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Research paper

Synthesis of Biodegradable Plastics from Janeng Starch with the Addition of Chitosan as a Strengthener

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Abstract

Nowadays the use of plastic is very rapidly growing in the broader community. Plastics are generally used for packaging, and the purpose is to maintain the physical condition of the packaged goods and also to increase the commercial value of the goods. Most of the plastic produced have properties that are difficult to decompose so that it takes a long time for the degradation process. Over time, plastic waste has increased and caused air pollution and the environment. Plastic waste problems encourage many researchers to make plastics that are more easily degraded and safe for the environment. This type of plastic is better known as biodegradable plastic. The purpose of this study was to examine the composition of the comparison of chitosan with the addition of glycerol as a plasticizer with a concentration of 1 ml, 3 ml, 6 ml. This research produces plastic in the form of thin, transparent and elastic sheets as well as bright color, slightly yellowish. The tensile strength produced from plastics ranged from 2.3 kgf / mm2 to 4 kgf / mm2, with an elongation value of 2.1% to 4.8%, the results of the density testing contained in plastics were 2.9% to 5.1%. Microstructure measurements using SEM for bioplastic samples showed that the particles bind to each other and were quite tight so that the absorbed water was quite low.

Keywords: *Plastics; Biodegradable; Glycerol; Pati Janeng; Kithosan.*

1. Introduction

The problem of waste is one thing that cannot be ignored from human life on this earth. Its existence which is increasingly increasing can worsen environmental sustainability if it is not managed correctly.
The researchers explained that as much as 15% of waste in Indonesia is the plastic waste. So, out of 220 million Indonesians produce 26,500 tons of plastic waste per day. Plastics are non-biodegradable packaging derived from petroleum synthesis. Its mechanical properties are excellent, the price is relatively low, and the manufacturing process and application are easy, making synthetic plastic the most popular packaging material in the community. However, synthetic plastics have a very high level of chemical physics stability so that plastics are tough to degrade by the environment.
Various attempts have been made to deal with pollution problems caused by plastic waste such as burning plastic, recycling, and stockpiling. Large amounts of plastic combustion can cause corrosive and toxic gases, such as HCl, HCN, NH3, and SO2. Besides that, the plastic material from the polyolefin group when burned does not degrade but only melts and then becomes solid again at room temperature. The recycling process requires enormous costs and is less effective because it has to separate plastic waste that can be recycled and that cannot be recycled. Disposal of plastic waste into landfills dramatically disrupts air circulation to and from the soil because plastic materials generally have a barrier that is high enough for O2 and CO2 permeability (Darni et al., 2008) [1].
Various alternatives have been made by scientists and the public to switch to environmentally friendly natural resources, namely by utilizing plant resources. So far, some agricultural products have been known that have the potential to utilize flexible biopolymers such as potatoes, corn, soybeans, sago, and Janeng.
Janeng is a type of fruit that grows in a dense forest that is underutilized because it contains toxins, so it is simply thrown away. Whereas in Janeng also contains starch which can be used. One of its uses as a raw material for making biodegradable plastics is expected to reduce environmental pollution and increase the potential of Janeng fruit which has been considered to be less economical. However, to make biodegradable plastic more effective and have mechanical properties (especially the nature of its elasticity), Janeng starch must be mixed with plasticizing. This study use glycerol as plasticizer.

2. Research methods

This research was conducted in the Laboratory of Chemical Analysis and Environmental Laboratory, Faculty of Engineering, Serambi Mekkah University, on June 5 – July 7, 2018.
The materials needed in this study were Janeng starch, acetic acid, aquadest, chitosan, and glycerol as plasticizer.
The tools used in this research are Casting Glass, Chemical Glass, Magnetic stirrer, Measuring cup, Spatula, Aluminum foil, Thermometer, Stopwatch, Scissors, Digital Scales, Hot Plate, Computer Type Universal Testing Machines, ovens, petri dishes

2.1. Research variable

Fixed variable
Fixed variables for making biodegradable plastics from Janeng starch:
1) 5-gram starch

2) Stirring speed of 75 rpm
3) 80° C gelatinization temperature
4) 1 ml acetic acid
5) 100 ml of distilled water

Variable Changes

Variables change in the manufacture of biodegradable plastic from Janeng starch:

1) Chitosan 1%, 3% and 6%
2) Plasticizer glycerol of 1 ml, 3, ml and 6 ml

2.2. Work proceduress manufacture of biodegradable plastics from Janeng starch

The manufacture of biodegradable plastic from Janeng starch is carried out as follows:

