Mechanical and Morphology Studies of Bioplastic-Based Banana Peels

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Abstract. The limitation of oil has been an intermittent worry in plastic production nowadays. One of the sources of plastic production is fuel. However, the synthetic plastic cause harm to the people and the environment. It has contributed as one of the major cause pollution to the surface of earth. Therefore, new alternative for the production of plastic have been studied. This study is conducted mainly to develop a bioplastic from food waste, banana peels. The additives used together with banana peels are natural-based materials such as corn starch, potato starch and sage while the chemical-based materials used consist of hydrochloric acid and sodium hydroxide. The addition of glycerol is used to increase the plasticity characteristic. From tensile properties results, it indicates that the banana peels bioplastic with chemical-based show high tensile strength and elongation at break compared to natural-based. However, the modulus of elasticity of bioplastic with natural-based retrieved the highest results. The scanning electron microscope (SEM) of tensile fracture surface shows that the additive is well dispersed with banana peels as matrix with good bonding and better adhesion.

1. Introduction
Plastic has become humans’ vital needs as it has a lot of usefulness. The word ‘plastic’ is originally meant flexible and easily shaped. Many studies have been carried out over the century on how to produce manufactured polymers, occasionally natural substance usage such as cellulose, but largely utilizing the plentiful carbon atoms provided by petroleum and other fossil fuels. Engineered plastic composites are comprised of long chains of atoms, arranged in repeating units, frequently any longer than those found in nature [1].

The lack of source from synthetic plastic is one of the main reasons this study was conducted. The vital source of synthetic plastics is crude oil [2]. Oil is limited and with the quickly draining fossil fuels, the ability to keep up and develop supply has been an intermittent worry for more than 50 years [3]. A sufficient supply of cheap (20$ or 30$ barrel) oil is no longer available, in light of the fact that the majority of the "easy to extract" oil is gone. The cost of extracting oil continues rising, however, the capacity of oil-bringing in economies to pay for this oil does not. There are no good low-cost substitutes for oil, so substitution is extremely restricted and will keep on being exceptionally constrained. The huge oil-importing economies are now winding up in poor money related condition, as higher oil costs prompt reductions in optional spending and cutbacks in optional ventures [4]. For so many years, studies have been made by the scientist to prolong the crude oil supply. However, due
to the increasing needs of crude oil, it has become the chief cause the reduction of oil supply to happen. Thus, research must be conducted to find new alternatives to overcome these problems. Apart from that, this research was conducted in order to assist in pollution control. Plastic has become one of the main sources of pollution. Plastic pollution in the surroundings has been taken into worldwide consideration recently. Therefore, the production of bio-plastic based materials using natural resources is a must to overcome this situation [5-6].

This study can be conducted as there were many types of research that have been conducted in order to find potential uses of banana peels for production of bio-plastic material. There are lots of benefits and usage of banana peels. Recently, the utilization of bananas as an element for utilitarian nourishments has accumulated critical intrigue. This is especially due to banana sugars (starch and non-starchy) having low digestibility, which makes it an amazing ingredient to add to food [7]. A huge amount of banana (102 million tons of fresh fruit) is produced yearly [8]. The banana peel conquered at around 35% of the whole fruit weight [9]. Thus, it is estimated around 26 million tonnes of banana peel is generated annually and this is a potential material for further usage. Thus this proves that banana peels have lots of benefits and potential to be utilized as an alternative source. The banana peels contribute to high sources of starch at around 18.5% [10]. As banana peels, age, the increasing level of glucose will occur. In any case, if the peels are excessively ripe, the starch will be changed into glucose while the least ripened peels, turns out to be too firm although high in starch molecules. Thus, the banana peels can be proposed as an appropriate hotspot for the manufacturing of bioplastics.

2. Experimental

2.1. Materials and Experimental Procedures

There were two procedures performed in order to obtain the bioplastic materials. The first experimental procedures were performed by mixing up the banana peels paste with chemical-based materials and glycerol as plasticizer. For the second experimental by mixing up the banana peels paste with natural-based materials and glycerol as plasticizer.

Preparation of banana peels:
   a) The banana peels were obtained from various waste sources.
   b) The peels were cut into pieces and then put in boiling pan.
   c) The peels were boiled in water using boiling pan and electric stove as heating instrument.
   d) The boiling took about 60 minutes and observed by using a stopwatch.
   e) After 60 minutes, the peels were taken out to be left dry on filter paper for about 30 minutes.
   f) After dried, the peels were placed in a blender container and blended until uniform paste was obtained.

Production of banana peels bioplastic with chemical-based:
   a) 100 gram of banana paste was placed in a beaker and weighted.
   b) 12 ml of HCL were mixed with the paste and stirred using glass rod.
   c) 8 ml of glycerol were added which act as a plasticizer and stirred using glass rod.
   d) 12 ml of NaOH were added to balance the pH value of the mixture and also stirred using glass rod.
   e) The mixture was stirred for 5 minutes.
   f) The mixture then was stretched and pressed on oven paper and was dried in the oven with a temperature of 120°C.
   g) The mixture then was allowed to cool.

