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EFFECT OF CARBON NANOTUBE CONTENT ON THE NATURE OF BIOPLASTIC FROM CASSAVA STARCH

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ABSTRACT

EFFECT OF CARBON NANOTUBE CONTENT ON THE NATURE OF BIOPLASTIC FROM CASSAVA STARCH. Bioplastic is a starch-based plastic that is easily degraded by microorganisms, so it can be used as an alternative to conventional plastics. In this research, the process of making bioplastic is made from starch cassava using glycerol as a plasticizer and used CNT type MWCNTs (Multi-Wall CNTs) as an amplifier with variations in composition 0%, 1%, 2%, and 3%. Bioplastics are made by dry blending method with pre-mixing, mixing, hot press and cold press. Bioplastics characteristics of starch/CNT include strong tensile, biodegradation and morphology. The test results showed that the addition of CNT composition affects bioplastic mechanical properties. The optimum tensile value of drag occurs in the addition of a 2% CNT of 13.52 MPa. Biodegradable test result use of *Aspergillus Niger* mushroom to prove bioplastic starch/CNT can be degraded well. The morphological characteristics result in the form of SEM results suggests that the bioplastic starch/CNT 3% have cracks and result in a strong tensile decline. FTIR test results showed a new function group C a" C due to the addition of CNT.

Keywords: Bioplastic, Cassava starch, Glycerol, CNT, Physical properties

ABSTRAK

PENGARUH KANDUNGAN NANOTUBE KARBON PADA SIFAT BIOPLASTIK DARI PATI SINGKONG. Bioplastik merupakan plastik berbahan dasar pati yang mudah terdegradasi oleh mikroorganisme, sehingga dapat dijadikan sebagai alternatif penggunaan plastik konvensional. Pada Penelitian ini dilakukan proses pembuatan bioplastik berbahan dasar pati singkong dengan menggunakan gliserol sebagai *plasticizer* dan digunakan CNT jenis MWCNTs (*Multi-Wall CNTs)* sebagai penguat dengan variasi komposisi 0%, 1%, 2%, dan 3%. Bioplastik dibuat dengan metode kering (*dry blending*) dengan tahapan *pre-mixing, mixing, hot press,* dan *cold press.* Karakteristik bioplastik pati/CNT meliputi kuat tarik, biodegradasi dan morfologi. Hasil pengujian menunjukkan bahwa penambahan komposisi CNT mempengaruhi sifat mekanik bioplastik. Nilai optimum kuat tarik terjadi pada penambahan CNT 2% sebesar 13,52 MPa. Hasil uji *biodegradable* menggunakan jamur *Aspergillus niger* membuktikan bioplastik pati/CNT dapat terdegradasi dengan baik. Hasil karakteristik morfologi berupa hasil SEM menunjukkan bahwa bioplastik pati/CNT 3% memiliki retakan dan mengakibatkan kuat tarik menurun. Hasil uji FTIR menunjukkan adanya gugus fungsi baru Ca"C karena adanya penambahan CNT.

Kata kunci: Bioplastik, Pati singkong, Gliserol, CNT, Sifat fisik

INTRODUCTION

One of the environmental problems in Indonesia is a plastic waste. The amount of waste will continue to increase in proportion to the growth of the population that continues to increase, the consumptive community, the Unprecise waste management system and the living pattern of people who do not follow the "Green Lifestyle" Will certainly be followed by increasing waste production in Indonesia. In 2015, Jenne Jamback (professor of Environmental Engineering, University of Georgia, USA) and his team released data that Indonesia threw plastic waste into the sea for about 187.2 million tonnes [1]. According to the latest data provided by INAPLAST (Association of Aromatic Plastic Industry Indonesian), the annual plastic consumption in Indonesia 4.7 million tons in 2015, rose to 5 million tons in 2016 and is expected to hit 9.52 million tons in 2019 [2].

Plastic-based Petrochemical Polyethylene (PET), Polyvinylchloride (PVC), Polyethylene (PE), Polypropylene (PP), Polystyrene (PS) and Polyamide (PA) have been widely used as a packaging material due to its large availability and affordability. In addition to the appearance of good mechanical work such as tensile and tear strength, good barrier to oxygen and carbon dioxide and heat stability of the petrochemical-based plastics, increase the use of packaging materials [3]. Conventional plastics made from petroleum-based polymer synthesis cannot be degraded by the environment, as in landfills has caused serious problems for the environment. Conventional plastics made from petroleum have low degradation properties, at least plastic bags will be outlined 500-1.000 years, this causes plastics to become the source of most of the world's garbage and certainly damaging the environment [4].

