Thermal Properties and Water Absorption Study of Thermoplastic Starch Film Reinforced with Rice Husk Biochar

Muhammad Amirul Adeeb bin Mohd Zaine, Suhaila binti Sauid

Faculty of Chemical Engineering, Universiti Teknologi Mara

***Abstract*—The aim of this study was to analyze thermal properties and water absorption of thermoplastic starch reinforce with rice husk biochar. The sample was prepared by using a conservative casting technique by blending starch with plasticizer, sulphur, acetic acid, and rice husk biochar. As observed, FTIR was used to investigate the chemical interaction between the different components. Water absorption of the film was tested under room temperature with an ambient humidity. As a result it showed that thermoplastic starch without any reinforcement rice husk biochar have the highest percentage of water absorption which is 45.23% while with 7% concentration of rice husk biochar give the lowest percentage of water absorption of 27.37%. The analysis of thermoplastic starch included. With the increment of the rice husk biochar to the thermoplastic starch the percentage of water absorb decreases.**

I. INTRODUCTION

Petrochemical based thermoplastic can cause pollution to the environment. Due to large volume of plastic used over the past few decades, researchers have been more focus on the study of creating and improving biodegradable and environmental friendly plastic which is thermoplastic starch. Starch is an important productive polysaccharide because the material availability is low cost, renewable and biodegradable. The processing of starch based polymers involves multiple chemical and physical reactions. Thermoplastic starch is a renewable resource for polymers in bioplastic. It consists of starch and plasticizer and has high potential for economic growth. The function of incorporation of starch in thermoplastic was to make the material biodegradable and also to reduce the production cost. Starch is hydrophilic, therefore by blending it with hydrophobic polymers is necessary to improve to improve the properties of procesibility, moisture susceptibility and brittleness.

Thermoplastic starch is a material that can be obtained by disrupting the starch granule structure while it is processed with low water content together with thermal and mechanical forces with presence of plasticizer. Generally, starches compose of carbon hydrogen and oxygen with a ratio of 6:10:5($C_6H_{10}O_5$). Starch can be obtained in plants such as potatoes, wheat, cassava, rice, and maize. The starch used in the process of thermoplastic is tacca leontopetaloidesand and it is slightly modified. Starch is widely used because of the abundant resources, cheap as well as renewable. Even so, [1] Kalambur et al, (2006) stated that starch is not suitable for bioplastic manufacture due to its hydrophilic nature and causes brittleness on the materials without a suitable plasticizer. At the end product, the thermal and mechanical properties degraded when exposure to humidity. As a solution, plasticizer was blended together with the starch to prevail over the disadvantages.

In order to improves thermoplastic starch properties, a reinforcement of rice husk biochar been applied. Generally rice husk is a natural sheath hat for around rice grains during their growth. Rice husk has been known to have potential to be used as reinforcement for polymer composites materials [2]. Rice husk biochar that was based on lignocellulose fibers in composites has recently gained attention due to low cost, easy availability, low density, strength full, stiffness, ease of separation and enhanced energy recovery furthermore, these materials can be easily obtained from waste products and have minimal effect on the environment, due to its biodegradable properties.

The properties of thermoplastic starch was investigated using tacca leontopetaloides as a starch, which generally composed of 22.5% amylose and 77.5% amylopectin and mean particle size of 2.64 μm (Ukpabi et al. 2009) reinforce with rice husk biochar which generally composed of 25%-35% cellulose 18%-21% hemicellulose and particle size of 26.64 μm [3]by using Fourier Transform Infrared Spectroscopy (FITR).

II. METHODOLOGY

A. Materials

In preparation of thermoplastic starch, the material that was used to perform this study is tacca leontopetaloides starch, glycerol, acetic acid, sulphur, distlled water, and rice husk biochar that was supplied by the Faculty of Chemical Engineering ,Universiti Teknologi Mara .

B. Preparation of films

Tacca leontopetaloides starch was mix homogenously with glycerol, 5% acetic acid and distilled water in a beaker. The mixture was stirred on top of hot plate at 80ºC until gelatinize. It was puroed into a casting plate and let cooled overnight. The trays then were let dry in oven at 45ºC until the film reaches constant weight. Rice husk biochar and sulphur was added and together with the film with roll mill at 50ºC. The sample was ready to cut for analysis.

C. Film water absorption

The water absorption of the film was determined by weighting each sample using an analytical balance and the beginning. It involve for the sample to be immerse in a beaker with water. The samples with measurement of 2 inch length x 2 inch wide x 5 mm thick were placed. The samples weight data were collected at initial at regular interval of 1 hour until it degraded. The final weight of the sample wetr collected. The samples were left at a room temperature and were weighted each day until it reached constant weight. The initial and final weight of sample was recorded.