Production of banana peels bioplastic with natural-based:
a) The banana peels paste was weighed at 40 gram and put into a bowl.
b) 1 gram of sage was added into the bowl.
c) 12 gram of glycerol was added into the bowl.
d) 12 gram of potato starch was added into the bowl.
e) 12 gram of corn starch was added into the bowl.
f) 38 gram of water was added into the bowl.
g) Mix all the substance for 3 minutes or until it blended together.
h) The mixture was dried using the oven at a temperature of 120°C for 3-4 hours.
i) After dried, the banana peels bio-plastic was let rest to cool down.

2.2 Testing Method

1. The testing was carried out using a Zwick/Roell Z100 machine and follows the ASTM D 638. The test speed of the test was 2mm/min and the gauge length was 50mm. The tensile test was done to determine its strength, elongation at break, and Young’s modulus. All the results obtained were automatically calculated and recorded by using its software.

2. This machine was manufactured by JEOL (MALAYSIA) Sdn. Bhd. The model of the machine is JSM-6010PLUS/LV. The aim of this study was to analyze the microstructure and fracture surface of the samples. The platinum was used to coat the sample before testing conducted.

3. Results and Discussion

3.1. Mechanical Properties (Tensile Properties)

![Graph of Tensile Strength vs Types of Composites](image)

**Figure 1.** Tensile strength of banana peels for natural and chemical-based bioplastic
Figure 1 shows the relationship between tensile strength for both natural and chemical-based bioplastic. As observed, there was an increasing pattern of the graph from the natural-based to chemical-based. During the testing, the natural-based obtained 150 KPa of the tensile strength. Different to chemical-based materials which obtained a higher tensile strength which is 228 KPa. The natural-based materials have a lower tensile strength possibly due to the high percentage of starch contains in composites as compared to a chemical-based which use mainly banana peels as their starch extraction. The use of potato starch and cornstarch in banana peels increase the percentage of starch in the samples. The tensile strength can be observed as decrease when the increase of starch percentage due to the filler-filler interaction becomes more prominent [11]. Therefore from this statement, it
proves that the higher tensile strength can be achieved using chemical and banana peels mixture. The concentration of the plasticizer also can be one of the reasons for this behavior.

Figure 2 shows a graph of Young’s modulus of the bioplastics. Based on the graph, natural-based materials achieved 1.88 MPa of the modulus elasticity. While the chemical-based obtained 1.53 MPa of the modulus of elasticity. The modulus of elasticity of natural-based materials was higher compared to chemical-based. It shows the composite stiffness of natural-based was much stronger than chemical-based. The increase of Young’s modulus can be said involves the stress propagation which leads to increase in stiffness [12]. This is probably because of the higher percentage of starch present in the natural additives composites. The increase in the concentration of starch results in the stronger bond of the polymer chain in the composites

Figure 3 shows the overview of the percentage elongation at break between both bioplastics. The natural-based have only 13.97% of the percentage of elongation. While the chemical-based achieved 18.77% of percentage elongation. Based on this data, the reduction of the elongation at break percentage was caused by the increment percentage of the fiber content [13]. Another reason for this behavior was possibly due to the presence of glycerol as the plasticizer improves the plasticity behavior of both samples. This caused the high elongation percentage for both bioplastics.

3.2. Morphology Studies

![SEM micrograph of banana peels bioplastic with natural-based materials at magnification (a) 300x (b)400x (c) 600x (d)1500x](image)
Figure 4 shows the micrograph obtained for the tensile fracture surface of the samples for 300x, 400x, 600x and 1500x magnification. It clearly show banana fibres were completely covered with the natural additives. The bioplastic itself has a weak interfacial adhesion problem. However, the use of glycerol improves the adhesion bonding between the fibres and others ingredient. The mixing of the natural ingredients with banana fibres also produce a good bonding and adhesion between the fibres and the natural additives.

4. Conclusion
The samples of bioplastic made from natural and chemical-based were obtained. The natural-based materials were much less costly compared to the chemical-based. It was also easy to obtain compared to chemical which is hard to find and potentially hazardous. The natural-based materials produce strong and durable bioplastic composites while the chemical-based produce very soft and fragile bioplastic composites. The addition of epoxy resin was needed in order to harden the samples. The presence of potato starch and the corn starch plays an important role in increasing the percentage of starch making it to form a stronger bond of polymer chain contains in starch. A thorough experimentation regarding the natural additives is strongly suggested focusing on obtaining the bioplastic film and using different percentage of natural materials for improvement in enhancing the properties of the materials bioplastic.

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