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The Effects of Wood Sawdust Loading on Tensile and Physical Properties of Up/Pf/Wsd Composites

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Abstract. Wood sawdust fiber is one of the viable by-products which turn composites into something useful and industrially applicable in manufacturing industries. In this study, the UP/PF composites with varies ratio of wood sawdust fiber (2, 4, and 6 phr) were prepared by using casting technique and the composite specimens were tested using universal testing machine (UTM). The results showed that the wood sawdust fiber can improve mechanical properties of UP/PF/WSD composites efficiently. For the best tensile properties of UP/PFF/WSD composites, the appropriate amount of wood sawdust fiber was 6 phr. The water absorption and oven aging properties also have been studied which the results shows positive indication towards UP/PF/WSD performance.

Keywords: Organic-inorganic filler reinforced composites, wood sawdust loading, mechanical properties

1. Introduction

Wood saw dust have been considered used as reinforcing polymer both from scientific and a commercial point of view. Many researches are investing time into modifying traditional materials to make them more user friendly and to design novel polymer composites out of naturally occurring materials. All polymer composites absorb moisture in humid atmosphere and when immersed in water. The effect of moisture absorption leads to degradation of fiber matrix interface region, resulting in a reduction of mechanical and dimensional properties [1]. Wood is a naturally occurring renewable resources that is commercially exploited for construction, timber, paper and in wood products-based industries. Chemically, wood is a bio polymeric composite of cellulose, hemicellulose and lignin.

Saw dust which produced as by product of the timber-based industries is generally utilized as a source for energy production. However, this process gives rise to a significant volume of wood-ash which has adverse environmental effects [2]. The characteristics of the ash depend upon biomass characteristics, combustion technology and the location where ash is collected [3]. Wood ash primarily consists of fine particulate matter which can easily get air bore by winds, it is a potential hazard as it may cause respiratory health problems to the dwellers near the dump site or can cause groundwater contamination.

One of the best alternatives to solve the problem of wood sawdust that have been caught many interests of researcher is by convert this by-product into valuable composites. Wood sawdust composites already exist many decades in varies kind of products with multiple functions. However, only few studies have been done towards wood sawdust-potash feldspar as reinforcement in thermoset where this kind of composites may have potential in manufacturing industries. Hence, in this research, wood sawdust has been utilized as reinforcement filler in UP/PF/WSD composites. As to achieve the main goal in this research, UP/PF/WSD composites have been casted according to different amount of wood sawdust loading. Meanwhile, the morphology properties of these composites were characterized using field emission scanning electron microscopy (FESEM). Physical properties such as water absorption and oven aging of UP/PF/WSD composites were also investigated.

2. Experimental Part

2.1 Materials
In this research, Unsaturated Polyester (UP) was used as the matrix in the composite while Potash Feldspar (PF), and Wood Saw Dust (WSD) were used to study the effect of different fillers towards its mechanical, physical and morphology of composites. Methyl Ethyl Ketone Peroxide (MEKP) was used as hardener which shorten the time taken for composite to cure. PF with mean particle size of 0.18μm was obtained from Commercial Minerals (M) Sdn. Bhd., Penang, Malaysia.

2.2 Preparation of composites
For the sample preparation, the mixture of unsaturated polyester/PF composite were prepared by using casting technique. The unsaturated polyester (100 %), PF with 5.0 phr, and different wood sawdust loading (2, 4, and 6 phr) were mixed together by using mixture for about 10 minutes. The MEKP as hardener was added into the mixture at 0.6% for all composition and be mix for 3 minutes at room temperature in order to achieve homogenous solution. After 3 minutes from an addition of MEKP, the mixture was cast into a plate and allowed to cure at room temperature.

2.3 Tensile test
Tensile properties were carried out according to ASTM D638 by using Instron 5569 with crosshead speed of 4 mm/min. Rectangular shaped specimens was used for the test. For each blend composition, 5 samples were used. From the tensile test, tensile strength, modulus at 100% elongation and elongation at break were achieved.

2.4 Flexural test
Sample composites were prepared as per ASTM D256 standards in rectangular cross section specimens (75mm x 12mm x 12mm). Three-point bending test was performed by using Universal Testing Machine (UTM) with a maximum load cell 5000 N. The test was carried at a crosshead speed 3 mm/min at 60 mm gauge gap.