1) Patient of Janeng 5 grams dissolved with 100 ml of distilled water in a beaker stirred for 25 minutes.
2) As much as 1%, 3% and 9% of chitosan are mixed into glacial acetic acid which has been diluted.
3) After the mixture is homogeneous, a solution of the starch is added with a specific ratio to the beaker placed on a hot plate. The purpose of using a hot plate is to speed up the rate of the reaction by increasing the temperature. Then put the magnetic stirrer into a beaker. The purpose of using a magnetic stirrer is to avoid the formation of clots in the starch while heating and help to flatten heat distribution. Starch is heated to a temperature of about 80 ° C for 15-20 minutes
4) Then add 1 ml, 3 ml, 6 ml plasticizer (glycerol) to the starch. The purpose of adding glycerol is to provide elastic properties. When adding glycerol, the starch must be stirred continuously for 15 minutes to avoid lumps and accelerate the homogenization of mixing between starch and glycerol. Then the beaker is removed from the hot plate (Anita, 2013) [2].
5) After the starch solution has been removed, the starch solution must remain stirred until the average temperature is around 25 -30 ° C for 30 minutes so that the viscosity is maintained.
6) After the starch solution is formed and the temperature of the starch solution is average, then the solution is poured onto the glass with a thickness of about 1 mm which has been given duct tape on the edges. The purpose of using duct tape is to keep the starch solution from spilling past the edge of the glass. The pouring of the starch solution must be done slowly. A thin layer formed on the glass is put into an oven at 70 ° C for 4 hours to solidify and dry.
7) The dried thin layer is removed from the glass by opening it with the help of a sharp razor blade slowly so that it can escape from the glass casting. The plastic is transferred to the desiccator and stored for one day in a place that is not in direct sunlight.

2.3. Testing

1) Tensile Strength and Percent Elongation Test This test aims to find out how much plastic resistance is due to the tensile force applied to the plastic and to find out the percent of the elongation.
2) Density Test
3) Density testing of biodegradable plastics is carried out using measuring cups, scales, and water. This test is conducted to determine the density of biodegradable plastic.
4) Morphological Test
5) Morphological testing of biodegradable plastics was carried out using an SEM (Scanning Electron Microscope).

This test was conducted to find out the morphological properties that exist in biodegradable plastic after experiencing decomposition.

3. Research result

3.1. Tensile strength bioplastic

The results of tensile strength and elongation of break can be seen in Figure 1, which is the graph of the effect of adding chitosan to the ratio of glycerol concentration on bioplastic tensile strength values.

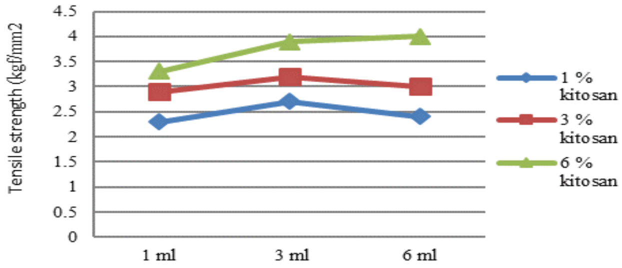


Fig. 1: Effect of Chitosan Addition Ratio on Bioplastic Tensile Strength Values with 1 Ml, 3 Ml, and 6 Ml Glycerol Percentages.

From Figure 1. it can be seen that the ratio of adding chitosan to tensile strength values is directly proportional. Where the higher the percentage of chitosan, the tensile strength value will also be higher. At a ratio of 6 grams of chitosan obtained a higher tensile strength value than bioplastic with a ratio of 3% chitosan, and so on. This strength is because the higher the concentration of chitosan, the more hydrogen bonds contained in bioplastics so that the chemical bond will be stronger and harder to break because it requires much energy to break the bond (Sanjaya, 2011) [3].

3.2. Elongation of break (%) bioplastics

Elongation of break testing is done to determine the amount of length of a polymer before breaking up. The measurement of elongation of break is carried out together with the measurement of tensile strength. The test results of extension break can be seen in Figure 2.

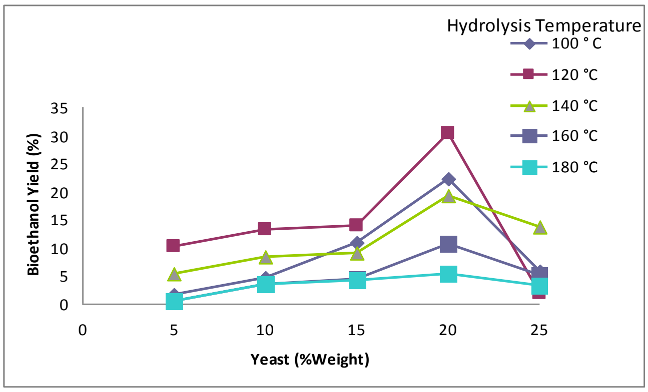


Fig. 2: Effect of Chitosan Concentration Ratio on Percent Elongation.

Figure 2 shows that the percentage of elongation is inversely proportional to the concentration of chitosan. Where the higher the concentration of chitosan, the percentage of elongation decreases (Ifuku, et al., 2012) [4]. From the test results obtained the highest percentage of elongation at a mixture ratio of 1% chitosan with 6 ml of glycerol. This elongation is caused by the decreasing distance of intermolecular bonds due to the high addition of glycerol as a plasticizer (Chairul A, 2015) [5].

