Journal of Civil Engineering, Science and Technology
Volume 6, Issue 2, September 2015

EFFECT OF GLYCIDYL METHACRYLATE ON WATER ABSORPTION PROPERTIES OF SAGO HAMPAS BIOCOMPOSITE

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Date received: 13/08/2015, Date accepted: 25/08/2015
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Abstract – This study examines the water absorption of sago hampas biocomposite utilizing glycidyl methacrylate as its matrix. Composites were fabricated with 25, 30, 40 wt% sago hampas content and another sample of pure sago hampas using hydraulics hot press machine. The water absorption properties of composites with different sago hampas composition were investigated according to Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials of ASTM D570. Water absorption of pure sago hampas composite have the highest average water absorption percentage with 59.1 wt% as compared to the lowest average water absorption percentage recorded for 30 wt% sago hampas content biocomposite with 16.8%. However sago hampas loading was increased resulting in the increased in average water absorption on biocomposite for 40 wt% sago hampas content which is 33.1%.

***Keywords*:** Glycidyl mehacrylate, sago hampas, biocomposite, water absorption test

1.0 INTRODUCTION

Most composites produced nowadays uses non-degradable fibers made from non-renewable resource. This is to produce high durability product and to ensure product longevity. However the use of plastic materials in agriculture causes serious hazards to the environment [1]. The introduction of biodegradable materials, which can be disposed directly into soil can be one possible solution to this problem. Sago hampas (SH) is an abundantly available agricultural waste which has contributed to environment pollution. From previous study, it has been proven that sago hampas contains cellulose, hemicellulose and lignin [2]. The production of natural biocomposite is formed by matrix (resin) and reinforcements (fiber) mainly formed by cellulose [3] and which is available in SH. Natural biocomposite can be define as composites made up of natural fibers and is readily degradable.

Natural fibers are produced by plants and animals. Plants fibers include seed hair (eg. cotton), stem, (eg. hemp), leaf fibers (eg. sisal) and husk fibers (eg. sago). Animal fibers include wool (eg. angora wool and alpaca wool) and secretions (eg. silk). Natural biocomposite research areas are divided into three which are short natural fiber research, long natural fiber research and biopolymer development research [4]. The interest on the usage of natural fibers as fillers is very high due to its low density, more biodegradable and non-abrasiveness during processing [5]. This research will focus on short natural fiber research which utilizes 'waste' cellulose fiber which is sago hampas

In this study, glycidyl methacrylate (GMA) were used as it is less harmful to human body compared to other reagent [6] and have balance chemical and mechanical properties. GMA is selected as the matrix due to the ease of handling it in room temperature [6]. GMA was utilized in many studies to facilitate chemical reaction between components (polypropelene and fiber) during melt mixing [6]. GMA will be utilized directly with sago hampas (SH) to produce composite. This research mainly focuses on formulating composite material utilizing sago hampas and glycidyl methacrylate (GMA) and testing its water absorption test was conducted. Based on Sahari et al, (2012) water absorption test on biocomposite is done for quality control as water absorption affects the mechanical properties of

composites. Besides that water absorption by biocomposites using natural fibers will affect its long term performance [7]. The water absorbed leads to physical degradation such as dimensional changes and thickness swelling [8].

2.0 METHODOLOGY

The biofillers used was sago hampas (SH) obtained from River Link Sago Resources Sdn. Bhd. Mukah, Sarawak. Glycidyl Methacrylate (GMA, CAS 106-91-2) was purchased from Aldrich.

SH was washed to remove dirt from milling machine, sago starch and starchy granules of sago bark leftovers and was immersed in distilled water at 90ºC for 6h to allow to destarched. The resulting slurry was washed thoroughly under running water to remove starch extractions. SH obtained was dried using an air oven at 60ºC for 24h. Treated SH was mixed in GMA epoxy and glycerol to increase fluidity, at room temperature according to the desired volume fractions as shown in the Table 1.

Table 1 Biocomposite mixing conditions

SH Content (wt%)	SH weight (g)	GMA weight (g)	Glycerol weight (g)
Pure SH	10	0	0
25	5	10	5
30	7	10	5
40	10	10	5

The design of biocomposite films were referred to standard ASTM D3039/D3039M international specimen geometry requirements shown in *Table 2*. The mixing solution was poured in moulds of 7 columns with 0.25 cm thick, 27 cm length and 2.5 cm width. Then the mould with composite mixture was placed under hydraulic hot press machine. The assembly was then pressed for 1h with 160ºC on both upper and lower plates [9]. Composite was left to cool down under room temperature before taken out from mould and cut into 5 cm films as shown in *Figure 2*. SH/GMA biocomposite was tested at 25, 30 and 40 wt% ratio. Then the SH/GMA biocomposite will be compared based on its effect on mechanical properties with pure SH.