2.5 Swelling behavior test
The swelling behavior test was carried out accordingly to ASTM D570 standard. For the swelling behavior test, three of each blend compositions with the dimension of 10mm x 20mm x 30mm were immersed into container that contained toluene for 3 days at room temperature. After 3 days, the samples were taken out and wiped with tissue paper. The samples were weighed by using an analytical balanced with 0.1mg resolution. The percentage of mass swell (% MS) was calculated from the formulae below:

$$\% MS = \frac{W_2 - W_1}{W_1} \times 100\% \quad (1)$$

Where W1 is the weight of dry sample and W2 is the weight of wet sample [4]. The difference of weigh was calculated and recorded into the table.

2.6 Oven aging test
Weight loss process was using an oven as the surrounding condition. ASTM D570 also being used for this sample measurement, sample were weighed and recorded at the beginning of the process. The temperature of the oven was set to 80 0C for 48 hours. The formula that being used to calculate the amount of weight loss for each sample are shown as below:

$$\% WL = \frac{W_2 - W_1}{W_2} \times 100\% \quad (2)$$

Where W1 is the original weight of sample and W2 is the final weight of the sample.

2.7 Morphology analysis
In this research, for morphology of the tensile fracture failure surface of composite were carried out by using optical microscope. This test was tensile fracture failure surface sample. The magnificent used was 5x. The resolution is primarily determined by the wavelength of the light source and the numerical aperture (NA) of the objective lens.

3. Results and discussion

3.1 Swelling analysis
Figure 1 shows the effect of WSD on percentages of mass swell in UP/PF/WSD. By referring to zero filler loading of UP/PF/WSD composites, it having the highest percentages of mass swell. From the graph, as increasing in WSD filler loading, the percentages of mass swell also increased. It indicated high porosity and presence of void on the surface of composite which responsible for dimension changing of cellulose based composites. Mechanical treatment caused the composites to absorb more solution for all wood composites. Absorption of solution in composites causes swelling of fiber, absorbed of solution causes weakening of interfacial adhesion and hydrolytic degradation of matrix and fibers [5]. Thus, lead to highest absorption of solution enters into composites structure.

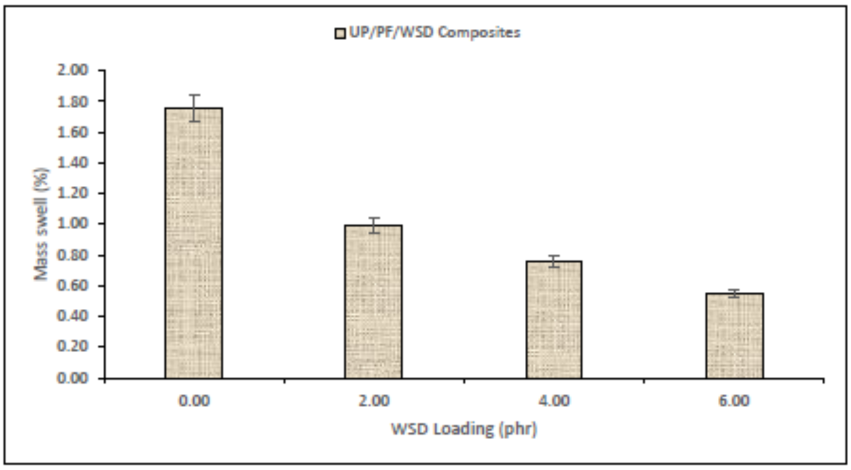

Figure 1. Effect of WSD loading on percentages of mass swell in UP/PF/WSD composites

3.2 Oven aging analysis

Figure 2 shows the effect of WSD filler loading on percentages of weight loss in UP/PF/WSD. As increasing of filler loading, the percentages of weight loss decreased, same goes to the percentages of mass swell. Composites with 2 phr of filler loading having highest percentages of weight loss compare to others which lead to the high loss of moisture content. Increase of percentages of weight loss caused by increased number of micro voids on the surface. As can see, the sample composites without WSD having the lowest percentages of weight loss. Composites with WSD caused poor bonded area between hydrophilic WSD and hydrophobic matrix polymer composites [5].

