Properties of Wood Plastic Composite from *Azadirachta excelsa* using Different Percentage of Sawdust

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Abstract

Sentang (Azadirachta excelsa) are formerly known as village tree and can be found in central and northern parts of Peninsular Malaysia. These studied was conducted to investigate the manufacturing of composite panels from unscreened particle (15%, 25% and 35%) of sentang mixed with polypropylene (PP) and also Maleic Anhydride Polypropylene (MAPP). The panels produced were then assessed for the mechanical strength properties (bending and tensile) and physical properties (water absorption and thickness swelling) in accordance with the ASTM Standards. Result revealed that the percentage of sawdust gave significant difference on thickness swelling (TS) and water absorption (WA). Assessments on mechanical strength tests indicated that there are significant difference on bending (MOE and MOR) and tensile (MOE). On the other hand, addition of MAPP on composite panels shows significant difference on bending (MOE and MOR), tensile (MOE) and WA but no significant difference on TS. Thus, it can be concluded that application of MAPP is required in the making process of wood plastic composite and higher amount of filler is not suitable in wood plastic composite.

Keywords: sentang, unscreened particle, mechanical strength properties, physical properties.

INTRODUCTION

Wood-plastics composites (WPC) are a new group of materials that are generating interest in universal. WPC covers an extremely wide range of composite materials using plastics ranging from polypropylene to PVC and binders or fillers ranging from wood flour to flax. These new materials extend the current concept of 'wood composites' from the traditional compressed materials such as particle-board and medium density fibreboard (MDF) into new areas and as a new generation of high performance products.

Sentang tree (*Azadirachta excelsea*) was chosen to be the filler in WPC. Sentang is the nation Meliaceae, and a local tree known in central and northern Peninsular Malaysia. This species is less popular among members of the forestry and the public at one time. However, among farmers to plant sentang trees has increased after the campaigns on the benefits of the tree (Sabariah, n.d).

Propylene was first polymerized to a crystalline isotactic polymer by Giulio Natta and his coworkers in March 1954. This pioneering discovery led to large-scale commercial production of isotactic polypropylene from 1957 onwards. Syndiotactic polypropylene was also first synthesized by Giulio Natta and his co-workers (Anon, 2011). Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging, textiles, stationery, plastic parts and reusable containers of various types, equipment (Anon, 2011).

Maleic Anhydride Polypropylene (MAPP) as additives to make WPC. Coupling agents improve the wood and polymer interaction. Wood is naturally hydrophilic (attracts water), while the thermoplastic polymers are hydrophobic (repel water). This basic chemical incompatibility makes it very difficult to bond polymers to wood. The use of coupling agents can help to overcome this incompatibility (Adam *et al.*, 2009).

So, this study aim is to study the different percentage of sawdust used in WPC by using Sentang sawdust as filler and (MAPP) as thermoplastic. Besides that, this study also to study the strength properties of WPC accordingly to with MAPP and without MAPP.

MATERIALS AND METHODS

Sentang was use as the raw material for making wood plastic composites. The wood plastic composites panels were produced at UiTM Jengka, Pahang. The raw materials were unscreened sawdust (15%, 25% and 35%) mixed with Polypropylene (PP) and with addition of 3% of Maleic Anhydride Polypropylene (MAPP) as the coupling agent. In theory, MAPP is the coupling agent that helps the bonding among sawdust and PP.

For board preparation, calculation was made before panel manufacturing (Table 1). Firstly, PP and sawdust were blended and mixed together in dispersion mixer. However, MAPP was added if required. The temperature was 190°C. After it mixed well, temperature was decrease to get granules shape.

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

Sawdust (%)	Polypropylene (%)	MAPP (%)
15	82	3
15	85	0
25	72	3
25	75	0
35	62	3
35	63	0

After that, the granules were changed to pallets by using crusher. Then, the pallets were put into plat bar; (1) tensile board, (2) bending board, which have different volume. After that, the plat bar was placed into hot press machine. Temperature were then set at 180°C with 1000p.s.i (tensile was 240 second, bending was 300 second). Then, the plat bar was taken to cold press machine immediately. The temperature is set to 20°C for three minutes.

