at the pressure 1000p.s.i for 240 seconds. While for the bending board, the mould was pressed under the same temperature and pressure but required time is 300 seconds. After hot press, the board was cooled

down using a cold press maintained at the temperature of 20°C. The tensile board was pressed for two minutes while the bending board was pressed for three minutes.

Composite Evaluation

The composite boards were then cut in accordance to ASTM Standards and tested for their bending properties (D6272), tensile properties (D638), impact properties (D256), thickness swelling and water absorption test.

Results and Discussions

Properties of Wood Plastic Composite

Table 1 shows the mechanical and physical properties of the wood plastic composites (WPC) from Batai spp (*Paraserianthes falcataria)* according to particle size, and MAPP. The highest value for FMOR was 39.97MPa from WPC made from particle size 75µm without MAPP. The lowest value (14.35MPa) was shown by WPC made from particle size 250µm without MAPP. The highest FMOE (2689MPa) was shown by WPC made from particle size 75µm with MAPP, while the lowest (2296MPa) from particle size of 250µm without MAPP. WPC with particle size 75µm and without MAPP had the highest value in TMOR (21.63MPa). The lowest TMOE (3107 MPa) was for WPC made from particle size 75µm and 3% MAPP. The impact value (16.39kJ) was highest for WPC made from particle size 75µm and without MAPP and the lowest is 12.88kJ with particle size of 250µm and no MAPP.

Table 1. Mechanical and physical properties of WPC from Batai spp(*Paraserianthes falcataria)*

Particle Size (µm)	MAPP (%)	BENDING (MPa)	MOE (MPa)	TMOR (MPa)	TMOE (MPa)	WA (%)	TS (%)	IMPACT (kJ)
250	3	17.8	2525	19.09	3626	1.30	3.00	13.72
	0	14.35	2296	21.35	3214	1.93	1.79	12.88
150	3	23.96	2656	20.35	3473	0.29	2.38	14.24
	0	32.86	2531	21.38	3419	1.81	1.86	12.92
75	3	27.96	2689	21.07	3107	0.83	3.53	16.04
	0	39.97	2573	21.63	3180	1.51	2.96	16.39

Table 1 also shows that the highest WA (1.93%) was shown by WPC with particle size 250µm without MAPP and the lowest (0.29%) with particle size of 150µm with MAPP. For TS the highest value is 3.54% shown by WPC with particle size 75µm and 3% MAPP and the lowest is 1.79% with the particle size of 250µm without MAPP.

Statistical Significance

Table 2 shows the statistical significance of the effects of MAPP and particle size on the WPC properties. MAPP shows significant effect on MOE, TS and WA. No significant effect was shown on MOR, TMOR, TMOE and impact value. PS showed significant effect on FMOR, FMOE, WA and impact value while no significant effect on TMOR, TMOE and TS. Their interaction (MAPP x PS) also showed significant on FMOR, FMOE and WA only.

Table 2. Analysis of Variance for particle size and MAPP in wood plastic composites properties.

SOV	df	BENDING	MOE	TENSILE	TMOE	WA	TS	IMPACT
MAPP	1	2.57^{ns}	37.55**	0.0^{ns}	0.90^{ns}	79.57**	16.76**	0.72^{ns}
PS	2	92.98*	16.25**	1.13^{ns}	1.77^{ns}	6.62**	0.86^{ns}	6.83**
MAPP x PS	2	25.46**	3.95*	2.52^{ns}	1.09^{ns}	3.85*	2.47^{ns}	0.49^{ns}

*Note: SOV-source of variance, ns-not significance at $P > 0.05$, *significance at $P < 0.05$, **highly significance at $P < 0.01$

Effect of Particle Size

Figure 1 shows that the effect of particle sizes on the mechanical properties of wood plastic composites made from Batai *spp.* (*Paraserianthes falcataria*). Increasing the PS showed a significant effect on the values of FMOR, FMOE and impact. Smaller PS easily fit in among the plastic matrix and does not disturb the bonding among the particle and the matrix. Jamaludin (2006) in his previous study shows that the higher values of FMOR and FMOE with smaller particle size are due to their compatibility with polypropylene and the amount of stress created by larger particles is another probable cause in reducing the strength of composites. The higher impact value with smaller particle size is due to the ability of smaller particles to generate gap free surface that gave rise to good bonding between particles, while increase in particle size reduce the bonding because more gap is available between particles. According to Dombrowski (2001), increasing the use of bigger wood particle size led to a decrease in mechanical properties of WPC.