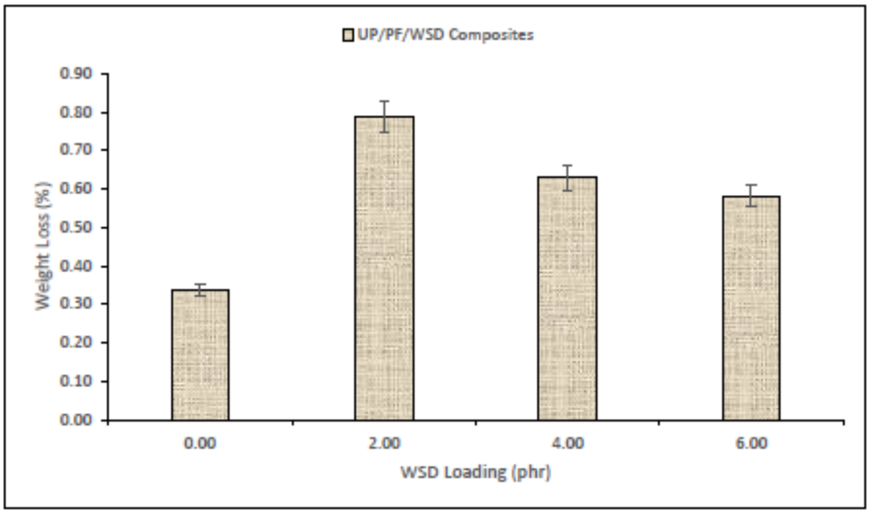

Figure 2. Effect of WSD loading on percentage of weight loss in UP/PF/WSD composites

3.3 Tensile properties

Figure 3 shows the effect of WSD loading on tensile strength in UP/PF/WSD composites. By referring to the figure, WSD makes UP/PF/WSD composites stronger in tensile strength. It can be seen as increasing in filler loading, the tensile strength also increased. 6 phr of filler loading having the highest tensile strength due to the filler matrix bond that is stronger than other composites with less amount of filler. However, there one obtains poor adhesion between wood and polymer which result in low tensile strength.

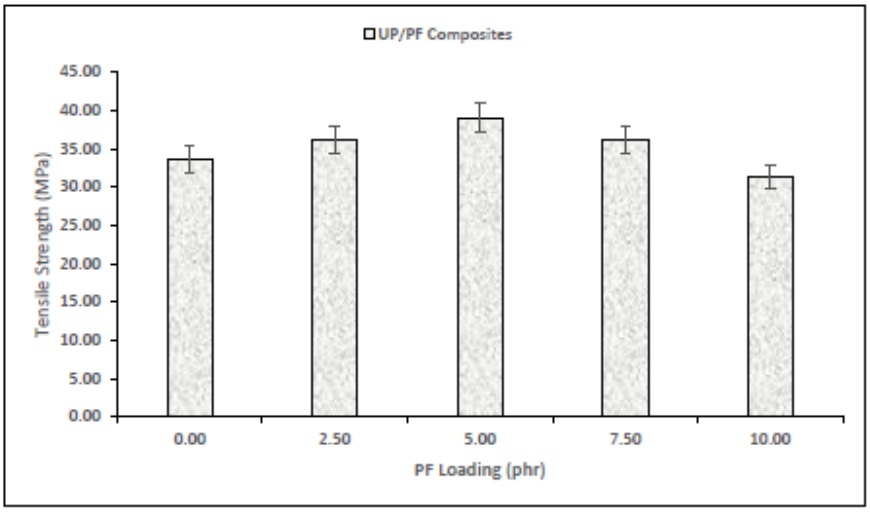

Figure 3. Effect of WSD loading on tensile strength in UP/PF/WSD composites

3.4 Elongation at break

Figure 4 shows the effect of WSD loading on elongation at break of tensile in UP/PD/WSD composites. From the figure, virgin UP/PF/WSD composites having high percentages of elongation at break compared to sample filled with filler. The difference in percentages for 2 until 6 phr filler loading were slightly decreased. As increased the filler loading, the percentages of elongation at break decreased. The decreasing in percentages of elongation at break could be cause by the increasing of stress concentration [6]. Kusmono and co researchers (2008) [7] and Leszcynska and co researchers (2007) [8] reported that, the reduction in elongation at break due to the restrains on mobility of the chains caused by the exfoliated or intercalated of material in composites.