Figure 1 Hydraulic hot-press machine

Table 2 Tensile sample geometry requirement

Parameter	Requirement
Shape	Constant rectangular cross-section
Min. length	Gripping + 2 times width + gage length
Sample width	as needed
Sample width tolerance	±1% of width
Sample thickness	as needed
Sample thickness tolerance	±4% of thickness
Sample flatness	Flat with light finger pressure

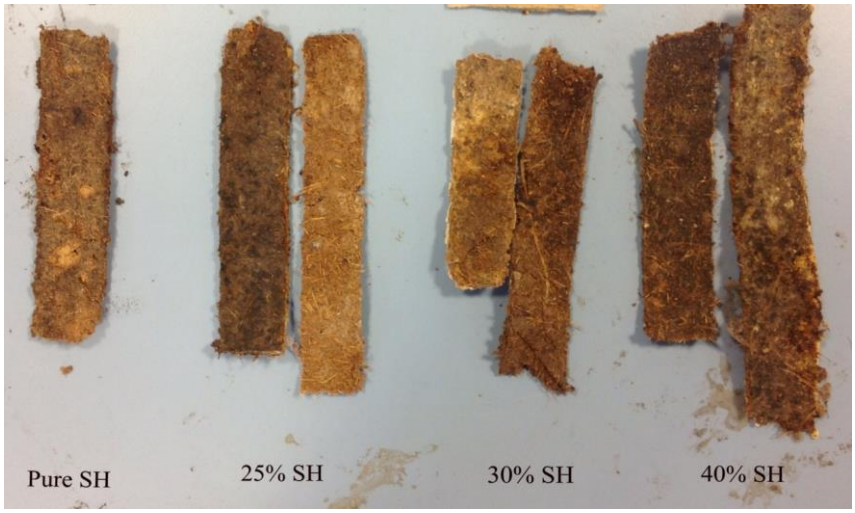

Figure 2 SH/GMA biocomposite films

Water absorption was determined according to ASTM D570 on rectangular samples with thickness of 0.25 cm, length of 7 cm, and width of 2.5 cm. Three replicates of each samples of different SH composition was prepared. The samples were dried in an oven for 24hrs at 60ºC and then placed in desiccator to cool. After cooled, samples were emerged in distilled water at room temperature up to 4 hours. The samples were simultaneously taken out from the water tank at 4 hours mark, dried with lint free cloth and subsequently weighted. The amount of water uptake by samples was calculated using the following equation referring to ASTM D570. The volume of water absorbed by sample is reported as percentage of water absorption as shown in Equation 1:

$$\text{Percentage of water absorption (\%)} = [(\text{wet weight} - \text{dry weight}) / \text{dry weight}] \times 100 \quad (1)$$

3.0 RESULTS AND ANALYSIS

Water absorption test results obtained from this study is reported referring to Table 4. Based on the Table 4, the percentage of water absorption for pure SH composite was the highest average water absorption percentage recorded which is 59.1% and the lowest water absorption percentage was composite with 30 wt% SH content with 16.8%. Based on Taib et al (2008), natural fiber is hydrophilic which explains the high water absorptivity of the pure SH composite. With the addition of matrix, reduces the water absorption of the composite [4], in this case the matrix is GMA.

Table 4 Average water absorption percentage

SH Content (wt%)	Water Absorption (%)
Pure SH	± 59.1
25	± 50.8
30	± 16.8
40	± 33.1

The addition of GMA helps to reduce the average percentage of water absorption of composite by forming an interfacial bond between matrix and fiber [8]. This can be proved because pure SH composite has a higher average water absorption percentage which is 59.1% compared to water absorption percentage of composite with 25 wt% SH content with 50.8%. Without matrix, pure fibers will have gaps and this increases the percentage of water uptake [15] as water molecules diffuse into pores and micro-cracks within the composite. In the other hand, water absorption by 30 wt% SH content biocomposite is 16.8% which is lower compared to the average water absorption percentage of the 25 wt% biocomposite. Scientist reported that the increase in fibre loading in biocomposite results in reduction of water absorption because the fiber acts as water resistant in biocomposite [8]. When SH load was increased from 25 wt% to 30 wt %, interfacial bond between SH and GMA becomes greater. It is believed that the interfacacial bond resist the water molecules from penetrating into the interface of the biocomposite, hence slowing down the initial rate of water absorption. Thus, result in the lower percentage of water absortion of biocomposite with 30 wt% SH compared to 25 wt% of SH.

However, 40 wt% SH content biocomposite has a higher average water absorption percentage with 33.1% as compared to the 30 wt% SH content biocomposite with 16.8%. As the amount of SH becomes too much in a biocomposite, the fiber acts more to its hydrophilic nature rather than hindrance towards water molecule [16]. The hydrophilic characteristic of natural fibre is the result of polysaccharide hydroxyl group found in cellulose which produces hydrogen bond between water and SH fiber [11]. Thus, increasing SH fiber loading to 40 wt% will only increase the hydrogen bond formed which allow water molecule to actively attack the biocomposite interface resulting in the increase water absorption properties of the biocomposite.

4.0 CONCLUSIONS

The results of study are discussed as follows. SH/GMA biocomposite can be further tested on morphological testing using SEM to view on the surface and adhesion of fiber to resin to explain on the relatively low average tensile strength. Furthermore, water absorption test was done to SH/GMA biocomposite to investigate the water uptake of the biocomposite formulated. The addition of matrix reduces water absorption properties of biocomposite. However the increase in SH fiber loading simultaneously increase water absorption properties due to hydrophilic properties of natural fiber. Plus, the composite can be improved with addition of other matrix and using GMA as a hardener instead of the main matrix.

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