Development of Biodegradable Plastics for Packaging using Wastes From Oil Palm and Sugar Cane

M.K.Wahid, M.N.Ahmad, M.H.Osman, N.A.Maidin, M.H.A. Rahman, H.M.S. Firdaus, M.A. Kasno

ABSTRACT: This paper presents the comparison of tensile strength and biodegradable test of three different biodegradable plastics made from tapioca starch that mixture with natural fiber such as oil palm fiber and sugar cane fiber. The application of this research is to produce biodegradable plastic packaging for the food industry purpose. Tapioca starch is used as the main ingredient with sugar cane fiber and oil palm fiber mixture and prepared in three different variation. The tensile strength test followed the ASTM D638 standard shown that biodegradable plastic produced with tapioca starch and oil palm fiber had highest tensile strength with 1.122 MPa as compared to biodegradable plastic with tapioca starch and sugar cane fiber that only obtained at 0.290 MPa. However, the combination of the mixture fiber had showed significant improvement at 0.33 MPa. Then these biodegradable plastic is evaluated with biodegradable test followed with ASTM-6400-99 standard.

KEYWORDS: Biodegradable; Plastics; Oil Palm Fiber; Starch

1. INTRODUCTION

Biodegradable plastic is the polymer that can be disposed biological in a short period of time as compared to the conventional polymer derived from petroleum based. However, this polymer does not have broad applications in the packaging sector industry to replace oil-based plastic materials, although it can be an attractive way to eliminate the limitations of petroleum resources.

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Fossil fuels and gas can be partially replaced by green agricultural resources, which should take part in the reduction of carbon dioxide emissions. Biodegradable plastics can be the basis for a more environmentally friendly and sustainable alternative to current materials based solely on petroleum.Bio-based materials offer value in the equation of sustainability and life cycle to be part of the cycle that is not contaminated. The objective of the project is to develop biodegradable plastic from natural fibers which were combined from tapioca starch, sugar cane fiber and oil palm fiber. Starch is a naturally occurring, biodegradable, inexpensive and abundantly available polysaccharide molecule. It is widely distributed in the form of tiny granules as the reserve carbohydrate in stems, roots, grains and fruits of all forms of green leafed plants [1]. Tapioca flour can be a thermoplastic material through the disruption of the molecular chains under specific conditions of temperature and presence of plasticizer. The process of compression molding was selected as a manufacturing process in which recharges containing chopped fibers were compressed in a mold. The structural fibers need to produce were volume fraction homogeneous and isotropic fiber orientation structure. This changes the fiber caused by the flow characteristics that are produced during the charging process. The mechanical properties of the final product is determined predominantly by fiber [2]. Tensile properties of composites are improved by adding fibers to the polymer matrix of the fiber strength and stiffness values were higher than the matrix [3]. Environmental properties evaluation of the natural fiber biopolymer composite were depends on the ingredient composite, filler content, fibers orientation, inter facial bonding and the processing applied in the fabricated process. Biodegradation test was performed to evaluate performance degradation rates and environmental impacts caused by the sample.

2. METHODOLOGY

Raw material that involved in this study were tapioca starch as a matrix material and the reinforcement which are sugar cane fiber and oil palm fiber. The

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glycerol was selected as the plasticizers in this composite. Liquid form of glycerol from vegetables was used in this study .Tapioca starch was selected as a matrix in the composite fabrication. A tapioca was abstract in the powder form. Tapioca starch is available in the market as a commodity tapioca starch. In this study nature fiber was obtained from sugar cane and oil palm fiber. The cleaning process should be emphasized to ensure that the fiber is not contaminated with foreign bodies. The nature fiber was crushed into blender to get the specific length and size.

Table1:The physical characteristics of natural fiber

Type of fiber	Diameter (μm)	Length (mm)	Density (g/m^3)
Sugar Cane	0.8-2.8	10.0-340	1.20
Oil Palm	250.0- 610.0	10.0–30.0	1.15

The drying process should be repeated to ensure that the fiber density is constant and make sure no moisture entrapped between the sugar cane and oil palm fiber. The formulation was divided into three main compositions of weight ratio of the fiber loading. Then all the raw materials that used were weighed according by using the analytical balance. In this research, the glycerol content is fixed in 5% addition, as additive in the mixture. Table 2 shows the composition of raw materials.

Table2:Composition

Sample	Fiber	Tapioca	Glycerol
Sugar Cane Fiber	60 %	35%	5%
Oil Palm Fiber	60%	35%	5%
Mixture Fiber	30%+ 30%	35%	5%

Hot Compression Molding compressed the composite material to fabricate the samples. This process involved temperature and pressure in order to perform the hot compression. Figure 1 shown the Hot Compression Machine that has been utilized to produce the samples. Designed mold as shown in Figure 2 were attached in hot compression molding to obtain the desired shape. The temperature should be analysis to ensure no overheating happen while during the compression process. The volume in cavity mold needs to determine before the process started.

Figure1:Hot compression molding

After the fabrication of these composites was made by a compression molding process, the samples were prepared for tensile test (ASTM D638-10) and biodegradable test or soil test (ASTM-6400-99). Each sample was labeled for each container. The time and date were recorded on the sample material placed in the ground. This biodegradable test was regularly checked to monitor the status of degradation since has been planted. Eventually, final inspection in two weeks after planting the specimens.