One ingredient that is easily degraded by microorganisms is starch [5]. In addition to its easily degradable nature, starch comes from a natural resource that can be renewed, is universal and reasonably priced, so that starch becomes a material promising to be combined with the amplifier and filler forming polycystic polymer [6]. However, the plastics from the source of starch still have a certain deficiency in terms of physical properties, thermal stability, hygroscopicity compared to conventional plastics [7].

To make bioplastics, in addition to the needed starch, we also need a material that can be used as an adhesive (plasticizer). The use of Plasticizer to increase the flexibility and extension of starch-based plastics. The plasticizer commonly used in the manufacture of bioplastics is glycerol. Use of glycerol as a plasticizer to lower chains of strong molecular interactions and enhance process and mechanical strength capabilities.

The CNT (Carbon Nanotube) was discovered for the first time by Sumio Iijima in 1991. This material is an important concern in Nanotechnology due to its very unique structure and nature [8]. The tensile strength of the CNT type MWCNT reaches 200 GPa, much higher than that of carbon fiber which is only 3-7 GPa, while the rigors can reach 1.2 Tpa, or five times greater than carbon fiber [9-10]. If viewed from the tensile strength of CNT type MWCNT can be used as a bioplastic amplifier because the bioplastic-based starch still has a weakness that is the nature of physics (strong drag) that is still less when compared to plastics Conventional.

Based on previously conducted studies it states that epoxy polymers with the addition of the CNT type MWCNT can improve mechanical properties [11]. Therefore the author is interested to research the influence of the composition of CNT on bioplastic physics-based cassava and glycerol. The purpose of this research is done to improve the mechanical properties of bioplastics made from cassava starch with the addition of CNT as reinforcement.

EXPERIMENTAL METHOD

Materials

Cassava starch materials used the production of PT. Budi Starch & Sweetener, Central Lampung, glycerol $C_3H_5(OH)_3$ Pure Analyse (PA) of the German Merck KGaA as Plasticizer, as well as CNT type MWCNTs (Multi-Wall Carbon Nanotube) Production Chengdu AlphaNano Tech, Co., LTD As additional material to enhance the bioplastic mechanical properties.

The equipment used in this research is the blender for the pre-mixing process of three main ingredients (cassava starch, glycerol, and CNT), Labo plastomil for mixing process, compression molding for bioplastic film printing, Universal Testing Machine to measure the mechanical properties of bioplastic composite samples at a speed of 50 mm/min. Bioplastic surface morphology is analyzed using SEM (Scanning Electron Microscope), FTIR (Fourier Transform InfraRed) method Attenuated Total Reflectance (ATR) to know the clusters found in bioplastic composites. While the tool used for the biodegradable test is laminar water flow and autoclaved.

Methods

The method used is the method of Experiment, where the researchers make the bioplastics starch/CNT use dry blending method or method of making bioplastics in a dry way. Comparison between cassava starch and glycerol 3:1 with the addition of CNT 0%, 1%, 2%, and 3% of the total mass of starch and glycerol.

The research procedure is done in this study as follows:

Pre-Mixing

The process of mixing cassava starch, glycerol and CNT until evenly using the blender for ± 3 minutes.

Then weigh the three materials as much as 50 grams (according to the capacity of the appliance of Labo plastomil).

Mixing

After the pre-mixing process using a blender, the powder is then processed to the mixing stage using a tool called Labo plastomil with a capacity of 50 grams, with a temperature of 130^{0}C within 10 minutes with a torque of about 3-4. The powder that has been through the process of mixing with the appliance of Labo plastomil will melt and become a chunk. After the mixing process is completed, the chunks are weighed 3-6 grams. The chunk will be in the press for bioplastic film.

Compression Molding

At this stage of compression molding of bioplastic the Using a hot press appliance coated with iron plates, using a temperature of 140^{0}C and P = 40 Kgf/cm^2. During the hot press process, chunks will be melted, so bioplastic films are obtained. The next stage is the cold-press process for ± 4 minutes, with the aim of the bioplastic film is not hot when moved to another storage place.

RESULT AND DISCUSSIONS

Physical Form

If viewed from the bioplastic result of starch/CNT produced, physically bioplastic cassava and glycerol starch has a clear/transparent color shown picture 1 (a), while bioplastic starch with additional CNT 1%, 2%, and 3% have a black color showed in Figure 1 (b)-(d). The color between the bioplastic starch/CNT 1%, 2%, and 3% do not have a significant difference, tends to be the same color. The texture of bioplastic starch/CNT picture 1 (a)-(d) has a smooth texture and there are no cracks, but bioplastic starch/CNT 2% has a harder texture than bioplastics starch/CNT 0%, 1%, and 3%.