3.3. Bioplastic density test

Density is a value that shows the mass of material per unit volume (gr/ml). This test aims to determine the density of biodegradable plastic. Bioplastic density testing is done by weighing a sample with a size of 3 × 1 cm, then inserting it into a measuring cup containing water to find out its volume value. The volume is known from the difference in water level before and after entering the water. Figure 3 shows the relationship of the addition of chitosan and glycerol to the density of bioplastic.

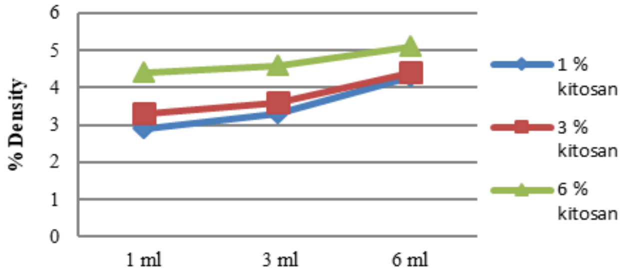


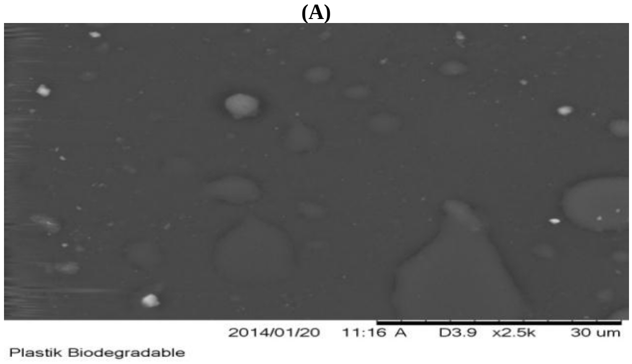
Fig. 3: Effect of Chitosan Concentration Ratio to Percent Density.

From Figure 3, it can be concluded that the more chitosan added, the higher the value of the bioplastic density. Likewise, with the increasing amount of glycerol added, the value of the bioplastic density also increases. At a ratio of 6%, chitosan with the addition of 6 ml glycerol obtained the highest value of density with 5.1%, and the smallest density in the mixture of 1% chitosan and 1 ml of glycerol got 2.9%. The more chitosan and glycerol added, the higher the mass of bioplastics produced. Density is directly proportional to the mass of material, so that the higher the mass of a material, the higher the density value (Isna S, 2016) [6].

3.4. Bioplastic morphology test (scanning electron microscopic)

Morphological analysis with SEM aims to determine the homogeneity of bioplastics, surface structure, cracks and surface smoothness of alloyed products (Erizal, 2010) [7]. The results of SEM analysis with 2500 × magnification can be seen in Figure 4 (a) and (b).

(A)



(B)

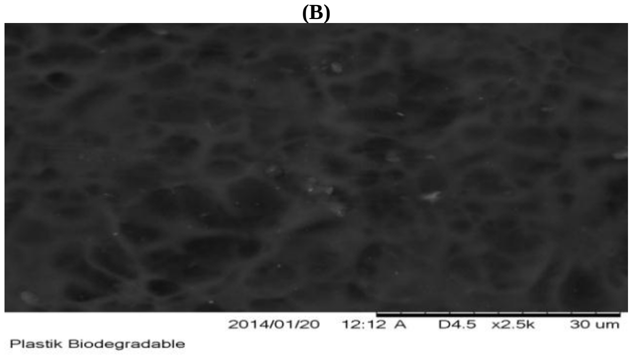


Fig. 4: (A) Bioplastic Surface and (B) Bioplastic Cross Section at A Ratio of 6% Chitosan with 6 Ml Glycerol Concentration (2500 × Magnification).

Microstructure observation using SEM for bioplastic samples presented in the figure above. It appears that the particles bind to each other and are quite tight so that the absorbed water is quite low compared to other bioplastics, but there are uneven pores caused by incomplete stirring, and the resulting morphological structure of the film is not homogeneous due to incomplete mixing and the presence of chitosan which is insoluble in organic solvents (Faris, 2008) [8].

On the surface of the resulting bioplastic, there are air bubbles. Air cavity formation is caused by stirring and bioplastic printing processes that affect the surface structure of the bioplastics produced. The better the printing process, the water vapor contained in the material will evaporate faster so that in the process of water evaporation, the particles of the material will move upwards and cause the inter-cell layer to fuse (Prasetyo, 2013) [9]. The bioplastic cross-sectional structure in Figure 4 (b) shows the presence of pores formed. Small pores because starch-based films to have a low transmission rate of moisture and gas. The figure also shows that there is still a structure of starch granules in them even though they are not intact. The size of the granule that can still be observed has a diameter of 30 μm. Starch derived from seeds, tubers, roots, and stems of plants has a granular diameter that varies between 2-100 μm (Utomo, 2013) [10].

4. Conclusion

From the study results, it can be concluded that the more glycerol added to the bioplastics the tensile strength value will decrease and increase the elongation value, in the case of the bioplastic density test the higher the concentration of chitosan and glycerol the higher density value.

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