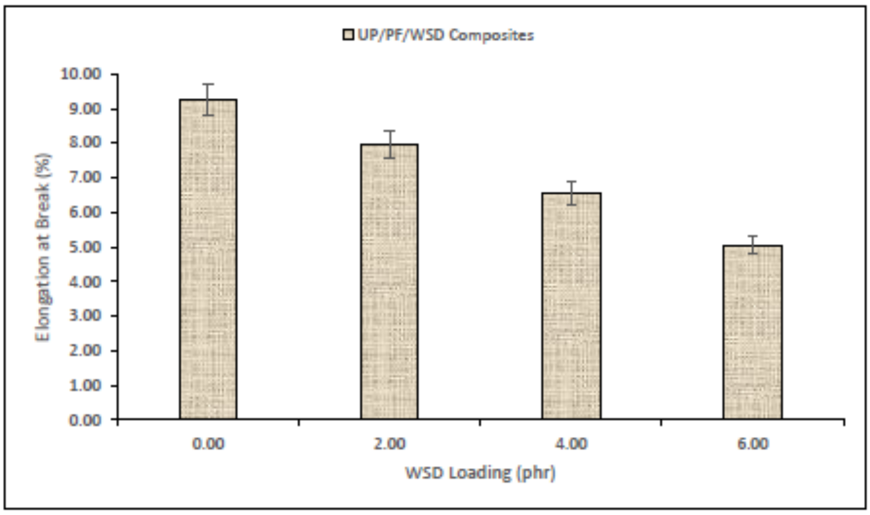

Figure 4. Effect of WSD loading on percentages of elongation at break of tensile in UP/PF/WSD composites

3.5 Modulus elasticity

Modulus of elasticity of WSD in UP/PF/WSD composites was shown in Figure 5. From the figure, as increased of filler loading, increased the modulus of elasticity. Modulus of elasticity usually shows the stiffness of the material [9]. Generally, as increased the composites forming will increased the stiffness of composites and effect the modulus of elasticity. Composites with 2 phr loading having the less modulus of elongation due to the less amount WSD filler. WSD filler in 6 phr composites makes it more elastic due to the structure of the fiber itself.

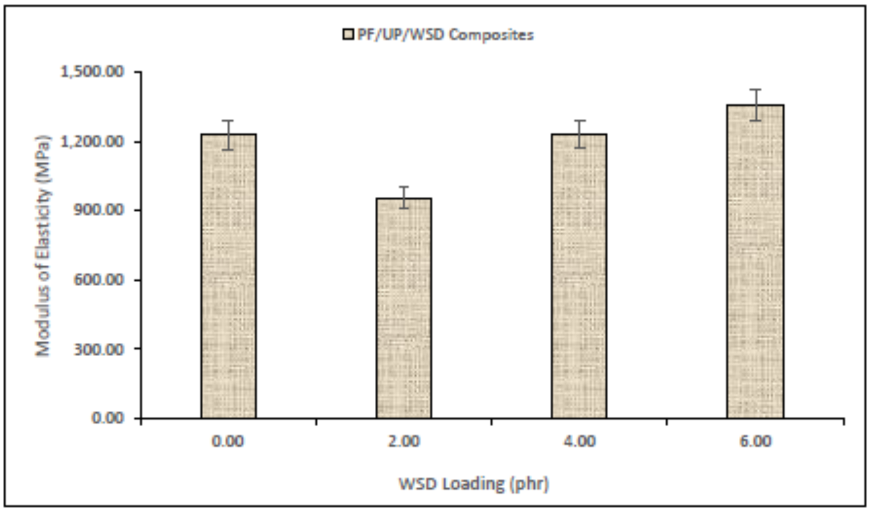

Figure 5. Effect of WSD loading on modulus elasticity of tensile in UP/PF/WSD composites

3.6 Flexural properties

Figure 6 shows the effect of WSD filler loading on flexural strength in UP/PF/WSD composites. From the figure, flexural strength for zero filler of WSD in UP/PF/WSD composites was higher than those with filler loading. By comparing to the filler contained, composites with 6 phr of filler loading having high flexural strength compare to sample composites with 2 and 4 phr of WSD loading. There were slightly differences in strength between each composites sample. The low value of flexural strength may be due to reduction in resistance to shearing in composite structure with the presence of WSD [5].