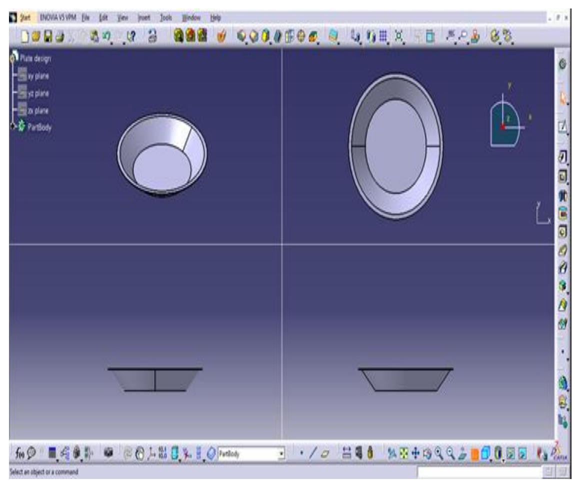

Figure 2:Mold Design

3. RESULTS AND DISCUSSION

The results had established to be observed were shown below in Figure 3. From a product point of view, the product of oil palm fiber was dark as compared to the product of sugar cane brighter in terms of color display. This was due to the original color of the base material which does not change during the process. Meanwhile, the product of a mixture of oil palm and sugar cane fiber look was in intermediate color brightness. The diameter of these biodegradable plastics plate is 15cm with 2mm thickness.

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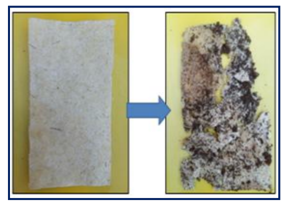
Figure 3:Biodegradable Plastic of Oil Palm Fiber (left) and Sugar Cane Fiber (right)

The average tensile test results and modulus young's were shown in Table 3. These were averaging of five samples tested. The average ultimate tensile stress of oil palm fiber samples had shown the highest value of 1.12 MPa as compared to sugar cane fibers that shown the lowest result of 0.29 MPa.Meanwhile, average ultimate tensile stress of the mixture of oil palm fiber and sugar cane yield point was 0.33 MPa.There are many factors that can affect the performance of natural fiber reinforced composites [4]. The difference was due to the strength of the features that were present in palm fiber were tough and compact as compared to the fiber from sugar cane. Modulus young's also known as the elastic modulus was a measurement of the material stiffness.In order to adjust the stiffness of the material it was to normalize the load with the cross-sectional area[5].For biodegradable test result for each sample had shown in Figure 4 after two week test performed [6].

Table3:Tensile & Modulus Young

Sample	Ultimate Tensile Strength (MPa)	Modulus Young (MPa)
Oil Palm Fiber	1.12	217.67
Sugar Cane Fiber	0.29	154.68
Mixture Fiber	0.33	132.40



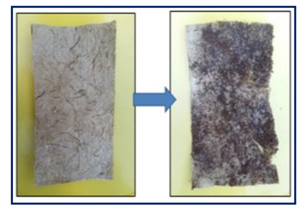


Figure 4:Biodegradable Test Results for Sugar Cane Fiber (left), Oil Palm Fiber (middle) and Mixture Fiber (right)

Table4:Biodegradable Test

Sample	Weight Before Biodegradable test	Weight After Biodegradable test	Rate of weight change (%)
From Sugarcane Fiber	5.00	7.820	56.4
From Oil Palm Fiber	5.00	8.050	61.0
From Mixture Fiber	5.00	7.670	53.4

Table 4 shows biodegradable test result in the rate of weight change .Two weeks of soil or compost biodegradable test results indicated a change in terms of weight and structure. The results show that changes in weight increased during the biodegradable test. The weight changed was the response of microorganism activities on the ground. The high moisture absorption of the test sample was indicated. Environmental factors influenced the disposal of biodegradable

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plastic depend on the microbial population and activity of different microorganisms themselves [7]. Parameters such as humidity, temperature, pH, salinity, presence or absence of oxygen and nutrient supply different has an important impact on microbial degradation of the polymer, and that this situation should be considered when tested for biodegradability of plastic [8]. Mixture fiber specimen showed the highest rate of degradable process as compared to sugar cane fiber and oil palm fiber degradable result. Meanwhile, oil palm fiber specimen was the highest volume remained as compared to sugar cane and mixture fiber specimen [9-11].

4. CONCLUSION

Biodegradable plastic using starch and nature fiber were successfully prepared by mixing process, heating process, molding process and drying process. Two standard tests were carried out to characterize the tensile strength test and biodegradable test had shown significant result that these biodegradable plastics can perform as a packaging product and eco-friendly. Selected nature fiber, such as sugar cane fiber and oil palm fiber are abundant agricultural waste. The tensile strength test followed the ASTM D638 standard shown that biodegradable plastic produced with tapioca starch and oil palm fiber had highest tensile strength with 1.122 MPa compared to biodegradable plastic with tapioca starch and sugar cane fiber that only obtained at 0.290 MPa.

The bonding between oil palm fiber and tapioca starch with the glycerol as the plasticizers enhanced the strength of this composite. However, the combination of the mixture fiber showed significant improvement at 0.33 MPa due to compensation of each fiber strength. In biodegradable test, it shows soil or compost biodegradable test shown result succeed after 14 days. It can be concluded that starch and nature fiber can produce biodegradable plastic. Bio based plastics help reduce the dependency on limited fossil resources, which are expected to become significantly more expensive in future.

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