Comparison on oil and water absorption ability of various natural fiber

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Abstract. The natural fibers from trees, agricultural waste, fruit skins and others will be considered as recyclable and recently have been used widely as filler materials in polymer composites. As an alternative, natural fibers have become the attention of researchers to substitute the commercial, synthetic and costly fibers. Therefore, this study has used 6 types of natural fibers from local fruit waste in Malaysia, and investigate the ability of each of them to absorb oil and water. All natural fiber showed different absorption percentage within the testing period. The natural fiber which more hydrophilic goes to coconut shell, against peanuts as the lowest in absorbing water. Meanwhile, coconut residue capable to absorb more oil than coconut shell which showed oleophobic behaviour. The cellulose content, the hollow or pores and also the types of natural fiber are the factors that affect the percentage of oil and water uptake.

1 Introduction

Agricultural residue and waste are major available use in value added products. In this last decade, the interest in natural plant and fruit fibers from agricultural as filler in polymer has grown quickly. Their advantages are low density, low in cost therefore are renewable. Natural fibers are biodegradable, which is crucial for the product’s end life [1].

There are some drawbacks in the use of natural fiber itself or in composite, due to hydrophilic and the adhesion problem between fiber and matrix. They have drawback when considering their sensitivity to water absorption because being rich in cellulose so they are hydrophilic in nature [1,2].

Other than water, natural fiber showing different behaviour to oil and this also received great attention to be studied. It may have potential for oil-related applications. Either absorb or resist water and oil, natural fiber may have potential ability to work in near future, for example as interior parts, insulations, wrapping papers, furniture, textile or packaging

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objects. Lignocellulosic fibers are good sorbents of oil [3]. Also, the fact that they are from natural resources makes them even more attractive in term of sustainability and environmental awareness [4]. The application of plants as sorbent material has great potential.

The novelty of this work lies in the value addition of natural fiber from agricultural waste. Each type of natural fiber which are coconut residue, corn stalk, sugarcane bagasse, coconut shell, peanut and coconut husk can have their own capability to absorb water and oil. This result will further help to understand underlying the potential of agriculture residue to replace the commercial fiber.

2 Methodology

The preparation of natural fiber from washing, cutting and grinding in this study were done within 2 months schedule. The chosen natural fibers from agricultural waste was coconut residue from coconut milk production, coconut husk and coconut shell from the coconut fruit itself, corn stalk from the corn farm, sugarcane bagasse was from the stall of sugarcane juice and the last is peanut skin.

Since the aim of this project is to study the behaviour of water absorption of the various type of natural, so the testing were carried out according to ASTM D 570-98 standard [1]. Six samples were prepared in a small size about 2 cm x 2 cm. All the samples were dried at 50°C during 24 h, and then cooled to room temperature. The samples were immersed in water and oil, separately. After 24 h of immersion, the samples were removed, immediately dried with dry cloth, and were weighed (mass) using a digital scale. This process was repeated for 28 days, to get the weigh of the samples regularly.

The percentage of water absorption is calculated by using the equation below, the same as some previous studies [5,6]:

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\text{Absorption percentage} \% = \frac{(W_2 - W_1)}{W_1}
\]  

where, \(W_1\) refer to the initial weight of natural fiber and \(W_2\) refer to the final weight of natural fiber.

The graph were plotted and compared among the six natural fibers, and also the result between water and oil. All of the fibers are originally received without any chemically treatment or modification. For evaluation of fiber’s oil sorption performance, vegetable oil was used as the experimental oil. The water is only distilled water.

3 Results and Discussions

This study evaluate and compares the performance of six different type of fiber from agricultural waste. Table 1 presented the initial and final weight of the samples. The data were used to calculate the absorption percentage as mentioned above and also to plot the graph.
Table 1. Initial and final weight of samples in water and oil for 28 days

| Natural fibers          | Water                  | Oil                  |
|-------------------------|------------------------|----------------------|
|                         | Initial weight (g)     | Final weight (g)     | Initial weight (g) | Final weight (g) |
| Coconut residue         | 0.752                  | 0.822                | 0.818              | 0.921            |
| Corn stalk              | 0.670                  | 0.796                | 0.599              | 0.664            |
| Sugarcane bagasse       | 0.557                  | 0.689                | 0.812              | 0.904            |
| Coconut shell           | 0.752                  | 0.965                | 0.749              | 0.772            |
| Peanut                  | 1.003                  | 1.170                | 0.828              | 0.877            |
| Coconut husk            | 0.740                  | 0.880                | 0.534              | 0.552            |

An analysis of the interaction between fiber type, and the immersion medium resulted in the most effective relationship for specific application. The result of this study demonstrate the absorption potential of various natural fiber in water and oil as plotted in Figure 1. The findings can encourage the use of natural fibers as an alternative to polymer material application. As we know, if the sample can resist water and oil, it can be as coating material. For the sample which can hold water and oil, it is so appropriately proposed as absorbent material. Here, this is the importance of this investigation and the finding obtained.