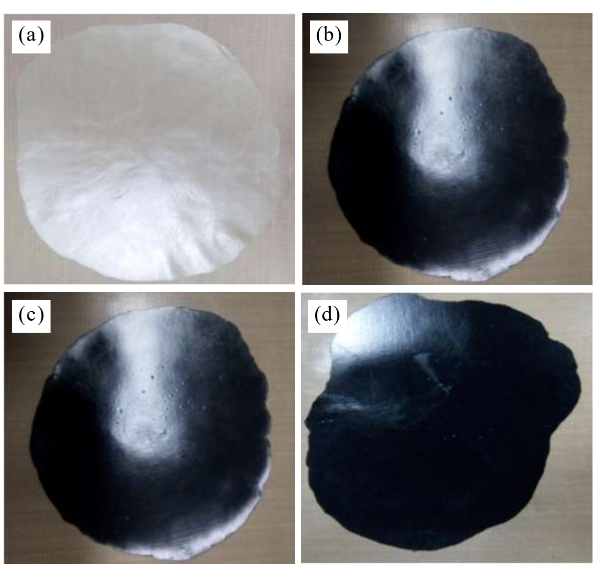

Figure 1. Physical form bioplastic Strach/CNT (a). CNT %, (b). CNT 1%, (c). CNT 2%, and (d). CNT 3%.

Bioplastic Starch/CNT Morphology

SEM (Scanning Electron Microscopy)

SEM (Scanning Electron Microscopy) is a tool that can be used to study or observe the details of the shape and the microstructure of an object that is not visible to the eye or by an optical microscope.

Based on the results of SEM above, presented in picture 2, bioplastic starch/CNT There is a pore on all the samples shown in picture 2 (a) – (d), this pore occurs because of the moisture that comes into bioplastics. Bioplastic starch/CNT 3% shown in picture 2 (d) There are cracks that are more noticeable than the picture 2 (a)-(c), this is what causes a strong tensile from bioplastic starch/CNT 3% decreased. The addition of excessive CNT causes the bioplastics to be produced more rigid and this can lead to greater cracks. The results of this SEM test explained the related strong test result of the tensile on the bioplastic starch/CNT 3% decreased.

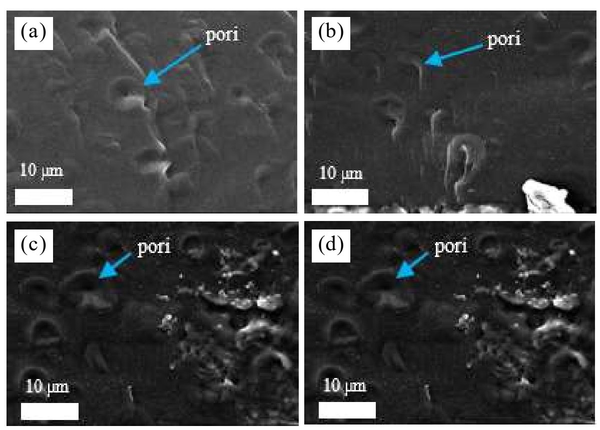

Figure 2. SEM bioplastic starch/CNT (a). CNT 0%, (b). CNT 1%, (c). CNT 2%, and (d). CNT 3%.

FTIR (Fourier Transform Infrared)

This FTIR test aims to thus the interaction between cassava starch as a matrix and glycerol as a plasticizer used in the manufacture of bioplastics and CNT as an amplifier. FTIR is also used with analytical methods to study molecular structures [12] and has the ability to measure groups of greater speed and greater sensitivity [13].

Based on the analysis of the resulting bioplastic FTIR of starch/CNT 0% showed the emergence of the O-H cluster at 3297.66 cm^{-1}, C-H in the wavenumber of 2931.02 cm^{-1}, C=O at 1644.54 cm^{-1}, and C-O in the wavenumber 1017 cm^{-1}. With the function cluster of C=O, carbonyl and ester (COOH) on plastics synthesized

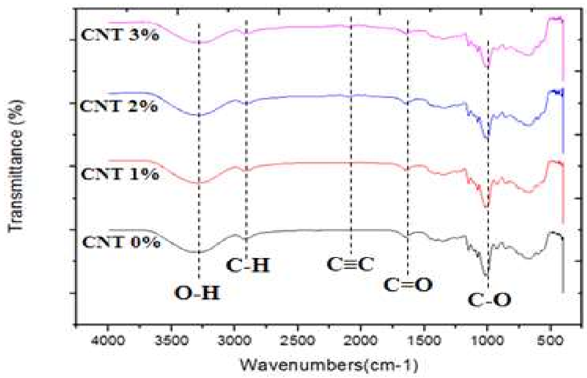

Figure 3. Results analysis of bioplastic FTIR starch/CNT.

identifying the plastic has the ability of biodegradability. In the bioplastic starch/CNT 1%, 2%, and 3% there is a new function group that emerged that is Ca"C on the number of waves 2118.18 – 2113.41 cm^{-1}. It is stated that the addition of the CNT in Bioplastics raises a new function group which signifies an interesting tensile force on the bioplastic matrix. The emergence of new function groups because of the appropriate components, there is a chemical interaction between the chain of starch, glycerol and CNT culminating in the FTIR spectrum changes [14].