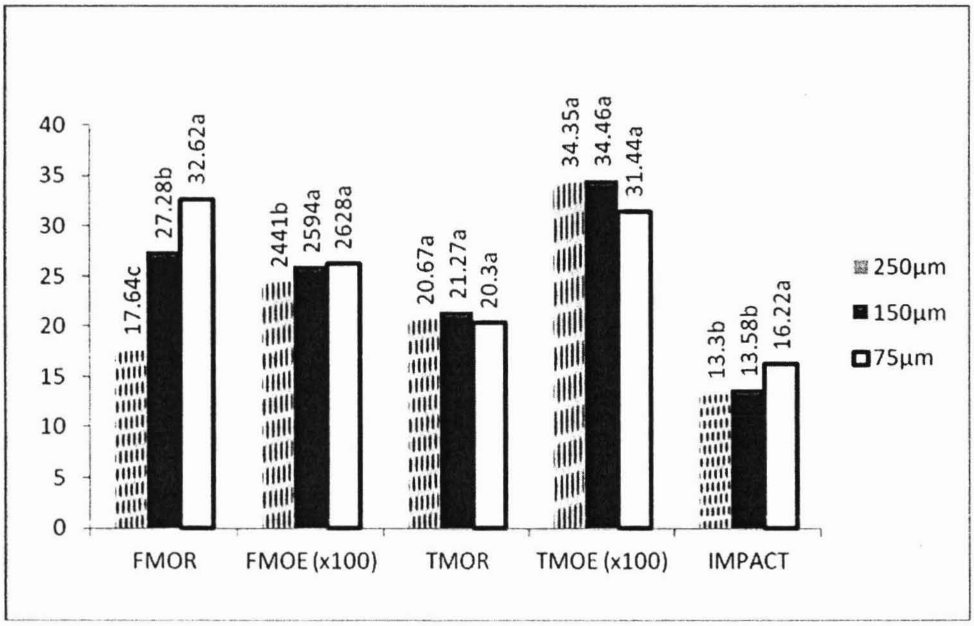

Figure 1. Effect of particle size for FMOR, FMOE, TMOR, TMOE and Impact

Figure 2 shows that the effect of particle sizes on the physical properties of Batai *spp.* (*Paraserianthes falcataria)* wood plastic composites. The effect of particle size on the water absorption (WA) was shown to be significant. Bigger particles tend to absorb more water thus increasing the amount of water being absorbed into the WPC as compared to smaller particles. For TS, there is no significant effect by varying the particle sizes. According to Stark (2001), WPC that having higher wood particle size, wood easily expose on the surface of the WPC.

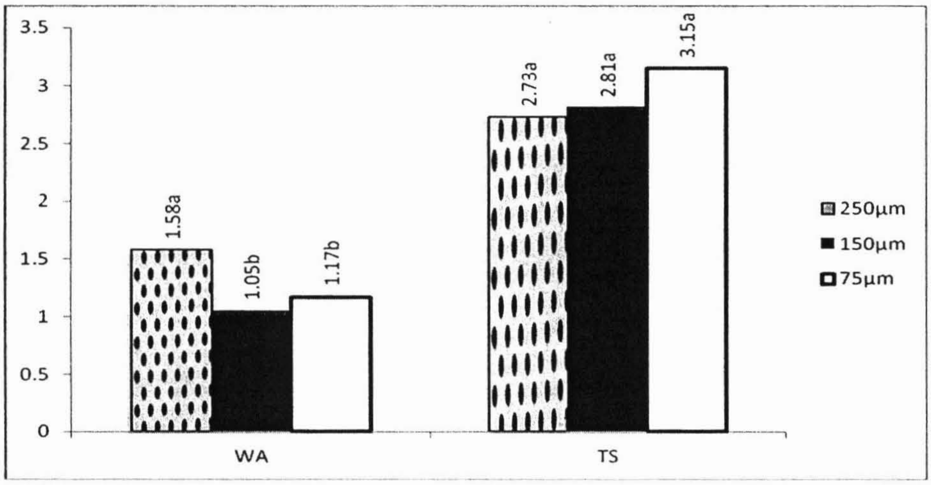

Figure 2. Effect of Particle Size on WA and TS

Effect of *Maleic anhydride-grafted PP* (MAPP)

Figure 3 shows that the effect of MAPP on the mechanical properties of Batai *spp.* (*Paraserianthes falcataria)* wood plastic composites. There are no significant difference in FMOR, TMOR, TMOE and impact with MAPP or without MAPP. Previous study shows that the higher percentage of MAPP used in WPC formulation caused big improvements in the flexural strength of WPC (Olsen, 1991). MAPP has been reported to function efficiently as compatibilizer in lignocellulosic-PP systems (Sanadi et al, 1994: Felix et al, 1991) reducing the interfacial energy between the wood particles and the plastic matrix, therefore improving the dispersion of the filler thus improving the strength (Oksman, 1996).