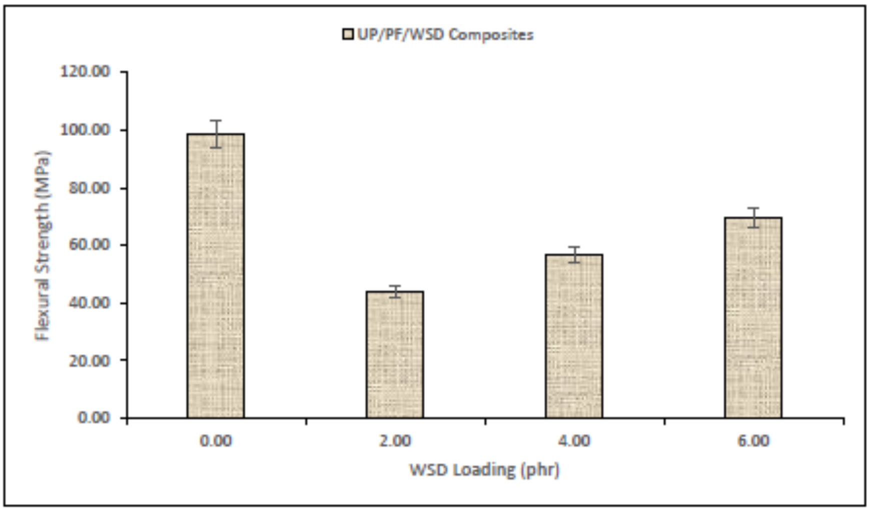

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Figure 6. Effect of WSD fiber loading on flexural strength in UP/PF/WSD composites

Figure 7 shows the effect of WSD on elongation at break of flexural in UP/PF/WSD composites. UP/PF/WSD composites with 2 phr of filler have the highest percentages in elongation at break compare to other. The decreasing of elongation at break could be caused the increasing of stress concentration also affected by the restrains on mobility of the chains caused by exfoliated or intercalated of filler particles [7]. From the graph, as can see in increased the filler loading, the percentages of elongation at break decreased.

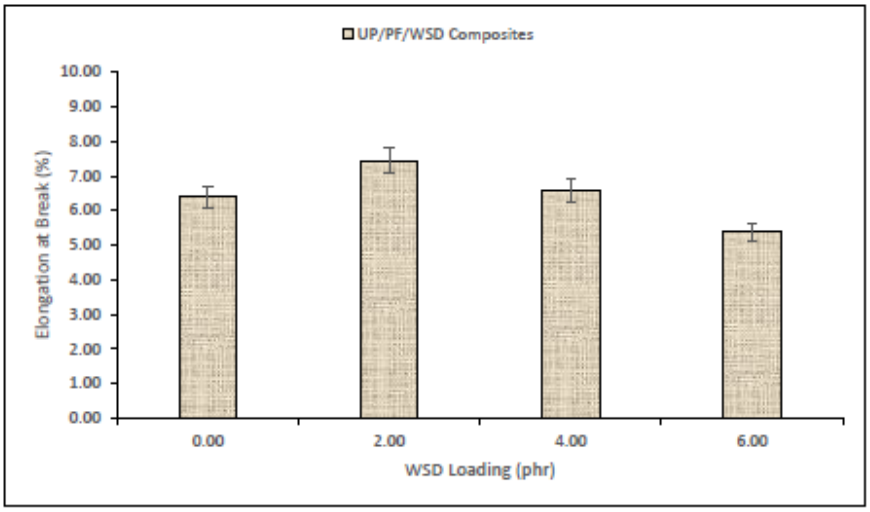

Figure 7. Effect of WSD fiber loading on percentages of elongation at break of flexural in UP/PF/WSD composites