Tensile Strength

The mechanical properties are influenced by the sheer amount of content of bioplastic constituent components such as starch, glycerol, and CNT. This robust test of attraction can be noted how the material is in action against traction and knowing the extent to which the material is growing [15].

Based on a strong test result of the poll above, presented in picture 4 shows the influence of the addition of CNT on bioplastics increases the strong value of tensile. The highest tensile strength occurs in the bioplastic starch/CNT 2% of 13.52 MPa which then decreased to 12.39 MPa on the bioplastic starch/CNT 3%. A strong increase in attraction is caused by increased interaction of interesting tensile styles on molecules. The addition of the amount of CNT of MWCNT more than 2% apparently does not increase strength and rigors, even tends to decline [16]. The still weak interface ties between the CNT and the bioplastic matrix cause the strengthening of bioplastics not to be maximized, this is also due to the lack of dispersed CNT in bioplastic matrices. Therefore, bioplastics that are added by CNT 3% have decreased. SEM results indicate excessive addition of CNT on bioplastics resulting in bioplastics have cracks and not bonded perfectly with starch and glycerol.

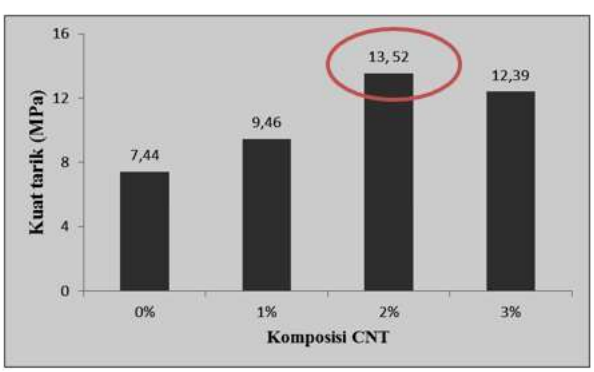

Figure 4. Tensile Strength bioplastic Starch/CNT.

Biodegradable Test

Testing Biodegradable on this research to know the nature of bioplastic biodegradation in the environment [17] by using the methods of planting fungi *Aspergillus Niger* type on bioplastic surface.

Based on the biodegradable test results, presented in picture 5 shows that with the addition of CNT to bioplastics can increase the growth of microorganisms faster. This is due to bioplastic-owned hydrophilic properties causing bioplastics to be degraded more easily [18]. Microorganisms have already covered >60% of the bioplastic surface of starch/CNT within 7 days and this result indicates biodegradable bioplastics at a heavy growth level according to ASTM G21-70.

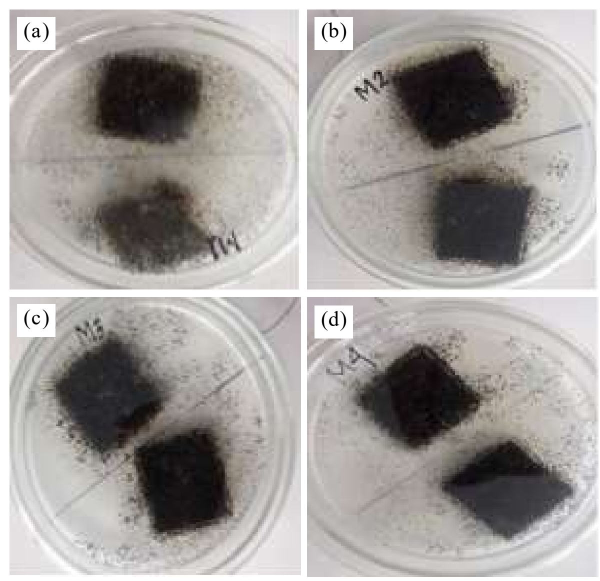

Figure 5. Biodegradable test bioplastic starch/CNT (a). CNT 0%, (b). CNT 1%, (c). CNT 2%, and (d). CNT 3%.

CONCLUSION

The bioplastic-based cassava starch using the glycerol as a plasticizer has a strong tensile value of 7.44 MPa, while the bioplastic made from cassava starch with the addition of CNT has an optimum value in the addition of CNT 2%. Tensile strenght bioplastic starch/CNT highs of 13.52 MPa. Bioplastic starch/CNT can be well-depreciable for 7 days using *Aspergillus Niger* mushroom, and the emergence of Ca"C function groups due to the addition of CNT.

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