After cold press process, the panels are cut into size required based on ASTM standards and divided for physical properties (thickness swelling and water absorption) and mechanical properties (tensile and bending). The results were analyzed by using Analysis of Variance (ANOVA) to determined the significant different of the variables used in this study.

RESULTS AND DISCUSSIONS

Statistical Analysis

Table 2 shows the effects of MAPP and percentage of sawdust on WPC properties. MAPP shows highly significant on WA, tensile (MOE) and bending (MOE and MOR). There is no significant difference shown on TS and tensile (MOR). On the other hand, percentage of sawdust shows a significant difference on physical properties, tensile (MOE), bending (MOE and MOR) and there no significant difference on tensile (MOR). The interaction between MAPP and percentage of sawdust also showed highly significant on WA, Tensile (MOE), bending (MOE and MOR). There also no significant difference shown on TS and tensile (MOR). MAPP is the coupling agent that enhances the bonding properties between sawdust and PP.

Table 2. Analysis of Variance of wood plastic composites on mechanical and physical properties.

SOV	df	TS	WA	TMOE	TMOR	FMOE	FMOR
MAPP	1	0.015^{ns}	8.401**	43.95**	0.284^{ns}	203.39**	222.34**
SAWDUST (%)	2	51.40**	51.38**	14.48**	0.121^{ns}	216.26**	4.954*
MAPP x SAWDUST	2	3.029^{ns}	25.42**	17.54**	1.260^{ns}	231.63**	41.064**

*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 Sawdust Percentage to Physical Properties of WPC

Fig. 1 shows that 35% of sawdust has the highest thickness swelling then 25% and 15% of sawdust. This is because 35% consists large amount of sawdust and it could absorb a large amount of water due to the wood behavior as hygroscopic material. Wood is a hydroscopic material that absorbs moisture in a humid environment and loses moisture in a dry environment (Jerold, 1994). In the other hand, 15% of sawdust contents a higher amount of plastic which was 85% where the plastic cannot absorb water.

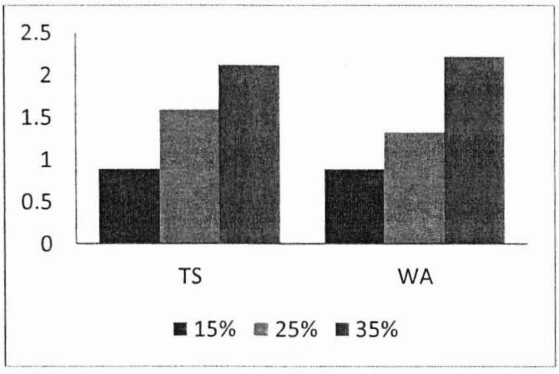

Figure 1 Percentage of sawdust on physical properties.

Percentage of sawdust of WA on Sentang wood plastic composites (Fig. 1) shows that 35% of sawdust has the highest of water absorption than 35% and 25% of sawdust. This is because wood is hygroscopic which is one of the wood properties. So, a large amount of sawdust will increase the water absorption of thermoplastic. The water absorption increases from 15% to 35%. Wood–plastic composites absorb moisture because of the hydrophilic character of the wood filler, and water uptake results in reductions in mechanical properties and susceptibility to fungal attack (Joseph *et al.*, 2002; Espert et al., 2004; Schirp and Wolcott, 2005). Coupling agents, such as maleic anhydride, can improve interfacial bonding between matrix and filler and reduce the penetration and absorption of water into WPC (Ichazo *et al.*, 2001; Joseph *et al.*, 2002; Mohanty *et al.*, 2004).

Effect of Sawdust Percentage to Tensile strength of WPC

Percentage of sawdust of TMOE on Sentang wood plastic composites (Fig. 2) shows that 35% of sawdust has the highest value and 25% gives the lowest value of TMOE as the lowest due to some error occur that happen during the manufacture of wood plastic composite. The reason was the fines sawdust used was unscreened type, so in 25% board manufacture may contain large size of sawdust. Wood filler addition has changed the nature of recycled polypropylene matrix upheaval. This is due to good adhesion between the powder with the resin matrix of lumber has increased the stiffness of the composite while the composite modulus (Hanafi et al, 2003). In a previous study shows that the MOE and TMOE of the WPCs both increased with increasing wood content, but the MOR and TMOR decreased when higher amount of wood content was used (Shao-Yuan et al., 2012).