Fig. 1. The absorption percentage for six types of natural fiber in water and oil.

Usually, the theory of absorption for any liquid is linear at the beginning. After that it slowly and by the extended immersion time, the samples then approaches the saturation stage. In this study, the result only showed the final reading after 28 days of immersion, as plotted in Figure 1. The water and oil absorption test is the calculation of the amount of water and oil in the sample, and the measurement of the weight difference over time. The differences between the initial weight give the absorption capability value in percentage [7].
3.1 Water absorption

Coconut shell showed high water absorption, followed by coconut residue, sugarcane bagasse, coconut husk and corn stalk. It seems that peanut gave the lowest percentage in ability to absorb water. Natural fibers which known are from agriculture have many free hydroxyl groups at molecular level that easily bond with water. Water absorption by natural fiber depends on fiber-related factor, such as size, shape, structure/arrangement and the condition in which fiber are exposed to the water [3].

The six types of used fiber will gave different physical, chemical characteristics to the fiber, it as expected that the different fibers would show different affinities towards each medium. The same finding by Wong [3] on natural fiber. As reported by Marko [8], due to their shape, surface area and their nature, natural fibers have some weakness on the absorption capacity. When considering to the nature of each filler, we may know that some natural fiber were in particulate form, irregular shape, short or long fiber size. Cutting and grinding also produced different size of them. Some of the natural fiber contains pores and holes, and these are responsible for water (and other liquid medium) as well as water transport.

Besides, natural fibers are absorptive in nature. They take up water and other liquid relying on the environment conditions. The available hydroxyl group provide an increased level of hydrophilic behaviour to the natural fiber. To differentiates the absorption capacity or percentage is depending on the type of natural fibers used in this study.

3.2 Oil absorption

Absorption of natural fiber in polymer composite considered the hydrophobic properties and void fraction as the two factors affect the oil sorption capacity, cellulosic materials from agricultural with hydrophobic surface and a hollow structure are of interest to researcher [9]. Natural fiber has been limited by function due to their chemical composition being rich in cellulose, hydrophilic in nature [2]. Diffusion, capillary and transport of water molecules are 3 majors mechanisms in absorption.

The oil absorption pattern after 4 weeks for six natural fibers can be referred as in Figure 1 above. All fibers were compared and it revealed that coconut residue capable to absorb more oil than others. Then it come next by sugarcane, corn stalk, peanut, coconut husk and coconut shell, respectively. Oil has low density and float on the surface of the fiber. According to Marko [8], some of fibers will showed obstacle like oil absorption capacity due to its oleophobicity property. Their shape, surface area and their nature also be as the reason to this. We can say that, corn stalk and sugarcane bagasse which naturally contain long and fine fibrous structure can easy access of the oil [10]. Coconut shell after grinded, are in powder form with irregular shape. Strong fiber and matrix interfacial adhesion also can help to limit the oil take in.

Any natural fiber which is long fiber with hollow tubes structures may serves a valuable for oil absorption. If the surface area is large, there will be more area for absorption of oil molecules, as reported by Jayamol [11]. Surface cavities are filled with oil molecules that have been absorbed. Furthermore, the percentage of oil absorption and swelling which
obtained with different type of oil are determined by the ability of the oil to interact with the cellulosic fiber.

In contrast between water and oil as absorption medium, it is clearly to prove that, the density of water is more than oil. Other than that, the viscosity of water is lesser than oil. Both properties of liquids influences the absorption ability in this investigation.

**Conclusion**

All the six natural fiber presented good in capability to absorb water and oil. There was no significant difference when comparing the result for both water and oil, but we can see the differences when compare it among the type of fibers. Coconut shell demonstrated highest in absorbing water but coconut residue good for oil absorption. In the future, the natural fiber will become one of the sustainable and renewable resources in the composite field which can replace synthetic fibers in many applications.

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