Figure 4 shows the effect of MAPP on the physical properties of Batai spp. wood plastic composites. The effect of MAPP on water absorption (WA) and thickness swelling (TS) was shown to be significant. For WPC with MAPP showed improved water absorption properties thus giving better TS as compared to WPC without MAPP. The strong interfacial bonding between the filler and the polymer matrix is probably caused by MAPP which limits the water being absorbs into the composites. According to Clemons (2002), the MAPP improve the bonding and in turn enhance the water resistance. The coupling agents also improve the quality of adhesion between plastic and fiber to reduce the gaps in the interfacial region and to block the hydrophilic group (Youngquist, 1999).

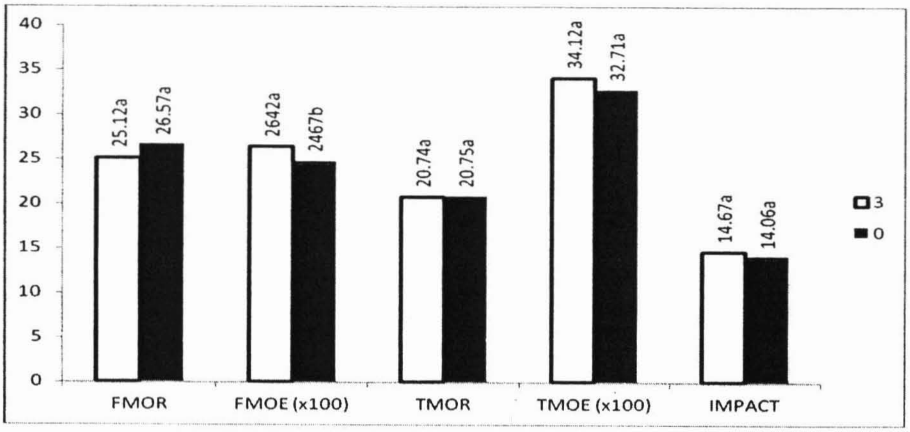

Figure 3. Effect of MAPP for FMOR, FMOE, TMOR, TMOE and Impact

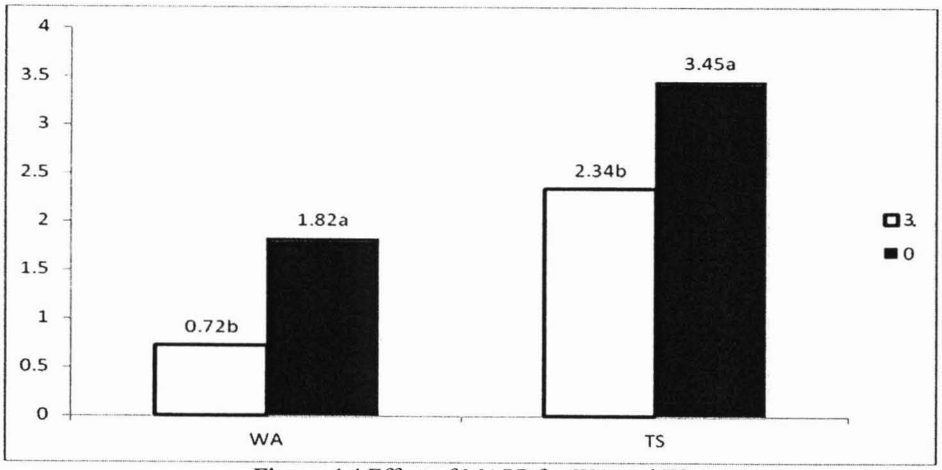

Figure 4.4 Effect of MAPP for WA and TS

Conclusion

The mechanical and physical properties of Batai *spp.* (*Paraserianthes falcataria)* filled with polypropylene (PP) composite were significantly influenced by all the main factors of particle size and *Maleic anhydride-grafted* PP (MAPP) addition. PS showed significant effect on FMOR, FMOE, WA and impact value while no significant effect on TMOR, TMOE and TS. MAPP shows significant effect on MOE, TS and WA. No significant effect was shown on MOR, TMOR, TMOE and impact value.

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