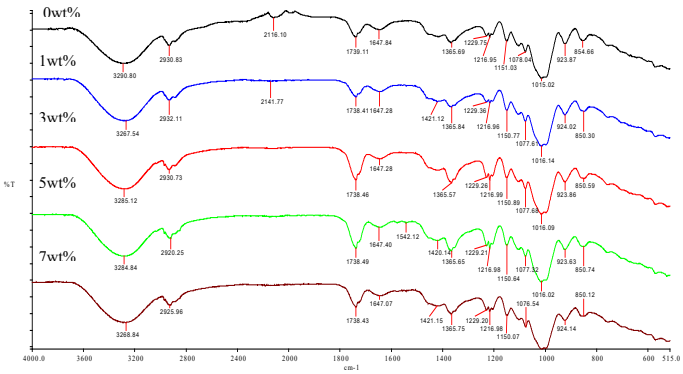
$$Moisture\ content = \left(\frac{W_f - W_i}{W_i}\right) \times 100$$

Where, $W_f = Final\ weight\ gain, W_i = Initial\ weight$

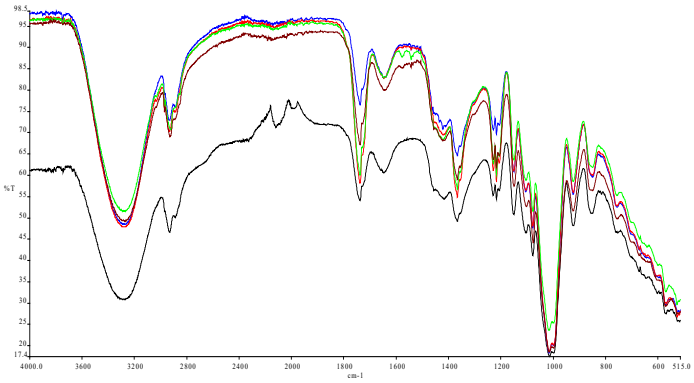
RESULTS AND DISCUSSION

D. Fourier transform infrared spectroscopy (FTIR)

FTIR spectrum of thermoplastic starch film and also those with 1wt%, 3wt%, 5wt%, and 7wt% of rice husk biochar are shown in figure 1. From Figure 1, based on the functional group a peak shown from 854 cm^{-1} and 1015 cm^{-1} to 1151 cm^{-1} shows a C-H stretching, at 1738 shows there's a C=O strech. In addition, a smooth curve from 3290 cm^{-1} to 2930 cm^{-1} indicates –OH groups of starch and glycerol structure and the molecule is completely saturated because there are no peaks below 3000cm^{-1}. The peak for every film that was reinforced with rice husk biochar was pretty similar. Not a lot of variation occurs among the spectra for each of the sample, showing that the modification of properties was due to chain scission alone. If there is some modification of functional groups detected, most probably because of a low extension and not detected by FTIR.



(1.a)



(1.b)

Figure 1: FTIR spectra of thermoplastic starch in with and without the presence of rice husk biochar. (1.a) Split graph, (1.b) Overlay graph

E. Water absorption

The water absorption experiments data, presented in Figure 2 and Figure 3. Rice husk biochar nature Generally, with the increment weight percent reinforcement of biochar to the thermoplastic starch the lower the percentage of absorption. For the first hour, thermoplastic starch film without rice husk biochar filling shows the highest percentage for water absorption of 45.23% followed by 42.29%, 33.63% 30.57/% and 27.37% for 1wt%, 3wt%, 5wt% and 7wt% of rice husk biochar respectively. After the 4th hour of the immersion of the samples, the samples start to degraded. This may due to the hydropihilic matrix condition, since biochar is quite sensitive to the water upteke

Hour / Weight percent biochar	Initial	1	2	3	4
0%	1.447g	2.642g	3.092g	3.304g	3.465g
1%	1.590g	2.755g	3.135g	3.347g	3.498g
3%	1.853g	2.792g	3.163g	3.337g	3.471g
5%	2.026g	2.918g	3.289g	3.453g	3.544g
7%	2.155g	2.967g	3.305g	3.498g	3.588g