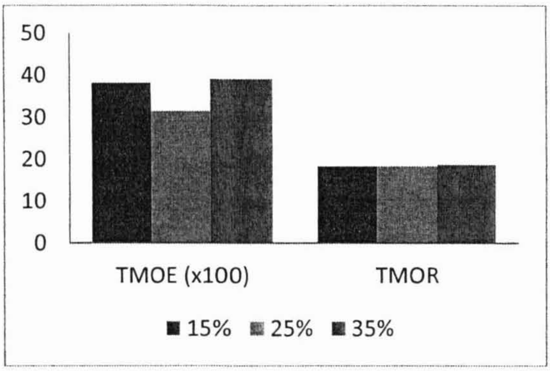

Figure 2 Percentage of sawdust on tensile.

Percentage of sawdust of TMOR on Sentang wood plastic composites (Fig.2) shows that 35% of sawdust has the highest value and 25% gives the lowest value of TMOR. The result was increase due to the increasing of percentage of sawdust. However, in previous study, the result shows that the MOR values and specific MOR values of the various WPCs decreased in the orders (Pei-Yu *et al.*, 2009). It shows that any of ratios of percentage of sawdust can be choose to make wood plastic composites as a board because it has no different. Although, wood plastic composites is a combination of wood sawdust and plastic but it would be better to find a good percentage of sawdust where can decrease plastic usage but it still can provide good properties.

Effect of Sawdust Percentage to Bending Strength of WPC

Percentage of sawdust of FMOE on Sentang wood plastic composites (Fig 3) shows that 35% of sawdust has the highest value and 15% gives the lowest value of FMOE. The result has shown an increasing percentage of wood dust into the polypropylene to increase stiffness and modulus of the composite. This is true because the polypropylene resin has a high flexibility because of the nature of amorphous structure. In a previous study observed that the flexural strength increases with decreasing wood content where the flexural strength and MOE of the composites made from the recycled high density polyethylene (rHDPE) are slightly higher than those using the very high density polyethylene vHDPE at the same plastic to wood ratio (Kamal et al., 2008). Thus, the composite has a high modulus is likely to have a modulus of filler and high aspect ratio, and a high percentage of filler in the composites (Sanadi et al., 2000).

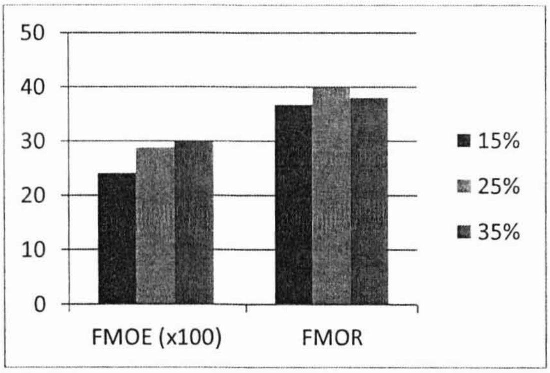

Figure 3 Percentage sawdust on bending.

Percentage of sawdust of FMOR on Sentang wood plastic composites (Fig 3) shows that 25% of sawdust has the highest value and 15% gives the lowest value of FMOR. 35% of sawdust was not significant with 15% and 25%. However, 15% and 25% were significant to each other which can be classifying as significant only. In previous study, the value of FMOR decrease when the percentage of filler was increases (Hasni, 2005). Logically, 15% of sawdust should have the highest value among them. The unscreened sawdust could not mix well with the plastic because of the size which affects the WPC.

CONCLUSIONS

The result of this study shows that the percentage of sawdust used in Sentang wood plastic composites (WPC) and (MAPP) as thermoplastic with where the percentage of sawdust on physical properties was a significant High percentage of sawdust tends to absorb more water thus increasing the amount of water being absorbed into the WPC as compared to lower percentage of sawdust. Besides that, the percentage of sawdust on TMOE was a significant while, there was no significant difference shown in the percentage of sawdust on TMOR. There was significant difference on percentage of sawdust on bending. Effect of MAPP on TS was no significant difference, while, the effect of MAPP on WA had shown a significant. Effect of MAPP on TMOE had shown there was a significant, while TMOR was no significant difference. Efect of MAPP on bending was significant.

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