Modulus of elasticity of WSD in UP/PF/WSD composites were shown in Figures 8. Samples composites with filler loading 6 phr having the highest modulus of elasticity due to the amount of filler contained. There is slightly increase trend between all of the sample composites. Also, the modulus of elasticity for sample with 2 phr filler loading was slightly less than samples with 4 phr filler loading. This modulus of elasticity for samples with 4 phr filler loading may also be affected by the thickness of the samples which was thicker than other and makes it more elastic. Shen and co researchers (2011) [10] reported that low flexural modulus of elasticity affected by the highest void content and vice versa.

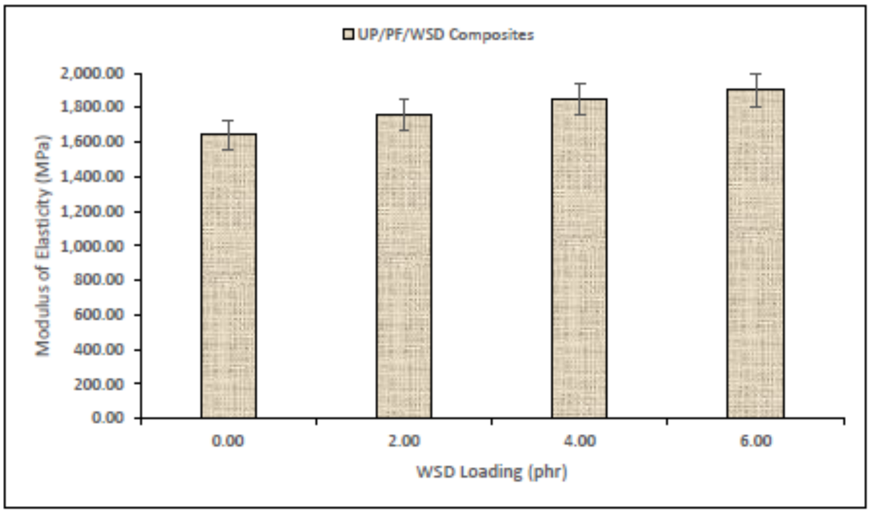

Figure 8. Effect of WSD fiber loading on modulus of elasticity of flexural in UP/PF/WSD composites

3.7 Failure surface of tensile analysis
Figure 9 shows the tensile fracture failure surface of 6 phr WSD loading in UP/PF/WSD composites under OM observation at 5 magnificent. From the observation, WSD evenly dispersed in matrix resin, voids and uneven layers contributes to weak mechanical properties. The existing of such surface due to poor interfacial bonding between WSD and UP [11-13].

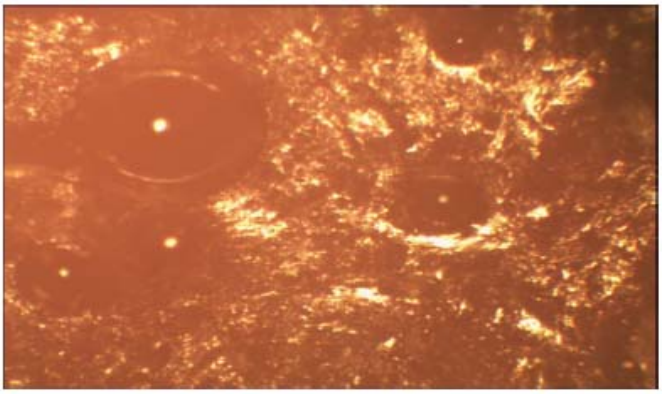

Figure 9. Morphology of UP/PF/WSD composites under Optical Microscope (OM) at 5 magnificent

4. Conclusion
1. The mechanical performance such as tensile and flexural of UP/PF/WSD composites were increased with increasing wood sawdust loading up to 6 phr.
2. The addition of wood sawdust in UP/PF/WSD composites was proved to enhance the stress transfer within the composites, where all the studied mechanical properties show positive increment as the filler loading increase.
3. Organic filler such as wood sawdust will be an alternative and vital reinforcement filler towards manufacturing composites as it can reduce the cost of raw material with better performance in composites.

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