Table 1: Water absorption weight data for each thermoplastic starch sample

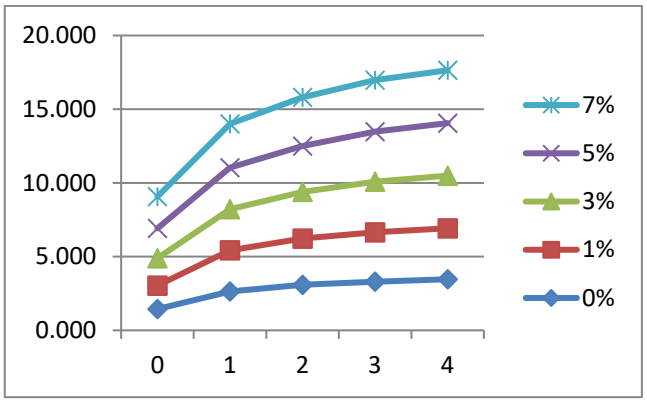


Figure 2: Graph of water absorption by weight (g) over time (hour).

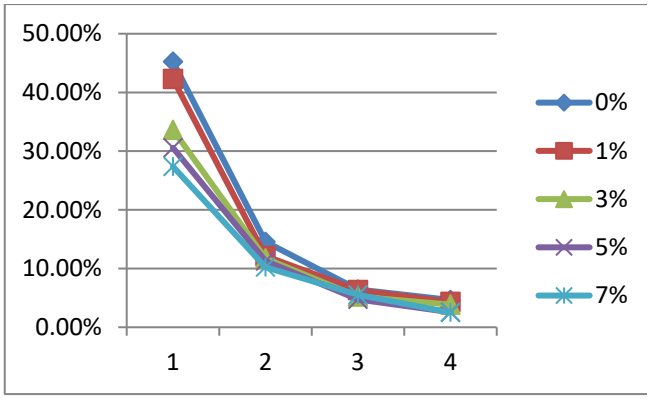


Figure 3: Graph of percent water absorb over time (hour)

III. Conclusion

For the present study, thermoplastic starch was processed in a beaker at 80°C in the presence of 10 ml glycerol, 80 ml distilled water and 5 ml acetic acid. FTIR spectra shows As a result the, in the presence of rice husk biochar it seems to have big influence to the percentage amount of water absorption. By means, it reduces the percentage of water absorption of the thermoplastic film as the weight of rice husk biochar reinforced increases. Hence it can be conclude that rice husk biochar can be ued to incorporate with thermoplastic starch as it improves its properties.

Acknowledgment

In the name of Allah, the Most Gracious, Most Merciful and Him alone is worthy of all praises I would like to extend my thankfulness towards my parent and family for their supports in terms of encouragements and financial. I also would like to extend my appreciation to my friends for always reminds me to always do my best, as well as for my supervisor, Madam Suhaila bt Mohd Sauid. Thank you for the patience in keep guiding me through all the time while I am performing my research project. During the past period, there were so many things I have learned and also recalling what I have learnt from the past semester.

References

[1] Kalambur, S., and Rizvi, S.S.H., 2006. An Overview of Starch-based Plastic Blends from Reactive Extrusion, Journal of Plastic Film and Sheeting Vol. 22.

[2] Reza Arjmandi, Azman Hassan, Khaliq Majeed, and Zainoha Zakaria, "Rice Husk Filled Polymer Composites," International Journal of Polymer Science, vol. 2015, Article ID 501471, 32 pages, 2015. doi:10.1155/2015/501471

[3] U.J. Ukpabi, E. Ukenya, A.O. Olejede (2009) Raw-Material Potentials of Nigerian wild Polynesian Arrowroot (*Tacca leontopetaloides*) Tubers and starch Journal of Food Technology, 7 (4) (2009), pp. 135–138

[4] Alessandra L. Da Róz, Márcia D. Zambon, Antonio A.S. Curvelo, Antonio J.F. Carvalho (2011) Thermoplastic starch modified during melt processing with organic acids: The effect of molar mass on thermal and mechanical properties

[5] Tanetrungroj Y., & Prachayawarakorn J. (2015). Effect of starch types on properties of biodegradable polymer based on thermoplastic starch process by injection molding technique. *Songklanakarin Journal Of Science And Technology*, *37*(2), 193-199.

[6] Teixeira, E. M., Da Róz, A. L., Carvalho, A. J. F., & Curvelo, A. A. S. (2007). The effect of glycerol/sugar/water and sugar/water mixtures on the plasticization of thermoplastic cassava starch. *Carbohydrate Polymers*, *69*(4), 619-624. doi:10.1016/j.carbpol.2007.01.022

[7] Nafchi A.M., Moradpour M., Saeidi M., & Alias A.K. (2013). Thermoplastic starches: Properties, challenges, and prospects. *Starch/Staerke*, *65*(1-2), 61-72. doi:10.1002/star.201200201